

Level III Feasibility Report
Energy Evaluation and Recommendations
Glencoe Park District Takiff Center



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Location: 999 Green Bay Road, Glencoe, Illinois 60022

Contact: Steve Nagle, Director of Operations

Phone: (847) 835-7540 snagle@glencoeParkDistrict.com

Auditor: Jean Ascoli, Report Author

Phone: (800) 214-7954, jean@sedac.org

Executive Summary

This report aims to reduce the annual operation costs at the Glencoe Park District Takiff Center (Takiff Center) facility through load reduction and energy efficiency.

The Takiff Center is an 85,000 SF facility that houses park district administrative offices, an early child-hood education program (including a full day preschool), a large gymnasium, multi-purpose classrooms, and community spaces for the village of Glencoe. The original two-story building was built to house an elementary school in 1928, with several one- and two-story additions in the 1950s, 1960s, and 2007.

This report considers six energy cost reduction measures (ECRMs) and one package (that combines all six ECRMs) for application to the facility. The recommended strategies include:

- **ECRM 1 – Gym Lighting Upgrade:** Replace the existing 400-watt metal halide high-bay fixtures in the gymnasium with new 2'x4' six-lamp T8 high-bay high-output (HO) fixtures.
- **ECRM 2 – Roof Insulation:** Increase the roof insulation to a total thermal resistance value (R-value) of R-25 continuous.
- **ECRM 3 – Lighting Upgrades:** Replace the current 32-watt T8 linear fluorescent lamps with 28-watt or 25-watt T8 lamps.
- **ECRM 4 – Reduced Schedule:** Reduce the occupied mode schedules of low-use or intermittently-occupied spaces in the BAS and add occupant override control.
- **ECRM 5 – Bi-level Switching:** Implement bi-level switching throughout the corridors and stairwells in the facility.
- **ECRM 6 – Air Sealing:** Replace weather stripping at doors as needed; in older portions of building, investigate air infiltration and air seal.
- **Package 1 – ECRMs 1 through 6:** Implementation of this package of ECRMs is strongly recommended as this combination of all six measures can reduce both annual facility energy and annual costs by approximately 21%.

The estimated annual cost savings associated with these ECRMs and the ECRM package are reported in Table 1. The estimated first cost and return on investment associated with these ECRMs are also reported. This table presents the results of the life cycle cost analysis performed for the recommended ECRMs. Projects are typically considered attractive if the internal rate of return (IRR) is greater than the discount rate (here 5%) and the net present value (NPV) is greater than zero. Detailed descriptions of these ECRMs and the package appear later in this report.

All ECRMs were modeled individually, without applying the other ECRMs to the building. This treatment will enable the reader to see exactly how each ECRM affects the annual utility bills. The most relevant ECRMs are then modeled together as a package. Note that the use of multiple ECRMs together often results in lower savings than the sum of single ECRMs due to interactions between the strategies.

Table 1: Economic Analysis for the Energy Cost Reduction Measures

	Annual Savings (\$/yr)	\$ Savings %	Initial Investment (\$)	Internal Rate of Return (IRR)	Net Present Value (NPV)
ECRM 1 – Gym Lighting Upgrade	\$2,784	1.8%	\$9,042	27%	\$10,228
with Incentives			\$4,308	64%	\$14,736
ECRM 2 – Roof Insulation	\$8,994	5.9%	\$40,122	22%	\$65,292
with Incentives			\$27,930	32%	\$76,903
ECRM 3 – Lighting Upgrades (3A: 28-watt)	\$4,755	3.1%	\$12,540	35%	\$20,245
with Incentives			\$9,540	48%	\$23,102
ECRM 3 – Lighting Upgrades (3B: 25-watt)	\$7,609	5.0%	\$15,080	49%	\$37,144
with Incentives			\$12,080	62%	\$40,001
ECRM 4 – Reduced Schedule	\$1,741	1.1%	\$10,000	10%	\$2,257
with Incentives			\$7,816	17%	\$4,337
ECRM 5 – Bi-level Switching	\$6,155	4.0%	\$20,328	27%	\$22,292
with Incentives			\$15,203	38%	\$27,174
ECRM 6 – Air Sealing	\$6,623	4.3%	\$20,000	30%	\$25,780
with Incentives			\$10,477	62%	\$34,850
Package 1: All ECRMs	\$31,749	20.7%	\$112,032	24%	\$108,224
with Incentives			\$75,274	40%	\$143,231

Notes to Table 1:

- (1) When ECRMs are implemented as a package, results vary from application of individual ECRMs.
- (2) For Package 1 the savings and investment cost are based on using 28-watt replacement lamps for ECRM 3.
- (3) This analysis does not include a likely increase in energy prices over the analysis period. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (4) The discount rate is assumed to be 5% for public facilities.
- (5) The life cycle used for calculating the IRR and NPV for ECRM 2 is 20 years. All of the other ECRMs (1, 3, 4, 5, and 6), as well as the Package, are calculated using a life cycle of 10 years.
- (6) See Table 14 for information on capital cost development and Table 15 for ECRM incentive estimation.

Additional measures considered and recommended in this report include:

- **Implement Additional HVAC Measures**
 - ✓ Occupancy (demand) controlled ventilation
 - ✓ Optimum start/ stop controls
 - ✓ Exhaust fan control
- **Implement Parking Lot Lighting 2:00AM Shutdown**
- **Install Vacancy Sensors**
- **Consider Facility Retro-commissioning**
- **Initiate Computer Energy Management**
- **Purchase ENERGY STAR appliances**
- **Schedule Domestic Hot Water Circulation Pumps**
- **Add Vending Control to Beverage Vending Machine**
- **Employee Strategies - Energy Management Team**

SEDAC encourages participation in the Illinois Department of Commerce and Economic Opportunity (DCEO) Public Sector Electric Efficiency Program (PSEEP), which offers incentives to owners/ operators of public sector buildings implementing energy efficiency measures. To reserve funding, SEDAC strongly recommends submitting a pre-application to this program in advance. Please note that a full application must be submitted and accepted prior to commencing any work.

The reader should note that this study alone is not intended to be sufficient documentation to allow contractors to produce bids to perform the work entailed with implementing the ECRMs described. This study does not replace engineering design which will still be necessary for project implementation. The reader should also be aware that the first cost pricing used herein was developed only for budgeting purposes and will vary according to the final design of the retrofits.

To demonstrate the effectiveness of the SEDAC energy audit program to the State of Illinois, we are asked to compile quarterly reports that documents implementation of energy efficiency measures. We ask that you keep us apprised of all work completed to allow us to accurately represent savings from our recommendations. We will also contact you periodically to discuss, answer questions, and review status.

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SEDAC Background

The objective of SEDAC is to encourage communities, building owners and operators, design professionals, and building contractors to incorporate energy efficiency practices and renewable energy systems. SEDAC supports the Smart Energy Program to increase the efficient and effective use of energy by for-profit businesses and public buildings throughout Illinois. SEDAC is sponsored by the Illinois Department of Commerce and Economic Opportunity (DCEO) and is managed by the School of Architecture at the University of Illinois at Urbana-Champaign.

Implementing energy efficiency measures is a proven method of controlling costs. Organizations that take a systematic and strategic approach to energy management enjoy a broad array of tangible and intangible benefits. We have entered an increasingly complex and volatile energy marketplace that requires a new emphasis on maximizing energy productivity. Improving energy performance helps to stabilize costs while increasing business profitability. Most buildings use 10 to 30% more energy than necessary and have abundant opportunities to save.

At the request of the Glencoe Park District, SEDAC conducted an energy audit of the Takiff Center facilities at 999 Green Bay Road, Glencoe, Illinois. This report includes a list of energy cost reduction measures for consideration.

1. Introduction

1.1 Energy Management / Implementation Strategy

Energy conservation is best achieved through a multifaceted approach involving load reduction and efficiency improvements. Addressing either of these pathways will conserve energy; however, a strategic and integrated approach involving both methods is the most cost effective energy solution.

Load reduction can have no cost or low cost and *should be the first step*. Load reduction entails managing energy consumption by turning things off when not needed or using controls systems to manage unnecessary energy use.

Energy efficiency improvements provide great opportunities for energy conservation. Efficiency improvements may require upgrading the building envelope and replacing old or failing systems with modern technologies which perform the same function while consuming less energy.

To lower grid energy consumption further, after reducing energy demands through load reduction and efficiency improvements, consider offsetting a portion of the remaining energy consumption with on-site energy generation. On-site energy generation would be recommended *only after load reduction and efficiency improvements* because expensive renewable generation systems can be downsized after other energy saving measures are already in place.

1.2 Analysis Approach

Our basic analysis approach involves several steps. First, initial information is collected from the client in regards to current building usage, energy consumption, and project design goals. Utility consumption data is input into a spreadsheet, examined for anomalies, and graphed with annual heating and cooling degree day data to see if there is a correlation between energy usage and seasonal temperature fluctuations. Then, during the site visit, detailed data and observations are recorded by SEDAC team members and used to develop a list of possible Energy Cost Reduction Measures (ECRMs) to be recommended for implementation.

Next, the baseline energy model is constructed using building energy simulation software. Trane TRACE™ 700 was the program used for this project. The program calculates the amount of energy (and the resulting utility cost of that energy) the building is expected to use over an entire typical weather year. Model inputs were taken from pictures and information provided by the client; outputs are calibrated to match the existing utility bill information.

Subsequently, the SEDAC team performs computer analyses of ECRMs. The baseline computer model is modified to reflect the implementation of these ECRMs and the model generates the resultant energy consumption and expected utility costs. When necessary, some ECRMs are evaluated outside of the modeling software.

Finally, the estimated savings, applicable incentives, and the costs of implementing ECRMs are evaluated in a life cycle cost analysis. This analysis assumes a ten to twenty year life cycle and calculates the internal rate of return (IRR) and the net present value (NPV) of each ECRM and package of ECRMs. IRR is essentially the annual yield on an investment. A project is a good investment if its IRR is greater than the rate of return that could be earned by an alternative investment (other projects, bonds, bank accounts, etc.). We assume 5% as the acceptable rate of return for public buildings. The NPV calculation uses a discount rate to find the present value of savings occurring at a future date. The discount rate is your minimum acceptable rate of return, or your time value of money; again, we assume 5%. Investments will have positive NPVs when their IRR is greater than the discount rate.

2. Building Design and Site Conditions

2.1 Site Conditions and General Building Details

The Glencoe Park District Takiff Center is an 85,000 square feet (SF) facility housed in a former elementary school with three additions. The original two-story masonry school building (~19,100 sf) was built in 1928. The largest addition (~26,250 sf) was constructed in the 1950s. This single-story masonry classroom wing with a relatively small-second story area (~1650 sf) originally functioned as a library; it now serves as mechanical space. This addition is constructed over a crawl space which runs the full length of the addition. The second addition (~18,000 sf) was built in the 1960s. This addition is a two-story wing which originally housed a 4,450 sf gymnasium, as well as more classroom space. The entire complex was renovated in 2007, adding approximately 25,700 sf of space. A portion of the 2007 addition houses administrative offices and replaced a section of connecting space between the 1928 building and 1950s addition. Another portion of that renovation/ addition project created the second floor classroom space in the area which was previously the two-story high gymnasium space—in the 1960s addition. The 2007 addition also included the new 8,400 sf gymnasium, a new entrance lobby, and a new parking area—all located at the northwest of the facility.

