INL/EXT-06-11310

Assessment of Load and Energy Reduction Techniques (ALERT)

Report For: Department of Energy
Rocky Mountain Oilfield Testing Center
Casper, Wyoming

Richard J. Horsley

May 2006

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance

Idaho National Laboratory

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Idaho National Laboratory
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Assistant Secretary for Energy Efficiency and Renewable Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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Federal Energy Management Program

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ALERT PROJECT CONTACT SHEET

Site Information

Agency Name: Department of Energy

Facility Name: Rocky Mountain Oilfield Testing Center (RMOTC)

Facility Address: 907 North Poplar Suite 150, Casper, Wyoming 82601

Names of Facilities Visited: ESSH Building, Upper Office, NPR #3 Science Center, Potable Water System Lower Office/Shop Building, Warehouse, and LTS Gas Plant NPR #3 (Office, and Compressor Buildings)

Date of Site Visit: November 15 - 17, 2005

Site Contacts

The following RMOTC staff personnel supported the ALERT effort.

Name	Title	Phone No.	Fax No.	Email
Doug Tunison	RMOTC Manager	307-261-5000 Ext. 5006	307-261-5997	doug@rmotc.doe.gov
Dan Newquist	Facilities Engineer	307-233-4826	307-233-4851	dan.newquist@rmotc.doe.gov
Brian Meidinger	Project Engineer	307-261-5000 Ext. 5027	307-261-5817	brian.meidinger@rmotc.doe.gov
Cecil Foote	Field Operations Manager	307-437-9631	307-437-9623	cecil.foote@rmotc.doe.gov
Michael J. Taylor	ESS&H Manager	307-437-9606 Ext. 5078	307-437-9605	mike.taylor@rmotc.doe.gov
Rod Taylor	Pacific Power Corp. Account Manager	307-577-6913		

ALERT Team

The on-site ALERT team was comprised of the following personnel.

Name	Title	Phone No.	Fax No.	Email
R. John Horsley[1,2]	Engineer	208-526-0968	208-526-5848	richard.horsley@inl.gov
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2. Idaho National Laboratory (INL)

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EXECUTIVE SUMMARY

Site Overview

An ALERT (Assessment of Load and Energy Reduction Techniques) assessment of selected facilities in the Field area of the Rocky Mountain Oilfield Testing Center (RMOTC) was performed during November 15-17, 2005. The ALERT team included two engineers from the Idaho National Laboratory (INL). The ALERT team was provided with excellent assistance by RMOTC staff members that included the Field Operations Manager, ESS&H Manager, Project Engineer, Facilities Engineer, and RMOTC Manager.

The RMOTC Field Site Area is located approximately 35 miles North of Casper, Wyoming in the South-central part of Wyoming at an elevation of around 5,300 feet above sea level. The location typically has cold, windy winters. The Field Site is comprised of a group of about 8 facilities that are used regularly or intermittently to perform field operations and community outreach.

Energy Usage Overview

RMOTC's primary energy source is electricity. RMOTC uses natural gas and some propane for heat and remote oil pump operations. The annual electrical usage is $869,621 (two-year ave). Currently RMOTC does not track natural gas or propane usage, for internal use, because these are not purchased products of the oilfield, but rather produced onsite.

Table ES-1. RMOTC energy consumption summary for FY 03 – 04 (2 year average)

Energy Type	Consumption Units	Annual Consumption	Annual Cost (Thou. $)	Unit Cost ($)	
Electricity	MWH	23,043.1	869.6	*$0.042	/kWh
* kWh Combined rate as of May'05		**Total Costs:**	**869.6**		

Energy Conservation Opportunities

The assessment resulted in observations and recommendations that were grouped into the categories of "Motors" and "Building Specific". As the assessment was conducted, observations were noted and, where applicable, discussions were held with the RMOTC staff about specific plans for the facility or operation being reviewed. The observations and recommendations are discussed in a separate section of the report. The recommendations were subsequently arranged by potential for dollar and energy savings and summarized in a separate table that appears in the body of the report. Sufficient data was not available to calculate precise energy savings for all recommendations. Where data was available, rough estimates of energy savings were developed and included in the table. Implementation of these recommended actions will result in improved energy efficiency and reduced operational costs.

An abbreviated summary of these recommended actions is shown below in Table ES-2. The following are the major recommendations. All recommendations are discussed in the report and summarized in the recommendations table.

Priority	Facility/Area and Recommendation	Cost	Savings
H	**Gas Plant Motors** – Soft start for the motors	Med/High	*$15K – $30K/yr
M	**Gas Plant** – Variable Frequency Drives, or plant downsizing.	High	High
M	**Field Pump Operations** – Reduce motor sizes and increase pump efficiencies.	Medium	Medium
M	**Lower Office/Shop** – Insulate walls	Medium	$5,170/yr
M	**NPR #3 Warehouse** – Better Lighting Controls	Medium	$175/yr
L/M	**Gas Plant/Field** – Small Electric Generation Plant	High	**Variable, up to $150k/year

* If utility meter with peak demand logging capability is used.

** After equipment is paid off, which may take approximately 10 years. $150k per year savings would be available for a 1 MW wind turbine.

Table ES-2. Quantitative energy savings recommendations summary.

FINAL REPORT

DEPARTMENT OF ENERGY

ROCY MOUNTAIN OILFIELD TESTING CENTER

CASPER, WYOMING

DESCRIPTION OF THE FEMP ALERT PROGRAM

FEMP ALERT (Assessment of Load and Energy Reduction Techniques) teams assist federal agencies with efforts to reduce energy demand at locations experiencing price volatility and electricity supply shortages. Working with site staff, the teams identify and, when feasible, implement measures during their assessments of sites. Teams assess operational efficiency measures (i.e. low-cost and no-cost measures), and work with site personnel to develop an implementation plan. The ALERT teams are made up of Department of Energy (DOE) laboratory technical staff and other appropriate personnel.

BACKGROUND

Site Description

RMOTC was established by the U.S. Department of Energy (DOE) to partner with the petroleum industry to improve domestic oil and gas production through the field testing of new technology, evaluation of new equipment, and demonstration of new processes. It is the field test site of choice for companies and individuals involved in the development of leading edge oil and gas technology.

RMOTC's field site is located on the Teapot Dome oil field, 35 miles north of Casper, WY where test partners have access to a 10,000 acre operating oilfield with six producing zones and around 600 producing well bores ranging in depth from 500 ft. to 6000 ft. These facilities are primarily for support of the oilfield operations except for the Science Center, which is currently supporting high school student internship.

Climate, Facility Descriptions, and Operations

Climate

The RMOTC is located at approximately 43.3º North latitude and 106.2º West longitude with a base elevation of approximately 5300-ft above mean sea level (MSL). As shown in Figure 1 below, the average temperature ranges between approximately 10 ºF and 35 ºF in winter and 55 ºF and 90 ºF in summer.

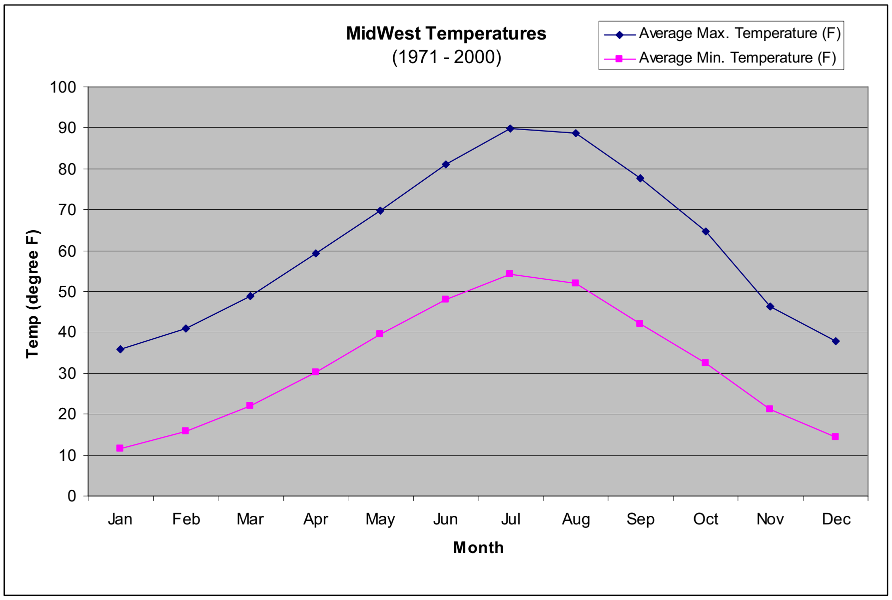

Figure 1 Midwest Area average air temperature, 1971-200. (About 10 miles north of RMOTC)

As in most locations, weather patterns can have significant shifts. The data shown in Figure 2 provide an example of this phenomenon. The RMOTC area can experience significant snow fall as late as May and as early as September, but as a "high desert" location this is not generally the case.

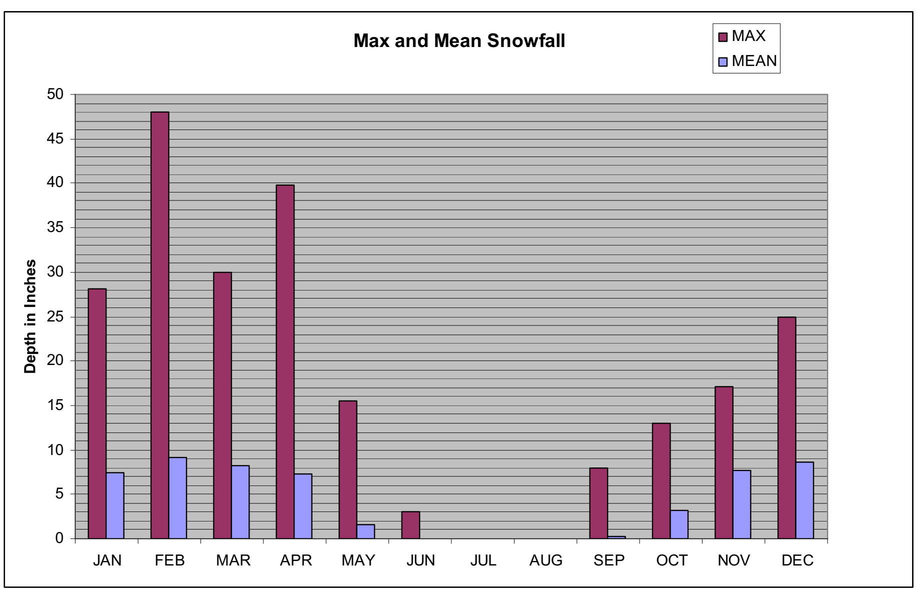

Figure 2 Midwest Area monthly snowfall, 1948-2005.

The data in Figure 3 show the monthly average wind speed during 2003 and 2004 at a height of 10 meters. The wind at the weather station is close to favorable conditions for wind turbines, however it is believed that there is an even more favorable site Northwest of the gas plant where we estimate that winds averaging between 15.7 and 16.8 miles per hour at 50 meters may be realized(see section under PURPA Project Possibilities).

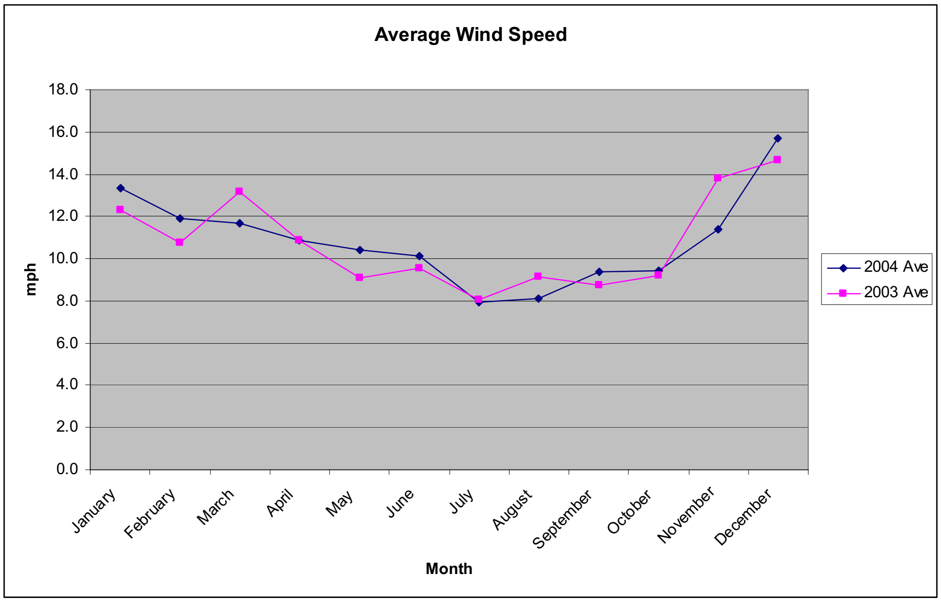

Figure 3 RMOTC Area average wind speed data, 2003-2004 (Taken from NREL weather station on RMOTC site)

The data in Figure 4 show the range of expected annual precipitation during each month of the year.

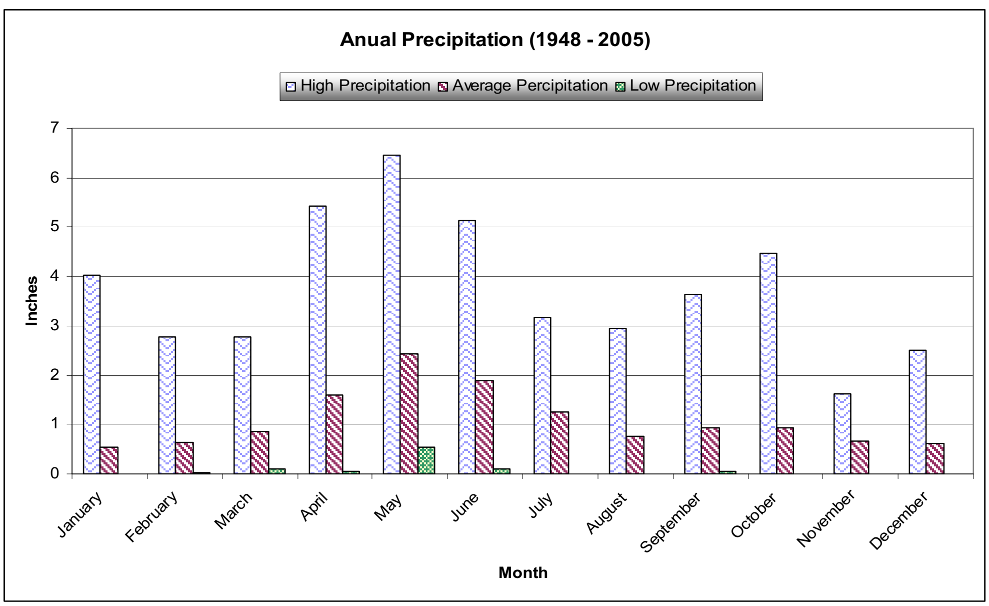

Figure 4 Midwest Area precipitation, 1948-2005.

