Handbook of Energy Auditing of Water Systems

Prepared for the South Dakota Department of Environment and Natural Resources

Prepared by HDR in association with the South Dakota Association of Rural Water Systems

Handbook of

Energy Auditing of Water Systems

Prepared for:

South Dakota Department of Environment & Natural Resources
Protecting SD's Tomorrow...Today

South Dakota Quality On Tap! Rural Water

HDR Engineering, Inc.

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Preface

In July 2009, HDR and South Dakota Rural Water were selected by the South Dakota Department of Environment and Natural Resources to provide technical assistance to community drinking water systems in South Dakota. This included training, select water system energy audits, information transfer, and associated activities to promote the long-term goal of maximizing energy conservation by drinking water systems in South Dakota.

This project was funded under the American Resource Recovery Act (ARRA) and was applicable to small water systems, serving a population of less than 10,000 only. While the systems involved were small water systems, items evaluated in the energy audit process are applicable to larger water systems and wastewater systems.

The project initially selected a representative cross section of small water systems across the state to conduct the energy audits. Criteria used in the selection of the facilities included:

- Met small system requirements
- Generally covered the state geographically
- Included surface and groundwater sources
- Included city, rural water and tribal water systems
- Include varied water treatment processes, such as direct pump and disinfect, iron and manganese removal, lime softening, and membrane technologies
- The system desired to participate

A total of nine systems were audited that included and a detailed report provided for each. In all cases energy conservation measures (ECMs) were identified and recommended for implementation. The magnitude of the savings varied widely due to water source, treatment processes, distribution coverage, topography of the service area, previous energy savings efforts, etc. Copies of the complete reports for the systems may be obtained from either the SD DENR in Pierre or HDR's offices in Sioux Falls or Rapid City, South Dakota.

Training and dissemination of information was a primary goal of this project, to be able to benefit all water systems, not just the nine systems actually audited. This handbook presents a summary of procedures, results, and benchmarking for system managers, operators, boards, or councils to use as a tool to identify potential energy savings at their facilities and to determine if detailed evaluation and auditing is desired. Additionally the project, procedures and results have been, or are scheduled to be presented at several conferences and meetings across the state, and nationally. A partial listing of these events follows this Preface.

Additionally, as part of this program, energy savings information is sent out via South Dakota Rural Water's monthly eNews to over 540 individuals in the water and wastewater industry and via "*Ergs Joules and Such*", an energy newsletter provided by National Rural Water containing

information regarding energy saving for rural water communities. Updates and information will continue to be distributed via these sources for the remainder of the program.

South Dakota Association of Rural Water Systems training staff members attended several of the audits conducted by HDR to “train the trainer”. They will be incorporating the procedures and results of the energy auditing process in association with utilizing this Handbook as part of their formal training for systems across South Dakota. Thorough distribution of information through presentations, development of this handbook, and training of the trainers will allow for widespread awareness of potential energy savings available to water and wastewater systems statewide.

Acknowledgements

HDR would like to acknowledge the State and Federal agencies involved in planning, conducting and funding of this project, including:

South Dakota Department of Environment and Natural Resources

The Environmental Protection Agency, Region 8

South Dakota Board of Water and Natural Resources

South Dakota Rural Water

The auditing process, presentations, report, and handbook preparation and technical review required input from several HDR staff members. We acknowledge their efforts and the fact that this has resulted in ongoing energy savings for the systems involved and will be expanded to other systems in South Dakota and beyond. The major contributors are acknowledged below.

Handbook Contributors

J. Mike Coleman	Allan Erickson	Ken Henderson
Nathan Kutil	Dave Reardon	Chris Robinson

Participating Systems

Brandon	Clay Rural Water	Clark Rural Water
Dakota Dunes	Rapid Valley	Lead Deadwood Sanitary District
Lower Brule	Spearfish	West River Lyman Jones

Outreach Events for Small Water Systems Energy Audit Program

Elected Official/Board Training

SDARWS Board Leadership Conference, November 19, 2009
SD Municipal League Conference, October 5-7, 2010
SDARWS Board Leadership Conference, Nov. 17-18, 2010

Native American Energy Summit

Mni Wiconi System Summit, December 16, 2009
Tribal Energy Summit, November 3-4, 2010 Ft. Pierre

Conferences

SDARWS Annual Technical Conference January 12 – 14, 2010
SDARWS Annual Technical Conference January 11 – 13, 2011
SDWWA Annual Conference, September 16, 2010
Pending National Rural Water Approval
National Rural Water In service - June 21-23, 2011 Albuquerque, NM
National Rural Water Conference - October 4-6, 2011 Louisville, KY
Rural Water and HDR presentation

Other

Energy Audit Workshops (five scheduled)
Finance Officer Training

I. Introduction

Background

An energy audit is intended to evaluate how much energy is consumed and identify measures that can be taken to utilize energy more efficiently. The primary goal is reducing power consumption and cost through physical or operational changes. Each system will have unique opportunities to reduce energy use or cost depending on system specific changes and opportunities within the power provider's rate schedules. An audit of an individual water treatment plant (WTP) is an attempt to pinpoint wasted or unneeded energy usage for that facility. With the cost of electricity on the rise, reducing energy use should be a priority for municipalities.

Nationwide, about 4% of U.S. power generation is used for water supply and treatment (DOE, 2006). Water facilities are energy intensive, with energy typically second only to staffing as the largest operations and maintenance expense (Biehl, 2010). Electricity usage represents roughly 30-50% of a water treatment plant's annual operating cost. Approximately 80% of municipal water processing and distribution costs are for electricity (EPRI, 2002).

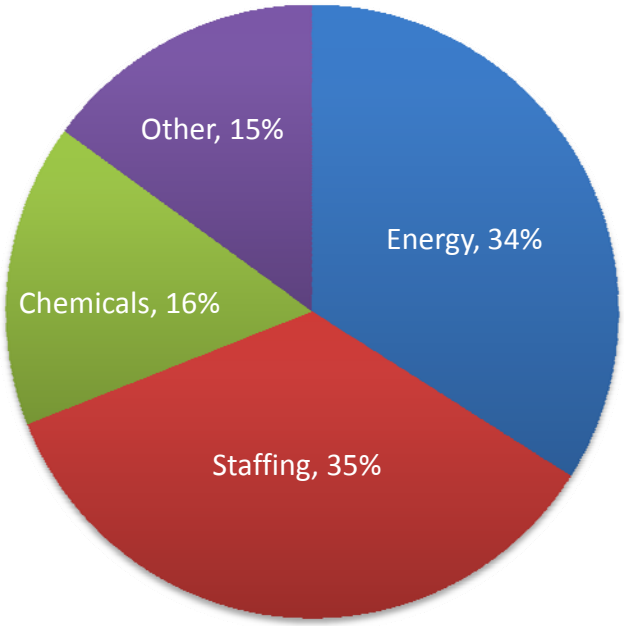


Figure 1. O&M Costs in a Typical Water Treatment Plant (Roberts, 2008)

A key part of energy audits is thorough analysis of the effects of overdesign on energy efficiency. Plants are designed to perform at maximum flow and loading conditions. Unfortunately, most plants are not efficient at average conditions. Aging infrastructure is another source of inefficient usage of energy in WTPs across the country. The basis for addressing aging infrastructure related energy waste is also included in the energy audit process.

Customers often don't understand the electrical power utility bill and that simple changes in day to day operations can lead to significant savings. Secondly, it is typical that the power bill is not seen by the treatment and distribution staff, rather delivered directly to finance for payment. As such, water system management and operations staff members are often unaware of power costs. Finally, operation staff rarely has incentive to minimize usage as the primary focus is centered on the quality of the water produced.

This handbook addresses these issues and provide guidance on how to develop an energy conservation program, identify and implement energy conservation measures (ECMs), and monitor the progress and success of the implementation program.

Treatment Process

Each water system is unique and will be presented with opportunities to reduce energy use and cost. Energy use by water systems also varies depending on several factors. The type of source water utilized by the system affects the amount of energy required to produce potable water. Groundwater systems require about 30% more electricity on a unit basis than surface water systems (EPRI, 2002). This is primarily due to a greater energy requirement for pumping groundwater to the surface. The treatment process employed also affects energy use. Membrane systems are generally more energy intensive to operate. Conventional plants require less energy, however, some processes can be energy intensive such as filter backwash or aeration.

Surface Water Systems

Surface water systems collect raw water from a lake, river, or other body of water. The treatment process typically involves screening, pre-oxidation, flocculation, sedimentation, filtration, disinfection, and high service pumping. A process flow diagram for a 10 million gallon per day (MGD) surface water treatment plant is presented in Figure 2. Regardless of the treatment plant size, the largest energy requirement is for high service pumping. This typically represents 80% to 85% of the total electricity consumption for surface water treatment (EPRI, 2002).

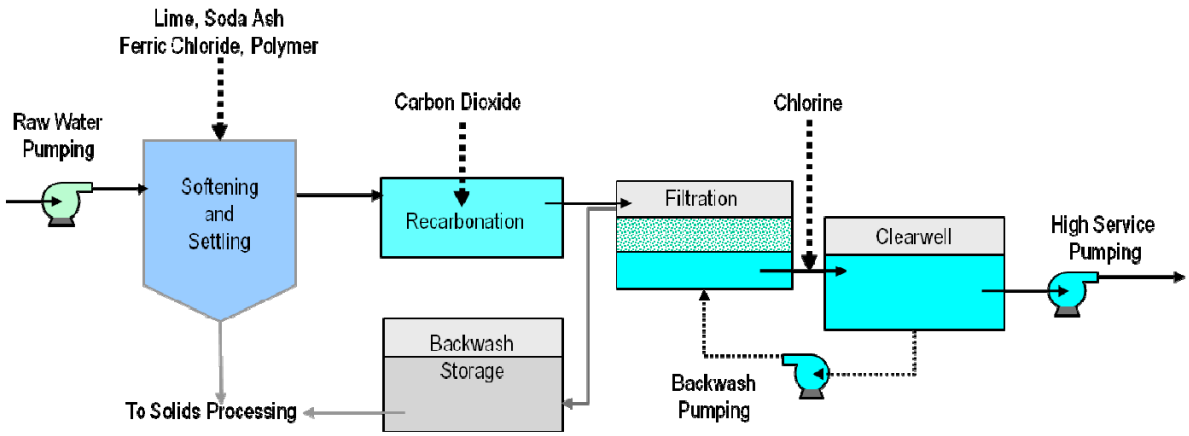


Figure 2. Process Flow Diagram for a Lime Softening Water Plant

Groundwater Systems

Groundwater quality can vary depending on the aquifer. Some groundwater systems operate a treatment plant while other sources do not require advanced treatment. Systems not requiring advanced treatment are able to simply pump groundwater to the surface, and typically chlorinate, then distribute to the system. A flow diagram for a treated groundwater system is presented in Figure 3.

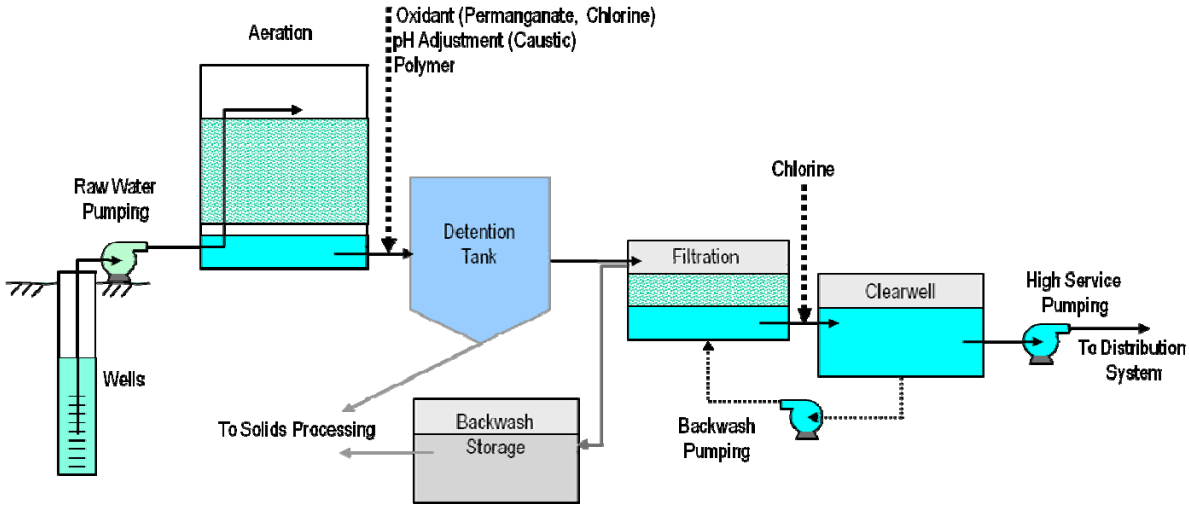


Figure 3. Process Flow Diagram for a Treated Groundwater System

Benchmarking

Energy requirements for water treatment and pumping can vary by water source. Data from the systems that participated in the Small Water Systems Energy Audit Project conducted for the South Dakota Department of Environment and Natural Resources (SD DENR) was used to determine a system benchmark. Figure 4 shows cost per million gallons ($/MG) and Figure 5

illustrates specific energy use (kWh/MG) for the systems evaluated. The systems are listed by the water source utilized.

Figure 4. Benchmarking of Specific Energy

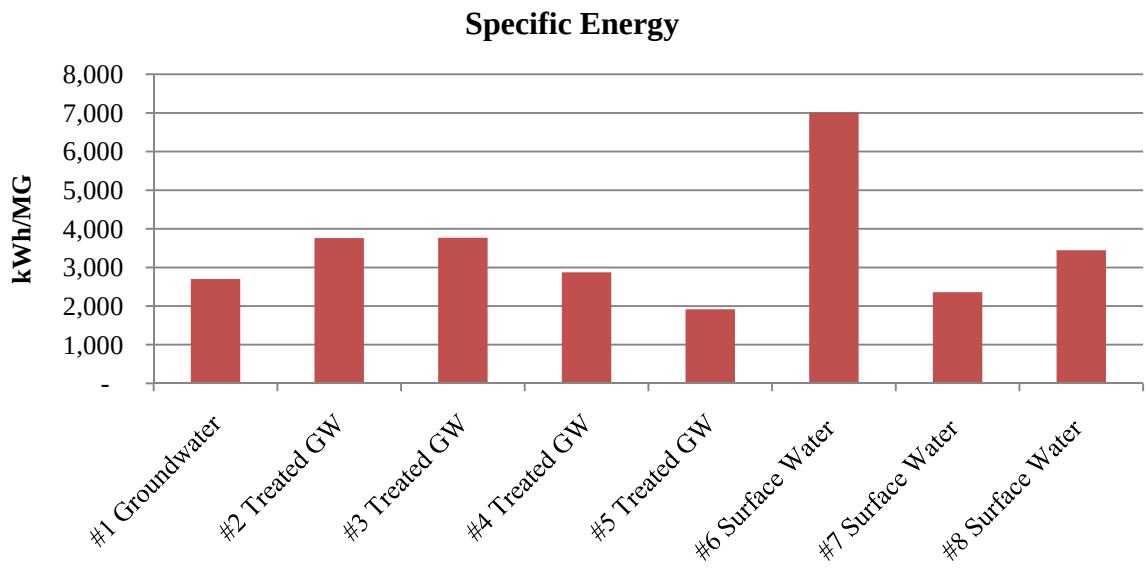
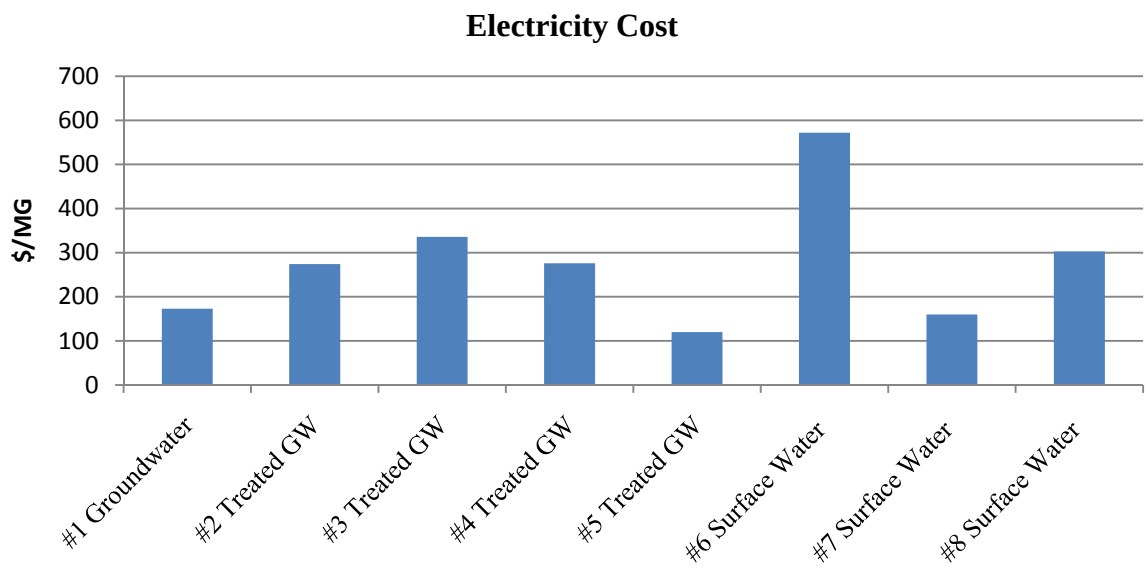


Figure 5. Benchmarking of Electricity Cost



Benchmarking of the audit participants doesn't give a clear relationship between water source and energy use. Five groundwater systems were evaluated, four of which operate a treatment plant. Three surface water plants were evaluated, two of which use membrane systems and the other does not operate a distribution system. Another unique aspect in this particular study is that rural water systems were included, which have significant energy use associated with booster pumping. These benchmarking figures can be used to indicate how a system compares with respect to its specific energy and electricity costs for the evaluated systems, and more specifically a similar system.

The US Environmental Protection Agency (EPA) has developed an Energy Star® program for water and wastewater utilities. The program offers an online benchmarking tool as part of the Portfolio Manager. The goal of the program is to help eliminate energy waste and lower operating costs of water and wastewater utilities (EPA, 2010). The Portfolio Manager tool allows utilities to track energy use, energy cost, and carbon emissions. Information about the program can be found at http://www.energystar.gov by entering "energy star for water systems" in the search field.

II. Energy Audit Approach

The first step to a successful energy audit is to develop an approach. An energy audit can be broken down into five phases.

- First an energy audit is part of an energy conservation program. Having an energy conservation program in place will help with implementation and monitoring of energy conservation measures (ECM).
- The second phase is data collection. Gathering as much energy related data, processing that data, and observing unusual energy consumption provides a good starting point for the audit.
- Following data collection, a site visit is performed. The site visit is the heart of the energy audit process. During the site visit managers and/or operators who are most familiar with the system should be present.
- Following the site visit, ECMs are developed, which is the fourth phase of the process. The ECMs are developed based on knowledge gained during the data collection and site visit phases.
- The final phase is implementation and monitoring of ECMs.

Phase 1 - Develop an Energy Conservation Program

An energy conservation program will allow water systems to set goals, plan, and implement energy conservation measures. A successful conservation program requires commitment from management and staff. An energy conservation team should be established with a team leader and staff members with knowledge of processes and energy use. Getting input from system staff, especially staff with large amounts of institutional knowledge, is critical to a successful program. Also critical to success is that the team must have the authority and responsibility to implement changes that are identified during the energy audit.

Part of developing an energy conservation program includes determining the scope of an energy audit. It is important to note that an energy audit is only a task in an energy conservation program, not the entire program. The audit alone will not result in energy conservation, but the results can be utilized in an energy conservation program for potential implementation and cost savings.

The largest energy consumers in a water system are pumps. Therefore, the greatest opportunity for energy reduction would focus on pumping – raw water, in plant, high service, and booster pumps. Narrowing the scope of an energy audit to focus on one aspect of operations would allow the energy conservation team to gain confidence and experience. From there additional aspects of operation, such as treatment processes, compressed air systems, sludge handling, HVAC, and lighting can be included.

Phase 2 - Data Collection

Before conducting any field work, the auditing team should discuss with operations staff all available process and energy data. Data review and analysis should be performed to familiarize the project team with processes and methods of operation. Electrical energy summaries, equipment inventories, energy diagrams, design data, operating data, and hydraulic profiles should be obtained, where possible, and reviewed.

