A White Paper on

Energy Use in Alaska's Public Facilities

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Alaska Housing FINANCE CORPORATION

White Paper on
Energy Use in Alaska's Public Facilities

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Abstract

The amount of heat and electricity used by all public facilities in Alaska is unknown. Additionally, a comprehensive inventory of all publicly-owned buildings does not exist in the State of Alaska (State). Though the State, Department of Education and Early Development (DEED), and the University of Alaska system all track their facilities, there is no single known source for the total number of municipally-owned facilities, their locations, or overall conditions. Because this data is typically tracked on a local government level for boroughs and municipalities, very little information is known about the combined total energy use and functionality of public facilities statewide.

In an effort to begin to understand this data and the energy use in public facilities, Alaska Housing Finance Corporation (AHFC) used federal American Recovery and Reinvestment ACT (ARRA) funds to benchmark over 1,200 publically-owned buildings, and complete 327 ASHRAE[1] Level 2 Investment Grade Audits (IGAs)[2].

The benchmarking and IGA efforts were not only the first steps taken to identify energy use in public facilities and condition of buildings, but also the cost effective measures that could lower overall energy use. To lower energy use, public facilities could invest in the energy efficiency measures (EEMs) recommended in the IGAs. Additionally, this data offers facility managers the opportunity to see how their buildings compare to others of comparable size in similar climates.

[1] American Society of Heating, Refrigerating, and Air-Conditioning Engineers

[2] An IGA is an audit that goes beyond the building envelope or low-hanging fruit. An IGA includes, but is not limited to, investigating energy use, interviewing owners and operators, and providing valuable recommendations to reduce energy usage and improve the building user's comfort.

Executive Summary

The Energy Use in the Alaska Public Facilities White Paper (Paper) presents the first major look at energy use in public facilities across the State of Alaska (the State). It was accomplished by reviewing the results of 327 Investment Grade Audits (IGAs) that were performed on municipal, state, and school district owned public buildings. This project was funded through the Department of Energy (DOE), using American Recovery and Reinvestment Act funds (ARRA) and was administered through the Alaska Housing Finance Corporation (AHFC). Throughout the audit process, AHFC has learned that some facilities manage energy use well, while others need significant improvement. Some regions face growing population resulting in continued construction of new schools, while other regions are experiencing a declining population. Consequently, some school districts are faced with operating buildings that were designed for more students than currently attend.

Some facilities were designed for milder climates and others were not constructed properly or were not commissioned to insure their systems ever worked properly to begin with. Few energy codes were followed in parts of the State. Many buildings were found to be under insulated and over ventilated. Gathering this data allowed AHFC and the Technical Service Providers (TSPs), who were contracted to do the work, begin to understand the needs and relationship of public facilities and energy use in Alaska.

While this Paper will not answer all questions about energy use in public buildings, it lays the groundwork for the following:

- Future policy decisions
- Changes in building design
- Future training needs for operators
- Facility owners and managers to compare their building's energy use and operating costs to similar buildings in comparable climate zones
- Educating facility owners to become more aware of how their decisions on design, construction, and operations dramatically affect energy usage and costs throughout the life of the building

1. Purpose

The purpose of this Paper is to share the results and lessons learned throughout this project. Additionally, it proposes design, policy, and behavior changes that, if implemented, can reduce the energy cost of operating a building, based on observations throughout this project.

Topics and more specific goals in this Paper include:

- Present comparative energy cost information to create awareness of the amount of money used for energy within public buildings.
- Provide a list of typical findings and recommendations across the various building types.
- Provide a list of general recommendations that are applicable to building designers, building owners and operators, building policy makers and the Legislature, as well as AHFC.

- Provide selected case studies and lessons learned to help highlight key audit findings.
- Provide energy use statistics from the benchmarking that may be used to help building owners evaluate their relative energy efficiency compared to other buildings of similar climate or function.
- Discuss factors that affect the audit findings, such as imperfect data for preparation of cost estimates which impacts payback period, thermal versus electric energy comparisons, reasons for variations, and audit goals.

2. Collaboration Efforts

AHFC contracted with four TSP's to perform the 327 IGAs. Upon project completion, AHFC and the TSPs compiled the lessons learned to create this White Paper on Energy Use in Alaska's Public Facilities. Throughout the duration of this project, the four TSPs had support from subcontractors, including auditors and engineers bringing the team size to over 40. Please see Appendix B: Organizational Chart for a listing of the key individuals and firms that contributed to the project.

3. Project Overview and Findings

The IGAs were performed after a large group of buildings were first benchmarked, wherein two years of utility and energy bills were examined to establish comparative performance metrics (See section eight under Background for more information on Benchmarking). The collective group of IGAs enables policy makers, facility owners, and the State to learn more about the energy consumption of publically-owned buildings. IGAs will be made publically available for further reference.

The Paper highlights energy consumption calculations in 14 different building types located in 12 distinct areas of the State, defined by Alaska Native Claims Settlement Act (ANCSA). Please see Figure 1, page 6 for a map of ANCSA Regions.

4. Over All Findings* For all 327 Buildings Audited

Total Square Footage	13,653,153 square feet
Money Spent on BTU***	$49,004,881 annually on approximately 1.76 trillion BTUs of energy
EUI Range	33,102 BTU/SF** – 1,973,345 BTU/SF**
EUI Average	149,372 BTUs/SF**
ECI Range	$0.68/SF* – $32.96/SF**
ECI Average	$4.45 SF
Square Footage Range	1,200 SF – 361,698 SF
Square Footage Average	41,864 SF
Building Average Age (All)	33 years
School Building Average Age	35 years

*** Additional findings and observations can be found under case studies**
****per year**
*****British Thermal Unit**

[3] Additional findings and observations can be found under case studies

Summary of Major Conclusions and Observations:

1. Having an energy policy and an Energy Conservation Manager appears to pay dividends in the reduction of energy consumption. Knowing the cost per hour for building operations can help owners and facility managers make informed decisions about operating schedules and facility usage,

2. Operator training was found to be lacking in many areas. Potential reasons include high turnover in the maintenance workforce and low incentives for continuing education in the maintenance workforce. The complexity of newer buildings demand continuous and intense training in order to operate the buildings as designed.

3. Lighting controls and upgrades were commonly found to have fast paybacks, which was consistently revealed in audits modeled through AkWarm-Commercial (AkWarm-C).

4. Numerous buildings appeared to have significant energy savings potential for relatively low cost measures, such as setback thermostats and optimizing automated controls.

5. Anchorage buildings, in general, and those in southeast Alaska outside of Juneau appeared to be less energy efficient than any others in the state, except the North Slope. Schools in Anchorage appeared to use twice as much energy per square foot as Fairbanks schools, though the cost was about one-third less due to lower fuel prices.

6. Results show the importance of how design and policy decisions affect energy use, as well as the importance of a commitment to efficient buildings. A shift within the design community towards more efficient designs will greatly benefit owners and users through substantial savings due to reduced energy usage. Building owner's awareness and support of these design and policy decisions are critical to making this shift as they hold the purse strings. Construction costs are only 11% of owning a building over its lifetime while operating costs are 50% of this expense, according to ASHRAE.

7. The highest energy use figures were typically found in the North Slope, where it is colder and darker than the rest of the state and where electric engine heaters are consuming vast amounts of power to keep vehicles and equipment operational during outside storage.

8. The costs of energy vary significantly across the state, from $0.08/kilowatt hours[3] (kWh) for interruptible electricity used for heating or domestic hot water in Wrangell (due to the availability of hydro power) to power at $0.80/kWh in some remote northern villages. Likewise, the cost of fuel oil delivered to remote places such as Anaktuvuk Pass, where it has to be flown in, is ten times more expensive than natural gas in Anchorage.

9. There is a strong correlation between average energy consumption and price per student per square footage. This is significant, as the funding formula for schools is based on enrollment, and the cost of energy per student varies greatly—$190 per student per year to almost $16,000/student/year based on data analysis.

10. The audit project found that there is an overall lack of accountability to manage energy use in many buildings. A disconnect between those operating the building and those paying the energy bills often exists. The operator may not know the energy use is high, and the accountant or administrator may not know improvements or changes in operations could be

[3] Wrangell Municipal Light & Power

made to lower the energy bill. Oftentimes the energy bills were paid by different departments located in different parts of the state and were never even seen by the facility staff. See Case Study: Power Of Accountability.

11. EUIs are not linked to energy prices. Schools and other public buildings throughout Alaska show very little correlation between EUI and the price paid for energy. Buildings with higher energy prices do not necessarily use less fuel, meaning there are likely cost effective EEMs that could be implemented. Many regions are not responding to higher energy prices for the reasons above, including lack of data or no energy policies, coordinators, or code requirements.