Facility Descriptions

Facility utilization in the desert site area includes administrative offices, maintenance buildings, and education facilities. The ESSH building is the main administrative building (visitor check-in) and the building is also equipped with a conference room and a room where personal protective equipment (PPE) is issued. The Upper Office building houses additional offices and document and file storage. The Science Center is where students can come and work on science projects. The Lower Office/Shop is where the large equipment is maintained and the building also houses some offices and a break room for the staff. The LTS Gas Plant Office and Compressor buildings support operations at the Gas Plant Area. Summary information for the facilities reviewed is included in Table 1 below.

Table 1. RMOTC ALERT facility summary information.

Facility	Floor Area (ft^2)	Location	Use
ESSH Building	2,170	Desert Site (Field)	Office
Upper Office	3,500	Desert Site (Field)	Offices
NPR #3 Science Center	5,310	Desert Site (Field)	Education/Research
Lower Office/Shop	8,000	Desert Site (Field)	Office/Equipment Shop
NPR #3 Warehouse	3,800	Desert Site (Field)	Warehouse
LTS Gas Plant Office	1,344	LTS Gas Plant NPR #3 (Field)	Office
LTS Gas Plant Compressor Building	6,800	LTS Gas Plant NPR #3 (Field)	Compress Gas

Operations

The RMOTC operates about 660 producing oil wells and covers an area of 10,000 acres. The field site is located about 35 miles north of Casper, Wyoming. There are office buildings and a safety training building at this field site for the 35-40 employees based in the field. There are 25 buildings at the RMOTC including a vehicle maintenance shop, pump shop, welding fabrication shop, Science Center, green house, and water treatment and disposal facilities. DOE leases office space in Casper, Wyoming for about 25 Federal and contractor employees.

Oil production is collected at tank batteries and sold to a commercial pipeline. Oil, gas, and water are separated in oilfield separators using hot water produced from geothermal wells. RMOTC also operates a gas plant that strips liquid hydrocarbons from the produced natural gas

(2,800 MCF/day) and makes about 2,500 gallons a day of propane and butane-gasoline mix, which is transferred by commercial tank trucks.

ENERGY USAGE

The RMOTC staff provided the energy consumption information contained in Table 2 below. Table 2 data includes data averaged over fiscal year 2003 and 2004.

Table 2. RMOTC energy consumption summary for FY 03 – 04 (2 year average)

Energy Type	Consumption Units	Annual Consumption	Annual Cost (Thou. $)	Unit Cost ($)	
Electricity	MWH	23,043.1	$869.6	*$0.042	/kWh
* kWh Combined rate as of May'05		**Total Costs:**	**$869.6**		

RMOTC has one metered account with Pacific Power Corporation. In a discussion with Rod Taylor, the Pacific Power Corporation Account Manager for RMOTC, we were told that RMOTC is using rate schedule 46 and the bill verifies that. The demand charges are (as of March 1, 2006) approximately $12.09 per kW and energy charges are approximately $0.01784 per kWh. The demand billing is for demand that occurs during the "On-Peak Period" which is from 7:00 a.m. to 11:00 p.m., Monday through Friday. The gas compressors are the main driver for the peak demand. Soft starts and/or Variable Frequency Drives may assist with reducing the demand (see the Power Systems section for more detail).

OBSERVATIONS AND RECOMMENDATIONS

General Observations and Information

General observations include current operations practices, stated priorities from RMOTC staff personnel, and general area observations that are not specific to an individual building or process.

Personnel Practices Issues

While the majority of this report addresses physical and system characteristics of the facilities assessed, it is important to note that occupant behavior and practices can provide significant contributions to energy savings. General energy awareness programs that inform facility occupants and reinforce good practices are excellent ways to enlist occupant participation in realizing no-cost energy savings. Examples of best practices that could be facets of such programs include (but are not limited to):

- Use of conservation thermostat settings

- Utilization of programmable heating controls

- Turning lights and equipment off when not in use.

The RMOTC staff that supported the ALERT assessment were very aware of energy savings techniques; however, such “personnel action” programs require a continuous positive reinforcement to avoid complacency.

Temperature and Occupancy

Outside temperature range was 17 °F to 35 °F during field observations.

The core occupancy schedule for the RMOTC staff at the desert site is approximately 6:30 am to 5:00 pm four days/week (Monday through Thursday).

Fuels

Most facilities currently heat with Natural Gas and one facility uses geothermal hot water. RMOTC staff is considering using Liquid Petroleum Gas (LPG) because it is considered a byproduct of the operation and they pump the natural gas back into the ground to help with oil production. However, they are receiving a good selling price for LPG from a local company.

Operations

The RMOTC resides within the Naval Petroleum Reserve No. 3 (NPR-3), the Teapot Dome Oil Field. The majority of the facilities are for the support of that operation. The oilfield has been in operation since the 1920’s. Production is tapering off and in 1993 the RMOTC was established by the U.S. Department of Energy as a testing alternative for the petroleum industry. The RMOTC now offers a wide range of services to industries with testing and evaluation needs.

The Teapot Dome site is a 10,000 acre operating oil field offering a full complement of associated facilities and equipment on-site. There are approximately 1,200 well bores and approximately 600 producing wells, in nine producing reservoirs ranging in depth from 500 ft. to 6,000 ft in depth.

Power Systems

Gas Plant Motor Soft Starting

Figure 5 (PH0022) Allen Bradley Motor Protection (model 825-p)

When INL inspected the 700 and 400 hp motors at the gas plant, some RMOTC personnel had mentioned that soft starts were already installed for those motors. Other personnel stated that soft starts were not yet installed. INL was unable to find any evidence of soft start hardware on those particular motors. What was found were some new Allen Bradley motor protection relays in the gas plant control room (model 825-P), but the appearance of any other new equipment was not obvious. It appears from the AB literature that the 825-P is only to provide motor protective capabilities. It does not appear to have any soft start functionality.

Soft start technology will lessen the mechanical stresses on the motors and increase their longevity. It may also reduce peak demand charges, but it depends on how the utility calculates RMOTC's peak demand. If RMOTC truly has a utility meter with peak demand logging capability, then the potential for savings could be significant. If the utility meter is the type where the utility back-calculates the 15-minute peak demand by using the energy values, then typically soft start will not save as much, if any. However, soft start would be easier on the motors. Another item to consider is the sequence of restarting the Site after a power outage, where starting the gas plant motors before other loads are online may also help reduce peak demand.

If RMOTC's utility meter is the type that has peak demand logging, then RMOTC should consider adding the soft starts to the 700 and 400 hp motors. Or RMOTC could approach its utility about the possibility of changing the meter (tough however to talk a utility into doing things that don't benefit them, at least in their opinion). The peak demand during starting of one of RMOTC's 700 hp motors is probably on the order of 2500 KW (just for that motor itself). By adding soft start, RMOTC may be able to reduce that peak by 25 to 50%.

INL would recommend the Allen Bradley SMC Plus Smart Motor Controller as a soft start package for RMOTC's 400 and 700 hp motors. That controller can handle up to 800 hp, depending on which model number is purchased.

If there are times in the production process where the gas plant motors can be run in a slow/idle mode, the motor controller recommended above has that capability. This might save some energy and demand costs, if used properly, because the motor would not always have to be re-started (demand reduction) and could be run at a low speed (lower energy) at certain times when full motor speed is not required.

Gas Plant VFD or Replacement Options

One of the ideas mentioned by RMOTC personnel during our site visit was the possibility for future downsizing of the gas plant. The existing gas plant is considerably oversized for the current production levels of the plant. In our discussions with some of the RMOTC personnel at the plant, it was mentioned that current processes typically use two of the 700 hp motors running at the same time. However, they felt that one of the 400 hp motors in combination with one of the 700 hp motors might be enough to maintain the current processes, although it appeared that the plant had not been successful in doing this.

Without more substantial knowledge of the gas plant operation, INL can only speculate on other possible ideas for improvement to reduce energy usage and demand at the plant. As mentioned above, one of the ideas is to downsize the plant. More research will be necessary to see if the savings benefits will outweigh the cost to replace the plant with a smaller, more optimized system. Or maybe it would be more cost effective to repair, maintain and/or make changes to the existing plant.

Other options could include re-sizing of the gas plant motors to better match the process, but again more research would be required to see how feasible and economic this option would be. RMOTC can also research if the existing 400 hp motors can be used more effectively.

Another option is to add a Variable Frequency Drive (VFD) for each motor in the gas plant. This option will only work if it is possible to run the motors at slower speeds (at certain times) and still maintain the proper process rates for the gas plant. VFD’s would include the soft start capabilities and benefits described above in the soft start section, but would also allow for totally adjustable power (and energy usage) levels to match the production process. This could save significant energy costs, but only if the existing processes and equipment would allow the motor to run at slower speeds yet still keep the system in proper operation. Addition of VFD’s for these motors will likely be relatively expensive, so more research would be required to determine if this option is cost effective or if it would be better to downsize the plant and/or adjust motor sizes. VFD’s are available for the motor sizes being discussed; manufacturers include Square D, Allen Bradley and others.

Of all the new equipment options described above for the gas plant, the addition of soft start equipment would be the least cost option and would still have potential for some cost savings.

Discussion of Pacific Power Energy Analysis Report

A previous energy analysis report was performed by Cascade Energy Engineering for RMOTC and Pacific Power, RMOTC's servicing utility. The report was published in September of 2005. It contains good information about the RMOTC site, and many of the findings in the report come with good recommendations. RMOTC has already started to implement some of the suggestions from the report.

Staggering of motor starting is one of the reasonable suggestions, and it is recommended for the gas plant motors, the submersible pump motors, and surface and oil pump motors. Implementation of staggered motor starting is relatively easy for the gas plant (and has already been implemented) as those starts are monitored and controlled by gas plant personnel. Staggered motor starting is also somewhat inherent in the oil pump motors as there are so many of those motors throughout the field; they are all on separate mechanical timers and are turned on and off at various times. One could try to implement more coordination with the oil pump motors (smarter controls), but the cost to do this would likely far outweigh the savings benefit because there is already some randomness to the number of motors that are on and off.

RMOTC personnel stated that staggered motor starting has also already been implemented for their submersible pumps through the use of coordinated start timers. INL recommends verification (by RMOTC engineering) of proper implementation of these start timers, and regular maintenance checks to ensure that the timers stay coordinated and still are working and staggering the start times properly.

One of the recommendations that INL thought could use additional supporting information was the recommendation regarding reducing the speed on submersible pump 63 with its corresponding VFD controller. The report mentions that this will slightly reduce oil production but will result in substantial energy and demand savings. INL does not see the data in the report to support this conclusion because the cost to produce each barrel of oil, while highest for pump 63, is still lower than the selling price for each barrel of oil. As long as the production cost stays below the selling price. If the recommendation was a combination of running some of the more cost-effective pumps more and pump 63 a little less or slower, then it would seem to make more sense. INL may be missing some of the points or data that went into the report that would better support the pump 63 finding, but it is unclear at this time. Perhaps the selling price per barrel of oil was closer to the production price at the time the data was collected for the Cascade report. INL recommends that this submersible pump finding be researched further to determine if it makes sense under current economic conditions.

Another good recommendation in the report is to reduce motor sizes and increase pump efficiencies whenever feasible for surface and oil pumps. This can be done in several ways, including downsizing, motor replacements with new or used motors, motor swaps where pump sizes or usages have changed, used motor rewinding/rebuilds, pump usage combination changes, pump swaps or change outs to more efficient units, etc. However, each change should be studied before implementation to make sure it makes economic sense. For example, it would probably not be cost effective to start replacing most motors with new ones, but downsizing a motor with a used motor from another pump that is not currently being used would be more cost effective (if it's determined that a particular pump motor could be downsized).

Submersible Pump VFD or Soft Start Options

Another option to research for electrical energy and demand cost savings is the addition of VFD's or soft start hardware to some of the submersible pumps. Since the three largest pumps already have VFD's installed (pump 63, 75, and 43-2), they should already have soft start capability and the ability for operational flexibility. At this time, the addition of VFD's or soft start to the smaller pumps is likely not necessary and would probably cost more than it would save because implementation of this type of equipment is more likely to produce cost savings if used on the larger motors around the site (particularly the gas plant motors), and because staggered motor starting has already been implemented.

Building Specific Observations and Recommendations

Each building will have a description or summary. Each building description will have a brief explanation of the building and a floor plan with findings noted on the floor plan.

In facilities where lights are found on and no occupants are present, calculations will be performed to determine the feasibility of installing occupancy sensors. The occupancy sensors are relatively easy to install and usually cost around $75 each for switch-mounted sensors and $175 for a ceiling mounted configuration. The following are the assumptions that will be used unless otherwise listed:

Assume:

1. The lights are only on during working hours.
2. The rooms identified, on average, are vacant 50% of the time.
3. The building occupancy schedule is 4 days/week 52 weeks/year.
4. The price for Energy is $.0178/kWh.
5. Projects are recommended if they have a 5 year simple payback or less.

In the section called "Building Photos" infrared and standard photos are displayed with comments listed below.

ESSH Building

For all visitors to the desert site, this is the building where they check in and receive safety and orientation training. This building has offices, training/conference room, and storage spaces.

Figure 6 shows the notes that were taken during the visit. There were no major findings. The building did not seem too hot or cold and most of the lights were off in spaces not being used.

Where the lights were left on, we would encourage employees to turn off the lights when they leave the office even if it is for as little as a half-hour.