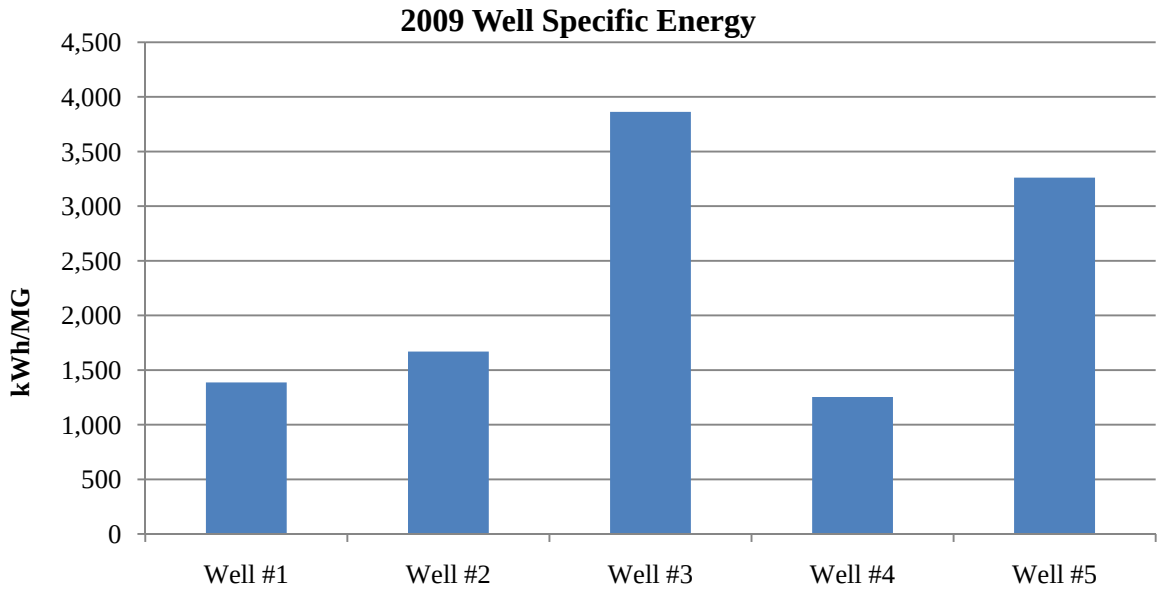
Prepare an inventory of energy uses, including, but not limited to, consumption of natural gas and other fuels, electric motors, and miscellaneous items. A master list of electric motors should be organized by process and should include such information as type of service, number of operating units, unit horsepower, percentage of time utilized, and estimated power consumption. Actual operating data should be used, when possible, to ensure accuracy. Determine the relative energy consumption for each process so that energy-conservation efforts center on items with the highest energy use. Frequently, considerable time and effort is devoted to saving relatively small quantities of energy (such as lighting, building heating, and cooling), when the largest potential savings can be realized in process operations.

Data needed for an energy audit includes:

- Flow data (MG or MGD)
- Electricity consumption (kWh)
- Peak demand (kW)
- Electrical rate schedules
- Power provider and copies of bills
- Pump curves
- Design summary drawings and specifications

Flow data and electricity consumption are used to determine the specific energy required (kWh/MG) for the various facilities within the system. This allows the facilities to be benchmarked and compared to similar facilities within the system or to other water systems. Determining specific energy also creates a baseline for energy use. This baseline can be used to identify changes in energy use and to track results of energy conservation measures. Creating graphical representations of energy use can help visualize trends and they can be useful for presenting information to others. Figure 6 presents specific energy for five well sites evaluated within a water system included in this study. The figure illustrates how an evaluation of flow data and energy use can be used to identify the sources of water that require the least energy input. Implementing this data into daily operations can significantly reduce energy use.

Figure 6. Example of Specific Energy Consumption for Five Wells within One System



Phase 3 - Site Visit (Field Investigation)

After completing data collection and review the next step is to conduct an on-site investigation of facility operations. The field investigation should include obtaining or identifying any information that was not previously provided, discussion with individuals who are knowledgeable with facility operations, discussion of potential ECMs, and seeking input from the system staff.

The level of detail of the energy audit will depend on the complexity of the system, expertise of the energy conservation team, time available to complete the audit, and the goals established for the audit. A key component of the field investigation is simply to ask "what if" or "why" in regards to system processes and operation. It may be possible to identify processes that can be optimized or in some cases eliminated all together. Oversized or inefficient equipment, inefficient processes, and physical or operational changes may be identified. An ECM can then be developed for making improvements or operational changes.

Phase 4 - Develop Energy Conservation Measures (ECM)

Energy conservation measures are developed using knowledge gained during data collection and the field investigation. Evaluating whether or not an ECM should be implemented depends on the criteria established. One common criterion is return on investment. An energy conservation project should ideally pay for itself within a predetermined time period. Other criteria used to evaluate ECMs could include availability of funding (including rebates or incentives), condition of existing equipment, and the perception of customers who value environmentally friendly practices.

The energy assessment preceding implementation of ECMs should provide an economic analysis of each proposed change, an estimate of cost, and the anticipated energy savings. For the most part

these will constitute a planning level analysis. Of the recommended improvements, some will require no further design. However, projects that involve construction or new equipment will require outside expertise for design. Examples of typical ECMs are described in Sections 4 and 5 of this handbook, and example ECM calculations are included in Appendix B.

Phase 5 - Implementation and Monitoring

The energy audit process is a tool to identify energy and or cost saving measures that will benefit the water system. The process is not complete until these measures are implemented. Following implementation, monitoring of the ECM should also be performed to determine the actual benefit being seen by the water system.

III. Electrical Power Cost

Reading Electric Bills

Examine utility billing schedules to determine the effects of power factor, demand, time of day, and other charges in addition to a basic charge for direct energy use. If applicable, alternative rate schedules should be examined to determine if reduced energy consumption at the facilities can result in a more favorable rate structure. Interruptible or time-of-use rate schedules should be considered if appropriate.

The key to sound energy management is understanding how the facility is billed. The two main charges are generally for "Energy" and "Demand". Because the cost for energy and demand vary with the electrical utilities and their rate schedules, energy efficiency projects must be tailored to maximize savings based on the schedules used. The utility provider can be an excellent source for information and assistance in evaluating proposed changes. A thorough energy audit must include communication with the utility provider.

Electric utilities often have numerous rate schedules, each of which are designed for a particular type of customer, i.e. residential, commercial, agricultural, etc. or even specific to water treatment and distribution. Assembling an equipment inventory that includes the facility, equipment size, rate schedule and power utility can be useful. An example of this is provided in Table 1. An example of a rate schedule summary is provided in Table 2. The rate schedules often have limitations involved that need to be considered in the evaluation.

Table 1. Example of Equipment and Rate Schedule Inventory

Facility Name	Total Horsepower	Rate Schedule	Power Utility
Well #1	200	Rate A	Electric Utility A
Well #2	150	Rate A	Electric Utility A
Well #3	75	Rate B	Electric Utility B
Booster #1	150	Rate A	Electric Utility A
Booster #2	75	Rate B	Electric Utility B

Table 2. Example Rate Schedules

	Rate A	Rate B
Service Charge ($ per month)	$50.00	$30.00
Demand Charge ($ per kW/month)	$13.00	$9.00
Energy Charge (¢ per kWh)	6.0¢	6.0¢

Rate schedules may also include miscellaneous taxes, fees, and customer charges that are added to each month's bill. These costs are generally pre-determined and are not otherwise affected by monthly energy use, except that some are based on kWh used and effectively increases the usage cost.

Energy Charges

Energy charges are directly associated with hours of use and equipment efficiency. The hours of operation can be reduced by minimizing use through water conservation and leak detection and correction. Improving pump and motor efficiency will reduce energy usage by reducing wasted energy.

Electric utility rate schedules should be evaluated to determine how energy charges are applied. Some electric utilities offer tiered rates that change with the amount of energy consumed, others offer a straight energy charge that remains constant. Time-of-use (TOU) rate schedules may be available and should be evaluated as a way to reduce energy charges. TOU energy charges vary by time of day and are set up to encourage off-peak energy use. If adequate storage is available within the water system, pumps can remain idle during peak hours and operated off-peak and substantial cost savings can be realized.

Energy use can be calculated using Equation 1 for pump horsepower, Equation 2 for energy use, and Equation 3 for energy cost.

Equation 1. Pumping Horsepower

$$\text{Pump bhp} = \frac{\text{Q x TDH}}{\text{3960 x pump efficiency}}$$

$$\text{bhp} = \text{brake horsepower}$$

$$\text{Q} = \text{pump flow (gpm)}$$

$$\text{TDH} = \text{total dynamic head (feet)}$$

Equation 2. Pumping Energy Use

$$\frac{\text{pump bhp x 0.746 kW/hp x hours/day x days/month}}{\text{motor efficiency}} = \text{monthly kWh}$$

Equation 3. Pumping Energy Cost

$$\text{monthly kWh x \$/kWh} = \text{monthly energy cost}$$

Demand Charge (Capacity Charge)

Demand charges are a common charge that most water systems can expect to pay. This can be thought of as essentially a charge established to reserve capacity from the power grid for the user. Demand charges are typically determined by the maximum average kilowatt load incurred in a 15 minute interval during the billing period (some providers do use other intervals, such as 30 minutes, however 15 is most common). The demand charge is then applied to the monthly utility bill independent of the energy charges. Demand charges can be significant and can be as much as 50% of the electric bill. Understanding how demand is calculated and charged will help water systems manage demand charges and reduce electrical costs.

The maximum kilowatt load for a pump motor can be approximated using Equation 4. Multiplying the demand by the demand rate gives the monthly demand charge, as shown in Equation 5.

Equation 4. Kilowatt input (Demand) to motor

$$\text{KW input to motor} = \frac{\text{pump bhp x } 0.7457}{\text{motor efficiency}}$$

Equation 5. Demand Charge

$$\text{maximum kW demand x \$/kW} = \text{monthly demand cost}$$

In some cases demand charges have a ratchet clause. Rather than charge for the actual peak demand in the billing period the highest demand over the past 6 or 12 months is charged. Any operation that results in a higher than normal demand will result in an increased demand charge during that billing period and for several future bills as well.

Reducing the load on a pump's motor for the entire billing period would in turn reduce the monthly demand charge. For pumps the only way to reduce the load on the motor is through the use of a variable frequency drive (VFD). Reducing a pump's speed can be an effective way to reduce demand charges, especially during winter months when water demands are low.

Power Factor

A third charge that is less frequently levied is for low power factor. The power factor is the ratio of the true power capacity of the circuit (measured in kW) to the power the utility actually needs to provide (measured in volt-amperes, VA). Customers whose loads have low power factor require greater generation capacity than what is actually used. A low power factor is caused by inductive loads. The most common type of inductive load is a motor.

If a power utility charges for low power factor the water system should evaluate equipment, such as capacitors, to correct power factor and reduce harmonics. Variable frequency drives also correct for power factor and can be a viable alternative for reducing charges for a low power factor. Low power factor does cause some energy loss through increased heat losses. However, power factor correction will rarely be cost-effective based on energy savings alone. Cost savings comes primarily from avoiding utility charges for low power factor. Power bills should be monitored to identify if the power utility begins charging for low power factor.

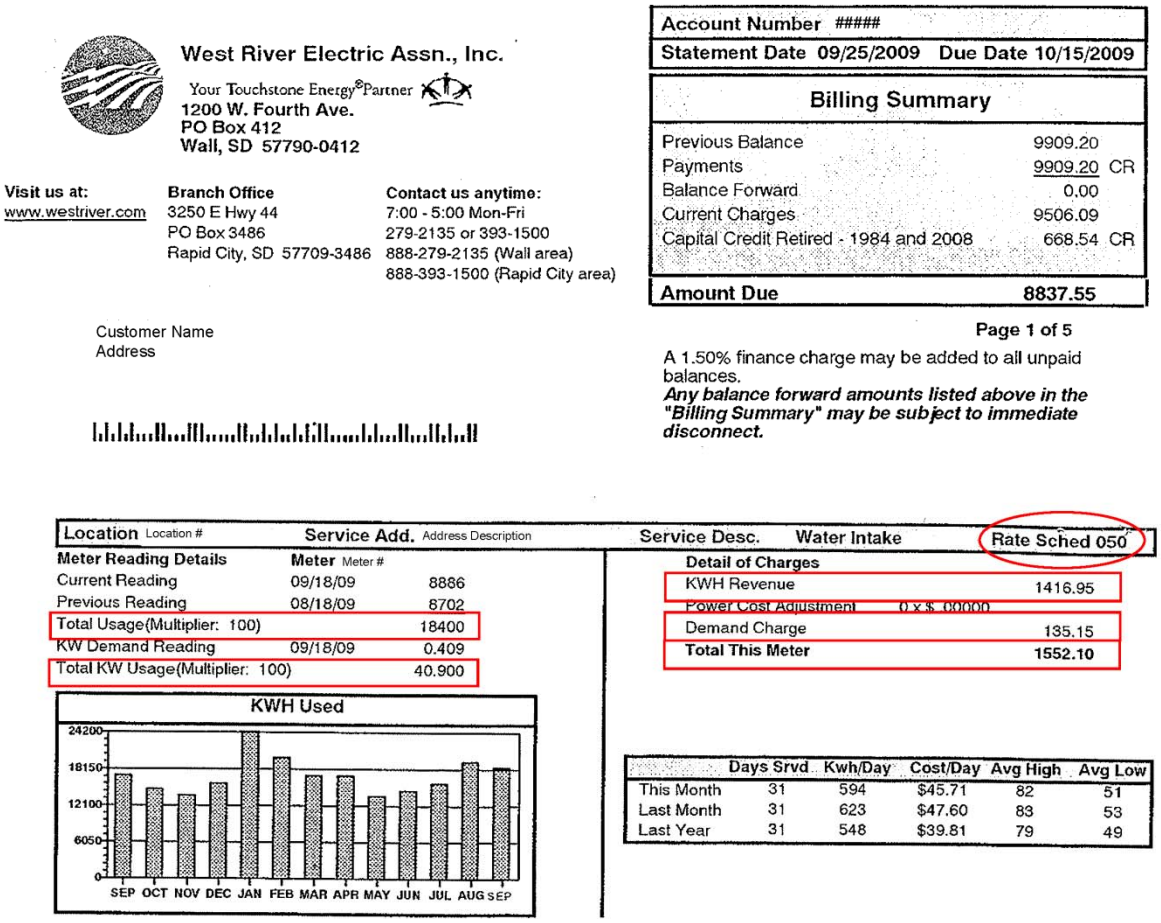
Other Charges

In addition to the typical power charges, many utilities also include other miscellaneous charges. The names and criteria for these charges vary. Some common charges include a customer charge, power cost adjustment, and transmission charges. The amount of the charges can be fixed or can

be based on energy use. Charges based on energy use should be considered when calculating payback on ECMs. By reducing energy use these charges will also be reduced.

An example electric bill is provided in Figure 7. Key elements of the bill have been highlighted. The example bill shows the rate schedule that is being applied to the energy use, energy use for the billing period, energy cost, peak demand, and demand cost.

Figure 7. Example Electric Bill



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279-2135 or 393-1500
888-279-2135 (Wall area)
888-393-1500 (Rapid City area)

Customer Name
Address

Account Number #####	
Statement Date 09/25/2009 Due Date 10/15/2009	
Billing Summary	
Previous Balance	9909.20
Payments	9909.20 CR
Balance Forward	0.00
Current Charges	9506.09
Capital Credit Retired - 1984 and 2008	668.54 CR
Amount Due	**8837.55**

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A 1.50% finance charge may be added to all unpaid balances.
Any balance forward amounts listed above in the "Billing Summary" may be subject to immediate disconnect.

Location Location #	Service Add. Address Description		Service Desc. Water Intake	Rate Sched 050
Meter Reading Details	**Meter** Meter #		**Detail of Charges**	
Current Reading	09/18/09	8886	KWH Revenue	1416.95
Previous Reading	08/18/09	8702	Power Cost Adjustment 0 x $ .00000	
Total Usage(Multiplier: 100)		18400	Demand Charge	135.15
KW Demand Reading	09/18/09	0.409	**Total This Meter**	**1552.10**
Total KW Usage(Multiplier: 100)		40.900		

KWH Used

24200
18150
12100
6050
0
SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP

	Days Srvd	Kwh/Day	Cost/Day	Avg High	Avg Low
This Month	31	594	$45.71	82	51
Last Month	31	623	$47.60	83	53
Last Year	31	548	$39.81	79	49

Rebates and Incentives

Rebates and incentives can provide a significant funding source for certain approved energy efficiency projects. Many electric utilities offer rebates or incentives as a way to reduce energy use and avoid major system upgrades that would otherwise be needed to meet energy demands. Prior to making future improvements the utility company should be contacted to determine if any rebates or incentives are available.

Water systems should also monitor funding sources available through SD DENR, EPA, and the US Department of Energy. Several new programs have been implemented and the current regulatory environment is favorable for grants or State Revolving Fund (SRF) loans. The US Department of Energy has created an Energy Efficiency and Renewable Energy (EERE) program. Information about opportunities to participate in their programs can be found at: http://www.eere.energy.gov/. The Energy Efficiency and Conservation Block Grant (EECBG) is one such program that may provide funding to implement energy efficiency and conservation programs. Information can also be found on the Database of State Incentives for Renewables & Efficiency (DSIRE™) at: http://www.dsireusa.org/.

Additionally a tax deduction of up to $1.80 per square foot is available for new or existing commercial buildings that are constructed or reconstructed to save at least 50% of the heating, cooling, ventilation, water heating, and interior lighting energy cost of a building that meets ASHRAE Standard 90.1-2001. Partial deductions of $.60 per square foot can be taken for improvements to one of three building systems that reduce total heating, cooling, ventilation, water heating and interior lighting energy use by a certain percentage below ASHRAE 90.1-2001—the building envelope (10%), lighting (20%), or heating and cooling system (20%). An interim system-specific goal for lighting is provided directly in the legislation and is valid until the IRS issues a final regulation. The interim lighting provision allows prorated deductions from 30 cents to 60 cents per square foot for lighting systems.

Rebates, incentives and tax deductions are continuously changing and the rebates and incentives offered by the power providers vary widely between providers. These need to be monitored and current offers utilized as appropriate when evaluating, making or planning for improvements and funding of proposed improvements.

IV. Energy Consumption and Cost Savings

Electrical energy and cost savings can be realized by improving equipment efficiency, demand management, process changes, operational changes, or reducing water loss. Many of the potential energy related improvements are common among all water systems. Some of the typical focus areas during an energy audit are described in the following subsections. This is not an all inclusive list, as many unique situations exist within individual water systems. However, if the following items are considered, a solid foundation will be established for conducting an energy audit.

Energy Consumption

Understanding where energy is being consumed is critical to focusing resources where the greatest savings potential exists. The greatest opportunity for savings comes from equipment that is routinely operated or from large improvements in efficiency. Replacing a pump with a limited run time with one that is only slightly more efficient will not likely be cost-effective. The available energy use data should be compiled and summarized for the facilities being audited.

A useful measure of performance is specific energy consumption. This measures energy use relative to water production and can be calculated where flow and energy use data is available. Energy cost per million gallons is another useful measure as it will include costs associated with demand and other miscellaneous charges. An example of specific energy and cost data for well facilities is provided in Table 3 for one of the systems included in the SD DENR Small Water Systems Energy Audit.

Table 3. Example Annual Water Production and Energy Cost

Facility Name	Pumping	Specific Energy	Annual Cost*	$/MG Produced	Average Energy Cost
Well #1	173 MG	1,254 kWh/MG	$17,468	$101 /MG	8.1 ¢/kWh
Well #2	207 MG	3,863 kWh/MG	$44,639	$215 /MG	5.6 ¢/kWh
Well #3	86 MG	1,387 kWh/MG	$9,951	$116 /MG	8.4 ¢/kWh
Well #4	163 MG	1,669 kWh/MG	$17,577	$108 /MG	6.5 ¢/kWh
Well #5	65 MG	3,261 kWh/MG	$14,031	$217 /MG	6.7 ¢/kWh
Well #6	0.0 MG	NA	$676	NA	30.7 ¢/kWh
Total/Average	694 MG	2,673 kWh/MG	$104,344	$150 /MG	6.4 ¢/kWh

* Includes miscellaneous taxes, fees, etc.

The energy consumption of the well sites was determined using past energy bills. This data indicates which wells cost less to operate per million gallons produced. In this example, well #2 and well #5 are approximately twice as expensive to operate as the other wells. In this case the cause of increased energy use is due to the depth of the aquifer and drawdown. In comparison, well #3 and well #4 can be free flowing and the static water elevation in well #1 is near the surface. Relying more on these three wells would significantly reduce power costs.

Another factor to consider is the location of pressure zones within the water system. Simply operating the most efficient well may not be the most efficient option. The location of booster pumps and pressure reducing valves within the system must also be considered. If a booster pump is used then the cost of production will include the energy consumed by the well and booster pumps.

Pressure Reducing Valves

Pressure reducing valves (PRVs) are necessary to limit system pressure at certain locations in the distribution system. While reducing pressure is necessary, the use of PRVs presents an opportunity to improve energy efficiency. Removing pressure from the system with a PRV also removes energy. Limiting the amount of pressure head that is removed can save energy, especially if water is boosted following a PRV. The use of PRVs in a water system should be limited where practical.