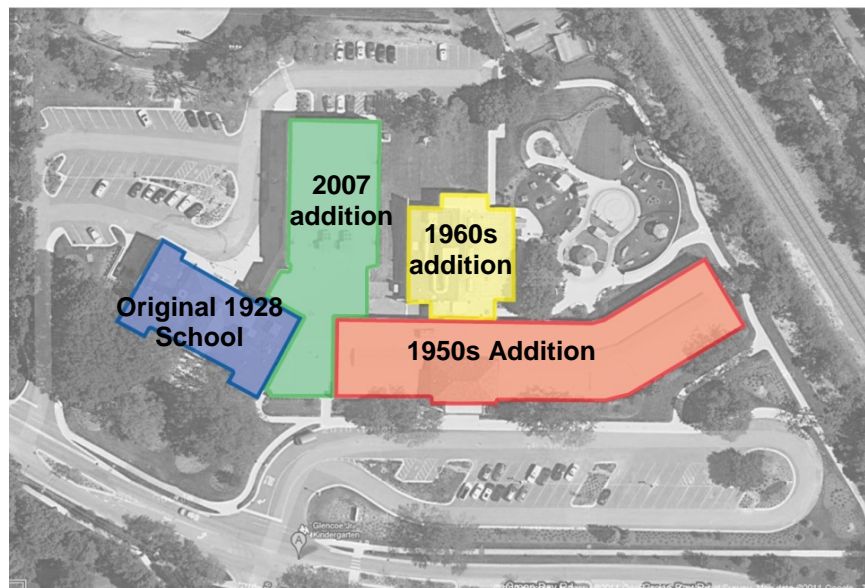


Figure 1: Phase Plan of the Takiff Center

The facility houses the Glencoe Park District central administrative offices, meeting rooms available for rental, a large gym, and several outdoor playgrounds, as well as several community and Park District programs, including pre-school and enrichment programs. The 1950s addition houses the Children's Circle Day Care, as well as the Glencoe Junior Kindergarten and Nursery School (GJK). During the summer months, summer camps are conducted by the park district.

Approximately 30 full time equivalent employees work in the facility. The average number of clients using the facility varies seasonally. During the summer months, occupancy ranges from 180-200 people daily. In the winter occupancy is about 250-270 people. The building is open on all days of the week throughout the year. Occupancy on the weekends is more limited, both in hours of operation and in areas occupied within the facility.

From September through May, the average operational hours are 6:00AM-10:00PM on weekdays and 8:00AM to 6:00PM on the weekends. From June through August, the facility operates from 6:00AM to 8:00PM on weekdays and 8:00AM to 4:00PM on the weekends.

The day care and school programs, housed in the 1950s wing, operate from 8:00AM to 4:00PM Monday through Friday. Other parts of the facility house various rental spaces which, on average, host two events per month, some with extended hours (as late as 11:00PM).

The client is actively engaged in the implementation of energy savings strategies. As part of their efforts to reduce costs the client has:

- Replaced all the windows with double paned, insulated windows in 2007;
- Added a new digital building automation system (BAS);
- Installed motion sensors that automatically turn off lights after ~2-10 minutes of inactivity, (these control about 80% of the lighting in the facility);
- Installed solar-powered, exterior emergency egress lighting (12 solar-powered LED lights for the exterior walkways).

We applaud these efforts.

2.2 Building Envelope

Walls: The facility is comprised of a two-story, 1928 vintage masonry building with several one- and two-story additions built in the 1950s, 1960s, and 2007. The exterior walls are mostly un-insulated multi-wythe masonry construction (in the original building and older additions). The walls in the 2007 addition are insulated cavity wall construction. The entire facility has face brick on the exterior. With the exception of the gymnasium and entrance lobby with interior masonry finish, the interior walls are metal stud construction with painted drywall finish. A portion of the lower level (in the 1928 and 1960s wings) is below grade and presumed to be uninsulated. For modeling purposes the walls of the older sections of the building are assumed to have an overall equivalent thermal resistance rating (R-value) of approximately R-3 and the walls of the 2007 additions are assumed to have an assembly rating of R-7.

Roofs: The roof assemblies of the building vary. Most of the facility has low-slope roof structures with light-colored membrane roofing. The exceptions are the low-slope roof areas over the 1928 building and the 1960s addition, with dark membrane roofing; and a part of the 1928 section plus a small portion of the 1950s addition have slate tile, pitched roofs. The 2007 addition is constructed with metal roof deck and rigid insulation (assumed to have a thermal resistance of approximately R-14.) The earlier 1928 building and 1960s addition largely comprise of wood deck roof assumed to have insulation that corresponds to an R-2 value. The flat portions of these earlier sections of the roof will be replaced with newer roofs. There is a one-story below grade connection between the 2007 and 1960 addition with a green roof (located at grade level). The studios on the east side of the 1960s addition lower level each have a skylight that brings natural light into the spaces. The thermal performance of these skylights is unknown.

Windows and Curtainwall: During the 2007 renovation, all windows except those in the (1960s addition) activity room were replaced with newer windows. All windows, both old and new, are double pane with low-E glass. Most windows in the classrooms are single hung and operable, though opening of windows is discouraged. The northwest entrance lobby is enclosed with a stick-built curtain wall system with double pane glazing. For modeling purposes these windows are assumed to have an assembly U-Value¹ of U=0.43 and a solar heat gain coefficient (SHGC)² of 0.57.

¹ U-Value is the rate at which a window, door, or skylight conducts non-solar heat flow. The lower the U-factor, the more energy-efficient is the window, door, or skylight. [Source: U.S. DOE EERE, www.energysavers.gov]

² The solar heat gain coefficient is the fraction of solar radiation admitted through a window, door, or skylight—transmitted directly and/or absorbed—and subsequently released as heat inside the building. [Source: U.S. DOE EERE, www.energysavers.gov]

2.3 Heating, Ventilation and Air Conditioning (HVAC)

Heating and Cooling

The facility is conditioned using two types of systems: three Trane® AHU units of 25, 40 and 15 hp; and two 50 ton each Carrier® packaged roof top units. The three 50 ton Trane® air cooled DX condensing units that serve the AHUs are also located on the roof. All of these new units were installed during the 2007 renovation (Figure 2).

The air handlers are equipped with variable frequency drives (VFDs) for modulated airflow to variable air volume (VAV) boxes in the zones. Both the air handlers and the roof top units have economizer control for free cooling in temperate weather.



Figure 2: AHU- 3

The primary source of heat for the building is two natural gas-fired Fulton® boilers located in a mechanical room on the lower level of the 1960s wing. The boilers are rated at 85% efficiency. The roof top units have gas-fired heat exchangers that provide them with the necessary heating. For the baseline modeling this heat exchanger is assumed to be 78% efficient.

Table 2 summarizes the known information regarding the rooftop package units, air handling units, and other systems serving the building. Figure 3 shows the location of the equipment.

Table 2: HVAC Equipment Details

Designation/ Location Served	Year Manuf.	CFM (Cooling Airflow)	Cooling Capacity (Gross)	Heating Capacity (Efficiency)	Type
RTU-1/ Gymnasium	2007	12,715	47 Ton	328MBH / 400MBH (82%)	Roof Top Unit (Constant Volume)
RTU-2/ NW Entrance Lobby	2007	13,000	47 Ton	656MBH / 800MBH (82%)	Roof Top Unit (Constant Volume)
AHU1 / 1950s Addition	2007	24,460	50 Ton	Two boilers each with 2,578MBH / 3,000MBH (85%)	Split System AHU (VAV)
AHU2 / 1960s Addition	2007	14,500	30 Ton		Split System AHU (VAV)
AHU3 / 1928 Building	2007	15,850	30 Ton		Split System AHU (VAV)

Notes for Table 2:

(1) Cooling Efficiency of the equipment is unknown

Ventilation

The three AHUs are VAV systems while the two RTUs are constant volume systems. VAV boxes are located in various zones and supply conditioned air through ceiling registers located throughout the building. These VAV boxes are equipped with reheat coils which use hot water supplied by the two boilers.

The 1950s single-story classroom wing is served by ducts located in the “catwalk” running through the center on the roof. This enclosed catwalk is not insulated but the individual ducts are insulated.

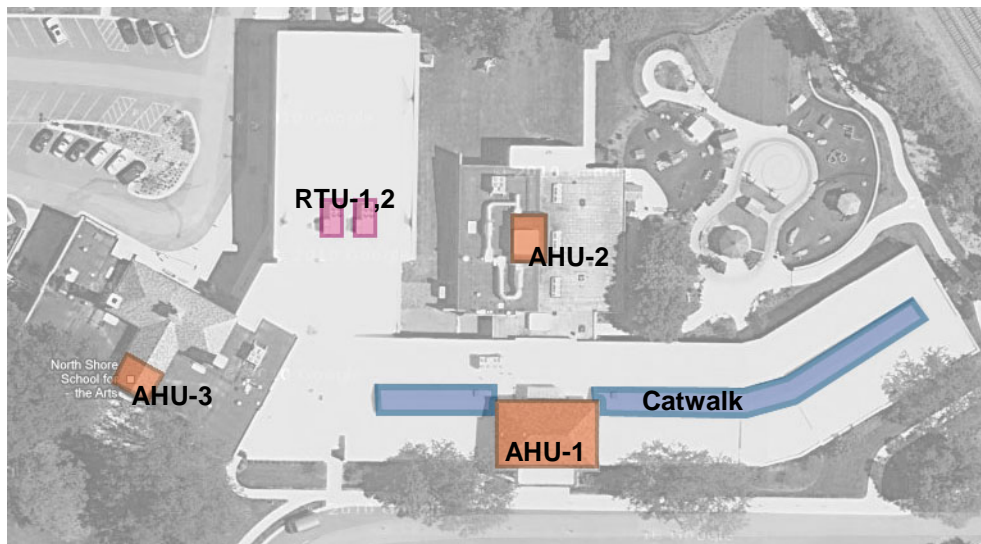


Figure 3: Location of the Equipment

Temperature Control

Each room has space temperature sensing thermostats which are controlled by a central building automation system (BAS). There are no manual over-ride switches available in the individual rooms. During the site visit, we observed that the AHUs supply air at 62° F. Air distribution is via the VAV boxes which are equipped with hot water reheat coils to supply the preset temperature to the individual zones. The facility also has 17 exhaust fans located on the roof. These exhausts serve the kitchens and toilets. Most of the exhausts are also controlled by the BAS, except for the kitchen exhausts which are manually operated whenever the space is in use. The systems operate according to the schedule of the building which, on an average day, is from 5:00AM to 9:00PM.

Table 3 gives the details of the set points during occupied and off-hours throughout the facility.

Table 3: Temperature Set Points in Various Areas

Area Served	Occupied Cooling Set Point	Off-Hour Cooling Set Point	Occupied Heating Set Point	Off-Hour Heating Set Point
Gym	72	80	67	60
Lobby	72	80	72	65
1928 Building	73	82	69	62
1950s Addition	75	82	72	60
1960s Addition	73	82	71	60
1960s Addition (Fitness Studios)	68	80	65	60

2.4 Domestic Hot Water

Hot water is provided by a 2007 Laars® PNCV hot water boiler, with 85% efficiency, located in the mechanical room. The building has no locker rooms or shower facilities. One small staff shower is used, at most, once a week. The boiler unit is used primarily to provide hot water to lavatories in the building's restroom facilities and to the sink and dishwasher in the kitchen.

2.5 Lighting

Motion sensor lighting controls that automatically go off after two minutes of inactivity govern lighting in 80% of the building. A staff member is assigned to turn off the master light switch when the building is unoccupied. The building also has a backup automatic lighting control panel that shuts off all the building lights at 2:00AM. Most of the interior fixtures in the facility have 32-watt T8s. The outdoor spaces and the parking lot are lit by exterior poles (250-watt metal halide), walkway lighting, and solar-powered LED lights (see Figure 4).



Figure 4: Solar LED Parking lot lights

2.6 Other Equipment

The facility is equipped with two kitchens. The service kitchen is located on the first floor by the Early Childhood wing and the catering kitchen is located on the second floor by the Community Hall. Of the two, the service kitchen is used the most while the catering kitchen is used for food warming and preparation during events in the community hall. The prep kitchen has a gas convection oven, a 36" heavy duty gas cooking range, an exhaust hood, a microwave oven, a reach-in freezer and a reach-in refrigerator, and a fire and electrical system.

The catering kitchen is equipped with a dishwasher, a condensate hood, a disposer, a cube-style ice maker, a reach-in refrigerator, a gas convection oven, 36" heavy duty gas cooking range, an exhaust hood, and a fire and electrical system. Other equipment present but not used include a mobile heated cabinet, an electric booster heater, a reach-in freezer, and a mobile refrigerated cabinet. All of the equipment in both the kitchens was replaced with new equipment during the latest renovation in 2008. Apart from these two major kitchens, some classrooms and activity rooms are equipped with basic kitchen equipment like a refrigerator, microwave and electric cooking stoves, but these are infrequently used.