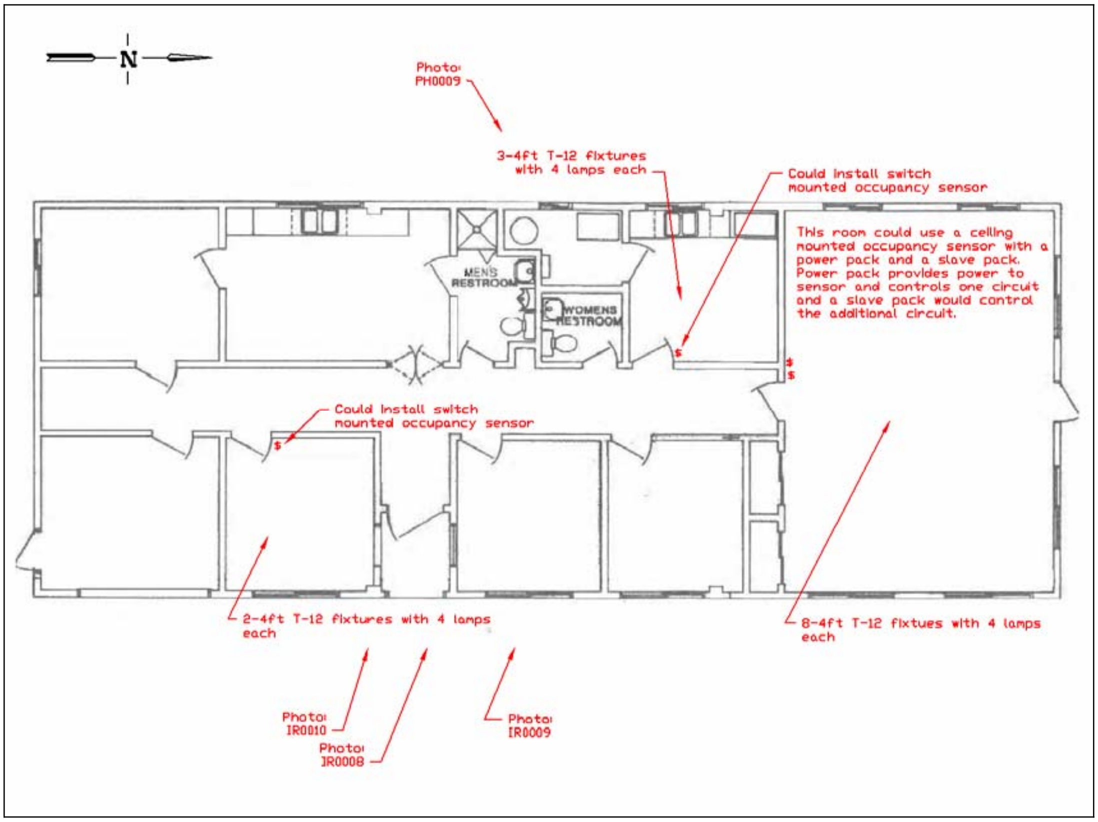

Figure 6 ESSH Building Observations.

Occupancy Sensors

There was a total of 13 four foot fixtures with 4 lamps each, left on in areas where there were no occupants. These fixtures generally consume about 144 watts each. The following are the calculations for energy savings:

Calculations:

13 fixtures x .144 kW/fixture = 1.872 kW

1.872 kW x (10 hrs/day x 4 days/week x 52 weeks/year)(50%) = 1,946 kWh

1,946 kWh x $.0178/kWh = $34.64

Cost of project with a 5 year payback = $173.19

This building could use 3 occupancy sensors and a power pack and a slave pack. This could cost up to $350 - $400.

Installation of occupancy sensors is currently not a recommended option for this building unless utility prices go up or office lights are actually being left on after the occupants go home.

Building Photos

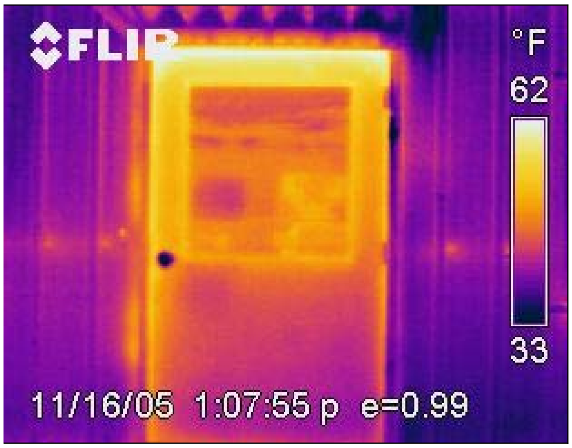

Figure 7 (IR0008) ESSH front Door.

Figure 8 (IR0010) Hole where door bell use to be on the ESSH building.

Figure 7 is an IR (Infrared Image) of the front door of the ESSH Building from the outside. The yellow/orange indicates a warmer temperature. The picture indicates the door is not as good an insulator as the walls. The yellowish color around the edges of the door could indicate bad weather stripping. Figure 8 is a close-up of a hole, near the door, where it looks like a doorbell used to be.

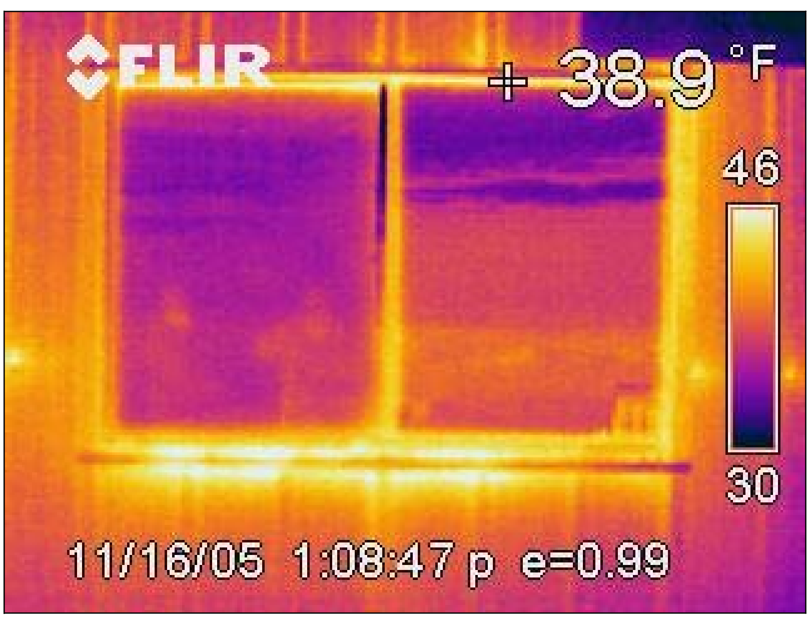

Figure 9 (IR0009) Window to the North of the door in the ESSH Building.

Figure 9 shows the outside window to the north of the main entrance. Notice the yellow coloring around the frame of the window. This could indicate heat loss through the window frame.

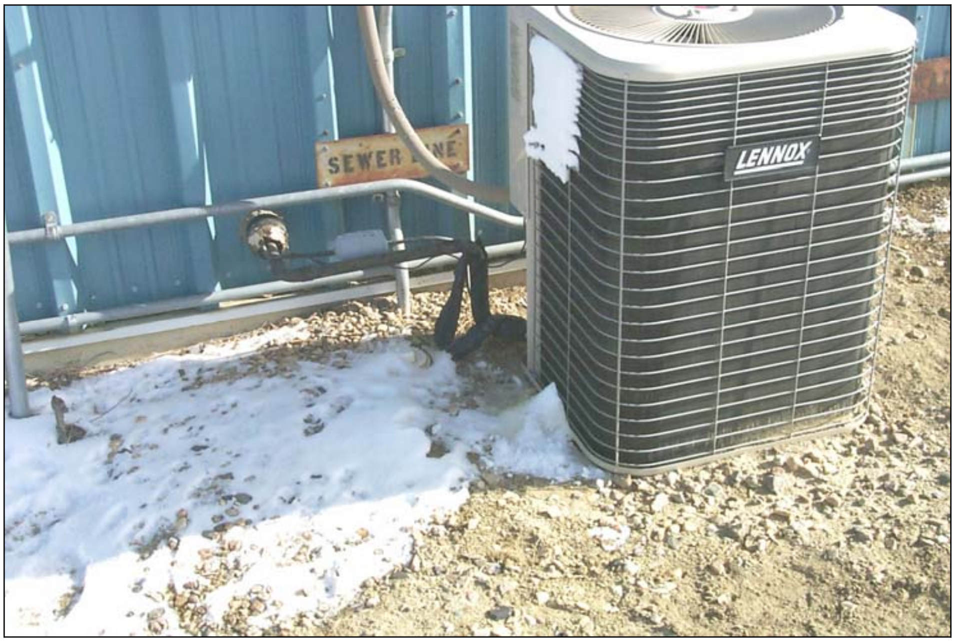

Figure 10 (PH0009) The air conditioner's refrigeration lines are losing insulation.

Figure 10 shows the insulation coming off the refrigeration lines from the air conditioner.

Upper Office

The Upper Office building is just to the North of the ESSH building. It has offices, a file storage area, and a conference/meeting area.

Figure 11 shows the notes that were taken during the visit. There were no major findings. The building did not seem too hot or cold. Most of the lights were turned off and the file and meeting areas had skylights which brought in an impressive amount of light from outside. Where the lights were left on it may be beneficial that an occupancy sensor be installed.

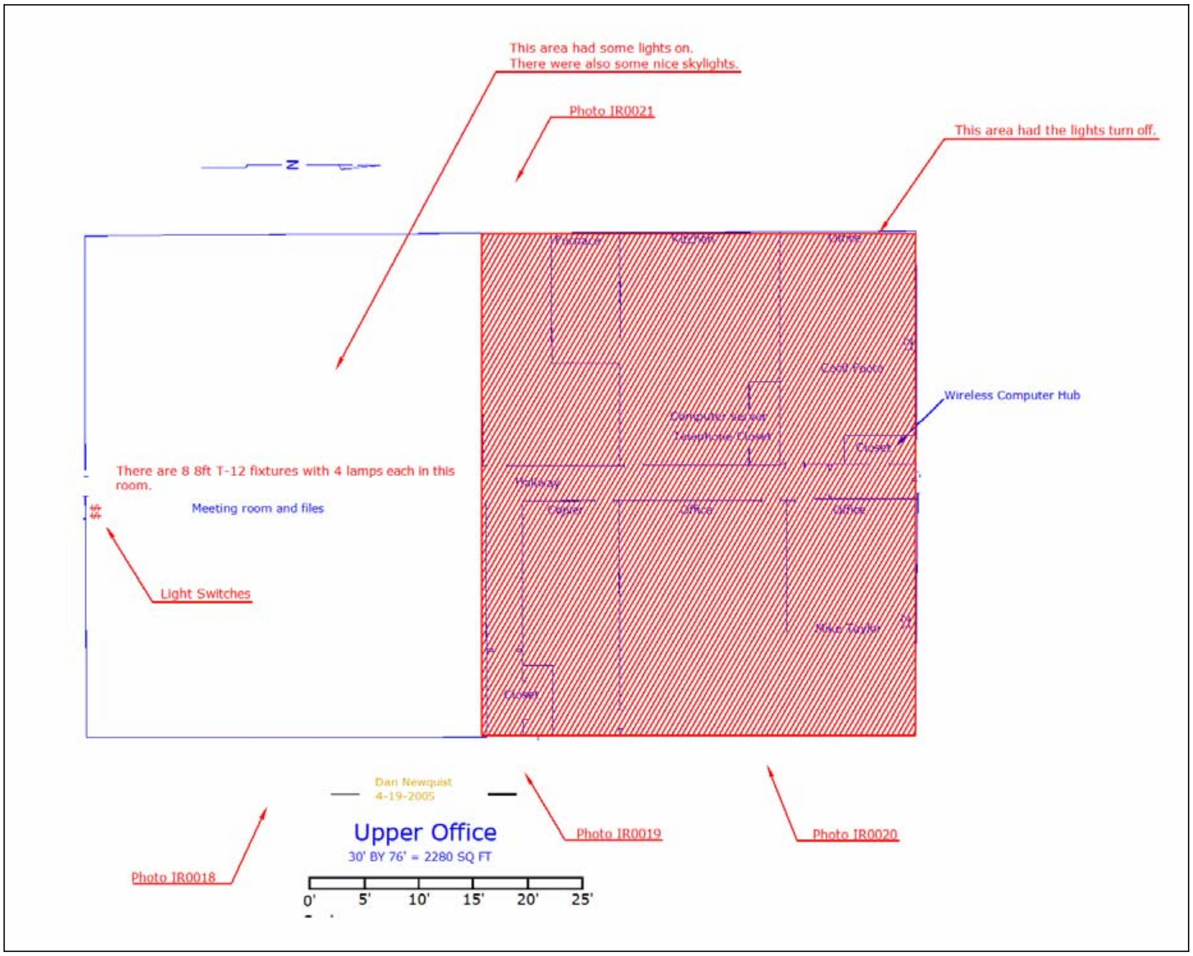

Figure 11 Upper Office Building Observations.

Occupancy Sensors

There were a total of 8 8-foot fixtures with 4 lamps each left on in areas where there were no occupants. These fixtures generally consume about 214 watts each. There are occupancy sensors on the market that also turn off the lights if the light level is above a pre-defined level. The following are the calculations for energy savings:

Assume:

The meeting and file room is vacant 75% of the day.

Calculations:

8 fixtures x .214 kW/fixture = 1.712 kW

1.712 kW x (10 hrs/day x 4 days/week x 52 weeks/year)(75%) = 2,670.7 kWh

2,670.7 kWh x $.0178/kWh = $47.54

Cost of project with a 5 year payback = $237.69

This building could use 1 to 2 ceiling mounted occupancy sensors, depending on the coverage, a power pack, and a slave pack. This could cost between $200 and $300 for equipment.

Installation of occupancy sensors currently is a marginal option for this building unless utility prices go up or office lights are actually being left on after the occupants go home. It may be worth some investigation. There are links to occupancy sensor manufactures in the section called "Additional Measures for Consideration" where more information can be obtained on specific occupancy sensor offerings.

Building Photos

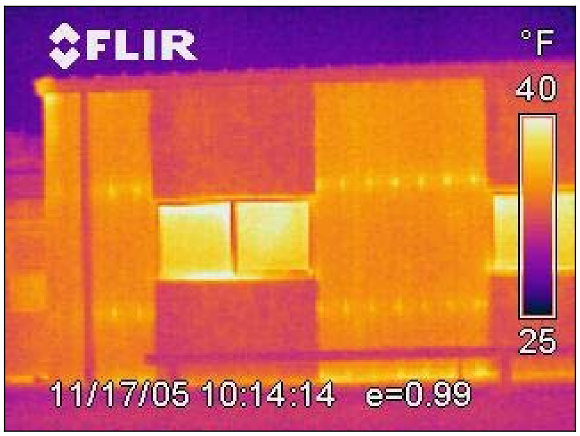

Figure 12 (IR0018) The Southeast corner of the Upper Office.