Throttling Valves

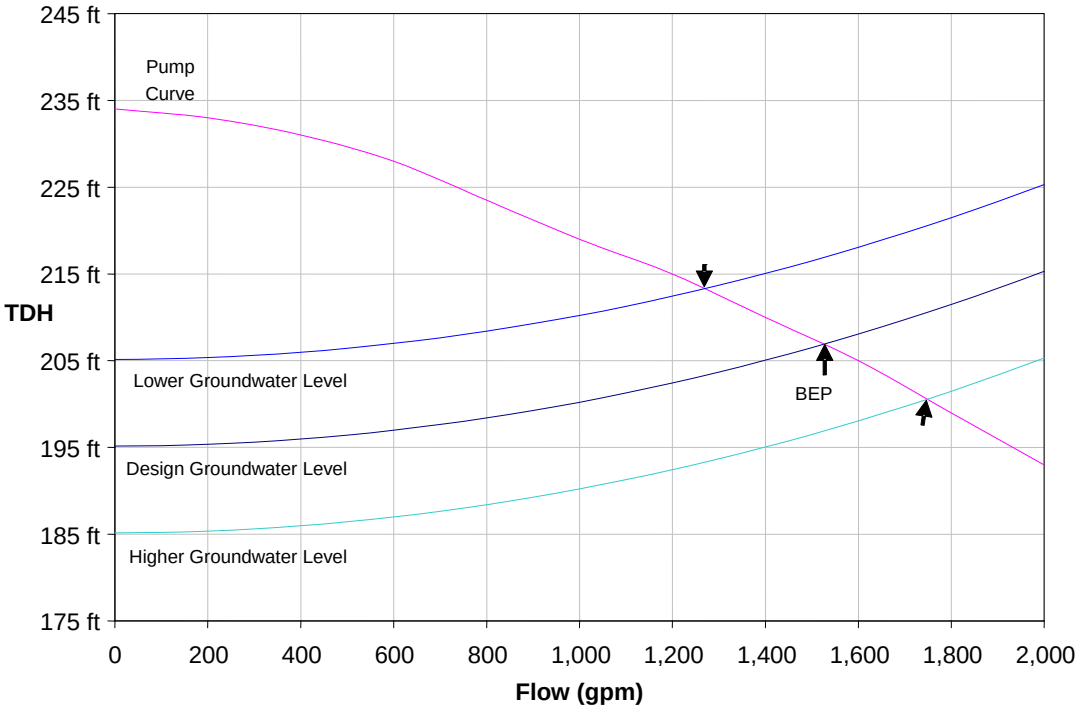
Controlling flow or pressure by throttling a valve is inefficient and presents a good opportunity for energy and cost savings. This is especially true where flow is constantly throttled on the discharge of a pump. Any valve that is not fully open is imparting losses to the system and wasting energy. Several options are available for increasing efficiency, such as; trim the pump impeller, install a new pump that is sized to fit operating conditions, or install a VFD. Each option should be evaluated separately in order to compare capital costs, cost savings, energy reduction, payback time, and operational impacts.

Variable Frequency Drives

VFDs are utilized in many applications and within many water systems. VFDs are perhaps the most efficient means to control flow and/or pressure of pumps. Their ability to match flow with demand decreases the number of times a pump starts and reduces surge on the system. Installing a VFD to replace a throttling valve or other types of artificial head can lead to significant energy savings. VFDs can be useful in many applications and generally are extremely useful when applied to water systems. The only drawbacks are their cost and minor electrical losses associated with their use, approximately 3%.

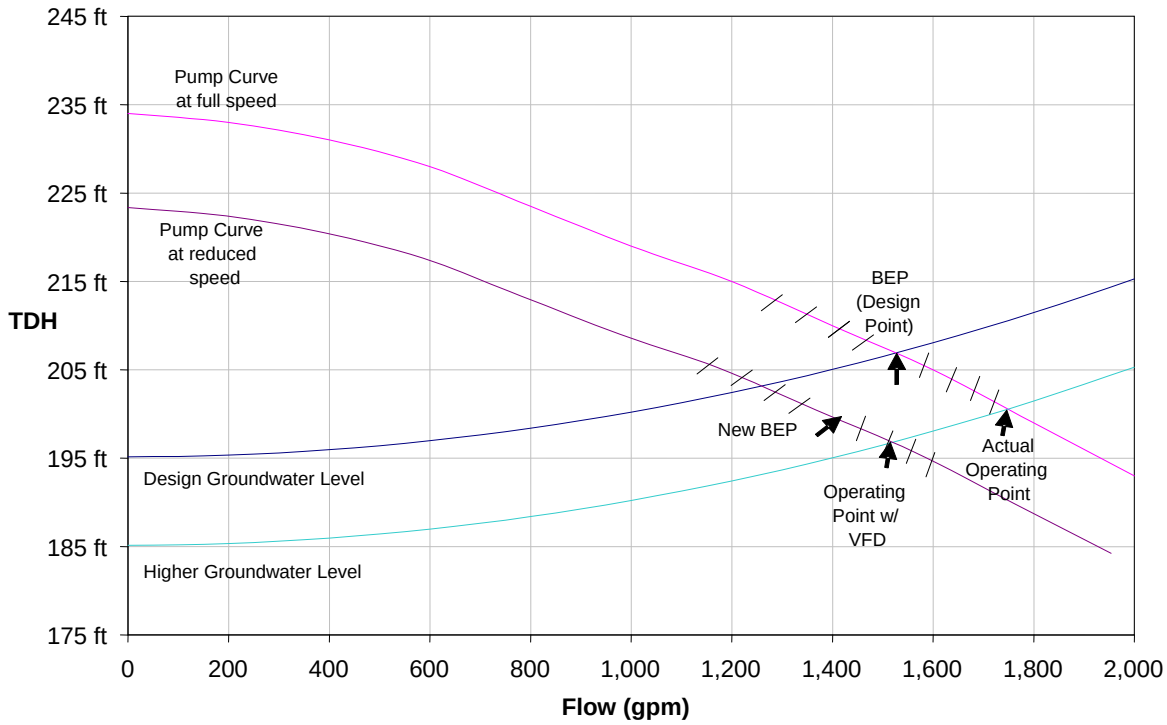
A VFD can improve efficiency when a pump is not operating near its best efficiency point (BEP). A pump is run at its best efficiency when the field conditions match the flow and total dynamic head (TDH – static lift plus friction losses) for which the pump was designed. However, the field conditions do not often remain the same. Changes in system pressure, distribution piping, groundwater level, etc. affect the TDH, shifting the pump to the left or the right of its BEP. Lower TDH causes a pump to run to the right on its curve where the flow rate increases, while higher TDH causes it to run back to the left where the flow decreases as shown in Figure 8.

Figure 8. Effect of Groundwater Level on Pump Curve



A VFD can help improve a pump's efficiency when the operating conditions are to the right of the pump's BEP. By reducing the speed of a pump, the operating point will shift left, back to a more efficient range as seen in Figure 9.

Figure 9. Effect of Motor Speed on Pump Curve



Water systems can also benefit from reduced demand charges while pumps are operated at less than full speed for an entire billing period. This can occur during off-peak months when the pumps are not required to run at 100% by extending the historical pumping period or in conditions when the pumps are oversized. Demand charges are decreased each month a pump is run at less than full speed.

The cost to install a VFD in an outdoor, climate controlled enclosure increases with horsepower. The added load of an air conditioner detracts from the electrical savings obtained with a VFD and needs to be considered in conjunction with the internal VFD losses mentioned previously.

Demand Management

Demand charges are an often overlooked charge that can make up a significant portion of the monthly power bill. Operational changes can often be made to reduce these demand charges. Examples include changing rate schedules, backwashing filters when other equipment is idle, maximizing individual well use within a billing cycle, reducing the number of wells that are operated during a billing cycle, etc. An awareness of how demand charges are applied can help water systems avoid unnecessary charges. An example of energy charges and demand charges are presented in Table 4.

Table 4. Example Demand Charge and Energy Use Comparison

Facility Name	Energy Use	Average Monthly Demand	Demand $	Total* $	Demand/Total Cost
Well #1	216,900 kWh	126.0 kW	$5,552	$17,468	32%
Well #2	800,480 kWh	131.6 kW	$7,106	$44,639	16%
Well #3	119,160 kWh	75.7 kW	$3,354	$9,951	34%
Well #4	267,501 kWh	61.5 kW	$2,617	$17,577	15%
Well #5	210,920 kWh	52.3 kW	$2,406	$14,031	17%
Well #6	2,200 kWh	8.9 kW	$373	$676	55%
Booster #1	206,160 kWh	71.4 kW	$3,147	$14,447	22%
Booster #2	26,240 kWh	8.9 kW	$396	$1,991	20%

* Includes miscellaneous taxes, fees, etc.

This example shows that demand charges can range from 15% to 55% of the total electrical bill. Measures to help manage demand charges are discussed further in the following sections.

Time-of-Use Rate Schedules

Some electric utilities offer time-of-use (TOU) rate schedules as a way to limit energy use or on-peak demand during times of peak energy use. The use of TOU rate schedules will likely increase as electric utilities will be faced with either increasing generation capacity or reducing peak energy use. TOU rate schedules can benefit water systems with adequate production and storage capacity. Water production could be shifted to times of off-peak energy use resulting in reduced energy and demand charges. Shifting water production hours would present a significant operational change. However, reduced energy charges and cost savings may warrant the change. An example of a TOU rate schedule is provided in Table 5.

Table 5. Example TOU Rate Schedule

	Standard Rate	Time-of-Use Rate
Service Charge per month	$16.50	$11.50
Off-Peak Hours	NA	Summer (Apr 1 – Oct 31) 10 PM – 10 AM
		Winter (Nov 1 – Mar 31) 11 PM – 7 AM
		Both Seasons Saturdays, Sundays, and Holidays
Demand Charge per kW per month	$4.08 - $4.54	
Off-Peak		No Charge
On-Peak		$7.68
Energy Charge (¢ per kWh)	6.05¢	
Off-Peak		3.20¢
On-Peak		5.15¢

Electric Utility Load Management Programs

Similar to TOU rate schedules, load management programs are available from some electric utilities. A load management program aims to control the electric loads of customers during times of peak usage. Loads on the electric system are reduced through load management by disconnecting groups of users, ensuring that not all users are consuming power at the same time.

Water systems participating in load management programs can still operate on standby generators during times of load management. The load management process can be automated in order to avoid disruption to the water system. A signal is received from the power utility, and the system is transferred to standby power. Cost savings are realized by avoiding demand charges or realizing a reduced demand charge. An example of load management savings is presented in Table 6.

Table 6. Example Load Management Statistics

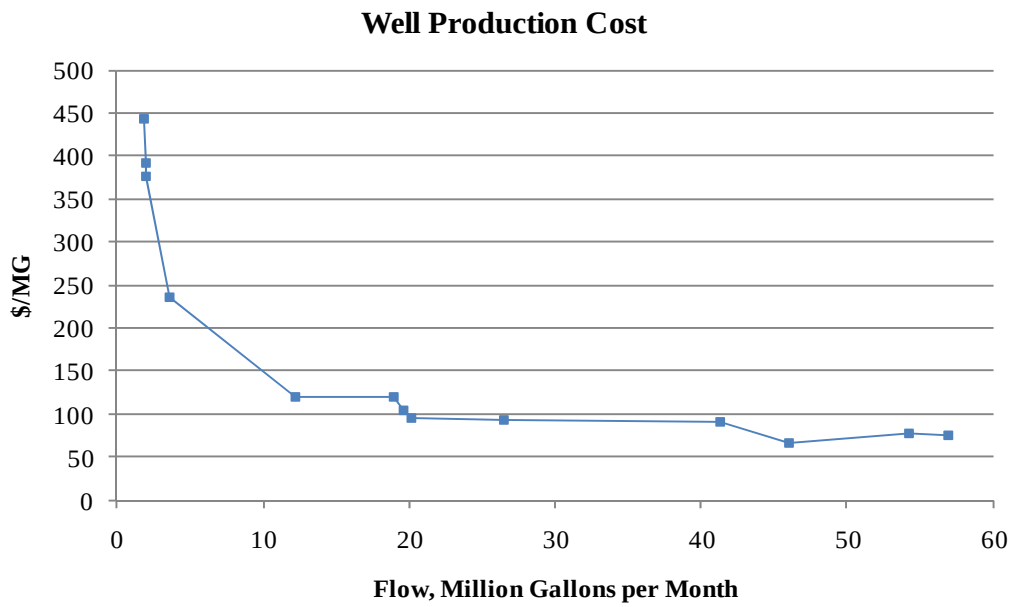
	WTP #1	WTP #2
Hours Generator Operated in 2009	243	382
Total Hours on Engine	3,752	1,358
kWh Generated	16,793	8,400
Demand Control Savings	$21,036	$18,466
Fuel Cost	$3,253	$3,810
Maintenance	$2,325	$1,215
Net Savings	$15,458	$13,441
Total Demand Savings to Date	$218,599	$42,673

Current regulations should be reviewed prior to making operational changes that will impact how generators are operated. Operating internal combustion generators for power generation rather than only for emergency backup may require additional provisions to meet air quality regulations.

Motor Run Times

Demand charges for infrequently used wells comprise a higher percentage of the electric bill than the demand charges of wells used routinely. Once a well is operated and the demand charge is incurred, the cost per million gallons pumped decreases with increased use. This is illustrated in Figure 10, which shows the production and cost for a well facility. The cost per million gallons is significantly less when the monthly volume pumped by the well exceeds 10 million gallons.

Figure 10. Effect of Run-Time on Production Cost



Pump Efficiency

Pump efficiency affects energy use. The more efficient a pump and motor are, the less energy they use to perform the same amount of work. Regular maintenance should be performed on pumps in order to keep them as efficient as possible. Daily observations such as operating pressure, flow rates, operating sound levels, and unusual sounds can give an early indication of pending pumping issues and potential less efficient operation. Also on a routine basis, proper lubrication is to be conducted along with evaluating seal condition, wear ring and impeller conditions, bearing running temperature and condition, amp draw, etc., and compared to historical observations. This can allow for repairs or adjustments to be made early to keep the system operating as efficiently as possible and reducing failures. As pumps near the end of their useful life, they should be replaced by high efficiency pumps and motors.

Pump Efficiency Testing

Pump efficiency testing is performed to determine the total system efficiency also known as the wire-to-water efficiency. The wire-to-water efficiency of a pump is the relationship between the energy consumed and the amount of water being delivered at a given pumping head. The greater the overall efficiency of the pump, the lower the cost per million gallons pumped will be.

Pump efficiency is determined by analyzing the water level in a well or wet well during pumping, discharge flow rates, and power inputs to the pump motor. In order to determine the pumping water level, it is necessary to sound the well. Some pumps have sounding access holes in the

pump head. Newer wells may include an airline, which can provide rapid determination of water levels.

In order to obtain flow rate, a means of measurement must be available or provided. In many instances, existing installed flow metering devices can be used. If an existing flow element is not available a flow meter may be installed in the discharge line or a strap-on Doppler type device may be used. The ideal location for flow measurement varies by manufacturer, but is commonly specified by stating an unobstructed length of the discharge pipe ahead of and downstream of the flow meter (for example no bends, valves, etc. in that "unobstructed" segment). This minimizes the impact of turbulence on the accuracy of the flow measurement. This unobstructed pipe length is typically in the range of eight times the discharge pipe diameter upstream and five times the pipe diameter downstream. Shorter lengths than recommended by the manufacturer may be used, although the accuracy may be affected.

Ideally, a vertical turbine (VT) pump sized for the field conditions should operate at ±76 percent total system efficiency. Submersible pumps are slightly less efficient, at ±72 percent total system efficiency. Pumps driven with a VFD are also less efficient due to losses associated with the VFD. Equation 6 shows how pump efficiency factors into the wire-to-water efficiency and provides an example using efficiencies typical of each component in the pump system.

Equation 6. Wire-to-Water Efficiency

$$\text{Wire} - \text{To} - \text{Water Efficiency} = \text{VFD Efficiency} \times \text{Motor Efficiency} \times \text{Pump Efficiency}$$

$$\text{Effic}_{w-t-w} = (0.95 \times 0.96 \times 0.8)\,100\% = 73\%$$

Two causes of poor efficiency for well pumps are typically attributed to mechanical wear and changing groundwater level. Worn impellers, wear rings, and bearings decrease mechanical efficiency while a drop in groundwater level increases the discharge head, pushing the pump back and up on its curve and away from its best efficiency point. Sand is the typical cause of premature wear in a well pump. Worn impellers and wear rings allow water to recirculate in the pump. Manufacturers anticipate about a 20 year life from a well pump due to wear on the impellers, wear rings, and bowls. The cost to replace or rebuild impellers and wear rings can be up to 50 percent of the cost for a new pump. This is usually feasible if the pump is still a good match for the field conditions. Owners typically opt to replace a pump when the repair cost approaches 75 percent of the cost for a new pump. This is usually the case when the line shaft and/or the bowls also need to be replaced.

Well pumps with low efficiency should be pulled and modified or replaced to better match head conditions. The flow rate can be changed and the motor can also be replaced where needed. Note that acceptable paybacks are only achievable on wells that are operated routinely or have an appreciable efficiency improvement.

Provisions to perform pump efficiency testing should be considered during the design of new facilities. For example sounding tubes and flow meters should be installed with new wells.

Performing pump efficiency testing on existing facilities without these provisions can be difficult or impossible.

Compressed Air Systems

Compressed air is utilized throughout most plants. Compressed air can be used to operate valve actuators, for filter or membrane air scour, and to operate pneumatic tools. Inefficient compressors and leaking air distribution piping are items that should be included in an energy audit. Pneumatic operators consume air and leaking valve actuators can result in a significant increase in run time of air compressors. Filter galleries in particular can be large consumers when fitted with pneumatic operators. When installing new or replacement actuators, certain designs such as some models of rotary vane actuators can drastically reduce air consumption with the side benefit of reducing noise in the filter gallery. Inspection of compressed air systems should be performed regularly to identify leaks or inefficient operations and compressor run times monitored. Energy savings will be achieved be reducing the run time of the air compressors. Additionally, the operating pressure of the system can be set to the minimum system requirement (for example the valve operator's minimum operating pressure) that requires less power to develop.

Water Treatment Processes

Generally processes within a water treatment plant have been established and making significant changes to process equipment is beyond the scope of an energy audit. There are, however, some process areas that can be included in an energy audit. Descriptions of some common process changes are provided.

UV Disinfection

Disinfection using ultraviolet (UV) light is becoming increasingly popular in water systems. Current regulations for disinfection contact time and disinfection byproducts can favor the use of UV systems. However, UV systems can be energy intensive to operate. As the cost of electricity rises, the use of UV systems will become less favorable. Rather, construction of larger clearwells or process changes to reduce disinfection byproducts may prove to be more cost-effective alternates. UV system controls should be set up to limit use. The UV system should only be used when flow rate, temperature, or pH make it necessary.

Filter Backwash

Filters are typically backwashed by dedicated pumps. Setting up the plant controls to ensure filter backwash occurs during times of low electrical demand can reduce demand charges. For example the monthly demand charge will be based on the greatest electrical demand observed during the billing period. By backwashing filters when other energy intensive equipment, such as high service pumps, are idle, a reduction in demand charges can be achieved. A Supervisory Control and Data Acquisition Systems (SCADA) system can be programmed to delay filter backwash or to temporarily shut down high service pumps during the backwash process.

Lime Sludge Disposal

Lime sludge generated by lime softening plants can provide an opportunity for improved energy efficiency. The way sludge is handled should be evaluated to determine if more efficient opportunities are available. In addition, lime sludge may be recycled through the plant to ensure the full potential of the lime is utilized.

Reducing Water Demand

Energy use by a water system is proportional to the amount of water produced. Therefore, reducing water production will reduce energy use. Reducing water demand can be accomplished by reducing water loss and encouraging water conservation.

Water Loss

Reducing water loss may present the greatest opportunity to reduce energy costs. Reducing water loss can be challenging and may require significant capital investments. Systems with relatively high water loss (greater than 25%) have an opportunity to significantly reduce energy use and costs. All water systems should track water loss and set goals of reducing loss. Systems with high percentages of water loss should make reducing water loss a priority.

The American Water Works Association (AWWA) has realized the importance of improving water management and has recently updated their manual Water Audits and Loss Control Programs. The third edition was published in 2009 and includes a major advancement in water audit methodology, giving water utilities greater guidance in improving accountability and economically controlling water and revenue losses (AWWA, 2009).

A water loss control program can identify real losses, unbilled consumption, and apparent losses. In general real losses are the primary type of loss and include distribution system leakage. Unbilled consumption is typically authorized by the water system. This would include flushing hydrants, backwashing filters, or other forms of use by the water system. Apparent losses include accounting errors, meter inaccuracy, and unauthorized consumption. Identifying the source of water loss can be difficult. Implementing a water loss control program will help identify sources of water loss and lead to corrective actions being taken. Water systems typically strive to account for 90% or more of their water.

