Final Report

Statewide Energy Auditing for Energy Master Plan

State of South Dakota

December 1, 2009

OSE No. ACC09-07X

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State of South Dakota

Energy Master Plan

Executive Summary

In 2009, the South Dakota Legislature mandated the Bureau of Administration to prepare and submit a report to the Legislature regarding the energy efficiency of State agencies no later than December 1, 2009. This report:

1. Quantifies current energy consumption by State agencies;
2. Identifies energy conservation measures that could be taken by State agencies to achieve a reduction in energy consumption by a date certain; and
3. Estimates the costs associated with the energy conservation measures.

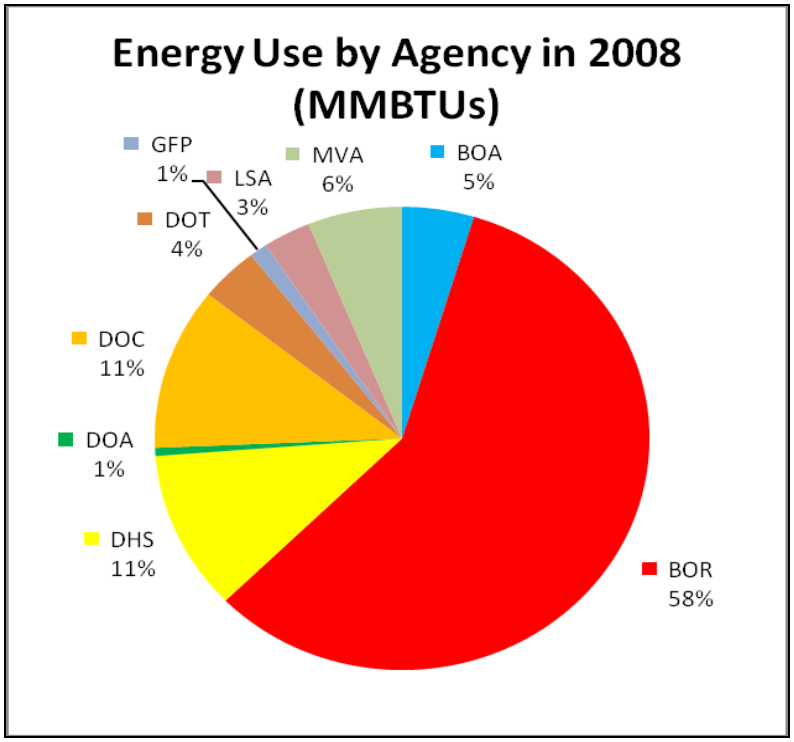
Energy usage data was collected from January 1, 2005 through December 31, 2008 was collected to analyze the most recent four years of utility data. The table below (Table ES-1) summarizes the energy data available by agency for each calendar year.

Table ES-1

Summary of Energy Data for 2008			
Agency	**Total Building Square Footage**	**Use (MMBTUs)**	**Cost**
Bureau of Administration (BOA)	789,932	101,637	$981,911
Board of Regents (BOR)	7,632,555	1,255,598	$11,332,390
Department of Human Services (DHS)	1,117,214	240,984	$2,188,040
Department of Agriculture (DOA)	832,742	12,257	$141,374
Department of Corrections (DOC)	1,657,624	245,293	$2,547,677
Department of Transportation (DOT)	836,559	83,491	$1,268,552
Game, Fish and Parks (GFP)	298101	25,118	$550,029
Leased Facilities (LSA)	775,194	67,670	$754,729
Military and Veterans Administration (MVA)	163,141	133,874	$702,210
TOTAL	**14,103,062**	**2,165,922**	**$20,076,376**

The figure below (Figure ES-2) shows the relative energy consumption by agency for the most complete year of data, calendar year 2008.

Figure ES-2



This study identifies a total of 1,168 Energy Conservation Measures (ECMs) for approximately two-thirds of the State's facilities' total square footage that if implemented could reduce annual energy use by 332,952 MMBTUs annually, representing a 15.3% reduction in Statewide energy use. Implementing all of these measures would cost an estimated $38,617,093. Annual cost savings from reduced energy use would amount to $3,558,450, in today's dollars. While implementing all of these measures is impractical, the aggregate savings shows that there are significant opportunities to reduce energy use at State facilities.

In the following scenarios, ECMs are identified to achieve energy use reductions in 5% increments up to a 20% energy use reduction. The corresponding incremental implementation costs are summarized with the estimated annual energy cost savings.

Table ES-3

% Energy Use Reduction	Reduction in MMBTUs
5%	108,296
10%	216,592
15%	324,888
20%	433,184

ARRA Projects under Contract

There are several projects currently underway which include ECMs at the Capitol Complex and the Public Safety Building. These "shovel-ready" projects include 15 ECMs. These ECMs include Central Boiler Plant conversion, chiller replacements at Becker-Hanson and Kneip buildings, Capitol building

lighting upgrades, Public Safety building boiler replacement, and retrocommissioning at multiple buildings on the Capitol Complex campus.

5% Energy Reduction

To achieve a Statewide 5% energy reduction, additional projects would need to be completed in addition to the ARRA projects currently under contract. If implemented based on greatest energy reduction per dollar invested, a total of 235 ECMs would need to be implemented at a cost of $3,869,108. Annual savings would amount to $1,020,432, yielding a payback of 3.8 years.

If each ECM is implemented based on shortest payback, a total of 292 ECMs would need to be implemented at a cost of $2,873,889. Annual savings would amount to $1,025,708, yielding a payback of 2.8 years.

10% Energy Reduction

If implemented based on greatest energy reduction per dollar invested, a total of 546 ECMs would need to be implemented at a cost of $9,567,513. Annual savings would amount to $2,062,112, yielding a payback of 4.6 years.

If each ECM is implemented based on shortest payback, a total of 669 ECMs would need to be implemented at a cost of $8,813,256. Annual savings would amount to $2,124,233, yielding a payback of 4.1 years.

15% Energy Reduction

Implementing all ECMs documented in this study will yield a 15.3% reduction in Statewide energy use. This would include implementing 1,168 ECMs at an estimated cost of $38,617,093. Annual cost savings from reduced energy use would amount to $3,558,450, in today's dollars, yielding a payback of 10.9 years. While implementing all of these measures is impractical, the aggregate savings shows significant opportunities to reduce energy use at State facilities.

20% Energy Reduction

Throughout the energy auditing process, approximately two thirds of the State's square footage was audited. These facilities were targeted for auditing based on savings potential, schedule, logistics and cost. An effort was also made to audit a representative sample of State agencies and building types. One-third of the State's facilities' square footage does not have potential project costs and savings included in this study. Based on a simple square footage extrapolation of results found in the two-thirds that was audited, it is reasonable to assume that an additional study of the final one-third of State facilities would produce potential energy conservation measures to reduce energy consumption by an additional 7% with similar project economics to this study. Implementation may be estimated at a cost of $12,000,000 with a potential savings of $1,125,000 per year. This would yield a total of 22% reduction in energy consumption Statewide.

Other recommendations include:

- Deploy an advanced metering and monitoring program at State-owned facilities
- Allocate additional resources to energy management to:
  - Record all energy use and energy costs from State facilities (including leased facilities) into a single database, whether that database tool remains EnergyCAP or is selected from other energy management software;
  - Pursue LEED certification for existing buildings using the LEED-EB: Operations and Maintenance rating system;
  - Complete the US EPA's ENERGY STAR Portfolio Manager for all significant State buildings, using the built-in tool in the State's energy management software;
  - Use the energy management software as a management tool, not just a database;
  - Coordinate energy management at a State level, with formal or informal methods of communication among energy managers at State campuses and agencies to share best practices and lessons learned; and
  - Take an active role in keeping up with the cost and viability of new technologies that could potentially reduce energy consumption at State facilities.

An Energy Conservation and Awareness program will also help to shift the culture towards more efficient energy use. This program may include:

- Regional guidelines for:
  - Temperature setpoints;
  - Personal appliances (i.e., refrigerators, space heaters);
  - Behavioral expectations (i.e., turning lights off, dress appropriately for the weather)
  - Occupant comfort and maintenance (i.e., how to inform maintenance staff if uncomfortable)
- Create competition and recognition programs to recognize State employees that are assisting the State to move towards increased energy efficiency
- When procuring new leased space, seek facilities that meet the same standards as those required for new State construction (i.e., minimum LEED Silver certified). These preferences should also be considered in approving extensions of current leases.
- Develop a LEED implementation guide to require all State projects achieve a higher number of energy performance, measurement and verification and enhanced commissioning credits.

1.0 Process Summary

In response to passage of Senate Bill 202, the State of South Dakota requested consulting services from Sebesta Blomberg & Associates, Inc. (Sebesta Blomberg) to assist in creating an Energy Master Plan. Sebesta Blomberg provided a strategic process to address these goals that included quantification of State energy consumption and on-site assessment of facilities within the State of South Dakota's campus portfolio. Sebesta Blomberg executed a process to address varying facility types through data collection and investigation tactics and provided a preliminary evaluation of high potential energy efficiency measures and associated economics.

Key steps included targeting facilities based on energy conservation potential. Specific objectives include:

1. Definition of facility types and receipt and analysis of energy consumption data;
2. Identification of key facilities with high potential for energy efficiency;
3. Prioritization of facilities by high annual energy spent and intensity; and
4. Definition of an investigation strategy for campus and facility type.

In collaboration with the State of South Dakota's energy management team, Sebesta Blomberg assessed facility and consumption data for each campus location for the purpose of quantifying the current energy consumption levels of State agencies. The data acquisition was completed via remote access to the State of South Dakota's network server to the EnergyCAP database tool. Sebesta Blomberg utilized the existing utility and cost data to review and analyze energy consumption for quantification of a 2005 energy baseline. Metrics of energy performance comparisons were completed by benchmarking existing data for the purpose of facility targeting for site investigations. Quantification of energy usage and costs were completed to establish energy profiles for each State agency and associated campus location, including leased buildings.

The goal of the investigation phase was the assessment of targeted facilities at each campus location to identify energy conservation opportunities. Sebesta Blomberg conducted an investigation of targeted buildings that included facility and systems data gathering, staff interviews and campus location site visits to identify and quantify energy efficiency opportunities for both operational and infrastructure improvements. Facility campuses were investigated to identify high impact energy saving opportunities. Investigation tactics were developed to identify campus-wide and facility-specific measures.

An assessment of campus systems and operations was completed and specific energy conservation strategies were defined and documented for selected target buildings. Through the site investigation and representative sampling of buildings, energy conservation strategies and savings potential were

extrapolated for each campus. The investigation included interviews with operating staff and focused on key demand-side energy opportunities that were economically attractive and operationally feasible.

This investigative process included planning, data gathering and review, on-site surveys and analysis and documentation of energy efficiency strategies and associated economics. Planning and data gathering focused on the following objectives:

- Gain understanding of the campus facility, systems and operations through interviews with site facility personnel;
- Review of available utility billing or metered utility consumption data;
- Review of available trend logs of heating, ventilating and air-conditioning (HVAC) systems parameters, such as air flow rates, equipment schedules, supply air temperature, static pressure, mixed air temperature, variable speed drive operation, chiller performance data, heating load data, and cooling load data; available controls sequence of operation were also reviewed; and
- Review and documentation of occupancy schedules, temperature set-points, and operating schedules of energy using equipment.

Campus site investigations were performed by teams of engineers and scheduled by location and number of days on location. Targeted assessments were completed on buildings identified through the energy performance metrics and facility prioritization. Sebesta Blomberg focused on areas with the greatest potential for savings, including:

- Lighting technology retrofits;
- Lighting controls;
- HVAC controls;
- HVAC operating strategies;
- Replacement of existing equipment with higher efficiency equipment;
- Water efficiency technology and controls;
- Insulation improvements to building envelope or piping and duct systems; and
- Building envelope improvements.

Each facility was unique and opportunities and magnitude of savings varied. Assessments consisted of evaluating equipment and energy, using standard engineering methodologies to model baseline operation of equipment observed in the field for comparison to actual use.

Sebesta Blomberg analyzed major energy users and key energy conservation opportunities to prepare a report outlining the scope and economics of each measure. For each such measure, Sebesta Blomberg

provided a brief description; an estimate of the probable implementation costs, a summary of any significant effects it may have on operations; and a preliminary estimate of the associated energy and energy cost savings. Relative priorities for the energy conservation opportunities were identified along with a recommended sequence of completion. Sebesta Blomberg also reviewed the potential for renewable energy technologies including wind and solar photovoltaic (PV) opportunities. This assessment reflected the relative availability of wind and solar resource at State campuses.

The final phase of the project focused on documenting the findings into an Energy Master Plan for the State of South Dakota. Using the information collected from the site visits, Statewide technical and financial impacts for energy savings were developed for review by the State which summarized all energy conservation measures identified in the study. Final Campus Overview reports included estimated cost, energy savings and simple payback calculations for identified energy conservation measures and categorized into campus-wide and facility-specific opportunities.

Sebesta Blomberg has provided recommendations for an implementation approach based on prioritization of opportunities considering feasibility, resource and funding options defined by the State. An Executive Summary of the Energy Master Plan has also been developed for presentation to the Legislature. A project representative from Sebesta Blomberg has also been made available to present this information in conjunction with the State's representative.

The numbers included in the economic analysis tables used to draw conclusions about the cost effectiveness of implementation of individual measures are based on an ASHRAE Level 1 analysis. The intent is to separate the no/low cost measures with a high rate of return from the capital intensive measures in order to prioritize implementation. Calculations include assumptions of run times based on the walkthrough engineer's understanding of the building at the time of the study. They are based on a 'snapshot' of the operating parameters determined from historical energy use, original design drawings, building operator interviews, equipment inventories, spot measurements of temperature, humidity, CO2 levels, light levels, etc. Calculation methods range from manual spreadsheet weather bin calculations based on 30 year moving averages, to hour-by-hour building simulation software. It is recommended that capital intensive measures are studied in a more in-depth manner to ensure the accuracy of the analysis. The economics are based on current construction and utility cost data and do not attempt to predict future price fluctuation. The numbers presented are from the direct calculations of cost and savings that have not been rounded to significant figures. This should not give the impression that the calculations are accurate to the smallest digit of presentation. They are included to give a more accurate presentation of cost effectiveness due to the potential of error propagation inherent with rounding.

2.0 Current Energy Situation

This section of the report provides a "snapshot" of current energy-related practices and recent energy usage at State facilities. This section specifically responds to Goal #1 for this study, "Quantify current energy consumption levels of State agencies," and briefly reviews other practices such as supply side management and distributed energy generation technologies to provide a high level overview of State energy practices. Recent studies commissioned by the Office of the State Engineer (OSE) and campus-commissioned studies were reviewed and incorporated into this section.

This section establishes baseline energy use, based on historical data and current operations. This baseline will be used to evaluate the potential for energy efficiency improvements by implementing energy conservation measures, summarized in Section 3 and detailed in Section 4.

2.1 Historical Energy Consumption

Past energy usage provides quantifiable data to describe the State of South Dakota's current energy situation. Energy usage was collected from 2005 through 2008 to analyze the most recent four years of utility data. The State uses EnergyCAP, a database software program to record and analyze energy consumption and billing data. Most State agencies have input energy data into this database, though some have not, including leased facilities, National Guard facilities, State Fair buildings, State Training School buildings and all Game Fish and Parks facilities. However, since this database provided the most complete source of historical energy data for the State, this database provided the basis for developing the State's baseline energy use. Where energy data could be identified as missing from the EnergyCAP database, utility data was collected with assistance from the respective agencies and compiled into a master spreadsheet. This provides the most complete record of historical State energy consumption.

Figure 2.1-1

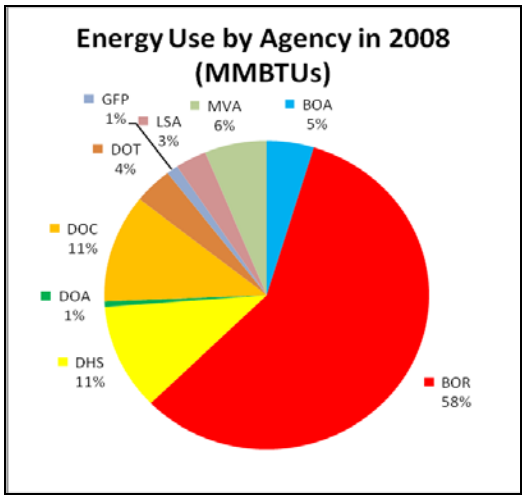


Table 2.1-2

Energy Use in MMBTUs [Note 1]				
Agency	**2005**	**2006**	**2007**	**2008**
Bureau of Administration (BOA)	81,038	105,497	105,341	101,637
Board of Regents (BOR)	1,143,347	1,648,553	1,950,462	1,255,598
Department of Human Services (DHS)	237,340	275,713	239,999	240,984
Department of Agriculture (DOA) [Note 2]	not available	not available	not available	12,257
Department of Corrections (DOC)	174,501	225,810	269,518	245,293
Department of Transportation (DOT)	not available	40,997	78,861	83,491
Game, Fish and Parks (GFP) [Note 2]	not available	not available	not available	25,118
Leased Facilities (LSA) [Note 2]	60,808	52,304	55,035	67,670
Military and Veterans Administration (MVA) [Note 3]	not available	145,143	116,041	133,874
TOTAL	**1,697,034**	**2,494,017**	**2,815,257**	**2,165,922**

Note 1: Annual consumption was summarized from the EnergyCAP database, unless otherwise noted. Energy use is accounted for when purchased. As more energy data is added to the EnergyCAP database, it appears that energy usage has risen sharply from 2005 through 2008, when in fact these meters existed in 2005 but the corresponding energy consumption was not being recorded in EnergyCAP.

Note 2: No energy data was available in EnergyCAP, energy data listed was obtained directly from the agencies. Some leased facilities have utilities included in the lease. For these facilities, limited energy consumption cost data was available. To account for this, the energy use for all leased space was extrapolated from the energy data provided by OSE.

Note 3: Limited energy data was available in EnergyCAP for Military and Veterans Affairs. The Veterans Home was the only location with energy data in EnergyCAP. For other locations, energy data listed was obtained directly from the agency.

Figure 2.1-3

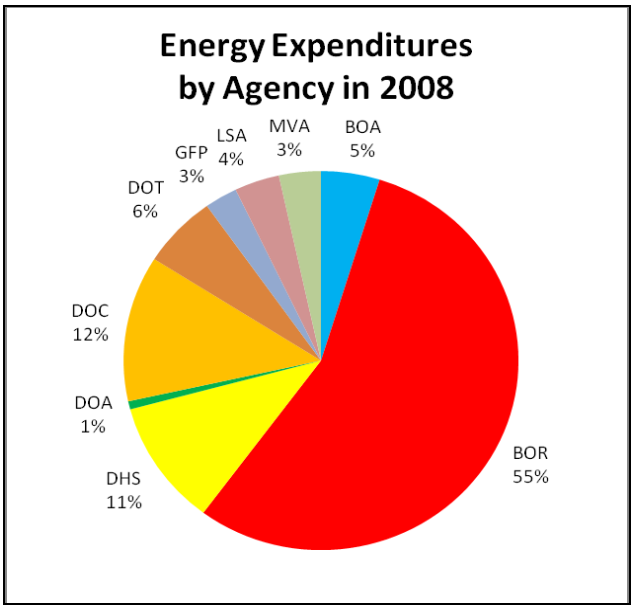


Table 2.1-4

Energy Expenditures [Note 1]				
Agency	**2005**	**2006**	**2007**	**2008**
Bureau of Administration (BOA)	$728,182	$942,057	$983,141	$981,911
Board of Regents (BOR)	$8,578,370	$10,251,375	$10,454,341	$11,332,390
Department of Human Services (DHS)	$1,801,789	$1,831,696	$2,021,167	$2,188,040
Department of Agriculture (DOA) [Note 2]	not available	not available	not available	$141,374
Department of Corrections (DOC)	$1,572,022	$2,197,358	$2,907,073	$2,547,677
Department of Transportation (DOT)	not available	$522,195	$1,130,419	$1,268,552
Game, Fish and Parks (GFP) [Note 2]	not available	not available	not available	$550,029
Leased Facilities (LSA) [Note 2]	$469,059	$507,137	$580,667	$754,729
Military and Veterans Administration (MVA) [Note 3]	not available	$410,829	$346,087	$702,210
TOTAL	**$12,873,600**	**$16,155,511**	**$17,842,229**	**$20,076,376**

Note 1: Annual expenditures were summarized from the EnergyCAP database, unless otherwise noted. Energy use is accounted for when purchased. As more energy data is added to the EnergyCAP database, it appears that energy expenditures have risen sharply from 2005 through 2008, when in fact these meters existed in 2005 but the corresponding energy consumption was not being recorded in EnergyCAP.

Note 2: No energy data was available in EnergyCAP, energy data listed was obtained directly from the agency. Some leased facilities have utilities included in the lease. For these facilities, limited energy consumption cost data was available. To account for this, the energy use for all leased space was extrapolated from the energy data provided by OSE.

Note 3: Limited energy data was available in EnergyCAP for Military and Veterans Affairs. The Veterans Home was the only location with energy data in EnergyCAP. For other locations, energy data listed was obtained directly from the agency.

Building energy use highly depends on the total square footage of facilities operated by the State. Since this varies from year to year, energy use will also vary. Based on Bureau of Administration records for building replacement values, total building square footage totalled 14,103,062 square feet in 2008.

Figure 2.1-5

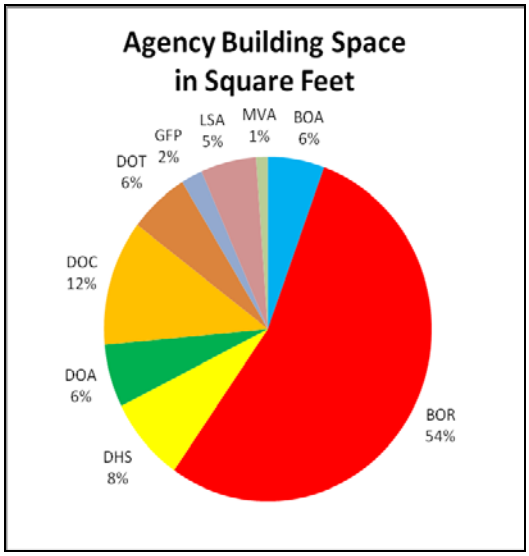


Table 2.1-6

Agency Square Footage in 2008	
Agency	**Total Building Square Footage**
Bureau of Administration (BOA)	789,932
Board of Regents (BOR)	7,632,555
Department of Human Services (DHS)	1,117,214
Department of Agriculture (DOA)	832,742
Department of Corrections (DOC)	1,657,624
Department of Transportation (DOT)	836,559
Game, Fish and Parks (GFP)	298101
Leased Facilities (LSA)	775,194
Military and Veterans Administration (MVA)	327,161
TOTAL	**14,267,082**

Energy Use Intensity (EUI) helps to account for the difference in the amount of building square footage operated by each agency. EUI is a common metric used to compare energy use across building types. EUI is defined as the ratio of total annual energy use in BTUs to total building square feet (kBTU/SF annually). For South Dakota, the Statewide EUI is 150 kBTU per square foot.[1] For comparison, the average State-owned building in the US consumes 134.8 kBTU per square foot[2]. The EUI for agencies is summarized in the following Table 2.1-7.

Agency	EUI (kBTU/SF)
BOA	128
BOR	164
DHS	215
DOA	14
DOC	147
DOT	99
GFP	84
LSA	87
MVA	409

Table 2.1-7

2.2 State Energy Practices

The US Department of Energy's (DOE) State Energy Program requires a State goal be established to reduce total energy usage in South Dakota by 25% from 1990 levels by 2012.[3] This goal applies to all energy usage in the State of South Dakota, including State-owned facilities and facilities owned by the private sector.

[2] Department of Energy, Energy Information Administration, 2003 Commercial Building Energy Consumption Survey. http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set19/2003pdf/e1-e11.pdf last accessed 11/2/09.
[3] South Dakota Statewide Energy Management, ARRA Application http://www.state.sd.us/boa/ose/ARRA%20SEP/ARRA__EECBG/SD%20-%20Strategy.pdf Last accessed: 10/15/09.

NOTE: The scope for this study focuses only on State-owned facilities and facilities leased by the State.

Energy projects are managed by the Office of the State Engineer (OSE) and currently funded from three primary sources:

- The DOE State Energy Program (SEP)
- American Recovery and Reinvestment Act (ARRA)
- Energy Efficiency and Conservation Block Grant (EECBG)

Other initiatives by the Office of the State Engineer and the Bureau of Administration have promoted energy efficiency, including the Leadership in Energy and Environmental Design (LEED) certification requirements for new State buildings, and procurement policies for products consuming energy. These initiatives are discussed in further detail in this section.

2.2.1 DOE State Energy Program

The US DOE's State Energy Program (SEP) provides grants to States and directs funding to State energy offices. In South Dakota, the SEP is administered by the Energy Management Office within the Bureau of Administration. The SEP in South Dakota provides funding for energy efficient projects at State owned facilities, including the higher education campuses. The funding is in the form of grants or zero interest loans. The program is intended to put SEP dollars directly into cost-effective, energy cost-saving projects. The projects reduce energy costs at facilities and directly benefits the taxpayers of South Dakota.

OSE's State Energy Manager files an annual request for funding through the US DOE's State Energy Program, which provides grants to States and directs funding to State energy offices. South Dakota's Energy Efficiency Grant program provides grants for State-owned facilities, including institutions of higher education for energy efficient projects. Projects must improve energy efficiency and resultant savings must produce a simple payback of 15 years or less. Last year the program helped fund lighting projects, energy recovery, and heating and controls upgrades, etc.

The State uses an energy tracking database to track energy savings for all projects receiving SEP funds. This tracking system allows the energy office to determine the success of each project. The database also provides a valuable tool in determining energy usage at each campus and identification of potential energy saving projects.

Annual Formula Funds have been decreasing in recent years, from $321,000 down to $165,000. In FY09, the State Energy Office also received ARRA funding in the amount of $23,709,000 for energy efficiency projects.

Figure 2.2-1

Year	Formula Funding Received
PY05	$310,000
PY06	$238,000
PY07	$321,000
PY08	$226,000
PY09	$165,000

The 2009 application for the State Energy Plan included the

following highlights relevant to public building efficiency[4]:

- State Energy Goal: to promote and encourage energy conservation and energy efficiency, in South Dakota.
- Selection of State Goal: to decrease the dependency on non-renewable energy sources
- Measuring achievements: The State continues to pursue energy savings measures in order to reduce energy consumption in the State.
- State Strategy:
  1. Projects must meet a reasonable payback period.
  2. State will participate financially up to 100% of project costs, but matching will be encouraged.
  3. Financial assistance via grants or loans will provide an incentive to complete energy efficient projects.
  4. Grant applications will be accepted year-round, but loan applications will be accepted once annually to evaluate and compare projects.
  5. State staff will be available for technical assistance and promotion of energy conservation measures at State facilities.
- Monitoring Approach: Measurement & Verification practices will be implemented for all projects completed under the SEP.

2.2.2 Recent Funding: ARRA

The 2009 State Energy Plan for South Dakota also included requests for funding from the ARRA allocation these projects are included in Section 4. South Dakota's formula allocation provided for $23,709,000 in ARRA project funding. The majority of this funding will be used for energy loans to fund energy conservation projects at State owned buildings and save an estimated 200,000 MMBTUs. Approximately $3 million will be used as grants. New construction projects are not eligible for this funding.

2.2.3 Recent Funding: EECBG

The State also submitted funding requests for the Energy Efficiency and Conservation Block Grant (EECBG), which amounted to $9,593,500. The State proposed that 60% of this funding would be provided to local government entities that were not eligible to receive direct grants from DOE, and awarded on the basis of simple payback, energy savings, job creation/retention, sustainability of the project beyond the funding period, maximum benefit to the community, and local financial participation. The second phase will distribute the remaining 40% of funding to other organizations not eligible in the first phase, including public and private entities, K-12

[4] South Dakota Statewide Energy Management, 2009 State Plan. http://www.state.sd.us/boa/ose/ARRA%20SEP/ARRA__EECBG/StatePlan.pdf Last accessed: 10/15/09

schools, technical schools, and community based non-profit community organizations, with 75% of the funds being distributed as zero interest loans to establish an energy efficiency project revolving loan fund in the State. The State estimated 95,935 MMBTUs will be saved through this plan, which will also result in reducing GHG emissions by 20,182 metric tons[5].

2.2.4 LEED Certification

The new standard requires that covered State building projects achieve US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) at a minimum of a Silver certification, a two-globe rating on the Green Building Initiative Green Globe rating system, or a comparable numeric rating from another accredited sustainable building certification program. The law references the two specifically identified rating systems as they existed on January 1, 2008. It applies to all new construction projects and renovations by State agencies, departments, or institutions that cost more than $500,000 or include more than 5,000 square feet of space. The standard only applies to buildings with heating, ventilation, and air conditioning systems. Waivers to this standard may be issued by the Office of the State Engineer if:

- The building will have minimal human occupancy;
- The increased capital cost will not be recouped within 15 years from decreased operational costs;
- The standard would conflict with existing Historic Properties laws
- The square footage of a renovation project is less than 50% of the total square footage of the building;
- The Bureau of Administration (BOA) determines that the standard is impractical for a given project

To date, most projects have been pursuing LEED certification, including twelve new construction and nine renovation projects. Few projects have filed for waivers with the State Engineer. The State Engineer has granted waivers for fifteen projects, six of them because the project was already in progress when the new law took effect. Remaining waivers were granted because of the small size and scope of the project.

2.2.4.1. USD's Lee Medicine Hall: The State's First LEED Certified building

Prior to the new standard requiring all new State buildings to achieve LEED Silver certification, the University of South Dakota's Lee Medicine Hall began pursuing LEED when the project began in 2004. In November 2009, the project was awarded LEED Certification under the LEED for New Construction rating system, version 2.1.

[5] South Dakota Statewide Energy Management, ARRA Application http://www.state.sd.us/boa/ose/ARRA%20SEP/ARRA__EECBG/SD%20-%20Strategy.pdf Last accessed: 10/15/09.

Lee Medicine Hall on the USD campus is the first State facility to receive LEED Certification. The building consists of two, three-story wings linked by a central atrium totaling 156,700 square feet. The Medical Education Wing, located on the west side of the building, and the Graduate Education and Research Wing on the east side of the building, are home to 37 laboratories/office suites; 28 faculty offices; 15 small group education rooms; 10 conference rooms; four teaching labs; three tiered classrooms, including an auditorium that seats 222 students; three flat classrooms with a combined seating capacity for up to 146 students, two student lounges; and one five-room clinical examination suite. The building is also wired for the latest technology and was designed to be adaptable to changes in technology.

2.2.4.2. LEED for Existing Buildings

LEED for Existing Buildings (LEED-EB) can assist building owners and managers to employ best practices for sustainable building operations in their facilities. Most buildings are eligible to participate in the system – the building does not have to be previously LEED certified under the new construction program. LEED-EB is structured in a similar manner to the LEED-NC program, with prerequisites and credits in seven categories; Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, Indoor Environmental Quality, Regional Priority and Innovation in Operations. The process of achieving LEED-EB certification applies to[6]:

- Building operations, processes, systems upgrades, minor space-use changes, and minor facility alterations or additions; and
- Buildings new to LEED certification as well as building previously certified under LEED for New Construction, LEED for Schools, or LEED for Core & Shell; these may be either ground-up new construction or existing buildings that have undergone major renovations.

The LEED-EB rating system can be an effective tool for promoting energy and resource conservation and is currently being studied for the Cultural Heritage Center on the Capitol Complex.

2.2.5 Procurement

In July 2008, the BOA adopted a Statewide Environmentally Preferred Products policy (ES-08-01) to provide direction to State agencies regarding the purchasing and appropriate use of environmentally preferable products. This also includes products that are energy efficient:

[6] USGBC. LEED Reference Guide for Green Building Operations & Maintenance, 2009 Edition, page 15.

When acquiring energy-consuming products State agencies shall purchase ENERGY STAR® designated products. Information regarding ENERGY STAR® is available via the Internet at ://www.energystar.gov/ . An agency is not required to procure an ENERGY STAR® designated product if the head of the agency determines in writing, to the Office of Procurement Management, that:

- No ENERGY STAR® designated product is reasonably available that meets the functional requirements of the agency; or that
- No ENERGY STAR® designated product is cost effective over the life of the product taking energy cost savings into account.

For product categories which are not eligible for an ENERGY STAR® label, the Federal Energy Management Program (FEMP) has additional resources available to identify and procure products with increased energy efficiency and low standby power[7]. These products may include commercial light fixtures, fluorescent lamps and ballasts and commercial and industrial equipment.

2.3 Supply-Side Management

Supply-side management seeks to control energy costs through purchase agreements, contract management and the generation and sale of energy. This section of the report documents the State's current activities in supply-side management, which is primarily focused on contracted purchase agreements.

2.3.1 Electric Power Purchase Agreements

The primary contract managed by the State is the Western Area Power Administration (WAPA) contract. The contract provides for the sale of firm electric power and energy to the State. The current contract has been in place since January 1992 and revised multiple times, most recently in February 2006 which allocates power as Contract Rates of Delivery (CROD) through December 2020. The CROD establishes the maximum kilowatt demand for each institution, which include:

State Institution
Black Hills State University
Northern State University
South Dakota Developmental Center
School of Mines & Technology
Human Services Center
South Dakota State Penitentiary
South Dakota State University
Mike Durfee State Prison
University of South Dakota
Capitol Complex [Note 1]

[7] Federal Energy Management Program, FEMP-designated Products. http://www1.eere.energy.gov/femp/pdfs/eep_productfactsheet.pdf Last accessed 10/30/09.

State Institution
Dakota State [1]
Note 1: CROD assigned to local municipal utility

Table 2.3-1. Institutions with WAPA power allocations.

The campuses are each allocated a maximum amount of power and energy for winter and summer months, as established in the WAPA contract. If the campuses exceed the power or energy maximum, a penalty rate is applied using an "X/Y factor". This penalty factor is calculated based on the ratio of the established power demand to the highest actual power demand occurring during seven previous billing periods and ending with the current billing period. When the CROD is exceeded and a penalty applied, supplemental power must be purchased for the energy and capacity above that delivered by WAPA. This can have significant and long-lasting effects on the electric rate for a State campus, since exceeding the allocation in one month will increase the electric rate for all WAPA electric for a minimum of six months following, even if the consumption remains below the allocation in the following months.

South Dakota State University and Black Hills State University are the only campuses that routinely exceed their CROD. The University of South Dakota is anticipating exceeding their allocation this year due to significant new construction and campus expansion. Once a campus exceeds the CROD, supplemental power is purchased from an alternate supplier. Black Hills State University obtains supplemental power from Black Hills Power. South Dakota State University and University of South Dakota obtain supplemental power from Heartland Electric. A new agreement was recently finalized with Heartland Electric that includes wind power produced in South Dakota.

The Capitol Complex and DSU allocations are assigned to the City of Pierre and City of Madison respectively. The wheeling contracts for these two campuses are unique in that the allotments are based on monthly fixed delivery schedules that look at coincidental demand.

Western can adjust the State's WAPA allocation every five years. Electric allocations from WAPA are not anticipated to increase, but may decrease as other campuses and buildings come online and are entitled to WAPA allocations. Most recently, the WAPA allocations were decreased 0.25% in 2006 for the overall allocation. This decreased all campus allocations by approximately 0.25%. The next adjustment is slated for January, 2011 but no adjustment will be made to the State's allocation

Star Academy and the Veterans Home buy electric service direct from Black Hills Power and are on combined billing, which provides a special tariff rate through the power company. The School for the Blind is on tariff rate with NorthWestern Energy. The School for the Deaf is on tariff rate with Xcel Energy. Electric power is also procured from local sources, some of which are municipal power authorities and some are rural electric associations (REAs).

2.3.2 Non-Electric Fuel Procurement

The natural gas provided to most State campuses is procured through a contract with Constellation NewEnergy. However, several campuses do operate individual gas meters that may be on the local distribution company tariff rate. The Capitol Complex procures natural gas for the Pierre campus at a tariff rate.

The Office of Procurement Management (OPM) negotiates rates for fuel oil and propane. Various vendors across the State supply propane and fuel oil, depending on vendor rates. Adjustments are sometimes made from increased supply costs, which the vendor passes onto the State. In recent years, no refunds have been provided to State agencies when prices happen to decrease, only increased fees due to market conditions and historically volatile prices.

The State operates central plants to provide district energy services to buildings on several campuses. However, in recent years it has proven more cost effective to decentralize these systems for heating. Centralized chilled water systems are more common. Central plants are still an economically viable means of delivering heat to buildings at many campuses; however the decision to build, provide a major renovation or convert campuses and buildings to a decentralized system is made on a case-by-case basis, depending on current use, condition of systems and economic benefits.

Biomass represents another opportunity in the State to consider as an alternative fuel. STAR Academy has a biomass boiler, which burns wood chips as fuel. The wood chip fuel supply is provided under a contract through OPM, and is negotiated on an annual basis. Competitively bidding the contract for biomass fuel and encouraging competition in this market would help to ensure cost-effective procurement of this fuel source. Taking this a step further, the State may consider the source of biomass fuel in nearby State lands that is currently being disposed of by another contractor. Establishing a connection between the need to dispose of deadfall in State lands and the need for wood chips at biomass boilers holds the potential to streamline fuel procurement and reduce costs for each contract.

2.4 Renewable Energy Generation

Renewable energy systems generate energy from sunlight, wind and water. Energy is produced in the form of heat or electricity, which is then used in buildings in lieu of natural gas, propane, or electricity produced at a power plant. Distributed systems (renewable energy systems installed at the point of use) reduce transmission losses in electric distribution and can provide significant energy cost savings by reducing overall demand.

2.4.1 Related Legislation

In February 2008, South Dakota enacted legislation (HB 1123) establishing an objective that 10% of all retail electricity sales in the State be obtained from renewable and recycled energy by 2015. In March 2009, this policy was modified by also allowing "conserved energy" to meet the objective. The objective applies to all retail providers of electricity in the State. However, as a voluntary objective (as opposed to a mandatory standard), there are no penalties or sanctions for retail providers that fail to meet the goal.

For renewable and recycled energy, the objective is measured by qualifying megawatt-hours (MWh) delivered at retail or by certificates representing credits purchased and retired to offset non-qualifying retail sales. In the case of conserved energy, the objective will be measured by methods established by the South Dakota Public Utilities Commission (PUC).

Qualifying electricity includes that produced from wind, solar, hydroelectric, biomass and geothermal resources, and electricity generated from currently unused waste heat from combustion or another process that does not use an additional combustion process and that is not the result of a system whose primary purpose is the generation of electricity. Hydrogen generated by any of the preceding resources is eligible. In addition to meeting the technology eligibility criteria, electricity must also meet the PUC's rules for tracking, recording and verifying renewable energy credits (RECs). The PUC is authorized to develop such rules under SDCL 49-34A-94 et seq. Both in-State and out-of-State facilities are eligible to generate qualifying RECs.

2.4.2 State Projects

Due to low energy rates in most of the State, renewable energy generation has lagged behind other areas of the US. However, improvements in renewable technologies, improved project economics, and increased interest from the general population and elected officials alike have prompted feasibility studies across the State studying an array of technologies. Several of these projects are underway, including the Capitol Lake Plaza geothermal, photovoltaic and wind project scheduled for completion in 2011.

Other renewable energy projects have been developed as part of the Governor's objectives for economic development. A recent study evaluated wind conditions at Blue Dog Fish Hatchery, and concluded that wind conditions in the Waubay area are fairly effective for generating electricity (considered fair to good, based on regional wind data). The scenarios in the study ranged from an implementation cost of $137,500 for a 50 kW turbine, to $495,000 for a 180 kW turbine, with simple paybacks of 22 and 25 years, respectively. These figures assume a 40% capacity factor; if this is decreased, payback periods extend up to 32 years.

Another wind study reviewed generation feasibility at McNenny Fish Hatchery in the Spearfish area. In this area, wind conditions varied considerably from the Waubay area and show

installations at reduced capacities. The scenarios in the study ranged from an implementation cost of $43,125 for a 10 kW turbine, to $86,250 for a 20 kW turbine, with simple paybacks of 22 and 26 years, respectively. These figures assume a 35% capacity factor; if this is decreased, payback periods extend up to 31 years.

A 2008 study evaluated the feasibility of using a solar system to assist in heating domestic water for showers at the Lewis and Clark Recreation Area Comfort Stations. The solar system would replace the two 100 gallon electric water heaters that currently provide hot water for showers and lavatories. The existing water heaters each have an electrical input capacity of 18 kW. Hot water usage was estimated to be 74,000 gallons per year, which consumes 8,118 kWh per year at a cost of about $650. The proposed solar system would have an 80 gallon storage tank with two black chrome solar collectors. The installed cost for the solar system was estimated to be $8000 in 2008. Potential energy savings was estimated to be 1415 kWh per year, or $113, therefore the payback for this system exceeded a goal of 10 years.

2.5 Statewide Energy Initiatives

The State has established an Energy Conservation Loan program using the Petroleum Violation Escrow funds[8]. The loan program is a zero interest loan to State agencies for energy efficiency projects. One funded project was decentralization of the Human Services Center (HSC) heating system. The HSC operated a central boiler plant with steam distribution throughout a tunnel system. The steam distribution system was inefficient and resulted in a significant amount of heat loss. The project included individual heating systems at each building on the campus and an upgrade to the control system. The project cost was approximately $3.2 million. The State completed the project in September 2008.

A recently completed study at Mike Durfee State Prison (MDSP) evaluated fuel oil and liquid propane usage, as well as alternatives and accompanying life cycle cost analysis. One option studied for MDSP was implementing natural gas condensing boilers with the natural gas supplied on a firm basis. This option was the most costly due to natural gas constraint upgrades and provided a 32 year simple payback. The study determined that converting to natural gas at the Central Plant, Laundry and Ludeman Hall with both a firm and interruptible supply of natural gas provided the best payback at 14 years.

Less traditional fuel sources are also being considered at State campuses. As part of the Black Hills State University Utility Master Plan, various options are being considered for upgrading or replacing the central heating plant. These include: purchasing steam from a nearby sawmill, installing a biomass boiler system and upgrading the existing boiler plant to high efficiency boilers. The steam

[8] NASEO State Energy Program and Activity Update, Winter 2009. http://www.naseo.org/publications/SEP_Update_2009.pdf Last accessed: 10/15/09.

purchase option also includes an alternate for a central chiller plant upgrade. Budget costs and paybacks are currently being reviewed.

The State also replaced an existing fossil fuel boiler with a biomass boiler at a youth correctional facility located in Custer, South Dakota. The facility is located in the Black Hills of South Dakota with a close proximity to wood chips. The use of the biomass boiler system has a dual benefit for the State, reduce fossil fuel use and reduce wood waste in the State Park by providing a market for wood chips from the slash piles. The State reduced fossil fuel use by approximately 180,000 gallons of propane saving approximately 16,500 MMBTUs in 2008.

Statewide , there is no policy for converting fuel oil systems to natural gas or biomass, this decision is evaluated on a case-by-case basis and determined based on anticipated life-cycle costs. For example, SDSU uses one coal as the main fuel source but also uses natural gas in the shoulder months and during milder winters.

An energy management effort by the Bureau of Information & Telecommunications (BIT) reduces energy consumed in IT operations. Computers and peripheral equipment must be ENERGY STAR® qualified pursuant to OPM policy. A policy is currently being implemented that sets desktop PCs and monitors to sleep mode after 2 hours of inactivity, reducing their energy use by 68% when not in use at night and on the weekends. A long-term server virtualization project has reduced the number of servers needed and the energy to power them.

2.6 Energy Management

Energy management at a State campus level refers to the responsibilities of tracking and trending energy use on a daily, monthly and annual basis. The goal of energy management is to:

1. provide a comfortable and productive indoor environment in State buildings by controlling the HVAC and lighting systems;
2. operate HVAC and lighting systems to optimize energy performance while maintaining a comfortable and productive indoor environment, i.e., demand side management;
3. control energy costs through supply-side management practices, i.e., review and negotiate power purchase agreements, procure supplemental power as necessary;
4. lead the identification, evaluation and implementation of energy conservation measures to improve building systems and reduce energy use;
5. acquire outside funding to support the implementation of energy conservation measures;
6. establish an M&V program to track energy savings from previously implemented energy conservation measures; and
7. manage utility bills, review for accuracy, approve payments, and track utility costs on a daily, monthly and annual basis.

In the State of South Dakota, monthly utility bills are tracked in the State's energy management software, EnergyCAP. This software program provides a tool for users to record monthly utility bills, audit utility rates to identify billing, metering or consumption problems and prepare management and analysis reports. Most State campuses are currently tracking energy use in EnergyCAP, with the exception of the Game Fish and Parks, National Guard, State Training School, the State Fairgrounds, and all leased facilities. The Physical Plant Director is responsible for managing their buildings in EnergyCAP, however in current practice this has frequently been executed by a business manager position. There are approximately 100 users registered to use the EnergyCAP software, however most users only upload data. This neglects the real value of tracking energy cost and use, which is to extract information to better manage energy use.

2.6.1 Case Studies in Energy Management

During the site investigations performed for this study, Sebesta Blomberg collected the information available from previously implemented energy conservation measures at State campuses. Though personnel on many campuses indicated they have implemented small projects to improve efficiency, few have tracked the savings realized from these investments. South Dakota State University was one exception, which provided an SDSU Energy Report which summarizes energy use and other factors over the past 10 years.

2.6.1.1. South Dakota State University

Since 2005, SDSU energy use has increased from 409,926 MMBTU to 457,902 MMBTU through 2008. Though this 12% increase is significant, student enrollment has increased by 9% and building square footage has also increased by 5%. New buildings on the campus are high energy intensity, meaning they use more energy per square foot than a typical building due to the space types in the buildings. Overall, energy use intensity at the campus has increased a total of 7% from 2005 to 2008, however it should also be noted that this is a reduction of 6% compared to the 5-year period from 1999-2003.

To control energy use, SDSU has upgraded and retrofitted much of the campus with new fixtures and technologies to achieve energy savings cost effectively. The following list summarizes the achievements through September 2009:

<u>Summary of Implemented ECMs at SDSU</u>

1. **Energy Efficient Fluorescent Lighting:** Upgraded 90% of fixtures on campus, approximately 2,000,000 square feet.
2. **LED Lighting:** Replacing conventional wall packs at end of life with LED wall packs, which consume less energy and require less maintenance.
3. **High Bay Fluorescent Lighting:** Upgrading metal halide and mercury vapor fixtures, which use 60% less energy.

4. **Occupancy Sensors:** Installing sensors in classrooms as upgraded or renovated. Installed 70 sensors in restrooms.
5. **ENERGY STAR Appliances:** Established a requirement that all break room appliances purchased on campus must have the ENERGY STAR label.
6. **Updating HVAC Controls:** Upgrading pneumatic controls with digital control systems/DDC. Digital controls are installed in about 1,000,000 square feet of facilities on campus. All new construction uses DDC. This reduced energy costs by 33%.
7. **VFD Technology:** Installing Variable Frequency Drives in new buildings. 60 VFD drives are currently installed. Anticipating 100 VFDs installed within 2 years.
8. **Pipe Insulation:** Reinsulating steam pipes and adding insulation to existing pipes has covered 80% of all steam lines in campus, which will reduce heat loss and save energy. By 2011, 100% of steam lines will be properly insulated.
9. **Steam Efficiency:** Annual inspections of steam system identify and replace steam traps and steam leaks to minimize energy losses. If unattended, one steam leak could cost $500 annually.
10. **Heat Recovery:** Heat recovery systems capture the heat from building exhaust air on cold days to preheat outdoor air for ventilation. Animal Resource Wing, Northern Plains Biostress Laboratory, Student Wellness Center and Animal Science Complex have heat recovery systems installed.
11. **High Efficiency Windows:** During window replacement projects, high efficiency windows are installed which improves insulation and reduces air infiltration, saving energy.
12. **Roof Insulation:** Approximately 300,000 square feet out of 850,000 square feet for all roofs on campus have had additional insulation added during roof replacement projects.
13. **LEED Construction:** The University Student Union, Avera Health and Science Center, and Dykhouse Student Athlete Center are all being designed as LEED Silver facilities, which will help control future energy growth.
14. **Energy Conservation Engineer:** In 1999, SDSU created a new position in Facilities and Services for an Energy Conservation Engineer to identify, propose and manage implementation of energy conservation projects throughout campus.

2.6.1.2. University of South Dakota

The University of South Dakota has a Project Engineer from Facilities Management leading energy initiatives. Recent energy projects include:

Summary of Implemented ECMs at USD

- Additional insulation is being added to steam and condensate lines. This project was started in September and should be completed in the beginning of November. The project cost is $127,132.00. This project was designed and bid internally.
- Two main water tube boilers were replaced in 2008 and came on at the start of 2009. It is estimated that the campus went from 72%-75% efficiency to 81%-86% efficiency in producing steam.
- The majority of the buildings on campus have upgraded lighting from T12 to T8
- The Dakota Dome roof was replaced in 2005 from a blown up fabric roof to a permanent insulated roof.
- The campus was switched from year around steam producing to winter months only. Electric water heaters were installed instead.
- An energy heat reclamation system was installed at the Lee Medical School. A wrap around loop was utilized to save energy.
- In August 2008, an energy grant provided funding for the installation of two new electric boilers as an alternative to keeping the Al Neuarth building on steam due to deteriorating steam lines.

2.6.1.3. Capitol Complex

The Office of the State Engineer recently installed a new central air conditioning chiller that serves the Capitol building. The frictionless compressor chiller uses magnetic bearing technology levitates the rotor of the shaft, resulting in a highly-efficient, super-quiet compressor. Without metal-to-metal contact, there are no high-friction losses, no oil to contaminate refrigerant and no oil-handling equipment to use energy or break down. Significant avoided costs were the big motivation for replacing three existing chillers and seven rooftop air conditioners on the capital building with one frictionless chiller plant. The frictionless chiller system was one of the first to be installed in South Dakota. This project reduced energy use by approximately 40%.

Other previously implemented energy conservation measures at the Capitol Complex campus include:

Summary of Implemented ECMs at Capitol Complex

1. Lighting upgrades to T-8 fluorescent lighting and de-lamping to avoid over lighting spaces;
2. Ventilation system improvements include new digital control systems and strategies, improved air distribution systems and new cooling units in computer rooms which are controlled to use “free cooling”;

3. Building insulation and window replacements with renovation projects;
4. Additional roof insulation installed within the scope of roof replacements;
5. Installed 46 variable speed drives (VFDs) for fans and pumps in six buildings;
6. Installed occupancy sensors for lighting control in three buildings;
7. Installed automatic shut off for office lighting in two buildings;
8. Installed heat recovery in two buildings, Forensics Lab and MacKay Building.

2.6.2 Measurement & Verification Capabilities

Measurement and Verification (M&V) for a building includes a program to evaluate building energy use by using a combination of hardware (i.e., building sensors, meters, submeters) and software (i.e., the building automation system (BAS), environmental management and control system (EMCS)). The goal is to better understand how energy is used in the building by having additional meters strategically placed around the building, rather than simply one utility meter that describes the whole building energy use.

An M&V program can also be used to track energy and cost savings realized from implementing energy conservation measures at State campuses. Upon completing the energy conservation measure, an M&V program would be developed specifically for the scope of the project – M&V varies depending on scope, systems involved, and complexity of the variables determining energy use. Often this can be accomplished by installing submeters at the point of use for the new equipment (i.e., at the electrical panel board for the circuit with new lighting). This submeter continuously logs the energy used by the new system, which is also dependent on actual operating hours, and records this information in the Building Automation System (BAS), Energy Management Controls System (EMCS) or data loggers that will store the information that can be periodically downloaded onto a computer for review. After a period of time, typically one year, this actual energy use is compared to the energy used by the former system to calculate the realized savings. Tracking these savings ensures energy conservation measures are reducing campus energy use and reducing campus operating costs, which will assist in identifying, evaluating and requesting funding for more energy conservation measures.

Currently, limited submetering exists on State campuses. The Capitol Complex recently installed sub-meters for eleven main buildings. While the Board of Regents have submeters on all revenue generating buildings (i.e., dorms, cafeterias, wellness centers), these submeters log energy used by the whole building, and do not describe energy used at the building system level. Meters at these campuses feed back to campus level; there is no capability for Statewide monitoring of submeters by the Office of the State Engineer, or another State agency.

OSE recognizes the importance for submetering to better manage energy consumption at State facilities. Additional resources are required to install more submetering and establish M&V programs at State campuses.

New construction of State buildings requires LEED Silver certification, which holds the opportunity to include the development of an M&V program and is rewarded with three points under the LEED-NC 2009 rating system. However, there is no formal guidance from the State to ensure projects are achieving these points – it is left to the project team's discretion and budget priorities.

2.6.3 Advanced Metering

Advanced metering is the integration of electronic communication into metering technology to facilitate one-way or two-way communication between utility and customer equipment[9]. With advanced metering, there is an automatic system for metering energy use that provides for continuous, real-time communication between the energy provider (i.e., the utility) and the consumer (i.e., the State agency).

At a basic level, advanced metering allows for automated meter reading from a remote location. When used in combination with other programs, the consumer can be provided with innovative rate structures to vary the cost of energy with demand, power factor and time-of-use. Advanced metering benefits the utility and the consumer, since utilities seek to generate energy at a steady and predictable rate and consumers seek to reduce their costs related to energy use.

State campuses have demand metering at larger campuses, i.e., State universities, the Capitol Complex and all campuses with WAPA allocations. The Board of Regents and Human Services have automatic programs through their BAS to shutoff equipment if demand is too high. However, this program is contained within the building, and does not integrate with the utility to provide information regarding time-of-use, power factor and real-time demand.

Implementing an advanced metering program across the State would require new hardware installation at State facilities and close coordination with utilities to achieve the desired results in energy cost savings, and a steadier, more predictable demand for energy.

2.7 State Culture

Historically, energy has been inexpensive in the State of South Dakota. This has established a culture that does not connect energy use with operational costs. At the same time, total demand for energy was low. The WAPA CROD allowed agencies to use their energy allocation without a strong focus on the financial impacts of energy consumption, since any cost savings resulting from improved

[9] Western Area Power Authority, Technical Brief: Advanced Metering. http://www.wapa.gov/es/pubs/techbrf/metering.htm Last accessed 10/21/09.

efficiencies would be minute. However, as demand for energy from State agencies has grown, the total energy consumption has exceeded the amount of energy allocated by the CROD. Consuming more energy from WAPA than what is allocated in the CROD is penalized with the "X/Y factor", which has severe impacts on agency energy budgets. The CROD from WAPA has not increased with State energy demand – in fact when last renewed the CROD for State agencies was reduced by 0.25% to allow for reallocation to other Western customers. As a result, energy rates have increased, in some cases rates have increased drastically. At campuses with a WAPA allocation, the effective blended rate has increased the total energy expense, through penalties or higher rates from alternate suppliers.

Other steps toward a portfolio of energy efficient buildings can include enforcement of an energy standard for buildings, engaging the building occupants to increase their energy awareness and building operator training programs.

2.7.1 State Energy Policy for New & Renovated State Buildings

It is State policy to follow the most current version of the International Building Code for the design, construction and renovation of State buildings. The current version is 2009 (updated every three years) and references the International Mechanical Code. The 2009 International Mechanical Code references ASHRAE 90.1-2007, which is used by the Office of the State Engineer to enforce a minimum energy efficient design standard for State buildings. This policy is enforced by including this requirement into design contracts. In addition, all State buildings must achieve LEED Silver certification requiring new building performance to be 10% more efficient than a baseline building, and requiring major renovations to existing buildings to be 5% more efficient than a baseline building[10].

2.7.2 Education & Awareness

An Energy Awareness Program seeks to engage all building users to increase knowledge and understanding of the impact of normal activities on the overall energy use of a building. These programs have shown to yield energy savings from 5 to 10% and are achieved through changing occupant behavior to reduce energy use.

There are several examples of such programs in the State:

- BOA has established an interagency Sustainable Work Group to address energy, water and solid waste reduction, recycling, sustainable procurement, and travel reduction/fuel efficiency in State government operations. The group encourages State employees to reduce energy use by turning off lights when not needed, minimizing personal electrical

[10] LEED Reference Guide for Green Building Design and Construction, 2009 edition, page 237.

devices, using blinds to reduce solar heat gain, and setting computers and monitors in hibernate mode overnight and on weekends.[11]

- BOA is developing plans to install a building dashboard for Capitol Lake Plaza and McKay to communicate real-time energy use to building occupants to raise energy awareness.
- Three State universities have signed the President's Climate Commitment, which seeks to address global warming by garnering institutional commitments to neutralize greenhouse gas emissions, and to accelerate the research and educational efforts of higher education to equip society to re-stabilize the earth's climate[12]. A key component of complying with the commitment is energy savings on campus to reduce emissions. The three universities are:
    - **Black Hills State University**
    - **South Dakota School of Mines & Technology**
    - **University of South Dakota**

The college and university presidents and chancellors who are joining and leading the President's Climate Commitment believe that exerting leadership in addressing climate change will stabilize and reduce their long-term energy costs, attract excellent students and faculty, attract new sources of funding, and increase the support of alumni and local communities.

2.7.3 Building Operations Staff Training

There is no formal Statewide training for building operations staff at State facilities to instruct personnel on how to operate buildings and use less energy. Few resources are available to building operators, and as a result operating problems are often ignored or temporary solutions improvised to continue performing in a suboptimal operation.

A professional development program would greatly assist building operations and maintenance staff in the energy and resource-efficient operation of State buildings. A building operator training program expands knowledge and cross-trains participants in important skill areas, maximizing the operator's versatility within the agency and allowing operations staff to take on more responsibility. Agencies can save money through training by developing the skills of their own staff and increasingly avoiding the need to hire outside contractors. The program also enhances careers and often results in improved job retention.

[11] http://sustainable.sd.gov/employees.aspx
[12] American College & University President's Climate Commitment http://www.presidentsclimatecommitment.org/about Last accessed 10/29/09

One certification program, Building Operator Certification (BOC) Central, reports average annual energy savings of $12,000 per facility with a BOC certified operator, or roughly $0.026 per square foot. The buildings also report increased customer satisfaction because building operation staff is more responsive to issues of air quality and comfort control, and staff are more proactive in compliance with environmental health and safety regulations affecting facility operations. [13]

The State recently deployed a preventative maintenance software program called Sprocket. At the present time, the program is in use by eight institutions for preventive maintenance activities. In combination with a training program for building operators, this preventive maintenance program will support improved building operations and reduce the risk of equipment failure which has a detrimental effect on energy consumption.

2.7.4 Summary

Energy consumption is anticipated to continue to grow as the State of South Dakota continues to grow. The requirement for all new State buildings to be LEED Silver certified will assist in managing energy consumption, but will not be sufficient in curbing energy demand for new and existing buildings. Raising the efficiency requirements to ensure these building projects exceed the minimum energy performance will help to transform the State's portfolio of buildings. Continued enforcement of ASHRAE 90.1-2007 (the energy standard which is frequently adopted as energy code) for State building projects will help to ensure buildings are designed with energy efficiency in mind.

Beyond design and construction, the operations phase of the building holds the responsibility to operate the building systems in an efficient manner. Building users must understand that their daily decisions affect building performance, and building operators must identify and prioritize maintenance activities to keep the building operating in a safe and economical manner. This requires a comprehensive preventive maintenance program, documented building operating procedures, and resources to obtain additional assistance for building malfunctions, when needed.

[13] Midwest Energy Efficiency Alliance. Building Operator Certification Program, Why Get Certified? http://www.boccentral.org/page.php?content=why_get_certified Last accessed 10/15/09.

3.0 Statewide Prioritization Plan

The purpose of this section is to focus on energy conservation measures (ECMs) that have a low-cost to implement and a comparatively high rate of return, yielding a short payback period for the investment. These ECMs with a short payback were identified by investigating targeted buildings, interviewing building staff and assessing building system design and performance. Each measure was quantified using the information available and reasonable assumptions based on engineering practice and the understanding of the building at the time of the study. Based on the findings from the representative sampling of buildings, energy conservation strategies and savings potential were extrapolated for other State buildings that were not investigated.

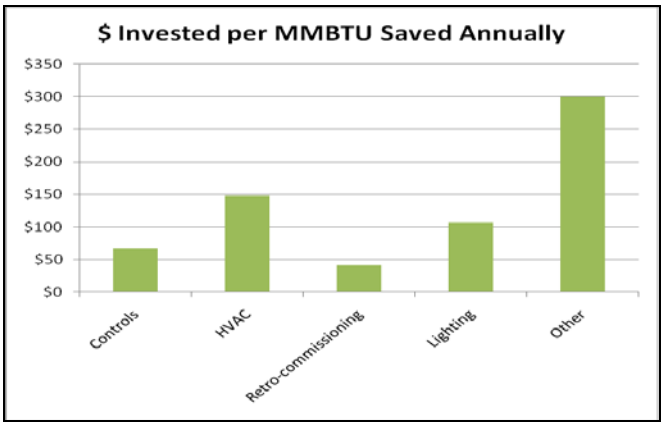
This section discusses ECMs in general terms as they apply to the two-thirds of State buildings investigated Statewide . Section 4 provides further detail for applying ECMs at specific campuses and buildings.

3.1 Summary of Findings

Upon completing our investigation of the facilities targeted in this study, we have identified a total of 1,168 ECMs that if implemented could reduce annual energy use by 332,952 MMBTUs annually, representing a 15.3% reduction in Statewide energy use. Implementing all of these measures would cost an estimated $38,617,093. Annual cost savings from reduced energy use would amount to $3,558,450, in today's dollars. While implementing all of these measures is impractical, the aggregate savings shows that there are significant opportunities to reduce energy use at State facilities.

The figure below (Figure 3.1-1) shows the required dollar invested in an energy conservation measure to generate 1 MMBTU of energy savings annually. This figure shows that Controls and Retrocommissioning measures are the cheapest means to reduce annual energy consumption, while lighting and HVAC measures tend to require larger investments for energy reductions.

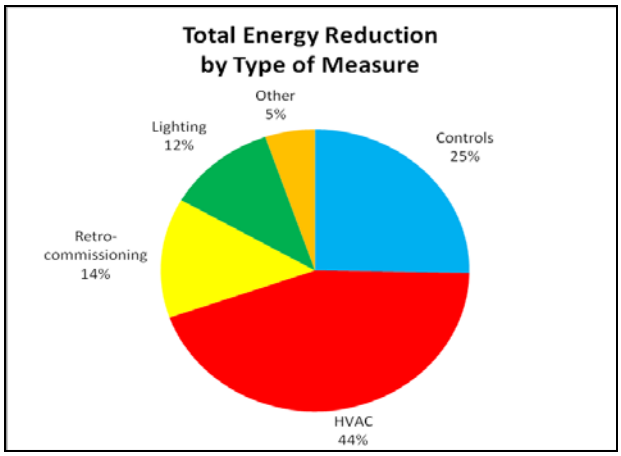
Figure 3.1-1



To achieve the most energy reductions per dollar invested in energy conservation projects, Controls and Retrocommissioning ECMs should be completed first, then Lighting, then HVAC measures. The Other category of measures includes a variety of ECMs that cannot be classified into one of the other four categories.

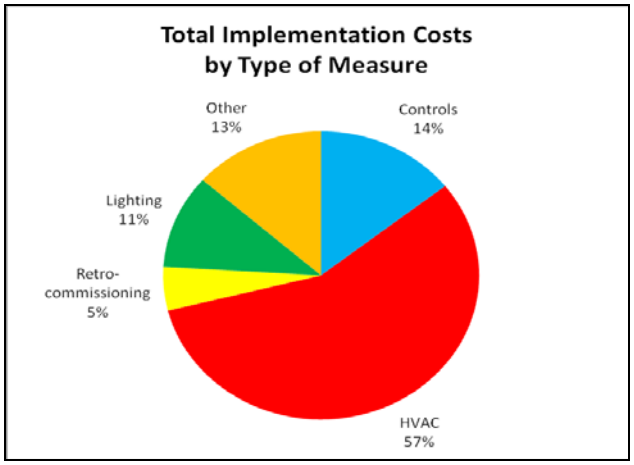
Based on total potential energy reduction of the ECMs evaluated in this study, the Controls and HVAC categories provide the most opportunity for energy conservation. This is illustrated with the following pie chart (Figure 3.1-2), showing 69% of energy savings (in MMBTUs) from Controls and HVAC measures.

Figure 3.1-2



Based on total implementation cost of the ECMs evaluated in this study, HVAC projects generally require more investment than Controls projects. This reinforces the Statement that Controls and Retrocommissioning projects provide the most energy savings per dollar invested.

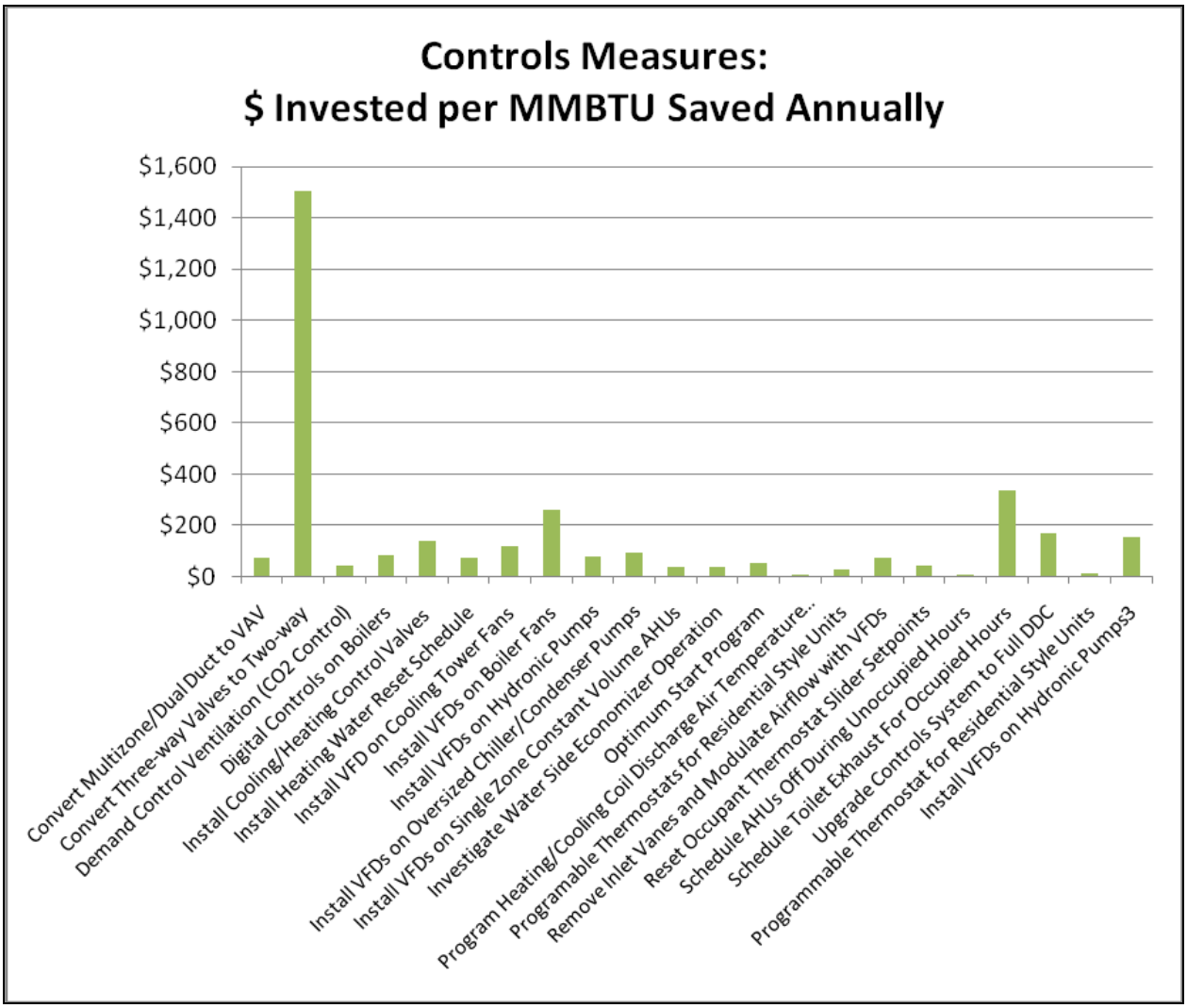
Figure 3.1-3



The next set of figures show the required dollar invested per 1 MMBTU of energy savings annually for each ECM category..

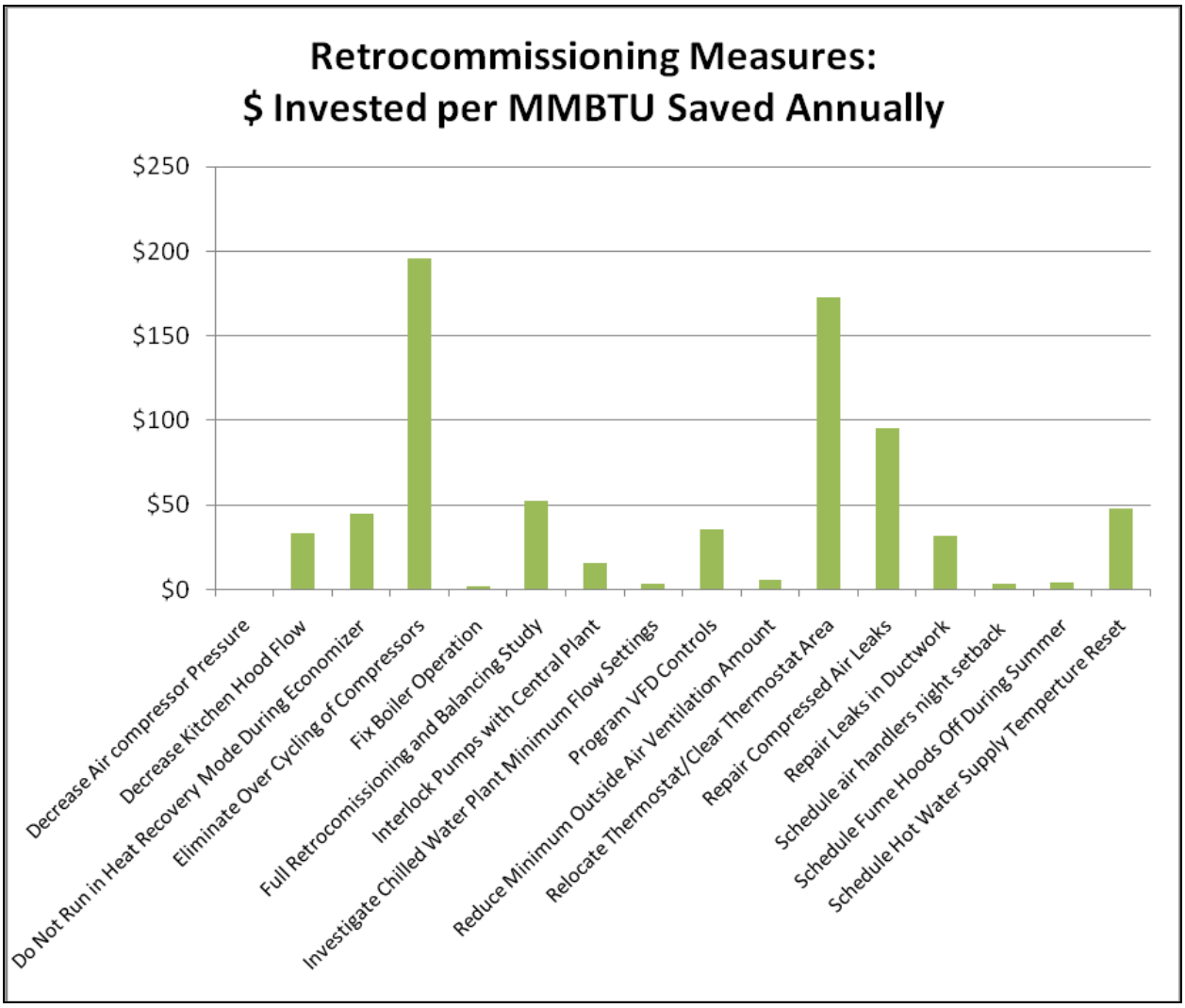
The Controls figure (Figure 3.1-4) shows very low ratios for most Controls measures, with the exception of the ECM for converting three-way valves to two-way valves. The remaining measures for this category are much more attractive. For all Controls ECMs, it will cost $66 on average to save 1 MMBTU annually.

Figure 3.1-4



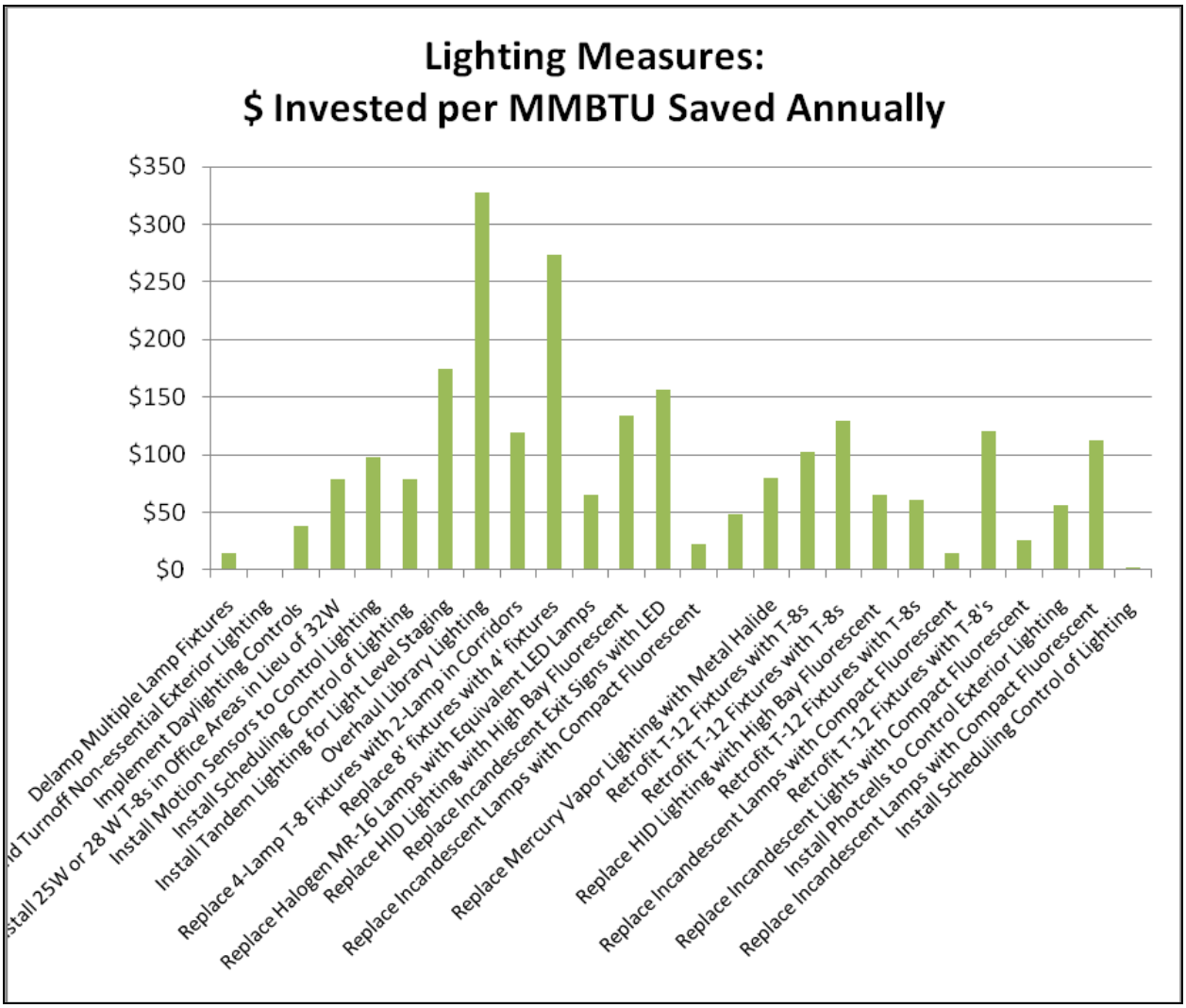
The Retrocommissioning figure (Figure 3.1-5) shows more consistently low ratios for Retrocommissioning measures. For all Retrocommissioning ECMs, it will cost $41 on average to save 1 MMBTU annually.

Figure 3.1-5



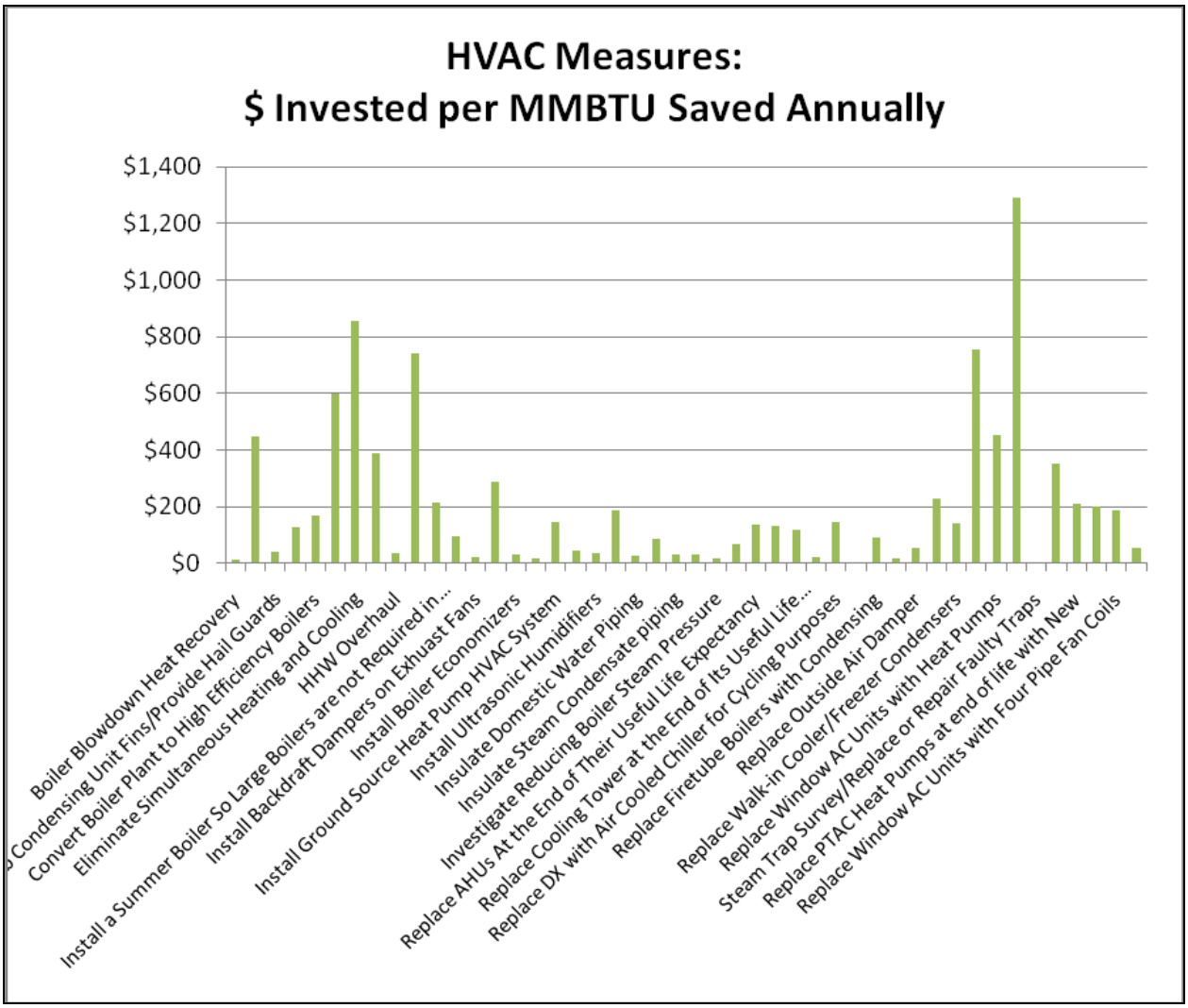
The Lighting figure (Figure 3.1-6) shows more consistently low ratios for Lighting measures. For all Lighting ECMs, it will cost $106 on average to save 1 MMBTU annually.

Figure 3.1-6



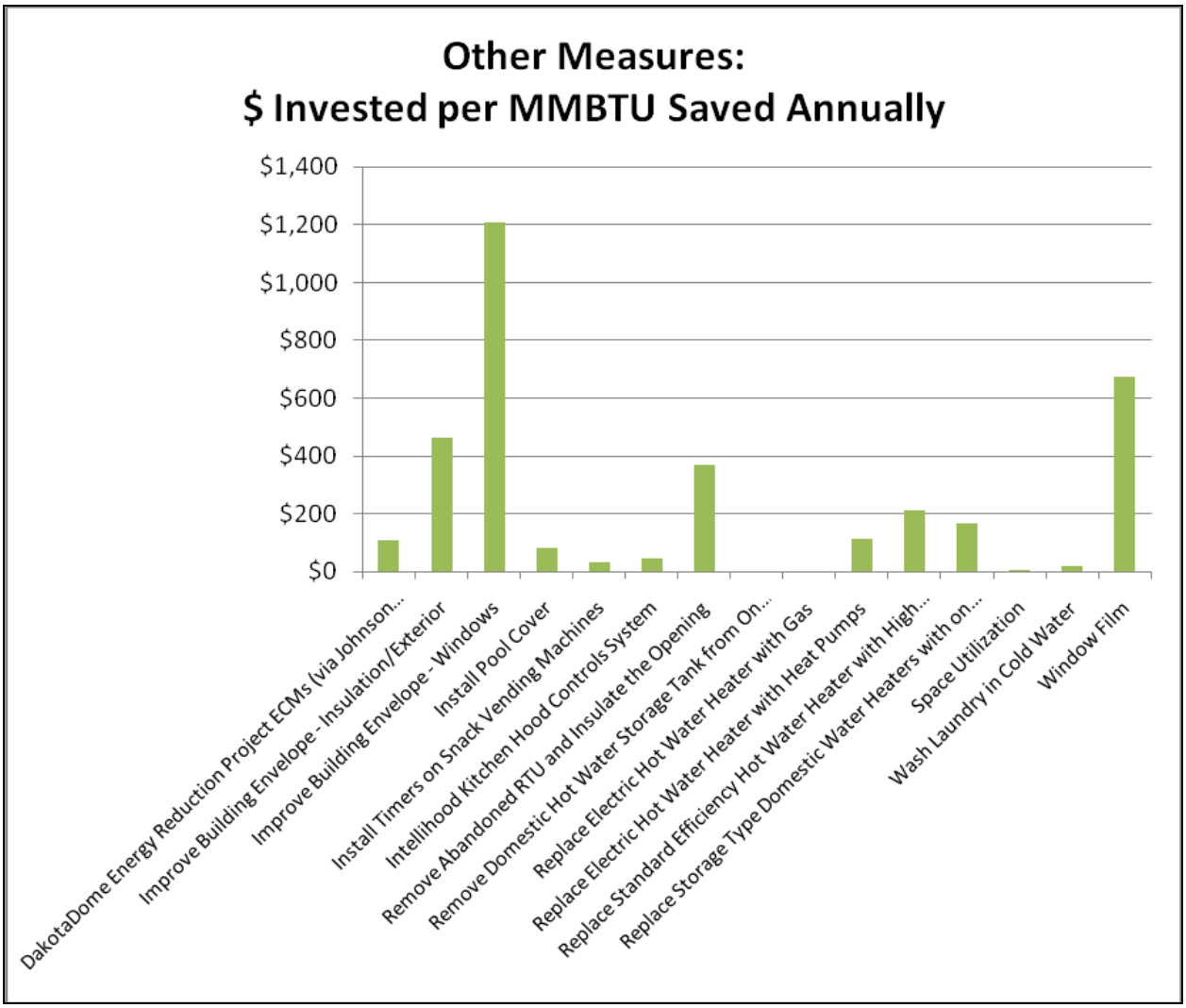
The HVAC figure (Figure 3.1-7) shows more consistently low ratios for HVAC measures. For all HVAC ECMs, it will cost $149 on average to save 1 MMBTU annually.

Figure 3.1-7



The Other figure (Figure 3.1-8) shows ratios for Other measures vary significantly. For all Other ECMs, it will cost $300 on average to save 1 MMBTU annually.

Figure 3.1-8



In the following sections, ECMs are identified to achieve energy use reductions in 5% increments up to a 20% energy use reduction. The corresponding incremental implementation costs are summarized with the estimated annual energy cost savings.

Table 3.1-9

% Energy Use Reduction	Reduction in MMBTUs
5%	108,296
10%	216,592
15%	324,888
20%	433,184

ARRA Projects under Contract

There are several projects currently underway which include ECMs at the Capitol Complex and the Public Safety Building. These "shovel-ready" projects include 15 ECMs. These ECMs include Central Boiler Plant conversion, chiller replacements at Becker-Hanson and Kneip buildings, Capitol building lighting upgrades, Public Safety building boiler replacement, and retrocommissioning at multiple buildings on the Capitol Complex campus.

5% Energy Reduction

To achieve a Statewide 5% energy reduction, additional projects would need to be completed in addition to the ARRA projects currently under contract. If implemented based on greatest energy reduction per dollar invested, a total of 235 ECMs would need to be implemented at a cost of $3,869,108. Annual savings would amount to $1,020,432, yielding a payback of 3.8 years.

If each ECM is implemented based on shortest payback, a total of 292 ECMs would need to be implemented at a cost of $2,873,889. Annual savings would amount to $1,025,708, yielding a payback of 2.8 years.

10% Energy Reduction

If implemented based on greatest energy reduction per dollar invested, a total of 546 ECMs would need to be implemented at a cost of $9,567,513. Annual savings would amount to $2,062,112, yielding a payback of 4.6 years.

If each ECM is implemented based on shortest payback, a total of 669 ECMs would need to be implemented at a cost of $8,813,256. Annual savings would amount to $2,124,233, yielding a payback of 4.1 years.

15% Energy Reduction

Implementing all ECMs documented in this study will yield a 15.3% reduction in Statewide energy use. This would include implementing 1,168 ECMs at an estimated cost of $38,617,093. Annual cost savings from reduced energy use would amount to $3,558,450, in today's dollars, yielding a payback of 10.9

years. While implementing all of these measures is impractical, the aggregate savings shows significant opportunities to reduce energy use at State facilities.

20% Energy Reduction

Throughout the energy auditing process, approximately two thirds of the State's square footage was audited. These facilities were targeted for auditing based on savings potential, schedule, logistics and cost. An effort was also made to audit a representative sample of State agencies and building types. One-third of the State's facilities' square footage does not have potential project costs and savings included in this study. Based on a simple square footage extrapolation of results found in the two-thirds that was audited, it is reasonable to assume that an additional study of the final one-third of State facilities would produce potential energy conservation measures to reduce energy consumption by an additional 7% with similar project economics to this study. Implementation may be estimated at a cost of $12,000,000 with a potential savings of $1,125,000 per year. This would yield a total of 22% reduction in energy consumption Statewide.

3.2 Additional Energy Reductions

3.2.1 Advanced Metering

Recent studies by major universities and metering companies suggest the typical savings potential for a campus to have an advanced metering system is installed could be as high as 5 to 20% of their current utility budget. This does not produce a true cost/payback because the metered data does not directly produce savings. The actions from the decisions made using the data are what drive the savings.

The following chart outlines the metering situations at State campuses where advanced metering and monitoring may provide the greatest value. Expected ranges for EUI are for generic campuses of types identified and published by the Department of Energy's ENERGY STAR® program.

Table 3.2-1

Campus	Agency	Significant Buildings	Utilities Consumed	Campus EUI	Expected EUI	ROM Metering [1]	Potential Annual Savings
Veterans Home	MVA	5	Electric, Steam, Propane, Fuel Oil	184	100-150	$75,000	$50,000 - $150,000
South Dakota School of Mines	BOR	12	Electric, Steam	272	100-150	$75,000	$50,000-$150,000
Black Hills State	BOR	7	Electric, Steam	128	100-150	$75,000	$25,000 - $75,000
South Dakota State Penitentiary	DOC	20	Electric, Steam, Natural Gas	150	125-175	$75,000	$0 - $50,000
South Dakota School for the Deaf	BOR	3	Electric, Steam, Natural Gas	94	80-100	$15,000	$0 - $10,000
State Training School	DOC	10	Electric, Steam	72	80-100	$25,000	$0 - $15,000
South Dakota Developmental Center	DHS	17	Electric, Steam	184	80-100	$75,000	$10,000 - $50,000
Dakota State University	BOR	13	Electric, Steam	204	100-150	$75,000	$25,000 - $100,000

NOTE 1: Rough Order of Magnitude (ROM) Metering cost is based on the investigation equivalent of an ASHRAE Level 1 Energy Audit. Full scope of metering requires additional investigation and design.

Installing advanced metering at these campuses would cost an estimated $500,000. Additional costs may be incurred through the process of establishing the monitoring program and implementing procedures to better control energy use. An advanced metering and monitoring program has the potential to yield an additional 50,000 MMBTUs in total energy use reductions at these campuses. This would have the effect of decreasing Statewide energy use by approximately 2%.

3.3 Other Recommendations

3.3.1 Energy Management

Few agencies and campuses have a dedicated position for energy management. As a result, it is unclear if the remaining energy management duties at State campuses are covered by other positions, or currently being unfulfilled. Principally, responsibilities are in question for the following energy management duties:

- operate HVAC and lighting systems to optimize energy performance while maintaining a comfortable and productive indoor environment, i.e., demand side management;
- lead the identification, evaluation and implementation of energy conservation measures to improve building systems and reduce energy use;
- acquire outside funding to support the implementation of energy conservation measures; and
- establish a Measurement & Verification (M&V) program to track energy savings from previously implemented energy conservation measures.

To resolve this uncertainty and ensure all energy management responsibilities are addressed at all State campuses, it is our recommendation that agency-level energy managers be identified, or created if necessary, and ensure all State buildings are managed by an energy manager position at an agency or campus level. Larger State campuses, such as Mike Durfee State Prison or Black Hills State University, should have their own energy manager. Smaller State campuses, such as Department of Transportation buildings or Leased facilities with locations scattered throughout the State, should have an energy manager position at the agency level.

ARRA (federal stimulus) project funding requires energy savings reporting quarterly for three years during the grant funding period. These reporting requirements can be incorporated into energy manager positions at the campus or agency level. After the three year federal reporting period, the Office of the State Engineer will require yearly energy savings reports from campuses and agencies.

Other recommendations in this area of energy management include:

- Require all agencies to record all energy use and energy costs from State facilities (including leased facilities) into a single database, whether that database tool remains EnergyCAP or is selected from competing energy management software;
- Require all agencies which implement ECMs to provide reporting, regardless of funding source (OSE can provide support to other agencies to complete reporting requirements, but OSE will bill the agency for analyzing and tracking energy use);
- Consider LEED certification for existing buildings using the LEED-EB: Operations and Maintenance rating system;
- Complete the US EPA's ENERGY STAR Portfolio Manager for all significant State buildings, using the built-in tool in the State's energy management software;
- Use the energy management software as a management tool, not just a database – the State Energy Manager is currently working with the software company to re-launch the EnergyCAP program to State agencies;
- Coordinate energy management at a State level, with formal or informal methods of communication among energy managers at State campuses and agencies to share best practices and lessons learned; and
- Take an active role in keeping up with the cost and viability of new technologies that could potentially reduce consumption of State facilities.

A professional development program would greatly assist building operations and maintenance staff in the energy and resource-efficient operation of State buildings. A building operator training program expands knowledge and cross-trains participants in important skill areas, maximizing the operator's versatility within the agency and allowing operations staff to take on more responsibility. Agencies can save money through training by developing the skills of their own staff and increasingly avoiding the need to hire outside contractors. The program also enhances careers and often results in improved job retention.

One certification program, Building Operator Certification (BOC) Central, reports average annual energy savings of $12,000 per facility with a BOC certified operator, or roughly $0.026 per square foot. The buildings also report increased customer satisfaction because building operation staff is more responsive to issues of air quality and comfort control, and staff are more proactive in compliance with environmental health and safety regulations affecting facility operations. [14]

[14] Midwest Energy Efficiency Alliance. Building Operator Certification Program, Why Get Certified? http://www.boccentral.org/page.php?content=why_get_certified Last accessed 10/15/09.

3.3.2 Advanced Metering and Monitoring

Electricity, natural gas, and water are delivered to users through city-wide or region-wide infrastructure where they are consumed to provide the necessities and luxuries that we have come to take for granted. In order to determine how much to bill, the utilities that provide the electricity, natural gas and water install meters onsite at the user's infrastructure take-off. Older style meters are mechanical and require a meter reader to physically go to and read the dial or readout on the meter on a regular interval to provide usage information for the utility to bill the user. Newer style meters have remote monitoring capabilities either through a wireless signal that can be read by remote devices or web-enabled that can transmit via phone or internet networks.

The value of the metering information is often lost. The utility bills arrive monthly and are paid without an analysis of the usage. An effort to track, interpret and analyze utility usage and changes over time usually results in an effort to find those areas that use the largest amounts of energy and reduce it. It is difficult to manage anything that is not being measured. Advanced metering and monitoring is a broad term used to describe the process of using the metered utility information to affect usage and costs by a user or users. This can be a broad range techniques and technologies which have a corresponding broad range of costs and benefits.

3.3.2.1. Options for Implementation

Typically, the most modest and least expensive metering and monitoring option that facilities utilize is manual entry of the billed usages and costs into a spreadsheet analysis tool for tracking. At a cost of only in-house personnel time, charts and graphs can be created and analyzed showing usage trends, year over year data and month over month data. Any spikes would be interpreted and investigated to determine if there are operational issues that could be fixed. Energystar.gov produces energy use indices for building owners and operators to compare their buildings to in order to determine if they are consuming more than their peers. Any high use buildings could be either justified or investigated as high potential opportunity for reduction. This service is also available from utilities often times at no cost or a low cost administrative fee.

A step up from tracking would be sub-metering utilities so that a better picture can be created in terms of where the energy is being consumed. A master-meter at a campus or a building can only show the consumption of a utility as a whole at that meter. Certain buildings or certain portions of a building may be the areas of opportunity but without metering at that level, the affect of those opportunities is muffled by the total usage at the master-meter. Sub-metering data can be collected manually, but there are many commercial products available currently that collect data and produce the charts and graphs of usage automatically.

Meters and sub-meters can be upgraded with pulse technology that will provide active feedback to building owners and operators. This requires a more sophisticated interface to compile and show the data with a network to support data transfer on a continuous basis. The pulse meter technology can deliver consumption and demand data for any meter it is installed on to the system in user defined increments. Typically this is set up to refresh every fifteen minutes. With that information building owners and operators will have the information of how the building uses energy throughout the day in however fine of detail the network of meters allows. Spikes in usage suggest there may be an issue. This could be caused by cycling equipment, fighting equipment, or malfunctioning equipment. High night usage suggests there may be an issue as buildings typically idle at 15% or less of their daytime usage in electricity. This data is then used by building operators to take corrective actions on the issues that are discovered, thereby saving energy and cost.

Most modern Direct Digital Controls (DDC) systems have integrated demand limiting strategies built into them. The information from a pulse meter could be fed into and displayed by the front end controls system. As a building operator monitors the HVAC and electrical equipment via the controls computer, they can also view the building's energy consumption in real time. In order to avoid demand penalties a building operator can employ a strategy known as demand limiting stagger starting equipment, changing setpoints, turning off non-essential equipment or cycling large equipment in order to manipulate and reduce any instantaneous demand level set by the building. This results in utility peak savings that results in bill savings as well as reduces the stress on the utility infrastructure. Demand limiting can also be programmed into the DDC system to automatically make demand limiting measures during certain periods defined by the building operator.

3.3.2.2. Benefits, Costs and Savings Potential

Effectively metered data can be used for a number of different purposes. It can be used to troubleshoot and identify equipment operating and control issues. It can be used to create energy usage accountability within an organization. Those operations that are more energy intensive can be budgeted accordingly to create the strongest fiscal position for the organization. The metered data can be used for trending and forecasting of energy usage. Energy costs are one of the fastest growing costs for businesses and government operations. Historical data and trends give them the ability to forecast usage and costs for more effective future budgeting.

Costs for advanced metering and monitoring range from no cost in-house analysis of energy bills to several hundred thousands of dollars for multiple meters per building at large campuses with DDC controls interfaces and analysis software. A simple system of a few sub-meters, an information network and data interface could be installed on a small campus of building for as little as $5,000 to $10,000. For large campuses that spend millions of

dollars per year in energy a $250,000 advanced metering program may be appropriate. A system could be installed to start small and have meters, software and capability added as time goes on and funding becomes available.

Recent studies by major universities and metering companies suggest the typical savings potential for a campus to have an advanced metering system is installed could be as high as 5 to 20% of their current utility budget. This does not produce a true cost/payback because the metered data does not directly produce savings. The actions from the decisions made using the data are what drive the savings. An elaborate and expensive metering system could be installed, but if personnel are not trained and empowered to use the data to make improvements no savings will be realized. The upside of a well managed advanced metering system is generally financially attractive but the savings potential will not be known until the system is installed and opportunities can be identified.

The following chart (Table 3.3-1) outlines the metering situations at the State campuses where advanced metering and monitoring may provide the greatest value.

Table 3.3-1

Campus	Agency	Significant Buildings	Utilities Consumed	Existing Metering Situation	Metering Recommendation
Veterans Home	MVA	5	Electric, Steam, Propane, Fuel Oil	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings. There is no fuel oil or propane meter - the only measure of usage is how many gallons they purchase to fill the tank periodically.	Install pulse electric meters and condensate meters on each significant building. Install propane and fuel oil meters on the central plant tanks. Install a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.
South Dakota School of Mines	BOR	12	Electric, Steam	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings.	Install pulse electric meters and condensate meters on each significant building. Install a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.
Black Hills State	BOR	7	Electric, Steam	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings.	Install pulse electric meters and condensate meters on each significant building. Install a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.
South Dakota State Penitentiary	DOC	20	Electric, Steam, Natural Gas	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings. There is only a single natural gas meter serving the entire campus.	Install pulse electric meters and condensate meters on each significant building. Install natural gas meters at each boiler. Install a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.
South Dakota School for the Deaf	BOR	3	Electric, Steam, Natural Gas	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings. There is only	Install pulse electric meters and condensate meters on each significant building. Install natural gas meters at each boiler. Install

Campus	Agency	Significant Buildings	Utilities Consumed	Existing Metering Situation	Metering Recommendation
				a single natural gas meter serving the entire campus.	a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.
State Training School	DOC	10	Electric, Steam	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings.	Install pulse electric meters and condensate meters on each significant building. Install a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.
South Dakota Developmental Center	DHS	17	Electric, Steam	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings.	Install pulse electric meters and condensate meters on each significant building. Install a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.
Dakota State University	BOR	13	Electric, Steam	There is only one master meter for electricity. There is no means for metering steam usage at individual buildings.	Install pulse electric meters and condensate meters on each significant building. Install a front end metering analysis tool to compile usage data and provide charts and graphs for in-house analysis.

3.3.2.3. Additional Metering Considerations

There are some additional elements to consider when installing an advanced metering and monitoring system that must be factored in. Certain utilities can be monitored in different ways. For example, on a campus with a central steam boiler plant that uses natural gas as a fuel source there are a number of different ways that heating could be metered. A natural gas meter could be installed at the boiler plant but that would only show the total usage of plant not individual building. Steam meters could be installed at each building that could be converted but steam meters are high cost and maintenance intensive although they would give the best active feedback. Condensate meters at each building would be less expensive, be less maintenance but since condensate flows in spurts as the condensate receivers fill and evacuate they do not give effective active feedback in short time intervals. All of these scenarios need to be considered and the ultimate goals and savings potential of the system in order to install the most appropriate and cost effective system.

An advanced metering and monitoring system is an investment in the value of the property. Meters need to be maintained and calibrated to provide good feedback for building operators. Building operators need to stay engaged with the metering and monitoring systems and actively use the data as a tool. The system and those who use it properly can effectively improve building, reduce energy consumption, reduce costs and improve the bottom line for the operation.

3.4 State Guidelines

Energy consumption is anticipated to continue to grow as the State of South Dakota continues to grow. A major culture shift is required in the State to recognize that the cost of energy is increasing dramatically as energy demand continues to grow. This can be accomplished by developing an Energy Conservation and Awareness program to:

- Establish regional guidelines for:
  - Temperature set-points;
  - Personal appliances guidelines (personal space heaters, refrigerators, microwaves, etc.);
  - Behavioral expectations (turning lights off, not opening windows, not propping doors open, not covering HVAC vents, turning computers/monitors off when not in use, dressing appropriately for the weather, etc.)
  - Occupant comfort and maintenance guidelines (how to inform maintenance staff if uncomfortable due to space temperatures, humidity, faulty equipment, etc.);
- Create competition and recognition programs to recognize State employees that are assisting the State to move towards increased energy efficiency since it is well proven that energy savings can be generated by establishing friendly competition between campuses and agencies. Simple awards and recognition will lead to substantial savings by motivating building occupants to be more energy conscious.
- When procuring new leased space, the State should encourage the private sector to adopt green building standards by striving to lease facilities that meet the same standards as those required for new State construction. These preferences should also be considered in approving extensions of current leases.

3.4.1 LEED Implementation Guide

It is recommended that consideration be given to additional requirements for compliance with the LEED energy performance, measurement and verification and enhanced commissioning credits. This would require projects to achieve LEED credits that will support energy efficiency and energy management during building operation. Specifically, these credits may include Energy & Atmosphere credit 5 for a Measurement & Verification program, and additional point requirements for Energy & Atmosphere credit 1, Optimize Energy Performance.

3.5 Renewable Energy Generation

Renewable energy generation systems convert sunlight, wind or water energy to heat or electricity which can be used by building systems in State facilities. In distributed generation applications, renewable systems can provide exceptional benefits when installed at the point of use. Distributed generation means the generation system is installed at, or adjacent to, the building to deliver the generated energy with minimal transmission losses. This locally generated energy reduces the amount

of energy required from utilities and other sources, which reduces the total amount of fuel consumed to generate energy, reducing associated emissions and providing cost savings through demand reductions.

Three general types of renewable energy systems were considered for the Energy Master Plan: flat plate photovoltaic, single axis tracking flat plate photovoltaic, and wind turbines (small capacities with tower height less than 100 feet, and larger capacities with tower height great than 100 feet.).

Installations of renewable energy systems were evaluated for 11 State agencies receiving WAPA allocations of electric service. The forecasts of annual performance of the renewable energy systems were based on reviews of product literature, solar resource map from the National Renewable Energy Laboratory, local wind data (NREL, NOAA and South Dakota Wind Resource Assessment Network) and public domain software such as PVWATTS and RETScreen. The blended cost of electricity ($/kWh) and expected annual average wind speed (tower height of 50 meters) for each agency is shown in the following Table 3.5.1.

The contracts for electric allocations from WAPA (Western Area Power Administration) are generally considered to be total requirements contracts. Entities receiving electric service are not allowed to install generating capacity or sign other contracts to reduce or avoid delivery and purchase of electricity from WAPA. However, the WAPA contract does include a provision for accommodating energy conservation programs and renewable energy systems.

Table 3.5-1

State Institution	WAPA kW Allocation	Blended Rate $/kWh	Average Wind Speed (MPH)
Northern State University	2,095	$0.028	16
Black Hills State University	1,510	$0.045	14
South Dakota Developmental Center	998	$0.030	16
School of Mines and Technology	2,245	$0.042	15
Human Services Center	1,696	$0.030	15
South Dakota State Penitentiary	1,711	$0.031	15
South Dakota State University	7,983	$0.034	15
Mike Durfee State Prison	998	$0.029	15
University of South Dakota	6,486	$0.033	15
Capital Complex	3,921	$0.034	15
Dakota State University	1,497	$0.032	15

The relative viability of the renewable energy systems are compared on the basis of simple payback period. The avoided annual expense is the product of annual electric generation (kWh) and local price of electricity ($/kWh). A shorter payback period represents a more attractive capital investment. A maximum acceptable payback period is a reflection of the business objectives of the organization, reflecting considerations for competing uses of capital resources, cost of capital, and potential operating risks. Yet typically a simple payback period should never exceed the expected service life of the system or equipment being considered.

3.5.1 Photovoltaic Systems

Photovoltaic systems use sunlight to produce electricity. Based on the available solar resource, the annual potential electric generation of a fixed plate 1 kW photovoltaic system ranges from 1,296 kWh at Brookings to 1,408 kWh at Rapid City. The estimated capital cost of such a system is $7,975. The simple payback period ranges from approximately 129 years for an installation at Black Hills State University to 215 years for an installation at Northern State University. The annual kWh generation is essentially equivalent if installed at Northern State University or Black Hills State University. The wide divergence in simple payback period is attributable to the blended cost of electricity: $0.028/kWh at Northern State University and $0.045/kWh at Black Hills State University.

A similar trend is observed with the single axis tracking photovoltaic system. Annual generation varies little across the potential locations: 1,665 kWh to 1,831 kWh. The simple payback period ranges from approximately 132 years to 221 years, again if located at Black Hills State University or Northern State University.

The expected avoided annual expense is not sufficient to pay back the capital investment within the expected service life of a photovoltaic system, about 20 years. Therefore if photovoltaic projects are being evaluated solely on the basis of cost savings, these projects should not be pursued. However, photovoltaic systems provide other benefits in addition to cost savings, including:

- Reduced peak power loads, since photovoltaic systems typically produce the most energy during periods of peak power load;
- Reduced transmission and distribution expenses, when the system is installed near the building where the electricity will be used;
- Improved grid reliability is realized once distributed generation systems become more common, which will reduce the strain on the electric grid;
- Control utility costs, since electric generation does not depend on the cost of fuel;
- Reduced emissions, since electricity is generated without fossil fuels.

3.5.2 Wind Systems

South Dakota has notable resources that can support the development of wind energy. However, small wind systems (less than 50 kW and tower height less than 100 feet) and large wind systems (greater than 250 kW and tower height greater than 100 feet) generally do not represent an effective of use of capital for reducing reliance on traditional energy sources at the selected State agencies. This is due to the low price of electricity under the WAPA allocation that does not provide an expense basis sufficient to justify the capital investment in wind energy.

Again, the expected avoided annual expense is not sufficient to pay back the capital investment within the expected service life of a wind system. Therefore if wind projects are being evaluated solely on the basis of cost savings, these projects should not be pursued. However, wind systems provide other benefits in addition to cost savings, including:

- Reduced peak power loads, since wind systems typically produce the most energy during periods of peak power load;
- Reduced transmission and distribution expenses, when the system is installed near the building where the electricity will be used;
- Improved grid reliability is realized once distributed generation systems become more common, which will reduce the strain on the electric grid;
- Control utility costs, since electric generation does not depend on the cost of fuel;
- Reduced emissions, since electricity is generated without fossil fuels.

3.5.3 Summary of Results

The following tables (Table 3.5-2 thru 3.5-12) provide a summary of expected annual generation, the associated annual avoided expense, capital cost and simple payback period for photovoltaic systems and wind energy systems for each selected agency and location.

Northern State University, Aberdeen **Blended Electric Rate:$0.028/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,322	$37.02	$ 7,975	215.4
Single Axis Tracking	1.0	1,713	$47.96	$10,600	221.0
Small Wind					
100' Tower	10.0	24,400	$683	$53,500	78.3
80' Tower	20.0	33,300	$932	$86,400	92.7
100' Tower	50.0	144,650	$4,050	$ 195,000	48.1
Large Wind					
165' Tower	350.0	811,000	$ 22,708	$ 658,800	29.0
260' Tower	2,100.0	**5,685,000**	**$ 159,180**	**$ 4,715,000**	**29.6**

Table 3.5-2

Black Hills State University, Spearfish **Blended Electric Rate:$0.045/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,375	$ 85.25	$ 7,975	128.9
Single Axis Tracking	1.0	1,789	$110.92	$10,600	131.7
Small Wind					

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
100' Tower	10.0	14,700	$ 911	$53,500	80.9
80' Tower	20.0	22,100	$ 1,370	$86,400	86.9
100' Tower	50.0	106,500	$ 6,603	$ 195,000	40.7
Large Wind					
165' Tower	350.0	661,000	$ 40,982	$ 658,800	22.1
260' Tower	2,100.0	4,633,000	$ 287,246	$ 4,715,000	22.6

Table 3.5-3

South Dakota Developmental Center, Redfield Blended Electric Rate:$0.030/kWh

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,329	$ 87.71	$ 7,975	200.0
Single Axis Tracking	1.0	1,713	$113.06	$10,600	206.3
Small Wind					
100' Tower	10.0	24,400	$ 1,610	$53,500	73.1
80' Tower	20.0	33,300	$ 2,198	$86,400	86.5
100' Tower	50.0	144,650	$ 9,547	$ 195,000	44.9
Large Wind					
165' Tower	350.0	811,000	$ 53,526	$ 658,800	27.0
260' Tower	2,100.0	5,709,000	$ 376,794	$ 4,715,000	27.5

Table 3.5-4

School of Mines and Technology, Rapid City Blended Electric Rate:$0.042/kWh

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,408	$92.93	$ 7,975	134.9
Single Axis Tracking	1.0	1,831	$ 120.85	$10,600	137.8
Small Wind					
100' Tower	10.0	20,800	$ 1,373	$53,500	61.2
80' Tower	20.0	27,300	$ 1,802	$86,400	75.4
100' Tower	50.0	125,500	$ 8,283	$ 195,000	37.0
Large Wind					
165' Tower	350.0	805,000	$ 53,130	$ 658,800	19.5
260' Tower	2,100.0	5,646,000	$ 372,636	$ 4,715,000	19.9

Table 3.5-5

Human Services Center, Yankton **Blended Electric Rate:$0.030/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,353	$ 43.30	$ 7,975	196.5
Single Axis Tracking	1.0	1,742	$ 55.74	$10,600	202.8
Small Wind					
100' Tower	10.0	20,800	$ 666	$53,500	85.7
80' Tower	20.0	27,300	$ 874	$86,400	105.5
100' Tower	50.0	125,500	$ 4,016	$ 195,000	51.8
Large Wind					
165' Tower	350.0	805,000	$ 25,760	$ 658,800	27.2
260' Tower	2,100.0	5,646,000	$ 180,672	$ 4,715,000	27.8

Table 3.5-6

South Dakota State Penitentiary, Sioux Falls **Blended Electric Rate:$0.031/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,310	$ 40.61	$ 7,975	196.4
Single Axis Tracking	1.0	1,683	$ 52.17	$10,600	203.2
Small Wind					
100' Tower	10.0	20,800	$ 645	$53,500	83.0
80' Tower	20.0	27,300	$ 846	$86,400	102.1
100' Tower	50.0	125,500	$ 3,891	$ 195,000	50.1
Large Wind					
165' Tower	350.0	805,000	$ 24,955	$ 658,800	26.4
260' Tower	2,100.0	**5,646,000**	**$ 175,026**	**$ 4,715,000**	**26.9**

Table 3.5-7

South Dakota State University, Brookings **Blended Electric Rate:$0.034/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,296	$ 54.43	$ 7,975	181.0
Single Axis Tracking	1.0	1,665	$ 69.93	$10,600	187.2
Small Wind					
100' Tower	10.0	20,800	$ 874	$53,500	75.7
80' Tower	20.0	27,300	$ 1,147	$86,400	93.1
100' Tower	50.0	125,500	$ 5,271	$ 195,000	45.7
Large Wind					
165' Tower	350.0	805,000	$ 33,810	$ 658,800	24.0
260' Tower	2,100.0	**5,646,000**	**$ 237,132**	**$ 4,715,000**	**24.6**

Table 3.5-8

Mike Durfee State Prison, Springfield **Blended Electric Rate:$0.029/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,381	$ 41.43	$ 7,975	199.1
Single Axis Tracking	1.0	1,771	$ 53.13	$10,600	206.4
Small Wind					
100' Tower	10.0	20,800	$ 624	$53,500	88.7
80' Tower	20.0	27,300	$ 819	$86,400	109.1
100' Tower	50.0	125,500	$ 3,765	$ 195,000	53.6
Large Wind					
165' Tower	350.0	805,000	$ 24,150	$ 658,800	28.2
260' Tower	2,100.0	5,646,000	$ 169,380	$ 4,715,000	28.8

Table 3.5-9

University of South Dakota, Vermillion **Blended Electric Rate:$0.033/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,330	$ 46.55	$ 7,975	181.7
Single Axis Tracking	1.0	1,698	$ 59.43	$10,600	189.2
Small Wind					
100' Tower	10.0	20,800	$ 728	$53,500	77.9
80' Tower	20.0	27,300	$ 956	$86,400	95.9
100' Tower	50.0	125,500	$ 4,393	$ 195,000	47.1
Large Wind					
165' Tower	350.0	805,000	$ 28,175	$ 658,800	24.8
260' Tower	2,100.0	5,646,000	$ 197,610	$ 4,715,000	25.3

Table 3.5-10

Capitol Complex/State Highway Building, Pierre **Blended Electric Rate:$0.034/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,387	$ 45.77	$ 7,975	169.1
Single Axis Tracking	1.0	1,798	$ 59.33	$10,600	173.4
Small Wind					
100' Tower	10.0	20,800	$ 1,643	$53,500	75.7
80' Tower	20.0	27,300	$ 2,157	$86,400	93.1
100' Tower	50.0	125,500	$ 9,915	$ 195,000	45.7
Large Wind					
165' Tower	350.0	805,000	$ 63,595	$ 658,800	24.0
260' Tower	2,100.0	5,646,000	$ 446,034	$ 4,715,000	24.6

Table 3.5-11

Dakota State University, Madison **Blended Electric Rate:$0.032/kWh**

Technology	Size (kW)	Energy Generated (kWh/yr)	Annual Avoided Expense	Installation Cost	Simple Payback (Years)
Flat Plate Solar PV					
Fixed Axis	1.0	1,328	$131.47	$ 7,975	60.7
Single Axis Tracking	1.0	1,706	$168.89	$10,600	62.8
Small Wind					
100' Tower	10.0	20,800	$ 2,059	$53,500	80.4
80' Tower	20.0	27,300	$ 2,703	$86,400	98.9
100' Tower	50.0	125,500	$ 12,425	$ 195,000	48.6
Large Wind					
165' Tower	350.0	805,000	$ 79,695	$ 658,800	25.5
260' Tower	2,100.0	5,646,000	$ 558,954	$ 4,715,000	26.1

Table 3.5-12

4.0 Campus Overviews by Agency

This section of the report provides the results of the investigations performed over a period of six weeks from September through October 2009. This section provides a general description of each building that was analyzed for this study, and provides the summary calculations for each Energy Conservation Measure (ECM) identified at each State facility.

This section is organized by State Agency, and by campus location. This organization allows for each agency or each campus location to review the results for their buildings in a standalone portion of the report. For example, project managers at the Capitol Complex may wish to print only building results (Section 4.1.1), or representatives with the Bureau of Administration may wish to print results for the entire agency (Section 4.1).

A necessary reference for this section is Section 5.0 (ECM Descriptions), which describes each ECM references in this section in greater detail. For example, ECM 5.4.2 is described in Section 5.4.2 as:

Program VFD Controls

The air handling unit is equipped with a VFD, but is operating at a fixed speed because the VFD controls have not been programmed. With programmed controls, the VFD speed would modulate, thus saving fan, cooling, and heating energy.

Outline Specification:

- Install any controls hardware for the modulation of VFD speeds.
- Program VFD controls.

Implementation Plan: It is anticipated that the equipment manufacturer will be able to update/install the controls required on the equipment with a walkthrough of the building.

Key Assumptions: The program will allow the VFD speed to modulate based on load.

Impact to Occupants: Improved temperature control in the space.

4.1 Bureau of Administration

The Bureau of Administration (BOA) serves the citizens and government agencies of South Dakota. Programs include property management, Records Management, Energy Management, Buildings and Grounds, Central Supply, Office of the State Engineer and Management. BOA manages all State owned and leased properties, including South Dakota's magnificent State Capitol.

Within the Bureau of Administration, there are a total of 789,932 square feet of facilities, with the majority of buildings at the Capitol Complex campus.

BOA Campus Summary.

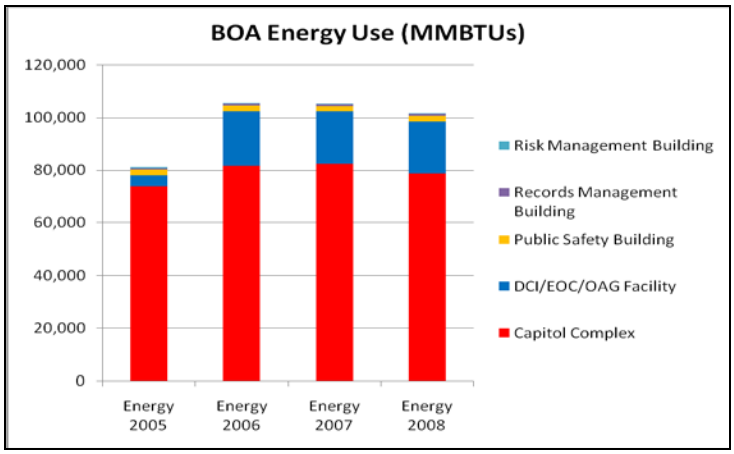
Campus	Location	Square Footage
Capitol Complex	Pierre	600,368
Commerce Building Public Safety	Pierre	21,349
DCI / EOC / OAG Facility	Pierre	152,700
Record's Management Building	Pierre	11,409
Risk Management Building	Pierre	4,106
	TOTAL	**789,932**

Energy Profile

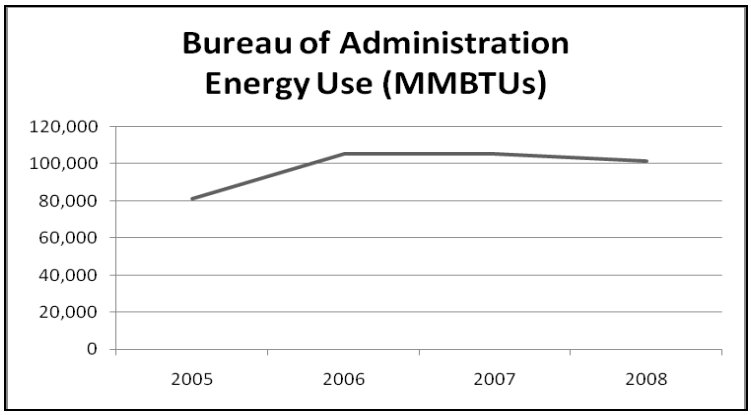
In 2008, BOA facilities consumed a combined 101,637 MMBTUs of energy. As the largest campus in building square footage, the Capitol Complex campus used the most energy. The average Energy Use Intensity across the BOA was 129 kBTU per square foot for 2008.

BOA Campus Energy Data (MMBTUs).

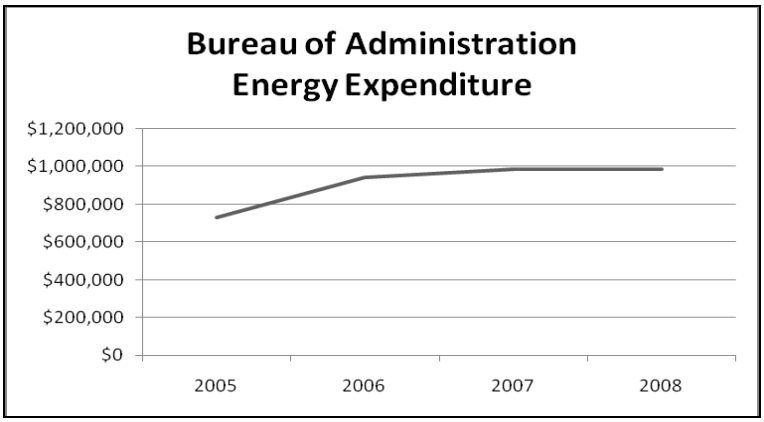
Campus	2005	2006	2007	2008
Capitol Complex	73,831	81,646	82,283	78,612
DCI/EOC/OAG Facility	4,168	20,846	20,185	19,924
Public Safety Building	2,054	2,078	2,008	2,151
Records Management Building	656	699	678	667
Risk Management Building	328	228	186	283
Grand Total	**81,038**	**105,497**	**105,341**	**101,637**



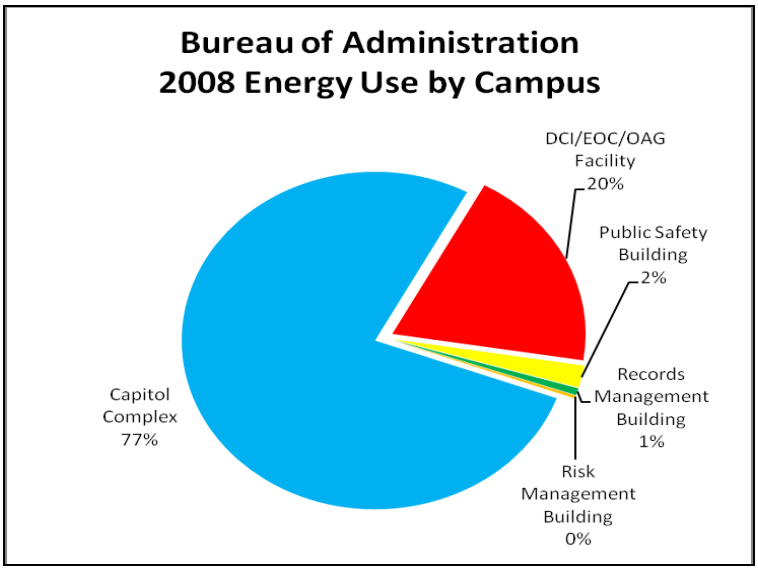
BOA Energy Use by Campus.



BOA Energy Use.



BOA Energy Expenditures.



BOA 2008 Energy Use by Campus.

4.1.1 Capitol Complex

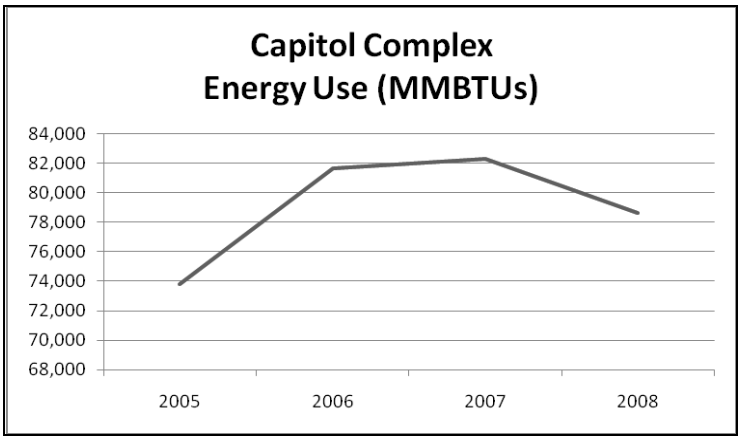
The Capitol Complex in central Pierre is a collection of twelve buildings used for many different aspects of State government operations totaling 585,000 square feet. Most of the square footage is office space, but there is also a significant amount of lab space, kitchens and dining facilities, legislative meeting space, training centers, and museums. The Capitol Complex is the heart of the State government operation.