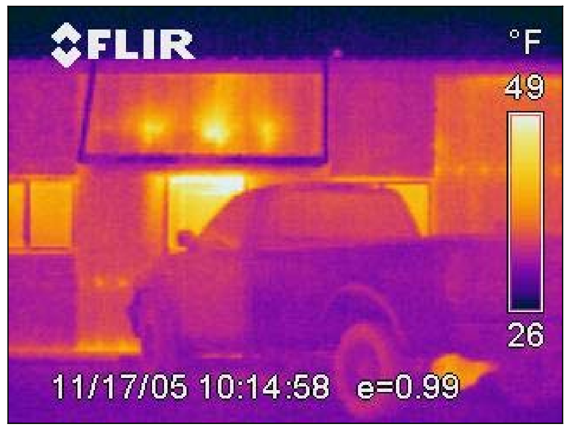

Figure 13 (IR0019) The main entrance of the Upper Office.

The windows in Figures 12 through 14 may be reflecting some energy from the sun. The door in Figure 13 could use some weather striping.

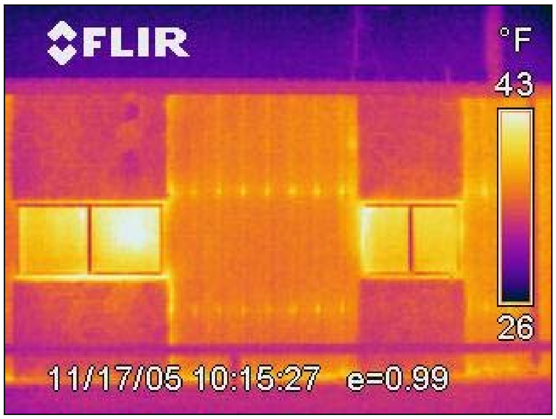

Figure 14 (IR0020) The Northeast corner of the Upper Office.

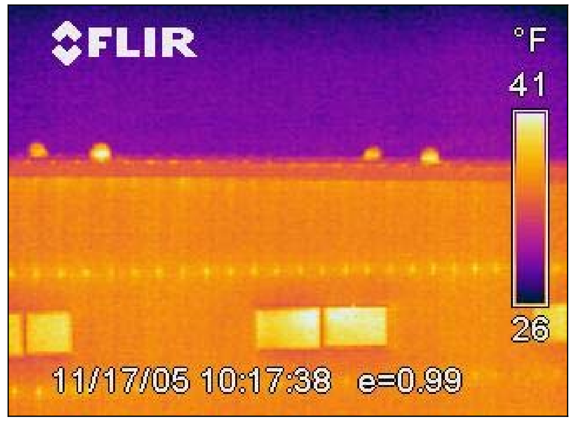

Figure 15 (IR0021) Sky lights from the back of the Upper Office.

NPR #3 Science Center

The Science Center has been used by summer hires from the local High Schools. The building is making use of the Geo-thermally heated water that some deep wells are pulling out of the ground. In the past, this building has supported a working green house, grown fish, and provided heat from this Geo-thermal water. The water is close to 190 °F when it arrives at the building. Figure 16 shows the notes that were taken during the visit.

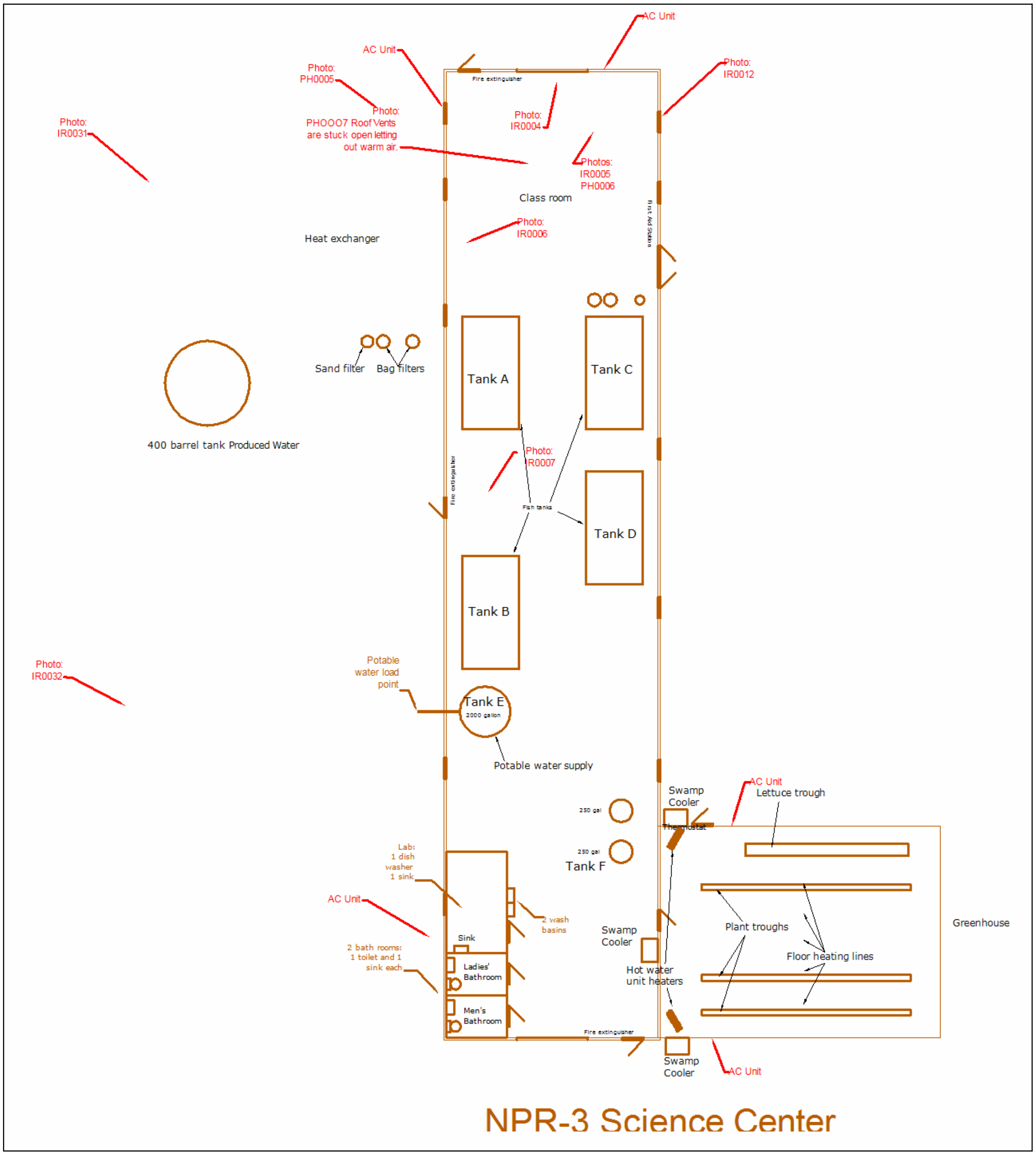

Figure 16 NPR-3 Science Center Building Observations

Building Photos

This building has a damaged wall area that the IR camera could pick up (see Figures 18 and 19). Because the building is heated with the hot water that is essentially free, it is likely not worth the cost of fixing some of the air leaks and damaged insulation.

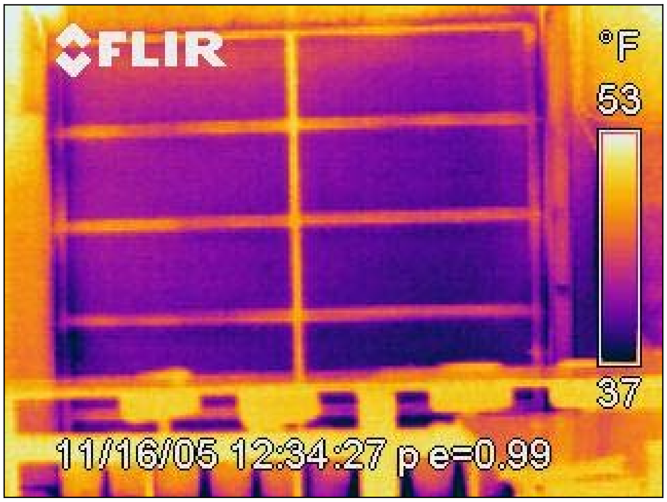

Figure 17 (IR0004) North roll-up door (from inside).

Figure 17 is taken from inside the building and shows that the overhead door is not very well insulated.

Figure 18 (IR0005) Northeast corner where a dent was present.

Figure 19 (PH0006) Northeast corner where a dent was present.

Figures 18 and 19 show the dent on the Northeast corner of the building in infrared and normal views. Notice the dark color in the IR image where there is damaged insulation and subsequent heat loss to the outside.

Figure 20 (IR0006) Where hot water comes into the building.

Figure 21 (IR0007) Cold air coming in West personnel door.

Figure 20 shows the piping where the hot water enters the building. Figure 21 shows an infrared photograph taken from the inside of the west personnel door and the dark color around the edges could indicate some bad weather stripping. It may be advisable to insulate the hot water lines to make use of as much heat as possible and deliver it where it is most needed.

Figure 22 (IR0012) Double doors on Northeast side.

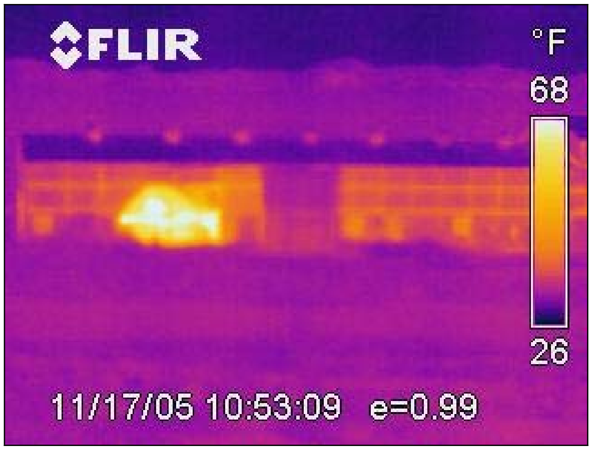

Figure 23 (IR0031) Northwest corner of Science Center.

Figure 24 (PH0005) Northwest corner of Science Center.

Figures 23 and 24 show the back side of the Science Center. There is a bit of heat coming from what seems to be a cooling tower. It seemed a little cold to be running a cooling tower this time of year. The heat may just be from some hot water lines running through the equipment.

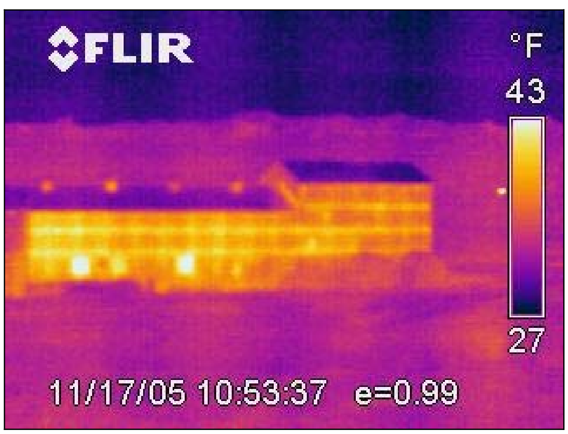

Figure 25 (IR0032) Southwest corner from a distance.

Figure 26 (PH0007) The vents were found open.

While walking through the Science Center we noticed that the ceiling vents were open. This would make it hard to keep the heat in the building during the winter time. In figure 25 the ceiling vents are shown from the outside. Notice the warmer colors against a dark colored roof. Figure 26 is a photo showing the condition of the vents at the time of the assessment.

Absorption Heater

While walking through the Science Center, the comment was made that the hot water makes it nice in the winter time, but they have a hard time cooling the building in the summer.

There is little information available on absorption chillers for a size below 50 tons of cooling. In an e-mail with Energy Concepts, they indicated that the cost for a 50 ton chiller would be about $50,000.

It looks like that would be too high of a cost for an absorption chiller to be practical for the Science Center.

Lower Office/Shop

The Lower Office/Shop is a two story concrete structure with offices, a lunch room, and locker rooms on the second floor. On the first floor there is a shop area, several offices, restrooms, and a boiler/hot water heater area. Figure 27 shows the notes that were taken during the visit.

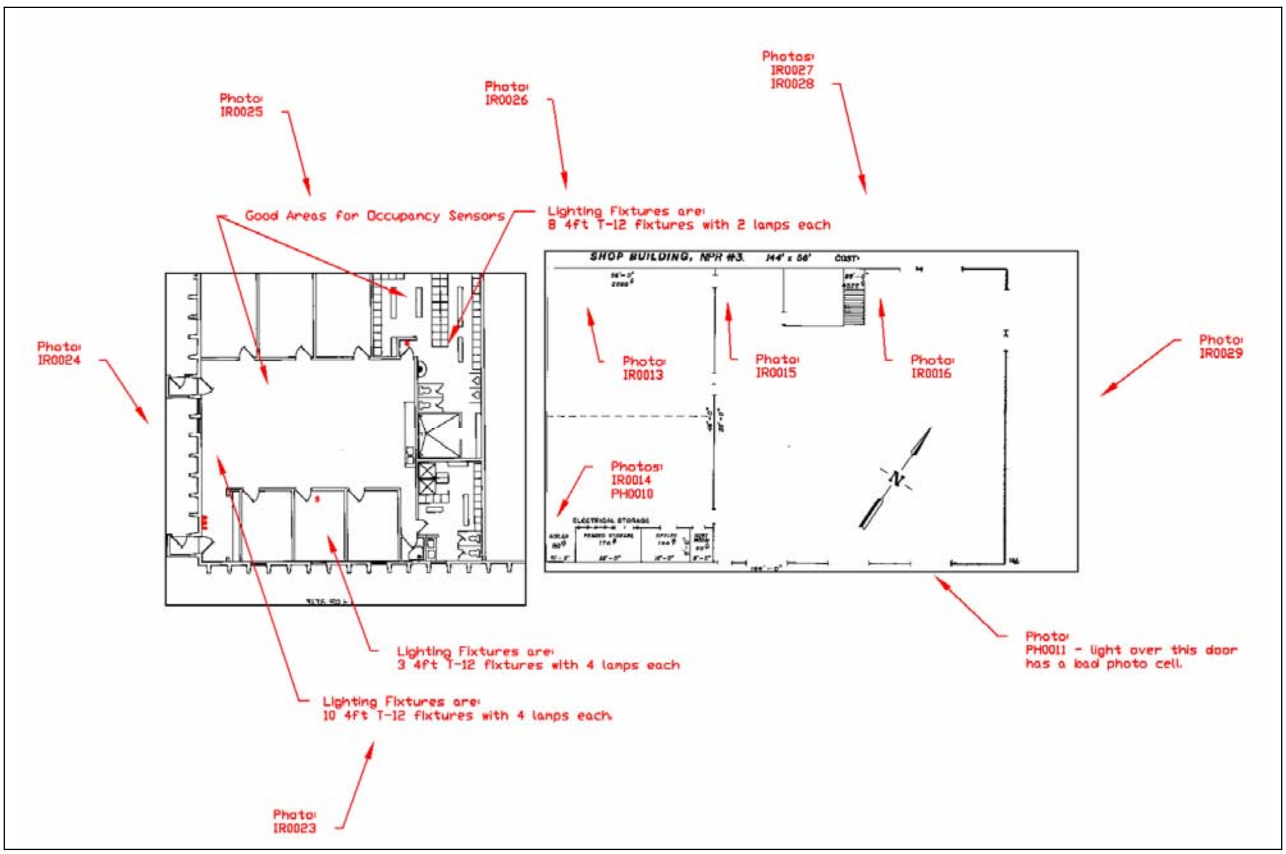

Figure 27 Lower Office/Shop Building Observations.