Water Conservation

Water conservation programs generally focus on educating the customer on efficient water use, environmentally friendly practices, water efficient products, and product rebates. As demand for natural resources increases, water conservation will become an increasingly important issue. Water systems are in a unique position of encouraging their customers to conserve.

Successful implementation of water conservation measures may have a negative impact on revenue. Decreased revenue prompts the water system to increase rates and can lead to frustration among consumers who feel they are being punished for their conservation efforts. Implementing

conservation measures, such as structured rates, that protect the water system from lost revenue and encourages conservation will be difficult. Rate structures with high fixed costs provide stability to the water utility's revenue but do little to encourage conservation. A rate structure with low fixed costs and tiered rate increases corresponding to water use provide the greatest incentive for conservation. However, such a rate structure leaves the water system vulnerable to volatile revenue. As water conservation becomes increasingly important, water systems in the state of South Dakota will need to find ways to encourage conservation while generating adequate revenue.

SCADA

SCADA systems are becoming the norm for control of most treatment facilities due to the affordability of robust computing systems, increased data transmission speed, open architecture design, flexibility, and more user friendly control software systems. A computer or computers in conjunction with programmable logic controllers (PLCs), remote telemetry units (RTUs) and other devices add significant flexibility in what data is monitored and collected as well as how equipment can be operated over hardwired relay and switch operated systems.

SCADA systems can result in energy savings by optimizing the treatment and pumping operations via real-time monitoring and automated control of equipment and systems. Automated operation or SCADA assisted operation to adjust driver speeds, pump sequencing, elevated storage filling timing, backwash initiation and duration, and HVAC monitoring and control are just some of the potential areas where power use can be reduced.

Additionally, the SCADA system can be beneficial in actually monitoring energy use, demand peaks, etc. This gives the operations staff members a means of visualizing what their operation decisions have on the energy consumption and demand. This could also be taken a step further to incorporate the power provider's rate schedule into the system, such that an approximation of what the power costs are can be shown. As mentioned previously, it is common that the plant staff members do not see the power bills and therefore don't fully understand how their decisions may impact actual costs.

HVAC

HVAC systems can be gas or electric powered on the heating side and electrical on the cooling side. No matter what the power supply, a cost savings may be available by reducing power consumption by replacement with more efficient systems, however payback can be quite long.

Additionally, geothermal heating system can be used to provide a much more efficient HVAC system. These can utilize a closed loop in which the ground (via a well or buried loop) is used as a heat source or in a water facility the water already being pumped can be used as the source. This is more feasible during initial construction due to the high capital costs, but with the availability of grants, rebates, tax incentives, etc., each application needs to be evaluated under its own conditions.

Check with the power provider for potential rebates on more efficient HVAC systems or components.

Items that can be done to existing systems that can reduce power use at low to no cost include:

- Keep filters on forced air units clean to reduce pressure drop,
- Seal leaking areas around doors,
- Use programmable thermostats to automatically reduce temperature when unoccupied (check for rebate offers from power provider)

For areas that are typically unoccupied, reduce normal temperature on the thermostat in the winter and raise the temperature in the summer if applicable.

Lighting

Lighting at water treatment facilities can realize a power cost savings associated with lighting spaces. When compared to pumping this can be a much smaller savings, but not insignificant. The savings can be through installation of occupancy sensors, reducing lighting coverage or intensity, using compact fluorescent (CFL) or LED lighting, etc. Savings can be impacted by rebates from the electrical service provider or through grants, incentives, tax breaks, and so on that are quite prevalent at this time of renewed emphasis on energy conservation.

Occupancy sensors turn the lights on when occupancy is detected and turn them off after an area has remained unoccupied for a set period of time. These sensors are most effective at reducing energy consumption from lighting in spaces where occupancy is intermittent or where lights are left on in spaces after occupants leave. Occupancy sensors use passive infrared sensors, ultrasonic sound waves, or both (called “dual technology”) to detect occupancy. These sensors can be installed either on walls or ceilings. Wall sensors are typically used in small rooms, such as private offices, whereas ceiling sensors are generally used in larger rooms.

Each sensor manufacturer has its own style of occupancy sensors. In general, ultrasonic sensors are more sensitive and work in a lot of spaces but are also subject to false “ons” due to air movement and motion outside of doors. Infrared sensors have a more focused coverage range and are more appropriate for smaller rooms, such as private offices. Dual technology sensors use an infrared sensor to activate lights and use an ultrasonic sensor to keep lights on, thus reducing false “ons” and “offs.” We suggest consulting the manufacturer’s literature to select the sensor with the right coverage area and sensor technology for each particular space.

Reducing lighting lamination is a consideration. Designers follow typical standards when lighting spaces and that may be more than needed or desired in certain areas. Reducing lamp wattages would directly reduce lighting energy usage.

CLF and LED lights will significantly reduce the kW usage to provide the same lamination as incandescent lighting. CFLs currently consume less than 25% of the power of an incandescent

bulb, with a 23W CFL being essentially equivalent to a 100W incandescent bulb and the expected life of the bulbs are 8 to 15 times longer. The cost of CFLs have reduced significantly over recent years, making them cost-effective in many instances. LED lamps are even more efficient, at approximately 10% of the energy consumption of an incandescent bulb, and with a life that can exceed 25 years. The cost of these lamps are still quite high, such that CFLs currently are normally more cost-effective, but should be compared. The use of LEDs in inaccessible areas may be desirable due to their extremely long life, regardless of the cost savings.

Unnecessary Equipment

There are cases in which equipment or processes are installed in a water treatment facility or distribution system that are not necessary to provide safe, reliable drinking water in compliance with SDWA requirements. This may be due to construction in anticipation of future regulations, changes in source water characteristics, effectiveness of treatment, demand, and numerous other factors. In such cases, the system can reduce operation or eliminate such unnecessary processing to reduce power consumption. Just because the equipment exists, or that is the way it was always operated, doesn’t mean that it needs to be operated or operated that way. Evaluate the process and operate as required to meet regulatory requirements in a safe and reliable manner without additional unnecessary steps.

V. Energy Conservation Measures

Ideally several ECMs will have been identified during the data collection and site visit phases of the energy audit. An ECM can be either a physical change, like replacing oversized pumps, or an operational change, such as setting the most efficient well as the lead well with others set for backup. Potential ECMs should be evaluated to determine how the proposed changes will affect the water system, what the energy or cost savings will be, and what costs are associated with the ECM. Each system will have unique opportunities and criteria for implementing changes. The previous sections have provided a background for conducting an energy audit. In addition to the physical and operational changes already discussed, Table 7 provides typical water and wastewater high-use energy operations and associated potential energy saving measures.

Table 7. Typical Water and Wastewater High-Use Energy Operations and Associated Potential Energy Saving Measures (EPA, 2008)

High Energy Using Operations	Energy Saving Measures
Pumping	• Reduce load • Manage load • Water to wire efficiency • Pump selection • Motor and drive selection • Automated control
Aeration	• Fine bubble • Improved surface aerators • Premium motors • High efficiency motor drive • Blower variable frequency drives • Automatic DO control
Dewatering	• Replace vacuum systems • Premium motors • Variable frequency drives for plant water pump
Lighting	• Motion sensors • T5 low and high bay fixtures • Pulse start metal halide • Indirect fluorescent • Super efficient T8s • Comprehensive control for large buildings
Heating, Ventilation, Air Conditioning (HVAC)	• Water source heat pumps • Prescriptive incentives for remote telemetry units • Custom incentives for larger units • Low volume fume hood • Occupancy controls • Heat pump for generator oil sump

Selected ECMs that were developed for the individual energy audit participants are provided in the Appendix. These ECMs have been provided so that the general ECM development process can be more easily understood. A payback period, or return on investment period, of 5 years was set as a limit for the ECMs provided.

VI. Renewable Power

Renewable power has gained popularity in recent years as increasing energy costs and efforts to reduce greenhouse gas emissions have become national priorities. An emphasis has been placed on clean energy that can be produced domestically. The current trend has been for large installations, such as large wind farms and solar arrays. However, advances in renewable technology are being made that will allow small installations to be cost-effective. Technological advances and funding opportunities may make renewable power a viable option for small water systems.

Solar Power

Solar energy technology has a number of different systems and variations of those systems. In addition, many of the technologies are advancing at this time with changes in the unit cost and development of larger and more efficient systems. In general, solar energy can be separated into systems that generate electrical energy and those that generate thermal energy. Solar electrical generation systems are photovoltaic (PV) and thermal energy generation systems are concentrating solar power (CSP). Both PV and CSP have a number of subsets or variations on the basic technology. Almost all of these systems are proprietary and have manufacturers that specialize and develop standard products. The following provides more detailed information regarding the PV electrical energy systems.

Photovoltaic

PV systems generate electricity as the light rays travel through a medium such as silicon crystals. The panels generate direct current power. Inverters are used to transform the power into alternating current (AC) power commonly provided by utilities. Each type of PV material will tend to capture the energy from a portion of the wave lengths or spectrum of the light source (e.g. red, yellow, or blue). Advances in PV material and systems are occurring and there has been a general improvement in the efficiency of the systems over time.

The main components of the systems include:

- PV material
  a. Crystalline – single and multi-junction
  b. Thin film

- Tracking
  a. Fixed – flat or tilted – generally facing south in the northern hemisphere.
  b. Single axis tracking – generally rotating east to west as the sun rises in the morning and sets in the evening.
  c. Double axis tracking – rotating east to west and up and down as the sun varies by day and season.

- Light Concentration
  a. Flat panels with no magnification or focusing.
  b. Concentrating PV with mirrors or lenses to concentrate the sunlight into a smaller area.

- Capacity or Size
  a. Size or capacity vary widely with larger systems currently in development. Installation capacities vary from small 10 watt panels to charge batteries, 500KW systems to provide a portion of the commercial buildings electrical needs, to a 10-250MW utility grade solar power plant connected to the utility's high voltage transmission system.

- Proprietary Systems

Wide arrays of proprietary systems are commercially available. Some systems are specially designed for residential, commercial/industrial, or utility installation. Building integrated systems for roofs, windows, light weight roof installation, flexible thin film membrane, mobile systems, emergency power, battery charging, and numerous other systems are available

Solar PV Pros:

- Low land use when installed on available rooftop and above parking area square footage.
- No transmission requirements.
- Provide power during peak demand as solar intensity typically coincides with peak power uses such as air conditioning peaks on hot summer days.
- Ability to ramp up quickly.

Solar PV Cons:

- Without energy storage (such as a battery), it is a "must take" energy source.
- Storing large amounts of electricity can be difficult.
- Dollar per watt is expensive when compared to large-scale base-load units.
- Variable and uncertain energy source.

The National Renewable Energy Laboratory (NREL), U.S. Department of Energy map in Figure 11 illustrates the solar resource potential by region. Solar conversion is an inefficient process; typical PV cells have a conversion efficiency ranging from 10% to 16%. The solar resource potential is reported in units of kilowatt-hour per square meter produced over the course of one day.

A typical 1-kW, 11% efficient PV array may range in size from 8 to 9 m^2; however, a larger array requires access space as well as spacing between the rows of panels to avoid self-shading and will subsequently require a greater amount of space per installed kW.

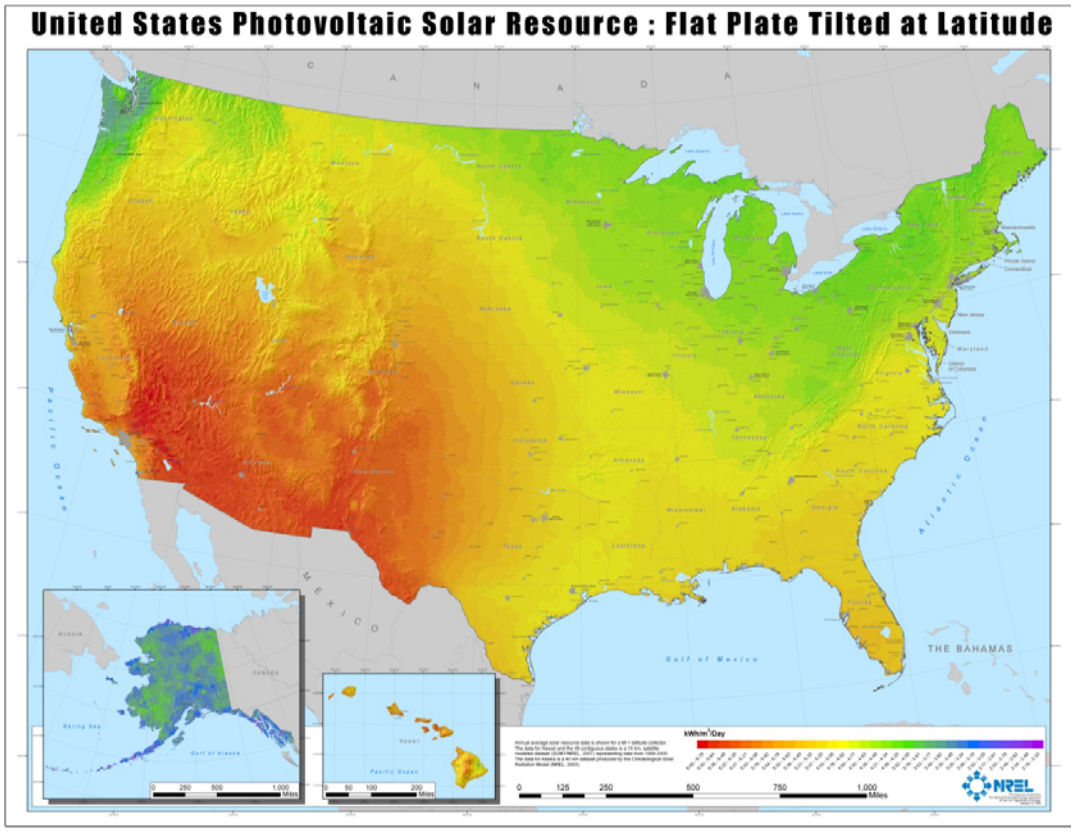


Figure 11. Solar Resource Map

Wind Power

The United States has the benefit of holding a vast wind power resource. Total wind power available in a region is calculated by multiplying the total kinetic energy per unit mass by the flow rate. Wind turbines are unable to extract the total power available as that would require reducing the wind speed to zero. Instead, the actual power extracted is found by the actual pressure and velocities before and after the turbine. However, the greater the total ideal power, the greater the actual power extracted. The method of multiplying total kinetic energy per unit mass results in the total ideal power being proportional to the cube of the wind velocity. Wind velocity is therefore critically important to feasible wind power generation.

There are two classifications of wind energy technologies: large scale industrial and small scale distributed or commercial systems.

- Industrial wind energy referred to as wind farms consist of larger groups of horizontal axis wind turbines (HAWT) that are capable of producing in the range of 660 kW to 3 MW of power output each.

- Distributed or commercial systems consist of smaller HAWT or vertical axis wind turbines (VAWT) and are typically mounted on top of, or amongst, urban construction.

Industrial commercial system turbines are typically HAWT configuration and are capable of producing in the range of up to 50 to 250 kW of power output each. Residential and commercial distributed systems are capable of producing in the range of 400 watts to 50 kW. These systems have varying hub heights and turbine spacing requirements.

Distributed Wind Power Pros:

- Low land use.
- No transmission requirements.
- Provide power during peak demand.
- Able to ramp up quickly.

Distributed Wind Power Cons:

- Without energy storage (such as a battery), it is a “must take” energy source.
- Variable and uncertain energy source.
- Storing large amounts of electricity can be difficult.
- Dollar per watt is expensive when compared to large-scale base-load units.

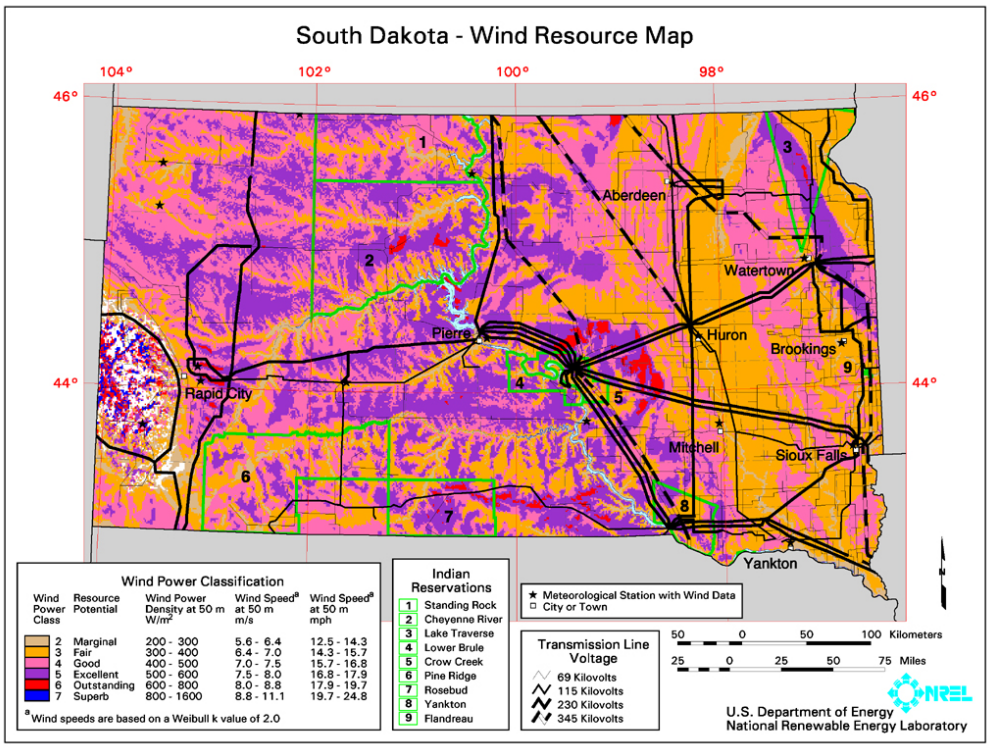


Figure 12. South Dakota Wind Resource Map

Hydropower

Hydropower may be a viable option in situations where large amounts of head are currently being wasted such as large pressure reducing stations. Hydropower facilities could benefit water systems by providing power to operate equipment and reduce the amount of power purchased from the power utility. The general equation for hydropower capacity is:

Equation 7. Hydropower Capacity

$$P_w = (0.0846)(Q)(H_n)(h)$$

Where:

P_w = power produced in kilowatts (kW)

Q = flow through turbine (cfs)

H_n = net head on turbine (ft)

h = hydropower plant efficiency (0.8 typical)

A substantial flow rate and net head must be available in order to generate a significant amount of power. The application of hydropower to small drinking water systems is not likely to occur in the near future. However the opportunity may be present in some systems. As electrical rates increase and funding for alternative energy sources becomes available, such systems may be cost-effective.

Alternative Energy Conclusion

Hydroelectric, solar, and wind may be long term options to be considered for the continued operation of drinking water systems. In consideration that these systems are likely to be a long term installation, the payback period may be considered feasible. Key points to consider for green energy applications include:

- Grant funding may be available to help offset costs
- Partnerships with private utilities for sale of excess power produced could be considered

VII. Applicability to Other Facilities

The focus of the project for which this handbook was developed was small water systems. The energy saving and power cost reduction measures discussed are not limited to that type of facility. Water plants of all sizes, wastewater treatment plants, wastewater lift stations, and other building facilities can benefit from applying these energy conservation concepts.

The potential for savings can be even greater on the wastewater treatment side when mechanical plants are involved. The pumping remains as a large power consumer as with water facilities. In addition, the aeration process and sludge handling processes can have even larger demands.

Pumping savings for wastewater facilities can be realized by varying speed with VFDs, optimizing impellers, replacing pumps with more efficient or appropriately sized units, and avoiding throttling with valves, as with water systems. For lift stations it is common for the pumps to be constant speed and cycle on and off, based on wetwell level. Under those conditions, utilization of a VFD to achieve power savings would focus on adjusting speed to a more efficient point on the pumping curve and reducing total pumping head by equalizing the pumping rate out over a longer period, or even continuous operation, reducing velocity and its associated friction loss. These potential savings need to be weighed against the cost of adding VFDs and considering the efficiency loss through the VFD of 3 to 4% and can also be accomplished by modifying or replacing pumps as described previously.

For wastewater systems that use the activated sludge process, aeration is a significant power use. Optimization of aeration to maintain a constant desired dissolved oxygen (DO) content will minimize the required power cost. Since facilities are designed for future flow conditions, it is common that there is not enough flexibility in the aeration system to achieve that goal. Since a low DO causes more operational problems than a higher DO, the latter will be favored when the flexibility is not available to maintain a constant DO. If the aeration supply is a positive displacement type, such as rotary lobe blowers, installation of a VFD will allow the speed to be controlled to maintain the desired DO. This is best accomplished if it is incorporated into the control system to automatically maintain a set point DO. With centrifugal blowers, varying the speed does not work well due to the speed and pressure delivered relationship. In this situation blower replacement with appropriate sized units or adding in smaller blowers to allow for a more “tunable” delivery rate can be evaluated.