The staff lounge/ kitchenette also is equipped with a refrigerator, microwave, toaster, and coffee maker. One activity room has pottery wheels and an electric kiln. Many classrooms are also equipped with television sets and a media center.

The entire building has three network servers, 25 PC workstations, and 10 printers. The age of these units ranges from 5-10 years. There are two copiers, each less than a year old. The

complex has two soda vending machines and one snack vending machine. The facility has a small laundry with one washer and one dryer unit that are used at least once a week.

The building also is equipped with a kiln room which has two electric Skutt® automatic kilns. The art room is equipped with about six pottery wheels. The kiln room is used once a week on an average. These kilns and pottery wheels are all new installations and the school has started using them only recently.

3. Energy Consumption Analysis

3.1 Utility Rates

Electricity is provided by MidAmerican Energy and delivered by Commonwealth Edison (ComEd). The average electric utility rate, based on the analysis year (February 2010 through January 2011), is \$0.11 per kWh including all charges. Natural gas is provided by Vanguard Energy Services, LLC and delivered by North Shore Gas. The average natural gas utility rate, based on the analysis year, is \$0.81 per therm.

The resurgence in a focus on energy efficiency has been brought about by increased concern about volatile energy costs and potential negative impacts on the environment. Energy costs are expected to rise in real terms, increasing the annual savings noted throughout this report. Although energy price increases lead to inflation, they also typically surpass the inflation rate. Given this phenomenon, energy costs savings secured today will probably “grow” over time. It is impossible to predict energy cost increases. However, nationally since 2000, commercial natural gas prices have increased 41 percent while commercial electric prices have increased 38 percent.³ Appendix B shows national utility pricing trends since 1975.

We used average rates based on the analysis year (\$0.11 per kWh and \$0.81 per therm) for our financial analysis, with no energy price escalation over time.

3.2 Benchmarking

A good method for benchmarking a building’s energy efficiency is to determine its energy use intensity (overall electric consumption in kWh/SF/yr and gas consumption in therms/sf/yr) and energy cost intensity (\$/SF/yr). A summary of energy use intensities (EUI) and energy cost intensities for the Glencoe Park District Takiff Center is given in Table 4.

Table 4: Energy Use Intensity

Annual Consumption			Annual Costs		Average Unit Cost
Electricity	1,054,081 kWh	41%	\$113,799	73%	\$0.108 \$/kWh
Natural Gas	52,655 Therms	59%	\$42,729	27%	\$0.811 \$/Therm
Total	8,862,172 kBtu	100%	\$156,528	100%	
Floor Area	85,000 SF				
Electricity Use Intensity	12 kWh/SF/yr		Gas Use Intensity		0.62 Therms/SF/yr
Site Energy Use Intensity	104 kBtu/SF/yr		Energy Cost Intensity		\$1.84 \$/SF/yr

Notes for Table 4:

- (1) Electric energy supply by MidAmerican Energy and delivery by ComEd (EDA-NS); Natural gas supply by Vanguard Energy Services and delivered by North Shore Gas (Rate 2 – General Service Heating).

3.3 Energy Consumption Profile

Figure 5 shows the reported monthly electric energy consumption profile for the Takiff Center from February 2010 through January 2011. The dashed line shows the corresponding cooling degree days. Cooling degree days (CDD) and heating degree days (HDD) are indicative of the length and intensity of the cooling and heating seasons for the specific analysis year. The lighter

³ Energy Information Administration Monthly Energy Review, September 2011, <http://www.eia.doe.gov/emeu/mer/contents.html>, Energy Prices, Tables 9.9 and 9.11

blue bars (Feb – Mar, May – Jul) indicate the estimated energy usage by the utility company for those months, whereas the solid blue lines are actual meter readings.

The graph shows an increased electric usage during the summer months. This increased electric usage in the summer months (May – Sept) is attributed to the cooling requirements of the building. The baseline building electricity use in the non-heating months (Oct – Apr) is approximately 65,000 kWh.

The black bars indicate the baseline modeled electric energy consumption from the Trane TRAC model. The total modeled electric energy consumption is approximately within 0.8% of total annual billed consumption for the analysis year.

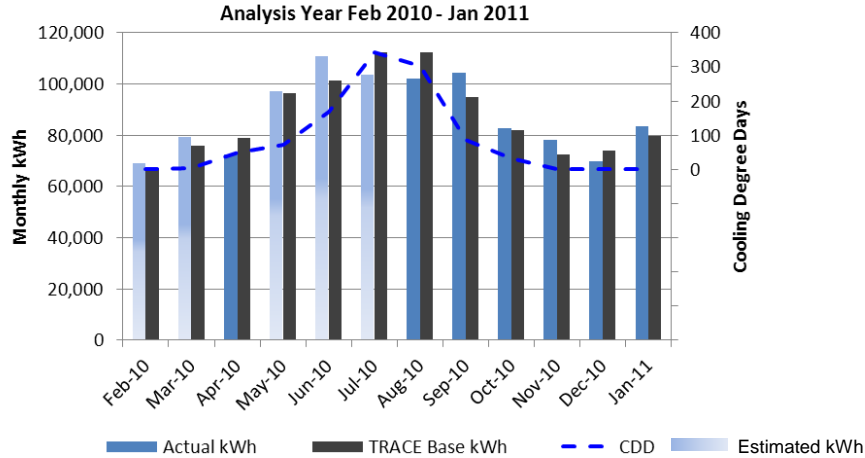


Figure 5: Monthly Electric Consumption Profile

Figure 6 shows the reported monthly natural gas energy consumption profile compared with the heating degree days. The dashed line shows the corresponding heating degree days for the specific analysis year. Natural gas is used primarily for space heating in the building as well as heating domestic water.

The utility bills show a baseline consumption of approximately 1,000 therms in the summer. This baseline includes the natural gas consumed for domestic hot water and hot water supplied to the re-heat coils. The usage follows the weather cycles closely, which is expected since heating is the largest gas use.

The black bars indicate the baseline modeled natural gas consumption from the Trane TRACE model. The total modeled natural gas energy consumption is within approximately 5% of total annual billed consumption for the analysis year.

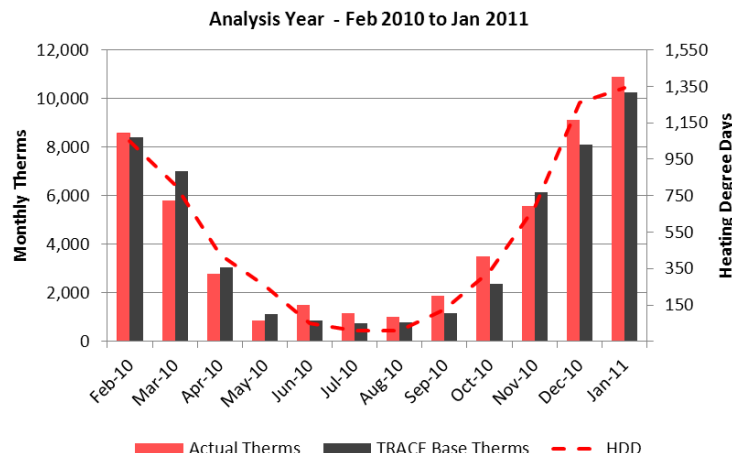


Figure 6: Natural Gas Usage

In addition to the year of monthly consumption data obtained for both electric and natural gas, we were able to obtain and analyze 24 months of 1/2-hour interval data for electric demand. January 2010 data is plotted in Figure 7 and May 2011 data in Figure 8. The solid red lines represent typical weekday demand patterns; the dashed green lines represent the weekends; the solid green line represents the New Year and the Memorial Day holidays.

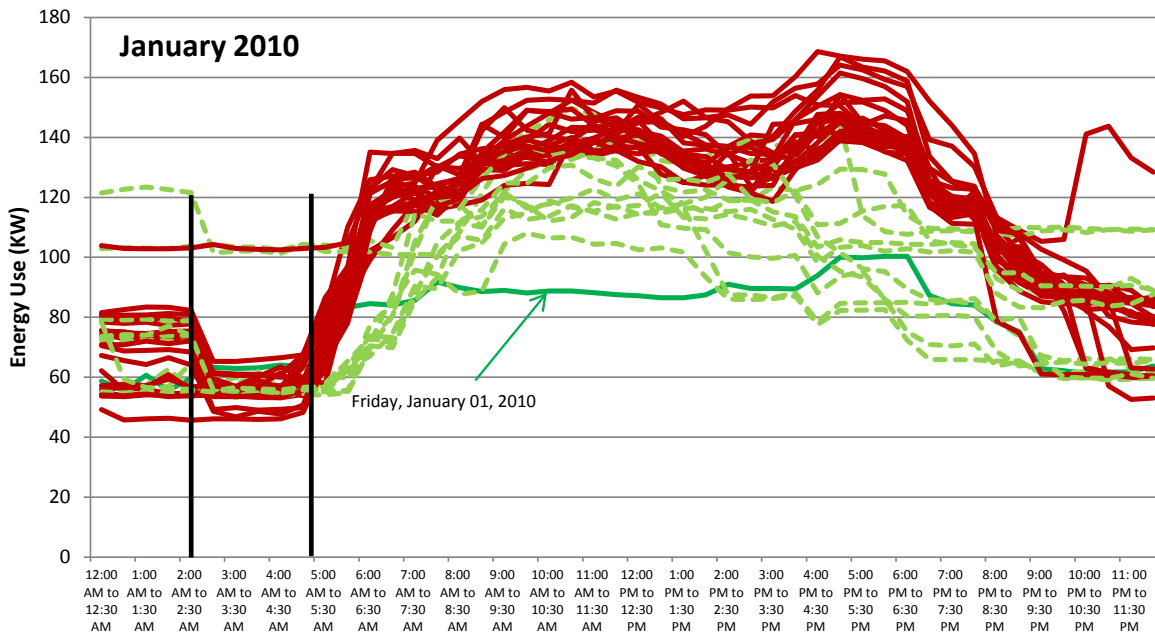


Figure 7: 1/2-Hour Interval Metered Electric Energy Demand – January 2010

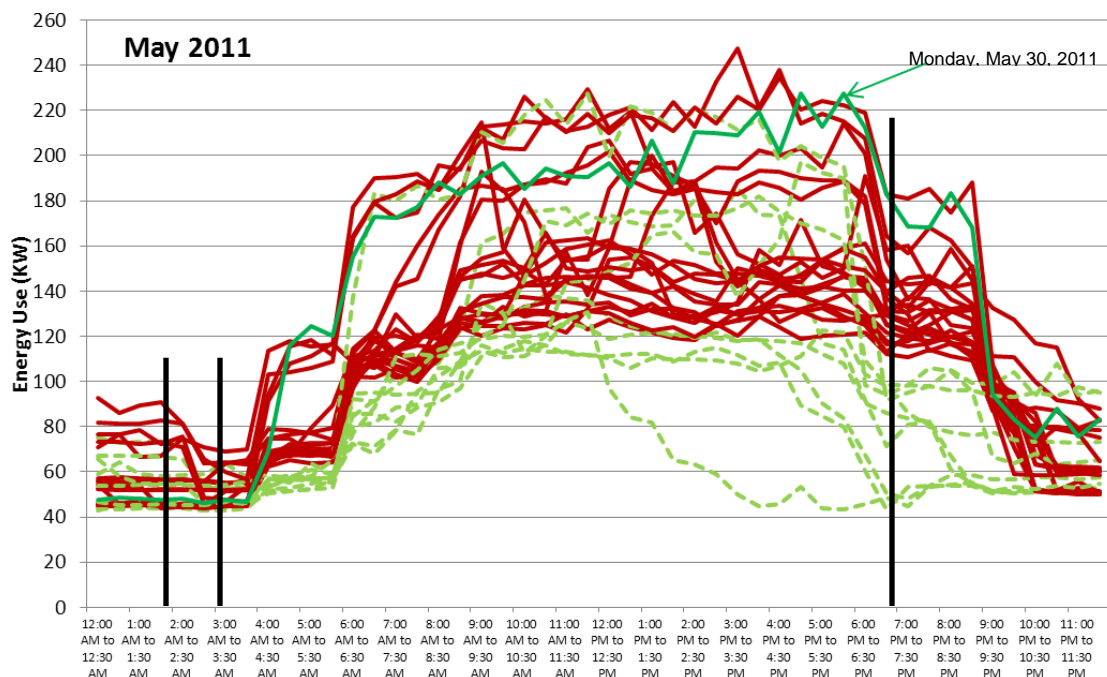


Figure 8: 1/2-Hour Interval Metered Electric Energy Demand – May 2011

The value of a graph like this one is the ability to observe usage patterns on a daily basis throughout a given month. The graph shows demand initially ramping up at the interval between 4:30 and 5:00AM on weekdays. The building starts operating at 6:00AM and this increase is presumed to reflect the practice of turning on lights throughout the building an hour or so before the start on typical weekday mornings. Electrical demand (kW) reaches close to

maximum daily levels (between 120 and 160 kW) between 6:00 and 7:00AM. Demand continues at roughly those levels (with a slight drop at about 3:00PM) until it begins to drop off again between 5:00 and 6:00PM until the end of the day. This drop can be attributed to the reduced occupancy after hours. We can also observe a drop at approximately 2:00AM, after which demand stays almost constant until it starts ramping up again at about 4:30AM. This drop can be attributed to the 2:00AM automatic shutdown of the lights.