Occupancy Sensors

The following lamp types were left on:

- 8 4ft T-12 fixtures with 2 lamps each (fixture wattage is: 65.5 watts)
- 13 4ft T-12 fixtures with 4 lamps each (fixture wattage is: 131 watts)

Calculations:

(8 fixtures x .0655 kW/fixture) + (13 fixtures x .131 kW/fixture) = 2.227 kW

2.227 kW x (10 hrs/day x 4 days/week x 52 weeks/year)(50%) = 2,316.1 kWh

2,316.1 kWh x $.0178/kWh = $41.23

Cost of project with a 5 year payback = $206.13

This building could use a total of 3 occupancy sensors. The switch-mounted sensor could go in the office and a ceiling sensor in the break room and the men's locker room. This could cost around $450 for equipment. If the lights are consistently being turned off when people go home then this would not be a good project.

If the lights are being left on during back shift or non-normal working hours then:

(Assuming the rooms are vacant 50% of the time)

2.227 kW x (24 hrs/day x 7 days/week x 52 weeks/year)(50%) = 9,727.5 kWh

9,727.5 kWh x $.0178/kWh = $173.15

Cost of project with a 5 year payback = $865.75

So, if the lights in these areas are being left on after normal working hours then it would be a reasonable project.

Building Photos

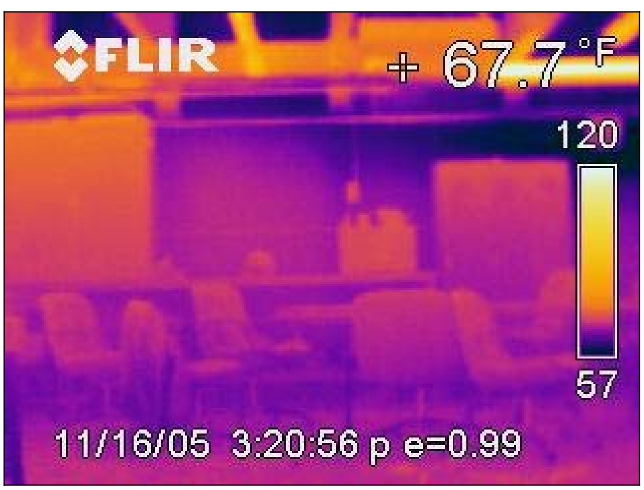

Figure 28 (IR0013) Northwest corner of 1st floor.

In figure 28 in the upper right hand corner is an un-insinuated hot water line. Insulating the line would, at least insure more heat at the location where the heater coils are located.

Figure 29 (IR0014) Un-insinuated hot water lines.

Figure 30 (PH0010) Un-insulated hot water lines.

In figures 29 and 30 there are un-insulated hot water lines in IR and normal photos or views.

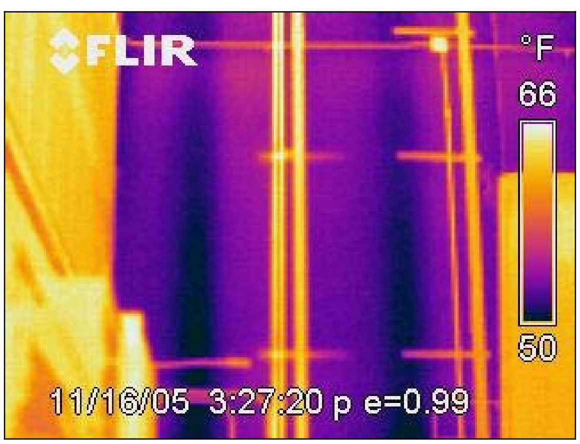

Figure 31 (IR0015) Inside of the Northwest wall.

Figure 32 (IR0016) Inside of Northwest wall.

In figures 31 through 32 show some of the conduits/lines that are warmer than the wall.

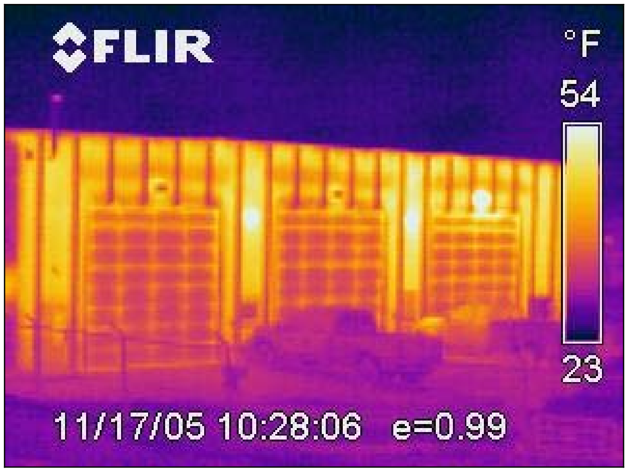

Figure 33 (IR0023) Front of the Shop area with 1 outside light on.

Figure 34 (PH0011) Front of the Shop area with 1 outside light on.

In figure 33, 38, and 39 the overhead doors look to have more insulation than the walls. Figures 33 and 34 show an outside light, above one of the overhead doors that is on during the day. The photo cell on that light fixture should be cleaned or replaced.

Figure 35 (IR0024) Entrance into Lower Office area.

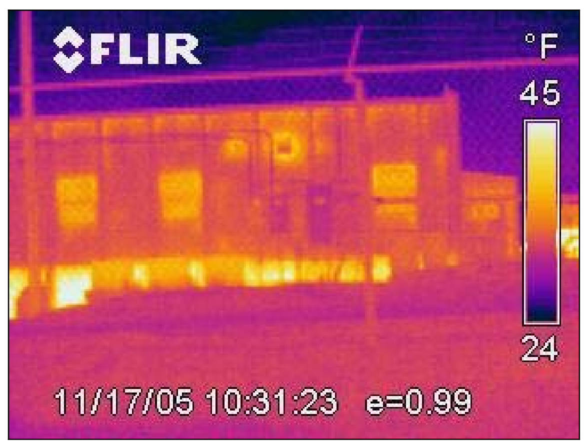

Figure 36 (IR0025) West Northwest corner

In figures 36 and 37 the difference between the insulation upstairs and downstairs is seen with the darker color indicates some form of insulation or extra material that the heat needs to travel through to get outside.

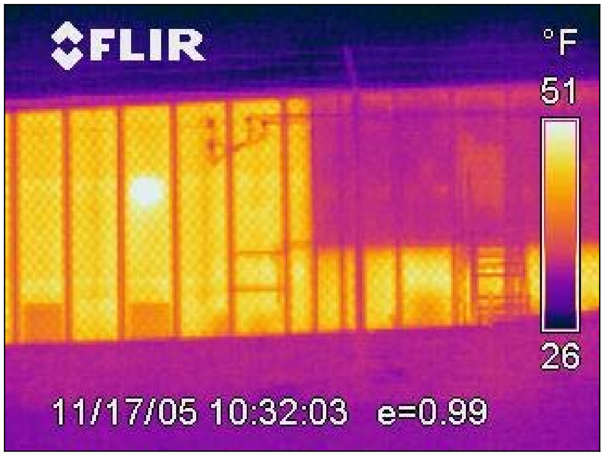

Figure 37 (IR0026) Northwest wall exterior.

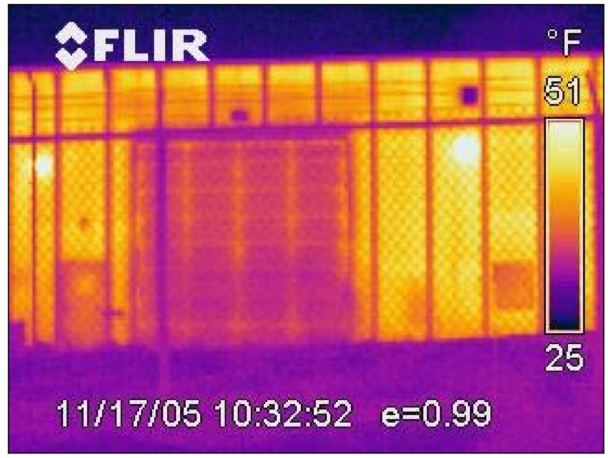

Figure 38 (IR0027) Northwest overhead door.

The bright spots on the walls could be where there are lights mounted on the walls, inside the building (figures 37 through 39).

Figure 39 (IR0029) The Northeast wall.

Insulation Calculations

Because the walls need insulation, the following calculations estimate energy savings that would be obtained if even a two inch layer of "Spray Applied" Polyurethane Foam is added to the inside of the walls exposed to the outside air.

Assumptions for all buildings:

- The average Heating Degree Days (HHD) (based on 55°F) for the RMOTC (Midwest) is 4582 °F Day

- R-values taken from Pedersen, Curtis, 1989, *Cooling and Heating Load Calculation* Principles, Atlanta, Georgia, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

- Propane is used to heat the building. (Propane was used because it is being considered for use in buildings and no cost for Natural Gas was determined).

- Propane cost is equal to what RMOTC can sell it for, which is $1.15/gallon.

- Boiler Efficiency = 70%

- Only considering the walls exposed to outside air of the shop and storage/downstairs office area.

    - ½ of the storage/downstairs office area is exposed to the outside air

    - none of the Southwest wall is exposed to outside air.

Wall Area Calculations:

# of personnel doors: 3

Area of personnel doors: 3 ft x 7 ft = 21 ft^2 (assumed dimensions)

Total personnel door area: 3 x 21 ft^2 = 63 ft^2

# of overhead doors: 5

Area of overhead doors: 12 ft x 12 ft = 144 ft^2

Total overhead door area: 5 x 144 ft^2 = 720 ft^2

Shop Wall Area

3 x (88 ft x 20 ft) = 5,280 ft^2

Storage/Downstairs Office Area

2 x (56 ft x (11 ft / 2)) = 616 ft^2

Total Gross Area = 5,280 ft^2 + 616 ft^2 = 5,896 ft^2

Subtract Doors & Vent (Assume one 3 ft x 3 ft vent = 9 ft^2)

5,896 ft^2 – (63 ft^2 + 720 ft^2 + 9 ft^2) = 5,104 ft^2

Existing Wall R-value

Outside Surface Resistance (AO) $= 0.33 \dfrac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$

8 inch Heavy Weight Concrete (C10) = $0.67 \dfrac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$

Inside Surface Resistance (EO) $= 0.69 \dfrac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$

$$R_O = (0.33 + 0.67 + 0.69)\frac{ft^2 \cdot {}^\circ F \cdot hr}{Btu} = 1.69 \frac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$$

Proposed Wall R-value

Outside Surface Resistance (AO) $= 0.33 \dfrac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$

8 inch Heavy Weight Concrete (C10) = $0.67 \dfrac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$

2 inch “Spray Applied” Polyurethane Foam = $11.12 \dfrac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$

Inside Surface Resistance (EO) $= 0.69 \dfrac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$

$$R = (0.33 + 0.67 + 11.12 + 0.69)\frac{ft^2 \cdot {}^\circ F \cdot hr}{Btu} = 12.81 \frac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}$$

Heat Transfer Coefficients

U_o = Existing Wall Heat Transfer Coefficient

$$U_o = \frac{1}{R_O} = \frac{1}{1.69 \frac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}} = 0.5917 \frac{Btu}{ft^2 \cdot {}^\circ F \cdot hr}$$

U = Proposed Wall Heat Transfer Coefficient

$$U = \frac{1}{R} = \frac{1}{12.81\frac{ft^2 \cdot {}^\circ F \cdot hr}{Btu}} = 0.0781\frac{Btu}{ft^2 \cdot {}^\circ F \cdot hr}$$

Heat Loss Savings

$$Q = A \cdot (U_O - U) \cdot HDD \cdot \left(24\frac{hr}{Day}\right)$$

Where: A= Wall Area to be insulated

$$Q = 5{,}104\,ft^2 \cdot (0.5917 - 0.0781)\frac{Btu}{ft^2 \cdot {}^\circ F \cdot hr} \cdot (4{,}582^\circ F \cdot Day) \cdot \left(24\frac{hr}{Day}\right) = 288.3 \times 10^6\,Btu$$

Propane Savings

$$\text{1 Gallon of Propane} = 91{,}600\frac{Btu}{Gallon}$$

Boiler Efficiency = 70%

$$288.3 \times 10^6\,Btu \cdot \left(\frac{1}{91{,}600\frac{Btu}{Gallon}}\right) \cdot \left(\frac{1}{70\%}\right) = 4{,}495.8\,Gallons$$

Cost Saving

(4,495.8 Gallons) x ($1.15/Gallon) = $5,170.19/yr.

Generally we consider a project worth doing if we can get a 5 year simple payback. So, if RMOTC could add some insulation to the walls that need it for $25,851 (5 x $5,170) then it would be worth the effort.