Campus Background and List of Facilities

There is a central plant for the Capitol Complex including a steam and chilled water system. Steam is delivered to the Capitol Building, Visitors Center, Health Administration Building, Foss Building, Anderson Building, Becker-Hansen and Soldiers and Sailors Building via steam tunnels and underground steam piping. The central chiller plant delivers chilled water to the Capitol Building via the steam tunnels. The Foss and Anderson Buildings share a chiller that is located between them and connected via underground chilled water piping.

Energy Profile

In 2008, Capitol Complex facilities consumed a combined 78,612 MMBTUs of energy. The average Energy Use Intensity across the campus was 134 kBTU/SF in 2008.



Capitol Complex Energy Use.

4.1.1.1. Anderson Building

Building Overview

The Anderson Building is 28,842 square feet. There are approximately 155 occupants on a regular working day. This building is operated 9 hours per day, 5 days per week. Most of the building has been renovated to include new windows, roof insulation, and HVAC. The building is mostly administrative offices and conference rooms.

There are two air handlers serving the Anderson building. A constant volume air handling unit located in the basement serves only the basement through locally controlled constant volume bypass boxes. A VAV air handling system located on the third floor and serves the second and third floors. Both air handlers have heating and cooling coils. The cooling coils are served by a 210 ton McQuay chiller, which is shared with the Foss building and resides between the two buildings. The heating coils are served by low pressure steam from the campus steam system. There are unit heaters in the stairwells and fin tube radiation providing parameter heating. The HVAC system has primarily pneumatic zone controls with DDC plant level controls that are connected to the central BAS. Domestic hot water is provided by a series of electric water heaters. There is a small air compressor for the pneumatic controls and a condensate pump that returns steam condensate back to the central plant once the heat has been used.

Office lighting is primarily T-8 fluorescent fixtures. Interior lighting has been recently retrofitted to 6100 K lamps with electronic ballasts. Some fixtures were de-lamped. Interior lights are manually controlled. Exit signs are incandescent and fluorescent.

The exterior finish is brick and the interior finish is sheet rock and block. The windows are double pane with shades. The roof is off-white, flat, and in good condition. There is an entrance vestibule and the building envelope is fairly well constructed.

ECM's

Previously Implemented ECMs

The lighting has been upgraded to fluorescent T-8 and de-lamped to only the required light levels in the space. Dump boxes have been converted to VAV. The building envelope has significantly improved with the replacement of windows. The 210 ton air cooled McQuay chiller is a high efficiency unit. The roof has recently replaced including improved insulation.

Opportunities for ECMs at Anderson Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$2,000	3.8	11,765		$400	5.0
5.1.2	Delamp Multiple Lamp Fixtures	$5,000		13,622		$463	10.8
5.1.3	Install Motion Sensors to Control Lighting	$20,000	8.1	70,588	726	$3,000	6.7
5.4.3	Replace Dump Boxes with VAVs3	$4,600	1.7	20,096	11,596	$10,262	0.4
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$7,130		15,306		$520	13.7
5.5.3	Improve Building Envelope - Insulation/Exterior	$350,000		22,554	5,243	$5,098	68.7
	TOTAL	**$388,730**	**14**	**153,932**	**17,566**	**$19,743**	**19.7**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure cost accounts for VFD only.
4. Cost assumes installation by in-house staff.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.2. Becker-Hansen Building

Building Overview

The Becker-Hansen Building is the home of the State department of transportation. It is 90,202 square feet with approximately 324 occupants on a regular working day. This building is occupied 9 hours per day, 5 days per week. The building is primarily administrative offices, conference rooms, cafeteria, server rooms, and mechanical spaces.

The heating and cooling of the offices and general space is accomplished by six air handlers. The building has recently undergone many renovations where systems were upgraded or converted to VAV. The heating coils in the units are served by a pair of 15 hp pumps and a pair of 7.5 hp pumps that pump heating water converted from the central steam plant. Cooling coils are served by a 215 ton water-cooled Trane chiller and cooling tower. The two 40 hp chilled water pumps and two 30 hp condenser water pumps are constant volume. The

Becker-Hansen building has several central data centers that have a constant load and are cooled by dedicated computer room air conditioning (CRAC) units connected to air cooled condensers or dry coolers. An elaborate variable speed packaged dry cooler system outside the building in an equipment yard provides efficient cooling to the new CRAC units installed in the building. The HVAC system has DDC controls and is connected to the central BAS that has replaced old pneumatic controls. Domestic hot water is provided by electric resistance hot water heaters.

Office lighting is primarily T-8 strip lighting and compact fluorescents. Some hallways are lit to as high as 76 foot-candles. Interior lights are manually controlled. Exit signs are fluorescent. Fluorescent T-12s illuminates many back of the house areas.

The exterior finish is brick and precast concrete. The interior finish is sheet rock and brick. The windows are double pane and tinted. The roof is black, flat, and is in fair condition. There is an entrance vestibule for the high traffic entrance. The building envelope has adequate insulation on the roof and limited insulation in the walls.

ECM's

Previously Implemented ECMs

As part of a multi-phase renovation project, the building has received significant HVAC and DDC upgrades, all of which are improvements to the energy efficiency of the building. This renovation also included exterior wall insulation, new insulated roofs, new electrical service and branch circuits. New computer room cooling units utilize variable speed controls, dry-coolers and free-cooling strategies wherever possible. The new air handling systems are variable speed and have improved controls capabilities to optimize the systems and improve comfort while using less energy.

Opportunities for ECMs at Becker Hanson Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$5,750	9.5	29,412		$1,000	5.7	4
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$5,750	9.5	29,412		$1,000	5.7	4
5.1.2	Delamp Multiple Lamp Fixtures	$0	14.0	43,344		$1,474	0.0	4
5.1.3	Install Motion Sensors to Control Lighting	$16,680		34,056		$1,158	14.4	
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,580	1.2	368		$13	126.1	6, 9
5.2.1	Full Retrocomissioning and Balancing Study	$50,000	26.9	235,294	2,421	$10,000	5.0	
5.3.3	Install VFDs on Hydronic Pumps	$31,860		92,487		$3,145	10.1	3,5,7
5.3.12	Install VFDs on Oversized Chiller/Condenser Pumps	$39,560	38.7	122,895		$4,178	9.5	8, 9

Opportunities for ECMs at Becker Hanson Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.4.6	Replace Chiller with Magnetic Bearing Technology	$100,800	161.3	137,413		$4,672	21.6	
5.4.7	Replace Cooling Tower at the End of Its Useful Life Expectancy	$29,000	11.8	72,890		$2,478	11.7	
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$13,110		30,612		$1,041	12.6	
5.5.6	Install Timers on Snack Vending Machines	$120		1,752		$60	2.0	4
	TOTAL	**$288,460**	**263**	**800,523**	**2,421**	**29,218**	**9.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure cost accounts for VFD only. No motor.
4. Costs assumes installation by in-house staff.
5. Heating water pumps (7.5 HP pair and 15 HP pair).
6. Penthouse lighting.
7. Cost includes replacent of 3-way valves with 2-way.
8. VFDs installed for balancing purposes Ths project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.3. Bureau of Administration

Building Overview

The Bureau of Administration Building is 1,496 square feet. There are approximately 11 occupants in the building on a regular working day. This building is occupied 9 hours per day, 5 days per week. The building was once a church but has been converted to office space and is mostly administrative offices and conference rooms.

Two 1000 BTUH high efficiency, gas fired heating and DX cooling, forced air residential style furnaces provide heating and cooling for the building. There is no direct means of bringing in outside air into the building and C02 reading was 1125 ppm. The building does have central air conditioning with two dedicated condensing units for the two furnace evaporator coils. The HVAC is controlled by a simple thermostat that cannot be programmed. Domestic hot water is provided by an electric water heater.

Office lighting is primarily T-8 strip lighting. Interior lights are manually controlled. Exit signs are fluorescent.

The exterior finish is brick and the interior finish is sheet rock and block. The windows are single paned with shades. The roof is pitched with tan-colored shingles and is in fair condition. There is limited insulation in the walls and roof.

ECM's

Previously Implemented ECMs

The high efficiency gas furnaces are up to 95% efficient.

Opportunities for ECMs at Bureau of Administration Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$200	0.7	2,136		$73	2.8
5.1.3	Install Motion Sensors to Control Lighting	$460		681		$23	19.9
5.2.1	Full Retrocomissioning and Balancing Study	$10,000	0.5	4,706	48	$200	50.0
5.3.2	Programmable Thermostats for Residential Style Units	$690		399	113	$107	6.4
5.5.3	Improve Building Envelope - Insulation/Exterior	$75,000		3,000	813	$774	96.9
5.5.4	Improve Building Envelope - Windows	$35,000		2,820	577	$573	61.1
	TOTAL	**$121,350**	**1**	**13,742**	**1,552**	**1,749**	**69.4**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.4. Capitol Building

Building Overview

The Capitol Building was originally constructed in 1910 and had an Annex section added in 1940.The building is 141,152 square feet and is comprised of administrative offices, legislative chambers, State Supreme Court judicial offices and chambers, cafeteria, and server rooms. Approximately, 275 personnel work in the Capitol Building on a typical12 hours a day, 5 days a week schedule. When the legislature is in session the number of personnel in the building grows to 500 and the schedule is 12-16 hour days for selected areas of the building.

Steam from the central plant is used for heating in the air handler heating coils and perimeter radiators. Chilled water from the central plant is used for cooling in air handlers and fan coil units. Once through water is also used for two heat pumps. The building has several data

centers located in the lower level. Each has its own dedicated CRAC cooling unit. The CRAC units are either DX or glycol and have either a dry cooler or air cooled condenser located outdoors. The fourth floor of the building was recently renovated where new VAV air handling units were installed along with a converter for hot water heat. Also, the unit serving the State Treasurer offices is also a new VAV air handling unit. All other air handlers are constant volume units. The Capitol building is on a capitol campus wide building automation system (BAS).

The BAS is a combination on pneumatic, electric, and DDC controlled devices. Each building in the Capitol Complex has a Honeywell controller that communicates with the central monitoring station. Domestic hot water is provided by several electric resistance water heaters. There are several additional pieces of support equipment that use significant amount of energy including air compressors, condensate pumps and vacuum pumps.

While most lighting in office areas has been converted to fluorescent T-8, the building has a large number of T-12 strip lighting primarily in the basement. Most of the lighting in the building is controlled by manual wall switches. The common areas of the Capitol Building are lit by compact fluorescent globe fixtures. The common area lighting remains on 24/7. The rotunda is illuminated by incandescent lamps. The dome is lit by metal halide monument lights. The grounds of the Capitol Building are lighted by approximately 200 high pressure sodium street lights. All exterior lights for the Capitol complex is controlled by photocells. There is a mixture of LED, fluorescent and incandescent exit signs.

The exterior finish is stone, brick, pre-cast concrete and metal wall panel. The interior finish is concrete, brick and sheet rock. The office areas have double pane, operable windows with shades. The roof is off white over the legislative chambers. In addition to flat roof the building has a dome. There are entrance vestibules and the building envelope is fairly well constructed. Any modifications or improvement made to the exterior of the capitol building cannot alter or disturb the historic quality of the building.

ECM's

Previously Implemented ECMs

Lighting has been upgraded to fluorescent T-8s. Computer room cooling units utilize glycol free-cooling strategies in many instances. Lighting in the common areas has been upgraded to compact fluorescent.

Opportunities for ECMs at Capitol Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$18,860		28,576		$972	19.4	
5.1.7	Retrofit T-12 Fixtures with T-8s	$111,550	51.4	254,665		$8,659	12.9	5
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$22,770	19.3	59,598		$2,026	11.2	
5.1.9	Install Scheduling Control of Lighting	$1,270	-	151,704		$5,158	0.2	4
5.2.1	Full Retrocomissioning and Balancing Study	$65,000	33.6	294,118	3,027	$12,500	5.2	5
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$479,670	103.7	255,684	99,634	$90,991	5.3	
5.4.10	Centralize Cooling Systems with Chilled Water Plant	$182,970	186.5	186,274		$6,333	28.9	3
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$43,700		102,039		$3,469	12.6	
	TOTAL	$925,790	394	1,332,657	102,661	130,108	7.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Relates to getting the remainder of the DX units onto the central chilled water plant. Cost assumes concurrent installation with 5.4.2 utilizing the existing plant.
4. Relates to installing circuit timclocks on the lighting above the State House and Senate floors.
5. Ths project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.5. Capitol Lake Plaza

Building Overview

The Capitol Lake Plaza Office Building, located at 711 E. Wells Avenue, Pierre, South Dakota, was constructed in the early 1970's. A two story addition was completed in the mid 1980's. The building is about 30,000 square feet. The building is currently being renovated and is anticipating a LEED Silver or Gold rating. This building was not investigated at the direction of OSE.

4.1.1.6. Central Plant / WWII Visitor's Center

Building Overview

The Visitor's Center is 4,067 square feet. Typically, occupancy is variable and heavier during the legislative session. This building is operated 9 hours per day, 7 days per week. The building is mostly for displaying historical information of the war memorials. The central plant located below the Visitor's Center houses the main steam plant and the chiller plant for the Capitol Building. The building construction is made up of block and brick.

In the Visitor's Center, hot water fin tube radiation provides the heating for the center. Cooling is provided by a 10 ton DX constant volume air handler. The HVAC system has pneumatic controls and is tied into the central BAS.

Fluorescent T-8 and T-12 lighting is installed throughout the Visitor's center and the Central Plant. Interior lights are manually controlled. Exit signs are a mixture of fluorescent and incandescent.

The central plant steam is driven by two 400 hp boilers. Both boilers are configured to burn #6 fuel oil and natural gas. The cost for #6 fuel oil is less than natural gas and #2 fuel oil but it is difficult to work with, maintain and to keep the boilers operating efficiently. For this reason the #6 fuel oil is currently planned for natural gas conversion. Condensate is typically returned to the plant at 160 to 180 degrees F. and is handled by a duplex condensate handling system. Boiler plant staff report good steam trap integrity and very little make-up water required for the system.

A chiller serving the capitol building is located in the central plant as well. Three existing chillers and seven air cooled condensing units were replaced in 2005 with a single high efficiency magnetic bearing chiller that has increased the cooling capacity by capturing diversity while dramatically reducing electric consumption. The chilled water and condenser water systems that reject heat and distribute cooling are constant speed. A cooling tower with a variable speed fan serves the chilled water system. Controls for the chilled water and boiler plant are DDC and are tied into the central campus BAS system.

ECM's

Previously Implemented ECMs

The boilers have improved efficiency with conversion to natural gas from #6 fuel oil. The chiller plant has improved efficiency by installing magnetic bearing compressors.

Opportunities for ECMs at Central Plant / WWII Visitors Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.7	Retrofit T-12 Fixtures with T-8s	$350	0.2	632		$21	16.3	
5.2.1	Full Retrocomissioning and Balancing Study	$12,000	1.1	9,412	97	$400	30.0	3
5.3.3	Install VFDs on Hydronic Pumps	$11,730		36,839		$1,253	9.4	
5.4.2	Convert Boiler Plant to High Efficiency Boilers	$819,348		66,588	29	$38,668	21.2	3
	TOTAL	**$843,428**	**1**	**113,470**	**126**	**$40,342**	**20.9**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. This project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.1.1.7. Cultural Heritage Center

Building Overview

The Cultural Heritage Center was constructed in 1987 and is 64,000 square feet. On average there are approximately 37 workers plus museum visitors. This building is operated on average of 9 hours per day Monday through Saturday and 4 hours on Sundays and most holidays. The building is built into the earth and has a building façade exposed on one side and a truck dock on another. The Heritage Center is primarily made up of a museum, offices, gift shop, and mechanical spaces.

The Cultural Heritage Center is built underground with an HVAC system that is very efficient because there is a limited envelope gain or loss. The heating and cooling is accomplished by numerous air handlers, computer room air conditioning (CRAC) units and heat pumps. The heat pumps, CRAC units and air handling unit coils are served by a constant volume core loop that the units either use a 'free cooling' loop water system or utilize a compression cycle determined by the need for heating or cooling. The core loop is driven by two 10 hp constant volume pumps. When the core loop needs heat it is provided by a 120 kW electric boiler. When the core loop needs cooling it is provided by both a cooling tower and a pair of Bohn fluid coolers. The cooling system takes advantage of "free cooling" when the ambient temperature permits pumping cooling tower water directly to the cooling coils. Two 5 hp condenser water pumps are constant volume. The system is very efficient because it moves energy within the building around rather than making it whenever possible. The energy from hot areas is transferred to cold areas and vice versa. A chiller is not required because the system can operate at temperatures where enough heat is rejected by a cooling tower/fluid cooler alone. The Cultural Heritage Center has a DDC building HVAC control system and is not tied into the Capitol Complex BAS. Domestic hot water is provided by the electric domestic water heaters. An air to air heat recovery system is installed on the main outside air intake to the building.

Office lighting is primarily 4' T-12 strip lighting and 2' T-12 U-lamp fixtures that are controlled by manual wall switches. The museum exhibition areas use Halogen spot lighting controlled by occupancy sensors. Exit signs are fluorescent.

The exterior finish is stone, brick and glass. The interior finish is sheet rock and block. The windows are double-paned and tinted. Because the building is built into the earth there is not an exposed roof. There is a main entrance vestibule and the building envelope is well constructed.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Cultural Heritage Center						
			Estimated Annual Utility Savings			
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.6	Replace Incandescent Spot Lighting with Ceramic Metal Halide	$4,250	11.8	39,410	$1,340	3.2
5.1.7	Retrofit T-12 Fixtures with T-8s	$3,855	3.7	12,376	$421	9.2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$165	1.2	417	$14	11.6
5.2.1	Full Retrocomissioning and Balancing Study (See Note 4)	$45,000	23.5	205,882	$7,000	6.4
5.3.1	Install VFD on Cooling Tower Fans	$7,360		12,729	$433	17.0
5.3.3	Install VFDs on Hydronic Pumps (See Note 3)	$6,100		8,072	$274	22.2
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$4,370	1.1	9,694	$330	13.3
	TOTAL	$71,100	41	288,580	9,812	7.2

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure cost accounts for VFD only. No motor.
4. This project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.8. Foss Building

Building Overview

The Foss Building is 60,230 square feet. There are approximately 290 occupants. This building is operated 9 hours per day, 5 days per week. Most of the building is presently being renovated to include all new windows. The building is primarily administrative offices and conference rooms.

Five air handlers provide cool air and ventilation to a number of terminal boxes throughout the spaces that are individually controlled by thermostats. Some have dump boxes to recycle air that is not needed from the air handler back to the air handler, and others have VAV boxes

that reduce the airflow rather than recycling it. Three constant volume air handling units serve the Matthews Training Center addition. All of the air handlers have cooling and heating coils. The cooling coils are served by a 210 ton McQuay chiller, which is shared with the Anderson building. The two main air handling units utilize lower pressure steam for heating coils and the Matthews Training Center utilizes a hot water converter served by the central steam system. Perimeter finned tube radiation also provides steam heat to the building. The HVAC system has a combination pneumatic and DDC zone controls with DDC plant controls. The control systems are connected to the central BAS. Domestic hot water is provided by electric resistance water heaters. There is a small air compressor for the pneumatic controls and a condensate pump that returns steam condensate back to the central plant once the heat has been used.

Office lighting is primarily provided by fluorescent T-8 fixtures with two, three or four lamps. Interior lighting has been recently retrofitted to 6100 K lamps with electronic ballasts. Some fixtures were de-lamped. The foyer and entry lighting uses compact fluorescent can lights. Interior lights are manually controlled by wall switches. The exit signs are fluorescent.

The exterior finish is brick and pre-cast concrete. The interior finish is sheet rock and block. The building is presently replacing windows. The new windows are double pane with shades. There is an entrance vestibule and the building envelope is fairly well constructed despite limited insulation.

Previously Implemented ECMs

The new interior fit-out utilizes the most economical efficient lighting available. The new air handling systems utilize variable speed systems to maintain comfort while using the least amount of energy required. Constant volume bypass terminal boxes on floor and part of floor were replaced with pressure independent VAV boxes. The building envelope has significantly improved with the replacement of windows. The 210 ton air cooled McQuay chiller is a high efficiency unit.

Opportunities for ECMs at Foss Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$4,000	7.6	23,530		$800	5.0	4
5.1.3	Install Motion Sensors to Control Lighting	$10,000		27,245		$926	10.8	
5.2.1	Full Retrocomissioning and Balancing Study	$40,000	16.7	145,882	1,501	$6,200	6.5	5
5.3.3	Install VFDs on Hydronic Pumps3	$7,820		14,801		$503	15.5	
5.4.3	Replace Dump Boxes with VAVs3	$10,470	5.0	55,415		$1,884	5.6	
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$8,740		20,408		$694	12.6	

Opportunities for ECMs at Foss Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.5.3	Improve Building Envelope - Insulation/Exterior	$450,000		47,100	5,475	$6,124	73.5	
	TOTAL	**$531,030**	**29**	**334,380**	**6,976**	**17,131**	**31.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure cost accounts for VFD only. No motor.
4. Cost assumes installation by in-house staff.
5. This project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.9. Governor's Residence

Building Overview

The Governor's Residence was constructed in 2005 and is 14,550 square feet. The mansion is home to the governor and his family but is also occupied by a small number of support staff regularly during the day. This building is operated 24 hours per day, 7 days per week. The residence building consists of five bedrooms, kitchen, living room, family room, and several offices.

A Carrier air handler with heating and cooling coils provides ventilation for the residence. Hot water is generated by two natural gas fired Triad 504 MBH boilers. HVAC equipment is controlled by local thermostats but are tied into and monitored by the campus BAS system. Domestic hot water is provided by two 27 kW A.O. Smith electric water heater.

The exterior finish is brick and vinyl siding. The interior finish is sheetrock and block. Windows are double paned with shades. There is not an entrance vestibule and the building envelope condition is in good condition.

ECM's

Previously Implemented ECMs

This residential building was built with a number of commercial high efficiency energy strategies and equipment.

Opportunities for ECMs at Governor's Mansion							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$120	0.5	376		$13	9.4
5.3.6	Install Heating Water Reset Schedule	$580			76	$62	9.3
5.5.5	Intellihood Kitchen Hood Controls System	$3,340	0.1	128	341	$286	11.7
	TOTAL	$4,040	1	504	417	361	11.2

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.10. Health Admin Building

Building Overview

The Health Admin Building is 10,573 square feet. There are approximately 25 occupants. The building is mostly administrative offices. The exterior finish is brick and the interior finish is sheet rock.

The Health Admin building is on the Capitol Complex central steam system. Ventilation is provided by a multi-zone air handler with a converter, hot water heating and DX cooling. Hot water finned tube radiation and a unit heater provide heating for mechanical space. Simultaneous heating and cooling is locked out via controls. The HVAC system has pneumatic controls with a DDC overlay that is tied into the central BAS. A small air compressor serves the pneumatic control system in the building. Electric resistance domestic water heaters provide hot water to the facility.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Health Admin Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$800	1.5	4,706		$160	5.0	3
5.1.3	Install Motion Sensors to Control Lighting	$2,000		5,449		$185	10.8	
5.2.1	Full Retrocomissioning and Balancing Study	$12,000	3.1	27,059	278	$1,150	10.4	4
	TOTAL	$14,800	5	37,214	278	1,495	9.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Cost assumes installation by in-house staff.
4. This project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.11. Health Lab

Building Overview

The Health Lab Building was constructed in 1995 and is 38,116 square feet.There are approximately 105 occupants.This office portions of the building (lower level) are occupied 9 hours per day, 5 days per week.The lab areas (upper level) are conditioned 24/7.

Ventilation is provided by two variable air volume air handlers with hot water heating and chilled water cooling. The hot water is produced by three Kewanee fuel oil fired boilers (2 – 2350 MBH; 1 – 1339 MBH).The two 10 hp and two 2 hp hot water pumps are constant speed. Chilled water is produced by two McQuay chillers (195 & 204 nominal tons).The chilled water system is primary-secondary. The two 7.5 hp primary pumps and two 20 hp secondary pumps are constant speed. The HVAC system has pneumatic controls and is tied into the central BAS via a DDC overlay. Make-up air for the lab exhaust hoods is provided by a 30,000 CFM make-up air system that does not currently have heat recovery. Domestic hot water is provided by three 13.5 kW electric water heaters. There is also a vacuum system, de-ionized water, autoclave, deep freezers and a liquid argon system in support of the lab operations.

Office and lab lighting is primarily CFL and T-8 strip lighting. Some labs are lit to as high as 150 foot-candles. Interior lights are manually controlled. Exit signs are fluorescent.

The exterior finish is brick and the interior finish is sheet rock and block. The windows are double pane with shades. There is an entrance vestibule and the building envelope condition is good. The roof and walls are adequately insulated.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Health Lab								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$4,370	25.9	80,109		$2,724	1.6	
5.1.3	Install Motion Sensors to Control Lighting	$17,710		25,542		$868	20.4	
5.2.1	Full Retrocomissioning and Balancing Study	$40,000	11.0	96,471	993	$4,100	9.8	4
5.3.3	Install VFDs on Hydronic Pumps	$18,630		95,896		$3,260	5.7	3
5.4.1	Replace Firetube Boilers with Condensing	$75,790			15,723	$12,988	5.8	
5.4.39	Install Air to Air Heat Recovery	$175,000	6.9	76,334	13,996	$14,156	12.4	
5.5.6	Install Timers on Snack Vending Machines	$230		876		$30	7.7	
	TOTAL	$331,730	44	375,228	30,712	38,126	8.7	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure cost accounts for VFD only. No motor.
4. This project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.12. Kneip Building

Building Overview

The Kneip Building is 79,184 square feet.There are approximately 425 occupants.This building is occupied 9 hours per day, 5 days per week.The building is primarily administrative offices, conference rooms, café, and mechanical space.

Ventilation is provided by two large central station variable volume air handling units.One unit serves primarily the interior of the building and is cooling only.The other unit serves primarily perimeter spaces and delivers both a hot and cold temperature air that are mixed at the terminal boxes though a dual duct system.Perimeter heat is provided by hot water radiators.The heating is hot water is produced by two 600 kW electric boilers that each have 20 stages of 30kW elements.The two hot water pumps are constant speed.The cooling is chilled water produced by a 30+ year old 400 ton Trane Centravac chiller.The two chilled

water pumps are constant speed.The two 20 hp condenser water pumps are constant speed.The HVAC system has DDC controls and is connected to the central BAS. Domestic hot water is provided by electric resistance water heaters.There is a 7.5 hp and a 3 hp air compressor to support the pneumatic controls in the building.A once through city water cooled computer room unit provides cooling for a small data room.

Office lighting is primarily T-8 strip lighting. CFLs are used in the basement level. Some office spaces are lit to as high as 100 foot-candles. Interior lights are manually controlled by wall switches. Exit signs are LED.

The exterior finish is stone and brick and the interior finish is sheet rock and block. The windows are double-paned and tinted.The roof is off-white, flat, and reasonably well insulated. There is an entrance vestibule and there is a complete, yet limited,amount of wall insulation.

ECM's

Previously Implemented ECMs

Exit signs were upgraded to LED. Lighting was upgrades to T-8. In 2007, air handling units were retrofitted from inlet vane control to variable drive controls.

Opportunities for ECMs at Kneipp Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$6,330	38.0	117,493		$3,995	1.6	4
5.1.3	Install Motion Sensors to Control Lighting	$25,990		37,462		$1,274	20.4	
5.2.1	Full Retrocomissioning and Balancing Study	$50,000	23.6	207,059	2,131	$8,800	5.7	6
5.3.3	Install VFDs on Hydronic Pumps	$8,740		39,094		$1,329	6.6	3
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$3,800	2.4	128,679		$4,375	0.9	5
5.4.6	Replace Chiller with Magnetic Bearing Technology	$120,000	309.5	247,773		$8,424	14.2	6
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$8,740		20,408		$694	12.6	
	TOTAL	**$223,600**	**374**	**797,967**	**2,131**	**28,891**	**7.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Notes
3. Measure cost accounts for VFD only. No motor.
4. Cost assumes installation by in-house staff.
5. VFDs are already installed and modulating.This measure is to remove the existing inlet vanes that are currently locked open.
6. This project has been approved for ARRA funding.

Estimated Blended Marginal Rates
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.13. McKay Building

Building Overview

The Mackay Building is located at 800 Governor's Drive, Pierre, South Dakota. It was constructed in 1974 with two stories, each approximately 25,000 net square feet. The building will include the State Library on first floor and Department of Education on second floor.

The original mechanical systems included electric boiler, electric humidifier boiler, central ventilation systems with constant volume fans, light troffer diffusers and pneumatic control systems. Cooling is generated by a centrifugal water chiller and is transported from the adjacent Kneip office building.

The scope of a planned remodel project includes a complete renovation with replacement of finishes, windows, heating, ventilating, air-conditioning (HVAC systems), electrical and life safety systems. The State is pursuing United States Green Building Council Leadership in Energy and Environmental Design (LEED) Silver Rating for this project. When renovation is complete in 2010, there will be 145 occupants..

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at McKay Building

No suitable energy conservation measures were discovered.

4.1.1.14. National Guard Museum / Pierre Maintenance Shop

Building Overview

The National Guard Museum & Pierre Maintenance Shopis 8,185 square feet.There are approximately 17 occupants on a regular working day but many of them are offsite for most of the working hours.This building is operated 9 hours per day, 5 days per week.The building's ground floor houses National Guard museum artifacts.The building's basement is the maintenance shop, offices, and break room.

The building is heated by two natural gas fired, high efficiency furnaces that are locally controlled via residential style thermostats.There is no cooling for the building.Domestic hot water is provided by an electric resistance hot water heater.An air compressor provides shop air for pneumatic tools.

Interior lighting is typically T-12 strip lighting.Fluorescent light fixtures are upgraded to T-8 when the ballasts fail.Interior lights are manually controlled via wall switches. The exit signs are a mixture of fluorescent.

The Pierre Maintenance Shop & Military Museum is an old WPA building which has a wall thickness of approximately 18" of concrete block.The interior finish is sheet rock and block. Most windows are single pane with shades.The envelope has no insulation.

ECM's

Previously Implemented ECMs

The furnaces that heat the shop space were replaced with high efficiency condensing units.

Opportunities for ECMs at Pierre Maintenance Shop / Museum

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,620	1.8	5,635		$192	8.5
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$22	0.2	477		$16	1.4
5.2.1	Full Retrocomissioning and Balancing Study	$12,000	2.6	23,059	237	$980	12.2
	TOTAL	**$13,642**	**5**	**29,170**	**237**	**1,188**	**11.5**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.1.1.15. Soldiers and Sailors Building

Building Overview

The Soldiers and Sailors building is 11,785 square feet.There are approximately 30 occupants on a regular working day.This building is operated 9 hours per day, 5 days per week.The building is primarily administrative offices.

The Soldiers and Sailors building is on the Capitol Complex central steam loop.Steam is converted to heating hot water before it is used in the Soldiers and Sailors building.Cooling is

provided by 40 ton Trane air cooled chiller.The building has two hot water pumps and one chilled water pump that are constant speed.A series of four pipe fan coils provide heating and cooling to the spaces within the building.Heating is also provided by perimeter radiation.For second floor, two makeup air units supply ventilation air to the fan coil units.The HVAC system has pneumatic controls which are tied into the central BAS system via a DDC overlay. Domestic hot water is provided by an electric resistance water heater.A small air compressor serves the pneumatic controls in the building.A dedicated computer room air conditioning unit provides cooling to the central computer/electrical room.

T-8 and T-12 strip lighting are used in the basement.Office lighting on the 1st and 2nd floors are primarily T-8 strip lighting.There are also some T-5 display lighting in the atrium area.Interior lights are manually controlled. Exit signs are a primarily fluorescent.

The exterior finish is limestone and brick and the interior finish is sheet rock and block. The windows are single pane with shades. There is an entrance vestibule. There is limited or no insulation in the building envelope.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Soldiers and Sailors Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.2.1	Full Retrocomissioning and Balancing Study (See Note 3)	$15,000	3.5	30,588	315	$1,300	11.5
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$2,190	0.5	4,592		$156	14.0
	TOTAL	**$17,190**	**4**	**35,180**	**315**	**$1,456**	**11.8**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. This project has been approved for ARRA funding.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.83	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

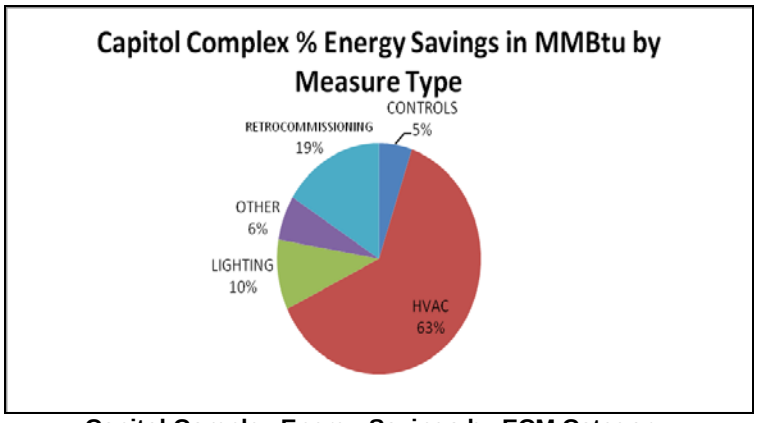
4.1.1.15.1. Campus Summary

A total of 88 ECMs were identified at Capitol Complex buildings, which include 36,161 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $3.8 million, and save an estimated $323,002 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

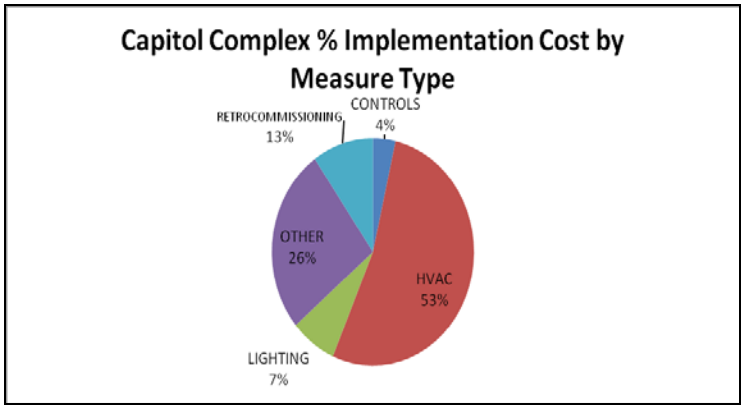
Capitol Complex buildings ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Fuel Oil	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	1,883	20	0	**1,903**	$18,920	$136,870	7.2
HVAC	3,828	14,867	3,948	**22,643**	$193,287	$2,011,918	10.4
LIGHTING	3,528	0	0	**3,528**	$35,161	$279,722	8.0
OTHER	975	1,287	0	**2,263**	$20,004	$1,003,860	50.2
RETROCOMMISSIONING	4,607	1,218	0	**5,824**	$55,630	$371,000	6.7
Total	**14821**	**17391**	**3948**	**36,161**	**$323,002**	**$3,803,370**	**11.8**

In total, these savings represent a 46% reduction from current energy consumption at the Capitol Complex campus, the majority of which is attributed to HVAC measures which will reduce natural gas, electrical and fuel oil consumption.



Capitol Complex Energy Savings by ECM Category.



Capitol Complex Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar

invested. This will yield a savings of 20,367 MMBTUs (26% of campus energy use) and a total estimated annual cost avoidance of $174,886. The total cost of implementation for these measures is $801,282, which yields a simple payback of 4.6 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Becker-Hansen Building	5.1.2	$0	148	$1,474	0.0	0.00
Records Management Building	5.1.2	$0	16	$162	0.0	0.00
Capitol Building	5.1.9	$1,270	518	$5,158	0.2	2.45
Anderson Building	5.4.3	$4,600	1,268	$10,262	0.4	3.63
Kneip Building	5.3.5	$3,800	439	$4,375	0.9	8.65
Pierre Maintenance Shop_Museum	5.1.8	$22	2	$16	1.4	13.52
Kneip Building	5.1.1	$6,330	401	$3,995	1.6	15.79
Health Lab	5.1.1	$4,370	273	$2,724	1.6	15.99
Becker-Hansen Building	5.5.6	$120	6	$60	2.0	20.07
Burea of Administration	5.1.1	$200	7	$73	2.8	27.44
Cultural Heritage Center	5.1.6	$4,250	134	$1,340	3.2	31.61
Health Admin Building	5.1.1	$800	16	$160	5.0	49.82
Anderson Building	5.1.1	$2,000	40	$400	5.0	49.82
Foss Building	5.1.1	$4,000	80	$800	5.0	49.82
Public Safety Building	5.1.1	$750	15	$150	5.0	49.82
Becker-Hansen Building	5.2.1	$50,000	1,053	$10,000	5.0	47.47
Capitol Building	5.2.1	$65,000	1,316	$12,500	5.2	49.37
Capitol Building	5.4.4	$479,670	11,175	$90,991	5.3	42.93
Foss Building	5.4.3	$10,470	189	$1,884	5.6	55.37
Kneip Building	5.2.1	$50,000	927	$8,800	5.7	53.95
Health Lab	5.3.3	$18,630	327	$3,260	5.7	56.94
Becker-Hansen Building	5.1.1	$5,750	100	$1,000	5.7	57.30
Records Management Building	5.4.1	$13,460	290	$2,316	5.8	46.43
Health Lab	5.4.1	$75,790	1,626	$12,988	5.8	46.62
TOTAL		**$801,282**	**20,367**	**$174,886**	**4.6**	**39.34**

4.1.2 Mickelson Criminal Justice Center (DCI / EOC / OAG) – Pierre

Campus Background and List of Facilities

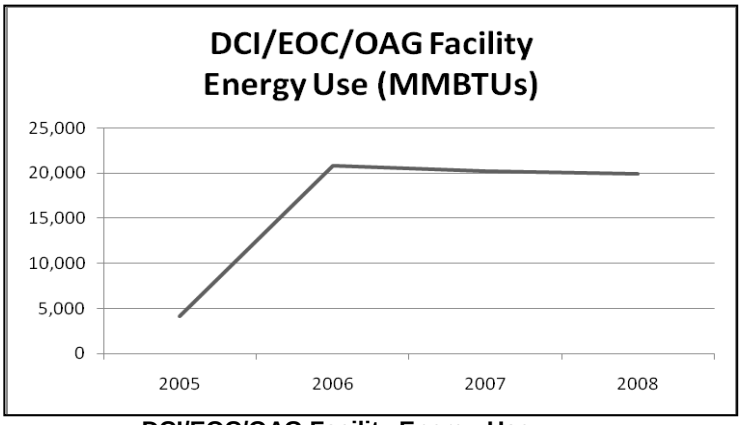
This is a stand-alone building. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Mickelson Criminal Justice Center (DCI/EOC/OAG) Pierre Facility consumed a combined 19,924 MMBTUs of energy. The average Energy Use Intensity across the campus was 130 kBTU/SF in 2008.



DCI/EOC/OAG Facility Energy Use.

4.1.2.1. Mickelson Criminal Justice Center (DCI / EOC / OAG)

Building Overview

The Mickelson Building was constructed in2005 and is 152,700 square feet.There are approximately 130 occupants.This building is typically occupied 9 hours per day, 5 days per week but has some operations that are extended or even 24/7.The building is comprised of administrative offices, auditorium, forensic laboratories, cafeteria, dormitory, gymnasium, and a firing range.

Ventilation of the Mickelson building is accomplished by approximately nine McQuay air handlers with heating and cooling capabilities. Forensics lab area is served by a VAV air handler with heat recovery capability. A variable air volume air handler serves the two adjacent firing ranges. Cooling is provided by three 180 ton McQuay chillers. Two chillers run at full load while one remains in standby mode. Units in operation is based upon run time hours. Three 20 hp chilled water primary pumps are constant speed and interlocked with the

chiller that they serve. Two 25 hp chilled water secondary pumps are variable speed. Hot water heating is generated by 3 Hurst boilers. Two boilers are 531 MBH each and one is 368 MBH. Two 30 hp hot water pumps are variable speed. There are two roof top units that provide ventilation for the gymnasium. Two 5 ton Data Aire units provide cooling for a UPS room. Two 20 ton Data Aire unit provides cooling for a Server room. HVAC controls are DDC and are on a Honeywell building automation system that is also tied into the web based BAS system for the Capitol Complex buildings in Pierre.Domestic hot water is heating by a heat exchanger tied to the buildingboiler system.There is also firing range exhaust, laboratory exhaust, 1.5 & 3 hp air compressors for lab, and a number of small systems in support of lab operations.

Interior lighting is primarily T-8 32W strip lighting. Auditorium lighting is compact fluorescent. Gymnasium lighting is a mixture of fluorescent and high intensity discharge fixtures. Interior lights are on a schedule controlled by the BAS. Many areas have occupancy sensors. Exterior building parameter and parking lot lighting is metal halide.

The exterior finish is brick and the interior finish is sheetrock. Windows are double pane with shades. There is an entrance vestibule and the building envelope condition is in good condition. There is significant insulation in the walls and roof.

ECM's

Previously Implemented ECMs

The building was recently constructed with many energy efficiency strategies and high efficiency equipment.

Opportunities for ECMs at DCI / EOC / OAG Facility (Mickelson Building)

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$14,150		20,434		$695	20.4	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$6,210	4.0	4,149		$141	44.0	
5.3.3	Install VFDs on Hydronic Pumps	$17,600		104,614		$3,557	4.9	3
5.4.1	Replace Firetube Boilers with Condensing	$189,750			11,088	$9,247	20.5	
5.5.5	Intellihood Kitchen Hood Controls System	$10,120	1.7	3,782	1,092	$1,039	9.7	
5.5.6	Install Timers on Snack Vending Machines	$120		1,752		$60	2.0	4
	TOTAL	**$237,950**	**6**	**134,731**	**12,180**	**$14,739**	**16.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil

Notes
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure cost accounts for VFD only. No motor.
4. Cost assumes installation by in-house staff.

Estimated Blended Marginal Rates		
$	-	Ton Biomass
1.82	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

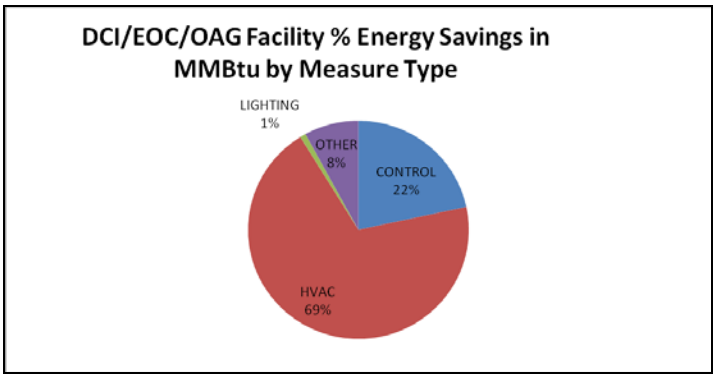
4.1.2.1.1. Campus Summary

A total of 5 ECMs were identified at DCI/EOC/OAG Facility, which include 1,649 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $223,800, and save an estimated $14,045 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

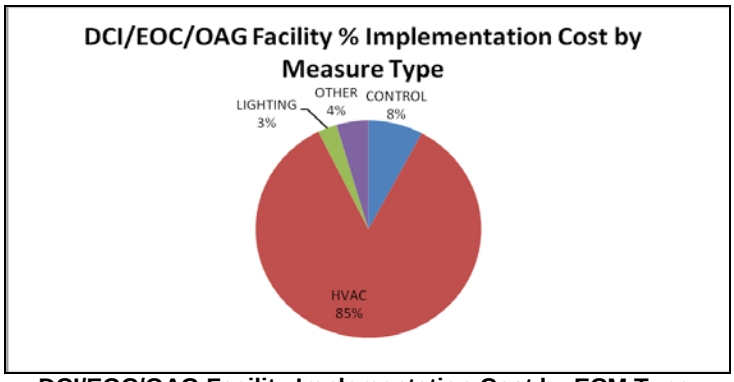
DCI/EOC/OAG Facility ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	357	0	**357**	$3,557	$17,600	4.9
HVAC	0	1,146	**1,146**	$9,247	$189,750	20.5
LIGHTING	14	0	**14**	$141	$6,210	44.0
OTHER	19	113	**132**	$1,099	$10,240	9.3
Total	**390**	**1,259**	**1,649**	**$14,044**	**$223,800**	**15.9**

In total, these savings represent a 8% reduction from current energy consumption at the DCI/EOC/OAG Facility, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



DCI/EOC/OAG Facility Energy Savings by ECM Category.



DCI/EOC/OAG Facility Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 363 MMBTUs (2% of campus energy use) and a total estimated annual cost avoidance of $3,616. The total cost of implementation for these measures is $17,720, which yields a simple payback of 4.9 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Mickelson Building	5.5.6	$120	6	$60	2.0	20.07
Mickelson Building	5.3.3	$17,600	357	$3,557	4.9	49.31
TOTAL		**$17,720**	**363**	**$3,616**	**4.9**	**48.83**

4.1.3 Public Safety Building

Campus Background and List of Facilities

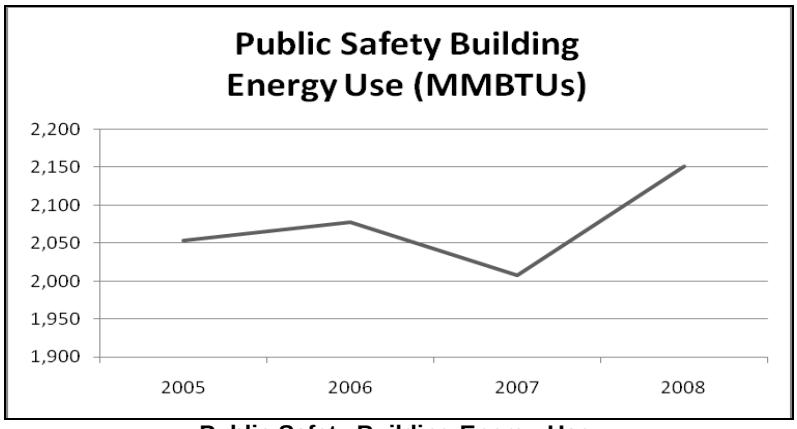
This is a stand-alone building. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Public Safety Building facilities consumed a combined 2,151 MMBTUs of energy. The average Energy Use Intensity across the campus was 100 kBTU/SF in 2008.



Public Safety Building Energy Use.

4.1.3.1. Public Safety Building

Building Overview

The Public Safety Building is 21,349 square feet.There are approximately87 occupants.This building is operated 9 hours per day, 5 days per week.The building is mostly administrative offices.

The Public Safety building is ventilated by four DX, constant volume air handlers with hot water heat.One air handler is dedicated per floor.Heating is provided by two 800 MBH Burnham boilers that burn fuel oil.There is also a series of hot water radiators on the perimeter of the building.The two 2 hp hot water pumps are constant speed.The HVAC system is controlled locally with a combination of pneumatic and electric controls devices.Domestic hot water is provided by an electric water heater.One 5 hp air compressor serves the pneumatics in the building.

Interior lighting is typically T-8 strip lighting. Fluorescent T-12s are used in the mechanical and electrical rooms.Interior lights are manually controlled. Exit signs are LED.

The exterior finish is stone and the interior finish is sheet rock and block. Most windows are double pane and tinted although several windows on the basement level are single pane with storm windows.There is an entrance vestibule and the building envelope condition is good.There is a limited amount of insulation in the walls.

ECMs

Previously Implemented ECMs

A 2004 retrofit of the HVAC systems included high efficiency motors and DX cooling systems that replaced the older and much less efficient equipment.

Opportunities for ECMs at Public Safety Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$750	1.4	4,412		$150	5.0	4
5.1.3	Install Motion Sensors to Control Lighting	$1,875		5,108		$174	10.8	
5.1.7	Retrofit T-12 Fixtures with T-8s	$790	0.6	1,858		$63	12.5	
5.2.1	Full Retrocomissioning and Balancing Study	$20,000	6.2	54,118	557	$2,300	8.7	
5.4.1	Replace Firetube Boilers with Condensing	$70,000			5,215	$4,308	16.2	
5.4.3	Replace Dump Boxes with VAVs	$13,920	15.9	43,573	737	$2,090	6.7	3
5.5.4	Improve Building Envelope - Windows	$75,000		3,843	1,340	$1,238	60.6	
	TOTALS	**$182,335**	**24**	**112,911**	**7,849**	**10,323**	**17.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure cost accounts for VFD only.
4. Costs assume installation by in-house staff.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

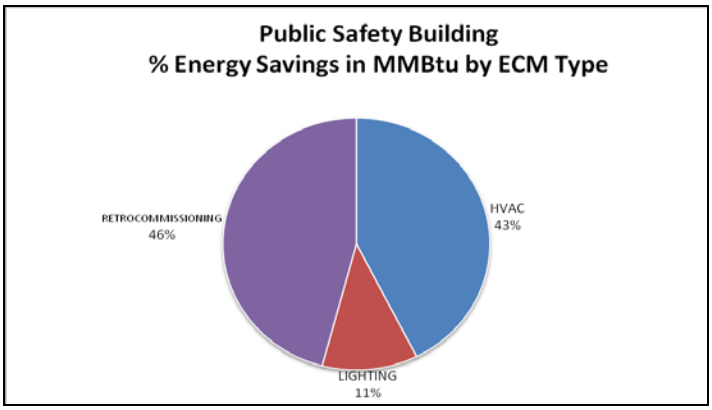
4.1.3.1.1. Campus Summary

A total of 7 ECMs were identified at Public Safety Building, which include 528 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $37,335, and save an estimated $4,998 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

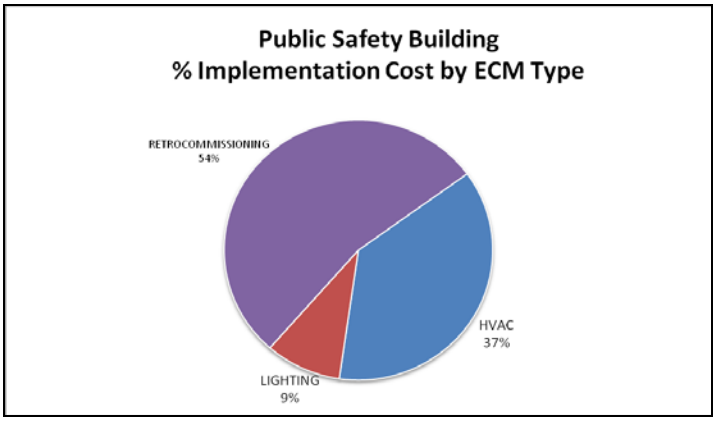
BOA ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
HVAC	149	76	**225**	$2,090	$13,920	**6.7**
LIGHTING	61	0	**61**	$608	$3,415	**5.6**
RETROCOMMISSIONING	185	58	**242**	$2,300	$20,000	**8.7**
Total	**394**	**134**	**528**	**$4,998**	**$37,335**	**7.5**

In total, these savings represent a 25% reduction from current energy consumption at the Public Safety Building, the majority of which is attributed to retrocommissioning measures which will reduce electric consumption.



Public Safety Building Energy Savings by ECM Category.



Public Safety Building Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 262 MMBTUs (12% of campus energy use) and a total estimated annual cost avoidance of $2,461. The total cost of implementation for these measures is $14,670, which yields a simple payback of 6.0 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Public Safety Building	5.1.2	$0	22	$221	0.0	0.00
Public Safety Building	5.1.1	$750	15	$150	5.0	49.82
Public Safety Building	5.4.3	$13,920	225	$2,090	6.7	61.91
TOTAL		**$14,670**	**262**	**$2,461**	**6.0**	**55.98**

4.1.4 Records Management Building Pierre

Campus Background and List of Facilities

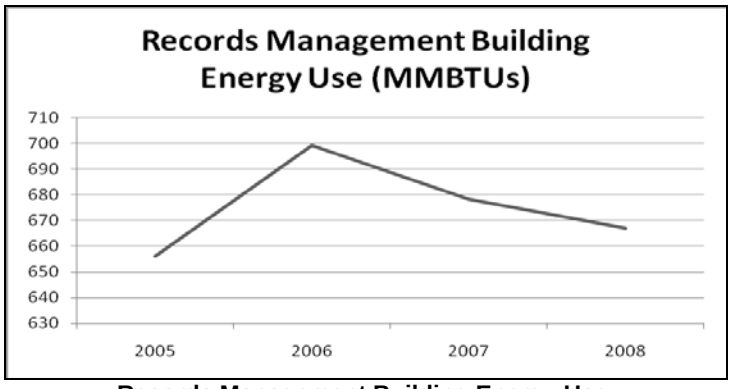
This is a stand-alone building. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Records Management Building facilities consumed a combined 667 MMBTUs of energy. The average Energy Use Intensity across the campus was 58 kBTU/SF in 2008.



Records Management Building Energy Use.

4.1.4.1. Records Management Building

Building Overview

The Records Management Building 11,409 square feet.There are approximately 14 workers occupying the building on a regular working day.This building is operated 9 hours per day, 5 days per week.The building is primarily administrative offices & storage.

The Records Management building is ventilated by a cooling only DX air handler located above the lay-in ceiling. Two condensing units working in parallel with the air handler are located on the roof. The air handler has economizer capability. Heating is by hot water parameter fin tube radiation. Hot water is provided by an oil fired Whirl Power boiler (535 MBH). A film storage room is cooled by a 2 ton Data Aire unit. Control of the HVAC is by local thermostats. Domestic hot water is provided by a 6.8 kW electric water heater. There are exhaust fans in storage area for ventilation because it is not actively conditioned.

Interior office lighting is T-8 strip lighting. Cubicles have task lighting. Single lamp, 4’ 34W T-12s are used to light the records storage area. The open office area is lit to as high as 96 foot-candles. Interior lights are manually controlled.

The exterior finish is brick and the interior finish is sheetrock and block. Most windows are double pane with shades. There is not an entrance vestibule and the building envelope condition is fair.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Records Management Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,270	1.0	3,235		$110	11.5	3
5.1.2	Delamp Multiple Lamp Fixtures	$0	1.5	4,768		$162	0.0	3
5.1.3	Install Motion Sensors to Control Lighting	$1,375		3,746		$127	10.8	
5.1.7	Retrofit T-12 Fixtures with T-8s	$9,375	3.8	11,610		$395	23.7	
5.4.1	Replace Firetube Boilers with Condensing	$13,460			2,803	$2,316	5.8	
5.4.20	Comb Condensing Unit Fins/Provide Hail Guards	$810	0.3	3,379		$115	7.0	
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$2,190		4,592		$156	14.0	
	TOTAL	$28,480	7	31,330	2,803	$3,381	8.4	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Costs assume installation by in-house staff.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

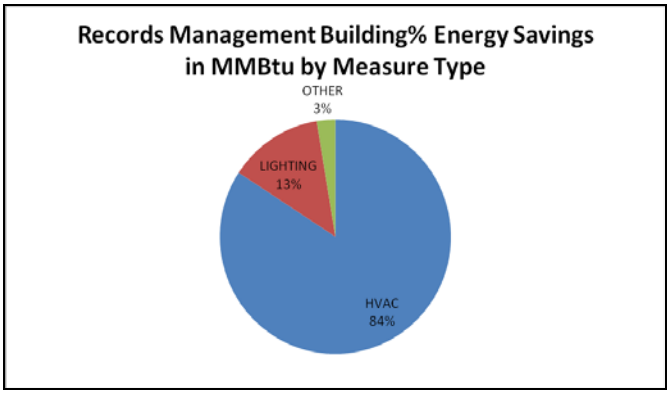
4.1.4.1.1. Campus Summary

A total of 7 ECMs were identified at Records Management Building, which include 604 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $28,480, and save an estimated $5,060 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

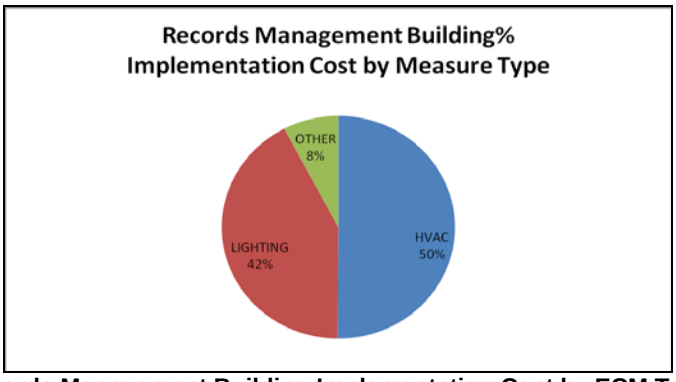
Records Management Building ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
HVAC	23	486	**509**	$4,109	$14,270	3.5
LIGHTING	80	0	**80**	$794	$12,020	15.1
OTHER	16	0	**16**	$156	$2,190	14.0
Total	**118**	**486**	**604**	**$5,059**	**$28,480**	

In total, these savings represent a 90% reduction from current energy consumption at the Records Management Building, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



Records Management Building Energy Savings by ECM Category.



Records Management Building Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 525 (79% of campus energy use) and a total estimated annual cost avoidance of $4,270. The total cost of implementation for these measures is $14,270, which yields a simple payback of 3.3 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Records Management Building	5.1.2	$0	16	$162	0.0	0.00
Records Management Building	5.4.1	$13,460	486	$3,879	3.5	27.72
Records Management Building	5.4.20	$810	23	$230	3.5	35.12
TOTAL		**$14,270**	**525**	**$4,271**	**3.3**	**27.18**

4.1.5 Risk Management Building Pierre

Campus Background and List of Facilities

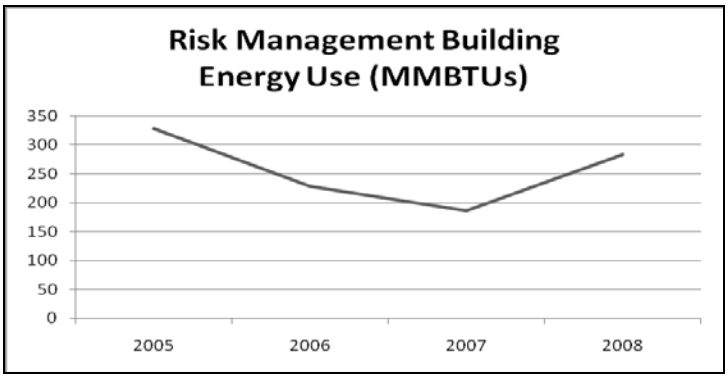
This is a stand-alone building. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Risk Management Building facilities consumed a combined 283 MMBTUs of energy. The average Energy Use Intensity across the campus was 68 kBTU/SF in 2008.



Risk Management Building Energy Use.

4.1.5.1. Risk Management Building

Building Overview

The Risk Management Building is 4,106 square feet.There are approximately 5 occupants.This building is operated 9 hours per day, 5 days per week.The buildings upper level is administrative offices and the lower level is storage.

The Risk Management building is heated by a residential style gas fired central air furnace with DX cooling. The storage area is heated by gas fired unit heaters. HVAC is controlled by local thermostats. Domestic hot water is provided by an electric water heater.

Interior lighting is a fluorescent T-8 and T-12 strip lighting with some incandescent accent lighting. Storage lighting is incandescent. Interior lights are manually controlled.

The office exterior finish is wood and the interior finish is sheet rock. Storage beneath the office level is unfinished. Office windows are double-paned with shades. Storage area windows are single paned. There is not an entrance vestibule and the building envelope condition is in fair condition. There is limited insulation in the walls and roof.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Risk Management Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$120	0.6	1,765		$60	2.0
5.3.2	Programmable Thermostats for Residential Style Units	$350		328	93	$88	4.0
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$7,480	0.6	22,239	98	$837	8.9
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$1,500		1,531		$52	28.8
5.5.4	Improve Building Envelope - Windows	$25,000		1,320	367	$348	71.9
	TOTAL	**$34,450**	**1**	**27,183**	**558**	**$1,385**	**24.9**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$	0.826	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

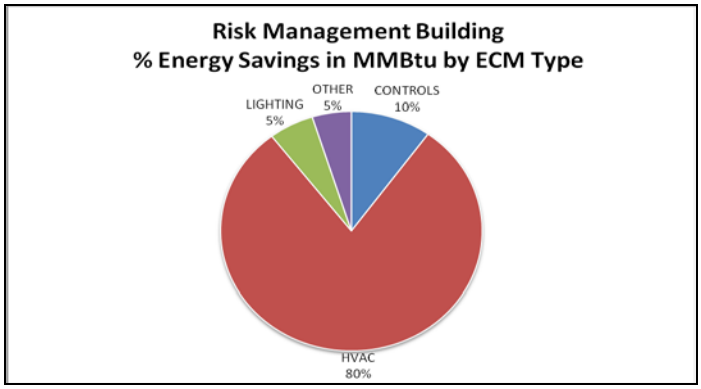
4.1.5.1.1. Campus Summary

A total of 5 ECMs were identified at Risk Management Building, which include 108 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $9,450, and save an estimated $1,038 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

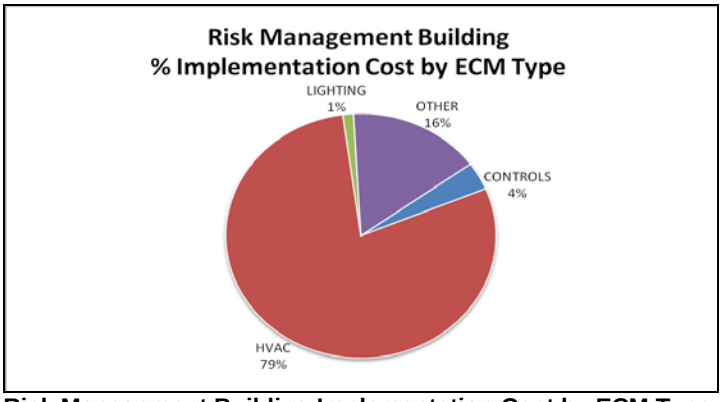
BOA ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	1	10	**11**	$88	$350	**4.0**
HVAC	76	10	**86**	$837	$7,480	**8.9**
LIGHTING	6	0	**6**	$60	$120	**2.0**
OTHER	5	0	**5**	$52	$1,500	**28.8**
Total	**88**	**20**	**108**	**$1,038**	**$9,450**	**9.1**

In total, these savings represent a 38% reduction from current energy consumption at the Risk Management Building, the majority of which is attributed to HVAC measures which will reduce electric consumption.



Risk Management Building Energy Savings by ECM Category.



Risk Management Building Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 17 MMBTUs (6% of campus energy use) and a total estimated annual cost avoidance of $148. The total cost of implementation for these measures is $470, which yields a simple payback of 3.2 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Risk Management Building	5.1.8	$120	6	$60	2.0	19.93
Risk Management Building	5.3.2	$350	11	$88	4.0	32.58
TOTAL		**$470**	**17**	**$148**	**3.2**	**28.03**

4.2 Board of Regents

The South Dakota Board of Regents (BOR) has constitutional authority to govern the system of public higher education in the State of South Dakota. Supported by an Executive Director and staff, the BOR provides leadership and sets policies for the programs and services delivered through its six universities and two special schools.

Within the Board of Regents, there are a total of 7,632,555 square feet of facilities, with the majority of buildings at the South Dakota State University and University of South Dakota campuses.

BOR Campus Summary.

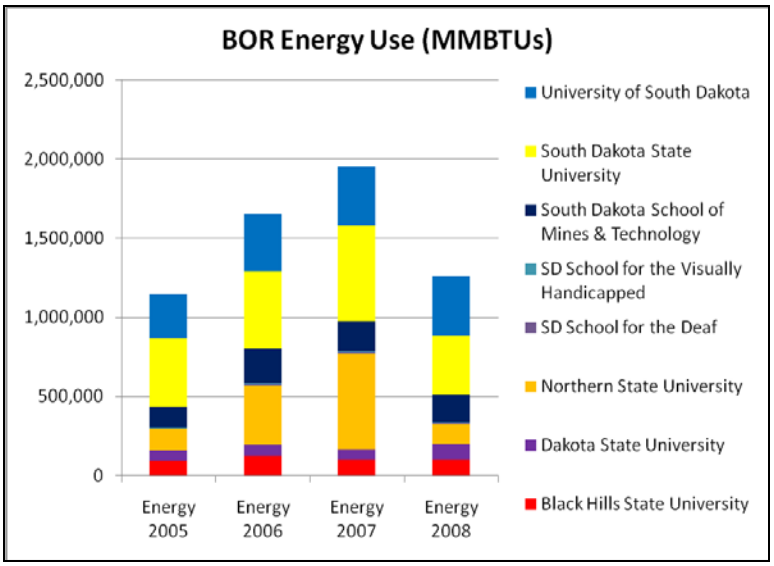
Campus	Location	Square Footage
Black Hills State University	Spearfish	734,935
Dakota State University	Madison	510,185
Northern State University	Aberdeen	786,659
SD School for the Deaf	Sioux Falls	97,955
SD School of Visually Handicapped	Aberdeen	65,000
South Dakota School of Mines & Technology	Rapid City	645,387
South Dakota State University*	Brookings	2,735,474
University of South Dakota	Vermillion	2,056,960
	TOTAL	**7,632,555**

Energy Profile

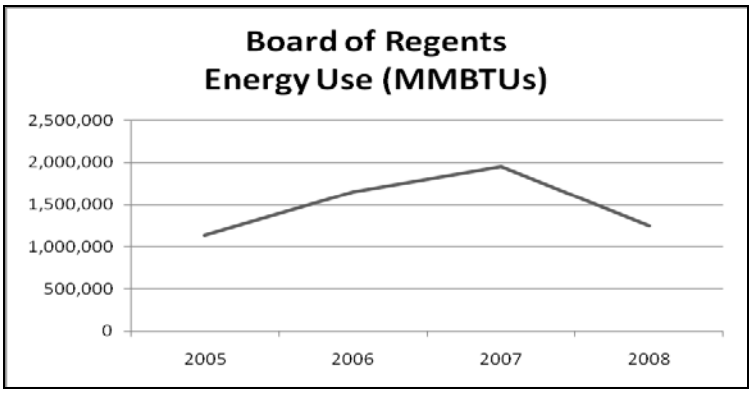
In 2008, BOR facilities consumed a combined 1,255,598 MMBTUs of energy. As the largest campus in building square footage, the South Dakota State University and University of South Dakota campuses used the most energy. The average Energy Use Intensity across the BOR was 164.5 kBTU per square foot for 2008.

BOR Campus Energy Data (MMBTUs).

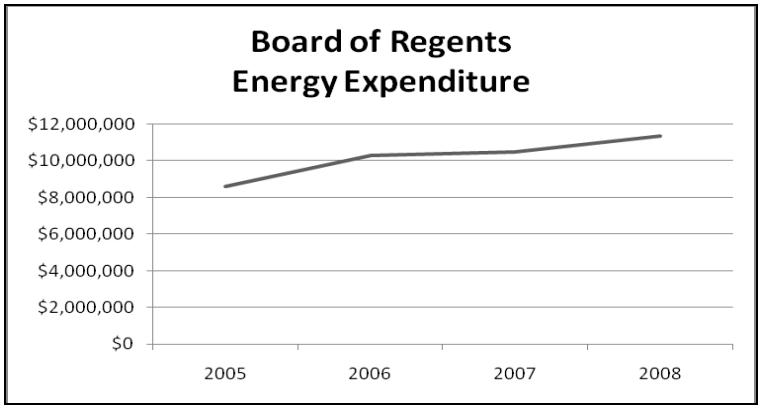
Campus	2005	2006	2007	2008
Black Hills State University	91,243	120,585	99,166	94,385
Dakota State University	64,605	73,536	65,288	104,522
Northern State University	139,305	369,653	605,250	120,517
SD School for the Deaf	4,878	10,380	8,007	9,237
SD School for the Visually Handicapped	1,391	6,267	5,729	6,563
South Dakota School of Mines & Technology	128,884	220,736	191,456	175,891
South Dakota State University	436,796	488,992	603,723	369,181
University of South Dakota	276,245	358,402	371,843	375,301
Grand Total	**1,143,347**	**1,648,553**	**1,950,462**	**1,255,598**



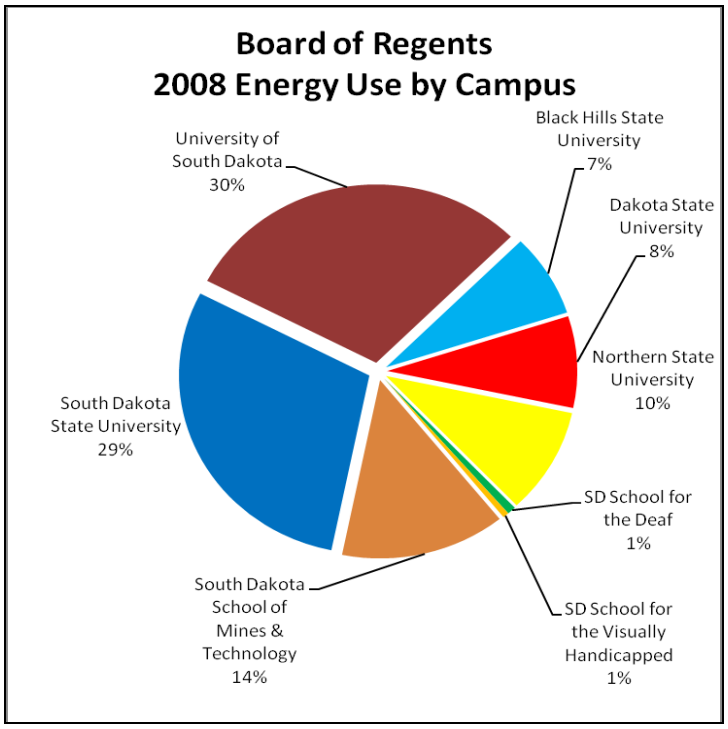
BOR Energy Use by Campus.



BOR Energy Use.



BOR Energy Expenditures.



BOR 2008 Energy Use by Campus.

4.2.1 Black Hills State University

Campus Background and List of Facilities

Black Hills State University (BHSU) is home to approximately 4,000 students and 300 faculty members that occupy approximately 13 major buildings, plus an additional campus apartment complex of eight buildings.

Campus-Wide Systems and Operational Profile

Black Hills State University utilizes both campus heating and cooling for most campus buildings. Neither steam usage nor chilled water usage is sub-metered by the central DDC system. Some buildings also have standalone chillers and boilers. For heating, natural gas service is interruptible, so all boilers have the ability to run using No. 2 fuel oil in addition to natural gas.

Most major HVAC systems are connected to the Barber Coleman central DDC system. While some systems still have partial or full local controls, the DDC system has the ability to schedule, override setpoints, and setback temperatures during unoccupied periods for most buildings on campus. As buildings are renovated, they are moved to the newer control system which is web enabled.

The central DDC system also has an interface for measuring peak electrical demand in major buildings, and also provides a campus wide total for peak demand. If the campus is at or near its

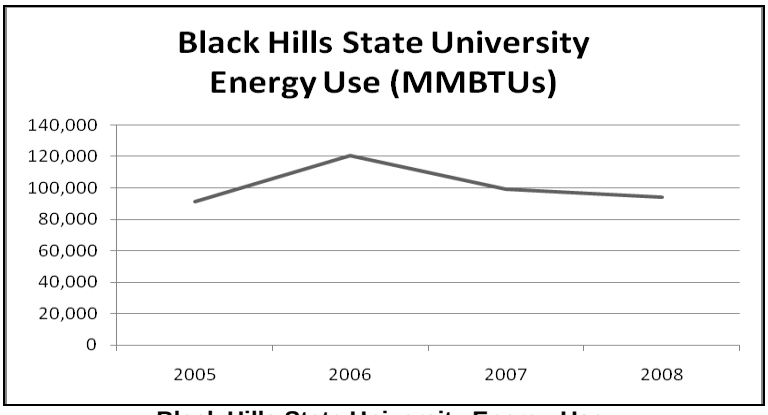
allowed 1800 kW peak demand, automatic load shedding will initiate, starting with chiller operations.

There is no central DDC lighting control on campus. Exterior lights, which are predominantly high pressure sodium with some metal halide fixtures, are controlled using photocells or manual time clocks. During a September 2009 walkthrough, some parking lot metal halide lights were on, however, during the middle of the day.

Black Hills State University has added and expanded buildings in recent years and plans to add a number of new buildings.Construction of the Student Union Expansion is being finished and will be the first LEED® Silver building on campus.A new science building will be constructed and will require a new chiller, which will be shared with a new art building proposed for construction.Several other projects, including an HVAC remodel of Woodburn Hall, and expansion of several dormitories, are either proposed or have funding.These will impact the overall campus heating and cooling infrastructure, as well as total energy use.

Energy Profile

In 2008, Black Hills State University facilities consumed a combined 94,385 MMBTUs of energy. The average Energy Use Intensity across the campus was 128 kBTU/SF in 2008.



Black Hills State University Energy Use.

4.2.1.1. Campus Apartments (8 Buildings)

Building Overview

The Campus Apartments consist of eight nearly identical buildings, each with eight apartments in each building. Normally, apartments are shared by three residents.

Each building contains a 400 MBH hot water boiler, and water is circulated to baseboards in each apartment. Cooling for each apartment is provided using wall mounted air conditioning units. Thermostats are manually controlled.

Each building also utilizes a 200 MBH domestic water heater to serve all eight apartments.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Campus Apartments (8 Buildings)								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.5	Replace Incandescent Exit Signs with LED	$2,650	0	2,635		$119	22.3	
5.4.38	Install Stack Dampers	$1,150			345	$248	4.6	2
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$7,360			993	$714	10.3	
	TOTAL	$11,160	0	2,635	1,338	$1,081	10.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assumes a 1% average efficiency increase in overall boiler performance.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.2. Donald Young Center

Building Overview

The Donald Young Center was built in 1988 occupies 178,061 square feet to house gymnasiums, workout facilities, offices, and a pool area. The building is open seven days per week. The red brick exterior appears to be in good condition. The double paned windows are not operable.

During the winter, heating for the building, pool, and domestic hot water are provided using hot water piped directly from the central boiler plant. During the summer, when the central plant is not in operation, several on site boilers with limited turndown provide heating for the pool and domestic hot water. The hot water system utilizes constant speed primary and secondary pumps. Cooling is provided using a standalone air cooled chiller located on the roof. The chilled water system utilizes constant speed pumps.

Makeup air units with a runaround heat recovery loop provide ventilation for the pool area. The varsity locker rooms also utilize makeup air units with heat recovery. The gymnasiums are served using constant volume air handling units, but for much of the year, the exhaust fans run without the makeup air unit, pulling outside air through doors and corridors. Some of the exhaust fans have VFDs. Several office air handling units, and the weight room unit, utilize VFDs. Constant volume fan coil units serve a variety of other areas, including the

fitness areas and classrooms. All systems are controlled by the central DDC system, although some units such as the pool units must run continuously.

Gymnasium lighting is provided using metal halide lamps. There is a lighting control system, but some of the lights remain on because the panel is not working correctly. Other lighting is provided using T-8 fixtures.

ECM's

Previously Implemented ECMs

Black Hills State University hired a consultant in 2004 to perform a retro-commissioning study for the Donald Young Center. The report recommended various energy conservation measures, many of which have been implemented. A new lighting control system has been added. VFDs which control to certain chemical concentrations have been added to the pool water treatment pumps. The pools are covered at night.

The school has applied for stimulus money to replace its metal halide lights in the gymnasium with fluorescent lighting, as well as to install variable frequency drives on the continuously operated ventilation units serving the pool and locker rooms.

Opportunities for ECMs at Donald Young Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,500	1	5,944	-	$267	5.6	2
5.1.3	Install Motion Sensors to Control Lighting	$2,650		13,870		$624	4.2	3
5.1.7	Replace HID Lighting with High Bay Fluorescent	$105,340	36	211,644		$9,524	11.1	
5.1.11	Implement Daylighting Controls	$810		3,468		$156	5.2	5
5.2.10	Do Not Run in Energy Recovery Mode During Economizer	$2,190		14,444		$650	3.4	7
5.3.3	Install VFDs on Hydronic Pumps	$20,470		87,059		$3,918	5.2	6
5.4.1	Replace Firetube Boilers with Condensing	$27,600			2,018	$1,451	19.0	4
	TOTAL	**$160,560**	**38**	**336,429**	**2,018**	**$16,590**	**9.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Measure applies to fitness center and classroom spaces.
3. Measure assumes that lighting can be controlled off an additional 4 hours per day by motion sensors.
4. Measure based on incremental cost increase to install condensing boilers in

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

Notes	Estimated Blended Marginal Rates
lieu of standard efficiency boilers at end of useful life. 5. Measure applies to photo-cells being utilized in fitness center. 6. Measure economics are dependent on ability to convert existing 3-way valves to 2-way operation. 7. Measure assumes that energy recovery pumps shut down when unit can be in economizer.	

4.2.1.3. Facility Services

Building Overview

The Facility Services building occupies 15,290 square feet and houses the central heating and cooling plants.The steam heating plant comprises of two 500 hp boilers, installed in 1965, that are used seasonally.While most buildings use the steam to create heating hot water in each individual building, Pangburn Hall and the Donald Young Center utilize heating hot water provided by heat exchangers within the central plant.A 260 ton air cooled chiller provides chilled water for Meier Hall, the library, the Jonas buildings, and the Student Union.

The Facility Services building itself houses a number of offices where window mounted air conditioners are utilized. These units are controlled by factory thermostats.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Demand kW	Electric kWh	Natural Gas Therms	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$580	1	4,380			$197	2.9	
5.1.3	Install Motion Sensors to Control Lighting	$2,650		4,942			$222	11.9	2
5.4.21	Install Biomass Fuel Boiler	$1,232,000		-	218,000	(1,810)	$89,003	13.8	3,4,5
	TOTAL	**$1,235,230**	**1**	**9,323**	**218,000**	**(1,810)**	**$89,423**	**13.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used.
3. Costs and savings assume biomass boiler installed at sawmill and connected to Heidepriem and Thomas, with vaults and infrastructure for future tie-ins to physical plant.
4. Costs andsavings taken from study prepared by Stanley Consultants(Utility Master Plan dated 3/6/09 and addendum dated 9/4/09).See report for full cost breakdown.
5. Assumes biomass energy costs of $5/MMBtu steam purchased from sawmill (equates to $60/ton biomass).

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	0.60-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.4. Heidepriem Hall

Building Overview

Heidepriem Hall is a dormitory which houses 154 residents on three floors and occupies 31,693 square feet. Since there is no forced air ventilation for the building, the single paned windows are operable. The brick exterior appears to be in fair condition.

Due to its location on the far west side of the campus, this building is not connected to the central plant. A 38 hp hot water boiler, which does not appear to have a stack damper, provides heating to radiators in all spaces. This boiler was installed in around 2001.There are two thermostats for each wing which control all radiators in a particular wing, and each zone has a constant speed circulation pump. Two natural gas domestic hot water heaters, both without stack dampers, provide water heating. There is no direct combustion air makeup path for the water heaters or boilers.

The building is not cooled, except for several window mounted air conditioning units in common areas on each floor.

Only the boiler is controlled by the central DDC system. All other controls are pneumatic. The electrical usage is not monitored at the central system.

Lighting is provided using T-8 fixtures and is manually controlled.

ECM's

Previously Implemented ECMs

Black Hills State University has applied for stimulus funding for metered hose bibs to control water usage associated with irrigation.

Opportunities for ECMs at Heidepriem Hall								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,500	2	6,760		$304	4.9	
5.1.3	Install Motion Sensors to Control Lighting	$3,450		14,643	-	$659	5.2	2
5.2.1	Full Retrocommissioning and Balancing Study	$13,500			1,301	$935	14.4	
5.4.1	Replace Firetube Boiler with Condensing	$17,250			2,342	$1,684	10.2	3
5.4.38	Install Stack Dampers	$4,830			260	$187	25.8	4
5.5.2	Replace Storage Type Domestic Water Heater with On Demand	$3,570			404	$291	12.3	5
5.5.16	Replace Standard Efficiency Hot Water Heater with High Efficiency	$2,300			216	$156	14.8	6
	TOTAL	**$46,400**	**2**	**21,403**	**4,524**	**$4,216**	**11.0**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used in residence rooms
3. Measure based on incremental cost increase to install Condensing Boiler at end of useful life of existing equipment.
4. Assumes a 1% average efficiency increase in overall boiler performance.
5. Based on the incremental cost increase to replace with On Demand Water Heaters at end of useful life of existing equipment.
6. Based on the incremental cost increase to replace with High Efficiency Water Heaters at end of useful life of existing equipment.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.1.5. Humbert Hall

Building Overview

Humbert Hall is a dormitory which houses 41 residents on two floors and occupies 16,352 square feet. Since there is no forced air ventilation for the building, the single paned windows are operable and in relatively poor condition. The brick exterior appears to be in fair condition.

Due to its location on the east side of the campus, this building is not connected to the central plant. A 45 hp hot water boiler, which does not appear to have a stack damper, provides heating to radiators in all spaces. Each room has individual unit control. Constant speed pumps circulate the heating water to six wings. A natural gas water heater provides domestic water heating. There is no direct combustion air makeup path for the water heaters or boilers.

The building is not cooled, except for several window mounted air conditioning units in common areas on each floor.

There is no central DDC control of systems, and electrical usage is not monitored at the central system.

Lighting is provided using T-8 fixtures and is manually controlled.

ECM's

Previously Implemented ECMs

Black Hills State University has applied for stimulus funding for metered hose bibs to control water usage associated with irrigation.

Opportunities for ECMs at Humbert Hall								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,040	1	3,661		$165	6.3	
5.1.3	Install Motion Sensors to Control	$2,070		5,990	-	$270	7.7	2

Opportunities for ECMs at Humbert Hall								
ECM No.	Energy Conservation Measure (ECM)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
	Lighting							
5.2.1	Full Retrocommissioning and Balancing Study	$13,500		5,728	1,448	$1,299	10.4	
5.4.1	Replace Firetube Boiler with Condensing	$17,250			1,651	$1,187	14.5	3
5.4.38	Install Stack Dampers	$3,450			138	$99	34.9	4
	TOTAL	**$37,310**	**1**	**15,379**	**3,237**	**$3,020**	**12.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used in residence rooms
3. Measure based on incremental cost increase to install Condensing Boiler at end of useful life of existing equipment.
4. Assumes a 1% average efficiency increase in overall boiler performance.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.6. Jonas Science and Jonas Academic

Building Overview

Campus steam service provides heating via hot water converters to both Jonas buildings. The buildings are connected to the campus chilled water system, but two 80 ton chillers are also located in the basement of the Jonas Academic building. Both hot water and chilled water pumps utilize constant speed motors.

The Jonas Academic building utilizes one multizone unit with a direct steam heating coil. The chilled water coil for the unit appears to run “wild”, that is, no control valve is installed.

Classrooms and labs in both buildings are conditioned using two pipe fan coil units along the walls. These units have been, or are planned, for a retrofit where VFDs are installed to modulate fan speed and space occupancy sensors cause the units to go into unoccupied modes. These areas have user adjustable thermostats which often are left at high or lower than “normal” temperatures.

Most laboratory hoods in the Jonas Science building have been replaced with more efficient models. There is no direct makeup air for the units, so the building is usually negatively pressurized.

Two 4.5 kW electric water heaters provide domestic hot water.

Fluorescent T-8 fixtures are utilized, and occupancy sensors are used in some classrooms.

ECM's

Previously Implemented ECMs

Both HVAC and lighting occupancy sensors are utilized. VFDs have been installed on many fan coil units.

Opportunities for ECMs at Jonas Science and Jonas Academic								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$14,000	10	29,640	-	$1,334	10.5	
5.2.1	Full Retrocomissioning and Balancing Study	$50,000	-	57,635	7,760	$8,173	6.1	
5.3.3	Install VFDs on Hydronic Pumps	$10,000	-	7,203	-	$324	30.9	2
5.3.7	Convert Multizone/Dual Duct to VAV	$10,000	-	4,367	391	$478	20.9	
5.3.17	Reset Occupant Thermostat Slider Setpoints	$5,000	-	20,739	420	$1,235	4.0	3
	TOTAL	**$89,000**	**10**	**119,584**	**8,571**	**$11,544**	**7.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Secondary CHW pumps.
3. Assume new hardware is not required.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.7. Library Learning Center

Building Overview

The Library Learning Center occupies 57,346 square feet on three main floors. The library houses offices, library stacks, and work areas. While few, the existing windows are single paned and operable.

Campus steam enters the building and is converted to heating hot water. Campus chilled water also serves the building, but two additional 60 ton air cooled chillers also provide cooling, in part due to year round computer room loads. The chilled water and hot water pumps are constant speed.

A dedicated multizone air handling unit had served each floor, but these units have been converted to variable air volume units. During the September 2009 walkthrough, the supply fans for the three units were all running at over 50 Hz, and the return fans were running at around 15 Hz. The building did have significant positive pressurization.

The basement area houses two computer rooms, one of which is conditioned by a Liebert unit that rejects its heat to the chilled water loop. Another small computer room uses a mobile 5 ton server room unit that rejects its heat to the return air plenum.

The area is somewhat overlit, with a large number of 2-lamp T-8 6'x6' fixtures, which have already been de-lamped from four lamps each. As a result of manual controls, the lights remain on, even during low occupancy periods.

ECM's

Previously Implemented ECMs

VFDs have been installed on the multizone unit supply and return fans. New zone dampers and actuators have also been installed.

Opportunities for ECMs at Library Learning Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.15	Overhaul Library Lighting	$230,000	14	156,125	-	$7,026	32.7	2
5.2.1	Full Retrocommissioning and Balancing Study	$20,240	-	26,050	1,672	$2,374	8.5	
5.3.3	Install VFDs on Hydronic Pumps	$6,210		10,024	-	$451	13.8	3
	TOTAL	**$230,000**	**14**	**156,125**	**-**	**$7,026**	**32.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Measure applies to lighting in Cafeteria area at exterior curtain wall that can be off an additional 6 hours per day through photo-cell control.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.8. Meier Hall

Building Overview

Meier Hall was built in 2002 and houses a recital hall, music practice rooms, and classrooms. The building is in good condition. Some areas of the building are occupied seven days per week. The exterior of the building appears to be in good condition.

Campus steam heating and chilled water serve the building. Both heating and cooling loops utilize constant speed pumps.

All air handling units are connected to the central DDC system and are scheduled according to occupancy. Classrooms and offices are served by a VAV air handling unit with hot water reheat. At the time of the September 2009 walkthrough, the supply duct had a very large leak which caused the supply fan VFD to run at 60 Hz.

The auditorium, band room, and choir room each have dedicated air handling units, all of which utilize constant speed fans. Each of these units utilize two-way hot water and chilled water valves. The band room and choir room units utilize carbon dioxide control of outside air.

Domestic hot water is provided using a 30 kW water heater.

The recital hall utilizes a large number of halogen lamps for both dimming and light quality purposes. Lighting in offices and classrooms is provided using T-8 fixtures.

ECM's

Previously Implemented ECMs

Occupancy sensors are installed for both lighting and VAV zones. Carbon dioxide control of outside air is used for two music room air handlers.

Opportunities for ECMs at Meier Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,610	2	5,813		$262	6.2	
5.2.9	Reduce Minimum Outside Air Ventilation Amount	$0		(1,131)	905	$600	0.0	2
5.3.3	Install VFDs on Hydronic Pumps	$5,180		10,870		$489	10.6	3
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$17,250		19,814	732	$1,418	12.2	
5.4.31	Isolate and Seal Supply Air Duct Leaks	$900		74,798		$3,366	0.3	4
	TOTAL	**$24,940**	**2**	**110,164**	**1,637**	**$6,134**	**4.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used in residence rooms
3. Measure based on incremental cost increase to install Condensing Boiler at end of useful life of existing equipment.
4. Assumes a 1% average efficiency increase in overall boiler performance.
5. Based on the incremental cost increase to replace with On Demand Water Heaters at end of useful life of existing equipment.
6. Based on the incremental cost increase to replace with High Efficiency Water Heaters at end of useful life of existing equipment.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.9. Pangburn Hall

Building Overview

Pangburn Hall is a dormitory which houses 78 residents on two floors and occupies 19,045 square feet. The basement area had previously served as the main kitchen and dining facility for the campus, but the new dining facility and kitchen were opened at the Student Union in

August 2009.Plans for the vacated area are unknown. Since there is no forced air ventilation for the building, the single paned windows are operable and in relatively poor condition. The brick exterior appears to be in fair condition.

This building is connected to the central plant for steam heating. When the central plant boiler is not in operation, a 45 hp hot water boiler, which does not appear to have a stack damper, provides heating to radiators in all spaces. Each room has individual unit control. Constant speed pumps circulate the heating water to six wings. Two gas water heaters provide domestic water heating. There is no direct combustion air makeup path for the water heaters or boilers.

The building is not cooled, except for several window mounted air conditioning units in common areas on each floor.

There is no central DDC control of systems, and electrical usage is not monitored at the central system.

Lighting is provided using T-8 fixtures and is manually controlled.

ECM's

Previously Implemented ECMs

Black Hills State University has applied for stimulus funding for metered hose bibs to control water usage associated with irrigation.

Opportunities for ECMs at Pangburn Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,040	1	3,744	$168	6.2	
5.1.3	Install Motion Sensors to Control Lighting	$2,925		9,734	$438	6.7	2
	TOTAL	**$3,965**	**1**	**13,478**	**$607**	**6.5**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used in residence rooms.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.10. Student Union

Building Overview

The Student Union has been under renovation and expansion, and had just reopened at the time of a September 2009 walkthrough.

ECM's

Previously Implemented ECMs

The new Student Union expansion will be LEED® Silver certified. Features include T-5 lighting, Melink Intellihood automatically controlled flow kitchen hoods and makeup air units, greywater recovery, and a "Somat" pulp system to save water and reduce waste volumes. The existing multizone units were in the process of conversion to VAV units at the time of the walkthrough. A green roof installation was also underway.

Opportunities for ECMs at Student Union						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.11	Implement Daylighting Controls	$690	4,087	$184	3.8	
	TOTAL	$690	4,087	$184	3.8	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Measure applies to lighting in Cafeteria area at exterior curtain wall that can be off an additional 6 hours per day through photo-cell control.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.11. Thomas Hall

Building Overview

Thomas Hall is a dormitory which houses 158 residents on three floors and occupies 32,692 square feet. Since there is no forced air ventilation for the building, the single paned windows are operable. The brick exterior appears to be in fair condition.

Due to its location on the far west side of the campus, this building is not connected to the central plant. A 85 hp hot water boiler, which does not appear to have a stack damper, provides heating to radiators in all spaces. Note that for a nearly identical building, the newer boiler in Heidepriem Hall utilizes a 38 hp boiler. There are two thermostats for each wing which control all radiators in a particular wing. Four constant speed pumps circulate the heating water to six wings. Two natural gas domestic hot water heaters, both without stack

dampers, provide water heating. There is no direct combustion air makeup path for the water heaters or boilers.

The building is not cooled, except for several window mounted air conditioning units in common areas on each floor.

Only the boiler is controlled by the central DDC system. All other controls are pneumatic. The electrical usage is not monitored at the central system.

Lighting is provided using T-8 fixtures and is manually controlled.

ECM's

Previously Implemented ECMs

Black Hills State University has applied for stimulus funding for metered hose bibs to control water usage associated with irrigation.

Opportunities for ECMs at Thomas Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,500	2	6,760		$304	4.9	
5.1.3	Install Motion Sensors to Control Lighting	$3,450		14,643	-	$659	5.2	2
5.2.1	Full Retrocommissioning and Balancing Study	$13,500		10,125	2,861	$2,513	5.4	
5.4.1	Replace Firetube Boiler with Condensing	$17,250			3,090	$2,222	7.8	3
5.4.38	Install Stack Dampers	$4,830			286	$206	23.5	4
5.5.2	Replace Storage Type Domestic Water Heater with On Demand	$3,570			404	$291	12.3	5
5.5.16	Replace Standard Efficiency Hot Water Heater with High Efficiency	$2,300			216	$156	14.8	6
	TOTAL	**$46,400**	**2**	**31,528**	**6,858**	**$6,350**	**7.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used in residence rooms
3. Measure based on incremental cost increase to install Condensing Boiler at end of useful life of existing equipment.
4. Assumes a 1% average efficiency increase in overall boiler performance.
5. Based on the incremental cost increase to replace with On Demand Water Heaters at end of useful life of existing equipment.
6. Based on the incremental cost increase to replace with High Efficiency Water Heaters at end of useful life of existing equipment.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.12. Wenona Cook Hall

Building Overview

Wenona Cook Hall, built in 1889, is the oldest building on campus occupies 41,353 square feet and houses offices on the first floor and dormitories on the upper three floors. The stone exterior is in good condition, and the windows are double paned. Since there is no forced air ventilation for the building, the single paned windows are operable.

This building utilizes campus steam for hot water heating. Each room has a baseboard radiator, and temperature setpoints are controlled by a central system in the hall director's office.

The building has no central cooling, but many of the offices on the lower level utilize window mounted air conditioning units.

The lighting has been converted to T-8 and is manually controlled.

ECM's

Previously Implemented ECMs

Lighting has been converted to T-8.Temperature controls have been given only to the hall director.

Opportunities for ECMs at Wenona Cook Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,040	1	8,112	$365	2.8	
5.1.3	Install Motion Sensors to Control Lighting	$2,190		9,152	$412	5.3	2
	TOTAL	**$3,230**	**1**	**17,264**	**$777**	**4.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used.

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.1.13. Woodburn Hall

Building Overview

Woodburn Hall was constructed in the 1920s and occupies nearly 58,000 square feet, including additions. The building houses classrooms, offices, and an auditorium. The building

is used each day during the week and is sometimes used on weekends. The red brick exterior is in good condition, and the windows are operable. The university hopes to fully remodel this building in the near future.

Campus steam provides heating for baseboard radiators. Some of the steam line insulation in the mechanical room is in poor condition.

Most of the building is not served by a central air handling unit. Operable windows provide ventilation, and perimeter offices are conditioned by locally controlled window mounted air conditioning units, of which there are approximately 65 in the building. The server room is not directly mechanically cooled and is served off of an adjacent cooling space. Some constant volume air handlers and split systems provide conditioning for various spaces.

The basement machine shop and associated HVAC equipment has been removed, and there are plans to renovate the space for other uses. The auditorium is also a candidate for renovation. Plans to fully update the building HVAC system are outlined in the campus's Utility Master Plan and would require a new campus chiller.

A 4.5 kW electric water heater provides domestic hot water for the building.

There is very little DDC control of any systems in Woodburn Hall. The building peak demand is monitored by the central system.

The lights are a mixture of T-8, T-12, dimming incandescent, halogen track lighting, and MR-16 accent lighting, all of which are manually controlled.

ECM's

Previously Implemented ECMs

Most lighting has been converted to T-8. Facilities staff is investigating an under floor air distribution system in the basement.

Opportunities for ECMs at Woodburn Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$2,990	3	11,716	$527	5.7	
5.1.3	Install Motion Sensors to Control Lighting	$7,250	-	15,375	$692	10.5	2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$200	3	8,112	$365	0.5	
5.4.9	Replace Window AC Units with Heat Pumps	$40,020	-	17,481	$787	50.9	
	TOTAL	$50,460	6	52,683	$2,371	21.3	

Notes
1. Estimated implementation cost includes allowance for materials, labor and

Estimated Blended Marginal Rates		
$	0.05	/kWh Elec

Notes
contractor overheads.
2. Assume four hour per day reduction in lighting where motion sensors are used in classrooms and offices.

Estimated Blended Marginal Rates		
$	0.72	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

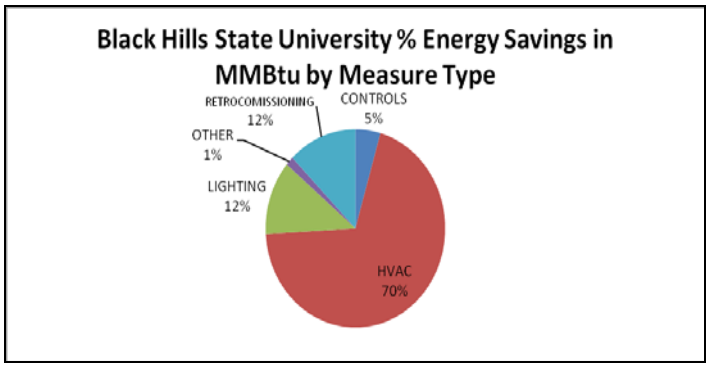
4.2.1.13.1. Campus Summary

A total of 50 ECMs were identified at Black Hills State University buildings, which include 15,689 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately$1,924,675, and save an estimated $147,029 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

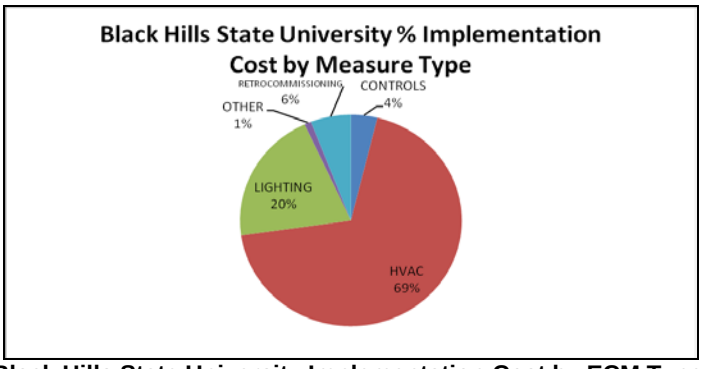
Black Hills State University ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	546	160	**706**	$8,313	$74,110	8.9
HVAC	0	23,589	**10,921**	$96,287	$1,325,610	13.8
LIGHTING	1,886	0	**1,886**	$24,878	$392,925	15.8
OTHER	0	231	**231**	$1,607	$19,100	11.9
RETROCOMMISSIONING	389	1,555	**1,944**	$15,945	$112,930	7.1
Total	2,821	25,535	**15,689**	$147,029	$1,924,675	**13.1**

In total, these savings represent a 16.5% reduction from current energy consumption at the Black Hills State University campus, the majority of which is attributed to Retrocommissioning measures which will reduce natural gas consumption and Lighting measures which will reduce electrical consumption.



Black Hills State University Energy Savings by ECM Category.



Black Hills State University Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 2,179 MMBTUs (2% of campus energy use) and a total estimated annual cost avoidance of $21,396. The total cost of implementation for these measures is $114,660, which yields a simple payback of 5.4 years.

Building	ECM Number	Estimated Implementation Cost1	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Wenona Cook	5.1.1	$1,040	28	$365	2.8	37.57
Facility Services	5.1.1	$580	15	$197	2.9	38.81
Donald Young Center	5.2.10	$2,190	49	$650	3.4	44.44
Student Union	5.1.11	$690	14	$184	3.8	49.48
Jonas Science and Jonas Academic	5.3.17	$5,000	114	$1,235	4.0	43.78
Donald Young Center	5.1.3	$2,650	47	$624	4.2	56.00
Campus Apartments	5.4.38	$1,150	36	$248	4.6	32.27
Heidepriem Hall	5.1.1	$1,500	23	$304	4.9	65.03
Thomas Hall	5.1.1	$1,500	23	$304	4.9	65.03
Donald Young Center	5.1.11	$810	12	$156	5.2	68.46
Donald Young Center	5.3.3	$20,470	297	$3,918	5.2	68.91
Heidepriem Hall	5.1.3	$3,450	50	$659	5.2	69.05
Thomas Hall	5.1.3	$3,450	50	$659	5.2	69.05
Wenona Cook	5.1.3	$2,190	31	$412	5.3	70.13
Thomas Hall	5.2.1	$13,500	330	$2,513	5.4	40.86
Donald Young Center	5.1.1	$1,500	20	$267	5.6	73.96
Woodburn Hall	5.1.1	$2,990	40	$527	5.7	74.80
Jonas Science and Jonas Academic	5.2.1	$50,000	999	$8,173	6.1	50.05
Total		**$114,660**	**2,179**	**$21,396**	**5.4**	**52.62**

4.2.2 Dakota State University

Campus Background and List of Facilities

Dakota State University (DSU), founded in 1881, is a college campus located in Madison South Dakota.Enrollment is estimated to be over 2,500 students.There are approximately 20 buildings on campus with a total square footage ofover 500,000 square feet.

Campus-Wide Systems and Operational Profile

The DSU campus has central low pressure steam heat that serves a majority of campus buildings. Staff indicates that there is likely little insulation on condensate return piping in the campus steam tunnels. There is no central cooling plant.

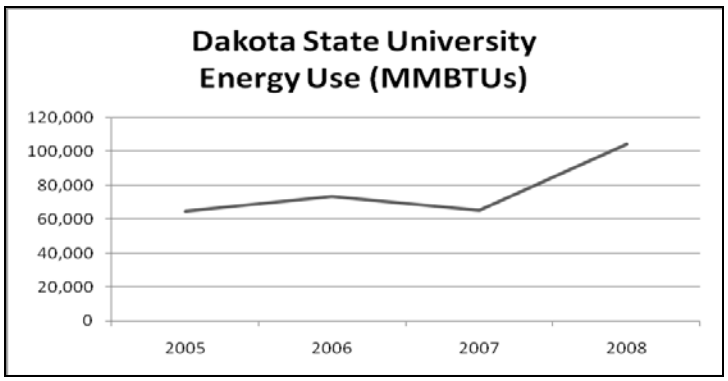
The DSU campus has two central DDC systems that are connected to a select number of campus buildings HVAC systems. Most buildings utilize an older Honeywell system, but newer buildings have utilized a Siemens system. Units on the Honeywell system utilize a morning warm-up sequence with no outside air.

Gas use to some buildings is sub-metered. Electric use and steam use are not sub-metered.

Campus wide, chilled water (CHW) is drained in the winter and contains no glycol. Hot water (HW) contains glycol but the concentration of glycol/water is unknown. Exterior lights are a combination of metal halide and high pressure sodium. When new lights are installed, pulse start metal halide lamps are utilized.

Energy Profile

In 2008, Dakota State University facilities consumed a combined 104,522 MMBTUs of energy. The average Energy Use Intensity across the campus was 204 kBTU/SF in 2008.



Dakota State University Energy Use.

4.2.2.1. Beadle Hall

Building Overview

Beadle Hall houses classrooms, offices, and computer rooms. Building is approximately 20,000 square feet. New windows were installed in 2008.

The building is normally occupied by 50-75 occupants (school year), 10 occupants (summer) from 8 am to 5 pm Monday thru Friday.

HVAC: Building has central steam heat. As one of the oldest buildings on campus, ventilation is provided using operable windows. The only cooling in building is provided by portable units serving the computer rooms. Heat is rejected directly into ceiling plenums. The building is heated by perimeter steam baseboard heaters. There is no central air system, but drop ceilings were added with the foresight of a full ducted air system in the future. All systems are controlled locally.

Domestic water is heated using an electric water heater.

Lighting: The majority of lighting is T-8 fixtures controlled by manual switches. The top floor has sky lighting.

ECM's

Previously Implemented ECMs

The building had a window upgrade in 2008.

Opportunities for ECMs at Beadle Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$6,000	-	9,360	$300	20.0	2
	TOTAL	$6,000	-	9,360	300	20.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 5 fixtures per sensor with a lighting reduction of 3 hours per day.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.2. Community Center

Building Overview

Gymnasium, swimming pool. Building is approximately 68,000 square feet and is attached to the Memorial Gym and Fieldhouse.

The normal hours of operation are 6 am to 11 pm Monday through Friday. Weekends have approximately 50% of the weekday hours of operation.

HVAC: The building has its own dedicated hot water boiler plant for the pool and for space heating. The pool temperature is maintained at 85° F. The building also has a dedicated air cooled chiller. There is a variable air volume HW/CHW air handler serving the majority of the building with a constant air volume HW/CHW air handler serving the gym. The pool area and locker rooms are served by two makeup air units, both of which have heat recovery. Due to the lack of a bypass of the heat recovery coil, however, the heat recovery unit increases mechanical cooling when the temperature is in the economizer range, since the exhaust streams add energy to the air, which then has to be re-cooled mechanically. The building is connected to the campus DDC (Honeywell) system.

Natural gas water heaters provide domestic hot water to the building.

Lighting: The majority of lighting is T-8 fixtures with 250 and 400 watt metal halide lights in gym and pool areas. All lights are controlled by manual switches.

ECM's

Previously Implemented ECMs

Heat recovery is utilized for major ventilation systems.

Opportunities for ECMs at Community Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.10	Replace HID Lighting with High Bay Fluorescent	$25,000	19	101,679	-	$3,254	7.7	2
5.2.1	Full Retrocommissioning and Balancing Study	$70,000	-	179,924	9,676	$14,011	5.0	3
5.3.3	Install VFDs on Hydronic Pumps	$40,000	-	90,948	-	$2,910	13.7	4
	TOTAL	**$135,000**	**19**	**372,551**	**9,676**	**20,175**	**6.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 10% electric and gas savings.
3. CHW and HW pumps.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.3. Dakota Prairie Playhouse

Building Overview

Performing arts, conference center. Building is approximately 18,000 square feet.

The building is normally occupied by 2 staff from 8 am to 5 pm Monday thru Friday in addition to higher occupancy during intermittent performing arts or conference center events.

HVAC: The building is heated using electric resistance heat. The buildings air handlers are on the campus DDC system. The conference center and theater areas are each served by constant volume electric heat, DX cooled air handlers. There is perimeter electric baseboard heat. The air handler serving the theater (rarely used) is normally shut off. The air handler serving the conference area remains on to serve the small office space normally occupied.

Domestic water is heated using an electric water heater.

Lighting: The majority is T-12s controlled by manual switches, but most areas are rarely used. There are also some incandescent track lights that are, again, rarely used.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Dakota Prairie Playhouse

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.5	Replace Incandescent Exit Signs with LED	$250	0	2,488	$80	3.1	
5.5.18	Space Utilization	$1,000	-	51,560	$1,650	0.6	2
	TOTAL	**$1,000**	**-**	**51,560**	**1,650**	**0.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Move two staff to another building to avoid running AHU. Building can be kept at setback temperatures except for events.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.4. East Hall

Building Overview

East Hall houses classrooms and offices in approximately 38,000 square feet.

The building is normally occupied by 50-75 occupants (school year), 10 occupants (summer) from 8 am to 5 pm Monday thru Friday.

HVAC: The building has central steam heat. An air cooled chiller provides space cooling. The lecture hall auditorium is served by a constant air volume steam/CHW air handler. Another air handling unit provides cooling only through high velocity tubes running to several spaces. The classrooms are served by two pipe HW/CHW fan coil units. All units are controlled by non-programmable thermostats. Some spaces utilize perimeter steam baseboard heating.

The two air handlers are monitored for status at the Honeywell DDC system and can only be scheduled.

Domestic water is heated using an electric water heater.

Lighting: Lighting is a mixture of T-12 and T-8 fixtures controlled by manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at East Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$6,000	-	13,728	-	$439	13.7	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$6,000	7	17,550	-	$562	10.7	3
5.2.1	Full Retrocommissioning and Balancing Study	$30,000	-	37,454	2,528	$2,516	11.9	4
5.3.2	Programmable Thermostats for Residential Style Units	$0	-	3,600	1,020	$647	0.0	
	TOTAL	**$42,000**	**7**	**72,332**	**3,548**	**4,163**	**10.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 5 fixtures per sensor with a lighting reduction of 3 hours per day.
3. Assume reballast by in-house staff.
4. Assume 5% savings on electric and gas. Electric and gas usage for the building determined on pro-rated campus usage.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.5. Emry Hall

Building Overview

This dormitory building is approximately 30,000 square feet. There are approximately 150 occupants. Rooms are fully occupied during school year and 50% occupied during the summer. In 2007, the building underwent a lighting, mechanical, and window renovation.

HVAC: Building is connected to central steam that is converted to hot water. Each dorm room and hallway is heated / cooled with 2 pipe fan coil units. The first floor lobby is served by a steam/CHW air handler unit. All units and room fan coil units can be controlled by the new Siemens control system.

Domestic hot water is provided by steam heat (winter) and natural gas hot water heater in the summer.

Lighting: Majority of lighting is T-8 fixtures controlled by manual switches.

ECM's

Previously Implemented ECMs

New mechanical equipment, lighting, controls system, and windows.

Opportunities for ECMs at Emry Hall

No suitable energy conservation measures were discovered.

4.2.2.6. Field House – Memorial Gym

Building Overview

The building houses the main gymnasium, classrooms, and offices. Building is approximately 40,000 square feet. Approximately half of the building is rented out to the National Guard.

The normal hours of operation are 8am to 5 pm Monday through Friday (office area) and 6 am to 9 pm Monday through Friday (sports arena).There are approximately 25 occupants in the offices area during normal hours of operation.

HVAC: Due to its long distance from the central campus, this building has its own low pressure steam boiler. A new air cooled chiller serves the gym air handling unit. The gymnasium is served by CHW/HW air handlers. Based on an estimated size of 50 tons, the chiller is likely undersize to serve the entire building. During the September 2009 walkthrough, the chiller return water temperature sensor indicated an obviously incorrect value on the DDC computer, although the operation of the system did not appear to be affected. The gym air handlers are connected to the central DDC (Honeywell) system.

Leased office areas are cooled with window mounted AC units and are heated using steam perimeter baseboard heat (not on DDC).

Domestic water is heated using natural gas water heaters.

Lighting: Gymnasium has compact fluorescent lighting which has eight CFL lamps which stage on and off according to a lighting control panel (Sportlite).Other spaces are lit using T-8 fixtures and some T-12s with manual switch controls.

ECM's

Previously Implemented ECMs

Installed compact fluorescent fixtures in gymnasium. A new chiller has also been installed.

Opportunities for ECMs at Field House – Memorial Gym

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$2,000	-	3,432	$110	18.2	3
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,000	1	1,456	$47	21.5	4
	TOTAL	**$3,000**	**1**	**4,888**	**156**	**19.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Office areas. Assume 4 fixtures per sensor with a lighting reduction of 3 hours per day.
3. Assume reballast by in-house staff.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.7. Girton House (President's House)

Building Overview

This building is approximately 3,700 square feet.According to facilities staff, this building is rented out to private tenants. The building was not open during the time of our onsite visit.

ECM's

Previously Implemented ECMs

Undetermined.

Opportunities for ECMs

The building was not accessible during the September 2009 walkthrough.

4.2.2.8. Heston Hall

Building Overview

Heston Hall houses offices and administration services. The building is approximately 21,000 square feet. The last major renovation is believed to be in the 1960's.

The normal hours of operation are 8am to 5 pm Monday thru Friday. There are approximately 50 occupants during normal hours of operation.

HVAC: The building is connected to central steam, which is converted to hot water. The hot water temperature is reset based on outside air temperature. The building is served by a dedicated air cooled chiller that is enabled at air temperatures above 40° F. During the September 2009 walkthrough, the outside air temperature was approximately 60° F, and the chiller was running with a temperature rise of less than 1° F across the system. Constant volume air handling units serve the building, but supplemental two pipe fan coil units have been added for additional heating or cooling. The Honeywell system controls the air handling units via a DDC overlay of pneumatic actuators, but the fan coil units in each space. There are no reheat coils, so the fan coil units reheat the air if the air handling unit overcools a space. The fan coil units utilize a local manual thermostat separate from all other controls.

An electric water heater provides domestic hot water to the building.

Lighting: Majority of building consists of T-8 fixtures controlled by manual switches. Some hallways and offices utilize 75W halogen fixture track lighting.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Heston Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$4,500	-	10,296	-	$329	13.7	2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$750	3	9,165	-	$293	2.6	3
5.3.2	Programmable Thermostats for Residential Style Units	$5,000	-	1,020	1,020	$564	8.9	5
	TOTAL	**$10,250**	**3**	**20,481**	**1,020**	**1,187**	**8.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 5 fixtures per sensor with a lighting reduction of 3 hours per day.
3. Assume direct screw-in CFL floor replacement. New fixtures will have similar

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Notes	Estimated Blended Marginal Rates
savings but higher costs. 4. Raise chiller enable setpoint. 5. Assume 50 units. Note that a programmable thermostat for fan coils is the "low cost" option.DDC control will provide superior comfort control and energy savings at higher costs.	Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.9. Higbie Hall

Building Overview

This dormitory building is approximately 30,000 square feet. There are approximately 150 occupants. Rooms are fully occupied during school year and 50% occupied during the summer. In 2007, the building underwent a lighting, mechanical, and window renovation.

HVAC: Building is connected to central steam system. Each dorm room is heated with steam perimeter baseboard heaters. Each hallway of the dormitories is cooled with a constant air volume DX fan coil with outdoor condensing unit. The lobby area is served by a constant air volume DX/HW air handler. The building air handling units have been added to the newer Siemens control system, but perimeter radiation in each room is controlled locally.

Domestic hot water is provided by steam heat (winter) and natural gas hot water heater in the summer.

Lighting: The majority of lighting is T-8 fixtures controlled by manual switches.

ECM's

Previously Implemented ECMs

New mechanical equipment, lighting, controls system, and windows.

Opportunities for ECMs at Higbie Hall

No suitable energy conservation measures were discovered.

4.2.2.10. Karl E. Mundt Library

Building Overview

This building houses the campus library, classrooms, and offices. The building is approximately 42,000 square feet.

The normal hours of operation are 8am to 5 pm Monday through Friday (summer) and 8 am to 11 pm Monday through Friday (school year).

HVAC: Building is connected to central steam system and utilizes a hot water converter. There are two HW/DX multizone deck air handlers, and one HW/DX air handler with direct

injected steam humidification and perimeter hot water baseboard heat. All air handlers are constant volume systems. The Honeywell DDC system controls the units using a DDC overlay of pneumatic actuators.
Air is not directly ducted from the units to the spaces. Rather, the ceiling plenum acts as a supply plenum, and air is pushed out of grilles and diffusers to condition spaces.

Lighting: The majority of the building is comprised of T-12 fixtures controlled by manual switches. There are approximately twenty 200 watt incandescent lights used within the library.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Karl E. Mundt Library

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Demand kW	Estimated Annual Utility Savings: Electric kWh	Estimated Annual Utility Savings: Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.15	Overhaul Library Lighting	$300,000	40	175,200	-	$5,606	53.5	2
5.3.7	Convert Multizone/Dual Duct to VAV	$40,000	-	49,988	3,021	$3,174	12.6	4
	TOTAL	**$340,000**	**40**	**225,188**	**3,021**	**8,780**	**38.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Includes T-12 removal, incandescent removal, motion sensors, etc.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.11. Kennedy Center

Building Overview

The Kennedy Center houses classrooms and offices. The building is approximately 19,000 square feet.

The building is normally occupied by 50-75 occupants (school year), 10 occupants (summer) from 8 am to 5 pm Monday thru Friday.

HVAC: The building has central steam heat. There is one main variable air volume steam/DX air handler. The building has perimeter hot water baseboard heaters. The air handlers are controlled locally but are monitored by the Honeywell DDC system.

An electric water heater provides domestic hot water.

Lighting: The majority of lighting is T-12 fixtures controlled by manual switches. Hallways have sky lighting.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Kennedy Center								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$4,500	-	11,349	-	$363	12.4	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$6,000	5	12,480	-	$399	15.0	3
5.2.1	Full Retrocommissioning and Balancing Study	$30,000	-	56,181	3,792	$3,773	8.0	4
	TOTAL	$40,500	5	80,010	3,792	4,536	8.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 5 fixtures per sensor with a lighting reduction of 3 hours per day.
3. Assume reballast by in-house staff.
4. Assume 15% savings on electric and gas. Electric and gas usage for the building determined on pro-rated campus usage.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.12. Lowry Hall

Building Overview

This building houses offices, computing services department. Building is approximately 12,000 square feet. There are plans to demolish & replace this building within the next 5 years.

The normal hours of operation are 8am to 5 pm Monday thru Friday. There are 25 occupants during normal operating hours.

HVAC: Building is connected to central steam. There are DX fan coil units serving the hallways with non-programmable thermostats. The building is heated with perimeter steam baseboard.

Lighting: Majority of lighting is T-8 fixtures controlled by manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Lowry Hall

No suitable energy conservation measures were discovered.

4.2.2.13. Physical Plant

Building Overview

This space contains the central boiler plant and facilities staff offices and shop. The building is approximately 12,000 square feet. The normal hours of operation are 8am to 5 pm Monday thru Friday. There are approximately 10 occupants during normal hours of operation

HVAC: Low pressure steam is produced by natural gas / fuel oil fire tube boilers located at the Physical Plant. There are two 750 Bhp boilers and one 500 Bhp boiler. Stack dampers did not appear to be installed. The boiler plant runs during the winter and is used to heat the domestic water in the dormitories during this period.(Each dormitory has summer domestic water heaters as well).

The building itself is served by a HW (converted from steam) and DX air handler controlled by a local, non-programmable thermostat. There is baseboard perimeter steam heat.

Boilers status is monitored using the Honeywell system, but all operation is manual.

Lighting:T-12 lighting is utilized in office areas, shop areas, and in the boiler plant. Exit signs utilize fluorescent lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Physical Plant Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,400	2	4,095	-	$131	10.7	2,3
5.1.12	Replace 8' Fixtures with 4' Fixtures	$4,000	3	12,324	-	$394	10.1	3
5.2.1	Full Retrocommissioning and Balancing Study	$50,000	-	201,069	5,666	$9,386	5.3	4
5.3.2	Programmable Thermostats for Residential Style Units	$100	-	480	136	$86	1.2	
5.4.38	Install Stack Dampers	$10,000	-	-	4,250	$2,214	4.5	5
	TOTAL	**$65,500**	**5**	**217,968**	**10,052**	**12,212**	**5.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 25W T-8.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Notes
3. Assume reballast by in-house staff.
4. Assume 2% natural gas savings from existing.
5. Existing dampers appear to be manually opened and closed. This measure assumes automatic dampers and 1.5% savings based on empirical studies.

Estimated Blended Marginal Rates
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.2.14. Richardson Hall

Building Overview

This dormitory building is approximately 31,000 square feet. There are approximately 200 occupants. Rooms are fully occupied during school year and 50% occupied during the summer. In 2007, the building underwent a lighting, mechanical, and window renovation.

HVAC: Building is connected to central steam that is converted to hot water. Each dorm room and hallway is heated / cooled with 2 pipe fan coil units. The first floor lobby is served by a steam/CHW air handler unit. The building is controlled by the new Siemens DDC system.

Domestic hot water is provided by steam heat (winter) and natural gas hot water heater in the summer.

Lighting: The majority of lighting is T-8 fixtures with T-5s in the lobby areas, all controlled by manual switches.

ECM's

Previously Implemented ECMs

New mechanical equipment, lighting, controls system, and windows.

Opportunities for ECMs at Richardson Hall

No suitable energy conservation measures were discovered.

4.2.2.15. Science Center

Building Overview

Science labs, classrooms, auditorium, offices. Building is approximately 36,000 square feet.

The normal hours of operation are 8am to 5 pm Monday through Friday. There are up to 200 occupants in the building during normal hours of operation.

The building is currently under renovation. At the completion of the renovation, which is expected to be completed in 2010, the building will be LEED Silver accredited.

ECM's

Previously Implemented ECMs

The building is under renovation and will be LEED Silver accredited.

Opportunities for ECMs at Science Center

No suitable energy conservation measures were discovered.

4.2.2.16. Trojan Center

Building Overview

The Trojan Center serves as the student union with a bookstore, common areas, conference rooms, and offices. Since it utilizes mechanical systems located in Zimmerman Hall, the dining center is assumed to be a part of Zimmerman for purposes of this report. Building is approximately 24,000 square feet.

The normal hours of operation are 7:30 am to 4:30 pm Monday thru Friday (summer) and 8 am to 11 pm Monday thru Friday (school year).

HVAC: Building is connected to central steam system and utilizes steam to hot water converters. The student union is served by two multizone air handling units. Unit MZU-1 has its economizer disabled due to overcooling issues. MZU-2 is very small and has its DX cooling coil disabled since it serves the basement with little cooling load. There are HW fan coil units in the basement. The building has perimeter steam baseboard and electric cabinet unit heaters.

Natural gas water heaters provide domestic hot water.

Lighting:The majority of the building is T-8 fixtures with T-12s in some corridors and offices, all controlled by manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Trojan Center								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,500	1	3,566	-	$114	13.1	2
5.3.7	Convert Multizone/Dual Duct to VAV	$14,000	-	19,995	1,208	$1,269	11.0	3
	TOTAL	$15,500	1	23,561	1,208	1,384	11.2	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume reballast by in-house staff.
3. MZU-1 only.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.2.17. Tunheim Building

Building Overview

This building houses an auditorium, classrooms, offices, computer room. Building is approximately 15,000 square feet. A new roof and new windows were installed in 2003.

The building is normally occupied by 50-75 occupants from 8 am to 5 pm Monday thru Friday in addition to higher occupancy during auditorium lectures.

HVAC: Building is connected to campus steam via a hot water converter. The building is served by a variable air volume HW/DX air handler with HW reheat VAV boxes. The auditorium VAV boxes are fan powered. The building has perimeter HW baseboard heat. The air handling unit is controlled using the Honeywell DDC system, but perimeter radiation and VAV boxes are controlled locally. Some sensors appeared to be out of calibration, in particular the static pressure sensor, at the time of the September 2009 walkthrough.

Domestic water is heated using an electric water heater.

Lighting: The majority of lighting is T-5 and T-8 fixtures controlled by manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Tunheim Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Demand kW	Estimated Annual Utility Savings: Electric kWh	Estimated Annual Utility Savings: Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$1,500	-	2,340	-	$75	20.0	2
5.2.1	Full Retrocommissioning and Balancing Study	$15,000	-	29,569	1,996	$1,986	7.6	3
	TOTAL	**$16,500**	**-**	**31,909**	**1,996**	**2,061**	**8.0**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas

Notes
contractor overheads.
2. Assume 5 fixtures per sensor with a lighting reduction of 3 hours per day in office areas.

Estimated Blended Marginal Rates		
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.2.18. Zimmerman Hall

Building Overview

The building houses dormitories on higher floors, offices on main floors, and the athletics weight room in the basement. Building is approximately 41,000 square feet and is connected to the Trojan Center. For purposes of this report, the kitchen and dining hall are assumed to be in the Zimmerman Hall. The building has been renovated (HVAC, lighting, windows) within the last few years.

The normal hours of operation are 8am to 5 pm Monday thru Friday (non-dorm areas).There are approximately 125 occupants in the dormitories and 30 additional staff during normal hours of operation. Note that dormitories are fully occupied during school year and 50% occupied during the summer.

In 2008, the building underwent a lighting, mechanical, and window renovation for all areas except the food service area, which was updated in 1996.

HVAC: Building is connected to central steam system. Each dorm room is heated with steam perimeter baseboard heaters. Each hallway of the dormitories is cooled with a constant air volume DX fan coil with outdoor condensing unit. The lobby area is served by a constant air volume DX/HW air handler. All non-food service air handling units and fan coil units are connected to the new Siemens DDC system.

