ENERGY ASSESSMENT OF SELECTED SCHOOLS IN ANCHORAGE SCHOOL DISTRICT

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ABSTRACT

In its continuous effort to improve energy efficiency and reduce energy cost of its facilities, Anchorage School District (ASD) has benchmarked the energy usage of the schools in its territory using EPA Benchmarking/Portfolio Manager. Based on benchmarking results and tracking the energy usage of the schools, eleven schools with abnormally high-energy consumption were identified for comprehensive energy assessments. Consultants were hired in a competitive bidding process, the assessments were performed, and the results were presented in a span of five months. The assessments included analyses of one-year worth of energy bills, site inspections, selected measurements, evaluation of trend data, detailed modeling of the energy usage of the facilities, and preparation of comprehensive assessment reports. The results show 20% to 40% energy savings potential with reasonable paybacks using the available energy efficient technologies.

INTRODUCTION

This paper summarizes the details and results of a comprehensive energy assessment of eleven K-12 school facilities served by the Anchorage School District (ASD) of Anchorage, Alaska. Details of the assessment process, major energy conservation measures that have been identified, and the economics of the measures will be discussed in this paper. These facilities were benchmarked against other similar-use buildings in the western United States as well as the entire country to evaluate and compare the level of energy usage.

Rebuild America (a program of the U.S. Department of Energy that focuses on promoting energy efficiency in existing commercial, institutional and multifamily residential buildings through private-public partnerships created at the community level) states that there are approximately 118,000 public and private K-12 schools nationwide. According to the U.S. Department of Energy, K-12 schools across the United States spend over $6 billion on energy costs alone each year.[1] This is more than the amount spent on books and computers combined. It is estimated that schools can save on average 25-30 % of this energy by applying available energy efficient technologies and making sensible changes in operation and maintenance practices.

Anchorage School District (ASD) is the 86th largest school district in the country. The district serves over ninety K-12 schools with a student population over 50,000.[2] ASD utilizes an energy accounting software called Faser to monitor the energy usage of their schools. Based on data extracted from this software for the 2001-2002 fiscal year, it is estimated that ASD spends over $7.8 million per year on electrical energy and natural gas costs for their schools and support facilities. In its continuous efforts to improve energy efficiency and reduce energy cost of its facilities,

[1] U.S. Environmental Protection Agency's Energy Plan. 2002. *How to Benchmark K-12 School Energy Performance with ENERGY STAR Portfolio Manager.*

[2] Anchorage School District, www.asdk12.org/aboutasd/

ASD extracted the electrical and natural gas information in various schools from Faser and benchmarked the energy usage of the schools using ENERGY STAR Portfolio Manager. ENERGY STAR Portfolio Manager is a benchmarking tool developed by the Environmental Protection Agency (EPA) to assist various organizations to track and measure the energy performance of their building(s) and be able to compare their buildings' performance (based on energy intensity) with that of other similar-use buildings in the nation. Using this benchmarking tool, ASD was able to determine which of the schools in their territory were more energy intensive (low-performing). The district had several prototype schools which newer schools are built based on, however in several cases the newer schools tended to be more energy intensive than their predecessors. Based on these parameters, ASD identified eleven schools for which they decided to perform comprehensive energy assessments. Energy consultants were hired after a competitive bidding process to audit these targeted schools for energy conservation potentials.

ASSESSMENT PROCESS

Anchorage School District (ASD) personnel provided data from the Faser software to the audit team prior to the energy assessment of the facilities. Electrical energy and natural gas energy usage and costs were extracted from the Faser data to determine the annual electrical and natural gas loads of the facilities to be studied. This data was later used to perform an energy balance of each facility's electrical and natural gas energy consuming equipment and provided a basis for comparing the individual facility's energy usage with that of other similar facilities in the study and in the nation. The average energy usage and demand values were extracted from the Faser data as well. Table 1 below summarizes the electrical and natural gas energy consumption and costs for the eleven facilities in the study.