May 2011 also follows a similar trend as January 2010 with a drop at approximately 2:00AM and ramping back up at about 4:00AM. The increased electric consumption corresponds to the cooling requirements of the building. However, Figure 8 shows a much wider range of daily usage patterns. The energy consumption on the Memorial Day holiday is very similar to a weekday and many weekend days also behave like weekdays. These fluctuations might be due to either increased usage on those days or to inappropriate scheduling in the BAS system.

3.4 Breakdown of Energy Consumption

Determining where and in what quantities energy is used throughout a facility helps prioritize energy improvement efforts for maximum effectiveness.

Figure 9 shows the breakdown for Takiff Center’s energy costs, as estimated from the Trane TRACE™ model. Based on the modeled breakdown, 35% of the total annual energy expenditure is for space heating (including reheat), about 25% is for interior lighting, about 15% is for space cooling, and about 15% for supply fans; the remainder is split between plug loads (receptacles), exterior lighting, and domestic hot water (DHW).

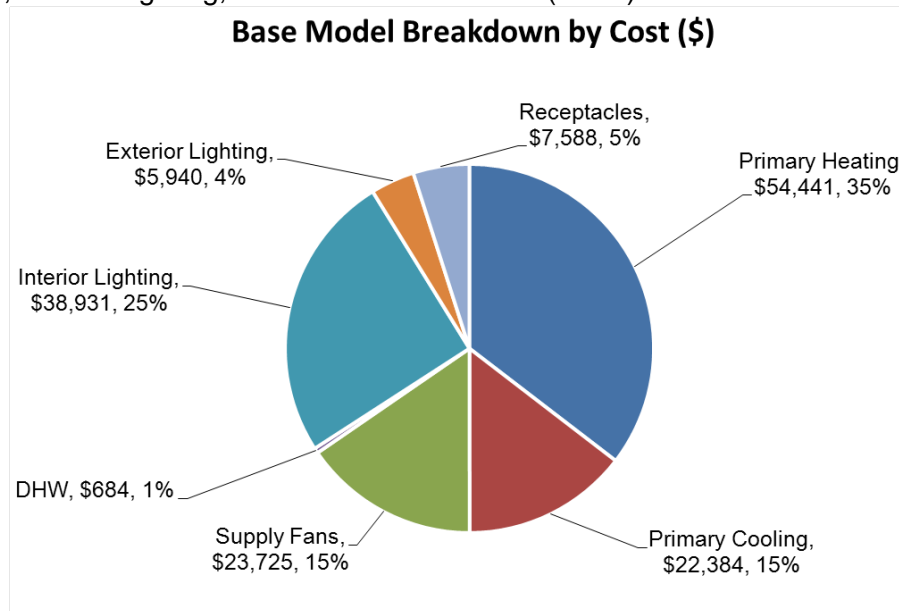


Figure 9: Energy Usage Breakdown by Percent of Cost (\$)

This breakdown gives an indication of possible areas for improvement, with the greatest opportunity found in the reduction of heating, cooling and interior lighting costs. This reduction can be achieved through improvements in the building system control, building envelope improvements, and improved lighting efficiency through lamp replacements and controls. Focusing efficiency efforts in the higher cost areas is likely to produce the greatest results and therefore recommendations described later in this report focus on these areas of improvement.

4. Recommended Energy Cost Reduction Measures (ECRMs)⁴

4.1 ECRM 1 – Gym Lighting Upgrade

This ECRM reviews and recommends replacing existing 400-watt metal halide high-bay fixtures in the gymnasium with new 2'x4', six-lamp T8 high-bay high-output (HO) fixtures.



Figure 10: Sample High Bay Fluorescent Fixture

There are twenty-four 400-watt metal halide fixtures in the gymnasium. Each fixture uses a total of 484 watts.⁵ These lights can be replaced with high-bay fluorescent T8s or T5s. In general, high-bay T8 fixtures are less expensive than high-bay T5 fixtures. For this analysis the metal halides would be replaced one-for-one with six-lamp 32-watt T8 high-bay fluorescent fixtures, using a total of 221 watts per fixture.⁶

In addition to the fixture wattage savings, this retrofit will allow more flexible lighting schedules and will reduce unnecessary system on-time. Metal halides have a relatively long re-strike time, which requires ten to fifteen minutes of warm up time for the lamps to reach their full lumen capacity. This factor makes it more convenient to leave these lights on rather than turning them off for short periods of time in which they are not needed. With the new fluorescent fixtures, the lights can be turned on and off with no waiting or downtime. We also recommend selecting fixtures and controls to allow for multiple fixture lighting scenarios—with two, four, or six lamps illuminated per fixture—to allow for different lighting levels and utilization of daylighting.

High-bay fluorescent lamps also have several other important benefits as compared to metal halide lamps. Fluorescent lamps experience less lumen depreciation than metal halide lamps. At 40% of its lifespan a metal halide will have lost up to 35% of its light output, compared to only 6% for a T8 lamp. This characteristic means that a lower total wattage of T8 linear fluorescent lamps can be used to provide the same overall lighting levels as metal halides. Lastly, fluorescent lighting has a superior service life compared to probe start metal halide lighting, with a rating of 28,000 hours of use compared to 10,000 hours.

Estimated savings are shown in Table 5. The calculation does not take into account the ability to easily turn these lights off when not in use and the additional 10%-15% associated savings of the lights not being on as often.

Incentives are available through DCEO and are \$ 0.75 per watt reduced. This high-bay fluorescent lamp upgrade would make the facility eligible for approximately \$4,734 in incentives.

⁴ Our work does not replace engineering design which will be necessary for project implementation.

⁵ Each fixture uses a 400-watt metal halide high-bay lamp with a very high power factor ballast of 1.21; therefore using an effective 485W per fixture.

⁶ Each fixture uses six 32-watt linear fluorescent lamps with high power factor ballast of 1.15; therefore using an effective 221W per fixture.

Table 5: ECRM 1 – Summary of Energy/ Cost Savings

ECRM 1 Summary:								
Gym Lighting Upgrade – Replace MH lamps with six-lamp T8HO								
Measure/ Description	Annual Savings					Capital Cost	IRR	NPV
	kWh	kW	Therms	\$	% Total \$			
ECRM 1 – Gym Lighting Upgrade	31,076	7	(705)	\$2,784	1.8%	\$9,042	27%	\$10,228
with Incentives						\$4,308	64%	\$14,736

Notes to Table 5:

- (1) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (2) An increase in natural gas usage is caused by a reduction in heat output by upgraded lighting. A decrease in cooling load is also produced by this upgrade and is reflected in the savings.
- (3) The life cycle used for calculating the IRR and NPV for this measure is 10 years.

4.2 ECRM 2 – Roof Insulation

This ECRM reviews and recommends increasing the roof insulation to a total thermal resistance value (R-value) of R-25 continuous.

The management is planning to redo the roofs above the 1960s addition and the flat roof portions of the 1928 section. These roofs have never been replaced and are currently assumed to have an R-2 value. With this scheduled roof replacement, SEDAC recommends using values found in the ASHRAE 189.1-2009: *Standard for the Design of High-Performance Green Buildings* (ASHRAE Standard 189.1) for roofing insulation levels. The level recommended for the Glencoe, IL climate zone is R-25 continuous insulation above the roof deck. This value can be achieved with the installation of 3 1/2" of polyisocyanurate (polyiso) insulation.

Modeling this ECRM demonstrates significant savings by increasing the insulation in the roof from an average of R-2 to R-25 continuous insulation. Implementation is highly recommended to reduce energy use and increase occupant comfort. Table 6 summarizes the modeling results for this ECRM from the Trane TRACE™ software. This ECRM results in both energy savings and significant annual cost savings.

The estimated initial cost used to calculate the IRR and NPV is the total cost to add 3 1/2" of polyiso insulation. The cost of installing a new roofing membrane is not included. NOTE: at minimum the facility should install a code compliant roof replacement (with minimum R-20 continuous insulation). This ECRM indicates a strong payback for increasing roof insulation to reduce heat loss. In cold climates, the greater the exposed surface area, the greater the loss of heat and therefore energy. Because most of the space is one-story, the building has a high exposed surface-to-volume ratio. In this instance, the increased exposure is largely through the large expanse of roof area.

This measure may qualify for the DCEO Custom Incentive which equals \$0.12 per annual kilowatt-hour saved and \$1.25 per annual therm saved for measures with a payback of 1 – 7 years.

Table 6: ECRM 2 – Summary of Energy/ Cost Savings

ECRM 2 Summary:								
Roof Insulation – Add 3 1/2" polyisocyanurate insulation to achieve a total of R-25.								
Measure/ Description	Annual Savings					Capital Cost	IRR	NPV
	kWh	kW	Therms	\$	% Total \$			
ECRM 2 – Roof Insulation	35,865	23	6,310	\$8,994	5.9%	\$40,122	22%	\$65,292
w/ Incentives						\$27,930	32%	\$76,903

Notes to Table 6:

- (1) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (2) The life cycle used for calculating the IRR and NPV for this measure is 20 years.

4.3 ECRM 3 – Lighting Upgrades

This ECRM reviews and recommends replacing the current 32W T8 linear fluorescent lamps with 28W or 25W T8 linear fluorescent lamps.

During our visit to the Takiff Center, we found that the lighting levels in many spaces were well above recommended minimum levels (in footcandles) and could provide opportunities for lighting power density reductions (watts per square foot). See recommended levels in Appendix D at the end of this report. To address this, SEDAC recommends replacing the current 32W T8 fluorescent lamps with 28W T8 linear fluorescent lamps either immediately (using currently available incentive funding) or when the current lamps reach their end of life. To avoid inconsistent lighting it is best to change all the lamps in any give room or contiguous space at one time. Before replacing the lamps, compatibility between the new lamps and the existing ballasts should be verified. This measure will have a large impact once each fixture is using 12.5% less power throughout the day, without going below the recommended minimum lumen levels in the spaces. When all lamps are changed over, the estimated savings will be \$4,757 per year or about a three percent reduction in the overall cost of energy.

Though replacing the 32W T8 linear fluorescent lamps with 28W T8 linear fluorescent lamps is a less costly option, using 25W T8 linear fluorescent lamps will provide even greater savings (approximately 22% per fixture)—and actually has the potential for a higher return on investment (IRR & NPV). Both these options were modeled and the corresponding savings are indicated in Table 7.

DCEO incentives are available for this recommendation, at \$1.50 per lamp.