The food services area is served by constant air volume HW/CHW air handler s (not part of recent renovation).Kitchen exhaust and makeup hoods usually run from 6 am to 10 pm on weekdays and for six hours per day on the weekends. The dining area is served by a variable air volume HW/CHW air handler with reheat coils in the VAV boxes.

Domestic hot water is provided by several gas fired water heaters.

Lighting: The above grade floors all have undergone lighting upgrades to T-8 fixtures. The lower floor weight room area still utilizes T-12 fixtures. The dining hall uses compact fluorescent fixtures.

ECM's

Previously Implemented ECMs

New mechanical equipment, lighting, controls system, and windows.

Opportunities for ECMs at Zimmerman Hall								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Replace T-12 Fixtures with T-8s	$1,000	1	2,246	-	$72	13.9	2
5.3.13	Demand Control Ventilation (CO2 Control)	$3,000	-	1,654	613	$373	8.1	3
5.5.5	Intellihood Kitchen Controls System	$60,000	-	38,298	8,244	$5,521	10.9	
	TOTAL	**$64,000**	**1**	**42,199**	**8,857**	**5,965**	**10.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs include fixture removal. Direct removal of lamps could be implemented at no cost with similar savings.
3. Dining area unit.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.52	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

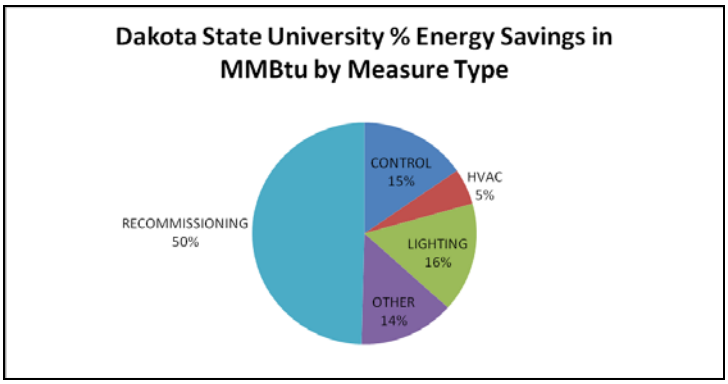
4.2.2.18.1. Campus Summary

A total of 32 ECMs were identified at Dakota State University, which include 8,403 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $739,500, and save an estimated $62,650 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

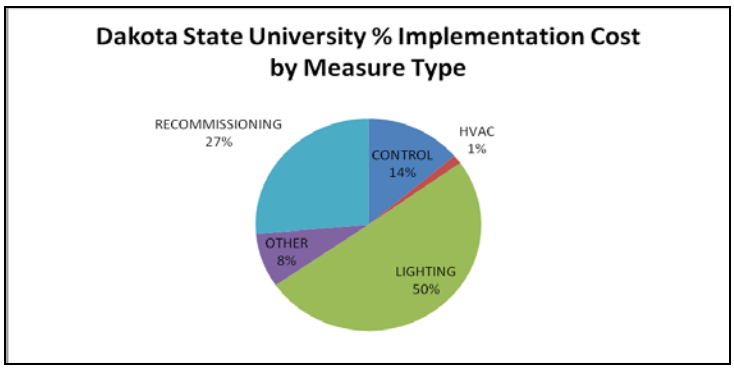
Dakota State University ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	572	726	**1,298**	$9,023	$102,100	11.3
HVAC	0	439	**439**	$2,214	$10,000	4.5
LIGHTING	1,340	0	**1,340**	$12,568	$371,400	29.6
OTHER	307	852	**1,159**	$7,171	$61,000	8.5
RECOMMISSIONING	1,720	2,446	**4,167**	$31,673	$195,000	6.2
Total	**3,939**	**4,464**	**8,403**	**$62,648**	**$739,500**	**11.8**

In total, these savings represent a 8% reduction from current energy consumption at the Dakota State University, the majority of which is attributed to Recommissioning measures which will reduce natural gas and electrical consumption.



Dakota State University Energy Savings by ECM Category.



Dakota State University Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 3,675 MMBTUs (3.5% of campus energy use) and a total estimated annual cost avoidance of $28,367. The total cost of implementation for these measures is $132,100, which yields a simple payback of 4.7 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
East Hall	5.3.2	$0	118	$647	0.0	0.00
Dakota Prairie Playhouse	5.5.8	$1,000	176	$1,650	0.6	5.68
Physical Plant	5.3.2	$100	16	$86	1.2	6.37
Heston Hall	5.1.8	$750	31	$293	2.6	23.98
Dakota Prairie Playhouse	5.1.5	$250	8	$80	3.1	29.45
Physical Plant	5.4.38	$10,000	439	$2,214	4.5	22.76
Community Center	5.2.1	$70,000	1,614	$14,011	5.0	43.36
Physical Plant	5.2.1	$50,000	1,272	$9,386	5.3	39.31
TOTAL		**$132,100**	**3,675**	**$28,367**	**4.7**	**35.95**

4.2.3 Northern State University

Campus Background and List of Facilities

Northern State University was founded in 1940.Today the campus consists of over 28 buildings totaling 785,000 square feet.

Northern State University employs over 325 people and has an attendance of over 3,000 students each year. Over 1,000 of those students live on campus.

Campus-Wide Systems and Operational Profile

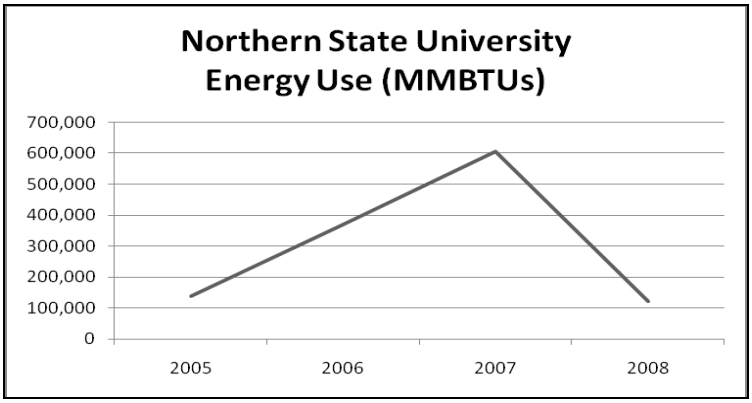
Three high pressure steam boilers serve 26 buildings on campus with 40 psi steam.

At least one boiler is operational at all times to serve the campus. Steam is used in campus buildings for building heat, making domestic hot water, and reheat coils.

100 psi compressed air is generated from a 25 hp Ingersoll-Rand reciprocating compressor and distributed from the central heating plant at 60 psi. The compressor motor is 91.7% which is the code minimum.

Energy Profile

In 2008, Northern State University facilities consumed a combined 120,517 MMBTUs of energy. The average Energy Use Intensity across the campus was 153 kBTU/SF in 2008.



Northern State University Energy Use.

4.2.3.1. Barnett Center

Building Overview

The 128,000 square foot athletic complex was built in 1987. The Barnett Center features an 8,000 seat arena, classrooms, six-lane swimming pool, 160-meter track, wrestling and weight-lifting facilities, and basketball, tennis, volleyball, and handball/racquetball/squash courts.

Students and employees occupy the building from 6:00 am to 11:00 pm on weekdays, however, the building is intermittently occupied during nights and weekends by staff. The HVAC systems are operated in occupied mode 24 hours per day, 7 days per week to maintain temperature and humidity control.

High pressure steam (40 psi) is brought into the facility and converted to hot water. The converter has two 5 hp pumps (one redundant) which distribute heating water (30% glycol) to unit heaters and the air handling unit heating coils. The triple duty valves on the pumps are 100% open. The pump motors are all standard efficiency. Steam heat is also used in two air handling units as well as a pair of converter style hot water heaters. Domestic hot water can also be supplied by a back up gas fired unit, but is rarely used.

Eleven air handling units provide heating, cooling and ventilation to the facility. The majority of the units are a constant volume, single zone unit. The constant volume, single zone unit is equipped with a chilled water cooling coil, steam heating coil, air filters, supply fan, and outside, return and relief air dampers. The minimum position on the outside air dampers is set at 15% open. During periods of high humidity, the facilities staff closes the outside air dampers. According to the facilities staff, the minimum outside air damper position is fixed at 15% during unoccupied hours to provide ventilation for the intermittently occupied building.

The facility has a Johnson Controls DDC system with pneumatic actuators and is currently undergoing a controls upgrade.

The building envelope is constructed of aluminum framed operable windows, and masonry block with exterior face brick. The roofing for the original 1955 area was upgraded in 2009.

The building is primarily lit by two and four lamp 32watt T-8 fixtures. The “Reading Room” uses both 150watt metal halide and 300watt halogen lamps as well as having large windows providing natural daylight. Lighting levels in some areas of the library were between 100 and 140 foot candles.

ECM’s

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Barnett Center								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$4,720	3	19,895		$557	8.5	
5.1.3	Install Motion Sensors to Control Lighting	$2,760		12,136		$340	8.1	7

Opportunities for ECMs at Barnett Center								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.10	Replace HID Lighting with High Bay Fluorescent	$84,070	47	286,577		$8,024	10.5	
5.1.11	Implement Daylighting Controls	$1,150		7,477		$209	5.5	4
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$83,720		653,978	23,319	$36,617	2.3	5
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0		280,287	14,285	$19,062	0.0	
5.3.13	Demand Control Ventilation (CO2 Control)	$84,640		13,190	17,860	$14,389	5.9	6
5.4.41	Replace Motors with Premium Efficiency at end of Useful life	$1,840		20,588		$576	3.2	3
	TOTAL	$262,900	50	1,294,129	55,464	79,775	3.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on incremental cost increase to install premium efficiency motors in lieu of code efficiency at end of useful life on AHU's only.
4. Measure based on motion control sensors being installed in classroom spaces only.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.3.2. Central Plant

Building Overview

The Central Heating Plant is an 8,300 square foot facility that was constructed in 1931.The facility operates 24 hours per day, seven days per week to provide steam for the campus.

Central heating is supplied two 650 Hp (21,758 MBH) Kewanee scotch marine fire tube, natural gas boilers and one 725 Hp (24,269 MBH) Kewanee scotch marine boiler. All three boilers are capable of firing on natural gas or No. 2 fuel oil.

The condensate return system is maintained at a vacuum of -3.0 in hg by two 10 hp condensate pumps equipped with high efficiency motors. The system was designed for -7.0 in hg, however due to leaks in the piping system; this level of vacuum is unattainable.

The building envelope is constructed of aluminum framed operable windows and masonry block with exterior face brick.

The boiler areas are primarily illuminated by 127watt Mercury Vapor fixtures. The remaining balance of the building is lit by either incandescent fixtures or two lamp T8 fixtures. All fixtures are manually controlled by the building occupants. The second floor offices and workshop have large windows which could allow for lights to be turned off during occupied hours.

The campus exterior lighting is various high pressure sodium fixtures ranging from 50watt bollards to 400watt light poles. The majority of the exterior lighting on campus is controlled by photocells.

ECM's

Previously Implemented ECMs

Premium efficiency motors on vacuum condensate pumps.

Opportunities for ECMs at Central Plant								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$120		722		$20	5.9	
5.1.3	Install Motion Sensor to Control Lighting	$350		358		$10	35.0	5
5.1.3	Install Motion Sensor to Control Lighting	$230		867		$24	9.5	6
5.1.10	Replace HID Lighting with High Bay Fluorescent	$3,340	1	3,444		$96	34.6	
5.2.13	Repair Compressor Air Leaks	$8,630		26,504		$742	11.6	3,4
5.4.26	Install Boiler Economizers	$87,290			27,674	$21,724	4.0	7
	TOTAL	**$99,960**	**1**	**31,895**	**27,674**	**22,617**	**4.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure assumes that by locating and repairing 30% of pneumatic system air leaks the compressor run time is reduced by 4 hours per day.
4. Measure assumes that labor is completed by university staff.
5. Measure assumes applies to tunnel lighting.
6. Measure applies to office and shop lighting.
7. Economics based on assumed performance of plant boiler in conjunction with Energy CAP utility data.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.3.3. H. P. Gerber Building

Building Overview

The H. P. Gerber Industrial Technology Building was built in 1905 at a cost of $15,000. This building was first known as the Industrial Technology Building. The 17,000 square foot facility underwent renovations in 2000 and currently houses offices and classrooms for the School of Education.

Students and employees occupy the building from 7:00 am to 10:00 pm on weekdays, however the building is intermittently occupied during nights and weekends by staff. Due to the unpredictability of the staff occupancy schedules, the HVAC systems are operated in

occupied mode 24 hours per day, 7 days per week to maintain temperature and humidity control.

High pressure steam (40 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate heating water for the building through two converters. Each converter has a pair of redundant pumps which distribute heating water (30% propylene glycol mixture) to finned tube radiators, VAV reheats, and air handling unit coils. The 5 hp pumps and converter serving the finned tube and AHU coils are enabled to operate when the outside air is below 55F, while the 1-1/2 hp pumps and converter serving the VAV reheats are operational throughout the year. The triple duty valves on the radiation pumps and reheat pumps are throttled to 20% open and 25% respectively. The pump motors are both standard efficiency.

Cooling is provided by one 100 ton air cooled Carrier chiller which was replaced in 2009.One 7-1/2 hp pump circulates chilled water through the chiller and air handling unit coils. The chiller and pump are enabled to operate when the outside air temperature is above 60F.Once enabled, the chilled water pump operates at constant speed while 3-way chilled water valves on the air handling unit coils modulate to maintain their respective discharge air temperature setpoints. The triple duty valve on the chilled water pump is throttled to 75% open. The chilled water pump has a premium efficiency motor.

Three VAV air handling units (total of 27,950 CFM) provide cooling and ventilation to the facility. The units are equipped with chilled water cooling coils, hydronic heating coils, air filters, supply fans, relief fans, and outside, return and relief air dampers. The minimum position on the outside air dampers is set at 15% open unless the outside air humidity levels are high. During periods of high humidity, the facilities staff closes the outside air dampers. According to the facilities staff, the minimum outside air damper position is fixed at 15% during unoccupied hours to provide ventilation for the intermittently occupied building.

The facility has a Johnson Controls DDC system with electronic actuation.

Domestic hot water is generated with electric water heaters.

The building envelope is constructed of aluminum framed operable windows, and masonry block with exterior face brick. The roofing is comprised of a ballasted membrane roof which was upgraded in 2000 with the remodel project.

The offices, corridors, and classrooms are lit with a combination of two, three, and four lamp, 32 watt, T-8 fluorescent fixtures.

Fixtures are manually controlled via wall mounted light switches. Task lighting is also used in some office areas on an as needed basis. Exit lights are equipped with LED’s.

ECM's

Previously Implemented ECMs

Chilled water pump was replaced with premium efficiency motor.

Opportunities for ECMs at hp Gerber Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$3,450	4	13,446		$376	9.2	
5.1.3	Install Motion Sensors to Control Lighting	$6,790		23,116		$647	10.5	4
5.3.3	Install VFDs on Hydronic Pumps	$7,940		30,971		$867	9.2	6
5.3.8	Schedule AHUs Off During Unoccupied Hours	$1,270		47,346	455	$1,683	0.8	
5.3.13	Demand Control Ventilation (CO2 Control)	$8,630		(2,121)	1495	$1,114	7.7	
5.4.29	Trim Impeller and Open Triple Duty Valve	$3,220	1	5,531		$155	20.8	
5.4.41	Replace Motors with Premium Efficiency at end of Useful life	$350		2,528		$71	4.9	3
	TOTAL	$31,650	5	120,817	1,951	4,914	6.4	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on incremental cost increase to install premium efficiency motors in lieu of code efficiency at and of useful life.
4. Measure assumes that lighting will be off an additional 4 hours per day when they were on before
5. Measure will require investigation of feasibility to convert existing three-way valves to two-way.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.3.4. Jerde Hall

Building Overview

A co-ed residence hall with one floor designated as non-smoking, Jerde Hall was built in 1968.The 80,680 square foot building can house 375 students and is complete with its own dining hall and kitchen.

Students occupy the building 24 hours/day, 7 days per week throughout the school year. The HVAC systems are operated in occupied mode 24 hours/day, 7 days per week to maintain ventilation and temperature control.

Two 125 hp Kewanee scotch marine low pressure steam boilers generate 10 psi steam for the AHU heating coils, instantaneous domestic water heater, dish machine, steam cooker, as well as the heating water converter for building heat. The converter has three ¾ hp primary pumps

which circulate heating water to the secondary pumps. There are four secondary zone pumps ranging from ¾ hp to 1 hp that distribute heating water to finned tube radiation on the residence floors. Each pump is dedicated to a separate zone of the building and is enabled to operate when the outside air is below 55F.The throttling valves on these pumps were 100% open at the time of our visit. All of the pump motors are standard efficiency.

Cooling is provided by one 50 ton air cooled chiller which is dedicated to the multizone AHU located in the basement. One chilled water pump circulates chilled water through the chiller and air handling unit coils. The chiller and pump are enabled to operate when the outside air temperature is above 60F.Once enabled, the chilled water pump operates at constant speed while 3-way chilled water valves on the air handling unit coil modulate to maintain the cold deck discharge air temperature setpoint.

Fourteen window A/C units are installed in the RA rooms and lounges to provide supplemental cooling.

Two air handling units provide cooling and ventilation to the facility. One 13,800 CFM multizone unit provides cooling and ventilation for the lobby, computer lab, and student store. The 19,500 CFM single zone air handling unit provides ventilation to the kitchen and dining room. The minimum position on the outside air dampers is set at 0% open for both of these units, however they are allowed to economize based on mixed air temperatures. The kitchen and dining area in Jerde Hall are no longer used for foodservice. The kitchen is only used intermittently during the week and the dining room is only used for special events. Each of these air handling units operate 24 hours/day, seven days per week.

Two heat recovery ventilators were installed on the roof in 2005 to provide ventilation for the residence hall. These units exhaust air from the toilet rooms and supply air to the corridors. Due to the high level of humidity in the exhaust air, the heat exchangers frost up when the outside air temperature drops below 15F.Consequently, they are shut off during low outside air temperatures. Also, since they lack the ability to dehumidify, they are shut off when the outside air temperature rises above 80F.Both of these units are equipped with electric heating coils.

The facility has a Johnson Controls DDC system with pneumatic actuators on control valves and thermostats.

Domestic hot water is generated with a low pressure steam instantaneous water heater.

The building envelope is constructed of aluminum framed operable windows, and masonry block with exterior face brick. The windows were replaced with low-e in 2004.

The dorm rooms in the building use a single two lamp T-8 fixture with one lamp T-12 fixtures for desk lighting (two per room).Corridors and public spaces as well as the dining

also use primarily two or three lamp 32watt T-8 fixtures. There is no lighting control system currently in place in the building and lighting is controlled locally by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Jerde Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Demand kW	Estimated Annual Utility Savings: Electric kWh	Estimated Annual Utility Savings: Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$2,990	2	4,816		$135	22.2	5
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$2,650	2	13,003		$364	7.3	6
5.1.3	Install Motion Sensors to Control Lighting	$1,840		2,890		$81	22.7	
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$9,090		29,443	28	$846	10.7	
5.3.7	Convert Multizone/Dual Duct to VAV	$23,000		52,701	3409	$4,159	5.5	
5.3.8	Schedule AHUs Off During Unoccupied Hours	$2,420		59,215	362	$1,943	1.2	7
5.3.8	Schedule AHUs Off During Unoccupied Hours	$7,020		21,106	5024	$4,545	1.5	8
5.4.41	Replace Motors with Premium Efficiency at end of Useful life	$350		7,564		$212	1.7	4
5.5.13	Install Stand Alone Hot Water Heater in Lieu of Boiler Generated Domestic Hot Water	$9,550			1309	$1,031	9.3	3
	TOTAL	**$58,910**	**4**	**190,738**	**10,133**	**13,315**	**4.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure assumes that high efficiency hot water system would be used to handle all building domestic hot water needs.
4. Measure based on incremental cost increase to install premium efficiency motors in lieu of code efficiency at and of useful life.
5. Measure pertains to residence rooms only.
6. Measure pertains to all non-residence spaces in the building.
7. Measure pertains to Single Zone AHU only.
8. Measure pertains to Multi-Zone AHU only. This measure includes alternate cooling system be provided for Student Store.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.3.5. Johnson Fine Arts Center

Building Overview

The Johnson Fine Arts Center includes a 1,000-seat theatre, a lecture auditorium, band and choir rehearsal halls, theatrical scene shop, dressing and costume rooms, plus instrumental and drama faculty offices. The 61,540 square foot building was constructed in 1972 and also serves the campus as a major classroom facility

Students and employees occupy the building from 7:00 am to 10:00 pm on weekdays, however the building is intermittently occupied during nights and weekends by staff. Due to the unpredictability of the staff occupancy schedules, the HVAC systems are operated in occupied mode 24 hours/day, 7 days per week to maintain temperature and humidity control.

High pressure steam (40 psi) is reduced to low pressure steam (15 psi) at the building where it is used for air handling unit coils and to generate heating water for the building through a single converter. The converter has three pumps (one redundant) which distribute heating water (30% glycol) to finned tube radiators, and unit ventilators. The 3 hp pumps and converter are enabled to operate when the outside air is below 55F. The triple duty valves on the pumps are throttled to 35% open. The pump motors are all high efficiency.

Cooling is provided by one McQuay 250 ton air cooled split chiller which was replaced within the last 10 years. Two 3 hp pumps (one standby) circulate chilled (30% glycol) water through the chiller, while five secondary pumps (three on standby) distribute chilled water to the unit ventilators and air handling unit coils. Each air handling unit has one or two tertiary chilled water pumps at the unit coils. The chillers and pumps are all enabled to operate when the outside air temperature is above 60F.Once enabled, primary, secondary, and tertiary pumps all operate at constant speed while 3-way chilled water valves on the air handling unit coils modulate to maintain their respective discharge air temperature setpoints. The triple duty valve on the 3 hp secondary pumps serving the unit ventilators are 50% open, while 3 hp secondary pumps serving the air handling units are 30% open. The primary pumps have standard efficiency motors, while the secondary pumps all have high efficiency motors.

Nine air handling units provide cooling and ventilation to the facility. Six of the units are constant volume, single zone units, while three of the units are constant volume multi-zone. Each of the units are equipped with chilled water cooling coils, steam heating coils, air filters, supply fans, return fans, and outside, return and relief air dampers. The minimum position on the outside air dampers is set at 15% open unless the outside air humidity levels are high. During periods of high humidity, the facilities staff closes the outside air dampers. According to the facilities staff, the minimum outside air damper position is fixed at 15% during unoccupied hours to provide ventilation for the intermittently occupied building.

Fifteen unit ventilators serve the classrooms and offices and are served with heating water and chilled water.

The facility has a pneumatically controlled temperature control system throughout.

Domestic hot water is generated with two 80 gallon and one 15 gallon electric water heaters.

The building envelope is constructed of masonry block with exterior face brick.

The classroom and office spaces in the building are lit by four lamp 32watt T-8 fixtures. Most classroom areas have multiple switching available to adjust light levels. The main auditorium seating area is lit by 150watt dimmable halogen lamps which are controlled by a central control panel. Several of these lamps were out during the time of the site visit due to the difficulty of replacement.

ECM's

Previously Implemented ECMs

Chiller was replaced within the last ten years.

Opportunities for ECMs at Johnson Fine Arts Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$4,720	3	13,870		$388	12.2	
5.1.2	Delamp Multiple Lamp Fixtures	$0		14,910		$417	0.0	
5.1.3	Install Motion Sensors to Control Lighting	$3,450		17,261		$483	7.1	4
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$54,280		295,650	4746	$12,004	4.5	
5.3.7	Convert Multizone/Dual Duct to VAV	$122,130		26,188	11259	$9,572	12.8	
5.3.8	Schedule AHUs Off During Unoccupied Hours	$3,680		268,339	4419	$10,983	0.3	
5.3.13	Demand Control Ventilation (CO2 Control)	$35,650		(9,842)	7160	$5,345	6.7	
5.4.29	Trim Impeller and Open Triple Duty Valve	$2,650		8,438		$236	11.2	
5.4.41	Replace Motors with Premium Efficiency at end of Useful life	$1,610		41,776		$1,170	1.4	3
	TOTAL	**$228,170**	**3**	**676,590**	**27,584**	**40,598**	**5.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on incremental cost increase to install premium efficiency motors in lieu of code efficiency at end of useful life on AHU's only.
4. Measure based on motion control sensors being installed in classroom spaces only.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.3.6. MeWaldt-Jensen/Technology Center

Building Overview

The Mewaldt-Jensen/Technology Center is a classroom and office building for the departments of mathematics, the sciences, and business. It has 60 private offices for staff, 16 classrooms and 13 laboratories. The 62,000 square foot facility was expanded to a total of 82,000 square feet with the addition of the Technology Center in 2008.

Students and employees occupy the building from 6:00 am to 11:00 pm on weekdays, however the building is intermittently occupied during nights and weekends by staff. The HVAC systems are operated in occupied mode 24 hours/day, 7 days per week to maintain temperature and humidity control.

High pressure steam (40 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate heating water for the building through two converters. One converter is dedicated to MeWaldt Jensen, while the other serves the Technology Center.

The hydronic system serving MeWaldt Jensen is a two-pipe change over system which uses two 10 hp circulating pumps to circulate heating/cooling water to the air handling units and unit ventilators. Change-over is initiated around April and October .Two ½ hp heating pumps also pull water off of the converter to supply finned tube radiators and unit heaters. The heating/cooling pumps operate 24 hours/day, 7 days per week while the heating pumps are started when the outside air temperature falls below 50F.

The converter serving the technology center distributes heating water (30% glycol) via two 15 hp pumps to the air handling unit coils, finned tube radiators, and VAV reheat coils. The triple duty valves on the pumps are 40% open. The pump motors are both premium efficiency.

Cooling for the two pipe system is provided by one McQuay 140 ton water cooled chiller which was installed in 2003.One 7-1/2 hp pump circulates condenser water through a roof mounted cooling tower. The cooling tower is over 15 years old, has a 5 hp fan motor and does not have a variable frequency drive. The heating/cooling pumps pull chilled water from the chiller when the system is in cooling mode.

Cooling for the Technology center is provided by one McQuay 140 ton air cooled chiller. One 15 hp pump circulates chilled water (30% glycol) through the AHU coils and chiller. The chilled water pump is throttled to 50% open and has a premium efficiency motor. The AHU coils are equipped with 3-way control valves.

Two air handling units provide cooling and ventilation to the MeWaldt-Jensen facility. One of the units is a constant volume, single zone unit, while the other unit is variable volume. The constant volume single zone unit is equipped with a single heating/cooling coil, air

filters, supply fan, and outside, and return air dampers. The variable volume unit is equipped with a single heating/cooling coil, air filters, supply fan, and outside and return air dampers. The minimum position on the outside air dampers is set at 5% open unless the outside air humidity levels are high. During periods of high humidity, the facilities staff closes the outside air dampers. According to the facilities staff, the minimum outside air damper position is fixed at 5% during unoccupied hours to provide ventilation for the intermittently occupied building.

Classrooms in MeWaldt Jensen are served by unit ventilators connected to the two-pipe change over system.

A project to upgrade the science classrooms in is progress.

Two VAV air handling units are located in the penthouse of the technology center and serve all floors of the new wing. Each unit has a hydronic heating coil, chilled water coil, air filters, supply fan, return fan, and outside, return and relief air dampers

MeWaldt Jensen facility has a Johnson Controls DDC system with pneumatic actuators, while the Technology Center has a fully integrated DDC system.

Domestic hot water is generated with electric water heaters in the Technology Center and with an instantaneous steam heater in MeWaldt Jensen.

The building envelope is constructed of aluminum framed windows, and masonry block with exterior face brick. The Technology Center addition exterior is primarily full height curtain wall. The roofing for the original 1961 area is original to the construction.

The majority of the MeWaldt Jensen building uses two, three or four lamp T-8 fixtures. The basement areas use primarily 150watt incandescent fixtures. The Technology Center addition is lit by T-8, T-5 and compact fluorescent fixtures. In the exterior corridor space there is no means of daylighting control to adjust lighting levels in the space. There is no lighting control system installing in the building and the majority of the lighting is controlled locally by wall switches. Select areas in the Technology Center utilize occupancy sensors to control lighting.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at MeWaldt-Jensen / Technology Center								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$11,730	9	28,506		$798	14.7	
5.1.3	Install Motion Sensors to Control Lighting	$1,840		8,476		$237	7.8	3
5.1.11	Implement Daylighting Controls	$1,150		7,889		$221	5.2	4
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$4,490		12,392	197	$502	8.9	
5.3.8	Schedule AHUs Off During Unoccupied Hours	$2,420		119,449	4,176	$6,623	0.4	
5.3.13	Demand Control Ventilation	$10,930		2,881	273	$295	37.1	
	TOTAL	**$32,560**	**9**	**179,593**	**4,647**	**8,676**	**3.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure pertains to office lighting being off an additional 2 hours per day.
4. Measure pertains to lighting located in North Corridor at curtain wall in the Tech Center.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.3.7. Student Center

Building Overview

The building was originally built in 1960 and was most recently renovated and expanded in 1999 for a total square footage of 42,350.Now called the Student Center, the remodeled and expanded building houses all student services related offices as well as the University Bookstore, campus post office, Student Center Gallery, dining hall, student game and activities room, and several meeting rooms.

Students and employees occupy the building from 7:00 am to 10:00 pm on weekdays, however the building is intermittently occupied during nights and weekends by staff. The HVAC systems are operated in occupied mode 24 hours/day, 7 days per week to maintain temperature and humidity control.

High pressure steam (40 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate heating water for the building through two converters. Each converter has a pair of redundant pumps which distribute heating water (30% propylene glycol mixture) to finned tube radiators, VAV reheats, and air handling unit coils. The 7-1/2 hp pumps and

converter serving the finned tube and AHU coils are enabled to operate when the outside air is below 60F, while the 3/4 hp pumps and converter serving the VAV reheats are operational throughout the year. The triple duty valves on the radiation pumps and reheat pumps are fully open. The 7-1/2 hp pump motors are premium efficiency while the ¾ hp motors are both standard efficiency.

Cooling is provided by one 164 ton air cooled McQuay chiller which is original to the 1999 remodel. One 15 hp pump circulates chilled water through the chiller and air handling unit coils. The chiller and pump are enabled to operate when the outside air temperature is above 60F.Once enabled, the chilled water pump operates at constant speed while 3-way chilled water valves on the air handling unit coils modulate to maintain their respective discharge air temperature setpoints. The triple duty valve on the chilled water pump is fully open and has a premium efficiency motor.

Six air handling units provide cooling and ventilation to the facility. Five of the units are constant volume, single zone units. One unit is variable volume. Each of the units are equipped with chilled water cooling coils, hydronic heating coils, air filters, supply fans, return fans, and outside, return and relief air dampers. The minimum position on the outside air dampers is set at 15% open unless the outside air humidity levels are high. During periods of high humidity, the facilities staff closes the outside air dampers. According to the facilities staff, the minimum outside air damper position is fixed at 15% during unoccupied hours to provide ventilation for the intermittently occupied building.

The facility has a Johnson Controls DDC system with electronic actuation.

Domestic hot water is generated with low pressure steam.

The building envelope is constructed of aluminum framed operable windows, and masonry block with exterior face brick. The roofing is comprised of a fully adhered membrane roof which was upgraded in 1999 with the remodel project.

The lighting in the Student Center is primarily fluorescent T-8 fixtures. Large atrium areas are lit by 400watt metal halide lamps along with compact fluorescent down lighting. Corridor spaces also utilize two lamp 42watt and 26watt compact fluorescent fixtures to provide lighting. The lower level deli and venue area is lit by 200watt incandescent lamps which are on a dimmer switch to adjust light levels during events. These lamps are typically on at full light output.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Student Center								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$2,420	2	9,037		$253	9.6	
5.1.3	Install Motion Sensors to Control Lighting	$4,030	-	8,374		$234	17.2	6
5.1.3	Replace Incandescent Lamps with Compact Fluorescent	$460	5	22,105		$619	0.7	7
5.3.3	Install VFDs on Hydronic Pumps	$2,760		23,023		$645	4.3	3,4
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$9,090		214,770	3,859	$9,043	1.0	
5.3.8	Schedule AHUs Off During Unoccupied Hours	$5,750		311,767	6,298	$13,673	0.4	5
5.3.13	Demand Control Ventilation (CO2 Control)	$29,560		(2,289)	3,591	$2,755	10.7	
5.5.3	Intellihood Kitchen Hood Controls System	$14,260		7,339	3,547	$2,990	4.8	
	TOTAL	**$68,330**	**6**	**594,127**	**17,295**	**30,212**	**2.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure is based on installing VFDs on chilled water pump and one 7.5 hp heating pump.
4. Measure assumes that perimeter radiation system operates with 2-way valves and air handling unit 3-way valves can be converted to 2-way.
5. Measure assumes that current exhaust rates in the building would allow for air handling units to close outside air dampers beyond 15%.
6. Measure assumes that motions sensors installed in office and classroom areas would allow lighting to be off for an additional 3 hours per day when they were left on before.
7. Measure applies to dimmable fixtures located in coffee shop area.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.3.8. Williams Library

Building Overview

The facility houses the instructional technology center as well as the NSU-TV and NSU-RDTN studios. The 70,000 square foot facility can seat 400 students comfortably and includes eight group study rooms, multi-media study stations and shelf space to accommodate growth for the next 20 years. The library underwent a major addition and renovation in 1995.

Students and employees occupy the building from 6:00 am to 11:00 pm on weekdays, however the building is intermittently occupied during nights and weekends by staff. The HVAC systems are operated in occupied mode 24 hours/day, 7 days per week to maintain temperature and humidity control.

High pressure steam (40 psi) is brought into the facility at two locations. The south steam service is reduced to low pressure steam (15 psi) in the basement mechanical room where it is used for the air handling unit coil. The north steam service is reduced to low pressure steam (15 psi) in the penthouse where it is used to generate heating water for the building. The converter has two pumps (one redundant) which distribute heating water (30% glycol) to finned tube radiators and the multizone unit heating coils. The 7-1/2 hp pumps and converter are enabled to operate when the outside air is below 55F. The triple duty valves on the pumps are 100% open. The pump motors are all high efficiency.

Cooling is provided by one McQuay 155 ton air cooled chiller which was installed in 1995.One 15 hp pump circulates chilled water through the chiller and air handling unit coils. The chiller and pump are enabled to operate when the outside air temperature is above 60F.Once enabled, the chilled water pump operates at constant speed while 3-way chilled water valves on the air handling unit coils modulate to maintain their respective discharge air temperature setpoints. The triple duty valve on the chilled water pump is 100% open. The chilled water pump has a premium efficiency motor.

Four air handling units provide cooling and ventilation to the facility. One of the units is a constant volume, single zone unit, while three of the units are constant volume multi-zone. The constant volume single zone unit is equipped with a chilled water cooling coil, steam heating coil, air filters, supply fan, and outside, return and relief air dampers. Each of the multi-zone units are equipped with chilled water cooling coils, hydronic heating coils, air filters, supply fans, return fans, and outside, return and relief air dampers. The minimum position on the outside air dampers is set at 15% open unless the outside air humidity levels are high. During periods of high humidity, the facilities staff closes the outside air dampers. According to the facilities staff, the minimum outside air damper position is fixed at 15% during unoccupied hours to provide ventilation for the intermittently occupied building.

The facility has a Johnson Controls DDC system with pneumatic actuators.

Domestic hot water is generated with electric water heaters.

The building envelope is constructed of aluminum framed operable windows, and masonry block with exterior face brick. The roofing for the original 1955 area was upgraded in 2009.

The building is primarily lit by two and four lamp 32watt T-8 fixtures. The “Reading Room” uses both 150watt metal halide and 300watt halogen lamps as well as having large windows providing natural daylight. Lighting levels in some areas of the library were between 100 and 140 foot candles.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Williams Library								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Lieu of 32W	$4,830	10	61,183		$1,713	2.8	
5.1.2	Delamp Multiple Lamp Fixtures	$0	13	77,222		$2,162	0.0	
5.1.9	Install Scheduling Control of Lighting	$34,730		144,975		$4,059	8.6	
5.1.11	Implement Daylighting Controls	$4,140		47,719		$1,336	3.1	3
5.3.7	Convert Multizone/Dual Duct to VAV	$88,320		167,306	12,626	$14,596	6.1	
5.3.8	Schedule AHUs Off During Unoccupied Hours	$2,420		113,497	14,178	$14,307	0.2	
	TOTAL	$134,440	23	611,902	26,804	38,174	3.5	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure assumes that lighting at exterior walls and in Reading Room can be controlled off an additional 9 hours per day.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

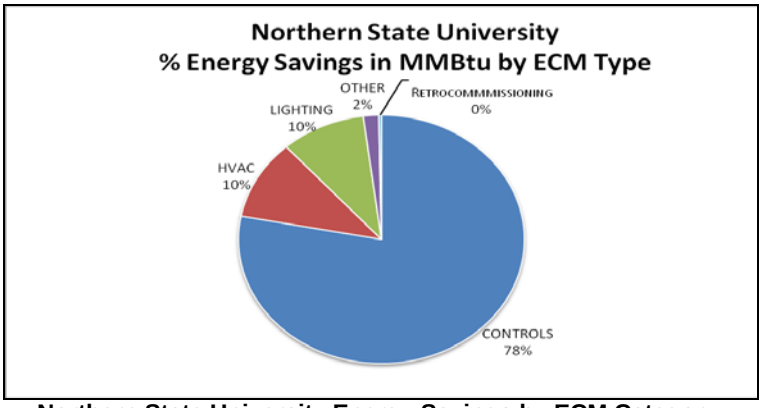
4.2.3.8.1. Campus Summary

A total of 59 ECMs were identified at Northern State University buildings, which include 30,362 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $916,920, and save an estimated $238,282 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

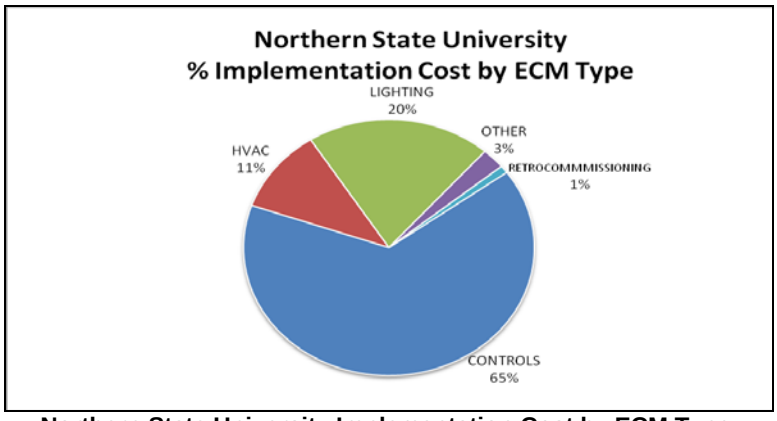
Northern State University ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	9,312	14,375	**23,687**	$185,568	$599,210	**3.2**
HVAC	295	2,861	**3,156**	$24,144	$97,310	**4.0**
LIGHTING	2,901	0	**2,901**	$23,808	$187,960	**7.9**
OTHER	25	502	**527**	$4,020	$23,810	**5.9**
RECOMMISSIONING	90	0	**90**	$742	$8,630	**11.6**
Total	**12,624**	**17,738**	**30,362**	**$238,282**	**$916,920**	**3.8**

In total, these savings represent a 25% reduction from current energy consumption at the Northern State University campus, the majority of which is attributed to controls measures which will reduce electric & natural gas consumption.



Northern State University Energy Savings by ECM Category.



Northern State University Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 25,223 MMBTUs (21% of campus energy use) and a total estimated annual cost avoidance of $197,712. The total cost of implementation for these measures is $488,340, which yields a simple payback of 2.5 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Barnett Center	5.3.8	$0	2,433	$19,062	0.0	0.00
Johnson Fine Arts Center	5.1.2	$0	51	$417	0.0	0.00
Library	5.1.2	$0	263	$2,162	0.0	0.00
Library	5.3.8	$2,420	1,853	$14,307	0.2	1.31
Johnson Fine Arts Center	5.3.8	$3,680	1,373	$10,983	0.3	2.68

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
MeWaldt Jensen - Tech Center	5.3.8	$2,420	839	$6,623	0.4	2.88
Student Center	5.3.8	$5,750	1,715	$13,673	0.4	3.35
Student Center	5.1.8	$460	75	$619	0.7	6.10
Gerber Building	5.3.8	$1,270	209	$1,683	0.8	6.09
Student Center	5.3.4	$9,090	1,132	$9,043	1.0	8.03
Jerde Hall	5.3.8	$2,420	239	$1,943	1.2	10.10
Johnson Fine Arts Center	5.4.41	$1,610	143	$1,170	1.4	11.30
Jerde Hall	5.3.8	$7,020	592	$4,545	1.5	11.87
Jerde Hall	5.4.41	$350	26	$212	1.7	13.56
Barnett Center	5.3.4	$83,720	4,643	$36,617	2.3	18.03
Library	5.1.1	$4,830	209	$1,713	2.8	23.14
Library	5.1.11	$4,140	163	$1,336	3.1	25.43
Barnett Center	5.4.41	$1,840	70	$576	3.2	26.19
Central Plant	5.4.26	$87,290	2,861	$21,724	4.0	30.51
Student Center	5.3.3	$2,760	79	$645	4.3	35.13
Johnson Fine Arts Center	5.3.4	$54,280	1,499	$12,004	4.5	36.20
Student Center	5.5.5	$14,260	392	$2,990	4.8	36.40
Gerber Building	5.4.41	$350	9	$71	4.9	40.58
MeWaldt Jensen - Tech Center	5.1.11	$1,150	27	$221	5.2	42.73
Barnett Center	5.1.11	$1,150	26	$209	5.5	45.08
Jerde Hall	5.3.7	$23,000	532	$4,159	5.5	43.20
Barnett Center	5.3.13	$84,640	1,892	$14,389	5.9	44.74
Central Plant	5.1.1	$120	2	$20	5.9	48.68
Library	5.3.7	$88,320	1,876	$14,596	6.1	47.07
TOTAL		**$488,340**	**25,223**	**$197,712**	**2.5**	**19.36**

4.2.4 South Dakota School for the Blind and Visually Impaired

Campus Background and List of Facilities

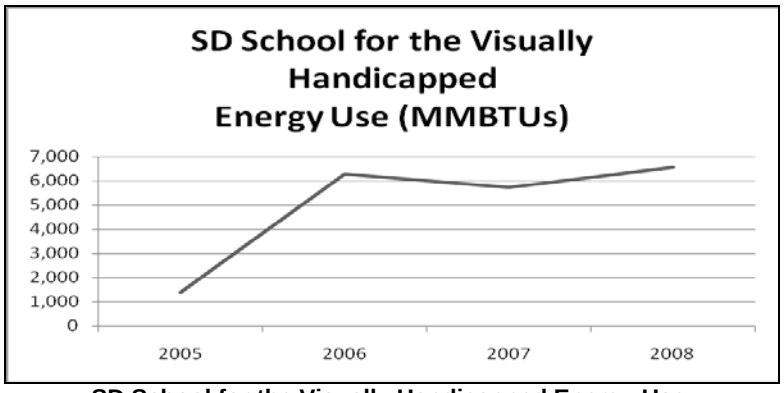
(See Building Description).

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, SD School for the Visually Handicapped facilities consumed a combined 6,563 MMBTUs of energy. The average Energy Use Intensity across the campus was 100 kBTU/SF in 2008.



SD School for the Visually Handicapped Energy Use.

4.2.4.1. South Dakota School for the Blind and Visually Impaired

Building Overview

The SD School for the Blind and Visually Impaired was constructed in 1961. The gymnasium addition was added in 1968 which increased the total square footage to 65,000.The school holds classes on weekdays from 9am to 3pm during the regular school year. The facility has 20 employees on staff and also houses 35 students in the dormitories.

During the summer months, classes are held from 9 am to 3 pm with the exception of the 4th of July week. Enrollment increases to 60 students during the summer months due to students participating in summer programs.

Central heating is supplied two 225 Hp (7,531 MBH) scotch marine boilers which provide heating water to finned tube radiators, unit ventilators, unit heaters, and air handling unit coils throughout the facility. The boilers were installed in 1961 and 1968 as part of the original construction and the gymnasium addition respectively. The 1961 boiler operates solely on fuel oil while the 1968 boiler operates solely on natural gas. The physical plant manager alternates the use of these boilers during the heating season.

Heating and ventilation for the classrooms, offices and dormitories is provided with hydronic finned tube radiation and unit ventilators. Each boiler has a 2 hp primary circulation pump, while heating hot water is distributed by three ¾ hp secondary pumps to one of three heating loops. Tertiary pumps are used to distribute heating water to the terminal units. The tertiary pumps are either cycled on/off based on the space temperature or enabled based on the status of the boiler plant. In situations where the tertiary pumps are operated based on the status of the heating plant, temperature control is maintained by cycling the unit ventilator fan on/off or by a two-position control valve in the finned tube radiation. There are 23 tertiary pumps ranging in size from 1/12 hp to 1/6 hp. Night setback was accomplished with the use of a dedicated night thermostat for each building area. The unoccupied heating setpoint for these areas was 60F.

Air conditioning is provided by 53 window mounted air conditioning units located throughout the facility. Each of these units is controlled locally with a unit mounted temperature dial and selector switch.

The building envelope is constructed of aluminum framed glass and insulation filled masonry block with exterior face brick. The roofing is comprised of a combination adhered and floating membrane insulated roof.

The offices, corridors, and classrooms are lit by two lamp, 32 watt, T-8 fixtures with electronic ballasts throughout the facility. All of these fixtures are manually controlled via wall mounted light switch. Task lighting is also used in some office areas on an as needed basis. The gymnasium is lit by fourteen 250 watt metal halide fixtures, which are manually controlled. Exit lighting has been completely converted to LED fixtures.

ECM's

Previously Implemented ECMs

- The boiler burners were replaced in 1999 to high efficiency burners.
- The roof was replaced in 2000 with a membrane roof with high R-value insulation.
- Eight steel exterior doors were replaced with store front, thermally broken, double pane insulated glass in 2001.
- Garage doors were replaced with insulated metal units in 2002.
- Power factor correction was implemented on all electrical sub-panels in 2003.
- Exterior lighting was replaced in 2004 from incandescent to fluorescent fixtures with photocells.
- Gas fired domestic water heaters were installed in 2004 to replace the heating water heat exchanger from the boiler.
- Pneumatic boiler controls were replaced in 2005 with DDC controls with outside air reset.
- Eighteen of the plate glass windows were replaced in 2006 with double pane, insulated low-E glass.
- All interior incandescent and fluorescent fixtures were replaced in 2007 with T-8 lamps with electronic ballasts.
- 26 of the original heating pumps were replaced in 2008 with higher efficiency pump, eliminating the need for balancing valve restrictions.

Opportunities for ECMs at the South Dakota School for the Blind and Visually Impaired

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8's in Lieu of 32W	$2,420	2	6,140		$583	4.1	2
5.1.1	Install 25W or 28W T-8's in Lieu of 32W	$690	1	2,063		$196	3.5	5

Opportunities for ECMs at the South Dakota School for the Blind and Visually Impaired								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.10	Replace HID Lighting with High Bay Fluorescent	$3,910	3	6,801		$646	6.1	
5.1.11	Implement Daylighting Controls	$1,270		1,486		$141	9.0	
5.4.1	Replace Firetube Boilers with Condensing	$113,850			4,788	$3,850	29.6	4
5.4.9	Replace Window AC Units with Heat Pumps	$23,920		17,852		$1,696	14.1	
5.4.33	Install a Summer Boiler so Large Boilers are not Required in Cooling Months	$108,910			3,045	$2,448	44.5	7
5.4.42	Replace Motors with Premium Efficiency at end of Useful life	$460		584		$55	8.3	6
5.5.2	Replace Storage Type Domestic Water Heaters with on Demand	$4,370			135	$108	40.4	4
5.5.20	Replace Standard Efficiency Hot Water Heater with High Efficiency	$5,750			46	$37	154.0	4
	TOTAL	**$265,550**	**6**	**34,927**	**8,014**	**9,762**	**27.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Savings and economics based on 200 T832W fixtures that can be re-lamped with 25W bulbs in nonresident spaces.
3. Measure pertains to areas surrounding central courtyard where curtain wall windows are installed.
4. Economics based on incremental cost increase to install high efficiency units at end of useful life of existing equipment.
5. Savings and economics based on 60 T832W fixtures that can be re-lamped with 25W bulbs in residence halls
6. Economics based on incremental cost to install premium efficiency motors on Boiler Primary Pumps at end of life in lieu of code efficiency motors.
7. Measure is based on using condensing boilers to handle building loads during shoulder months.

Estimated Blended Marginal Rates		
$	0.10	/kWh Elec
$	0.80	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

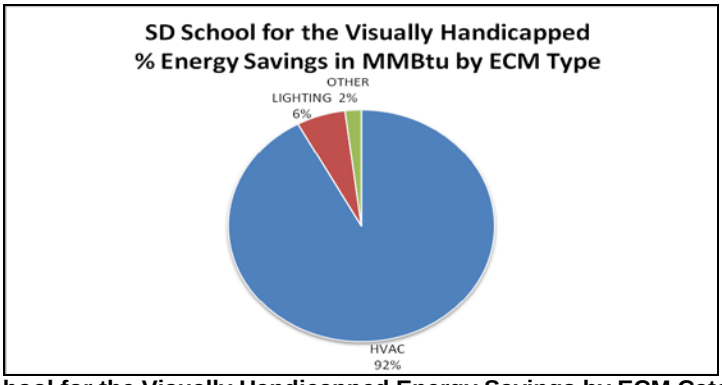
4.2.4.1.1. Campus Summary

A total of 10 ECMs were identified at SD School for the Visually Handicapped buildings, which include 948 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $265,550, and save an estimated $9,762 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

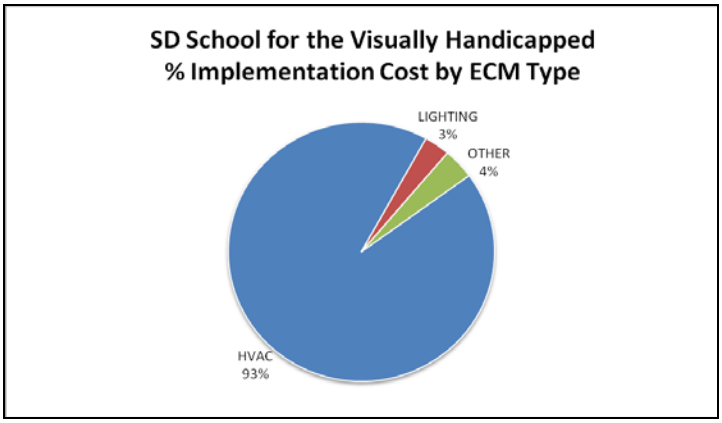
BOR ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
HVAC	63	810	**873**	$8,049	$247,140	**30.7**
LIGHTING	56	0	**56**	$1,567	$8,290	**5.3**
OTHER	0	19	**19**	146	$10,120	**69.5**
Total	**119**	**829**	**948**	**$9,762**	**$265,550**	**27.2**

In total, these savings represent a 14.5% reduction from current energy consumption at the SD School for the Visually Handicapped campus, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



SD School for the Visually Handicapped Energy Savings by ECM Category.



SD School for the Visually Handicapped Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 51 MMBTUs (1% of campus energy use) and a total estimated annual cost avoidance of $1,425. The total cost of implementation for these measures is $7,020, which yields a simple payback of 4.9 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
SD School for the Visually Handicapped	5.1.1	$690	7	$196	3.5	98.02
SD School for the Visually Handicapped	5.1.1	$2,420	21	$583	4.1	115.51
SD School for the Visually Handicapped	5.1.10	$3,910	23	$646	6.1	168.49
TOTAL		**$7,020**	**51**	**$1,425**	**4.9**	**137.12**

4.2.5 South Dakota School for the Deaf

Campus Background and List of Facilities

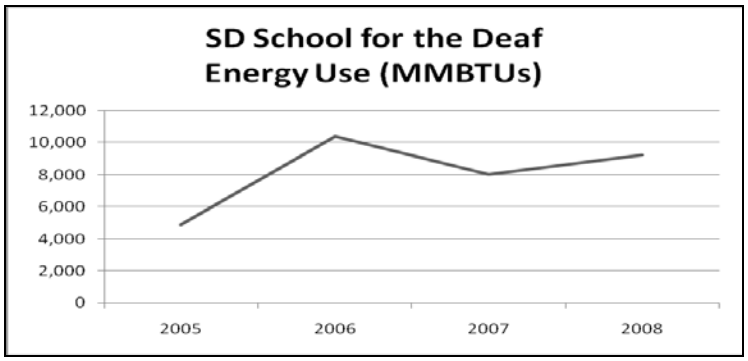
The basement of the Recreation Center houses the campus boilers. Two gas-fired 2,511 MBH Hurst Firebox boilers provide steam, which is converted to hot water in each building, to the campus. The campus includes the Berry/Wright Educational Facility, the Dormitory, and the Recreation Center (Gym & Pool).

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, SD School for the Deaf facilities consumed a combined 9,237 MMBTUs of energy. The average Energy Use Intensity across the campus was 94 kBTU/SF in 2008.



SD School for the Deaf Energy Use.

4.2.5.1. Berry / Wright Educational Facility

Building Overview

The Educational Facility was constructed in 1979 and is approximately 63,000 square feet. The building primarily serves as administration offices and classrooms. There are approximately 35 workers and 6 students that maintain a M-F 8-5 schedule.

Two constant volume cooling only air handlers with supply and return fans provide ventilation for the building. The building is heated by hot water radiation panels. A steam-to-hot water converter that takes steam from the boilers located in the basement of the gym and converts it to hot water for the radiation panels. Two 2 hp hot water pumps are constant speed. Two air cooled condensing units located outside provide the refrigeration for cooling. It was reported that the older McQuay (approximately 78 tons) condenser leaks and is in need or replacing. Zones have one thermostat for control, which has the potential to heat and cool simultaneously. Controls are pneumatic. There is an old JCI Metasys control system but how

to interface it is a question. It was reported that at one time the air handlers were attempted to be put into a night setback but the building didn't recover in time so the units now run 24/7.

Lighting is primarily 4ft 4-lamp F34T12 and 2ft T12 U-lamp. Lights are on toggles and are shut off by maintenance staff at the end of the day. There are some 75W incandescent display lights. Exit signs are incandescent.

Exterior is brick. Roof is flat and covered with rock. Roof is original but no reports of any leaking. Windows are double pane with shades.

ECM's

Previously Implemented ECMs

No recent ECMs to report

Opportunities for ECMs at the Berry / Wright Educational Facility

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.3	Install Motion Sensors to Control Lighting	$14,260	-	27,554		$2,259	6.3
5.1.5	Replace Incandescent Exit Signs with LED	$4,050	0.9	7,464		$612	6.6
5.1.6	Replace Incandescent Spot Lighting with Ceramic Metal Halide	$120	0.5	1,579		$129	0.9
5.1.7	Retrofit T-12 Fixtures with T-8s	$11,475	9.3	28,793		$2,361	4.9
5.3.9	Upgrade Controls System to Full DDC	$276,000	33.6	107,239	1,729	$10,301	23.3
5.4.3	Replace Dump Boxes with VAVs	$20,930	8.6	146,847		$12,041	1.7
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$152,610	30.8	183,764	2,594	$17,331	8.8
	TOTAL	**$479,445**	**84**	**503,239**	**4,323**	**$45,035**	**10.6**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.082	/kWh Elec
$	0.872	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.5.2. Dormitory

Building Overview

The Dormitory was constructed in 1963 and is approximately 15,870 square feet. The building is not occupied. May 2009 the last couple of tenant offices were moved into the school and this building has been occupant free since.

Because the building is empty it is heated to 50°F and isn't being cooled. One of twelve fan coil units is energized to move some air to prevent stratification. The building is otherwise heated by hot water baseboard radiation and heating coils within the fan coil. There is a steam-to-hot water converter that takes steam from the boilers located in the basement of the gym and converts it to hot water for the radiation terminal devices. Two 1 hp hot water pumps are constant speed. A 40 ton McQuay chiller provides chilled water to the twelve fan coil units. The fan coils operate in an either/or fashion where it is either hot water or chilled water piped through the coil and switchover is manual. Each zone has one thermostat.

Controls are pneumatic. Domestic hot water is provided by two 30 kW electric water heaters.

Lighting is primarily 4ft 4-lamp F34T12 and 2ft T12 U-lamp. Lights are on toggles. Exit signs are incandescent.

One wing's exterior is brick and precast concrete the others are block and vinyl siding. Roof is pitched and either asphalt with rock cover or shingles. Roof and soffit is old and in poor condition. The roof is scheduled to be replaced by 2011.Windows and exterior doors were replaced May 2009.Windows are double pane with shades.

ECM's

Previously Implemented ECMs

Management moved personnel out of building May 2009 to allow for temperature setback.

Opportunities for ECMs at Dormitory

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$7,570	2.1	9,232		$757	10.0
5.3.9	Upgrade Controls System to Full DDC	$115,000	14.6	33,147	535	$3,185	36.1
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$10,580		61,181		$5,017	2.1
	TOTAL	**$133,150**	**17**	**103,560**	**535**	**8,959**	**14.9**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.082	/kWh Elec
$	0.872	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.5.3. Recreation Center

Building Overview

The Recreation Center building size is approximately 15,870 square feet. The building has been shut down since 2007 as it is presently undergoing a major renovation in order to be leased out to the community. However, the project has been put on hold due to re-evaluation of the buildings structural integrity.

The construction documents show that the gym is to receive a new air handler to be installed to provide ventilation. The pool area is heated by parameter radiation. Two old Trane air handlers (2 & 5 hp) provide ventilation for the pool. In the basement of the gym houses the campus boilers. There is a steam-to-hot water converter that takes steam from the boilers and converts it to hot water for the perimeter radiation in the pool and the air handlers heating coils. Two 3 hp hot water pumps are constant speed. Domestic hot water is provided by a 4.5 kW electric water heater and a 120 gallon gas fired water heater.

Lighting in the gym and pool area is primarily 8ft 2-lamp T-12s.Lighting is controlled by toggle switches. Both gym and pool area have a good amount of natural lighting.

The gym's exterior is mostly stone. The pool's exterior is brick. The roof of the gym is curved and white. The pool's roof is flat and off-white.

ECM's

Previously Implemented ECMs

The current renovation project has new air handlers and lights to be installed. Project has been put on hold.

Opportunities for ECMs at Recreation Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,140	4.9	17,123		$1,404	2.9
5.3.9	Upgrade Controls System to Full DDC	$130	0.8	2,702		$222	0.6
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$74,750	2.2	17,034	1,592	$2,785	26.8
5.1.7	Retrofit T-12 Fixtures with T-8s	$69,000	0.2	29,860	2,388	$4,531	15.2
		$148,020	**8**	**66,718**	**3,980**	**$8,941**	**16.6**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.082	/kWh Elec
$	0.872	/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

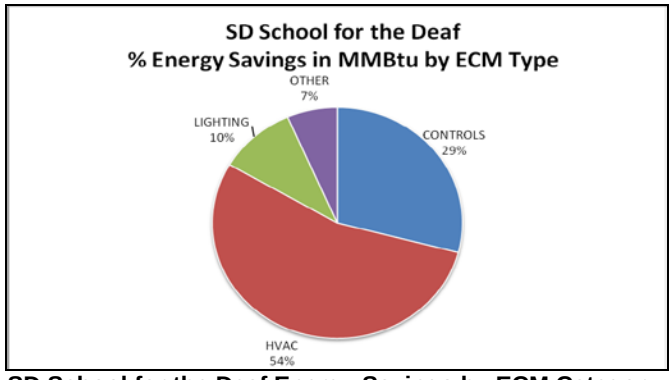
4.2.5.3.1. Campus Summary

A total of 14 ECMs were identified at SD School for the Deaf buildings, which include 3,212 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $760,615, and save an estimated $62,935 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

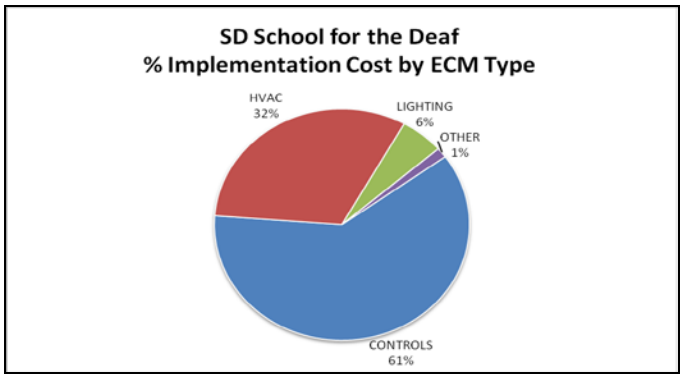
BOR ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	537	399	**936**	$16,271	$465,750	**28.6**
HVAC	1,230	515	**1,745**	$33,903	$242,540	**7.2**
LIGHTING	322	0	**322**	$7,745	$41,745	**5.4**
OTHER	209	0	**209**	$5,017	$10,580	**2.1**
Total	**2,298**	**914**	**3,212**	**$62,935**	**$760,615**	**12.1**

In total, these savings represent a 35% reduction from current energy consumption at the SD School for the Deaf campus, the majority of which is attributed to HVAC measures which will reduce natural gas & electric consumption.



SD School for the Deaf Energy Savings by ECM Category.



SD School for the Deaf Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 881 MMBTUs (10% of campus energy use) and a total estimated annual cost avoidance of $21,174. The total cost of implementation for these measures is $47,375, which yields a simple payback of 2.2 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Recreation Center	5.1.8	$130	9	$222	0.6	14.10
Berry/Wright Educational Facility	5.1.6	$120	5	$129	0.9	22.27
Berry/Wright Educational Facility	5.4.3	$20,930	501	$12,041	1.7	41.77
Dormitory	5.5.1	$10,580	209	$5,017	2.1	50.68
Recreation Center	5.1.7	$4,140	58	$1,404	2.9	70.86
Berry/Wright Educational Facility	5.1.7	$11,475	98	$2,361	4.9	116.80
TOTAL		**$47,375**	**881**	**$21,174**	**2.2**	**53.77**

4.2.6 South Dakota School of Mines

Campus Background and List of Facilities

The South Dakota School of Mines is home to approximately 2,000 students and 100 faculty members that occupy approximately 20 major buildings. Buildings visited during an August 2009 walkthrough are included in this report. Due to walkthrough time constraints, not all campus buildings are presented.

Campus-Wide Systems and Operational Profile

The South Dakota School of Mines utilizes both district heating and cooling for most campus buildings. Both the campus steam and chilled water systems run continuously throughout the year. On most buildings, neither steam usage nor chilled water usage is monitored by the central DDC system.

Most major HVAC systems are connected to the Johnson Controls Metasys central DDC system. While some systems still have partial or full local controls, the DDC system has the ability to schedule, override setpoints, and setback temperatures during unoccupied periods for most buildings on campus. Air handling units, including those recently installed, do not utilize an optimum start or a special morning warm-up sequence. The existing control system does not have graphical representation of points, and graphing trends is tedious. The newest version of Johnson Controls is being installed for the Surbeck Student Union, and upgrades are planned for the remaining buildings.

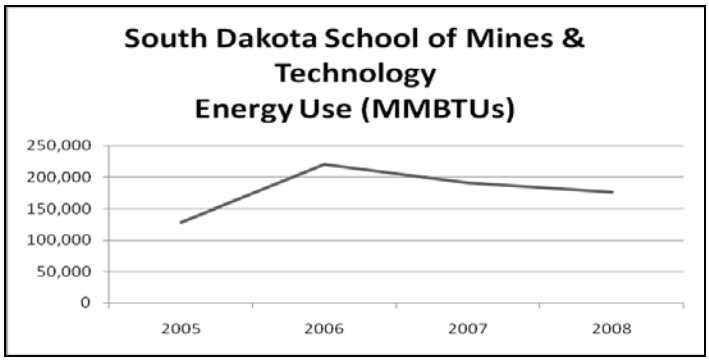
The central DDC system also has an interface for measuring peak electrical demand in major buildings, and also provides a campus wide total for peak demand. Each building's (and total campus) electrical usage is also tracked via the DDC system and recorded on a monthly basis.

There is no central DDC lighting control on campus. Exterior lights, which are a mix of metal halide, high pressure sodium, and mercury vapor, are controlled using photocells or manual time clocks. The time clocks are adjusted monthly to account for changes in sunrise and sunset times. All exit signs on campus have been converted to LED. Incandescent lights have been eliminated campus wide, except in select back of house areas which are rarely used.

The school has applied for stimulus funding of several energy saving projects. These projects include a new campus wood fired boiler; lighting upgrades to the O'Harra Building, McLaury Building, Boiler Plant, and King Center; and new windows for the McLaury Building.

Energy Profile

In 2008, South Dakota School of Mines & Technology facilities consumed a combined 175,891 MMBTUs of energy. The average Energy Use Intensity across the campus was 272 kBTU/SF in 2008.



South Dakota School of Mines & Technology Energy Use.

4.2.6.1. Boiler Plant

Building Overview

The Boiler Plant occupies 6,408 square feet and houses the boiler plant, chilled water plant, and emergency generator. The brick envelope appears to be in fair condition, but the single paned windows are in somewhat poor condition.

Two large boilers, one Kewanee 750 hp and one Superior 500 hp, provide low pressure steam for campus heating. Some buildings also use the steam for domestic hot water heating. The older Kewanee boiler has no modulating burner but was in operation during an August 2009 walkthrough. The Superior boiler was installed in 2006, but control issues with its modulating burner have left it mostly unused. Most air handling unit coils on campus, and a few unit heaters and baseboard radiators, use direct steam. Reheat coils and most unit heaters utilize hot water generated via steam to hot water heat exchangers. Some buildings also utilize steam for domestic hot water generation. Because some heating loads exist during the summer, the steam boiler plant runs continuously, even during the summer. During summer operation, older steam boilers are likely inefficient because steam is generated, but very few loads exist on the system. Another Kewanee 50 hp boiler provides high pressure steam for various process and heating loads in select buildings.

Two 500 ton centrifugal chillers provide chilled water for the campus. The chilled water plant is sized for the addition of a third 500 ton chiller as existing and new buildings are added to the system. Two constant speed 25 hp primary pumps and two variable speed 125 hp secondary pumps operate in a lead/lag arrangement. Currently, the secondary loop maintains a flow of 1,000 GPM, but the reasoning behind this setpoint is unclear. Two constant speed 30 hp pumps serve the condenser water loop. The campus chilled water system runs continuously throughout the year. Most buildings also utilize a chilled water booster pump at each building. These local chilled water pumps are automatically bypassed during low load periods when the central plant pumps are adequate to serve the buildings.

The chilled water system is also equipped with a water side economizer for free cooling when outside air temperatures allow. The changeover between economizer and non-economizer mode has created some control issues, and currently, steam is actually used to heat the chilled water return during the changeover period.

One conditioned space is served by an air handler located in the building. The air handler is equipped with a variable frequency drive (VFD), but no controls were ever installed. The drive has been operated in “HAND” at 51% speed since installation.

The chiller plant and boiler plant areas are conditioned using steam unit heaters. Ceiling exhaust hoods do have backdraft dampers. However, one section was manually held open using a chain, and another appeared to be permanently damaged and was stuck partially open.

Lighting for the plant area is provided by a combination of high pressure sodium and mercury vapor lamps. These lights are manually controlled.

ECM's

Previously Implemented ECMs

A new steam boiler with modulating burners was installed in 2006, but has been rarely used due to control issues. New chillers were installed in 2004 to reduce DX cooling and window air conditioners. The chilled water loop also utilizes variable speed secondary pumps. The three cooling tower fans also have variable speed drives.

The school has applied for stimulus money to fund a new wood-fired steam boiler and for new high bay fluorescent in lieu of HID lighting in the boiler plant.

Opportunities for ECMs at Boiler Plant

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings					Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms	Fuel Oil Gal	Biomass Tons			
5.1.10	Replace HID Lighting with High Bay Fluorescent	$20,000	7	63,668	-	-	-	$2,674	7.5	2
5.2.1	Full Retrocommissioning and Balancing Study	$50,000	-	100,000	11,145	160	-	$12,406	4.0	3,4
5.2.4	Program VFD Controls	$700	-	4,010	56	-	-	$208	3.4	
5.2.7	Investigate Chilled Water Minimum Flow Settings	$1,000	-	85,337	-	-	-	$3,584	0.3	5
5.2.12	Fix Boiler Operation	$6,000	-	-	37,052	-	-	$26,270	0.2	
5.3.10	Investigate Water Side Economizer Operation	$10,000	-	19,654	1,895	-	-	$2,169	4.6	
5.4.18	Install Backdraft Dampers on Exhaust Fans	$2,000	-	-	976	-	-	$692	2.9	
5.4.21	Install Biomass Fuel Boiler	$3,000,000	-	-	557,260	8,000	(6,369)	$155,537	19.3	6
	TOTAL	**$3,089,700**	**7**	**272,669**	**608,385**	**8,160**	**(6,369)**	**$203,541**	**15.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Stimulus project funding application pending.Costs and savings are those provided with application.
3. Assume 2% savings for natural gas and fuel oil.Assume 55,726 DKT annual usage for boilers and 8,000 gallons fuel oil.
4. Assume 2% savings for chiller electrical usage.Assume 5,000,000 kWh chiller electrical usage annually.
5. Reset minimum flow GPM and document.
6. Savings assume $40 per ton biomass.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.2. Chemistry/Chemical Engineering

Building Overview

The Chemistry/Chemical Engineering building occupies 36,941 square feet and is home to offices, laboratories, and classrooms. The red brick exterior appears to be in good condition, and the windows are operable.

Space conditioning for the building is characterized by a wide variety of systems. Despite its close proximity to the chiller plant, the building is not served by the campus chilled water system. The building is, however, served by the campus steam system.

One heating-only constant volume air handling unit serves a single classroom, but the unit is scheduled to run continuously during the week. One rooftop unit serves a lab, but was installed to avoid roof penetrations, so the ductwork runs from the roof, down the side of the building, and into the lab which it serves. Steam unit heaters provide heating for corridors. Cooling for offices and laboratories is provided using approximately 20 window air conditioners, sized between ½ and ¾ tons each. There are also several mini-split cooling units serving various spaces.

There are eight laboratory classrooms, each with two fume hoods. The fume hoods run continuously. While some hoods have continuous chemical storage, many hoods are left empty, both during non-classroom hours and during the summer. Facilities staff indicates that one to two laboratory classrooms are used during the summer. The hood exhaust is manually controlled. Makeup air ducts into the classrooms have pneumatically controlled dampers that change position, possibly based on fume hood operation. Makeup air is provided via a heating only unit with a variable frequency drive (VFD). During the August 2009 walkthrough, it did not appear that the makeup air unit was connected to the DDC system, thus, the VFD control strategy is unclear.

The majority of controls for the space are pneumatic. The DDC system has the ability to monitor some points and schedule units, although some units run continuously.

ECM's

Previously Implemented ECMs

The laboratory exhaust makeup air unit is equipped with a VFD, but the control strategy is unknown.

Opportunities for ECMs at Chemistry / Chemical Engineering Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$7,500		18,304		$769	9.8	2
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0		21,392	1,689	$2,096	Instant	3
5.3.11	Schedule Fume Hoods Off During Summer	$1,000	84	76,173		$3,199	0.3	4
5.4.8	Replace Window AC Units with Four Pipe Fan Coil Units	$750,000	16	22,360	9,696	$7,814	96.0	5
	TOTAL	$758,500	100	138,229	11,385	$13,878	54.7	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction of 200 fixtures and four fixtures per sensor.
3. Classroom unit AH-1.
4. Assume 16 Hoods, 800 CFM each.
5. Order of magnitude cost estimate. Includes controls connection of fan coil units to DDC system.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.3. Civil / Mechanical Engineering

Building Overview

The Civil/Mechanical Engineering building occupies 52,697 square feet and houses offices, classrooms, and laboratories. The light colored brick exterior appears to be in good condition. Approximately 15% of the total square footage is a new addition for computational mechanics and was built in 2007.

Campus steam enters the building and is converted to hot water. There are no longer any steam air handler coils, and direct steam is used only for a few corridor unit heaters. Steam is also used to satisfy most of the domestic hot water needs of the building. The new addition utilizes a small electric water heater.

The older portion of the building is served by an air cooled chiller. Because the existing chiller did not have the capacity to support the new addition and its server room, the new addition space is served by the campus chilled water loop. A booster pump runs when the outside air temperature is above 60° F. The new campus chilled water piping to the building is sized such that the older part of the building could also be added to the campus chilled water system.

The main areas of the older portion of the building are served by a penthouse air handling unit, which was installed in approximately 2002.The variable flow system utilizes inlet vanes for flow control. There are approximately ten additional constant volume, gas fired DX

rooftop units that condition various laboratory and classroom spaces. Most of the air handlers are scheduled on between 5 am and 6 pm, but RTU-2, and the RTUs serving the laser area and the friction stir weld area were scheduled to operate continuously at the time of the August 2009 walkthrough. Almost all of the pneumatic controls in the building have been converted to DDC.

The new addition is served by a variable volume rooftop unit with chilled water and hot water coils, as well as hot water reheat on its VAV boxes. Supply air, return air, and outside air are all directly measured. Carbon dioxide concentrations are monitored, but are not used to control outside air quantities.

The new addition server room utilizes a Liebert unit that rejects heat to the campus chilled water system. Because the Liebert unit does not utilize a local dry cooler, the chilled water plant, albeit using its water side economizer function in the winter, must run year round.

The new addition lighting is all T-8, as is the majority of the older part of the building. Some shop and laboratory areas contain a total of approximately 75 8', 2-lamp T-12 fixtures.

ECM's

Previously Implemented ECMs

The new addition was connected to the campus chilled water system, and the air handler features variable frequency drives with hot water reheat VAV terminal units. A variable air volume unit was installed in 2002.Most lighting has been converted to T-8.The roof was replaced in 2008.

Opportunities for ECMs at Civil / Mechanical Engineering Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$12,000	-	27,456	-	$1,153	10.4	2
5.1.12	Replace 8' Fixtures with 4' Fixtures	$7,500	4	12,870	-	$541	13.9	
5.2.1	Full Retrocommissioning and Balancing Study	$50,000	-	174,724	7,489	$12,648	4.0	
5.3.8	Schedule AHUs off During Unoccupied Hours	$0	-	95,055	4,960	$7,509	Instant	4
5.3.13	Demand Control Ventilation (CO2 Control)	$5,000	-	(177)	750	$524	9.5	5
5.3.15	Optimum Start Program	$1,000	-	1,887	134	$174	5.7	5
5.4.10	Centralize Cooling Systems with Chilled Water Plant	$100,000	22	34,034	-	$1,429	70.0	6, 7, 8
5.4.23	Install Dry Cooler	$15,000	-	242,622	-	$10,190	1.5	9
	TOTAL	**$190,500**	**26**	**588,471**	**13,332**	**$34,168**	**5.6**	

Notes	
1.	Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2.	Assume four hour per day reduction of 300 fixtures and four fixtures per sensor.
3.	Assume 10% savings on electric and gas. Electric and gas usage for the building determined on pro-rated campus usage.
4.	Laser and welding rooftop units.
5.	Penthouse and new addition rooftop units.
6.	Other operational benefits, including decreased maintenance requirements.
7.	Order of magnitude cost estimate.
8.	Building infrastructure for chilled water expansion already in place.
9.	Savings associated with shutting down chiller plant during winter.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.4. Classroom Building

Building Overview

The Classroom Building was constructed in 1993 and occupies 45,177 square feet.

Campus steam serves the building and is converted to heating hot water. Campus chilled water also serves the building. The heating hot water pumps are constant speed, and the chilled water pumps use variable speed drives. The chilled water pump triple duty valve was throttled to 20% open, and the pump VFD was running at 60 Hz at the time of the August 2009 walkthrough.

Approximately seven air handlers serve the building. The majority of the units utilize VFDs for varying airflows. Several small units use constant speed fans. During the walkthrough, the zone served by AH-5 appeared to be overcooled to 64° F with the unit supply duct static pressure setpoint satisfied.

The original controls were pneumatic, but have been upgraded with a DDC system overlay. At the time of the August 2009 walkthrough, most of the units were scheduled to run continuously.

Lighting is provided using T-8 fluorescent fixtures. Incandescent lamps illuminate the mechanical room. An art gallery on the first floor also uses approximately 25 100-Watt incandescent track lights.

The building envelope appears to be in good condition. The double paned windows are operable.

ECM's

Previously Implemented ECMs

The majority of air handling units has had VFDs installed. The chilled water pumps were converted to variable flow with VFDs, and air handling unit chilled water coils were converted from three-way to two-way by installing a valve on the bypass line for each coil.

Opportunities for ECMs at Classroom Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W of 28W T-8s in Lieu of 32W	$600	2	4,992	-	$210	2.9	2
5.1.3	Install Motion Sensors to Control Lighting	$3,000	-	9,152		$384	7.8	3
5.2.1	Full Retrocommissioning and Balancing Study	$30,000	-	74,739	3,203	$5,410	5.5	4
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0	-	70,208	1,843	$4,255	Instant	5
5.3.15	Optimum Start Program	$2,000	-	9,499	260	$583	3.4	5
5.4.29	Trim Impeller and Open Triple Duty Valve	$0	-	5,642	-	$237	Instant	6
	TOTAL	**$35,600**	**2**	**174,233**	**5,306**	**$11,079**	**3.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. 28W selected.
3. Assume four hour per day reduction of 100 fixtures and five fixtures per sensor.
4. Assume 5% savings on electric and gas. Electric and gas usage for the building determined on pro-rated campus usage.
5. All AHUs.
6. No impeller trim required. Open valve and allow VFD to compensate.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.5. Devereaux Library

Building Overview

The Devereaux Library occupies 56,661 square feet, including a basement and three floors above grade.

Campus steam is converted to heating hot water, and campus chilled water is also utilized. Both chilled water and hot water pumps are constant volume. A single air handling unit with a VFD serves the entire building, although only the third floor, which was recently renovated, has VAV boxes. The basement and first and second floors are supplied by a relatively constant volume of air. The mechanical room serves as the mixed air plenum. The outside air dampers are damaged and, and the dampers are inoperable. As a result, only a small amount

of outside air enters the buildings. The air handling unit is scheduled for occupied and unoccupied modes.

There are several incandescent exterior lights, as well as miscellaneous can and track lights inside the building. In the basement and on the first and second floors, there is a one-lamp T-8 (converted from T-12) gypsum board light fixture per 2'x4' lay-in ceiling grid. As a result, these floors are significantly overlit to115 foot-candles at all occupied times, even during periods of low occupancy. The third floor has undergone a lighting and ceiling renovation where T-8 pendant lights have been installed. All lights are controlled manually.

The windows are double paned and are in fair condition.

ECM's

Previously Implemented ECMs

VFDs have been installed on the air handling unit and two return fans.VAV boxes have been installed on the third floor. Lighting has been converted to T-8, and pendant lighting has been installed on the third floor.

Opportunities for ECMs at Devereaux Library								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.15	Overhaul Library Lighting	$300,000	60	411,840	-	$17,297	17.3	2
5.3.3	Install VFDs on Hydronic Pumps	$5,000	-	10,495	-	$441	11.3	
5.3.13	Demand Control Ventilation (CO2 Control)	$10,000	-	-	3,018	$2,140	4.7	3
5.4.36	Install VAV Boxes	$100,000	-	117,336	1,368	$5,898	17.0	
	TOTAL	**$415,000**	**60**	**539,670**	**4,387**	**$25,776**	**16.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Areas include basement, first floor, and second floor.
3. Cost includes replacement of broken outside air damper.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.6. Electrical Engineering and Physics

Building Overview

The Electrical Engineering and Physics building occupies 59,993 square feet and houses offices, classrooms, and labs. The building was constructed in 1973.

Campus steam serves the building. The air handling unit coils use direct steam, and hot water is produced for use in pneumatically controlled baseboards and reheat coils. A long stretch of

steam condensate pipe is not insulated in the mechanical room. Campus chilled water also serves the building. The heating hot water pumps are constant speed, and the chilled water pump uses a variable speed drive.

The building utilizes two constant volume reheat units. The north side of the building houses a multizone unit. While the units can be scheduled from the DDC system, the units run continuously in order to prevent belts from breaking upon hard starting the motors. There is a data center with a Liebert unit that utilizes a dry cooler for heat rejection.

Two lecture areas are separated by a movable partition. Each area has its own fan coil unit with local thermostat. In addition to the fan coil units, the pneumatic baseboard radiators each utilize a thermostat in its respective lecture area. When the partition is open, the opportunity exists for four different thermostats controlling four different systems, which may lead to simultaneous heating and cooling.

The DDC system utilizes an overlay of pneumatic devices. The multizone dampers for zone control are locally controlled using pneumatics. The hot deck discharge air temperature setpoint is on a reset schedule.

Lighting is provided using T-8 fluorescent fixtures. Some areas are significantly overlit, registering between 110 and 140 foot-candles. Some of these areas need bright lights for intricate electrical work, but there is tandem pairing of light control to increase light levels for lab work, while keeping lower light levels for the remaining periods.

Some portions of the envelope are in poor condition. The windows are operable and single paned. Insulation for the penthouse is severely degraded, and there are many cracks where infiltration may occur. There are no vestibules, and gaps between the door seals are clearly visible.

ECM's

Previously Implemented ECMs

Lights have been upgraded from T-12 to T-8 fluorescent.

Opportunities for ECMs at Electrical Engineering and Physics Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W of 28W T-8s in Lieu of 32W	$800	2	7,488	-	$314	2.5	2
5.1.3	Install Motion Sensors to Control Lighting	$11,000	-	27,456	-	$1,153	9.5	3
5.1.14	Install Tandem Lighting for Light Level Staging	$13,000	-	21,840	-	$917	14.2	
5.3.7	Convert Multizone/Dual Duct to VAV	$15,000	-	18,296	2,160	$2,300	6.5	4

Opportunities for ECMs at Electrical Engineering and Physics Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0	-	385,878	7,836	$21,763	Instant	5
5.3.9	Upgrade Controls to Full DDC	$130,000	-	163,438	4,659	$10,168	12.8	6
5.3.16	Program Heating/Cooling Coil Discharge Air Temperature Reset	$1,000	-	53,984	4,071	$5,154	0.2	6
5.4.17	Insulate Steam/Heating Hot Water Piping	$500	-	-	435	$308	1.6	7
	TOTAL	$171,300	2	678,379	19,162	$42,078	4.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. 28W selected.
3. Assume four hour per day reduction of 300 fixtures and four fixtures per sensor.
4. MZ-1.
5. This analysis assumes no cost. If hard starting is a concern, a VFD could be installed at additional costs.
6. Includes all AHUs.

Estimated Blended Marginal Rates		
$	0.07	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.7. Howard Peterson Hall

Building Overview

The Howard Peterson Hall dormitory was built in 2004 and houses almost 300 students. The building is directly connected to Surbeck Student Union. The air handler serving common areas in Peterson Hall are actually located in Surbeck, as are the hydronic system pumps and domestic hot water tanks.

The campus steam and chilled water systems serve the building. All steam is converted to hot water. Both the hot water and chilled water pumps utilize VFDs. Despite the VFD, the heating hot water and chilled water loop triple duty valves were throttled to 20% at the time of the August 2009 walkthrough.

A VAV air handler serves the corridor and common areas of Peterson Hall. There are three-way vales on both the chilled water and hot water coils, despite a VFD for both loops. Dormitory rooms are conditioned using four pipe fan coil units which bring in a small amount of outside air. During the walkthrough, one fire damper appeared to be closed, restricting airflow and causing a loud whistling sound.

Domestic hot water is heated using steam. The double paned windows are operable. All controls are DDC.

ECM's

Previously Implemented ECMs

The building is relatively new and contains energy efficient systems such as VAV air handlers and variable speed drives on pumps.

Opportunities for ECMs at Howard Peterson Hall							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.3.14	Convert Three-way Valves to Two-way	$2,000	-	9,101	$382	5.2	
5.4.29	Trim Impeller and Open Triple Duty Valve	$0	3	15,792	$663	Instant	2
	TOTAL	$2,000	3	24,893	$1,046	1.9	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. No impeller trim required. Open valve and allow VFD to compensate.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.6.8. King Center

Building Overview

The King Center (also known as the New Gym), houses the basketball court, pool, and workout facilities for the campus and occupies 60,475 square feet. A "Hall of Fame" is the newest addition to the building. The red and brown brick exterior is in fair condition.

Mechanically, a wide variety of systems serve the building. Direct campus steam heating is used for the majority of air handling unit coils. A 118 ton York packaged air cooled screw chiller was installed in 2001 and is located on the roof. The unit has an integral chilled water pump with a VFD. At the time of the August 2009 walkthrough, the chilled water pump was operating at 100% speed, but according to the central DDC system, the chiller was providing only a 47.6° F supply temperature with a 2° F temperature rise in the system. The low temperature rise suggests a low system load, and thus should correlate to a lower chilled water pump speed.

The gymnasium is served by steam heated, heating only air handling units. The gym units have variable frequency drives (VFDs).Corridors and other spaces are served using constant volume units which are pneumatically controlled. Most of the pneumatic units are monitored by the DDC and can only be started and stopped via schedules. Some units which are capable of DDC schedule control did not have schedules programmed at the time of the August 2009

walkthrough. The weight room is served by a new air handling unit that was installed in approximately 2008.

The pool air handling unit and exhaust must run continuously per code requirements. There are no energy recovery systems installed. Both the pool and domestic hot water are heated using campus steam.

Lighting in the gymnasium and pool areas is provided using 400W metal halide lamps. Some lights in the workout area are T-8, but the majority of other spaces utilize T-12 fixtures. The lobby are also utilizes metal halide fixtures which tend to over-light the space.

ECM's

Previously Implemented ECMs

The gymnasium air handling units have been retrofitted with VFDs.

The school has applied for stimulus money to fund a lighting upgrade at the King Center, which includes replacing T-12 lighting with T-8, high bay lighting with fluorescent, and replacing fixtures in over-lit areas.

Opportunities for ECMs at King Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Demand kW	Estimated Annual Utility Savings: Electric kWh	Estimated Annual Utility Savings: Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$2,250	-	5,491	-	$231	9.8	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$40,000	44	213,427	-	$8,964	4.5	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$10,000	47	178,186	-	$7,484	1.3	3
5.1.10	Replace HID Lighting with High Bay Fluorescent	$25,000	15	60,034	-	$2,521	9.9	3,4
5.2.1	Full Retrocommissioning and Rebalancing Study	$50,000	-	200,966	8,613	$14,547	3.4	5
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0	-	79,569	4,862	$6,789	Instant	6
5.3.9	Upgrade Controls to Full DDC	$50,000	-	82,269	1,704	$4,663	10.7	7
5.4.39	Install Air to Air Heat Recovery	$75,000	28	35,355	10,806	$9,146	8.2	
	TOTAL	**$252,250**	**134**	**855,296**	**25,984**	**$54,345**	**4.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction of 60 fixtures and four fixtures per sensor.
3. Stimulus project funding application pending. Costs and savings are those provided with application.
4. Includes both gym and pool areas.
5. Assume 10% savings on electric and gas. Electric and gas usage for the building determined on pro-rated campus usage.
6. Modify schedules for RTU-2 and AH-6.
7. Improve AH-7 and AH-8 to full DDC control with VFD fan motors.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.9. McLaury Building

Building Overview

The McLaury building occupies 24, 895 square feet and houses offices and classrooms.

Campus steam provides heating directly to two multizone air handling unit coils. Another constant volume air handling unit serves the first floor. Campus chilled water is also utilized. The chilled water pump utilizes a VFD, but the air handling unit chilled water coils utilize three-way valves. Window shaker air conditioners also serve many spaces.

Domestic hot water is provided using a 4.5 kW electric water heater.

The central DDC system can monitor the hot and cold deck temperatures, but can only schedule the units on and off. The multizone units are scheduled on from 5:00 A.M. until 9:30 P.M., Monday through Saturday and are off on Sundays, but the two constant volume air handling units run continuously.

The operable windows are single paned and in poor condition. Storm windows had recently been added. The majority of lighting is provided using T-12 fluorescent lamps which are manually controlled.

ECM's

Previously Implemented ECMs

The school has applied for stimulus money to fund a window replacement, as well as a lighting upgrade to replace T-12 lighting with T-8.

Opportunities for ECMs at McLaury Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$6,000	-	21,965	-	$923	6.5	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$23,000	41	130,611	-	$5,486	4.2	3
5.3.7	Convert Multizone/Dual Duct to VAV	$30,000	-	32,496	3,668	$3,966	7.6	4
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0	-	26,925	285	$1,333	Instant	5
5.3.9	Upgrade Controls System to Full DDC	$80,000	-	48,408	4,617	$5,307	15.1	4,5
5.5.4	Improve Building Envelope - Windows	$525,000	-	-	2,000	$1,418	370.2	6
	TOTAL	**$664,000**	**41**	**260,406**	**10,571**	**$18,432**	**36.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume four hour per day reduction of 60 fixtures and four fixtures per sensor.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass

Notes
3. Stimulus project funding application pending. Costs and savings are those provided with application.
4. MZ-1 and MZ-2.
5. AH-1 and AH-2
6. Stimulus project funding application pending. Costs provided with application. Savings are assumed at 5% of current gas usage, which was estimated in application.

Estimated Blended Marginal Rates
$ - /Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.10. Mineral Industries

Building Overview

The Mineral Industries building occupies 56,976 square feet and houses offices, laboratories, and classrooms.

The building is conditioned with a wide variety of mechanical systems. Steam is converted to heating hot water, which is circulated using a constant speed pump to serve perimeter radiation and unit heaters. There are approximately 50 window mounted air conditioners serving the building. A larger DX fan coil unit serves a lab area, and a computer lab has several split systems serving the same room. The lower floors do not have a direct ventilation system. The third floor HVAC has been upgraded and is served by two rooftop units, each with campus chilled water and VFD controls on supply and return fans. At the time of the walkthrough, the relief dampers on the rooftop units appeared to be under a very negative building pressure. Several exhaust gravity backdraft dampers are stuck open, even with their respective fans off.

Only the two new rooftop units are controlled by the DDC system. These units are scheduled 6:00 A.M. until 10:00 P.M., one six days per week, and the other seven days per week.

The operable windows are double paned and are in fair condition. Some windows had fans semi-permanently mounted, likely by occupants, using plywood.

Lighting is provided using T-8 fluorescent fixtures.

During the August 2009 walkthrough, there were four electric ovens, approximately 4.5 kW each, in a laboratory that were on, although the lab did not appear to be in use at the time.

ECM's

Previously Implemented ECMs

Lighting has been converted from T-12 to T-8.New VAV rooftop units have been installed to serve the third floor.

Opportunities for ECMs at Mineral Industries								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$500	1	4,380	-	$184	2.7	2
5.1.3	Install Motion Sensors to Control Lighting	$7,500	-	18,304	-	$769	9.8	3
5.3.3	Install VFDs on Hydronic Pumps	$8,000	-	16,525	-	$694	11.5	4
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0	-	11,602	184	$617	Instant	5
5.4.8	Replace Window AC Units with Four Pipe Fan Coil Units	$750,000	-	29,641	7,757	$6,745	111.2	6
	TOTAL	$766,000	1	80,452	7,941	$9,009	85.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. 28W selected.
3. Assume four hour per day reduction of 200 fixtures and four fixtures per sensor.
4. HW pump only.
5. Schedule RTU-1 and RTU-2 off on weekends.
6. Order of magnitude cost estimate. Includes controls connection of fan coil units to DDC system.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.11. O'Harra Building

Building Overview

The O'Harra Building occupies 28,376 square feet on the South Dakota School of Mines campus.

Due to time constraints, this building was not observed as a part of the August 2009 walkthrough. However, economic analyses associated with stimulus funding proposals are included in this report.

ECM's

Previously Implemented ECMs

New HVAC units have been recently installed, and the building was connected to the central plant.

The school has applied for stimulus money to fund a lighting upgrade to replace T-12 lighting with T-8.

Opportunities for ECMs at O'Harra Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$15,000	16	87,181	$3,662	4.1	
5.4.8	Replace Window AC Units with Four Pipe Fan Coils	$71,190	48	111,438	$4,680	15.2	2
	TOTAL	$86,190	63	198,619	$8,342	10.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Stimulus project funding application pending. Costs and savings are those provided with application.

Estimated Blended Marginal Rates		
$	0.042	/kWh Elec
$	0.709	/Therm Gas
$	1.90	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.6.12. Palmerton Hall

Building Overview

The Palmerton Hall dormitory was built in the 1960s, occupies 35,987 square feet, and houses approximately 180 students. When the renovation of Connolly Hall is complete, Palmerton Hall is scheduled for renovation.

Campus steam is converted to heating hot water, which is circulated using constant speed pumps. The building is currently not mechanically cooled. Operable windows are the primary means for ventilation air.

The electric demand and usage for the building is sub-metered, but there are no other DDC controls.

Lighting is provided using fluorescent T-12 fixtures, both in common areas and in student rooms.

ECM's

Previously Implemented ECMs

Energy efficient double paned windows were installed in 2008.

Opportunities for ECMs at Palmerton Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$750	-	4,052	$170	4.4	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$10,000	4	15,330	$644	15.5	3
5.3.3	Install VFDs on Hydronic Pumps	$5,000	-	19,111	$803	6.2	
	TOTAL	$15,750	4	38,492	$1,617	9.7	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Motion sensors for five common areas.
3. Costs are incremental over those of a system utilizing campus steam. Incremental costs were assumed $4.50/SF.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.6.13. Physical Plant Building

Building Overview

The Physical Plant Building occupies 19,502 square feet and houses facilities personnel and maintenance activities. The main floor houses offices, and the lower floor houses the vehicle and maintenance garages. The office spaces utilize a handful of double paned, operable windows. The brick exterior appears to be in fair condition.

A single rooftop DX air handling unit provides conditioning for the offices. Despite the central DDC control, this rooftop unit was not on a schedule at the time of the August 2009 walkthrough. The garage area is served by steam unit heaters, and a small makeup air unit provides minimum ventilation air to the space. This unit is pneumatically controlled and is not connected to the central DDC system. The large makeup air unit for the garage and the paint room makeup air unit are not used.

The offices are lit by T-8 fixtures that are controlled manually. The garage areas are lit by approximately 100 4' 2-lamp T-8 fixtures. The garage lights are controlled in groups of about 8 fixtures each, where each group lights a particular zone of the garage. The northeast facing garage bay doors let in a considerable amount of natural light during the day.

ECM's

Previously Implemented ECMs

Lighting has been upgraded from T-12 to T-8 lamps.

Opportunities for ECMs at Physical Plant Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$180	0	1,498		$63	2.9	2
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0		27,391	417	$1,446	Instant	
	TOTAL	**$180**	**0**	**28,889**	**417**	**$1,509**	**0.1**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. 28W selected.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.6.14. Surbeck Student Union

Building Overview

Surbeck Student Union occupies 71,677 square feet and houses the main dining center, ballroom, and bookstore, among other common areas. At the time of the August 2009 walkthrough, the building was just opening after a major renovation of interior spaces and HVAC equipment. The building is connected to Howard Peterson Hall dormitory building, and the main hydronic systems and air handler serving Peterson Hall are located in Surbeck Student Union. These systems are described in the narrative for Howard Peterson Hall

The campus steam and chilled water systems serve the building. All steam is converted to hot water, as air handling coils and VAV reheat coils utilize hot water. Both the hot water and chilled water pumps utilize VFDs. Despite the VFD, the heating hot water loop triple duty valves were throttled to 80% at the time of the August 2009 walkthrough. For the ballroom unit, the air handling unit heating coils are on the Surbeck heating loop, while the VAV coils are on the Peterson Hall heating loop.

There appeared to be a flow issue with the chilled water piping to the rooftop makeup air handling unit serving the kitchen. A surging noise and possible cavitation was observed during the walkthrough.

Outside air is monitored on all units, but spot checks of the stations revealed that sensors had not been calibrated at the time of the August 2009 walkthrough. Controls technicians were still working to finish all programming. The ballroom air handler monitors carbon dioxide concentrations, but the values are not used to modulate outside airflows. The newest Johnson Controls version is being implemented as part of the renovation. Other buildings are planned to add to the new system.

The new kitchen exhaust system utilizes a Melink Intellihood control system which modulates both exhaust and makeup based on the amount of heat, steam, and smoke coming from kitchen equipment.

All lighting has been upgraded to T-8.A new Lithonia lighting control system has also been installed as part of the renovation.

Domestic hot water is heated using campus steam.

ECM's

Previously Implemented ECMs

The entire building has been upgraded to variable air volume systems with outside airflow monitoring, and some have control. Kitchen exhaust systems use the energy saving Melink Intellihood system. Hydronic pumps also utilize VFDs.

Opportunities for ECMs at Surbeck Student Union Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$6,000	-	13,929	424	$886	6.8	2
5.3.13	Demand Control Ventilation (CO2)	$12,000	-	-	749	$531	22.6	3
5.3.15	Optimum Start Program	$2,000	-	4,110	135	$268	7.5	4
5.4.29	Trim Impeller and Open Triple Duty Valve	$0	-	2,116	-	$89	Instant	5
	TOTAL	**$20,000**	**-**	**20,154**	**1,308**	**$1,774**	**11.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Bookstore air handling unit.
3. AHU-2, AHU-4, AHU-5, AHU-6, and AHU-7.
4. All scheduled units.
5. CHW and HW Pumps. No impeller trim required. Open valve and allow VFD to compensate.

Estimated Blended Marginal Rates		
$	0.04	/kWh Elec
$	0.71	/Therm Gas
$	1.50	/Gal Fuel Oil
$	40.00	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

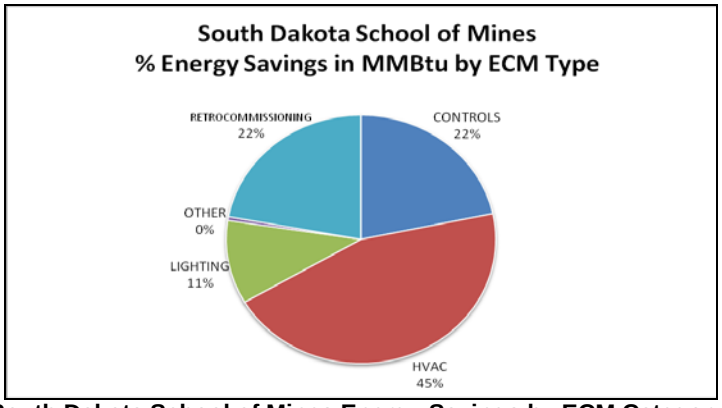
4.2.6.14.1. Campus Summary

A total of 72 ECMs were identified at South Dakota School of Mines buildings, which include 43,240 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $6.44 million, and save an estimated $428,265 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

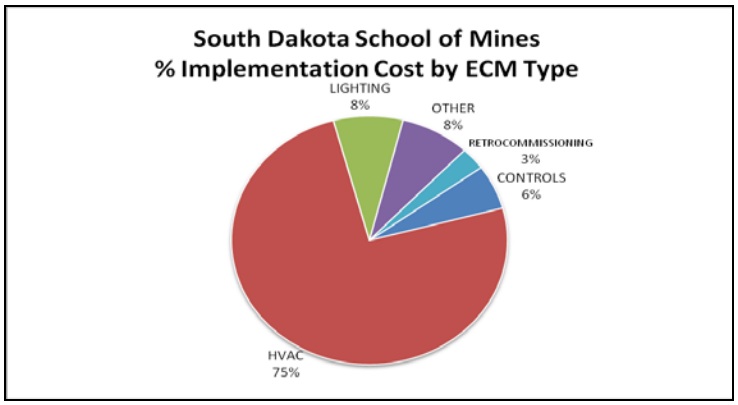
BOR ECM Summary Table.

	MMBtu Electric	MMBtu Other	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	4,166	5,203	**9,369**	$86,961	$374,000	**4.3**
HVAC	2,038	17,367	**19,405**	$202,902	$4,833,420	**23.8**
LIGHTING	4,719	0	**4,719**	$58,111	$523,280	**9.0**
OTHER	0	207	**207**	$1,418	$525,000	**370.2**
RETROCOMMISSIONING	2,439	7,101	**9,540**	$78,872	$188,700	**2.4**
Total	**13,362**	**29,879**	**43,240**	**$428,265**	**$6,444,400**	**15.0**

In total, these savings represent a 25% reduction from current energy consumption at the South Dakota School of Mines campus, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



South Dakota School of Mines Energy Savings by ECM Category.



South Dakota School of Mines Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 19,043 MMBTUs (11% of campus energy use) and a total estimated annual cost avoidance of $177,560. The total cost of implementation for these measures is $323,380, which yields a simple payback of 1.8 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Meier Hall	5.2.9	$0	90	$600	0.0	0.00
Chemistry/Chemical Engineering	5.3.8	$0	248	$2,096	0.0	0.00
Classroom Building	5.3.8	$0	430	$4,255	0.0	0.00
Classroom Building	5.4.29	$0	19	$237	0.0	0.00

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Electrical Engineering	5.3.8	$0	2,127	$21,763	0.0	0.00
Howard Peterson Hall	5.4.29	$0	54	$663	0.0	0.00
King Center	5.3.8	$0	774	$6,789	0.0	0.00
McLaury Building	5.3.8	$0	121	$1,333	0.0	0.00
Civil/Mechanical Engineering	5.3.8	$0	837	$7,509	0.0	0.00
Mineral Industries	5.3.8	$0	59	$617	0.0	0.00
Physical Plant Building	5.3.8	$0	137	$1,446	0.0	0.00
Surbeck Student Union	5.4.29	$0	7	$89	0.0	0.00
Electrical Engineering	5.3.16	$1,000	605	$5,154	0.2	1.65
Boiler Plant	5.2.12	$6,000	3,831	$26,270	0.2	1.57
Meier Hall	5.4.31	$900	255	$3,366	0.3	3.53
Boiler Plant	5.2.7	$1,000	291	$3,584	0.3	3.43
Chemistry/Chemical Engineering	5.2.17	$1,000	260	$3,199	0.3	3.85
Woodburn Hall	5.1.8	$200	28	$365	0.5	7.23
King Center	5.1.8	$10,000	608	$7,484	1.3	16.45
Civil/Mechanical Engineering	5.4.23	$15,000	828	$10,190	1.5	18.12
Electrical Engineering	5.4.17	$500	45	$308	1.6	11.12
Electrical Engineering	5.1.1	$800	26	$314	2.5	31.31
Mineral Industries	5.1.1	$500	15	$184	2.7	33.46
Classroom Building	5.1.1	$600	17	$210	2.9	35.23
Physical Plant Building	5.1.1	$180	5	$63	2.9	35.23
Boiler Plant	5.4.18	$2,000	101	$692	2.9	19.81
Boiler Plant	5.2.4	$700	20	$208	3.4	35.87
Classroom Building	5.3.15	$2,000	59	$583	3.4	33.74
King Center	5.2.1	$50,000	1,576	$14,547	3.4	31.72
Civil/Mechanical Engineering	5.2.1	$50,000	1,370	$12,648	4.0	36.48
Boiler Plant	5.2.1	$50,000	1,516	$12,406	4.0	32.98
O'Harra Museum	5.1.7	$15,000	297	$3,662	4.1	50.43
McLaury Building	5.1.7	$23,000	446	$5,486	4.2	51.61
King Center	5.1.7	$40,000	728	$8,964	4.5	54.93
Boiler Plant	5.3.10	$10,000	263	$2,169	4.6	38.02
Devereaux Library	5.3.13	$10,000	312	$2,140	4.7	32.04
Howard Peterson Hall	5.3.14	$2,000	31	$382	5.2	64.41
Classroom Building	5.2.1	$30,000	586	$5,410	5.5	51.17
Civil/Mechanical Engineering	5.3.15	$1,000	20	$174	5.7	49.35
TOTAL		**$323,380**	**19,043**	**$177,560**	**1.8**	**16.98**

4.2.7 South Dakota State University

Campus Background and List of Facilities

South Dakota State University was founded in 1881 as a land grant university. Today the campus consists of over 150 buildings totaling 2.8 million square feet.

South Dakota State University has an attendance of over 13,000 students each year. Over 5,000 of those students live on campus.

Campus-Wide Systems and Operational Profile

The campus is served by high and low pressure steam from the central heating plant. Steam is distributed through tunnels and direct buried piping at 90 psi to 47 buildings on campus, while 6 buildings are served from the 10 psi steam system. Five buildings have steam services from both distribution systems. The remaining buildings are heated with local gas fired boilers, electric boilers, or electric resistant heat.

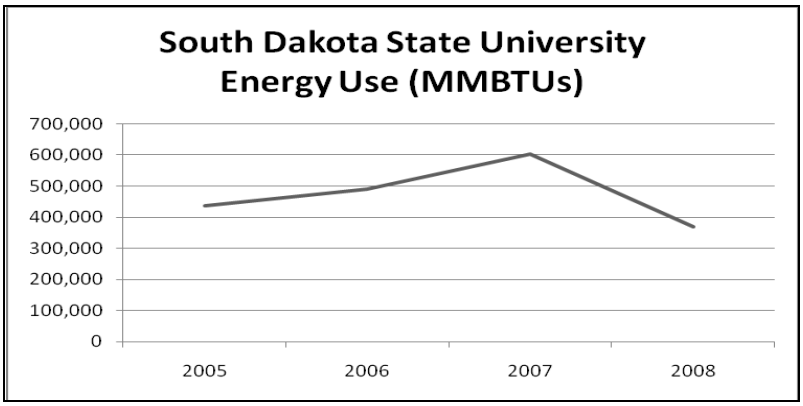
Many buildings on campus are served with 95 psi compressed air distributed from the central heating plant.

Chilled water is produced at the chiller plant and distributed to Shepard Hall via direct buried piping. The distribution system is planned to expand to the Avera, Dairy Microbiology, Ag Hall, SD Art Museum, and the new dormitory facility.

Campus lighting consists of high pressure sodium parking lot lighting and metal halide sidewalk lighting. These lights are controlled via photocells throughout campus.

Energy Profile

In 2008, South Dakota State University facilities consumed a combined 369,181 MMBTUs of energy. The average Energy Use Intensity across the campus was 134 kBTU/SF in 2008.



South Dakota State University Energy Use.

4.2.7.1. Animal Science Complex

Building Overview

The Animal Science Complex was originally built in 1977 with a total square footage of 73,000.The building is used as an animal research facility. The facility recently underwent a large scale remodel in 2004.

Students and employees occupy the building from 6:00 am to 10:00 pm on weekdays. The HVAC systems are operated 24 hours/day, 7 days per week to maintain control of temperature, pressure, and humidity.

High pressure steam (90 psi) is reduced to medium pressure steam (45 psi) and low pressure steam (5 psi) at the building. Medium pressure steam is used for autoclaves and low pressure steam is used for instantaneous domestic water heaters, as well as the two heating water converters for building heat.

Each converter has a pair of redundant pumps which distribute heating water to finned tube radiators, VAV reheats, and air handling unit coils. The 10 hp pumps and converter serving the air handling unit coils are enabled to operate when the outside air is below 55F.The 15 hp pumps and converter serving the VAV reheats and fan coil units are operational throughout the year. The pump motors are all driven with variable frequency drives connected to premium efficiency motors.

Cooling is provided by one 385 ton air cooled chiller which was installed as part of the 2004 addition. Two 40 hp pumps circulate chilled water (30% glycol) through the chiller and air handling unit coils. The chiller and pump are enabled to operate when the outside air temperature is above 60F.Once enabled, one of the chilled water pumps modulates to maintain a differential pressure setpoint while 2-way chilled water valves on the air handling unit coils modulate to maintain their respective discharge air temperature setpoints. The chilled water pumps are powered by premium efficiency motors.

Nine air handling units provide cooling and ventilation to the facility. All of the air handling units are either new or have been retrofitted with new controls. Laboratory exhaust systems have been installed with pumped coil energy recovery systems.

The entire facility is controlled via Johnson Controls Metasys DDC system.

Domestic hot water is generated with an instantaneous steam water heater using low pressure steam in the basement mechanical room.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed.

The roofing is comprised of a fully adhered membrane which was upgraded in 2004 with the remodel project.

The offices, corridors, and classrooms are lit with a combination of two, three, and four lamp, T-8 fluorescent fixtures.

Fixtures are manually controlled via wall mounted light switches. Task lighting is also used in some office areas on an as needed basis. Exit lights are incandescent.

ECM's

Previously Implemented ECMs

Remodel project in 2004 upgraded HVAC systems to energy efficient strategies throughout. VFDs on pumps and fans, high efficiency motors, energy recovery etc.

Opportunities for ECMs at Animal Science Complex

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$11,500	-	34,056	$1,158	9.9	
5.1.5	Replace Incandescent Exit Signs with LED	$5,180	1.3	11195.28	$381	13.6	
	TOTAL	$16,680	1	45,251	1,539	10.8	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.2. Binnewies Hall

Building Overview

The building was originally built in 1969 with a total square footage of 79,000.The building is used as a dormitory.

Students occupy the building 24 hours per day, 7 days per week from the last week in August to the middle of May. The facility is also intermittently occupied during the summer months for camps.

High pressure steam (90 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate domestic hot water and heating water for the building through three converters.

Each converter serves a different area of the building; one converter serves the bathrooms, one serves the North wing, and one serves the South wing. The North and South zones are served with 2 hp circulating pumps, while the bath zone is served with a 1/3 hp pump.Each of the pumps are powered by standard efficiency motors.

The lobby is air conditioned with a single zone constant volume Dx rooftop unit.

Since the terminal units lack control valves, the only way to control temperature is to reset the heating hot water temperature. This strategy tends to satisfy some occupants while overheating all others.As a result, most occupants leave their windows open to keep their rooms comfortable.The converters and pumps are started and stopped based on outside air temperature.

Toilet exhaust is central to each wing. Make up air to the toilet/shower rooms is provided by fan coil units with hydronic heating coils. An air to air energy recover ventilator was installed in 2009 to reclaim energy from the bath exhaust.

Domestic hot water is generated with an instantaneous steam water heater located in Larson Commons.

The facility has a Johnson Controls DDC front end system with pneumatic valve and damper actuators.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows.

The lighting in Binnewies Hall is primarily 32watt fluorescent T-8 fixtures.

ECM's

Previously Implemented ECMs

Energy Recovery Ventilator installed on bath exhaust.

T8 lighting upgrade.

Opportunities for ECMs at Binnewies Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$6,900	7	23,478	$798	8.6	1,
5.1.5	Replace Incandescent Exit Signs with LED	$3,450	0.852	7463.52	$254	13.6	1,
	TOTAL	$10,350	7	30,942	1,052	9.8	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.7.3. Briggs Library

Building Overview

The building was originally built in 1977 with a total square footage of 118,000.The building is used as the central Library for the Campus.

Students and employees occupy the building from 8:00 am to 11:30 pm on weekdays, from 10 am to 5 pm on Saturday, and from 1 pm to 11 pm on Sundays.

The building is heated with one 1,228 MBH electric hot water boiler. The boiler is original to the 1977 construction. The boiler has a pair of redundant pumps which circulate heating water through the boilers and to finned tube radiators. The 3/4 hp pumps are enabled to operate when the outside air is below 60F.The pump motors are high efficiency.

Cooling is provided by one 120 ton water cooled Trane chiller located in the basement mechanical room, which is original to the 1977 construction. Two chilled water pumps located in the basement mechanical room circulate water through the chiller and air handling unit coils. Both pumps are powered by 5 hp, standard efficiency motors.

One 120 ton Evapco cooling tower is located on grade next to the building. The unit is fitted with a VFD and was replaced in 2009.Two 10 hp (one back up) condenser water pumps circulate water through the chiller and tower. The pump motors are standard efficiency.

Three air handling units provide cooling and ventilation to the facility. Each of the units are variable speed, VAV units. Each of the units are equipped with chilled water cooling coils, air filters, supply fans, exhaust fans, and outside, return, and exhaust air dampers. The outside air duct is limited in size to accommodate the minimum outside air only, limiting the system's ability to accomplish air side economizing. Because of this the chiller plant and cooling tower operates during the heating season to provide cooling. The chiller has refrigerant based "free cooling" which allows the system to make chilled water from condenser water when the outside air temperature is below 35F.The outside air and exhaust air systems have a pumped coil energy recovery system which has been abandoned for years. Since the air handling unit lacks heating coils, the system is controlled to bring in minimal outside air. The air handling systems operate 24 hours per day, seven days per week to maintain temperature and humidity control.

Temperature control for individual zones is accomplished with pneumatically actuated VAV terminal units with zero minimums.

The facility has a Johnson Controls DDC front end system with pneumatic valve and damper actuators. The VAV controllers and space temperature sensors are pneumatically powered.

Domestic hot water is generated in the basement mechanical room with one 12 kW, 50 gallon electric water heater.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows.

The lighting in the library has been updated to 32W T8 lamps with electronic ballasts.

ECM's

Previously Implemented ECMs

T8 lighting upgrade.

VFDs have been installed on all supply and exhaust fans in the AHUs.

Opportunities for ECMs at Briggs Library

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$64,400	38	169,936	$5,778	11.1	1,
5.3.3	Install VFDs on Hydronic Pumps	$23,350	0	133,618	$4,543	5.1	1, 2, 3
5.2.1	Full Retrocommissioning and Balancing Study	$35,650		85000	$2,890	12.3	1, 2, 4
	TOTAL	$123,400	38	388,554	13,211	9.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.4. Brown Hall

Building Overview

The building was originally built in 1959 with a total square footage of 60,000.The building is used as a dormitory.

Students occupy the building24 hours per day, 7 days per week from the last week in August to the middle of May. The facility is also intermittently occupied during the summer months for camps.

High pressure steam (90 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate domestic hot water and heating water for the building through four converters.

Each converter serves a different area of the building; one converter serves the first floor apartment, one serves the bathrooms, one serves the North wing, and one serves the South wing. The North and South zones are served with 2 hp circulating pumps, while the bath and apartment zones are served with 1/3 hp pumps.Each of the pumps are powered by standard efficiency motors.

Since the terminal units lack control valves, the only way to control temperature is to reset the heating hot water temperature. This strategy tends to satisfy some occupants while overheating all others.As a result, most occupants leave their windows open to keep their rooms comfortable.The converters and pumps are started and stopped based outside air temperature.

Toilet exhaust is central to each wing. Make up air to the toilet/shower rooms is provided by fan coil units with hydronic heating coils.

Domestic hot water is generated with two instantaneous steam water heaters. One heater is served with low pressure steam, while the other uses high pressure steam.

The facility has a Johnson Controls DDC front end system with pneumatic valve and damper actuators.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows.

The lighting in Brown Hall is primarily 32watt fluorescent T-8 fixtures.

ECM's

Previously Implemented ECMs

T8 Lighting upgrade.

Opportunities for ECMs at Brown Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$5,870	5	19,685	$669	8.8	1,

Opportunities for ECMs at Brown Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.5	Replace Incandescent Exit Signs with LED	$3,450	0.852	7463.52	$254	13.6	1,
	TOTAL	$9,320	6	27,149	923	10.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.5. Central Chiller Plant

Building Overview

The Central Chiller Plant was recently completed in the fall of 2009.The facility will operate 24 hours per day, seven days per week from April 15th to October 15th to provide chilled water to Shepard Hall.

The chiller plant consists of two 500 ton Carrier model 19XRV555 variable speed water cooled chillers and two Evapco AT 112-08 induced draft cooling towers. Each 40 hp tower fan is equipped with a variable frequency drive.

The chillers are pumped in primary-secondary arrangement. Each chiller has a 1150 gpm primary pump powered by a 30 hp premium efficiency constant speed motor. The triple duty valves on these pumps are both throttled to 30% open. There are two secondary pumps used for distribution of the chilled water. Each pump is equipped with a variable frequency drive, rated for 1159 gpm and powered by a 100 hp premium efficiency motor. The balancing valves on these pumps were 100% open at the time of our visit.

Each chiller has a 1575 gpm condenser water pump equipped with a variable frequency drive and powered by a 100 hp premium efficiency motor. The balancing valves on these pumps were 100% open at the time of our visit.

The entire facility is controlled via Johnson Controls Metasys DDC system.

The facility is lit with 32 watt, T-8 fluorescent lamps throughout.

The building envelope is constructed from concrete masonry block with exterior face brick.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Central Chiller Plant							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.3.3	Install VFD on Hydronic pumps	$4,600	23	72,524	$2,466	1.9	1, 3
	TOTAL	$4,600	23	72,524	2,466	1.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure is for Primary Chilled Water pumps, triple duty valves to be full open with VFD.

Estimated Blended Marginal Rates		
$	0.034	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.6. Central Heating Plant

Building Overview

The Central Heating Plant is a 20,000 square foot facility that was originally constructed in 1921.Since its original construction, several additions have been constructed with most recent addition in 1992.The facility operates 24 hours per day, seven days per week to provide steam for the campus. A one week campus wide shut-down of the steam system is planned for each summer for maintenance and repair.

The heating plant consists of five high pressure steam boilers as follows:

1. Boiler 4: 55,000 lb/hr, coal fired.
2. Boiler 5: 55,000 lb/hr, coal fired.
3. Boiler 6 55,000 lb/hr, coil fired. 45,000 gas fired.
4. Boiler 7 11,000 lb/hr, gas fired.
5. Boiler 8 51,000 lb/hr, gas fired.

Both gas fired boilers are capable of firing on natural gas or No. 2 fuel oil. Steam is metered as it leaves the central plant. Last heating season, the peak recorded steam production rate was approximately 96,000 lb/hr.

Steam is produced by the high pressure boilers at 125 psi, then reduced down to 90 psi and 10 psi at the plant.

The condensate return system is maintained at a vacuum by three 15 hp condensate pumps equipped with standard efficiency motors. The vacuum condensate pumps transfer condensate to a large holding tank, where three condensate transfer pumps draw from to fill the deaerator. The boiler feed pumps draw from the deaerator to maintain water level in the boilers.

The coal fired boilers are equipped with combustion air fans and stack draft fans. The three forced draft combustion air fans are powered by two 20 hp standard efficiency motors and one 15 hp standard efficiency motor. All three fans have pneumatically actuated inlet vanes for volume control. The induced draft stack fans are powered by three 60 hp standard efficiency motors. All three fans have pneumatically actuated inlet fans for volume control. All three boilers are also equipped with cyclone precipitators for ash removal. Approximately 20% of the flue gases are pulled through a baghouse by centrifugal fans. The baghouse fans are constant speed and are powered by 30 hp standard efficiency motors.

A single Ingersol Rand model SSR UP6-40-125HA screw air compressor generates 95 psi compressed air for campus distribution.

The building envelope is constructed of poured concrete with exterior face brick.

Lighting for the facility is provided by a wide range of fixtures containing T12 and T8 fluorescent, incandescent of various wattages, and a few metal halide fixtures.

ECM's

Previously Implemented ECMs

A study was completed in 2009 which made recommendations for improving boiler plant efficiency. ECM's being pursued include:

1. Combustion air preheat.
2. Boiler blowdown heat recovery
3. Eliminate the vacuum return system
4. VFD's and DDC for combustion air fans

The economics for these strategies are included in this report.

Opportunities for ECMs at Central Heating Plant								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Electric kWh	Natural Gas Therms	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.5.21	Combustion Air Pre-Heater	$515,090		17,985	93	30,081	17.1	1, 2, 3,4
5.5.22	Boiler Blowdown Heat Recovery	$138,120		44,050	233	74,303	1.9	1, 2, 3,4
5.5.23	Eliminate the Vacuum Return System	$161,000	122148			4,153	38.8	1, 2, 3,4

Opportunities for ECMs at Central Heating Plant								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Electric kWh	Natural Gas Therms	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.5.24	Install VFDs on Boiler Fans	$427,460	469079			15,949	26.8	1, 2, 3,4
5.5.25	Digital Controls on Boilers	$575,000		9100	243	38,469	14.9	1, 2, 3,4
	TOTAL	$1,816,670	591,227	71,135	569	162,954	11.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Energy savings provided by SDSU study, payback using current energy costs

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	1.06	/Natural Gas
$	118.65	Ton Coal
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.7. Matthews Hall

Building Overview

The building was originally built in 1962 with a total square footage of 63,000.The building is used as a dormitory.

Students occupy the building 24 hours per day, 7 days per week from the last week in August to the middle of May. The facility is also intermittently occupied during the summer months for camps.

High pressure steam (90 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate domestic hot water and heating water for the building through four converters.

Each converter serves a different area of the building; one converter serves the first floor apartment, one serves the bathrooms, one serves the North wing, and one serves the South wing. The North and South zones are served with 2 hp circulating pumps, while the bath and apartment zones are served with 1/3 hp pumps.Each of the pumps are powered by standard efficiency motors.

Since the terminal units lack control valves, the only way to control temperature is to reset the heating hot water temperature. This strategy tends to satisfy some occupants while overheating all others.As a result, most occupants leave their windows open to keep their rooms comfortable.The converters and pumps are started and stopped based outside air temperature.

Toilet exhaust is central to each wing. Make up air to the toilet/shower rooms is provided by fan coil units with hydronic heating coils.

Domestic hot water is generated with an instantaneous steam water heater located in Grove Hall.

The facility has a Johnson Controls DDC front end system with pneumatic valve and damper actuators.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows.

The lighting in Matthews Hall is primarily 2 lamp 32watt fluorescent T-8 fixtures.

ECM's

Previously Implemented ECMs

T8 lighting upgrade.

Opportunities for ECMs at Matthews Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$5,870	5	19,685	$669	8.8	1,
5.1.5	Replace Incandescent Exit Signs with LED	$2,880	0.71	6219.6	$211	13.6	
	TOTAL	*$8,750*	*6*	*25,905*	*881*	*9.9*	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.7.8. Northern Plains Biostress Laboratory

Building Overview

The building was originally built in 1993 with a total square footage of 128,000.The building houses the department of biology/microbiology.

Students and employees occupy the building from 6:00 am to 10:00 pm on weekdays, and from 8 am to 5 pm on weekends. The HVAC systems are operated 24 hours/day, 7 days per week to maintain temperature and humidity control.

High pressure steam (90 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate domestic hot water and heating water for the building through two converters located in the basement.Each converter has a pair of redundant pumps which distribute heating water to finned tube radiators, VAV reheats, and air handling unit coils.

The 3 hp pumps and converter serving the finned tube are enabled to operate when the outside air is below 60F.The 10 hp pumps and converter serving the VAV reheats are operational throughout the year.The pump motors are premium efficiency.LPS is also piped to the penthouse where it is converted to heating hot water for the air handling unit coils.Two 5 hp pumps circulate water through the loop and converter, while small circulating pumps circulate water through the AHU coils for freeze protection.

Cooling is provided by two 170 ton air cooled McQuay chillers which are original to the 1992 construction. Two 10 hp pumps circulate chilled water through the chiller, while a single 30 hp pump circulates chilled water from the primary loop to the air handling unit coils. The chillers and pumps are enabled to operate when the outside air temperature is above 55F.Once enabled, the chilled water pumps operate at constant speed while 3-way chilled water valves on the air handling unit coils modulate to maintain their respective discharge air temperature setpoints. The triple duty valve on the chilled water pumps are fully open and they all have premium efficiency motors.