TABLE 1 – SUMMARY OF ELECTRICITY AND NATURAL GAS USAGE AND COSTS**

Facility	**Year Built**	**Facility Size** (ft^2)	**Number of Students**	**Electricity Usage** (kWh/yr)	**Natural Gas Usage** (therm/yr)	**Energy Costs** ($/yr)
Elementary Schools						
Elementary School A	1971	37,370	368	519,920	40,551	62,472
Elementary School B*	2000	61,599	505	636,240	59,827	77,762
Elementary School C*	1996	61,599	547	506,400	70,729	71,252
Elementary School D*	1996	61,599	489	614,640	61,796	78,011
Elementary School E*	1991	66,367	577	746,600	82,327	96,278
Elementary School F	1993	62,076	456	640,200	82,087	87,262
Elementary School G	1973	60,610	507	573,400	60,144	76,824
Elementary School H	1957	32,470	256	307,440	38,338	37,874
Secondary Schools						
Secondary School A	1949	45,910	300	557,760	50,712	56,644
Secondary School B	1991	27,275	330	368,800	35,017	46,681
High Schools						
High School A	1953	340,797	1,566	4,249,920	287,400	400,034
Totals				**9,721,320**	**868,928**	**1,091,094**

* These are prototype schools, which have similar designs and construction.

** Data is for the 2001-2002 fiscal year.

Facility Audit

The audit of the facilities included but was not limited to the following:

- Interviewing the personnel in charge of the operation and maintenance of the facility to determine the concerns personnel may have regarding potential energy conservation measures
- Touring the facility
- Taking inventory of all energy consuming/producing devices in the facility including lighting, electric motors, boilers, air handlers, etc.
- Observing if occupancy sensors are installed in the facility and if not potential areas where they can be installed
- Observing and timing of the equipment
- Making measurements related to major energy consuming devices, including measurements of light intensity, electric power (voltage, current and power factor), temperature, etc.
- Formulation of the energy efficiency measures at the facility based on the findings at the conclusion of the site visit

Collection and Analyses of Information

The analyses of the energy conservation measures recommended for the facilities were based on information gathered during the energy audit of the facilities and also on the following:

Direct Digital Control (DDC) System Trend Data – DDC is a type of energy management system (EMS). The facilities are equipped with DDC systems to monitor the operating conditions of various equipment in the facility. Trend data were obtained from the school EMS. Data from the DDC system, which included setpoint temperatures for different zones in the facility, the operating hours and the operating conditions (e.g. supply and return temperatures) of various equipment (e.g. air handlers, boilers, and pumps) and lighting were extracted from the trend data and used to estimate the annual electrical or natural gas consumption of various equipment. This information allowed us to perform an energy balance of the facility's energy consuming equipment and perform calculations for potential energy conservation measures.

AutoCAD Drawings – Structural, mechanical and electrical AutoCAD drawings of the facilities were provided to the audit team. The drawings were analyzed prior to the facility audit to prepare us for the type of equipment, lighting, etc. that is in the facility. Building construction material was also extracted from the drawings for modeling the building in eQuest. The mechanical and electrical drawings also helped to confirm the field data taken by the audit team.

Boiler Flue Gas Analysis – Boiler flue gas analyses (FGA) performed by an outside contractor for individual boilers within the facilities were provided to the audit team. From the FGA reports, the boilers' combustion efficiency and operating conditions were examined for potential energy conservation measures.

eQuest – eQuest™ is a graphical interface to DOE-2.2. The U.S. Department of Energy and J.J. Hirsch & Associates developed DOE-2.2 specifically for analyzing the energy use of commercial and residential buildings. The simulation model of the building consists of a detailed description of the actual building being analyzed, including hourly scheduling of occupants, lighting, equipment, and thermostat settings. All the constructions used in the building including exterior walls, roofs, floors, and windows are accurately represented. All the building's lighting and receptacle equipment as well as the heating, cooling, ventilation, and domestic hot water equipment used to maintain the building's comfort are accounted for in the energy calculations made by the simulation model. The energy conservation measure (ECM) analyses were made by making slight changes to the model that corresponds to the ECMs that could be implemented in the building.

MAJOR ENERGY CONSUMERS

Electrical energy and natural gas were the only two sources of energy used in all the facilities in this study. The major electrical energy consuming equipment in most of the facilities were lighting and air handling. A significant difference between schools in Alaska and other schools in the nation is that there is no cooling needed in Alaska, only heating. Due to the extreme weather conditions in Alaska, heating is a very significant portion of the energy usage. A breakdown of the major electrical energy consuming equipment for the eleven facilities in the study and the range of percentage of electricity usage for these equipment in the facilities can be seen in Table 2. Similar breakdown of the major natural gas energy consuming equipment can be seen in Table 3.