Table 7: ECRM 3 – Summary of Energy/ Cost Savings

ECRM 3 Summary:								
Lighting Upgrade – Replace 32W T8 with 28W or 25W fixture								
Measure/ Description	Annual Savings					Capital Cost	IRR	NPV
	kWh	kW	Therms	\$	% Total \$			
ECRM 3A – 28W lamps	51,711	14	(1,020)	\$4,757	3.1%	\$12,540	35%	\$20,245
with incentives						\$7,040	67%	\$25,483
ECRM 3B – 25W lamps	77,685	19	(959)	\$7,612	5.0%	\$15,080	49%	\$37,144
with incentives						\$12,080	62%	\$40,001

Notes to Table 7:

- (1) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (2) An increase in natural gas usage is caused by a reduction in heat output by upgraded lighting. A decrease in cooling load is also produced by this upgrade and is reflected in the savings.
- (3) The life cycle used for calculating the IRR and NPV for this measure is 10 years.

4.4 ECRM 4 – Reduce Schedule

This ECRM reviews and discusses reducing the BAS schedules for less-used spaces. These spaces include the event spaces, 1950s addition, and the 1960s addition.

As mentioned earlier, the Takiff Center serves varied activities which take place in different locations throughout the facility. All of these activities operate at different times of the day. Currently, the BAS is programmed to operate the entire building as one and does not serve the different zones according to their operating schedule

This ECRM recommends re-programming the BAS to incorporate the schedules of the different activities that take place throughout the facility. Table 8 outlines the schedule reduction applied to the various areas in the Trane TRACE™ model.

Table 8: Proposed Reduction in Current Schedule

Area	Sep – May		Jun - Aug	
	Weekdays	Weekends	Weekdays	Weekends
1950s Addition	45%	90%	30%	90%
1960s Addition (2 nd Floor)	20%	25%	35%	65%
Event Spaces (Community Hall, Activity Room, Multipurpose Rooms, kitchens)	80%	85%	80%	85%

In conjunction with re-programming occupancy schedules in the BAS, SEDAC recommends installing occupant override buttons in spaces with very low and/or highly variable daily usage (e.g. event rooms and other intermittently-used spaces). Override buttons will allow these spaces to be permanently set in unoccupied mode (in the BAS) for most or all hours of the day (using temperature setbacks, lowered ventilation rates, etc.)—while giving occupants the ability to use the override button to return to occupied mode settings at any time (occupied temperature set points, ventilation rates, etc.). The override button can be set to maintain occupied settings for a pre-set fixed amount of time (such as two hours).

Table 9 summarizes the modeling results for this ECRM from the Trane TRACE™ software.

With an investment of approximately \$10,000,⁷ this measure may qualify for the DCEO Custom Incentive which equals \$0.12 per annual kWh saved for electric measures and \$1.25 per annual therm saved for natural gas measures with a payback of 1 – 7 years.

Table 9: ECRM 4 – Summary of Energy/ Cost Savings

ECRM 4 Summary:								
Reduce Schedule – Reduce schedule in BAS for less-used areas (Event spaces, 1950s addition, and 1960s addition)								
Measure/ Description	Annual Savings					Capital Cost	IRR	NPV
	kWh	kW	Therms	\$	% Total \$			
ECRM 4 - Reduce Schedule	10,735	3	716	\$1,741	1.1%	\$10,000	10%	\$2,257
w/ Incentives						\$7,816	17%	\$4,337

Notes to Table 9:

- (1) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (2) The life cycle used for calculating the IRR and NPV for this measure is 10 years.

4.5 ECRM 5 – Bi-level Switching

This ECRM reviews and recommends implementing bi-level switching throughout the corridor spaces in the facility.

Most individual rooms within the facility have occupancy sensors. However, corridors throughout the facility appear to be illuminated for the full extent of building's occupied hours (some corridors may be illuminated 24/7). Corridor light levels in most areas were also well above the minimum required levels for illumination, according to the Illuminating Engineering Society of North America (IESNA) guidelines.

Bi-level switching is a relatively simple and durable way of achieving energy savings. One method involves rewiring alternate fixtures in a space onto separately switched circuits. Depending on the fixture configurations (number of lamps and number of ballasts), an alternate way to achieve the same savings is to wire all fixtures to turn on half the lamps in each fixture separately. Bi-level control will ensure that half the lights stay on at all times when the building is occupied and the other half will only be turned on when the corridor itself is occupied.

The control of the second (100% on) circuit can either be manual or sensor-based. Bi-level switching will allow two configurations in the spaces during building occupancy: 50% or 100% lights on. Based on the facility's schedule, we calculate that this measure reduces the lighting power density by 25% during occupied hours and 50% during the off-hours. This reduction translates into a total energy saving of \$6,155 annually or 4% of the current total energy cost. Note: SEDAC recommends using occupancy sensor-controlled switches (auto-on/auto-off) in the stairwells and corridors for security reasons.

DCEO incentives are available for bi-level stairwell fixtures with integrated sensors at \$70 per fixture installed. The bi-level switching in the corridors may qualify for the DCEO Custom Incentive which equals \$0.12 per annual kWh saved for electric measures

⁷ The suggested capital investment of \$10,000 represents an allowance for staff training and BAS programming (\$5,000), plus an allowance for adding occupant override buttons in multiple spaces (10 @ \$500).

Table 10 summarizes the modeling results for this ECRM from the Trane TRACE™ software.

Table 10: ECRM 5 – Summary of Energy/ Cost Savings

ECRM 5 Summary:								
Bi-level Switching – Implement bi-level switching throughout the facility								
Measure/ Description	Annual Savings					Capital Cost	IRR	NPV
	kWh	kW	Therms	\$	% Total \$			
ECRM 5 - Bi-level Switching	57,424	-	(57)	\$6,155	4.0%	\$20,328	27%	\$22,292
with Incentives						\$15,203	38%	\$27,174

Notes to Table 10:

- (1) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (2) An increase in natural gas usage is caused by a reduction in heat output by upgraded lighting. A decrease in cooling load is also produced by this upgrade and is reflected in the savings.
- (3) The life cycle used for calculating the IRR and NPV for this measure is 10 years.

4.6 ECRM 6 – Air Sealing

This ECRM reviews and recommends replacing weather stripping at doors as needed; in older portions of building, investigate air infiltration and air seal.

Constructing buildings to be air-tight was not an overriding concern in buildings built before the 1970s. In many areas, exterior wall construction may have cracks and gaps where air can infiltrate. Staff should investigate any areas where air can infiltrate into the structure. Of particular interest are areas above suspended ceilings where floor and roof structures bear on exterior walls and openings low in the building, such as weather stripping on doors. Preventing air infiltration in both high and low areas will impede the *stack effect*—whereby warm air is pushed out of the upper areas and cold air is drawn into lower areas. Any cracks should be caulked or insulated.

Additionally, all operable window seals, door sweeps, weather-stripping, and all exterior caulk joints should be inspected and repaired where necessary. Figure 11 is an infrared image (taken at another facility) that illustrates the impact of failed weather stripping in cold weather. The blue indicates cold air at 31°F leaking into the building, through the gaps between the door frames. The 52°F temperature inside the room is indicated by the red. During our site visit at the Takiff Center, daylight was visible under some exterior doors of the older sections of the building (Figure 12). Door weather-stripping wears out over time and, to maintain a tight seal, must be replaced to maximize energy efficiency.

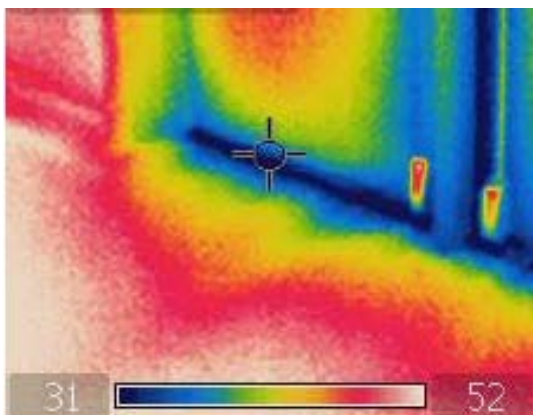


Figure 11: Failed Threshold Gaskets and Jamb Weather Stripping

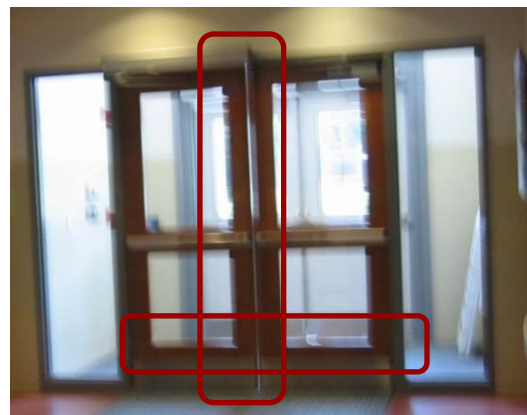


Figure 12: Exterior Doors of the 1950s Addition

Reducing air infiltration can result in significant savings, more comfortable interiors, and less potential for mold and moisture issues.

To calculate the savings associated with this ECRM, the infiltration values in the Trane TRACE™ model were reduced by approximately 25%. Table 11 summarizes the modeling results for this ECRM.

This measure may qualify for the DCEO Custom Incentive which equals \$0.12 per annual kWh saved for electric measures and \$1.25 per annual therm saved for natural gas measures with a payback of 1 – 7 years.

Table 11: ECRM 6 – Summary of Energy/ Cost Savings

ECRM 6 Summary:								
Reduce Infiltration – Replace weather stripping at doors as needed and investigate air infiltration in older portions of building								
Measure/ Description	Annual Savings					Capital Cost	IRR	NPV
	kWh	kW	Therms	\$	% Total \$			
ECRM 6 – Air Sealing	14,641	3	6,213	\$6,623	4.31%	\$20,000	30%	\$25,780
with Incentives						\$10,477	62%	\$34,850

Notes to Table 11:

- (1) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (2) The life cycle used for calculating the IRR and NPV for this measure is 10 years.

4.7 Package 1 – ECRMs 1, 2, 3, 4, 5 and 6

This package reviews and recommends implementation of all individual ECRMs outlined in the previous sections.

Each recommended ECRM discussed individually in this report offers considerable energy and cost savings. We offer a package that combines all the ECRMs to account for any interaction between the strategies. Incorporating these ECRMs can reduce the site energy usage intensities for the facility from 104 kBtu/sf/yr to approximately 78 kBtu/sf/yr.

The strategies included are:

- **ECRM 1 – Gym Lighting Upgrade:** Replace the existing 400-watt metal halide high-bay fixtures in the gymnasium with new 2x4 six-lamp T8 high-bay high-output (HO) fixtures.
- **ECRM 2 – Roof Insulation:** Increase the roof insulation to a total thermal resistance value (R-value) of R-25 continuous.
- **ECRM 3 – Lighting Upgrades:** Replace the current 32-watt T8 linear fluorescent lamps with 28-watt or 25-watt lamps. NOTE: savings and cost for the package are based on 28-watt.
- **ECRM 4 – Reduced Schedule:** Reduce the occupied mode schedules of low-use or intermittently-occupied spaces in the BAS and add occupant override control.
- **ECRM 5 – Bi-level Switching:** Implement bi-level switching throughout the corridors and stairwells in the facility.
- **ECRM 6 – Air Sealing:** Replace weather stripping at doors as needed; in older portions of building, investigate air infiltration and air seal.

SEDAC estimates that Package 1 will save 207,960 kWh and 11,458 therms annually, resulting in a net \$31,757 annual savings. These figures represent a 22.8% reduction in the building energy consumption (kWh) and a 20.7% reduction in annual energy costs. The results of our analysis are summarized in Table 12.

Modeling shows a 33% reduction in the heating peak load and 23% reduction in the cooling peak load. This package of ECRMs is extremely favorable and we recommend immediate implementation.

Table 12: Package 1 – Summary of Energy/ Cost Savings

Package 1 Implement all the ECRMs								
Measure/ Description	Annual Savings					Capital Cost	IRR	NPV
	kWh	kW	Therms	\$	% Total \$			
Package 1	207,960	65	11,458	31,757	20.7%	\$112,032	24%	\$108,224
with Incentives						\$75,274	40%	\$143,231

Notes to Table 12:

- (1) When ECRMs are implemented as a package, results vary from application of individual ECRMs.
- (2) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis, based on \$0.108 per kWh and \$0.811 per therm.
- (3) The life cycle used for calculating the IRR and NPV for this package is 10 years.