Six air handling units provide cooling and ventilation to the facility. All six of the units are variable speed, VAV units. Each of the units are equipped with chilled water cooling coils, hydronic heating coils, air filters, supply fans, return fans, and outside, return and relief air dampers.

The facility has a Johnson Controls DDC front end system with pneumatic actuators. The VAV controllers and space temperature sensors are pneumatically powered.

Domestic hot water is generated with low pressure steam via an instantaneous water heater in the basement mechanical room.

Laboratory compressed air is generated with a 10 hp Ingersoll Rand reciprocating air compressor. The compressor is equipped with a water cooled aftercooler which is cooled with once-through domestic water.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows. The roofing is original to the 1992 construction.

The lighting in the Biostress Laboratory is primarily fluorescent T-8 fixtures and compact fluorescent recessed can fixtures. Exit signs are incandescent.

ECM's

Previously Implemented ECMs

Incandescent can fixtures have been retrofit with CFLs.

Opportunities for ECMs at Northern Plains Biostress Laboratory							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$47,730	40	203,330	$6,913	6.9	1, 2
5.1.3	Install Motion Sensors to Control Lighting	$35,880	-	104,395	$3,549	10.1	1, 2
5.3.3	Install VFDs On Hydronic Pumps	$23,120	-1	67,354	$2,290	10.1	1, 2, 3
5.3.3	Install VFDs On Hydronic Pumps	$18,520	-1	73,799	$2,509	7.4	1, 2, 4, 5
5.3.13	Demand Control Ventilation (CO2 Control)	$5,870		14,985	$509	11.5	
	TOTAL	$131,120	38	463,864	15,771	8.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. VFDs on CHW pumps, 3 way valves on AHUs to be converted to 2-way
4. VFDs on HHW pumps for AHUs, 3 way valves on AHUs to be converted to 2-way
5. Pumps which run lead/lag only require 1 VFD

Estimated Blended Marginal Rates		
$	0.34	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	14.26	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.9. Nursing, Family & Consumer Sciences, and Arts and Sciences

Building Overview

The building was originally built in 1969 with a total square footage of 100,000.The building is used for Nursing, Family & Consumer Sciences, and Arts and Sciences offices and classrooms.

Students and employees occupy the building from 6:00 am to 12:00 pm on weekdays, and from 4 pm to 10 pm on Sundays.

High pressure steam (90 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate heating water for the building through one converter located in the penthouse.The converter has a pair of redundant pumps which distribute heating water to finned tube radiators, unit heaters and reheat coils. The 1-1/2 hp pumps and converter operate 24 hours per day, seven days per week. The pump motors are standard efficiency.

Cooling is provided by one 200 ton water cooled Trane chiller located in the penthouse, which is original to the 1969 construction. Three chilled water pumps located in the penthouse circulate water through the chiller and air handling unit coils. All three pumps are powered by 5 hp, standard efficiency motors. A single booster pump, located in the Rotunda penthouse, draws water from the primary chilled water loop and circulates it through the Rotunda air handling unit coils.

One 200 ton Evapco cooling tower is located on the roof. The unit is fitted with a VFD and was replaced in 2009.Two 7.5 hp (one back up) condenser water pumps circulate water through the chiller and tower. The pump motors are standard efficiency.

Two 43,500 CFM air handling units provide cooling and ventilation to the facility. Both of the units are variable speed, VAV units. Both of the units are equipped with chilled water cooling coils, hydronic heating coils, air filters, supply fans, return fans, and outside, return, and relief air dampers. The minimum position for the outside air dampers is currently set at 15%.The air handling systems operate 24 hours per day, seven days per week to maintain temperature and humidity control.

The perimeter zones are served from the central air handling units with constant volume reheat coils, while the interior zones are equipped with VAV terminal units with zero minimums.

The facility has a Johnson Controls DDC front end system with pneumatic valve and damper actuators. The VAV controllers, reheat coil valves, and space temperature sensors are pneumatically powered.

Domestic hot water is generated in the penthouse with one Aerco instantaneous steam water heater.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows.

The lighting in the NFA building is primarily 4 lamp 32watt fluorescent T-8 fixtures.

ECM's

Previously Implemented ECMs

T8 lighting upgrade throughout building.

Opportunities for ECMs at Nursing, Family & Consumer Sciences and Arts and Sciences Building									
			Estimated Annual Utility Savings						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$67,850	59	296,525			$10,082	6.7	1
5.1.3	Install Motion Sensors to Control Lighting	$63,020	0	135116.8			$4,594	13.7	1, 3
5.1.17	Replace 4-Lamp T8 Fixtures with 2-Lamp In Corridors	$40,250	14.2	99400			$3,380	11.9	1, 4
5.3.13	Demand Control Ventilation (CO2)	$11,500	20	665	1,331	21	$3,939	2.9	1, 6
5.3.3	Install VFDs on Hydronic pumps	$17,940	1	35,099			$1,193	15.0	5
	TOTAL	**$200,560**	**95**	**566,806**	**1,331**	**21**	**23,188**	**8.6**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Motion Sensors in classrooms and offices reduce by 2hrs per day
4. Run Hours Provided by SDSU
5. Calculation includes VFD and premium efficiency motor upgrade
6. Realized savings will be higher due to the reduction in makeup water, chemical additives, etc. used by the heating plant.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	1.06	/Therm Gas
	-	/Mtb Steam
$	-	/Gal Fuel Oil
$	118.65	Ton Coal
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.7.10. Pugsley Hall

Building Overview

Pugsley Hall was originally constructed in 1940.Additions in 1975 and 2007 increased the total square footage to 68,000 square feet.Pugsley Hall houses offices and classrooms for early childhood development and continuing education.Pugsley Hall is also home to the SDSU RTDN TV studio and the Christy Ballroom which is the location for band, jazz and orchestral ensemble rehearsals.

Students and employees occupy the building from 6:00 am to 10:00 pm on weekdays, and from 8 am to 12 pm on weekends. The HVAC systems are operated 24 hours/day, 7 days per week to maintain control of temperature and humidity.

High pressure steam (90 psi) is reduced to low pressure steam (5 psi) at the building where it is used for air handling unit heating coils, instantaneous domestic water heater, as well as the two heating water converters for building heat.

The heating system has three constant speed pumps (one redundant) which distribute heating water to air handling unit coils for the 1975 units, finned tube radiators for the entire facility, and reheat coils for the 2007 addition.The 1 hp pumps and converters are enabled to operate when the outside air is below 50F. The triple duty valves on the pumps are throttled to 15% open.The pump motors are all standard efficiency.

Cooling is provided by two 60 ton air cooled Trane chillers which are original to the 1975 addition. Three 3 hp pumps circulate chilled water (30% glycol) through the chiller and air handling unit coils. The chiller and pump are enabled to operate when the outside air temperature is above 60F.Once enabled, two of the three chilled water pumps operate at constant speed while 3-way chilled water valves on the air handling unit coils modulate to maintain their respective discharge air temperature setpoints. The chilled water pumps are powered by standard efficiency motors.

Seven air handling units provide cooling and ventilation to the facility. Two of the units are constant volume, single zone units (28,000 CFM total).Five of the units are variable volume

(42,850 CFM total).The three original 1957 units are equipped with chilled water cooling coils, steam heating coils, air filters, supply fans, return fans, and outside, return and relief air dampers. The three 1975 and one 2007 units are equipped with chilled water cooling coils, hydronic heating coils, air filters, supply fans, return fans, and outside, return and relief air dampers. The minimum position on the outside air dampers is set at 15% for all units.

The VAVs installed in 1975 are pneumatically controlled, single duct, cooling only, terminal units which are equipped with bypass dampers. These bypass dampers divert conditioned air back to the air handling unit when the space cooling load decreases. As a result, the air handling unit supply air volume stays constant with respect to the air conditioning load.

The ductwork downstream of the 1975 VAV terminal units is not constructed of galvanized sheet metal. Instead, this distribution ductwork is constructed of fiberglass ductboard. This system is subject to chronic duct leakage issues due to separation of the duct seams. The facilities staff estimates that these systems leak as much as 30 to 35 percent of their supply volume.

The finned tube radiators throughout the 1957 and 1975 areas lack control valves for individual zone control. As a result, these spaces served by the radiation receive heating regardless of whether or not they need it. The air system is then used to cool off the spaces that are overheated. During the spring and fall, the heating and cooling systems operate simultaneously in an effort to maintain comfort. This creates an extremely energy inefficient system.

Pneumatic thermostats and panels are used to control the air handling unit dampers, control valves and VAV dampers. The campus DDC system has the ability to start/stop and monitor basic HVAC alarms.

Domestic hot water is generated with a storage tank using low pressure steam in the basement mechanical room.

The building envelope is constructed of masonry block with exterior face brick. The windows are single pane, wood framed, operable windows, are original to the 1975 construction, and are in need of replacement.

The offices, corridors, and classrooms in the throughout the building, except for the newest addition are lit with a combination of two and four lamp, T-12 fluorescent fixtures. The addition utilizes T8 fixtures.

Fixtures are manually controlled via wall mounted light switches. Task lighting is also used in some office areas on an as needed basis. Exit lights are equipped with incandescent bulbs.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Pugsley Hall								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$14,380		66352			$2,256	6.4
5.1.5	Replace Incandescent Exit Signs with LED	$4,030	2	17415			$592	6.8
5.1.7	Retrofit T-12 Fixtures with T-8s	$73,370	36	164050			$5,578	13.2
5.4.42	HVAC Overhaul	$1,056,280	8	417877			$14,208	74.3
5.4.43	HHW Overhaul	$86,250	0	2411	5,021	80	$14,856	5.8
5.3.8	Schedule AHUs Off During Unoccupied Hours	Included in DDC Upgrade	0	46281			$1,574	0.0
5.4.28	Replace Chillers and add VFDs to CHW pumps	$162,730	112	363713			$12,366	13.2
5.3.18	Schedule Toilet Exhaust Off During Unoccupied Hours	$1,730		1516			$52	33.6
	TOTAL	**$1,706,550**	**159**	**1,079,615**	**5,021**	**80**	**51,481**	**33.1**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. HVAC overhaul includes the following improvements: VFDs on fan motors, premium efficiency fan motors, VAV boxes, DDC controls, faulty ductwork replacement, CO2 control on OA
4. HHW overhaul includes the following improvements: HHW VFD, control valves for radiation zone control.
5. Completing HVAC and HHW overhauls will allow for the following to be possible: HVAC schedule to match occupancy, OA Economizer.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	1.06	/Therm Gas
$	-	/Mtb Steam
$	-	/Gal Fuel Oil
$	118.65	Ton Coal
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.11. Rotunda

Building Overview

The building was originally built in 1969 with a total square footage of 27,000.The building is used for general purpose classrooms.

Students and employees occupy the building from 6:00 am to 10:00 pm on weekdays.

High pressure steam (90 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate heating water for the building through one converter located in the penthouse.The converter has a pair of redundant pumps which distribute heating water to finned tube radiators and unit heaters. The 3/4 hp pumps and converter serving the finned

tube are enabled to operate when the outside air is below 60F.The pump motors are standard efficiency.

Cooling is provided by chilled water from the nearby NFA facility. A single booster pump is located in the Rotunda penthouse which draws water from the primary chilled water loop and circulates it through the air handling unit coils. The pump motor is premium efficiency.

Nine air handling units provide cooling and ventilation to the facility. All nine of the units are single zone, constant volume units. Each of the units are equipped with chilled water cooling coils, steam heating coils, face and bypass dampers, air filters, supply fans, and outside, and return air dampers. The chilled water coils do not possess control valves, instead, the coil is allowed to run wild while the face and bypass dampers are modulated to maintain the supply air temperature setpoint.

The facility has a Johnson Controls DDC front end system with pneumatic valve and damper actuators. The controllers and space temperature sensors are pneumatically powered. The DDC system has the ability to schedule the air handling units on/off, however not on an individual basis. All the units must be scheduled together as one.

Domestic hot water is generated in the nearby NFA facility.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows.

The lighting in the Rotunda is primarily four lamp 32watt fluorescent T-8 fixtures and 150 watt recessed can and spotlight fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Rotunda									
			Estimated Annual Utility Savings						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Tons Coal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$3,570	4	11,835			$402	8.9	1, 2
5.1.3	Install Motion Sensors to Control Lighting	$7,480	0	15650			$532	14.1	1, 2, 3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$6,100	23.114	35780.472			$1,217	5.0	1, 2
5.3.3	Install VFDs on Hydronic Pumps	$3,110	0	2,215			$75	41.3	1, 2
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$39,560	0	21,915	4,179	125	$20,035	2.0	1, 2, 5
5.3.13	Demand Control Ventilation	$31,860	5	1,143	2,951	88	$13,661	2.3	1, 2, 5

Opportunities for ECMs at Rotunda									
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings				Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms	Tons Coal			
	(CO2)								
5.3.13	Upgrade Controls to Full DDC	$116,500	-	22,633	740	22	$4,184	27.8	1, 2, 4, 5
	TOTAL	$208,180	32	111,172	7,869	236	40,106	5.2	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Motion control assumes 4hr reduction in classrooms only

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	1.06	/Therm Gas
$	-	/Mtb Steam
$	-	/Gal Fuel Oil
$	118.65	Ton Coal
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.7.12. Young Hall

Building Overview

The building was originally built in 1969 with a total square footage of 79,000.The building is used as a dormitory.

Students occupy the building 24 hours per day, 7 days per week from the last week in August to the middle of May. The facility is also intermittently occupied during the summer months for camps.

High pressure steam (90 psi) is reduced to low pressure steam (15 psi) at the building where it is used to generate domestic hot water and heating water for the building through three converters.

Each converter serves a different area of the building; one converter serves the bathrooms, one serves the North wing, and one serves the South wing. The North and South zones are served with 2 hp circulating pumps, while the bath zone is served with a 1/3 hp pump.Each of the pumps are powered by standard efficiency motors.

The lobby is air conditioned with a single zone constant volume Dx rooftop unit.

Since the terminal units lack control valves, the only way to control temperature is to reset the heating hot water temperature. This strategy tends to satisfy some occupants while overheating all others.As a result, most occupants leave their windows open to keep their rooms comfortable.The converters and pumps are started and stopped based outside air temperature.

Toilet exhaust is central to each wing. Make up air to the toilet/shower rooms is provided by fan coil units with hydronic heating coils.

Domestic hot water is generated with an instantaneous steam water heater located in Larson Commons.

The facility has a Johnson Controls DDC front end system with pneumatic valve and damper actuators.

The building envelope is constructed of masonry block with exterior face brick. The windows are double pane, aluminum framed windows.

The lighting in Young Hall is primarily 32watt fluorescent T-8 fixtures.

ECM's

Previously Implemented ECMs

T8 Lighting upgrade.

Opportunities for ECMs at Young Hall

ECM No.	Energy Conservation Measure (ECM)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$6,900	7	23,478	$798	8.6	1,
5.1.5	Replace Incandescent Exit Signs with LED	$3,450	0.852	7463.52	$254	13.6	1,
	TOTAL	$10,350	7	30,942	1,052	9.8	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.7.12.1. Campus Summary

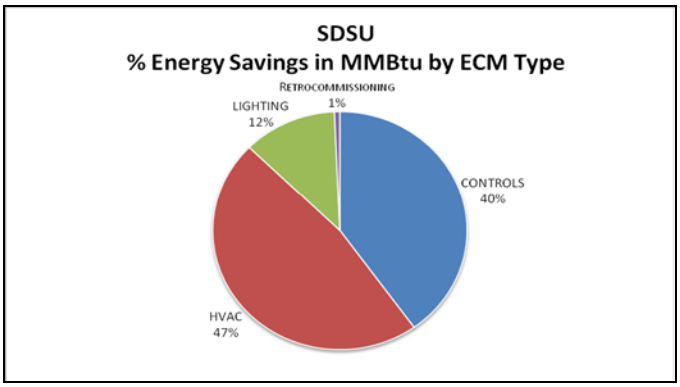
A total of 44 ECMs were identified at SDSU buildings, which include 42,335 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $3.9 million, and save an estimated $315,147 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

BOR ECM Summary Table.

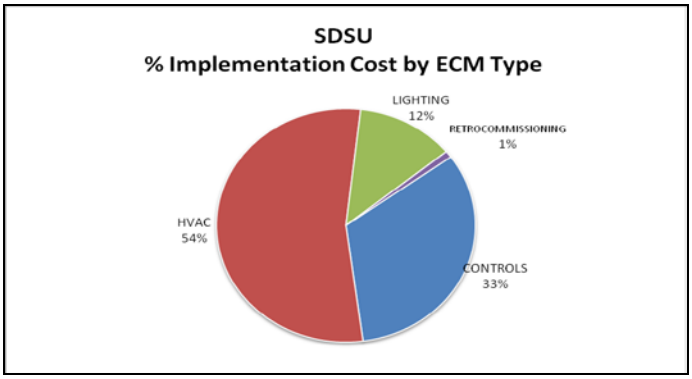
	MMBtu Electric	MMBtu Natural Gas & Coal	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	3,090	13,894	**16984**	$109,506	$1,295,520	**11.8**
HVAC	3,339	16,672	**20011**	$152,432	$2,124,070	**13.9**
LIGHTING	5,050	0	**5050**	$50,319	$483,510	**9.6**

RETROCOMMISSIONING	290	0	**290**	$2,890	$35,650	**12.3**
Total	**11,769**	**30,566**	**42,335**	**$315,147**	**$3,938,750**	**12.5**

In total, these savings represent a 11% reduction from current energy consumption at the SDSU campus, the majority of which is attributed to HVAC measures which will reduce natural gas & coal consumption.



SDSU Energy Savings by ECM Category.



SDSU Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 20,165 MMBTUs (5.5% of campus energy use) and a total estimated annual cost avoidance of $135,593. The total cost of implementation for these measures is $341,340, which yields a simple payback of 2.5 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Pugsley	5.3.8	Included in DDC Upgrade	158	$1,574	0.0	n/a
Central Heating Plant	5.4.43	$138,120	10,148	74,303	1.9	13.61
Chilled Water Plant	5.4.30	$4,600	247	$2,466	1.9	18.59

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Rotunda	5.3.4	$39,560	3,514	$20,035	2.0	11.26
Rotunda	5.3.13	$31,860	2,432	$13,661	2.3	13.10
NFA	5.3.13	$11,500	647	$3,939	2.9	17.78
Rotunda	5.1.8	$6,100	122	$1,217	5.0	49.97
Briggs Library	5.3.3	$23,350	456	$4,543	5.1	51.22
Pugsley	5.4.31	$86,250	2,440	$14,856	5.8	35.34
TOTAL		**$341,340**	**20,165**	**$136,593**	**2.5**	**16.93**

4.2.8 University of South Dakota

Campus Background and List of Facilities

The University of South Dakota is home to over 9,000 students and 380 faculty members that occupy approximately 63 major buildings, totaling approximately 2,000,000 square feet. Buildings visited during a September 2009 walkthrough are included in this report. Due to walkthrough time constraints, not all campus buildings are presented.

Campus-Wide Systems and Operational Profile

The campus has a central plant located in the Davidson Building that houses four high pressure steam boilers and serves most of the campus. Steam is generated at 150 psig and is reduced down to 40 psig and 5 psig in the plant before it is distributed to campus. The steam pressure sent to each building is based primarily on the distance between the building and the central plant. Steam pressure is typically reduced to 5 psig inside of each building. Most buildings use the central steam, but there are a few that have their own steam or hot water boilers. Within the buildings steam is both used directly for heating and also converted to hot water. Several buildings have their own chillers or air compressors.

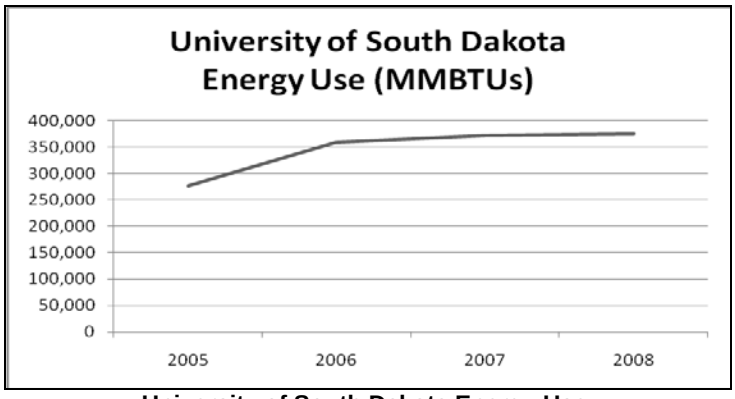
All exterior lighting is controlled by a single campus-wide photocell.

Most buildings on campus are on a common building automation system in the Davidson Building. The BAS is a Johnson Controls Metasys system.

The campus is limited to a peak demand of 7000 KW. When the campus approaches this limit the BAS will begin to stage chillers off and on to reduce demand.

Energy Profile

In 2008, University of South Dakota facilities consumed a combined 375,301 MMBTUs of energy. The average Energy Use Intensity across the campus was 182 kBTU/SF in 2008.



University of South Dakota Energy Use.

4.2.8.1. Akeley-Lawrence Science Center

Building Overview

The Akeley-Lawrence Science Center is a 40,662 square feet facility that primarily consists of classrooms and offices.

40 psig steam is supplied to the building from the power plant, however it is reduced to 15 psig before it enters the building. The steam is sent through a steam to hot water heat exchanger. The building does not have central cooling, approximately six offices have split system fan coils.

A 100% outside air, heating only unit serves the second floor for makeup. Also a dedicated air handler serves the auditorium and has DX cooling and hot water heating. Floor-mounted, hot water fan coil units provide heating throughout the building.

The building hot water systems are fed by constant speed pumps.

Lighting in the building is by T-8 fixtures and CFLs. Incandescent fixtures were observed in the hallways. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Akeley-Lawrence Center							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,630	1	3,019	$100	16.4	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$280	3.42	13764.816	$454	0.6	
5.3.3	Install VFDs on Hydronic Pumps	$3,450		4,590	$151	22.8	
	TOTAL	$5,360	4	21,373	705	7.6	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.2. Al Neuharth Media Center

Building Overview

The Al Neuharth Media Center is a 62,482 square feet facility that primarily consists of classrooms and offices.

All heating for the building is provided by a hot water boiler installed in the building. An air-cooled chiller produces chilled water for the building.

The building hot water and chilled water systems are fed by constant speed pumps.

Several air handlers serve the building. The units have constant speed fans, hot water coils, and chilled water coils. One air handling unit has VAV boxes.

Lighting in the building is by T-8 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

Building controls are DDC.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Al Neuharth Media Center								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in	$3,260	2	6,037		$199	16.4	

Opportunities for ECMs at Al Neuharth Media Center								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
	Office Areas in Lieu of 32W							
5.1.5	Replace Incandescent Exit Signs with LED	$3,110	0.568	4975.68		$164	18.9	
5.2.1	Full Retrocomissioning and Balancing Study	$37,260		21,844	2204.836	$2,372	15.7	
5.3.3	Install VFDs on Hydronic Pumps	$4,600		14,004		$462	10.0	
5.3.3	Install VFDs on Hydronic Pumps	$4,600		12,852		$424	10.8	
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$16,100		72,238		$2,384	6.8	
5.3.13	Demand Control Ventilation (CO2 Control)	$17,250		7,259	2,141	$1,843	9.4	
5.3.21	Install Cooling/Heating Control Valves	$1,150		-		$0	NA	3
	TOTAL	$87,330	2	139,209	4,346	7,849	11.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Control valves must be installed for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.3. Belbas Center

Building Overview

The Belbas Center is a 16,565 square feet facility that primarily consists of offices.

5 psig steam is supplied to the building from the power plant. The steam is sent through a steam to hot water heat exchanger. An air-cooled chiller produces chilled water for the building. A heat recovery chiller is also in place.

The building hot water system is fed by constant speed pumps. The building chilled water system is fed by a variable speed pump.

One main air handling unit serves the building. Fan coil units are installed in each room and use both chilled water and hot water.

Lighting in the building is by T-8 fixtures. Exit signs are LED. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Belbas Center							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,300	1	2,415	$80	16.3	
5.3.3	Install VFDs on Hydronic Pumps	$3,570		6,487	$227	15.7	
	TOTAL	$4,870	1	8,902	294	16.6	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.4. Business School Building

Building Overview

The Business School Building is a 69,000 square feet facility that primarily consists of classrooms and offices. The building was just recently built and was still undergoing some construction during the time of the walk-through.

Hot water for the building is produced by boilers installed in the building. An air-cooled chiller produces chilled water for the building.

The building chilled water and hot water systems are fed by variable speed pumps.

Three large air handlers serve the building. The units have VFDs, chilled water coils, and hot water coils.

Lighting in the building is by T-8 and T-5 fixtures. MR-16 fixtures were observed in the lobby and the outside canopy. Exit signs are LED. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Business School Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$4,780	2	8,855		$292	16.4	
5.1.11	Implement Daylighting Controls	$1,730	0	31,332		$1,034	1.7	
5.1.18	Replace Halogen MR-16 Lamps with Equivalent LED Lamps	$2,650	1.8	7,245		$239	11.1	
5.2.1	Full Retrocomissioning and Balancing Study	$37,260		21,608	3,246	$3,145	11.8	
5.3.3	Install VFDs on Hydronic Pumps	$7,360		28,619		$944	7.8	
5.3.3	Install VFDs on Hydronic Pumps	$4,370		18,360		$606	7.2	
5.3.13	Demand Control Ventilation (CO2 Control)	$8,630		7,172	2,025	$1,754	4.9	
5.3.14	Convert Three-way Valves to Two-way	$8,630		-		$0	NA	3
5.3.14	Convert Three-way Valves to Two-way	$8,630		-		$0	NA	3
	TOTAL	$84,040	4	123,189	5,272	8,014	10.5	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.5. Churchill-Haines Labs

Building Overview

Churchill-Haines Labs is a 74,273 square feet facility that primarily consists of classrooms and lab spaces. The building is slated for significant HVAC renovations. The renovations have been designed and are currently out for bid.

5 psig steam is supplied to the building from the power plant. The steam is used at the air handlers and is also sent through a steam to hot water heat exchanger.

The building hot water systems are fed by constant speed pumps.

Three main air handlers serve the building. The units are 100% outside air, have variable speed fans, hot water coils, and steam coils. One air handling unit has VAV boxes. There is no central cooling in the building, but there are several rooftop cooling units and DX fan coil units that serve individual areas.

Lighting in the building is by T-8 and T-12 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Renovation of air handling equipment has been designed and is currently out for bid. The renovation includes a water-cooled chiller, variable speed pumps, and an energy recovery coil.

Opportunities for ECMs at Churchill-Haines Labs							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$10,320	5	19,118		$631	16.4
5.1.5	Replace Incandescent Exit Signs with LED	$3,110	0.568	4975.68		$164	18.9
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,090	2.7	10866.96		$359	11.4
5.2.1	Full Retrocomissioning and Balancing Study	$37,260		40,347	4368.186	$4,603	8.1
5.4.42	Install Ultrasonic Humidifiers	$161,000		(59,472)	41,829	$29,367	5.5
	TOTAL	**$215,780**	**8**	**15,835**	**46,197**	**35,124**	**6.1**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.6. DakotaDome

Building Overview

The DakotaDome is a 218,829 square feet facility that primarily consists of a stadium, a pool, common areas, and offices.

All heating for the building is electric. Two air-cooled chillers produce chilled water for the building.

The building chilled water systems are fed by constant speed pumps.

Four large air handlers serve the building, but only two are typically online. The units have constant speed fans, electric heat coils, and chilled water coils.

Lighting in the building is by T-8 and T-12 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches. The stadium lights are metal halides.

Building controls are pneumatic.

Chillers are run at night on peak days to shed peak electric load. They are then turned off in the morning and the rest of campus is able to avoid exceeding their kW demand limit.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at DakotaDome							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$2,170	1	4,025	$133	16.3	
5.1.3	Install Motion Sensors to Control Lighting	$1,730	0	13622.4	$450	3.8	
5.1.5	Replace Incandescent Exit Signs with LED	$6,210	1.136	9951.36	$328	18.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$3,120		16249	$536	5.8	3
5.1.9	Install Scheduling Control of Lighting	$41,700		138000	$4,554	9.2	3
5.2.1	Full Retrocomissioning and Balancing Study	$38,870		318,000	$10,494	3.7	
5.2.6	Schedule air handlers night setback	$6,500		256,828	$8,475	0.8	3
5.2.9	Reduce Minimum Outside Air Ventilation Amount	$8,000		366,109	$12,082	0.7	3
5.3.3	Install VFDs on Hydronic Pumps	$40,250		177,602	$5,861	6.9	
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$79,500		173,183	$5,715	13.9	3
5.3.14	Convert Three-way Valves to Two-way	$13,800		-	$0	NA	4
5.4.35	Replace Outside Air Damper	$15,500		92,663	$3,058	5.1	3
5.5.17	Remove Return Air Duct Sound Attenuators	$20,200		111,228	$3,671	5.5	3
5.5.17	Install Dedicated Locker Room Air Handlers	$120,000		233599	$7,709	15.6	3
5.5.17	Retrofit HID Lighting in Bowl	$38,900		85,400	$2,818	13.8	3
5.5.17	Upgrade Weight Room Lighting with LED Fixtures	$52,800		28,080	$927	57.0	3
5.5.17	Vent Laundry Dryers Outdoors	$6,500		19,454	$642	10.1	3
5.5.17	Bowl Air Destratification	$185,000		650,758	$21,475	8.6	3
	TOTAL	**$680,750**	**2**	**2,694,752**	**88,927**	**7.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on data from stimulus applications.
4. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.7. Davidson Building

Building Overview

The Davidson Building is a 21,496 square feet facility that primarily consists of a steam plant and offices. The Johnson Control system that serves campus is located in the basement.

Lighting in the building is by T-8 and T-12 fixtures. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Davidson Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$6,810	5	39,420		$1,301	5.2
5.4.44	Investigate Reducing Boiler Steam Pressure	$13,800			21,924	$16,421	0.8
	TOTAL	$20,610	5	39,420	21,924	17,722	1.2

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.8. Delzell Education Center

Building Overview

The Delzell Education Center is a 51,227 square feet facility that primarily consists of classrooms and lab spaces.

40 psig steam is supplied to the building from the power plant. The steam is sent through a steam to hot water heat exchanger. An air-cooled chiller produces chilled water for the building. The building is set up as a two-pipe system.

The building hot water and chilled water systems are fed by constant speed pumps.

A 100% outside air unit serves the hallway corridors. Floor mounted fan coil units are installed in each room.

Lighting in the building is by T-8 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Delzell Education Center							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,960	1	3,622	$120	16.4	
5.1.2	Delamp Multiple Lamp Fixtures	$2,420	4.5	18,112	$598	4.0	
5.1.3	Install Motion Sensors to Control Lighting	$3,450	0	20,434	$674	5.1	
5.1.5	Replace Incandescent Exit Signs with LED	$2,330	0.426	3,732	$123	18.9	
5.3.3	Install VFDs on Hydronic Pumps	$4,600		33,623	$1,110	4.1	
5.5.4	Improve Building Envelope - Windows	$106,000			$13,307	8.0	3
	TOTAL	**$120,760**	**6**	**79,522**	**15,931**	**7.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on data from stimulus applications.

Estimated Blended Marginal Rates		
$	.04	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.9. Dormitories

Building Overview

Student housing observed during the walkthrough is comprised of six buildings totaling 296,167 square feet. The buildings include Julian Hall Addition, Brookman Hall, Richardson Hall, Olson Hall, Beebe Hall, and Mickelson Hall. There is additional housing on campus that was not included in the building walkthroughs.

All six of the buildings receive steam from the Power Plant. Julian/Brookman receives steam at 40 psig, while Richardson/Olson/Beebe/Mickelson receives steam at 150 psig. The steam is sent through steam to hot water converters. Julian/Brookman does not have a central cooling system, while Richardson/Olson/Beebe/Mickelson are cooled by water-cooled chillers.

The building hot water systems are fed by constant speed pumps in all six buildings. The building chilled water systems in Richardson/Olson/Beebe/Mickelson are fed by constant speed pumps.

Julian/Brookman do not have air handlers. Heating is by hot water fin tube radiators. Cooling is by window AC units, which are only installed in some rooms. Richardson/Olson/Beebe/Mickelson each have make-up air units with DX cooling and hot water coils that serve the corridors. Each room then has fan coil units, which are supplied by a two-pipe system, with either chilled water or hot water, depending on the season.

The lighting in the buildings is a mixture of T-8 and T-12 fixtures. Incandescent lights are also in place. Exit signs are incandescent. Lighting is controlled manually by wall switches.

Building controls in Richardson/Olson/Beebe/Mickelson are DDC.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Dormitories

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.5	Replace Incandescent Exit Signs with LED	$10,090	2	16,171	$534	18.9
5.1.7	Retrofit T-12 Fixtures with T-8s	$45,430	30	262,800	$8,672	5.2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$1,560	19.38	169,769	$5,602	0.3
5.3.3	Install VFDs on Hydronic Pumps	$4,370		25,217	$832	5.3
	TOTAL	**$61,450**	**51**	**473,957**	**15,641**	**3.9**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.10. I.D. Weeks Library

Building Overview

The I.D. Weeks Library is a 124,697 square feet facility that primarily consists of common areas, storage areas, and offices.

150 psig steam is supplied to the building from the power plant. Some of the steam is used for humidification. The rest of the steam is sent through a steam to hot water heat exchanger. An air-cooled and a water-cooled chiller produce chilled water for the building.

The building chilled water and hot water systems are fed by constant speed pumps.

Three large air handlers serve the building. The units have constant speed fans, chilled water coils, hot water coils, and humidifiers. One of the air handlers is a multizone unit. Fin tube radiators are installed around the perimeter of the building to provide supplemental heat.

Lighting in the building is by T-8 fixtures. CFL can lights were also observed. Exit signs are LED. Lighting for most rooms is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at I.D. Weeks Library Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$3,260	2	6,037		$199	16.4	
5.2.1	Full Retrocomissioning and Balancing Study	$40,370		51,070	4,400	$4,981	8.1	
5.3.3	Install VFDs on Hydronic Pumps	$8,970		23,849		$787	11.4	
5.3.3	Install VFDs on Hydronic Pumps	$4,370		12,852		$424	10.3	
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$10,350		82,437		$2,720	3.8	
5.3.13	Demand Control Ventilation (CO2 Control)	$14,380		22,602	6,383	$5,527	2.6	
5.3.14	Convert Three-way Valves to Two-way	$9,200		-		$0	NA	3
5.4.42	Install Ultrasonic Humidifiers	$92,000		(34,295)	25,365	$17,866	5.1	
	TOTAL	**$182,900**	**2**	**164,552**	**36,148**	**32,505**	**5.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas

Notes
contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$		/Gal Fuel Oil
$		Ton Biomass
$	1.52	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.8.11. Julian Hall Offices

Building Overview

The Julian Hall Offices is a 50,173 square feet facility that primarily consists of classrooms and offices.

150 psig steam is supplied to the building from the power plant. Steam fin tube radiators are installed throughout the building.

No air handlers are installed in the building. Some rooms have window AC units for cooling.

Lighting in the building is by T-8 and T-12 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Julian Hall Offices

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$5,220	2	9,660	$319	16.4	
5.1.5	Replace Incandescent Exit Signs with LED	$2,330	0.426	3,732	$123	18.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$9,990	6.6	26,564	$877	11.4	
	TOTAL	**$17,540**	**9**	**39,955**	**1,319**	**13.3**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.52	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.8.12. Lee Medical School

Building Overview

The Lee Medical School is a 102,015 square feet facility that primarily consists of lab areas and classrooms.

Steam is produced by boilers installed in the building. Steam is sent through the building at 70 psig and 5 psig. The rest of the steam is sent through a steam to hot water heat exchanger. Air-cooled chillers produce chilled water for the building.

The building chilled water and hot water systems are fed by variable speed pumps.

Several air handlers serve the building. The units have VFDs, chilled water coils, and hot water coils. The 100% outside air units have humidifiers. An energy recovery system is used to recover heat from the building exhaust during heating season.

Lighting in the building is by T-8 fixtures. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Lee Medical School							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$6,520	3	12,074		$398	16.4
5.1.3	Install Motion Sensors to Control Lighting	$3,450	0	27,245		$899	3.8
5.1.11	Implement Daylighting Controls	$1,730	0	28,483		$940	1.8
5.2.1	Full Retrocomissioning and Balancing Study	$52,790		81,106	8,400	$8,968	5.9
5.3.13	Demand Control Ventilation (CO2 Control)	$5,750		7,140	2,016	$1,746	3.3
5.3.21	Install Cooling/Heating Control Valves	$1,730		3,086		$102	17.0
5.4.29	Trim CHW Pump Impeller and Open Triple Duty Valve	$2,300	1	4,186		$138	16.6
5.4.42	Install Ultrasonic Humidifiers	$327,750		(130,759)	91,967	$64,568	5.1
	TOTAL	**$402,020**	**4**	**32,563**	**102,383**	**77,760**	**5.2**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.2.8.13. Muenster University Center

Building Overview

The Muenster University Center is a 70,000 square feet facility that primarily consists of common areas, dining, and conference rooms.

150 psig steam is supplied to the building from the power plant where it is sent through a steam to hot water heat exchanger. The building also has a separate boiler that serves the building during the shoulder months. An air-cooled chiller produces chilled water for the building.

The building chilled water system is fed by a constant speed pump. The building hot water system is fed by variable speed pumps.

13 air handlers serve the building. Two of the fans have VFDs, the rest are constant speed. Each air handler is equipped with a hot water coil and a chilled water coil.

Lighting in the building is by T-8 fixtures. MR-16 fixtures were observed in the lobby. Exit signs were LED. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Muenster University Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$2,170	1	8,760		$289	7.5	
5.1.11	Implement Daylighting Controls	$2,070	0	12,384		$409	5.1	
5.1.18	Replace Halogen MR-16 Lamps with Equivalent LED Lamps	$3,310	2.25	19,710		$650	5.1	
5.2.1	Full Retrocomissioning and Balancing Study	$37,260		43,958	3,294	$3,917	9.5	
5.3.3	Install VFDs on Hydronic Pumps	$10,120		42,928		$1,417	7.1	

Opportunities for ECMs at Muenster University Center								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.3.13	Demand Control Ventilation (CO2 Control)	$34,500		11,283	3,187	$2,760	12.5	
5.3.14	Convert Three-way Valves to Two-way	$27,600		-		$0	NA	3
	TOTAL	$117,030	3	139,024	6,481	9,442	12.4	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.04	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.14. National Music Museum

Building Overview

The National Music Museum is a 27,650 square feet facility that primarily consists of exhibit and storage space.

5 psig steam is supplied to the building from the power plant. An air-cooled chiller produces chilled water for the building.

The building chilled water system is fed by a constant speed pump.

Five air handling units serve the building. Each unit has constant speed fans, chilled water coils, steam heating coils, and steam humidifiers.

Lighting in the building is by T-8 and T-12 fixtures. Incandescent can lights and chandelier fixtures are also in place. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at National Music Museum								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Paybac k Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8s	$5,450	4	14,489		$478	11.4	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$370	4.56	18,353		$606	0.6	

Opportunities for ECMs at National Music Museum								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.3.3	Install VFDs on Hydronic Pumps	$3,570		7,632		$252	14.2	
5.3.13	Demand Control Ventilation (CO2 Control)	$14,380		2,608	736	$638	22.6	
5.3.14	Convert Three-way Valves to Two-way	$10,350		-		$0	NA	3
5.4.42	Install Ultrasonic Humidifiers	$37,950		(2,332)	23,320	$17,390	2.2	
	TOTAL	**$72,070**	**8**	**40,750**	**24,056**	**19,363**	**3.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.15. Old Main

Building Overview

Old Main is a 37,803 square feet facility that primarily consists of classrooms, offices, and an auditorium.

40 psig steam is supplied to the building from the power plant. Some of the steam is used directly by air handlers. The rest of the steam is sent through a steam to hot water heat exchanger. An air-cooled chiller produces chilled water for the building.

The building hot water and chilled water systems are fed by constant speed pumps.

Three air handling units serve the building. The two larger units have VFDs, steam heating coils, and chilled water coils. Floor mounted fan coil units are installed in each room and use both chilled water and hot water.

Lighting in the building is by CFL fixtures. Incandescent lights were observed in the auditorium. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Old Main Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$2,610	1	4,830		$159	16.4	
5.1.5	Replace Incandescent Exit Signs with LED	$1,550	0.284	2,488		$82	18.9	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$250	3.135	12,618		$416	0.6	
5.3.3	Install VFDs on Hydronic Pumps	$4,370		7,632		$252	17.4	
5.3.13	Demand Control Ventilation (CO2 Control)	$5,750		1,869	528	$457	12.6	
5.3.14	Convert Three-way Valves to Two-way	$3,450		-		$0	NA	3
	TOTAL	$17,980	5	29,436	528	1,367	13.2	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.16. Patterson Hall

Building Overview

Patterson Hall is a 40,002 square feet facility that primarily consists of classrooms and offices.

40 psig steam is supplied to the building from the power plant. A cooling tower on the roof is used to cool all of the building air handler DX compressors.

Six packaged air handling units serve approximately half of the building. The units have constant speed fans, steam heat, and DX cooling. Steam fin tube radiators are installed in each of the rooms.

Lighting in the building is by T-8 and T-12 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs

Opportunities for ECMs at Patterson Hall							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$2,170	1	4,025	$133	16.3	
5.1.3	Install Motion Sensors to Control Lighting	$1,380	0	23,839	$787	1.8	
5.1.5	Replace Incandescent Exit Signs with LED	$1,550	0.284	2,488	$82	18.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$7,950	5.25	21,130	$697	11.4	
5.5.4	Improve Building Envelope - Windows	$172,000			$12,463	13.8	3
	TOTAL	**$185,050**	**7**	**51,482**	**14,162**	**13.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on data from stimulus applications.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.17. School of Law

Building Overview

The School of Law is a 68,659 square feet facility that primarily consists of classrooms, common areas, and offices.

All heating for the building is electric. An electric hot water boiler is used to generate hot water for the building. A water-cooled chiller produces chilled water for the building.

The building chilled water and hot water systems are fed by constant speed pumps.

Two large air handlers serve the building. The units have constant speed fans, chilled water coils, and electric steam humidifiers. All heating is done via hot water reheat coils.

Lighting in the building is by T-8 and T-12 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

A recommissioning study has been done for this building.

Opportunities for ECMs at School of Law								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,740	1	3,220		$106	16.4	
5.1.5	Replace Incandescent Exit Signs with LED	$3,110	0.568	4,976		$164	18.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$13,630	9	52,013		$1,716	7.9	
5.3.3	Install VFDs on Hydronic Pumps	$4,600		15,263		$504	9.1	
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$15,640		108,424		$3,578	4.4	
5.3.13	Demand Control Ventilation (CO2 Control)	$5,750		5,829	1,646	$1,425	4.0	
5.3.14	Convert Three-way Valves to Two-way	$3,450		-		$0	NA	3
5.4.29	Trim CHW Pump Impeller and Open Triple Duty Valve	$2,300	1	3,864		$128	18.0	
5.4.42	Install Ultrasonic Humidifiers	$25,300		512,447		$16,911	1.5	
	TOTAL	**$75,520**	**12**	**706,037**	**1,646**	**24,532**	**3.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.18. Slagle Hall/Auditorium

Building Overview

Slagle Hall/Auditorium is an 89,480 square feet facility that primarily consists of classrooms, offices, and an auditorium. The auditorium was in the process of being renovated during the time of the walkthrough.

5 psig steam is supplied to the building from the power plant. Steam fin tube radiators are installed throughout the building. A steam to hot water heat exchanger and an air-cooled chiller, both with variable speed driven pumps, will serve the renovated auditorium.

One air handling unit serves the auditorium. The rest of the building is heated with steam fin tube radiators. Some office areas have DX split system units.

Lighting in the building is by T-8 and T-12 fixtures. Corridor lighting is by CFLs and incandescent fixtures. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Auditorium renovation is underway and uses variable speed driven pumps.

Opportunities for ECMs at Slagle Hall / Auditorium						
			Estimated Annual Utility Savings			
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$3,690	2	6,842	$226	16.3
5.1.7	Retrofit T-12 Fixtures with T-8s	$17,260	11.4	45,883	$1,514	11.4
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$600	7.41	29,824	$984	0.6
	TOTAL	**$21,550**	**21**	**82,549**	**2,724**	**7.9**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.19. South Dakota Union

Building Overview

The South Dakota Union is a 35,256 square feet facility that primarily consists of classrooms, offices, and meeting rooms.

5 psig steam is supplied to the building from the power plant.

Steam fin tube radiators are installed in each of the rooms, the radiators are controlled by hand valves. There are no central air handlers. Some rooms have window AC units and small DX units serve dedicated areas throughout the building.

Lighting in the building is by T-12 fixtures. Lighting for most rooms is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at South Dakota Union Building						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,740	1	3,220	$106	16.4
5.1.7	Retrofit T-12 Fixtures with T-8s	$13,630	9	36223.2	$1,195	11.4
	TOTAL	$15,370	10	39,443	1,302	11.8

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.20. Temporary Administrative/Classrooms

Building Overview

The Temporary Administrative/Classrooms Building is a 17,104 square feet facility that primarily consists of classrooms, offices, meeting rooms, and storage.

150 psig steam is supplied to the building from the power plant. Some of the steam is used directly for humidification. The rest of the steam is sent through a steam to hot water heat exchanger. An air-cooled chiller produces chilled water for the building.

The building hot water and chilled water systems are fed by constant speed pumps.

Two air handling units serve the building. Both units are multizone and have constant speed fans, chilled water coils, hot water coils, and steam humidifiers.

Lighting in the building is by T-8 and T-12 fixtures. CFL can lights were also observed. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Temporary Administration / Classrooms								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$650	0	1,207		$40	16.3	
5.1.2	Delamp Multiple Lamp Fixtures	$970	1.8	7,245		$239	4.1	
5.1.3	Install Motion Sensors to Control Lighting	$350	0	11,889		$392	0.9	
5.1.5	Replace Incandescent Exit Signs with LED	$1,240	0.2272	1,990		$66	18.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,540	3	12,074		$398	11.4	
5.3.3	Install VFDs on Hydronic Pumps	$3,570		7,632		$252	14.2	
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$5,750		45,780		$1,511	3.8	
5.3.13	Demand Control Ventilation (CO2 Control)	$5,750		2,346	663	$574	10.0	
5.3.14	Convert Three-way Valves to Two-way	$3,450		-		$0	NA	3
5.4.42	Install Ultrasonic Humidifiers	$25,300		(3,560)	2,633	$1,854	13.6	
	TOTAL	**$51,570**	**5**	**86,604**	**3,295**	**5,326**	**9.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Three-way valves must be converted to two-way valve operation for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.03	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.21. Warren M. Lee Center for the Fine Arts

Building Overview

The Warren M. Lee Center for the Fine Arts is a 104,190 square feet facility that primarily consists of classrooms, work studios, and storage.

150 psig steam is supplied to the building from the power plant. Some of the steam is used directly by air handlers. The rest of the steam is sent through a steam to hot water heat exchanger. An air-cooled chiller produces chilled water for the building.

The building hot water and chilled water systems are fed by constant speed pumps.

Approximately 25 air handling units serve the building. Two of the units are multizone. All units have constant speed fans, chilled water coils, hot water coils, and some steam coils.

Lighting in the building is by T-8 and T-12 fixtures. Exit signs are incandescent. Lighting for most rooms is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Warren M. Lee Center for the Fine Arts								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$2,830	1	5,232		$173	16.4	
5.1.3	Install Motion Sensors to Control Lighting	$3,450	0	23,220		$766	4.5	
5.1.5	Replace Incandescent Exit Signs with LED	$4,660	0.852	7,464		$246	18.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$20,440	13.5	54,335		$1,793	11.4	
5.3.3	Install VFDs on Hydronic Pumps	$4,600		15,263		$504	9.1	
5.3.3	Install VFDs on Hydronic Pumps	$4,370		13,770		$454	9.6	
5.3.9	Upgrade Controls System to Full DDC	$86,250		79,777	6,128	$7,222	11.9	
5.3.13	Demand Control Ventilation (CO2 Control)	$8,630		4,025	1,137	$984	8.8	
5.3.21	Install Cooling/Heating Control Valves	$29,900		-		$0	NA	3
	TOTAL	**$165,130**	**16**	**203,086**	**7,264**	**12,143**	**13.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Control valves must be installed for pump VFD savings to be realized.

Estimated Blended Marginal Rates		
$	.04	/kWh Elec
$	.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.2.8.21.1. Campus Summary

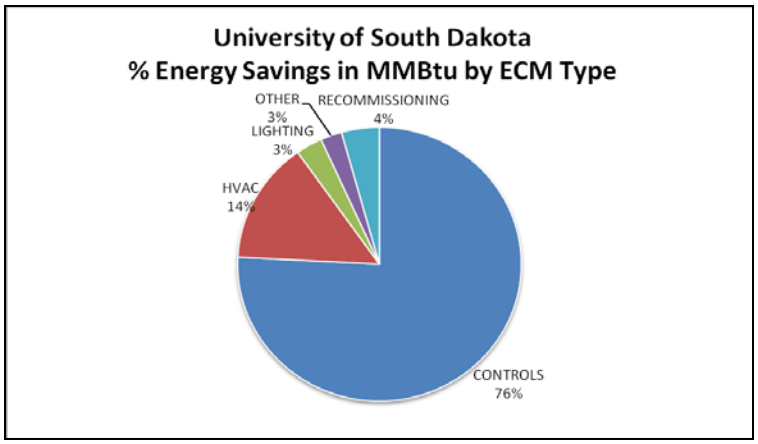
A total of 133 ECMs were identified at University of South Dakota buildings, which include 44,619 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $2.6 million, and save an estimated $392,150 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

BOR ECM Summary Table.

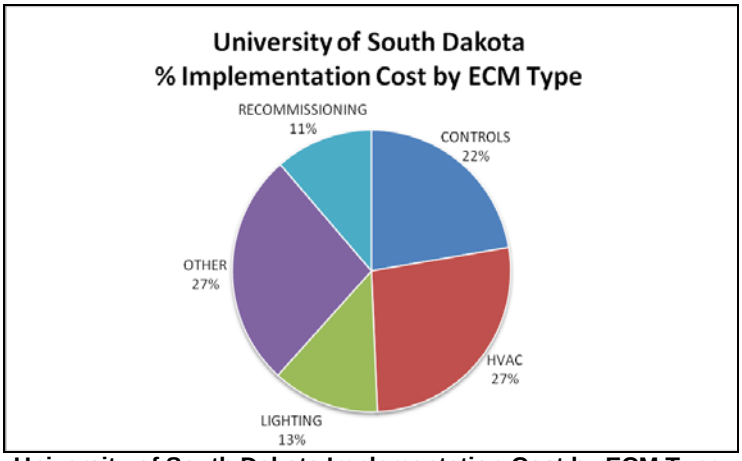
	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	3,771	115,736	**119,507**	$874,831	$581,410	**0.7**
HVAC	1,306	21,408	**22,714**	$167,701	$703,200	**4.2**
LIGHTING	4,757	0	**4,757**	$46,011	$323,100	**7.0**

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
OTHER	3,851	0	**3,851**	$63,011	$701,400	**11.1**
RECOMMISSIONING	4,097	2,679	**6,777**	$59,037	$295,570	**5.0**
Total	**17,782**	**139,823**	**157,605**	**$1,210,592**	**$2,604,680**	**2.2**

In total, these savings represent a 42% reduction from current energy consumption at the University of South Dakota campus, the majority of which is attributed to controls measures which will reduce natural gas consumption.



University of South Dakota Energy Savings by ECM Category.



University of South Dakota Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 32,294 MMBTUs (8.5% of campus energy use) and

a total estimated annual cost avoidance of $255,883. The total cost of implementation for these measures is $959,340, which yields a simple payback of 3.7 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Payback	$ Invested / MMBTU saved
Dormitories	5.1.8	$1,560	579	$5,602	0.3	2.69
Old Main	5.1.8	$250	43	$416	0.6	5.81
Slagle Hall	5.1.8	$600	102	$984	0.6	5.90
National Music Museum	5.1.8	$370	63	$606	0.6	5.91
Akeley-Lawrence Science Center	5.1.8	$280	47	$454	0.6	5.96
DakotaDome	5.2.9	$8,000	1,249	$12,082	0.7	6.40
DakotaDome	5.2.6	$6,500	876	$8,475	0.8	7.42
Davidson Building	5.4.27	$13,800	2,267	$16,421	0.8	6.09
Temporary Administrative/Classrooms	5.1.3	$350	41	$392	0.9	8.63
School of Law	5.4.42	$25,300	1,748	$16,911	1.5	14.47
New School Business	5.1.11	$1,730	107	$1,034	1.7	16.18
Patterson Hall	5.1.3	$1,380	81	$787	1.8	16.97
Lee Medical School	5.1.11	$1,730	97	$940	1.8	17.80
National Music Museum	5.4.42	$37,950	2,403	$17,390	2.2	15.79
ID Weeks Library	5.3.13	$14,380	737	$5,527	2.6	19.51
Lee Medical School	5.3.13	$5,750	233	$1,746	3.3	24.69
DakotaDome	5.2.1	$38,870	1,085	$10,494	3.7	35.82
ID Weeks Library	5.3.5	$10,350	281	$2,720	3.8	36.80
Temporary Administrative/Classrooms	5.3.5	$5,750	156	$1,511	3.8	36.81
Lee Medical School	5.1.3	$3,450	93	$899	3.8	37.11
DakotaDome	5.1.3	$1,730	46	$450	3.8	37.22
School of Law	5.3.13	$5,750	190	$1,425	4.0	30.25
Delzell Education Center	5.1.2	$2,420	62	$598	4.0	39.16
Temporary Administrative/Classrooms	5.1.2	$970	25	$239	4.1	39.24
Delzell Education Center	5.3.3	$4,600	115	$1,110	4.1	40.10
School of Law	5.3.5	$15,640	370	$3,578	4.4	42.28
Warren Lee Center for the Fine Arts	5.1.3	$3,450	79	$766	4.5	43.55
New School Business	5.3.13	$8,630	234	$1,754	4.9	36.90
Muenster University Center	5.1.11	$2,070	42	$409	5.1	48.99
DakotaDome	5.4.35	$15,500	316	$3,058	5.1	49.02
Lee Medical School	5.4.42	$327,750	9,063	$64,568	5.1	36.16
Muenster University Center	5.1.18	$3,310	67	$650	5.1	49.22
Delzell Education Center	5.1.3	$3,450	70	$674	5.1	49.48
ID Weeks Library	5.4.42	$92,000	2,506	$17,866	5.1	36.72

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Payback	$ Invested / MMBTU saved
Davidson Building	5.1.7	$6,810	135	$1,301	5.2	50.63
Dormitories	5.1.7	$45,430	897	$8,672	5.2	50.67
Dormitories	5.3.3	$4,370	86	$832	5.3	50.79
Churchill-Haines Lab	5.4.42	$161,000	4,122	$29,367	5.5	39.06
DakotaDome	5.5.17	$20,200	380	$3,671	5.5	53.23
DakotaDome	5.1.7	$3,120	55	$536	5.8	56.28
Lee Medical School	5.2.1	$52,790	1,145	$8,968	5.9	46.09
TOTAL		**$959,340**	**32,294**	**$255,883**	**3.7**	**29.71**

4.3 Department of Agriculture

The Department of Agriculture (DOA) is responsible for the promotion and enhancement of South Dakota agriculture, and for the implementation of a variety of State laws relating to agriculture.

The primary facilities of the Department of Agriculture are at the State Fairgrounds, where there are a total of 832,742 square feet of facilities.

4.3.1 State Fair Grounds

Campus Background and List of Facilities

The South Dakota State Fair Grounds consists of approximately 99 buildings totaling 832,742 square feet. The State Fair runs annually during the first week in September. Between 100,000 and 160,000 people attend the State fair each year. Non-fair events are also held throughout the calendar year at various buildings on the campus.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, the facilities at the State Fairground consumed a combined 12,257 MMBTUs of energy. The average Energy Use Intensity for these facilities was 14.7 kBTU per square foot for 2008. Limited energy consumption data was available for the State Fairgrounds prior to 2008.

4.3.1.1. Administration Building

Building Overview

The 3,800 square foot administration building is one of the few on the State Fair campus that is used year round. The six building occupants typically follow an 8am to 5:30pm schedule.

Building heating and cooling is provided by a two Trane XE800 gas fired furnace each with DX cooling. The furnace AFUE is rated at 80%.Each unit is controlled by individual thermostats. These thermostats are non-programmable. Typical temperature setpoints are 78°F in the summer and 65°F in the winter. Winter unoccupied setpoints are set manually at 50°F at the end of each business day and the units are turned to off position in the evenings during the summer months.

Lighting in the building is primarily 100w down light fixtures. Approximately 70% of these fixtures use compact fluorescent bulbs. Areas of the building are also lit by two lamp T12 fluorescent fixtures.

Domestic hot water is provided by a 40 gallon gas fired atmospheric heater.

ECM's

Previously Implemented ECMs

Change over to compact fluorescent bulbs in down lighting fixtures.

Opportunities for ECMs at Administration Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$260	0	546		$64	4.1
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$330	2	795		$93	3.5
5.3.2	Programmable Thermostat for Residential Style Units	$350		9,907	237	$1,397	0.3
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$1,150			70	$70	16.4
5.5.20	Replace Standard Efficiency Hot Water Heater with High Efficiency	$120			12	$12	10.3
	TOTALS	**$2,210**	**2**	**11,248**	**319**	**1,635**	**1.4**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Payback based on incremental cost increase to use high efficiency systems at end of useful life of existing equipment.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	1.00	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.3.1.2. Barn and Exhibit Buildings

Building Overview

There are several barn style and exhibit buildings located on the State Fair Campus. The building square footages range from 2,000 to 96,000 for a total of approximately 490,000 square feet. These buildings are primarily only used during the week of the fair. The Open Class Beef Complex and Hippodrome are both used for individual non-fair events during the year.

There are no heating or cooling systems installed in the barn buildings. The majority of the buildings are ventilated by a single fractional horsepower exhaust fans installed in exterior walls. These fans are individually switch operated and typically only used during the fair.

Lighting in the barn buildings are primarily high bay metal halide fixtures with 200, 300 or 400 watt lamps. Several barn buildings also utilize incandescent light fixtures with lamps ranging from 100 to 300 watts.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Barn and Exhibit Buildings							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$12,840	84	30,153	$3,528	3.6	2
5.1.10	Replace HID Lighting with High Bay Fluorescent	$57,960	74	26,709	$3,125	18.5	2
		$57,960	**74**	**26,709**	**3,125**	**18.5**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Calculations assume facility is only during the week of the fair and select events throughout the year.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	1.00	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.3.1.3. Expo Building

Building Overview

The Expo Building is a 14,700 square foot building used for exhibits and large gatherings. The building is primarily used during the week of the State Fair, but is also used for non-fair events during the year.

The building is ventilated by two DX rooftop cooling only units. Each unit is controlled by an individual non-programmable thermostat. Heating in the building is accomplished by six electric heaters. The heating and cooling equipment only operates when the building is occupied.

The building uses 300watt metal halide high bay fixtures for lighting when the building is occupied.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Expo Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$13,800	18	4,770	$558	24.7	1,2
5.1.10	Replace HID Lighting with High Bay Fluorescent	$2,590	12	4,554	$533	4.9	1,3
		$16,390	**29**	**9,324**	**1,091**	**15.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.3.1.4. Fair Grounds Restroom Buildings

Building Overview

There are nine Restroom Buildings located on the State Fair Campus. The building square footages range from 570 to 2,500 for a total of approximately 11,000 square feet. These restrooms are used heavily during the week of the fair and during race events, but are left in operational status between the months of June and October annually.

There are no heating or cooling systems installed in the restroom buildings. The majority of the buildings are ventilated by a single fractional horsepower exhaust fans.

Lighting in the restroom buildings are primarily incandescent with 75watt lamps. Four foot T12 fixtures with two lamps are also used for lighting in the majority of the buildings. The lighting remains on day and night when the restrooms are operational.

In the majority of the restroom buildings 100 gallon gas fired atmospheric heaters provide domestic hot water. These hot water heaters operate continually while the restrooms are in operational status.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Fair Grounds Restroom Buildings								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$4,090	-	9,622		$1,126	3.6	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$3,110	1	3,641		$426	7.3	2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$2,150	9	31,208		$3,651	0.6	2
5.1.11	Implement Daylighting Controls	$3,310	-	13,003		$1,521	2.2	2
5.5.2	Replace Storage Type Domestic Water Heaters with on Demand	$8,280			503	$503	16.5	2
	TOTAL	$20,940	10	57,474	503	7,228	2.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Savings assumes that buildings are on and fully illuminated continuously for five months during the year.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	1.00	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.3.1.5. Family Living / Tech Center

Building Overview

The Family Living and Tech Center is a 23,427 square foot building used for exhibits and large gatherings. The building is primarily used during the week of the State Fair.

There is no central heating or cooling systems installed in the Family Living and Tech Center building. In the Tech Center area there are four 3 ton heat pumps used to air condition the space. These heat pumps use single pass domestic cold water and are run only during the summer months to prevent mold growth in the building.

Lighting in the Family Living Center portion of the building is primarily incandescent lighting with either 100 or 300 watt bulbs. The Tech Center lighting uses 300watt metal halide fixtures. The exit lighting in the building uses compact fluorescent lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Family Living / Tech Center Buildings						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$4,030	22	8,493	$994	4.1
5.1.10	Replace HID Lighting with High Bay Fluorescent	$3,910	5	1,880	$220	17.8
		$3,910	**5**	**1,880**	**220**	**17.8**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.3.1.6. Grandstand

Building Overview

The Grandstand consists of approximately 32,400 square feet of either open room or seating area. The Grandstand is used during the week of the State Fair as well as during race events between the months of April and October annually.

There is no central heating or cooling systems installed in the Grandstand facility. There are eight 8,000 BTU/h window style air conditioning units installed in the office are portion of the building. These units reject heat to the space below the Grandstand.

Lighting in the building is primarily incandescent lighting with either 100 or 300 watt bulbs. Areas in the building are also lit with either four foot four lamp T12 or eight foot two lamp T12 fixtures.

The race track lighting uses metal halide fixtures with either 300 or 400 watt lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Grandstand Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,150		220	$26	44.6	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$2,990	16	10,980	$1,285	2.3	3

Opportunities for ECMs at Grandstand Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.11	Implement Daylighting Controls	$460		941	$110	4.2	3,4
5.1.13	Replace 8' Fixtures with 4' Fixtures	$7,940	1	739	$86	91.8	3,5
	TOTAL	$12,540	17	12,881	1,507	8.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure assumes that facility is only used during the State Fair and Speedway events.
4. Savings based on assumption that lighting can be turned off an additional 8 hours per day while sun is up.
5. Measure replaces 8' T-12 fixtures with two 4' T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.3.1.7. Horticulture Building

Building Overview

The Horticulture Building is a 15,800 square foot building used for exhibits and large gatherings. The building is primarily used during the week of the State Fair, but is also used for non-fair events during the year.

There are no heating or cooling systems installed in this building. Ventilation is accomplished by several small fans located along the perimeter of the building. These fans are manually controlled and typically only used during the fair.

Building lighting is accomplished primarily by eight foot T12 fixtures each with two lamps. Additional lighting is also provided by 200watt incandescent fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Horticulture Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,190	1	4,257		$498	4.4	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$2,300	19	9,907		$1,159	2.0	3
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$1,150			29	$29	39.8	3,4
5.5.20	Replace Standard Efficiency Hot	$230			5	$5	47.8	3,4

Opportunities for ECMs at Horticulture Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
	Water Heater with High Efficiency							
	TOTAL	**$5,870**	**21**	**14,164**	**34**	**1,691**	**3.5**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure assumes that building is only used during the week of the State Fair and select events throughout the year
4. Measure assumes that water heaters are currently operated continuously for 5 months during the year.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	1.00	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.3.1.8. Women's Building and Auditorium

Building Overview

The Women's Building and Auditorium is an 18,518 square foot building used for exhibits and large gatherings. The building is primarily used during the week of the State Fair, but is also used for non-fair events during the year.

The building is ventilated by six gas fired furnaces with DX cooling. Each unit is controlled by an individual non-programmable thermostat. The units were replaced in 2005 and operate only when the facility is in use.

Lighting in the auditorium portion of the building is primarily incandescent lighting with either 100 or 300 watt bulbs. The main exhibit area lighting uses four foot T12 fixtures each with four lamps. The display cases are lit with 125watt incandescent spot lighting. The exit lighting in the building uses compact fluorescent lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Women's Building and Auditorium							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,070	0	211	$25	83.8	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$1,380	9	3,951	$462	3.0	2,3
	TOTAL	**$3,450**	**9**	**4,162**	**487**	**7.1**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. This measure includes incandescent light fixtures in display cases as well as ceiling fixtures in Auditorium.
3. Calculations assume facility is only during the week of the fair and select events throughout the year.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

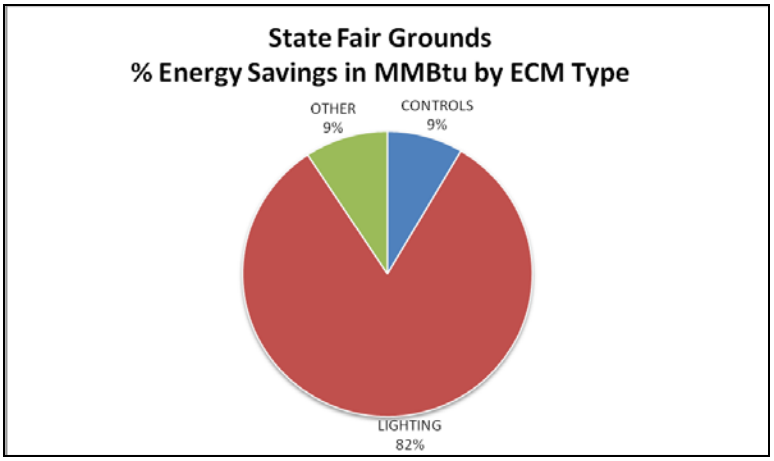
4.3.1.8.1. Campus Summary

A total of 26 ECMs were identified at State Fair Grounds, which include 691 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $140,140, and save an estimated $21,505 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

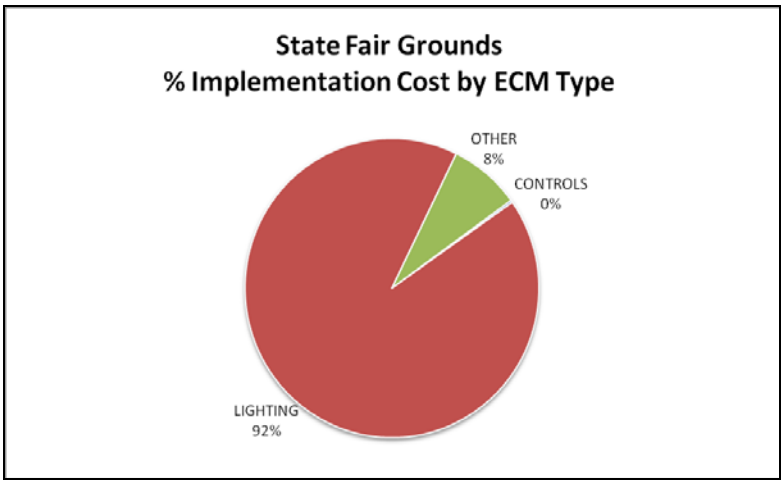
DOA ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	34	25	**58**	$1,397	$350	**0.3**
LIGHTING	568	0	**568**	$19,490	$128,860	**6.6**
OTHER	0	64	**64**	$619	$10,930	**17.7**
Total	**602**	**88**	**691**	**$21,505**	**$140,140**	**6.5**

In total, these savings represent a 5.5% reduction from current energy consumption at the State Fair Grounds, the majority of which is attributed to lighting measures which will reduce electric consumption.



State Fair Grounds Energy Savings by ECM Category.



State Fair Grounds Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 496 MMBTUs (4% of campus energy use) and a total estimated annual cost avoidance of $16,421. The total cost of implementation for these measures is $39,270, which yields a simple payback of 2.4 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Administration Building	5.3.2	$350	58	$1,397	0.3	6.00
Restroom Buildings	5.1.8	$2,150	106	$3,651	0.6	20.19
Horticulture Building	5.1.8	$2,300	34	$1,159	2.0	68.04
Restroom Buildings	5.1.11	$3,310	44	$1,521	2.2	74.61
Grand Stand	5.1.8	$2,990	37	$1,285	2.3	79.81
Women's Building	5.1.8	$1,380	13	$462	3.0	102.37
Administration Building	5.1.8	$330	3	$93	3.5	121.71
Restroom Buildings	5.1.3	$4,090	33	$1,126	3.6	124.58
Barn and Exhibit Buildings	5.1.8	$12,840	103	$3,528	3.6	124.80
Family Living and Tech Center	5.1.8	$4,030	29	$994	4.1	139.07
Administration Building	5.1.7	$260	2	$64	4.1	139.49
Grand Stand	5.1.11	$460	3	$110	4.2	143.30
Horticulture Building	5.1.7	$2,190	15	$498	4.4	150.78
Expo Building	5.1.11	$2,590	16	$533	4.9	166.69
TOTAL		**$39,270**	**496**	**$16,421**	**2.4**	**79.10**

4.4 Department of Corrections

The South Dakota Department of Corrections (DOC) is responsible for the management of the State adult prison system, the State adult parole system and the State juvenile corrections system.This includes juveniles committed to the Department of Corrections and placed in residential out-of-home placement, as well as youth that have completed their correctional placement and are on supervised release known as aftercare.

Within the Department of Corrections, there are a total of 1,657,624 square feet of facilities, with the majority of buildings at the State Penitentiary campus.

DOC Campus Summary.

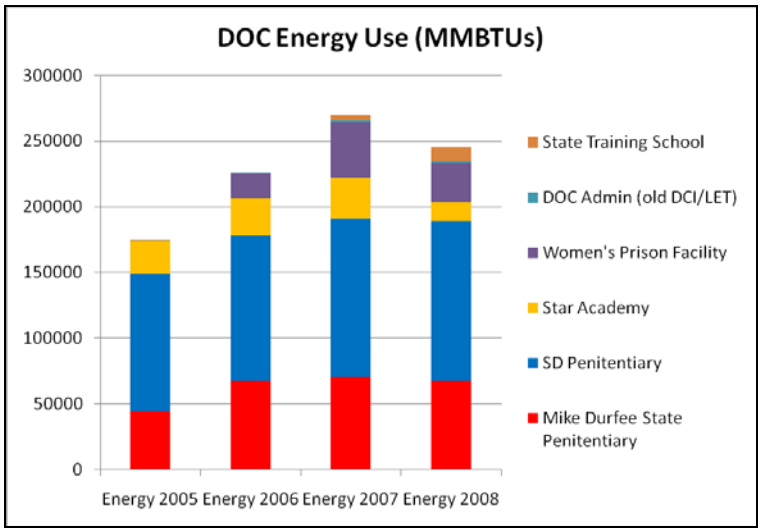
Campus	Location	Square Footage
DOC Admin (old DCI / LET)	Pierre	20,991
Mike Durfee State Prison	Springfield	375,365
SD Penitentiary	Sioux Falls	806,481
Star Academy	Custer	169,911
State Training School	Plankinton	154,831
Women's Prison Facility	Pierre	130,045
	TOTAL	**1,657,624**

Energy Profile

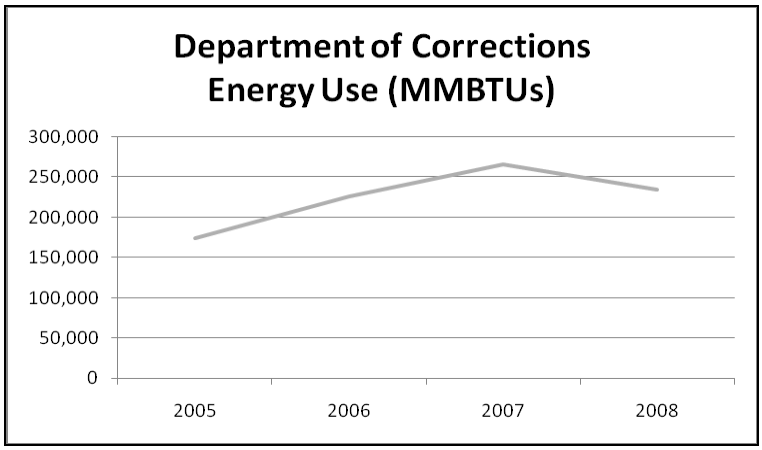
In 2008, DOC facilities consumed a combined 245,293 MMBTUs of energy. As the largest campus in building square footage, the State Penitentiary campus used the most energy. The average Energy Use Intensity across the DOC was 148 kBTU per square foot for 2008.

Table 2. DOC Campus Energy Data (MMBTUs).

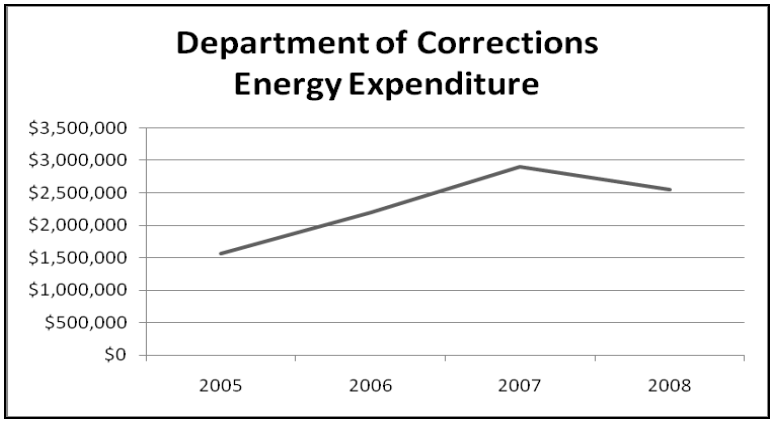
Campus	2005	2006	2007	2008
Mike Durfee State Prison	43,823	67,323	70,252	67,410
SD Penitentiary	104,684	110,728	120,337	121,208
Star Academy	25,720	28,172	31,386	14,905
Women's Prison Facility	274	19,146	42,457	29,965
DOC Admin (old DCI/LET)	0	440	866	585
State Training School	0	0	4,221	11,220
Grand Total	**174,501**	**225,810**	**269,518**	**245,293**



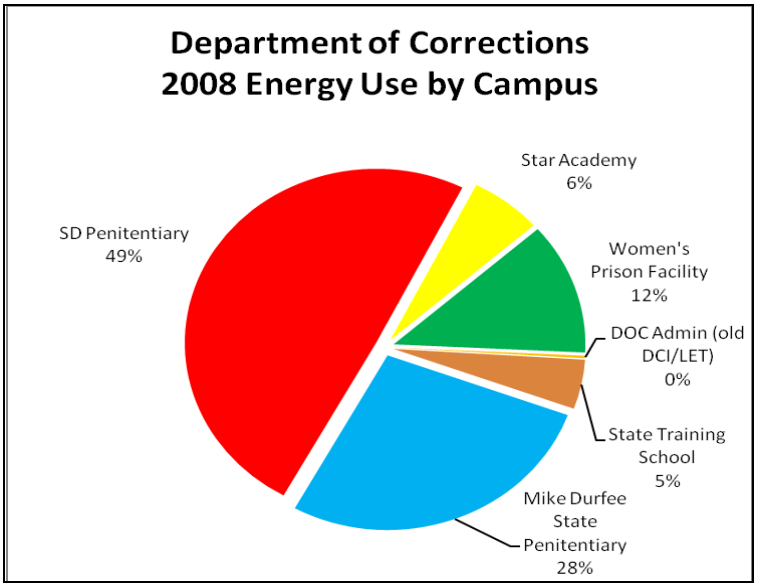
DOC Energy Use by Campus.



DOC Energy Use.



DOC Energy Expenditures.



DOC Energy Use by Campus.

4.4.1 DOC Admin H-Unit (old DCI / LET) - Pierre

Campus Background and List of Facilities

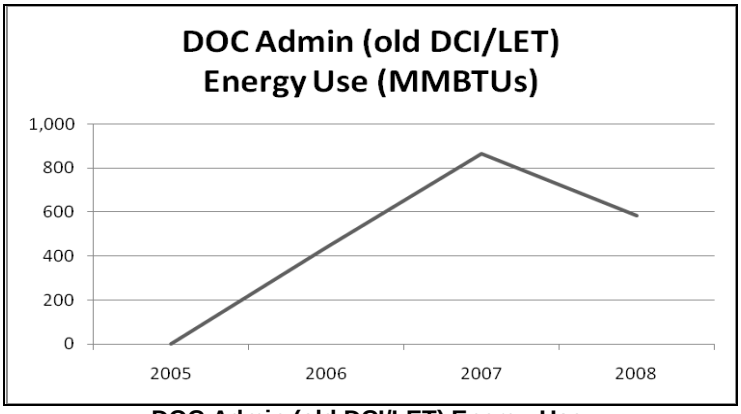
H Unit is a stand-alone facility.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, DOC Admin (old DCI/LET) facilities consumed a combined 585 MMBTUs of energy. The average Energy Use Intensity across the campus was 27 kBTU/SF in 2008.



DOC Admin (old DCI/LET) Energy Use.

4.4.1.1. H-Unit

Building Overview

The H-Unit is a methamphetamine treatment unit and was formally the old DCI building before DCI moved to the Mickelson Building in 2005.It is 8,185 square feet.There are approximatelyoccupants but it varies based on the number of inmates that need to be housed in this building.This building is operated 24 hours per day, 7 days per week.The building is mostly dormitories, offices and classrooms.The building's HVAC systems were originally designed to handle an office occupancy and have difficulty maintaining the load when the rooms are heavily occupied.

The HVAC equipment is very old and consists of a constant speed multi-zone McQuay air handler and a Trane air cooled chiller. One 3 hp chilled water pump is constant speed. Hot water is produced by an old 2000 MBH gas fired boiler. Two 3 hp hot water pumps are constant speed. Two classrooms are cooled by two 5 ton cooling only DX split units. HVAC controls are pneumatic and are on an antiquated Honeywell building automation system. Domestic hot water is provided by an electric water heater.

Interior lighting is primarily fluorescentT-12 strip lighting and U lamp lighting. Interior lights are manually controlled.

The exterior finish is brick and precast concrete. The interior finish is sheetrock and block. Windows are single pane with shades. There is an entrance vestibule and the building envelope condition is in poor condition.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at H-Unit Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.4	Replace Mercury Vapor Lighting with Metal Halide	$2,063	1.8	6475		$382	5.4	3
5.1.5	Replace Incandescent Exit Signs with LED	$810	0.2	1493		$88	9.2	
5.1.7	Retrofit T-12 Fixtures with T-8s	$810	0.9	3287		$194	4.2	
5.4.1	Replace Firetube Boilers with Condensing	$39,560			17,410	$14,537	2.7	
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$56,700	2	14,649		$864	65.6	
5.4.6	Replace Chiller with Turbo-Cor	$79,120	60	51,209		$3,021	26.2	
	TOTAL	**$179,063**	**65**	**77,112**	**17,410**	**19,087**	**9.4**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Exterior wallpack lighting

Estimated Blended Marginal Rates		
$	0.059	/kWh Elec
$	0.835	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

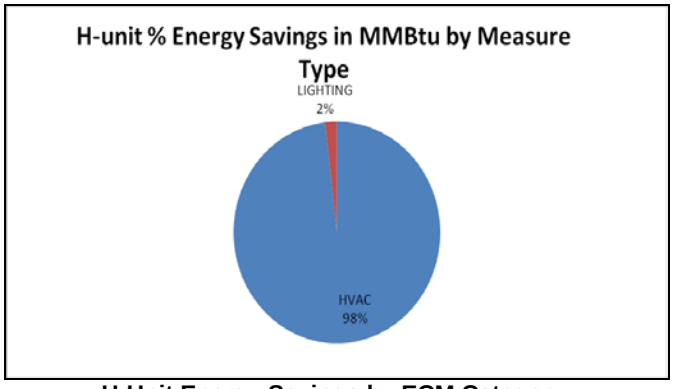
4.4.1.1.1. Campus Summary

A total of 6 ECMs were identified at H-Unit, which include 2,063 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $179,380, and save an estimated $19,085 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

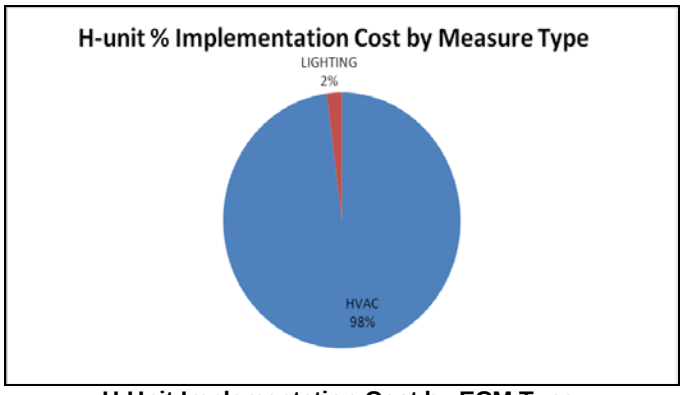
H-Unit ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
HVAC	225	1,800	**2,025**	$18,423	$175,380	9.5
LIGHTING	38	0	**38**	$664	$3,683	5.5
Total	**263**	**1,800**	**2,063**	**$19,087**	**$179,063**	

H-Unit has changed occupancy and function in recent years. The numbers included in this report are based on year round, fully occupied use. A reduction in runtime or decommissioning of this building would have the effect of reducing savings. If this building is replaced or abandoned, these measures will not produce any savings.



H-Unit Energy Savings by ECM Category.



H-Unit Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
H-Unit	5.4.1	$39,560	1,800	$14,537	2.7	21.98
H-Unit	5.1.7	$810	11	$194	4.2	72.22
H-Unit	5.1.4	$2,063	22	$382	5.4	93.36
TOTAL		**$42,433**	**1,834**	**$15,113**	**2.8**	**23.14**

4.4.2 Mike Durfee State Prison

Campus Background and List of Facilities

The Mike Durfee State Prison is comprised of 25 buildings and totals almost 375,000 square feet. The campus was originally constructed in the late 1800s as a college and has been expanded over time. Overall age of the facility ranges from the late 1800s to 2005.

Campus-Wide Systems and Operational Profile

The campus has a Power House that houses three high pressure steam boilers. Only one boiler operates at a time and boiler on/off control is automatic and is based off of outside air temperature. Steam is generated at 40 psig and is reduced down to 7 psig in the Power House before it is distributed to campus. Most buildings use the central steam, but there are a few that have their own boilers (Ludeman Hall, Dietary/Laundry, Health Services). Within the buildings steam is either used directly for heating or is converted to hot water. All buildings using steam to hot water converters have hot water temperature reset schedules in place.

Four buildings have their own chillers and several other buildings have window air conditioning units in place to serve individual rooms. Chiller on/off control is automatic and is based off o outside air temperature. Window air conditioning units are all locally controlled.

Heat is provided to the campus by fuel oil and propane. Natural gas is not available at this time.

There is no central DDC lighting control on campus. The campus exterior lights are a mixture of metal halides and mercury vapor. All exterior lighting is controlled by a single campus-wide photocell. All interior lighting is manually controlled by wall switches.

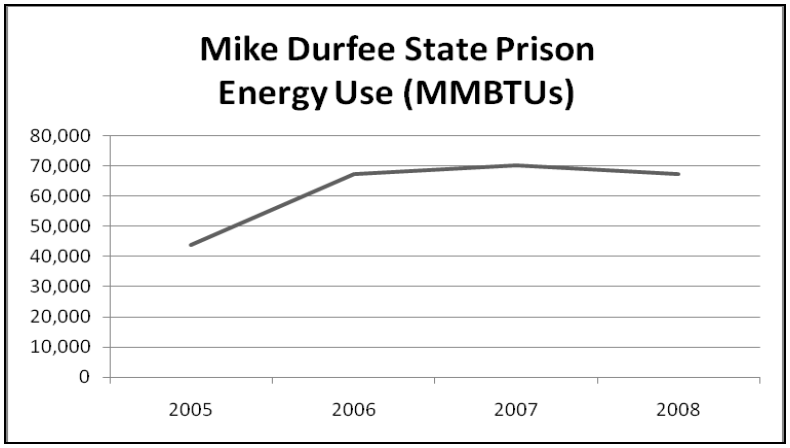
Most buildings on campus are on a common building automation system in the Power House. The BAS is a Barber Coleman system. Building temperature setpoints are set manually by the controls operator in the 70-72 ºF range year-round. Building setback setpoints are adjusted by the operator for each building based on building use and how long it takes to get the building back to its setpoint.

The campus is limited to a peak demand of 1186 KW. When the campus approaches this limit the BAS will begin to stage chillers off and on to reduce demand.

The State recently had an Energy Optimization Study done on the campus. The study primarily focused on the heating system and the costs associated with decentralizing the system and bringing natural gas to the site to replace most of the fuel oil and propane usage.

Energy Profile

In 2008, Mike Durfee State Prison facilities consumed a combined 67,410 MMBTUs of energy. The average Energy Use Intensity across the campus was 179 kBTU/SF in 2008.



Mike Durfee State Prison Energy Use.

4.4.2.1. Construction Technology

Building Overview

Construction Technology is a 29,216 square feet facility that primarily consists of shop areas with high bay ceilings. Some offices are also present.

Building heat is provided by unit heaters that use campus steam from the Power House. There are no central air handlers. Small split system DX fan coil units serve the office areas.

The lighting in the building is by metal halide fixtures. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Construction Technology Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$1,380	-	59,976	$1,739	0.8	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$16,560	6.198	54294.48	$1,575	10.5	
	TOTAL	**$17,940**	**6**	**114,270**	**3,314**	**5.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.2. Dietary / Laundry

Building Overview

Dietary/ Laundry is a 24,000 square feet facility that primarily consists of kitchen and storage areas.

Building is heated by steam boilers installed in the building. A steam to hot water converter is used to produce hot water that is sent to the building air handlers. The boilers remain online during occupied hours since the laundry service requires the heat. There is no cooling in the building, except for a DX unit in the kitchen.

The building hot water systems are fed by variable speed pumps.

The lighting in the building is by T-8 fixtures. Lighting is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Dietary / Laundry Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.3.14	Convert Three-way Valves to Two-way	$3,450		9,180	$266	13.0	
	TOTAL	$3,450	-	9,180	266	13.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.3. Gill Hall

Building Overview

Gill Hall is a 16,375 square feet facility that primarily consists of kitchen and storage areas.

Building heat is provided by campus steam from the Power House. Building cooling is provided by an air-cooled chiller (which was non-operable during the site visit). All rooms in the building are served by floor mounted fan coil units that utilize direct steam and chilled water. There are no central air handlers.

The building chilled water systems are fed by a constant speed pump.

Much of the lighting in the building is by T-8 fixtures, although there were some T-12 lamps observed. Some CFL fixtures were also observed. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Gill Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$10,220	9	31,579	$916	11.2	3
5.3.3	Install VFDs on Hydronic Pumps	$4,720		7,632	$221	21.3	
5.5.4	Improve Building Envelope - Windows	$144,315			$4,995	28.9	4
	TOTAL	$159,255	9	39,211	6,132	26.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.
4. Measure based on data from stimulus applications.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.4. Inmate Housing

Building Overview

Inmate Housing is comprised of five buildings on campus totaling 174,827 square feet. The buildings include the Armory, Barracks, Crawford Hall, Harmon Hall, and Ludeman Hall.

Four of the buildings receive steam from the Power Plant, while Ludeman Hall has its own boilers. The Barracks has a backup fuel oil boiler that is used when steam is unavailable. Ludeman Hall and the Armory use steam directly via fin tube radiators, while the other three buildings have steam to hot water converters. The Armory has a temporary fan coil unit, otherwise the rest of the inmate housing buildings are not cooled, save for some guard areas served by small DX fan coil units.

The building hot water systems are fed by variable speed pumps in the Barracks and constant speed pumps at Crawford Hall and Harmon Hall.

The lighting in the buildings is a mixture of T-8 and T-12 fixtures. Exit signs are both LED and incandescent. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Inmate Housing									
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings				Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal			
5.1.5	Replace Incandescent Exit Signs with LED	$2,300	0.568	4,976			$144	15.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$17,030	11.25	98,550			$2,858	6.0	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$550	6.84	34,200			$992	0.6	
5.3.13	Demand Control Ventilation (CO2 Control)	$12,770			466	321	$1,760	7.3	
5.5.4	Improve Building Envelope - Windows (Crawford Hall)	$206,305					$29,252	7.1	4
5.5.4	Improve Building Envelope - Windows (Harmon Hall)	$111,435					$8,070	13.8	4
5.5.4	Improve Building Envelope - Windows (Ludeman Hall)	$155,795					$7,570	20.6	4
	TOTAL	**$506,185**	**19**	**137,726**	**466**	**321**	**50,646**	**10.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.
4. Measure based on data from stimulus applications.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	3.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.5. Library

Building Overview

The Library is a 29,335 square feet facility that primarily consists of common areas.

Building heat is provided by campus steam from the Power House. Some of the steam is sent directly to a preheat coil, the rest of it is sent through a steam to hot water heat exchanger. The building is cooled using an air-cooled chiller.

One central air handler serves the building. The air handler has a hot deck cold deck configuration with a constant speed fan, a hot water coil, a chilled water coil, a steam preheat coil, and an economizer.

The building chilled water and hot water systems are fed by constant speed pumps.

The lighting in the building is by T-12 fixtures. Some incandescent fixtures were also observed. Lighting is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Library								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$13,630	9	52,013			$1,508	9.0
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$180	2.28	13176.576			$382	0.5
5.2.1	Full Retrocomissioning and Balancing Study	$9,320		13,475	531.33019	365.92466	$2,396	3.9
5.3.13	Demand Control Ventilation (CO2 Control)	$3,340		3,578	778	536	$3,042	1.1
	TOTAL	**$26,470**	**11**	**82,242**	**1,310**	**902**	**7,329**	**3.6**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.6. Montgomery Center

Building Overview

The Montgomery Center is an 11,782 square feet facility that primarily consists of kitchen and storage areas.

Building heat is provided by campus steam from the Power House. Some of the steam is sent directly to a preheat coil, the rest of it is sent through a steam to hot water heat exchanger. The building is cooled using an air-cooled chiller.

One central air handler serves the building. The air handler has a constant speed fan, a steam coil, a chilled water coil, and an economizer.

The building chilled water and hot water systems are fed by constant speed pumps.

The lighting in the building is by T-12 and T-8 fixtures, along with a mixture of CFL and incandescent fixtures. Exit signs are incandescent. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Montgomery Center									
			Estimated Annual Utility Savings						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.5	Replace Incandescent Exit Signs with LED	$620	0	995			$29	21.5	
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,590	1.05	5309.64			$154	10.3	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$280	3.42	17294.256			$502	0.6	
5.2.11	Repair Leaks in Ductwork	$350			54.097946	37.257006	$204	1.7	
5.3.13	Demand Control Ventilation (CO2 Control)	$3,340		1,437	200	138	$797	4.2	
	TOTAL	**$6,180**	**5**	**25,036**	**254**	**175**	**1,685**	**3.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.7. OJ House

Building Overview

The OJ House is a 9,540 square feet facility that primarily consists of offices, storage, and shop areas.

Building heat is provided by fin tube radiators that use campus steam from the Power House. There are no central air handlers. Fan coil units with DX coils are installed in a few areas in the building.

The lighting in the building is by T-12 fixtures. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at OJ House							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,760	2	13,003	$377	7.3	3
	TOTAL	**$2,760**	**2**	**13,003**	**377**	**7.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.8. Power House

Building Overview

The Power House is a 2,488 square feet facility that houses the central steam boilers and campus control system.

The building is not cooled, with the exception of the control room, which has a window AC unit. Steam unit heaters heat the building, as needed.

The lighting in the building is by T-12 fixtures. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

The State is looking into the recommendations from the Energy Optimization Study.

Opportunities for ECMs at Power House Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,840	1	10,512	$305	6.0	3
	TOTAL	**$1,840**	**1**	**10,512**	**305**	**6.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.9. Science Hall

Building Overview

Science Hall is a 13,200 square feet facility that primarily functions as a treatment center. It consists of offices and conference rooms.

Building heat is provided by fin tube radiators that use campus steam from the Power House. There are no central air handlers. Window AC units are installed in most of the rooms.

The lighting in the building is by T-8 fixtures. Exit signs are incandescent. Lighting is controlled manually by wall switches.

The windows were observed to be in very rough shape in many of the rooms.

ECM's

Previously Implemented ECMs

Windows are being re-glazed.

Opportunities for ECMs at Science Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings				Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal			
5.1.5	Replace Incandescent Exit Signs with LED	$930	0	1,493			$43	21.5	
5.3.21	Install Cooling/Heating Control Valves	$7,820			478.17	329.31348	$1,805	4.3	
5.5.4	Improve Building Envelope - Windows	$199,475					$4,025	49.6	4
	TOTAL	**$208,225**	**0**	**1,493**	**478**	**329**	**5,873**	**35.5**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.
4. Measure based on data from stimulus applications.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	3.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.10. Sheep Shed

Building Overview

The Sheep Shed is a 6,000 square feet facility that primarily consists of a workout facility and storage areas.

Building heat is provided by fin tube radiators that use campus steam from the Power House. There are no central air handlers. A window AC unit is installed in the workout room.

The lighting in the building is by T-12 fixtures. Lighting is controlled manually by wall switches.

The building does not have external insulation.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Sheep Shed									
			Estimated Annual Utility Savings						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,820	1	1,858			$54	33.8	3
5.5.8	Space Utilization	$2,300			3260.25	2245.3192	$12,307	0.2	4
	TOTAL	$4,120	1	1,858	3,260	2,245	12,361	0.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.
4. Measure assumes decommissioning building during winter months and turning off heat.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.11. Student Union

Building Overview

The Student Union is a 7,040 square feet facility that primarily consists of a chapel and classrooms.

Building heat is provided by fin tube radiators that use campus steam from the Power House. There is a central air handling with a steam heating coil and a DX cooling coil.

The lighting in the building is by T-8 and T-12 fixtures. CFLs were also observed in one of the classrooms. Lighting is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

Some lighting has been upgraded.

Opportunities for ECMs at Student Union Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$910	1	3,468	$101	9.0	3
	TOTAL	$910	1	3,468	101	9.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass
$	1.52	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.2.12. Technology Center

Building Overview

Technology Center is a 23,026 square feet facility that primarily consists of shop areas with high bay ceilings.

Building heat is provided by campus steam from the Power House. The steam is sent through a steam to hot water heat exchanger. Fan coil units with hot water coils are used to heat each of the shop areas. Window AC units are used to cool the shop areas.

The building hot water systems are fed by constant speed pumps.

The lighting in the building is by T-12 fixtures. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Technology Center							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,820	1	10,512	$305	6.0	3
5.1.10	Replace HID Lighting with High Bay Fluorescent	$5,520	2.066	10330	$300	18.4	
	TOTAL	$7,340	3	20,842	604	12.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability,

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	-	/Therm Gas
$	2.73	/Gal Fuel Oil
$	-	Ton Biomass

Notes
replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	1.52	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

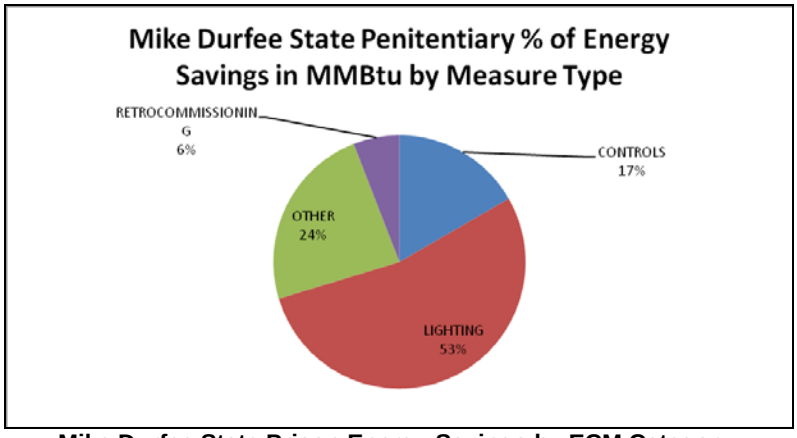
4.4.2.12.1. Campus Summary

A total of 33 ECMs were identified at Mike Durfee State Prison, which include 2,787 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $948,985, and save an estimated $89,420 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

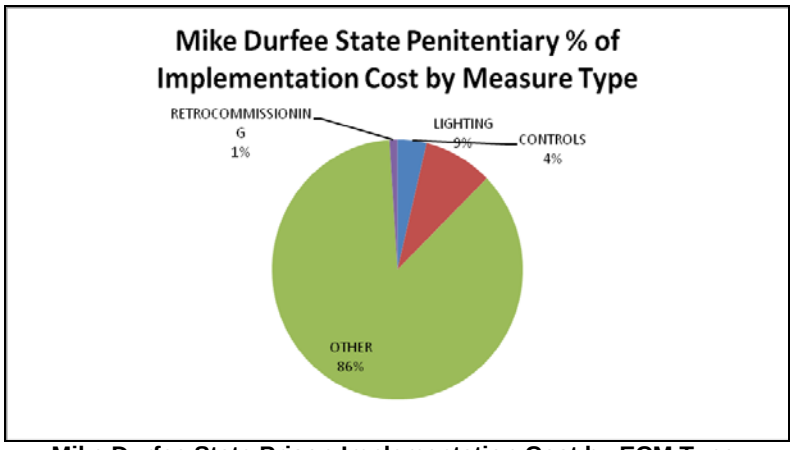
Mike Durfee State Prison ECM Summary Table.

	MMBtu Electric	MMBtu Propane	MMBtu Fuel Oil	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	74	121	269	**465**	$7,891	$35,440	4.5
LIGHTING	1,495	0	0	**1,495**	$12,709	$84,250	6.6
OTHER	0	206	456	**662**	$66,219	$819,625	12.4
RETROCOMMISSIONING	46	37	82	**165**	$2,601	$9,670	3.7
Total	1,616	364	808	2,787	$89,419	$948,985	10.6

In total, these savings represent a 4% reduction from current energy consumption at the Mike Durfee State Prison, the majority of which is attributed to Lighting measures which will reduce electrical consumption.



Mike Durfee State Prison Energy Savings by ECM Category.



Mike Durfee State Prison Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 1,973 MMBTUs (3% of campus energy use) and a total estimated annual cost avoidance of $27,635. The total cost of implementation for these measures is $49,550, which yields a simple payback of 1.8 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Sheep Shed	5.5.8	$2,300	662	$12,307	0.2	3.47
Library	5.1.8	$180	45	$382	0.5	4.00
Inmate Housing	5.1.8	$550	117	$992	0.6	4.71
Montgomery Center	5.1.8	$280	59	$502	0.6	4.75
Construction Technology	5.1.3	$1,380	205	$1,739	0.8	6.74
Library	5.3.13	$3,340	170	$3,042	1.1	19.61
Montgomery Center	5.2.11	$350	11	$204	1.7	31.86
Library	5.2.1	$9,320	154	$2,396	3.9	60.57
Montgomery Center	5.3.13	$3,340	46	$797	4.2	73.37
Science Hall	5.3.11	$7,820	97	$1,805	4.3	80.53
Inmate Housing	5.1.7	$17,030	336	$2,858	6.0	50.65
Technology Center	5.1.7	$1,820	36	$305	6.0	50.74
Power House	5.1.7	$1,840	36	$305	6.0	51.30
TOTAL		**$49,550**	**1,973**	**$27,634**	**1.8**	**25.11**

4.4.3 South Dakota Penitentiary

The South Dakota State Penitentiary is comprised of two campuses and totals over 806,000 square feet. The Hill is the original maximum security penitentiary and was originally constructed

in the late 1880's. Jameson Annex is the modern penitentiary constructed in 1992-93. Jameson Annex consists of 4 units; Units A, B, & D are maximum security correctional residence and Unit C is a stand-alone minimum security residence.

Campus Background and List of Facilities

- Jameson Annex: Units A, B, C, & D
- The Hill: Admin, Chapel, Kitchen, East, West, & Federal Halls, Boiler House, PI1 & PI2, Special Housing Unit, Rec. Center

Campus-Wide Systems and Operational Profile

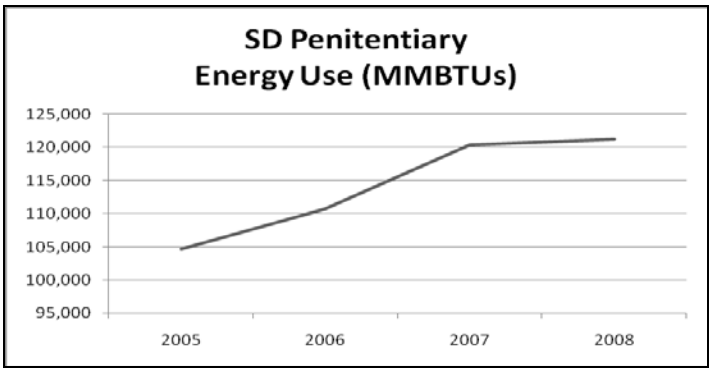
The Hill has a campus wide boiler house that provides steam for heating. Steam-to-heating hot water converters transfer heat energy to hot water for some of the areas on the Hill complex. Boilers are also responsible for domestic hot water on the Hill.

The Hill exterior lights are high pressure sodium cluster lights (4 lights – 600W ea) and a pair of 150W quartz wall pack lights that are on a photocell. Two of the four cluster lights are automatically controlled by photocells the other two are controlled manually. Most of the building's internal areas are lit to 1 watt/SF using fixtures with 32-34 watt T-12 bulbs. All internal lighting is manually controlled.

Both Jameson Annex and the Hill are on a common building automation system. The BAS is a JCI Metasys system. Not all the HVAC equipment is controlled from the Metasys system. Actuators for dampers and control valves are pneumatically controlled.

Energy Profile

In 2008, SD Penitentiary facilities consumed a combined 121,208 MMBTUs of energy. The average Energy Use Intensity across the campus was 150 kBTU/SF in 2008.



SD Penitentiary Energy Use.

4.4.3.1. Admin Building

Building Overview

Part of the Hill complex and originally constructed in 1880's.This building consists of offices, cafeteria, and reception areas on basement through floors. Admin building is occupied primarily M-F 8am-5pm except for the cafeteria and reception areas which are used 24/7.There are approximately 60 occupants during normal working hours.

There are two constant volume multi-zone air handlers with hot water heating coils and chilled water cooling coils. The heating hot water is converted from steam provided by the Boiler House. Chilled water is provided by a 60 ton Trane chiller located on the roof. Both AHUs are capable of economizer mode. A wall mounted air conditioner unit serves a computer room on the floor but does not work well and is reported to not be able to keep up with the heating load from the equipment.

Lighting consists of primarily 4' 4-lamp F34T12 in most areas. The Warden's office and support staff on the floor have 4' 4-lamp F32T-8s.All areas are on toggle switches. Exit lights are a mixture of fluorescents and LED.

Building exterior is stone. Roof is black and no leaks are reported

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use

Opportunities for ECMs at Administration Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$450	0.9	2,972		$89	5.0	3
5.1.2	Delamp Multiple Lamp Fixtures	$0	6.4	21,036		$631	0.0	3
5.1.3	Install Motion Sensors to Control Lighting	$3,410	-	10,139		$304	11.2	
5.1.5	Replace Incandescent Exit Signs with LED	$3,375	0.7	6,220		$187	18.1	
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,973	2.1	6,869		$206	24.1	
5.2.1	Full Retrocomissioning and Balancing Study	$17,500	7.4	65,173	606	$2,444	7.2	
5.2.6	Schedule air handlers night setback	$1,150	-	144,617	8,177	$10,937	0.1	
5.3.7	Convert Multizone/Dual Duct to VAV	$103,500	2.3	28,501	12,728	$11,127	9.3	
5.4.29	Replace Air-cooled chiller	$60,950	26.0	33,136		$994	61.3	
5.5.4	Improve Building Envelope - Windows	$15,000		1,800	309	$304	49.4	
	TOTAL	**$210,308**	**46**	**320,464**	**21,820**	**27,223**	**7.7**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Cost assumes installation by in-house staff.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.3.2. Boiler House (Hill)

Building Overview

The Boiler House provides steam for the Hill Complex. This building contains three 1990's vintage, 8,369 MBH, dual fuel (NG & No. 2 Fuel Oil) boilers and associated equipment. Steam is generated at 75 psig for the laundry area. The majority of the campus uses 7 psig steam for heating. The hot domestic hot water heater takes 20 psig steam. Two 5 hp and one 7.5 hp constant volume pumps provide boilerfeed water to the boilers. Two 3 hp condensate pumps are constant volume. Two steam-to-hot water converters (2,843 MBH input each) provide domestic hot water for the Hill. Because the steam is used for generating hot water the boilers run year round. The boilers do not have economizers and therefore do not take advantage of the hot exhaust heat that could be used to preheat the boilerfeed water. Boiler House operations assumes that 100% of the condensate is returned to the boilers. The temperature of the condensate coming back was 185 deg F which is fairly high. This may be due to some steam traps not holding the steam back. There are no meters on the fuel or steam being generated from the plant

The deaerator is in poor condition and in need of replacing. The boiler control system is very basic. It does not provide the operator with much operational information. Boiler House operations office is cooled by a wall mounted air conditioner.

Lighting in the Boiler House is 8ft and 4ft 2-lamp T-12 fixtures.

Building roof is flat and rock covered. Exterior is stone & brick. Windows are single pane without shades

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use.

Opportunities for ECMs at Boiler House (Hill) Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,905	1.5	3,155		$95	20.1
5.1.13	Replace 8' fixtures with 4' fixtures	$3,680	0.9	2,046		$61	60.0
5.3.9	Upgrade Controls System to Full DDC	$80,500			26,193	$21,138	3.8
5.4.14	Steam Trap Survey/Replace or Repair Faulty Traps	$4,590			43,000	$34,701	0.1
5.4.27	Install Boiler Economizers	$243,890			107,180	$86,494	2.8
5.4.31	Insulate Steam Condensate piping	$30,480			5,644	$4,555	6.7
5.5.4	Improve Building Envelope - Windows	$2,500		220	61	$56	44.8
	TOTAL	**$367,545**	**2**	**5,421**	**182,078**	**147,099**	**2.5**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.3. Chapel Building

Building Overview

The Chapel building consists of a chapel, the Hill visiting room, and Captain's Row (offices).This building is connected to the main Hill building. The visiting room and chapel are operated M-F 8-5.The Captain's Row offices are operated 24/7.There are approximately 15 occupants.

The chapel is served by two constant volume air handling units with hot water heating and DX cooling (~10 tons each).One of the units is a multi-zone unit with hot water heat for adjacent office spaces. The other unit is a single zone unit. The visiting room is served by two constant volume (2000 CFM) air handling units with steam heating and DX cooling (5 ton ea.).One of the units steam coil has been disconnected because the space gets warm from residual heat radiating from steam piping in adjacent spaces. The Captain's row is served by a single constant volume multi-zone unit with steam heating and DX cooling (5 ton).The Captain's Row unit is not on the Metasys control system.

Lighting consists primarily of 2ft and 4ft 2-lamp T-12s in office spaces and the visitors' center. The chapel has incandescent lights. Exit signs are fluorescent.

The roof is pitched and white. The exterior walls are stone. The windows are single pane without shades.

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use.

Opportunities for ECMs at Chapel Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.2	Delamp Multiple Lamp Fixtures	$600	3.2	11,053		$332	1.8
5.1.7	Retrofit T-12 Fixtures with T-8s	$3,410	1.2	4,211		$126	27.0
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$320	1.9	6,754		$203	1.6
5.2.6	Schedule air handlers night setback	$1,150	-	46,737	1,807	$2,860	0.4
5.5.4	Improve Building Envelope - Windows	$50,000		3,520	978	$895	55.9
	TOTAL	**$55,480**	**6**	**72,274**	**2,785**	**4,416**	**12.6**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.4. East / West Federal Halls

Building Overview

Part of the Hill complex and originally constructed in 1880's.West Hall added around 1930.This building is inmate housing unit with four floors of cells and a partial basement containing a shower room and a fan room. It is occupied 24/7.There are approximately 400 inmate occupants.

There is a fan room in each hall. The fan room houses two constant volume AHUs and an exhaust fan of the ventilation system. The AHUs have hot water heating provided by the Hill boiler house. There is a chase between two rows of cells and serves as a return air plenum for the two air handlers. The two supply air fans and the exhaust air fan are 5 hp each. Cold water heat pumps are used for security control rooms. A split-system natural gas fired furnace with DX cooling serves the West Hall counseling offices.

Shower rooms are have 2 zones of 30 shower heads each with low flow aerators. When in use there are normally more shower heads discharging water than inmates showering.

General lighting consists of primarily 8ft 2-lamp T12s.Cell lighting consists of single lamp 4ft T12 fluorescent and an incandescent reading light fixture. All areas are manually controlled.

Building exterior is stone. Roof is covered with rock and no leaks are reported

ECM's

Previously Implemented ECMs

Water flow restriction on shower heads.

Opportunities for ECMs at East Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$3,810	1.7	9,582		$287	13.3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$475	2.1	5,924		$178	2.7
5.1.13	Replace 8' fixtures with 4' fixtures	$4,140	1.1	6,138		$184	22.5
5.2.1	Full Retrocomissioning and Balancing Study	$14,000	3.3	29,333	273	$1,100	12.7
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$20,700	2.3	53,286	1,394	$2,723	7.6
	TOTAL	**$43,125**	**10**	**104,262**	**1,666**	**4,473**	**9.6**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

Opportunities for ECMs at West Hall

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,980	1.3	7,663		$230	13.0
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$440	1.6	4,739		$142	3.1
5.1.13	Replace 8' fixtures with 4' fixtures	$4,230	0.9	5,456		$164	25.8
5.2.1	Full Retrocomissioning and Balancing Study	$14,000	3.0	26,667	248	$1,000	14.0
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$36,230	2.1	47,120	1,220	$2,398	15.1
	TOTAL	**$57,880**	**9**	**91,644**	**1,467**	**3,934**	**14.7**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

Opportunities for ECMs at Federal Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,890	1.0	5,687		$171	11.1
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$285	1.2	3,554		$107	2.7
5.1.13	Replace 8' fixtures with 4' fixtures	$2,760	0.7	4,092		$123	22.5
5.2.1	Full Retrocomissioning and Balancing Study	$10,000	1.9	14,667	136	$550	18.2
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$41,400	1.2	26,907	697	$1,370	30.2
	TOTAL	**$56,335**	**6**	**54,906**	**833**	**2,320**	**24.3**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.3.5. Jameson Annex Units A & B (Building)

Building Overview

Jameson Annex is correctional residence for maximum security inmates and was constructed in 1993.Units A & B house 200-300 inmates. The building operates 24/7.The building has offices, dorm rooms, gym, kitchen and dining facility.

Jameson Annex has a central boiler room that houses two 2,400 dual fuel boilers. Two 20 hp heating hot water pumps are constant volume. Two 175 ton air cooled chillers provide chilled water for the building. One 60 hp chilled water pump is constant speed. Approximately, 41 air handling units serve this building. All units are constant volume and have economizer capability, hot water heating and chilled water cooling capability. Four AHUs serving the main control areas are 100% outdoor air units. All units are on the Metasys control system. Domestic hot water is produced by three dual fuel water heaters that produce 110F (1,250 MBH), 140F (1,150 MBH), and 180F (450MBH) water temperatures.

Lighting is typically T-12s and manually controlled. Exit signs are LED. Exterior lights are 1500W metal halides (two per light pole) and are controlled by security or triggered automatically if the fence is breached.

The building's exterior is pre-cast concrete. The roof is insulated, flat and covered with river rock. Windows are double paned.

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use. Water flow restriction on shower heads.

Opportunities for ECMs at Jameson Annex Units A & B Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$35,190	12.8	73,974		$2,219	15.9
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$130	0.8	4,450		$133	1.0
5.2.1	Full Retrocomissioning and Balancing Study	$50,000	42.6	373,333	3,470	$14,000	3.6
5.3.3	Install VFDs on Hydronic Pumps	$30,250		271,855		$8,156	3.7
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$62,680	0.9	146,617	11,500	$13,679	4.6
5.4.29	Replace Air-cooled chiller	$252,080	101.5	189,420		$5,683	44.4
	TOTAL	**$430,330**	**159**	**1,059,649**	**14,970**	**43,870**	**9.8**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.6. Jameson Annex Unit C (Building)

Building Overview

Unit C is correctional residence for minimum security inmates and was constructed in 1993.Unit C houses 200-300 inmates. The building operates 24/7.The building has offices, dorm rooms, kitchen and dining facility.

Two 450 MBH gas-fired Bryan boilers provide heating hot water to 10-12 AHUs that are located up in the ceiling space. Two 5 hp heating hot water pumps are constant speed. Two 40 ton air cooled chillers provide chilled water to the air handlers. One 5 hp chilled water

pump is constant speed. The air handlers are constant speed single zone units. Domestic hot water is provided by two 54 kW electric water heaters.

Lighting is a mixture of 4' 2-lamp T-8 or T-12s, controlled with manual toggles. Exit signs are LED.

The building exterior is pre-cast concrete. The roof is mostly flat, off-white color. The parameter of the building has an architectural metal pitched roof for aesthetics. Windows are double paned and there is an entrance vestibule.

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use. Water flow restriction on shower heads.

Opportunities for ECMs at Jameson Annex Unit C Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$750	0.8	3,251		$98	7.7	3
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,963	1.2	5,201		$156	19.0	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$110	0.8	3,337		$100	1.1	
5.2.1	Full Retrocomissioning and Balancing Study	$20,000	9.1	80,000	743	$3,000	6.7	
5.2.5	Schedule Hot Water Supply Temperature Reset	$580			65	$53	11.0	
5.3.3	Install VFDs on Hydronic Pumps	$11,040		29,519		$886	12.5	
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$19,670		88,725		$2,662	7.4	
5.4.29	Replace Air-cooled chiller	$66,930	30.4	58,307		$1,749	38.3	
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$19,320		110,126		$3,304	5.8	
	TOTAL	**$141,363**	**42**	**378,466**	**809**	**$12,007**	**11.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Cost assumes installation by in-house staff.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.7. Jameson Annex Unit D

Building Overview

Unit D is a correctional residence that was constructed to be nearly identical to Units A & B. Unit D was constructed in 2005 and connects to Jameson Annex. It is operated 24/7 and houses approximately 150 inmates.

Unit D HVAC is stand alone from the Jameson Annex. There are two 2,400 MBH dual fired boilers that provide heating hot water heating for the building. The heating hot water system is primary-secondary. Two 2 hp primary hot water pumps are constant speed. Two 15 hp and one 10 hp secondary hot water pumps are variable speed. Two 80 ton Trane air cooled chillers are located on the roof and provide chilled water to the building. The chilled water distribution system is primary-secondary. Two 3 hp primary chilled water pumps are constant volume. Two 25 hp secondary chilled water pumps are variable speed. Nine constant speed air handlers serve the building and have chilled water cooling and hot water heat coils. All units are on the Metasys automation system. Domestic hot water is produced by two 2,800 MBH dual fuel water heaters.

Lighting is T-8 fluorescents and manually controlled. Exit signs are LED.

The building's exterior is pre-cast concrete and the roof is flat and covered with rock

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use. Water flow restriction on shower heads

Opportunities for ECMs at Jameson Annex Unit D Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$130	0.8	3,337		$100	1.3
5.2.5	Schedule Hot Water Supply Temperature Reset	$580			98	$79	7.4
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$32,780	-	93,295	3,850	$5,906	5.6
	TOTAL	**$33,490**	**1**	**96,633**	**3,948**	**6,085**	**5.5**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.3.8. Kitchen

Building Overview

The Kitchen building consists of a kitchen, dining hall, and health services offices and exam rooms. This building is connected to the main Hill building.

The kitchen is heated by steam radiators and by a makeup air unit. The make-up air unit is heated by a steam coil that provides make-up air removed by the kitchen's exhaust hoods. The dining hall does not have ventilation and is heated by steam radiators. The health services area is heated by steam radiators. There are two constant volume AHUs located in the Health Services' Penthouse. One is fitted with a small air conditioner. The nurse's office has a window air conditioner. Another AHU is located above Captain's Row and provides 5 tons of cooling. A fourth AHU is located in the between floors crawl space above the Associate Warden's office. This is a recirculation AHU with 5 tons of cooling and with no outside air intake. This unit operates year round because of the steam lines running in the tunnels under this area. None of this HVAC equipment in this building is monitored by the Metasys system.

Kitchen lighting is primarily 8ft 2-lamp T-8s. Dining hall lighting is 4ft 2-lamp T-12s. Lighting in the Health Services area is a mixture of 4ft 2 lamp T-12s and T-8s. Typical operating philosophy is to replace T-12 fixtures with T-8s upon failure. Exit signs are fluorescent.

The roof is flat and black. No roof leaks were reported. The exterior walls of the building are stone.

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use

Opportunities for ECMs at Kitchen Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,148	0.3	1,300		$39	29.4
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,850	2.82	12,223		$367	13.2
5.1.13	Replace 8' fixtures with 4' fixtures	$4,600	1.18	5,115		$153	30.0
5.3.9	Upgrade Controls System to Full DDC	$46,000	8	15,477	2,058	$2,125	21.6
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$47,960	13	38,109	387	$1,455	33.0
	TOTAL	**$104,558**	**25**	**72,224**	**2,445**	**4,140**	**25.3**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.9. Pheasantland Industries I

Building Overview

Pheasantland Industries is a company that uses inmate labor to make products or provide services for the State. Pheasantland Industries I (PI1) is part of the original Hill campus constructed in 1880's.There is a school at the west end of the building added in 1900.This building consists of two levels and is sectioned into numerous trade shops including license plate manufacturing, welding, book binding, sign manufacturing, cabinet making, Braille and upholstery manufacturing.In addition to inmate vocation the building houses a laundry facility and a school.Approximately 100-125 inmates work in the trade shops and another 40 occupy the school on a typical M-F 7am-4pm day.The east end of the building is the Special Housing building.

The laundry facility is heated by 2 steam unit heaters in addition to heat provided by equipment. There is some evaporative cooling provided by two swamp coolers in poor condition. There is a steam-to-hot water converter system that provides dryer heat. Dryer heat is discharged to atmosphere. Hot water for the washers comes from the 1.4 million BTUH hot water heaters that use the 75 psi steam from the boiler house. The license plate manufacturing area has a 2 ton DX split air handler and is heated by 3-5 steam unit heaters. The welding shop has a constant volume, heating only air handler in addition to two steam unit heaters. The Braille/upholstery shop offices are cooled by a couple of mini-split systems. Heating is via 2-4 steam unit heaters. The wood shop has make-up air unit that provides unconditioned

outdoor air to the shop to replace exhaust air. Wood shop office is cooled by a wall air conditioner that cannot keep up with load. Heating is via steam unit heaters but they don't run much because there is a lot of heat that radiates from the steam pipes and processes. Even during the winter windows are opened to bring in cool air. The sign shop is heated by 2-4 steam unit heaters and has a control room that is cooled by a mini-split DX system. The book binding shop is heated by several steam unit heaters. The offices are cooled by four wall air conditioners. The school is heated by steam baseboard radiators. Cooling is provided by a 2 ton air handling unit in the basement, that appeared to be disconnected, and approximately 12-14 wall air conditioner units.

Lighting typically consists of 8ft 2-lamp T-12 fixtures. But some areas have been upgraded to 8ft 2-lamp T-8s.Typical campus philosophy is to replace T-12's with T-8s upon failure. The school has a mixture of 4ft 4-lamp T-8 & T-12s.In the school as in the trade shops there is a high density (2 watt/SF) of lighting that is required for the work performed. A mixture of CFLs and incandescent lights are used in the basement of the school.

The building exterior is stone. The roof is flat and covered with rock. Windows are double pane. Windows in the school have shades

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use. Windows are double pane. Windows in the school have shades.

Opportunities for ECMs at Pheasantland Industries I

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$7,470	8.0	20,576		$617	12.1
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$130	0.8	1,987		$60	2.2
5.1.13	Replace 8' fixtures with 4' fixtures	$26,450	6.8	17,505		$525	50.4
5.4.9	Replace Window AC Units with Heat Pumps	$33,350	13.0	11,285		$339	98.5
5.5.13	Wash Laundry in Cold Water	$0			3,045	$2,457	0.0
	TOTAL	**$67,400**	**29**	**51,353**	**3,045**	**3,998**	**16.9**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.10. Pheasantland Industries II

Building Overview

Pheasantland Industries 2 (PI2)is an open warehouse used for inmate vocation. It is approximately 30,000 square feet.It is operated M-F 7am-4pm.There are approximately 70 inmate workers that work there throughout the day.

The building is connected to the Hill steam system and is heated by 6 steam unit heaters. There is a 2 ton cooling unit for the security control office. The office space is heated by a natural gas fired furnace. Domestic hot water is provided by a 4.5 kW electric water heater.

Lighting consists of (72) 175W Metal Halide fixtures and are controlled by toggle switches.

The building walls and roof is metal and well insulated. There are three (14'x8') roll-up doors.

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use.

Opportunities for ECMs at Pheasantland Industries II						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.10	Replace HID Lighting with High Bay Fluorescent	$17,280	8.9	26,868	$806	21.4
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$1,610		4,589	$138	11.7
	TOTAL	$18,890	9	31,457	944	20.0

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.11. Recreation Center

Building Overview

Part of the Hill complex and originally constructed in 1930's.This building is for inmate recreation in the colder months (Sept – May) or when there is an adverse weather condition.

The Rec. Center is served by four AHU's. Two are located in the gym and are 100% outdoor air constant volume single zone 20,000 CFM units with hot water heating provided by a

2,125 MBH natural gas fired boiler located in the basement. There are two 3 hp constant speed hot water pumps. The third air handler is located in the weight room and is a constant volume single zone unit with hot water heating. The fourth unit is located in the music room and is a constant volume single zone unit with hot water heating. All four units run continuously regardless of the occupancy schedule.

Lighting is primarily 4' & 8' 2-lamp T-12's.The gym is outfitted with (16) 400W metal halides. Many areas appeared to be overlit.

The building walls are concrete and the roof is flat and covered with rock. There aren't any windows

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Recreation Center							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$6,676	7.1	12,540		$376	17.7
5.1.13	Replace 8' Fixtures with 4' Fixtures	$10,120	2.6	4,554		$137	74.1
5.2.1	Full Retrocomissioning and Balancing Study	$18,000	4.0	34,667	322	$1,300	13.8
5.2.6	Schedule Air Handlers Night Setback	$1,380		27,519	2,555	$2,888	0.5
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$51,750	1.3	29,182	2,803	$3,137	16.5
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$1,270		4,589		$138	9.2
	TOTAL	**$89,196**	**15**	**113,052**	**5,680**	**$7,975**	**11.2**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.12. Special Housing Unit

Building Overview

The Special Housing Unit is a temporary housing unit for inmates that require isolation from the general inmate population. This building is attached but isolated from PI1 on the far east end of the building. This building is occupied 24/7 and houses approximately 40 inmates.