12. Building systems are not getting routine tune ups. Many building systems audited under this project were found to be operating at less than peak efficiency. Operating building systems such as control strategies, outside air dampers, boilers, furnaces, pumps and flow dampers as designed and in concert with one another could significantly reduce a building's energy use." Retro-commissioning these systems every three to five years would keep them functioning at optimal performance, and give operators a better understanding of how to run the building at peak efficiency, while maintaining safety, good indoor air quality, and comfort.

13. Public facilities could benefit from receiving an IGA on multiple levels. For operations, owners could use the IGA as a tool to leverage state and federal funding, as well as to assist in prioritizing capital improvements and budgets. By implementing EEMs, owners could potentially purchase and use less fuel, provide improved thermal control and comfort, improve light quality, and assure healthy indoor air quality (IAQ).

Summary of Major Recommendations:

1. **Education**: Create and offer building operator training, and building owner education on energy use in buildings. This could include a resource of trained professionals assigned to regions or districts who act as trainers and mentors for building operators. See Case Study: Opportunity to Fund Training.

2. **Data**: Install metering and accurate data collection systems in all public facilities. Collecting this data is the first step in establishing useful benchmark information, the beginning point of energy management. Establishing an energy usage baseline, and then monitoring spikes and anomalies allows recognition of problems and equipment malfunctions. The baseline provides a point at which to measure policy and training effectiveness. See Case Study: Inadequate Metering Of Energy Sources.

3. **Equipment and controls**: The equipment and controls in a building should be appropriate in terms of simplicity for the building and operators. The equipment should be variable and programmable for changing occupancy needs, yet simple enough to be effectively maintained and operated by local staff. See Case Study: Gym Lighting Systems, Lighting Continuously Operating.

4. **Policy**: Every public building should develop an energy policy to efficiently manage energy use while maintaining occupant comfort and indoor air quality. An energy policy should include accountability, operation's schedules and setbacks, procedures for variable

occupancy and energy management education for operators and occupants. Good energy stewardship should be rewarded. See Case Study: Energy Policy Benefits.

5. **Energy Conservation Coordinator/Manager Position**: Create and hire an energy conservation manager position. The audit process identified several buildings, agencies and organizations who employed an energy coordinator. These buildings showed lower energy use than comparable buildings. In many cases, the energy saved by the energy coordinator and policies more than paid for the position. See Case Study: Necessity For Energy Awareness.

6. **Code requirements:** All new state funded buildings should be required to comply with energy codes, such as the International Energy Conservation Code (IECC), American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standards, and published Illumination Standards.

7. **Consolidation/Modular Design**: Student density in rural schools was found to be very low. This creates enormous energy costs per student. One of the most interesting findings from the study showed that the energy cost per Alaska student varies greatly—from a low of $190 in one Anchorage school, to an average of $4,502/student at False Pass School, and a high of $15,961/student[4] in one rural school. None of these schools are above the Arctic Circle (i.e. in extremely cold climates). However, False Pass and the rural school mentioned are in very remote, isolated areas of the State where energy costs are higher than urban areas. Moreover, declining enrollment in rural Alaska has created a situation where many rural schools are now underutilized—up to 450 percent oversized, based on the DEED website[5].

   Consideration might be given to utilizing unused space in schools for post offices, clinics, city management offices or other public uses. Areas with projected or current declining enrollment should also consider the EEMs recommended in this Paper, such as demand-controlled ventilation, zoned setback temperatures, and occupancy sensors.

8. **Seasonal shutdown of appliances**: Refrigerators, freezers, and boilers in buildings that may sit vacant for several months each year should be shutdown where possible—especially in schools. See Case Study: Seasonal Shutdown Of Refrigeration Systems.

9. **Setback of thermostats**: Setting back thermostats or controlling setback temperatures through direct digital control (DDC) systems is found to be very effective, as this is a low cost/fast payback recommendation. See Case Study: Building Setback Temperatures.

10. **Control ventilation:** Demand-controlled ventilation that reduces the amount of outside air (OSA) to a space based on the air quality needs of the actual occupant load versus those of a hypothetical maximum or design occupant load, has the potential for very large energy savings. This was frequently recommended. See Case Study: Controlling OSA Levels.

11. **Retro-commissioning**: Building systems go out of tune, much like automobiles. In order to improve the EUI, which is similar to the miles per gallon in a car, building systems need to be re-commissioned every three to five years.

[4] Data is from CCHRC

[5] http://www.eed.state.ak.us/

5. Conclusion

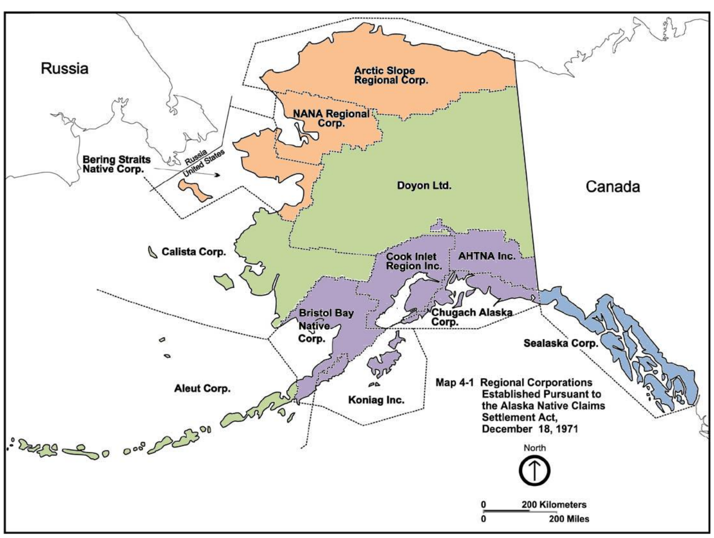
The data collected through the IGA process begins to establish a foundation for understanding energy use in public facilities on a statewide level. It is estimated that upwards of 5,000 publicly-owned buildings exist in Alaska. The estimated energy cost equates to approximately $641,245,000 to the public each year. At the average projected savings of $25,000/year/building, this would equal $125,000,000 in annual potential savings*.

The actual overall energy use of these buildings is unknown, but as explored above, it could be, and is assumed to be, quite significant. This audit process has shown that most, if not all of the public facilities in Alaska, have the opportunity to reduce energy consumption by significant amounts. The information gathered to date provides valuable data from which to compare energy use by building type and to identify where energy is used. It outlines additional educational resources and opportunities needed to reduce costs and to manage energy use in public facilities, as well as identifies the common EEMs by region.

The State or local taxpayers pay the energy bills in all public buildings. As stewards of public funds, efficient use of energy is essential public policy. The information in this report could be used as the groundwork for creating energy management and policy for public buildings, to encourage implementation of recommended EEMs, and to promote the continued effort to benchmark and audit all public facilities in the State.

Alaskans have a potential to save millions of dollars due to higher energy prices and harsher climates than lower 48 Americans. For example, Fairbanks heating oil prices alone jumped 277 percent, from $1.42 a gallon in 2004, to $3.93 a gallon in 2012, according to a fuel price survey conducted by AHFC. The State, community leaders, community members, building occupants, building owners, and building designers should take the lessons learned presented through this Paper to move forward in reducing the energy use and cost in their own public facilities.

Figure 1: ANCSA Regions



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* This is an extrapolation from a biased, not random sample of public buildings. The initial energy use data was voluntarily submitted by building owners, and further biased by audits being performed on larger buildings. The extrapolation is using an estimated 5000 buildings, at a median of 28,820 square feet, with an average energy Cost index of $.45/SF

Targeted Recommendations

The recommendations listed in the following section are ones that have been identified for specific target audiences. The included audiences are those identified as having the ability to implement or take the lead on addressing the specific recommendations. It is possible that duplication exists where more than one group would be involved with implementing a recommendation. Following this section is the "IGA Common EEM Recommendations," which is an expanded, comprehensive list of recommendations, including building specific EEM's noted below.