TABLE 2 - MAJOR ELECTRICAL ENERGY CONSUMING EQUIPMENT	
Major Electrical Energy Consuming Equipment	**Percentage of Usage**
Lighting	28 – 62 %
Office & Classroom Equipment (computers, laminators, etc.)	5 – 15 %
Air Handling Equipment	11 – 35 %
Kitchen Equipment (refrigerators ,ovens, etc.)	2 – 7 %
Hot Water Equipment (hot water supply pumps)	7 – 24 %

TABLE 3 - MAJOR NATURAL GAS CONSUMING EQUIPMENT	
Major Natural Gas Energy Consuming Equipment	**Percentage of Usage**
Hot Water Boilers	82 – 97 %
Hot Water Heaters	2 – 13 %

MAJOR OPPORTUNITIES FOR ENERGY EFFICIENCY

Detailed audits of the ASD facilities and analysis of the data provided by ASD personnel resulted in identification of a number energy saving opportunities. Summaries of some of the major energy conservation measures are briefly described as follows.

High Efficiency Lighting

As seen in Table 2, lighting on average accounts for 28-62% of the electrical energy usage in these facilities. Many of the newer facilities have been constructed with high efficiency T8 lighting and some facilities have retrofitted the existing standard efficiency lighting with high efficiency lighting, but some of the older schools still had T-12 fluorescent lamps, which should be retrofitted. Energy savings can be realized due to less power consumption of high efficiency T-8 fluorescent lamps with electronic ballasts. Many of the facilities utilize high intensity discharge metal halide lamps in areas such as the Gymnasium or Multipurpose Room. It is recommended that these lamps be replaced with high intensity T-5 fluorescent lighting with electronic ballasts. High-intensity fluorescent lamps are more efficient than HID lamps and feature lower lumen depreciation rates, better dimming options, instant start-up and better color rendition. Because high-intensity fluorescent fixtures feature higher lamp and ballast efficacy and greater fixture efficiency, they consume less electricity than conventional HID systems to produce the same quantity of light. Energy savings can be realized due to less power consumption of high intensity T-5 fluorescent lamps with electronic ballasts. Lighting measurements were made during the audit of these facilities and compared to illumination levels recommended by the Illuminating Engineering Society of North America (IESNA) and recommended lighting power densities from California's Title 24 Standards. A general overview of the measured lighting levels in different areas within the schools and the recommended lighting levels is shown in Table 4.

TABLE 4 – SUMMARY OF LIGHTING LEVELS IN SCHOOLS				
Area	**Recommended Lighting Level[3] (lux)**	**Measured Lighting Level (lux)**	**CA Title 24 LPD Standards[4] (W/ft^2)**	**Estimated LPD (W/ft^2)**
Classrooms	320 – 540	240 – 1000	1.6	1.1 – 2.5
Multipurpose Room	400 – 500	340 – 900	1.1	1.4 – 2.9
Library	320 – 540	490 – 1180	1.5	1.4 – 3.4
Gymnasium	430 – 540	155 – 1050	1.0	0.6 – 2.2
Corridors	110 – 215	230 – 580	0.6	0.8 – 1.8
Computer Room	160 – 320	300 – 450	1.1	1.1 – 2.4
Offices	320 –540	300 – 1000	1.1	1.5 – 2.4

[3] Rea, M. S., 2000. "The IESNA Lighting Handbook Reference & Application", 9th Edition, *Illuminating Engineering Society of North America*.

[4] California Energy Commission. 2001. *2001 Energy Efficiency Standards for Residential and Nonresidential Buildings.*

Other lighting energy efficiency measures which were recommended as appropriate included:

- Installation of occupancy sensors in areas that do not have them (including classrooms)
- Delamping or separating lighting circuits for areas that are overlit
- Installation of light sensors in areas that receive enough natural lighting
- Replacing other existing standard efficiency light source with more efficient light source (e.g. replacing conventional incandescent with compact fluorescent)
- Installation of bi-level lighting control on high intensity discharge lighting in the gymnasium and multipurpose rooms