A constant speed multi-zone air handler with hot water heating.There is no cooling in this building.This unit does not appear to draw in any outdoor air.The unit is on the Metasys system and has pneumatic controls.Domestic hot water is provided by the Boiler House though there is an electric water heater that acts as a booster for the building.

Lighting in the cells are 40W PL lamps.

The exterior is stone and the roof is flat and rock covered

ECM's

Previously Implemented ECMs

Water flow restriction on shower heads.

Opportunities for ECMs at Special Housing Unit							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$910	0.3	1,387		$42	21.9
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$130	0.8	3,337		$100	1.3
5.2.1	Full Retrocomissioning and Balancing Study	$10,000				$700	14.3
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$4,260	0.6	21,115	349	$915	4.7
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$25,880	1.1	24,319	422	$1,070	24.2
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$1,610		4,589		$138	11.7
	TOTAL	**$42,790**	**3**	**54,747**	**771**	**$2,965**	**14.4**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.030	/kWh Elec
$	0.807	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.3.12.1. Campus Summary

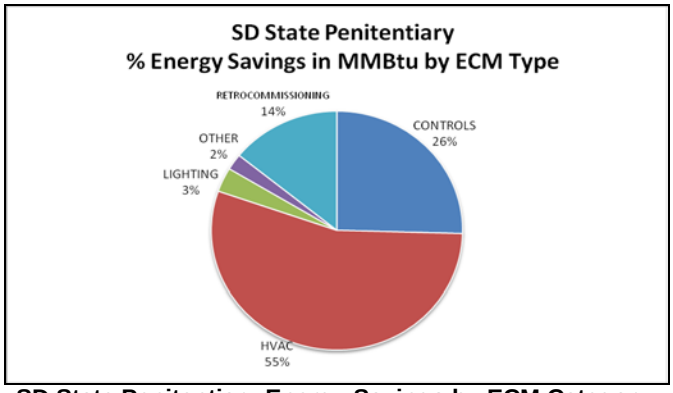
A total of 79 ECMs were identified at SD State Penitentiary buildings, which include 25,258 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $1.67million, and save an estimated $273,115 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

DOC ECM Summary Table.

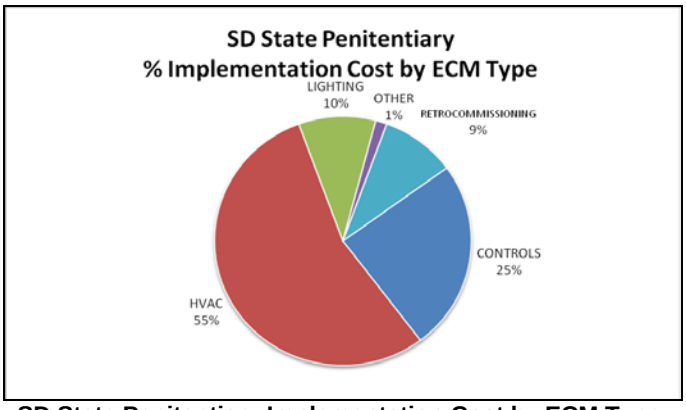
	MMBtu Electric	MMBtu Natural	MMBtu Total	Estimated Annual Cost	Estimated Implementation	Simple Payback

		Gas		Avoidance	Cost	
CONTROLS	2,401	6,202	**8,603**	$69,515	$413,680	**6.0**
HVAC	1,744	16,828	**18,572**	$146,668	$916,190	**6.2**
LIGHTING	1,120	0	**1,120**	$9,847	$162,168	**16.5**
OTHER	423	315	**738**	$6,174	$23,810	**3.9**
RETROCOMMISSIONING	2,875	1,913	**4,788**	$40,911	$158,340	**3.9**
Total	**8,563**	**25,258**	**33,820**	**$273,115**	**$1,674,188**	**6.1**

In total, these savings represent a 28% reduction from current energy consumption at the SD State Penitentiary campus, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



SD State Penitentiary Energy Savings by ECM Category.



SD State Penitentiary Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 26,292 MMBTUs (22% of campus energy use) and a total estimated annual cost avoidance of $209,609. The total cost of implementation for these measures is $535,150, which yields a simple payback of 2.6 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Admin Building	5.1.2	$0	72	$631	0.0	0.00
Pheasantland Industries 1	5.5.13	$0	315	$2,457	0.0	0.00
Admin Building	5.2.6	$1,150	1,339	$10,937	0.1	0.86
Boiler House (Hill)	5.4.14	$4,590	4,446	$34,701	0.1	1.03
Chapel Building	5.2.6	$1,150	346	$2,860	0.4	3.32
Recreation Center	5.2.6	$1,380	358	$2,888	0.5	3.85
Jameson Annex Units A & B	5.1.8	$130	15	$133	1.0	8.56
Jameson Annex Unit C	5.1.8	$110	11	$100	1.1	9.66
Jameson Annex Unit D	5.1.8	$130	11	$100	1.3	11.42
Special Housing Unit (Hill)	5.1.8	$130	11	$100	1.3	11.42
Chapel Building	5.1.8	$320	23	$203	1.6	13.89
Chapel Building	5.1.2	$600	38	$332	1.8	15.91
Pheasantland Industries 1	5.1.8	$130	7	$60	2.2	19.18
East Hall	5.1.8	$475	20	$178	2.7	23.50
Federal Hall	5.1.8	$285	12	$107	2.7	23.50
Boiler House (Hill)	5.4.27	$243,890	11,082	$86,494	2.8	22.01
West Hall	5.1.8	$440	16	$142	3.1	27.21
Jameson Annex Units A & B	5.2.1	$50,000	1,633	$14,000	3.6	30.63
Jameson Annex Units A & B	5.3.3	$30,250	928	$8,156	3.7	32.61
Boiler House (Hill)	5.3.9	$80,500	2,708	$21,138	3.8	29.72
Jameson Annex Units A & B	5.3.4	$62,680	1,689	$13,679	4.6	37.10
Special Housing Unit (Hill)	5.3.4	$4,260	108	$915	4.7	39.41
Admin Building	5.1.1	$450	10	$89	5.0	44.37
Jameson Annex Unit D	5.3.4	$32,780	716	$5,906	5.6	45.75
Jameson Annex Unit C	5.5.1	$19,320	376	$3,304	5.8	51.42
TOTAL		**$535,150**	**26,292**	**$209,609**	**2.6**	**20.35**

4.4.4 South Dakota Women's Prison Facility - Pierre

Campus Background and List of Facilities

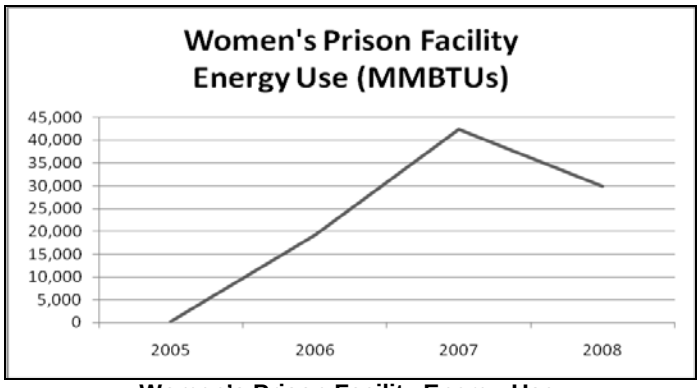
The Women's Prison is a stand-alone building. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Women's Prison Facility consumed a combined 29,965 MMBTUs of energy. The average Energy Use Intensity across the campus was 230 kBTU/SF in 2008.



Women's Prison Facility Energy Use.

4.4.4.1. South Dakota Women's Prison

Building Overview

The Women's Prison was constructed in 1996 and is 78,000 square feet. There are approximately 100 occupants but it varies based on the number of inmates that need to be housed in this building. This building is operated 24 hours per day, 7 days per week. The facility houses a prison, State corrections offices, law enforcement personnel and a full service kitchen.

Cooling and Ventilation are provided by approximately ten DX Trane air handlers with hot water heating that are variable air volume wherever possible.s with heating and cooling coils.Hot water is provided by two 2000 MBH gas fired Bryan boilers.Four (2 at 5 hp & 2 at 2 hp) hot water pumps are constant speed. There is one 30 ton roof top unit that provide ventilation for the kitchen and a 2 ton cooling unit for the dishwashing area.HVAC controls are pneumatic and are on a Honeywell building automation system.Domestic hot water is provided by four gas fired 200 MBH water heaters.Additionally, there are two gas fired 240 MBH water heaters for laundry facilities.There is also a 7.5 hp air compressor for the pneumatics in the building, HW unit heaters, and infrared heaters for the truck dock.

Interior lighting in most areas is fluorescent T-8 strip lighting. Laundry room lighting is fluorescent T-12. Gymnasium lighting is a mixture of fluorescent and metal halide. Interior lights are on a schedule controlled by the BAS in the common areas and manually controlled in offices and support areas. Exterior building parameter is metal halide.

The exterior finish is brick and precast concrete. The interior finish is sheetrock and block. Windows are double pane with shades. There is an entrance vestibule and the building envelope condition is in good condition.

ECM's

Previously Implemented ECMs

The staff is conscientious about turning lights out in areas not in use.

Opportunities for ECMs at South Dakota Women's Prison								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.4	Replace Mercury Vapor Lighting with Metal Halide	$3,750		14304		$844	4.4	
5.1.5	Replace Incandescent Exit Signs with LED	$315	0.4	1851		$109	2.9	
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,420	4.6	19748		$1,165	3.8	
5.4.1	Replace Firetube Boilers with Condensing	$96,140			10,538	$8,799	10.9	
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$82,800	6	164,313		$9,694	8.5	3.0
5.4.6	Replace Chiller with Turbo-Cor	$10,120		3,782	1,092	$1,135	8.9	
	TOTAL	**$197,545**	**10**	**203,997**	**11,630**	**21,747**	**9.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Exterior wallpack lighting
4. ECM 5.4.6: there currently is no central chiller. Only DX units are described. Replacement of the DX units with a central chiller would cost much more than as shown.

Estimated Blended Marginal Rates		
$	0.059	/kWh Elec
$	0.835	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

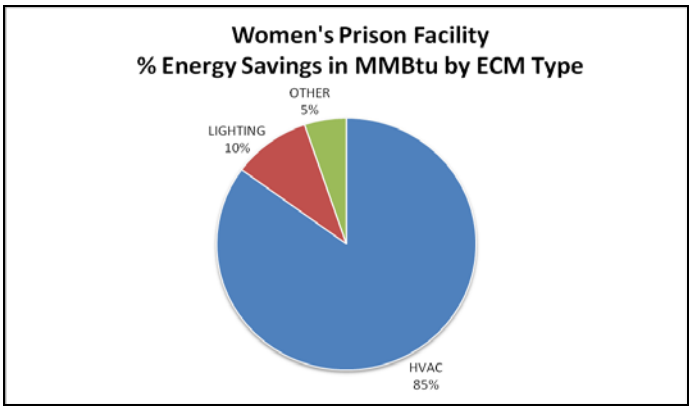
4.4.4.1.1. Campus Summary

A total of 6 ECMs were identified at Women's Prison Facility, which include 1,899 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $197,545 and save an estimated $21,747 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

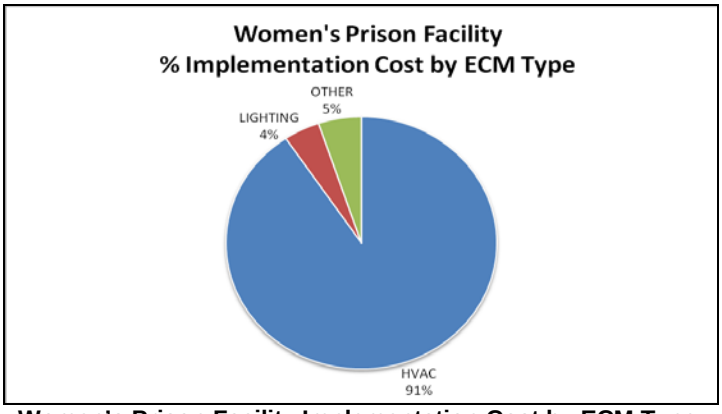
DOC ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
HVAC	561	1,090	**1,650**	$18,494	$178,940	**9.7**
LIGHTING	122	0	**122**	$2,118	$8,485	**4.0**
OTHER	13	113	**126**	$1,135	$10,120	**8.9**
Total	**696**	**1,203**	**1,899**	**21,747**	**197,545**	**9.1**

In total, these savings represent a 6% reduction from current energy consumption at the Women's Prison Facility, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



Women's Prison Facility Energy Savings by ECM Category.



Women's Prison Facility Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 1,899 MMBTUs (6% of campus energy use) and a total estimated annual cost avoidance of $21,747. The total cost of implementation for these measures is $197,545, which yields a simple payback of 9.1 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
SD Women's Prison	5.1.7	$315	6	$109	2.9	49.88
SD Women's Prison	5.1.10	$4,420	67	$1,165	3.8	65.60
SD Women's Prison	5.1.3	$3,750	49	$844	4.4	76.84
SD Women's Prison	5.4.11	$82,800	561	$9,694	8.5	147.69
SD Women's Prison	5.5.5	$10,120	126	$1,135	8.9	80.44
SD Women's Prison	5.4.1	$96,140	1,090	$8,799	10.9	88.23
TOTAL		**$197,545**	**1,899**	**$21,747**	**9.1**	**104.05**

4.4.5 STAR Academy

Campus Background and List of Facilities

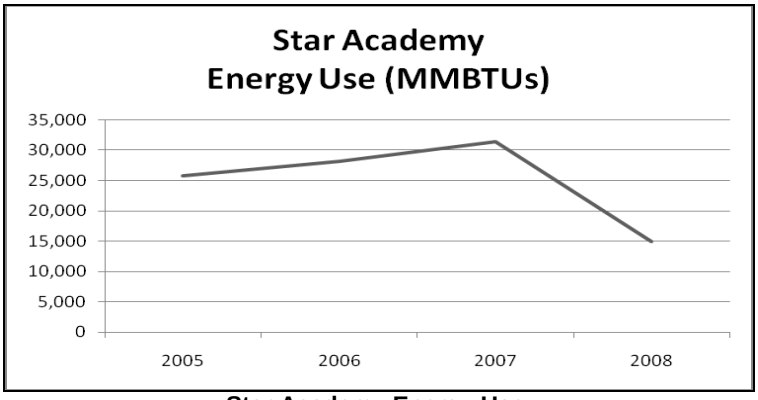
STAR (State Treatment and Rehabilitation Facility) Academy is a 21 building campus in Custer. There is a main boys (west) campus near the city of Custer and a girls (east) campus in Custer State Park. The west campus was originally built as a State developmental center but later changed function and was adapted for the department of corrections. The east campus was original built for park functions but became home to the STAR academy girls in 1996.The two campuses have approximately 150 people at them total on a regular working day

Campus-Wide Systems and Operational Profile

The STAR Academy east campus has central steam heat and domestic water systems that serve many buildings. Steam is created by a central boiler plant that has the capability of burning wood biomass, propane or fuel oil. Domestic hot water is created with a central domestic hot water heat exchanger that utilizes steam heat from the central boiler plant. Domestic water, steam and condensate are routed underground and through tunnels throughout the west campus. The east campus has central domestic water systems.

Energy Profile

In 2008, Star Academy facilities consumed a combined 14,905 MMBTUs of energy. The average Energy Use Intensity across the campus was 87 kBTU/SF in 2008.



Star Academy Energy Use.

4.4.5.1. Administration Building

Building Overview

The Administration building is approximately 12,000 square feet. This building was originally built in the 1911 with some lighting updates in 1998.This building is mainly used as office space.

The administration building envelope is in fair shape given its age. The windows are old and single paned. There is limited insulation in the walls that are thick concrete, block and brick. The roof has limited insulation and the roof membranes are in need of repair.

Building heating is provided by steam radiators. Steam is piped to the building through underground tunnels from the main boiler plant. Manual radiator valves and open windows are the occupant's only means of temperature control. Many offices have individual window air conditioners as this is the only source of cooling in the building. There is no central building automation system in the building. Lighting is provided by a mixture of fluorescent T-8, T-12 and compact with a mixture of fixture types and ballast configurations. Exit signs are primarily fluorescent

ECM's

Previously Implemented ECMs

As T-12 ballasts fail they are replaced with T-8 ballasts and lamps. Thermostatic radiator valves have been installed but have not tested successfully because they have not provided acceptable levels of temperature control.

Opportunities for ECMs at Administration Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
5.1.3	Install Motion Sensors to Control Lighting	$1,270	-	2,768		$249	5.1	
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,514	1.5	5,137		$462	9.8	
5.2.1	Full Retrocomissioning and Balancing Study	$25,000	1.6	13,930	5	$1,639	15.3	
5.3.3	Install VFDs on Hydronic Pumps	$6,560	0.8	13,892		$1,250	5.2	
5.3.9	Upgrade Controls System to Full DDC	$80,000	3.2	27,861	9	$3,277	24.4	
5.4.10	Centralize Cooling Systems with Chilled Water Plant	$118,680	32.9	53,777		$4,840	24.5	3
5.4.13	Steam Condensate Heat Recovery	$40,940			5	$385	106.4	
5.4.14	Steam Trap Survey/Replace or Repair Faulty Traps	$9,200			18	$1,540	6.0	
5.4.15	Convert Steam System Heating System to Hot Water	$35,000			5	$385	90.9	2,5
5.4.17	Insulate Steam/Heating Hot Water Piping	$1,200			4	$318	3.8	4
5.5.3	Improve Building Envelope - Insulation/Exterior	$100,000		395	14	$1,260	79.4	
5.5.4	Improve Building Envelope - Windows	$150,000		2,172	17	$1,682	89.2	
5.5.9	Window Film	$10,000		1,824		$164	60.9	
	TOTAL	**$582,364**	**40**	**121,755**	**76**	**$17,450**	**33.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil

Notes
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics assume installation concurrent with Annex, Main, and Admin buildings.
4. Assumes approximately 100ft of two inch diameter piping has poor insulation
5. Cost assumes concurrent installation with complete hot water conversion of the West Campus.

Estimated Blended Marginal Rates		
$	85.00	Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.5.2. Auditorium/Annex

Building Overview

The Auditorium/Annex building is 27,000 square feet. This building was originally built around 1917 with newer windows installed within the last 10 years. This building contains different workshops and classrooms for residents to work in.

The main building envelope is in fair shape given its age. The windows are in fair condition. Many windows have been replaced but a few old windows remain. There is limited insulation in the walls that are thick concrete, block and brick. The roof has limited insulation and the roof membranes are in need of repair.

Building heating is provided by steam radiators. Steam is piped to the building through underground tunnels from the main boiler plant. Manual radiator valves and open windows are the occupant's only means of temperature control. Many offices have individual window air conditioners as this is the only source of cooling in the building. There is no central building automation system in the building. Lighting is provided by a mixture of fluorescent T-8, T-12 and compact with a mixture of fixture types and ballast configurations. Exit signs are primarily fluorescent.

ECM's

Previously Implemented ECMs

As T-12 ballasts fail they are replaced with T-8 ballasts and lamps.

Opportunities for ECMs at Auditorium / Annex								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$1,270	-	2,898		$261	4.9	
5.1.5	Replace Incandescent Exit Signs with LED	$2,160	0.7	5,981		$538	4.0	
5.1.7	Retrofit T-12 Fixtures with T-8s	$14,850	8.0	27,983		$2,518	5.9	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$435	2.3	2,861		$257	1.7	
5.3.9	Upgrade Controls System to Full DDC	$85,000	3.3	29,250	10	$3,497	24.3	
	Centralize Cooling Systems with Chilled	$67,050	73.1	62,425		$5,618	11.9	

Opportunities for ECMs at Auditorium / Annex								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
5.4.10	Water Plant							
5.4.15	Convert Steam System Heating System to Hot Water	$45,000			10	$865	52.0	2,3
5.4.18	Install Backdraft Dampers on Exhaust Fans	$350		120	0.3	$34	10.2	
5.5.3	Improve Building Envelope - Insulation/Exterior	$25,000		81	4	$384	65.1	
5.5.4	Improve Building Envelope - Windows	$150,000		4,880	20	$2,109	71.1	
	TOTAL	**$391,115**	**87**	**136,478**	**45**	**16,082**	**24.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Cost assumes concurrent installation with complete hot water conversion of the West Campus.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.3. Biomass Building

Building Overview

The Biomass Building houses the biomass boiler and the wood chips that are conveyed to the boiler. The boiler and wood chip storage have been in use since 2007.

The biomass boiler is a custom built system designed to provide 400 boiler horsepower of heat to supplant the need to run the fossil fuel boilers in the power house. In order to feed wood chips into the boiler and keep the operation going, there are several schemes and devices designed to deliver woodchips, sift debris, handle ash, preheat combustion air and keep the heat exchanger surfaces clean and effective. Boiler controls are a combination of DDC and pneumatic.

The building is heated by unit heaters. There is no cooling. Lighting is provided by fluorescent T-8s and high bay metal halide fixtures. Exit signs are LED.

ECM's

Previously Implemented ECMs

The construction of the building was an energy conservation measure. Through the first year of operation, the less expensive wood chips saved approximately $180,000 when compared to an equivalent amount of propane or fuel oil that would have been burned if the biomass boiler plant was not built.

Opportunities for ECMs at Biomass Building						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.10	Replace HID Lighting with High Bay Fluorescent	$2,700	3	9,390	$845	3.2
	TOTAL	$2,700	3	9,390	845	3.2

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.4. Brady Academy Building

Building Overview

The Brady Academy Building was built in 1996 and is 16,600 square feet. This building is mainly used as a residence hall. This building is primarily occupied for a few hours each morning, evening and overnight.

The Brady Building is a block and brick building with adequate insulation and windows. There two central constant volume air handlers. Reheat coils throughout the building are controlled by zone thermostats. Heat is provided to the building by the main campus boiler plant that is converted to hot water in the penthouse of the building. Heating hot water is pumped through the building by a pair of hot water pumps that are controlled lead/lag. The air handlers, pumps, coils and steam valve is controlled by a Barber Coleman 8000 building automation system.

Lighting is provided by fluorescent T-8 fixtures. Exit signs are or fluorescent. Exterior lighting is metal halide.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Brady Academy Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$3,900	2.8	9,754		$878	4.4	
5.3.4	Install VFDs on Single Zone	$8,630	-	20,641	11	$2,795	3.1	

Opportunities for ECMs at Brady Academy Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
	Constant Volume AHUs							
5.4.17	Insulate Steam/Heating Hot Water Piping	$240			1	$114	2.1	3
5.4.31	Insulate Steam Condensate piping	$90			1	$86	1.0	3
	TOTAL	**$12,860**	**3**	**30,396**	**13**	**3,873**	**3.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.5. Chapel

Building Overview

The Chapel was built in 1998 and is 1,000 square feet. This building is currently being used for classes and recreational activities as well as a place of worship.

The building envelope is primarily log and mortar type construction. There is limited insulation in the walls. The windows are adequate.

There are no central HVAC systems in the building. Cooling is provided by one window air conditioning unit. Heating is provided by electric radiators. Lighting is provided by incandescent candelabra chandelier fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Chapel Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.5	Replace Incandescent Exit Signs with LED	$144	0.0	399	$36	4.0	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$510	0.8	1,858	$167	3.1	3
5.4.9	Replace Window AC Units with Heat Pumps	$1,840	1.2	1,274	$115	16.0	
	TOTAL	**$2,494**	**2**	**3,531**	**318**	**7.8**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Chandelier lights.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.5.6. Domestic Water Plant

Building Overview

The Domestic Water Plant building was built in 1990 and is approximately 850 square feet. This small building treats the water used throughout the campus.

A series of four water pumps pull water out of wells and into water storage tanks to be delivered by gravity throughout campus. A well pump controls system controls the operation of the pumps. Lighting is provided by fluorescent T-12s.Exit Lighting is fluorescent. There is no ventilation in the building. Heating is provided by electric heaters controlled by local thermostats to keep the building above freezing.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Domestic Water Plant						
			Estimated Annual Utility Savings			
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$540	0	1,018	$92	5.9
5.2.1	Full Retrocomissioning and Balancing Study	$1,000		5,446	$490	2.0
	TOTAL	**$1,540**	**0**	**6,463**	**582**	**2.6**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Pertains to the domestic water delivery packaged controls system.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.5.7. East Gymnasium

Building Overview

The East Gymnasium was built in 1979 and is 6,250 square feet. This building has a climbing wall and a basketball court for the residents to exercise.

The East Gymnasium is made up of metal panel construction. The windows are adequate. There is no central ventilation system in the building. Exhaust fans with open windows are relied upon for air circulation. There is a central heating hot water system powered by a propane fired boiler with perimeter radiant heaters. Window air conditioning units provide cooling for select spaces. Three small electric water heaters provide domestic hot water to the facility.

Lighting in the gym is provided by mercury vapor high intensity discharge fixtures. Fluorescent T-12 fixtures provide lighting in the non-gym floor areas. Exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at East Gymnasium

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,700	1.5	5,088	-	$458	5.9	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$2,025	1.9	6,957	-	$626	3.2	
5.4.9	Replace Window AC Units with Heat Pumps	$21,510	11.1	19,116	-	$1,720	12.5	
5.4.17	Insulate Steam/Heating Hot Water Piping	$450	-	-	57	$101	4.5	3
	TOTAL	**$26,685**	**14**	**31,161**	**57**	**2,906**	**9.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Assuming approximately 50 feet of piping can be insulated

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.76	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.8. Excel Building

Building Overview

The Excel Building was built in 1968 and is 7,400 square feet. This building is used by the girl's program and is used as a residence and a dining hall. This building is occupied throughout the daytime and evening by residents and employees.

The building has residential style construction with an adequate building envelope. The interior of the building underwent extensive modifications when STAR academy adapted it as a corrections residence.

There are no central cooling or ventilation systems for the building. Window air conditioners are used for cooling in select rooms and offices. A central boiler plant with three propane fired boilers provides heating hot water for a perimeter radiation heating system. Two domestic hot water heaters that burn propane are used for building domestic water and hot water for the kitchen.

A full service kitchen in the Excel building serves all of the east campus. There are several reach in coolers, three walk in coolers/freezers. There is a large kitchen hood with a propane fired heating only make-up air unit.

Fluorescent T-12s are the predominant lighting source in the building with a few incandescent, compact fluorescent and fluorescent T-8 fixtures throughout the building. Exit signs are fluorescent

ECM's

Previously Implemented ECMs

As T-12 ballasts fail the fixtures are retrofitted with T-8s.

Opportunities for ECMs at Excel Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,700	1.5	5,088		$458	5.9
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$58	0.3	1,081		$97	0.6
5.4.1	Replace Firetube Boilers with Condensing	$41,400			827	$1,464	28.3
5.4.9	Replace Window AC Units with Heat Pumps	$24,610	10.2	17,390		$1,565	15.7
5.4.19	Replace Walk-in Cooler/Freezer Condensers	$8,400	4.8	10,512		$946	8.9
5.5.5	Intellihood Kitchen Hood Controls System	$10,120	0.4	3,782	954	$2,028	5.0
5.5.3	Improve Building Envelope - Insulation/Exterior	$7,500			452	$801	9.4

Opportunities for ECMs at Excel Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years
	TOTAL	$94,788	17	37,853	2,233	7,359	12.9

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.9. Garage/Maintenance Building

Building Overview

The Garage/Maintenance building was build in 1979 and is about 1,300 square feet. This building is currently being remodeled to facilitate a class that will be conducted inside. There is also a shop space and a shop office.

The garage is made up of metal panel construction. The windows and insulation are adequate. There are no central HVAC systems. Heating is provided by small electric unit heaters. The shop office is cooled by a window air conditioning unit.

Lighting is provided by a mixture of fluorescent T-12 and T-8 lighting. Exterior lighting is provided by halogen PAR fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Garage / Maintenance Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.7	Retrofit T-12 Fixtures with T-8s	$648	0.3	1,221	$110	5.9	
5.1.12	Replace Halogen PAR's with Ceramic Metal Halide	$144	0.1	392	$35	4.1	3.0
5.4.9	Replace Window AC Units with Heat Pumps	$1,840	1.8	3,176	$286	6.4	
	TOTAL	$2,632	2	4,789	$431	6.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil

Notes
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Exterior Lights.

Estimated Blended Marginal Rates		
$	85.00	Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.5.10. Gymnasium

Building Overview

The Gymnasium was built in 1996 and is 6,250 square feet. The Gymnasium has a rock climbing wall and basketball hoops. It is used a few hours each day for residents to get exercise.

The gym is a metal panel building with adequate insulation and windows. There are hot water radiators with local line voltage thermostats for heat and no cooling systems. Exhaust fans provide air circulation. Lighting is provided by high bay metal halide fixtures. Exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Gymnasium Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$440	-	6,167	$555	0.8	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$3,150	3.1	10,954	$986	3.2	
	TOTAL	**$3,590**	**3**	**17,122**	**1,541**	**2.3**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Exterior Lights.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$		Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.5.11. Laundry Building

Building Overview

The Laundry building was built in 1914 and is approximately 6,500 square feet. The primary use of this building is in the morning and early afternoon hours. There is a garage underneath the laundry building that is used for storage and some shop work.

The building is in poor condition as it is almost 100 years old and has never received significant infrastructure upgrades. The windows are single paned and in poor condition. The standard doors and overhead door seals leak significantly.

Heating is provided by steam radiators and unit heaters. Steam is provided to the building by the central plant. There is no cooling. Exhaust fans are interlocked with the dryer operation. Lighting is provided by fluorescent T-12 fixtures with two lamps. Exit signs are incandescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Laundry Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
5.1.5	Replace Incandescent Exit Signs with LED	$360	0.1	997		$90	4.0	
5.1.7	Retrofit T-12 Fixtures with T-8s	$4,600	2.0	7,123		$641	7.2	
5.4.15	Convert Steam System Heating System to Hot Water	$10,000			3	$214	46.8	2,3
5.4.16	Insulate Domestic Water Piping	$900			5	$409	2.2	4
5.4.17	Insulate Steam/Heating Hot Water Piping	$1,200			2	$212	5.7	5
5.5.3	Improve Building Envelope - Insulation/Exterior	$25,000		1,810	12	$1,191	21.0	
5.5.4	Improve Building Envelope - Windows	$20,000		840	4	$444	45.0	
	TOTAL	**$62,060**	**2**	**10,770**	**26**	**3,200**	**19.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Cost assumes concurrent installation with complete hot water conversion of the West Campus.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.12. Main Building

Building Overview

The Main building is approximately 44,000 square feet. This building was originally built in 1953 with a kitchen area added in 1979. This building is primarily used for educational programs, youth residence and dining in the kitchen/lunchroom area.

The main building envelope is in fair shape given its age. The windows are in fair condition. Many windows have been replaced but a few old windows remain. Window films have been installed on many of the south facing windows to reduce the amount of heat gain from the sun in the summer. There is limited insulation in the walls that are thick concrete, block and brick. The roof has limited insulation and the roof membranes are in need of repair.

Building heating is provided by steam radiators. Steam is piped to the building through underground tunnels from the main boiler plant. There is a central air cooled chiller that provides chilled water to a network of constant volume air handlers throughout the building. Each air handling unit has a single local thermostat that controls the discharge air temperature of each unit. Mechanical HVAC equipment is controlled by a Barber Coleman Network 8000 system with a keypad based interface.

Lighting is provided by a mixture of fluorescent T-8, T-12 and compact with a mixture of fixture types and ballast configurations. Exit signs are primarily fluorescent.

ECM's

Previously Implemented ECMs

As T-12 ballasts fail they are replaced with T-8 ballasts and lamps.

Opportunities for ECMs at Main Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.4	Replace Mercury Vapor Lighting with Metal Halide	$2,250	2.8	9,933	-	$894	2.5	
5.1.5	Replace Incandescent Exit Signs with LED	$3,600	1.2	9,969	-	$897	4.0	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$24,300	13.1	45,790	-	$4,121	5.9	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$425	3.9	4,768	-	$429	1.0	
5.2.1	Full Retrocomissioning and Balancing Study	$49,680	11.8	103,015	33	$12,118	4.1	
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$14,260	5.5	48,101	6	$4,841	2.9	
5.3.9	Upgrade Controls System to Full DDC	$93,150	11.8	103,015	33	$12,118	7.7	
5.4.10	Centralize Cooling Systems with Chilled Water Plant	$82,000	46.1	95,575	-	$8,602	9.5	2,3
5.4.15	Convert Steam System Heating System to Hot Water	$65,000	-	-	17	$1,423	45.7	4
5.4.16	Insulate Domestic Water Piping	$225	-	-	1	$48	4.7	5
5.4.17	Insulate Steam/Heating Hot Water Piping	$1,200	-	-	4	$318	3.8	5

Opportunities for ECMs at Main Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
5.4.19	Replace Walk-in Cooler/Freezer Condensers	$8,280	9.6	16,819	-	$1,514	5.5	
5.5.5	Intellihood Kitchen Hood Controls System	$10,120	0.4	3,782	7	$957	10.6	
5.5.9	Window Film	$10,000		6,877		$619	16.2	
	TOTAL	$364,490	106	447,644	101	48,898	7.5	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics assumes installation concurrent with Annex and Admin buildings.
4. Cost assumes concurrent installation with complete hot water conversion of the West Campus.
5. Assumes current insulation is 1/2 inch or less on majority of piping

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.13. Med/Ed. Building

Building Overview

The Med/Ed. Building was originally a warehouse but was remodeled in 1998 and is approximately 2,400 square feet. This building contains a small number of classrooms and medical spaces. The Med/Ed. Building is occupied various hours of the day for classroom activities and medical appointments.

The Med/Ed building has residential style construction with adequate insulation and windows. There are no central HVAC systems in the building. Heating is provided by perimeter electric radiation. Window air conditioning units provide cooling throughout the building. One small electric water heater provides domestic hot water to the building. Lighting is fluorescent T-8 throughout. Exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Med / Ed Building							
ECM No.	Energy Conservation Measure (ECM)	Estimated Implementation	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Propane Gal		
5.4.9	Replace Window AC Units with Heat Pumps	$14,380	7	12,816	-	$1,153	12.5
5.5.12	Space Utilization	$7,500			147	$260	28.9
	TOTAL	$21,880	7	12,816	147	1,413	15.5

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.5.14. Power House Building

Building Overview

The Power House Building was built in 1917 and is approximately 8,500 square feet. This building contains the backup boilers and fuel tanks for heating the campus. Before the Biomass Building was built, the boilers in the power house was the main boiler plant for the boys campus.

The building envelope and windows are poor but it has little consequence because the boilers throw off enough excess heat in the winter that the heaters do not come on anyway. There are no cooling systems. Lighting is primarily provided by fluorescent T-12 fixtures with two lamps. Exit lights are fluorescent. Exterior lighting is mercury vapor.

There are two main boilers that can operate on propane or fuel oil. One boiler is 400 hp, the other is 500 hp. Prior to the installation of the biomass boiler, the fuel was chosen based on which was cheaper at the time. The steam boiler system has a deaerator and chemical feed. Condensate is collected throughout campus and delivered back to the main condensate receiver in the power house building by several condensate pumps. There is a 9,000 gallon propane tank and two 10,000 gallon fuel oil tanks with a duplex fuel oil pump. Three feed water pumps keep the steam system water levels above low-water cutout. Boiler controls are a combination of electric and pneumatic.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Powerhouse Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
5.1.4	Replace Mercury Vapor Lighting with Metal Halide	$45	0.1	199		$18	2.5	
5.1.7	Retrofit T-12 Fixtures with T-8s	$10,800	5.8	20,351		$1,832	5.9	

Opportunities for ECMs at Powerhouse Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.4.15	Convert Steam System Heating System to Hot Water	$14,500			6.5	$550	26.3	2,3
5.4.17	Insulate Steam/Heating Hot Water Piping	$1,200			2.49076	$212	5.7	4
	TOTAL	$26,545	6	20,550	9	$2,612	10.2	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.090	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.15. Quest Building

Building Overview

The Quest Building was built in 1975 and is 6,850 square feet. This building is a residence hall for the girl's program. It is mainly occupied for a few hours in the morning, evening, and overnight as the residents sleep. This building is basically the same as the Excel Building but does not have a kitchen.

The building has residential style construction with an adequate building envelope. The interior of the building underwent extensive modifications when STAR academy adapted it as a corrections residence.

There are no central cooling or ventilation systems for the building. Window air conditioners are used for cooling in select rooms and offices. A central boiler plant with three propane fired boilers provides heating hot water for a perimeter radiation heating system. There is a propane fired domestic water heater as well as a heat hot water to domestic water heat exchanger so that domestic water can either be heated directly or by the boilers.

Fluorescent T-12s are the predominant lighting source in the building with a few incandescent, compact fluorescent and fluorescent T-8 fixtures throughout the building. Exit signs are fluorescent. Exterior lighting is provided by halogen PAR lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Quest Building									
			Estimated Annual Utility Savings						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,080	0.6	2,035	-	-	$183	5.9	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$64	0.2	758	-	-	$68	0.9	
5.1.12	Replace Halogen PAR's with Ceramic Metal Halide	$144	0.1	392	-	-	$35	4.1	3.0
5.4.9	Replace Window AC Units with Heat Pumps	$32,320	17.4	29,753	-	-	$2,678	12.1	
5.4.16	Insulate Domestic Water Piping	$225				1.5	$123	1.8	4.0
5.5.12	Space Utilization	$7,500			419		$741	10.1	
	TOTAL	**$41,333**	**18**	**32,938**	**419**	**1**	**$3,829**	**10.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Exterior lights.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.5.16. Wastewater Treatment Building

Building Overview

The Wastewater Treatment facility was built in 2000 and is just over 300 square feet. This small building houses pumps that treat the wastewater for the entire campus.

Several small pumps move water through a series of water treatment stages before the treated water is sent to ground. There is no ventilation in the building. Heating is provided by electric heaters controlled by local thermostats to keep the building above freezing. The building is lit by fluorescent T-12s. The exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Wastewater Treatment Building						
			Estimated Annual Utility Savings			
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$540	0	1,018	$92	5.9
	TOTAL	**$540**	**0**	**1,018**	**$92**	**5.9**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.5.17. Welding Shop

Building Overview

The Welding Shop is approximately 1,000 square feet. This small building is used for a few hours in the morning and again for a few hours each afternoon. This metal panel building was constructed in 2005 with a good building envelope and windows.

The welding shop uses steam heat from the central plant and delivers it to the space through radiators. There is no cooling in the building. Ventilation is provided by exhaust fans that are controlled by a wall switch. Space lighting is fluorescent T-8. Exit signs are incandescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Welding Shop						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.5	Replace Incandescent Exit Signs with LED	$144	0	399	$36	4.0
	TOTAL	**$144**	**0**	**399**	**$36**	**4.0**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

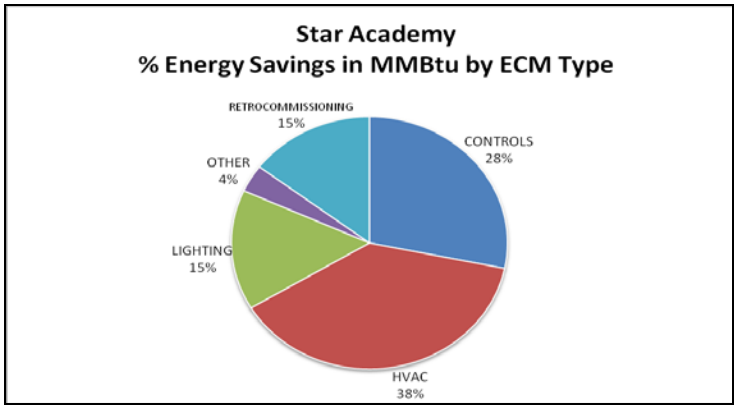
4.4.5.17.1. Campus Summary

A total of 84 ECMs were identified at Star Academy buildings, which include 4,660 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $1.22 million, and save an estimated $101,812 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

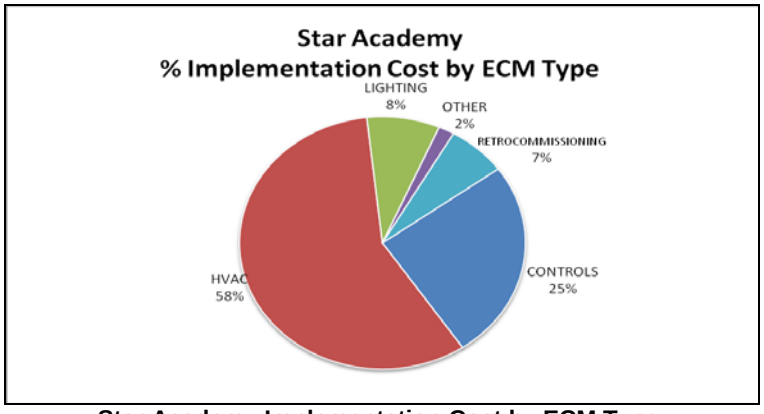
DOC ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	828	488	**1,317**	$27,779	$287,600	**10.4**
HVAC	1,101	676	**1,777**	$37,836	$649,230	**17.2**
LIGHTING	719	0	**719**	$18,965	92,510	**4.9**
OTHER	26	138	**164**	$2,985	20,240	**6.8**
RETROCOMMISSIONING	418	266	**684**	$14,247	75,680	**5.3**
Total	**3,092**	**1,568**	**4,660**	**$101,812**	**$1,125,260**	**11.1**

In total, these savings represent a 31% reduction from current energy consumption at the Star Academy campus, the majority of which is attributed to HVAC measures which will reduce electric consumption.



Star Academy Energy Savings by ECM Category.



Star Academy Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar

invested. This will yield a savings of 2,124 MMBTUs (14% of campus energy use) and a total estimated annual cost avoidance of $46,377. The total cost of implementation for these measures is $198,056, which yields a simple payback of 4.3 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Excel Building	5.1.8	$58	4	$97	0.6	15.73
Gymnasium	5.1.3	$440	21	$555	0.8	20.91
Quest Building	5.1.8	$64	3	$68	0.9	24.75
Main Building	5.1.8	$425	16	$429	1.0	26.13
Brady Building	5.4.31	$90	7	$86	1.0	12.71
Auditorium/Annex	5.1.8	$435	10	$257	1.7	44.57
Quest Building	5.4.16	$225	10	$123	1.8	22.15
Domestic Water Plant	5.2.1	$1,000	19	$490	2.0	53.82
Brady Building	5.4.17	$240	9	$114	2.1	25.59
Laundry/Garage Building	5.4.16	$900	34	$409	2.2	26.73
Main Building	5.1.4	$2,250	34	$894	2.5	66.39
Power House	5.1.4	$45	1	$18	2.5	66.39
Main Building	5.3.4	$14,260	206	$4,841	2.9	69.13
Chapel	5.1.8	$510	6	$167	3.1	80.47
Brady Building	5.3.4	$8,630	148	$2,795	3.1	58.45
Biomass Building	5.1.10	$2,700	32	$845	3.2	84.28
Gymnasium	5.1.10	$3,150	37	$986	3.2	84.28
East Gym	5.1.10	$2,025	24	$626	3.2	85.31
Administration Building	5.4.17	$1,200	26	$318	3.8	45.88
Main Building	5.4.17	$1,200	26	$318	3.8	45.88
Auditorium/Annex	5.1.5	$2,160	20	$538	4.0	105.84
Chapel	5.1.5	$144	1	$36	4.0	105.84
Laundry/Garage Building	5.1.5	$360	3	$90	4.0	105.84
Main Building	5.1.5	$3,600	34	$897	4.0	105.84
Welding Shop	5.1.5	$144	1	$36	4.0	105.84
Garage	5.1.6	$144	1	$35	4.1	107.62
Quest Building	5.1.6	$144	1	$35	4.1	107.62
Main Building	5.2.1	$49,680	586	$12,118	4.1	84.79
Brady Building	5.1.1	$3,900	33	$878	4.4	117.18
East Gym	5.4.17	$450	5	$101	4.5	86.03
Main Building	5.4.16	$225	4	$48	4.7	57.35
Auditorium/Annex	5.1.3	$1,270	10	$261	4.9	128.45
Excel Building	5.5.5	$10,120	100	$2,028	5.0	100.94
Administration Building	5.1.3	$1,270	9	$249	5.1	134.48
Administration Building	5.3.3	$6,560	47	$1,250	5.2	138.40

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Main Building	5.4.19	$8,280	57	$1,514	5.5	144.28
Laundry/Garage Building	5.4.17	$1,200	17	$212	5.7	68.83
Power House	5.4.17	$1,200	17	$212	5.7	68.83
Domestic Water Plant	5.1.7	$540	3	$92	5.9	155.53
Quest Building	5.1.7	$1,080	7	$183	5.9	155.53
Wastewater Plant	5.1.7	$540	3	$92	5.9	155.53
Garage	5.1.7	$648	4	$110	5.9	155.53
Auditorium/Annex	5.1.7	$14,850	95	$2,518	5.9	155.53
Main Building	5.1.7	$24,300	156	$4,121	5.9	155.53
East Gym	5.1.7	$2,700	17	$458	5.9	155.53
Excel Building	5.1.7	$2,700	17	$458	5.9	155.53
Power House	5.1.7	$10,800	69	$1,832	5.9	155.53
Administration Building	5.4.14	$9,200	127	$1,540	6.0	72.56
TOTAL		**$198,056**	**2,124**	**$46,377**	**4.3**	**93.25**

4.4.6 State Training School - Aurora Plains Academy

Campus Background and List of Facilities

Aurora Plains Academy (APA) is an intensive residential treatment facility located in Plankinton South Dakota. The Academy is a LLC of Clinicare Corporation from Milwaukee Wisconsin. Aurora Plains Academy was established in January 2007 after Clinicare Corporation responded to a request for proposal.

Campus-Wide Systems and Operational Profile

The APA campus has central low pressure steam heat that serves a majority of campus buildings. Low pressure steam is produced by an electric boiler (with fuel oil boilers as backup) located at the Boiler Plant. Fuel oil had been utilized as the primary fuel source in the past, but currently, electric heat is more cost effective.

The APA campus has a central DDC system that is connected to a select number of campus buildings HVAC systems with the remaining campus building HVAC systems controlled at the individual building.DDC controlled buildings include the Female Secure Unit and Administration, Dietary Building, Cottages, Kennedy Building, School, Old Gym, Lincoln Annex, and New Gym.

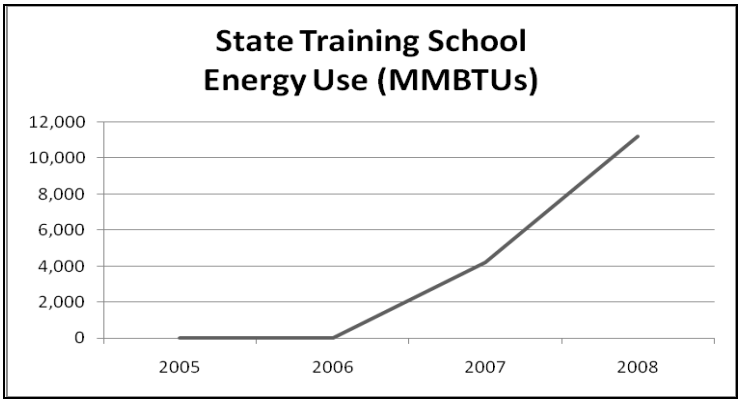
Buildings on campus which do not use campus steam are heated with either electric or propane. There is no natural gas onsite, and the nearest natural gas mains are over five miles away.

Campus wide, chilled water (CHW) is drained in the winter. Hot water (HW) contains glycol but the concentration of glycol/water is unknown.

Given the electric boiler configuration, ground source heat pumps may be worth consideration. While immediate replacement may not have an attractive payback, the incremental costs over traditional HVAC systems may lead to attractive life cycle costs.

Energy Profile

In 2008, State Training School facilities consumed a combined 11,220 MMBTUs of energy. The average Energy Use Intensity across the campus was 72 kBTU/SF in 2008.



State Training School Energy Use.

4.4.6.1. Ag Science Building 29

Building Overview

The building has not been used recently, but may be used for classes. The building occupies approximately 1,800 square feet.

HVAC: Building is connected to campus steam, which serves several unit heaters. A window air conditioner provides cooling for a small portion of the building. The single pane windows are old and are in poor condition.

Lighting: There are several T-12 fluorescent fixtures, as well as two incandescent exit signs.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Ag Health Building 29							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.5.18	Space Utilization	$1,000	9	11,204	$1,008	1.0	
	TOTAL	$1,000	9	11,204	1,008	1.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Propose moving any activities to the Old Gym second floor or other acceptable area and decommissioning the Ag Science Building.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$		Ton Biomass
$	1.77	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.6.2. Boiler Plant Building 39

Building Overview

The boiler plant occupies approximately 2,500 square feet.

HVAC:The main boiler is a 600 kW electric boiler, which is utilized due to currently low electric rates and higher fuel oil prices. The electric boiler is sufficient for heating all of its systems when the outside air temperature is above 20° F.Three additional #2 fuel oil boilers, two at 150 Bhp and one at 100 Bhp, to provide additional heating as required.All condensate and boiler feedwater pumps are fairly old and are likely in need of upgrading.

Lighting: The plant is lit using 400W metal halide fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Boiler Plant Building 39								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings				Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Fuel Oil Gal	Biomass Tons		
5.1.10	Replace HID Lighting with High Bay Fluorescent	$2,000	2	3,858	-	-	$347	5.8
5.4.21	Install Biomass Fuel Boiler	$1,500,000	600	1,200,000	17,985	(830)	$103,163	14.5
	TOTAL	$1,502,000	602	1,203,858	17,985	(830)	$103,510	14.5

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs are order of magnitude and are based on similar projects. Biomass is assumed at $60/ton and fuel oil is assumed at $2.50/gallon.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	2.50	/Gal Fuel Oil
$	60.00	Ton Biomass
$	1.50	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.6.3. Cottages (Typical of 7) Buildings 16 thru 22

Building Overview

Each resident building is approximately 2,000 square feet. The Cottages are usually occupied from 3 pm until 9 am. There are approximately 8 occupants per building. Siding was replaced in 1998.

HVAC: The building is connected to campus DDC system. Each building has a residential style electric heat with split AC condenser unit. The setpoints are controlled via the DDC system. The system is capable of daytime setbacks, although this feature is not currently utilized.

Each building contains a residential electric domestic water heater and a washer/dryer.

Lighting: Lights are incandescent controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Cottages (Typical of 7) Buildings 16 thru 22

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$900	7	24,024	-	$2,162	0.4	2,4
5.2.6	Schedule Air Handlers Night Setback	$400	-	5,311	65	$575	0.7	3,4
	TOTAL	$1,300	7	29,335	65	$2,737	0.5	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume screw-in CFL replacement.
3. Setbacks will be during daytime hours.
4. Costs and savings take into account eight buildings (Staff House Buildings 16-22).

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$		Ton Biomass
$	1.77	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.6.4. Dietary Food Services Building 14

Building Overview

This building consists of a dining area and kitchen. The building is approximately 8,500 square feet. The normal hours of occupancy 6 am to 6 pm, 7 days per week.

HVAC: Building is connected to campus steam and DDC control system. It is served by two constant air volume steam/DX air handlers, one serving the kitchen and one serving the dining hall. There is no dedicated makeup air unit for kitchen hood exhaust. The building has perimeter steam baseboard heat. The air handling units utilize a DDC overlay of pneumatic actuators.

The building is served by a 27 kW capacity electric domestic hot water heater.

Lighting: Building is approximately 50% T-8 and 50% T-12 fixtures. All lighting is controlled by manual switches.2.

ECM's

Previously Implemented ECMs

Half of the lights have been converted to T-8.

Opportunities for ECMs at Dietary Food Services Building 14

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,000	1	3,640	$328	6.1	
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$7,000	-	16,075	$1,447	4.8	
5.5.6	Intellihood Kitchen Hood Controls System	$25,000	-	74,128	$6,671	3.7	2
	TOTAL	**$34,000**	**1**	**93,842**	**8,446**	**4.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. There is no existing makeup air unit. This measure assumes that infiltration will still provide makeup air.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.6.5. Female Secure Unit & Administration Buildings 12 & 13

Building Overview

One area of the building area serves as a recreation room, but the remaining areas, formerly used for office space, are now used for storage. Building is approximately 12,000 square feet.

The normal hours of occupancy (in recreation room only) are 5 hours per day. The building was remodeled in the mid 1980's.

HVAC: The building is connected to campus steam & DDC control system. There are four constant air volume steam heat air (DX cooling for the one air handler serving the recreation room area) handlers serving the building. Three of the four air handlers are kept off unless needed to maintain minimal heat (40 to 50 deg F) in non-occupied spaces. The one air handler serving the recreation room area operates to maintain an occupied space temperature set point. The units are scheduled via the central DDC system and utilize a DDC overlay of pneumatic actuators.

Domestic water is heated using an electric water heater.

Lighting: The building has both T-8 and T-12 fixtures controlled by manual switches. Lights are kept off when spaces are non-occupied.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Female Secure Unit & Administration Buildings 12 & 13						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh			
5.3.8	Schedule AHUs Off during Unoccupied Hours	$0	17,594	$1,583	Instant	2
	TOTAL	$0	17,594	1,583	0.0	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.6.6. Highway Patrol House Building 11

Building Overview

These residential buildings are approximately 1,800 square feet each and house between two and five occupants per building. Windows and siding have been replaced in recent years.

HVAC: The building has a residential style propane gas furnace with split AC condenser unit with non-programmable thermostat.

Each building contains a residential electric domestic water heater and a washer/dryer.

Lighting: Lights are incandescent controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Highway Patrol Building 11								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$113	1	3,003	-	$270	0.4	2,4
5.3.2	Programmable Thermostat for Residential Style Units	$100	-	390	4	$42	2.4	3,4
	TOTAL	$213	1	3,393	4	$312	0.7	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.6.7. Ice House, Pump House, Auto Mechanics

Building Overview

Buildings are normally non-occupied

HVAC: The buildings are kept at minimal heat using electric heaters (steam heat for Auto Mechanics) to prevent freezing.

Lighting: Lights are incandescent and are rarely used.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Ice House, Pump House, Auto Mechanics

No suitable energy conservation measures were discovered.

4.4.6.8. Kennedy Building 23 thru 25 (thru floors)

Building Overview

The building houses school residents on three floors and occupies approximately 20,000 square feet. There are approximately 30 occupants per floor. The building is usually occupied from 3 pm until 9 am. Building HVAC and lighting were renovated in the mid 1990's.

HVAC: The building is connected to campus steam. Steam heat is converted to hot water, which serves air handling unit coils and baseboard heaters. The hot water supply temperature resets based on outside air temperature. An air cooled chiller provides chilled water to each of the air handlers. Both hot water and chilled water pumps are constant speed. Each floor is served by a constant air volume air handler controlled by the DDC. All actuators are electronic.

The building utilizes an electric domestic water heater.

Lighting: Lights are T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Kennedy Building 23 thru 25 (thru floors)

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh			
5.3.3	Install VFDs on Hydronic Pumps	$12,000	14,255	$1,283	9.4	2
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$25,000	71,065	$6,396	3.9	
	TOTAL	$25,000	71,065	6,396	3.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. CHW pumps only.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.50	/Gal Propane

4.4.6.9. Lincoln Annex (Male Detention Center) Building 31

Building Overview

The building houses many detention cells, but the cells are now used for storage. Other areas are utilized for offices and meeting areas. The building occupies approximately 16,000 square feet. The normal hours of occupancy are 8 am to 6 pm, 7 days per week.

HVAC: Building is connected to campus steam via hot water converters. The heating water supply temperature is reset based on outside air temperature. DDC system. The office areas are served using a VAV air handling unit with hot water reheat VAV boxes. The heating water system utilizes two pump pairs in series – one for supply and one for return. Two cell block areas are served using dedicated constant volume units, each with four reheat zones. The cells are not used, but the air handlers are still utilized to avoid humidity issues.

There is a small kitchen with a7' length hood above a residential style electric range. Based on the hood rating, the hood exhausts 1,680 CFM. While a 7' hood is likely not required for the application, an electric range would still only require 350 CFM using the existing hood.

Lighting: Lighting is provided using T-8 fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Lincoln Annex (Male Detention Center)Building 31						
			Estimated Annual Utility Savings			
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Natural Gas Therms	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$1,250	$1,250	2,288	$206	6.1
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$45,000	$45,000	16,493	$1,484	30.3
5.5.19	Decrease Kitchen Hood Exhaust Flow	$1,500	$1,500	13,299	$1,197	1.3
	TOTAL	$47,750	$47,750	32,080	2,887	16.5

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 2 hours per day.
3. Includes VAV boxes for four zones per unit.
4. Assume operation average of four hours per day.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.6.10. New Gym Building 32

Building Overview

The New Gym occupies approximately 6,500 square feet. The normal hours could be occupied anytime from 9 am to 10 pm, 7 days per week.

HVAC: Building is connected to campus steam via hot water converters. A makeup air handling unit provides ventilation and heating to the gym. The makeup unit is controlled via the DDC system to come on only when ventilation air is required. A classroom area is served by a small DX cooling unit with hot water heating.

Lighting: The gym is served by 250W metal halide fixtures. The classroom is served by T-8 fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at New Gym Building 30						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.10	Replace HID Lighting with High Bay Fluorescent	$4,000	2	5,875	$529	7.6
	TOTAL	$4,000	2	5,875	529	7.6

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 2 hours per day.
3. Includes VAV boxes for four zones per unit.
4. Assume operation average of four hours per day.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane

4.4.6.11. New Warehouse Building 15

Building Overview

The New Warehouse is approximately 5,000 square feet and is normally non-occupied

HVAC: The building is connected to campus steam. Building is heated with steam unit heaters. The space is minimally heated.

Lighting: Building has T-8, T-12 and six 300 watt metal halide fixtures all controlled by manual switches. Lights are kept off when non-occupied.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at New Warehouse Building 15

No suitable energy conservation measures were discovered.

4.4.6.12. Old Gym Building 30

Building Overview

The Old Gym building occupies approximately 10,000 square feet. The lower floor houses the gym area, but the upper floor is not utilized. The normal hours of occupancy are 6 am to 6 pm, 5 days per week.

The exterior brick is in good condition, but the windows are in very poor condition. Many windows and frames are broken. While this floor has been sealed off from the main gym area, infiltration likely occurs. With an interior renovation and new windows, the space could be utilized.

HVAC: Building is connected to campus steam via hot water converters. The air handling unit is controlled and scheduled by the DDC system. The heating water supply temperature is reset based on outside air temperature. The gym area is served by a heating only, constant volume air handling unit.

Lighting: Lighting is provided using T-8 lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Old Gym Building 30

No suitable energy conservation measures were discovered.

4.4.6.13. Physical Plant Office / Shop Building 38

Building Overview

Offices, shop area Building is approximately 5,500 square feet. The normal hours of occupancy are 8 am to 5 pm, Monday thru Friday.

HVAC: Building is connected to campus steam, which serves unit heaters in garage areas. The office areas are served by a residential style DX cooling unit with electric heat. The thermostat is manually controlled.

Lighting: The lighting in office areas a T-8 lamps, and 8' T-12s illuminate garage areas. Some unheated garages utilize incandescent lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Physical Plant Office / Shop Building 38							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.12	Replace 8' Fixtures with 4' Fixtures	$1,000	1	4,004	$360	2.8	2,4
5.3.2	Programmable Thermostat for Residential Style Units	$100	-	2,351	$212	0.5	3,4
	TOTAL	$1,100	1	6,355	$572	1.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume screw-in CFL replacement.
3. Setbacks will be during daytime hours.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.50	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.6.14. School Building 27

Building Overview

The School Building occupies approximately 17,000 square feet. The building is occupied during normal school hours (9 am to 3 pm), but has the potential to be occupied during all times of day. The single paned windows are fair condition.

HVAC: The building is connected to campus steam. Steam heat is converted to hot water, which serves air handling unit coils and reheat coils. The hot water supply temperature resets based on outside air temperature. An air cooled chiller provides chilled water to each of the air handlers. Both hot water and chilled water pumps are constant speed. Variable air volume air handling units provide space conditioning. The air handlers run continuously.

Lighting: Lights are T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

The building interior has been remodeled, and new VAV HVAC equipment and lighting have been installed.

Opportunities for ECMs at School Building 27						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$2,500	4,680	$421	5.9	2
5.3.3	Install VFDs on Hydronic Pumps	$12,000	16,288	$1,466	8.2	3
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0	2,453	$221	0.0	4
	TOTAL	$14,500	23,421	2,108	6.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 3 hours per day.
3. CHW pumps only. Savings assume that schedule changes are not possible. If schedule changes occur, savings from a VFD would significantly decrease.
4. Assume space program can be changed such that scheduling is possible.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.6.15. Staff House (Typical of 3) Building 2 thru 4

Building Overview

These residential buildings are approximately 700 square feet each and house between two and five occupants per building. Windows & siding has been replaced in recent years.

HVAC: The building has a residential style propane gas furnace with split AC condenser unit with non-programmable thermostat. The furnace was replaced in 1992.

Each building contains a residential electric domestic water heater and a washer/dryer.

Lighting: Lights are incandescent controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Staff House (typical of 3) Building 2 thru 4								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$450	3	12,012	-	$1,081	0.4	2,4
5.3.2	Programmable Thermostat for Residential Style Units	$300	-	1,008	13	$111	2.7	3,4
	TOTAL	$750	3	13,020	13	$1,192	0.6	

Notes

1. Estimated implementation cost includes allowance for materials, labor and

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas

Notes
contractor overheads.
2. Costs assume screw-in CFL replacement.
3. Setbacks will be during daytime hours.
4. Costs and savings take into account three buildings (Staff House Buildings 2, 3, and 4).

Estimated Blended Marginal Rates		
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.6.16. Staff House (typical of 2) Building 9 & 10

Building Overview

These residential buildings are approximately 1,200 square feet each and house between two and five occupants per building. Windows and siding appear to be in poor condition.

HVAC: The building has a residential style propane gas furnace with split AC condenser unit with non-programmable thermostat.

Each building contains a residential electric domestic water heater and a washer/dryer.

Lighting: Lights are incandescent controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Staff House (typical of 2) Building 9 & 10

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$120	1	3,203	-	$288	0.4	2,4
5.3.2	Programmable Thermostat for Residential Style Units	$200	-	699	9	$76	2.6	3,4
	TOTAL	$320	1	3,902	9	$365	0.9	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume screw-in CFL replacement.
3. Setbacks will be during daytime hours.
4. Costs and savings take into account two buildings (Staff House Buildings 9-10).

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.4.6.17. Superintendents Residence Building 1

Building Overview

This residential building is approximately 2,800 square feet and houses five occupants. The building is scheduled to be re-sided.

HVAC: The building has a residential style propane gas furnace with split AC condenser unit with non-programmable thermostat. The furnace was replaced in 1993.

Each building contains a residential electric domestic water heater and a washer/dryer.

Lighting: Lights are incandescent controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Superintendents Residence Building 1

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$150	1	4,004	-	$360	0.4	2,4
5.3.2	Programmable Thermostat for Residential Style Units	$100	-	780	9	$83	1.2	3,4
	TOTAL	$250	1	4,784	9	$444	0.6	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume screw-in CFL replacement.
3. Setbacks will be during daytime hours.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.50	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.4.6.18. Trades Building 35

Building Overview

This building is predominantly a garage shop with a small break and office area. The building occupies approximately 4,500 square feet. The normal hours of occupancy are 6 am to 5 pm, Monday through Friday.

HVAC: The garage is heated using two electric unit heaters.

Lighting: Garage lighting is provided by 8' T-12 fixtures, while the break area lighting is provided using 4' T-12 fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Trades Building 35						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.7	Retrofit T-12 Fixtures with T-8s	$200	0	702	$63	3.2
5.1.12	Replace 8' Fixtures with 4' Fixtures	$500	1	2,054	$185	2.7
	TOTAL	**$700**	**1**	**2,756**	**248**	**2.8**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. There is no existing makeup air unit. This measure assumes that infiltration will still provide makeup air.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.50	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

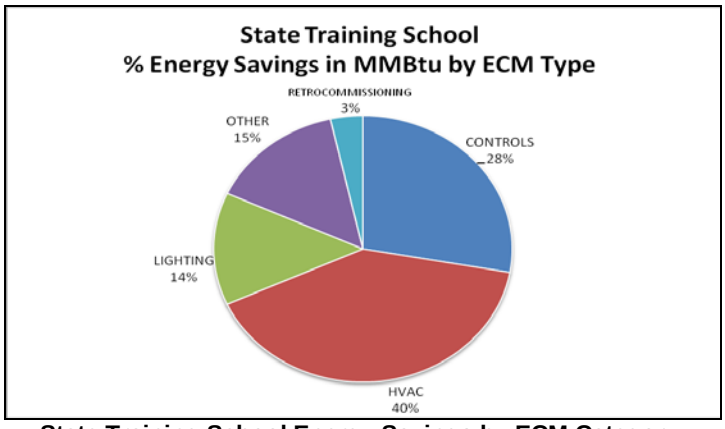
4.4.6.18.1. Campus Summary

A total of 32 ECMs were identified at State Training School buildings, which include 1,988 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $1.6 million, and save an estimated $134,341 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

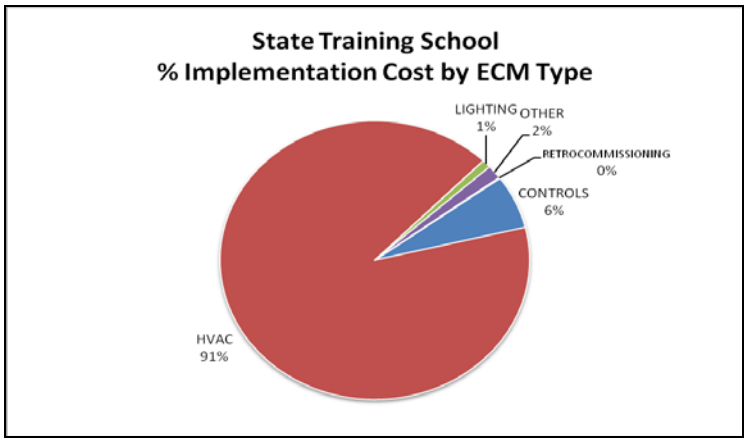
State Training School ECM Summary Table.

	MMBtu Electric	MMBtu Other	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	549	4	**553**	$14,549	$102,200	**7.0**
HVAC	4,094	-3,292	**802**	$103,163	$1,500,000	**14.5**
LIGHTING	272	0	**272**	$7,178	$15,423	**2.1**
OTHER	291	0	**291**	$7,680	$26,000	**3.4**
RETROCOMMISSIONING	63	6	**69**	$1,772	$1,900	**1.1**
Total	**5,270**	**-3,292**	**1,988**	**$134,341**	**$1,645,523**	**12.2**

In total, these savings represent a 18% reduction from current energy consumption at the State Training School campus, the majority of which is attributed to HVAC measures which will reduce electric consumption.



State Training School Energy Savings by ECM Category.



State Training School Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 1,006 MMBTUs (9% of campus energy use) and a total estimated annual cost avoidance of $26,417. The total cost of implementation for these measures is $72,523, which yields a simple payback of 2.7 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
School Building	5.3.8	$0	8	$221	0.0	0.00
Female Secure Unit and Administration	5.3.8	$0	60	$1,583	0.0	0.00
Cottages Buildings 16-22	5.1.8	$900	82	$2,162	0.4	10.98
Superintendent Residence Building #1	5.1.8	$113	10	$270	0.4	10.98
Staff House Buildings 2-4	5.1.8	$450	41	$1,081	0.4	10.98
Superintendent Residence	5.1.8	$150	14	$360	0.4	10.98

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Building #1						
Staff House Buildings 5-8	5.1.8	$240	22	$577	0.4	10.98
Staff House Buildings 9-10	5.1.8	$120	11	$288	0.4	10.98
Physical Plant Office / Shop	5.3.2	$100	8	$212	0.5	12.47
Cottages Buildings 16-22	5.2.6	$400	24	$575	0.7	16.63
Ag Science Building	5.5.8	$1,000	38	$1,008	1.0	26.16
Superintendent Residence Building #1	5.3.2	$100	3	$83	1.2	28.79
Lincoln Annex	5.2.15	$1,500	45	$1,197	1.3	33.06
Superintendent Residence Building #1	5.3.2	$100	2	$42	2.4	57.58
Staff House Buildings 9-10	5.3.2	$200	3	$76	2.6	62.54
Building Trades	5.1.12	$500	7	$185	2.7	71.34
Staff House Buildings 2-4	5.3.2	$300	5	$111	2.7	64.38
Staff House Buildings 5-8	5.3.2	$400	6	$145	2.8	65.35
Physical Plant Office / Shop	5.1.12	$1,000	14	$360	2.8	73.20
Building Trades	5.1.7	$200	2	$63	3.2	83.50
Dietary Food Services	5.5.5	$25,000	253	$6,671	3.7	98.84
Kennedy Building	5.3.4	$25,000	242	$6,396	3.9	103.10
Dietary Food Services	5.3.4	$7,000	55	$1,447	4.8	127.63
Boiler Plant	5.1.10	$2,000	13	$347	5.8	151.93
School Building	5.1.3	$2,500	16	$421	5.9	156.56
Lincoln Annex	5.1.3	$1,250	8	$206	6.1	160.12
Dietary Food Services	5.1.7	$2,000	12	$328	6.1	161.03
TOTAL		**$72,523**	**1,006**	**$26,417**	**2.7**	**72.12**

4.5 Department of Human Services

The Department of Human Services (DHS) assists citizens of South Dakota in obtaining services and support in the following areas, substance abuse and prevention, developmental disabilities, mental health, vocational rehabilitation and services to the blind and visually impaired.

Within the Department of Human Services, there are a total of 1,117,214 square feet of facilities.

DHS Campus Summary.

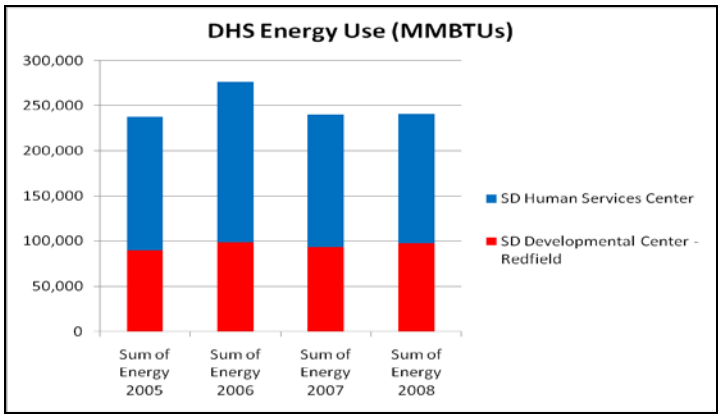
Campus	Location	Square Footage
SD Developmental Center - Redfield	Redfield	530,683
SD Human Service Center	Yankton	586,531
	TOTAL	**1,117,214**

Energy Profile

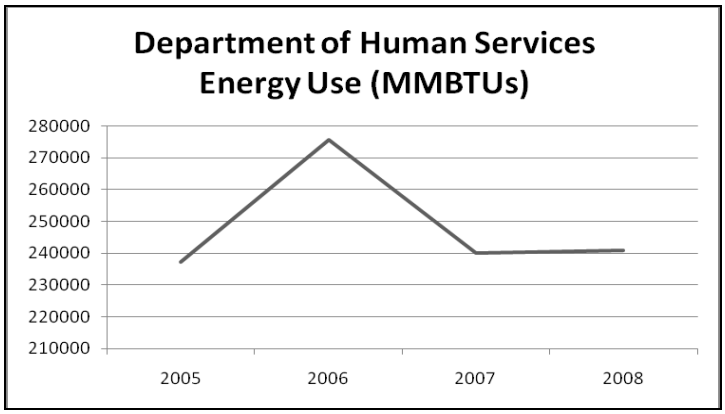
In 2008, DHS facilities consumed a combined 240,984 MMBTUs of energy. The average Energy Use Intensity across DHS was 216 kBTU/SF for 2008.

DHS Campus Energy Data (MMBTUs).

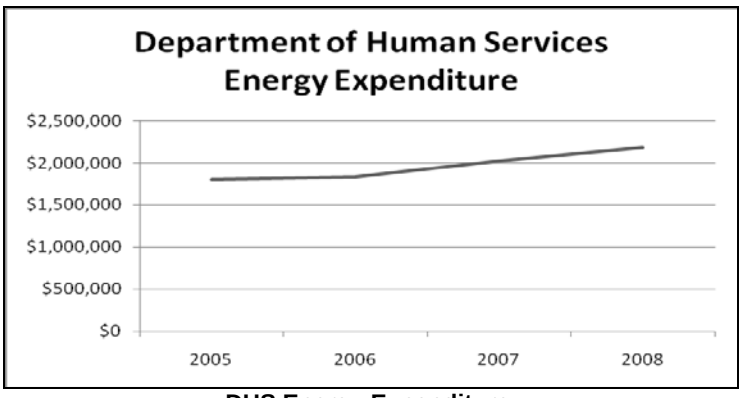
Campus	2005	2006	2007	2008
SD Developmental Center - Redfield	89,252	98,925	93,671	97,631
SD Human Service Center	148,088	176,788	146,328	143,353
TOTAL	**237,340**	**275,713**	**239,999**	**240,984**



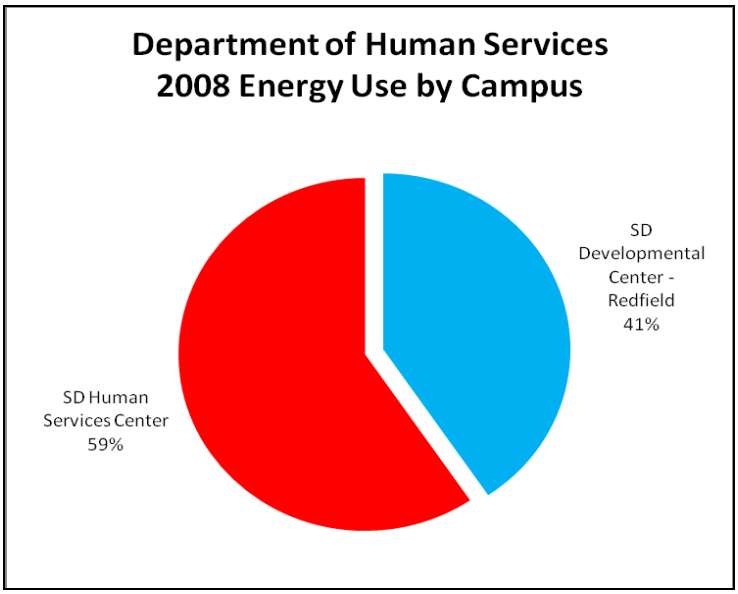
DHS Energy Use by Campus.



DHS Energy Use.



DHS Energy Expenditure.



DHS Energy Use by Campus.

4.5.1 South Dakota Developmental Center (SDDC)

Campus Background and List of Facilities

The South Dakota Developmental Center was established by the State legislature in 1899. The facility opened in February 1902 with 45 people in a three story building made of Sioux Falls granite. All direct contact staff as well as administrative staff lived there. All legislation concerning establishment, admissions, and support indicates that these facilities were not intended to be used by people who had mental illness, but for those persons who had a developmental disability. In 1913, the name was changed to State School and Home for the Feeble Minded. It became known as The Redfield State Hospital and School in 1951 and in 1989 took the current name.

Population at SDDC increased rapidly and by 1918, population had increased ten times its original number to 471 persons. This trend in population increase continued until 1963 when population hit its all time high at 1199 persons. At that time, there were 11 large buildings on campus used for housing. The TB Sanatorium at Custer, SD was remodeled and reopened as The Custer State Hospital and School. Several people were transferred to Custer to ease the crowding at the Redfield facility. The Custer facility was closed in 1996 and the people were moved into the community.

By 1970, population had dropped to 980 and with the passing of the Developmental Disabilities Act in 1970 which provided for the deinstitutionalization of inappropriately placed persons, the number of people living at SDDC dropped quickly. At present, there are approximately 145 persons with Developmental Disabilities living onsite.

Campus-Wide Systems and Operational Profile

The SDDC campus has central low pressure steam heat that serves a majority of campus buildings as well as high pressure steam heat serving a few buildings.

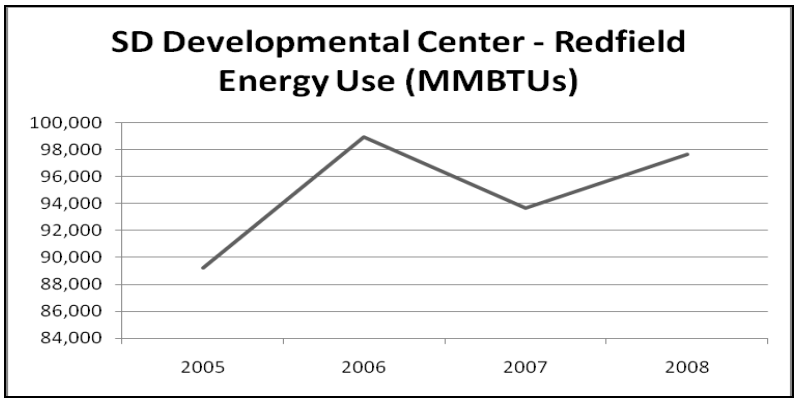
In addition to central steam, the SDDC campus has a central compressed air and domestic hot water systems.

The SDDC campus has two separate central DDC systems that are connected to a select number of campus buildings. The older Metasys system is used for buildings still utilizing pneumatic actuators, but a DDC overlay exists. A newer Invensys system has been phased in for new projects, and some are converted from the Metasys system periodically. Some systems and entire buildings are controlled locally using pneumatics. The DDC system monitors campus electrical demand for manual load shedding, but there is no sub-metering.

Campus wide, chilled water is drained in the winter and contains no glycol. Hot water contains glycol but the concentration of glycol/water is unknown.

Energy Profile

In 2008, SD Developmental Center - Redfield facilities consumed a combined 97,631 MMBTUs of energy. The average Energy Use Intensity across the campus was 184 kBTU/SF in 2008.



SD Developmental Center - Redfield Energy Use.

4.5.1.1. Activity Center

Building Overview

Built in 1968, the Activity Center is approximately 34,000 square feet. The building is normally occupied from 8am to 8 pm, 7 days a week. Staff rates the building as having a good envelope.

HVAC: The building has numerous constant air volume air handlers. The canteen, barber, crafts, bowling alley and game room areas are each served by a CAV steam / DX air handlers

that are locally controlled by a non-programmable thermostat and run 24/7.The swimming pool area is served by a 2 speed steam heat air handler that is locally controlled by a non-programmable thermostat and runs 24/7.The locker room area is served by a constant air volume steam heat 100% makeup air unit that is locally controlled by a non-programmable thermostat and runs 24/7.The building has perimeter hot water baseboard heat. There is also HW duct reheat located throughout the building.

The building are controlled using local pneumatics but can be scheduled from the Metasys system. The units are scheduled to run from 7 am to 9 pm each day.

Lighting: Building is mostly T-8 fixtures controlled with manual switches. The pool area has T-12 fixtures.

ECM's

Previously Implemented ECMs

Lighting has been upgraded to T-8 in most areas.

Opportunities for ECMs at Activity Center

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,000	-	1,664	-	$50	20.0	2
5.4.4	Replace AHUs at the End of Their Useful Life Expectancy	$1,000,000	39	143,872	4,485	$7,864	127.2	3,4
5.4.39	Install Air to Air Heat Recovery	$60,000	(1)	(1,444)	5,989	$4,694	12.8	5
	TOTAL	**$1,061,000**	**38**	**144,092**	**10,474**	**12,607**	**84.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assumes reballast by in-house staff.
3. New features include DDC control, VFDs, economizer, and setbacks.
4. Order of magnitude costs. Equipment is original to 1968 construction and may be nearing end of life.
5. Pool and Locker Room Units

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.2. Administration

Building Overview

The Administration building houses the main offices, as well as some staff housing. Built in 1919, this building is approximately 49,000 square feet. The building is normally occupied from 7am to 6 pm, 5 days a week. There are always a few staff in the building 24/7.There are housing areas on upper floor. The unoccupied floor is kept cold in winter. Staff rates the building as having a poor envelope. The windows are operable and are single paned with storm windows. There are currently no plans for renovating this building.

HVAC: There is a main building dedicated outside air unit that no longer works. There are 23 window AC units. There are six separate split DX units serving the auditorium. Three of the units of them have programmable thermostats. The basement offices are served using packaged DX units. There is perimeter steam baseboard heating. The basement is not directly heated; instead, steam lines in the ceiling plenum serving the first floor are used to provide ambient heat. If more heat is required, ceiling egg crate return grilles are installed.

The air handling unit can be turned and off from the Metasys DDC system, but no setbacks are possible.

Lighting: Building is mainly T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

Lighting has been converted to T-8.

Opportunities for ECMs at Activity Building							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$3,750	11,648	-	$349	10.7	2
5.3.2	Programmable Thermostats for Residential Style Units	$500	1,200	340	$305	1.6	3
	TOTAL	$4,250	12,848	340	654	6.5	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 4 fixtures per sensor with a lighting reduction of 4 hours per day.
3. Auditorium units. Combine to single thermostat to eliminate simultaneous heating and cooling.
4. Steam radiation setbacks.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.3. Central Workshop

Building Overview

Built in 1923, the Central Workshop is approximately 30,000 square feet. The normal hours of occupancy are 8:30 am to 4 pm, Monday thru Friday. Staff rates the building as having a fair envelope.

HVAC: Building has six window AC units, three 4 ton mini-splits and six 2 ton mini-split units that maintain space temperatures 24/7.Perimeter steam radiation serves the building.

Lighting: Lighting consists of T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Central Workshop						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$3,000	4,680	$140	21.4	2
	TOTAL	**$3,000**	**4,680**	**140**	**21.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 5 fixtures per sensor with a lighting reduction of 3 hours per day.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.4. Chapel

Building Overview

Built in 1978, the Chapel is approximately 1,800 square feet. The normal hours of occupancy are 10am to 12 pm Sunday. Staff rates the building as having a good envelope.

HVAC: There are two split DX cooling units with non-programmable thermostat. According to staff, thermostat is not set-back during non-occupied hours. Perimeter steam baseboard heat.

Lighting: There are some incandescent lamps for dimming and some T-8 fixtures controlled with manual switches. Lights are rarely on.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Chapel Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh	Natural Gas Therms			
5.3.2	Programmable Thermostats for Residential Style Units	$100	408	116	$104	1.0	2
	TOTAL	**$100**	**408**	**116**	**104**	**1.0**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.5.1.5. Clark

Building Overview

The Clark building serves as living quarters. Built in 1959, this building is approximately 17,000 square feet. The spaces are continuously occupied. This building is nearly identical to Meadowview.

HVAC: The building is served using campus steam, which is utilized by direct steam air handling unit coils and perimeter baseboards. The building has a dedicated air cooled chiller. The building has a variable air volume air handling unit which adjusts airflows using inlet vanes.VAV boxes serve spaces. The building is controlled using the Metasys system with a DDC overlay of pneumatic actuators. Based on the September 2009 walkthrough, many of the spaces are overcooled, likely due to the lack of reheat coils, and the building indicated a negative pressurization of -0.261" w.c.

Lighting: Building is mostly T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

Lights have been converted to T-8.

Opportunities for ECMs at Clark Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh	Natural Gas Therms			
5.2.1	Full Retrocommissioning and Balancing Study	$20,000	26,716	2,356	$2,665	7.5	2
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$10,000	23,254	151	$817	12.2	3
	TOTAL	$30,000	49,970	2,507	3,482	8.6	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 15% savings on electric and gas. Electric and gas usage for the building determined on pro-rated campus usage.
3. AHU-1.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.5.1.6. Clinic / Infirmary

Building Overview

Medical. Adjoining buildings, the 17,000 square foot clinic was built in 1925 and the 6,000 square foot infirmary was built 1984.The building is normally occupied from 7am to 5:30 pm, Monday through Friday. Staff rates the building as having a good envelope. The building is partially staffed at all times.

HVAC: The building is connected to campus steam system. The older section utilizes locally controlled window AC units for cooling and steam perimeter radiation with no setbacks. One constant air volume steam / DX air handler serves the newer section. Due to continuous occupancy, the air handler is not setback and remains at 72 deg F set-point 24/7.The newer addition HVAC controls have been converted to full DDC actuators on the Invensys system.

Lighting: The building utilizes T-12 lighting. There are also many incandescent lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Clinic / Infirmary Building						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$3,750	24,242	$727	5.2	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$12,000	38,237	$1,147	10.5	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$400	7,644	$229	1.7	
	TOTAL	**$16,150**	**70,124**	**2,104**	**7.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 6 hours per day.
3. Assume reballast for straight fixtures and new fixtures for U-tubes.
4. Assume screw-in CFL.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.7. Cottages

Building Overview

The Cottages serves as living quarters. Built in 1978, this single building is approximately 36,000 square feet.

HVAC: The building is heated using campus steam and hot water converters. Cooling is provided using DX air handling unit coils. The condensing units were replaced in 2006.The building HVAC is split into two identical sections, each with its own constant volume with reheat air handling unit. Four resident pods comprise each section, each with two wings, for a building total of sixteen wings in eight pods. Each wing serves as a thermal zone with a constant volume reheat coil. There is an energy recovery system run-around loop between the exhaust stream and the incoming outside air stream.

There are two heating water pumps which operate in lead/lag arrangement, but one pump always runs continuously regardless of boiler status to the lack of an interlock.

The controls were converted to the newer Invensys DDC system with electronic actuators in 2007.

Lighting: Corridors and common areas utilize U-tube T-12s, and resident rooms utilize T-12 straight tubes.

ECM's

Previously Implemented ECMs

The windows were replaced, and the actuators were converted to DDC in 2007.

Opportunities for ECMs at Cottages

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8s	$26,300	6	93,745	-	$2,812	9.4	2
5.2.14	Interlock Pumps with Central Plant	$1,000	-	19,023	-	$571	1.8	
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$90,000	-	106,767	1,947	$4,743	19.0	3
	TOTAL	**$117,300**	**6**	**219,535**	**1,947**	**8,126**	**14.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume reballast for straight fixtures and new fixtures for U-tubes.
3. Costs assume sixteen VAV boxes will be installed in lieu of existing reheat coils.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.8. Dakota Hall

Building Overview

Workshop. Built in 1909, this building is approximately 25,000 square feet. The building is normally occupied by 30 people from 8am to 4 pm, Monday thru Friday. Only first floor is

used. The top two floors are not heated or powered. Staff rates the building as having a poor envelope.

There are no plans for renovating this building

HVAC: The building has approximately seven window AC units and perimeter steam baseboard heat. Building has an air handler but it no longer works. All units are controlled locally using pneumatics, but the air handling unit can be scheduled via the Metasys system.

An electrical upgrade to the building is in progress.

Lighting: Building is mostly T-8 fixtures controlled with manual switches.2.

ECM's

Previously Implemented ECMs

Lights have been converted to T-8.

Opportunities for ECMs at Dakota Hall							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$3,750	-	7,020	$211	17.8	2
	TOTAL	$3,750	-	7,020	211	17.8	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 3 hours per day.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.9. Damm & Norgello

Building Overview

These buildings house living quarters. Originally built in 1952, these buildings are each 10,000 square feet and currently in the process of being completely renovated. Construction is expected to be complete in 2010.When completed, buildings will be LEED Silver accredited.

ECM's

Previously Implemented ECMs

The buildings are being renovated and will be LEED Silver certified.

Opportunities for ECMs at Damm & Nogello

No suitable energy conservation measures were discovered.

4.5.1.10. Duplex

Building Overview

This building houses living quarters. Built in 1938, this building is approximately 2,500 square feet.

HVAC: The building uses campus steam for its perimeter baseboard heat. The building also uses window AC units. All equipment is locally controlled using pneumatics and packaged controls.

Lighting: Building is mostly incandescent fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Duplex Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh			
	Replace Incandescent Lamps with Compact Fluorescent	$300	3,120	$94	3.2	2
	TOTAL	**$300**	**3,120**	**94**	**3.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs include fixture removal. Direct removal of lamps could be implemented at no cost with similar savings.
3. Assume 6 fixtures per sensor with a lighting reduction of 2 hours per day.
4. Lobby area fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.11. Grace Schaefer

Building Overview

Built in 1958, the Grace Schaefer building serves as a school and is approximately 9,000 square feet. The building is normally occupied from 8am to 4 pm, 5 days a week. There are always a few staff in the building 24/7.Staff rates the building as having a good envelope.

HVAC: The building has five mini-split DX units with local non-programmable controls and four window AC units with perimeter hot water baseboard heat. The building utilizes local pneumatic controls.

Lighting: Building is mainly T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

Lights have been converted to T-8.

Opportunities for ECMs at Grace Schaefer Building						
ECM No.	Energy Conservation Measure (ECM)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$3,750	7,020	$211	17.8	2
	TOTAL	$3,750	7,020	211	17.8	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 3 hours per day.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.12. Granite

Building Overview

The Granite Building houses offices. Built in 1901, this building is approximately 18,000 square feet. The building is normally occupied by 30 people from 8am to 5:30 pm, Monday through Friday. Only the basement, first and second floors are occupied. The third floor is used not conditioned and the fourth floor is sealed off from the rest of the building and is insulated. Staff rates the building as having a fair envelope.

HVAC: The building has approximately thirteen window AC units and perimeter steam baseboard heat.

Lighting: Building is mostly T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

Lights have been converted to T-8.2.

Opportunities for ECMs at Granite Building						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$1,875	3,510	$105	17.8	2
	TOTAL	$1,875	3,510	105	17.8	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 3 hours per day.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.13. Horizon Homes

Building Overview

The Horizon Homes is a residential building housing approximately eight people.

HVAC: Heating is accomplished using residential style gas furnaces. There is the potential that the space may be occupied at any time of day, so manual thermostats are utilized.

There are two electric water heaters per building.

Lighting: Lighting is provided using T-8 Fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Horizon Homes

No suitable energy conservation measures were discovered.

4.5.1.14. Lift Station

Building Overview

Built in 1960, this 500 square foot building is normally non-occupied

HVAC: The building is kept at minimal heat using one gas and one electric heater to prevent freezing. There is an exhaust fan that runs continuously

Lighting: Lights are kept off.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Lift Station Building

No suitable energy conservation measures were discovered.

4.5.1.15. Meadowview

Building Overview

This building serves as living quarters. Built in 1959, this building is approximately 17,000 square feet. The spaces are continuously occupied.

Staff rates the building as having a good envelope. Building had HVAC, windows and roof renovation approximately 10 years ago. This building is nearly identical to Clark.

HVAC: The building is served using campus steam, which is utilized by direct steam air handling unit coils and perimeter baseboards. The building has a dedicated air cooled chiller. The building has a variable air volume air handling unit which adjusts airflows using inlet vanes.VAV boxes serve spaces. The building is controlled using the Metasys system with a DDC overlay of pneumatic actuators. Based on the September 2009 walkthrough, many of the spaces are overcooled, likely due to the lack of reheat coils.

Lighting: Building is mostly T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

Envelope improvements have been made, along with a T-8 fluorescent conversion.

Opportunities for ECMs at Meadowview Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh	Natural Gas Therms			
5.2.1	Full Retrocommissioning and Balancing Study	$20,000	26,716	2,356	$2,665	7.5	2
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$10,000	23,254	151	$817	12.2	3
	TOTAL	$30,000	49,970	2,507	3,482	8.6	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 15% savings on electric and gas. Electric and gas usage for the building determined on pro-rated campus usage.
3. AHU-1.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.5.1.16. Motor Pool

Building Overview

Storage: Built in 1955, this building is approximately 18,000 square feet. The normal hours of occupancy are 7 am to 5 pm, Monday thru Friday. Staff rates the building as having a good envelope (10 inches of foam insulation has been sprayed to the building exterior).

HVAC: The building has a few small AC units and perimeter steam baseboard heat.

Lighting:T-12 fixtures are controlled with manual switches. Some incandescent lamps are also utilized.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Motor Pool Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,500	1	2,184	$66	22.9	2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$100	1	1,456	$44	2.3	3
5.1.12	Replace 8' Fixtures with 4' Fixtures	$1,500	1	3,575	$107	14.0	2
	TOTAL	**$3,100**	**3**	**7,215**	**216**	**14.3**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume reballast by in-house staff.
3. Assume screw-in CFL.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.5.1.17. Powerhouse / Laundry

Building Overview

This building houses the central boiler plant and laundry facility. Built in 1913, this building is approximately 22,000 square feet. The powerhouse building is normally occupied from 8am to 5pm, Monday thru Friday. The laundry area is normally occupied from 5am to 2pm, Monday through Friday. Staff rates the building as having a poor envelope.

HVAC: The building itself has approximately (6) window AC units, a split DX cooling unit, electric baseboard heat (rarely used) and steam radiant heat (from boilers).

High pressure steam is produced by natural gas /fuel oil (backup) boilers located at the Boiler Plant. High pressure steam is reduced in pressure for low pressure steam users.

April thru October, the 300 hp Kewanee boiler is used. October thru April, one of the two 600 hp boilers (Kewanee & Hurst) are used. There are no steam trap maintenance programs for the campus, and staff believe that some traps are likely fully open at any given time.

Compressed air for the campus is produced at 110 psig but distributed throughout the campus at 25 psig.

Lighting: Building is mostly T-12 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Powerhouse / Laundry Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,500	3	7,280	-	$218	11.4	2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$50	0	2,453	-	$74	0.7	3
5.1.12	Replace 8' Fixtures with 4'	$3,000	3	18,068	-	$542	5.5	2
5.2.1	Full Retrocommissioning and Balancing Study	$30,000	-	-	12,600	$9,967	3.0	4
5.5.20	Decrease Air Compressor Pressure	$0	-	41,200	-	$1,236	Instant	5
	TOTAL	**$35,550**	**6**	**69,000**	**12,600**	**12,037**	**3.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume reballast by in-house staff.
3. Assume screw-in CFL.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy		

Notes
4. Assume 2% savings for natural gas.
5. Assume decrease from 110 psig to 40 psig.

Estimated Blended Marginal Rates
consumption that can be saved through energy conservation measures.

4.5.1.18. Root Cellar, Salt Shed, Well Houses, Coal Bin, Calf Barn, Bull Barn, Tool Shed, Green House, Ice House, Sunnyview, Hayshed and Garage

Building Overview

These are normally non-occupied and are minimally conditioned (or unconditioned).

HVAC: The buildings are not heated or cooled.

Lighting: Lights are kept off.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Root Cellar, Salt Shed, Well Houses, Coal Bin, Calf Barn, Bull Barn, Tool Shed, Green House, Ice House, Sunnyview, Hayshed and Garage							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$600	1	910	$27	22.0	3
5.1.12	Replace 8' Fixtures with 4' Fixtures	$2,700	2	6,435	$193	14.0	3
	TOTAL	$3,300	3	7,345	220	15.0	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 6 fixtures per sensor with a lighting reduction of 6 hours per day.
3. Assume reballast by in-house staff.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.5.1.19. Service Kitchen

Building Overview

This building houses the kitchen and dining areas for the campus. Built in 1979, this building is approximately 34,000 square feet. The building is normally occupied from 5am to 8 pm, 7 days a week. Staff rates the building as having a good envelope.

There are no plans for renovating this building

HVAC: The building is heated with campus steam. A hot water converter provides heating water for some units. An air cooled chiller provides cooling for the spaces. A constant air volume makeup unit serves the kitchen. The kitchen hoods operate 24/7 and have heat recovery with the kitchen air handler. The dining area is served by a VAV unit which uses inlet vanes for static pressure control. Terminal VAV boxes have hot water reheat coils. The dining area has perimeter steam baseboard heat. There is temperature setback in cooling season but not in heating season.

Building is connected to campus DDC system.

Lighting: Building is mostly T-8 fixtures controlled with manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Service Kitchen

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Electric kWh	Natural Gas Therms			
5.2.1	Full Building Retrocommissioning and Balancing Study	$25,000	35,990	4,760	$4,845	5.2	3
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$20,000	44,736	161	$1,470	13.6	4
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0	262,024	12,112	$17,442	Instant	
5.5.5	Intellihood Kitchen Hood Controls System	$25,000	186,985	7,024	$11,166	2.2	
	TOTAL	**$70,000**	**529,735**	**24,058**	**34,922**	**2.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Dining area unit AHU-1.
3. AHU-1 and AHU-2.
4. Savings assume schedule change has been implemented.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.79	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.1.20. Warehouse

Building Overview

The Warehouse is used for inventory. Built in 1925, this building is approximately 19,000 square feet. The building is normally occupied from 7am to 5 pm, 5 days a week. Staff rates the building as having a fair envelope.

HVAC: The building has one window AC unit in the office area, and the remainder of the space is heated using steam unit heaters, all of which have non-programmable thermostat. The temperature set-point depends on what is being stored, although there are no partitions separating different storage areas. They try to place items which can be in cold storage near the back to reducing heating requirements.

Lighting: The building has many T-12 fixtures controlled with manual switches.2.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Warehouse

No suitable energy conservation measures were discovered.

4.5.1.21. Willhite

Building Overview

Willhite currently serves as living quarters. Finished in 1953, this building is approximately 42,000 square feet. When construction of the renovated Damm & Norgello living quarters is completed (expected to be complete in 2010), Willhite will no longer be used and will be decommissioned.

HVAC: Wilhite is known as an "energy hog". The building has 30+ window AC units, (9) split DX cooling units, and perimeter steam baseboard heat. A dedicated outside air unit serves corridors.

The building contains some large industrial size clothes washers and dryers.

Lighting: Approximately half of the building lights are T-12 and half are T-8.

ECM's

Previously Implemented ECMs

There are plans to abandon this building once the more efficient Damm and Norgello buildings are finished.

Opportunities for ECMs at Willhite

No suitable energy conservation measures were discovered.

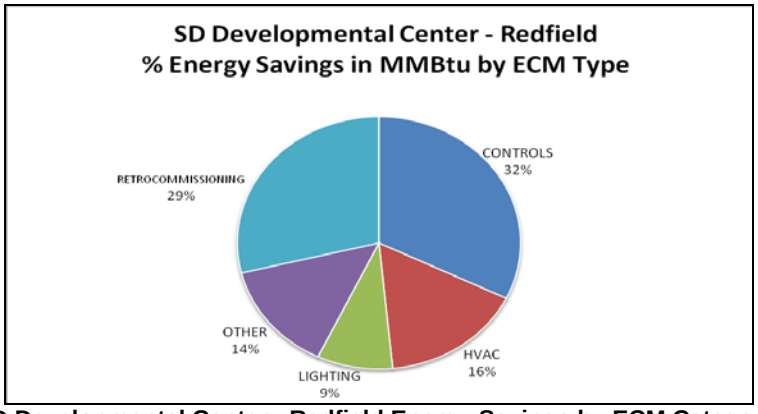
4.5.1.21.1. Campus Summary

A total of 35 ECMs were identified at SD Developmental Center - Redfield buildings, which include 9,685 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $1.38 million, and save an estimated $78,715 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

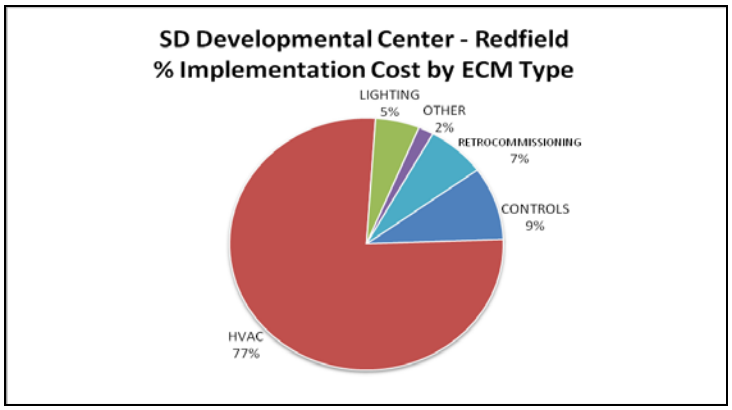
DHS ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	1,575	1,549	**3,124**	$25,698	$130,600	**5.1**
HVAC	486	1,083	**1,569**	$12,558	$1,060,000	**84.4**
LIGHTING	836	0	**836**	$7,347	$71,825	**9.8**
OTHER	638	726	**1,364**	$11,166	$25,000	**2.2**
RETROCOMMISSIONING	511	2,282	**2,793**	$21,948	$96,000	**4.4**
Total	**4,045**	**5,640**	**9,685**	**$78,715**	**$1,383,425**	**17.6**

In total, these savings represent a 10% reduction from current energy consumption at the SD Developmental Center - Redfield campus, the majority of which is attributed to retrocommissioning measures which will reduce natural gas consumption.



SD Developmental Center - Redfield Energy Savings by ECM Category.



SD Developmental Center - Redfield Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 5,881 MMBTUs (6% of campus energy use) and a total estimated annual cost avoidance of $47,343. The total cost of implementation for these measures is $89,200, which yields a simple payback of 1.9 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Kitchen	5.3.8	$0	2,146	$17,442	0.0	0.00
Powerhouse/Laundry	5.2.16	$0	141	$1,236	0.0	0.00
Powerhouse/Laundry	5.1.8	$50	8	$74	0.7	5.97
Chapel	5.3.2	$100	13	$104	1.0	7.49
Administration Building	5.3.2	$500	39	$305	1.6	12.74
Infirmary	5.1.8	$400	26	$229	1.7	15.34
Cottages	5.2.14	$1,000	65	$571	1.8	15.41
Kitchen	5.5.5	$25,000	1,364	$11,166	2.2	18.32
Motor Pool	5.1.8	$100	5	$44	2.3	20.13
Powerhouse/Laundry	5.2.1	$30,000	1,303	$9,967	3.0	23.03
Duplex	5.1.8	$300	11	$94	3.2	28.18
Infirmary	5.1.3	$3,750	83	$727	5.2	45.34
Kitchen	5.2.1	$25,000	615	$4,845	5.2	40.65
Powerhouse/Laundry	5.1.12	$3,000	62	$542	5.5	48.66
TOTAL		**$89,200**	**5,881**	**$47,343**	**1.9**	**15.17**

4.5.2 South Dakota Human Services Center

Campus Background and List of Facilities

The South Dakota Human Services Center is comprised of 25 buildings and totals approximately 375,000 square feet. The campus is a treatment center and was originally constructed in the late 1800s. The campus has been expanded over time, the most significant addition being the Mickelson Center, opened in 1996. Overall age of the facilities ranges from the late 1800s to the 1990s.

Campus-Wide Systems and Operational Profile

The campus has a decentralized heating plant.A major project completed in 2008 removed the old central heating plant from service.In its place, boilers were placed in various buildings.The heating plant currently serves the north campus is located in theKyle Building that houses four high pressure steam boilers that serve the Mickelson Center complex. Steam is generated at 75 psig and is reduced down to 15 psig in the plant before it is distributed to the Mickelson building. The steam boilers remain online year-round since the Mickelson Center uses steam to heat DHW and hot water reheats to condition the spaces. Several buildings have their own chillers or air compressors. Chillers are set to turn on at an outside temperature of 60ºF.

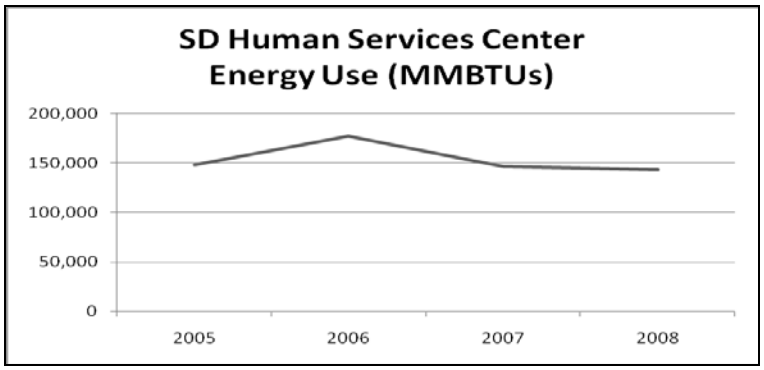
All exterior lighting is controlled by a single campus-wide photocell.

Most buildings on campus are on a common building automation system in the Industrial Building. The BAS is a Siemens system.

The campus is limited to a peak demand of 1800 KW. When the campus approaches this limit the BAS will begin to stage chillers off and on to reduce demand.

Energy Profile

In 2008, SD Human Services Center facilities consumed a combined 143,353 MMBTUs of energy. The average Energy Use Intensity across the campus was 244 kBTU/SF in 2008.



SD Human Services Center Energy Use.

4.5.2.1. Activities Building

Building Overview

The Activities Building is a 43,424 square feet facility that primarily consists of a recreation center, including a rarely used pool (95,000 gallons). The building is located adjacent to the Mickelson Center.

The building is served steam by the Kyle Building boilers, and uses the steam directly opposed to running it through a steam to hot water converter. The air handlers serving the pool and gym are heating only.

Much of the lighting in the building is by T-12 fixtures, although there were some T-8 lamps observed. Exit signs were florescent. Lighting is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

T-12 light fixtures are gradually being replaced with T-8 light fixtures.

Opportunities for ECMs at Activities Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.5	Replace Incandescent Exit Signs with LED	$6,210	1	6,447		$193	32.1	
5.1.7	Retrofit T-12 Fixtures with T-8s	$13,630	9	78840		$2,365	5.8	3
5.1.10	Replace HID Lighting with High Bay Fluorescent	$8,280	3.099	13432.3056		$403	20.5	
5.3.13	Demand Control Ventilation (CO2 Control)	$6,670		5,297	1,496	$1,411	4.7	
5.5.18	Install Pool Cover	$51,750			6,061	$5,073	10.2	
	TOTAL	**$86,540**	**13**	**104,016**	**7,557**	**9,446**	**9.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.2.2. Dietary Building

Building Overview

The Dietary Building is a 30,336 square feet facility that primarily consists of a kitchen and dining area.

Building air handlers have DX cooling and steam heating. Steam is provided by building boilers. Auxiliary heating (unit heaters, fin tube radiation, and cabinet heaters) is provided by hot water, generated by a steam to hot water converter. The building hot water system is fed by variable speed pumps.

Several exhaust hoods were located in the kitchen, manual on/off. Off switches don't seem to work.

Much of the lighting in the building is by T-12 fixtures, although there were some T-8 lamps observed. Exit signs were incandescent. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

T-12 light fixtures are gradually being replaced with T-8 light fixtures.

Opportunities for ECMs at Dietary Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.5	Replace Incandescent Exit Signs with LED	$4,660	1	7,464		$224	20.8	
5.1.7	Retrofit T-12 Fixtures with T-8s	$10,450	6.9	39,876		$1,196	8.7	3
5.2.1	Full Retrocomissioning and Balancing Study	$15,530		12,659	3,456	$3,273	4.7	
5.3.13	Demand Control Ventilation (CO2 Control)	$3,800		3,700	1,045	$986	3.9	
5.5.5	Intellihood Kitchen Hood Controls System	$34,500		46,612	8,290	$8,337	4.1	
	TOTAL	**$68,940**	**8**	**110,311**	**12,791**	**14,015**	**4.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.2.3. Industrial Building

Building Overview

The Industrial Building is a 15,840 square feet facility that primarily consists of offices. However, the Siemens central campus control system is located in this building.

Much of the lighting in the building is by T-12 fixtures, although there were some T-8 lamps observed. Incandescent light fixtures were also observed. Exit signs were incandescent. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Industrial Building							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.5	Replace Incandescent Exit Signs with LED	$1,240	0	1,990	$60	20.8	
5.1.7	Retrofit T-12 Fixtures with T-8s	$5,450	3.6	18,204	$546	10.0	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$70	0.912	4,612	$138	0.5	
	TOTAL	$6,760	5	24,807	744	9.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.2.4. Kanner Building

Building Overview

The Kanner Building is a 23,784 square feet facility that primarily consists of offices.

There are four air handlers in the building, each with DX cooling and VFDs. Building heat is provided by a steam boiler in the building. Two of the air handlers are supplied steam, the rest of the building is heated by steam fin tube radiators.

Much of the lighting in the building is by T-12 fixtures, although there were some T-8 lamps observed. Exit signs were florescent. Lighting is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

T-12 light fixtures are gradually being replaced with T-8 light fixtures.

Opportunities for ECMs at Kanner Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.5	Replace Incandescent Exit Signs with LED	$1,860	0	988		$30	62.7	
5.1.7	Retrofit T-12 Fixtures with T-8s	$9,090	6	21,053		$632	14.4	3
5.3.13	Demand Control Ventilation (CO2 Control)	$12,880		2,901	1,281	$1,159	11.1	
5.3.9	Upgrade Controls System to Full DDC	$44,240		64,996		$1,950	22.7	4
5.4.35	Replace Outside Air Damper	$3,700			327	$273	13.5	4
5.5.3	Improve Building Envelope - Insulation/Exterior	$5,500			2,592	$2,170	2.5	4
5.5.4	Improve Building Envelope - Windows	$210,000			3,493	$2,924	71.8	4
	TOTAL	*$287,270*	*6*	*89,938*	*7,692*	*9,136*	*31.4*	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.
4. Measure based on data from stimulus applications.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.2.5. Kyle Building

Building Overview

The Kyle Building is a 69,680 square feet facility that primarily consists of storage and offices. However, the steam plant that serves Mickelson Center is located in the basement.

The building does not have any central air handlers or central cooling. Building heat is by hot water fin tube radiators. Hot water for the building is generated by hot water boilers, not the steam boilers in the basement. The building hot water system is fed by constant speed pumps.

Much of the lighting in the building is by T-12 fixtures, although there were some T-8 lamps observed. Exit signs were incandescent. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

T-12 light fixtures are gradually being replaced with T-8 light fixtures.

Opportunities for ECMs at Kyle Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.5	Replace Incandescent Exit Signs with LED	$3,110	1	4,976		$149	20.8	
5.1.7	Retrofit T-12 Fixtures with T-8s	$15,900	11	36,842		$1,105	14.4	3
5.2.1	Full Retrocomissioning and Balancing Study	$18,630			19,331	$16,180	1.2	4
5.3.3	Install VFDs on Hydronic Pumps	$3,340		11,475		$344	9.7	
	TOTAL	**$40,980**	**11**	**53,293**	**19,331**	**17,779**	**2.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.
4. Measure based on recommissioning boiler operation.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.2.6. Laundry Building

Building Overview

The Laundry Building is an 18,126 square feet facility that primarily consists of laundry services.

Building is heated by steam boilers installed in the building. The boilers remain online during occupied hours since the laundry service requires the heat. A heating-only air handler serves the space. Unit heaters and fin tube radiators also provide heat. The fin tube radiators are not controlled and often overheat the space. There is no cooling in the building.

Much of the lighting in the building is by T-8 fixtures, although there were some T-12 lamps observed. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

T-12 light fixtures are gradually being replaced with T-8 light fixtures.

Opportunities for ECMs at Laundry Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,360	1	4,551		$137	10.0	3
5.3.21	Install Cooling/Heating Control Valves	$3,680			2,065	$1,729	2.1	
5.4.17	Insulate Steam/Heating Hot Water Piping	$920			977	$818	1.1	

Opportunities for ECMs at Laundry Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
	TOTAL	$5,960	1	4,551	3,042	2,683	2.2	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.2.7. Mickelson Center

Building Overview

The Mickelson Center is a 230,876 square feet facility that primarily consists of housing (occupied 24/7), and patient care areas.

The complex has five larger mechanical rooms that serve their respective wings. These five mechanical rooms are each equipped with a steam to hot water converter, an air-cooled chiller, an instantaneous steam DHW heater, and an air-handling unit.

The building chilled water system is fed by a constant speed pump. The building hot water system is fed by a variable speed pump.

The air-handling unit is equipped with VFDs on the supply and return fans, a chilled water coil, a small HW coil, and VAV boxes that typically serve 2-3 rooms.

In addition, there are six smaller mechanical rooms with individual air handlers serving dedicated offices and patient care areas.

Building heat is primarily by hot water radiant panels installed in the ceilings around the perimeter of the building and reheat coils at each VAV box.

Much of the lighting in the complex is by T-12 fixtures, although there were some T-8 lamps observed. Exit signs were florescent. Corridor lighting is staged on based on the time of day. Lighting for most rooms is controlled manually by wall switches.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

T-12 light fixtures are gradually being replaced with T-8 light fixtures.

Opportunities for ECMs at Mickelson Center								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$6,900	-	125,698		$3,771	1.8	
5.1.5	Replace Incandescent Exit Signs with LED	$12,080	2	16,118		$484	25.0	
5.1.7	Retrofit T-12 Fixtures with T-8s	$131,100	60	346,752		$10,403	12.6	3
5.2.1	Full Retrocomissioning and Balancing Study	$62,100		96,269	15,783	$16,098	3.9	
5.3.13	Demand Control Ventilation (CO2 Control)	$43,470		28,161	9,941	$9,165	4.7	
	TOTAL	**$255,650**	**62**	**612,999**	**25,723**	**39,920**	**6.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.5.2.8. Pierce Building

Building Overview

The Pierce Building is a three story, 44,432 square feet facility that primarily consists of inmate housing.

One air handler installed in the attic serves the top two floors. The supply and return fans are both fitted with VFDs, DX cooling, and HW heat. A second air handler serves the first floor. The building has hot water boilers, and is served by constant speed pumps dedicated to each floor.

Much of the lighting in the building is by T-12 fixtures, although there were some T-8 lamps observed. Exit signs were incandescent. Lighting is controlled manually by wall switches.

ECM's

Previously Implemented ECMs

T-12 light fixtures are gradually being replaced with T-8 light fixtures.

Opportunities for ECMs at Pierce Building								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.5	Replace Incandescent Exit Signs with LED	$1,860	0	2,985		$90	20.8	

Opportunities for ECMs at Pierce Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.7	Retrofit T-12 Fixtures with T-8s	$13,630	9	65016		$1,950	7.0	3
5.3.13	Demand Control Ventilation (CO2 Control)	$7,590		3,252	918	$866	8.8	
	TOTAL	$23,080	9	71,253	918	2,906	7.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.03	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

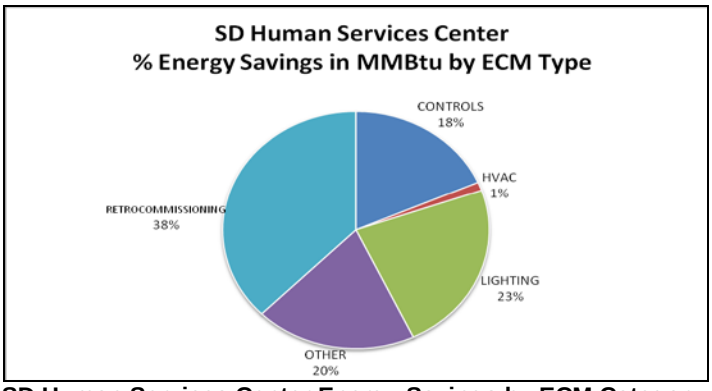
4.5.2.8.1. Campus Summary

A total of 35 ECMs were identified at SD Human Services Center buildings, which include 11,622 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $775,180, and save an estimated $96,630 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

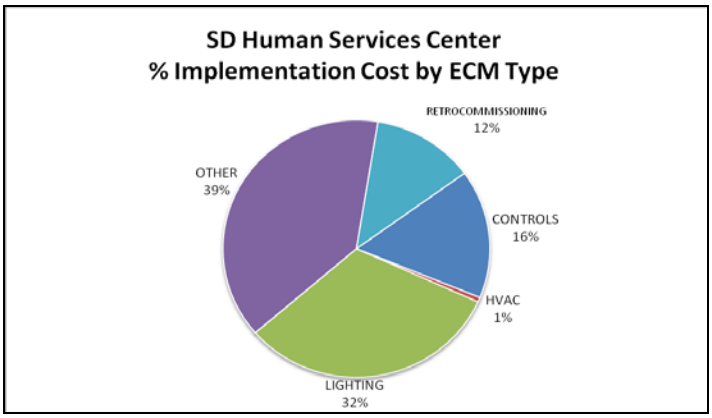
DHS ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	409	1,731	**2,140**	$17,610	$125,670	**7.1**
HVAC	0	135	**135**	$1,091	$4,620	**4.2**
LIGHTING	2,715	0	**2,715**	$23,875	$246,880	**10.3**
OTHER	159	2,113	**2,272**	$18,503	$301,750	**16.3**
RETROCOMMISSIONING	372	3,988	**4,360**	$35,551	$96,260	**2.7**
Total	3,655	7,967	**11,622**	$96,630	$775,180	**8.0**

In total, these savings represent a 8% reduction from current energy consumption at the SD Human Services Center campus, the majority of which is attributed to retrocommissioning measures which will reduce natural gas consumption.



SD Human Services Center Energy Savings by ECM Category.



SD Human Services Center Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings 8,090 MMBTUs (6% of campus energy use) and a total estimated annual cost avoidance of $66,440. The total cost of implementation for these measures is $215,400, which yields a simple payback of 3.2 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Industrial Building	5.1.8	$70	16	$138	0.5	4.45
Laundry	5.4.17	$920	101	$818	1.1	9.10
Kyle Building	5.2.1	$18,630	1,999	$16,180	1.2	9.32
Mickelson Center	5.1.3	$6,900	429	$3,771	1.8	16.09
Laundry	5.3.11	$3,680	214	$1,729	2.1	17.23
Kanner Building	5.5.3	$5,500	268	$2,170	2.5	20.52
Dietary Building	5.3.13	$3,800	121	$986	3.9	31.49
Mickelson Center	5.2.1	$62,100	1,960	$16,098	3.9	31.68

Department of Human Services

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Dietary Building	5.5.5	$34,500	1,016	$8,337	4.1	33.95
Activities Building	5.3.13	$6,670	173	$1,411	4.7	38.61
Mickelson Center	5.3.13	$43,470	1,124	$9,165	4.7	38.68
Dietary Building	5.2.1	$15,530	401	$3,273	4.7	38.77
Activities Building	5.1.7	$13,630	269	$2,365	5.8	50.67
TOTAL		**$215,400**	**8,090**	**$66,440**	**3.2**	**26.63**

4.6 Department of Transportation

The South Dakota Department of Transportation (DOT) provides a transportation system to satisfy diverse mobility needs in a cost effective manner while retaining concern for safety and the environment. The DOT has facilities across the State, which were grouped into regions for this study.

Within the Department of Transportation, there are a total of 296,226 square feet of facilities.

DOT Campus Summary.

Campus	Square Footage
Aberdeen DOT	10,000
Brookings Maintenance Shop	21,957
Mitchell DOT	14,392
Pierre DOT	55,630
Plankinton Rest Stop	6,000
Rapid City DOT	49,418
Sioux Falls DOT	105,336
Murdo Maintenance Shop	14,248
Huron DOT	19,245
TOTAL	296,226

Energy Profile

In 2008, DOT facilities consumed a combined 83,491 MMBTUs of energy. The average Energy Use Intensity across DOT was 283 kBTU/SF for 2008.

DOT Campus Energy Data (MMBTUs).

Campus	2007	2008
Aberdeen DOT	507	645
Brookings Maintenance Shop	1,737	2,481
Mitchell DOT	1,331	1,439
Pierre DOT	4,529	3,975
Plankinton Rest Stop	498	382
Rapid City DOT	5,143	5,415
Sioux Falls DOT	11,269	11,295
Murdo Maintenance Shop	1,157	1,408
Huron DOT	2,000	1,986
TOTAL	78,861	83,491

4.6.1 Aberdeen Regional Offices

Campus Background and List of Facilities

The Aberdeen Department of Transportation facility consists of five buildings. The total square footage is approximately 42,200 square feet of which 4,000 square feet is cold storage. The building ages range from 1970 to 1990.

Campus-Wide Systems and Operational Profile

Each building has independent heating and cooling systems. The entire campus is on a single set of electric and natural gas utility meters.

Energy Profile

In 2008, the Aberdeen regional facilities consumed a combined 645 MMBTUs of energy. The average Energy Use Intensity across Aberdeen regional facilities was 64 kBTU/SF for 2008.

4.6.1.1. Area Maintenance Shop

Building Overview

The Area Maintenance Shop was originally constructed in 1990.The building is primarily used for storage and repair of equipment. The building is approximately 8,400 square feet.

The building hours of operation vary based on daily schedules of the occupants but can be estimated to be occupied for approximately 3 hours per weekday.

The garage bays are heated by gas fired radiant units and are not air conditioned. The office spaces in the building are ventilated by a residential style gas fired furnace with DX cooling coil.

Domestic hot water is provided by a 15 gallon 1.5 kW heater.

Lighting in the garage spaces are primarily 300watt metal halide fixtures. The offices are illuminated by either four foot T12 fixtures with either two or three lamps per fixture.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Area Maintenance Shop							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8's	$650		433		$41	15.8
5.1.10	Replace HID Lighting with High Bay Fluorescent	$6,260	8	8,365		$795	7.9
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$580		450		$43	13.6
5.5.19	Replace Electric Hot Water Heater with Gas	$810		821	(29)	$69	11.8
	TOTAL	**$7,650**	**8**	**9,636**	**(29)**	**906**	**8.4**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.10	/kWh Elec
$	0.33	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.1.2. District Highway Patrol

Building Overview

The District Highway Patrol building was originally constructed in 1972.The building total square footage is approximately 10,000.The 20 building occupants typically follow a 7am – 5:30pm schedule Monday through Friday.A cleaning crew typically occupies the building for two additional hours each night.

The exterior of the building is brick and has an insulated membrane roof.The windows are original to the building construction.

The building is currently under renovation of the lighting and HVAC systems.This project is scheduled for completion in May of 2010.

ECM's

Previously Implemented ECMs

The building is currently under a HVAC and lighting renovation and upgrades project. The project will include new VAV air handling systems, high efficiency boilers, Project completion is scheduled for May of 2010.

Opportunities for ECMs at District Highway Patrol Building

No suitable energy conservation measures were discovered.

4.6.1.3. Regional Cold Storage

Building Overview

The Regional Cold Storage building was originally constructed in 1971.The building is primarily used for storage and repair of equipment. The building is approximately 1,500 square feet.

The building hours of operation vary based on daily schedules of the occupants but can be estimated to be occupied for approximately 6 hours per weekday.

The one of the garage bays is heated by propane gas fired unit heaters and is not air conditioned.

Lighting in the garage spaces are primarily 200watt incandescent fixtures and by eight foot T12 fixtures with two lamps per fixture.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Regional Cold Storage Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.8	Replace Incandescent Lights with Compact Fluorescent	$230	1	1,796	$171	1.3
5.1.12	Replace 8' fixtures with 4' fixtures	$6,060	1	1,447	$138	44.1
	TOTAL	**$6,290**	**2**	**3,243**	**308**	**20.4**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.10	/kWh Elec
$	0.83	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.1.4. Regional Office

Building Overview

The Regional Office building was originally constructed in 1970.The building total square footage is approximately 13,600.The 16 building occupants typically follow a 7am – 5pm schedule Monday through Friday. A cleaning crew typically occupies the building for two additional hours each night.