1. Recommendations for building owners and operators:
   a. **Benchmark buildings and track energy costs:** Look for trends and spikes in use. Continued energy use tracking can help spot leaks, fuel misuse and potential inefficiencies.
   b. **Get an IGA:** Throughout the audit process, a building owner can find out the specific conditions of the facility and its energy usage. This is useful even if no immediate upgrades are planned—it can help future planning. Public facilities could benefit from receiving an IGA in multiple ways.
      i. For operations, some facility owners said they would use the IGA as a tool to leverage state and federal funding, as well as to assist in prioritizing capital improvements and budgets. By implementing EEMs, owners could potentially purchase and use less fuel, reducing financial risks associated with future fuel price increases.
      ii. For building occupants, implementing audit recommendations can provide improved thermal control and comfort, improve light quality, and assure healthy indoor air quality (IAQ).
      iii. For the community, benefits could include creating local jobs, reducing environmental impacts, and potential long-term community sustainability. Additionally, addressing recommendations could provide comfortable and safe public buildings and schools for community members and children.
   c. **Provide maintenance and technician training for staff:** One of the largest challenges observed in many buildings was the lack of training provided. The DDC systems are indeed complex, and persons who do not work on them routinely find themselves overwhelmed. Auditors found controls bypassed and operating in the "hand" and manual mode to make them operational. This occurs simply because the technician has not been trained in building operations or the trained technician has moved on and his replacement does not know how to operate the systems. Examples include finding back up pumps, intended to only operate if the primary pump fails, to be turned on so both pumps are always running in "hand" mode and lighting contactors that have bypassed the daylight sensors and time clocks to leave the lights on continuously. See Case Study: Poor O&M for more information.

d. **Develop an energy management plan.** An energy management plan maps out internal maintenance schedules, equipment logs, and keeps equipment manuals and building drawings on hand for reference. Unlike the energy policy, the energy management plan is regularly updated, typically on an annual basis. It is used to document recent achievements, changes in performance, and shifting priorities.

e. **Tune DDC controls and implement preventative maintenance:** Control systems should have periodic tune-ups to verify proper operation. If the building owner has many buildings, like the larger school districts, they typically have adequately qualified control technicians to continuously perform tune-ups and check proper operation. For the building owners with fewer buildings, it is recommended that they contract with a controls company to provide periodic tune-ups on the controls and preventive maintenance.

f. **Establish an Energy Conservation Coordinator/Manager:** Larger school districts have benefitted from having a dedicated Energy Coordinator or Conservation Manager. This position manages the energy costs from operating all of the schools, and prioritizes improvements to reduce energy consumption in the worst performers. This has reportedly worked well in Anchorage, Fairbanks, and Juneau. Smaller sets of building owners could pool resources and hire an energy coordinator to serve several smaller communities or school districts.

g. **Set goals:** Building owners who set energy consumption goals and reward achievement of lower energy consumption are finding that their savings are considerable and their managers are more aware of energy consumption reduction. This also enhances accountability of energy use throughout all people using the building.

h. **Develop an energy policy:** Some larger facility owners and school districts have adopted an energy policy to encourage reduced energy consumption. When a policy exists, such as required thermostat setback temperatures and times for turning off lights and fans during unoccupied periods, the maintenance people can refer complaints to the policy. An energy policy can also establish goals that raise energy awareness for both larger and smaller scale buildings. See Case Study: Energy Policy Benefits for more information.

i. **Meter and monitor energy use:** This issue has been a consistent finding in remote locations, especially concerning waste heat and fuel oil metering, or sub-metering of outbuildings. Some examples are listed below. Metering can provide web-based energy monitoring so that multiple people within an organization can see energy use, trends, and potential problems as they arise—instead of finding out when a huge bill is received. Please see Case Study: Inadequate Metering of Energy Sources for more information.

   i. **Install fuel oil metering:** Many locations that use oil heat have poor fuel consumption records, especially in cases when one tank serves several buildings. Meters allow facility owners to detect fuel oil leaks in piping as well as the potential misuse of fuel. Consequently measurement of actual building energy consumption is difficult. Many installations are now equipped with fuel oil deareators, which allow the use of one-pipe oil delivery systems, so only one meter is necessary as fuel oil typically no longer returns to the storage tank for recirculation.

ii. **Install waste heat meters:** Several of the rural schools are heated with waste heat from a nearby village's generator, but the waste heat is typically not metered. It only takes two temperature sensors and one flow meter to acquire the data necessary to determine the amount of waste heat being used by the facility. The data will help the school be properly billed for the energy and inform the owners whether improvements are reducing energy consumption.

iii. **Install power sub-meters:** There are cases where auditors have seen several buildings all served by one electrical meter, such as teacher housing being fed from the main school meter. This makes it difficult to track actual power consumption between the buildings served. It is recommended that either new power main meters be installed for each building served or sub-meters be installed from the existing main meter to measure power to each of the outbuildings. If the building has a DDC system, then it can be revised to also monitor gas, oil, waste heat and power consumption.

j. **Shut down kitchen exhaust systems after cooking:** Kitchen hood systems are required to have very large exhaust rates to remove smoke during cooking. The systems are also required to have make-up air fans that operate whenever the exhaust fans are working. Kitchen personnel who do not turn off the cooking exhaust/make-up air fans when they are done cooking are wasting huge amounts of energy.

k. **Shut down small and large refrigerators and freezers for summer:** Some audits found refrigerators, walk-in coolers and freezers were left operating all summer long, even though no food was stored in the appliance. It is recommended that these devices be shut off during summer months and that a refrigeration service contract be set up to have the equipment serviced and turned back on just before school reopens in the Fall.

l. **Reduce corridor and night lighting:** Many locations leave the corridor lighting on continuously, presumably for security or emergency egress. It is suggested that the amount of night lighting be reduced and occupancy sensors be placed on other corridor lighting to go to full lighting only when persons are present. There were other instances of continuous lighting. Please see Case Study: Lighting Continuously Operating.

m. **Setback temperatures:** The AkWarm-C software has shown that there is a very fast payback to implementing aggressive temperature set-back schedules using set-back thermostats or by simply programming the DDC control system to set-back the system during unoccupied times.

n. **Reduce ventilation:** Most school districts have their DDC system shut down ventilation after the programmed occupied times, but some are more aggressive and tighten the occupied times to just one half hour before and after classes or scheduled occupied times in order to further reduce ventilation times. Demand controlled ventilation should also be considered to reduce the amount of OSA introduced to the HVAC system, as discussed above in the IGA recommendations. Zoning areas for reduced occupancy use makes sense, and protects air quality.

o. **Compare Energy use to comparable buildings:** Building owners should compare their energy consumption to other comparable buildings in comparable climates, or with normalized HDDs. This allows them to know how well they are managing energy compared to other building owners with similar buildings in similar climates.

p. **Consider establishing a roving maintenance team:** While larger building owners, such as city school districts, have a cadre of well-trained maintenance people to address problems with their schools, the smaller villages face very expensive travel and per diem costs to get maintenance specialists to the villages. Regionally located, roving maintenance teams could be tasked with maintaining all buildings in any given village, with the various owners all sharing in the cost of this, rather than having each different building owner or organization sending their own maintenance to fix only their building.

q. **Check hand-off-auto (HOA):** HOA switches on lighting contactors, motor starters, and air handling systems have been found to be left in the “hand” position, which bypasses programmed time clock schedules or lighting sensors, potentially wasting large amounts of energy. All owners should question any occurrence of finding HOA switches in “hand”, unless the system is being troubleshot for some reason. Please see Case Study: HOA Switches on Contractors and Motor Starters for more information.

r. **Check air-handler unit (AHU) dampers:** OSA and return air dampers have been found to be disconnected, frozen in place with rust, or improperly adjusted. If an OSA damper is left fully open, then the building is being significantly over ventilated and huge amounts of thermal energy is being used to heat 100 percent of the air that is being circulated. The OSA dampers should be routinely checked for proper operation. Please see Case Study: Air Handler Damper Operator Positioning for more information.

s. **Access to audits:** A great deal of time and resources went into auditing these buildings, at no direct cost to the owners through this program. The owners should avail themselves of these audits, get them in the hands of the right people and order reviews of what is practical and feasible over time, and evaluate the suggestions for potential implementation where appropriate. Audits will be available at www.ahfc.us.

t. **Consider low hanging fruit:** Consider the first cost and the life-cycle costs, as well as long-term comfort and energy savings when evaluating energy measures with long paybacks, such as window replacement. EEMs with short paybacks, combined with those of longer terms, can substantially reduce long-term energy costs. The cost of doing nothing is high. See Case Study: Kenai Elementary School Windows.