<u>Setback Temperature Levels When the School is Unoccupied</u>

Air handling is the second largest consumer of electrical energy aside from lighting in these schools. On average, air handling accounts for about 11-35 % of the electrical energy usage. Each facility has a number of air handling units to circulate air throughout the building. Hot water, produced by the facility's hot water boilers, is circulated through hot water coils in the air handlers to provide space heating for the building. Based on observations made by the audit team while at the facilities, many of the facilities were controlled at a relatively high constant temperature of 70-72 °F during the weekends and nights, which is when the school is typically unoccupied. It was recommended that the facilities utilize their energy management systems in place to setback the temperature of the schools to 60 °F during evenings and weekends when the schools are typically unoccupied. Setting back the temperature when the school is unoccupied will reduce the usage of the boilers and air handlers resulting in electrical and natural gas energy savings. Other measures for energy savings relating to the air handling and heating systems which were recommended as appropriate include:

- Installing adjustable speed drives on the air handling units (that are not equipped with one) to reduce the power consumption of the supply fans depending on the temperature of the returning air
- Turning off the relief fans, used for controlling the CO_2 level in the facility during evenings and weekends, which is when the schools are typically unoccupied. This will also result in significant natural gas energy savings due to the fact that the fans are exhausting warm air that needs to be re-supplied and heated from the cold outside air
- Installing adjustable speed drives on the hot water supply pumps to reduce the power consumption of the supply pumps depending on the temperature of the returning water.
- Tuning the hot water boilers on a regular basis to improve the boilers' energy efficiency and reduce natural gas consumption
- Installing economizers on exhaust stack of the hot water boilers to preheat boiler feedwater

A summary of some of the common energy conservation measures recommended in the schools as well as those recommended for each school is listed in Table 5.

Table 6 shows the total electrical and natural gas energy saving percentages for the individual facilities that were audited as well as the average overall savings and simple payback for these facilities.

The energy conservation measures identified during the energy assessment of the eleven facilities in the Anchorage School District is estimated to save about 22.1 % of the total electrical energy usage in these eleven facilities, and about 28.4 % of the total natural gas energy usage. The recommendations will also reduce the average monthly demand usage by about 16.4 %. The annual total cost savings of the eleven facilities due to implementation of the indicated measures are estimated at about 20.9 % of the facilities' annual energy costs, with an overall simple payback period of 2.9 years (Ganji, et al. 2003)

BENCHMARKING

Benchmarking is the process by which a school's performance can be compared to the performance of other schools with similar characteristics. Benchmarking should constitute a fundamental part of the school improvement process. The purpose of benchmarking is to continuously improve levels of performance or service by identifying where changes can be made in how things are done. By analyzing information about an individual school's performance and comparison with other schools that are achieving better performance, one can identify where improvement is needed, how to achieve it, and what impact it might have on the overall success rate. However, to be effective, there is a need to ensure that comparisons are valid, meaning that the schools are similar and similar measurements and data are used for benchmarking. Benchmarking can provide schools with alternatives in resource management, suggesting other methods for doing things better, improving efficiency and reducing costs. A school can benchmark against its own past effectiveness, or compare itself with other schools. In this manner, a school can see how effective it is in relation to the past or relative to other schools. It can therefore identify areas for improvement.

TABLE 5 – SUMMARY OF ENERGY CONSERVATION MEASURES RECOMMENDED IN SCHOOLS											
Energy Conservation Measure / **School**	Elementary School A	Elementary School B	Elementary School C	Elementary School D	Elementary School E	Elementary School F	Elementary School G	Elementary School H	Secondary School A	Secondary School B	High School A
Install High Efficiency T-8 Lighting								✓	✓	✓	✓
Install Light Sensors		✓	✓	✓	✓						
Delamp Lighting or Separate Lighting Circuits		✓	✓	✓		✓					✓
Replace HID Lighting w/ T-5 Fluorescents			✓	✓	✓	✓	✓	✓	✓		
Install Occupancy Sensors	✓				✓	✓	✓	✓	✓	✓	✓
Install High Efficiency Metal Halide Lamps	✓										
Replace Conventional Incandescent Lamps w/ Compact Fluorescent									✓		
Install Bi-level Lighting Control	✓										
Replace Current Laminators with Cold Laminators	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Turn Off Computers During Evenings & Weekends	✓	✓	✓	✓	✓	✓	✓				
Pull Down Blinds During Evenings & Weekends	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Setback Temperature Levels During Evenings & Weekends	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Control & Setback Temperature in Relocatable Classrooms	✓		✓								
Turn Off Relief Fans During Evenings & Weekends					✓						
Install Adjustable Speed Drives on Air Handlers					✓					✓	✓
Install Economizer to Preheat Boiler Feedwater						✓					
Tune Hot Water Boilers	✓			✓			✓				
Install Adjustable Speed Drives on Hot Water Supply Pumps	✓						✓		✓		✓
Install Adjustable Speed Drive on Glycol Pumps		✓	✓	✓					✓	✓	✓
Install Higher Efficiency Motors											✓
Turn Off Pool Circulation Pump											✓