NPR #3 Warehouse

The Warehouse is used for storage of spare parts and equipment. The building is heated and is equipped with fiberglass panels that act like a sun roof. The building has space for an office but is currently only manned when someone comes in for parts or equipment. Figure 40 shows the notes that were taken during the visit.

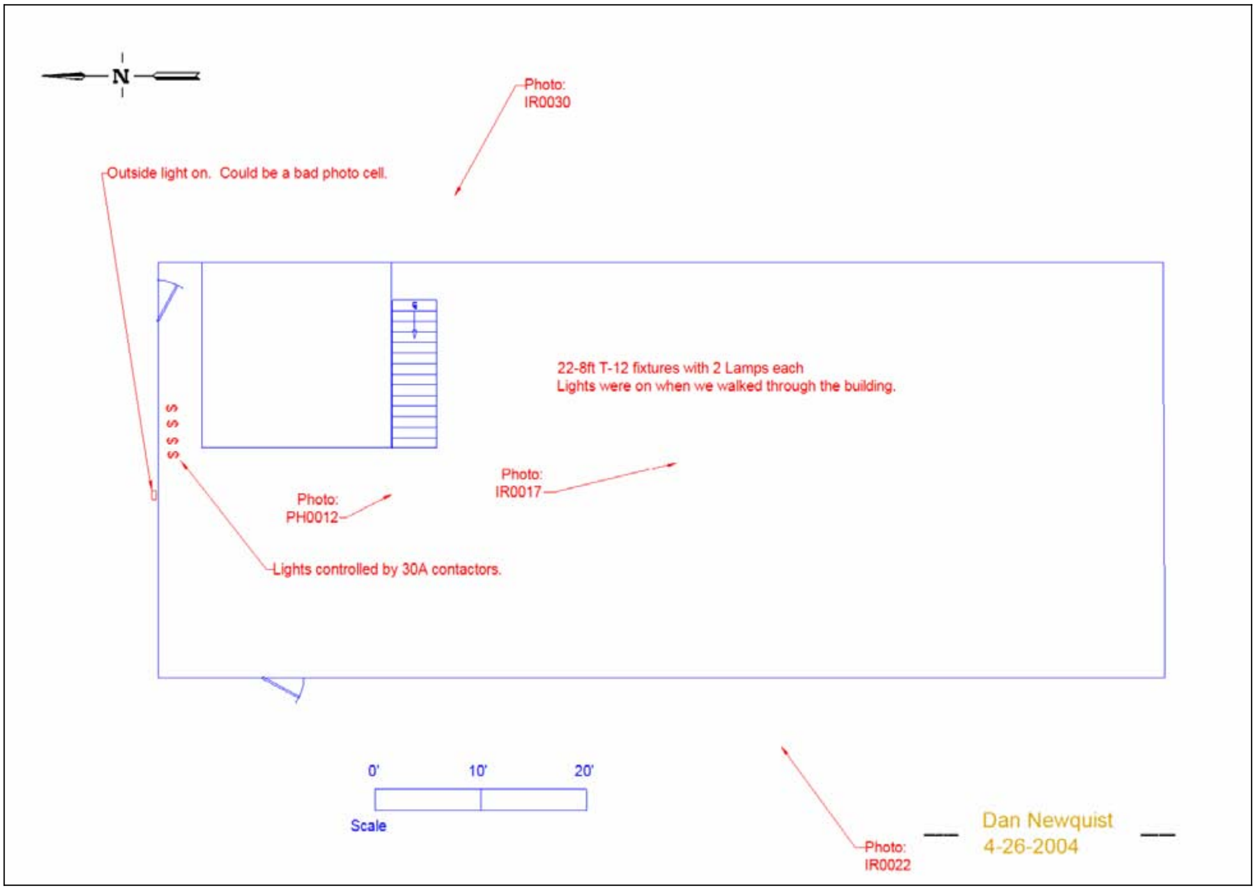

Figure 40 Warehouse Building Observations

Occupancy Sensors

The following lamp types were left on:

- 22-8ft T-12 fixtures with 2 lamps each (fixture wattage is: 107 watts)

  Assume:

  The meeting room and files room are vacant 75% of the work day.

  Calculations:

  (22 fixtures x .107 kW/fixture) = 2.354 kW

  2.354 kW x (10 hrs/day x 4 days/week x 52 weeks/year) (75%) = 3,672.2 kWh

  3,672.2 kWh x $.0178/kWh = $65.37

  Cost of project with a 5 year payback = $326.83

The best thing to do would be to tell the employees to turn off the lights when they leave. But, if that doesn't work, it may be worthwhile to look into switch mounted timers. The same manufacturers that sell occupancy sensors also sell switch mounted timers that have a digital display and are capable of sending optical (flash the lights) and audio (beep) signals when the timer is running out of time. The current setup looks like the light switches are hooked up to some relays and maybe a time clock. It was difficult to determine if the current setup would support switch-mounted timers. An Electrician would be able to determine compatibility.

Building Photos

Figure 41 (IR0017) Warehouse Ceiling

Figure 42 (PH0012) Warehouse interior

From figures 41, 43, and 44 it looks like the sky lights are the biggest area where heat loss is occurring. However, the sky lights are allowing enough light in, during the day, that the lights wouldn't need to be turned on.

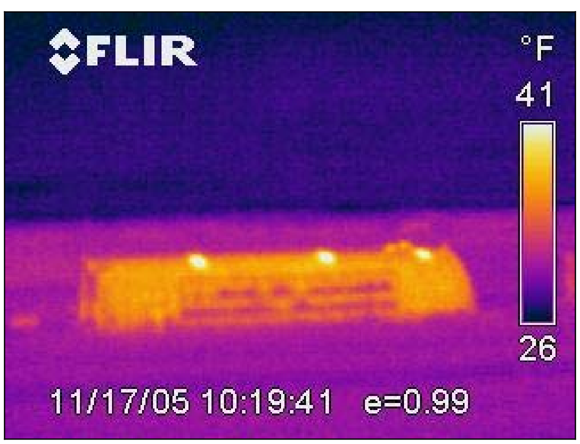

Figure 43 (IR0022) The Warehouse from the Southwest.

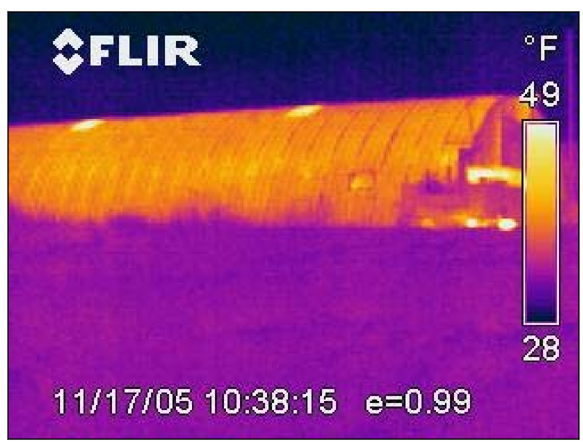

Figure 44 (IR0030) The Warehouse from the Southeast.

LTS Gas Plant Office

The Gas Plant Office is a manufactured building that houses office, locker/change room, class/briefing room, lunch room, and restroom spaces. The building is occupied intermittently though out the shift periods.

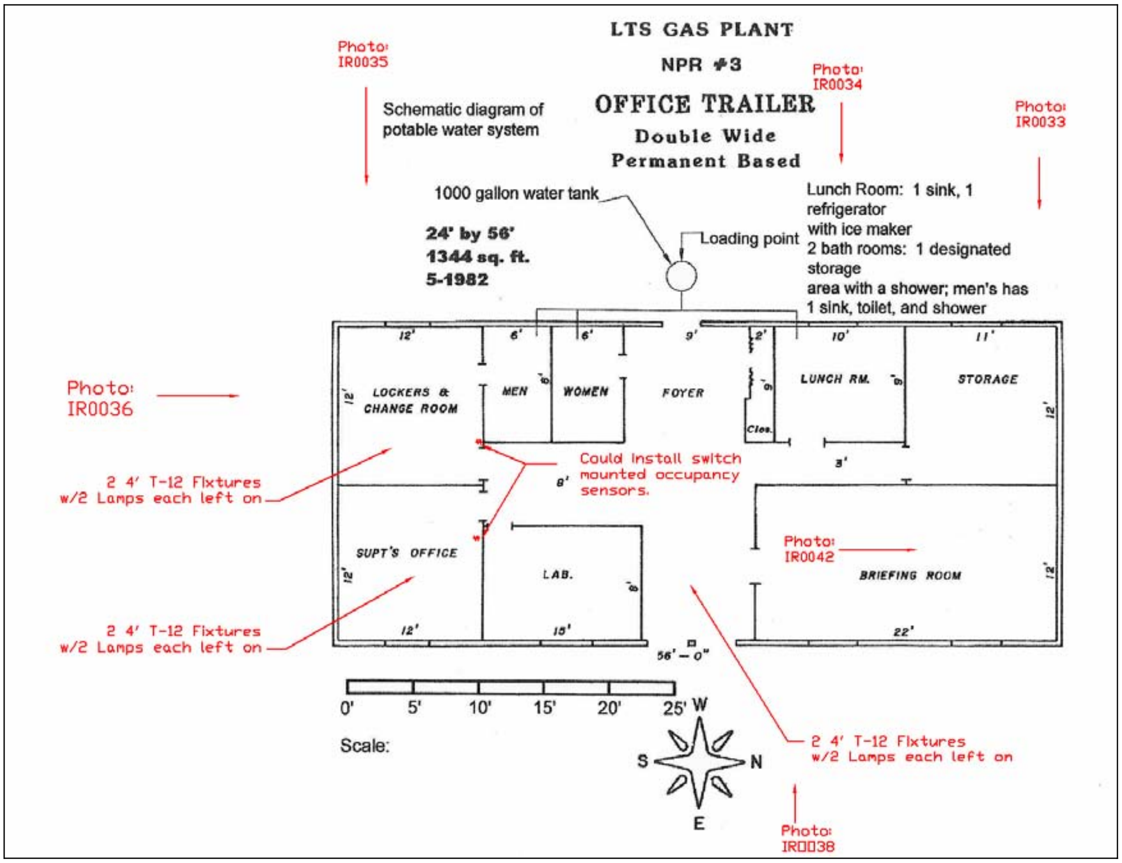

Figure 45 Gas Plant Office Building Observations

Occupancy Sensors

The following lamp types were left on:

- 6-4ft T-12 fixtures with 2 lamps each (fixture wattage is: 65.5 watts)

  Assume:

    The Gas Plant Office Trailer is used 24 hrs/day 7 days/week 52 weeks/year

    These spaces are unoccupied 75% of the time

  Calculations:

    (6 fixtures x .0655 kW/fixture) = .393 kW

.393 kW x (24 hrs/day x 7 days/week x 52 weeks/year)(75%) = 2,574.9 kWh

2,574.9 kWh x $.0178/kWh = $45.83

Cost of project with a 5 year payback = $229.17

This building could use a total of 3 occupancy sensors. The switch-mounted sensors could go in the Supply Office and the Locker Room. A ceiling sensor could go in the entrance. This could cost around $375 for equipment. So, the project would not be feasible and having employees turn the lights off when they leave would be the best.

Building Photos

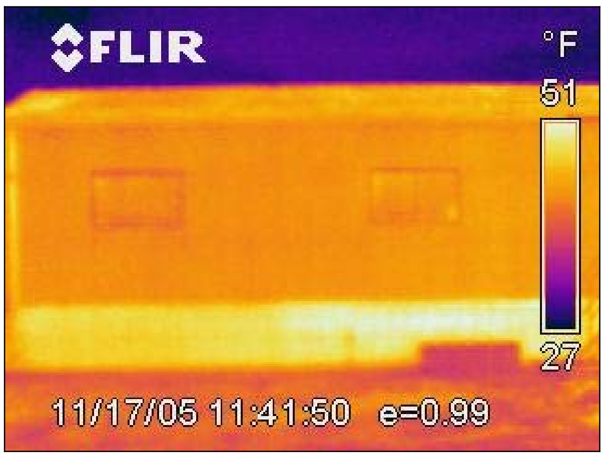

Figure 46 (IR0033) Northwest corner of Gas Plant Office.

Figure 47 (IR0034) West door of the Gas Plant Office.

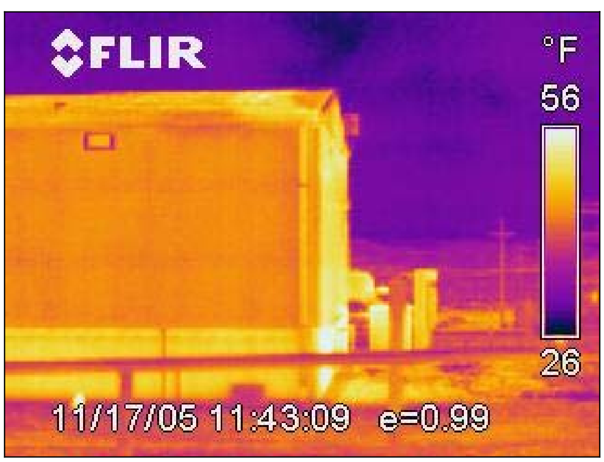

Figure 48 (IR0035) Southwest corner of the Gas Plant Office

Figure 49 (IR0036) South side of the Gas Plant Office.

Figure 50 (IR0038) East side of the Gas Plant Office.

Figure 51 (IR0042) Inside the Briefing Room looking at the North wall.

In figures 46-50 the brightest area seems to be the crawl space underneath the building. We would recommend installing a fiberglass board or batting insulation in this area. While performing a search for mobile home insulation on the internet a product was found, which may help, by Reflectix Inc. This product appears to be a type of bubble rap with foil on both sides. The company claims that it can reflect 97 % of the radiant heat. The product looks to be easily installed and available at major home improvement stores like Home Depot and Lowes.

Figure 51 is showing the studs in the wall as darker than the other part of the wall. The studs can even be seen through the chalk/dry erase board.

SUMMARY OF RECOMMENDATIONS

Table 3 summarizes the recommendations discussed in the previous sections; however, for this table, the recommendations are listed by order of priority. The high priority items are those that will directly save energy costs immediately upon completion, or will assist the RMOTC staff with their operational priorities. Medium priority items will save a small amount of energy or should be further investigated to ensure they fit with current RMOTC operational priorities. Low priority items will save little or no energy but will provide RMOTC employees with an enhanced working environment.