The exterior of the building is brick and has an insulated membrane roof. The windows are original to the building construction. The South facing windows are tinted. In a 2004 construction project insulation was added to the exterior walls to help improve occupant comfort and energy costs.

The building is currently under renovation of the lighting and HVAC systems. This project is scheduled for completion in May of 2010.

ECM's

Previously Implemented ECMs

The building is currently under a HVAC and lighting renovation and upgrades project. The project will include new VAV air handling systems, high efficiency boilers, upgrade to DDC controls, complete T8 lighting upgrades and occupancy sensor lighting control. Project completion is scheduled for May of 2010.

Opportunities for ECMs at Regional Office Building

No suitable energy conservation measures were discovered.

4.6.1.5. Regional Repair Shop

Building Overview

The Regional Office building was originally constructed in 1970.The building total square footage is approximately 20,250.A 4,200 square foot addition was completed in 2007.The 14 building occupants typically follow a 7am – 5:30pm schedule Monday through Friday. A cleaning crew typically occupies the building for two additional hours each night.

The exterior of the building is brick and has an insulated membrane roof which was replaced in 1990.

The heating systems were upgraded at the time of the 2007 addition construction. The majority of the building heating is provided by two 1,000 MBTU gas fired high efficiency boilers. The hot water is pumped through a constant flow system to the building radiation and unit heaters. The terminal units in the building are all original to the building construction. Two constant volume air handling units with DX cooling provide ventilation to the office and store room areas at the North end of the building. The building temperature controls are DDC.

The 2007 addition is heated and cooled by two gas fired DX roof top units. These RTU's are on their own control systems run independently from the rest of the building. The boiler plant also provides heating water to the in-floor radiant heating system in the 2007 addition welding shop.

Building lighting primarily consists of eight and four foot T12 fixtures each with two 34watt lamps. The welding shop is illuminated by 150watt metal halide fixtures.

Domestic hot water is provided by two 60 gallon 4.5 kW heaters. One of these water heaters is dedicated to the 2007 addition.

ECM's

Previously Implemented ECMs

The building heating plant was replaced in 2007 with high efficiency gas fired hot water boilers. These replaced the original standard efficiency heating plant.

Opportunities for ECMs at Regional Repair Shop

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.7	Retrofit T-12 Fixtures with T-8's	$3,450	2	6,357		$604	5.7	
5.1.8	Replace Incandescent Lights with Compact Fluorescent	$290	1	4,115		$391	0.7	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$1,100	1	3,557		$338	3.3	
5.1.12	Replace 8' fixtures with 4' fixtures	$27,770	4	10,926		$1,038	26.8	
5.3.3	Install VFDs on Hydronic Pumps	$8,860		10,297		$978	9.1	3
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$1,150		1,241		$118	9.8	
5.5.19	Replace Electric Hot Water Heater with Gas	$4,830		4,928	(173)	$324	14.9	
	TOTAL	**$44,000**	**7**	**35,063**	**(173)**	***3,187***	***13.8***	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure will require installation of 2-way valves on terminal heating units.

Estimated Blended Marginal Rates		
$	0.10	/kWh Elec
$	0.83	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.1.5.1. Campus Summary

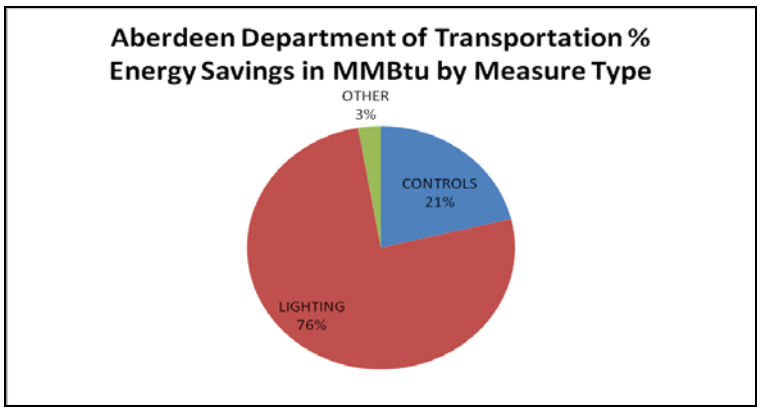
A total of 13 ECMs were identified at Aberdeen Department of Transportation, which include 166 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $62,040, and save an estimated $5,045 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

Aberdeen Department of Labor ECM Summary Table.

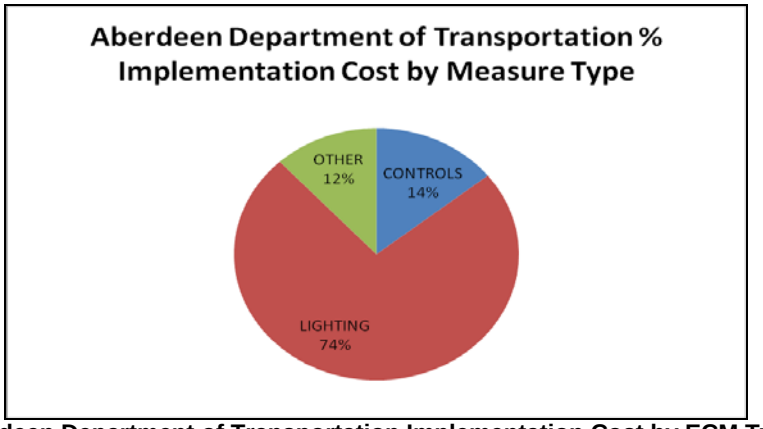
	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	35	0	**35**	$ 978	$8,860	9.1
LIGHTING	126	0	**126**	$3,515	$45,810	13.0
OTHER	25	-21	**5**	$ 553	$7,370	13.3
Total	**187**	**-21**	**166**	**$5,046**	**$62,040**	**12.3**

In total, these savings represent a 26% reduction from current energy consumption at the Aberdeen Department of Transportation, the majority of which is attributed to Lighting measures which will reduce electrical consumption.



Aberdeen Department of Transportation Energy Savings by ECM Category.



Aberdeen Department of Transportation Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 54 MMBTUs (8% of campus energy use) and a total estimated annual cost avoidance of $1,500. The total cost of implementation for these measures is$5,070, which yields a simple payback of 3.4 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Regional Repair Shop	5.1.8	$290	14	$391	0.7	20.65
Regional Repair Shop	5.1.8	$230	6	$171	1.3	37.54
Regional Repair Shop	5.1.10	$1,100	12	$338	3.3	90.65
Regional Repair Shop	5.1.7	$3,450	22	$604	5.7	159.06
TOTAL		$5,070	54	$1,503	3.4	93.90

4.6.2 Brookings Department of Transportation

Campus Background and List of Facilities

None.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, the Brookings regional facilities consumed a combined 2,481 MMBTUs of energy. The average Energy Use Intensity across Brookings regional facilities was 113 kBTU/SF for 2008.

4.6.2.1. Brookings Department of Transportation

Building Overview

The Brookings Department of Transportation is a 22,000 square foot facility that was constructed in 2006.The facility has 20 employees who occupy the building from 7:00 am to 5:30 pm on weekdays. With the exception of the Highway Patrol, the building is not occupied during weekends or holidays.

Central heating is supplied two 220,000 MBH, Thermal Solutions, natural gas fired, condensing water boilers which provide heating water (30% propylene glycol mixture) to radiant panels, VAV reheats, and the air handling unit coil. The boiler is enabled to operate year round and was operating at the time of our visit with a heating water setpoint of 150F.Two 1/6 hp circulating pumps circulate water through the boilers and two 1 hp heating water pumps circulate heating water to the terminal units.

One 6,500 CFM air handling unit provides cooling and ventilation to the office area. The unit is equipped with a direct expansion cooling coil, hydronic heating coil, MERV 8 filters, 7.5 hp supply fan, 1.5 hp relief fan, and outside and return air dampers. A 20 ton condensing unit is located outside to serve the unit. The unit is controlled via the DDC system to start and stop at 7:30 am and 5:30 pm respectively. The unit does not operate during weekends. According

to the temperature control shop drawings, the minimum outside air damper setting is 650 CFM.

The building envelope is constructed of concrete masonry and steel frame with aluminum framed operable windows.

The offices, corridors, and conference rooms are lit with a combination of two, three, and four lamp 32 watt T-8 fixtures, and compact fluorescent lights. The maintenance garage is lit with metal halide fixtures.

All interior lighting fixtures are manually controlled via wall mounted light switch. Task lighting is also used in some office areas on an as needed basis. Exit lights are LED fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Brookings DOT Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,150	2	6,641		$418	2.7	1
5.1.3	Occupancy Sensors Lighting	$5,290		7,979		$503	10.5	1
5.3.8	Schedule AHUs Off During Unoccupied Hours	$1,150		22,832	748	$2,105	0.5	17
	TOTAL	**$53,940**	**-**	**7,979**	**-**	**921**	**58.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.06	/kWh Elec
$	0.89	/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

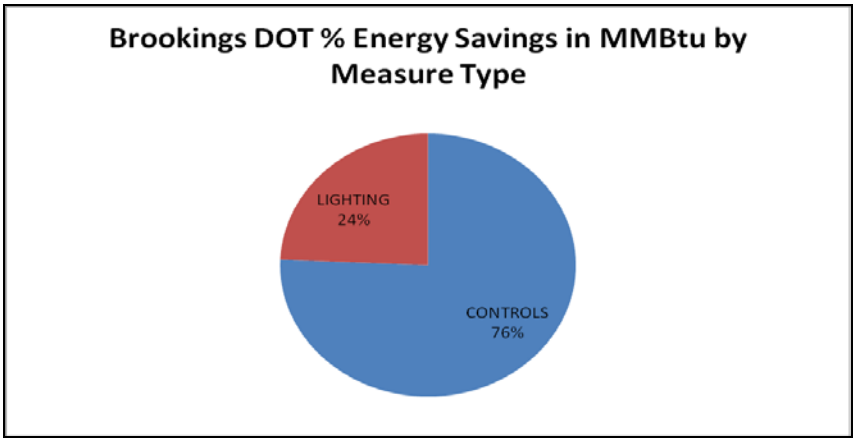
4.6.2.1.1. Campus Summary

A total of 3ECMs were identified at Brookings DOT, which include 205 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $7,590, and save an estimated $3,026in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

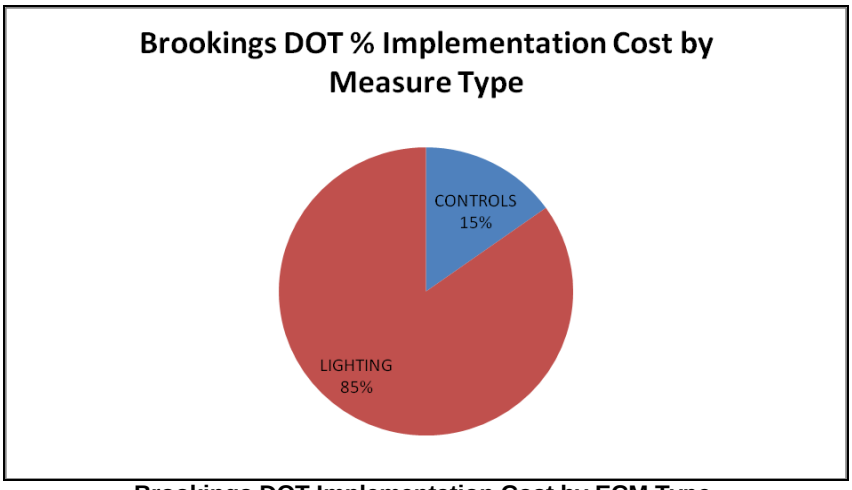
Brookings DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	78	77	**155**	$2,105	$1,150	**0.5**
LIGHTING	50	0	**50**	$921	$6,440	**7.0**
Total	**128**	**77**	**205**	**$3,026**	**$7,590**	**2.5**

In total, these savings represent a 8% reduction from current energy consumption at the Brookings DOT, the majority of which is attributed to Controls measures, which will reduce natural gas and electrical consumption.



Brookings DOT Energy Savings by ECM Category.



Brookings DOT Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 205 MMBTUs (8% of campus energy use) and a

total estimated annual cost avoidance of $3,026. The total cost of implementation for these measures is $7,590, which yields a simple payback of 2.5 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Brookings Maintenance Shop 1032	5.3.8	$1,150	**155**	$2,105	0.5	7.41
Brookings Maintenance Shop 1032	5.1.1	$1,150	**23**	$418	2.7	50.75
Brookings Maintenance Shop 1032	5.1.3	$5,290	**27**	$503	10.5	194.31
TOTAL		**$7,590**	**205**	**$3,026**	**2.5**	**36.99**

4.6.3 Huron Department of Transportation

Campus Background and List of Facilities

The Huron department of Transportation facility consists of three buildings. The total square footage is approximately 21,000 square feet. The building ages range from the early 1900's to 1970.The Maintenance Shop is the oldest building and is scheduled for demolition in 2011.This building is currently a high energy user but will not be included in the ECM calculations.

Campus-Wide Systems and Operational Profile

Each building has independent heating and cooling systems. The entire campus is on a single set of electric and natural gas utility meters.

Energy Profile

In 2008, the Huron regional facilities consumed a combined 1,986 MMBTUs of energy. The average Energy Use Intensity across Huron regional facilities was 103 kBTU/SF for 2008.

4.6.3.1. Area Office

Building Overview

The Area Office building was originally constructed in 1970.The building total square footage is approximately 8,000.The 10 building occupants typically follow a 7am – 5pm schedule Monday through Friday. A cleaning crew typically occupies the building for two additional hours each night.

The exterior of the building is brick and the roof is original to the building construction. The windows are original to the building construction.

The building heating and ventilation are provided by two gas fired multi-zone air handling units with DX cooling. The unit serving the upper level operates between the hours of 6am and 6pm each weekday and is off on the weekend. The unit serving the lower level operates

on a 24/7 basis to provide temperature control for the radio dispatch department. The units are original to the building construction.

Domestic hot water is provided by a 38 gallon 40 MBTU natural gas fired atmospheric heater.

Building lighting primarily consists of two and four foot T12 fixtures each with four 34watt lamps. Incandescent lighting is used in toilet rooms, mechanical rooms and storage spaces. The lighting in the building is switch operated and is typically only used during occupied hours. All exit lighting is incandescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Area Office Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$1,040	-	495		$55	18.7	3
5.1.3	Install Motion Sensors to Control Lighting	$1,840	-	13,403		$1,501	1.2	4
5.1.7	Retrofit T-12 Fixtures with T-8s	$8,050	3	11,308		$1,266	6.4	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$460	2	2,575		$288	1.6	
5.3.7	Convert Multizone/Dual Duct to VAV	$36,800		16,600	1,553	$3,204	11.5	
5.3.13	Demand Control Ventilation (CO2 Control)	$13,570		884	1,466	$1,369	9.9	
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$920			82	$71	13.0	
	TOTAL	**$62,680**	**5**	**45,265**	**3,101**	**7,755**	**8.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. This measure pertains to toilet room lighting.
4. This measure assumes that lighting in the lower level corridor and open areas can be off an additional 12 hours per day.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	0.87	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.3.2. Highway Patrol Building

Building Overview

The Highway Patrol building was originally constructed in 1964.The building total square footage is approximately 2,400.The 5 building occupants typically follow a 7am – 5pm

schedule Monday through Friday. A cleaning crew typically occupies the building for two additional hours each night.

The exterior of the building is brick. The windows and roof were replaced during a 2007 construction project.

The building heating and ventilation are provided by two gas fired furnace units with DX cooling. The furnace units operate on an as needed basis to maintain temperature setpoints. A gas fired unit heater provides additional heating in the materials lab area.

Domestic hot water is provided by a 30 gallon 32 MBTU natural gas fired atmospheric heater.

Building lighting primarily consists of two and four foot T12 fixtures each with four 34watt lamps. The lighting in the building is switch operated and is frequently left on outside of normal occupant hours.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Highway Patrol Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$690		714		$80	8.6	
5.1.7	Retrofit T-12 Fixtures with T-8's	$1,270		929		$104	12.2	
5.1.13	Replace 8' Fixtures with 4' Fixtures	$230		1,259		$141	1.6	
5.3.2	Programmable Thermostat for Residential Style Units	$690		4,755	162	$673	1.0	
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$1,150			70	$61	18.9	
5.5.20	Replace Standard Efficiency Hot Water Heater with High Efficiency	$350			12	$10	34.6	3
	TOTAL	**$4,380**		**7,657**	**243**	**1,068**	**4.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Cost based on incremental unit replacement premium at end of useful life of existing equipment.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	0.87	/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

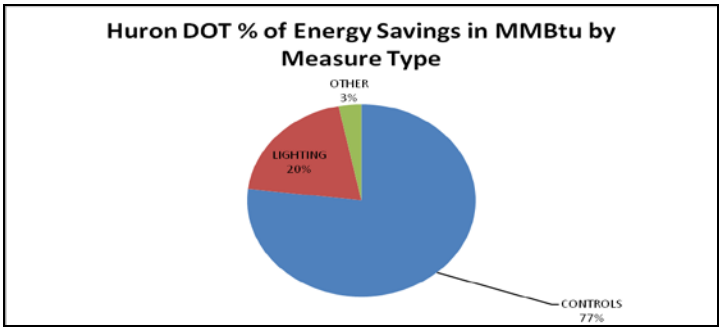
4.6.3.2.1. Campus Summary

A total of 13 ECMs were identified at Huron DOT, which include 526 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $67,060, and save an estimated $8,825 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

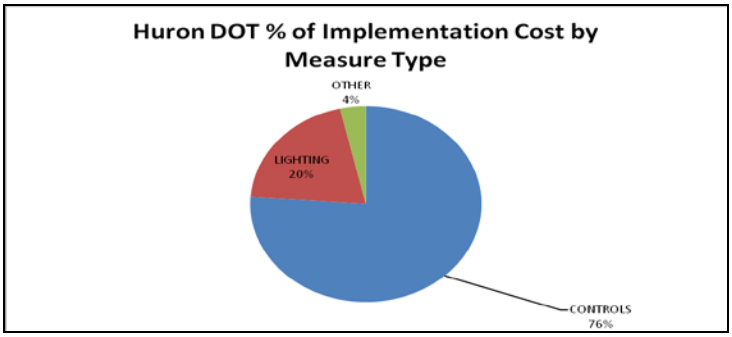
Huron DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	76	329	**405**	$5,246	$51,060	9.7
LIGHTING	105	0	**105**	$3,436	$13,580	4.0
OTHER	0	17	**17**	$142	$2,420	17.1
Total	181	346	**526**	$8,824	$67,060	**7.6**

In total, these savings represent a 26% reduction from current energy consumption at the Huron DOT, the majority of which is attributed to Controls measures which will reduce natural gas consumption.



Huron DOT Energy Savings by ECM Category.



Huron DOT Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 130 MMBTUs (6.5% of campus energy use) and a

total estimated annual cost avoidance of $3,870. The total cost of implementation for these measures is $11,270, which yields a simple payback of 2.9 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Highway Patrol Building	5.3.2	$690	33	$673	1.0	20.95
Area Office	5.1.3	$1,840	46	$1,501	1.2	40.24
Area Office	5.1.8	$460	9	$288	1.6	52.36
Highway Patrol Building	5.1.12	$230	4	$141	1.6	53.54
Area Office	5.1.7	$8,050	39	$1,266	6.4	208.64
TOTAL		**$11,270**	**130**	**$3,870**	**2.9**	**86.47**

4.6.4 Mitchell DOT Site

Campus Background and List of Facilities

The Mitchell DOT Site consists of the region office, region maintenance shop, region materials lab, area office & shop, area materials lab, and striping crew garage.

Campus-Wide Systems and Operational Profile

There are no campus wide heating, cooling, compressed air, or domestic water systems. There is a Siemens DDC system located in the region office which controls HVAC for both the region office and region maintenance shop.

Energy Profile

In 2008, the Mitchell regional facilities consumed a combined 1,439 MMBTUs of energy. The average Energy Use Intensity across Mitchell regional facilities was 100 kBTU/SF for 2008.

4.6.4.1. Area Materials Lab

Building Overview

The area materials lab is approximately 750 square feet. The building was originally built in 2005.The building consists mainly of lab space.

The building is used a few hours a day, Monday thru Friday.

HVAC: There is a single residential style gas furnace with split AC unit serving the building. A local non-programmable thermostat controls the furnace.

Lighting: Lighting consists of T-8 fixtures controlled by manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Area Materials Lab								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.3.2	Programmable Thermostat for Residential Style Units	$100	-	288	82	$88	1.1	
	TOTAL	$100	-	288	82	$88	1.1	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	0.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.6.4.2. Area Office & Shop

Building Overview

The area office & shop is approximately 14,000 square feet. The building was originally built in 1993.The building consists mainly of office area and high bay maintenance area.

The normal hours of operation are 7am to 5 pm Monday thru Friday. There are approximately 15 occupants in the office area and 10 occupants in the maintenance area during normal hours of operation.

HVAC: There are three gas furnaces with split AC units serving the office and shop areas. Each furnace is controlled by a local programmable thermostat, but it did not appear that the thermostats were programmed at the time of the September 2009 walkthrough. Some office areas also utilize electric baseboard heaters. Vestibules are heated using electric cabinet unit heaters. The high bay shop areas are heated with gas fired IR heat. There are no fans in the high bay areas.

Domestic hot water is supplied by a single gas water heater.

Lighting: Lighting consists of T-12 fixtures controlled by manual switches in the office spaces and metal halides and 8' T-12 fixtures in the garage space controlled by manual switches.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Area Office and Shop Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$2,400	-	6,053	-	$569	4.2	2
5.1.5	Replace Incandescent Exit Signs with LED	$250	0	2,595	-	$244	1.0	3
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,500	2	5,577	-	$524	4.8	4
5.1.10	Replace HID Lighting with High Bay Fluorescent	$8,000	11	29,395	-	$2,763	2.9	5
5.1.12	Replace 8' Fixtures with 4'	$1,200	1	3,588	-	$337	3.6	
5.3.2	Programmable Thermostats for Residential Style Units	$300	-	1,200	340	$367	0.8	
	TOTAL	$14,650	15	48,407	340	$4,805	3.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 5 fixtures per sensor with a lighting reduction of 3 hours per day.
3. Costs assume installation by in-house staff.
4. Costs assume reballast for 25W T-8 fixtures by in-house staff. Fixture replacements will increase costs.
5. Assume T-8 lamps.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	0.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.4.3. Region Office

Building Overview

The region office building is approximately 8,000 square feet. The building was originally built in 1963.The building consists mainly of private offices.

The normal hours of operation are 8am to 5 pm Monday thru Friday. There are approximately 15 occupants during normal hours of operation

HVAC: Hot water is supplied a gas fired boiler, which serves hot water baseboards, as well as airside heating coils. The majority of the building is served by a single variable air volume air handler with hot water heat and chilled water cooling. A chilled water evaporator is located inside the mechanical room, and there are two air cooled condensing units located outside.

A DDC system monitors & controls the HVAC systems

Domestic hot water is supplied by a single electric water heater.

Lighting: The building mainly consists of T-8 fixtures, which were installed in 1998.Lighting levels in the offices were measured at 125 foot candles and the hallway at 30 foot-candles. The floor hallways have sky lighting.

ECM's

Previously Implemented ECMs

The building was updated with T-8 fluorescent light fixtures in 1998.A new VAV air handler, boiler, and control system have been recently installed.

Opportunities for ECMs at Region Office Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.2	Delamp Multiple Lamp Fixtures	$7,500	3	7,800	-	$733	10.2	2
5.1.3	Install Motion Sensors to Control Lighting	$2,500	-	3,120	-	$293	8.5	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$500	0	2,453	-	$231	2.2	4
5.3.15	Optimum Start Program	$1,000	-	1,316	15	$135	7.4	
5.4.31	Isolate and Seal Supply Air Duct Leaks	$1,000	-	2,118	36	$226	4.4	
5.5.15	Replace Electric Hot Water Heater with Gas	$1,500	-	2,464	(86)	$167	9.0	
	TOTAL	**$14,000**	**3**	**19,270**	**(36)**	**$1,785**	**7.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs include fixture removal. Direct removal of lamps could be implemented at no cost with similar savings.
3. Assume 6 fixtures per sensor with a lighting reduction of 2 hours per day.
4. Lobby area fixtures.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	0.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.4.4. Region Maintenance Shop

Building Overview

The region maintenance shop is approximately 16,000 square feet. The building was originally built in 1963.The building consists mainly of high bay garage area with a few offices and workshop areas.

The normal hours of operation are 8am to 4:30 pm Monday thru Friday in the winter and 7am to 4:30pm Monday thru Friday in the summer. There are approximately 10 occupants during normal hours of operation

HVAC: The high bay garage area is heated using hot water unit heaters, baseboard hot water as well as a waste oil heating system. Hot water is supplied by two new gas fired boilers.

There are a three window AC units serving office spaces. There are ceiling fans in the high bay areas

A DDC system monitors & controls the HVAC systems

Domestic hot water is supplied by a single electric hot water heater. The shop uses compressed air for pneumatic tools and jacks.

Lighting: High bay lighting consists of metal halides controlled by manual switches.

ECM's

Previously Implemented ECMs

Two new boilers were recently installed.

Opportunities for ECMs at Region Maintenance Shop Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$500	1	3,328	-	$313	1.6	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$14,000	19	50,522	-	$4,749	2.9	2
5.5.12	Replace 8' Fixtures with 4'	$1,600	0	1,144	-	$108	14.9	
5.5.15	Replace Electric Hot Water Heater with Gas	$1,500	5	2,464	(86)	$167	9.0	
	TOTAL	**$17,600**	**26**	**57,458**	**(86)**	**$5,336**	**3.3**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs and savings assume T-8 high bay fixtures.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	0.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.4.5. Region Materials Lab

Building Overview

The region materials lab is approximately 4,000 square feet. The building was originally built in 1963.The building consists mainly of office, lab space and shop areas.

The normal hours of operation are 7am to 4:30 pm Monday thru Friday. There are approximately 5 occupants during normal hours of operation

HVAC: There are three residential style gas furnaces with split AC units serving the building .Each furnace is controlled by a local non-programmable thermostat. According to staff, the

thermostats are not set back during non-occupied times. The shop area has a gas fired unit heater.

Lighting: Lighting consists of T-8 fixtures controlled by manual switches. Light levels at 100 foot-candles for office areas are slightly higher than required.

ECM's

Previously Implemented ECMs

Lighting was upgraded to T-8 fluorescent in 1998.

Opportunities for ECMs at Region Materials Lab Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$180	0	749	-	$70	2.6	2
5.3.2	Programmable Thermostat for Residential Style Units	$300	-	960	272	$294	1.0	
	TOTAL	$480	0	1,709	272	$364	1.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. 25W selected.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$	0.75	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.4.6. Striping Crew Garage

Building Overview

The stripping crew bay normally occupied in the winter from 8am to 4:30 pm, Monday thru Friday.

HVAC: There is a single high bay gas fired unit heater serving the space. There is no high bay fan.

Lighting: Lighting consists of metal halides, but the building is not consistently utilized.2.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Stripping Crew Garage

No suitable energy conservation measures were discovered.

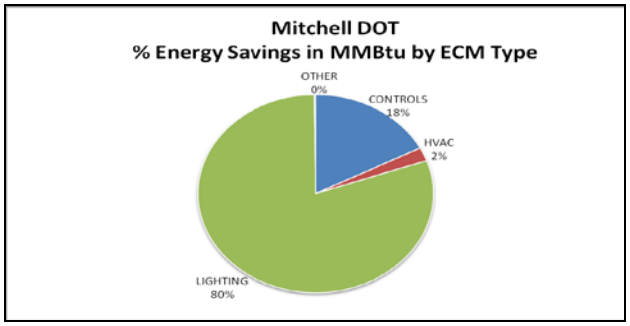
4.6.4.6.1. Campus Summary

A total of 33 ECMs were identified at Mitchell DOT, which include 493 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $46,830, and save an estimated $12,378 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

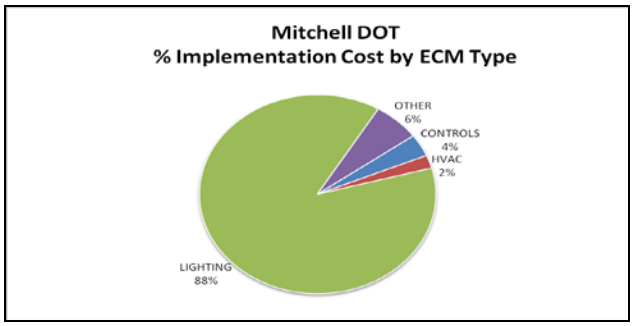
Mitchell DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	13	73	**86**	$884	$1,700	**1.9**
LIGHTING	7	4	**11**	$226	$1,000	**4.4**
OTHER	397	0	**397**	$10,934	$41,130	**3.8**
RETROCOMMISSIONING	17	-18	**-1**	$334	$3,000	**9.0**
Total	434	59	**493**	$12,378	$46,830	**3.8**

In total, these savings represent a 34% reduction from current energy consumption at the Mitchell DOT, the majority of which is attributed to Lighting measures which will reduce electrical consumption.



Mitchell DOT Energy Savings by ECM Category.



Mitchell DOT Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 447 MMBTUs (31% of campus energy use) and a total estimated annual cost avoidance of $10,775. The total cost of implementation for these measures is $31,230, which yields a simple payback of 2.9 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Area Office	5.3.2	$300	39	$367	0.8	7.64
Region Office	5.3.2	$300	31	$294	1.0	9.55
Area Office	5.1.5	$250	9	$244	1.0	28.24
Region Office	5.3.2	$100	9	$88	1.1	10.62
Region Maintenance Shop	5.1.8	$500	11	$313	1.6	44.03
Region Office	5.1.8	$500	8	$231	2.2	59.74
Region Office	5.1.1	$180	3	$70	2.6	70.45
Area Office	5.1.10	$8,000	100	$2,763	2.9	79.77
Region Maintenance Shop	5.1.10	$14,000	172	$4,749	2.9	81.22
Area Office	5.1.12	$1,200	12	$337	3.6	98.02
Area Office	5.1.3	$2,400	21	$569	4.2	116.21
Region Office	5.4.31	$1,000	11	$226	4.4	91.48
Area Office	5.1.7	$2,500	19	$524	4.8	131.38
TOTAL		**$31,230**	**447**	**$10,775**	**2.9**	**69.91**

4.6.5 Murdo Maintenance Facility

Campus Background and List of Facilities

The Murdo Maintenance Facility consists of a single maintenance shop – building 3045.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, the Murdo facility consumed a total 1,408 MMBTUs of energy. The Energy Use Intensity for the Murdo facility was 99 kBTU/SF for 2008.

4.6.5.1. Murdo Maintenance Shop 3045

Building Overview

The Murdo maintenance shop 3045 building is approximately 14,000 square feet. The building was originally built in 1973.The building consists of high bay maintenance garage, wash bay and offices. According to Frank Meyers, the high bay garage doors as well as the outside doors in the office area are drafty. There are plans to renovate this building within the next 5 years.

The normal hours of operation at the maintenance shop are 8am to 4:30 pm Monday thru Friday in the winter and 7am to 5:30 pm Monday thru Thursday in the summer. There are approximately 8 occupants during normal hours of operation

HVAC: The building is heated using high bay hot water unit heaters and baseboard heaters. Heating hot water is produced by a single fuel oil fired boiler. The boiler appears to be the original from 1973.The boiler plant is turned on manually, and the boiler and circulating pumps run continuously from October through April. Office spaces are cooled with two rooftop AC units. The garage area has manually controlled exhaust fans which are equipped with motorized dampers.

Domestic hot water is supplied by a single electric hot water heater. Compressed air is used onsite for pneumatic tools and jacks.

Lighting: The building mainly consists of T-12 fixtures with a few incandescent fixtures. Bay areas are also lit using T-12 fixtures. All lighting is controlled with manual switches, and all T-12 fixtures utilize magnetic ballasts.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Murdo Maintenance Shop 3045								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Fuel Oil Gal			
5.1.7	Retrofit T-12 Fixtures with T-8s	$5,000	1	3,042	-	$286	17.5	2
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$1,000	2	5,283	-	$497	2.0	3
5.1.10	Replace HID Lighting with High Bay Fluorescent	$10,000	7	17,041	-	$1,602	6.2	4
5.3.2	Programmable Thermostats for Residential Style Units	$600	-	-	248	$618	1.0	5
5.5.3	Improve Building Envelope - Insulation/Exterior	$10,000	-	-	1,734	$4,319	2.3	6
	TOTAL	**$26,600**	**10**	**25,366**	**1,982**	**$7,321**	**3.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs include fixture replacement by qualified contractor.
3. Replace 60W office fixtures with screw-in CFL. Replace 300W garage incandescent with 2 6-lamp T-8 high bay fixtures.
4. Replace T-12 garage lighting with 6-lamp T-8 high bay fixtures.
5. Programmable thermostats in offices are the "low cost" option until the planned remodel. For the remodel, DDC control should be implemented for setbacks and boiler controls.
6. Assume improvements will reduce infiltration by 1,000 CFM on average.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$	2.49	/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

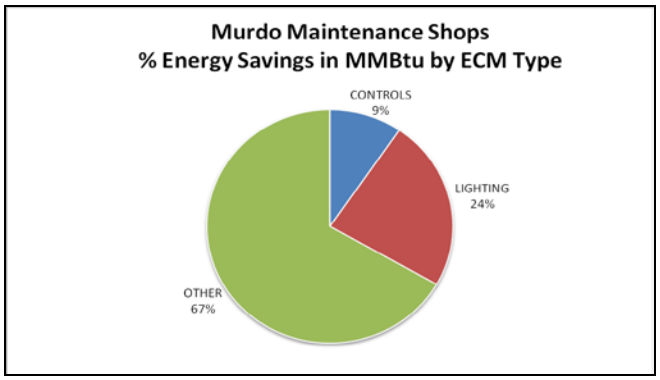
4.6.5.1.1. Campus Summary

A total of 5 ECMs were identified at the Murdo Maintenance Shop facility, which include 364 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $26,600, and save an estimated $7,321 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

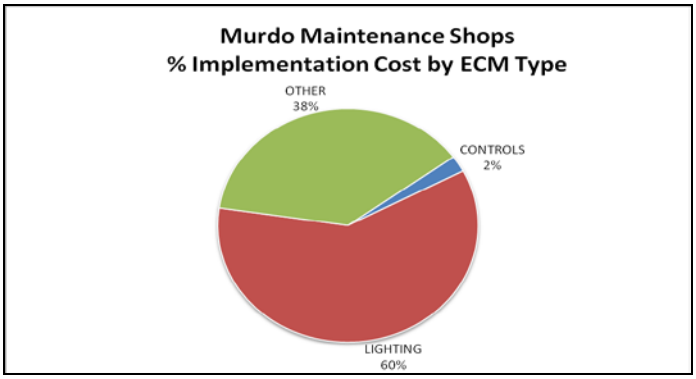
DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	0	35	35	$618	$600	1.0
LIGHTING	87	0	87	$2,384	$16,000	6.7
OTHER	0	243	243	$4,319	$10,000	2.3
Total	**87**	**278**	**364**	**$7,321**	**$26,600**	**3.6**

In total, these savings represent a 26% reduction from current energy consumption at the Murdo Maintenance Shop, the majority of which is attributed to other measures which will reduce natural gas consumption.



Murdo Maintenance Shops Energy Savings by ECM Category.



Murdo Maintenance Shops Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 354 MMBTUs (25% of campus energy use) and a total estimated annual cost avoidance of $7,035. The total cost of implementation for these measures is $21,600, which yields a simple payback of 3.1 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Shop 3045	5.3.2	$600	35	$618	1.0	17.28
Shop 3045	5.1.8	$1,000	18	$497	2.0	55.48
Shop 3045	5.5.3	$10,000	243	$4,319	2.3	41.18
Shop 3045	5.1.10	$10,000	58	$1,602	6.2	171.99
TOTAL		**$21,600**	**354**	**$7,035**	**3.1**	**61.07**

4.6.6 Pierre Department of Transportation

Campus Background and List of Facilities

The Pierre DOT is a collection of several buildings on a single site where the State Department of Transportation has many of their administrative, management and lab/testing operations

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, the Pierre regional facilities consumed a combined 3,975 MMBTUs of energy. The average Energy Use Intensity across Pierre regional facilities was 71 kBTU/SF for 2008.

4.6.6.1. Pierre DOT Maintenance Shop and Lab

Building Overview

The Pierre DOT Maintenance Shop and Lab was constructed in 1963 and 2002 and are 15,214 and 33,696 square feet respectively. This building is primarily occupied 9 hours per day, 5 days per week. The facility is mostly truck garage and lab space.

The maintenance side of the building has a cooling only air handler for the adjacent offices. Heating in the maintenance area is via infrared heaters and there isn't any cooling. The laboratory is served by a VAV multizone air handling unit with heating and cooling. Two natural gas fired Hurst boilers provide the hot water for the air handler and VAV heating coils. Two 2 hp hot water pumps are constant speed. The HVAC system has DDC controls tie into a front end computer interface. Domestic hot water is provided by two 200 MBH gas water heaters. There are also two 7.5 hp air compressor for pneumatic tools and a truck exhaust system controlled based on carbon monoxide levels. There are a number of high energy intensity lab activates that are required in order to do the testing necessary by the DOT.

Interior lighting is typically T-8 strip lighting Interior lights are manually controlled. Exit signs are fluorescent.

The exterior finish is brick and precast concrete. The interior finish is sheet rock and block. The windows are double pane and tinted. The roof is metal and pitched but field verification of the condition was not possible due to limited access. The maintenance spaces have 4-5 roll-up doors to for vehicles. There is an entrance vestibule and the building envelope condition is good.

ECM's

Previously Implemented ECMs

The exhaust systems in the lab area have 100% heat recovery. The building currently uses an aggressive night setback to reduce heating costs in the winter in those areas that can be set back at night.

Opportunities for ECMs at Pierre Maintenance Shop and Lab								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.10	Replace HID Lighting with High Bay Fluorescent	$9,780	2.6	7995		$640	15.3	
5.2.1	Full Retrocomissioning and Balancing Study	$15,530	5.4	47,050	122	$3,867	4.0	4
5.2.3	Relocate Thermostat/Clear Thermostat Area	$580		342	10	$36	16.2	5
5.3.9	Upgrade Controls System to Full DDC	$69,000	10.7	94,100	244	$7,734	8.9	3
5.4.20	Comb Condensing Unit Fins/Provide Hail Guards	$690	0.2	13,420		$1,074	0.6	
	TOTAL	**$95,580**	**19**	**162,907**	**375**	**13,349**	**7.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Assuming DDC upgrades decrease usage of newly controlled systems by 10%.
4. Assuming 100 hours retrocommissioning reduces consumption by 5%.
5. Assume the elimination of 100 MBH of simultaneous heating and cooling annually. This measure pertains to moving the maintenance office T-Stat.

Estimated Blended Marginal Rates		
$	0.080	/kWh Elec
$	0.844	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.61	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.6.2. Pierre DOT Regional Office

Building Overview

The Pierre DOT Regional Office was constructed in 1962 and is 6,720 square feet. There are approximately 10 occupants on a regular working day. This building is occupied 9 hours per day, 5 days per week. The building is mostly administrative offices and conference rooms.

A split DX, multi-zone (3 zones), constant speed air handler tempers and provides humidity control to the office. The air handler is approximately 20-25 years old. A 540 MBH Kewanee boiler provides hot water to the air handler and parameter fin tube radiation. The HVAC system has local pneumatic controls.

32W 3-lamp T-8 strip lighting used throughout the office. Open office space in the basement is lit to as high as 180 foot-candles and 86 foot-candles for the 1st floor private offices. Interior lights are manually controlled. Exit signs are fluorescent.

The exterior finish is brick and precast concrete. The interior finish is sheet rock and block. The windows are double pane and tinted. There is an entrance vestibule and the building envelope condition is good.

ECM's

Previously Implemented ECMs

The building is currently in the planning stages of a renovation that will replace controls and upgrade equipment. The project will reduce energy bills by replacing equipment with higher efficiency units and provide tighter controls to reduce energy usage in the building.

Opportunities for ECMs at Pierre DOT Regional Office Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,610	4.8	14954		$1,196	1.3	3
5.1.2	Delamp Multiple Lamp Fixtures	$1,500	2.0	6068		$485	3.1	
5.1.3	Install Motion Sensors to Control Lighting	$3,340		4768		$381	8.8	
5.2.1	Full Retrocomissioning and Balancing Study	$12,420	1.1	9478	26	$780	15.9	
5.2.2	Eliminate Over Cycling of Compressors	$810	0.1	1211		$97	8.4	
5.3.8	Schedule AHUs Off During Unoccupied Hours	$6,210	-	16271	278	$1,536	4.0	4
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$2,190		4592		$367	6.0	
	TOTAL	**$28,080**	**8**	**57,342**	**303**	**$4,844**	**5.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Cost assumes installation by in-house staff.
4. 5% estimated utility cost reduction through an 80 hour retrocomissioning effort.

Estimated Blended Marginal Rates		
$	0.080	/kWh Elec
$	0.844	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.61	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

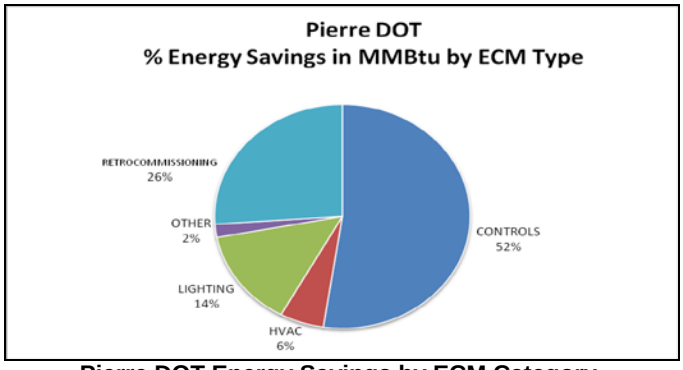
4.6.6.2.1. Campus Summary

A total of 12 ECMs were identified at Pierre DOT buildings, which include 822 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $123,660, and save an estimated $18,193 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

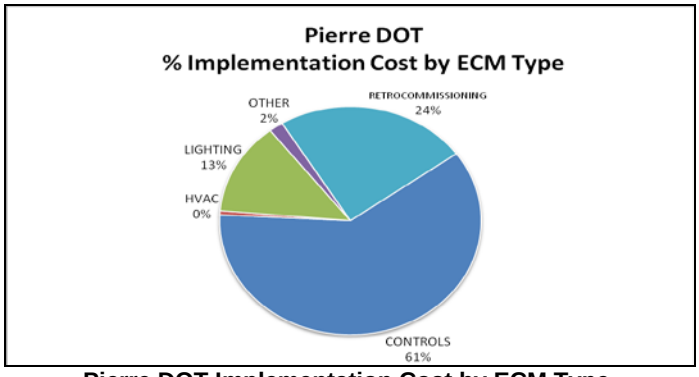
DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	377	54	**430**	$9,270	$75,210	**8.1**
HVAC	46	0	**46**	$1,074	$690	**0.6**
LIGHTING	115	0	**115**	$2,703	$16,230	**6.0**
OTHER	16	0	**16**	$367	$2,190	**6.0**
RECOMMISSIONING	198	16	**214**	$4,779	$29,340	**6.1**
Total	751	70	**822**	$18,193	$123,660	**6.8**

In total, these savings represent a 21% reduction from current energy consumption at the Pierre DOT buildings, the majority of which is attributed to controls measures which will reduce electric consumption.



Pierre DOT Energy Savings by ECM Category.



Pierre DOT Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 391 MMBTUs (10% of campus energy use) and a

total estimated annual cost avoidance of $8,526. The total cost of implementation for these measures is $27,730, which yields a simple payback of 3.3 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Pierre DOT Maintenance Shop and Lab	5.4.20	$690	46	$1,074	0.6	15.07
Pierre DOT Regional Office	5.1.1	$1,610	51	$1,196	1.3	31.56
Pierre DOT Regional Office	5.1.2	$1,500	21	$485	3.1	72.45
Pierre DOT Maintenance Shop and Lab	5.2.1	$15,530	173	$3,867	4.0	89.70
Pierre DOT Regional Office	5.3.8	$6,210	84	$1,536	4.0	73.72
Pierre DOT Regional Office	5.5.1	$2,190	16	$367	6.0	139.78
TOTAL		**$27,730**	**391**	**$8,526**	**3.3**	**71.00**

4.6.7 Plankinton Rest Stop

Campus Background and List of Facilities

The Plankington rest stop consists of a single building on both the west bound and east bound sides of Interstate 90. Each building is identical, therefore only the west bound rest stop building was investigated in our onsite walkthrough.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, the Plankinton facilities consumed a combined 382 MMBTUs of energy. The average Energy Use Intensity across Plankinton facilities was 64 kBTU/SF for 2008.

4.6.7.1. Plankinton Rest Stop Building

Building Overview

The Plankinton rest stop building is approximately 3,000 square feet. The building consists of a lobby, men's & women's restrooms and a mechanical room.

HVAC: Two constant air volume direct vent condensing propane gas units with split AC condensing units serve the building. One of the units serves the restrooms with the other unit serving the lobby. Electric reheat duct heaters are installed in supply air ductwork to the bathroom areas. Each bathroom has a continuously running 1/6 hp exhaust fan. Thermostats for each unit are located in the mechanical room with remote temperature sensors located in the return air ductwork. According to the sequence of operation manual, heating set-point is

70 deg F and cooling set-point is 74 deg F. The outside air duct has a motorized damper controlled by a mixed air temperature sensor. The temperature sensor is set to maintain mixed air temperature of at least 65 deg F.A motorized damper controls the return air which can never be closed further than 50% closed. A motorized damper is installed on the combustion air duct. It will open whenever the gas unit heater (serving mechanical room) or hot water heater is firing.

Domestic hot water is provided by a propane gas fired hot water heater.

Lighting: All lighting consists of T8 fixtures & manual switches.

ECM's

Previously Implemented ECMs

None were identified.

Opportunities for ECMs at Plankinton Rest Stop Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$600	-	9,461	$851	0.7	2.0
	TOTAL	**$600**	**-**	**9,461**	**851**	**0.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume two motion sensors installed to control men's and women's room lighting for an average reduction of 12 hours per day.
3. The calculation assumes both rest stop buildings on westbound and eastbound I-90.

Estimated Blended Marginal Rates		
$	0.09	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$	1.45	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

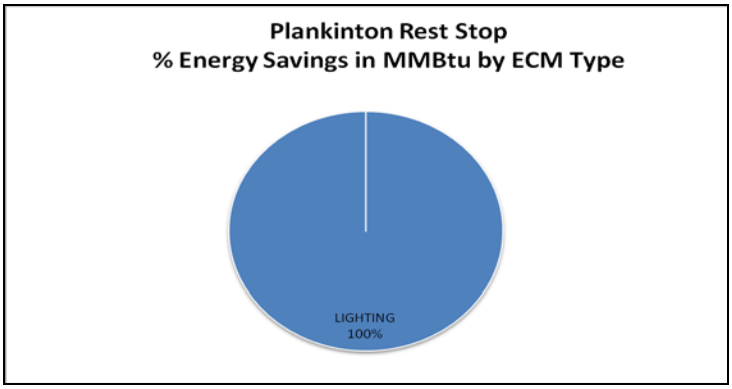
4.6.7.1.1. Campus Summary

A total of 1 ECMs were identified at Plankinton Rest Stop, which include 32 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $851, and save an estimated $600 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

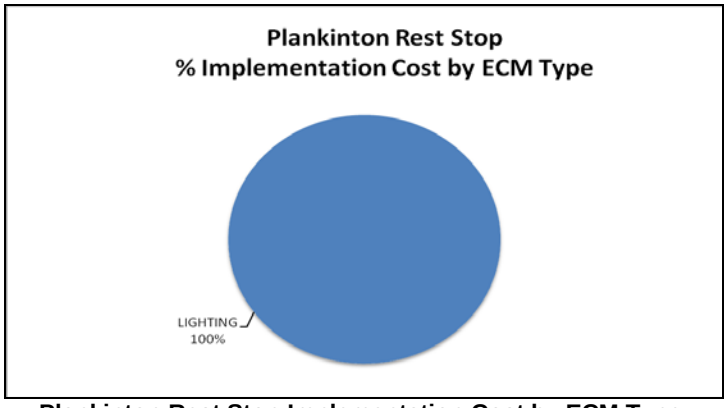
DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	32	0	**32**	$851	$600	**0.7**
Total	**32**	**0**	**32**	**$851**	**$600**	**0.7**

In total, these savings represent a 8% reduction from current energy consumption at the Plankinton Rest Stop, the majority of which is attributed to lighting measures which will reduce electric consumption.



Plankinton Rest Stop Energy Savings by ECM Category.



Plankinton Rest Stop Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 32 MMBTUs (8% of campus energy use) and a total estimated annual cost avoidance of $600. The total cost of implementation for these measures is $851, which yields a simple payback of 0.7 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Plankinton Rest Stop	5.1.3	$600	32	$851	0.7	18.59
TOTAL		**$600**	**32**	**$851**	**0.7**	**18.59**

4.6.8 Rapid City Department of Transportation

Campus Background and List of Facilities

The Rapid City Department of Transportation houses office, maintenance, and storage areas to serve western South Dakota.

Campus-Wide Systems and Operational Profile

There are no campus wide systems.

Energy Profile

In 2008, the Rapid City regional facilities consumed a combined 5,415 MMBTUs of energy. The average Energy Use Intensity across Rapid City regional facilities was 110 kBTU/SF for 2008.

4.6.8.1. Building A – Maintenance Crew

Building Overview

The Department of Transportation – Rapid City Building A, Maintenance Crew Building occupies 11,250 square feet and houses office and garage areas.

Several DX air handling units provide conditioning for office areas. Some units are controlled using programmable thermostats.

Garage bay areas are heated using gas fired infrared heaters. Garage ventilation is provided using manually controlled makeup air units and exhaust fans.

There are two makeshift offices on the top level that are directly exposed to an un-insulated roof. Occupants note that the spaces get very cold in the winter. Because the offices were not originally designed as offices, they are not ventilated. The negative pressurization sometimes causes carbon monoxide concentrations to rise. Occupants keep carbon monoxide detectors in the offices, and the detectors sometimes indicate alert levels.

Lighting is manually controlled and is provided using T-12 fluorescent fixtures.

ECM's

Previously Implemented ECMs

A programmable thermostat was installed for the break room.

Opportunities for ECMs at Building A – Maintenance Crew								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$750	-	2,418	-	$271	2.8	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,000	1	4,056	-	$454	2.2	3
5.1.12	Replace 8' Fixtures with 4' Fixtures	$6,000	3	10,296	-	$1,153	5.2	
5.3.2	Programmable Thermostat for Residential Style Units	$120	-	240	68	$51	2.3	
5.1.15	Replace Electric Hot Water Heater with Gas	$3,600	-	6,570	(231)	$653	5.5	
	TOTAL	**$11,470**	**5**	**23,580**	**(163)**	**$2,583**	**4.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume 25 fixtures, with 5 fixtures per sensor, and a 3 hour reduction in lighting per day.
3. Costs assume reballast completed by in house staff. Additional contractors or fixture changes will add more cost.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	0.36	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.8.2. Building B – Repair Shop

Building Overview

The Department of Transportation – Rapid City Building B, Repair Shop occupies 21,788 square feet and houses office, garage, and storage areas.

Residential style furnaces with DX cooling provide heating to office areas. Some units are controlled using programmable thermostats.

Garage bay areas are heated using gas fired infrared heaters. Garage and paint booth ventilation is provided using manually controlled makeup air units. The main garage bay utilizes a heat recovery system for exhaust and makeup air.

Lighting is manually controlled and is provided using T-12 fluorescent fixtures. High bay areas are lit using metal halide fixtures.

ECM's

Previously Implemented ECMs

Air to air heat recovery is installed for the garage exhaust and makeup air.

Opportunities for ECMs at Building B – Repair Shop								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control	$750	-	2,418	-	$271	2.8	2

Opportunities for ECMs at Building B – Repair Shop								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
	Lighting							
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,000	3	8,112	-	$909	2.2	3
5.1.10	Replace HID Lighting with High Bay Fluorescent	$10,000	8	17,625	-	$1,974	5.1	4
5.1.12	Replace 8' Fixtures with 4' Fixtures	$3,000	2	5,148	-	$577	5.2	
5.5.15	Replace Electric Hot Water Heater with Gas	$3,600	-	6,570	(231)	$653	5.5	
	TOTAL	**$19,350**	**12**	**39,873**	**(231)**	**$4,383**	**4.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume 25 fixtures, with 5 fixtures per sensor, and a 3 hour reduction in lighting per day.
3. Costs assume reballast completed by landlord's staff. Additional contractors or fixture changes will add more cost.
4. This measure assumes 6 lamp T-8 high bay replacement.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	0.36	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.8.3. Building C – Cold Storage

Building Overview

The Department of Transportation – Rapid City Building C, Cold Storage building provide storage for snow plows and trucks.

The space is generally unconditioned, but the space is sometimes heated with a used oil furnace, which takes waste oil from trucks and burns the oil for heating.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Building C – Cold Storage

No suitable energy conservation measures were discovered.

4.6.8.4. DOT Office Building

Building Overview

The Department of Transportation – Rapid City Office Building occupies 16,380 square feet and houses offices and some laboratory areas.

The building is heated using two boilers, which provide heating hot water to the air handler and to reheat coils. The heating water pumps are constant speed; although both the air handling unit and VAV reheat coils utilize two-way valves. Space temperature sensors control pneumatic VAV boxes which adjust airflows through zone dampers and the constant speed air handling unit. Hydronic radiant heating panels provide additional heating for exterior zones.

There is a preheat coil installed, but it is located upstream of the outside air mixing plenum, so it provides little assistance for heating of ventilation air. There had been another preheat coil installed per design drawings, but the coil likely froze and was abandoned in place. The new coil was installed as a replacement but was incorrectly positioned. To strengthen this theory, building staff noted that the building has had some trouble providing heating in the winter.

A standalone control system is maintained by a service contractor. The HVAC equipment is not scheduled. Design drawings indicate temperature setbacks, but manual thermostats with full sliders are installed in most spaces.

Lighting is manually controlled and is provided using T-12 fluorescent fixtures.

ECM's

Previously Implemented ECMs

The air handling unit utilizes a warm-up cycle, which shuts off outside air while the building warms up (or cools down) to occupied conditions.

Opportunities for ECMs at DOT Office Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$6,000	-	19,344	-	$2,167	2.8	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$10,000	16	48,672	-	$5,451	1.8	3
5.3.9	Upgrade Controls System to Full DDC	$75,000	-	3,811	556	$627	119.7	
5.4.37	Relocate Preheat Coil	$5,000	-	-	700	$251	19.9	4
5.5.15	Replace Electric Hot Water Heater with Gas	$3,600	-	6,570	(231)	$653	5.5	
	TOTAL	**$99,600**	**16**	**78,397**	**1,026**	**$9,149**	**10.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume 200 fixtures, with 5 fixtures per sensor, and a 3 hour reduction in lighting per day.
3. Costs assume reballast completed by in house staff. Additional contractors or fixture changes will add more cost.
4. This measure will also increase occupant comfort during the winter.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	0.36	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

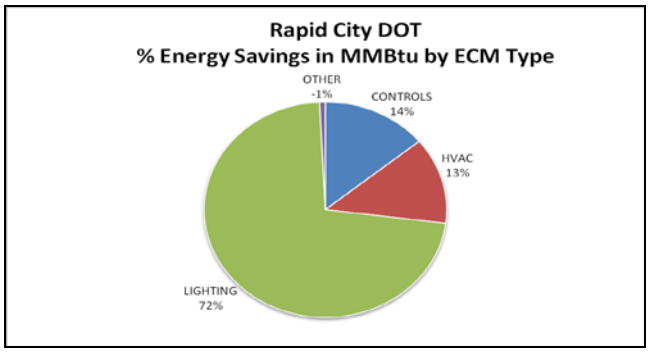
4.6.8.4.1. Campus Summary

A total of 15 ECMs were identified at Rapid City DOT buildings, which include 549 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $130,420, and save an estimated $16,114 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

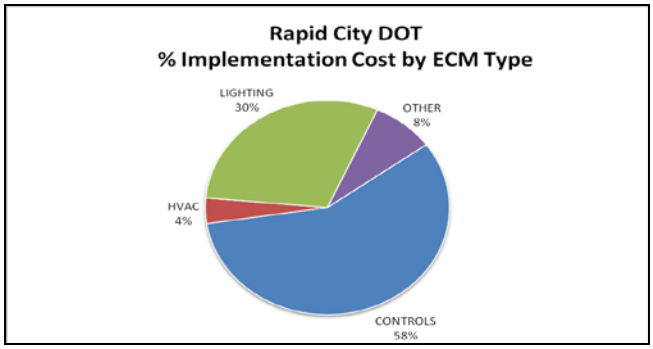
DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	14	65	**78**	$678	$75,120	**110.8**
HVAC	0	72	**72**	$251	$5,000	**19.9**
LIGHTING	403	0	**403**	$13,226	$39,500	**3.0**
OTHER	67	-72	**-4**	$1,959	$10,800	**5.5**
Total	**484**	**65**	**549**	**$16,114**	**$130,420**	**8.1**

In total, these savings represent a 10% reduction from current energy consumption at the Rapid City DOT campus, the majority of which is attributed to lighting measures which will reduce electric consumption.



Rapid City DOT Energy Savings by ECM Category.



Rapid City DOT Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 407 MMBTUs (7.5% of campus energy use) and a total estimated annual cost avoidance of $15,236. The total cost of implementation for these measures is $50,420, which yields a simple payback of 3.3 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Office Building	5.1.7	$10,000	166	$5,451	1.8	60.22
Building A	5.1.7	$1,000	14	$454	2.2	72.26
Building B	5.1.7	$2,000	28	$909	2.2	72.26
Building A	5.3.2	$120	8	$51	2.3	15.29
Building A	5.1.3	$750	8	$271	2.8	90.91
Building B	5.1.3	$750	8	$271	2.8	90.91
Office Building	5.1.3	$6,000	66	$2,167	2.8	90.91
Building B	5.1.10	$10,000	60	$1,974	5.1	166.29
Building A	5.1.12	$6,000	35	$1,153	5.2	170.79
Building B	5.1.12	$3,000	18	$577	5.2	170.79
Building A	5.5.15	$3,600	(1)	$653	5.5	n/a
Building B	5.5.15	$3,600	(1)	$653	5.5	n/a
Office Building	5.5.15	$3,600	(1)	$653	5.5	n/a
TOTAL		**$50,420**	**407**	**$15,236**	**3.3**	**124.03**

4.6.9 Sioux Falls Department of Transportation

Campus Background and List of Facilities

Buildings 100, 200, 300, 400, 500, 700, 800, 900

Campus-Wide Systems and Operational Profile

The DOT campus is made up of 8 buildings.It was constructed in 2001-2002.In addition to the DOT, the complex is local home to the Highway Patrol (portion of bldg 100) and Game, Fish, and Parks (bldg 600).The DOT uses the buildings and grounds for staging and logistical support for all DOT operations including road repair and maintenance.The buildings the DOT operates are offices in Building 100, maintenance facilities in Buildings 200, 400, & 500, wash bay in bldg 300, and vehicle and equipment storage in Buildings 700 & 800.

The campus has considerable exterior lighting. Both building parameter wall packs and light pole. Review of the campus utility data showed that more electricity is consumed in the winter months than in the summer. It is speculated that as the days get shorter and nights longer in the winter the

great amount of exterior lights stay on longer and longer. The facility maintenance personnel have been investigating ways of reducing the amount of exterior lighting.

Energy Profile

In 2008, the Sioux Falls regional facilities consumed a combined 11,295 MMBTUs of energy. The average Energy Use Intensity across Sioux Falls regional facilities was 107 kBTU/SF for 2008.

4.6.9.1. Buildings 100 and 200

Building Overview

Building 100 is primarily office space for the DOT and Highway Patrol.Building 200 is primarily DOT maintenance repair shop.Combined there are about 60 occupants.Typical occupant schedule is M-F 8-5.The Highway Patrol operates 24/7.

Two VAV air handlers with hot water heating and chilled water cooling serves the office space in Buildings 100 & 200.AHU-1 is dedicated to highway patrol area of the building and AHU-2 is dedicated to the DOT side of the building. Hot water for the AHU heating coils as well as in floor heating in the repair shop is provided by three 746 MBH natural gas fired boilers. The boiler system is operational all year. On the site visit (with outdoor air temps 74 deg F) the boiler was cycling every 20 minutes. Investigation revealed the BAS is showing the hot water return temperature as warmer than the supply water temperature. Measurement with a temperature gun confirmed that the temperatures were not accurate. This temperature inaccuracy may be causing and likely was causing the boilers to cycle in the summer time. The air handlers were supplying 55 deg air. There is opportunity for supply temperature reset programming. Two 15 hp hot water pumps are variable speed. Chilled water is provided by a 67 ton Trane chiller. Two 15 hp chilled water pumps are variable speed. Two constant speed air handling units with hot water heating and chilled water cooling serve the building 200 repair shop. A Siebe control system provides HVAC automation control for buildings 100 & 200.Domestic hot water is provided by two gas fired water heaters (150 & 125 MBH).

Lighting in the office space is primarily 4ft 3-lamp T-8s.Lights are controlled by toggle switches and there are no occupancy sensors. Lighting in the repair shop is 400W metal halide. Exit signs are LED.

The building exterior is pre-cast concrete. The roofs are flat and off-white. Windows are double pane.

ECM's

Previously Implemented ECMs

Disconnection of many exterior lights to save electrical cost.

Opportunities for ECMs at Building 100 and 200								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,730	2.9	8,824		$688	2.5	3
5.1.2	Delamp Multiple Lamp Fixtures	$0	4.2	13,003		$1,014	0.0	3
5.1.3	Install Motion Sensors to Control Lighting	$5,350	-	10,217		$797	6.7	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$12,560	11.3	23,232		$1,812	6.9	
5.1.14	Identify and Turnoff Non-essential Exterior Lighting	$320	36.3	104,892		$8,182	0.0	
5.2.1	Full Retrocomissioning and Balancing Study	$40,000	8.8	76,923	1,940	$7,500	5.3	
		$59,960	**63**	**237,092**	**1,940**	**$19,993**	**3.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.78	/kWh Elec
$	0.773	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.9.2. Building 300

Building Overview

Building 300 is a vehicle wash bay and houses the campus back-up generator. It is occupied only when vehicles need to be washed. The wash bay is heated by a gas fired make up air unit and four gas fired unit heaters. A 258 MBH gas fired boiler provides hot water to the in floor heating system.

Lighting is primarily 4' 2-lamp or 4-lamp F32T8.Controlled by toggle switches.

The building exterior is pre-cast concrete. The roofs are flat and off-white

ECM's

Previously Implemented ECMs

No recent ECMs to report.

Opportunities for ECMs at Building 300

No suitable energy conservation measures were discovered.

4.6.9.3. Building 400 and 500

Building Overview

Building 400 is highway construction equipment maintenance and building 500 is signs and bridge crew equipment maintenance. Approximately 30 workers occupy buildings 400 & 500.Typical occupancy is M-F 8-5.

Two 56 MBH gas fired furnaces with DX cooling serve office space in building 400.One 93 MBH gas fired furnaces with DX cooling serve office space in building 500.Maintenance bays in both 400 & 500 are heated by a combination of gas fired infrared heaters and gas fired unit heaters.

Lighting in the office space is primarily 4' 2-lamp F32T8.Lights are controlled by toggle switches and there are no occupancy sensors. Lighting in the repair shop is 400W metal halide. Exit signs are LED.

The building exterior is pre-cast concrete. The roofs are flat and off-white. Windows are double pane.

ECM's

Previously Implemented ECMs

No recent ECMs to report.

Opportunities for ECMs at Building 400 and 500

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$690	0.6	1,548	$121	5.7	3
5.1.3	Install Motion Sensors to Control Lighting	$2,140	0.6	3,870	$302	7.1	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$15,850	14.2	29,317	$2,287	6.9	
	TOTAL	**$18,680**	**15**	**34,735**	**2,709**	**6.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.078	/kWh Elec
$	0.773	/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.6.9.4. Building 700, 800, 900

Building Overview

Buildings 700 and 800 are cold storage (non-heated areas) for vehicles and equipment. Building 900 is parking for a loader. These buildings are unoccupied.

There is no HVAC in buildings 700 & 800.Building 900 has a space heater.

Lighting in building 700 & 800 is primarily 250W high bay metal halide. Lights are controlled by toggle switches. Lights are not on a timer nor occupancy sensors and it has been reported that light banks are commonly turned on and left on.

Building 700 & 800 construction is insulated metal panels. Building 900 is an un-insulated wood structure

ECM's

Previously Implemented ECMs

No recent ECMs to report.

Opportunities for ECMs at Building 700, 800 and 900						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.3	Install Motion Sensors to Control Lighting	$2,350	-	15,070	$1,175	2.0
5.1.10	Replace HID Lighting with High Bay Fluorescent	$18,220	12.4	21,418	$1,671	10.9
	TOTAL	$20,570	12	36,488	2,846	7.2

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.078	/kWh Elec
$	0.773	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

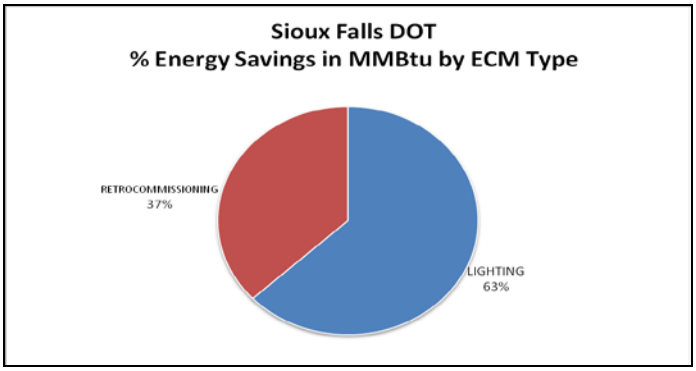
4.6.9.4.1. Campus Summary

A total of 11 ECMs were identified at Sioux Falls DOT buildings, which include 1,253 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $99,210, and save an estimated $25,549 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

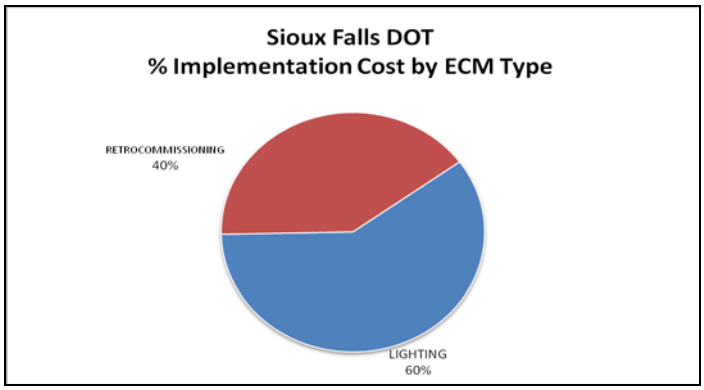
DOT ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	790	0	**790**	$18,049	$59,210	**3.3**
RETROCOMMISSIONING	262	201	**463**	$7,500	$40,000	**5.3**
Total	**1,052**	**201**	**1,253**	**$25,549**	**$99,210**	**3.9**

In total, these savings represent a 11% reduction from current energy consumption at the Sioux Falls DOT campus, the majority of which is attributed to lighting measures which will reduce electric consumption.



Sioux Falls DOT Energy Savings by ECM Category.



Sioux Falls DOT Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 952 MMBTUs (8% of campus energy use) and a total estimated annual cost avoidance of $18,680. The total cost of implementation for these measures is $45,090, which yields a simple payback of 2.4 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Bldgs 100 & 200	5.1.2	$0	44	$1,014	0.0	0.00
Bldgs 100 & 200	5.1.13	$320	358	$8,182	0.0	0.89
Bldgs 700, 800, 900	5.1.3	$2,350	51	$1,175	2.0	45.70
Bldgs 100 & 200	5.1.1	$1,730	30	$688	2.5	57.46
Bldgs 100 & 200	5.2.1	$40,000	463	$7,500	5.3	86.37
Bldgs 400 & 500	5.1.1	$690	5	$121	5.7	130.64
TOTAL		**$45,090**	**952**	**$18,680**	**2.4**	**47.35**

4.7 Game, Fish and Parks

The purpose of Game, Fish and Parks (GFP) is to perpetuate, conserve, manage, protect, and enhance South Dakota's wildlife resources, parks, and outdoor recreational opportunities for the use, benefit, and enjoyment of the people of this State and its visitors, and to give the highest priority to the welfare of this State's wildlife and parks, and their environment, in planning and decisions.

Documentation from OSE showed 298,101 square feet of GFP facilities. Several facilities were investigated in this study, and the following table lists these facilities and their corresponding total square feet of building space.

GFP Campus Summary.

Campus	Location	Square Footage
Wildlife Sioux Falls Regional Office & TOX	Sioux Falls	17,320
Farm Island Area	Pierre	8,175
Missouri River Fisheries Development Center	Fort Pierre	12,655
Custer State Park	Custer	69,791
Palisades	Sioux Falls	1,152
Wildlife District Office	Huron	2,055
Wildlife Office Region 4	Watertown	2,588
Wildlife Sioux Falls Maintenance Shop	Sioux Falls	17,320
Cleghorn Springs State Fish Hatchery	Rapid City	12,564

Energy Profile

In 2008, GFP facilities consumed a combined 24,471 MMBTUs of energy. The average Energy Use Intensity across the GFP was 82 kBTU/SF for 2008. For the GFP facilities selected for investigation in this study, the energy use is provided in the following table.

GFP Campus Energy Data (MMBTUs).

Campus	2008
Wildlife Sioux Falls Regional Office & TOX	3,020
Area: Farm Island	646
Missouri River Fisheries Development Center	647
Custer State Park	6,483
Palisades	123
Wildlife District Office	69
Wildlife Office Region 4	391
Wildlife Sioux Falls Maintenance Shop	3,020
Cleghorn Springs State Fish Hatchery	1,455

4.7.1 Custer State Park

Campus Background and List of Facilities

Custer State Park is a 71,000 acre nature preserve with approximately 400 building throughout ranging from campground comfort stations to a 20 room lodge. The buildings are scattered throughout the park but are primarily located in the North half of the park along the major roads that run through it. The first group of major buildings was originally built in the 1930's as part of the Civilian Conservation Corps efforts. Over the 80 year of existence, park buildings have been built as they are needed and existing buildings are replaced or renovated as their useful lives expire.

Campus-Wide Systems and Operational Profile

There are no central heating or cooling systems in Custer State Park. There are 12 well houses throughout the park that provide running water to different areas.

Energy Profile

Records from OSE indicate Custer State Park facilities consumed a combined 1,236 MMBTUs of energy. However, based on investigation we believe there is energy use that was unaccounted for in the documentation.

4.7.1.1. Aspen Cabin

Building Overview

The Aspen Cabin is a residential style building that can house 3 occupants. It was constructed in the 1970's as residential style home for the higher level people in the oil boom. It was reconfigured after as employee dorms for seasonal workers The insulation is minimal and the windows are single paned with storm windows on the exterior.

The building has residential style amenities. There is no cooling in the building. Heating is provided by radiant electric cove heaters. Since the building is winterized there is no need to heat them when it is very cold outside. There is a kitchen with an electric oven, microwave and refrigerator. Hot water is provided by an electric resistance domestic water heater.

Lighting is provided by fluorescent T-12s in the common areas of the building. Lighting in the dorm rooms is provided by incandescent fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Aspen Cabin						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$43	0.4	954	$105	0.4
5.1.12	Replace Halogen PAR's with Ceramic Metal Halide	$144	0.1	279	$31	4.7
	TOTAL	**$187**	**0**	**1,232**	**$136**	**1.4**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.2. Carpenter Shop

Building Overview

The seven Coolidge Dorm Buildings were built in the 1970's as barracks because of an oil exploration boom.They were reconfigured after as employee dorms for seasonal workers.Some of the dorms are occupied year round but the ones that are not occupied over the winter months are winterized.

The Carpenter Shop is a metal panel building with adequate insulation and windows. The office areas are heated and cooled with PTAC units. The garage areas are heated using propane fired radiant heaters. Domestic water is heated with one electric resistance hot water heater. Lighting is provided by fluorescent T-12 fixtures.

ECM's

Previously Implemented ECMs

Propane fired unit heaters were replaced with propane fired radiant heaters in the garage areas.

Opportunities for ECMs at Carpenter Shop							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.7	Retrofit T-12 Fixtures with T-8s	$648	$648	0.3	1,221	$134	4.8
5.4.26	Replace PTAC Heat Pumps at end of life with New	$2,990	$2,990	2.4	4,078	$449	6.7
	TOTAL	**$3,638**	**$3,638**	**3**	**5,299**	**$583**	**6.2**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.3. Chemical Storage

Building Overview

The Chemical Storage building has 3 separate rooms. The 3 rooms are used to store different chemicals year round. One of the three rooms is built to be explosion proof and is for the storage of flammable chemicals.

Heating is provided by electric cove radiant heaters to ensure the building does not freeze up in the winter. Lighting is provided by incandescent fixtures. A small exhaust fan in each room is controlled by a wall switch.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Chemical Storage Building						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$77	0.7	429	$47	1.6
	TOTAL	**$77**	**1**	**429**	**$47**	**1.6**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.4. Cold Storage

Building Overview

The Cold Storage building was built in 1991.This building is not actually kept cold it is just not heated in the winter months. It is used for storage of parts and small tools that are not sensitive to temperature.

There is limited insulation but that is inconsequential because the space is not conditioned. Lighting is provided with fluorescent T-12 fixtures and incandescent lamps. There are also skylights.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Cold Storage Building						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.7	Retrofit T-12 Fixtures with T-8s	$270	0.1	509	$56	4.8
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$169	1.6	1932	$213	0.8
	TOTAL	**$439**	**2**	**2,441**	**$268**	**1.6**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.5. Coolidge Dorm Complex

Building Overview

The 7 Coolidge Dorm Buildings were built in the 1970's as barracks because of an oil exploration boom. They were reconfigured after as employee dorms for seasonal workers. Some of the dorms are occupied year round but the ones that are not occupied over the winter months are winterized.

There are 18 rooms and each has its own unit ventilator. Each unit vent provides heating and cooling to the room based on a dial setting on the unit. There are electric unit heaters in the entryways. A single electric resistance water heater provides domestic hot water to the facility. Residential style washers and dryers are available to the residents in a common laundry room.

Lighting is provided by fluorescent T-12s in the common areas of the building. Lighting in the dorm rooms is provided by incandescent fixtures. The exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Coolidge Dorm Complex						
			Estimated Annual Utility Savings			
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,700	1.5	3,816	$420	6.4
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$340	2.1	1932	$213	1.6
5.4.26	Replace PTAC Heat Pumps at end of life with New	$34,960	16.5	28,004	$3,080	11.3
	TOTAL	**$38,000**	**20**	**33,751**	**$3,713**	**10.2**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.6. Coolidge Inn Cabins

Previously Implemented ECMs

There are approximately 35 Coolidge Inn Cabins that are very similar. These are original CCC buildings that were built in the 1930's.These building are State owned and maintained but are leased by the concessionaires. The cabins are only occupied during the summer months.

The buildings are log cabin style construction with no insulation and single paned windows. HVAC is provided by a central residential style AC unit that is cooling only. The AC unit is controlled by a standard residential thermostat. Domestic hot water is provided by an electric resistance water heater. Lighting is provided with incandescent fixtures.

ECM's

Previously Implemented ECMs

Condensing units on the residential style air handling units were recently replaced by efficient units (13SEER).

Opportunities for ECMs at Coolidge Inn Cabin							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$2,380	15	18,031	$1,983	1.2	3
	TOTAL	**$2,380**	**15**	**18,031**	**$1,983**	**1.2**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics extrapolated to 35 similar cabins.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.7. Creekside Inn

Building Overview

The Creekside Inn was built in 2007.This building is a 30 room hotel that is operated by the concessionaires. The Creekside Inn is open year round.

The building has a good envelope and energy efficient windows. The high traffic entrance is equipped with a vestibule.

Each guest room is equipped with a unit ventilator that is controlled by a programmable hotel t-stat. Domestic hot water is provided by two AO Smith propane fired water heaters that are high efficiency condensing. One high efficiency residential style furnace provides HVAC to a large common area of the building.

Lighting is provided by a mixture of efficient fluorescent technologies.T-8 and CFL lighting is the predominant lighting throughout the common areas of the building. The exterior lights are CFL. Exit signs are fluorescent.

ECM's

Previously Implemented ECMs

The Creekside Inn was built with the latest and most cost effective energy conservation strategies that were available.

Opportunities for ECMs at Creekside Inn					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years
			Electric kWh		
5.1.3	Install Motion Sensors to Control Lighting	$1,100	2,303	$253	4.3
	TOTAL	**$1,100**	**2,303**	**$253**	**4.3**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.8. Game Lodge

Building Overview

The Aspen Cabin is a residential style building that can house 3 occupants. It was constructed in the 1970's as residential style home for the higher level people in the oil boom. It was reconfigured after as employee dorms for seasonal workers. The insulation is minimal and the windows are single paned with storm windows on the exterior.

The building has residential style amenities. There is no cooling in the building. Heating is provided by radiant electric cove heaters. Since the building is winterized there is no need to heat them when it is very cold outside. There is a kitchen with an electric oven, microwave and refrigerator. Hot water is provided by an electric resistance domestic water heater.

Lighting is provided by fluorescent T-12s in the common areas of the building. Lighting in the dorm rooms is provided by incandescent fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Game Lodge

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.7	Retrofit T-12 Fixtures with T-8s	$870	0.9	3,053	$336	2.6
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$34	0.3	381	$42	0.8
	TOTAL	**$904**	**1**	**3,434**	**$378**	**2.4**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.9. Gamekeepers Cabin

Building Overview

The Gamekeepers Cabin was built in the 1940's.This residential style building is operated year round and is rented to tourists. This building is State owned and maintained but leased to the concessionaires. The cabin has several bedrooms in addition to residential amenities. The cabin has the capacity to host large groups of occupants at a time. There is limited insulation and the single paned windows have storm inserts on the exterior.

Each room has a heat pump for cooling and mild day heating. There is not central HVAC system. Perimeter radiators with heating hot water are driven by a single fire-tube boiler in the basement. The propane fired boiler is not actively controlled. It runs in the winter and is off in the summer. An electric domestic water heater provides hot water to the building.

The primary lighting source is incandescent. Desk lamps, room lights, exterior lights and primary lighting fixtures are all incandescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Gamekeepers Cabin

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Propane Gal		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$85	1	1,288	-	$142	0.6
5.4.1	Replace Firetube Boilers with Condensing	$5,060	-	-	72	$131	38.6
	TOTAL	**$5,145**	**1**	**1,288**	**72**	**$273**	**39**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.10. Ground Equipment Storage

Building Overview

The Ground Equipment Storage building is used to store different equipment that the grounds crew uses. This building is not heated or cooled. Lighting is provided by incandescent fixtures

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Ground Equipment Storage						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$68	1	381	$42	1.6
	TOTAL	$68	1	381	$42	1.6

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.11. Grounds Shop

Building Overview

The Grounds Shop is used to store and maintain the equipment the grounds crew uses. Small areas are also used by the fire crew for storage. There are offices adjacent to the main storage areas.

The grounds shop is a metal panel building with adequate insulation and windows. The office areas are heated and cooled with PTAC units. The garage areas are heated using propane fired radiant heaters. Domestic hot water is provided by one electric resistance water heater. Lighting is provided by fluorescent T-12 fixtures.

ECM's

Previously Implemented ECMs

Propane fired unit heaters were replaced with propane fired radiant heaters in the garage areas.

Opportunities for ECMs at Grounds Shop						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,620	1	3,053	$336	4.8
5.4.26	Replace PTAC Heat Pumps at end of life with New	$1,840	2	3,059	$336	5.5
	TOTAL	$3,460	3	6,111	672	5.1

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.12. Irrigation Water Pump Station

Building Overview

The Irrigation Water Pump Station supplies the shop area with domestic water. This building is used year round.

The building is heated with an electric resistance unit heater that keeps the building from freezing in the winter. The well is pumped using a single submersible pump. Domestic water pressure is maintained is a duplex pair of 3 hp pumps. A small exhaust fan in the building is controlled by a humidistat to ensure there isn't too much moisture built up in the building

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Irrigation Water Pump Station					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years
			Electric kWh		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$17	48	$5	3.2
	TOTAL	**$17**	**48**	**$5**	**3.2**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.13. Legion Lake Custer State Park Campgrounds

Building Overview

There are 8 campgrounds throughout the park that have a convenience station.The Legion Lake Custer State Park Campgrounds was chosen as a representative sample of the

campgrounds.The convenience stations are used by park visitors for bathing, toilets and shelter (if needed).All of the Custer State Park Campgrounds are open spring through fall.

The convenience stations each use domestic water from a nearby well house and have electric resistance water heaters with a large amount of storage because of the multiple showers in the building that could all be used at once. Lighting is provided by a combination of compact fluorescent lamps and fluorescent T-12.The lights are controlled manually by a wall switch. Heat is provided by electric resistance heaters controlled by local wall thermostats that keep the buildings from freezing. In the winter the buildings are winterized and closed.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Legion Lake Custer State Park Campgrounds

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Biomass Tons			
5.1.3	Install Motion Sensors to Control Lighting	$3,520	-	6,955	-	$765	4.6	3
5.1.7	Retrofit T-12 Fixtures with T-8s	$5,184	2.8	7326	-	$806	6.4	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$136	1.2	1526	-	$168	0.8	3
5.4.16	Insulate Domestic Water Piping	$338	-	-	2.217375	$188	1.8	3,4
5.5.2	Replace Storage Type Domestic Water Heaters with on Demand	$18,400	-	7,897	-	$869	21.2	3
	TOTAL	**$27,578**	**4**	**23,704**	**2**	**$2,796**	**9.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics include extrapolation of the Legion Lake Campgrounds to seven similar campgrounds around the park.
4. Assuming 150ft of 3/4 inch piping can be insulated

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.14. Legion Lake Wellhouse

Building Overview

There are 12 well houses throughout the park that are all very similar. The representative building chosen for this group of building was the Legion Lake Wellhouse. These buildings house water pumping and treatment equipment to soften and chlorinate water that is delivered to various areas of the park.

The well houses are single room in a small wood and gypsum board building with residential style construction. There is an adequate amount of insulation and no windows. They are heated using a single small electric resistance unit heater controlled by a local wall thermostat that is set to keep the building from freezing. Lighting is provided by incandescent lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Legion Lake Wellhouse

No suitable energy conservation measures were discovered.

4.7.1.15. Locker Plant

Building Overview

The Locker Plant was built in the 1940's and is in use year round. This building was originally used to butcher buffalo but more recently has turned into an equipment storage space with one small attached office.

The building envelope is in poor condition. Heating and cooling in the office areas is provided by PTAC units. Heating in the storage space is provided by a propane fired unit heater controlled by a local line voltage thermostat. There is no cooling in the storage space. Lighting is provided by fluorescent T-12 fixtures throughout. Exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Locker Plant							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.7	Retrofit T-12 Fixtures with T-8s	$464	0	1,628		$179	2.6
5.4.9	Replace Window AC Units with Heat Pumps	$2,990	2	4,151		$457	6.5
5.4.22	Replace Unit Heaters with Infrared Heat	$2,300			295	$537	4.3
	TOTAL	**$5,754**	**3**	**5,779**	**295**	**$1,173**	**4.9**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.16. Pandora Dorm Complex

Building Overview

The four Pandora residential style dorms are all very similar. These building were constructed in the 1960's and 1970's as residential style homes for the higher level people in the oil boom. They were reconfigured after as employee dorms for seasonal workers. Some of the dorms are occupied year round but the ones that are not occupied over the winter months are winterized. The insulation is minimal and the windows are single paned with storm windows on the exterior.

Each building has residential style amenities. There is no cooling in the building. Heating is provided by radiant electric cove heaters. Since the buildings are winterized there is no need to heat them when it is very cold outside. There is a kitchen with an electric oven, microwave and refrigerator. Hot water is provided by a pair of electric resistance domestic water heaters.

Lighting is provided by fluorescent T-12s in the common areas of the building. Lighting in the dorm rooms is provided by incandescent fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Pandora Dorm Complex						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.7	Retrofit T-12 Fixtures with T-8s	$864	0	1,628	$179	4.8
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$170	1.54	2861	$315	0.5
	TOTAL	**$1,034**	**2**	**4,489**	**$494**	**2.1**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.17. Park Entrance Booths

Building Overview

Park Entrance Booths are located in various parts of the park for visitors to stop and pay an entry fee. These small buildings are operated seasonally by one or two volunteer workers. There are five total booths throughout the park, two of which have bathrooms and the others do not. There is no insulation and the widows are operable.

The only energy consuming devices in the buildings are incandescent light fixtures and a plug in for a computer. The water, for those booths with a toilet, is not heated. Heating is provided by a small electric resistance heater.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Park Entrance Booths						
			Estimated Annual Utility Savings			
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$43	0	268	$30	1.4
	TOTAL	**$43**	**0**	**268**	**$30**	**1.4**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.18. Park Headquarters

Building Overview

The Park Headquarters was built in the 1930's with an addition in 2004.This building is an original Civilian Conservation Corps (CCC) building used primarily for office space and storage. The typical hours of operation are Monday through Friday 7am – 5pm year round. There are approximately 20 people who occupy the building on a regular working day.

The old building is log construction with mortar on the log butts with no insulation. The windows are single paned with storm windows on the exterior. There is no insulation in the roof or ceiling space. The new addition includes energy code compliant insulation, windows and envelope. It has log veneer on the outside to match the old building.

Heating, ventilation and air conditioning (HVAC) is provided by residential style furnaces that are propane fired with direct expansion (DX) cooling AC units in the new and old parts of the building. Lighting is primarily provided by fluorescent T-12 fixtures in the old building and fluorescent T-8 fixtures in the new addition. Incandescent lamps are used sparingly in closets and mechanical spaces. Exit signs are fluorescent. Domestic hot water is heated using electric resistance water heaters.

ECM's

Previously Implemented ECMs

T-12 fixtures are replaced with T-8s as ballasts fail. Operating budgets are currently allocated to replace old single paned windows and to replace the furnace/AC unit with a new high efficiency unit.

Opportunities for ECMs at Park Headquarters							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Propane Gal		
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,350	1.0	3,667	-	$403	3.3
5.1.3	Install Motion Sensors to Control Lighting	$1,100	-	3964	-	$436	2.5
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,160	1.2	4070	-	$448	2.6
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$170	1.5	1907	-	$210	0.8
5.3.2	Programmable Thermostats for Residential Style Units	$920	-	-	123	$224	4.1
5.4.34	Install Ground Source Heat Pump HVAC System	$81,650	3.1	(661)	917	$1,597	51.1
5.5.3	Improve Building Envelope - Insulation/Exterior	$7,500	-	1,291	331	$744	10.1
5.5.4	Improve Building Envelope - Windows	$45,000	-	880	276	$599	75.1
	TOTAL	**$138,850**	**7**	**15,118**	**1,647**	**4,661**	**29.8**

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.1.19. Park Shop

Building Overview

The Park Shop was built in the 1930's and is an original CCC building. This building is operated year round and is used for many types of general maintenance work. Park vehicles are serviced in this facility.

The original building construction consisted of logs and mortar. The logs on the inside of the building were shaved flat and painted to give the appearance of flat walls. The walls are not insulated in half of the building. The other half of the building has ¾" rigid foam insulation covering the inside walls. Large garage doors are located on two sides of the building. Blow-in insulation covers the ceiling of the conditioned space. The windows are single paned.

Heating is provided by three Reznor propane fired handing unit heaters each controlled by a local thermostat. There is no cooling in the building. Two large air compressors are used for pneumatic tools. One electric resistance domestic water heater provides hot water to the facility. There are exhaust systems that are run to remove vehicle exhaust in the winter when they are required to run indoors.

Lighting is provided by a mixture of incandescent, fluorescent T-12, and mercury vapor. Exit signs are fluorescent

ECM's

Previously Implemented ECMs

Blow-in and R-19 insulation above the ceiling of the shop has been added to decrease the heat loss the building experiences in the winter.

Opportunities for ECMs at Park Shop								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
5.1.4	Replace Mercury Vapor Lighting with Metal Halide	$450	1.4	1,486	-	$163	2.8	
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,160	1.2	4070	-	$448	4.8	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$26	0.4	219	-	$24	1.1	
5.3.2	Programmable Thermostats for	$920	-	-	162	$295	3.1	3.0

Opportunities for ECMs at Park Shop								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
	Residential Style Units							
5.4.22	Replace Unit Heaters with Infrared Heat	$10,700	-	-	324	$590	18.1	
5.5.3	Improve Building Envelope - Insulation/Exterior	$2,000	-	165	110	$218	9.2	
5.5.4	Improve Building Envelope - Windows	$12,000	-	870	230	$514	23.3	
	TOTAL	$28,256	3	6,810	826	$2,252	12.5	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. This measure refers to the thermostats controlling the hanging unit heaters.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.20. Peter Norbeck Visitor Center

Building Overview

The Peter Norbeck Visitor Center was built in the 1930's and is an original CCC building. This building is usually in operation seasonally from March to October. The Visitor Center is a building where tourists are able to view displays, books, and videos about the Custer State Park and the Black Hills area.

The Peter Norbeck Visitor Center is on the national registry of historic places. There is no insulation in the walls and the windows are single paned. There is no HVAC in the visitor's areas of the building as it is only open in the summer and ventilated through operable windows. Display lighting is provided by halogen PAR lighting. This is also T-12 fluorescent lighting in some areas of the building. A small electric resistance water heater provides domestic hot water.

ECM's

Previously Implemented ECMs

The underground office area cooling system was replaced with a high efficiency heat pump.

Opportunities for ECMs at Peter Norbeck Visitor Center						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,080	0.6	1,526	$168	6.4

Opportunities for ECMs at Peter Norbeck Visitor Center						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.6	Replace Incandescent Spot Lighting with Ceramic Metal Halide	$1,100	2.5	6966	$766	1.4
	TOTAL	$2,180	3	8,492	$934	2.3

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.21. Sylvan Lake Dorms

Building Overview

The Sylvan Lake Dorms have approximately 32 separate living units in two buildings. All of the different living units are independent and are operated May through October. The dorms were originally built in the 1970s as barracks because of an oil exploration boom. They were reconfigured after as employee dorms for seasonal workers. The dorms are not occupied in the winter so the buildings are winterized.

There are 18 rooms and each has its own unit ventilator. Each unit vent provides heating and cooling to the room based on a dial setting on the unit. There are electric unit heaters in the entryways. Each room has a small electric resistance water heater for domestic hot water. Residential style washers and dryers are available to the residents in a common laundry room.

Lighting is provided by fluorescent T-12s in the common areas of the building. Lighting in the dorm rooms is provided by incandescent fixtures. The exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Sylvan Lake Dorms							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,700	1.5	3,816	$420	6.4	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$510	3.1	5796	$638	0.8	
5.3.2	Programmable Thermostats for Residential Style Units	$15,070	0.0	18,320	2,015	7.5	

Opportunities for ECMs at Sylvan Lake Dorms							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.4.9	Replace Window AC Units with Heat Pumps	$61,870	19.1	32,569	3,533	17.3	
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$32,430	42.7	26419	$2,906	11.2	
	TOTAL	**$112,580**	**66**	**8,920**	**9,581**	**11.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.22. Sylvan Lake Lodge

Building Overview

The Sylvan Lake Lodge is a State owned building that is leased to and managed by concessionaires. This building has approximately 50 rooms and is occupied by tourists from May through October. There is also a main kitchen and dining facility for the Lodge Restaurant. The building was originally built in the 1920s but received a major renovation and addition in the 1980s.

The building envelope and the energy consuming systems throughout the building are not consistent. Modifications, repairs and upgrades are made on an as needed basis which can detract from the efficiency of the building if the systems cannot work together to optimize their function.

The building envelope is good in some areas in not in others. There is adequate insulation in some walls, and none in others. Most guest rooms have heat pumps for heating and cooling that are controlled by a manual dial. Some of the main areas of the building do not have central HVAC systems. Other areas, and some guest rooms, have central station air handlers which were recently installed. A full service kitchen has one 16 foot kitchen hood and commercial cooking equipment. The laundry area has commercial washing and drying machines.

Lighting throughout the building is a mixture of lighting technologies. There are fluorescent T-12s, T-8s and CFLs. There are incandescent lamps. There are halogen spot lights. There are halogen PAR lamps on the exterior of the building.

ECM's

Previously Implemented ECMs

The new heat pumps and new central station air handlers installed are high efficiency.

Opportunities for ECMs at Sylvan Lake Lodge								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Propane Gal			
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,700	1.5	3,816	-	$420	6.4	
5.1.12	Replace Halogen PAR's with Ceramic Metal Halide	$3,600	2.5	6966	-	$766	4.7	3
5.5.5	Intellihood Kitchen Hood Controls System	$10,120	-	3,782	954	$2,152	4.7	
	TOTAL	$16,420	4	14,564	954	$3,338	4.9	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Exterior Lighting.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.1.23. Visitors Services Storage

Building Overview

The Visitors Services Storage was built in 1997.This building is used for storage of equipment.

The building is well insulated with efficient windows. Two electric resistance unit heaters keep the space 55 degrees in the winter. There is no cooling. Lighting is provided by incandescent fixtures.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Visitor's Service Storage						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$85	1	954	$105	0.8
	TOTAL	$85	1	954	$105	0.8

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.82	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

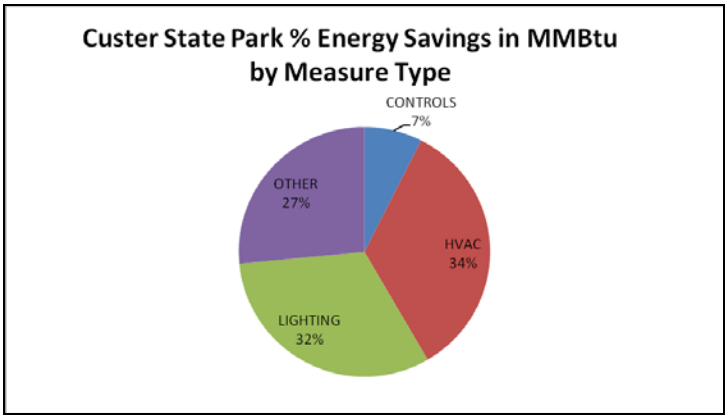
4.7.1.23.1. Campus Summary

A total of 57 ECMs were identified at Custer State Park, which include 1,188 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $388,190, and save an estimated $33,700 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

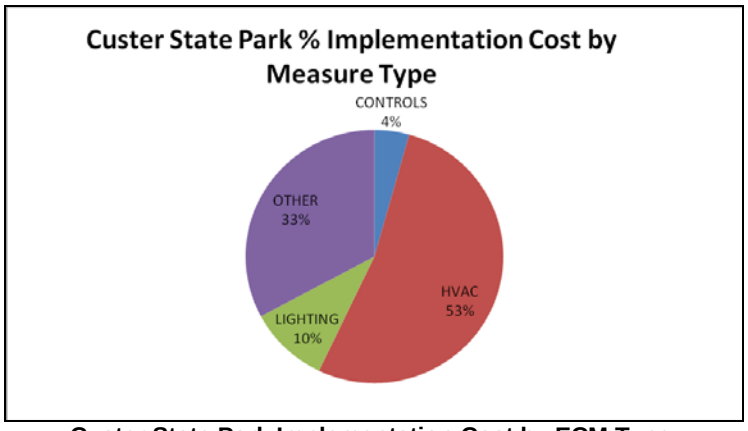
Custer State Park ECM Summary Table.

	MMBtu Electric	MMBtu Propane	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	63	26	**89**	$2,534	$16,910	**6.7**
HVAC	243	147	**406**	$10,948	$204,698	**18.7**
LIGHTING	379	0	**379**	$12,213	$39,135	**3.2**
OTHER	141	174	**315**	$8,003	$127,450	**15.9**
Total	**825**	**348**	**1,188**	**$33,697**	**$388,193**	

These estimated energy savings should be revisited once more reliable energy data is obtained for the facilities at Custer State Park.



Custer State Park Energy Savings by ECM Category.



Custer State Park Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 489 MMBTUs and a total estimated annual cost avoidance of $13,712. The total cost of implementation for these measures is $41,209, which yields a simple payback of 3.0 years. However, these estimated energy savings should be revisited once more reliable energy data is obtained for the facilities at Custer State Park.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Aspen Cabin	5.1.8	$43	3	$105	0.4	13.06
Pandora Dorm Complex	5.1.8	$170	10	$315	0.5	17.42
Gamekeepers Cabin	5.1.8	$85	4	$142	0.6	19.34
Cold Storage	5.1.8	$169	7	$213	0.8	25.64
Sylvan Lake Dorms	5.1.8	$510	20	$638	0.8	25.79
Game Lodge	5.1.8	$34	1	$42	0.8	26.13
Legion Lake Campgrounds	5.1.8	$136	5	$168	0.8	26.13
Park Headquarters	5.1.8	$170	7	$210	0.8	26.13
Visitor Service Storage	5.1.8	$85	3	$105	0.8	26.13
Park Shop	5.1.8	$26	1	$24	1.1	34.10
Coolidge Inn Cabin	5.1.8	$2,380	62	$1,983	1.2	38.69
Peter Norbeck Visitor Center	5.1.6	$1,100	24	$766	1.4	46.28
Park Entrance Booths	5.1.8	$43	1	$30	1.4	46.44
Coolidge Dorm Complex	5.1.8	$340	7	$213	1.6	51.58
Grounds Equipment Storage	5.1.8	$68	1	$42	1.6	52.25
Chemical Storage	5.1.8	$77	1	$47	1.6	52.25

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Legion Lake Campgrounds	5.4.16	$338	16	$188	1.8	21.74
Park Headquarters	5.1.3	$1,100	14	$436	2.5	81.33
Park Headquarters	5.1.7	$1,160	14	$448	2.6	83.53
Locker Plant	5.1.7	$464	6	$179	2.6	83.53
Game Lodge	5.1.7	$870	10	$336	2.6	83.53
Park Shop	5.1.4	$450	5	$163	2.8	88.75
Park Shop	5.3.2	$920	15	$295	3.1	62.00
Irrigation Water Pump Storage	5.1.8	$17	0	$5	3.2	104.50
Park Headquarters	5.1.1	$1,350	13	$403	3.3	107.91
Park Headquarters	5.3.2	$920	11	$224	4.1	81.66
Locker Plant	5.4.22	$2,300	27	$537	4.3	85.12
Creekside Inn	5.1.3	$1,100	8	$253	4.3	139.96
Legion Lake Campgrounds	5.1.3	$3,520	24	$765	4.6	148.34
Aspen Cabin	5.1.6	$144	1	$31	4.7	151.46
Sylvan Lake Lodge	5.1.6	$3,600	24	$766	4.7	151.46
Sylvan Lake Lodge	5.5.5	$10,120	100	$2,152	4.7	100.94
Cold Storage	5.1.7	$270	2	$56	4.8	155.53
Park Shop	5.1.7	$2,160	14	$448	4.8	155.53
Carpenter Shop	5.1.7	$648	4	$134	4.8	155.53
Pandora Dorm Complex	5.1.7	$864	6	$179	4.8	155.53
Grounds Shop	5.1.7	$1,620	10	$336	4.8	155.53
Grounds Shop	5.4.25	$1,840	10	$336	5.5	176.31
TOTAL		**$41,209**	**489**	**$13,712**	**3.0**	**84.29**

4.7.2 Farm Island State Park

Campus Background and List of Facilities

See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Farm Island Area facilities consumed a combined 646 MMBTUs of energy. The average Energy Use Intensity across the campus was 79 kBTU/SF in 2008.

4.7.2.1. Farm Island State Park

Building Overview

Farm Island State Park is located on the Missouri River near Pierre and consists of the park headquarters building, entrance booth, park director's residence, various maintenance/equipment buildings, visitors center, public restrooms, and 90 campsites and numerous cabins for rent. There are approximately 4 workers occupying the office and maintenance buildings. The office/maintenance buildings are operated 8 hours per day, 5 days per week. The campsites are open 24/7

The park HQ is cooled by 4 individual heat pumps that interface a single condensing unit. Heating is via electric radiators. The park HQ has three offices and reception area each with its own control thermostat. The director's residence is ventilated by a high efficiency propane fired, forced air Carrier furnace with DX cooling. Domestic hot water is provided by a 180 MBH Rinnai instantaneous water heater. Heating and cooling of the cabins is provided by an electric wall heater and wall hung air conditioning unit. The public restrooms have a 100 gallon electric resistance water heater. The shop is heated by an oil furnace and there is one 6.5 hp air compressor for pneumatic tools.

Interior lighting in the park HQ building is a mixture of T-8 and T-12 fixtures. Some of the maintenance/equipment buildings have incandescent fixtures. Interior lights are manually controlled.

ECM's

Previously Implemented ECMs

An on demand water heater in the park director's residence was installed to replace a tank style propane water heater.

Opportunities for ECMs at Farm Island State Park								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$200	0.3	882		$95	2.1	5
5.1.3	Install Motion Sensors to Control Lighting	$400		1,022		$110	3.6	
5.1.5	Replace Incandescent Exit Signs with LED	$600	0.1	995		$107	5.6	
5.1.6	Replace Incandescent Spot Lighting with Ceramic Metal Halide	$200	0.8	2,384		$257	0.8	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$100	0.5	238		$26	3.9	4
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$10,200	0.1	89,956		$9,715	1.0	
	TOTAL	$7,380	4	10,673	203	$1,543	4.8	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. This pertains to two comfort station water heaters.
4. Several cooling units throughout the park had damaged fins. No cost considers this to be an in-house staff assignment.
5. This pertains to the window AC unit in the Visitors Center.

Estimated Blended Marginal Rates		
$	.108	/kWh Elec
$		/Therm Gas
$		/Gal Fuel Oil
$	0.192	Ton Biomass
$		/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

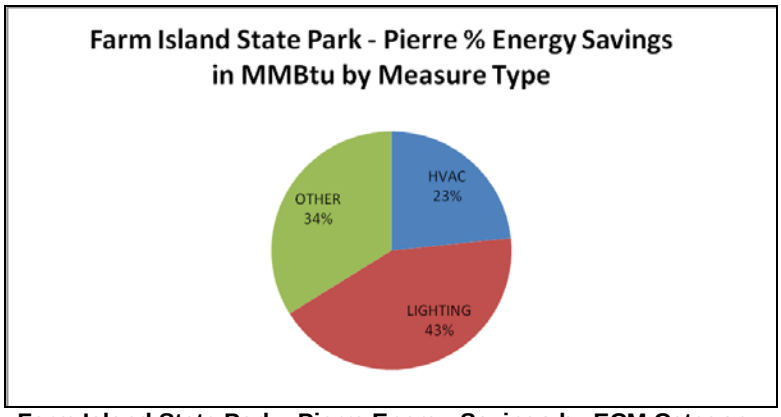
4.7.2.1.1. Campus Summary

A total of 6 ECMs were identified at Farm Island State Park - Pierre, which include 55 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $7,380, and save an estimated $1,545 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

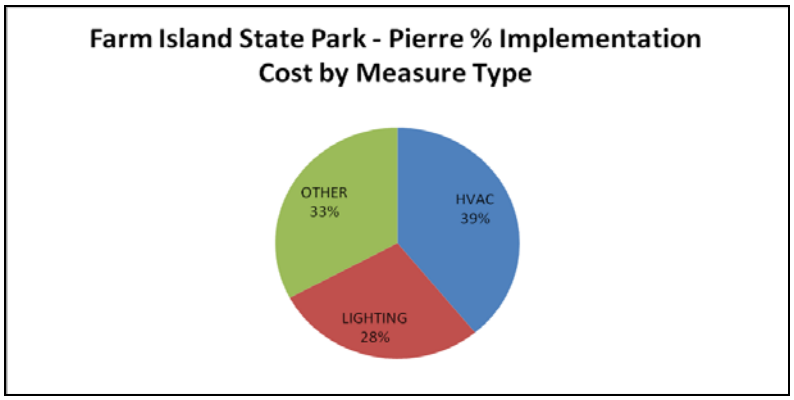
Farm Island State Park - Pierre ECM Summary Table.

	MMBtu Electric	MMBtu Propane	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
HVAC	13	0	**13**	$407	$2,880	7.1
LIGHTING	24	0	**24**	$746	$2,080	2.8
OTHER	0	19	**19**	$390	$2,420	6.2
Total	**36**	**19**	**55**	**$1,543**	**$7,380**	

In total, these savings represent a 8.5% reduction from current energy consumption at the Farm Island State Park - Pierre, the majority of which is attributed to Lighting measures which will reduce electrical consumption.



Farm Island State Park - Pierre Energy Savings by ECM Category.



Farm Island State Park - Pierre Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 42 MMBTUs (6.5% of campus energy use) and a total estimated annual cost avoidance of $1,135. The total cost of implementation for these measures is $3,810, which yields a simple payback of 3.4 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Farm Island State Park	5.4.20	$0	3	$81	0.0	0.00
Farm Island State Park	5.1.8	$120	8	$257	0.5	14.75
Farm Island State Park	5.1.7	$1,270	13	$408	3.1	98.54
Farm Island State Park	5.5.2	$2,420	19	$390	6.2	129.92
TOTAL		**$3,810**	**42**	**$1,137**	**3.4**	**90.25**

4.7.3 Missouri River Fisheries Development Center

Campus Background and List of Facilities

See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Missouri River Fishery facilities consumed a combined 647 MMBTUs of energy. The average Energy Use Intensity across the campus was 51 kBTU/SF in 2008.

4.7.3.1. Missouri River Fishery

Building Overview

The Missouri River Fisheries main office/visitor's center was constructed in 1996 and is 8,185 square feet. There are approximately 10 occupants on a regular working day. This building is operated 8 hours per day, 5 days per week. The building is mostly administrative offices and conference rooms. The main office/visitor's center is presently in the planning phase of a building expansion project.

A constant speed Trane air handler with heating and DX cooling provides ventilation. A condensing unit resides outside. Hot water is used for heating and is provided by a 180 kW electric boiler. Hot water pump is constant speed. HVAC controls are DDC and tie into a building automation system with a wall mount interface. Domestic hot water is provided by a 12 kW electric water heater. There is also lab hood exhaust, shop exhaust and a hot water unit heater, restroom exhaust, and conference room exhaust

Interior lighting is primarily 4' T-8 32W strip lighting. Shop area has 8' 2-lamp T-12 strip lighting. Interior lights are manually controlled.

The exterior finish is wood and the interior finish is sheetrock and block. Windows are double pane with shades. There is not an entrance vestibule and the building envelope condition is in good condition.

ECM's

Previously Implemented ECMs

A new building addition is currently under construction that includes many energy conservation strategies and high efficiency equipment.

Opportunities for ECMs at Missouri River Fisheries							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$200	0.3	882	$95	2.1	5
5.1.3	Install Motion Sensors to Control Lighting	$400		1,022	$110	3.6	
5.1.5	Replace Incandescent Exit Signs with LED	$600	0.1	995	$107	5.6	
5.1.6	Replace Incandescent Spot Lighting with Ceramic Metal Halide	$200	0.8	2,384	$257	0.8	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$100	0.5	238	$26	3.9	4
5.3.4	Install VFDs on Single Zone Constant Volume AHUs	$10,200	0.1	89,956	$9,715	1.0	
5.4.12	Insulate Refrigerant Piping	$200		686	$74	2.7	
	TOTAL	**$11,900**	**2**	**96,163**	**10,386**	**1.1**	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Exterior lighting
4. Mechanical room lighting.
5. Cost Assumes installation by in-house staff.

Estimated Blended Marginal Rates		
$	.108	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

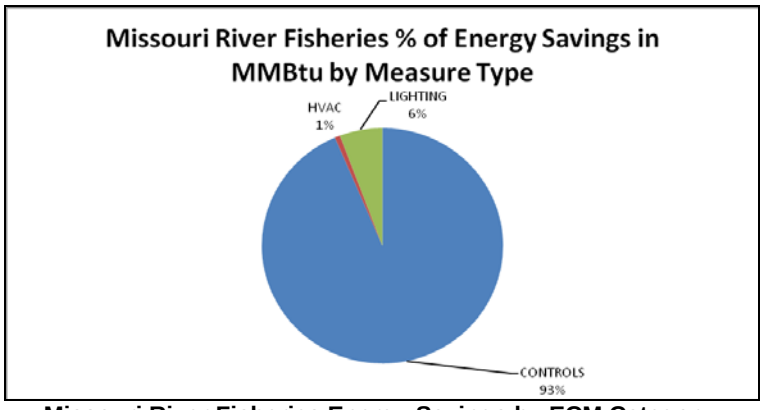
4.7.3.1.1. Campus Summary

A total of 7 ECMs were identified at Missouri River Fisheries, which include 328 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $10,386, and save an estimated $11,900 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

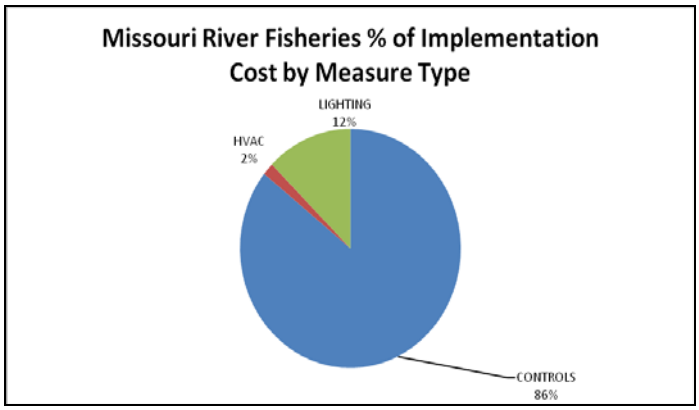
Missouri River Fisheries ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	307	0	307	$9,715	$10,200	1.0
HVAC	2	0	2	$74	$200	2.7
LIGHTING	19	0	19	$596	$1,500	2.5
Total	328	0	328	$10,386	$11,900	1.1

In total, these savings represent a 50% reduction from current energy consumption at the Missouri River Fisheries, the majority of which is attributed to Controls measures which will reduce natural gas consumption.



Missouri River Fisheries Energy Savings by ECM Category.



Missouri River Fisheries Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 328 MMBTUs (50% of campus energy use) and a total estimated annual cost avoidance of $10,386. The total cost of implementation for these measures is $11,900, which yields a simple payback of 1.1 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Missouri River Fishery	5.1.6	$200	8	$257	0.8	24.59
Missouri River Fishery	5.3.4	$10,200	307	$9,715	1.0	33.23
Missouri River Fishery	5.1.1	$200	3	$95	2.1	66.43
Missouri River Fishery	5.4.12	$200	2	$74	2.7	85.49
Missouri River Fishery	5.1.3	$400	3	$110	3.6	114.75
Missouri River Fishery	5.1.8	$100	1	$26	3.9	122.94
Missouri River Fishery	5.1.5	$600	3	$107	5.6	176.71
Total		**$11,900**	**328**	**$10,386**	**1.1**	**36.27**

4.7.4 Palisades State Park

Campus Background and List of Facilities

- Main Headquarters
- Park Director's Residence
- West Shed, Group Lodge
- Cabins 1-6, Comfort Station
- Guard Shack Palisades State Park

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Palisades, Garretson SD facilities consumed a combined 123 MMBTUs of energy. The average Energy Use Intensity across the campus was 106 kBTU/SF in 2008.

4.7.4.1. Comfort Station / Cabins / Guard Shack

Building Overview

The Comfort Station is a communal bathroom with showers. Domestic hot water is provided by an electric hot water heater.

The cabins have electric heating and wall air conditioning. Cabins do not have running water. Cabins are approximately 100-150 square feet.

The guard shack is scheduled to be replaced in 2010.

ECM's

Previously Implemented ECMs

No recent ECMs to report.

Opportunities for ECMs at Comfort Station / Cabins / Guard Shack

No suitable energy conservation measures were discovered.

4.7.4.2. Group Lodge

Building Overview

The Group Lodge is a residential home built around 1986 and renovated in 2007 when the park purchased the property. It is approximately 1700-1800 square feet. The lodge contains four bedrooms and two bathrooms.

The Group Lodge has a high efficiency forced air furnace and heat pump combo installed in 2007.The domestic hot water is provided by a 105 gal, 4.5 kW high efficiency Marathon electric water heater.

Lighting is a mixture of incandescent and CFLs.

Exterior is wood composite siding. The roof is wood shake and original. Some leaking is occurring around flashing. Windows are double pane with window treatments.

ECM's

Previously Implemented ECMs

No recent ECMs to report.

Opportunities for ECMs at Group Lodge						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$150	0.9	1,335	$158	1.0
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$2,190		4,589	$541	4.0
	TOTAL	$2,340	1	5,924	699	3.3

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.118	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	2.21	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.4.3. Main Headquarters / West Shed

Building Overview

Main HQ building consists of offices, break room, and shop. The building occupancy is not a set schedule. Park personnel use the space sporadically between 6am – 11pm.Shop and break room were added to the Main HQ building in 2005 and is approximately 450 square feet.

Office area and break room are heated by electric radiation. The shop is heated by a propane fired infrared heater. Two wall air conditioners provide cooling for the office area and break room. Park personnel are disciplined to shut units off when building is unoccupied. Control is local non-programmable thermostats. The West Shed does not have any HVAC.

Office/break room lighting is a mixture of 4' 2-lamp, 32W T-8s and 40W T12s.Shop area is a mixture of (13) 4' 2-lamp, 32W T-8s and (4) 250W sodium vapor fixtures. Sodium Vapor lighting does not get used frequently. All lighting is on toggle switches. Exit signs are LED. The West Shed has incandescent lighting.

Exterior is aluminum siding. Windows are double pane with shades

ECM's

Previously Implemented ECMs

None.

Opportunities for ECMs at Main Headquarters / West Shed							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$120	0.1	206	$24	4.9	3
5.1.3	Install Motion Sensors to Control Lighting	$210	-	409	$48	4.4	
5.1.7	Retrofit T-12 Fixtures with T-8s	$270	0.2	372	$44	6.2	
	TOTAL	$600	0	987	116	5.2	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.118	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	2.21	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.4.4. Park Director's Residence

Building Overview

The Director's Residence was constructed in the 1970's and is approximately 1100 square feet. The Residence is used a primary home for the Director's family.

Residence has a high efficient central air propane furnace installed in 2002.The air conditioning condensing unit is old and in need of replacement. Domestic hot water is provided by a 52 gallon, 4.5 kW electric hot water heater.

Exterior is wood composite siding that's in need of painting. The roof was replaced in 2002 with a complete tear-off. Windows are double pane with window treatments were installed in 2000

ECM's

Previously Implemented ECMs

Efficient furnace installed.

Opportunities for ECMs at Park Director's Residence					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings	Estimated Annual Cost Avoidance	Simple Payback Years
			Electric kWh		
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$2,190	4,589	$541	4.0
	TOTAL	$2,190	4,589	541	4.0

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.118	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	2.21	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

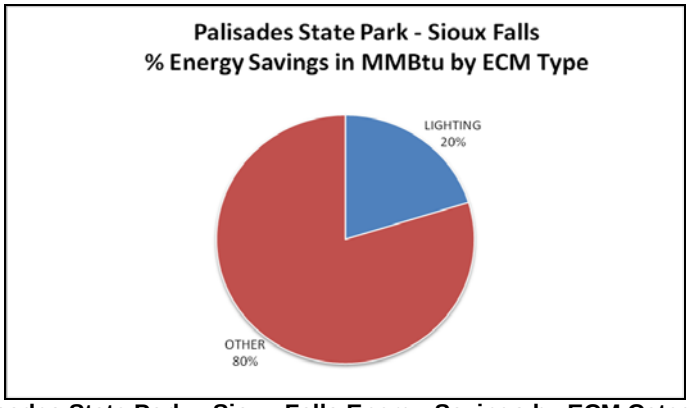
4.7.4.4.1. Campus Summary

A total of 6 ECMs were identified at Palisades State Park – Sioux Falls buildings, which include 39 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $5,130, and save an estimated $1,357 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

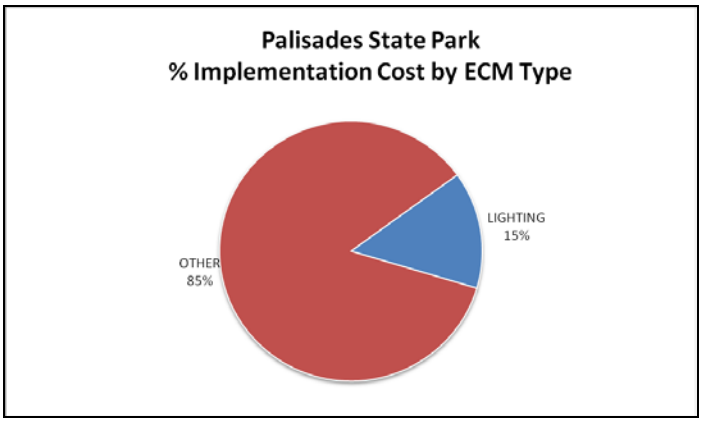
GFP ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	8	0	**8**	$274	$750	**2.7**
OTHER	31	0	**31**	$1,083	$4,380	**4.0**
Total	**39**	**0**	**39**	**$1,357**	**$5,130**	**3.8**

In total, these savings represent a 32% reduction from current energy consumption at the Palisades State Park – Sioux Falls campus, the majority of which is attributed to other measures which will reduce electric consumption.



Palisades State Park – Sioux Falls Energy Savings by ECM Category.



Palisades State Park – Sioux Falls Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 39 MMBTUs (32% of campus energy use) and a total estimated annual cost avoidance of $1,357. The total cost of implementation for these measures is $5,130, which yields a simple payback of 3.8 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Group Lodge	5.1.8	$150	5	$158	1.0	32.93
Group Lodge	5.5.1	$2,190	16	$541	4.0	139.88
Park Director's Residence	5.5.1	$2,190	16	$541	4.0	139.88
Main HQ / West Shed	5.1.3	$210	1	$48	4.4	150.60
Main HQ / West Shed	5.1.1	$120	1	$24	4.9	170.40
Main HQ / West Shed	5.1.7	$270	1	$44	6.2	213.00
TOTAL		**$5,130**	**39**	**$1,357**	**3.8**	**130.75**

4.7.5 Sioux Falls Regional Maintenance Complex

Only one building for this campus. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Wildlife Sioux Falls Maintenance Shop, Sioux Falls SD facilities consumed a combined 3,020 MMBTUs of energy. The average Energy Use Intensity across the campus was 174 kBTU/SF in 2008.

4.7.5.1. Building 600 (DOT Campus)

Building Overview

Building 600 is occupied by Game, Fish, & Parks. Building is used for offices and maintenance area. Approximately 25 workers occupy the building. Typical occupancy is M-F 8-5.

One 56 MBH gas fired furnaces with DX cooling serve office space in building 600.Maintenance bays are heated by a combination of gas fired infrared heaters and gas fired unit heaters.

Lighting in the office space is primarily 4' 2-lamp F32T8.Lights are controlled by toggle switches and there are no occupancy sensors. Lighting in the repair shop is 400W metal halide. Exit signs are LED.

The building exterior is pre-cast concrete. The roofs are flat and off-white. Windows are double pane

ECM's

Previously Implemented ECMs

No recent ECMs to report.

Opportunities for ECMs at Building 600 (DOT Campus)

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$500	0.5	1,290	$101	5.0	3
5.1.3	Install Motion Sensors to Control Lighting	$1,550	-	2,322	$181	8.6	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$2,340	2.4	4,978	$388	6.0	
	TOTAL	**$4,390**	**3**	**8,590**	**670**	**6.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.078	/kWh Elec
$	0.773	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.5.2. Regional Maintenance Complex – Sioux Falls

Building Overview

This building was originally constructed in 1996-1997.There is approximately 10-12 full time staff. The complex is occupied M-F 6am-9pm, Sat 8-4, Sun 10-4.

Two VAV air handlers with DX cooling and hot water heating serve the building. The hot water is provided by three 276 MBH gas fired modular boilers. Two 2 hp hot water pumps are constant speed. The building control system is a DOS based Landis Staefa package. During the investigation discharge air static pressure sensor was faulty and causing AHU-1 fan to operate at 100% resulting in a wind tunnel effect in the main corridor. The building was being over-pressurized and the building exhaust was at 100% in attempt to meet the pressure setpoint. Considerable amount of conditioned air was being exhausted making the system inefficient. The building's local controls technician is expected to replace the faulty sensor and return equipment to normal operation. Domestic hot water is provided by a 50 gallon gas fired water heater.

Lighting is primarily 4' 2-lamp F32T8 controlled by toggle switches. Exit signs are a mixture of incandescent and fluorescent

ECM's

Previously Implemented ECMs

No recent ECMs to report.

Opportunities for ECMs at Regional Maintenance Complex – Sioux Falls

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$1,200	1.2	5,511		$353	3.4	3
5.1.3	Install Motion Sensors to Control Lighting	$3,720	-	7,802		$499	7.5	
5.1.5	Replace Incandescent Exit Signs with LED	$810	0.2	1,493		$96	8.5	
5.2.1	Full Retrocomissioning and Balancing Study	$17,500	1.7	15,000	301	$1,200	14.6	
5.3.9	Upgrade Controls System to Full DDC	$92,000	12.8	31,990	550	$2,486	37.0	
	TOTAL	**$115,230**	**16**	**61,795**	**851**	**4,634**	**24.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.078	/kWh Elec
$	0.773	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

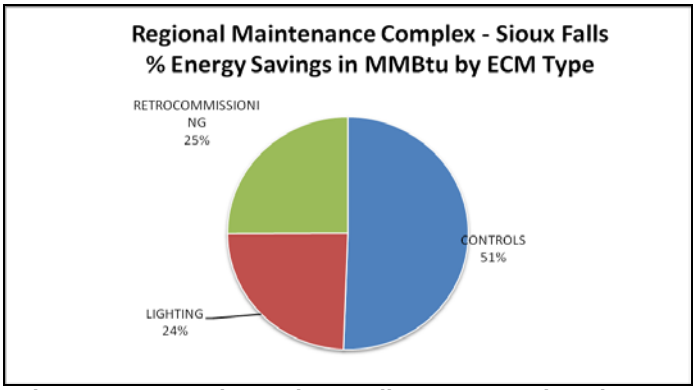
4.7.5.2.1. Campus Summary

A total of 14 ECMs were identified at Regional Maintenance Complex – Sioux Falls buildings, which include 328 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $119,620, and save an estimated $5,304 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

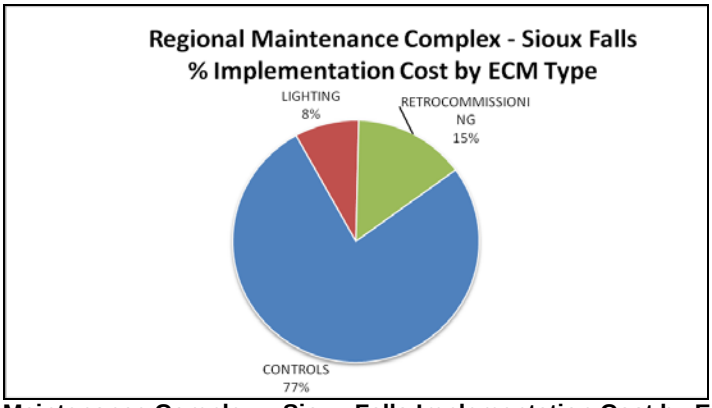
GFP ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	109	57	166	$2,486	$92,000	**37.0**
LIGHTING	80	0	80	$1,618	$10,120	**6.3**
RETROCOMMISSIONING	51	31	82	$1,200	$17,500	**14.6**
Total	**240**	**88**	**328**	**$5,304**	**$119,620**	**22.6**

In total, these savings represent a 11% reduction from current energy consumption at the Regional Maintenance Complex – Sioux Falls campus, the majority of which is attributed to controls measures which will reduce natural gas & electric consumption.