2. Recommendations for building designers

a. **Consider life-cycle cost when selecting new or replacement building components and equipment:** The life cycle cost of equipment, materials and systems in the construction of new facilities must warrant careful analysis. Shell components, or those with the longest life expectancy, require deeper analysis and budget allocations during initial construction and at the end of their useful lives. If a roof will be in place for 25 years, it needs to be insulated, detailed and built correctly the first time. . Energy costs will likely not go down, but keep rising over time. There is a payback with prudent, energy efficient equipment and component selection. In both initial construction and renovation work, the obvious list of equipment to consider includes: motors, boilers, pumps, insulation, lighting, controls, and window systems.

b. **Consider Building Use:** Designers should fully understand the owner's project requirements and optimize systems to meet that need.

c. **Consider sizing**: Systems should be designed so they are most efficient at part-load conditions that dominate operating hours while ensuring they also meet the peak load requirements.

d. **Specify premium efficiency motors:** Motors that are specified as NEMA Premium are about 1 percent—3.5 percent more efficient than standard efficiency motors. Since many motors run continuously or during a major portion of the day, there is a payback to using NEMA Premium motors. The NEMA Premium motors also operate cooler, reducing cooling costs in commercial applications. Insure the pumps are properly sized when replacing. Too large a pump increases energy costs. Choose the smallest pump—deemed sufficient by a qualified energy engineer—to handle the load.

e. **Consider demand controlled ventilation:** As discussed in the IAQ recommendations, if buildings are designed for the ability to make ventilation systems responsive to occupant loads and VOC levels through variable speed fans and modulating OSA dampers, then demand ventilation can have an excellent payback in reduction of energy consumption. Many buildings are occupied at less than design occupancy, so less ventilation air needs to be heated and pushed through the building.

f. **Consider occupant sensor lighting**: Older technology occupant sensors had some nuisance shutoffs that frustrated some owners. Newer, dual technology and dual-level designs use occupant sensor technology to turn off lights, fans, air handlers in unoccupied spaces, and such innovations also reduce the number of nuisance shutoffs.

g. **Reduce excessive glass in buildings:** There are still buildings that have a large window to wall ratio, which results in excessive energy loss. Minimize the use of aluminum storefront window and door systems. Their poor thermal performance makes them unsuitable for Alaska's climate. Another item to consider, with regards to windows, is prudent placement of windows to increase the natural lighting and satisfaction, as well as a good payback for the owner. Thermal conductivity, U-values, SHGC ratings etc. should be evaluated per the cardinal orientation of each façade. If façade changes are contemplated, consider reducing the size of windows.

h. **Harvest Daylight**: Incorporate daylight harvesting for spaces, using correctly sized and climate appropriate glazing, and use lighting systems that respond to daylight levels through dimming controls.

i. **Energy use should be metered:** Specify fuel and waste heat metering. This should include pulsars for gas and fuel oil meters, power meters, and DDC sensors to report fuel consumption through independent or DDC monitoring systems. Larger buildings in areas where demand charges apply should also include smart electrical meters to provide time of day analysis of electrical use.

j. **Require commissioning:** Require commissioning as part of the design process and at completion of construction, including training of users and maintenance personnel. Consider retro-commissioning every three to five years. Please see Case Study: Opportunity to Fund Training and Commissioning for more information.

k. **Provide O&M manuals:** Provide O&M manuals on project completion, including maintenance checklists for equipment specified.

l. **Analyze energy consumption:** Prepare forecasted energy consumption analysis during the design phases using simulation software such as Trane Trace or AkWarm-C so the building owner knows the projected operation costs of his/her new building.

m. **Simplify controls when necessary:** Consider the complexity levels of specified DDC systems and the capability of the on-site maintenance personnel, compared to the payback to be achieved. It is worth considering sacrificing the top end of efficiency to instead match the operator skill level to the complexity of the proposed system. Tune-up and retro-commission every three-five years thereafter.

n. **Follow energy codes and guidelines:** A new building does not necessarily have to be designed to Leadership in Energy and Environmental Design (LEED) guidelines to still be energy efficient. At a minimum, it is recommended to design to the IECC. Alaskan, regional specific amendments are available through AHFC and other state entities. For Alaska, the design should consider the IECC a *minimum* requirement. It is also recommended to educate maintenance staff on energy codes. Please see Case Study: Necessity for Energy Awareness for more information.

4. Recommendations for AHFC

a. **Continue to develop and implement outreach programs:** AHFC should continue to develop and implement outreach programs to inform building owners of funding opportunities for energy upgrades and assist with implementation of IGA recommendations.

b. **Educate public on project findings:** PowerPoint presentations should be produced that are directed at building owners, building maintenance technicians, building designers, and the general public that can share the results of the IGAs as well as other energy conservation concepts.

c. **Effectively administer loan program:** AHFC should continue developing straightforward ways to implement and administrate loan programs for building energy upgrades.

d. **Continue research on public facility energy use:** AHFC should continue to research and collect data on energy use in public facilities statewide.

e. **Consider developing additional case studies that address the following:**
    i. Policy driven and Code driven challenges/issues
    ii. Funding source driven challenges due to legislation
    iii. Building manager challenges
    iv. Energy savings offsets

4. Recommendations for Statewide Policy Makers, Administrators, Legislative Offices

a. **Adopt and enforce energy codes and minimum standards** for all state funded buildings at the state, school district, borough and municipal levels, similar to the requirements used for AHFC programs. Currently only State owned facilities are required to meet minimum energy standards while others are not.

b. **Appropriately size new buildings being funded**: Assure buildings are sustainable in terms of energy, operating and maintenance costs. For new schools, rigidly enforce DEED school population density requirements.

c. **Establish a level of aaccountability:** There seems to be a disconnect between the building owners and operators and those who pay the energy bills, as well as the absence of accountability in both remote villages and large communities. Require building owners and operators to assume more responsibility for the operating costs and potentially reward those who prove to be good stewards of the energy budget. Please see Case Study: Subsidized Energy Cost Impacts and Case Study: Power of Accountability for further discussion on accountability.

d. **Consolidate facility use where possible:** Encourage and allow multiple uses of buildings to reduce energy footprint. For example: combine post offices, city offices, schools, and city administration offices together and combine police and fire in future buildings.

e. **Prioritize funding for energy upgrades in buildings**: Only fund a school expansion if required (and justified) by a population increase. Fund Preventive maintenance efforts to ensure existing infrastructure and past investments are properly maintained and operated in the most energy efficient manner possible. This will help them realize their full anticipated life and usefulness.

IGA Common EEM Recommendations

This Paper includes approximately 50 typical audit recommendations. It is important to note that some recommendations, such as policy and operational changes, can apply to every building and at little to no costs. Examples of these include setting back thermostats at night, turning off corridor lights, and limiting public use of facilities after a certain hour. However, changes to systems through construction, such as replacing windows or adding insulation, should be considered in a whole building audit. Taking a whole building approach is vital because a building works as a combination of systems, and changing one system may have adverse effects on other systems if not looked at in an integrated fashion. Typical IGA findings and recommendations, in no particular order, are listed below.

1. Install Fuel Oil Metering

Many locations that use oil heat have poor fuel consumption records, especially in cases when one tank serves several buildings. Without meters, fuel oil leaks in piping are not always detected and the potential for fuel misuse or misappropriation occurs without detection. Consequently, measurement of actual building energy consumption is difficult. Many installations are now equipped with fuel oil de-areators, which allow the use of one-pipe oil delivery systems. See Case Study: Inadequate Metering of Energy Sources for more information.

2. Install Waste Heat Meters

Several rural schools are heated with waste heat from a nearby village generator, but the waste heat is typically not metered. It takes two temperature sensors and one flow meter to acquire the data necessary to determine the amount of waste heat being used by the facility. With the use of that data a school can be billed properly for the energy and owners will know when improvements are in fact reducing energy consumption. See Case Study: Inadequate Metering of Energy Sources.

3. Install Power Sub-Meters

Auditors have identified several buildings all served by one electrical meter, such as teacher housing being fed from the main school meter. This makes it difficult to track energy use consumption between the buildings served. Therefore it is recommended that either new power main meters be installed for each building served or sub-meters be installed from the existing main meter to measure power to each of the outbuildings. If an overall bill for all buildings on one meter is deemed to be too high, then an auditor or owner has difficulty finding which buildings have problems unless there are sub-meters. See Case Study: Inadequate Metering of Energy Sources.

4. Develop an Energy Policy

Several urban school districts have adopted a written energy policy to encourage reduced energy consumption. When such a policy exists, such as required thermostat setback temperatures and times for turning off lights and fans during unoccupied periods, the maintenance people have written support to explain operating procedures. An energy policy can also establish goals that raise energy awareness. Auditors have observed that energy policies are effective where they have been adopted. See Case Study: Energy Policy Benefits for more information.

5. Hire an Energy Coordinator

Larger school districts have benefitted from having a dedicated Energy Coordinator or Conservation Manager. This position manages the energy costs from operating all of the schools, and prioritizes improvements to reduce energy consumption in the worst performers. The energy manager can also remotely monitor the operation of buildings with DDC systems. This has reportedly worked well in Anchorage, Fairbanks, and Juneau. See Case Study: Power of Accountability.

6. Remotely Monitor Energy Consumption

Since most modern buildings have DDC controls, it is not difficult to remotely monitor buildings for energy consumption and alarm when consumption is outside reasonable levels. Energy meters are available from many manufacturers to monitor and report both cumulative energy consumption, as well as power quality, peak demand, and instantaneous demand consumption. A local facility manager might view this data daily or weekly to insure efficient operations.

7. Remotely Monitor DDC Controls

DDC controls can also be troubleshot and monitored by a central agency or by the owner's maintenance staff who may be located at a remote location from the school or commercial building. This can save money and energy by early detection of malfunctioning controls, with potential troubleshooting from the remote location to help the on-site personnel address the problem.