The recommendations are also identified by estimated costs. Low/no cost means that the recommended action can be accomplished with in-house labor without significant time requirements. Low cost means that it can be completed with in-house labor and minimal material costs. Medium cost means that some amount of capital funds will be needed and that the RMOTC staff may choose to subcontract the work. High cost would indicate a capital-intensive project that would also require significant design and engineering efforts.

Table 3. RMOTC ALERT Energy Conservation Recommendations Summary.

Priority	Facility and Recommendation	Cost	Savings	Comments
High	**Gas Plant Motors** Install a soft start on the gas compressor motors (700 and 400 hp). The savings should be significant if the utility meter uses peak demand logging.	High	Demand and some maintenance saving (≈$15K - $30K/yr)	The soft start will lessen mechanical stress on the motors and reduce electrical demand, depending on how the utility calculates demand.
High	**Variable Frequency Drives (VFD)** Install VFDs on the gas compressor motors (700 and 400 hp). This would allow the compressor power to better match the load. Depending on how close or far from full load the compressors are. This could be significant. (If this recommendation is followed, the soft start option would be included.)	High	Depends on actual compressor loads	VFD's incorporate soft start plus can help with matching the power to the load if the load is variable or below the full load of the compressors.
High	**Science Center** Close vents in ceiling (Winter Time).	Low (Easy Fix)	Med/High	If the building is heated at all during the cooler months the hot air can go right up and out the vents.
Med	**Lower Office/Shop** Insulate un-insulated walls.	Med	Energy (≈$5,170/yr)	Assuming something could be done for ≈$25,851 (5 year simple payback)
Med	**Lower Office/Shop** Insulate hot water lines (for domestic and heating uses) .	Low	Med/ Low	This will allow better control of hot water and possibly reduce over heating of downstairs areas.

Table 3. RMOTC ALERT Energy Conservation Recommendations Summary.

Priority	Facility and Recommendation	Cost	Savings	Comments
Med	**Field** Reduce motor sizes and increase pump efficiencies whenever feasible for surface and oil pumps. (Pacific Power Recommendation)	Med/ Low	Med/ Low	Each change should be studied before implementation to make sure it makes economic sense.
Med	**Gas Plant Office** Insulate crawl space/skirt around office building space.	Med/ Low	Med	From the IR photos there is a significant difference in heat loss between the building and the crawl space. Maybe even more than the 1st and 2nd floors of the Lower Office/Shop.
Low	**Occupancy Sensors Various Buildings** Due to the low cost of electricity occupancy sensors are marginal the best location would be areas where lights are left on after normal working hours.	Low	Low	If lights are being left on after normal working hours, the recommendation would be more feasible.
Low	**Weather striping on Doors** Install weather stripping on doors with drafts	Low	Low/Med	This should be worth the effort, especially if it is windy.
Low	**Science Center** Fix insulation in Northeast corner.	Med	Med/Low	If the building is used much during the winter months, a greater savings or benefit would be realized.

PURPA PROJECT POSSIBILITIES

Figure 52 Ascension Island Wind Turbine

RMOTC has multiple possibilities for small power generation at their site. The most likely scenario would be a Public Utility Regulatory Policies Act (PURPA) qualifying-facility project. Possible generation sources at RMOTC could include wind turbines, propane gas generators, micro-turbines, and Stirling engine or similar power generation systems.

The PURPA project size limit in Wyoming is currently one Megawatt, and the PacifiCorp rate schedule developed for payment to these types of projects is called Schedule 37. That rate schedule looks reasonably promising economically for a small wind power project, and it would be best if the project could qualify for the firm rates identified in that Schedule.

RMOTC has worked with NREL to perform initial wind energy feasibility and wind data assessment at their site. New sites that are candidates for wind data towers and eventually wind turbines have been identified in that study. INL agrees with many of the study findings and believes that further wind data analysis and wind power feasibility studies are worth pursuing. The new site identified just to the Northwest of the gas plant appears to be the best location for further wind data collection and wind turbine project planning, as it would be relatively easy to tie wind turbines into the existing power grid from there and the wind in that area appears to be in the Class 4 range. This appears to be the most realistic site for wind power development at RMOTC, as the higher ridges are under different ownership and are much less accessible for any type of construction.

To explain the estimate of Class 4 designation, there are 7 classes of wind energy, Class 7 being highest. Most economically successful wind farms/turbines are constructed in wind regimes between Class 3+ to Class 6. Class 4 means the average wind speed at a site is between 15.7 and 16.8 mph at 50 meters above the ground, which is a "good" resource potential and gives a wind project a good chance to be economically successful.

INL has started initial discussions with PacifiCorp about a potential PURPA project there. PacifiCorp is open to the idea and appeared to be willing to work through certain issues that would pertain to this type of project. Some of those issues include:

- Who owns (and who maintains) the power distribution system that runs through the RMOTC property

- Would a PURPA type of project need to tie into the existing electrical grid on the utility side of RMOTC's existing service meter, or could it tie in somewhere else on the RMOTC grid and be submetered (initial talks with PacifiCorp indicated that submetering was a good possibility)

- If a PURPA project was submetered, would this prevent a change in rate schedule for RMOTC (we don't want to do a project if it's going to force the utility to change RMOTC's rate schedule from Schedule 46 to Schedule 33)

- Could a propane generator be incorporated into a PURPA project for some power firming without keeping the project from obtaining Qualifying Facility status

- Could a wind power project get the firm prices on Schedule 37 without having any firming power at the project location

Since the PURPA size limit in Wyoming is relatively small (1 MW), the utility may be less resistant to working with somebody to incorporate that type of project into their grid. An ideal project for the RMOTC site would be something like one or two wind turbines totaling 600 to 1,000 Kilowatts nameplate, combined with a propane engine generator sized between 250 to 340 KW for firming if necessary.

Inclusion of a propane-fueled generator in a PURPA or other type of project is dependent upon the qualifying facility rules. It would also be heavily dependent on the determination that all or part of the propane currently being generated by the RMOTC gas plant process is a waste stream. RMOTC personnel stated that their propane is currently being sold to an outside purchaser for approximately $1.15 per gallon, but that the local market for their propane was relatively weak and could go away in the near future. If that market was reduced or went away, the propane would become a waste stream. It could then be used for power generation or heating and it would make sense economically. However, $1.15 per gallon equates to about $0.13 per kWh just in fuel cost, which doesn't include generator maintenance and initial cost. The rate schedule for PURPA power generation ranges between \$0.04 and \$0.0756 per kWh. So unless the propane's worth becomes much less than \$1.15 per gallon, generating electricity with it would not make sense economically.

As mentioned above, metering and electrical interconnection points will be critical to the success of a PURPA or other type of power generation project. In order to achieve the best project and RMOTC economics, a new small power plant would need to interconnect electrically at a location where much of the proper electrical equipment already exists, such as at the gas plant substation/switchgear. This would keep electrical interconnect and infrastructure costs way down for the new equipment. Metering will also be a big issue because the best interconnect point is at the gas plant, and this point is on the load-side of the existing utility metering point for the RMOTC site. In order to connect on the utility-side of that meter, several miles of new power line would have to be installed from the wind turbine site and more new electrical interconnect equipment will be required. This will very likely make the economics look unattractive for a small power project.

If the utility will allow the new power project to be submetered (i.e. connected somewhere on the load-side of RMOTC's service meter and metered separately) without affecting the rate structure for the rest of the RMOTC site, then a project may be feasible. In initial discussions with PacifiCorp, they indicated that submetering may be a possibility for this type of project.

Other possibilities for RMOTC on-site power generation include Stirling engine electrical generation using the hot water from the submersible pump system or using that heat to drive some sort of Stirling pump system for certain oil wells/pumps. RMOTC has had some previous involvement with research and development of the Stirling engine pump system for oil wells and may want to pursue this development further. The idea of generating electricity with a Stirling engine generator would be tougher to implement because of the separate electrical interconnect issues and costs (sub pump area is relatively remote from other buildings and main infrastructure). The low cost of electricity at RMOTC is difficult to compete with, even if one is doing a small, net-metering project such as RMOTC would with a Stirling engine generator system. It is much more likely that a subsidized pilot project or research project would be feasible for testing a Stirling power system at the RMOTC site. Initial calculations also show that the amount of energy that could be extracted from the volume of RMOTC hot water is relatively low (less than 30 kW continuously), so the site may be better served by looking at using the heat for more building heating and cooling (besides just the heating system in the Science Center building).

ADDITIONAL MEASURES FOR CONSIDERATION

Additional strategies to assist in the RMOTC staff's energy consumption reduction efforts can be found in the appendix attached to this report. This appendix provides the RMOTC staff with addition information that can be incorporated into their continuing renovation projects and future new building designs. This appendix is meant to complement their current existing energy efficiency operations practices. The appendix lists various energy efficient design parameters and technologies that should be considered for any new building design, existing building modification, or complete building renovation. The concepts discussed in this appendix should always be considered but may not always be included due to cost constraints, building configuration or use.

Occupancy Sensors

There are three manufactures of occupancy sensors for lighting controls that the INL has used in the past. An internet search may bring up more. The following lists the three:

- http://www.wattstopper.com/
- http://www.hubbell-automation.com/
- http://www.novitas.com/

Electric Distribution

Two common areas to save operational costs on distribution systems are electric energy costs due to equipment and system losses, and maintenance and repair costs to operate older electric distribution equipment. Infrared thermography can be used to identify loose connections and aging switchgear when performing a distribution system upgrade. Any connection or component that is generating heat needs to be either tightened or replaced.

Assuming that all electric lines are in good condition and are sized correctly for the existing and anticipated loads, the transformers are a natural opportunity to obtain additional energy savings. Generally, the energy savings gained through the installation of energy efficient power transformers is not enough to justify replacing and operating transformer simply to obtain the additional energy savings. However, when transformers need to be replaced due to operational, repair, or upgrade purposes, then the additional cost of high efficiency transformers can usually be justified. In addition to energy efficiency benefits, transformers are now being manufactured with hermetically sealed cases and internal lighting rods that can result in improved maintenance and operational benefits.

As an example of a transformer replacement project, the INL installed a series of nine amorphous core transformers to replace the City of Idaho Falls owned transformers in one of its laboratory complexes. These new high efficiency transformers ranged in size from 300 kVA to 2,000 kVA and replaced units that were up to 18 years old. This project resulted in a rate structure change due to an ownership change of the transformers and provided over $54,000 per year in energy cost savings. In addition to the rate related savings, the new transformers provided electric savings of 118,037 kWh annually for a total of $3,246 using an electric rate of $.0275/kWh. These savings represent an average of 1.4% of the total annual usage and cost for the complex.

IMPLEMENTATION STRATEGY

Project Financing

The RMOTC staff can pursue alternative project financing mechanisms. Energy Savings Performance Contracts (ESPC) and Utility Energy Services Contracts (UESC) should both be further investigated as a means to implement the recommendations suggested in this report as well as for future renovation projects that the RMOTC staff is planning.

A UESC may be the best choice for upgrading the motor controls in the Gas Plant. An ESPC could be best suited for the development of power generation at the RMOTC, if found feasible.

Alternative financing programs tend to be dynamic. Opportunities to develop an ESPC or UESC should be discussed with the Seattle Regional Office to determine the current program requirements and availability of contractors that can cost-effectively implement these programs at RMOTC.

Further information on both ESPC and UESC opportunities can be found by selecting the financing link at http://www.eere.energy.gov/femp/.

Energy Savings Performance Contracts

Energy Savings Performance Contracts (ESPC) are mechanisms of project financing where the government enters into a contract with an Energy Services Contractor (ESCo) to design, and implement an Energy Conservation Opportunity (ECO). The ESCo secures financing, designs the project, and installs the equipment or system. The government then pays for the project directly to the ESCo from energy savings over the period of the contract. These types of contracts are especially useful for government agencies that do not have the up-front capital to implement large project opportunities. Outside of administrative support to the effort, there is essentially no cost to the government as the contracts are repaid with saved energy costs that would have gone to the utility anyway. The primary contact for this program is Scott Wolf (Scott.wolf@ee.doe.gov, at the DOE Seattle Regional Office (206-553-2405).

Utility Energy Services Contracts

Utility Energy Services Contracts (UESCs) are similar to ESPCs except that the local utility does not provide a performance guarantee. These types of projects are offered by many utilities and usually are less expensive to implement. They can include a variety of services from financing only to full project management services. Pacific Power Corporation does offer a program called FinAnswer as discussed in the Energy Analysis Report from Cascade Energy Engineering, Inc. and Pacific Power Corporation (9/28/2005 pg 25).

APPENDIX A
Energy Efficiency and Sustainable Design

Energy Efficiency and Sustainable Design

This appendix was developed to provide the RMOTC staff with addition information that can be incorporated into their continuing renovation projects and future new building designs, if applicable

This appendix lists the various energy efficient design parameters and technologies that should be considered for any new building design, existing building modification, or complete building renovation. The concepts discussed in this appendix should always be considered but may not always be included due to cost constraints, and building configuration or use.

Design References

1. ANSI/ASHRAE/IESNA Standard 90.1-2001 – Energy Standard for Buildings Except Low-Rise Residential Buildings

2. Code of Federal Regulations, 10 Energy, Part 434 – Energy Code For New Federal Commercial and Multi-Family High Rise Residential Buildings (1-1-05)

3. U.S. Green Buildings Council – Whole Building Design Guide and the Sustainable Building Technical Manual among others, located at www.wbdg.org.

References 1 and 2 contain general design criteria concerning energy loads, maximum lighting levels, minimum insulation performance, etc. Of these two references, Standard 90.1-2001 is the more stringent and is favored by the Federal Energy Management Program (FEMP).

Reference 3 contains a vast amount of information from the U.S. Green Buildings Council concerning energy efficient and sustainable design. This reference contains very detailed information from multiple sources.

Suggested Minimum Design Criteria

The remainder of this appendix consists of energy efficiency and sustainable design checklists that have been developed by the Idaho National Laboratory (INL) for use during new building designs and modification projects. These checklists provide the user with a method to consider energy conserving technologies and concepts for the primary energy consuming building systems.

These checklists are not intended to be all-inclusive, but rather are intended to direct the user in proactive direction toward further investigation of and implementation of energy efficient and sustainable technologies.