TABLE 6 – SUMMARY OF ENERGY SAVINGS					
Facility	**Electrical Energy Savings** (%)	**Maximum Demand Savings** (%)	**Gas Usage Savings** (%)	**Total Energy Cost Savings** (%)	**Simple Payback** (yr)
Elementary Schools					
Elementary School A	16.4	12.0	28.2	15.9	2.3
Elementary School B	9.7	10.9	24.7	11.9	1.8
Elementary School C	21.1	19.6	27.1	20.0	2.3
Elementary School D	15.0	13.6	31.5	17.4	2.2
Elementary School E	40.4	32.6	34.6	33.2	2.8
Elementary School F	12.4	12.3	32.5	17.4	2.7
Elementary School G	20.1	21.2	32.4	22.3	2.4
Elementary School H	18.5	25.3	28.6	24.2	4.7
Secondary Schools					
Secondary School A	28.9	27.8	34.4	28.8	4.8
Secondary School B	32.0	26.0	24.5	25.3	5.1
High Schools					
High School A	22.7	11.0	22.5	19.8	2.6
Weighted Averages	**22.1**	**16.4**	**28.4**	**20.9**	**2.9**

Benchmarking typically compares the annual energy use intensity (EUI) of various buildings. Comparing annual energy use intensities (EUIs) can quickly show the energy performance of a building compared to others. EUI (usually expressed as kBtu/ft^2) indicates the rate at which energy is used at a building.

Two benchmarking tools were used in this project to compare the energy usage of the subject ASD schools with that of schools across the nation.

Portfolio Manager

One of the benchmarking tools used is the ENERGY STAR Portfolio Manager. Portfolio Manager is an internet-based tool specifically designed by the U.S. Environmental Protection Agency (EPA) to help businesses track and objectively compare energy use on a continual basis for both individual and large groups of buildings. Portfolio Manager calculates normalized energy consumption levels for a building, based on user-specified data for location, space type, occupancy, hours of operation, and metered energy use for electricity and various fuel types (EPA, 2001). The tool then generates a score on a 1 to 100 scale, using the Commercial Building Energy Consumption Survey (CBECS) database as the basis for comparison (Sharp, 1998). Buildings that are among the top 25% nationwide in terms of energy performance (earning a benchmarking score of 75 or greater) can qualify to receive the ENERGY STAR label. This information provides building managers and owners with a valuable resource to effectively manage energy use within their building(s). Portfolio Manager is best used to compare buildings across an entire portfolio. This allows the user to identify and prioritize investments to the poorest performing buildings and learn best practices from the top performing buildings. The worst performing buildings in the portfolio are typically best candidates for improvement, and are where most energy savings will be realized.

To ensure an accurate benchmark score, the portfolio manager's benchmarking model for K-12 schools requires buildings to meet the following criteria:

- Building must be at least 5,000 ft^2 in size
- Be primarily used for academic instruction including Kindergarten, Elementary, Junior High and Senior High
- Have been occupied for at least 9 of the last 12 months
- Have at least 50% of its area designated for academic use and no more than 10% of its area designated for computer data center space
- Be occupied and in use at least 35 hours per week
- Have energy consumption data for one year

Portfolio Manager utilizes an index called the Normalized Annual Consumption (NAC) to represent the building's energy consumption during a "normal" weather year (EPA, 2001). The "normal" outdoor air temperature is determined from 30-year Typical Meteorological Year (TMY-2) or Weather Year for Energy Calculation (WYEC) data sets developed by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). Utilizing the information extracted from the Faser software, the audit team benchmarked the targeted facilities utilizing Portfolio Manager and the results of the benchmark are shown in Figure 1 below.

As seen in Figure 1, the ENERGY STAR scores of the targeted schools ranged from 10 to 27. Several factors may contribute to these low scores and counterintuitive results.