4.8 Additional Energy Cost Reduction Measures

The following additional measures are recommended for implementation in the Takiff Center.

- **Implement Additional HVAC Measures**

- ✓ **Occupancy (demand) controlled ventilation:** By controlling ventilation based on the actual occupancy at any given time (demand), rather than maximum design capacity, a significant amount of energy can be saved—by avoiding the heating or cooling of unnecessary quantities of outside air. These savings can be accomplished through the application of occupancy-sensing technologies (such as CO₂ sensors) or time-based controls to adjust ventilation rates.

The *2009 International Mechanical Code*[®] (2009 IMC[®]), which directs the basic design of HVAC systems, allows ventilation systems to reduce outside air based on the actual number of persons present (2009 IMC[®] § 403.5). The current Illinois Energy Conservation Code (IL ECC) requires this automatic reduction of outdoor air intake when the occupancy falls below design rates.⁸ The requirement applies to most spaces larger than 500 ft² with an average design occupant load greater than 40 people per 1000 ft² of floor area. Following the recommendations in ASHRAE's green building standard,⁹ SEDAC encourages incorporation of relatively low-cost demand control ventilation in all occupied spaces with a design occupant density greater than or equal to 25 people per 1000 ft².

The strategy could be applied to most of the offices, conference rooms, and classrooms in the Takiff Center. At minimum, we urge consideration of this strategy in the facility's larger

⁸ Reference: 2009 International Energy Conservation Code[®] (2009 IECC[®]) § 503.2.5.1; ANSI/ASHRAE/IESNA Standard 90.1-2007 *Energy Standard for Buildings Except Low-Rise Residential Buildings* (ASHRAE 90.1-2007) § 6.4.3.9

⁹ ANSI/AHSRAE/USGBC/IES Standard 189.1-2009 *Standard for the Design of High-Performance Green Buildings* (ASHRAE 189.1).

spaces that experience high-occupancy fluctuations including—but not limited to—the main gymnasium, the multi-purpose rooms in the lower level of the 1960s addition, and the large lobby at the northwest entry. To apply this strategy, the constant volume roof top units (RTUs) will have to be converted to variable air volume systems. This conversion will require engineering design and include the addition of a variable frequency drive on the fan motors and variable volume dampers and controls. The two RTUs serve the gym and northwest lobby.

Energy cost savings for demand control ventilation result from bringing in less outside that requires conditioning. This change will yield significant heating and cooling energy reductions.

- ✓ **Optimum start/ stop controls:** Optimum start controls activate HVAC systems as late as possible to bring the building up to temperature set points for the start of occupancy. Optimum start control routines vary the start of heating and cooling systems, based on the difference between outside and interior space temperatures, with adjustment for the building's thermal storage and heat loss properties. For example, in more temperate weather, the building HVAC system needs little time to recover from its night temperature setback so equipment start-up could be delayed. Similarly, equipment reactivation would not be postponed during weather extremes or after interior temperatures have drifted farther from desired set points.

ASHRAE 90.1 (§ 6.4.3.3.3) requires individual heating and cooling air distribution systems (with a total design supply air capacity > 10,000 cfm and served by one or more supply fans) to have optimum start controls.

The same type of control routines can also be programmed to shut systems down as early as possible while maintaining comfortable temperature set points. SEDAC strongly recommends installation *and operation* of optimum start controls.

This strategy should be applied through the BAS to all primary air handling systems in the building (AHUs and RTUs).

- ✓ **Exhaust fan control:** Consider implementing occupancy-based control for exhaust fans in toilet rooms and other spaces. This feature can reduce energy consumption for both exhaust and supply fans (which currently operate with variable frequency drive control).

- **Implement Parking Lot Lighting 2AM Shutdown**

Exterior lighting is estimated to represent 4% of the total energy cost for the Takiff Center. In addition to costing money, exterior lighting can have a negative effect on both animal and plant life surrounding the building, as well as create potential issues of safety, light pollution, light spill, etc.¹⁰

Re-thinking the hours needed for parking lot illumination in a given area can result in instant, substantial, and permanent energy and cost savings; expenses for re-wiring or adding new controls can achieve payback from energy savings in short order.

Partial-night lighting can be achieved in a number of different ways, depending on the area being illuminated and the type of lamps in use. In an area with multiple luminaires, like a parking lot, the lights may be wired so that a timer shuts off some percentage during the night, while scattered security lights stay on.

We recommend reducing the hours of operation for the majority of the exterior facility lighting by approximately 33% (4 out of 12 hours, average) and consider further reducing hours of operation for fixtures at the outside perimeter of the parking lots. We also

¹⁰ Illinois Coalition for Responsible Outdoor Lighting <http://www.illinoislighting.org/>

recommend considering replacement of the 250-watt metal halide fixtures with LED or induction parking lot lighting in the future.

DCEO will provide incentive funding (under the Custom Incentive program) for exterior lighting that comprises a demonstration of breakthrough equipment and devices. The exterior lighting incentive amount equals \$0.30 per annual kWh reduced. They may also provide a custom incentive at the regular rate of \$0.12 per annual kWh reduced for the addition of advanced time clock-based controls.

- **Install Vacancy Sensors**

Vacancy Sensors automatically turn the lights off when a room is vacant. These sensors can replace any standard wall switch and use passive infrared technology to detect occupancy. The sensors require the user to turn lights on manually, but will optionally turn the lights off automatically following a predetermined time delay once the user exits the room. Since, unlike occupancy sensors they don't automatically turn lights on when motion is detected, vacancy sensors can maximize energy savings by ensuring the lights are not turned on unless they are needed.

- **Consider Facility Retro-commissioning**

We recommend investing in HVAC system retro-commissioning in the Takiff Center facility. This system retro-commissioning should include verification of the functioning, scheduling, set points, and sequences of operation. It should also include documentation, repair, adjustment, and optimizing control of the system to meet space requirements without using excess energy.

Most new buildings get a basic commissioning before and after occupancy to assure that all systems are installed and functioning as intended. However, it is not unusual for this service to be provided in a cursory fashion or skipped altogether if the construction schedule is rushed.

Retro-commissioning is a full-building tune-up for an existing building that may never have been fully commissioned. Likewise, retro-commissioning is appropriate after significant changes in the building configuration (the construction of a linked addition, for instance) or following major changes in the building envelope, internal loads (lighting, plug loads), or changes to the HVAC system settings or functionality.

The strategies which should be considered for implementation with retro-commissioning of the Takiff Center building include:

- ✓ Exhaust air scheduling/control
- ✓ Equipment rescheduling
- ✓ Terminal unit scheduling
- ✓ Economizer optimization and repair
- ✓ Airflow adjustments – reduce minimum flow
- ✓ Discharge air temperature increase
- ✓ Minimum VAV setting reduced
- ✓ Reduce or eliminate use of VAV reheat
- ✓ Temperature set point adjustments
- ✓ Expanded thermostat deadband
- ✓ Field logging

- **Initiate Computer Energy Management:**

Computers can consume significant amounts of energy, even when not in use. A desktop computer uses about 65 to 250 watts and a monitor uses 35 to 80 watts. Check rated equipment wattage at time of purchase to assure efficient equipment selection.

To maximize power savings, the EPA also recommends setting monitors to enter sleep mode after 5 to 20 minutes of inactivity. To save even more, computer CPUs can be set to enter system standby or preferably hibernate after 30 to 60 minutes of inactivity. The lower the setting, the more energy you save¹¹. There are many ways to activate sleep settings across entire networks of computers, including a number of public domain/ operating system solutions, and a number of commercial software packages. Commonly-used screensavers, if they display an image on the screen, do not save any energy at all.

Table 13 shows the electricity that computers use in different modes.

Table 13: Desktop Computer Power Consumption

Computers	Desktop Computer	60-250 Watts
	On screen saver	60-250 Watts (no energy savings)
	Sleep/ standby	1-6 Watts
	Hibernate	0 Watts
	Laptop	15-45 Watts
Monitors	Typical 17" CRT	80 Watts
	Typical 17" LCD	35 Watts
	ENERGY STAR 17" LCD	27 Watts
	Screen saver (any image on screen)	Same as above (no energy savings)
	ENERGY STAR Sleep Mode	2 Watts or less
	ENERGY STAR Off Mode	1 Watt or less

Purchase ENERGY STAR® appliances:

We recommend purchasing ENERGY STAR efficient office equipment when making new purchases. ENERGY STAR certifies computers, office equipment, kitchen appliances, and other equipment. New ENERGY STAR printers and copiers will have built-in occupancy sensor controls as well as other energy-saving features.

ENERGY STAR copy machines use 25% less energy than conventional equipment. ENERGY STAR refrigerators use 15% less energy than required by government standards and 40% less than conventional refrigerators sold in 2001. ENERGY STAR freezers use at least 10% less energy than required by current federal standards.

For more information on ENERGY STAR appliances and tools to estimate your building's energy efficiency, see www.energystar.gov.

¹¹ http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_management

- **Schedule Domestic Hot Water Circulation Pumps:**

Currently, the domestic hot water (inline) pumps circulate water 24/7. This circumstance results in significant unnecessary heat loss through the piping. The use of schedule-based timers can reduce hot water consumption by turning off circulation pumps during the night and on weekends when the facility is unoccupied.

- **Add Vending Control to Beverage Vending Machine:**

SEDAC recommends installing a controller for automated management of vending machine energy use. Vending machines run 24 hours a day and use considerable amounts of energy. A VendingMiser™ is a device that senses the occupancy of a room and turns off the machines when the area is unoccupied. To maintain beverage temperature levels, the VendingMiser™ cycles the compressor once every one-to-three hours. This cycling results in substantial energy and maintenance savings. Installation is relatively simple; the Miser is placed between the plug of the machine and the outlet. An occupancy sensor is attached to the top of the machine. USA Technologies manufactures the Misers.¹² VendingMisers™ retail for \$179.

Misers are also available for non-refrigerated snack machines. A snack machine's lights and electronics typically draw 80 to 100 watts, 24 hours a day, every day of the year. A SnackMiser can be used to turn off the machines when no one is present. SnackMisers are available for a retail cost of \$79.¹³

USA Technologies includes an economics calculator on their website and it can be used to calculate potential savings from a VendingMiser or SnackMiser.¹⁴

VendingMisers are also available for merchandisers, or reach-in coolers, with similar costs and economics.

Various incentives are available for vending equipment through DCEO. Standard incentives include \$150 per unit for ENERGY STAR refrigerated vending machines (with built-in sensor control); external beverage machine control devices (like the VendingMiser) are eligible for an incentive of \$110 per control; controls for snack vending machines are eligible for a \$45 incentive.

- **Employee Strategies - Energy Management Team**

One of the most effective ways to reduce energy consumption is through an organization-wide education and policy-change program aimed at reducing (and eventually eliminating) wasteful personal habits and unnecessary operation of equipment. It involves the internal assessment of current performance, goal setting, and the dissemination of energy efficiency strategies throughout the facility by a team of individuals willing to take on the challenge. This approach could improve the Takiff Center's efficiency without significant added cost. ENERGY STAR has provided effective guidelines for formation of an energy management team within a company. (Figure 13 is an illustration which can be found on their website.¹⁵) This energy management team will consist of volunteer employees who will be charged with developing the facility's energy efficiency policies (and potentially other green strategies) and their enactment. Policies can range anywhere from new operational strategies that save energy, to recycling polices, to implementing low-flow fixtures in the restrooms.

¹² http://www.usatech.com/energy_management/energy_vm.php

¹³ http://www.vendingmiserstore.com/c154/snack_miser.php

¹⁴ http://www.usatech.com/energy_management/energy_calculator.php

¹⁵ http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index

An organization's upper management is encouraged to take part in the meetings as well. Research has shown that in certain settings, others will follow the actions of their peers or coworkers in order to fit in. If the energy team develops an official energy conservation policy, others will be likely to follow.