VIII. Summary of Systems Evaluated

Nine small water systems were evaluated across the state for potential energy savings. These were selected to be a representative cross section of statewide potable water systems. Criteria used in the selection included:

- Coverage of the state geographically
- Include surface and groundwater sources
- Include city, rural water and tribal water systems
- Include varied water treatment processes
    - Direct pump and disinfect
    - Iron and manganese removal
    - Lime softening
    - Membranes

Below, in Table 8, the nine systems evaluated are listed along with the effective power cost, power use, and costs on a per million gallons (MG) basis.

Table 8. Energy Use and Costs at Nine Small Water Systems Evaluated

Facility Name	Served Population	Annual Water Treated / Distributed MG	Average Effective Power Cost (¢ /kWh)	Average Electrical Power Use kWh/MG	Average Electrical Power Cost $/MG
City of Brandon	8,400	302	9.62	2,872	$276
Clark Rural Water System	2,700	301	8.9	3,768	$336
Clay Rural Water System	2,100	233	6.1	3,762	$274
Dakota Dunes	2,850	212	6.25	1,916	$120
Lead-Deadwood Sanitary District	5,700	207	6.8	2,360	$160
Lower Brule Rural Water System	2,000	111	8.1	7,013	$572
Rapid Valley Sanitary District	9,000	290	8.8	3,445	$303
City of Spearfish	9,300	693	6.5	2,700	$173
West River/Lyman Jones Rural Water	8,300	784	11.6	1,151	$139
Total/Average	50,350	3,133	8.07	3,221	$261

Since this was a representative cross section, the information collected and results of the analysis can be used by other systems across the state to see how they compare currently and get a gross estimation of potential energy savings they could realize by implementing energy conservation measures. For the initial comparison the system will need to:

1. Collect a minimum of one year of electrical power used for the entire treatment and distribution system to arrive at:
    - The total annual kWh used

- The total annual cost of power

2. Calculate
   - The power usage/MG used in treatment and distribution by dividing the total annual kWh used by the annual water treated for that year in MG (kWh/MG).
   - The power cost/MG for treatment and distribution by dividing the total annual power cost by the annual water treated for that year in MG ($/MG).

3. Compare the *range* and *average values* calculated in Step 2 above with those in Table 8 to get an indication of how the facility compares to those evaluated. To be more specific, the comparison can be made with the values presented for the facilities with similar treatment and distribution conditions.

Several ECMs were evaluated for these systems and desirable ECMs with a short payback were recommended to be implemented. Examples of ECM calculations are presented in Appendix B. The total estimated annual power and cost savings are presented, along with a savings per MG in Table 9. These can also be utilized for comparisons and an indication of potential energy savings.

Table 9. Estimated Energy Savings at Nine Small Water Systems Evaluated

Facility Name	Annual Water Treated / Distributed MG	Estimated Annual Power Use Savings kWh	Estimated Annual Power Cost Savings $	Estimated Annual Power Use Savings kWh/MG	Estimated Annual Power Cost Savings $/MG
City of Brandon	302	32,840	$6,020	109	$19.90
Clark Rural Water System	301	116,990	$24,550	389	$81.60
Clay Rural Water System	233	107,380	$8,550	461	$36.70
Dakota Dunes	212	59,870	$3,500	282	$16.50
Lead-Deadwood Sanitary District	207	50,410	$5,830	244	$28.20
Lower Brule Rural Water System	111	74,530	$5,570	671	$50.20
Rapid Valley Sanitary District	290	184,020	$15,320	635	$52.80
City of Spearfish	693	493,080	$46,480	712	$67.10
West River/Lyman Jones Rural Water	784	80,430	$19,280	103	$24.60
Total/Average	3,133	1,199,550	$135,100	383	$43.10

An indication of what energy savings could be realized across the state of South Dakota for all community water system if feasible ECMs were implemented can be estimated using the average values presented in Table 9 and system annual treated water values from the SD DENR. In all, there are approximately 460 community water systems in South Dakota with an annual treated water production of approximately 45 billion gallons.

Assuming similar results and recommended ECMs are implemented, the annual power savings statewide for all public water systems could be approximately 17 million kWh and $2 million dollars.

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Appendix A – Example Rate Schedule

Electric Rate Schedule: RG

Class of Service: **Residential / General Service**

Applicability:

This rate applies to single-phase services with installed transformer capacity of 100 KVA or less.

Type of Service:

Single-phase, 60 cycles, at available secondary voltages.

Rate:

Facility Charge: $30.00 per month

Energy Charge: 8.4 cents per kWh

Tax Liability Clause:

Billing charges calculated using rates in this schedule are subject to any taxes the Cooperative must pay or collect during the application of this rate schedule.

Minimum Monthly Charge:

The minimum monthly charge is $30.00 when installed transformer capacity is 15 KVA or less.

When transformer capacity exceeds 15 KVA, the minimum monthly charge will increase at the rate of $0.75 for each additional KVA of capacity. If KVA capacity is not a whole number, KVA capacity is rounded to the next whole number before calculating minimum monthly charge.

Purchased Power Adjustment Clause:

If the wholesale cost for purchased power changes, the Cooperative may increase or decrease billing charges that are calculated by using the rates in this schedule.

Adopted by board action: February 23, 2010
Effective: Billings on and after May 1, 2010

Electric Rate Schedule: LP

Class of Service: **Large Power Service**

Applicability:

This rate applies to single-phase services with installed transformer capacity greater than 100 KVA and to multi-phase services.

Type of Service:

Single-phase or multi-phase, 60 cycles, at Cooperative's standard voltages.

Rate:

Facility Charge:	$50.00 per month
Demand Charge:	$13.30 per kW of billing demand
Energy Charge:	6.2 cents per kWh

Tax Liability Clause:

Billing charges calculated using rates in this schedule are subject to any taxes the Cooperative must pay or collect during the application of this rate schedule.

Determination of Billing Demand:

The maximum kilowatt demand that occurs during any period of fifteen (15) consecutive minutes within a billing cycle, as indicated or recorded by metering equipment installed by the Cooperative, determines billing demand.

Minimum Monthly Charge:

In some cases, a contract for service will specify the minimum monthly charge.

If no contract exists, the minimum monthly charge is the monthly facility charge or an amount equal to $1.00 per KVA of installed transformer capacity, whichever is greater. If KVA capacity is not a whole number, KVA capacity is rounded to the next whole number before calculating minimum monthly charge.

Interruptible Service:

The demand charge portion of the rate is waived for any service site controlled by a Cooperative-approved load control device; provided, the member/consumer has paid in full any applicable fees or charges, and any device or seal remains intact throughout the billing cycle and exhibits no evidence of tampering.

(more)

Service Provisions:

If service is furnished at secondary voltage, the delivery point is the metering point, unless otherwise specified in a contract for service. The member/consumer owns and has maintenance responsibility for all wiring and other electrical equipment on the load side of the delivery point.

If service is furnished at Cooperative's primary line voltage, the delivery point is the point of attachment of Cooperative's primary line to member/consumer's transformer structure, unless otherwise specified in a contract for service. The member/consumer owns and has maintenance responsibility for all wiring and other electrical equipment on the load side of the delivery point, except for metering equipment owned by the Cooperative.

Purchased Power Adjustment Clause:

If the wholesale cost for purchased power changes, the Cooperative may increase or decrease billing charges that are calculated by using the rates in this schedule.

Adopted by board action: February 23, 2010
Effective: Billings on and after May 1, 2010

Electric Rate Schedule: LPG

Class of Service: **Large Power Service with Auto-start Generator**

Applicability:

This rate applies to single-phase service with installed transformer capacity greater than 100 KVA and to multi-phase service, without regard to transformer size, when either type of service is equipped with a load control device, standby generation and control-time demand metering.

Type of Service:

Single-phase or multi-phase, 60 cycles, at Cooperative's standard voltages.

Rate:

Facility Charge:	$50.00 per month
Demand Charge:	$13.30 per kW of billing demand
Energy Charge:	6.3 cents per kWh

Tax Liability Clause:

Billing charges calculated using rates in this schedule are subject to any taxes the Cooperative must pay or collect during the application of this rate schedule.

Determination of Billing Demand:

Billing demand does not apply during the months of March, April, May, September and October.

The maximum kilowatt demand that occurs during load control periods within a billing cycle, as indicated or recorded by metering equipment installed by the Cooperative, determines billing demand during the months of January, February, June, July, August, November and December.

Demand charges associated with this rate will apply to demand recorded in any two billing cycles during a 24-calendar month rolling period. On the third occurrence of demand recorded in a billing cycle during the rolling period, demand charges will increase to three (3) times the demand charges associated with this rate as penalty for not complying with the spirit and intent of the rate class.

Minimum Monthly Charge:

In some cases, a contract for service will specify the minimum monthly charge.

If no contract exists, the minimum monthly charge is the monthly facility charge or an amount equal to $1.00 per KVA of installed transformer capacity, whichever is greater. If KVA capacity is not a whole number, KVA capacity is rounded to the next whole number before calculating minimum monthly charge.

(more)

Service Provisions:

If service is furnished at secondary voltage, the delivery point is the metering point, unless otherwise specified in a contract for service. The member/consumer owns and has maintenance responsibility for all wiring and other electrical equipment on the load side of the delivery point.

If service is furnished at Cooperative's primary line voltage, the delivery point is the point of attachment of Cooperative's primary line to member/consumer's transformer structure, unless otherwise specified in a contract for service. The member/consumer owns and has maintenance responsibility for all wiring and other electrical equipment on the load side of the delivery point, except for metering equipment owned by the Cooperative.

Purchased Power Adjustment Clause:

If the wholesale cost for purchased power changes, the Cooperative may increase or decrease billing charges that are calculated by using the rates in this schedule.

Date adopted: February 23, 2010
Date effective: Billings on and after May 1, 2010

MUNICIPAL PUMPING

AVAILABLE

At points on the Company's existing distribution facilities supplied by its interconnected transmission system within Butte, Custer, Fall River, Lawrence, Meade, and Pennington Counties of South Dakota.

APPLICABLE

To incorporated municipalities for electric service which is needed for and used in connection with the year-round operation of water utility pumping and treatment and sewage disposal facilities. This schedule is not applicable to temporary, standby, supplementary, emergency, resale, shared, or incidental service.

CHARACTER OF SERVICE

Alternating current, 60 hertz, at the voltage and phase of the Company's established distribution system most available to the location of customer.

NET MONTHLY RATE

Rate	Summer Rate	Winter Rate	
Customer Charge	$16.50	$16.50	(R)
Capacity Charge	$4.54 per kW of Billing Capacity	$4.08 per kW of Billing Capacity	(R)
Energy Charge	All usage at 6.05¢ per kWh	All usage at 6.05¢ per kWh	(R)

Minimum
The Capacity Charge but not less than the applicable Customer Charge.

BILLING CAPACITY

Customer's average kilowatt load during the fifteen-minute period of maximum use during the month.

Power Factor Adjustment – If the power factor for the month (determined at the Company's option by permanent measurement or by a test of not less than fifteen-minute duration under conditions which the Company determines to be normal) is less than eighty-five percent at the point of delivery, the Billing Capacity will be increased by multiplying the eighty-five percent and dividing the power factor expressed in percent. The power factor is defined to be the quotient obtained by dividing the kilowatt-hours used during the month by the square root of the sum of the squares of the kilowatts used and the lagging reactive kilovolt-ampere-hours supplied during the same period. Any leading kilovolt-ampere-hours supplied during the period will not be considered.

MUNICIPAL PUMPING

ENERGY COST ADJUSTMENT

The above schedule of charges shall be adjusted in accordance with: (D)

1. The Fuel and Purchased Power Adjustment tariff. (N)
2. The Transmission Cost Adjustment tariff. (D)

When the billing period includes a change in the charges of an above referenced Energy Cost Adjustment tariff, the customer's bill shall be prorated accordingly.

PAYMENT

Net monthly bills are due and payable twenty days from the date of the bill, and after that date the account becomes delinquent. A late payment charge of 1.5% on the current unpaid balance shall be calculated and included as part of each monthly billing. A non-sufficient funds charge of $15.00 shall apply to process a payment from a customer that is returned to the Company by the bank as not payable. If a bill is not paid, the Company shall have the right to suspend service, providing ten (10) days written notice of such suspension has been given. When service is suspended for nonpayment of a bill, a Customer Service Charge will apply.

TERMS AND CONDITIONS

1. This schedule is predicated on continuous service of twelve months per year. If the customer desires only seasonal service, such service will be provided under the Company's applicable General Service schedule.
2. This schedule is not applicable for the pumping of water from streams, ponds, or lakes and applied directly to public parks and grounds for irrigation purposes or for other similar projects.
3. The Summer Rate shall apply to usage between June 1 through October 31. The Winter Rate shall apply to usage between November 1 through May 31. The Company reserves the right to modify the months applicable to the summer-winter billing periods.
4. Service will be rendered under the Company's General Rules and Regulations.

TAX ADJUSTMENT

Bills computed under the above rate shall be adjusted by the applicable proportionate part of any impost, assessment or charge imposed or levied by any governmental authority as a result of laws or ordinances enacted, which is assessed or levied on the basis of revenue for electric energy or service sold, and/or the volume of energy generated and sold.

ENERGY STORAGE SERVICE

AVAILABLE

To customers installing certain energy efficient electrical equipment that will increase off-peak electrical use and reduce the Company's On-Peak demand, at points on the Company's existing secondary distribution lines supplied by its interconnected transmission system. The rate has been developed as part of the Company's Demand-Side Management strategy.

APPLICABLE

At the customer's election, to General Service customers who operate Company approved energy storage facilities for the purpose of utilizing off-peak electric energy for space conditioning, water heating, battery charging, water pumping, and/or snowmaking. Electric energy will be supplied through a separately metered circuit utilizing the same transformer and service used to serve the balance of the customer's electrical load.

CHARACTER OF SERVICE

Alternating current, 60 hertz, at the voltage and phase of the Company's established distribution system most available to the location of the customer. Energy Storage Service will be provided on a Time-Of-Use schedule for qualified Partial Storage and Geothermal systems. The number of off-peak hours available will amount to eight hours each day during the winter season, twelve hours each day during the summer season, and 24 hours a day on weekends and major holidays during both summer and winter seasons.

NET MONTHLY BILL

Rate

Customer Charge
$11.50 per month (R)

Energy Charge
Off-Peak: 3.20¢ per kWh (R)
On-Peak: 5.15¢ per kWh (R)

Capacity Charge
Off-Peak: no charge (R)
On-Peak: $7.68 per kW of Billing Capacity (R)

Minimum
The Customer Charge

ENERGY STORAGE SERVICE

BILLING CAPACITY

Customer's average kilowatt load during the fifteen minute period of maximum On-Peak use during the month.

Power Factor Adjustment – If the power factor for the month (determined at the Company's option by permanent measurement or by a test of not less than fifteen minute duration under conditions which the Company determines to be normal) is less than eighty-five percent (85%) at the point of delivery, the Billing Capacity will be increased by multiplying by eighty five percent (85%) and dividing by the power factor expressed in percent. Power factor is defined to be the quotient obtained by dividing the kilowatt-hours used during the month by the square root of the sum of the squares of the kilowatt-hours used and the lagging reactive kilovolt-ampere-hours supplied during the same period. Any leading kilovolt-ampere-hours supplied during the period will not be considered.

Penalty for Non-compliance (T)

If a Partial Storage customer exceeds their partial storage Limit (expressed in kW) during peak time periods, a penalty of five (5) times the Capacity Charge per kW will be assessed for the difference in kW that the maximum billing capacity exceeds the partial storage limit. The partial storage limit will be determined using design day load profiles from standard industry load calculation methods. A conversion factor of 0.75 kW per ton will be used for Cool Storage applications.

ENERGY COST ADJUSTMENT

The above schedule of charges shall be adjusted in accordance with: (D)

1. The Fuel and Purchased Power Adjustment tariff. (N)
2. The Transmission Cost Adjustment tariff. (D)

When the billing period includes a change in the charges of an above referenced Energy Cost Adjustment tariff, the customer's bill shall be prorated accordingly.

PAYMENT

Net monthly bills are due and payable twenty days from the date of the bill, and after that date the account becomes delinquent. A late payment charge of 1.5% on the current unpaid balance shall be calculated and included as part of each monthly billing. A non-sufficient funds charge of $15.00 shall apply to process a payment from a customer that is returned to the Company by the bank as not payable. If a bill is not paid, the Company shall have the right to suspend service, providing ten (10) days written notice of such suspension has been given. When service is suspended for nonpayment of a bill, a Customer Service Charge will apply.

ENERGY STORAGE SERVICE

TERMS AND CONDITIONS

1. Service will be rendered under the Company's General Rules and Regulations where not inconsistent with any specific provisions of this rate schedule or the service contract.

2. Service will be provided under this rate schedule only to customers who have contracted for service for an initial term of not less than three years. The contract may be terminated at any time on or after the expiration date of the initial term by twelve months written notice.

3. The Company will supply and maintain Time-of-Use metering to provide Off-Peak energy to Full Storage systems and to provide On-Peak and Off-Peak energy for Partial Storage and Geothermal systems.

4. The Company shall have the right to inspect all wiring and equipment connected to the storage circuit. In the event the Company finds that the customer's wiring has been altered or arranged in any manner so that energy is used in any equipment other than Company approved energy storage facilities, the contract for service under this rate schedule may be terminated.

5. The Company may, at its option, install in the energy storage circuit load limiting devices to limit the total load to be served through the energy storage circuit.

6. Off-Peak Hours:

Summer Months	(April 1 – October 31) 10:00 p.m. – 10:00 a.m.	Monday through Friday
Winter Months	(November 1 – March 31) 11:00 p.m. – 7:00 a.m.	Monday through Friday
Both Seasons	Saturdays, Sundays, and major holidays are considered Off-Peak.	

The hours may be shifted one (1) hour in accordance with the recognized Daylight Savings Time (DST) in the local area and customers will be notified prior to such change.

ENERGY STORAGE SERVICE

7. MEANS OF CONTROL:

On Full Storage and Partial Storage systems, Company will install time of use metering to monitor on-peak demand limits. If the On-Peak limit is exceeded the Penalty for Non-Compliance will be assessed.

8. QUALIFIED SYSTEMS:

A. Full Storage – Available to heating, water heating, cooling, battery storage and water pumping applications that are able to store energy during Off-Peak periods for use during On-Peak periods.

B. Partial storage – Cooling – Partial storage equipment size must be at least 25% less than conventional equipment size during On-Peak time periods. Chiller equipment, cooling tower pumps and fans, and cool water circulating pumps qualify for the rate. Air handling equipment and hot water circulating pumps do not qualify. A penalty for non-compliance will be assessed if the partial storage limit is exceeded.

C. Partial Storage – Heating and Water Heating – Electric heating and water heating equipment used with Off-Peak storage capability and a heat storage medium (sand, bricks, liquid, etc.) qualify for partial storage when used in the applications listed below. A penalty for non-compliance will be assessed if the partial storage limit is exceeded.
   1. An Electric Boiler used in combination with water loop heat pumps qualifies for Partial Storage. The Electric Boiler size must be 25% less than conventional equipment during On-Peak periods. Water-loop heat pumps, air handling equipment, and circulating pumps do not qualify.
   2. Resistance Heat and Water Heating qualify for Partial Storage when no more than 50% of the system capacity is allowed to operate during On-Peak periods.

D. Geothermal Applications – Geothermal heat pumps, associated air handling equipment and circulating pumps qualify for the rate. Supplementary resistance heat associated with each heat pump or supplementary electric boiler heat associated with the geothermal system also qualify for the rate.

ENERGY STORAGE SERVICE

8. QUALIFIED SYSTEMS: (*continued*)

   E. Partial Storage – Snowmaking – Partial storage equipment size must be at least 50% less than conventional equipment during On-Peak time periods. Primary snowmaking equipment eligible for the rate includes air compressors and water pumps.

9. DESIGN REVIEW:

   Detailed design information must accompany each Energy Storage Application including:

   A. A 24-hour design day cooling, heating, water pumping, and/or snowmaking load profile using standard industry load calculation methods.

   B. A system description with operating strategy. The Demand-Side Management Department shall review and approve the Energy Storage Application and proposed contract.

TAX ADJUSTMENT

Bills computed under the above rate shall be adjusted by the applicable proportionate part of any impost, assessment, or charge imposed or levied by any governmental authority as a result of laws or ordinances enacted, which is assessed or levied on the basis of revenue for electric energy or service sold, and/or the volume of energy generated and sold.

CLASS OF SERVICE: General Service - Commercial Rate No. C

APPLICABILITY:
Applicable to all commercial, industrial, school, and public uses that are billed on a monthly basis.

CHARACTER OF SERVICE:
Alternating current 60 cycle Hertz, volt single and three phase, available in voltages we normally provide.