Regional Maintenance Complex – Sioux Falls Energy Savings by ECM Category.



Regional Maintenance Complex – Sioux Falls Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 40 MMBTUs (1% of campus energy use) and a total estimated annual cost avoidance of $842. The total cost of implementation for these measures is $4,040, which yields a simple payback of 4.8 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Regional Maintenance Complex	5.1.1	$1,200	19	$353	3.4	63.82
Bldg 600 (DOT Campus)	5.1.1	$500	4	$101	5.0	113.60
Bldg 600 (DOT Campus)	5.1.10	$2,340	17	$388	6.0	137.76
TOTAL		**$4,040**	**40**	**$842**	**4.8**	**100.52**

4.7.6 Wildlife District & Region Office - Huron

Campus Background and List of Facilities

See Building Description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Wildlife District Office, Huron SD facilities consumed a combined 69 MMBTUs of energy. The average Energy Use Intensity across the campus was 33 kBTU/SF in 2008.

4.7.6.1. Wildlife District & Region Office - Huron

Building Overview

The Wildlife District & Regional Office building in Huron is a 4,000 square foot leased facility. The facility has 7 employees who occupy the building from 8 am to 5 pm on weekdays. The building is not occupied during weekends or holidays.

Heating and cooling for the facility is provided by a Lennox residential style gas fired 75 MBTU input (92% rated efficiency) furnace with DX cooling. Control for the furnace is accomplished with a local non-programmable electronic thermostat set for 70°F.The thermostat is not adjusted daily for unoccupied hours. The facility uses an air to air heat recovery system to pre-condition outdoor air. This energy recovery unit is interlocked with

the furnace to run only when the furnace is operating. Each toilet room is individually exhausted and has a manually operated timer switch.

The building envelope is constructed of wood framed operable windows, wooden siding and frame construction.

The offices, corridors, and conference rooms are lit with two lamp, 34 watt, T12 fixtures. Exterior lighting is accomplished with 60watt incandescent bulbs. The interior fixtures are manually controlled via wall mounted light switch. Exterior lighting is controlled with a time clock which is set to have the lights on from 9pm to 7:30am daily.

Domestic hot is provided by a 30 gallon 32 MBTU gas fired atmospheric heater.

ECM's

Previously Implemented ECMs

An air to air heat exchanger is installed on the furnace system to pre-condition outdoor air for ventilation.

A timer is installed on the exhaust fans in each toilet room.

Opportunities for ECMs at Wildlife District & Region Office - Huron								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$150		200		$16	9.4	1,4
5.1.7	Retrofit T-12 Fixtures with T-8's	$1,730	1	4,200		$336	5.1	1,
5.1.8	Replace Incandescent Lights with Compact Fluorescent	$420	1	4,779		$382	1.1	1,
5.1.17	Install Photocells to Control Exterior Lighting	$120		628		$50	2.4	1,3
5.3.2	Programmable Thermostat for Residential Style Units	$350		3,351	165	$433	0.8	1,
5.5.2	Replace Storage Type Domestic Water Heaters with On Demand	$1,150			70	$70	16.4	1,
	TOTAL	$3,770	3	12,958	235	1,272	3.0	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Assumes one additional hour per day that the exterior lighting would be off.
4. Assumes that toilet room lighting is off one additional hour per day.

Estimated Blended Marginal Rates		
$	0.10	/kWh Elec
$	1.00	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.6.1.1. Campus Summary

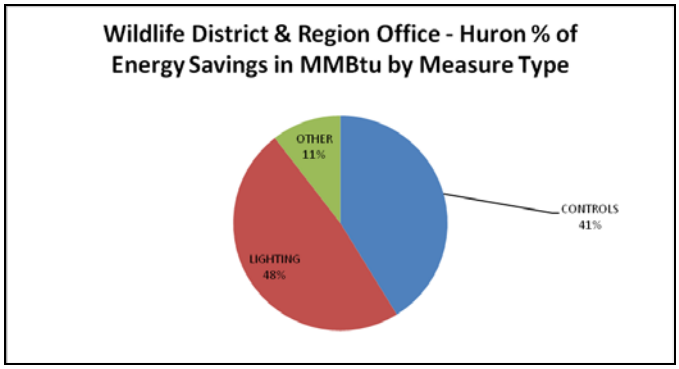
A total of 6 ECMs were identified at Wildlife District & Region Office - Huron buildings, which include 69 MMBTUs in potential annual energy savings. Implementing

all ECMs would cost a total of approximately $3,920, and save an estimated $1,288 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

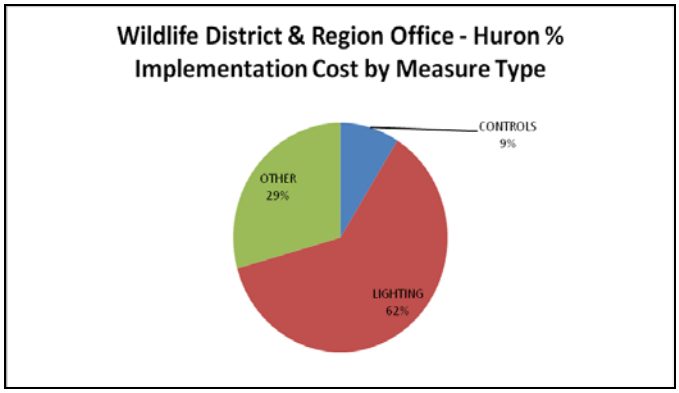
GFP ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	11	17	**28**	$433	$350	0.8
LIGHTING	33	0	**33**	$785	$2,420	3.1
OTHER	0	7	**7**	$70	$1,150	16.4
Total	**45**	**24**	**69**	**$1,288**	**$3,920**	**3.0**

In total, these savings represent a 3.5% reduction from current energy consumption at the Wildlife District & Region Office - Huron, the majority of which is attributed to Lighting measures which will reduce electric consumption.



Wildlife District & Region Office - Huron Energy Savings by ECM Category.



Wildlife District & Region Office - Huron Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar

invested. This will yield a savings of 61 MMBTUs (3% of campus energy use) and a total estimated annual cost avoidance of $1,202. The total cost of implementation for these measures is $2,620, which yields a simple payback of 2.2 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Wildlife District & Region Office - Huron	5.3.2	$350	28	$433	0.8	12.28
Wildlife District & Region Office - Huron	5.1.8	$420	16	$382	1.1	25.76
Wildlife District & Region Office - Huron	5.1.16	$120	2	$50	2.4	55.96
Wildlife District & Region Office - Huron	5.1.7	$1,730	14	$336	5.1	120.72
TOTAL		$2,620	61	$1,202	2.2	42.76

4.7.7 Wildlife Region I - Cleghorn Hatchery

Campus Background and List of Facilities

The Cleghorn Hatchery is located in Rapid City, SD. The hatchery receives trout eggs, the eggs hatch, the fish grow, and after approximately one year, the fish are released to various locations in the State. There is one office for staff, and several buildings which serve to facilitate the hatching and development processes. There is also a visitors center and several small buildings on the campus.

Campus-Wide Systems and Operational Profile

There are no campus wide systems.

Energy Profile

In 2008, Wildlife – Cleghorn Springs Fish Hatchery, Rapid City SD facilities consumed a combined 1,455 MMBTUs of energy. The average Energy Use Intensity across the campus was 115 kBTU/SF in 2008.

4.7.7.1. Food Storage Building

Building Overview

The Food Storage Building is unheated but does contain six 300W incandescent lights. The building is used daily for about one hour each day.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Food Storage Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$6,000	-	19,344	-	$2,205	2.7	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$10,000	-	48,672	-	$5,549	1.8	3
5.3.9	Upgrade Controls System to Full DDC	$75,000	-	3,811	556	$634	118.3	
5.4.37	Relocate Preheat Coil	$5,000	-	-	700	$251	19.9	4
5.5.15	Replace Electric Hot Water Heater with Gas	$3,600	-	6,570	(231)	$666	5.4	
	TOTAL	**$99,600**	**-**	**78,397**	**1,026**	**$9,306**	**10.7**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume 200 fixtures, with 5 fixtures per sensor, and a 3 hour reduction in lighting per day.
3. Costs assume reballast completed by in house staff. Additional contractors or fixture changes will add more cost.
4. This measure will also increase occupant comfort during the winter.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	0.36	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.7.7.2. Generator Building

Building Overview

The generator building houses the electrical generator and pavilion pump VFD controls. The space is minimally conditioned using electric unit heaters.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Generator Building

No suitable energy conservation measures were discovered.

4.7.7.3. Hatchery Building

Building Overview

The Hatchery Building houses many tanks where the trout grow and develop for several months. Water is constantly circulated from underground by pumps located outside the building, up to oxygenation towers, and into the open tanks. Two ten horsepower pumps are each equipped with VFDs which control to a tower head pressure. The VFD controls are housed in the Hatchery Office building. A small laboratory area utilizes a point of use electric water heater, as well as a fume exhaust hood that is rarely used.

The constant circulation of 55° F water into the building helps to maintain a 55° F temperature in the building with no conditioning. A gas fired furnace can provide heat for freeze protection when needed, but the unit rarely operates.

Lighting is provided by T-8 fluorescent fixtures.

ECM's

Previously Implemented ECMs

Circulation pumps are equipped with VFDs. Lighting was upgraded from T-12 to T-8 in 2002.

Opportunities for ECMs at Hatchery Building

No suitable energy conservation measures were discovered.

4.7.7.4. Hatchery Office

Building Overview

The office building at the Cleghorn Hatchery was built in 2007.Space conditioning is provided using a DX air handling unit. A programmable thermostat provides setback temperatures during unoccupied times.

The shop utilizes gas fired unit heaters. The units must run for long periods during the winter, as the roof in the shop is not insulated. The garage is not conditioned.

Domestic hot water is provided using a 30 gallon, 4.5 kW electric water heater.

Lighting is provided using T-8 fluorescent lamps which are manually controlled and are wired in a tandem configuration.

The double paned windows are operable.

ECM's

Previously Implemented ECMs

The lights are wired in tandem.

Opportunities for ECMs at Hatchery Office								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$110	-	499	-	$36	3.1	2
5.5.15	Replace Electric Hot Water Heater with Gas	$1,500	5	3,285	(115)	$146	10.2	3
	TOTAL	$1,610	5	3,784	(115)	$182	8.8	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. 28W selected.

Estimated Blended Marginal Rates		
$	0.07	/kWh Elec
$	0.78	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

4.7.7.5. Oxygen Storage Building

Building Overview

Prior to the new oxygenation system, an oxygen storage facility was used to store oxygen tanks to support the hatchery. The building is rarely used but is conditioned by an electric unit heater which maintains a space temperature of 60° F.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Oxygen Storage Building

No suitable energy conservation measures were discovered.

4.7.7.6. Pavilion

Building Overview

The Pavilion houses many tanks where the trout are moved following their time in the Hatchery Building. Again, water is oxygenated using two sets of pumps which run continuously. The pumps utilize VFDs which modulate to maintain the oxygenation tower head pressures.

There are no fully enclosed spaces in the pavilion; the tanks are open to outside conditions. Lighting is provided using incandescent lamps to ensure operation during all weather conditions. The lights are only used during the winter when the sunrise is later in the day. All other times, natural light provides adequate illumination.

ECM's

Previously Implemented ECMs

Circulation pumps are equipped with VFDs.

Opportunities for ECMs at Pavilion

No suitable energy conservation measures were discovered.

4.7.7.7. Visitor's Center

Building Overview

The Visitor's Center at the Cleghorn Hatchery houses exhibits which are open from 9:30 A.M. until 3:30 P.M. for three months during the summer.

The space is conditioned using a gas fired rooftop unit with DX cooling. During the winter, temperatures are set back to 55° F.

Domestic hot water is provided using a 4.5 kW electric water heater.

Lighting is provided using T-12 fluorescent lamps, halogen track lighting, and some incandescent lamps.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Visitor's Center

No suitable energy conservation measures were discovered.

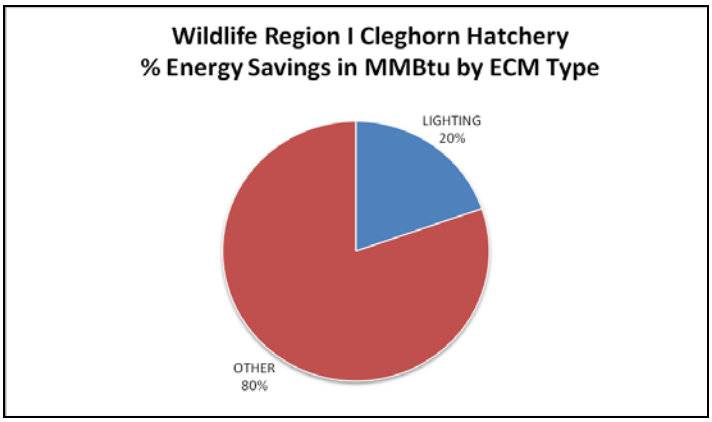
4.7.7.7.1. Campus Summary

A total of 2 ECMs were identified at Wildlife Region I Cleghorn Hatchery buildings, which include 1 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $1,610, and save an estimated $182in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

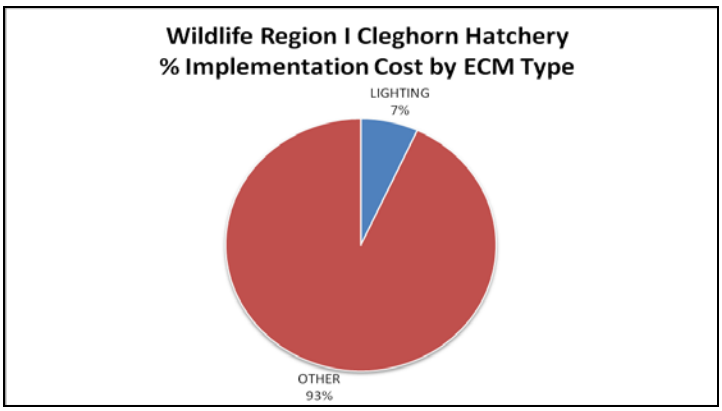
GFP ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	2	0	**2**	$36	$110	**3.1**
OTHER	11	-12	**-1**	$146	$1,500	**10.2**
Total	13	-12	**1**	$182	$1,610	**8.8**

In total, these savings represent a minimal reduction from current energy consumption at the Wildlife Region I Cleghorn Hatchery.



Wildlife Region I Cleghorn Hatchery Energy Savings by ECM Category.



Wildlife Region I Cleghorn Hatchery Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a total estimated annual cost avoidance of $182. The total cost of implementation for these measures is $1,610, which yields a simple payback of 8.8 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Hatchery Office	5.1.1	$110	2	$36	3.1	64.58
Hatchery Office	5.5.15	$1,500	-1	$146	10.2	n/a
TOTAL		**$1,610**	**1**	**$182**	**8.8**	**1,620.57**

4.7.8 Wildlife District & Region Office - Watertown

Campus Background and List of Facilities

See Building Description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Wildlife Office – Region 4, Watertown, SD facilities consumed a combined 391 MMBTUs of energy. The average Energy Use Intensity across the campus was 151 kBTU/SF in 2008.

4.7.8.1. Wildlife District & Region Office - Watertown

Building Overview

The Wildlife District & Regional Office building in Watertown is a 16,000 square foot facility. The facility has 18 employees who occupy the building from 8 am to 5 pm on weekdays. The building is intermittently occupied during weekends or holidays.

Heating and cooling for the office areas is provided by two Trane XL 90 gas fired furnaces with DX cooling. Control for the furnaces is accomplished with a local non-programmable electronic thermostat set for 70°F.The thermostat is not adjusted daily for unoccupied hours or weekend setbacks. The 2004 office expansion area is served with one Carrier air to air heat pump. The shops and storage areas are heated with gas fired unit heaters on local thermostats.

Each toilet room is individually exhausted and has a manually operated switch.

The building envelope is constructed of wood framed operable windows, and wooden siding and construction.

The offices, corridors, and conference rooms are lit with two lamp, 32 watt, T8 fixtures. Exterior lighting is accomplished with incandescent bulbs. The interior fixtures are manually controlled via wall mounted light switches.

Domestic hot water is provided by a 30 gallon 4.5 kW electric water heater.

ECM's

Previously Implemented ECMs

Incandescent lighting is being replaced with compact fluorescent as they expire.

Opportunities for ECMs at Wildlife District and Region Office - Watertown								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM)	Estimated Implementation	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Office Areas in Lieu of 32W	$580	1	2,976		$241	2.4	1
5.1.7	Retrofit T-12 Fixtures with T-8	$3,450	2	5,144		$417	8.3	1
5.3.2	Programmable Thermostats for Residential Style Units	$350	0	3,990	395.5547	$574	0.6	1
	TOTAL	**$4,380**	**3**	**12,110**	**396**	**1,231**	**3.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.08	/kWh Elec
$	0.63	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

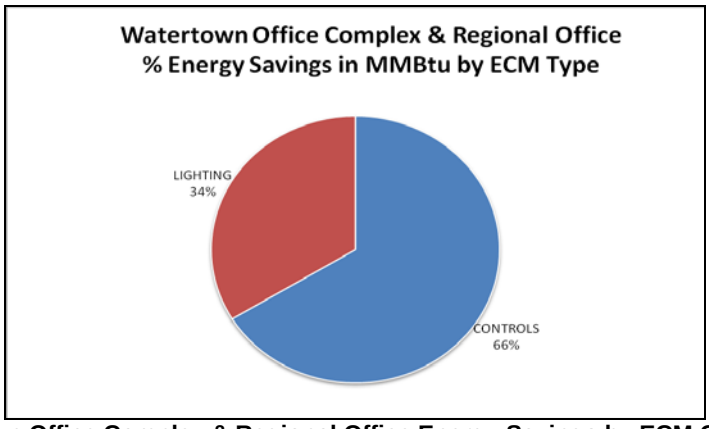
4.7.8.1.1. Campus Summary

A total of 3 ECMs were identified at Watertown Office Complex & Regional Office, which include 82 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $4,380, and save an estimated $1,231 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

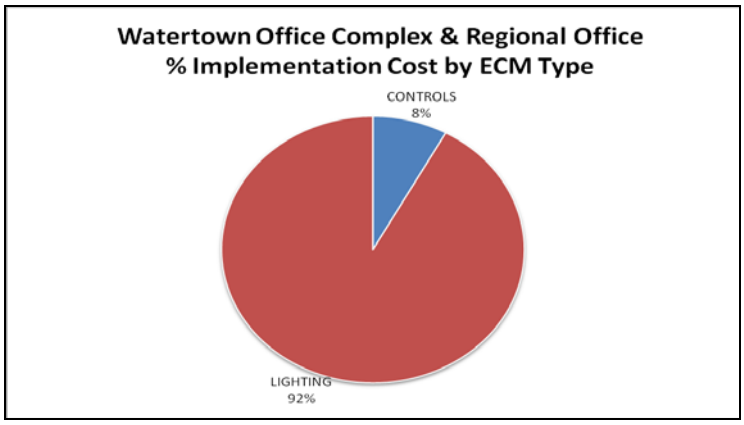
GFP ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	14	41	**55**	$574	$350	**0.6**
LIGHTING	28	0	**28**	$658	$4,030	**6.1**
Total	**41**	**41**	**82**	**$1,231**	**$4,380**	**3.6**

In total, these savings represent a 21% reduction from current energy consumption at the Watertown Office Complex & Regional Office, the majority of which is attributed to controls measures which will reduce natural gas consumption.



Watertown Office Complex & Regional Office Energy Savings by ECM Category.



Watertown Office Complex & Regional Office Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 82 MMBTUs (21% of campus energy use) and a total estimated annual cost avoidance of $1,231. The total cost of implementation for these measures is $4,380, which yields a simple payback of 3.6 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
	5.3.2	$350	55	$574	0.6	6.42
	5.1.1	$580	10	$241	2.4	57.11
	5.1.7	$3,450	18	$417	8.3	196.59
TOTAL		**$4,380**	**82**	**$1,231**	**3.6**	**53.27**

4.8 Leased Facilities (LSA)

Leased Facilities were grouped into a separate section to account for the difference between facilities owned by the State and those owned by a third party for which the State pays for occupancy. For some leased facilities, the lease includes the cost of utilities, and therefore the State does not receive the utility bills to track energy use. In all leased facilities, operations are the responsibility of the Lessor and as a result, the State is limited in their ability to affect changes in operations to reduce energy use.

There is a total of 704,409 square feet of Leased Facilities controlled by the State of South Dakota, based on documentation provided by OSE. Energy use in 2008 was provided for 543,200 square feet of space, which totaled 52,183 MMBTUs of energy consumed at these locations. This results in an average EUI of 96 kBTU per square foot for 2008.

To estimate energy use at Leased Facilities where no energy consumption data was available, the EUI (96 kBTU/SF) can be extrapolated to the remaining 161,209 square feet of facilities, assuming the average EUI is the same. This calculation results in an additional 15,487 MMBTUs in energy used at Leased Facilities, bringing the total estimated energy consumed to 67,670 MMBTUs in 2008.

4.8.1 Bureau of Administration (Central Services) - Pierre

Campus Background and List of Facilities

This is a stand-alone building. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, leased Administration facilities consumed a combined 1,526 MMBTUs of energy. The average Energy Use Intensity across the campus was 37 kBTU/SF in 2008.

4.8.1.1. Central Services

Building Overview

The Central Services Building is 8,185 square feet.This building is leased.There are approximately 15 occupants on a regular working day.This building is occupied 9 hours per day, 6 days per week.The building is administrative offices, print area and warehouse.The building was originally designed for and operated as a grocery store before it was converted to office and storage type occupancy.

There are six gas fired furnaces that supply heat to the building. There are five split DX cooling systems that provide cooling to the building. Additionally, there is a rooftop unit that provides gas fired heating and DX cooling to the main office space. Each unit is controlled independently based on an independent thermostat for each. Domestic hot water is provided by an electric water heater.

Interior office lighting is T-8 strip lighting. Two lamp, 8' T-12s are used throughout the warehouse. The open office area is lit to as high as 85 foot-candles. Interior lights are manually controlled. There is high pressure sodium lighting illuminating the perimeter of the building.

The exterior finish is brick and corrugated metal siding. The interior finish of the office is sheetrock and block and metal siding in the warehouse. Most windows are double pane with shades. There is an entrance vestibule. There is limited insulation in the walls and roof.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Central Services Building						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$2,650	2.1	6409	$493	5.4
5.1.2	Delamp Multiple Lamp Fixtures	$690	0.8	2601	$200	3.4
5.1.5	Replace Incandescent Exit Signs with LED	$1,270	0.2	1493	$115	11.0
5.1.7	Retrofit T-12 Fixtures with T-8s	$8,740	8.5	26440	$2,036	4.3
5.3.2	Programmable Thermostats for Residential Style Units	$1,040		5507	$424	2.5
5.4.20	Comb Condensing Unit Fins/Provide Hail Guards	$1,150	1.0	2,926	$225	5.1
	TOTAL	**$15,540**	**13**	**45,374**	**3,494**	**4.4**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.077	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

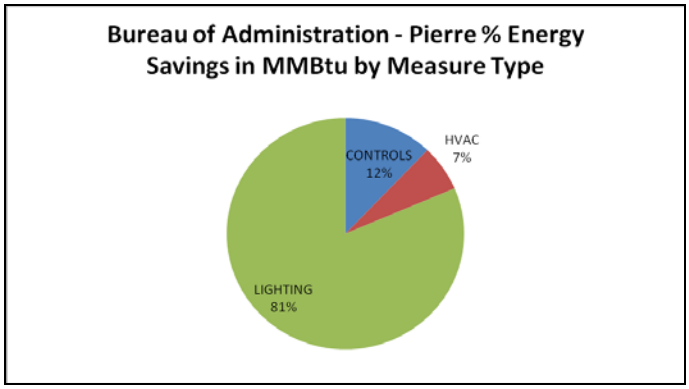
4.8.1.1.1. Campus Summary

A total of 6 ECMs were identified at Central Services, which include 155 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $15,540, and save an estimated $3,500 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

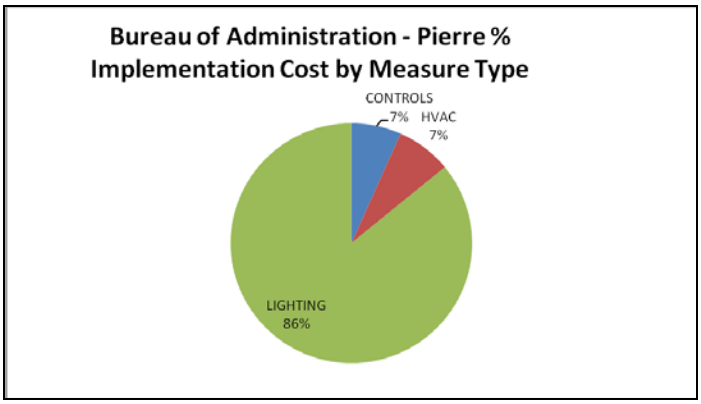
Bureau of Administration - Pierre ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	19	0	**19**	$424	$1,040	2.5
HVAC	10	0	**10**	$225	$1,150	5.1
LIGHTING	126	0	**126**	$2,845	$13,350	4.7
Total	**155**	**0**	**155**	**$3,494**	**$15,540**	**4.4**

In total, these savings represent a 10% reduction from current energy consumption at Central Services, the majority of which is attributed to lighting measures which will reduce electrical consumption.



Bureau of Administration – Pierre (Central Services)Energy Savings by ECM Category.



Bureau of Administration – Pierre (Central Services)Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 150 MMBTUs (10% of campus energy use) and a total estimated annual cost avoidance of $3,380. The total cost of implementation for these measures is $14,270, which yields a simple payback of 4.2 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Central Services	5.3.2	$1,040	19	$424	2.5	55.35
Central Services	5.1.2	$690	9	$200	3.4	77.76
Central Services	5.1.7	$8,740	90	$2,036	4.3	96.88
Central Services	5.4.20	$1,150	10	$225	5.1	115.19
Central Services	5.1.1	$2,650	22	$493	5.4	121.19
TOTAL		**$14,270**	**150**	**$3,379**	**4.2**	**95.31**

4.8.2 Department of Labor - Aberdeen

Campus Background and List of Facilities

See Building Description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, leased Labor facilities consumed a combined 17,242 MMBTUs of energy.

4.8.2.1. Department of Labor - Aberdeen

Building Overview

The Aberdeen Department of Labor building is a 40,000 square foot leased facility that was constructed in 1986.The property owner, 605 Holdings, assists with facility maintenance and is responsible for capital improvements. The facility has 150 employees who occupy the building from 8 am to 5 pm on weekdays. The building is not occupied during weekends or holidays.

Central heating is supplied one 25 hp (646 MBH output) Bryan flex tube, natural gas fired, water boiler which provides heating water to radiant panels, unit heaters, and the air handling unit coil as well as the heat pump loop. The boiler was installed in 1986 as part of the original construction. The boiler is enabled to operate year round and was operating at the time of our visit with a heating water setpoint of 180F. A 3/4 hp heating water pump circulates heating water (20% glycol) to the terminal units, while the condenser pump pulls water from the boiler if it needs heat for the heat pump loop.

A 120 ton evaporative fluid cooler cools the heat pump loop while two 10 hp condenser water pumps circulate water (20% glycol) through the heat pumps and fluid cooler. The condenser pumps operate as primary and standby with one pump operating 24 hours/day.

Heating and cooling for the facility is provided by water source heat pumps located above the ceilings. Control for the heat pumps is accomplished with local electronic thermostats which give the occupants the ability to adjust setpoints. Night setback is accomplished with local space temperature sensors which control a group of heat pumps to unoccupied heating and cooling setpoints. Stairwells are heated with cabinet unit heaters, while perimeter offices have supplemental ceiling mounted radiant panel heaters.

One 3,800 CFM air handling unit provides ventilation to the entire facility. The unit is equipped with a heating coil, MERV 8 filters, and outside and return air dampers. The dampers were set at 50% open at the time of our visit. The unit is controlled via a timeclock to start and stop at 7:30 am and 5:30 pm respectively.

Air conditioning for the server room is provided by two 8,000 Btu/hr window mounted air conditioning units and a ventilation fan.

The building envelope is constructed of wood framed operable windows, and masonry block with exterior face brick. The roofing is comprised of a ballasted membrane roof.

The offices, corridors, and conference rooms are lit with a combination of two, three and four lamp, 34 watt, T-12 fixtures as well as similar fixtures with, 32 watt T-8 lamps. Several areas in the building are manually de-lamped by office staff due to undesirable light levels.

Occupancy sensors are used for lighting control throughout the open office areas, however are not used in the conference rooms. The remaining fixtures are manually controlled via wall mounted light switch. Task lighting is also used in some office areas on an as needed basis. Exit lighting has been completely converted to LED fixtures.

ECM's

Previously Implemented ECMs

The roof was replaced in 2006 with a membrane roof with high R-value insulation.

Approximately 50% of all interior light fixtures have been replaced with T-8 lamps with electronic ballasts.

Opportunities for ECMs at Department of Labor - Aberdeen

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Office Areas in Lieu of 32W	$580	5	13,229		$966	0.6	1
5.1.2	Delamp Multiple Lamp Fixtures	$0	7	20,383		$1,488	0.0	4
5.1.3	Install Motion Sensors to Control Lighting	$920	-	901		$66	14.0	1
5.1.7	Retrofit T-12 Fixtures with T-8s	$21,390	5	14,763		$1,078	19.8	1
5.1.11	Implement Daylighting Controls	$690	-	3,199		$234	3.0	
5.3.1	Install VFD on Cooling Tower Fans	$8,400		25,940		$1,894	4.4	
5.3.3	Install VFDs on Hydronic Pumps	$9,200		36,191		$2,642	3.5	
5.4.2	Replace Boiler Plant at the end of its Useful Life Expectancy	$18,000			7,650	$5,967	3.0	6
5.4.25	Replace PTAC Heat Pumps at end of life with New	$24,840		56,007		$4,088	6.1	1,6
5.4.30	Trim Impeller and Open Triple Duty Valve	$2,760	1	8,867		$647	4.3	
5.5.2	Replace Storage Type Domestic Hot Water Heaters with On Demand	$1,610			66	$51	31.4	
5.5.16	Replace Standard Efficiency Hot Water Heater with High Efficiency	$230			11	$9	26.9	1,6
	TOTAL	**$88,620**	**18**	**179,479**	**7,726**	**19,129**	**4.6**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Payback based on incremental cost increase to use high efficiency systems at end of useful life of existing equipment.
4. Assumes de-lamping is completed by in house staff.
5. Measure assumed to be implemented in stairwells and open office spaces adjacent to windows.
6. Based on incremental cost premium for upgrade to high efficiency units.

Estimated Blended Marginal Rates		
$	0.07	/kWh Elec
$	.78	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

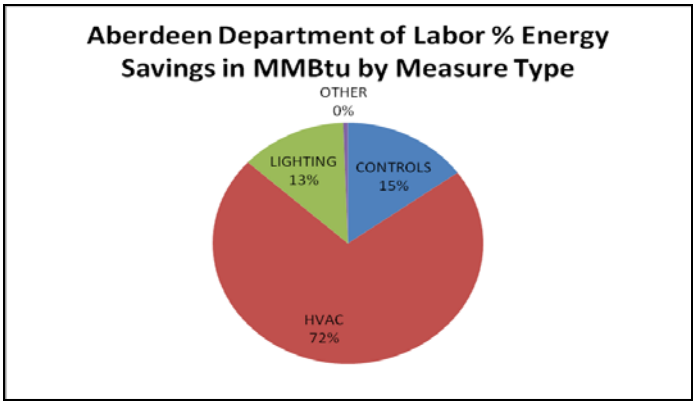
4.8.2.1.1. Campus Summary

A total of 12 ECMs were identified at Aberdeen Department of Labor, which include 1,411 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $88,620, and save an estimated $19,129 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

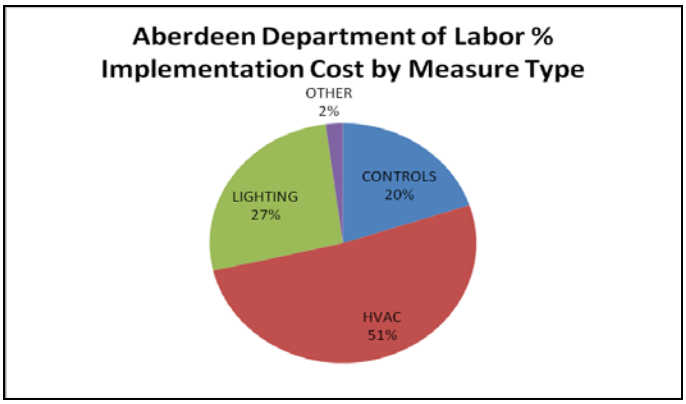
Aberdeen Department of Labor ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	212	0	**212**	$4,536	$17,600	**3.9**
HVAC	221	791	**1,012**	$10,703	$45,600	**4.3**
LIGHTING	179	0	**179**	$3,831	$23,580	**6.2**
OTHER	0	8	**8**	$60	$1,840	**30.8**
Total	**612**	**799**	**1,411**	**$19,129**	**$88,620**	**4.6**

In total, these savings represent a 6% reduction from current energy consumption at the Aberdeen Department of labor, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



Aberdeen Department of Labor Energy Savings by ECM Category.



Aberdeen Department of Labor Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 1,350 MMBTUs (6% of campus energy use) and a total estimated annual cost avoidance of $17,925. The total cost of implementation for these measures is $64,470, which yields a simple payback of 3.6 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Aberdeen Department of Labor	5.1.2	$0	70	$1,488	0.0	-
Aberdeen Department of Labor	5.1.1	580	45	$966	0.6	12.85
Aberdeen Department of Labor	5.1.11	$690	11	$234	3.0	63.21
Aberdeen Department of Labor	5.4.2	$18,000	791	$5,967	3.0	22.76
Aberdeen Department of Labor	5.3.3	$9,200	123	$2,642	3.5	74.50
Aberdeen Department of Labor	5.4.30	$2,760	30	$647	4.3	91.23
Aberdeen Department of Labor	5.3.1	$8,400	89	$1,894	4.4	94.91
Aberdeen Department of Labor	5.4.25	$24,840	191	$4,088	6.1	129.99
TOTAL		**$64,470**	**1350**	**$17,925**	**3.6**	**47.76**

4.8.3 Department of Labor – Rapid City

Campus Background and List of Facilities

The Department of Labor has several leased spaces in Rapid City at and around 111 New York Avenue.

Campus-Wide Systems and Operational Profile

There are no campus wide systems.

Energy Profile

In 2008, leased labor facilities in Rapid City consumed a combined 1,278 MMBTUs of energy. The average Energy Use Intensity across the campus was 62 kBTU/SF in 2008.

4.8.3.1. Department of Labor – 107C/109A New York Avenue

Building Overview

These two leased areas occupy 3,500 square feet which are in a separate building from the main office at the Department of Labor.

The spaces are served by constant volume, DX rooftop units. Fans cycle on and off using thermostats.The109A office has a programmable thermostat, but the 107C office has a manual thermostat.

The manually controlled lighting is primarily T-8 fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Department of Labor – 107C/109A New York Avenue

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.3.2	Programmable Thermostats for Residential Style Units	$500	-	480	136	$144	3.5
	TOTAL	$500	-	480	136	$144	3.5

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.

Estimated Blended Marginal Rates		
$	0.07	/kWh Elec
$	0.80	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.8.3.2. Department of Labor – 111 New York Avenue

Building Overview

This main office area occupies 16,150 square feet. Not included in this total is a 3,500 square foot area of the building that is leased by the Department of Human Services (DHS) for a Vocational Rehabilitation office. All utilities, however, are paid by the Department of Labor.

The building is served mainly by constant volume, DX rooftop units. Fans cycle on and off using manual dial thermostats.

In the Vocational Rehabilitation office, workers in this office explained that some areas are so cold in the summer that some bring in electric space heaters to avoid overcooling.

The manually controlled lighting is primarily T-12 fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Department of Labor – 111 New York Avenue								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$6,000	-	46,042	-	$3,402	1.8	2
3.1.7	Retrofit T-12 Fixtures with T-8s	$10,000	16	56,909	-	$4,206	2.4	3
5.3.2	Programmable Thermostats for Residential Style Units	$1,000	-	3,840	1,088	$1,152	0.9	
5.4.34	Eliminate Simultaneous Heating and Cooling	$0	-	4,067	-	$301	Instant	4
	TOTAL	**$17,000**	**16**	**110,858**	**1,088**	**$9,061**	**1.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume 200 fixtures, with 5 fixtures per sensor and a 5 hour lighting runtime reduction.
3. Costs assume reballast completed by landlord's staff. Additional contractors or fixture changes will add more cost.
4. Increase summer setpoints to prevent overcooling and eliminate electric space heaters.

Estimated Blended Marginal Rates		
$	0.07	/kWh Elec
$	0.80	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

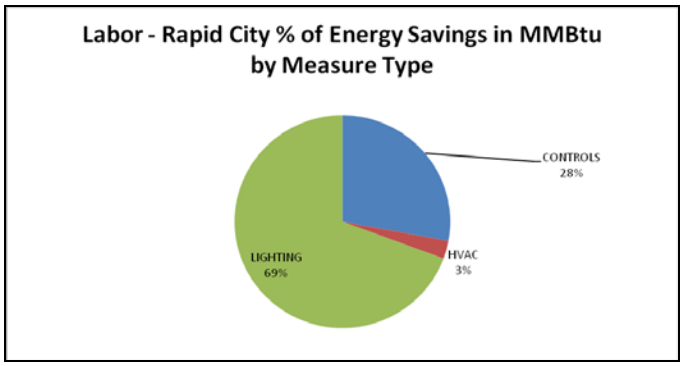
4.8.3.2.1. Campus Summary

A total of 5 ECMs were identified at Labor – Rapid City, which include 506 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $17,500, and save an estimated $9,205 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

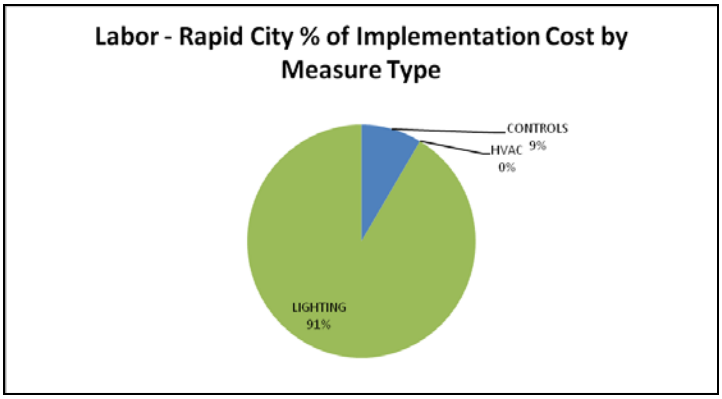
Labor – Rapid City ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	15	127	**141**	$1,296	$1,500	1.2
HVAC	14	0	**14**	$301	$0	0.0
LIGHTING	351	0	**351**	$7,608	$16,000	2.1
Total	**380**	**127**	**506**	**$9,205**	**$17,500**	**1.9**

In total, these savings represent a 39% reduction from current energy consumption at the Labor – Rapid City, the majority of which is attributed to Lighting measures which will reduce electrical consumption.



Labor – Leased Labor facilities in Rapid City, Energy Savings by ECM Category.



Leased Labor facilities in Rapid City, Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 506 MMBTUs (39% of campus energy use) and a total estimated annual cost avoidance of $9,205. The total cost of implementation for these measures is $17,500, which yields a simple payback of 1.9 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
111 New York Building	5.3.2	$1,000	126	$1,152	0.9	7.96
111 New York Building	5.1.3	$6,000	157	$3,402	1.8	38.19
111 New York Building	5.1.7	$10,000	194	$4,206	2.4	51.50
107C/109A New York Building	5.3.2	$500	16	$144	3.5	31.85
111 New York Building	5.4.34	$0	14	$301	Instant	0.00
TOTAL		**$17,500**	**506**	**$9,205**	**1.9**	**34.55**

4.8.4 Department of Social Services - Rapid City

Campus Background and List of Facilities

The Department of Social Services – Rapid City is located in a single leased building.

Campus-Wide Systems and Operational Profile

There are no campus wide systems.

Energy Profile

In 2008, leased Social Services facilities consumed a combined 2,219 MMBTUs of energy. The average Energy Use Intensity across the campus was 58 kBTU/SF in 2008.

4.8.4.1. Department of Social Services

Building Overview

The Department of Social Services in Rapid City occupies 38,500 square feet of primarily office space. One section of the building is sublet to the Department of Corrections. Typical office hours are from 7:00 A.M. to 5:00 P.M., Monday through Friday. Due to the nature of services provided, however, some office areas may be occupied at any time of day at a moment's notice.

The building is served mainly by constant volume, DX rooftop units and some residential style furnaces. Fans cycle on and off based on manual dial thermostats and some programmable thermostats, although setbacks are not currently programmed. Some areas utilize electric duct reheat coils.

Domestic hot water is provided by several 4.5 kW electric water heaters.

The manually controlled lighting is primarily T-12 fluorescent with magnetic ballasts. The custodian turns off the lights at approximately 8:00 P.M. each night.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Department of Social Services								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$7,500	-	47,454	-	$3,507	2.1	2
5.1.7	Retrofit T-12 Fixtures with T-8s	$30,000	47	166,226	-	$12,284	2.4	3

Opportunities for ECMs at Department of Social Services								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.3.2	Programmable Thermostats for Residential Style Units	$2,000	-	9,240	2,618	$2,772	0.7	
5.5.15	Replace Electric Hot Water Heater with Gas	$3,000	-	6,570	(231)	$302	9.9	
	TOTAL	$42,500	47	229,490	2,387	$18,864	2.3	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Costs assume 250 fixtures, with 5 fixtures per sensor.
3. Costs assume reballast completed by landlord's staff. Additional contractors or fixture changes will add more cost.

Estimated Blended Marginal Rates		
$	0.07	/kWh Elec
$	0.80	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

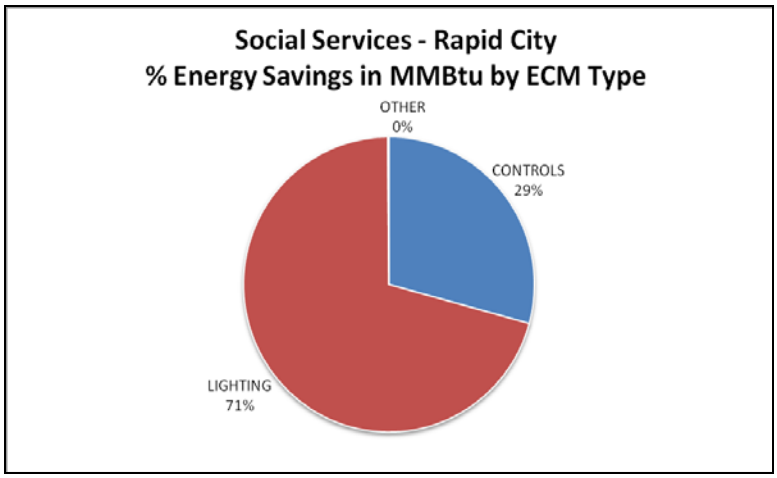
4.8.4.1.1. Campus Summary

A total of 4 ECMs were identified at Social Services – Rapid City buildings, which include 1,030 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $42,500, and save an estimated $18,864 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

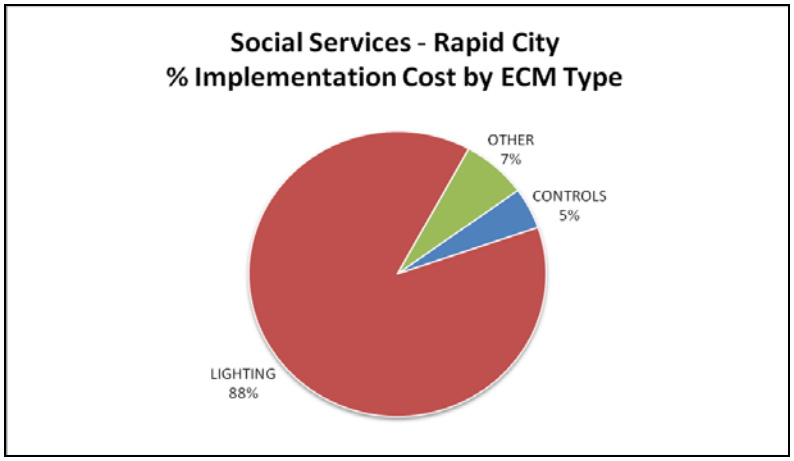
LSA ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	32	271	**302**	$2,772	$2,000	**0.7**
LIGHTING	729	0	**729**	$15,791	$37,500	**2.4**
OTHER	22	-24	**-1**	302	$3,000	**9.9**
Total	**783**	**247**	**1,030**	**$18,864**	**$42,500**	**2.3**

In total, these savings represent a 46% reduction from current energy consumption at the Social Services – Rapid City campus, the majority of which is attributed to lighting measures which will reduce electric consumption.



Leased Social Services facilities in Rapid City, Energy Savings by ECM Category.



Leased Social Services facilities in Rapid City Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 1,030 MMBTUs (46% of campus energy use) and a total estimated annual cost avoidance of $18,864. The total cost of implementation for these measures is $42,500, which yields a simple payback of 2.3 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Social Services – Rapid City	5.3.2	$2,000	302	$2,772	0.7	6.62
Social Services – Rapid City	5.1.3	$7,500	162	$3,507	2.1	46.32
Social Services – Rapid City	5.1.7	$30,000	567	$12,284	2.4	52.89
Social Services – Rapid City	5.5.15	$3,000	-1	$302	9.9	n/a

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
TOTAL		$42,500	1,030	$18,864	2.3	41.27

4.8.5 Hillsview Plaza / Human Services - Pierre

Campus Background and List of Facilities

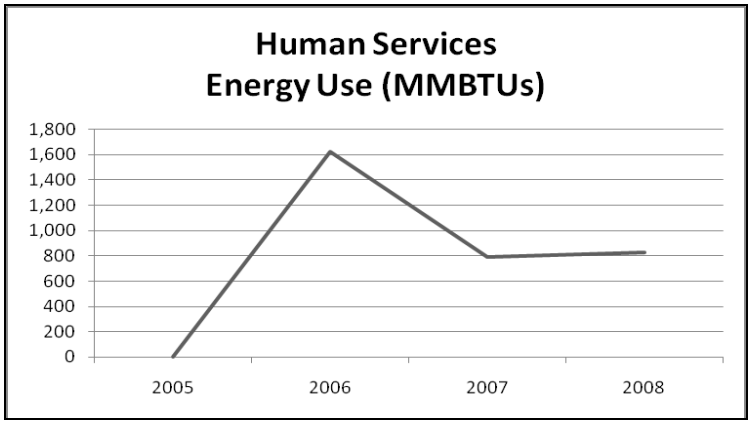
This is a stand-alone building. See building description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, leased Human Services facilities consumed a combined 829 MMBTUs of energy. The average Energy Use Intensity across the campus was 60 kBTU/SF in 2008.



Human Services Energy Use.

4.8.5.1. Hillsview Plaza / Human Services

Building Overview

The Hillsview Plaza/Human Services building is a leased space that is 13,720 square feet.There are approximately 30 occupants on a regular working day.This building is operated 9 hours per day, 5 days per week.The building is mostly administrative offices, conference rooms, print room and break room.

Four packaged Trane Weathertron heat pumps heat and cool the building. Three of them were installed in 1978 and one is newer having been installed in the last 4-5 years. The heat pumps are each controlled individually by local residential style thermostats. Domestic hot water is provided by an electric water heater.

Interior lighting is primarily 4' 4-lamp T-12 strip lighting. Reception area has halogen flood fixtures. The open office area is lit to as high as 92 foot-candles. Interior lights are manually controlled. The exit signs are incandescent.

The exterior finish is metal or vinyl and the interior finish is sheetrock. Windows are double pane with shades. There is not an entrance vestibule and the building envelope is in good condition. Blown in insulation was added to the ceiling space in the last 3-4 years. The roof is pitched and has limited insulation but it is fairly inconsequential to the building heat because of the blow-in insulation above the ceiling.

ECM's

Previously Implemented ECMs

Blow in insulation was added above the ceiling to reduce heat loss through the roof. The recently replaced heat pump included a programmable thermostat.

Opportunities for ECMs at Hillsview Plaza / Human Services Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$1,875		6502	$475	4.0	
5.1.5	Replace Incandescent Exit Signs with LED	$810	0.2	1493	$109	7.4	
5.1.6	Replace Incandescent Spot Lighting with Ceramic Metal Halide	$153	0.5	1588	$116	1.3	
5.1.7	Retrofit T-12 Fixtures with T-8s	$22,950	9.6	29722	$2,170	10.6	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$66	0.5	1430	$104	0.6	
5.2.3	Relocate Thermostat/Clear Thermostat Area	$0		342	$25	0.0	3
5.3.2	Programmable Thermostats for Residential Style Units	$1,040		2470	$180	5.8	
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$59,110	7.1	59631	55,543	9.0	
5.5.1	Replace Electric Hot Water Heater with Heat Pumps	$1,500		2551	$186	8.1	
	TOTAL	**$87,504**	**18**	**135,727**	**$9,908**	**8.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics assume the elimination of 100 MBH of simultaneous heating and cooling annually.

Estimated Blended Marginal Rates		
$	0.073	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.8.5.1.1. Campus Summary

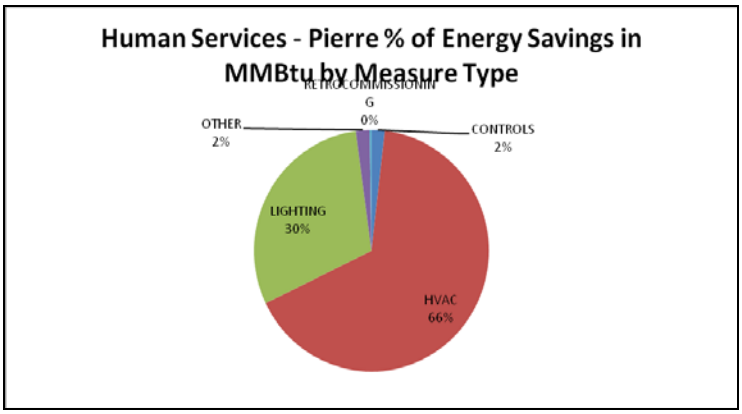
A total of 9 ECMs were identified at Hillsview Plaza/Human Services in Pierre, which include 463 MMBTUs in potential annual energy savings. Implementing all ECMs would

cost a total of approximately $87,504, and save an estimated $9,908 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

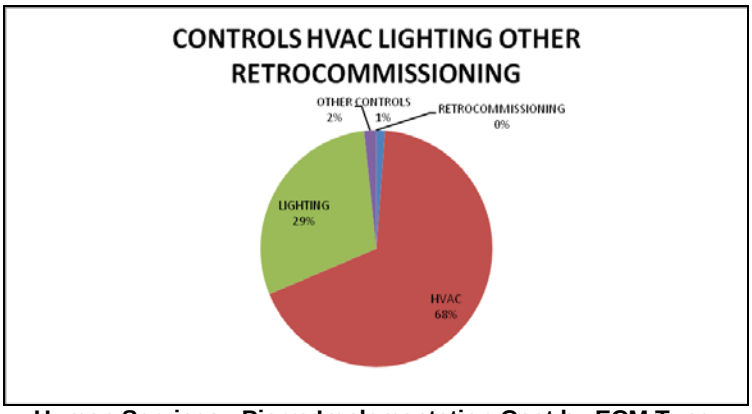
Human Services - Pierre ECM Summary Table.

	MMBtu Electric	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	8	**8**	$180	$1,040	5.8
HVAC	306	**306**	$6,543	$59,110	9.0
LIGHTING	139	**139**	$2,974	$25,854	8.7
OTHER	9	**9**	$186	$1,500	8.1
RETROCOMMISIONING	1	**1**	$25	$0	0.0
Total	463	**463**	$9,908	$87,504	

In total, these savings represent a 56% reduction from current energy consumption at the Human Services - Pierre, the majority of which is attributed to HVAC measures which will reduce electrical consumption.



Human Services - Pierre Energy Savings by ECM Category.



Human Services - Pierre Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 42 MMBTUs (5% of campus energy use) and a total estimated annual cost avoidance of $900. The total cost of implementation for these measures is $3,135, which yields a simple payback of 3.5 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Human Services	5.2.3	$0	1	$25	0.0	0.00
Human Services	5.1.8	$66	5	$104	0.6	13.52
Human Services	5.1.6	$153	5	$116	1.3	28.23
Human Services	5.1.3	$1,875	22	$475	4.0	84.52
Human Services	5.3.2	$1,040	8	$180	5.8	123.42
TOTAL		**$3,134**	**42**	**$900**	**3.5**	**74.49**

4.9 Military and Veterans Affairs

The Department of Military and Veterans Affairs (MVA) supports national objectives by providing highly trained units capable of mobilizing for active federal service in time of war or national emergencies; providing units organized, manned, trained, and equipped to assist civil authorities in the protection of life and property; preserving order and public safety under direction of the Governor; protecting lives and property through direction and coordination of state and local government; aiding and assisting veterans and their dependents in securing local, state, and federal entitlements/services for which they are eligible; and providing a comfortable independent living environment, along with adequate medical support, for eligible veterans and their spouses, widows, or widowers.

Documentation from OSE showed 327,161 square feet of MVA facilities. Several facilities were investigated in this study, and the following table lists these facilitices and their corresponding total square feet of building space.

MVA Campus Summary.

Campus	Square Footage
Veterans Home	163,141
Aberdeen Armory	12,662
Camp Rapid	12,231
Armory Yankton	16,396
Watertown	18,662
Armory Brookings	22,195
OMS Pierre Armory	2,435
Armory Sioux Falls	79,439

Energy Profile

In 2008, GFP facilities consumed a combined 133,874 MMBTUs of energy. Accordingly, the calculated Energy Use Intensity forMVA was 409 kBTU/SF in 2008, however this energy use total is also believed to include MVA buildings that were not included in the MVA square footage totals (i.e., non-State controlled buildings that were not included in this study). For the MVA facilities included in this study, the energy use is provided in the following table.

GFP Campus Energy Data (MMBTUs).

Campus	2008
Veterans Home	30,195
Aberdeen Armory	10,835
Camp Rapid	21,291
Armory Yankton	9,331

Campus	2008
Watertown	14,166
Armory Brookings	12,002
OMS Pierre Armory	303
Armory Sioux Falls	35,751

4.9.1 National Guard Armory - Aberdeen

Campus Background and List of Facilities

See Building Description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Aberdeen MVA facilities consumed a combined 10,835 MMBTUs of energy. Due to a lack of sufficient square footage information, an Energy Use Intensity could not be calculated for this campus.

4.9.1.1. National Guard Armory - Aberdeen

Building Overview

The National Guard Armory in Aberdeen, SD was originally constructed in 1964. A locker room and classroom addition was completed in 2007. The building total square footage is approximately 8,850.

During non-drill times there are approximately 15 occupants that are on a Tuesday through Friday 7-5 schedule. During the once a month drill times there are 200-300 that will utilize the building.

Exterior is brick and the roof is flat with rock cover. Windows are double pane.

Building heat is provided by an LES HF3-40 1,340 MBTU output standard efficiency steam boiler. Five pound steam is generated between October 15 and April 15 annually. Duplex 1/3 hp condensate pumps act as the boiler feed water source. The boiler system is manually operated and was installed in 2006.The steam system is only provides heat to the 1964 portions of the building via fin tube radiation, ceiling mounted unit heaters, and air handler coils.

Four 199,900 BTU input gas fired instantaneous domestic hot water heaters were installed in 2005.Three are operational and are used to maintain 135°F water in an 80 gallon storage tank and the recirculated hot water loop. The hot water heaters operate year round.

A large heating only makeup air unit (5,000 CFM estimated) is used to ventilate the Drill Hall. The unit used approximately 10 hours per month in the winter when the large garage doors are opened.

Several general exhaust fans are installed in the building and are on occupant timers. The timer dials allow for 60 minutes of run time. The toilet room exhaust runs continuously.

Three Aaon constant volume DX roof top units with DX cooling and gas fired heating provide ventilation for three separate zones of the building. A Trane roof top unit also is used for ventilation of a single zone and cooling only. Each air handler is controlled by programmable thermostats and is capable of night setback. The setpoints for both occupied and unoccupied times were inconsistent between the four units.

The four main offices are cooled by a ductless split DX system. Each office has its own programmable thermostat. The offices are heated by steam radiation controlled by a separate thermostat than the air conditioning system.

The majority of the interior building is lit by either three or four lamp F32T8 fixtures. There are approximately 270 F32T8 lamps in the building. There are approximately 18 two lamp F34T12 fixtures with 8’ bulbs used in supply rooms. The drill room is lit by sixteen 500 watt incandescent high output fixtures. Two of these fixtures remain on 24/7 for security purposes. The boiler room and vault are both lit by 200 watt incandescent lamps for a total of 8 fixtures. These fixtures are on approximately 20 hours per month. There is no interior lighting control system installed. All exterior lighting is accomplished by metal halide fixtures and are controlled on photo cells.

ECM’s

Previously Implemented ECMs

Personnel disciplined to turn off lights when areas not occupied.

During 2007 addition the majority of the building lighting was converted to T8 fixtures from T12.All exist lighting was replaced with LED at that time as well.

Opportunities for ECMs at National Guard Armory - Aberdeen								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Office Areas in Lieu of 32W	$230	1	2,599		$289	0.8	
5.1.3	Install Motion Sensor Control Lighting	$920	-	347		$38	23.9	3
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,270	1	333		$37	34.4	
5.1.8	Replace Incandescent Lights with Compact Fluorescent	$460	7	11,054		$1,228	0.4	4
5.1.10	Replace HID Lighting with High Bay Fluorescent	$8,510	6	13,753		$1,527	5.6	3
5.2.6	Schedule air handlers night set back	$0			452	$379	0.0	6,7
5.5.21	Remove Domestic Hot Water Storage Tank from On Demand System	$0			199	$167	0.0	5
	TOTAL	$10,240	14	25,139	651	$ 3,665	3.1	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Assumes that toilet room lighting is off one additional hour per day.
4. Calculations include replacing lighting in Drill Hall as well as other locations in the building.
5. Assumes that On Demand domestic hot water heaters already installed can accommodate full building domestic water demand.
6. Calculations assumes that building is allowed to setback an additional 5 degrees during unoccupied hours.
7. This measure only applies to the roof top units installed at the facility.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	0.84	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

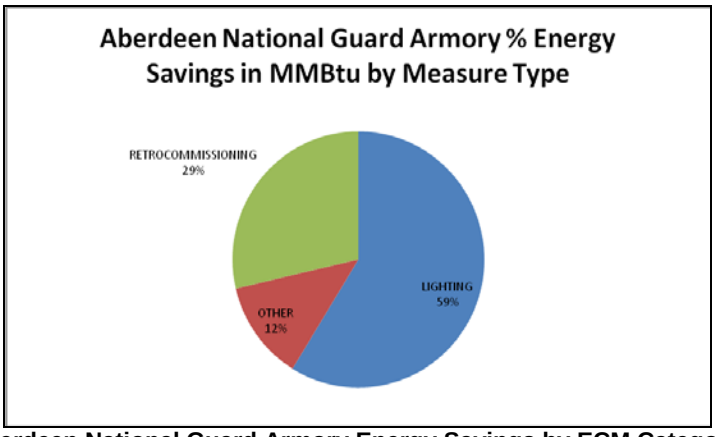
4.9.1.1.1. Campus Summary

A total of 7 ECMs were identified at Aberdeen National Guard Armory, which include 163 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $11,390, and save an estimated $3,665 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

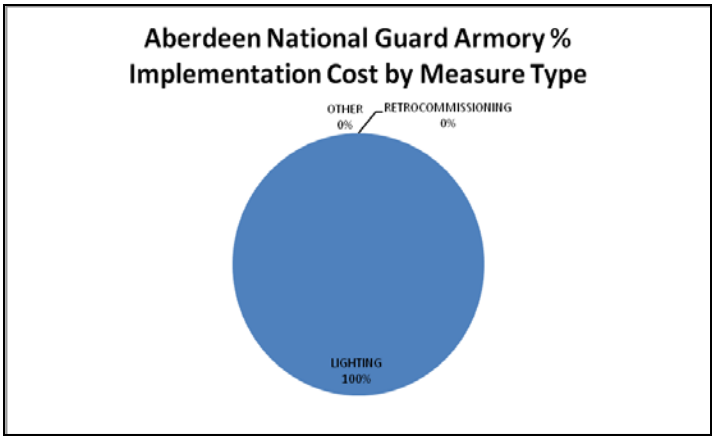
Aberdeen National Guard Armory ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	96	0	**96**	$3,119	$11,390	3.7
OTHER	0	21	**21**	$167	$0	0.0
RETROCOMMISSIONING	0	47	**47**	$379	$0	0.0
Total	**96**	**67**	**163**	**$3,665**	**$11,390**	**3.1**

In total, these savings represent a 1.5% reduction from current energy consumption at the Aberdeen National Guard Armory, the majority of which is attributed to Lighting measures which will reduce electrical consumption.



Aberdeen National Guard Armory Energy Savings by ECM Category.



Aberdeen National Guard Armory Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 161 MMBTUs (1.5% of campus energy use) and a total estimated annual cost avoidance of $3,590. The total cost of implementation for these measures is $9,200, which yields a simple payback of 2.6 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Aberdeen National Guard Armory	5.2.6	$0	47	$379	0.0	0.00
Aberdeen National Guard Armory	5.5.11	$0	21	$167	0.0	0.00
Aberdeen National Guard Armory	5.1.8	$460	38	$1,228	0.4	12.20
Aberdeen National Guard Armory	5.1.1	$230	9	$289	0.8	25.94

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Aberdeen National Guard Armory	5.1.10	$8,510	47	$1,527	5.6	181.36
TOTAL		**$9,200**	**161**	**$3,589**	**2.6**	**57.22**

4.9.2 National Guard Armory - Brookings

Campus Background and List of Facilities

See Building Description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, the Armory MVA facility at Brookings consumed a combined 12,002 MMBTUs of energy. Due to a lack of sufficient square footage information, an Energy Use Intensity could not be calculated for this campus.

4.9.2.1. National Guard Armory - Brookings

Building Overview

The National Guard Armory in Brookings, SD was originally constructed in 1975.The building total square footage is approximately 25,000.

During non-drill times there are approximately 12 occupants that are on a Tuesday through Friday, 7-5 schedule. During the once a month drill times there are 200-300 that will utilize the building.

Exterior is brick and the built up roof is original to the 1975 construction. Windows are aluminum frame, double pane construction. The roof was replaced recently with a fully adhered membrane roof.

Building heat is provided by two 855 MBTU output Fulton high efficiency water boilers. Heating water is circulated through three 1 hp constant speed circulating pumps that provide heating water to the drill floor air handling unit, unit heaters, and finned tube radiation.

Air conditioning and ventilation for locker rooms, office areas and classrooms is accomplished with packaged Dx rooftop units. Three of the units are gas fired, and were installed in 2008 as part of the addition. Three of the units are cooling only units and original to the 1975 construction.

Two heating only makeup air units (10,000 CFM estimated) are used to ventilate the Drill Hall. The units are used approximately 10 hours per month in the winter when the large garage doors are opened.

Several general exhaust fans are installed in the building and are controlled via the DDC system.

The HVAC system is controlled by Johnson Control Metasys DDC system. Operating schedules as well as occupied and unoccupied setpoints are programmed into the system. During our site visit, the system was programmed to be occupied on Mondays, however the facility is unoccupied during this time.

Domestic water is provided by one 100 gallon, 250,000 BTU input gas fired hot water heater. The hot water heater operates year round with a local 1/6 hp circulating pump to maintain the loop temperature.

The majority of the interior building is lit by three lamp T8 fluorescent fixtures and two lamp T12 fluorescent fixtures. The T8s are found in the recently renovated areas and the T12s are found throughout the original portions of the building. The assembly hall is lit by nine 250 watt mercury vapor fixtures. There is no interior lighting control system installed. All exterior lighting is accomplished by high pressure sodium fixtures and are controlled by a photocell.

ECM's

Previously Implemented ECMs

T8 lighting in newly constructed and renovated portions of the building.

LED exit signs.

Opportunities for ECMs at National Guard Armory - Brookings								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28W T-8s in Office Areas in Lieu of 32W	$1,150	3	6,311		$480	2.4	1, 3
5.1.3	Install Motion Sensors to Control Lighting	$2,190	-	8,110		$616	3.6	1
5.1.7	Retrofit T-12 Fixtures with T-8	$11,270	5	13,064		$993	11.4	1
5.3.8	Schedule AHUs Off During Unoccupied Hours	$0		7,740	504	$975	0.0	4
5.4.4	Replace AHUs At the End of Their Useful Life Expectancy	$51,750		4,484		$341	151.8	1, 2
	TOTAL	$66,360	8	39,709	504	3,404	19.5	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.08	/kWh Elec
$	0.77	/Therm Gas
$		/Gal Fuel Oil
$		Ton Biomass
$		/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

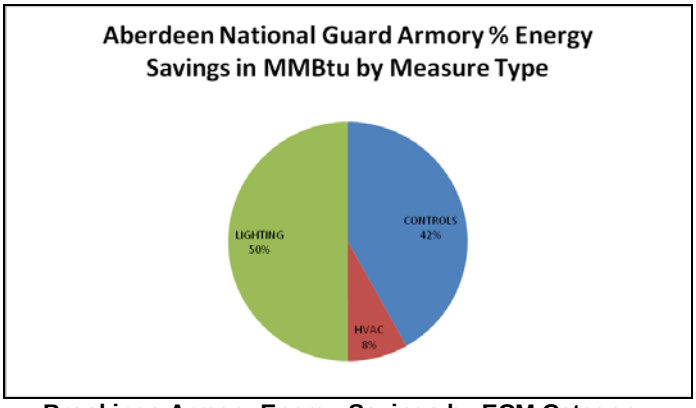
4.9.2.1.1. Campus Summary

A total of 5 ECMs were identified at Brookings Armory, which include 188 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $66,360, and save an estimated $3,405 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

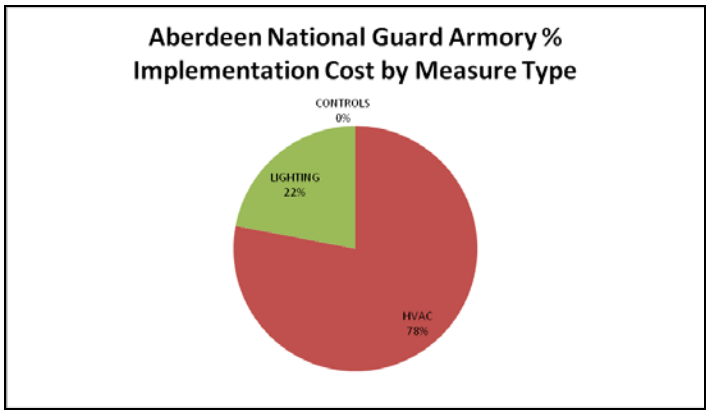
Brookings Armory ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	26	52	**79**	$975	$0	0.0
HVAC	15	0	**15**	$341	$51,750	151.8
LIGHTING	94	0	**94**	$2,089	$14,610	7.0
Total	**135**	**52**	**188**	**$3,404**	**$66,360**	

In total, these savings represent a 1.5% reduction from current energy consumption at the Brookings Armory, the majority of which is attributed to Lighting measures which will reduce electrical consumption.



Brookings Armory Energy Savings by ECM Category.



Brookings Armory Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 128 MMBTUs (1% of campus energy use) and a total estimated annual cost avoidance of $2,070. The total cost of implementation for these measures is $3,340, which yields a simple payback of 1.6 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Armory	5.3.8	$0	79	$975	0.0	0.00
Armory	5.1.1	$1,150	22	$480	2.4	53.41
Armory	5.1.3	$2,190	28	$616	3.6	79.14
TOTAL		**$3,340**	**128**	**$2,071**	**1.6**	**26.14**

4.9.3 National Guard Armories – Rapid City (Camp Rapid)

Campus Background and List of Facilities

Camp Rapid contains two buildings which are funded by the State of South Dakota and are included in this study

Campus-Wide Systems and Operational Profile

There are no campus wide systems.

Energy Profile

In 2008, the Camp Rapid facilities consumed a combined 21,291 MMBTUs of energy. Due to a lack of sufficient square footage information, an Energy Use Intensity could not be calculated for this campus.

4.9.3.1. Building 100 – Duke Corning Armory

Building Overview

The Duke Corning Armory provides offices, a gym/hangar space, and a firing range at Camp Rapid.

Three 300 MBH heating water pulse boilers provide heating hot water for the building. Two constant speed pumps circulate the hot water, but the lead/lag changeover is not automatic.

Space conditioning is provided using rooftop air handling units. Some of the units have VFDs and some utilize inlet vanes for flow control, while some units are constant volume. Some also utilize gas heating, while others utilize hydronic heating. Rooftop unit RTU-1 utilizes a VFD, although its corresponding VAV boxes still utilize local pneumatic controls.

Two makeup air units with hydronic heat and no cooling provide space conditioning for the gym.

A gas fired makeup air handling unit provides ventilation air for the firing range. Only plastic, rubber, or other types of bullets are now used in lieu of lead bullets. Since the dangerous lead dust is no longer generated, the airflow requirements could be relaxed if allowed by National Guard firing range design guidelines.

A federally-funded simulation area is conditioned using three rooftop units. While this area is rarely utilized, it appears that these units run continuously. It is unclear if the federal areas of the building have sub-metered utilities.

Lighting is manually controlled and is provided using T-8 fluorescent fixtures. There are also a number of incandescent can lights in some areas where dimmers are used.

Most of the building air handling units are controlled using the Invensys DDC system. This system can be accessed remotely, and staff at Camp Rapid can access controls for any State operated National Guard facilities in South Dakota.

ECM's

Previously Implemented ECMs

Some of the units have been upgraded to include VFDs. One RTU also utilizes carbon dioxide control of outside air.

Opportunities for ECMs at Building 100 – Duke Corning Armory								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.1	Install 25W or 28W T-8s in Lieu of 32W	$1,500	3	6,656	-	$772	1.9	2
5.1.3	Install Motion Sensors to Control Lighting	$7,500	-	9,152	-	$1,062	7.1	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$800	3	4,493	-	$521	1.5	4
5.3.5	Remove Inlet Vanes and Modulate Airflow with VFDs	$12,000	-	6,299	-	$731	16.4	
5.3.8	Schedule AHUs During Unoccupied Hours	$5,000	-	82,071	1,300	$10,419	0.5	5
5.4.39	Install Air to Air Heat Recovery	$50,000	-	1,805	2,230	$1,750	28.6	6
5.5.15	Replace Electric Hot Water Heater with Gas	$3,000	-	6,570	(231)	$603	5.0	
	TOTAL	**$79,800**	**6**	**117,046**	**3,299**	**$15,857**	**5.0**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. 28W selected.
3. Assume 200 fixtures, 5 fixtures per sensor, and a 2 hour lighting reduction per day.
4. Assume dimmable CFLs.
5. Assume controls work to enable/disable units based on schedule.
6. Assumes average 6 hour per day operation.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	0.69	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.3.2. Building 560 – Administrative Offices

Building Overview

Building 560 houses administrative offices and is funded by the State of South Dakota.

Space conditioning is provided using three residential style furnaces with DX cooling. Two units utilize a programmable thermostat, while the other uses a manual dial thermostat.

Lighting is manually controlled and is provided using T-12 fluorescent fixtures. There are also a number of incandescent track lights. The exit signs also utilize incandescent lamps.

ECM's

Previously Implemented ECMs

Programmable thermostats have been installed on two of the three air handling units.

Opportunities for ECMs at Building 500 – Administrative Offices								
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Natural Gas Therms			
5.1.3	Install Motion Sensors to Control Lighting	$4,000	-	3,405	-	$395	10.1	2
5.1.5	Replace Incandescent Exit Signs with LED	$500	1	4,976	-	$577	0.9	
5.1.7	Replace T-12 Fixtures with T-8s	$3,400	3	8,775	-	$1,018	3.3	
5.3.2	Programmable Thermostats for Residential Style Units	$100	-	-	68	$47	2.1	
	TOTAL	**$8,000**	**4**	**17,155**	**68**	**$2,037**	**3.9**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Assume 135 fixtures, 5 fixtures per sensor, and a 3 hour lighting reduction per day.

Estimated Blended Marginal Rates		
$	0.12	/kWh Elec
$	0.69	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

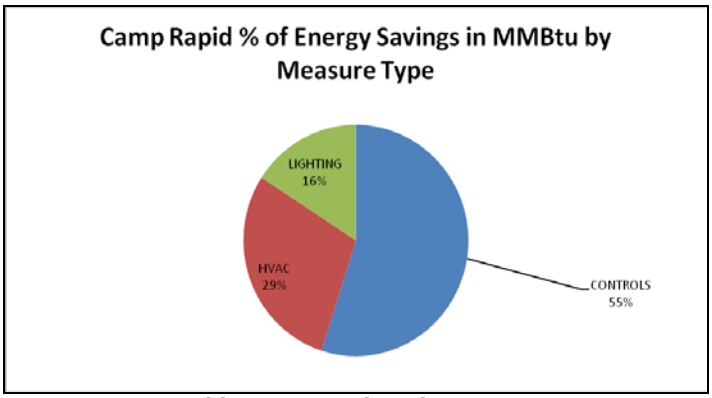
4.9.3.2.1. Campus Summary

A total of 11 ECMs were identified at Camp Rapid, which include 806 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $87,800, and save an estimated $17,894 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

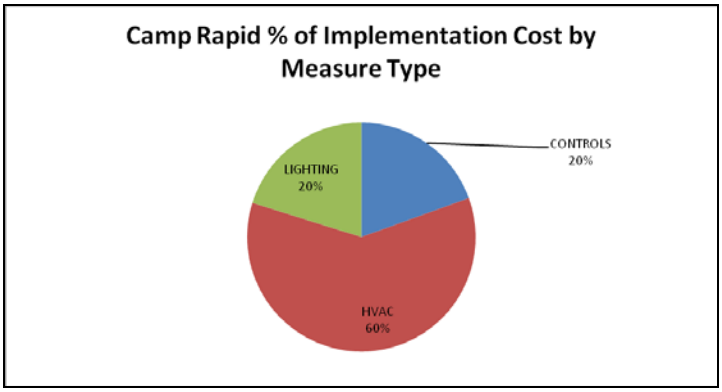
Camp Rapid ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	302	141	**443**	$11,196	$17,100	1.5
HVAC	29	207	**235**	$2,353	$53,000	22.5
LIGHTING	128	0	**128**	$4,345	$17,700	4.1
Total	**458**	**348**	**806**	**$17,894**	**$87,800**	**4.9**

In total, these savings represent a 3.7% reduction from current energy consumption at the Camp Rapid, the majority of which is attributed to Controls measures which will reduce natural gas and electrical consumption.



Camp Rapid Energy Savings by ECM Category.



Camp Rapid Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 506 MMBTUs (2.3% of campus energy use) and a total estimated annual cost avoidance of $13,354. The total cost of implementation for these measures is $11,300, which yields a simple payback of 0.8 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Camp Rapid - Duke Corning Armory	5.3.8	$5,000	414	$10,419	0.5	12.06
Camp Rapid - Building 560	5.1.5	$500	17	$577	0.9	29.45
Camp Rapid - Duke Corning Armory	5.1.8	$800	15	$521	1.5	52.19
Camp Rapid - Duke Corning Armory	5.1.1	$1,500	23	$772	1.9	66.05

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
Camp Rapid - Building 560	5.3.2	$100	7	$47	2.1	14.22
Camp Rapid - Building 560	5.1.7	$3,400	30	$1,018	3.3	113.56
TOTAL		**$11,300**	**506**	**$13,354**	**0.8**	**22.31**

4.9.4 National Guard Armory - Sioux Falls

Campus Background and List of Facilities

Though the two buildings on this campus are adjacent they were constructed at different times and have completely separate mechanicals.

Facilities:

Main HQ, RTI

Campus-Wide Systems and Operational Profile

None identified.

Energy Profile

In 2008, Sioux Falls MVA facilities consumed a combined 35,751 MMBTUs of energy. Due to a lack of sufficient square footage information, an Energy Use Intensity could not be calculated for this campus.

4.9.4.1. Main Headquarters

Building Overview

The Main Headquarters building is primarily office space and gymnasium.The building is used for National Guard drills as well as associated administrative work.During non-drill times there are approximately 60 occupants that are on a M-F 8-5 schedule.During the once a month drill times there are 200-400 that will utilize the building.

Four constant volume McQuay packaged roof top units with DX cooling provide ventilation to four zones in the building. A direct fired 1,375 MBH make-up air unit provides air to the kitchen facilities. Two heating only (15,000 CFM each) air handlers supply the gymnasium.(6) 2 ton condensing units, (3) 2 ton mini splits and (2) 5 ton condensing units provide cooling for various offices and computer rooms. Ceiling mounted hot water radiation panels provide heating for the building. Hot water is provided by three gas-fired 900 MBH Fulton pulse combustion boilers. Two hot water pumps are constant speed. Electric cabinet unit heaters in vestibules and hallways. HVAC controls are a combination of pneumatic and

digital. The control system has the ability to schedule the air handling units however control is remotely located in Rapid City and schedules are overridden to run 24/7. It was reported that the heating is not well distributed and heating is not even. Some areas are cold in the winter months. Domestic hot water for sinks is provided by an electric water heater. Domestic hot water for showers is provided by a gas fired 1,170 MBH water heater

Lighting is primarily 4ft 4-lamp F34T12.Incandescent lights in mechanical spaces. Lights are controlled by toggle switches. Some areas lit to as high as 76 foot-candles. Exit signs are incandescent and fluorescent.

Exterior is brick and the roof is flat with rock cover.Windows are double pane.Numerous exterior doors have insufficient weather stripping causing the doors to not close all the way.Snow drifts into the building in the winter through cracks.

ECM's

Previously Implemented ECMs

Personnel disciplined to turn off lights when areas not occupied.

Opportunities for ECMs at Main Headquarters

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings			Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh	Natural Gas Therms		
5.1.3	Install Motion Sensors to Control Lighting	$6,510	-	20,155		$1,471	4.4
5.1.5	Replace Incandescent Exit Signs with LED	$5,400	1.1	9,951		$726	7.4
5.1.7	Retrofit T-12 Fixtures with T-8s	$16,065	6.7	23,579		$1,721	9.3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$154	1.1	556		$41	3.8
5.2.1	Full Retrocomissioning and Balancing Study	$50,000	18.1	158,904	3,806	$14,500	3.4
5.2.6	Schedule Air Handlers Night Setback	$2,190	-	102,144	5,827	$11,897	0.2
5.3.3	Install VFDs on Hydronic Pumps	$11,270		48,486		$3,539	3.2
	TOTAL	**$91,589**	**27**	**363,775**	**9,633**	**33,896**	**2.7**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.073	/kWh Elec
$	0.762	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.4.2. Regional Training Instruction Building

Building Overview

The RTI (Regional Training Instruction) building was originally constructed in 2003.This building is primarily office and classrooms on the first level and housing on the second level.

When training is not going on there are 10 occupants that maintain a T-F 6-5 schedule. When training is going on there can be as many as 100-200 students. The housing can accommodate 120 occupants and is typically during drill dates that the housing is full.

Three VAV air handlers with hot water heating and chilled water cooling provide ventilation for the building. Hot water is provided by 3 gas fired 747 MBH boilers. Two 3 hp hot water pumps are constant speed. Chilled water is provided by a 90 ton York chiller. Two 7.5 hp chilled water pumps are constant speed. This building has its own control system which is also remotely located in Rapid City.

Lighting is primarily 4ft 3-lamp F32T8 and controlled manually.Exit signs are LED.Open office space lit to as high as 67 foot-candles.It was noticed that the building has a good amount of natural daylight coming into the building though all the lights are on.

Exterior lighting: Exterior is brick and roof is flat and off-white. Windows are double pane with shades.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Regional Training Instruction Building

ECM No.	Energy Conservation Measure (ECM)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings: Demand kW	Electric kWh	Natural Gas Therms	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$4,000	7.6	23,530		$1,718	2.3	3
5.1.2	Delamp Multiple Lamp Fixtures	$0	11.2	34,675		$2,531	0.0	3
5.1.3	Install Motion Sensors to Control Lighting	$18,860	-	27,245		$1,989	9.5	
5.2.1	Full Retrocomissioning and Balancing Study	$50,000	11.9	104,110	2,493	$9,500	5.3	
5.2.6	Schedule air handlers night setback	$1,150	-	52,749	3,081	$6,198	0.2	
	TOTAL	**$74,010**	**31**	**242,308**	**5,574**	**21,936**	**3.4**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.073	/kWh Elec
$	0.762	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.4.2.1. Campus Summary

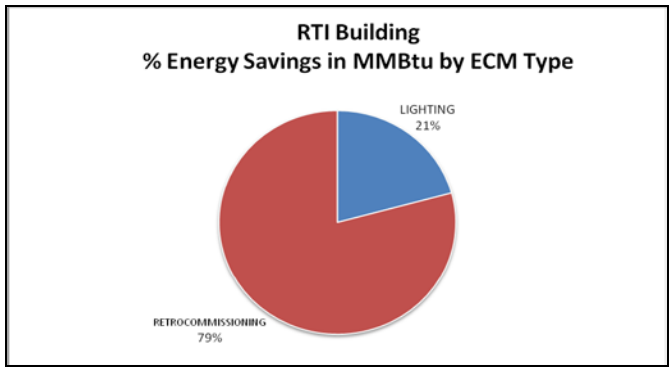
A total of 5 ECMs were identified at RTI Building, which include 1,403 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of

approximately $74,010, and save an estimated $21,936 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

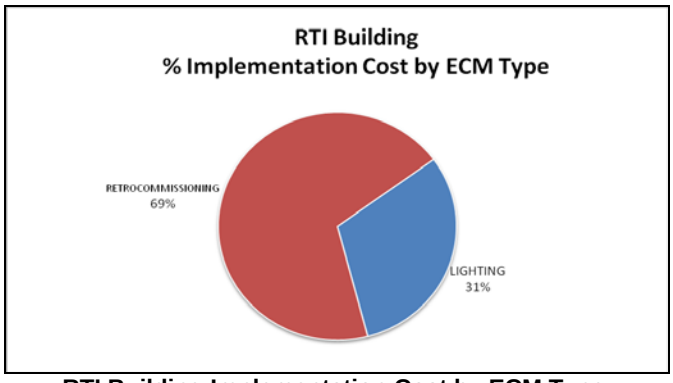
MVA ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	292	0	**2,92**	$6,238	$22,860	**3.7**
RETROCOMMISSIONING	535	576	**1,112**	$15,698	$51,150	**3.3**
Total	**827**	**576**	**1,403**	**$21,936**	**$74,010**	**3.4**

In total, these savings represent a 4% reduction from current energy consumption at the RTI Building, the majority of which is attributed to retrocommissioning measures which will reduce electric and natural gas consumption.



RTI Building Energy Savings by ECM Category.



RTI Building Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 1,310 MMBTUs (3.5% of campus energy use) and a

total estimated annual cost avoidance of $19,947. The total cost of implementation for these measures is $55,150, which yields a simple payback of 2.8 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
RTI Bldg	5.1.2	$0	118	$2,531	0.0	0.00
RTI Bldg	5.2.6	$1,150	499	$6,198	0.2	2.31
RTI Bldg	5.1.1	$4,000	80	$1,718	2.3	49.82
RTI Bldg	5.2.1	$50,000	613	$9,500	5.3	81.56
TOTAL		**$55,150**	**1,310**	**$19,947**	**2.8**	**42.09**

4.9.5 National Guard Armory - Watertown

Campus Background and List of Facilities

See Building Description.

Campus-Wide Systems and Operational Profile

None.

Energy Profile

In 2008, Watertown MVA facilities consumed a combined 14,166 MMBTUs of energy. Due to a lack of sufficient square footage information, an Energy Use Intensity could not be calculated for this campus.

4.9.5.1. National Guard Armory - Watertown

Building Overview

The National Guard Armory in Watertown, SD was originally constructed in 1953.The building total square footage is approximately 19,000.

During non-drill times there are approximately 9 occupants that are on a Tuesday through Friday, 7-5 schedule. During the once a month drill times there are 200-300 that will utilize the building. The driver's exam station also occupies the facility from 7 am to 6 pm on weekdays.

Exterior is brick and the built up roof is original to the 1953 construction. Windows are aluminum frame, operable double pane construction.

Building heat is provided by one Kewanee 2,460 MBTU output standard efficiency steam boiler. Five pound steam is generated between October 15 and April 15 annually. Duplex 1/3hp condensate pumps act as the boiler feed water source. The boiler system is manually

operated and is original to the 1953 construction. The steam system is provides heat to the main building via fin tube radiation, ceiling mounted unit heaters, and air handler coils.

Air conditioning in office areas and classrooms is accomplished with window mounted air conditioning units. There are fifteen of these located throughout the facility.

A large heating only makeup air unit (10,000 CFM estimated) is used to ventilate the Drill Hall. The unit used approximately 10 hours per month in the winter when the large garage doors are opened.

Several general exhaust fans are installed in the building and are on local switches.

Domestic water is provided by one 80 gallon, 250,000 BTU input gas fired hot water heater. The hot water heater operates year round with a local circulating pump to maintain the loop temperature.

The majority of the interior building is lit by either three or four lamp T12 fixtures. There are approximately 120 T12 lamps in the building. The drill room is lit by thirty three 300 watt incandescent high output fixtures. Approximately half of these fixtures are in use during a typical day. The boiler room is lit by 300 watt incandescent lamps for a total of 4 fixtures. These fixtures are on approximately 20 hours per month. There is no interior lighting control system installed. All exterior lighting is accomplished by high pressure sodium fixtures and are controlled on photo cells.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at National Guard Armory - Watertown							
			Estimated Annual Utility Savings				
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.3	Install Motion Sensors to Control Lighting	$580	-	1,816	$147	3.9	1
5.1.5	Replace Incandescent Exit Signs with LED	$120	0	3,784	$307	0.4	1
5.1.7	Retrofit T-12 Fixtures with T-8s	$20,930	6	16,443	$1,332	15.7	1
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$1,150	4	10,263	$831	1.4	1
	TOTAL	$22,780	10	32,307	2,617	8.7	

Notes
1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	0.08	/kWh Elec
$	0.66	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.		

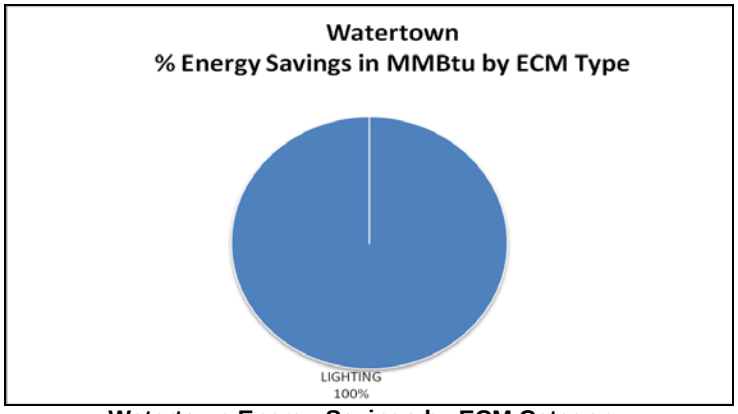
4.9.5.1.1. Campus Summary

A total of 4 ECMs were identified at Watertown, which include 110 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $22,780, and save an estimated $2,617 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

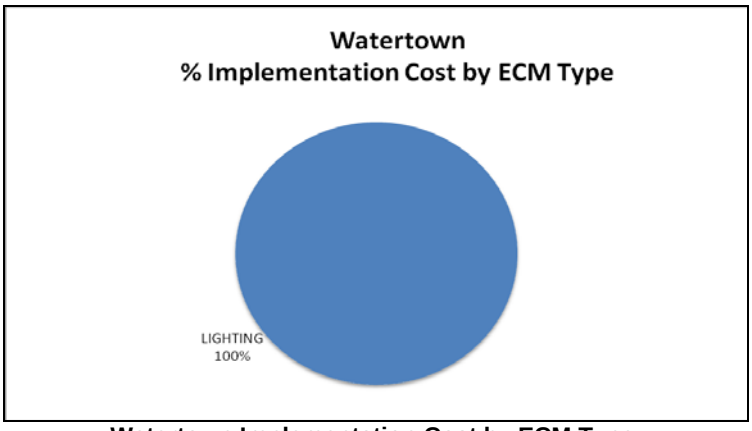
MVA ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	110	0	**110**	$2,617	$22,780	**8.7**
Total	**110**	**0**	**110**	**$2,617**	**$22,780**	**8.7**

In total, these savings represent a 1% reduction from current energy consumption at the Watertown, the majority of which is attributed to lighting measures which will reduce electric consumption.



Watertown Energy Savings by ECM Category.



Watertown Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 54 MMBTUs (.5% of campus energy use) and a total estimated annual cost avoidance of $1,285. The total cost of implementation for these measures is $1,850, which yields a simple payback of 1.4 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Watertown Armory	5.1.5	$120	13	$307	0.4	9.29
Watertown Armory	5.1.8	$1,150	35	$831	1.4	32.84
Watertown Armory	5.1.3	$580	6	$147	3.9	93.59
TOTAL		**$1,850**	**54**	**$1,285**	**1.4**	**34.18**

4.9.6 National Guard Armory - Yankton

Campus Background and List of Facilities

The Yankton Armory is comprised of 3 buildings. The main building is estimated at 10,000 square feet and is comprised of offices, conference rooms, and a large high bay area. The other two buildings are normally unoccupied; one is used for storage and the other is used as a maintenance garage.

Campus-Wide Systems and Operational Profile

Exterior lighting is either on photocells or timers.

The State controls the HVAC temperature setpoints at the Armory, but the setpoints can be overridden for two hours at a time when necessary.

Energy Profile

In 2008, Yankton MVA facilities consumed a combined 9,331 MMBTUs of energy. Due to a lack of sufficient square footage information, an Energy Use Intensity could not be calculated for this campus.

4.9.6.1. Main Building

Building Overview

The Main Building is a facility that primarily consists of offices, conference rooms, and a large high bay area. The building was in the process of being renovated during the site visit.

There are four air handlers being installed as part of the renovation, each with DX cooling and gas-fired heat. Two smaller fan coil units are used to cool server areas. Building heat is provided by hot water boilers in the building. Hot water fin tube radiators are installed in the perimeter offices. It is believed that most or all of these are being decommissioned as part of the renovation.

Much of the lighting in the building is by T-12 fixtures, although it is assumed that the renovation will use T-8s. Lighting is controlled manually by wall switches. Metal halide fixtures were installed in the high bay area.

Building controls are pneumatic.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Main Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh			
5.1.3	Install Motion Sensors to Control Lighting	$1,040	-	1,106	$101	10.3	
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,360	0.9	2,786	$254	5.4	3
5.3.3	Install VFDs on Hydronic Pumps	$3,910		9,639	$877	4.5	
	TOTAL	**$6,310**	**1**	**13,531**	**1,231**	**5.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Measure based on changing T-12 fixtures to 25W T-8 fixtures.

Estimated Blended Marginal Rates		
$	0.091	/kWh Elec
$	.0921	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

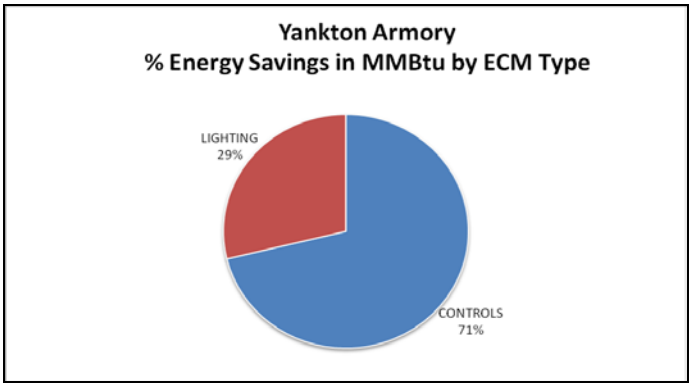
4.9.6.1.1. Campus Summary

A total of 3 ECMs were identified at Yankton Armory, which include 46 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $6,310, and save an estimated $1,231 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

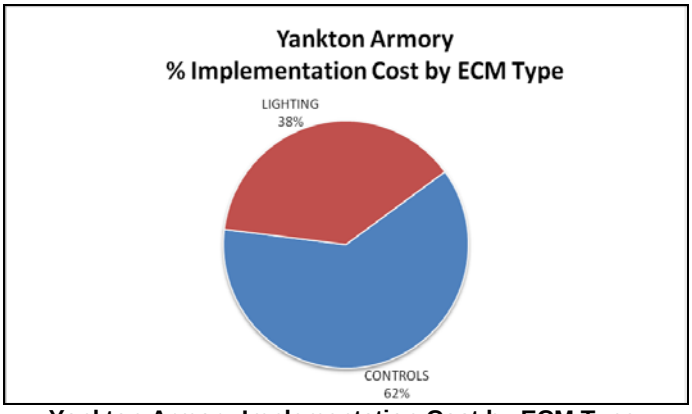
MVA ECM Summary Table.

	MMBtu Electric	MMBtu Natural Gas	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	33	0	**33**	$877	$3,910	**4.5**
LIGHTING	13	0	**13**	$354	$2,400	**6.8**
Total	**46**	**0**	**46**	**$1,231**	**$6,310**	**5.1**

In total, these savings represent a 0.5% reduction from current energy consumption at the Yankton Armory, the majority of which is attributed to controls measures which will reduce electric consumption.



Yankton Armory Energy Savings by ECM Category.



Yankton Armory Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 42 MMBTUs (0.5% of campus energy use) and a total estimated annual cost avoidance of $1,131. The total cost of implementation for these measures is $5,270, which yields a simple payback of 4.7 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Yankton Armory	5.3.3	$3,910	33	$877	4.5	118.89
Yankton Armory	5.1.7	$1,360	10	$254	5.4	143.05
TOTAL		**$5,270**	**42**	**$1,131**	**4.7**	**124.31**

4.9.7 OMS Pierre National Guard Armory

Campus Background and List of Facilities

None identified.

Campus-Wide Systems and Operational Profile

None identified.

Energy Profile

Due to a lack of sufficient past energy usage and square footage information, an Energy Use Intensity could not be calculated for this campus.

4.9.7.1. OMS Pierre National Guard Armory

Building Overview

The National Guard Armory building is approximately 8,185 square feet. There are approximately 6 occupants. This building is operated 8 hours per day, 5 days per week. The building is mostly administrative offices and gymnasium.

Thirteen constant speed packaged roof top units provide the cooling and ventilation for the office areas of the building. Most units have economizer capabilities. Heating is provided by two 585 MBH natural gas fired Fulton boilers. Two heating pumps are constant speed. HVAC controls are pneumatic and are on a Honeywell building automation system. Domestic hot water is provided by an 80 gallon Amtrol electric water heater.

Other Equipment: Hot water unit heaters in gymnasium,

Interior lighting is primarily T-12 strip lighting and U lamp lighting. Interior lights are manually controlled.

The exterior finish is brick. The interior finish is sheetrock and block. Windows are double pane with shades. There is an entrance vestibule and the building envelope condition is in good condition.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at OMS Pierre National Guard Armory								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.4	Replace Mercury Vapor Lighting with Metal Halide	$2,750	2.4	8633		$829	3.3	4
5.1.7	Retrofit T-12 Fixtures with T-8s	$13,050	5.0	15604		$1,498	8.7	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$200	3.9	11920		$1,144	0.2	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$5,760	4.5	3498		$336	17.2	5
5.5.3	Improve Building Envelope - Insulation/Exterior	$40,000		440	874	$911	43.9	
5.5.4	Improve Building Envelope - Windows	$100,000		870	1,079	$1,156	86.5	
5.5.7	Remove Abandoned RTU and Insulate the Opening	$920			27	$27	33.9	3
	TOTAL	$162,680	16	40,964	1,980	5,901	27.6	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics based on the elimination of 2500 MBH of heat loss per year.
4. This measure refers to the exterior wallpack lighting.
5. This measure refers to the gym lighting.

Estimated Blended Marginal Rates		
$	.96	/kWh Elec
$		/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	0.994	/Gal Propane

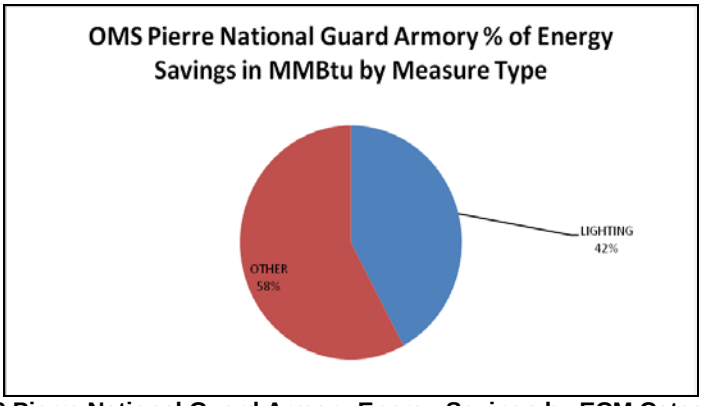
Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.7.1.1. Campus Summary

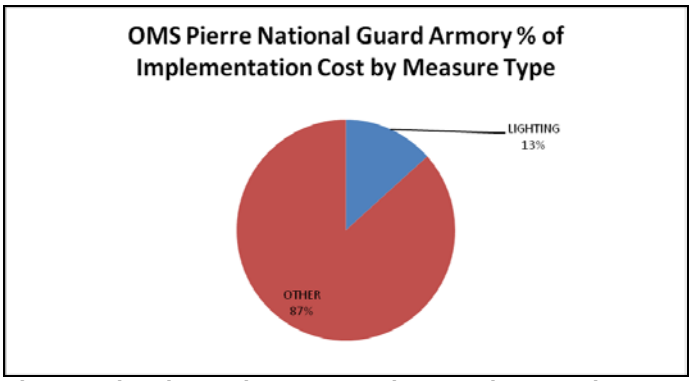
A total of 7 ECMs were identified at OMS Pierre National Guard Armory, which include 321 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $162,680, and save an estimated $5,900 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

OMS Pierre National Guard Armory ECM Summary Table.

	MMBtu Electric	MMBtu Propane	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
LIGHTING	135	0	**135**	$3,807	$21,760	5.7
OTHER	4	181	**186**	$2,094	$140,920	67.3
Total	**140**	**181**	**321**	**$5,901**	**$162,680**	**27.5**



OMS Pierre National Guard Armory Energy Savings by ECM Category.



OMS Pierre National Guard Armory Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 123 MMBTUs and a total estimated annual cost avoidance of $3,470. The total cost of implementation for these measures is $16,000, which yields a simple payback of 4.6 years.

Building	ECM Number	Estimated Implementation	Total MMBtu	Estimated Annual Cost Avoidance	Simple Payback Years	$ Invested / MMBTU saved
OMS Pierre National Guard Armory	5.1.8	$200	41	$1,144	0.2	4.92
OMS Pierre National Guard Armory	5.1.4	$2,750	29	$829	3.3	93.36
OMS Pierre National Guard Armory	5.1.7	$13,050	53	$1,498	8.7	245.12
TOTAL		**$16,000**	**123**	**$3,471**	**4.6**	**129.70**

4.9.8 Veterans Home – Hot Springs

Campus Background and List of Facilities

The South Dakota Veterans Home campus is located in the city of Hot Springs.The campus contains approximately 20 buildings including 6 major buildings as well as several outbuildings for storage, garaging, utilities and private residences.The Veterans Home provides housing for a number of full time residents as well as has accommodations and amenities for the people living and working on campus.

This campus was originally built in the late 1800s and the many of the buildings are in poor condition. There is limited insulation, poor envelope and poor windows in many of the buildings on campus. Buildings are continually adapted to the existing needs of the campus but are usually not being used for what they were originally designed for. Building #4 was once dormitories for residents but is currently used only for storage and is largely abandoned. This study excludes measures on building #4 as it will likely be decommissioned or demolished.

Campus-Wide Systems and Operational Profile

There is a central heating plant consisting of steam boilers and condensate handling that provides heat to all of the major buildings on campus.Steam heat is delivered to each building through a network of tunnels before it is converted to hot water for use in the buildings.The Veterans Home electrical infrastructure only has one main meter and is distributed underground and through the tunnels to the buildings on campus without a way to monitor usage at the individual buildings.There are central water wells, pumps stations and treatment tanks that provide domestic water to campus.The campus is also connected to city water but pumping independently of the city is significantly less expensive.There are exterior wall packs and pole lighting that are high pressure sodium and controlled by photocells.

The Veterans Home does not have any global controls systems on campus. The boiler plant is controlled to steam pressure locally. The HVAC systems have local line voltage control or packaged controllers.

Energy Profile

In 2008, the Veterans Home facilities consumed a combined 30,195 MMBTUs of energy. The average Energy Use Intensity across the Veterans Home campus was 185 kBTU/SF in 2008.

4.9.8.1. Boiler Plant

Building Overview

The Boiler Plant is used to house 2 steam boilers and various pumps. The Boiler plant was built in the 1950's and in service year round. The typical heating season for the campus is October through April but can extend longer if depending on whether. In the summer the building heat is shut down but the boiler plant is still required to run so that there is steam for the kitchen and heat for domestic water.

The Boiler Plant is made up of two 300 horsepower steam boilers. The boilers can run on fuel oil or propane. The determination is made which fuel to burn on based on current fuel prices. Steam pressure is currently maintained at 48 psi in the boiler. This is the required pressure in order to provide heat to the outer reaching buildings on the underground and tunnel steam piping distribution infrastructure. The fuel oil pump set is a duplex ¾ hp system. Each boiler has an independent feed system. Fuel oil and propane are stored in large above ground tanks located behind the boiler room. One main condensate receiver and pump set receive the pumped condensate from all of the buildings.

A domestic water heat exchanger utilizes steam heat from the boiler plant to heat domestic hot water. Domestic hot water is pumped throughout the network of tunnels, parallel to the steam, and delivered to each individual building. The domestic water pumps are a lead lag pair of 1 ½ hp pumps.

Lighting is provided by a mixture of mercury vapor high bay fixtures, Fluorescent T-12 fixtures, compact fluorescent and incandescent lighting. Exit signs are fluorescent.

ECM's

Previously Implemented ECMs

A de-aerator system was installed to improve the efficiency of the system as well as reduce the chemical treatment requirements.

Opportunities for ECMs at Boiler Plant										
			Estimated Annual Utility Savings							
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal	Biomass Tons	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,160	1.2	4,070	-	-	-	$448	4.8	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$73	0.4	954	-	-	-	$105	0.7	
5.1.10	Replace HID Lighting with High Bay Fluorescent	$2,250	2.2	7,825	-	-	-	$861	2.6	
5.4.17	Insulate Steam/Heating Hot Water Piping	$36,000	-	-	-	12,236	-	$17,620	2.0	3
5.4.21	Install Biomass Fuel Boiler	$4,000,000	-	-	10,844	220,046	(1,798)	$193,850	20.6	
5.4.31	Insulate Steam Condensate Piping	$6,750	-	-	-	1,958	-	$2,819	2.4	3
5.4.33	Install a Summer Boiler So Large Boilers are not Required in Cooling Months	$38,870	-	-	-	7,683	-	$11,064	3.5	
	TOTAL	$4,086,103	4	12,848	10,844	241,923	(1,798)	$226,767	18.0	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Assuming 1,500 ft of steam piping could be re-insulated.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	2.75	/Gal Fuel Oil
$	85.00	Ton Biomass
$	1.44	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.8.2. Building #1

Building Overview

Building #1 is a 3 floor building that was built in the 1950's and is used primarily for as a tenant residence. There are approximately 50 tenant rooms throughout the building that are occupied year round. The building envelope is block and brick with limited insulation.

Steam from the central boiler plant is converted to hot water and pumped throughout the building to perimeter radiators. Many of the radiators are uncontrolled or the thermostatic valves controlling them are not working properly. There are no central HVAC systems in the building. Residents have the option of having and window air conditioner put in their room in the summer. The window ACs are removed by facilities staff for the winter. Domestic hot water is provided by a steam heat exchanger utilizing steam from the central plant.

Lighting is provided by a mixture of fluorescent T-8 and T-12 fixtures. Exit signs are LED

ECM's

Previously Implemented ECMs

A majority of the T-12s in the building have been replaced with T-8s.The incandescent exit signs have been replaced with LED.

Opportunities for ECMs at Building #1									
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings				Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal			
5.3.9	Upgrade Controls System to Full DDC	$71,760	0.2	2,122	186	3,777	$6,184	11.6	
5.4.10	Centralize Cooling Systems with Chilled Water Plant	$207,690	74.3	97,003	-	-	$10,670	19.5	3
5.4.17	Insulate Steam/Heating Hot Water Piping	$9,000	-	-	-	2284	$3,289	2.7	4
5.4.31	Insulate Steam Condensate Piping	$2,250	-	-	-	653	$940	2.4	4
	TOTAL	$290,700	75	99,125	186	6,713	21,083	13.8	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics take into account simultaneous installation with buildings #1, #2 and #3.
4. Assuming approximately 500 ft of steam pipe that can be re-insulated

Estimated Blended Marginal Rates		
$	0.110	/kWh Elec
$	-	/Therm Gas
$	2.75	/Gal Fuel Oil
$	-	/Ton Biomass
$	1.44	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.8.3. Building #2

Building Overview

Building #2 was built around 1900.This building is primarily used as office space and is occupied year round. This building is on the National Register of Historic Places.The exterior was constructed with block and mortar with limited insulation.The windows are old and below standard.

Steam from the central boiler plant is converted to hot water and pumped throughout the building to perimeter radiators. Many of the radiators are uncontrolled or the thermostatic valves controlling them are not working properly. There are no central HVAC systems in the building. Perimeter offices have window air conditioners. The window ACs are removed by facilities staff for the winter. Domestic hot water is provided by a steam heat exchanger utilizing steam from the central plant.

Lighting is provided by a mixture of fluorescent T-8 and T-12 fixtures. Exit signs are LED

ECM's

Previously Implemented ECMs

A majority of the T-12s in the building have been replaced with T-8s.The incandescent exit signs have been replaced with LED.

Opportunities for ECMs at Building #2									
			Estimated Annual Utility Savings						
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.1	Install 25W or 28 W T-8s in Office Areas in Lieu of 32W	$7,800	5.6	19,509	-	-	$2,146	3.6	
5.1.3	Install Motion Sensors to Control Lighting	$2,200	-	5796	-	-	$638	3.5	
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$290	1.5	1907	-	-	$210	1.4	
5.3.9	Upgrade Controls System to Full DDC	$71,760	0	2,425	213	4,316	$7,067	10.2	
5.4.10	Centralize Cooling Systems with Chilled Water Plant	$207,690	71.2	100434	-	-	$11,048	18.8	3
5.5.4	Improve Building Envelope - Windows	$250,000	-	22,528	-	4,736	$9,298	26.9	
	TOTAL	**$539,740**	**79**	**152,599**	**213**	**9,052**	**$30,406**	**17.8**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics take into account simultaneous installation with buildings #1, #2 and #3.

Estimated Blended Marginal Rates		
$	0.11	/kWh Elec
$	-	/Therm Gas
$	2.75	/Gal Fuel Oil
$	-	/Ton Biomass
$	1.44	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.8.4. Building #3

Building Overview

Building #3 was built in 1928 and the interior was remodeled in 1996.This building has a large kitchen and dining area for the tenants that is operated year round. There are approximately 50 tenant rooms throughout. The building envelope is block and brick with limited insulation. The windows are old and below standard.

Steam from the central boiler plant is converted to hot water and pumped throughout the building to perimeter radiators. Many of the radiators are uncontrolled or the thermostatic valves controlling them are not working properly. There are no central HVAC systems in the building. Residents have the option of having and window air conditioner put in their room in the summer. The window ACs are removed by facilities staff for the winter. Domestic hot water is provided by a steam heat exchanger utilizing steam from the central plant. There is full commercial kitchen and dining facility that includes steam kettles, a commercial

dishwasher, and three large exhaust hoods for cooking. Each of three floors has a clothes washer and dryer for tenant use.

Lighting is provided by a mixture of fluorescent T-8 and T-12 fixtures. Exit signs are LED

ECM's

Previously Implemented ECMs

A majority of the T-12s in the building have been replaced with T-8s.The incandescent exit signs have been replaced with LED.

Opportunities for ECMs at Building #3

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings				Estimated Annual Cost Avoidance	Simple Payback Years	Notes
			Demand kW	Electric kWh	Fuel Oil Gal	Propane Gal			
5.1.3	Install Motion Sensors to Control Lighting	$2,200	-	4,607	-	-	$507	4.3	
5.1.7	Retrofit T-12 Fixtures with T-8s	$2,700	1.5	524	-	-	$58	46.9	3
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$145	0.8	1,907	-	-	$210	0.7	
5.3.9	Upgrade Controls System to Full DDC	$92,350	0	4,320	379	7,688	$12,588	7.3	
5.4.10	Centralize Cooling Systems with Chilled Water Plant	$269,560	104.0	181,073	-	-	$19,918	13.5	
5.5.4	Improve Building Envelope - Windows	$350,000	-	64,205	-	4,231	$13,156	26.6	
5.5.5	Intellihood Kitchen Hood Controls System	$10,120	0.4	3,782	-	954	$1,789	5.7	
	TOTAL	**$727,075**	**107**	**260,418**	**379**	**12,873**	**$48,225**	**15.1**	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. T-12 lighting is on the emergency circuits only.
4. Economics take into account simultaneous installation with buildings #1, #2 and #3.

Estimated Blended Marginal Rates		
$	0.110	/kWh Elec
$	-	/Therm Gas
$	2.75	/Gal Fuel Oil
$	-	/Ton Biomass
$	1.44	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.8.5. Laundry

Building Overview

The Laundry Building is operated year round and houses two commercial steam heated washing machines and a series of commercial dryers. There are typically about 5 employees occupying this space during laundry hours.

Two central station air handling units with steam heat and DX cooling provide cool air and ventilation to the space. Each serves a single zone and is constant volume. Additional heat is

provided by steam unit heaters. A pair of walk-in freezers and coolers provides additional cold storage to campus. The laundry building gets domestic hot water from the central plant.

Lighting is provided by a mixture of fluorescent T-12s and incandescent lamps. Exterior lighting is provided by incandescent lamps. Exit signs are fluorescent.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Laundry Building

ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Estimated Annual Utility Savings		Estimated Annual Cost Avoidance	Simple Payback Years
			Demand kW	Electric kWh		
5.1.7	Retrofit T-12 Fixtures with T-8s	$1,350	0.7	2,544	$280	4.8
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$73	0.4	954	$105	0.7
5.1.12	Replace Halogen PAR's with Ceramic Metal Halide	$144	0.1	392	$43	3.3
5.4.19	Replace Walk-in Cooler/Freezer Condensers	$13,000	19.2	33,638	$3,700	3.5
	TOTAL	**$14,567**	**20**	**37,528**	**$4,128**	**3.5**

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.

Estimated Blended Marginal Rates		
$	.103	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	-	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

4.9.8.6. Pump House

Building Overview

The Pump House is home to the domestic water treatment and delivery system for campus. There are multiple wells and storage tanks for campus driven by submersible well pumps. The Veterans Home campus is also connected to the city water system but can be operated at a significantly lower expense so the wells are used in lieu of the city water.

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Pump House

No suitable energy conservation measures were discovered.

4.9.8.7. Resident Housing

Building Overview

There are 4 resident houses on campus that are occupied year round by campus employees. They are single family homes with propane furnaces and residential style air conditioners. These homes have all of the typical residential amenities including refrigerators, microwaves and ovens etc. The domestic water heaters are electric. A majority of the lighting is incandescent

ECM's

Previously Implemented ECMs

None identified.

Opportunities for ECMs at Resident Housing Building								
			Estimated Annual Utility Savings					
ECM No.	Energy Conservation Measure (ECM) (See Note 2)	Estimated Implementation Cost (See Note 1)	Demand kW	Electric kWh	Propane Gal	Estimated Annual Cost Avoidance	Simple Payback Years	Notes
5.1.8	Replace Incandescent Lamps with Compact Fluorescent	$870	3.1	5,796	-	$638	1.4	3
5.3.2	Programmable Thermostats for Residential Style Units	$2,420	-	-	400	$576	4.2	3
	TOTAL	$3,290	3	5,796	400	$1,214	2.7	

Notes

1. Estimated implementation cost includes allowance for materials, labor and contractor overheads.
2. Other benefits include resolution of operating issues, improved reliability, replacement of equipment at the end of its useful service life.
3. Economics extrapolated to include 5 residences.

Estimated Blended Marginal Rates		
$	0.10	/kWh Elec
$	-	/Therm Gas
$	-	/Gal Fuel Oil
$	-	Ton Biomass
$	1.44	/Gal Propane

Estimated current cost per unit of energy consumption that can be saved through energy conservation measures.

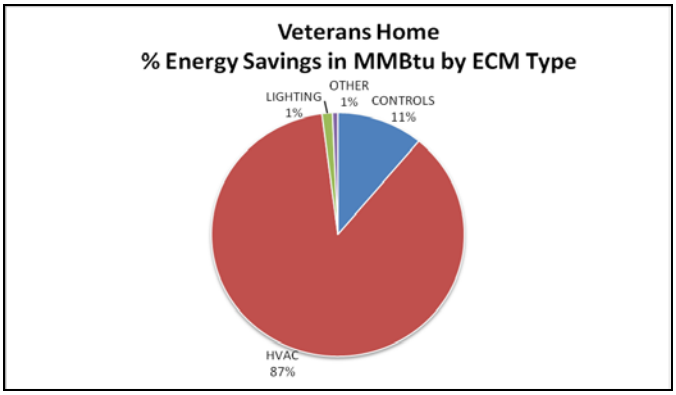
4.9.8.7.1. Campus Summary

A total of 32 ECMs were identified at Veterans Home buildings, which include 14,684 MMBTUs in potential annual energy savings. Implementing all ECMs would cost a total of approximately $3.5 million, and save an estimated $309,422 in energy costs each year. The costs and savings are further broken down by type of ECM in the following tables.

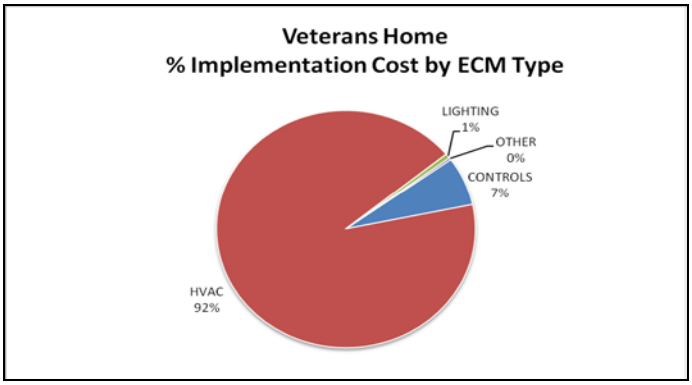
MVA ECM Summary Table.

	MMBtu Electric	MMBtu Other	MMBtu Total	Estimated Annual Cost Avoidance	Estimated Implementation Cost	Simple Payback
CONTROLS	30	1,591	**1621**	$26,415	$238,290	**9.0**
HVAC	1,406	11,361	**12,767**	$274,919	$3,290,810	**12.0**
LIGHTING	195	0	**195**	$6,299	$22,334	**3.5**
OTHER	13	87	**100**	$1,789	$10,120	**5.7**
Total	**1,645**	**13,039**	**14,684**	**$309,422**	**$3,561,554**	**11.5**

In total, these savings represent a 48% reduction from current energy consumption at the Veterans Home campus, the majority of which is attributed to HVAC measures which will reduce natural gas consumption.



Veterans Home Energy Savings by ECM Category.



Veterans Home Implementation Cost by ECM Type.

Recommendations

Based on the savings potential for these ECMs, our recommendations are to pursue ECMs in the following table with the highest potential for energy savings per dollar invested. This will yield a savings of 2,718 MMBTUs (9% of campus energy use) and a

total estimated annual cost avoidance of $48,039. The total cost of implementation for these measures is $138,044, which yields a simple payback of 2.9 years.

BUILDING NAME	ECM	Estimated Cost	MMBtu Total	Estimated Annual Cost Avoidance	Pay-back	$ Invested / MMBTU saved
Boiler Plant	5.1.8	$73	3	$105	0.7	22.28
Building #3	5.1.8	$145	7	$210	0.7	22.28
Laundry Building	5.1.8	$73	3	$105	0.7	22.28
Employee Housing	5.1.8	$870	20	$638	1.4	44.00
Building #2	5.1.8	$290	7	$210	1.4	44.57
Garage	5.1.8	$80	2	$52	1.5	49.18
Boiler Plant	5.4.17	$36,000	1,121	$17,620	2.0	32.12
Boiler Plant	5.4.31	$6,750	179	$2,819	2.4	37.64
Building #1	5.4.31	$2,250	60	$940	2.4	37.64
Boiler Plant	5.1.10	$2,250	27	$861	2.6	84.28
Building #1	5.4.17	$9,000	209	$3,289	2.7	43.02
Laundry Building	5.1.12	$144	1	$43	3.3	107.62
Building #2	5.1.3	$2,200	20	$638	3.5	111.25
Boiler Plant	5.4.33	$38,870	704	$11,064	3.5	55.23
Laundry Building	5.4.19	$13,000	115	$3,700	3.5	113.27
Building #2	5.1.1	$7,800	67	$2,146	3.6	117.18
Employee Housing	5.3.2	$2,420	37	$576	4.2	66.05
Building #3	5.1.3	$2,200	16	$507	4.3	139.96
Boiler Plant	5.1.7	$2,160	14	$448	4.8	155.53
Laundry Building	5.1.7	$1,350	9	$280	4.8	155.53
Building #3	5.5.5	$10,120	100	$1,789	5.7	100.94
TOTAL		**$138,044**	**2,718**	**$48,039**	**2.9**	**50.78**

5.0 Recommended Energy Conservation Measures

Based on the site visits and the utility rate analysis, Sebesta Blomberg has identified energy conservation measures that will reduce base energy use. Each project is briefly described, summarizing the recommendation and associated outline specifications, implementation plan and the expected impact to occupants. Estimated project economics are presented in sections 3 and 4.

5.1 Lighting

This section outlines the recommended lighting energy conservation measures. These measures include upgrades due to more efficient lighting technology, improved control schemes and lighting control technologies.Savings result from lower run times, improved efficacy, and improved lighting technologies available.

5.1.1 Install 25 or 28 Watt Fluorescent T-8 Tubes in Lieu of 32 Watt

There are four foot fluorescent fixtures in the building with one, two, three or four lamp fixtures that provide a significant amount of lighting to the building.The lighting levels in the building are higher than may be required for the tasks currently going on in the building.Many buildings older than 15 years were designed for workstations where tasks at desk level required high light levels for reading and working.Today, most office activities involve computers which do not require much general light.32 Watt T-8 lamps were identified in the building and light level readings were higher than required by IES standards.There are 25 Watt and 28 Watt fluorescent replacement lamps available that will slightly reduce light levels in the building but can reduce electric consumption of the lighting in a building by 20%.

Outline Specification:

- Determine areas lit by T-8 lighting suitable for a lighting wattage reduction.
- Test a small number of 25 Watt replacement lamps to ensure ballast compatibility and that the lighting change is acceptable.If there are issues, test 28 Watt lamps which create a smaller lighting reduction and fewer ballast compatibility issues are reported.
- Group re-lamp all available fixtures to the lower wattage lamp.
- As ballasts are replaced in the fixture according to maintenance schedules select ballasts designed for the wattage and lamp configuration installed.

Implementation Plan: To be installed by in-house staff.

Key Assumptions: All of the 32W T-8 fluorescent tubes in the building will be replaced by 25W.Estimates of lighting counts and run times were made onsite during walkthroughs to substantiate economics estimates.

Impact to Occupants: Slightly reduced lighting levels.

5.1.2 De-lamp Multiple Lamp Fixtures

The building has areas that exceed the minimum light level IES standards and would be candidates for reduction in lighting levels.Based on light level readings taken in the building, areas were found to be grossly overlit.A multiple lamp fixture can have one or two lamps removed to reduce the light output as well as electric consumption.Generally, for aesthetical purposes three lamp fixtures have the middle lamp removed, and four lamp fixtures have either the outer or inner two lamps removed.

Outline Specification:

- Confirm lighting levels in over lit areas.
- Remove appropriate number of lamps to test lighting levels and ballast compatibility.Fixtures can be circuited such that all of the lamps need in place for the fixture to complete the circuit and power any lamps.If this is the case a dummy lamp can be installed which completes the circuit but does not consume electricity or create light.
- Once a suitable scenario is determined, install throughout overlit areas.

Implementation Plan: It is anticipated that this will be completed by in-house staff.

Key Assumptions: Estimates of lighting counts and run times were made onsite during walkthroughs to substantiate economics estimates.

Impact to Occupants: There will be a reduction in light levels.

5.1.3 Install Motion Sensors to Control Lighting

There are many buildings where lights are controlled by manual wall switches.As a result, lights remain on in spaces which are periodically non-occupied for a majority of the day.These types of rooms include private offices, conference rooms, toilet rooms, locker rooms, and utility rooms.Occupancy sensors could be installed to automatically turn the lights off when there is no activity in a room for a user specified amount of time.This can be accomplished with an occupancy sensor retrofit of the manual wall switch or a ceiling mounted sensor that is hard wired into the room’s lighting circuit.

Outline Specification:

- Confirm final sensor areas and fields verify exact sensor location and count, making note of where installations are more complex.
- Purchase and install new sensors at existing wall switches and otherwise in ceiling or using multiple sensors as dictated by detailed review. Dual IR/ultrasonic technology devices generally provide the most satisfaction based on feedback from our clients.
- Adjust sensors for desirable time delay and sensitivity.
- Notify area staff of change.

Implementation Plan: This measure is intended to be completed by an electrical contractor in conjunction with the other lighting measures recommended in this study.