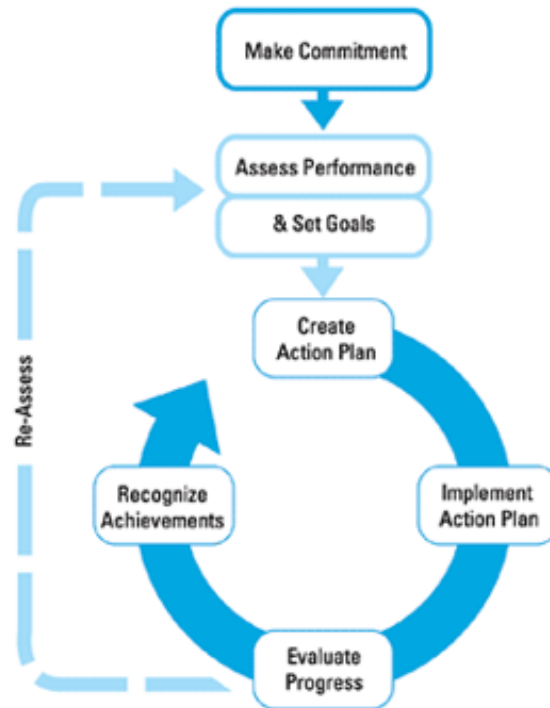


Figure 13: Steps for an Energy Management Team

4.9 ECRM Cost Estimation

ECRM first-cost estimation was based on the following budget numbers.

Table 14: Cost Estimation

Energy Cost Reduction Measure (ECRM)	Description, Quantities, and Cost Basis	Source of Cost Estimate
ECRM 1 –Gym Lighting Upgrade	Cost to change out Gym Lighting: \$125 per fixture (assumes ballast cost included) plus \$30 per fixture for wire cages plus cost of six lamps. Doubled that to account for labor costs. Added \$1,000 for more complex control switching etc. (2, 4, or 6 lamps on). \$9,042	Warehouse-Lighting.com http://www.warehouse-lighting.com/high-bay-lights/6-lamp-hfa3-series-fluorescent-light-fixture-32-watt-120-volt-miro-4-reflector-high-bf-electronic-ballast.aspx
ECRM 2 – Roof Insulation	Cost to install additional 3 1/2" of polyisocyanurate insulation to achieve an R-25 continuous insulation layer on roof. \$40,122	RSMeans Building Construction Cost Data 2011 p.206: 3 1/2" polyisocyanurate NOTE: the incremental to go from R-20 (code) to R-25 should be considerably less
ECRM 3 – Lighting Upgrades (3A)	Cost to replace approximately 2,000 32-watt 4-foot linear fluorescent lamps with the same number of 28-watt 4-foot linear fluorescent lamps. Assumptions include reuse of existing electronic ballasts. Added allowance of \$3500 for in-house re-lamping (~\$5.00/fixture) \$12,540	GoodMart.com (used Philips Alto II 28 Watt 4100K (F32T8/ADV841/EW/ALTO) http://www.goodmart.com/products/philips-f32t8-adv841-ew-alto-28w-147348.htm
ECRM 3 – Lighting Upgrades (3B)	Cost to replace approximately 2,000 32-watt 4-foot linear fluorescent lamps with the same number of 25-watt 4-foot linear fluorescent lamps. Assumptions include reuse of existing electronic ballasts. Added allowance of \$3500 for in-house re-lamping (~\$5.00/fixture) \$15,080	Bulbs.com (used Philips Alto 25 Watt 4100K (F32T8/ADV841/XEW/ALTO) http://www.bulbs.com/espec.aspx?ID=11971&RefId=58
ECRM 4 – Reduced Schedule	Allowance for training and BAS programming (\$5,000). Plus an allowance for adding occupant override buttons in multiple spaces (10 @ \$500). \$10,000	Allowance only
ECRM 5 – Bi-level Switching	For stairwells: fixture costs were estimated at \$187; installation time estimated as approximately 30 minutes @ \$35/fixture. For the corridor lighting we assumed a \$15,000 allowance for the necessary rewiring and controls. \$20,328	UC Berkeley case study: http://www.archenergy.com/lrp/products/brochures/deliverable_6.2.5_CaseStudy_5.1.pdf
ECRM 6 – Air Sealing	Assumed an allowance for new door seals, caulking, etc. of \$20,000 \$20,000	Allowance only

4.10 ECRM Incentive Estimation

Many of the ECRMs presented in this report may be eligible for DCEO Public Sector Energy Efficiency Program incentives. Table 15 provides information on these grants.

Table 15: Incentive Estimation

Energy Cost Reduction Measure (ECRM)	Incentives
ECRM1 Gym Lighting Upgrade	2011-2012 DCEO PSEEPS Incentive: "T8/T5 New Fluorescent Fixtures with Electronic Ballast" \$0.75 / per connected watt reduction Estimated Incentive: \$4,734
ECRM 2 – Roof Insulation	2011-2012 DCEO PSEEPS Incentive: Custom programs equals \$0.12 per annual kWh saved for electric measures and \$1.25 per annual therm saved for natural gas measures with a payback of 1 – 7. Estimated Incentive: \$12,191
ECRM 3 – Lighting Upgrades	2011-2012 DCEO PSEEPS Incentive: "High Performance or Reduced Wattage 4-foot T8" \$1.50 per lamp for 4-foot Reduced Watt Lamp Only Estimated Incentive: \$3,000
ECRM 4 – Reduced Schedule	2011-2012 DCEO PSEEPS Incentive: Custom programs equals \$0.12 per annual kWh saved for electric measures and \$1.25 per annual therm saved for natural gas measures with a payback of 1 – 7. Estimated Incentive: \$2,184
ECRM 5 – Bi-level Switching	2011-2012 DCEO PSEEPS Incentive: For the stairwell lights "Bi-Level Stairwell/Hall/Garage Fixtures with Integrated Sensors" @ \$70.00 per fixture; for the suggested corridor lighting, the measure may qualify for a custom incentive. Estimated Incentive: \$5,125
ECRM 6 – Air Sealing	2011-2012 DCEO PSEEPS Incentive: Custom programs equals \$0.12 per annual kWh saved for electric measures and \$1.25 per annual therm saved for natural gas measures with a payback of 1 – 7. Estimated Incentive: \$9,523
Package 1 – All ECRMs	Total Estimated Incentives: \$36,757

5. Conclusions & Recommendations

The results of this report indicate that all the Energy Cost Reduction Measures, either alone or in combination, have favorable net annual energy cost savings for the Glencoe Park District facility.

The ECRMs considered in this report include:

- **ECRM 1 – Gym Lighting Upgrade:** Replace the existing 400-watt metal halide high-bay fixtures in the gymnasium with new 2x4 six-lamp
- **ECRM 2 – Roof Insulation:** Increase the roof insulation to a total thermal resistance value (R-value) of R-25 continuous insulation.
- **ECRM 3 – Lighting Upgrades:** Replace the current 32-watt T8 linear fluorescent lamps with 28-watt or 25-watt T8 lamps.
- **ECRM 4 – Reduced Schedule:** Reduce the occupied mode schedules of low-use or intermittently-occupied spaces in the BAS and add occupant override control.
- **ECRM 5 – Bi-level Switching:** Implement bi-level switching throughout the corridors and stairwells in the facility
- **ECRM 6 – Air Sealing:** Replace weather stripping at doors as needed; in older portions of building, investigate air infiltration and air seal.

The energy savings for these ECRMs and a package of all these ECRMs together is summarized in Tables 16 and 17. The package of ECRMs is strongly recommended for implementation because implementation can reduce annual facility energy costs by 22.7%.

Table 16: ECRMs 1 to 6 and Package 1 – Summary of Energy/ Cost Savings

Measure/ Description	Annual Savings					
	kWh	kW	Therms	\$	% Total \$	
ECRM 1 – Gym Light	31,076	7	(705)	\$2,784	1.8%	
ECRM 2 – Roof Insulation	35,865	23	6310	\$8,994	5.9%	
ECRM 3 – Lighting Upgrades	28W Fixture	51,711	-	(1,020)	\$4,757	3.1%
	25W Fixture	77,685	-	(959)	\$7,612	5.0%
ECRM 4 – Reduced Schedule	10,735	3.17	716	\$1,741	1.1%	
ECRM 5 – Bi-level Switching	57,424	-	(57)	\$6,155	4.0%	
ECRM 6 – Air Sealing	14,641	3	6,213	\$6,623	4.3%	
Package 1: ECRMs 1 - 6	207,960	65	11,458	\$31,749	20.7%	

Notes to Table 16:

- (1) When ECRMs are implemented as a package, results vary from application of individual ECRMs.
- (2) This analysis does not include a likely increase in energy prices. Results are in today's dollars on a pre-tax basis based on \$0.108 per kWh and \$0.811 per therm.
- (3) The reader should note that this study alone is not intended to be sufficient documentation to allow contractors to produce bids to perform the work entailed with implementing the ECRMs described. This does not replace engineering design which will still be necessary for project implementation

Table 17: Economic Analysis for ECRMs 1 to 6 and Package 1

	Annual Savings (\$/yr)	Initial Investment (\$)	Internal Rate of Return (IRR)	Net Present Value (NPV)
ECRM 1 – Gym Lighting	\$2,784	\$9,042	27%	\$10,228
with Incentives		\$4,308	64%	\$14,736
ECRM 2 – Roof Insulation	\$8,994	\$40,122	22%	\$65,292
with Incentives		\$27,930	32%	\$76,903
ECRM 3 – Lighting Upgrades (3A: 28-watt)	\$4,755	\$12,540	35%	\$20,245
with Incentives		\$9,540	48%	\$23,102
ECRM 3 – Lighting Upgrades (3B: 25-watt)	\$7,609	\$15,080	49%	\$37,144
with Incentives		\$12,080	62%	\$40,001
ECRM 4 – Reduced Schedule	\$1,741	\$10,000	10%	\$2,257
with Incentives		\$7,816	17%	\$4,337
ECRM 5 – Bi-level Switching	\$6,155	\$20,328	27%	\$22,292
with Incentives		\$15,203	38%	\$27,174
ECRM 6 – Air Sealing	\$6,623	\$20,000	30%	\$25,780
with Incentives		\$10,477	62%	\$34,850
Package 1: All ECRMs	\$31,749	\$112,032	24%	\$108,224
with Incentives		\$75,274	40%	\$143,231

Notes to Table 17:

- (1) When ECRMs are implemented as a package, results vary from application of individual ECRMs.
- (2) For Package 1 the savings and cost are based on using 28-watt replacement lamps for ECRM 3.
- (3) This analysis does not include a likely increase in energy prices over the analysis period. Results are in today's dollars on a pre-tax basis based on \$0.108 per kWh and \$0.811 per therm.
- (4) The discount rate is assumed to be 5% for public facilities.
- (5) The life cycle used for calculating the IRR and NPV for ECRM 2 is 20 years. All of the other ECRMs (1, 3, 4, 5, and 6), as well as the Package, are calculated using a life cycle of 10 years.
- (6) The reader should note that this study alone is not intended to be sufficient documentation to allow contractors to produce bids to perform the work entailed with implementing the ECRMs described. This does not replace engineering design which will still be necessary for project implementation
- (7) See Table 14 for information on capital cost development and Table 15 for ECRM incentive estimation.