RATE PER MONTH

A. Customer Charge:
1. Commercial, Industrial, Schools, and Public Uses
   $11.00 per month for single phase with transformer capacity of 50 KVA or less (rate class 40).

   $18.00 per month for three phase with transformer capacity of 50 KVA or less (rate class 41).

   $36.00 per month for service with over 50 KVA of transformer capacity to 250 KVA transformer capacity (rate class 50 & 66).

B. ENERGY CHARGE:

First	650 KWH @	$0.1050 /kWh
Next	9,350 KWH @	$0.0820/ kWh
Next	30,000 KWH @	$0.0650/ kWh
All over	40,000 KWH @	$0.0520/ kWh

C. DEMAND CHARGE:

First 25 KW of measured demand per month: no charge
All KW over 25 at $ 8.50 per KW

Minimum Monthly Charge:

Minimum monthly charge shall be the customer charge.

SPECIAL CONDITIONS:

1. The consumer assumes all responsibility on his side of the delivery point. The Association will make reasonable effort to provide good quality service but does not guarantee service against irregularities or interruption.

2. Where the Association is required to expand its distribution facilities, it may increase the monthly customer charge to the extent necessary to assure the Association adequate compensation for the added facilities. Where transformer capacity requested is more than 50% above actual peak KW load, the customer charge may be increased to provide a reasonable return on investment.

3. Approval of the Association must be obtained prior to installation of any motor having a rated capacity of five (5) horsepower or more.

4. If service is provided where load is seasonal or intermittent and usage will not reasonably cover power cost plus fixed cost, the minimum charge will be due for 12 months. This service is available only on a permanent, year-round basis, and is not available on a seasonal or intermittent basis.

5. Where new construction is required the extension policy of the Association shall apply.

6. Determination of Billing Demand: The billing demand shall be the maximum average kilowatt load used by the consumer for any period of the fifteen consecutive minutes during the month for which the bill is rendered, as indicated or recorded by a demand meter.

7. Power Factor: The consumer agrees to maintain unity power factor as nearly as practicable. The Association reserves the right to measure such power factor at any time. Should such measurements indicate that the power factor is less than 90%, the demand for billing purposes shall be the demand as indicated or recorded by the demand meter multiplied by 90% and divided by the present power factor.

ADJUSTMENTS

A. Taxes - The above rate may be increased or decreased by 0.1 mill per kilowatt-hour for each 0.1 mill or major fraction thereof by which the Seller's total taxes per kilowatt-hour sold for the preceding calendar year exceeds or is less than 0.5 mills power kilowatt-hour

B. Power Cost Adjustment: The Power Cost Adjustment (PCA) charge shall provide for an energy rate adder to all rate classes equal to the difference between the

budgeted wholesale power cost per KWH established by Rushmore Electric Power Cooperative for the next 12 months and the Rushmore Electric wholesale power rate per KWH purchased by the Cooperative for the base year. The PCA charge shall be calculated at the end of each year and effective for the next 12 months. The base year for calculation shall be December 2009

ISSUED BY_____ EFFECTIVE DATE: January 1, 2009
President

New: November 1, 2006
Date Revised: 11-17-2008

CLASS OF SERVICE: Storage Time of Day Rate No. 35

APPLICABILITY:

Applicable to all commercial and industrial and public uses where demand exceed 25 KW.

CHARACTER OF SERVICE:

Alternating current 60 cycle Hertz, single and three phase available in voltages we normally provide.

RATE PER MONTH: Rate Class 35

A. Customer Charge:
$36.00 for First 25 kVA capacity plus $0.60 per kVA for over 25

B. Energy Charge:
Off Peak: 10:30 PM to 6:30 AM Rate Class 352
All kWh @ $0.0440 /kWh
On Peak: 6:30 AM to 10:30 PM Rate Class 35
650 kWh @ $0.1290 /kWh
9,350 kWh @ $0.1010 /kWh
30,000 kWh @ $0.0930 /kWh
Excess kWh @ $0.0780 /kWh

C. Demand Charge: (Applies to on peak only)
First 25 kW: No charge
Over 25 kW: All @ $9.25 per kW

MINIMUM MONTHLY CHARGE:

Minimum monthly charge shall be the customer charge.

SPECIAL CONDITIONS:

1. Load served from a service under the schedule cannot be transferred to another service under a different rate schedule during the hours of 6:30 AM to 10:30 PM.

2. The consumer assumes all responsibility on his side of the delivery point. The Association will make reasonable effort to provide good quality service but does not guarantee service against irregularities or interruption.

3. Approval of the Association must be obtained prior to the installation of any motor having a rated capacity of five (5) horsepower or more on single or three phase service, and will be governed by Policy 20-16.

4. Where the Association is required to expand its distribution facilities, it may increase the monthly customer charge to the extent necessary to assure the Association adequate compensation for the added facilities.

5. This service is available only on a permanent, year-round basis, and is not available on a seasonal or intermittent basis.

6. Power Factor: The consumer agrees to maintain unity power factor as nearly as practicable. The Association reserves the right to measure such power factor at any time. Should such measurements indicate that the power factor is less than 90% the demand for billing purposes shall be the demand as indicated or recorded by the demand meter multiplied by 90% and divided by the present power factor.

ADJUSTMENTS

A. Taxes - The above rate may be increased or decreased by 0.1 mill per kilowatthour for each 0.1 mill or major fraction thereof by which the Seller's total taxes per kilowatthour sold for the preceding calendar year exceeds or is less than 0.5 mills power kilowatthour.

B. Power Cost Adjustment: The Power Cost Adjustment (PCA) charge shall provide for an energy rate adder to all rate classes equal to the difference between the budgeted wholesale power cost per KWH established by Rushmore Electric Power Cooperative for the next 12 months and the Rushmore Electric wholesale power rate per kWh purchased by the Cooperative for the base year. The PCA charge shall be calculated at the end of each year and effective for the next 12 months. The base year for calculation shall be December 2009.

ISSUED BY_____ EFFECTIVE DATE January 1, 2010
President

Revised: New rates 11-1-2006
Revised: 11-17-2008
Revised: 1-1-2010

Appendix B – Example ECM Calculations

Computed:	CLR	**Date:**	8/6/2010	**HDR Job No:**	119142
Checked:		**Date:**			
Project:	SD DENR Energy Audits - Spearfish				

HDR Computation

ECM No. 01

Subject: Energy Savings and Cost Analysis

ECM Type: Operational

Task: Switch Nevin Well to Energy Storage Rate

Existing Condition:

Nevin well is operated on municipal pumping rate. Demand charges are assessed for operating the well on this rate schedule.

Proposed Change:

Switch to the energy storage rate. Demand charges are not assessed during times of off-peak usage.

Energy Savings:

There are no energy savings for this ECM. Cost savings is realized by avoiding demand charges.

Condition	Municipal Pumping 2009	Energy Storage
Annual Production	212 MG	212 MG
Energy Use	216,900 kWh	216,900 kWh
Billed Capacity	169 kW	0 kW

Energy: Existing Condition

Energy Cost = energy use * energy charge
= 216,900 kWh * $0.0605/kWh
= $13,120

Capacity Cost = kW input * capacity charge * 12 months
= 169 kW * $4.31/kW * 12 months
= $8,740

Energy Storage Rate

Energy Cost = energy use * energy charge
= 216,900 kWh * $0.032/kWh
= $6,940

Capacity Cost = No Charge

Savings: Energy Cost = $13,120 - $6,940
= $6,180

Capacity Cost = $8,740 - $0

= $8,740

Total Savings = $6,180 + $8,740
= $14,920

Capital Cost:

Generator $65,000

Simple Payback: = $65,000 / $14,920
= 4.4 years

Recommended: **YES** (< 5 yrs)

Comments:
This is basic calculation of cost savings. Annual run times were assumed to be the same for both scenarios. To increase savings the Nevin well should be ran as much as possible during off peak hours. Additional savings would be realized be reducing the run times of the other wells.

Computed:	CLR	**Date:**	8/6/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - Spearfish

HDR Computation

ECM No. 02

Subject: Energy Savings and Cost Analysis

ECM Type: Physical

Task: Reduce Water Loss to 10%

Existing Condition:

Existing water loss is approximately 32%

Proposed Change:

Reduce water loss to 10%

Energy Savings:

Condition	Current Loss	10% Loss
Water Loss	32%	10%

Energy: Current Water Loss 32%

Yearly Energy Use = 1,871,000 kW-hr / yr

Recommended 10% Water Loss

Yearly Energy Use = Current Energy Use * (1 - percent improvement)

= 1,871,000 * (1 - 0.22)

= 1,459,380 kW-hr / yr

Savings: kW-hr / yr = 1,871,000 - 1,459,380

= 411,620 kW-hr / yr

$ / yr = $0.0605 / kW-hr x 411,620 kW-hr / yr

= $24,900 / yr

Capital Cost:

Reduce Water Loss None - funded by existing O&M budget.

Simple Payback:

= NA

= NA

Recommended:

YES

Comments:

A water audit and distribution system leak detection should be performed. A water audit will help identify any apparent losses that may be occuring due to items such as inaccurate meters or accounting errors. A distribution leak detection program could be performed on the entire distribution system. The potential savings justify making a significant effort to find and eliminate water loss.

Computed:	CLR	**Date:**	8/6/2010	**HDR Job No:**	119142
Checked:		**Date:**			
Project:	SD DENR Energy Audits - Spearfish				

HDR Computation

ECM No. 03

Subject: Energy Savings and Cost Analysis

ECM Type: Physical

Task: Install Varible Frequency Drives on Pump Motors

Existing Condition:

None of the well pumps currently have VFDs installed.

Proposed Change:

Install VFDs on the 4 primary wells - Nevin, Dickey, College, and Vigna

Energy Savings:

Cost savings will be realized by gaining the ability to operate motors at reduced speeds. Reduced speed operation would be able to meet demands during winter months and would reduce demand charges. Cost savings were determined for operating wells at 60% speed from October 1st to March 31st.

Condition	Average kW Demand	kW Reduction @ 60%	Montly Savings @ $4.08 / kW	Yearly Savings
Nevin	89.6	35.8	$146	$876
College	76.7	30.7	$125	$750
Dickey	73.9	30.0	$122	$732
Vigna	131.7	52.7	$215	$1,290
Total		149.2	$608	$3,648

Capital Cost:

VFDs	Nevin	$20,000
	College	$10,000
	Dickey	$15,000
	Vigna	$15,000
	Total	$60,000

Simple Payback: = $60,000 / $3,648
= 16.4

Recommended: **NO** (>5 yrs)

Comments:

Reduced demand charges do not provide the necessary savings for a payoff of 5 years. VFDs also reduce overall efficiency by approximately 4%. Increased energy use would be offset in this situation by eliminating the start-to-waste cycles.

Computed:	CLR	**Date:**	8/6/2010	**HDR Job No:**	119142
Checked:		**Date:**			
Project:	SD DENR Energy Audits - Spearfish				

HDR Computation

ECM No. 04

Subject: Energy Savings and Cost Analysis

ECM Type: Operational

Task: Prioritize Wells to Operate Most Efficient Wells First

Existing Condition:

Wells have varying specific energy requirements.

Proposed Change:

Operate wells with the least specific energy requirements more often.

Energy Savings:

Energy savings were calculated based on pumping records from June through August of 2009 for the Kyte and Dickey wells.

Condition	Production 6/09 - 8/09	Specific Energy
Kyte Well	65 MG	3,261 kWh/MG
Dickey Well	0 MG	1,669 kWh/MG

Savings: 1,871,000 - 1,459,380

Specific Energy Reduction = 3,261 - 1,669

= 1,592 kWh / MG

Energy Savings = 1,592 kWh/MG x 65 MG

= 103,480 kWh

Cost Savings = $0.0605 / kW-hr x 103,480 kW-hr

= $6,260

Capital Cost:

Operational Change $0

Simple Payback:

=

=

Recommended:

YES (<5 yrs)

Comments:

Cost savings were determined based on a specific example from 2009 pumping records. This ECM is an excellent example of how a simple operational change can provide cost savings to the water system.

Computed:	CLR	**Date:**	8/2/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - Clark Rural Water

HDR Computation

ECM No. 01

Subject: Energy Savings and Cost Analysis

ECM Type: Operational

Task: Switch Main Plant, Well Field, and Kampeska Plant to Load Control

Existing Condition:

Generators and switch gear are in place.

Proposed Change:

Standby power will be used during periods of load control.

Energy Savings:

This is a cost saving ECM. No energy savings will be achieved.

	Savings	Expenses
Main Plant	$16,190	$5,262
Well Field	$6,059	$2,586
Kampeska Plant	$5,181	$2,319
Total	$27,430	$10,167

Savings: $ / yr = Savings - Expenses
= $27,430 - $10,167
= $17,263

Capital Cost:

None NA

Simple Payback:

= NA
= NA

Recommended:

YES (< 5 yrs)

Comments:

Complete cost savings calculations are provided in Appendix C.

Codington-Clark
Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

Clark RWS - Main Plant

July 2009 to June 2010

Load Control Summary

Non-Controlled Months:	**5**
Controlled Months:	**7**
Minimum Control Time:	**1:22**
Maximum Control Time:	**11:04**
Average Control Time:	**4:21**
Total Hours of Control:	**222:42**
Total Control Events:	**61**

Off-Peak Rate Savings Before Expenses: **$16,190.59**

Estimated Generator Operation and Maintenance:

Operating Costs for Load Control **-$5,261.89**

Off-Peak Rate Savings After Expenses: **$10,928.69**

Codington-Clark Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

LM Savings Calculations

Clark RWS - Main Plant

July 2009 to June 2010

Current Rate, Generator Activated for Load Control

Rate	Usage			Charges			Itemized Detail						
LPG	**Demand**		**Energy**	**Demand**		**Energy**	**Demand**	**Energy**	**Facility**	**Tax**	**Total**	**$/kW**	**L. F.**
Large Power Service With Auto-start Generator	Non-Coincident kW	Max During Control kW	Total kWh Usage	Non-Co-Incident	Max During Control	All Energy	Demand Cost	Energy Cost	Facility Charge	Sales Tax	Total Charges	Total Cost per kWh	Monthly Load Factor
				$0.00	**$13.10**	**$0.054**			**$50.00**	**4%**			
				$0.00	**$13.30**	**$0.063**			**$50.00**				
				per kW	per kW	per kWh						(Pre Tax)	
January 2010	112		56,189	$0.00		$3,034.21	$0.00	$3,034.21	$50.00	$123.37	$3,207.57	$0.05489	68%
February 2010	110		55,622	$0.00		$3,003.59	$0.00	$3,003.59	$50.00	$122.14	$3,175.73	$0.05490	75%
March 2010	96		52,638	$0.00		$2,842.45	$0.00	$2,842.45	$50.00	$115.70	$3,008.15	$0.05495	74%
April 2010	102		54,911	$0.00		$3,459.39	$0.00	$3,459.39	$50.00	$140.38	$3,649.77	$0.06391	75%
May 2010	111		50,740	$0.00		$3,196.62	$0.00	$3,196.62	$50.00	$129.86	$3,376.48	$0.06399	62%
June 2010	109		52,414	$0.00		$3,302.08	$0.00	$3,302.08	$50.00	$134.08	$3,486.17	$0.06395	67%
July 2009	102		53,967	$0.00		$2,914.22	$0.00	$2,914.22	$50.00	$118.57	$3,082.79	$0.05493	71%
August 2009	87		47,912	$0.00		$2,587.25	$0.00	$2,587.25	$50.00	$105.49	$2,742.74	$0.05504	74%
September 2009	91		46,939	$0.00		$2,534.71	$0.00	$2,534.71	$50.00	$103.39	$2,688.09	$0.05507	72%
October 2009	93		51,116	$0.00		$2,760.26	$0.00	$2,760.26	$50.00	$112.41	$2,922.67	$0.05498	74%
November 2009	89		47,963	$0.00		$2,590.00	$0.00	$2,590.00	$50.00	$105.60	$2,745.60	$0.05504	75%
December 2009	109		68,347	$0.00		$3,690.74	$0.00	$3,690.74	$50.00	$149.63	$3,890.37	$0.05473	84%
Totals	1,212		638,758	$0.00		$35,915.52	$0.00	$35,915.52	$600.00	$1,460.62	$37,976.14	$0.05717	72%

For Comparison, No Generator Activation

Rate	Usage			Charges			Itemized Detail						
LP	**Demand**		**Energy**	**Demand**		**Energy**	**Demand**	**Energy**	**Facility**	**Tax**	**Total**	**$/kW**	
Large Power Service	Non-Coincident kW		Total kWh Usage	Non-Co-Incident		All Energy	Demand Cost	Energy Cost	Facility Charge	Sales Tax	Total Charges	Total Cost per kWh	**Load Control Savings**
				$13.10		**$0.050**			**$50.00**	**4%**			
				$13.30		**$0.062**			**$50.00**				
				per kW		per kWh						(Pre Tax)	
January 2010	112		57,878	$1,465.37		$2,893.89	$1,465.37	$2,893.89	$50.00	$176.37	$4,585.63	$0.07618	**$1,378.05**
February 2010	110		58,622	$1,439.04		$2,931.08	$1,439.04	$2,931.08	$50.00	$176.80	$4,596.92	$0.07540	**$1,421.19**
March 2010	96		52,638	$1,256.42		$2,631.90	$1,256.42	$2,631.90	$50.00	$157.53	$4,095.85	$0.07482	**$1,087.70**
April 2010	102		54,911	$1,360.99		$3,404.48	$1,340.52	$3,404.48	$50.00	$191.80	$4,986.81	$0.08732	**$1,337.04**
May 2010	111		50,740	$1,473.77		$3,145.88	$1,451.61	$3,145.88	$50.00	$185.90	$4,833.39	$0.09159	**$1,456.91**
June 2010	109		54,602	$1,447.71		$3,385.34	$1,425.94	$3,385.34	$50.00	$194.45	$5,055.72	$0.08903	**$1,569.56**
July 2009	102		54,373	$1,342.62		$2,718.63	$1,342.62	$2,718.63	$50.00	$164.45	$4,275.70	$0.07561	**$1,192.91**
August 2009	87		50,771	$1,144.68		$2,538.53	$1,144.68	$2,538.53	$50.00	$149.33	$3,882.54	$0.07353	**$1,139.80**
September 2009	91		46,939	$1,190.27		$2,346.95	$1,190.27	$2,346.95	$50.00	$143.49	$3,730.70	$0.07642	**$1,042.61**
October 2009	93		51,116	$1,220.53		$2,555.80	$1,220.53	$2,555.80	$50.00	$153.05	$3,979.38	$0.07486	**$1,056.71**
November 2009	89		51,069	$1,169.31		$2,553.44	$1,169.31	$2,553.44	$50.00	$150.91	$3,923.66	$0.07388	**$1,178.05**
December 2009	109		72,907	$1,429.73		$3,645.35	$1,429.73	$3,645.35	$50.00	$205.00	$5,330.08	$0.07030	**$1,439.72**
Totals	1,212		656,565	$15,940.42		$34,751.27	$15,876.02	$34,751.27	$600.00	$2,049.09	$53,276.39	$0.07802	**$15,300.25**

Codington-Clark Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

Net LM Savings Calculations

Clark RWS - Main Plant

July 2009 to June 2010

Current Rate, Generator Activated for Load Control													
Generator Size in kW:		250		Generator Operating Costs						Estimate of Reduced kWh Purchases from Electric Co-op Due to Load Management			
Electrical Rate	Gross $	Run Time	Controls	Fuel			Maintenance	Total	Gen $/kWh				Net $
LPG				Usage	Price	Total	Maintenance Interval In Hours:	Operation & Maintenance Cost			Total Hours In the Year:	8760:00	
	Gross	Generator Run Time for Load Control		Total for Load Control @	Price Per Gallon For Diesel Fuel	Fuel Costs Due To Load Control	250	$23.63	Estimated Average Cost for Energy Produced On Site per kWh	Average Hourly Usage from Electric Co-op kW	Total Hours on Central:	8537:17	Net
Uncontrolled							Maintenance Cost In Dollars:	per Hour of Control			Total Hours on Generator:	222:42	
5	Load Control Savings		Load Control Periods	9			$500.00	Total O&M $ per Month			Percentage on Generator:	2.5%	Load Control Savings
Controlled				Gallons Per Hour			Maintenance $: per Month				Average Hourly Usage in kWhs:	75	
7		hrs:min									Expense Reduction per kWh @:	$0.050	
											Estimated kWhs and Expense Reduction Provided By Generator Due To LM:		
January 2010	$1,378.05	21:42	4	195	$2.54	$496.27	$63.63	$559.90	$0.33154	78	1,689	$84.44	$902.59
February 2010	$1,421.19	34:23	12	309	$2.37	$733.44	$63.63	$797.08	$0.26573	87	3,000	$149.98	$774.09
March 2010	$1,087.70									71			$1,087.70
April 2010	$1,337.04									76			$1,337.04
May 2010	$1,456.91									68			$1,456.91
June 2010	$1,569.56	28:51	6	260	$2.51	$651.83	$63.63	$715.46	$0.32696	76	2,188	$109.41	$963.51
July 2009	$1,192.91	5:33	2	50	$1.99	$99.41	$63.63	$163.04	$0.40194	73	406	$20.28	$1,050.15
August 2009	$1,139.80	41:53	6	377	$2.26	$852.08	$63.63	$915.71	$0.32032	68	2,859	$142.93	$367.03
September 2009	$1,042.61									65			$1,042.61
October 2009	$1,056.71									69			$1,056.71
November 2009	$1,178.05	43:47	16	394	$2.44	$961.57	$63.63	$1,025.21	$0.33009	71	3,106	$155.29	$308.14
December 2009	$1,439.72	46:31	15	419	$2.44	$1,021.87	$63.63	$1,085.50	$0.23805	98	4,560	$228.00	$582.21
Totals	$15,300.25	222:42	61	2,004	$2.36	$4,816.47	$445.42	$5,261.89	$0.31638	75	17,807	$890.34	$10,928.69