- ***Geographic Resolution*** – One possible limitation is most likely due to geographic resolution (NYSERDA, 2003). Portfolio Manager sorts CBECS data into any of nine regional categories. Alaska is grouped in Division 9, which includes California, Oregon, Washington and Hawaii. Since the weather conditions vary widely in this region, the scores may be significantly affected by geographic location.
- ***Swimming Pools*** – Another major factor that is not included in the benchmark model is swimming pool energy usage (Kinney and Piette, 2002). Swimming pools can account for a major source of energy use and thus greatly affect the energy usage intensity score. A simplified "pool correction" method has been developed by Lawrence Berkeley National Laboratory that will be incorporated into future ENERGY STAR models. High School A had a swimming pool that consumed approximately 27% of its electrical energy usage and a significant portion of its natural gas usage.
- ***Student Population*** – The ENERGY STAR model is highly sensitive to occupant densities; when the occupant densities are adjusted to national averages, the scores are adjusted accordingly (Kinney and Piette, 2002). Therefore, schools where student densities are smaller will receive a lower score compared to a similar facility that is more populated. A school was benchmarked to investigate the effects of occupant density on the benchmark score. It was found that doubling the number of students practically doubles the benchmark score.
- ***Mechanical Ventilation*** – Studies have shown that the presence of a mechanical ventilation system can have a large negative impact on the benchmark score (Hinge, et al. 2002). Providing outdoor air into a large area requires significant fan energy usage. The study found that some of the early ENERGY STAR labeled schools had inadequate mechanical ventilation systems in place contributing to their lower fan usage energy. Newer buildings are designed and built with ventilation systems to provide good indoor air quality, increasing the energy usage in a facility which results in a lower benchmark score.

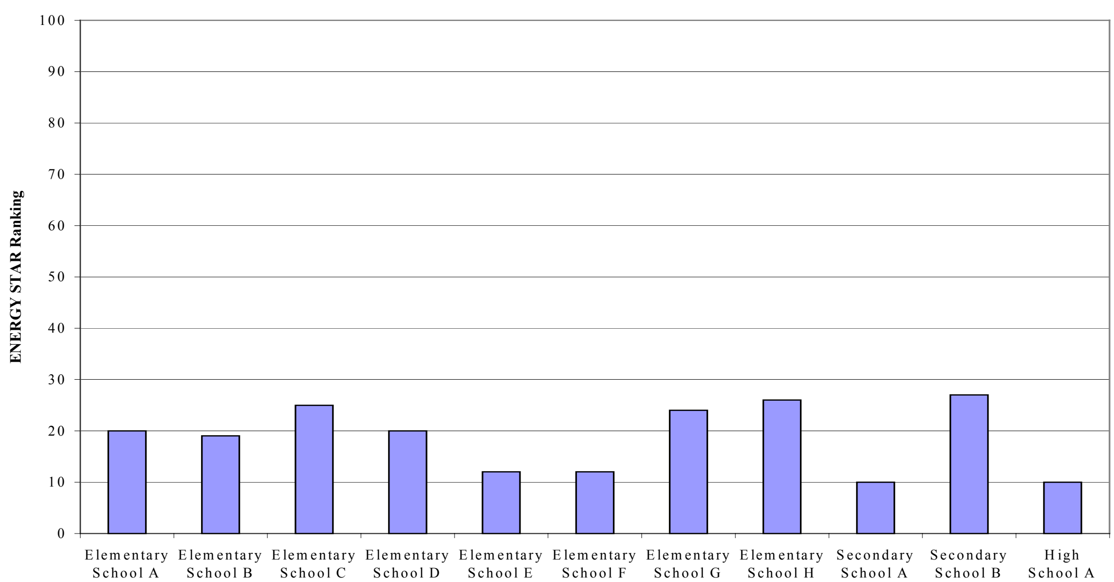

FIGURE 1 – ANCHORAGE SCHOOL DISTRICT ENERGY STAR SCORES FOR TARGETED FACILITIES

- ***Occupancy of Facility*** – Although the ENERGY STAR model does take into consideration the average hours of operation, after school hour activities and events vary during the course of the year and can affect the operating hours of the various equipment in the facility, thus increasing the energy usage intensity. A school was benchmarked to investigate the effects occupancy hours had on the benchmark score. It was found that increasing the occupancy hours only slightly increased the benchmark score, symbolizing that occupancy hours is not an important factor in the benchmark model, while studies have shown can be an important factor (Hinge, et al. 2002).
- ***Maintenance*** – The ENERGY STAR model is sensitive to changes in operation and maintenance practices (Hinge, et al. 2002). Facilities with more experienced custodians that are well familiar with the operations of the support equipment tend to score higher than facilities that are not maintained well.
- ***Other Factors*** - Some other factors that may affect the score determined by the benchmark include the construction material of the building and other miscellaneous loads such as personal computers, art kilns, electric ovens, etc. These factors are not included in the benchmark model. As seen in Table 2, the miscellaneous loads constitute between 5 – 15 % of the electrical energy usage in the subject schools.