8. Upgrade Interior Lighting

Lighting ballasts and lamps have experienced significant technological improvements that result in large energy savings, sometimes over 50 percent for lighting. While the amount of heat given off from the upgraded light fixtures is reduced, the comfort system is better controlled and energy is still reduced overall. See Case Study: Lighting Retrofits Economics for more information regarding heating requirement effects due to energy efficient lighting.

9. Upgrade Exit Lighting Fixtures

Lighted exit signs operate 24/7. Upgrading these devices from incandescent lamps or even fluorescent lamps to LED-lighted fixtures can result in excellent payback. A typical energy reduction would be to change a 20 Watt exit sign fixture to 5.6 Watts, for a 72 percent savings, and a 100,000 hour life for reduced maintenance. Please see Case Study: Interior Lighting—LED Versus Fluorescent for more information.

10. Implement Seasonal Shutdown of Boilers

Several facilities were found to have boilers and circulators operating year round, even if heat was not needed for three to five months of the year due to the summer ambient conditions, or internal heat gain of the building from lights, motors, and occupants. Some buildings have indirect water heaters that require the boiler to make domestic hot water, which drives the year-round operation of the boiler and circulators. In those cases, electric water heaters are suggested when the boiler is off, unless there is a very large demand for the hot water that would make electric water heaters impractical.

11. Retro-Commission Buildings

Many of the buildings examined were never commissioned after initial construction, which means some aspects of the heating, ventilation, or lighting systems may never have operated as intended by the designer, and may increase energy use. Retro-commissioning would involve a periodic (for example every five years) re-examination of the functionality of the entire key mechanical, control, and lighting systems.

12. Upgrade Exterior Lighting

It has been found that exterior lighting systems can be upgraded with low power draw LED light fixtures offering an attractive payback. While the LED fixtures produce a lower lumen level, the type of light given off by LEDs requires fewer lumens. This is because it allows the human eye to see things using both the rods and the cones of the eye (scotopic lighting) during low ambient lighting levels, thus being more effective at lower operating cost. Since LED fixtures put out more light as they get colder they are an excellent application in Alaska's northern areas.

13. Turn Off Computers/Monitors When Not In Use

This can be accomplished manually or by the use of an occupancy sensor equipped with plug strips that will turn off if no occupants are in the area after a defined period of time. This can work especially well for computer monitors or printers that can be cycled off or on without loss of data, while computers should be manually shut down.

14. Install Electric Water Heater

In buildings where electric water heaters produce hot water at a higher cost than indirect water heaters that derive their heat from higher efficiency boilers, there are cases where small electric water heaters make a lot of sense. For example, a remote location that requires excessive time to bring the hot water to the fixture or in cases where the boiler can be shut down for the season, but domestic hot water is still needed. Instantaneous electric water heaters at remote lavatories or sinks are an appropriate application of this as well.

15. Tune Up Boilers/Burners

Oil fired boilers need to be cleaned at least annually and more frequently in cold climates. The burners likewise need to be tuned, with nozzles replaced and combustion tests done to fine tune the burners for optimum efficiency.

16. Remove Space Heaters

Electric space heaters at desks can create a fire hazard if placed too close to combustibles or if they are not equipped with tip-over switches. Also, they are not as cost efficient as a central heating system.

17. Replace Overhead Doors

Some overhead doors were found to be warped, or poorly insulated, with worn or missing weatherstripping. In certain shops that have numerous overhead doors, it was recommended that the doors be retrofitted with well insulated and properly installed doors.

18. Provide Automatic Closers on Overhead Doors

Fire stations and ambulance bay doors can be retrofitted with automatic closers to lower the door after the emergency vehicle leaves, provided they are also equipped with a sensor to prevent closure if an object or person is still under the door.

19. Reduce Lighting Levels

Some areas were observed to be over lit, which wastes energy. There are fixtures that automatically dim lights based on day lighting controls. There are also new fixtures available that can be wired with bi-level switching to allow for lower lighting levels the majority of the time, while still providing higher levels when really needed. These bi-level controls are also available with bi-level occupancy sensors that can be programmed to light the room at the lower level unless the switch is manually pressed to increase the level. This is done either with bi-level ballasts, or with two sets of ballasts, one for lower level and the second for the second set of lamps. See Case Study: Interior Lighting - LED vs Fluorescent.

20. Install Electric Boilers

This recommendation only works well where there is renewable energy, such as hydro power or wind power that is a lower cost than fossil fuels. Wrangell, Alaska, for example, has a special rate for electric heat and hot water production of $.08/kWh, compared to current fuel oil costs of $4.27/gallon. Converting both fuels to MMBTUs and assuming 95% efficiency for the electric unit and 70% efficiency for the fuel oil unit, the fuel oil is $43.88/MMBTU and the electricity is $24.67/MMBTU. This represents a significant potential cost savings, but the service has to be interruptible by the utility in the event of low hydro production.

21. Install Indirect Water Heaters

Direct fired water heaters are typically not as efficient as indirect hot water generators that take the heat from the boiler hot water or glycol. Where the boiler is needed to operate year round, or where there is a high demand for domestic hot water, this is a good application for energy savings.

22. Remove Unused Roof Vent Hoods, Close Dampers

In some cases, vent hoods were found to continuously exhaust warm air through the vent, even though the vent hood is no longer needed in the building. Remove or close the vent, add insulation and seal accordingly.

23. Insulate Top of Wall Cavity Above Lay-In Ceiling

Some buildings were found to have uninsulated wall cavities above the lay-in ceilings that should be insulated since plenum air heat is being lost through the upper wall.

24. Install Setback Thermostats

Many DDC systems incorporate temperature setbacks, but rooms or zones that are not on a DDC system benefit greatly with the use of setback thermostats. See Case Study: Building Setback Temperature.

25. Install Occupancy Sensors

Some school districts mandate incorporation of occupancy sensors to automatically turn off lights when rooms are vacant for a programmed period of time. While historically there were reported nuisance lighting shutoff incidents, overall the newer devices work well and result in serious light energy reduction. These sensors can also turn off fans, such as toilet exhaust fans after a programmed amount of inactivity in a room.

26. Control Lighting and Cooling on Vending Machines

There are retrofit devices that simply plug into the wall outlet and then cycle on the vending machine lights and cooler when people walk in front of the machine or when needed to keep the product cool.

27. Install Swimming Pool Covers

It is estimated that energy savings of 50-70 percent are possible through the use of indoor swimming pool covers. These savings reduce evaporation, reduce ventilation requirements that are needed to maintain relative humidity, reduce energy needed to heat the water that is evaporating, reduce operation costs for exhaust fans, and prevent degradation to the building envelope. See Case Study: Pool Covers for Swimming Pools.

28. Maintain Clear Access to Perimeter Heaters

Some baseboard and convectors were found to be blocked by furniture or stored materials, which significantly reduces the effectiveness or efficiency of the heater.

29. Keep Backup Boiler in Cold Standby

Many buildings in cold climates are designed with two or more boilers so there is always a backup to prevent building freeze up in the event that one boiler fails. The back-up boiler was typically found to be hot all the time, overheating the boiler room and wasting energy. Piping modifications and controls are possible to make the boiler circulate and operate only when needed using primary/secondary piping or by valving off and isolating the stand-by boiler for manual startup and operation only when needed.

30. Install Pipe Insulation

Some boiler rooms and parts of buildings were found to have no insulation on the heating water/glycol piping or on the domestic hot water piping. This causes overheating of the space and wastes energy.

31. Upgrade Toilet Fixtures

Older toilets required 3 gallons per flush (GPF) to operate, but newer toilets are mandated by code to operate with no more than 1.6 GPF. Current technology allows use of two level toilets that utilize 1.6 GPF for solids and 0.9 GPF for liquids. The retrofit of toilets from 1.6 GPF to two level flush types is estimated to save 33 percent water, with even more savings when retrofitting the older 3 GPF toilets. Reducing Water usage reduces energy used to heat and pump the water.

32. Upgrade Urinal Fixtures

Urinals can be retrofitted from the older (pre-1992) styles that used 3 GPF, to the current style that uses 1.0 to 1.5 GPF models. Waterless urinals or 1 pint per flush urinals are available to further reduce water consumption; however, waterless urinals corrode copper drain piping, and can be more maintenance intensive to avoid odors and complaints. They are not accepted (1 pint per flush style is accepted) in Alaska by code. Water reduction at fixtures also reduces filtering, preparation, heated storage, and pumping energy in many remote facilities not served with a water utility.

33. Upgrade Faucets in Public Restrooms

Code requires that all lavatories and public restrooms be equipped with automatic start/stop faucets. Infra-red actuated faucets have been proven to save energy by reducing water consumption, as well as domestic hot water requirements.

34. Replace Shower Heads

Older shower heads delivered three to nine gallons per minute (GPM) of water, but over ten years ago this was reduced to 2.5 GPM heads. Now, shower heads have been developed that feel like 2.5 GPM, but they only use 1.6 to 1.75 GPM, yielding a 30 percent reduction in hot water.