Key Assumptions: Savings are based on estimates of potential reductions in lighting run times of newly controlled lighting.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: It is anticipated that most occupants will have experience with the devices and that there will be a minimal adjustment period.

5.1.4 Replace Mercury Vapor Lighting with Metal Halide

There are Mercury Vapor high intensity discharge (HID) lighting fixtures in the building.These fixtures can be replaced by Metal Halide which is a new technology that produces a similar type and quality of light while using less electricity to produce it.

Outline Specification:

- Determine whether a lamp and ballast retrofit is possible or if the whole fixtures has to be replaced.
- Disconnect power and replace fixture or lamp/ballast on a one for one basis.Reconnect power.

Implementation Plan: This measure is intended to be completed by an electrical contractor in conjunction with the other lighting measures recommended in this study.

Key Assumptions: Savings are based on estimates of potential reductions in lighting electrical draw.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.Cost is based on a lamp/ballast retrofit as opposed to a new fixture.Generally a new fixture will be more expensive than shown but the savings will not change whether it is retrofit or a replacement.

Impact to Occupants: None.

5.1.5 Replace Incandescent Exit Signs with LED

Primary lighting technologies used in exit signs are incandescent, fluorescent and LED.When buildings are built and interior spaces are fit up, the most current lighting technology is usually installed but exit lighting is not always upgraded when new technologies come out.This is the case in many building across campus where the original exit lighting contains incandescent technology.Since exit lights are required to be on 24/7, the savings from a more efficient lighting source is constantly realized.The savings for upgrading from incandescent to LED will justify widespread implementation.

Outline Specification:

- Determine a suitable LED fixture for widespread replacement.
- Disconnect power for the existing fixture and remove it.
- Mount new fixture and reconnect power.

Implementation Plan: This measure is intended to be completed by an electrical contractor in conjunction with the other lighting measures recommended in this study.

Key Assumptions: Estimates of lighting counts were made onsite during walkthroughs to substantiate economics estimates.

Impact to Occupants: None.

5.1.6 Replace Incandescent Spot Lighting with Ceramic Metal Halide

There are incandescent or halogen spot lights used for accent lighting in showpiece areas or exterior lighting near entrances of the building.These lamps can be replaced by self ballasted Ceramic Metal Halide which is a new technology that produces a similar type and quality of light while using less electricity to produce it.

Outline Specification:

- Determine whether a lamp and ballast retrofit is possible or if the whole fixture has to be replaced.
- Disconnect power and replace fixture or lamp/ballast on a one for one basis.Reconnect power.

Implementation Plan: This measure is intended to be completed by an electrical contractor in conjunction with the other lighting measures recommended in this study.

Key Assumptions: Savings are based on estimates of potential reductions in lighting electrical draw.Specific areas of implementation, if applicable, are included with the individual building

economics in section 4.Cost is based on a lamp/ballast retrofit as opposed to a new fixture.Generally a new fixture will be more expensive than shown but the savings will not change whether it is retrofit or a replacement.

Impact to Occupants: None.

5.1.7 Retrofit T-12 Fixtures with T-8s

Four-foot and eight-foot fluorescent T-12 lighting is currently installed in many office, corridor, and high bayand garage areas in many of the buildings.As ballasts fail and areas are remodeled, the T-12s are gradually being replaced with T-8s and electronic ballasts.T-8s will provide the same amount of light while using less electricity and putting out less heat which the cooling systems must then remove.Although it seems cost effective to wait until failure to make the upgrades, the payback for immediate widespread implementation is attractive and is much less of a maintenance burden.

Outline Specification:

- Field verify the exact number of fixtures
- Depower fixture, remove old lamps, clean fixtures and lenses.
- Replace ballast with new electronic unit of correct voltage and lamp quantity rating for the fixture.
- Typically a qualified electrician is required to make electrical connections on ballasts.
- Replace T-12 lamps with T-8 lamps.
- Collect and properly dispose of old lamps and ballasts (some PCB ballasts expected).

Implementation Plan: This measure is intended to be completed by an electrical contractor in conjunction with the other lighting measures recommended in this study.

Key Assumptions: Savings are based on estimates of potential reductions in lighting electrical draw.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: None.

5.1.8 Replace Incandescent Lamps with Compact Fluorescent

Incandescent light bulbs are installed in various areas in the building.They could be replaced by self ballasted screw-in compact fluorescent lamps which will provide the same amount of light while using significantly less electricity.Alternatively, the incandescent fixture could be replaced with a plug-in CFL base that will be more expensive but generally provides a better power factor than screw in fluorescents.If the compact fluorescent replacement is not widespread, a low power factor will not have a great affect on the building electrical infrastructure.If it is widespread, a low

power factor can put the building into a low power factor penalty and cost more with the utility.Fluorescent lamps generally have about 4 times the life expectancy of an incandescent lamp.

Outline Specification:

- Field verify the exact number of fixtures and light levels
- Select and purchase appropriate wattage compact fluorescent units.
- Depower fixture, remove old lamps and clean fixtures.
- Replace incandescent bulb with compact fluorescent unit with similar luminosity. Ideally, use socketed ballast with a plug-in CFL to ensure that an incandescent is not put back in after the initial CFL burns out.
- Collect and properly dispose of old fixtures and lamps.

Implementation Plan: This measure is intended to be completed by in-house staff in most cases.Where the appropriate replacement requires fixture changes, it should be implemented by a qualified contractor.

Key Assumptions: Savings are based on estimates of potential reductions in lighting electrical draw.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: None.

5.1.9 Install Scheduling Control Lighting

Lighting within the buildings is currently being manually turned on and off by building personnel via wall switches at the end of the day. As a result of this, lights are on significant more hours of the day than if they were part of a more sophisticated lighting controls system.The system could be as simple as timeclocks in the lighting circuitry or as complex as a system ties into the DDC building controls system if it is available.

Outline Specification:

- Determine the requirements of the existing lighting controls system.
- Interface lighting system with central DDC or install a new timeclock as applicable.
- Add lighting schedule to appropriate buildings.
- Install override option for occupants working past normal business hours

Implementation Plan: It is anticipated that a qualified lighting contractor can provide the needed design and firm pricing from the above specification and brief walk-through for a design/building installation and proceed directly to implementation without further engineering.

Key Assumptions: Savings are based on estimates of potential reductions in lighting run times of newly controlled lighting.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: Occupants working past normal working hours would have to enable a lighting override to continue working.

5.1.10 Replace HID Lighting with High-Bay Fluorescent

There are metal halide, mercury vapor and high pressure sodium high intensity discharge fixtures installed in the high bay areas in the building.These fixtures could be replaced by high bay fluorescent T-8 or T-5 fixtures which will put out the same amount of light of a higher quality while consuming less electricity.In addition, fluorescent lights do not have a re-strike time requirement which would allow them to be shut off when the areas are unoccupied for short periods of time.

Outline Specification:

- Field verify the exact number of fixtures and light levels
- Further engineering may be required to determine exact quantity and location of new fixtures.
- Install new conduit, wiring, and fixtures from man-lift.
- Test new circuits and lighting, measure area light level to assure compliance.
- Collect and properly dispose of old fixtures and lamps.

Implementation Plan: It is anticipated that a qualified lighting contractor can provide needed design and firm pricing from above specification and brief walk-through for a design/build installation and proceed directly to implementation without further engineering

Key Assumptions: Savings are based on estimates of potential reductions in lighting run times of newly controlled lighting. There is also a wattage reduction as a result of improved light quality despite a potential parallel reduction in efficacy. Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: Lighting can be turned on and off as the space is occupied as opposed to always on due to lighting warm-up and re-strike requirements.

5.1.11 Implement Daylighting Controls

There is lighting that does not need to be on during the day in the presence of adequate daylight.Photocells can be installed in the lighting circuit such that the lighting only comes on when the light is sufficiently beneficial.Daylighting can be accomplished by a number of

strategies, included turning off perimeter fixtures, turning off one level of lighting throughout and dimming fixtures.Costs are greatly impacted by the circuiting of the lighting which was not specifically identified as a part of this study.Further investigation will be required.

Outline Specification:

- Determine acceptable light levels for office operations.
- Investigate fixture circuiting to determine the most cost effective daylighting installation.
- Confirm final sensor areas and field verify exact sensor location and count, making note of where installations are more complex.
- Purchase and install new sensors at existing wall switches and otherwise in ceiling or using multiple sensors as dictated by detailed review.
- Adjust sensors for desirable time delay and sensitivity.
- Notify area staff of change.

Implementation Plan: A lighting designer should determine appropriate light levels and photocell locations. It is anticipated that the qualified lighting contractor can provide the needed design and firm pricing from the above specification and brief walk-through for a design/building installation.

Key Assumptions: Savings are based on estimates of potential reductions in lighting run times of newly controlled lighting. There is also may be a wattage reduction if dimming is selected as the most economical daylighting installation. Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: Occupants may notice reduction in light levels during daylight hours.

5.1.12 Replace 8’ Fixtures with 4’ Fixtures

There are 8’ fluorescent fixtures that utilize 8’ fluorescent tubes in the building.8’ tubes are inherently less efficient that 4’ tubes.The 8’ fixtures could be replaced by two 4’ fixtures that with the same number of lamps that would put out the same amount of light while consuming less electricity. Additionally, this eliminates the requirement to store 8’ tubes in addition to the 4’ tubes already in stock for the rest of the building

Outline Specification:

- Determine the areas and counts of the applicable lighting
- Disconnect power and replace the 8’ fixtures, 2 for 1 with 4’ fixtures.
- Wire as required.The fixtures can be replaced end to end to create a similar distribution of light or the fixtures can be relocated to distribute light more evenly.This may offer wattage reduction opportunities as well.

- Restore electrical connection.

Implementation Plan: A qualified lighting contractor should be able to implement this measure with a walkthrough of the affected areas of the building.

Key Assumptions: Savings are based on estimates of potential reductions in lighting wattage. Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: None.

5.1.13 Identify and Turnoff Non-Essential Exterior Lighting

There is exterior lighting that may not be required for much of the time that it is on or at all.Exterior lighting provides security and aesthetics to buildings at night.A review of the intended value of exterior lighting and its cost has revealed that some or all is not required.This non-essential exterior lighting should be shut off for those periods it does not provide appreciable value.

Outline Specification:

- Determine the lighting and periods of use that are not required.
- Utilize the existing controls system or install new controls to ensure lighting is off when it is not advantageous.

- **Implementation Plan**: It is anticipated that when there is an existing lighting control system in place this can be implemented by in-house staff.When implementation of this measure requires additional controls installation, a qualified contractor will be retained to complete the work.

Key Assumptions: Savings are based on estimates of potential reductions in lighting run times.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: Non-essential or expendable exterior lighting will no longer provide lighting.

5.1.14 Install Tandem Lighting for Light Level Staging

There are some spaces which require high light levels for intricate work such as laboratory classrooms.However, high light levels are only required at select times.The rest of the time, lower light levels would be sufficient for the space.However, the single circuits installed to control the multiple lamp fixtures do not allow for any staging.The lights could be re-circuited for tandem

lighting control where half of the lamps in a particular fixture would be controlled by one circuit, and the other half would be controlled by a separate circuit.

Outline Specification:

- Identify areas where tandem lighting could be utilized.
- Confirm lower light levels are sufficient for the spaces.
- Re-wire lighting circuits and ballasts.Add switches as necessary.

Implementation Plan: It is anticipated that this could be completed by a qualified contractor with a walkthrough of the building.

Key Assumptions: Savings are based on estimates of potential reductions in lighting power during occupied times.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: Lower light levels for certain activities.

5.1.15 Overhaul Library Lighting

The libraries at select college campuses are relatively overlit and lack energy saving lighting control features.Some areas tested showed light levels as high as 135 foot-candles.In addition, many of the fluorescent fixtures utilize fiberboard ceiling tile material as the primary reflectors, which absorb light and decrease the overall efficacy of the light fixtures.Lights are also left on in unoccupied stack areas.

In common areas and work areas, new fixtures and ceilings could be installed to increase the overall efficacy of the lighting system, and to reduce light levels in overlit areas.In stack areas, pendant fluorescent tubes could be installed along the rows of each stack, and occupancy sensors could be installed to activate the lights as a library patron walks into the stack row.

Outline Specification:

- Determine areas where lighting should be modified.
- Identify proper light fixture types for each functional area.
- Devise a layout of fixtures, sensors, and circuits.
- Install new lighting and adjust and repair ceilings as required.

Implementation Plan: It is anticipated that a qualified lighting designer will need to provide a lighting layout and analysis.Some architectural and engineering services may also be required.

Key Assumptions: Savings are based on reductions in light quantities and in overall lighting power.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: Changes in light levels.

5.1.16 Install Photocells to Control Exterior Lighting

Exterior lighting is currently controlled by a timeclock system or is not controlled at all.Throughout the year the timeclock may or may not be adjusted for the shorter days in the winter and the longer days in the summer.Typically, in this scenario the exterior lighting is on average on many more hours than is actually required by the lack of natural light.A photocell could be installed in the exterior lighting control scheme to ensure that the exterior lighting is not on when there is a sufficient amount of daylight.

Outline Specification:

- Determine requirements of the existing controls scheme to have a series photocell installed to override the system when appropriate daylight is available.
- Investigate fixture circuiting to determine the most cost effective installation and implement.
- Adjust sensors for desirable time delay and sensitivity.

Implementation Plan: It is anticipated that this could be completed by a qualified contractor with a walkthrough of the building.

Key Assumptions: Savings are based on estimates of potential reductions in lighting run times.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: None

5.1.17 Replace 4-Lamp Fixtures in Corridors with 2-Lamp

The existing lighting in the NFA corridors consists of 4-lamp T8 parabolic fixtures with electronic ballasts.With these fixtures in place the corridors are over lit and de-lamping the 4-lamp fixtures is not an option.Since they are parabolic fixtures removing lamps will make sections of the fixture dark and it was explained during the walkthrough that the change in appearance will disrupt the occupants.Removing the 4-lamp fixtures and replacing them with 2-lamp fixtures will provide sufficient lighting for the corridors while saving energy and will not disrupt the occupants.

Outline Specification:

- Determine the areas and counts of the applicable lighting
- Disconnect power and replace the 4-lamp fixtures, 1 for 1 with 2-lamp fixtures.

- Wire as required.The fixtures can be to create a similar distribution of light or the fixtures can be relocated to distribute light more evenly.Restore electrical connection.

- **Implementation Plan**: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Savings are based on estimates of potential reductions in lighting wattage. Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: None

5.1.18 Replace Halogen MR-16 Lamps with Equivalent LED Lamps

Decorative and accent lighting is currently provided by halogen MR-16 light fixtures.Typically, these lights are used to illuminate artwork or create an impressive ambiance in and entryway.The halogen lamps in these fixtures can be replaced with LED fixtures that put out the same amount of light, create less heat and consume on a fraction of the electricity.

Outline Specification:

- Determine the areas and counts of the applicable lighting
- Replace halogen MR-16s with LED MR-16 lamps.Ensure the bases are the same.

- **Implementation Plan**: It is anticipated that this can be implemented by in-house staff.

Key Assumptions: Savings are based on estimates of potential reductions in lighting wattage. Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: None

5.2 Retro-commissioning

This section outlines the recommended retro-commissioning energy conservation measures. These measures include troubleshooting the existing controls systems, calibrating sensors, upgrades to controls software, and changes to setpoints that can be accomplished without large capital investment or significant changes to the existing systems.

5.2.1 Full Retro-Commissioning Study

More often than not, all buildings have systems and components that do not work as originally intended due to a variety of factors such as improper installation and equipment age.Re-commissioning and Retro-commissioning are terms that describe custom functional performance testing of building systems and controls.The process involves in depth testing of all the large

energy consuming HVAC systems by putting them through all of their paces (heating mode, cooling mode, economizers, schedules, warm up, setback, actuator strokes etc.) in order to verify that the equipment controls properly in each mode and the terminal devices in the space react appropriately such that the system performs optimally.The benefits of retro/re-commissioning include improved occupant comfort and indoor air quality, as well as reduced energy use.A 2004 study by the Lawrence Berkeley National Laboratory found that typical savings from retro/re-commissioning ranged from 3% to 15% of total building energy use

Outline Specification:

- Commissioning Authority (CxA) to review plans, control drawings and sequences, and programming logic.
- CxA will write systematic test procedures for all major HVAC systems.Procedures are designed to test all ranges of operation and automation.
- CxA and owner to perform test procedures for all major HVAC systems.
- CxA will compile deficiency log for HVAC for equipment and programming that require corrective action.
- Controls contractor and other applicable parties will coordinate with CxA and owner to resolve operational deficiencies.
- After items have been corrected, CxA will re-test for final resolution of deficiencies.

Implementation Plan: Commissioning consultant services will be required. A representative from the existing control service contractor should be available to jointly implement this recommendation and to provide further training to staff.

Key Assumptions: Based on results from previous projects, full building retro-commissioning can yield savings of 3% - 15% of a building's energy usage.The walkthrough staff's estimation of savings potential is identified in the economics of section 4 on a building by building basis.

Impact to Occupants: Improved occupant comfort.

5.2.2 Eliminate Over-Cycling of Compressors

During the walkthrough over-cycling compressors were identified.Direct Expansion (DX) cooling system rely on the cycling of compressors in order to meet the cooling load required of them.In order for a 20 ton cooling system to meet load, if there is a 10 ton load the compressor will have to turn on and off to average 10 tons of delivered cooling over some specified period of time.When compressors are allowed to over-cycle they turn on and off in short bursts which will cause the equipment to fail prematurely at the same time as consume more electricity than would otherwise be required due to frequent in-rush current of start-up.Since decreasing the level of staging intervals would require replacement of compressors which is very expensive, the most

appropriate way to eliminate over-cycle is to install controls to delay starts and stops beyond some user input time interval.With delays, there is enough time for the building to build up and deplete loads that the number of starts and stops can be reduced.

Outline Specification:

- Determine the controls requirements to install over-cycling limits on the system.This likely requires consultation with the equipment manufacturer.
- Install time-delays as appropriate.
- Calibrate time delays such that occupant comfort equipment operation is adequate while ensuring the longest on and off periods of the DX systems possible.

Implementation Plan: It is anticipated that the equipment manufacturer will be able to update/install the controls required on the equipment with a walkthrough of the building.

Key Assumptions: Elimination of over-cycling will increase the average efficiency of the cooling equipment by 5%.

Impact to Occupants: None.

5.2.3 Relocate Thermostat/Clear Thermostat Area

There were thermostats that control HVAC equipment that were identified as to being susceptible to a poor location or improperly obstructed.When a thermostat is subjected to an artificial load or is not allowed to reside in areas with appropriate circulation, it will not provide the HVAC system it is controlling with a reliable temperature feedback. Based on bad information, the HVAC will not produce optimal energy transfer in or out of the building and will operate less efficiently.Bad thermostat locations can result in a situation where adjacent HVAC systems fight each other and create uncomfortable conditions for occupants in addition to wasting energy.Thermostats that are covered by casework or cabinets do not get air movement around them and tend to deliver high control signals that make HVAC system work harder than they should.Thermostats located on exterior walls tend to deliver a controls signal that is influenced by the outside air temperature and makes interior HVAC equipment control out of optimization.

Outline Specification:

- Determine thermostats that are obstructed or in poor locations.
- Determine and take the corrective action.This may involve relocating the thermostat or moving the casework/cabinets from the immediate area of the thermostat.

Implementation Plan: Based on the corrective action determined by the walkthrough team, a cost may or may not be provided for relocating the thermostat.If the corrective action can be implemented by in-house staff no cost was included.

Key Assumptions: The unobstructed or properly located thermostat will appreciably increase the efficiency of the heating and cooling systems within the building.

Impact to Occupants: Improved occupant comfort.

5.2.4 Program VFD Controls

The air handling unit is equipped with a VFD, but is operating at a fixed speed because the VFD controls have not been programmed.With programmed controls, the VFD speed would modulate, thus saving fan, cooling, and heating energy.

Outline Specification:

- Install any controls hardware for the modulation of VFD speeds.
- Program VFD controls.

Implementation Plan: It is anticipated that the equipment manufacturer will be able to update/install the controls required on the equipment with a walkthrough of the building.

Key Assumptions: The program will allow the VFD speed to modulate based on load.

Impact to Occupants: Improved temperature control in the space.

5.2.5 Schedule Hot Water Temperature Reset

Constant volume heating hot water systems benefit from hot water temperature reset schedules.As the outside air temperature goes down, so should the heating hot water temperature required to satisfy the building heating loads.Since heating water systems have standby losses that correlate with temperature, less heating energy is released to unintended areas when the temperature is lowered.A reset schedule currently exists but is not fully utilized to lower the heating hot water temperatures over a range of outside air temperatures that still allow the building heating system to maintain the heating load.

Outline Specification:

- Program the outside air reset of the heating water system.
- Test the reset sequence and tune the PID controls so that the outside air reset schedule is as aggressive as possible, the controls are stable, and the temperatures do not hunt.
- Through trial and error throughout the heating season, determine the coldest heating water temperatures can be set on the reset schedule while the building maintains comfort and set them permanently.

Implementation Plan: It is anticipated that this can be completed by in-house staff.

Key Assumptions: The outside air reset schedule will eliminate 1% of the natural gas usage in the building due to standby losses.

Impact to Occupants: None.

5.2.6 Schedule Air Handlers Night Setback

Night setback controls sequences allow for the building HVAC systems relax when the building is empty thereby savings energy.The only requirements are to maintain an environment that will not damage the fixtures, finishes or infrastructure of the building and to be back at occupied comfort conditions by the time the first occupants arrive in the morning.Night setback temperatures are typically set for 55 degrees in the winter and 85 degrees in the summer but vary depending how well a building coasts and the HVAC systems are able to recover.

Outline Specification:

- Determine the upgrade required for the existing building controls system to enable night setback controls or verify that they currently exist.
- Enable the night setback sequences starting with 65 deg F (winter) and 80 deg F (summer) setback temperatures.Gradually make the setback deeper until problems with startup are encountered.
- Ensure the setback temperatures are the deepest that the building can tolerate and still provide appropriate conditions for building occupants when they arrive.

Implementation Plan: It is anticipated that operations staff can implement this measure without any further engineering input.

Key Assumptions: The building will tolerate setbacks of 55 deg F (winter) and 85 degree F (Summer)

Impact to Occupants: Temperatures will be hotter or colder during unoccupied setback hours.Training will be required to inform building occupants that off hours HVAC is relaxed in order to save significant amounts of energy.Typically, building occupants are ok will non-occupied conditions in the building if they are aware that the building sees significant operational energy consumption and cost reduction.

5.2.7 Investigate Chilled Water Plant Minimum Flow Settings

At the South Dakota School of Mines central chiller plant, the secondary pump VFD speed is programmed to ensure a minimum flow of 1,000 GPM.However, the reasoning behind the minimum flow setpoint is unclear.Since there are constant speed primary pumps serving the chillers, minimum chiller flow is likely not an issue.As long as the chiller operation can support a lower secondary flow rate, the flow could be reduced to save pumping energy.

Outline Specification:

- Confirm from chiller manufacturer, system designer, and controls contractor that minimum flow setpoint can be changed.
- Change the minimum flow setpoint.

Implementation Plan: It is anticipated that the chiller manufacturer, system designer, and controls contractor can provide the necessary clarifications.In-house staff can provide the control changes.

Key Assumptions: Assume an average secondary pump speed reduction from 57% to 51% while the pumps are running.

Impact to Occupants: None.

5.2.8 Calibrate Sensors

Upon investigation of the building DDC control system, there were control points that were reading values that were obviously incorrect.Sensor calibration should be investigated to determine why they are not reading the correct values. The locations of the sensors may also create issues, such as a temperature sensor located such that it is in direct sunlight directly over a black roof will read higher than actual temperatures.This creates issues with the controls system when they use these points to optimize the systems for energy use.For example, when the building believes it is 75 deg F outside, but it is actually 55 deg F outside the controls system will call for mechanical cooling when an airside economizer could satisfy any cooling load without any mechanical cooling energy use at all.Note that sensor calibration is a continuous process that should be incorporated into regular maintenance plans.

Outline Specification:

- Identify malfunctioning sensors and provide corrective actions as required.
- Implement strategy that continually checks sensor readings for calibration issues.

Implementation Plan: It is anticipated that this can be completed by in-house staff.

Key Assumptions: System efficiency will improve based on the judgment of the walkthrough team.Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: Improved occupant comfort.

5.2.9 Reduce Minimum Outside Air Ventilation Amount

The outside air dampers are currently set at a fixed minimum position.This is intended to ensure that enough outside air is being brought into the building when it is fully occupied to be

appropriately ventilated.Space occupancy can vary dramatically, and usually contain fewer people than at design conditions, there is more outside air being brought into the building than is required.Since heating and cooling outside air is energy intensive it would be cost effective to revisit the existing building occupancy and current minimum ventilation building code to limit the amount of OA brought in to the level required by the building load.A minimum outside air flow or damper position setpoint should also be taken into consideration to avoid negative building pressurization.

Outline Specification:

- Work with controls vendor or engineering consultantto specify the current outside air requirement for the building
- Install sensors and update ventilation control programming.Reset minimum damper positions
- Program to include self test that reverts to minimum ventilation mode if sensor fault is detected, or reading are outside standard range.
- Update sequence of operation documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Outside air amounts will be reduced by a fixed amount throughout the air eliminating the requirement of the existing HVAC equipment to condition that air.

Impact to Occupants: None.

5.2.10 Do Not Run in Heat Recovery Mode During Economizer

The building makeup air and exhaust systems utilize energy recovery to recover heat to and from the exhaust stream when it is beneficial for heating and cooling.Heat recovery is accomplished using a run-around pumped coil loop, where a pump circulates fluid through coils in the makeup air and exhaust air ducts.The loop runs continuously whenever the unit is running.When the heat recovery loop is active during periods where economizer cooling could be utilized, however, the exhaust air stream actually adds energy to the incoming outside air.As a result, more mechanical cooling is required to cool the air back down.The pump could be controlled based on outside air temperature to turn off whenever the outside air temperature is between 50° F and 70° F.

Outline Specification:

- Install on/off controls capability to pumps from central system.
- Program control logic to activate pump at the appropriate outside air temperatures.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Specific areas of implementation, if applicable, are included with the individual building economics in section 4.

Impact to Occupants: None.

5.2.11 Repair Leaks in Ductwork

When ductwork is leaking it cannot appropriately deliver the heating and cooling to spaces that it was originally designed to.Not only does this make the HVAC systems work harder, occupant comfort suffers as the heating and cooling leaks into the plenum space above the ceiling.Sealing the ductwork will result in an increase in occupant comfort and a decrease in energy use.

Outline Specification:

- Systematically test ductwork joints for leakage starting at the air handling unit and working toward the terminal devices.
- Repair any joints deemed to have excessive leakage.Replace gaskets on flanged ductwork if necessary.Re-set slip and drive ductwork connections and tighten appropriately.
- Using an appropriate duct sealant, reseal any openings.
- Provide sheet metal patching, gaskets and duct sealant on openings too large to cover with sealant alone where appropriate.

Implementation Plan: It is anticipated that a contactor can complete the above scope of work with no additional input for the buildings identified in this report.Maintenance staff can add specifics to this list of buildings as many specific areas and distribution ductwork has already been identified as leaky.

Key Assumptions: A total air handling unit fan speed reduction of 10% will occur when air no longer recycles from the plenum due to duct leakage.

Impact to Occupants: There will be an increase in comfort, temperature control and ventilation throughout the occupied spaces of the building.

5.2.12 Fix Boiler Operation

The boiler plant at the South Dakota School of Mines runs continuously throughout the year due to many steam loads during the summer.A new boiler with enhanced turndown capabilities was recently installed so that it could run as the “summer” boiler instead of the old boiler with very little turndown capability.However, the newer boiler rarely operates because of control issues, and the older boiler must operate, leading to very poor thermal efficiencies at low load

conditions. The boiler operation could be fixed so that the full savings of the new boiler can be realized.

Outline Specification:

- Consult with boiler manufacturer to diagnose the issues.
- Determine and execute the appropriate control repairs.

Implementation Plan: It is anticipated that a qualified contractor or boiler service personnel can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Average efficiency improvement from 64% to 73% for temperatures above 50°F.

Impact to Occupants: None.

5.2.13 Repair Compressed Air Leaks

The building currently has a compressed air system and serves pneumatic controls or pneumatic tools.For controls and tools, pneumatics are simple and reliable.Their main drawback is that creating compressed air at high pressure is energy intensive.As long as the system integrity and air usage are minimal the systems are effective.When there are excessive amounts of leakage or air usage the large motors that drive the compressors log excessive run times which consumes significant amounts of electricity with little work actually accomplished.Based on the understanding during the walkthrough, the integrity of the existing pneumatic system is in question.Frequent cycling or long cycles of compressor run time are indicators that there may be leaks in the system.Leaks should be identified and fixed.That will reduce compressor run time and the associated electrical consumption.

Outline Specification:

- Determine the most suitable procedure for fixing leaks in a pneumatic system based on type, size and equipment served.
- Isolate and pressurize small sections of the system at a time.Any sections which create frequent cycling of the compressors, test the joints and users of the compressed air for leaks.
- Repair or replace faulty tubing, joints or equipment in the system.
- **Implementation Plan**: It is anticipated that a qualified controls contractor can accomplish the above the above scope of work with no further input.

Key Assumptions: Significant cycling was observed or understood during the walkthrough in the buildings reported for this measure.The savings are based on a 20% reduction in compressor run time after they are tightened up and the air pressure is reduced.

Impact to Occupants: None

5.2.14 Interlock Pumps with Central Plant

Pumps can be controlled in many different was as part of many different systems.In hydronic heating and cooling applications they are generally controlled by a building automation system, a packaged controls system, or manually.Wasted run time can occur when the systems controlling the pumps and the systems controlling other portions of the hydronic systems do not communicate.There will be situations where the chiller(s), cooling tower (s) or boiler are enabled to run but the internal controls of the equipment have determined that the load is satisfied and shut down their operation.Since they are still enabled, the pumps continue to run.For some modes of operation this is required, for others they can be shut down as well.Most hydronic equipment controls packages allow for pump control by the plant that ensures the pumps will not run when they hydronic equipment does not need them to.

Outline Specification:

- Determine the hydronic equipment controls package capabilities and upgrade options in order control the pumps from that system.
- Determine the scenarios of control where pumps are required and not.Set up the controls system accordingly.
- Wire and install the pump controls.
- Commission the controls system to ensure that the pumps react according to control expectation through all modes of operation.

- **Implementation Plan**: It is anticipated that a qualified controls contractor can complete the above scope of work with no further engineering input.

Key Assumptions:Pump run times will be reduced.

Impact to Occupants: None.

5.2.15 Decrease Kitchen Hood Airflow

There is a dedicated kitchen hood in the building that removes heat, vapor, smoke or grease from a commercial cooking type application.Building codes require minimum flows and velocities based on the size of the hood and what kitchen equipment is underneath of it.Typically, the whole hood is sized for the worst case equipment.It was identified during the walkthrough the hood is currently configured to exhaust more air than is required by code.Since, the air going out of the

hood was once conditioned by the central HVAC systems, decreasing the kitchen hood airflow to the levels required by code will result in the savings of energy that it takes to heat and cool that air.

Outline Specification:

- Take and inventory of kitchen equipment under the hood, ensure each piece requires a dedicated exhaust hood.Remove equipment that does not require at dedicated hood.
- Determine the worst case piece of equipment under the hood and its exhaust requirements by code.
- Rebalance the hood CFM to code required levels and adjust the make-up air system accordingly (if applicable).

- **Implementation Plan**: It is anticipated that a qualified contractor can complete the above scope of work with no further engineering input.

Key Assumptions:Local building codes require 400 CFM/ft for a Type 1 (grease) hood and 200 CFM/ft for a Type 2 (non-grease) hood.

Impact to Occupants: None.

5.2.16 Decrease Air Compressor Pressure

There is a compressed air system in the building that serves pneumatic tools or controls.The pneumatic pressure is left at a static level 24/7 no matter what the actual equipment using it needs to operate appropriately.Typically, controls and equipment have minimum working pressures at the terminals of the system so the pneumatic pressure at the compressor is set higher in order to have at least that pressure at the devices.When the pressure is set higher, more air finds leaks in the system and leaks develop and worsen faster than at lower pressure.Since the creation of compressed air is energy intensive, reducing the air pressure to only what is required and turning the system off when it is not being used will reduce energy consumption.

Outline Specification:

- Determine the largest minimum required pressure of all of the pneumatic devices connected to the system.
- Systematically decrease the air pressure at the compressor until the devices do not work to the satisfaction of the operators.
- Record the system air pressure and periodically check the setpoint to ensure it has not be raised.
- Determine if there are any periods where the pneumatic systems can be shut off and ensure that the systems are off during that time.

- **Implementation Plan**: It is anticipated that this can be completed by in-house staff.

Key Assumptions:The working pressure and cycling time of the air compressor(s) was documented by walkthrough staff.It assumed that the percentage reduction in working pressure will equal the percentage reduction in overall compressor run time.

Impact to Occupants: The pneumatic systems may be slower to recover during periods of high pneumatic air usage.

5.2.17 Schedule Fume Hoods Off During Summer

There are approximately sixteen fume hoods in the building which are utilized for laboratory classrooms.During the school year, the hoods are used to store chemicals and are left to operate continuously.During the summer, most, if not all, of the fume hoods are left unused.The hoods, however, still run continuously.If no storage or lab activity is needed, these hoods could be turned off for significant fan and cooling energy savings.

Outline Specification:

- Consult with faculty and school code officials to determine when hoods can be turned off.
- Make any controls modifications necessary to enable hood scheduling.

Implementation Plan: It is anticipated that the School of Mines can implement this measure in-house without further engineering.

Key Assumptions: Assume that the hoods are off from May-August.Costs assume minimal controls work.Costs for additional equipment such as hazardous chemical storage cabinets are not included.

Impact to Occupants: None.

5.3 Controls

This section outlines the recommended controls energy conservation measures. These measures include significant controls system upgrades that are large enough by scale or quantity to be categorized as a significant capital investment.

5.3.1 Install VFD on Cooling Tower Fans

Cooling towers take warm condenser water and reject heat to the ambient air by drawing air through a spray.As spray evaporates the temperature of the condenser water is reduced and delivered back to the chiller.A constant speed fan currently stages on and off in order to maintain a constant condenser water temperature back to the chiller.A VFD could be installed and controlled to the condenser water temperature in order to slow the fan as much as possible in lieu

of staging it on and off.Not only does this reduce electric consumption, it also provides tighter control for the chiller and increases the life of the tower fan motor.

Outline Specification:

- Field verify motor size, voltage and actual amperage use for VFD selection – drives will not function correctly if undersized. Record motor amps.
- Select drives in accordance with applicable engineering standards.
- All new drives shall be equipped with line bypass switching so that pumps may continue to operate if drive fails.
- For installations with VFD to motor wiring distance greater than 100 feet, output filters shall be provided with drive package.
- Drive location shall be selected to be compatible with manufacture recommendations – cool, reasonably dry and with adequate ventilation.
- Install temperature sensor in the condenser water supply piping.
- Use DDC panel, VFD control capabilities, or otherwise select and install appropriate pressure controller, to vary pump speed output to maintain differential pressure set point.
- Provide VFD startup services making adjustment as necessary; provide operator training.

Implementation Plan: It is anticipated that the controls vendor for the building could complete this work with no further engineering input.

Key Assumptions: None

Impact to Occupants: None.

5.3.2 Programmable Thermostats

Programmable thermostats allow for occupied and unoccupied times, with different set points, to be programmed into the thermostat so that it will automatically adjust everyday to the occupancy of the building.This allows for the building's HVAC systems to setback or relax when the building is empty thereby saving energy.The only requirements are to maintain an environment that will not damage the fixtures, finishes or infrastructure of the building and to be back at occupied comfort conditions by the time the first occupants arrive in the morning.

Outline Specification:

- Determine a suitable programmable thermostat product.This should include a seven day schedule with upper limit and lower limit night setbacks.
- Replace the existing thermostats with the new programmable thermostats and ensure that they control properly in each of their modes.

- Train building occupants to program the thermostat and ensure they understand the energy benefits of deep setbacks.
- Ensure the thermostat is still programmed periodically.

Implementation Plan: It is anticipated that operations staff can implement this measure without any further engineering input.

Key Assumptions: The fan run time of the units will reduce in proportion to the reduction in heating and cooling during setback hours.

Impact to Occupants: Temperatures may be hotter or colder during unoccupied setback hours.

5.3.3 Install VFDs on Hydronic Pumps

The hydronic (heating or chilled) water pumping systems in the building are currently constant volume.Variable Frequency Drives (VFDs) could be installed on the pumps that would reduce the pump speed, and associated electrical consumption, to the minimum possible while maintaining the building load.This would require the control valves throughout the system to be 2-way, and a differential pressure sensor.As the 2-way valves close down with a reduced load, pressure builds up in the system than when sensed by the differential pressure sensor would signal the pumps to slow down until the system reaches equilibrium.

Outline Specification:

- Field verify motor size, voltage and actual amperage use for VFD selection – drives will not function correctly if undersized. Record motor amps.
- Select drives in accordance with applicable engineering standards.
- All new drives shall be equipped with line bypass switching so that pumps may continue to operate if drive fails.
- For installations with VFD to motor wiring distance greater than 100 feet, output filters shall be provided with drive package.
- Drive location shall be selected to be compatible with manufacture recommendations – cool, reasonably dry and with adequate ventilation.
- Install pressure differential sensor on supply/return header.Ideally the sensor is located at the point of lowest pressure differential between the supply/return headers; however the location shall have reasonable access for service and ease of wiring to the control panel.
- Use DDC panel, VFD control capabilities, or otherwise select and install appropriate pressure controller, to vary pump speed output to maintain differential pressure set point.
- Provide VFD startup services making adjustment as necessary; provide operator training.
- Select and install differential pressure sensors and controls.

- Install new triple duty 2-way valves, or convert existing 3-way valves.
- Update as-built documentation.

Implementation Plan: Detailed engineering is required to produce a final controls points list and sequence of operation for each unit.

Key Assumptions: Motors that previously were 90% loaded at constant speed will modulate linearly between 90% and 50% throughout the weather patterns during the year.

Impact to Occupants: None.

5.3.4 Install VFDs on Single Zone Constant Volume AHUs

The HVAC fan systems in the building are currently constant volume.Variable Frequency Drives (VFDs) could be installed on the fan motors with appropriate controls that would reduce the fan speed, and associated electrical consumption, to the minimum possible while maintaining the building load.This is a simple installation for single zone systems.Instead of the discharge air temperature controlling to the space set point.The fan speed will control to the space set point at the same discharge air temperature.The result is the same amount of heating or cooling energy being delivered with less fan energy.

Outline Specification:

- Field verify motor size, voltage and actual amperage use for VFD selection – drives will not function correctly if undersized. Record motor amps.
- Select drives in accordance with applicable engineering standards.
- All new drives shall be equipped with line bypass switching so that pumps may continue to operate if drive fails.
- For installations with VFD to motor wiring distance greater than 100 feet, output filters shall be provided with drive package.
- Drive location shall be selected to be compatible with manufacture recommendations – cool, reasonably dry and with adequate ventilation.
- Use EMS panel, VFD control capabilities, or otherwise select and install appropriate pressure controller, to vary fan speed output to maintain the duct static pressure set point.
- Provide VFD startup services making adjustment as necessary; provide operator training.
- Update as-built documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Motors that previously were 90% loaded at constant speed will modulate linearly between 90% and 50% throughout the weather patterns during the year.

Impact to Occupants: Improved occupant comfort.

5.3.5 Remove Inlet Vanes and Modulate Airflow with VFDs

The HVAC fan systems in the building are variable airvolume (VAV) that utilize variable pitch inlet vanes to control the amount of airflow.Variable Frequency Drives (VFDs) could be installed on the fan motors with appropriate controls that would reduce the fan speed, and associated electrical consumption, to the minimum possible while maintaining the building load without modulating the inlet vanes.The inlet vanes should then be removed so that they do not increase the static pressure of the system which will allow for the VFD to back of even further.This is a simple installation for VAV inlet vane systems.The controls signal that currently modulates the blade pitch is converted and input to the VFD to control speed.

Outline Specification:

- Field verify motor size, voltage and actual amperage use for VFD selection – drives will not function correctly if undersized. Record motor amps.
- Select drives in accordance with applicable engineering standards.
- All new drives shall be equipped with line bypass switching so that pumps may continue to operate if drive fails.
- For installations with VFD to motor wiring distance greater than 100 feet, output filters shall be provided with drive package.
- Drive location shall be selected to be compatible with manufacture recommendations – cool, reasonably dry and with adequate ventilation.
- Use EMS panel, VFD control capabilities, or otherwise convert the existing controls signal, to vary fan speed output to maintain the duct static pressure set point.
- Provide VFD startup services making adjustment as necessary; provide operator training.
- Update as-built documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: The air volume will be identical to the current operation.The fan speed will reduce 2% throughout the range of modulation due to the elimination of the static pressure drop over the inlet vanes.

Impact to Occupants: None.

5.3.6 Install Heating Water Reset Schedule

Constant volume heating hot water systems benefit from hot water temperature reset schedules.As the outside air temperature goes down, so should the heating hot water temperature required to satisfy the building heating loads.Since heating water systems have standby losses that correlate with temperature, less heating energy is released to unintended areas when the temperature is lowered.A reset schedule should be installed to utilize the lowest heat hot water temperatures over a range of outside air temperatures that still allow the building heating system to maintain the heating load.

Outline Specification:

- Determine the controls upgrade required on each individual system in order to install and outside air reset.This could be a software upgrade on a controls system that already controls the boilers or a standalone Watlow type system that attaches to the internal boiler controls system and only controlled the boiler water temperature.
- Install the appropriate reset air system.
- Test the reset sequence and tune the PID controls so that the outside air reset schedule is as aggressive as possible, the controls are stable, and the temperatures do not hunt.
- Through trial and error throughout the heating season, determine the coldest heating water temperatures can be set on the reset schedule while the building maintains comfort and set them permanently.

Implementation Plan: Utilize existing control service contracts or hire controls service technicians for each controls vendor to complete the work in the outline specification above.It is anticipated that this can be accomplished without any further engineering input.

Key Assumptions: The outside air reset schedule will eliminate 1% of the natural gas usage in the building due to standby losses.

Impact to Occupants: None.

5.3.7 Convert Multi-zone/Dual Duct to VAV

There are multi-zone/dual duct air handling units that provide HVAC to the building.Multi-zone units are inherently inefficient because they require mixing of hot and cold air streams and constant air volumes to match the heating and cooling loads of the space.This could be accomplished by a complete overhaul, but based on the life expectancy of the current equipment it has been determined that a retrofit of the existing units would yield the most economically effective result.The multizone units would converted VAV systems by installing variable frequency drives on the fans, controlling the zone dampers independently in lieu of opposed, and controlling the fan speeds based on duct pressure.

Outline Specification:

- Determine the building heating and cooling loads in the spaces currently served by the respective air handler.
- Field verify motor size, voltage and actual amperage use for VFD selection – drives will not function correctly if undersized. Record motor amps.
- Select drives in accordance with applicable engineering standards.
- All new drives shall be equipped with line bypass switching so that pumps may continue to operate if drive fails.
- For installations with VFD to motor wiring distance greater than 100 feet, output filters shall be provided with drive package.
- Drive location shall be selected to be compatible with manufacture recommendations – cool, reasonably dry and with adequate ventilation.
- Use EMS panel, VFD control capabilities, or and duct static pressure sensors in both the heating and cooling chambers to vary fan speed output to maintain the duct static pressure set point.Replace zone actuators with independent actuation in lieu of opposed such that each zone uses only one airstream at a time depending on a call for cooling or heating.
- Provide as-built documentation.

Implementation Plan: It is anticipated that a qualified contractor can design and install this retrofit through a design/building process.This could also be designed plan/spec/bid by a qualified consulting engineer.

Key Assumptions: Simultaneous heating and cooling will be eliminated and the fan speed will vary according to a typical distribution.

Impact to Occupants: None.

5.3.8 Schedule AHUs Off During Unoccupied Hours

Currently there are local HVAC devices or building HVAC systems that are locally controlled.The controls enable the systems to run 24/7.The fans run 24/7 and the heating and cooling systems are allowed to come on based on the direction of the thermostat.Controls could be added to the system that would allow schedules to be put into effect on all of the HVAC devices.This would allow the HVAC systems to shut down when they are not necessary or when the building is not occupied.In buildings with an existing central DDC controls system, these devices would require power and control points of the devices to be wired to the central system and programming added to control them.In buildings where there is no central system, a time clock system can be cut into the power supply of the devices.This would disable the devices

whenever the scheduler cuts power.Any power interrupting circuitry must be designed with special attention to how the devices react to interruptible power as well as maintaining night setback temperatures to ensure there is freeze protection where required.

Outline Specification:

- Determine the suitability of the different options of scheduling controls upgrades for each individual building.In buildings where there currently is a supported central DDC system, the un-schedulable devices should be added to the system.In buildings where there is no central system the prospect of installing a central system for scheduling should be investigated.If that is cost prohibitive a simple timeclock system can be installed that will interrupt the power supply to the HVAC equipment.
- Install the most suitable scheduling controls system.
- Meet with management of the building occupants for each building and determine the most aggressive schedule available.
- Set up the schedules based on a reasonable expectation for the requirements of morning warm-up.Adjust this schedule seasonally adjusting for the likely requirement for morning warm-up.In winter there will likely be a significant morning warm-up required.In the spring and fall it will likely be minimal.In the summer there will likely be no need for morning warm-up.

Implementation Plan: Utilize existing control service contracts or hire controls service technicians for each controls vendor to complete the work in the outline specification above.It is anticipated that this can be accomplished without any further engineering input.

Key Assumptions:

Impact to Occupants: Some spaces will be unconditioned or be exposed to setback temperatures during unoccupied hours.

5.3.9 Upgrade Controls System to Full DDC

The building controls systems are currently a combination of pneumatic, electric and direct digital controls (DDC).There is an industry consensus that DDC controls are superior to pneumatic controls for ease of operation, self-diagnostics, and safety reasons.Replacing/upgrading the existing controls to DDC will enhance the effectiveness of the building control system.An upgrade would allow building staff to troubleshoot the building for energy wasting issues much more effectively.It would also allow the controls system to take advantage of more aggressive energy saving strategies that they are currently unable to be accomplished because of the inability to coordinate the terminal devices with the central systems.Many levels of upgrades are available and generally the greater level of control installed the more efficient a system is capable of operating.

Outline Specification:

- Create an inventory of control points within the building.
- Determine the most cost effective way to upgrade control to a front end DDC system.This could be full DDC or an DDC overlay on a pneumatic system.
- Determine the most cost effective sequence of operation for the HVAC equipment and install accordingly.
- Commission the operation of the system to ensure it is installed and operating as intended and is set up in an optimal condition.
- Test and adjust setpoints to create the most aggressive energy efficient strategies that the HVAC systems can be set up with.

Implementation Plan: Hire a qualified consultant to create points lists and sequences of operations for the most cost effective controls upgrade.Competitively bid or work with the existing controls vendor to upgrade the controls system according to spec.

Key Assumptions: Controls upgrades typically achieve savings of 5-40% but this depends heavily on the level of control that is installed and how limited the existing controls are.An economic estimate of potential was made during the walkthrough based on a brief review of the existing system with building staff and is included in section 4.

Impact to Occupants: Improved occupant comfort.

5.3.10 Investigate Waterside Economizer Operation

The chilled water system at the South Dakota School of Mines utilizes a water side economizer feature for free cooling during the fall, winter, and spring.When the system comes out of economizer mode and requires mechanical cooling from the chiller, the condenser water return temperature is feared too low for chiller operation.Thus steam heating is actually utilized during the changeover to heat the return water above the allowable minimum temperatures at the expense of both heating and cooling energy.Another work-around, such as mixing valves, could be utilized to facilitate the changeover to avoid heating a large volume of condenser water.

Outline Specification:

- Consult the chiller manufacturer to determine the minimum entering water temperatures.
- Design and implement an alternative flow schematic to avoid adding energy to the chilled water loop.

Implementation Plan: It is anticipated that a qualified contractor can design and install this retrofit through a design/building process.

Key Assumptions: The costs assume provisions for engineering, controls contractor, and minor controls hardware costs.

Impact to Occupants: None.

5.3.11 Install Cooling/Heating Control Valves

The hydronic heating and cooling systems in the building rely on loops of pumped hot or cold water to provide heating and cooling to the facility.There are opportunities in the building to add control valves to this system.More control valves allow the system to control better which reduces simultaneous heating and cooling as well as eliminates overcooling or overheating.On hydronic systems equipped with VFDs and variable speed controls, the pumps will turn down further thereby saving electrical pump energy.

Outline Specification:

- Inventory the system affected to determine sections and equipment of the building that would benefit from an increased number of control valves.
- Determine an appropriate controls strategy.Develop a system design.
- Install valves, piping and controls according to the determined design strategy.
- Commission the new valves to ensure proper operation.
- Update building documentation.

Implementation Plan: It is anticipated that this project would best be approached through an engineered plan/specification and hard bid process.

Key Assumptions: An estimate of reduced simultaneous heating and cooling, overcooling, overheating and pump speed turndown were used based on the walkthrough engineers understanding of the building while onsite.

Impact to Occupants: Improved occupant comfort.

5.3.12 Install VFDs on Oversized Chilled Water Pumps

The hydronic (heating and/or chilled) water pumping systems in the building are currently constant volume. Although there may no opportunities for variable speed control, variable frequency drives (VFDs) could be installed on the pumps that would reduce the pump speed, and associated electrical consumption, to the minimum possible while maintaining the building load. The application of variable speed pumping would need to be accompanied by replacement of existing 3-way coil valves with 2-way valves and appropriate pressure controls. The costs shown for various ECM's so not seem to reflect this requirement. The scenario found in the building was triple duty (balancing) valves on several pumps was found to be in a 15-30% open condition. The pumps are so large and powerful compared to the load they are serving that they need to be

choked down by significant amounts. By doing this the pump does the same amount of work as if it was pumping its full capability. Installing VFDs would allow for the triple duty vales to be opened completed and the pumps balanced by reducing the amount of electricity going to them.

Outline Specification:

- Field verify motor size, voltage and actual amperage use for VFD selection – drives will not function correctly if undersized. Record motor amps.
- Select drives in accordance with applicable engineering standards.
- All new drives shall be equipped with line bypass switching so that pumps may continue to operate if drive fails.
- For installations with VFD to motor wiring distance greater than 100 feet, output filters shall be provided with drive package.
- Drive location shall be selected to be compatible with manufacture recommendations – cool, reasonably dry and with adequate ventilation.
- Provide VFD startup services making adjustment as necessary; provide operator training.
- Open the triple duty valves and balance using a static VFD speed.
- Update as-built documentation.

Implementation Plan: It is anticipated this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: The pumps can be reduced to 50% speed with the triple duty valves opened for balancing for their entire run time.

Impact to Occupants: None.

5.3.13 Demand Control Ventilation (CO2 Control)

The outside air dampers are currently set at a fixed minimum position.This is intended to ensure that enough outside air is being brought into the building when it is fully occupied to be appropriately ventilated.Since space occupancy can vary dramatically, and usually contain fewer people than at design conditions, there is more outside air being brought into the building than is required.Since heating and cooling outside air is energy intensive it would be cost effective to limit the amount of OA brought in to the level required by the building load.By installing carbon dioxide (CO2) sensors in various strategic places throughout the building, the outside air dampers can be actively controlled to maintain a maximum CO2 level.The OA dampers would only open to the level required by the amount of occupants.While this is a code acceptable method of OA control, attention must also be paid to other air contaminants than CO2 as this system will not account for them.A minimum outside air flow or damper position setpoint should also be taken into consideration to avoid negative building pressurization.

Outline Specification:

- Work with the controls vendor or a controls contractor to specify CO2 sensor installation. At minimum there should be one sensor in each return duct to air handler.
- Install sensors and update ventilation control programming.
- Program to include self test that reverts to minimum ventilation mode if sensor fault is detected, or reading are outside standard range.
- Building should monitor space CO2 levels with a remote monitor device and verify monitoring device and CO2 space readout levels are reasonably close in relation.
- Update sequence of operation documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Active control of CO2 will result in only 15 CFM of outside air will require conditioning by the HVAC systems during occupied times throughout the year.

Impact to Occupants: Ensured appropriate CO2 concentrations per indoor air quality requirements.

5.3.14 Convert Three-way Valves to Two-way

Currently, the building has a chilled water or hot water pump with a VFD, but the pumps cannot turn their speeds down because three-way valves on the air handling unit coils artificially keep the loop differential pressure low so that the VFDs must run at higher speeds. VFD's in applications with 3-way valves are good candidates for retrofits. Systems will three way valves tend to have low delta Ts (difference in temperature supply versus return). This suggests that the coils were not loaded and valves were diverting the water through the bypass. If two-way valves were installed on these coils, the valves would be closed during low load periods, and the differential pressure signal would turn the pump speed down. In addition to saving pump energy, a larger temperature rise across the chilled water coils will greatly increase the cooling efficiency of the chiller.

Outline Specification:

- Field verify three-way valve installations. To save potential costs, determine which three-way valves could be used as two-way valves by simply capping the coil bypass line.
- Install two-way valves.If necessary, install bypass line with modulating valve to maintain minimum flow through the chiller per manufacturer's recommendations.
- Balance coils and adjust differential pressure setpoint.Record changes in O&M manual.

Implementation Plan: Moderate engineering services may be required.It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed to implementation.

Key Assumptions: Pump speeds will reduce by a fixed amount throughout the modulation of the system.

Impact to Occupants: None.

5.3.15 Optimum Start Program

Most modern DDC control systems that are currently supported by the manufacturer offer an optimum start programming option with their building automation systems.In an optimum start program, the actual occupancy schedule is input by the user and the amount of time the HVAC systems must run prior to occupancy time is automatically calculated based on outdoor and indoor temperatures.Currently, the standard practice is to initiate the HVAC systems to maintain occupancy set points an hour before occupants arrive to ensure the building is to comfort levels no matter the outdoor air temperature.During the months that are not bitterly cold, the amount of time required is generally much shorter.An optimum start system will ensure that the HVAC systems are not running when they are not necessary thereby saving energy, reducing maintenance effort and cost, as well as helping to improve occupant comfort.On those buildings that have controls system that will support optimum start programs, they should be installed and programmed aggressively.This will not be available on buildings that have antiquated controls, local controls or systems that are not supported by the manufacturer any longer.A new system would have to be installed to realize savings.

Outline Specification:

- Determine which controls systems allow for an optimal start upgrade, which controls systems already have this feature but it is not used, and which controls systems are no longer supported by the manufacturer.
- Install, upgrade and program the optimal start program to be as aggressive as possible to reduce HVAC system run times.

Implementation Plan: Utilize existing control service contracts or hire controls service technicians complete the work in the outline specification above.It is anticipated that this can be accomplished without any further engineering input.

Key Assumptions: Optimal start/stop will reduce air handling unit operation one hour per day, on average, throughout the year.

Impact to Occupants: None

5.3.16 Program Cooling Coil Discharge Air Temperature Reset

Currently, some units have a constant supply air temperature setpoint, usually 55°F.A discharge air temperature this low is required for times when either space cooling or dehumidification is required.When cooling is not required in any zones served by the unit, cooling the air to its discharge air temperature setpoint leads to reheating of the air at the terminal units or VAV boxes.A reset schedule should be employed to reset the temperature upward when neither cooling nor dehumidification is required to save both cooling and reheat energy.

Outline Specification:

- Program discharge air temperature reset strategy schedule based on VAV calls for cooling.
- Update sequence of operation documentation.

Implementation Plan: Utilize existing control service contracts to complete the work in the outline specification above.It is anticipated that this can be accomplished without any further engineering input.

Key Assumptions: 55°F discharge temperature at peak cooling, 65°F discharge air temperature at 40°F outside air temperature, linear interpolation in between.

Impact to Occupants: When heating plants are disabled, this strategy will avoid potential overcooling.

5.3.17 Reset Occupant Thermostat Slider Setpoints

User adjustable thermostats are an effective way to improve occupant thermal comfort on an individual zone basis.Typically this type of control system will allow the individual occupants of a space to adjust temperatures within an 8 to 10 degree range of the design temperatures.The ability of a buildings front end control system to reset thermostats during unoccupied mode to a standard temperature can prevent spaces from either over cooling or heating when there space is unoccupied.A temperature reset strategy should be implemented to bring all spaces with adjustable thermostats back to design temperatures each night to save both heating and cooling energy.

Outline Specification:

- Program zone with adjustable thermostats to reset temperatures each night to design temperatures.

Implementation Plan: Utilize existing control service contracts to complete the work in the outline specification above.It is anticipated that this can be accomplished without any further engineering input.

Key Assumptions: Thermostats currently installed have the ability to be reset without the need of manual adjustment.

Impact to Occupants: Individual space users will need to readjust space temperatures on a daily basis if desired.

5.3.18 Schedule Toilet Exhaust Fans for Occupied Hours

There are dedicated toilet exhaust fans in the building that currently are powered 24/7 no matter what occupancy levels are in the building.The air handling systems are scheduled according to typical building occupancy.When they turn off on nights and weekends, the toilet exhaust fans continue to run.Not only does this unnecessarily use motor power, but the fans gradually draw a negative pressure in the building which causes outside air infiltration that the HVAC systems must recover from when they are restarted according to occupancy.A system to control the exhaust fans with an identical schedule as the air handling units serving the area around them should be installed to eliminate wasted energy.

Outline Specification:

- Determine the current controls strategy, hardware and software for the toilet exhaust fans and air handling units.
- Determine the extent of work required and the most economical method of scheduling the exhaust fans off with the air handling units.
- Wire, install and program the exhaust fans.
- Commission the system to ensure they are working accordingly.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: Exhaust fan run times will be reduced to that of the air handling units as they are currently scheduled.

Impact to Occupants: There will be no toilet exhaust during unoccupied conditions.

5.3.19 Digital Controls on Boilers

The existing boiler combustion air and burner controls are currently controlled via pneumatic logic.Pneumatic controls are susceptible to drift.Replacing the burner and combustion air fan controls with DDC controllers will improve system response time, improve accuracy, and reduce hysteresis.As a result, the fuel to air ratio for the combustion process will be more accurately controlled thereby improving combustion efficiency and ultimately, boiler thermal efficiency.

Outline Specification:

- Work with controls vendor or engineering consultant to specify control system for boiler combustion process.
- Update sequence of operation documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of the heating plant, and proceed directly to implementation without further engineering.

Key Assumptions: The efficiency of the coal boilers will increase 2% and 1% for the gas boilers.

Impact to Occupants: None.

5.3.20 Install VFDs on Boiler Fans

The existing boiler combustion air and stack induction fans are currently controlled via pneumatically actuated inlet vanes.Removing the inlet vanes and installing variable frequency drives on these fans will reduce the operating static pressure and allow the fan speed to modulate as needed to provide the required amount of combustion air and combustion chamber static pressure.This will improve the overall heating plant efficiency by reducing the electrical consumption of the system.

Outline Specification:

- Field verify motor size, voltage and actual amperage use for VFD selection – drives will not function correctly if undersized. Record motor amps.
- Select drives in accordance with applicable engineering standards.
- All new drives shall be equipped with line bypass switching so that fans may continue to operate if drive fails.
- For installations with VFD to motor wiring distance greater than 100 feet, output filters shall be provided with drive package.
- Drive location shall be selected to be compatible with manufacture recommendations – cool, reasonably dry and with adequate ventilation.
- Use EMS panel, VFD control capabilities, or otherwise convert the existing controls signal, to vary fan speed output to maintain the duct static pressure set point.
- Provide VFD startup services making adjustment as necessary; provide operator training.
- Update as-built documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: The air volume will be identical to the current operation.The fan speed will be reduced significantly at part load conditions throughout the range of modulation and the removal of the inlet vanes will result in a reduction of the static pressure drop.

5.4 HVAC

This section outlines the recommended energy conservation measures related to the HVAC systems. These measures include significant HVAC system upgrades that are large enough by scale or quantity to be categorized as a significant capital investment.

5.4.1 Replace Firetube Boilers with Condensing

Fire tube boilers operate at a maximum combustion efficiency of approximately 80%.The is the maximum possible for two reasons: high return water temperatures must be maintained in order to prevent the boiler shock and the combustion gasses must leave the boiler and vent stack at temperatures high enough that they do not condense.Boiler shock or condensed flue gasses which are acidic will eventually cause boiler failure.These boilers could be replaced with condensing boilers that operate at a maximum combustion efficiency of approximately 95%.Condensing boilers are specifically designed to be shock-able and to be able to handle acidic condensed flue gasses.They are also most efficient at low fire with low return water temperatures.

Outline Specification:

- Determine the appropriate size, number and pumping scheme to replace the existing fire tube boiler plant with a condensing boiler plant.
- Remove the existing fire tube boiler(s) and install condensing boilers.Connect to the existing piping schemes.Modify the controls schemes to take advantage of the boiler plants efficiencies especially at low load conditions at low fire with low return water temperatures.
- Make any architectural, electrical or structural improvements required for the new boilers.Little is expected in the category because the space, electric draw and weight of the unit will all be reduced.
- Install new intake and exhaust flue piping suitable for condensing applications.
- Commission the operations of the new boilers and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: The condensing boiler(s) will operate at an average efficiency of 90%.

Impact to Occupants: None.

5.4.2 Convert Boiler Plant to High Efficiency Boilers

The central boiler plant was originally installed in 1910 with coal fired boilers. There are two 400 HP boiler vessels with 250 HP burners. In 1961 the boilers were replaced with #6 fuel oil Scotch Marine boilers .In 2008 one of the two boilers was upgraded to a natural gas/fuel oil dual fuel burner.Through the age of the equipment and the different upgrades that have occurred over the years, the boiler plant does not operate as efficiently as new technology allows.The plant can be replaced with a modular type system that is all natural gas fired.This would result in increased thermal efficiency, reduced standby losses, better turndown and improved load matching.All of these aspects add up to significant savings.

Outline Specification:

- Study the existing plant in-depth to determine the feasibility, cost and savings potential of all the different upgrades options.
- Implement the most cost effective option the study provides.
- Commission the systems to ensure they are working as they are intended to.
- Update building documentation.

Implementation Plan:A high efficiency boiler plant study has already been conducted by Stanley Consultants.Of five options determined, one has stood out as being the most cost effective upgrade.Hire an engineer to create plans and specifications based on that study option to be hard bid by a qualified contractor.

Key Assumptions: Heating efficiency will increase by a seasonal average of 23%.

Impact to Occupants: None.

5.4.3 Replace Dump Boxes with VAV

The air handling systems in the building that utilize dump boxes to deliver variable volumes of air to the spaces.Dump boxes allow the terminal devices to work like a variable air volume (VAV) system while the air handling unit still operates at constant speed.Instead of back off, the dump boxes divert whatever air it does not need back to the plenum and ultimately back to the air handling unit without using it to condition the space.The dump boxes could be replaced with true

VAV boxes or retrofit to cap the bypass such that when they back off, air pressure builds up in the ductwork.That in turn allows for the air handling unit to slow down and save fan energy in addition to eliminating energy waste that occurs when the plenum is conditioned with the excess supply air.

Outline Specification:

- Inventory the dump boxes in place and the air handling units that serve them.Determine if the air handling units are equipped with VFDs and how they are currently controlled.Determine what upgrades to the existing controls system is required to support VAV boxes and VAV air handling.
- Replace the dump boxes with VAV boxes including controls.
- Modify the controls and add VFDs to air handling units if required to create a complete VAV air handling system.
- Commission the operation of the system to ensure it is installed and operating as intended and is set up in an optimal condition.
- Update record drawing building documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Once completed the air handling units will operate based on a typical modulation distribution.

Impact to Occupants: None.

5.4.4 Replace AHUs At the End of Their Useful Life Expectancy

There are air handling units that have exceeded their useful life and is still relied upon for HVAC in the buildings they serve.Savings can be realized by replacing the air handling units with high efficiency units.The motors, cooling systems and heating systems will operate more efficiently thereby reducing energy usage. Less leakage, smoother operation and a reduced maintenance requirement will also contribute to savings.Typically the savings from a air handling unit replacement will not be attractive simply from an economics standpoint due to the high first cost.End of life scenarios must take into account the regular maintenance and replacement costs that are avoided.

Outline Specification:

- Determine the building heating and cooling loads in the spaces currently served by the air handler(s) in question.

- Size, select and install one for one HVAC equipment with the highest efficiency available.
- Investigate, engineer and install any mechanical, structural, electrical or architectural modifications required for successful installation of the new unit.
- Commission the operations of the new unit and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: Depending on the size and complexity of the replacement it is anticipated that small one for one replacements can be completed by a qualified contractor with no further engineering input.Large and complicated projects should be engineered to produce a plan/spec hard bid project.

Key Assumptions: Gas fired heating will improve from 70%-80% to 80%-85% (where applicable).Direct expansion cooling efficiency will improve from 2.0 kW/ton to 1.1 kW/ton where applicable).The motor efficiency will improve from 85% to 92%.Further details of each project are included in section 4.

Impact to Occupants: Improved comfort, reduced noise.

5.4.5 Eliminate the Vacuum Return System

Vacuum condensate return systems use special vacuum condensate pumps that are capable of pulling a vacuum in the piping. The advantage of this system is that the steam pressure in the heating terminal units could be lowered to extract more energy from each pound of steam.The efficiency of this system is highly dependent upon the piping systems being air tight.Over time, air leaks develop in the piping and it becomes difficult to hold a vacuum.

Eliminating vacuum return system and providing condensate pumps in the buildings that are currently dependant on gravity will reduce the electrical consumption of the plant.

Outline Specification:

- Determine the appropriate capacity and number of vacuum condensate pumping units.Replace these units with pumping scheme to replace the existing chiller(s).Vacuum condensate pumps need to be replaced with conventional condensate pumps.

Implementation Plan: Select a qualified engineer and prepare documents for bidding.Select contractors to complete scope of work.Commission systems upon completion of contractors scope of work.

Key Assumptions: Existing vacuum pumps are 15 hp, one runs continuously during the heating season and the other 25% of the time.Five ½ hp condensate pumps (one per building) are to

replace the vacuum system and will run intermittently as needed to empty the condensate tanks. Pump run hours are reduced by 80%.

Impact to Occupants: None

5.4.6 Replace Chiller with Magnetic Bearing Technology

Traditionally, large water-cooled centrifugal and screw chillers are constructed with bearings and bushings that reduce the efficiency of the machines.Recently, chillers have become available with magnetic bearings that are frictionless.They have allowed the energy consumption of the new chillers to be dramatically reduced.Not only do they provide a substantial kW/ton savings at peak load they are especially beneficial for efficiency at lower load conditions when the chiller is turned down.

Outline Specification:

- Determine the appropriate size, number and pumping scheme to replace the existing chiller(s).
- Remove the existing chiller(s) and install the new one.Connect to the existing piping schemes.Modify the controls schemes to take advantage of the high efficiencies especially at low load conditions with low condenser water temperatures.
- Make any architectural, electrical or structural improvements required for the new chiller.Little is expected in the category because the space, electric draw and weight of the unit will all be reduced.
- Commission the operations of the new chiller(s) and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: The efficiency of the new chiller will be 0.4 kW/ton at peak load.

Impact to Occupants: None.

5.4.7 Replace Cooling Tower At the End of Their Useful Life Expectancy

There is a cooling tower that has exceeded its useful life and is still relied upon for HVAC in the building that it serves.Savings can be realized by replacing the cooling tower units with an oversized unit.The motors and heat rejection systems will operate more efficiently thereby reducing energy usage.Typically the savings from a cooling tower replacement will not be

attractive simply from an economics standpoint due to the high first cost.End of life scenarios must take into account the regular maintenance and replacement avoided as well.

Outline Specification:

- Determine the building cooling loads in the spaces currently served by the cooling tower.
- Size, select and install an oversized cooling tower with the a premium efficiency motor and a VFD to control the fan motor.
- The controls system should provide the coldest condenser water temperature to the chiller possible to increase its efficiency whenever it is beneficial to the total energy usage of the cooling systems.
- Commission the operations of the new unit and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: Depending on the size and complexity of the replacement it is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: Cooling tower motor efficiency will improve and the chiller will operate at a slightly reduced kW/ton.

Impact to Occupants: None.

5.4.8 Replace Window AC Units with Four Pipe Fan Coils

Window air conditions are very inefficient cooling devices and do not distribute their cooling very well.Anywhere that there are several window air conditioners, a central system utilizing an air-cooled chiller and hydronic chilled water piping system with fan coils can provide cooling more than twice as efficiently and distribute that cooling much more effectively.Given the existing heating systems in the building, new fan coils should be installed with a four pipe system that takes advantage of heating the building with the fan coils as well.It is cost effective to take advantage of the new controls and equipment at the time of fan coil installation.Although this strategy has a high first cost, the savings are significant.

Outline Specification:

- Determine the cooling load for each space currently served by window shaker cooling unit and the heating load served by other means in each space.
- Engineer a total heating and cooling system overhaul for the buildings identified.Install a central chiller system and distribution piping for chilled water throughout the building to areas that require cooling.
- Replace window shaker air handling units with appropriately sized four pipe fan coils.

- Extensive architectural and electrical work may be required in order to route the required chilled water, condensate piping and power services for the new fan coil system.
- Commission the operations of the new unit and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: This project will best be served as a heavily engineered project with a plan/spec and hard bid to a contractor.Further engineering services will be required.

Key Assumptions: System cooling efficiencies will be increased from 2.0 kW/ton to 0.9 kW/ton in the spaces affected by this measure.Improved heating systems control will produce heating savings.

Impact to Occupants: Improved cooling capacity, distribution and comfort will result from this project.

5.4.9 Replace Window AC Units with Heat Pumps

There are several window AC units used for cooling in the summer.Window air conditions are very inefficient cooling devices and do not distribute their cooling very well.Since they are not permanent fixtures they also create gaps in the building envelope and cannot effectively seal the conditioned zone inside the building from the outside.These window AC units could be replaced by permanent split system heat pumps that provide cooling more efficiently.They would also seal the building envelope and provide efficient heating in the winter, if applicable.

Outline Specification:

- Inventory and determine the appropriately sizes for the highest efficiency heat pumps available to replace the window AC units.
- Remove the window AC units and install the heat pumps with a pre-charged refrigerant line-set.Seal the exterior refrigerant piping penetration.
- Provide with a hard wired, concealed electrical connection.
- Provide as-built documentation.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: The cooling efficiency will increase from 2.0 kW/ton to 1.1 kW/ton.

Impact to Occupants: Improved comfort and control.

5.4.10 Centralize Cooling Systems with Chilled Water Plant

Window air conditions are very inefficient cooling devices and do not distribute their cooling very well.Anywhere that there are several window air conditioners, a central system utilizing an air-cooled chiller and hydronic chilled water piping system with fan coils can provide cooling more than twice as efficiently and distribute that cooling much more effectively.Although this strategy has a high first cost, the savings are significant.

Outline Specification:

- Determine the cooling load for each space currently served by window shaker cooling unit.
- Engineer a total cooling system overhaul for the buildings identified.Install a central chiller system and distribution piping for chilled water throughout the building to areas that require cooling.
- Replace window shaker air handling units with appropriately sized two pipe fan coils.
- Extensive architectural and electrical work may be required in order to route the required chilled water, condensate piping and power services for the new fan coil system.
- Commission the operations of the new unit and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: This project will best be served as a heavily engineered project with a plan/spec and hard bid to a contractor.Further engineering services will be required.

Key Assumptions: System cooling efficiencies will be increased from 2.0 kW/ton to 0.9 kW/ton in the spaces affected by this measure.

Impact to Occupants: Improved cooling capacity, distribution and comfort will result from this project.

5.4.11 Replace DX with Air Cooled Chiller for Cycling Purposes

Cooling throughout the building is currently provided by individual DX cooling systems at the individual air handling unit.For a majority of the building, this is an adequate system for providing cooling throughout the cooling season.The air handlers are equipped with airside economizers for any cooling required at cooler outside air temperatures.A single air handling unit that serves a 24/7 interior space requires cooling year round because it is an interior space with a significant internal load from people and monitoring equipment.The airside economizer suffices for the winter but the varying loads during the summer create significant issues with over cycling and hot gas bypass that runs.This is due to an oversized condition of the DX system where the lowest stage is not low enough so the equipment puts a false load on itself or turns on and off to

deliver less cooling.While this works, it is hard on the equipment and inefficient.Since this is a 24/7 system there is enough run time during the year for a dedicated air cooled chilled water system could be installed and be economically attractive.Chilled water system would increase the turndown as well as would reduce cycling, because it can store more cooling energy in a volume of water rather than refrigerant, and would eliminate the wasteful hot gas bypass.The chilled water system will run almost twice as efficiently in the application and extend the life of the HVAC equipment

Outline Specification:

- Determine the maximum and minimum cooling loads that the HVAC systems handle when airside economizer cooling is not available.
- Select an appropriate packaged air cooled chilled water system with integral pumps.
- Remove the DX unit and install a chilled water coil with the packaged chilled water system.
- Expand the existing building controls system to incorporate the new equipment.
- Commission the cooling systems through all their modes of operation to ensure they work according to design.
- Update building documentation.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: The cooling efficiency will increase from 1.3 kW/ton to 0.8 kW/ton.

Impact to Occupants: None

5.4.12 Insulate Refrigerant Piping

When refrigerant piping is poorly insulated, the cooling systems they serve reduce in capacity and draw the same amount of electricity.The net effect is a slightly reduce efficiency.Insulating the refrigerant piping will help the cooling system operate at peak efficiency and reduce the cooling that is misappropriated by the piping losses in mechanical spaces.

Outline Specification:

- Investigate any refrigerant piping suspected to have poor insulation or is missing insulation altogether.
- Insulate liquid piping with 1” polyolefin or flexible elastomeric insulation.

Implementation Plan: It is anticipated that a contactor can complete the above scope of work with a building walkthrough.No additional input should be required.

Key Assumptions: A 1% cooling efficiency increase will result.

Impact to Occupants: None

5.4.13 Steam Condensate Heat Recovery

Steam is currently made by the central boiler plant and either used directly or converted into heating hot water for use in the building.The condensate from the converted steam is then pumped back to the boiler feed water system at approximately 200 deg. F.Since the boilers operate most efficiently with cold feed water, it is beneficial to extract as much heating energy as possible out of the condensate prior to returning it to the plant.A heat exchanger could be installed between the heating hot water return and the steam condensate before it is returned to the utility.This will result in an increase of the building return water temperature which then requires less steam to heat it back up to the hot water supply setpoint thereby reducing steam use.

Outline Specification:

- Verify the existing piping scheme of the condensate and return heating water piping are conducive to heat recovery.
- Install a shell and tube heat exchanger to draw heat off the condensate and put it into the return heating hot water before the main steam heat exchanger.
- Provide a pumped or valved scheme using the condensate pumps with a bypass such that the return water only runs through the heat exchanger when heat recovery is beneficial.
- Provide controls of the heat recovery system to determine when it is beneficial and activate accordingly.
- Commission the operations of the new unit and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: This project will best be served as a heavily engineered project with a plan/spec and hard bid to a contractor.Further engineering services will be required.

Key Assumptions: A 2% reduction in steam and the fuel used to create it will result.

Impact to Occupants: None

5.4.14 Steam Trap Survey/Replace or Repair Faulty Traps

Steam traps hold steam in the steam lines until enough heat has been extracted that the steam condenses back into a liquid.The steam trap then allows only the liquid back to the boiler plant via the condensate network.Maintenance staff currently suspects that there faulty traps throughout campus.Faulty traps create higher condensate temperatures and reduce the efficiency of the heating systems.High condensate temperatures can also cause problems in condensate handing

equipment.Through a steam trap survey and regular steam trap maintenance program, faulty traps can be remedied.

Outline Specification:

- Verify and document steam trap locations.
- Systematically test steam traps for leaks.
- Take corrective actions on faulty steam traps.
- Keep detailed records of which steam traps have had problems and which are new.

Implementation Plan: It is anticipated that a qualified contractor can complete this measure with no further input.

Key Assumptions: An estimated steam savings based on the understood condition of the steam traps and temperature of the steam condensate was made by walkthrough staff.

Impact to Occupants: None

5.4.15 Convert Steam System Heating System to Hot Water

The system for heating currently relies on the creation of steam by a boiler plant and distribution to the plant by steam radiators, and steam coils.Steam heating systems rely on the change of phase of the water to release the heat from the water vapor through the radiator into the space.Once the heat is removed, the steam condenses back into water and is either gravity fed or pumped back to the boiler plant to be turned back into steam.Steam systems are favored in campus plants because steam naturally distributes its energy through the piping without needing to be pumped.Pumping large volumes and long distances requires significant pumping power.The difficulty is that old steam systems generally have old components that are maintenance intensive and their faulty operation can deplete the efficiency of the system as a whole.Steam boiler plants currently cannot operate at more than 80% efficiency because steam requires such high temperature flue gas to stay in vapor form, especially at high pressures.The whole system could be converted to heating hot water by replacing the steam boilers with condensing heating water boilers, utilizing the steam piping for supply water piping, utilizing the existing radiators and coils if they are in good condition, and installing a new return line with pumps and a new water feed system.Not only would the plant be able to create heating at a higher efficiency, but the maintenance requirement will be reduced and the flexibility in working temperatures will allow for less standby loss.This would be an energy savings trade-off with the increased pumping energy required to move the water through the system.

Outline Specification:

- Determine the building/campus heating load.

- Size and select boilers, terminal units, pumps and additional heating system components.Allow additional capacity to add air handlers to hot water system as units are replaced.
- Generate drawings and specifications for construction.
- Remove the steam components that will not be re-used.
- Evaluate hydronic piping sizes to air handling unit coils and replace if necessary.
- Replace steam boilers with condensing hot water boilers.
- Install pumps, return lines, feed water and any other ancillary piping required.
- Install control valves at each terminal device with a central controls scheme to reset water temperature based on outside air temperature.
- Investigate, engineer and install any mechanical, structural, electrical or architectural modifications required for successful installation of the new equipment.
- Commission the operations of the new unit and support systems to ensure the installation is correct.
- Provide as-built documentation.

Implementation Plan: It is anticipated that this will require heavy engineering to produce a plan and specification project for bid.It is recommended that a consultant be retained to create drawings.

Key Assumptions: The overall efficiency of the system will improve by 5%.

Impact to Occupants: Better control

5.4.16 Insulate Domestic Water Piping

When domestic water piping is poorly insulated, the domestic cold water pipes can condense and create moisture issues while domestic hot water pipes will release energy into the ambient air and allow the water temperature to be reduced requiring the water heater to work harder.Re-insulating or repairing the existing insulation will provide energy savings and a reduced risk of moisture and mold problems.

Outline Specification:

- Investigate any domestic water piping suspected to have poor insulation or is missing insulation altogether.
- Insulate with 1” Fiberglass insulation with vapor barrier.

Implementation Plan: It is anticipated that a contactor can complete the above scope of work with a building walkthrough.No additional input should be required.

Key Assumptions: An inventory of insulation condition while onsite was used to determine the severity of heat loss that could be avoided.

Impact to Occupants: Hotter and colder domestic water at the terminal sources in the building.

5.4.17 Insulate Steam Piping

When steam piping is poorly insulated, the steam inside the piping will lose energy and will start to condense within the piping without having the opportunity for a controlled distribution of heat to the conditioned spaces in the building.The end result a waste of heating energy due to overheating spaces or heating spaces that do not need to be. Re-insulating or repairing the existing insulation will provide energy savings and an increase in comfort.

Outline Specification:

- Investigate any steam piping suspected to have poor insulation or is missing insulation altogether.
- Insulate with 1-2” Fiberglass insulation with vapor barrier (more for higher pressure steam).

Implementation Plan: It is anticipated that a contactor can complete the above scope of work with a building walkthrough.No additional input should be required.

Key Assumptions: An inventory of insulation condition while onsite was used to determine the severity of heat loss that could be avoided.

Impact to Occupants: Increased occupant comfort.

5.4.18 Install Backdraft Dampers on Exhaust Hood Openings

Typically exhaust hood systems are equipped with a damper system that closes when the exhaust fan is off.This can either be a motorized damper or a gravity back draft damper that only allows air to exit the building while the exhaust fan is on.When outside air is allowed to be drawn back into the building it undermines what the HVAC systems are doing to condition the interior air and requires them to work harder than they otherwise would. Dampers should be installed in the ductwork or louver of any exhaust fans that leave openings to the interior of the building.

Outline Specification:

- Locate and determine the exhaust fans in the building that do not need to run 24/7 but do not have backdraft damper protection.
- Install a gravity backdraft or motorized damper

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: None.

Impact to Occupants: Improved occupant comfort.

5.4.19 Replace Walk-in Cooler/Freezer Condensers

The building currently has walk-in coolers and freezers that are cooled using packaged direct expansion (DX0 condensing units.They were installed 10+ year ago, and are no longer in a condition good enough to produce their original efficiency.New replacement units are available that operate more efficiently.

Outline Specification:

- Determine size, type, installation and compatibility requirements of the packaged condensing units.
- Remove the old unit, install the new unit and verify that the controls are operating appropriately.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: An improved average kW/ton from a degraded nameplate efficiency of the existing equipment to 1.3 kW/ton.

Impact to Occupants: None

5.4.20 Comb Condensing Unit Fins/Provide Hail Guards

Air cooled condensing units rely on cooling coils that have copper, aluminum or tin fins that provide surface area for heat exchange in order for the cooling system to reject the heat it collects to the ambient air.In order cool anything, the heat needs a consistent rejection medium.The coil fin surfaces on cooling equipment were observed to be in poor condition.When coil fins get plugged, are bent or are flattened the surface area available for heat transfer rejection is reduced thereby reducing the cooling capacity and efficiency of the equipment.Any damaged fins should be combed straight, any plugs cleaned and any damaged fins replaced in order to have cooling unit operate at maximum efficiency.Hail guards are also available for most units or can be field fabricated in order to protect the fins of damage.

Outline Specification:

- Survey the condensing coil fins on the cooling equipment in the building.
- Determine the appropriate action to remedy any damaged fins.
- Take the corrective action and document any changes in capacity or operation of the equipment.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.Small issues can likely be remedied by in-house staff.

Key Assumptions: An inventory of fin condition while onsite was used to determine the severity of capacity or efficiency loss that could be avoided.

Impact to Occupants: Improved cooling capacity.

5.4.21 Install Biomass Fuel Boiler

There is currently a fossil fuel burning central boiler plant that provides campus steam or heating hot water to multiple buildings on the campus.Pending the availability of appropriate amounts of biomass (wood chips for the sites identified) a new boiler plant could be installed to change the fuel source from fossil to biomass.This creates a significant drop in energy prices.

A biomass boiler plant was recently installed at the STAR Academy with encouraging results.The project had significant issues with cost overruns, ash handling, solids handling, biomass quality and maintenance intensively that have been difficult to overcome but the plant is currently operating successfully.Although the plant has created its share of difficulties for the plant operations staff, it has reduced heating system fuel costs by more than 80% since it has been running.

Outline Specification:

- Provide an in-depth study to ensure the viability of the technology.
- Procure a biomass fuel contract.State and Federal government resources should be consulted to determine the viability of using deadfall from the black hills that is currently burnt in place.A means of chipping and transporting will be required in order to successfully implement.
- Implement per study recommendations.

Implementation Plan: This should be studied in-depth prior to significant capital investment.Once proven by in-depth study, it is assumed the project will be implemented through a heavily engineered plan/sped and bid project.

Key Assumptions: The total energy used by the boiler plant will not change.A cost savings is provided due to the difference in the fossil fuel cost when compared to biomass assumed to cost $85/ton.

Impact to Occupants: None

5.4.22 Replace Unit Heaters with Infrared Heat

The garage and warehouse type high bay areas in the building currently utilize unit heaters that are direct or indirect gas fired, hot water, or steam driven.These could be replaced by infrared (IR) heaters driven by natural gas or propane that radiate heat to the area rather than heating the air in the area.The end result is a more comfortable space with a cooler air temperature.It takes less energy to keep a space at a cooler temperature in heating mode.This is especially beneficial in shop type areas where tools are kept warm and there is a perception of a warmer space.

Outline Specification:

- Confirm IR heating appropriate for the application.
- Size heaters appropriately with a fuel delivery system from a source already available at the building.
- Remove the hold heaters and install the new heaters according to manufacturer's instructions.
- Set the thermostat setpoint between 50 and 65 degrees F, depending on space requirements.
- Provide as-built documentation.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: Changing to a radiant type heater will allow the space thermostat setpoint to be reduced by 10 degrees Fahrenheit.

Impact to Occupants: Improved occupant comfort.

5.4.23 Install Dry Cooler

The Liebert unit located in the Civil/Mechanical Engineering server room must run continuously.It rejects heat to the campus chilled water loop.As a result, the campus chilled water plant must run continuously throughout the year, with only the Liebert unit as its load.While the chilled water plant does utilize a water side economizer, the pumping associated with the minimum 1,000 GPM flow of the secondary loop uses a tremendous amount of energy.A local dry cooler could be installed using the existing booster pump located in the building to circulate

water from the Liebert unit to the dry cooler for heat rejection during the winter.During the summer, the Liebert Unit could reject its heat to the campus chilled water loop.

Outline Specification:

- Design a flow schematic to determine the appropriate orientation of piping and control for all modes of operation.
- Select and install an appropriately sized drycooler.
- Install piping and controls associated with the designed schematic.
- Commission the system to ensure its proper operation through all operating modes.
- Update building documentation.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: Assume that central plant secondary pumps will shut down below 40° F.

Impact to Occupants: None.

5.4.24 Heating Ventilating and Air Conditioning (HVAC) Overhaul

This work description is specific to Pugsley Hall at South Dakota State University.

The existing air systems utilize bypass VAV terminal units coupled with pneumatically controlled constant volume air handling units.In addition, the supply ductwork is constructed of non-metallic ductwork that is prone to significant duct leakage.

Significant modifications can be made to the HVAC system in this facility to improve energy efficiency, reduce maintenance costs and improve occupant comfort.

Outline Specification:

- Replace bypass VAV terminal units with conventional single duct VAV terminal units with DDC controllers.Replace local pneumatic thermostats with DDC space temperature sensors.
- Provide variable frequency drives on the VAV air handling unit supply and return fans.Replace pneumatic AHU controls with DDC controllers networked into the campus Metasys system.Program duct static pressure reset sequence using VAV and AHU controllers.
- Provide CO2 sensors on the return ducts and reset the minimum outside airflow setpoint.
- Remove fiberglass supply ductwork downstream of the VAV terminal units and replace with conventional galvanized externally insulated ductwork.

- Remove and replace ceilings as required to replace the VAV terminal units and ductwork.

Implementation Plan: Select a qualified engineer and prepare documents for bidding.Select contractors to complete scope of work.Commission systems upon completion of contractors scope of work.

Key Assumptions: Currently, the existing air handling systems operate 24 hours per day seven days per week to keep the building temperature and humidity under control.It is assumed that the systems can be turned off during nights and weekends after completion of this work.The duct leakage can be reduced from 35% to 10 % by installing galvanized ductwork.

Impact to Occupants: Improved occupant comfort.

5.4.25 Replace PTAC Heat Pumps at End of Life With New

Packaged Terminal Air Conditioning (PTAC) units currently provide heating and cooling to the building.They have, or will soon exceed their useful life expectancy. New PTAC units are available that have significant improvements in efficiency and controls that will result in appreciable energy savings once they replace the existing units.Instead of waiting for the existing units to fail, they could be replaced wholesale in order to realize the savings from those increases in efficiency.

Outline Specification:

- Inventory and determine the appropriately sizes for the highest efficiency PTAC units available
- Remove and replace the PTAC units.
- Provide as-built documentation.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: The cooling efficiency will increase from 1.5 kW/ton to 1.1 kW/ton.

Impact to Occupants: Improved comfort and control.

5.4.26 Install Boiler Economizer

Boiler economizers are equipment that is installed in the exhaust stack of the boiler.The economizer transfers heat from the high temperature exhaust gases to preheat the make-up water for the boiler system.The existing boilers do not have economizers incorporated.

Outline Specification:

- Confirm boiler stack temperatures and make-up water requirements

- Determine/develop a structural design to support the economizer(s)
- Determine changes related to the make-up water system that are required.
- Create installation drawings
- Develop a specification for a bid request.
- Install boiler economizer(s)

Implementation Plan: Further investigation and design is required for this project.This will require some engineering support by an outside consultant or trusted contractor.

Key Assumptions: Economizer will have the capability to preheat the boiler feed water by 120 deg F.

Impact to Occupants: None if the economizer installation occurs during the cooling season.

5.4.27 Investigate Reducing Boiler Steam Pressure

Steam boiler plants and buildings that use steam for heat are designed based on an intended pressure.Loads are calculated, equipment and piping are sized and systems are installed based on the heat that a steam system can create and release at a specific pressure.The higher the pressure, the more heat a system can carry but the less efficient it is.Based on information gathered during the walkthrough, there may be opportunities to reduce steam pressure at the boiler without negatively affecting the system or the heating devices in the building.Since steam pressure is typically reduced at the device level anyway, and many older building include oversized equipment, there may be ample opportunity to reduce steam pressure.Reduced steam pressure reduces standby losses, makes boiler plants more thermally efficient, extends equipment life, helps steam traps hold steam, and reduces make-up water and chemical treatment.

Outline Specification:

- Review the original design intent of the steam system and determine the design temperature of the boilers, system and users.
- Determine the pressure required at the end users of the system.
- Determine the capacity of the users in the system at reduced pressure.
- Systematically reduce the system pressure using the boiler controls system until the system is no longer working properly or heating capacity is no longer sufficient.
- Set the steam system up to operate at the lowest working pressure possible that maintains appropriate operation.

Implementation Plan: It is anticipated that this can be completed by in-house staff.

Key Assumptions: Boiler pressure can be reduced by 10%.

Impact to Occupants: None.

5.4.28 Replace Air Cooled Chiller

Air cooled chillers generate chilled water to support HVAC cooling systems within the building.Existing model chillers have older technology and have become less efficient through annual use.Installing a new air cooled chiller as a replacement will require a lower electrical energy requirement to produce the same cooling.

Outline Specification:

- Confirm required load required for the cooling system
- Confirm chiller capacity
- Verify chilled water circulation pump matches required chilled water load requirements
- Investigate electrical requirements of new chiller
- Replace existing chiller with newer model

Implementation Plan: Some further investigation is required by either the owner or an engineer to verify the required chiller size and system flow requirements.An air cooled chiller bid package should be developed by ether the owner or an engineer to obtain competitive quotes from contractors.

Key Assumptions: The existing chiller requires 1.3 kW/ton.A replacement chiller requires 0.9 kW/ton

Impact to Occupants: None if the chiller replacement takes place during the heating season.

5.4.29 Trim Impellers and Open Triple Duty Valve

When constant speed pumps are balanced, the triple duty valve is often throttled back to restrict flow and create an artificial pressure drop.Some valves were throttled to as much as 5% open.An alternative strategy would be to trip the pump impellers and keep the triple duty valves at 100% open.The same flow would be supplied to the loop, but at a reduced pressure drop, thereby saving energy.Installing a VFD and manually changing pump speeds is also an alternative strategy.

Outline Specification:

- Confirm required design flows for each heating water loop.
- Document pump, triple duty valve, motor, and impeller model numbers.
- Measure flows with triple duty valves fully open.
- Trim impellers and balance system as required.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: The pump will unload the entire pressure drop currently applied by the triple duty valve setting.

Impact to Occupants: None.

5.4.30 Insulate Steam Condensate Piping

When steam condensate piping is poorly insulated, the condensate inside the piping will lose temperature on its way back to the boiler plant requiring extra energy to be added back to it in order to regenerate into steam for building heat.It also creates excessive heat gain in the areas where the condensate piping runs through.The end result a waste of heating energy due to overheating spaces or heating spaces that do not need to be in addition to the colder condenser water temperature going back into the boilers. Re-insulating or repairing the existing insulation will provide energy savings and an increase in comfort.

Outline Specification:

- Investigate any steam condensate piping suspected to have poor insulation or is missing insulation altogether.
- Insulate with 1” Fiberglass insulation with vapor barrier.

Implementation Plan: It is anticipated that a contactor can complete the above scope of work with a building walkthrough.No additional input should be required.

Key Assumptions: An inventory of insulation condition while onsite was used to determine the severity of heat loss that could be avoided.

Impact to Occupants: Increased occupant comfort.

5.4.31 Heating Hot Water (HHW) Overhaul

This work description is specific to Pugsley Hall at South Dakota State University.

The finned tube radiators throughout the 1957 and 1975 areas lack control valves for individual zone control. As a result, these spaces served by the radiation receive heating regardless of whether or not they need it.The air system is then used to cool off the spaces that are overheated.During the spring and fall, the heating and cooling systems operate simultaneously in an effort to maintain comfort.This creates an extremely energy inefficient system.

Significant modifications can be made to the HVAC system in this facility to improve energy efficiency, reduce maintenance costs and improve occupant comfort.

Outline Specification:

- Install reheat coils in new VAV terminal units and control valves in perimeter finned tube radiation. Control the reheat coils and radiation valves in sequence to maintain heating and cooling space temperature setpoints.

Implementation Plan: Select a qualified engineer and prepare documents for bidding.Select contractors to complete scope of work.Commission systems upon completion of contractors scope of work.

Key Assumptions: Currently, the existing air handling systems operate 24 hours per day seven days per week to keep the building temperature and humidity under control.It is assumed that the systems can be regulated during occupied periods and turned off during nights and weekends after completion of this work.

Impact to Occupants: Improved occupant comfort.

5.4.32 Install a Summer Boiler So Large Boilers are not Required in Cooling Months

The building currently relies on the central boiler plant to provide heat to the domestic water system via a heat exchanger year round.This occurs despite the lack of a heating load in the summer.The end result is large boilers that must meet a load that is smaller than their low fire position.In order do that they must cycle on and off throughout the day in short increments such that their average heat delivery matches the load.Every time the boiler cycles on and off the boiler goes through a purge cycle where the burner cycles air through the boiler to ensure that there are no built up combustibles in the boiler when the burner ignites.This is a safety measure for the boiler but also rejects a significant amount of boiler heat up the exhaust stack.When the boiler cycles ever few minutes, more heat goes up the stack than gets into the building domestic water for heat.This situation could be eliminated by providing a summer boiler that appropriately matches the summer load.The summer boiler will run consistently according to the load and will not cycle.The boiler will operate more efficiently at the building load and eliminate the standby and cycling losses of the large boilers.

Outline Specification:

- Determine the summer heating load of the boiler plant.This could come from any combination of limited reheat, process steam (kitchen cooking or humidification), or domestic hot water.
- Install a summer boiler to match the summer load in order to shut down the large boilers for the non-heating seasons.
- Commission the boiler operation and the changeover points based on load.

- Provide as-built documentation.

Implementation Plan: It is anticipated that a contactor can complete the above scope of work with no additional input for the buildings identified in this report.

Key Assumptions: Based on the size of the boiler, the standby loss, purge cycle and cycle ratio during the summer were estimated.It is assume that all of these losses will be eliminated during the summer months.

Impact to Occupants: None

5.4.33 Install a Ground Source Heat Pump HVAC System

The building in question is a good candidate to have a ground source heat pump HVAC system installed.There is an existing forced air heating and cooling system that utilizes propane fired heat and direct expansion (DX) cooling.Since the HVAC systems in the older half of the building have reached the end of their useful expectancies they are due for replacement.This is an opportune time to investigate ground source heat pumps.Instead of making heat by burning fossil fuels, heat pumps move heat from one source to another.During the summer cooling season the heat pumps will take energy out of the building, thereby cooling it, and rejecting it into the earth via a wellfield.Then during the winter heating season the heat pumps reverse and pull heat our of the earth via the wellfield and put it into the building.Since the heat pumps move heat, rather than making it, they can operate at 4 to 5 times the efficiency of a standard fossil fuel system.The major drawbacks to ground source heat pumps are the high first cost of the system, increased maintenance effort and cost, and difficulty in predicting the viability of a wellfield without excessive testing.The greatest benefit is the energy efficiency of the system once installed.Typically there is a 30% cooling savings and a 90% heating savings in building with balanced loads.

Outline Specification:

- Determine the heating and cooling loads in the building.
- Study the potential heat pump system for viability.Provide as many soil borings and test wells required to determine if the site is suitable and conducive to ground source heat pumps.Determine the well field requirements and ensure it can be installed.
- Ensure heating and cooling loads are balanced so the heat capacitance of the well field does not deplete.
- Design and construct the HVAC system making architectural, electrical and structural upgrades as required.
- Commission the operations of the new unit and support systems to ensure the installation is correct.

- Provide as-built documentation.

Implementation Plan: Enlist a design consultant to study the feasibility and viability of ground source heat pumps.Upon proven economics, enlist a design consultant to prepare a plant and specification for a hard bid construction project.

Key Assumptions:A suitable well field can be constructed and obtain 1 ton per well in both heating and cooling with a balanced load.

Impact to Occupants: None

5.4.34 Eliminate Simultaneous Heating and Cooling

Some spaces have supplemental heating or cooling units, such as electric space heaters, wall mounted PTACS, fan coil units, or split systems, which are also served by central air handlers.For locally controlled units, the factory supplied thermostatic controls could create situations where the central air handler is trying to heat and the local unit is trying to cool, and vice versa.Local control units could be added to the DDC system so that the setpoints can be controlled only by the energy management system to avoid setpoint overlap, or the supplemental units could be removed altogether.

Outline Specification:

- Install controls, upgrade controls, or modify programming such that two units cannot run in opposing conditioning modes.

Implementation Plan: Utilize existing control service contracts or hire controls service technicians to complete the work in the outline specification above.It is anticipated that this can be accomplished without any further engineering input.

Key Assumptions: Supplemental units and main conditioning units will not run in opposing modes.

Impact to Occupants: None.

5.4.35 Replace Outside Air Damper

Modulating outside air dampers allow for fresh air to be brought into the building while the unit is running, economizer operation when available, and to shut off the opening to the outside when the unit is not running.An old or faulty damper may have trouble controlling, stroking and closing tight allowing more air to come through the unit requiring conditioning or less than an optimal amount of air in economizer modes.Replacing the outside air damper and commissioning its operation will ensure that there is no energy waste due to a faulty damper.

Outline Specification:

- Inventory and test the outside air dampers.Close the damper and apply the design static pressure to one side of the damper to determine leakage.Stoke the damper to ensure it closes tightly and opens all the way through its range of motion.
- Replace faulty outside air dampers, actuators and controls.
- Seal ductwork connections to the pressure standard of the entire system or air handling unit.
- Commission the operation of the outside air damper to ensure proper operation.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: An estimate of leakage or faulty operation was made by walkthrough staff to determine its affect using 30 year weather bin data for the local climate and air handling operation.

Impact to Occupants: None.

5.4.36 Install VAV Boxes on Unit with Existing VFD

There are existing air handling units that operate with constant volume despite the fact that they have been equipped with a VFD.The VFD in most cases is there to provide soft start and balancing capabilities but stays at a static air volume throughout the year.The system could be retrofit to replace the existing terminal units VAV boxes and new thermostats.Pressure control would then be installed on the VFD such that when the VAV boxes closed down because they were able to satisfy the load with less air, the VFD would automatically slow the fan down to match the airflow requirements of the worst zone.This saves fan energy at the unit due to reduced fan speeds throughout the range of modulation and heating energy from a reduction in reheat.

Outline Specification:

- Inventory the terminal devices and determine the most economical way to install a VAV box for each zone in the system.
- Determine the most economical controls installation to control each zone individually.
- Remove the existing terminal devices and install the VAV boxes and controls.
- Install a pressure sensor in the supply ductwork and control the air handling and VFD speed as a VAV system with duct static pressure reset.
- Commission the operations of the new unit and support systems to ensure the installation is correct.

- Provide as-built documentation.

Implementation Plan: This would be best implemented through and engineered plans and specifications that are hard bid by qualified contractors.

Key Assumptions: The new system will modulate according to a typical VAV distribution.

Impact to Occupants: Improved occupant comfort.

5.4.37 Relocate Preheat Coil

At the Rapid City Department of Transportation, there is a preheat coil installed, but it is located upstream of the outside air mixing plenum, so it provides little assistance for heating of ventilation air.There had been another preheat coil installed per design drawings, but the coil likely froze and was abandoned in place.The new coil was installed as a replacement but was incorrectly positioned.As a result of the current placement, the coil opens its valves for full heating but accomplishes little, and some of the energy likely escapes the building out the relief plenum.Occupants often note in the winter that the incoming air is too cold.The coil could be repositioned such that it will improve occupant comfort and avoid excess heating coil use.

Outline Specification:

- Remove abandoned coil.
- Move working coil into position as indicated on original design drawings.

Implementation Plan: It is anticipated that a contactor can complete the above scope of work with no additional input for the buildings identified in this report.

Key Assumptions: None.

Impact to Occupants: Improved thermal comfort.

5.4.38 Install Stack Dampers

Boilers with atmospheric burners take room air from the boiler room into the burner, mix it with a fuel source and burn it to provide the heating that the boiler puts into the heating water or steam.Atmospheric boilers typically have about a 4:1 turndown ration which results in a minimum firing rate of 25%.When the load is below 25% the boiler cycles on and off.During the off periods convection naturally pulls room air through the burner, through the boiler and up the exhaust stack of the boiler.Since the boiler is as efficient at warming up the room that passes through it as it is as warming up the heating water, a significant amount of heat from the system goes up the stack.Stack dampers should be installed which close when the boiler cycles off and does not allow room air to be pulled through the boiler and up the stack.

Outline Specification:

- Inventory the boiler stack size(s) stack damper installation options.
- Install the most economical stack damper configuration.

Implementation Plan: It is assumed that this can be completed by a qualified contractor with no additional engineering input.

Key Assumptions: Convective forces in the boiler were estimated for the stack size and normal heating water temperature.

Impact to Occupants: None.

5.4.39 Install Air to Air Heat Recovery

When there are significant amounts of exhaust in a building it is typically economical to recover energy from the exhaust air stream and deliver it to an outside air intake airstream.This is typically installed via an air to air plate heat exchanger, air to air heat wheel, or a pumped coil system.All three options have their advantages and disadvantages.A heat wheel usually provides the most savings but is the most expensive and maintenance intensive.A pumped coil typically provides the least amount of savings but is simple and effective.

Outline Specification:

- Determine the most economical heat recovery option.
- Install the heat recovery system including any modifications to ductwork and equipment.
- Install, wire and program controls for the heat recovery system.Ensure the heat recovery system only operates when it is beneficial.
- Commission the heat recovery system by running it through all modes to ensure it is working properly.
- Update record drawings.

Implementation Plan: It is anticipated that this would best be implemented through engineered plans and specifications that are hard bid by a qualified contractor.

Key Assumptions: Air to air effectiveness is 50%.Pumped coil effectiveness is 45%.Heat wheel effectiveness is 75%.

Impact to Occupants: None.

5.4.40 Combustion Air Preheater

Currently, combustion air is drawn into the boiler house by the burner fans through dampered openings in the walls.The combustion air is drawn from the floor level at room temperature.Due to the high temperature differences between the outside air and the heating plant, warm air moves

upward, while cold combustion air moves downward toward the burners.Increasing the temperature of the combustion air will increase the thermal efficiency of the combustion process.

For the gas fired boilers, combustion air can be pre-heated by using heat from the flue gas.An air to water heat exchanger can be used to extract heat from the flue gas.The water can be pumped to a heating coil which is used to heat the incoming combustion air.This strategy cannot be implemented for the coal fired boilers.Instead, a fan can be used to pull the warm air from the upper levels of the heating plant down to the floor level.

Outline Specification:

- Provide flue gas economizer heat exchanger on the gas fired boilers.Provide pumps, piping, heating terminal units, and controls for combustion air pre-heaters.
- Provide centrifugal fans and ductwork to draw warm air from the ceiling down to the floor level.

Implementation Plan: Select a qualified engineer and prepare documents for bidding.Select contractors to complete scope of work.Commission systems upon completion of contractors scope of work.

Key Assumptions: Efficiency of both coal and natural gas boilers will increase by 2%.

Impact to Occupants: None.

5.4.41 Replace Motors with Premium Efficiency at End of Useful life

Generally, replacing standard efficiency motors that have a significant useful life remaining with premium efficiency motors will not produce an attractive payback.However, when the existing standard efficiency motors must be replaced, premium efficiency motors should be selected to replace them because the payback on the incremental cost of the higher efficiency motors will be attractive.Premium efficiency motors are also built more robustly and will likely have a longer service life than standard efficiency motors in the same application.

Outline Specification:

- Inventory the motors in the building and their efficiency and run time.
- Implement a motor replacement policy whereby whenever motors require replacement, the highest efficiency motor available is chosen.

Implementation Plan: It is anticipated that this can be implemented by in-house staff.

Key Assumptions: Estimated motor run times based on occupancy schedules and sequences of operation.

Impact to Occupants: None

5.4.42 Install Ultrasonic Humidifiers

Steam, gas or electric resistance humidifier currently provide humidification for HVAC or process applications in the building.Ultrasonic technologies can provide the same amount of humidification with a fraction of the electric consumption.Traditional steam, gas or electric humidifiers heat up water until it boils to make steam.A significant amount of energy is used to bring the water up to temperature and the resulting high temperature steam also increases the temperature of the airstream it is introduced to.This can require a simultaneous cooling requirement to maintain indoor air conditions.Ultrasonic humidifiers use an inaudible ultrasonic sound wave to vibrate water into vapor form.The local and central steam humidification system could be replaced by local ultrasonic humidifiers for energy savings.

Outline Specification:

- Inventory the steam humidification system to determine everything that is being served, and the total steam load for the building.
- Determine the most appropriate sizing and strategy for ultrasonic humidification.
- Install the ultrasonic humidifiers along with the required electric, domestic water, ductwork and controls infrastructure.
- Commission the operation to ensure they are working properly.

Implementation Plan: It is anticipated that this would be best implemented through an engineered plan and specification that is hard bid by a contractor.

Key Assumptions: The nameplate efficiency of the existing system will be increased to the nameplate efficiency of the ultrasonic humidification system throughout the range of operation.

Impact to Occupants: None

5.4.43 Boiler Blowdown Heat Recovery

Steam boilers are intermittently blown down to limit the concentration of dissolved and suspended solids and prevent scale formation, corrosion, and carryover.The blowdown water is currently drained to a holding tank where it is allowed to cool, then wasted down the sanitary sewer.

Significant energy savings can be realized by capturing the heat energy from the blowdown process and using it to preheat incoming make up water.

Outline Specification:

- Provide a total dissolved solids (TDS) meter to monitor boiler total dissolved solids. Provide modulating valves on boiler blowdown piping and control blowdown rate to maintain a TDS setpoint.
- Provide a heat exchanger to recover heat from the blowdown water and transfer the heat to the incoming make up water.

Implementation Plan: Select a qualified engineer and prepare documents for bidding.Select contractors to complete scope of work.Commission systems upon completion of contractors scope of work.

Key Assumptions: The frequency, duration, and amount of blowdown water will remain the same whether manually controlled or controlled via the TDS meter.

Impact to Occupants: None.

5.5 Other Measures

This section outlines other miscellaneous measures that do not fall into lighting, retro-commissioning, controls or HVAC categories.

5.5.1 Replace Electric Water Heaters with Heat Pumps

There are electric resistance hot water heaters that provide domestic hot water (DHW) to the facility.These water heaters could be replaced by heat pump water heaters.Not only do heat pump water heaters operate three times as efficiently as electric resistance, they also provide reject cooling that can offset the cooling that the building HVAC system have to do in the summer months.Heat pump water heaters take ambient energy and reject it to the domestic water.Instead of making heat they move it from once source to another.

Outline Specification:

- Inventory the size and capacity of the electric resistance hot waters in the facility.
- Ensure that there is enough available ambient energy so that the heat pump water heaters can operate efficiently.This may require a transfer duct to be installed from an adjacent plenum if the water heater is located in a small utility closet.
- Provide and install equivalently sized heat pump domestic water heaters.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with nor further engineering input.

Key Assumptions: Heat pump water heaters operate at a coefficient of performance of 3.0.

Impact to Occupants: None

5.5.2 Replace Storage Type Water Heaters with On-Demand

The water heaters in the building currently include a storage tank.This allows the water heater to hold enough heat in storage that it can consistently provide enough hot water throughout periods of heavy usage even though it does not have the direct capacity to match the peak loads.The downside to storage systems is that they also provide surface air for heat transfer to create a standby loss by the system.The water heater must then always create heat for the water even when no hot water is being used.In situations where there are significant periods of no hot water use or domestic hot water systems that are spread out, the hot water heaters could be replaced by on-demand type of heaters for energy savings.Instead of keeping a whole system hot all the time waiting for a need for hot water, on-demand systems only operate when there is a need for hot water.On-demand hot water heaters eliminate a majority of the standby losses of the domestic hot water system.

Outline Specification:

- Inventory the size and capacity of the domestic hot waters in the facility.
- Determine the equivalent on-demand capacity required to match the existing units.Determine if that capacity is adequate for the fixture units attached to it.
- Ensure the electrical connection and distribution are capable of providing the increased instantaneous electricity.If not, make the appropriate upgrades to the electrical system.
- Provide and install appropriately sized on-demand domestic water heaters.

Implementation Plan: It is anticipated that this can be completed by a qualified contractor with no further engineering input.

Key Assumptions: A 2% of capacity standby loss reduction will occur.

Impact to Occupants: None.

5.5.3 Improve Building Envelope – Insulation/Exterior

While it is not usually cost effective to undergo a complete envelope insulation renovation, there are some areas on the base that have non-existent insulation that may be cost effectively addressed.Based on the understanding of the building insulation levels during the walkthrough, enough savings is available to provide an appreciable amount of savings to justify building insulation improvements.ASHRAE 90.1 (2004) recommends exterior walls that have at least R-13 insulation and roofs that have at least R-19 insulation.

Outline Specification:

- Field verify un-insulated or the limitations of the existing wall insulation and determine the most cost effective insulation addition.
- Field verify un-insulated or the limitations of the existing roof insulation and determine the most cost effective insulation addition.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification and section 4 descriptions with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.

Key Assumptions: See section 4 for building specific assumptions.

Impact to Occupants: Improved thermal comfort in exterior zones.

5.5.4 Replace Windows

The newest buildings State buildings have double-paned, tinted windows that are in good condition.Some of the older buildings, and buildings built of the metal panel wall constructions, have windows that are either single paned, have cracks or holes, loosely constructed frames, have poor thermal breaks, or a combination of all four.While new window installations typically do not have attractive paybacks, any egregious issues will have appropriate paybacks and should be pursued.In addition to economic benefits, new windows could have additional comfort, productivity, and maintenance benefits. ASHRAE 90.1 (2004) recommends windows that have U-values of 1.22 and solar heat gain coefficients of 0.25.

Outline Specification:

- Field verify windows which should be replaced.
- Conduct analyses as required to determine the correct glazing properties.Prior to installation, verify selected glazing products satisfy project requirements.
- Utilize third party to verify proper installation and seals.

Implementation Plan: It is anticipated that a qualified contractor can provide firm pricing from above specification and section 4 descriptions with a brief walk through of respective building areas, and proceed directly to implementation without further engineering.Competitive bids should be obtained.

Key Assumptions: See section 4 for building specific assumptions.

Impact to Occupants: Improved thermal comfort in exterior zones.

5.5.5 Intellihood Kitchen Hood Controls System

There is a dedicated kitchen hood in the building that removes heat, vapor, smoke or grease from a commercial cooking type application.Building codes require minimum flows and velocities based on the size of the hood and what kitchen equipment is underneath of it.Typically, the whole hood is sized for the worst case equipment.A packaged kitchen hood controls system could be installed that monitors the heat smoke in the hood and modulates the speed of the exhaust fans and make-up air units accordingly.Whenever there is no, or a limited amount, of cooking happening the hoods will go to minimum speed.In addition to reduced fan electrical consumption, less outside air will need to be conditioned as it is brought in to make-up the exhaust air.

Outline Specification:

- Select an appropriate packaged kitchen hood controls system including temperature sensors and optical sensors, with VFDs for exhaust and make-up air fans.
- Install the temperature sensors inside the hoods.Install the optical sensors along the length of the hood.Install the VFDs on the fans.
- Wire the controls sensors back to the packaged controller and set the minimum and maximum volumes according to code required levels.
- Commission the system to ensure it is operating according to design.

Implementation Plan: It is anticipated that this measure can be completed by a qualified contractor with no further engineering input.

Key Assumptions: The average volume of the kitchen exhaust and make-up air will be 60% of the current amount.

Impact to Occupants: None.

5.5.6 Timers on Snack Vending Machines

There are snack vending machines that are powered 24/7 in the building.A residential style light timer could be installed on these vending machines allowing them to eliminate their energy consumption at night when they are not used anyway.

Outline Specification:

- Inventory the snack vending machines.
- Install a residential style light timer for each unit.
- Set the time for the occupancy of the building.
- Alert occupants that in order to use the snack vending machines after hours they must bypass the timer.

Implementation Plan: It is anticipated that this can be completed by in-house staff.

Key Assumptions: The existing vending machines draw 120W.The run time can be reduced from 24/7 to the schedule of the HVAC systems.

Impact to Occupants: The snack vending machines will not operate after-hours.

5.5.7 Remove Abandoned RTU and Insulate the Opening

There is a rooftop air handling unit (RTU) that is no longer operational.It has been decommissioned in place.Even though it does not consume electricity in itself, it has leaky dampers and limited casing insulation that allow outside air infiltration into the building and heat to escape out of the building.The unit should be removed and the opening should be insulated to the same level as the rest of the roof.

Outline Specification:

- Remove the RTU in place by cutting it into small enough pieces that it can be carried off of the roof.
- Provide roofing insulation the same level as the existing roof.
- Provide a roof membrane patch and secure weather tight.Ensure any roof warranties are maintained.

Implementation Plan: It is assumed a qualified contractor can implement this measure with no further engineering input.

Key Assumptions: An estimated amount of infiltration was made by walkthrough staff based on the condition of the outside air dampers.The air handling unit casing is R-9.The roof insulation is R-23.

Impact to Occupants: Improved occupant comfort.

5.5.8 Space Utilization

There is a building onsite kept at occupied conditions despite a lack of complete utilization.The operations inside the building could be moved to a suitable location in a building that already requires occupy-able conditions, HVAC and lighting.The building may also be less efficient than the building that could be moved to.Although this would be an inconvenience to those who would have to move, there is the potential to eliminate the energy usage associated with this building.

Outline Specification:

- Determine the exact requirements of the space and find a suitable relocation.
- Relocate all operations to an existing building.

- Decommission the building if possible by eliminating power, emptying plumbing lines and sealing all the openings.The building could be re-occupied at a later date if it could be fully utilized.
- The decommissioned building may also be converted to non-conditioned storage.

Implementation Plan: It is anticipated that this can be completed by in-house staff.

Key Assumptions: The building can be decommissioned completed thereby eliminated all of the energy use associated with keeping it conditioned, occupy-able and lit.

Impact to Occupants: Occupants and activities in the building will require relocation.

5.5.9 Window Film

There are windows in the building that are not tinted.Modern window films are engineered to reflect heat (infrared) and transmit visible light thereby reducing summer cooling loads while maintaining illumination levels. If the existing tint is not State-of-the-art, installing window film on exposures that receive direct sunlight would reduce cooling loads, increase comfort, and also protect fabrics from fading.Window films are most economical on South facing windows but do provide savings for windows that receive any direct sunlight.

Outline Specification:

- Install the most cost effective window film available on the inside or outside of the window.

Implementation Plan: It is anticipated that a qualified

Key Assumptions: Hour by hour building simulations were created to determine the savings potential of this measure.

Impact to Occupants: Improved occupant comfort.

5.5.10 Replace Dishwasher Booster Heater with Steam

There is a commercial style kitchen in the building that includes a high production commercial dishwasher.In order to meet code requirements, the domestic water must be at least 140 degrees F.When domestic water is not stored at that high of a temperature in the building, an electric booster heater is installed for whatever additional temperature increase is necessary.There is central steam currently piped to the kitchen for cooking equipment.That steam source can be used for a steam powered booster heater.Savings could be achieved by replacing the electric heater with a steam heater because steam is less expensive per unit of energy than electric.

Outline Specification:

- Size and select and appropriate steam powered booster heater.

- Determine if the existing steam piping in the kitchen can support the additional load of the dishwasher booster heater.
- Remove the electric and install the steam dishwasher booster heater.
- Install steam and condensate piping as required for the booster heater.

Implementation Plan: It is anticipated that a qualified contractor can complete the above scope of work with no further engineering input.

Key Assumptions: The existing steam infrastructure in the kitchen can support the addition of the booster heater without increase in pressure or pipe sizing.

Impact to Occupants: None.

5.5.11 Remove Domestic Water Storage Tank From On-Demand System

There is currently on on-demand domestic hot water system in the building that provides hot water to the building.It also has a storage system installed with it.On-demand systems intentionally eliminate the storage element in order to reduce the standby loss of the system.On-demand systems are sized to match the highest instantaneous domestic hot water load by fixture loading so storage is not necessary.Removal of the storage tank from the system will result in energy savings due to the reduced standby loss that it creates.

Outline Specification:

- Remove the domestic water storage tank, remove the domestic water lines back to the mains and cap.
- Re-insulate piping where the vapor barrier was compromised by the equipment removal.

Implementation Plan: It is anticipated that a qualified contractor can implement this measure with no further engineering input.

Key Assumptions: A savings of 2% of the system capacity will be eliminated.

Impact to Occupants: None

5.5.12 Install Stand Alone Hot Water Heater in Lieu of Boiler Generated Domestic Hot Water

Domestic hot water is currently provided by a heat exchanger that utilizes the central boiler system for heat year round.When the central plant needs to make heat for a significant building heating load this is a very efficient method for heating domestic water.When the boiler plant is operating at low load, or only the domestic hot water load it does not operate efficiently because the boiler has to cycle on and off to match the load.The boiler system also has a significant

amount of standby loss that it experiences when it is only providing heat for the domestic water system.A majority of those losses can be avoided by installing a standalone domestic hot water heater so that the boiler plant can be shut off in the summer.The stand alone system could be operated year round or it could be installed in parallel with the existing heat exchanger to still use the central plant during the heating season.

Outline Specification:

- Determine the most economical installation for a standalone domestic hot water system.
- Provide an automatic change-over system if required.
- Determine the domestic hot water load during the non-heating season and provide an appropriately sized high efficiency domestic water heater.
- Install the domestic hot water heater.

Implementation Plan: It is anticipated that this would best be implemented through engineered plans and specifications that are hard bid by qualified contractors for installation.

Key Assumptions: The stand alone water heater will operate at 98% thermal efficiency.

Impact to Occupants: None.

5.5.13 Wash Laundry in Cold Water

Approximately 80% of the energy used by the laundry washing process is the heating of the water.In many cases, an adequate cleaning job can be done in cold water.Hot water should only be necessary for excessively dirty material or when the heat is required for disinfection purposes.It takes less energy to wash something twice in cold water than once in hot water.

Outline Specification:

- Review the current laundry washing standards at the facility to determine if it is acceptable to wash in cold water.
- Whenever possible, wash in cold water.

Implementation Plan: It is anticipated that this can be implemented by in-house staff.

Key Assumptions: See section 4 for individual measure details.

Impact to Occupants: This practice must be adopted by the users of the equipment.

5.5.14 Disable Operable Windows

Some of the older buildings currently have operable windows.During the walkthrough, many occupants had windows open although there was an active system providing cooling to the respective space.Open windows provide an easy path for infiltration of outside air or exfiltration

of conditioned air.Except in rare applications such as where operable windows are utilized for code required ventilation, all operable windows should be disabled.

Outline Specification:

- Communicate to staff that windows must stay closed.
- Disable mechanisms for opening windows.
- Perform periodic inspections to ensure disabled mechanisms have not been tampered with.

Implementation Plan: It is anticipated that this can be implemented by in-house staff.

Key Assumptions: The severity of the energy impact was estimated based on the understanding during the walkthrough.

Impact to Occupants: Occupants will not be able to operate windows.

5.5.15 Replace Electric Water Heaters with Gas

In a large number of buildings, electric resistance devices are used for domestic water heat.Since gas heating is available at approximately 40-50% of the cost of electric in making heat, any electric resistance heaters in place should be replaced with gas.Gas fired heaters require a flue ducted outdoors, whereas electric resistance don't, but they savings far outweighs the additional cost of the installation.

Outline Specification:

- Remove the electric water heater.
- Purchase and install an equivalent capacity and storage natural gas domestic water heater as the existing electric.
- Connect to the existing hot and cold water piping.
- Provide gas piping and an electrical connection.During the walkthrough it was noticed that gas piping is available in the vicinity in all of the buildings included in the measure.
- Provide flue vent piping to the exterior of the building.

Implementation Plan: This can be completed by the preferred plumbing vendor with no additional input.

Key Assumptions: Equal hot water consumption from before to after implementation.

Impact to Occupants: None.

5.5.16 Replace Standard Efficiency Water Heater with High Efficiency

Water heater efficiencies, like boilers, used to be intentionally limited at 80% thermal efficiency in order to prevent condensation of flue gasses.That was because it was considerable more expensive to manufacture and install water heaters capable of handling condensation of the flue gases.Condensed flue gasses are very acidic and corrosive so the materials of the internal heat exchanger and flue must be able to handle it.As energy prices have risen, it has become increasingly cost effective to install high efficiency condensing water heaters.Currently, there are water heaters available up to 98% efficient.

Outline Specification:

- Remove the existing water heater.
- Purchase and install an equivalent capacity and storage high efficiency water heater.
- Connect to the existing hot and cold water piping.
- Provide gas piping and an electrical connection.
- Provide sealed combustion flue vent piping capable of handling combustion condensate to the exterior of the building.

Implementation Plan: It is anticipated that a qualified contractor can implement this measure with no further engineering input.

Key Assumptions: Increased efficiency from the nameplate value of the existing unit to 98%.

Impact to Occupants: None

5.5.17 DakotaDome Energy Reduction Project ECMs (via Johnson Controls)

An energy study was recently completed by Johnson Controls at the DakotaDome at the University of South Dakota.The economics for all of the recommendations of that study are included in this study.See the Johnson Controls study for the details of the measure, its implementation and its economics.

5.5.18 Install Pool Cover

The relationship between the temperature of the pool water, the temperature of the air and the humidity of the air in a pool building is delicate.If it is too warm or humid in the building it can create issues with the building envelope.If it is too cold or dry the pool water can evaporate quickly, require excessive make-up water and make pool chemicals go out of balance.A pool cover can greatly reduce these issues when the pool is unoccupied as well as reducing the heat and water loss in the pool to the air that must be made up by the pool heater and HVAC systems.

Outline Specification:

- Contract with a pool cover supplier/installer to provide the most appropriate pool cover system available.

Implementation Plan: It is assumed that a local contractor can complete the above scope of work with no further engineering input.

Key Assumptions: The pool water temperature is 90 deg F, the air temperature is 88 deg F, and these conditions are kept 24/7.

Impact to Occupants: The pool cover will need to be removed so that the pool can be used.

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