Codington-Clark
Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

Clark RWS -Well Field

July 2009 to June 2010

Load Control Summary

Non-Controlled Months:	**5**
Controlled Months:	**7**
Minimum Control Time:	**1:22**
Maximum Control Time:	**11:04**
Average Control Time:	**4:21**
Total Hours of Control:	**222:42**
Total Control Events:	**61**

Off-Peak Rate Savings Before Expenses: **$5,181.47**

Estimated Generator Operation and Maintenance:

Operating Costs for Load Control **-$2,318.50**

Off-Peak Rate Savings After Expenses: **$2,862.98**

Codington-Clark Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

LM Savings Calculations

Clark RWS -Well Field

July 2009 to June 2010

Current Rate, Generator Activated for Load Control

Rate	Usage			Charges			Itemized Detail						
LPG	**Demand**		**Energy**	**Demand**		**Energy**	**Demand**	**Energy**	**Facility**	**Tax**	**Total**	**$/kW**	**L. F.**
Large Power Service With Auto-start Generator	Non-Coincident kW	Max During Control kW	Total kWh Usage	Non-Co-Incident	Max During Control	All Energy	Demand Cost	Energy Cost	Facility Charge	Sales Tax	Total Charges	Total Cost per kWh	Monthly Load Factor
				$0.00	**$13.10**	**$0.054**			**$50.00**	**4%**			
				$0.00	**$13.30**	**$0.063**			**$50.00**				
				per kW	per kW	per kWh						(Pre Tax)	
January 2010	36		10,821	$0.00		$584.33	$0.00	$584.33	$50.00	$25.37	$659.71	$0.05862	40%
February 2010	23		10,089	$0.00		$544.81	$0.00	$544.81	$50.00	$23.79	$618.60	$0.05896	66%
March 2010	36		8,434	$0.00		$455.44	$0.00	$455.44	$50.00	$20.22	$525.65	$0.05993	31%
April 2010	49		10,177	$0.00		$641.15	$0.00	$641.15	$50.00	$27.65	$718.80	$0.06791	29%
May 2010	28		9,641	$0.00		$607.38	$0.00	$607.38	$50.00	$26.30	$683.68	$0.06819	47%
June 2010	28		8,861	$0.00		$558.24	$0.00	$558.24	$50.00	$24.33	$632.57	$0.06864	44%
July 2009	28		9,403	$0.00		$507.76	$0.00	$507.76	$50.00	$22.31	$580.07	$0.05932	45%
August 2009	28		8,201	$0.00		$442.85	$0.00	$442.85	$50.00	$19.71	$512.57	$0.06010	39%
September 2009	36		8,437	$0.00		$455.60	$0.00	$455.60	$50.00	$20.22	$525.82	$0.05993	33%
October 2009	32		7,643	$0.00		$412.72	$0.00	$412.72	$50.00	$18.51	$481.23	$0.06054	32%
November 2009	28		6,133	$0.00		$331.18	$0.00	$331.18	$50.00	$15.25	$396.43	$0.06215	31%
December 2009	33		11,866	$0.00		$640.76	$0.00	$640.76	$50.00	$27.63	$718.39	$0.05821	48%
Totals	385		109,706	$0.00		$6,182.24	$0.00	$6,182.24	$600.00	$271.29	$7,053.52	$0.06182	40%

For Comparison, No Generator Activation

Rate	Usage			Charges			Itemized Detail						
LP	**Demand**		**Energy**	**Demand**		**Energy**	**Demand**	**Energy**	**Facility**	**Tax**	**Total**	**$/kW**	
Large Power Service	Non-Coincident kW		Total kWh Usage	Non-Co-Incident		All Energy	Demand Cost	Energy Cost	Facility Charge	Sales Tax	Total Charges	Total Cost per kWh	**Load Control Savings**
				$13.10		**$0.050**			**$50.00**	**4%**			
				$13.30		**$0.062**			**$50.00**				
				per kW		per kWh						(Pre Tax)	
January 2010	36		11,146	$476.19		$557.31	$476.19	$557.31	$50.00	$43.34	$1,126.84	$0.09721	**$467.13**
February 2010	23		10,633	$296.45		$531.65	$296.45	$531.65	$50.00	$35.12	$913.23	$0.08258	**$294.63**
March 2010	36		8,434	$471.47		$421.70	$471.47	$421.70	$50.00	$37.73	$980.90	$0.11183	**$455.24**
April 2010	49		10,177	$649.44		$630.97	$639.67	$630.97	$50.00	$52.83	$1,373.47	$0.12977	**$654.68**
May 2010	28		9,641	$369.08		$597.74	$363.53	$597.74	$50.00	$40.45	$1,051.72	$0.10489	**$368.04**
June 2010	28		9,231	$371.34		$572.32	$365.75	$572.32	$50.00	$39.52	$1,027.59	$0.10704	**$395.02**
July 2009	28		9,474	$367.72		$473.68	$367.72	$473.68	$50.00	$35.66	$927.06	$0.09409	**$346.98**
August 2009	28		8,690	$366.93		$434.52	$366.93	$434.52	$50.00	$34.06	$885.50	$0.09798	**$372.94**
September 2009	36		8,437	$470.29		$421.85	$470.29	$421.85	$50.00	$37.69	$979.83	$0.11167	**$454.00**
October 2009	32		7,643	$424.44		$382.15	$424.44	$382.15	$50.00	$34.26	$890.85	$0.11208	**$409.62**
November 2009	28		6,530	$362.74		$326.51	$362.74	$326.51	$50.00	$29.57	$768.82	$0.11321	**$372.39**
December 2009	33		12,658	$432.30		$632.88	$432.30	$632.88	$50.00	$44.61	$1,159.79	$0.08810	**$441.40**
Totals	385		112,694	$5,058.37		$5,983.29	$5,037.47	$5,983.29	$600.00	$464.83	$12,085.59	$0.10312	**$5,032.07**

Codington-Clark Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

Net LM Savings Calculations — Clark RWS -Well Field

July 2009 to June 2010

Current Rate, Generator Activated for Load Control													
Generator Size in kW:		75		Generator Operating Costs						Estimate of Reduced kWh Purchases from Electric Co-op Due to Load Management			
Electrical Rate	Gross $	Run Time	Controls	Fuel			Maintenance	Total	Gen $/kWh				Net $
LPG				Usage	Price	Total	Maintenance Interval In Hours:	Operation & Maintenance Cost			Total Hours In the Year:	8760:00	
	Gross	Generator Run Time for Load Control		Total for Load Control @	Price Per Gallon For Diesel Fuel	Fuel Costs Due To Load Control	250	$10.41	Estimated Average Cost for Energy Produced On Site per kWh	Average Hourly Usage from Electric Co-op kW	Total Hours on Central:	8537:17	Net
Uncontrolled							Maintenance Cost In Dollars:	per Hour of Control			Total Hours on Generator:	222:42	
5	Load Control Savings		Load Control Periods	3.5			$500.00	Total O&M $ per Month			Percentage on Generator:	2.5%	Load Control Savings
Controlled				Gallons Per Hour			Maintenance $: per Month				Average Hourly Usage in kWhs:	13	
7		hrs:min									Expense Reduction per kWh @:	$0.050	
											Estimated kWhs and Expense Reduction Provided By Generator Due To LM:		
January 2010	$467.13	21:42	4	76	$2.54	$192.99	$63.63	$256.63	$0.78905	15	325	$16.26	$226.76
February 2010	$294.63	34:23	12	120	$2.37	$285.23	$63.63	$348.86	$0.64119	16	544	$27.20	-$27.02
March 2010	$455.24									11			$455.24
April 2010	$654.68									14			$654.68
May 2010	$368.04									13			$368.04
June 2010	$395.02	28:51	6	101	$2.51	$253.49	$63.63	$317.12	$0.85722	13	370	$18.50	$96.40
July 2009	$346.98	5:33	2	19	$1.99	$38.66	$63.63	$102.29	$1.44730	13	71	$3.53	$248.23
August 2009	$372.94	41:53	6	147	$2.26	$331.36	$63.63	$395.00	$0.80724	12	489	$24.47	$2.41
September 2009	$454.00									12			$454.00
October 2009	$409.62									10			$409.62
November 2009	$372.39	43:47	16	153	$2.44	$373.95	$63.63	$437.58	$1.10183	9	397	$19.86	-$45.33
December 2009	$441.40	46:31	15	163	$2.44	$397.39	$63.63	$461.02	$0.58235	17	792	$39.58	$19.96
Totals	$5,032.07	222:42	61	779	$2.36	$1,873.07	$445.42	$2,318.50	$0.88945	13	2,988	$149.40	$2,862.98

Codington-Clark
Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

Clark RWS - Kampeska Plant

July 2009 to June 2010

Load Control Summary

Non-Controlled Months:	**5**
Controlled Months:	**7**
Minimum Control Time:	**1:22**
Maximum Control Time:	**11:04**
Average Control Time:	**4:21**
Total Hours of Control:	**222:42**
Total Control Events:	**61**

Off-Peak Rate Savings Before Expenses: $6,059.44

Estimated Generator Operation and Maintenance:

Operating Costs for Load Control -$2,586.08

Off-Peak Rate Savings After Expenses: $3,473.36

Codington-Clark Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

LM Savings Calculations

Clark RWS - Kampeska Plant

July 2009 to June 2010

Current Rate, Generator Activated for Load Control

Rate	Usage			Charges			Itemized Detail						
LPG	**Demand**		**Energy**	**Demand**		**Energy**	**Demand**	**Energy**	**Facility**	**Tax**	**Total**	**$/kW**	**L. F.**
Large Power Service With Auto-start Generator	Non-Coincident kW	Max During Control kW	Total kWh Usage	Non-Co-Incident	Max During Control	All Energy	Demand Cost	Energy Cost	Facility Charge	Sales Tax	Total Charges	Total Cost per kWh	Monthly Load Factor
				$0.00	**$13.10**	**$0.054**			**$50.00**	**4%**			
				$0.00	**$13.30**	**$0.063**			**$50.00**				
				per kW	per kW	per kWh						(Pre Tax)	
January 2010	38		15,344	$0.00		$828.58	$0.00	$828.58	$50.00	$35.14	$913.72	$0.05726	54%
February 2010	38		14,811	$0.00		$799.79	$0.00	$799.79	$50.00	$33.99	$883.79	$0.05738	59%
March 2010	40		15,385	$0.00		$830.79	$0.00	$830.79	$50.00	$35.23	$916.02	$0.05725	52%
April 2010	36		16,212	$0.00		$1,021.36	$0.00	$1,021.36	$50.00	$42.85	$1,114.21	$0.06608	63%
May 2010	39		16,920	$0.00		$1,065.96	$0.00	$1,065.96	$50.00	$44.64	$1,160.60	$0.06596	59%
June 2010	32		12,945	$0.00		$815.54	$0.00	$815.54	$50.00	$34.62	$900.16	$0.06686	57%
July 2009	40		18,051	$0.00		$974.75	$0.00	$974.75	$50.00	$40.99	$1,065.74	$0.05677	60%
August 2009	39		14,885	$0.00		$803.79	$0.00	$803.79	$50.00	$34.15	$887.94	$0.05736	52%
September 2009	40		17,073	$0.00		$921.94	$0.00	$921.94	$50.00	$38.88	$1,010.82	$0.05693	59%
October 2009	40		14,612	$0.00		$789.05	$0.00	$789.05	$50.00	$33.56	$872.61	$0.05742	49%
November 2009	36		15,676	$0.00		$846.50	$0.00	$846.50	$50.00	$35.86	$932.36	$0.05719	60%
December 2009	37		17,122	$0.00		$924.59	$0.00	$924.59	$50.00	$38.98	$1,013.57	$0.05692	62%
Totals	454		189,036	$0.00		$10,622.64	$0.00	$10,622.64	$600.00	$448.91	$11,671.54	$0.05937	57%

For Comparison, No Generator Activation

Rate	Usage			Charges			Itemized Detail						
LP	**Demand**		**Energy**	**Demand**		**Energy**	**Demand**	**Energy**	**Facility**	**Tax**	**Total**	**$/kW**	
Large Power Service	Non-Coincident kW		Total kWh Usage	Non-Co-Incident		All Energy	Demand Cost	Energy Cost	Facility Charge	Sales Tax	Total Charges	Total Cost per kWh	**Load Control Savings**
				$13.10		**$0.050**			**$50.00**	**4%**			
				$13.30		**$0.062**			**$50.00**				
				per kW		per kWh						(Pre Tax)	
January 2010	38		15,805	$501.47		$790.26	$501.47	$790.26	$50.00	$53.67	$1,395.40	$0.08489	**$481.68**
February 2010	38		15,610	$491.51		$780.49	$491.51	$780.49	$50.00	$52.88	$1,374.88	$0.08469	**$491.09**
March 2010	40		15,385	$520.46		$769.25	$520.46	$769.25	$50.00	$53.59	$1,393.30	$0.08708	**$477.28**
April 2010	36		16,212	$473.88		$1,005.14	$466.75	$1,005.14	$50.00	$60.88	$1,582.77	$0.09387	**$468.56**
May 2010	39		16,920	$516.97		$1,049.04	$509.20	$1,049.04	$50.00	$64.33	$1,672.57	$0.09505	**$511.97**
June 2010	32		13,485	$423.07		$836.10	$416.71	$836.10	$50.00	$52.11	$1,354.92	$0.09661	**$454.76**
July 2009	40		18,187	$530.29		$909.33	$530.29	$909.33	$50.00	$59.58	$1,549.21	$0.08191	**$483.46**
August 2009	39		15,773	$504.48		$788.66	$504.48	$788.66	$50.00	$53.73	$1,396.86	$0.08515	**$508.92**
September 2009	40		17,073	$523.61		$853.65	$523.61	$853.65	$50.00	$57.09	$1,484.35	$0.08360	**$473.53**
October 2009	40		14,612	$520.59		$730.60	$520.59	$730.60	$50.00	$52.05	$1,353.24	$0.08905	**$480.63**
November 2009	36		16,691	$476.97		$834.55	$476.97	$834.55	$50.00	$54.46	$1,415.99	$0.08157	**$483.62**
December 2009	37		18,264	$487.19		$913.22	$487.19	$913.22	$50.00	$58.02	$1,508.42	$0.07941	**$494.85**
Totals	454		194,018	$5,970.50		$10,260.29	$5,949.23	$10,260.29	$600.00	$672.38	$17,481.90	$0.08664	**$5,810.36**

Codington-Clark Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

Net LM Savings Calculations

July 2009 to June 2010

Clark RWS - Kampeska Plant

Current Rate, Generator Activated for Load Control													
Generator Size in kW:		100		Generator Operating Costs						Estimate of Reduced kWh Purchases from Electric Co-op Due to Load Management			
Electrical Rate	Gross $	Run Time	Controls	Fuel			Maintenance	Total	Gen $/kWh				Net $
LPG				Usage	Price	Total	Maintenance Interval In Hours:	Operation & Maintenance Cost			Total Hours In the Year:	8760:00	
	Gross	Generator Run Time for Load Control		Total for Load Control @	Price Per Gallon For Diesel Fuel	Fuel Costs Due To Load Control	250	$11.61	Estimated Average Cost for Energy Produced On Site per kWh	Average Hourly Usage from Electric Co-op kW	Total Hours on Central:	8537:17	Net
Uncontrolled											Total Hours on Generator:	222:42	
5	Load Control Savings		Load Control Periods				Maintenance Cost In Dollars:	per Hour of Control			Percentage on Generator:	2.5%	Load Control Savings
Controlled				4.0			$500.00				Average Hourly Usage in kWhs:	22	
7				Gallons Per Hour			Maintenance $: per Month	Total O&M $ per Month			Expense Reduction per kWh @:	$0.050	
		hrs:min									Estimated kWhs and Expense Reduction Provided By Generator Due To LM:		
January 2010	$481.68	21:42	4	87	$2.54	$220.57	$63.63	$284.20	$0.61624	21	461	$23.06	$220.54
February 2010	$491.09	34:23	12	138	$2.37	$325.98	$63.63	$389.61	$0.48778	23	799	$39.94	$141.42
March 2010	$477.28									21			$477.28
April 2010	$468.56									23			$468.56
May 2010	$511.97									23			$511.97
June 2010	$454.76	28:51	6	115	$2.51	$289.70	$63.63	$353.33	$0.65379	19	540	$27.02	$128.45
July 2009	$483.46	5:33	2	22	$1.99	$44.18	$63.63	$107.81	$0.79462	24	136	$6.78	$382.43
August 2009	$508.92	41:53	6	168	$2.26	$378.70	$63.63	$442.33	$0.49805	21	888	$44.41	$110.99
September 2009	$473.53									24			$473.53
October 2009	$480.63									20			$480.63
November 2009	$483.62	43:47	16	175	$2.44	$427.37	$63.63	$491.00	$0.48370	23	1,015	$50.75	$43.38
December 2009	$494.85	46:31	15	186	$2.44	$454.16	$63.63	$517.79	$0.45328	25	1,142	$57.12	$34.17
Totals	$5,810.36	222:42	61	891	$2.36	$2,140.65	$445.42	$2,586.08	$0.56964	22	4,982	$249.08	$3,473.36

Computed:	CLR	**Date:**	10/6/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - Lead-Deadwood Sanitary District

HDR Computation

ECM No. 01

Subject: Energy Savings and Cost Analysis

ECM Type: Physical

Task: Install Varible Frequency Drives on Hanna Pump Motors

Existing Condition:

The motors do not currently have VFDs installed.

Proposed Change:

Install a VFD on pump motors.

Energy Savings:

Cost savings will be realized by gaining the ability to operate motors at reduced speeds. Reduced speed operation would reduce energy and demand charges. Energy savings calculated using Fuji Electric Energy Savings Estimator.

	Existing Condition	Motor with VFD
Annual Energy Use	62,376 kWh	34,470 kWh

Savings: kW-hr / yr = 62,376 - 34,470
= 27,906 kW-hr / yr

$ / yr = $0.0605 / kW-hr x 27,906 kW-hr / yr
= $1,688 / yr

Capital Cost:

VFD $10,000

Simple Payback:

= $10,000 / $1,688
= 5.9

Recommended:

CONSIDER (>5 yrs)

Comments:

Reduced energy charges do not provide the necessary savings for a payoff of 5 years. Additional savings would likely be realized by reducing capacity charges. We recommend considering this ECM. In addition to energy and capacity savings, a VFD would provide increased operational flexibility. Fuji Electric savings report is attached.