Oak Ridge National Laboratory Model

The second benchmarking tool used in the project has been developed by Oak Ridge National Laboratory (ORNL). Oak Ridge National Laboratory (ORNL) has developed this tool for comparing the energy performance of an individual building to other buildings in the nation based on the building's floor area and one year of utility bills for each fuel used. A national benchmarking distribution was created using annual energy use intensity (EUI) data from 449 K-12 public schools across the nation in the form of a descending cumulative histogram. Similar histograms, regional-based for the nine regions, are also available. By determining the EUI of your building, you can plot your data point on the curve to see how your building compares against other similar building types. The higher the rating, the better the relative energy performance of the building. This tool, however, does not take weather as a substantial normalizing factor into the analysis, which could substantially change the results of the benchmark. Also longer operating hours, higher occupant density (students/ft^2), or a large number of computers compared to other schools may attribute to a low rating, which have not been incorporated into the model. These factors must also be taken into consideration when comparing the energy intensity to other schools. Comparing other similar type buildings in an area will provide a better benchmarking tool because this will help account for the differences in weather, building construction, building systems, and other factors that differ regionally and significantly impact building energy usage. The schools in this study were plotted against the ORNL benchmark national and regional distribution curves and the results are shown in Figure 2. As seen in Figure 2, the location of the facility does not appear to affect the rating of the school because in most cases the two ratings were very similar. The ratings for the targeted schools in the study ranged from 20 % to 35 %, meaning that 65 % to 80 % of the schools in the nation are more efficient than the subject schools. However, as mentioned before, there are many factors that have not been taken into consideration in this model that can greatly affect the rating of these schools.

CONCLUSIONS

Significant opportunities for energy efficiency exist for the eleven audited schools in the Anchorage School District. Lighting and air handling are the major uses of electrical energy, accounting for almost half or more of the total electricity used in the schools. Consequently major electrical energy savings were identified in these two areas. Heating is the major natural gas energy usage due to the extreme weather conditions in the area during the winter. The energy conservation measures identified during the energy assessment of the eleven schools in the Anchorage School District are estimated to save about 22.1 % of the total electrical energy usage in these schools, and about 28.4 % of the total natural gas energy usage. The recommendations will also reduce the average monthly demand usage by about 16.4 %. The annual total cost savings of the eleven facilities due to implementation of the indicated measures are estimated at about 20.9 % of the facilities' annual energy costs. Although each facility has its own unique features, the measures identified can have applications in similar type schools. There are a variety of resources for assisting schools in becoming more energy efficient. A listing of some of the available resources can be found in the Appendix following this paper.