In addition to the package of ECRMs analyzed, SEDAC also strongly encourages consideration of and implementation of strategies described in the Additional Energy Cost Reduction Measures section of this report. These measures include:

- **Implement Additional HVAC Measures**
 - ✓ Occupancy (demand) controlled ventilation
 - ✓ Optimum start/stop controls
 - ✓ Exhaust fan control
- **Implement Parking Lot Lighting 2AM Shutdown**
- **Install Vacancy Sensors**
- **Consider Facility Retro-commissioning**
- **Initiate Computer Energy Management**
- **Purchase ENERGY STAR appliances**
- **Schedule Domestic Hot Water Circulation Pumps**

- **Add Vending Control to Beverage Vending Machine**
- **Employee Strategies - Energy Management Team**

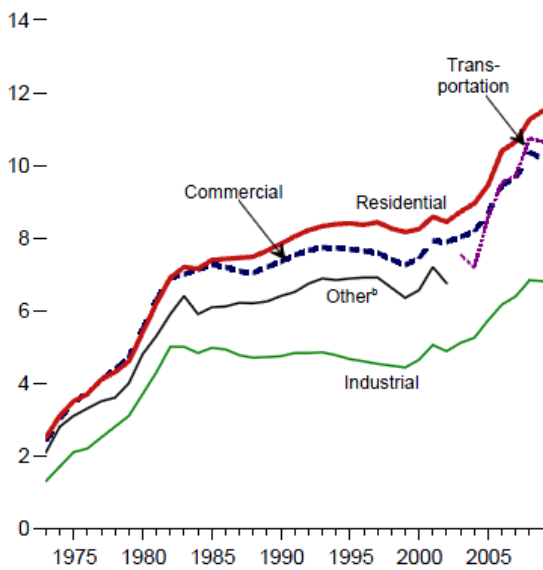
To demonstrate the effectiveness of SEDAC's energy audit program to the State of Illinois, we are asked to compile quarterly reports that document implementation of energy efficiency measures. We ask that you keep us apprised of all work completed to allow us to accurately represent savings recommended. We will also contact you periodically to discuss, answer questions, and review status.

Appendix A – Abbreviations

A/C – Air conditioning	kBtu – kiloBtu, one thousand British thermal units
ACH – Air Changes per Hour	kW – kilowatt, one thousand watts
AFUE - Annual Fuel Utilization Efficiency	kWh – kilowatt-hours, one thousand watt-hours
AL – Air Leakage	LCD – Liquid crystal display
BF – Ballast Factor	LLC – Life Cycle Cost
BTU – British thermal unit	LPD – Lighting Power Density (W/sf)
CBECS – Commercial Building Energy Consumption Survey	MBtu/h – One thousand British thermal units per hour
CFL – Compact Fluorescent Lamp	ORNL – Oak Ridge National Laboratory
CHP – Central Heat and Power	NLO - Electronic Normal Light Output Ballast
CMU – Concrete Masonry Unit (Concrete Block)	NPV – Net Present Value
COP – Coefficient of performance	PSEE – Public Sector Energy Efficiency Program
CRT – Cathode-ray tube	PTAC – Package Terminal Air Conditioning Unit
DCEO – Illinois Department of Commerce and Economic Opportunity	PV – Photovoltaics
DOE – U.S. Department of Energy	R-Value – a measure of the resistance of building materials to heat transfer
ECRM – Energy Cost Reduction Measure	SEDAC – Smart Energy Design Assistance Center
EER – Energy Efficiency Ratio	SEER - Seasonal Energy Efficiency Ratio
EPA – U.S. Environmental Protection Agency	SF or Ft ² – Square Feet
Equip. – Equipment	SHGC – Solar Heat Gain Coefficient
EUI – Energy Use Intensity	T5 – A tubular fluorescent lamp 5/8” in diameter
F – Fahrenheit	T8 – A tubular fluorescent lamp one-inch in diameter
GPF - Gallons Per Flush	T12 – A tubular fluorescent lamp one-and a half inch in diameter.
ft – Foot, or Feet	Therm – A unit of measure for natural gas. Equal to 100,000 Btus or 100 Cubic Feet.
HET – High Efficiency Toilets	VHO – Electronic Very High Output Ballast
hr – Hour	yr – Year(s)
High-bay – Applications where lights are designed to be installed above 20’	
HSPF – Heating Seasonal Performance Factor	
HVAC – Heating, Ventilating, and Air Conditioning	
HO – High Output	
IRR – Internal Rate of Return	

Appendix B – Energy Prices

By Sector, 1973-2010



By Sector, Monthly

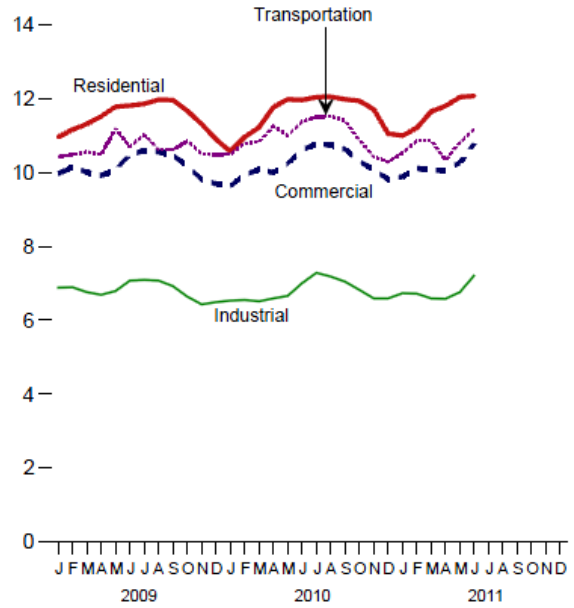
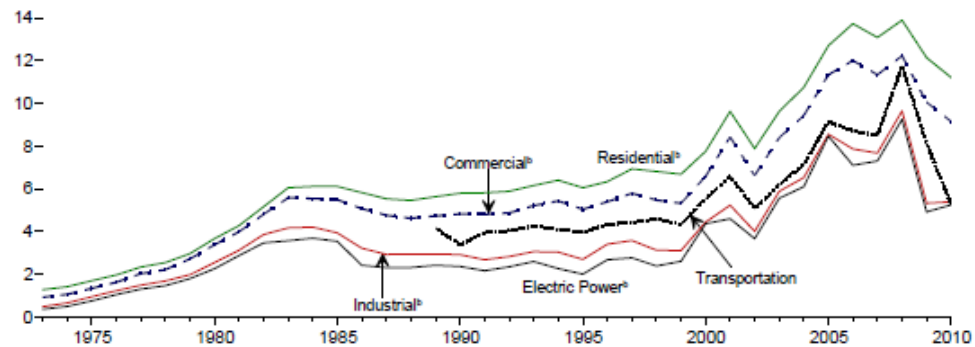


Figure 14: Average Retail Price of Electricity (nominal cents per kWh)

Consuming Sectors, 1973-2010



Consuming Sectors, Monthly

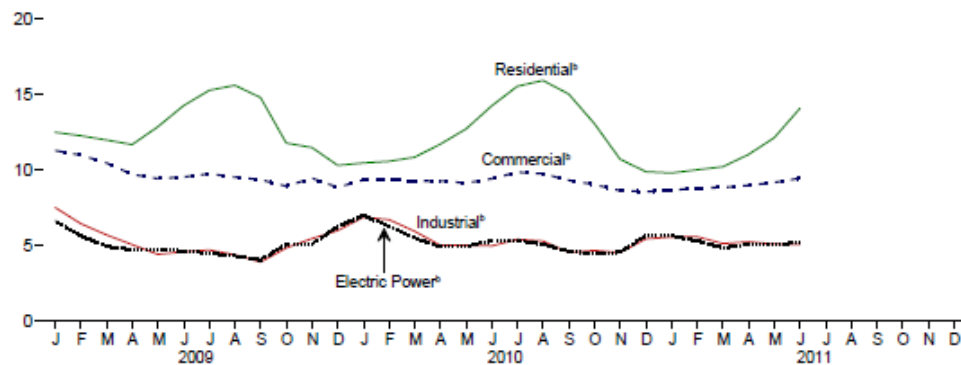


Figure 15: Average Retail Price of Natural Gas (nominal dollars per 1,000 ft³)¹⁶

¹⁶ Energy Information Administration Monthly Energy Review, December 2009

Appendix C – Energy Savings Incentives

Illinois Energy Efficiency Portfolio Standards (EEPS)

DCEO's Public Sector Energy Efficiency Program offers incentives for energy efficiency measures for customers in the ComEd or Ameren service areas. Incentives are available; less than or equal to \$50,000 awarded as rebates, while those greater than \$50,000 processed as grants. Multiple applications with project subsections may be submitted. Further, incentives are limited to 75% of the total project cost and 100% of the incremental project cost (beyond standard replacement option).

SEDAC provides a website that posts relevant documents and link to programs and services at www.IllinoisEEPS.org. Please bookmark this page and watch for further developments.

DCEO's Public Sector Electric Efficiency Program can be found at:
www.illinoisbiz.biz/dceo/Bureaus/Energy_Recycling/Energy/Energy+Efficiency/

Other Sources of Funding Information

Illinois Clean Energy Community Foundation provides grants for energy efficiency improvements and renewable energy projects:
<http://www.illinoiscleanenergy.org/>

For information on state and federal rebates and tax credits, see Database of State Incentives for Renewables and Efficiency:
<http://www.dsireusa.org/index.cfm?EE=0&RE=1>

SEDAC maintains a website for posting links to various funding opportunities:
http://smartenergy.arch.uiuc.edu/html/info_loan.html

Sources of Information on Contractors and Installers

There are several websites with preferred providers for implementation.

SEDAC: http://smartenergy.arch.uiuc.edu/html/info_serviceprovider.html

ComEd: <http://www.comed.com/sites/PartnersBusiness/Pages/tradeallies.aspx>

Ameren: <http://www.actonenergy.com/for-my-business/find-a-service-provider/>

EPA Act Tax Deduction

Building owners may be able to claim tax deductions for energy efficiency improvements put into service in 2006-2013. In the case of municipal buildings, the tax deduction is earned by the design professional, or the person primarily responsible for designing the property, in lieu of the public entity.

The 2005 Energy Policy Act (EPA Act) provides tax deductions of \$1.80/sf for buildings that are 50% more efficient than the 2001 ASHRAE Standard 90.1. Building modeling and engineering certification is necessary for the whole building savings. Businesses may also receive deductions if individual components of the building (lighting, envelope, HVAC) meet the requirements. A summary of the deductions is shown in Table 18.

Table 18: Summary of Federal Tax Deductions

Category	Energy Savings (vs. ASHRAE 90.1-2001)	Tax Deduction	Requires Energy Simulation?
Whole Building	50%	Up to \$1.80/ft ²	Yes
Lighting, HVAC, or Envelope	16.7% per system	Up to \$0.60/ft ² per system	Yes
Lighting savings of at least 25%	25-40%	Sliding scale: \$0.30/ft ² for 25% savings to \$0.60/ft ² for ≥40%	No, just lighting power density calculation

Notes to Table 18:

- (1) Note that as an alternative to achieving savings of 16.7% per system when applying for individual systems, you may also attempt to achieve savings for 20%, 20%, and 10% for lighting, HVAC, and envelope respectively as per IRS Notice 2008-40.

Appendix D – Recommended Minimum Interior Light Levels

The following lighting levels have been selected based on criteria established by the Illuminating Engineering Society of North America (IESNA); the recommended maximum lighting power density (LPD) levels are SEDAC suggested levels.¹⁷

Table 19: Recommended Minimum Light Level / Maximum LPD

Functional Area	Minimum Recommended Light Levels (fc=foot candles)	Maximum Recommended Lighting Power Density (W/sf=watts per square foot)
Classrooms – Standard	50-60 fc	1.2 W/sf
Classrooms – High Task (Drafting/ Art)	50-75 fc	1.5 W/sf
Computer Rooms	35 fc	0.8 W/sf
Conference/ Meeting/ Multi- purpose Rooms	35 fc	0.8 W/sf
Gymnasium – Fitness	30 fc	0.7 W/sf
Gymnasium – Game Playing	50 fc	1.0 W/sf
Offices – Enclosed (w/o Task Lighting)	50 fc	1.0 W/sf
Offices – Open (w/ Task Lighting)	35 fc	0.8 W/sf
Offices – Computer Work	30 fc	0.7 W/sf
Dining Area	20 fc	0.6 W/sf
Food Preparation	75 fc	1.5 W/sf
Hallways/ Lobbies	20 fc	0.6 W/sf
Restrooms	20 fc	0.6 W/sf

¹⁷ Suggested LPDs have been selected based on reviews of the latest published editions of the ANSI/ASHRAE/IESNA Standard 90.1-2010 Energy Standard for Buildings Except Low-Rise Residential Buildings (ASHRAE 90.1-2010) and ANSI/AHSRAE/USGBC/IES Standard 189.1-2009 *Standard for the Design of High-Performance Green Buildings* (ASHRAE 189.1), recommendations from the Oregon Office of Energy, as well as review of presentations and publications on current lighting design.