Fuji Electric
e-Front runners

Energy Savings Estimator

for Pump Applications

Project Name:	**Lead Deadwood Sanitary District**	*
Equipment Tag/ID:	**Hanna Pump Station**	*

System Data

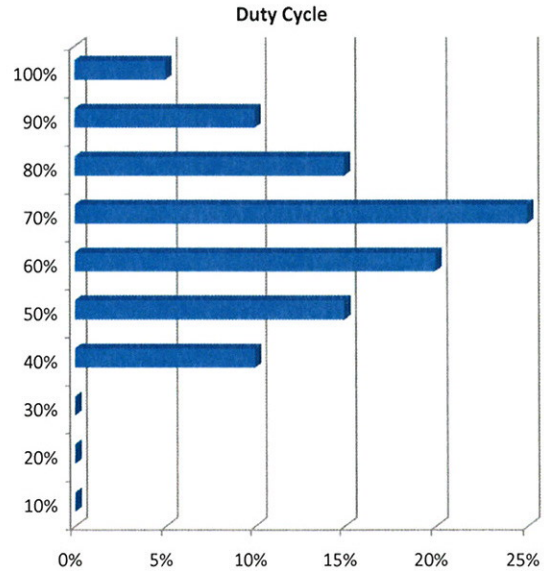
Mechanical Flow Control:	Throttle	VFD Model Number:	FRN100F1S-4U & NEMA1-75F1-4
VFD Configuration:	Standalone VFD	VFD List Price:	$ 9,480
Voltage:	460V	VFD List Price Multiplier:	1.0 ~~0.75~~ *
Hp Rating:	100	Total Number of Units:	1 *
Typical Motor Eff.:	92%	Total Est. Install./Start-Up Cost:	$ 500.00 *
Nominal VFD Eff.:	96%	Utility Rate ($/kwHr):	$ 0.06 *
		Total Utility Rebate:	$ - *
		Actual Motor Eff.:	92% *

Operation Data

Hrs/Day:	12	*
Days/Wk:	7	*
Wks/Yr:	12	*
Total Hrs/Yr:	1008	Hrs

Duty Cycle

%Flow Rate	% Time	Hrs
100%	5%	50
90%	10%	101
80%	15%	151
70%	25%	252
60%	20%	202
50%	15%	151
40%	10%	101
30%	0%	0
20%	0%	0
10%	0%	0
Total:	100%	



Estimated Energy Savings & Carbon Dioxide Reduction

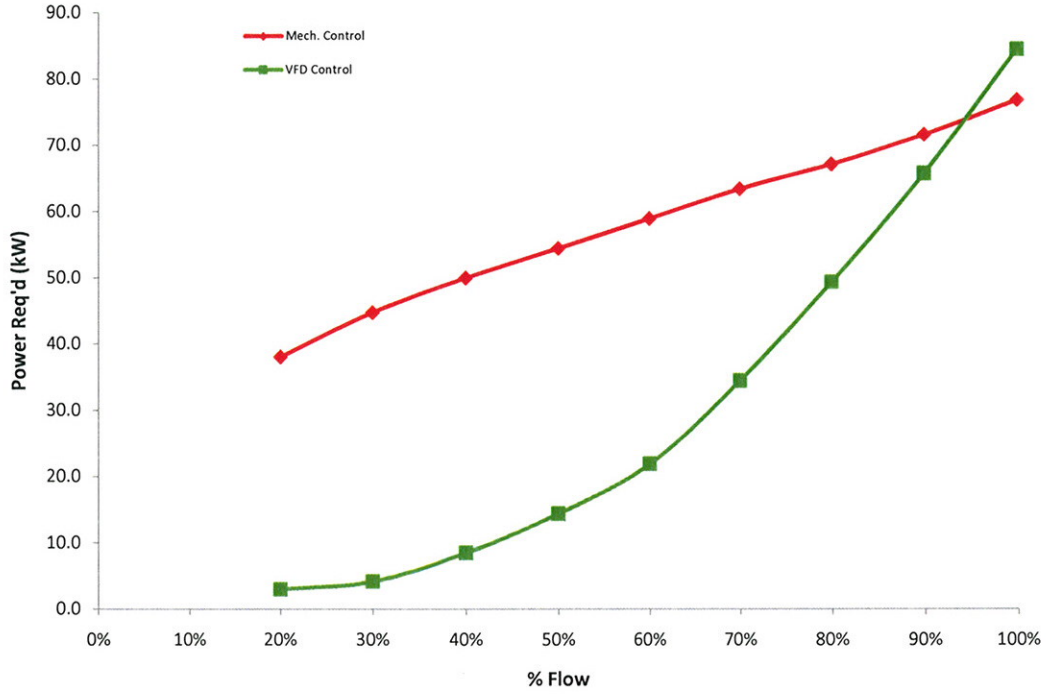
Total Operating Hours (for all units):	1008	Hrs/Yr		
Mechanical System(s):	62,376	kWh/Yr	84,831	lbs/Yr of CO_2
VFD System(s):	34,470	kWh/Yr	46,879	lbs/Yr of CO_2
Estimated Annual Energy Savings & CO2 Reduction:	27,906	kWh Saved	37,952	lbs/Yr of CO_2 Reduced

Payback Analysis

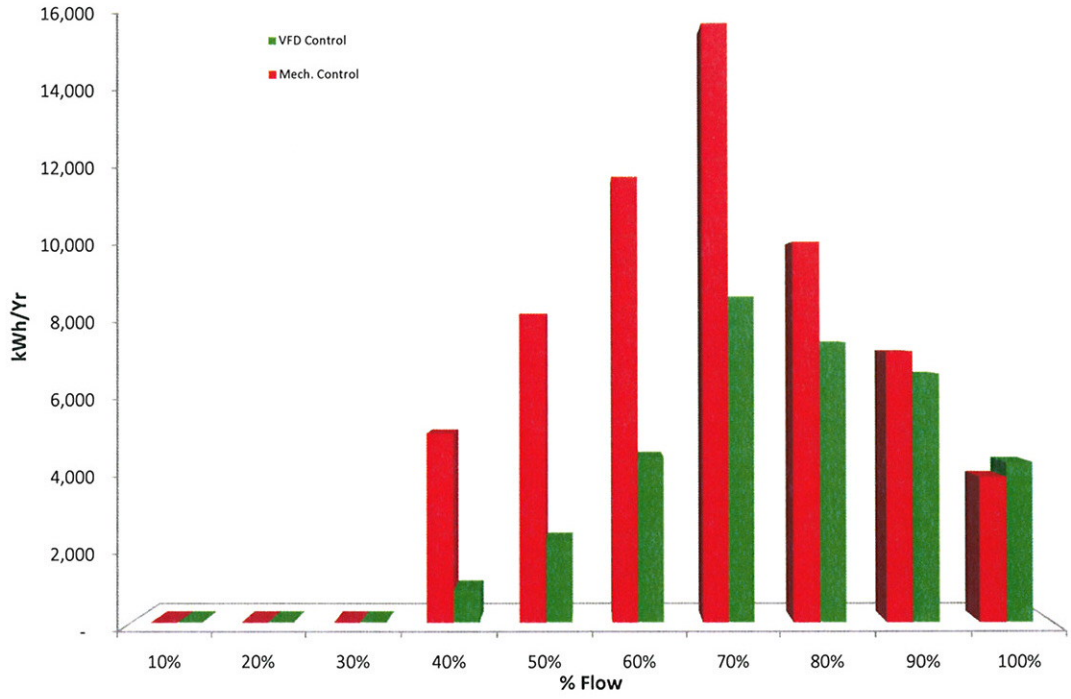
	1st Year	2nd Year	3rd Year
Mechanical System(s) Annual Energy Cost:	$ 3,774	$ 3,774	$ 3,774
VFD System(s) Annual Energy Cost:	$ 2,085	$ 2,085	$ 2,085
Annual Energy Savings:	$ 1,688	$ 1,688	$ 1,688
VFD Cost:	$ 9,500 ~~7,110~~	$ -	$ -
Installation/Start-up Cost:	$ 500	$ -	$ -
Utility Rebate:	$ -	$ -	$ -
Total Savings:	$ ~~(5,922)~~	$ 1,688	$ 1,688
Simple Payback:	5.9 ~~4.51~~ Years		

For Estimating Purposes Only,
Results Not Guaranteed.

Power Required Graph



Annual Energy Usage Graph



For Estimating Purposes Only,
Results Not Guaranteed.

Computed:	CLR	**Date:**	10/6/2010	**HDR Job No:**	119142
Checked:		**Date:**			
Project:	SD DENR Energy Audits - Lead-Deadwood Sanitary District				

HDR Computation

		ECM No.	**02**
Subject:	Energy Savings and Cost Analysis	**ECM Type:**	**Physical**
Task:	Evaluate Energy Use at Hanna Pump Station		

Existing Condition:

Substantial energy use year round. Pumps are operated during summer months only.

Proposed Change:

To be determined.

Energy Savings:

We assumed energy use could be reduced to 1,000 kWh per month during off peak months. Also assumed is that capacity charges could be reduced during off peak months. Recent Hanna pump station data is provided below.

Month	Energy kWh	Energy $	Capacity kW	Capacity $	Cost Adj $	Total Cost $
Jan-09	7,200	383.42	12.0	83.84	3.52	470.78
Feb-09	6,000	322.10	12.0	89.70	2.94	414.74
Mar-09	6,000	322.10	12.0	91.43	12.57	426.10
Apr-09	6,300	337.43	12.0	97.29	20.79	455.51
May-09	6,300	337.43	12.0	95.57	20.79	453.79
Jun-09	6,600	352.76	93.0	725.11	21.78	1,099.65
Jul-09	7,800	414.08	90.0	667.78	25.73	1,107.59
Aug-09	55,500	2,836.05	96.2	369.41	198.66	3,404.12
Sep-09	21,600	1,103.76	94.6	363.26	86.78	1,553.80
Oct-09	600	306.60	26.0	99.84	35.30	441.74
Nov-09	6,300	321.93	159.0	548.55	36.29	906.77
Dec-08	5,400	291.44	12.0	89.36	2.65	383.45
Total	**135,600**	**7,329**		**3,321**	**468**	**11,118**

Computed:	CLR	**Date:**	10/6/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - Lead Deadwood Sanitary District

HDR Computation

ECM No. 03

Subject: Energy Savings and Cost Analysis

ECM Type: Physical

Task: Eliminate Grand Avenue Booster Station (Lead)

Existing Condition:

Grand Avenue Booster Station is used to fill the 75,000 gallon Peak Street Reservoir.

Proposed Change:

Modify distribution system to fill the Peak Street Reservoir from a nearby main that is fed from a higher pressure zone.

Energy Savings:

The Grand Avenue Booster Station can be eliminated.

Energy: Current Energy Use

Yearly Energy Use = 24,624 kW-hr / yr

Cost: Current Energy Cost

Yearly Energy Cost = $3,372 / yr

Savings: kW-hr / yr = 24,624 kWh x 50%

= 12,312 kW-hr / yr

$ / yr = $3,372 - (12,312 x $0.0605)

= $2,627 / yr

Capital Cost:

Altitude valve and minor distribution changes $10,000

Simple Payback:

= $10,000 / $2,627

= 3.8

Recommended:

YES (<5 yrs)

Comments:

Eliminating the Grand Avenue Booster Station is recommended. Additional costs will be associated with demolishion of the building. However these costs should be more than offset by a reduction in operation and maintenance costs.

Computed:	ADE	**Date:**	10/11/2010	**HDR Job No:**	119142
Checked:		**Date:**			
Project:	SD DENR Energy Audits - City of Brandon Water				

HDR Computation

		ECM No.	**01**
Subject:	Energy Savings and Cost Analysis	**ECM Type:**	**Physical**
Task:	Decommission Country Club Booster		

Existing Condition:

Booster is no longer used. Area is now served by Redwood Booster.

Proposed Change:

Decommission Country Club Booster so heating and electrical service are no longer needed.

Energy Savings:

Energy will be saved due to elimination of heating and lighting and service charges will also be eliminated. Annual kW-hr savings is estimated to be 6,258.

	Savings	Expenses
Service Charge	$732	$0
Power	$531	$0
Total	$1,263	

Savings: $ / yr = Savings - Expenses
= $1,263 - $0
= $1,263

Capital Cost:

None $1,500

Simple Payback:

= Annual Savings/Capital Cost
= $1,263/$1,500
= 1.2 years

Recommended:

YES (< 5 yrs)

Comments:

Computed:	ADE	**Date:**	10/11/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - City of Brandon Water

HDR Computation

ECM No. 03

Subject: Energy Savings and Cost Analysis

ECM Type: Operational

Task: Set Maximum Pump Speed on Well 3 to Limit kW Demand to < 75 kW

Existing Condition:

Well 3 is used only when treated water from the WTP cannot maintain the water level in the elevated storage at a specific set point. This is not conveyed to or treated at the plant. Its use imparts significant costs on a per gallon basis when used.

Proposed Change:

Set existing VFD such that the demand does not exceed 75 kW. If 75 kW is reached at any time in a 12 month period, it places the facility into the Large Power rate category, subject to demand charges and a higher facility charge. The maximum experienced when pumping full speed has been 77 kW. Only a slight speed reduction will be required to keep this below 75 kW.

Energy Savings:

There will be no power savings based on kW-hrs used, but the electrical bills will be reduced due to elimination of demand charges and a reduced facility charge. The kW-hr rate would be higher but the additional energy charges are much lower than the savings for demand and facility charges.

	Savings	Expenses
Facility Charge	$440	$0
Demand Charge	$2,180	$0
Power	$0	$428
Total	$2,620	$428

Savings: $ / yr = Savings - Expenses
= $2,620 - $428
= $2,192

Capital Cost: NA

Simple Payback: NA

Recommended: **YES** (< 5 yrs)

Comments:
This is recommended over ECM 02 since it saves additional money on the net power bill and allows Well 3 to stay in service.

Computed:	CLR	**Date:**	8/17/2010	**HDR Job No:**	119142
Checked:		**Date:**			
Project:	SD DENR Energy Audits - Lower Brule RWSS				

HDR Computation

ECM No. **001**

Subject: Energy Savings and Cost Analysis

ECM Type: **Physical**

Task: Repair Compressed Air System

Existing Condition:

Compressed air piping leaks causing the compressors to run nearly nonstop.

Proposed Change:

Repair leaks in order to reduce compressor run time.

Energy Savings:

Energy savings are realized by reducing compressor run time.

Air Compressor
Atlas Copco GA11FF
15 HP

Energy:

Energy Lost = power loss due to leak x annual time leak occurs x conversion factor
= 0.35 x 15 hp x 8,760 hr/year x 0.7457 kW/hp
= 34,295 kWh / year

Savings: Energy = 34,295 kWh/yr x $0.075/kWh
= $2,572

Capital Cost:

Repair Air Line $2,500

Simple Payback: = $2,500 / $2,572
= 1.0 years

Recommended: **YES** (< 5 yrs)

Comments:

Power lost to air leaks was assumed to be 35%.

Computed:	CLR	**Date:**	8/17/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - Lower Brule RWSS

HDR Computation

ECM No. 002

Subject: Energy Savings and Cost Analysis

ECM Type: Operational

Task: Limit Use of UV Disinfection

Existing Condition:

UV disinfection will be used in conjunction with chlorine disinfection.

Proposed Change:

Do not operate UV system unless adequate chlorine contact time is not being provided.

Energy Savings:

Energy savings is realized by reducing the amount of energy required for disinfection.

Condition	UV System
Size	10 kW system

Energy: Existing Condition

Energy Consumption = UV demand x % of capacity x hours of operation x annual run time
= 10 kW x 50% x 8,760 hours/year x 0.5
= 21,900 kWh/year

Cost Savings = energy use * energy charge
= 21,900 kWh * $0.075/kWh
= $1,643

Capital Cost:

None $0

Simple Payback:

= NA
= NA

Recommended:

YES (< 5 yrs)

Comments:

This ECM illustrates the energy savings of operating the UV system half of the year compared to year round. The UV system should be programmed to operate only when the plant output exceeds the flow rate for which adequate CT time can be provided.

Computed:	CLR	**Date:**	8/11/2010	**HDR Job No:**	119142
Checked:		**Date:**			
Project:	SD DENR Energy Audits - Rapid Valley Sanitary District				

HDR Computation

ECM No. 01

Subject: Energy Savings and Cost Analysis

ECM Type: Physical

Task: Replumb Air Burst Piping at Inlet

Existing Condition:

Air burst piping is plumbed above ground at the inlet structure. Air line enters into Rapid Creek and freezes during winter months. Electric heat elements are used to keep the inlet functioning.

Proposed Change:

Replumb the air line to enter the inlet structure below grade. This will prevent icing at the water surface.

Energy Savings:

Cost savings are realized by eliminating the need for the element style heaters.

Condition	Element Heaters
Annual Electricity Use	18,000 kWh
Annual Cost	$1,170

Energy: Existing Condition

Energy Cost = energy use * energy charge
= 18,000 kWh * $0.065/kWh
= $1,170

Increased Compressor Run Time

kW-hr / air burst = 5 Hp x 0.7457 kW/Hp x 0.08 hr
= 0.311
kWh / year = 0.311 kWh x 6 air burst / hour x 732 hours / month x 4 months / year
= 5,460
Energy Cost = 5,460 kWh x $0.065/kWh
= $355

Savings: Energy = $1,170 - $355
= $815

Capital Cost:

Replumb Air Line $2,500

Simple Payback: = $2,500 / $815
= 3.1 years

Recommended: **YES** (< 5 yrs)

Comments:

Computed:	CLR	**Date:**	8/11/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - Rapid Valley Sanitary District

HDR Computation

ECM No. 02

Subject: Energy Savings and Cost Analysis

ECM Type: Physical

Task: Insulate CIP hot water tank

Existing Condition:

Hot water for CIP cylce is stored in a tank. The tank is not insulated and is placed directly on the concrete floor.

Proposed Change:

Insulate tank and place on a layer of rigid insulation.

Energy Savings:

Energy savings are realized be reducing the volume of water that must be reheated.

	Insulate Tank	
Annual Savings	350 Therms	

Energy: Existing Condition

Energy Savings = energy use * energy charge

= 350 therms * $0.7034 / therm

= $246

Capital Cost:

Insulate Tank $1,000

Simple Payback:

= $1,000 / $246

= 4.0 years

Recommended:

YES (< 5 yrs)

Comments:

Annual reduction in natural gas consumption was estimated based increasing the R value of the tank.

Computed:	CLR	**Date:**	8/11/2010	**HDR Job No:**	119142
Checked:		**Date:**			

Project: SD DENR Energy Audits - Rapid Valley Sanitary District

HDR Computation

ECM No. 06

Subject: Energy Savings and Cost Analysis

ECM Type: Physical

Task: Install Occupancy Sensors

Existing Condition:

Occupancy sensors are not currently used to turn off lights.

Proposed Change:

Install occupancy sensors so that lights are automatically shut off if a room is empty.

Energy Savings:

Energy savings are realized be reducing energy consumption.

Condition	Occupancy Sensors
Electricity Use Reduction	2,000 kWh / year

Savings: Energy = energy use * energy charge
= 2,000 kWh * $0.065/kWh
= $130

Capital Cost:

Occupancy Sensors $500

Simple Payback:

= $500 / $130
= 3.8 years

Recommended:

YES (< 5 yrs)

Comments:

Energy savings were estimated. Actual energy savings will depend on the number of light fixtures controlled by occupancy sensors, energy used by lighting, and reduction of time lights are on.

Appendix C – Energy Audit Checklist

Water System Energy Audit Approach Checklist

Determine type of audit

- [ ] Pumping, HVAC, lighting, and/or process

Determine audit team members, everyone will have different goals

- [ ] Engineers - reduce energy cost
- [ ] Plant staff - reduce disruption to system
- [ ] Electric utility - reduce peak demand

Collect data

- [ ] Power bills - get actual bills that show energy use, demand charges, cost adjustments, etc
- [ ] Electric rate schedules - get current rate schedules
- [ ] Alternative rate schedules - are alternate rates available that will benefit the water system?
- [ ] Flow data - include booster stations, wells, high service pumps, anything with a flow meter
- [ ] Meter data - sold vs produced, bulk purchases or sales, water loss data
- [ ] Pump curves - collect pump curves to verify pumps are operating near their design point
- [ ] Process flow diagrams, design summary - useful to help understand operation of the system
- [ ] Water quality standards - any unique processes required?
- [ ] Previous audit findings - have energy audits been performed in the past?
- [ ] System pressure - operating pressures with distribution system
- [ ] Pressure zones - how are different zones operated, how is water moved around the system?
- [ ] PRVs - amount of head removed, number in the system, any way to limit wasting head?
- [ ] Reservoirs - storage capacity, elevation, head range
- [ ] Compressed air systems - horsepower, receiver tank size, devices consuming compressed air
- [ ] HVAC - efficiency and performance of existing equipment
- [ ] Gas bills - HVAC audit
- [ ] Lighting - efficiency and performance of existing lights

Conduct Site Visit

- [ ] Meet with staff and operators
- [ ] Q&A session - discuss operations, gain understanding of how system is operated
- [ ] Seek input from operators and those familiar with the sytem
- [ ] Walk through - tour facilities, more Q&A
- [ ] Obtain any missing info, check motor sizes, observe valve positions
- [ ] Focus on big power consumers, they will offer best payback opportunity
- [ ] Raw water pumping, wells, HSP, air compressors - typically largest power consumers
- [ ] Seek energy efficiency ideas from plant staff

Develop Energy Conservation Measures

- [ ] Estimate energy or cost savings
- [ ] Determine capital cost
- [ ] Consider operational impacts to the plant
- [ ] Look for rebates or incentives

About the **Handbook**

This Handbook was developed as a component of a project for the South Dakota Department of Environment and Natural Resources, funded under the American Resource Recovery Act (ARRA) to promote the long-term goal of maximizing energy conservation and reducing energy expenditures by drinking water systems in South Dakota. Nine small water systems across South Dakota with varying source waters and treatment technologies were audited for energy usage. Individual reports were developed and energy conservations measures identified. While the systems audited were small water systems, the items evaluated in the energy audit process are applicable to larger water systems, as well as wastewater systems.

Training and dissemination of information was a primary goal of this project, to be able to benefit all water systems, not just the nine systems actually audited. This Handbook presents a summary of procedures, results, and benchmarking for system managers, operators, boards, or councils to use as a tool to identify potential energy savings at their facilities and to determine if detailed evaluation and auditing is desired.