The RMOTC staff is encouraged to use these checklists in whatever manner they see fit including tailoring them to meet specific criteria for buildings and structures particular to the Tea Pot Dome area. They can be used internally or can be freely given to an outside A/E firm.

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ____ Project #: ________________

Designer: ____ Date: ___________________

Lighting Systems

☐ *Has an effort been made to limit lighting levels to the minimum needed to meet IES and Energy Efficiency standards?*

The IES Handbook lists many lighting applications with ranges of illumination levels that are presented as guidelines. The ranges are given so that the designer can provide light dependent upon the exact nature of the task, occupant's needs, and interior configuration.

The following illumination levels provide a general guide for typical work areas:

- Work station surfaces: **50 foot candles** (measured at 30" above floor level)
- Work areas: **30 foot candles** (measured at 30" above floor level)
- Non-work areas: **10 foot candles, but not less than 1 foot candle** (measured at the walking surface)
- Elevator boarding areas: **5 foot candles**
- Middle of corridors and stairwells: **1 foot candle minimum**
- Storage areas: **10 foot candles**.

☐ *Have daylighting strategies been considered?*

Daylighting generally means that building orientation, window size, light shelves, and daylighting controls have been taken into account to harvest as much natural light as possible and then turn off building lighting circuits when natural light levels are sufficient.

☐ *Has task lighting been considered?*

If task lighting for desktop or bench top work is provided, the general area lighting can often be designed at lower light levels than when task lighting will not be a part of a facility design or planned operations.

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ______________________________ Project #: ______________

Designer: ________________________________ Date: ________________

Task lighting also allows for general area lighting systems to remain shut down during off-hours periods when only one or two employees are working.

☐ *Have compact fluorescent lamps been considered?*

Incandescent lamps should not be used at all. Applications that have historically used incandescent lamps should now only have compact fluorescent lamps specified.

Existing incandescent lamps should be replaced with compact fluorescent lamps whenever possible.

☐ *Have efficient exit lighting fixtures been specified?*

Single Sided: **5 watts or less**

Double Sided: **10 watts or less**

Note: LED exit light fixtures are an excellent choice for low maintenance and energy use. Photo-luminescent exit signs should also be considered for areas with consistent lighting levels and occupancy. INL Energy Management has a supply of photo-luminescent exit signs.

☐ *Has T-8 fluorescent technology been specified?*

Standard fluorescent technology is now T-8 lamps with electronic ballasts. Ballasts should be selected as follows:

Frequent switching (3 hr cycles or less): specify **rapid start ballasts**

Longer lighting cycles (12 hrs typical): specify **instant start ballasts**

Ballasts with a low ballast factor (.77 to .87) should be chosen since they will perform with lower energy use.

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ____ Project #: ________________

Designer: ____ Date: ___________________

☐ *Have low mercury lamps been considered?*

If the facility is located in an area that typically sends used lamps to a landfill, then low mercury lamps should always be specified. If the facility will be located where used lamps are typically crushed and recycled, then low mercury lamp selection would be at the discretion of the designer with consultation from the facility or area manager.

☐ *Have efficient HID lamps been specified?*

If High Intensity Discharge (HID) fixtures are specified, select the most energy efficient type that will provide the needed color rendering for the application. Remember to research the application to determine if a more energy efficient type can be used! Typical applications include:

Exterior: **Low or High Pressure Sodium**

Interior: **High Pressure Sodium or Metal Halide**

Alternative Technology: **Multiple Lamp Compact Fluorescent Fixtures or T5 fluorescent fixtures**

☐ *Has a lighting control system been considered that will automatically control all of the individual lighting fixtures and systems?*

For large multi-use facilities, a complete lighting control system should be specified that will control the lighting according to work schedules.

☐ *Have motion sensors been specified?*

Motion sensor controls should be specified to control all common use areas. The following types of technologies are available:

Passive Infrared (PIR): Offices, classrooms, conference rooms, and other areas that provide a direct line of sight to the sensor.

Ultrasonic: Restrooms, libraries, and other areas where the area is typically cluttered or equipment and machinery can block a direct line of sight.

Dual Technology: Cubicle areas and other areas with difficult environments such as high or inconsistent air flow.

☐ *Has outside lighting for parking lots been configured and zoned so some or all of the fixtures can be turned off during low use periods?*

☐ *Has the outside lighting of neighboring facilities been taken into account when determining the outside lighting needs for a new facility?*

☐ *In all cases, have the most energy efficient lighting systems been specified that will meet the performance need?*

HVAC Systems

☐ *Will the specified HVAC system be <u>incapable</u> of simultaneous heating and cooling?*

Simultaneous heating and cooling has historically been an effective method to control building temperature but has been proven to be a significant waste of energy. New HVAC system designs or modifications must not operate with the principle of simultaneous heating and cooling.

☐ *Have electronic temperature controls been specified that are capable of being programmed to set-back the temperature whenever the facility is unoccupied?*

The following temperature settings provide a general guide for typical work areas during off hours:

Heating: **55° F**

Cooling: **System turned off**

☐ *Have economizer controls been considered?*

Economizer controls open dampers to bring in additional outside air to cool the facility during cooler weather. Economizer controls should be standard in building designs to take advantage of the significant amount of cooler weather at the INL.

☐ *Have efficient chillers been specified?*

The efficiency recommendations for large chillers (175 to 1600 tons) as described in ARI Standard 550-92 are as follows:

Full-Load (kW/ton)

Centrifugal: **0.60 or less**

Rotary Screw: **0.65 or less**

Integrated Part-Load Value (IPLV) (kW/ton)

Centrifugal: **0.56 or less**

Rotary Screw: **0.59 or less**

Note: Reciprocating chillers do not meet the given efficiency levels.

☐ *Have heat recovery systems been considered?*

Laboratory, industrial, and process facilities that utilize once through 100% fresh air are always good candidates for heat recovery systems.

☐ *Have de-stratification strategies been considered to cycle trapped warm air from the ceiling level back down to the floor level?*

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ______________________________ Project #: ______________

Designer: ______________________________ Date: ______________

☐ *Has properly sized equipment been specified?*

Oversize equipment is generally not energy efficient while undersize or misapplied equipment will not adequately condition the facility and can be costly to maintain.

☐ *Have heat pumps been considered?*

Geothermal heat pump technologies will work more effectively in regions with cold winter seasons. In general, the ground makes a better heat sink or source than does widely fluctuating air temperatures.

☐ *Have passive solar applications been considered?*

Solar water heating and solar makeup air preheating by the use of a solar wall are the two primary passive solar technologies.

☐ *Has insulation been specified for <u>all</u> refrigerant, steam, and glycol lines?*

☐ *Has protection been considered for outside condensers?*

Wind can carry debris that can damage condenser fins over time. Such damage will reduce airflow and efficiency. Some type of barrier protection should be provided that reduces the potential for fin damage but not reduce airflow to the condenser.

☐ *Has a location for condensers been considered that will provide the least or most solar heat gain as applicable?*

☐ *Have high efficiency motors with variable frequency controllers been considered for all rotating equipment applications?*

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ____ Project #: _________________

Designer: ____ Date: ____________________

Water Usage

☐ *Have low water use fixtures been specified for all casual water use applications?*

Maximum flow for fixtures should be specified as follows:

Sinks and faucets: **2.0 gpm**

Showers: **2.2 gpm** gpm = gallons per minute

Toilets: **1.6 gpf** gpf = gallons per flush

Urinals: **1.0 gpf**

☐ *Has insulation for hot water lines been specified?*

☐ *Has landscaping been selected that will minimize the need for irrigation?*

Trees and shrubs provide shade and windbreaks while grass and high maintenance vegetation requires frequent irrigation and cultivation. Note the examples listed in the Miscellaneous section, which describe the use of deciduous and evergreen trees.

☐ *Have point source or tankless water heaters been considered?*

A significant amount of energy can be lost with long piping runs from a centralized water heating system. Point source water heaters can be used economically where there is a low water need or where long distances would have to be piped. Construction savings are available by not having to run two piping runs to each distant location.

Conversion to tankless water heaters can have two significant impacts 1) energy savings: from the elimination of stand-by losses from a hot water storage tank and 2) maintenance in areas where the water is unusually hard or the tanks need frequent replacement due to high sediment and corrosion.

Project Name: ____ Project #: ________________

Designer: ____ Date: ___________________

For areas where only hand washing or low hot water usage occurs, conversion to smaller 110 volt 2-gallon water heaters will have significant impacts from: 1) energy savings from the elimination of stand by losses from a hot water storage tank, 2) maintenance in areas where the water is unusually hard or the tanks need frequent replacement due to high sediment and corrosion, and 3) costing approximately $100 each, these units are relatively inexpensive and require 110V circuits which may be less costly and more convenient to install than 220V circuits.

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ______________________________ Project #: ________________

Designer: ______________________________ Date: ________________

Building Envelope

☐ *Has weather and prevailing wind direction been considered for the placement of various building openings such as doors, windows, and ventilation intakes to minimize unwanted air infiltration?*

☐ *Has orientation to maximize daylighting been considered?*

North facing windows provide the best daylighting strategies while south and west facing windows provide the best heat gain strategies.

☐ *Have insulated and coated windows been specified?*

Windows should be coated and/or insulated at least as follows:

North facing: **Triple glazing with low e-coating**

South, East, and West facing: **Double glazing with low e-coating**

Note: Very cold regions should consider triple glazing on all windows.

☐ *Have insulated outside personnel doors been specified?*

☐ *Are vestibules part of the design for outside doors? Are the vestibules non-heated?.*

Vestibules are designed into facilities to reduce infiltration of unconditioned air. The primary doors are insulated and weather-stripped whereas the secondary doors (either inside or outside) are typically not insulated and are not weather-stripped.

Project Name: ____ Project #: ________________

Designer: ____ Date: ___________________

Vestibules are often designed with fire sprinklers which then must be protected from freezing. This is accomplished by installing a heater in the vestibule or by propping the inside vestibule doors open during the winter. These practices negate the benefits of the vestibules. As is appropriate and whenever possible, vestibules should be specified without heat or sprinkler systems.

☐ *Have insulated equipment and garage doors with use-appropriate weather-stripping been specified?*

☐ *Has the appropriate amount of insulation been specified?*

☐ *Have materials been considered for construction that will provide the highest insulating benefit?*

☐ *Have daylighting strategies been considered to decrease the need for installed lighting been considered?*

Daylighting strategies include appropriately placed windows, skylights, light shelves, and related controls for installed lighting systems.

☐ *Have interior and exterior treatments been considered that will reduce the need for energy use (such as dark exteriors and light colored interiors)?*

Building Control Systems

☐ *Have as many systems as possible been specified to be controlled by an automated system so they can be optimally controlled and so individual systems cannot be inadvertently left on by the tenants?*

☐ *Has a complete building control system been considered that will control all building functions including lighting, HVAC, and other systems such as safety alarms?*

☐ *Is the selected building control system compatible with other existing building control systems at the INL so they can be networked together as is applicable?*

Miscellaneous Considerations

☐ *For energy intensive or special use facilities, have energy efficient strategies such as variable frequency drives, combined heat and power, alternative fuels, and demand side management been considered for processes or equipment while still maintaining performance requirements?*

☐ *Have on-site generation systems been considered to supplement the building energy load? Many of these systems are becoming widely used and may reduce overall life cycle cost of the facility.*

☐ *Have emerging technologies been considered? These technologies should be used as they become cost effective.*

Emerging technologies include alternate fuels, wind, solar, fuel cells, micro turbines, flywheels, and others as they become available and cost effective.

☐ *Has metering been considered that will interface with the building control system so that energy consumption data can be electronically and remotely compiled and used for customer charge-back strategies?*

☐ *Has sub-metering been considered that will meter each section of the facility that has a different purpose or function?*

A multi-purpose facility should have sub-metering for functional areas such as laboratories, office areas, process areas, etc.

☐ *Has landscaping been considered that will provide the maximum energy benefit for the facility (deciduous trees, shrubbery, earthen berms, etc)?*

Project Name: ____ Project #: ________________

Designer: ____ Date: ___________________

Deciduous trees will provide shade and reduced heat gain in the summer while providing needed heat gain in the winter. Evergreens are effective in providing year round protection from prevailing winds.

Operational and Maintenance Efficiency

☐ *Have administrative controls been put in place to ensure that all employees turn off their computers and lighting systems when leaving work and when not needed during the day?*

☐ *Have computers, printers, fax machines, and copy machines been programmed to take advantage of energy saving sleep and power down features?*

☐ *Have designs been reviewed to ensure adequate access to mechanical and electrical equipment, which ensures ease of maintenance.*

When maintenance is completed correctly, the energy using system is more capable operating efficiently as designed.

☐ *Are procedures in place to ensure that fan coils are regularly cleaned, dampers and damper linkage are tightened and adjusted properly, and filters are routinely replaced?*

☐ *Does the maintenance program inspect outside lights that remain on during the day to ensure that the photocells are clean and capable of turning the light off?*

☐ *Do maintenance personnel or building tenants regularly inspect buildings to ensure that office furniture, stored items, or personal belongings do not impede the airflow from the buildings HVAC system?*

This practice can put a building's HVAC system in an out of balance condition that results in employee discomfort and increased energy use.

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ______________________________ Project #: ______________

Designer: ________________________________ Date: ______________

Resource Efficiency in Construction

Fabrication/Manufacture

☐ *Have building materials been considered that have low energy costs associated with their manufacture?*

☐ *Have materials been considered that contain a maximum of recycled content?*

☐ *Have building materials been considered that have the lowest impact upon the environment for either their manufacture, use, or disposal?*

INL Energy Efficiency and Sustainable Design Checklists

Project Name: ____ Project #: ________________

Designer: ____ Date: ___________________

Design Parameters

☐ *Have changeable or movable materials or systems been considered for facilities that are subject to change. This will result in reduced life cycle demolition and scrap?*

☐ *Has a preference been given to design parameters that are the most space, energy, and resource efficient as possible?*

☐ *Has consideration been given to reducing wasted space attributed to aesthetic purposes whenever possible?*

☐ *Have recycling centers or containers been given consideration for space layout plans?*

Construction

☐ *Have construction processes been considered that are the most energy and resource efficient?*

☐ *Have pre-cut or pre-fabricated materials been considered to reduce on-site waste generation?*

Construction Debris

☐ *Have construction processes been considered that will result in the least amount of left over material needing disposal?*

☐ *For construction processes that will require a large amount of left over material or scrap, have materials been considered that are fully recyclable?*