35. Install Arctic Entry Doors

Buildings in cold climates are typically designed with arctic entries to reduce infiltration rates and avoid drafts for those located in the area of the entry. It was found that some larger buildings did not have arctic entries; however, they are recommended in all buildings in cold climates.

36. Avoid Excessive Infiltration

Air leakage into buildings creates drafts, causes frozen pipes, and consumes a lot of energy. Proper design details and attention to detail during design are essential to reducing infiltration. Correcting leakage paths after construction is expensive and does not completely tighten the envelope.

Building infiltration can make up more than half of the thermal energy loss in a building, so tightening the building to reduce infiltration will significantly reduce energy consumption and will make the building more comfortable. One easily installed upgrade is to replace worn or ineffective weather stripping at doors and windows.

37. Upgrade Furnaces and Boilers

Newer technology boilers and furnaces can improve efficiency by 3-20 percent using condensing combustion technology, or three pass boilers as opposed to single pass boilers, or turndown combustion controls to reduce cycling of burners. Older forced air furnaces had typical efficiencies of 78 percent but now models are available with efficiencies at over 90 percent. These efficient models will be mandated for installation after April, 2013. See Case Study: Klatt Elementary Condensing Boilers.

38. Install Fan Speed Controls

VFD controls can be used on some air handlers, such as variable air volume (VAV) systems to reduce fan energy by slowing the fan during periods that require less air, as is typical in cooling air systems.

39. Install Circulator Speed Controls

Most hydronic heating systems have hot water or glycol circulators that distribute the heat to the terminal devices. As heating zones are satisfied, the circulator can be programmed to sense the reduced demand for flow and slow the motor down to reduce electrical energy requirements for the motor. Due to the exponential nature of the fan and pump laws, a 30 percent average motor speed reduction can result in a 61 percent energy savings, and a 60 percent average speed reduction can result in an 89 percent energy savings, as examples. Some circulators are available now that have built-in sensing and VFD controls.

40. Turn Off Standby Circulators

Most designers will include stand-by hydronic circulators so the loss of a circulator does not cause a freeze up or loss of function in the building. Operators who do not understand the reason for having two circulators have been found to operate both of the circulators at the same time, thinking this is necessary. In addition to wasting energy this can also cause zone valves to bypass and overheat spaces due to the pressure on the control valves exceeding the shut-off pressure of the device.

41. Cycle Head Bolt Heaters

Where engine heater receptacles are provided, controls that cycle the amount of time the receptacle is live has been found to be effective. There are standalone controls that can cycle entire head bolt heater subpanels, as well as individual receptacles that sense OSA temperature and adjust the amount of time the device is providing power as a function of the OSA temperature.

42. Provide De-Stratification Fans

High ceiling applications tend to get stratified air near the ceiling that causes the need to provide more heat at the floor level to maintain occupant comfort. De-stratification fans are very effective in moving the warm air back down to the floor and maintaining a consistent temperature in the space from the floor to the ceiling, making the space more comfortable and using less energy.

43. Upgrade Motors

Motors that are upgraded to National Electrical Manufacturers Association NEMA Premium recommendations are about 1 percent—3.5 percent more efficient than standard efficiency motors. Since many motors run continuously or during a major portion of the day, there is a payback to using NEMA Premium motors. The NEMA Premium motors also operate cooler, reducing cooling costs in commercial applications.

44. Improve Building Insulation

Some older buildings were observed to have minimal attic insulation that can easily be retrofitted to improve the R-value to current standards. Adding insulation in wall cavities and around foundations is much more difficult and often does not pay back. Building shell components must have optimal thermal values during initial construction and any shell renovation work because such EEMs rarely pay back at other times. For example, aluminum frame windows and doors should be eliminated because their thermal performance so poor. Additionally, they are not suitable for Alaska's climate.

45. Replace Refrigerators

Older refrigerators are recommended to be replaced with new, Energy Star rated appliances. New refrigerators can pay back from energy savings in 7 or 8 years. A link to calculate energy savings on refrigerators can be found at: http://www.energystar.gov/index.cfm?c=refrig.pr_crit_refrigerators.

46. Tune Up HVAC Digital Controls

Many of the DDC controls in buildings are too complex for the remote area building technicians. The auditors frequently recommend that the DDC controls be put on a maintenance contract through the qualified DDC supplier so the controls can be tuned up and maintained properly. See Case Study: Lighting Continuously Operating.

47. Adjust Lighting Photocell

Some photocells have a cover that is adjustable for how much darkness is needed to turn on the lights. If the photocell is improperly adjusted, with the cover blocking most of the sensor, the outside lights will be on much longer than needed or desired, wasting energy. Controlling exterior lighting with both a photocell and time clock allows the lighting to be reduced during periods when the building is not in use and where security is not a concern. Also, some exterior LED fixtures have occupancy sensors that reduce the lighting to minimal levels but turn up the light when people are present.

48. Seasonal Shut Down of Appliances

Large appliances such as refrigerators, freezers, and vending machines should be unplugged during seasons when they are not used—for example in schools over summer break. See Case Study: Seasonal Shutdown of Refrigeration Systems.

49. Lower Temperatures in Transition Zones

Reduce temperatures in transition zones, such as arctic entries. The goal is to reduce the temperature as far as possible while controlling humidity and maintain thermal comfort in adjacent spaces. Also, reduce temperature set-points in occupied spaces. Some thermostats (with locking covers) were observed to be set at 85-90 degrees F, with windows open to reduce the overheating.

50. Reduce Over-Ventilation, Control IAQ

Some buildings are designed strictly to the ventilation requirements of the code without the ability to reduce OSA ventilation during periods of reduced or no occupancy. The code only requires that the building be *capable* of certain ventilation rates, but reduced OSA rates are permissible provided that IAQ is monitored and maintained. Additional consideration should be given to items listed below

a. **Demand controlled ventilation versus IAQ:** CO_2 sensors can detect the level of CO_2 in the space and increase OSA ventilation to maintain set-point, which is typically 750 PPM. This is typically done by modulating open the OSA damper when the CO_2 level rises above an action level. Since many of the spaces have large volumes, OSA delivery at code mandated rates of 15 or 20 cubic feet per minute (CFM) per occupant typically results in over-ventilation since because the design is based on the maximum number of occupants being in the space all the time. DCV is also effective at adjusting ventilation flow in spaces with high infiltration rates due to normal ingress/egress.

b. **Environmental Protection Agency (EPA) Initiative**: The following link has some excellent suggestions on how to control proper IAQ.

   http://www.epa.gov/iaq/schooldesign/hvac.html

c. **Volatile Organic Compounds (VOC) Sensors**: The web site below shows a VOC sensor, as well as a combination sensor that can detect both CO_2 from human respiration, or VOC out gassing of construction materials, as well as relative humidity to be used for feedback control of the HVAC ventilation system. The device can even show VOC levels and indicate good, fair, or poor VOC levels.

   http://www.bapihvac.com/products/air-quality-sensors/

d. **Combined VOC Sensors by Siemens**: The web site following also offers an HVAC control sensor that can measure and control CO_2/VOC, or CO_2/T, or CO_2/H/T including a built in self-test capability.

   http://w3.usa.siemens.com/buildingtechnologies/us/en/building-automation-and-energy-management/sensors/air-quality-sensors/Pages/air-quality-sensors.aspx

White Paper Methodology

Richard Armstrong is the lead writer for developing this White Paper with help and input from the TSPs, AHFC, REAP, and CCHRC. Some of the key steps involved included the following:

1. Benchmarking Data Review

CAEC and *NORTECH* collected the benchmark data in 2011 and CCHRC analyzed the data for trends and key energy consumption indicators.

2. Review of Investment Grade Audits

After IGA's were performed from 2011 to 2012 by the four TSPs: AEE, CAEC, RSA, and *NORTECH*, they were reviewed by AHFC for completeness, to insure AkWarm-C© files were uploaded to ARIS and then to determine the top five EEMs recommended

3. Interviews with TSPs

Once the audits were completed and the data was collected and assimilated, each TSP was individually interviewed by the author and AHFC. The purpose of the interviews was to debrief each primary auditor and openly discuss lessons learned, challenges, and successes with regards to regional matters, logistics, and the overall process of the project, as well as the other components of the project (such as AkWarm-C© and REAP).

The interviews also included a discussion of specific issues such as equipment, fuel usage and tracking, controls monitoring systems, facility management, and design features. Many of the findings that resulted from these discussions can be used to benefit future projects that are striving for energy efficient designs.

4. Data review by CCHRC

Utilizing ARIS, CCHRC performed an analysis at both the ANCSA geographic region level and an "auditor region" level. AHFC created the auditor regions by aggregating adjacent ANCSA geographic regions with similar population and climate characteristics. The four auditor regions are shown in Figure 9, page 33.