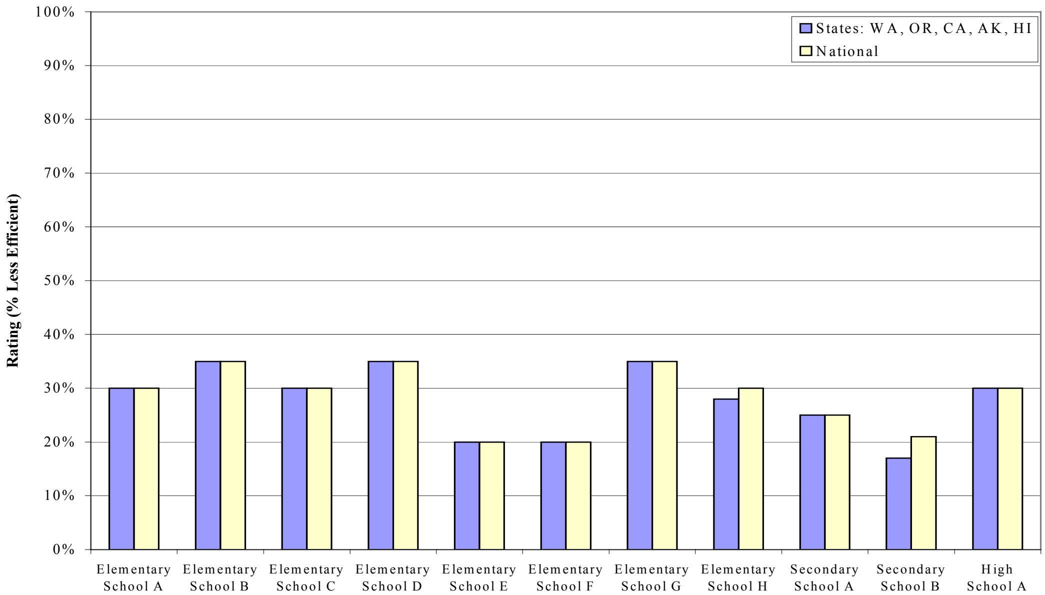

FIGURE 2 – ANCHORAGE SCHOOL RANKINGS USING OAK RIDGE NATIONAL LABORATORY MODEL

Benchmarking the targeted schools utilizing the ENERGY STAR Portfolio Manager resulted in benchmark scores ranging from 10 to 27. Plotting the annual energy usage intensity of these facilities on the benchmark distribution curve developed by Oak Ridge National Laboratory resulted in ratings ranging from 20 - 30 %. Although the benchmarking scores for the targeted schools appear low compared to other schools in the nation, many issues regarding the validity of the benchmarking tools are still in question and warrant further investigation into these issues. Nevertheless, benchmarking is a very effective tool in tracking an individual building's performance over time and comparing one building with others in the same geographical area, and helping to identify opportunities to improve operation and maintenance practices.

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APPENDIX – RESOURCES FOR ASSISTING SCHOOLS TO BECOME MORE ENERGY EFFICIENT

Energy Smart Schools – A U.S. Department of Energy (DOE) Rebuild America program that helps K-12 schools develop energy education programs and save energy and dollars through energy efficiency. The program works with school districts to introduce energy saving improvements to:

- Improve learning and teaching environments
- Reduce energy consumption and costs
- Increase use of clean energy
- Provide instructional material to teach students about the importance of energy conservation and efficiency through hands-on lessons

Energy Smart Schools has developed a design guideline titled "High Performance Schools Design Guidelines" for the new or retrofit design of K- 12 schools in seven different climate zones in the United States. *(www.eere.energy.gov/energysmartschools)*

National Clearinghouse for Educational Facilities – A free public service funded by the U.S. Department of Education to provide information for school personnel on planning, designing, funding, building, improving and maintaining schools. *(www.edfacilities.org)*

Green Schools – A program that helps schools use energy efficiently through changes in the behavior of building users and changes in operational and maintenance routines. The program combines energy efficiency management and building retrofit intervention with student involvement in planning and implementing school wide behavior changes. The Green Schools Program enters into an agreement with the school district to return a portion of the savings back to the schools. *(www.ase.org/greenschools)*

Collaborative for High Performance Schools (CHPS) The goals of CHPS are to:

- Increase the performance of California students with better-designed and healthier facilities.
- Raise the level of awareness in California districts to the impact and advantages of high performance school design.
- Provide the design professional better tools to facilitate effective design.
- Increase the energy and resource efficiency of California schools.
- Reduce peak electric loads. *(www.chps.net)*

National Energy Education Development Project (NEED) – A nonprofit association dedicated to promoting a realistic understanding of the scientific, economic and environmental impacts of energy, so that students and teachers can make educated decisions. The program includes curriculum materials, professional development, evaluation tools, and recognition. NEED teaches the scientific concepts of energy and provides objective information about energy sources - their use and impact on the environment, the economy and society. The program also includes information to educate students about energy efficiency and conservation, and tools to help educators, energy managers and consumers use energy wisely. *(www.need.org)*

Bright Schools – A California Energy Commission program that offers specific services to help schools become more energy wise, such as identifying cost-effective energy-efficient and providing design and implementation assistance at little or no cost to them. *(www.energy.ca.gov/efficiency/brightschools)*

High Performance School Buildings Program – A nonprofit organization that offers training or education for achieving a High Performance School. A resource guide titled "Resource & Strategy Guide for High Performance School Buildings" was developed with the funding from DOE, EPA, PG&E, and others that shows the details of the process for achieving a High Performance School. *(www.sbicouncil.org)*

A more complete listing of available energy efficiency programs for schools is available on the Consortium for Energy Efficiency's (CEE) website (*www.cee1.org/com/bldgs/schools.php3*). The listing includes program strategies, resources, contacts and tools to help members run their school programs.