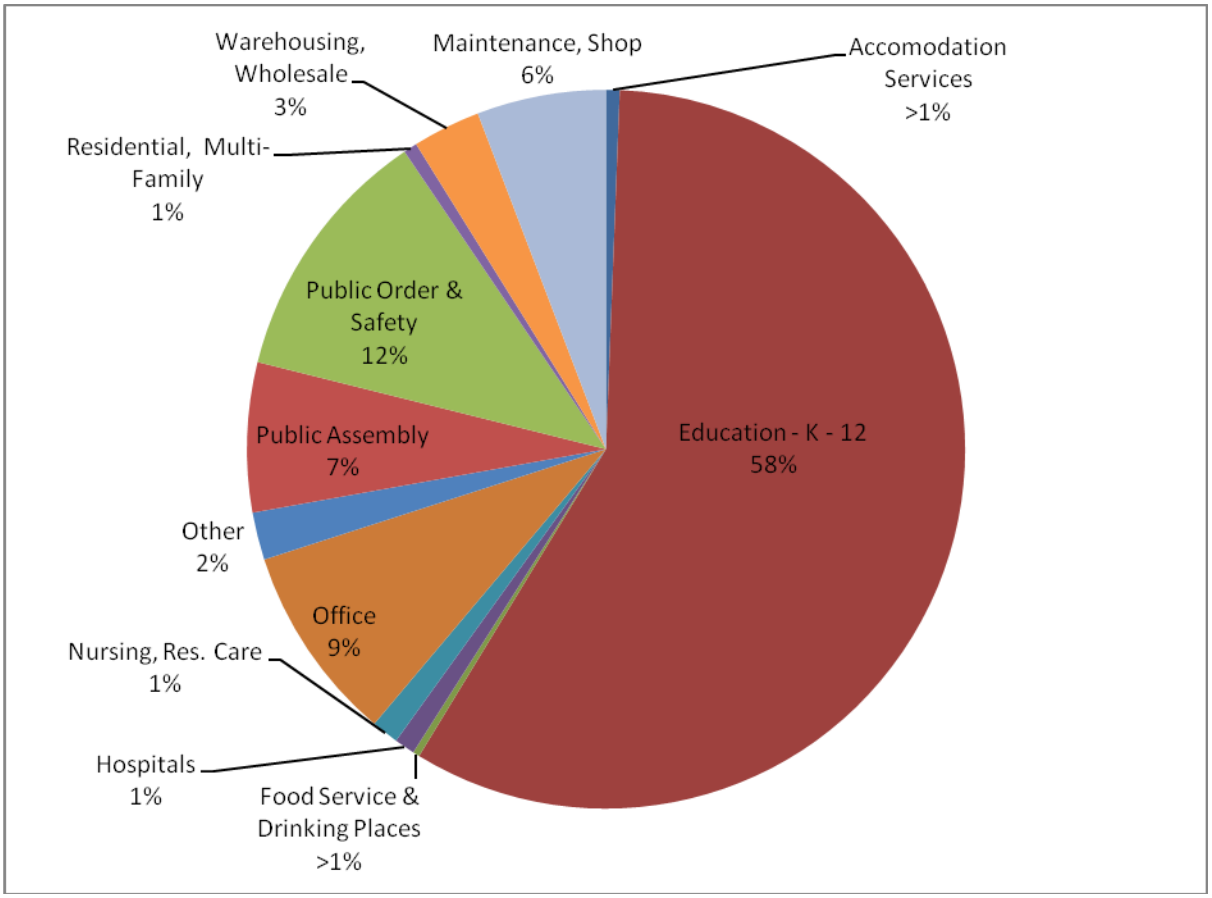
5. Building Type Classification

AHFC contracted with Cascadia Green Building Council to develop the *General Guidelines For Public And Commercial Building Audit and Retrofit Strategies for Alaska*. This document is what was used to establish building types in ARIS and can be found at the link following:

http://www.ahfc.us/iceimages/energy/building_type_audit_recomm_rpt.pdf

The public buildings were classified as one of 14 distinct usage types (see Appendix E: Building Use for more information regarding building usage type). CCHRCs first step in analyzing the data was to determine whether buildings were properly classified according to the definitions given in the AkWarm-C Energy Rating Software help file and to recode them if deemed necessary. Even after recoding, buildings were not evenly distributed among usage types; while 183 educational buildings were audited, there were only two accommodation services buildings, and only a single audited food service building. The distribution of audited building usage types is shown in Figure 2 below.

Figure 1: Percentage by Building Usage Type, Based on Total Number of Buildings



Statewide Energy Use & Cost Statistics

Mean, minimum, and maximum statistics were calculated by usage type for several characteristics, shown in Figure 3 on the following page. This table provides a baseline of energy usage and costs that can give owners and managers of similar buildings a comparable benchmark. The number of audits that these statistics are based on should also be considered, as the accuracy will be affected by the sample size.

The ranges between minimum and maximum values on a statewide level in Figure 3 are fairly significant. The EUIs for all buildings range from 33,102 BTU/SF per year to 1,973,345 BTU/SF per year. Note that statewide, the highest average EUI is found in Maintenance and Shop facilities at 371,465 BTU/SF per year, while the lowest is found in residential multi-family buildings at 99,560 BTU/SF per year.

At the same time, the ECIs for all buildings range from $0.68/SF to $32.96/SF per year. The highest average ECI is found in Accommodation Services at $7.67/SF per year, while the lowest average ECI is found in Nursing/Residential Care buildings at $2.41/SF per year[6].

A consequence of the large range of energy values found within a particular usage type is that the cost to run these buildings differs greatly. For example, the minimum ECI for a Maintenance and Shop facility is $0.68/SF and the maximum is $18.97/SF. Based on the average building size of 22,952 SF, the annual difference in cost for two buildings with these energy characteristics is about $420,000; clearly this is incentive for public organizations to identify poor performing buildings that could benefit from retrofits and to thoughtfully design new construction to consume less energy.

[6] Food Services and Drinking Places had a sample size of one. More data is needed to state conclusively what the expected range of ECI are for Food Services and Drinking Places.

Figure 2: Basic Characteristics by Usage Type Statewide

Building Usage Type	Audited Buildings	EUI (BTU/SF)			ECI ($/SF)			SF			Age (Years)		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
All Building Types	327	149,372	33,102	1,973,345	$4.45	$0.68	$32.96	41,864	1,200	361,698	33	2	82
Education - K - 12	183	114,405	36,664	278,055	$4.33	$1.60	$12.46	54,976	5,213	361,698	35	2	77
Public Order and Safety	38	168,841	73,567	945,441	$4.13	$1.25	$9.07	13,387	1,684	63,050	26	3	77
Office	29	112,995	37,951	224,972	$4.02	$1.31	$9.59	21,785	2,448	70,531	40	12	82
Public Assembly	29	219,187	33,102	1,061,667	$5.65	$1.49	$32.96	37,717	6,382	151,470	31	8	67
Maintenance/Shop	19	371,465	57,046	1,973,345	$3.95	$0.68	$10.32	22,952	5,100	107,846	32	4	75
Warehousing and Wholesale	10	212,896	61,094	414,195	$6.81	$1.15	$19.53	19,425	1,200	60,000	25	4	43
Other	7	148,820	93,354	205,457	$3.93	$1.79	$6.39	33,642	3,061	135,671	28	10	55
Health Care - Nursing/Residential Care	4	174,760	70,820	346,597	$2.41	$1.07	$4.34	41,616	8,276	79,311	29	19	34
Health Care - Hospitals	3	158,989	93,142	287,073	$5.37	$3.22	$8.76	81,541	52,014	138,908	42	26	57
Accommodation Services	2	134,372	93,444	175,299	$7.67	$5.88	$9.45	8,163	5,000	11,325	27	26	28
Residential - Multi-Family	2	99,560	96,304	102,817	$4.07	$3.06	$5.08	17,224	12,536	21,912	51	28	73
Food Service and Drinking Places	1	208,927	208,927	208,927	$3.51	$3.51	$3.51	48,075	48,075	48,075	24	24	24

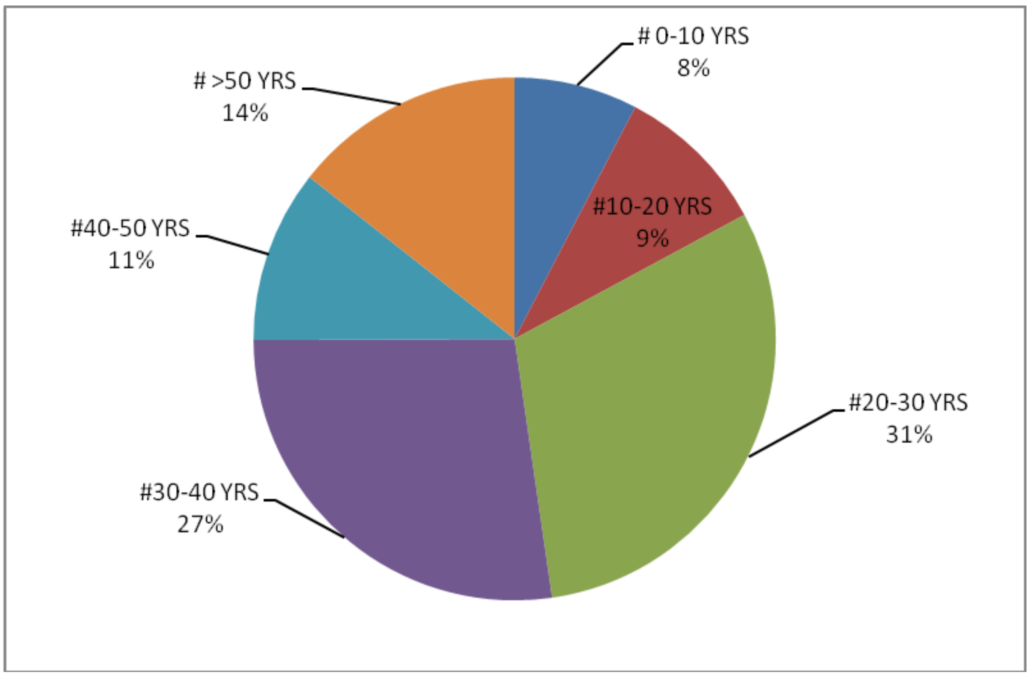
Detailed Data Analysis Findings

The findings below were produced with information that the benchmark contractor and each TSP upload to the ARIS database. This data is the source used to analyze the program and produce the statistical data presented herein.

1. Statistical Data:

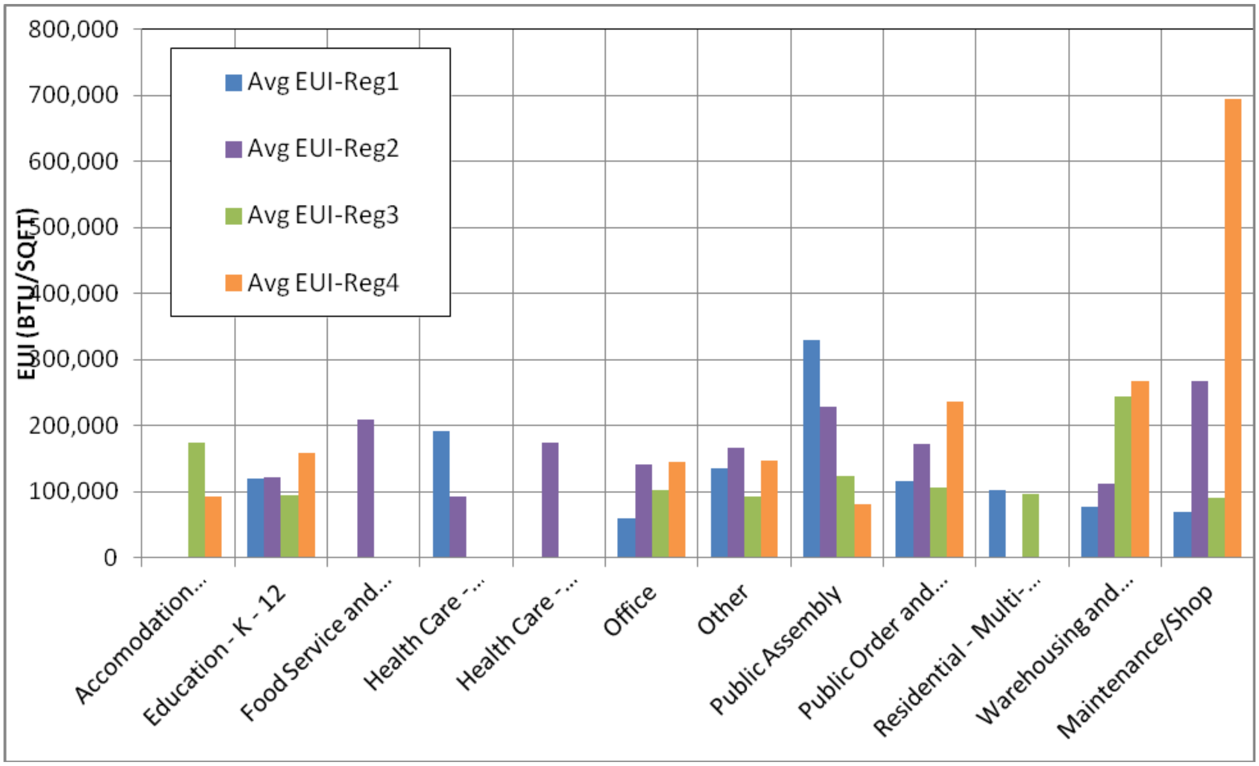
   a. **Age range statistics of buildings:** See the pie chart below for a graphical depiction of the relative age of the buildings that were audited.

Figure 3: Building Age Ranges



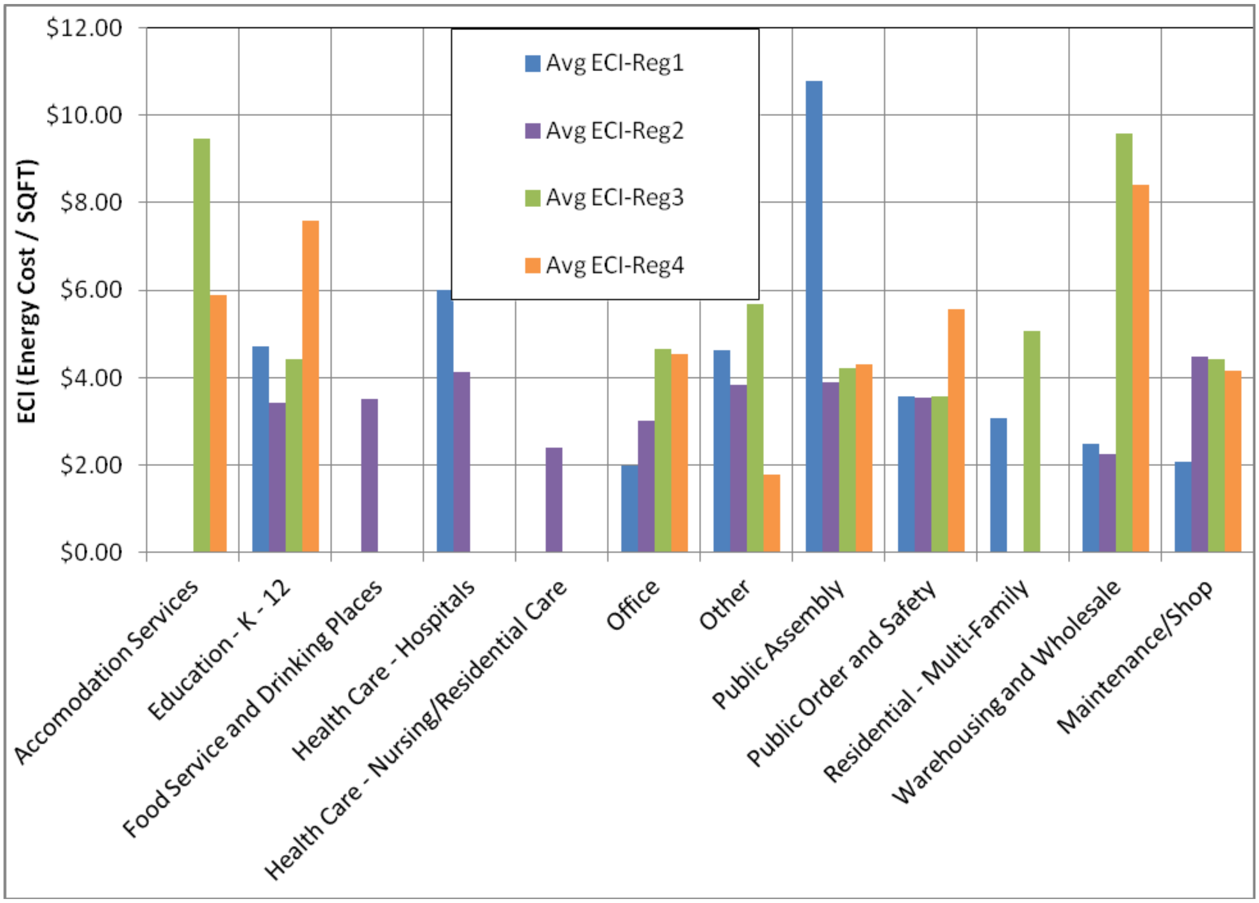
   b. **Auditor Region Energy Characteristics:** Figure 5 illustrates patterns that begin to emerge when going beyond the statewide level and looking at the Auditor Region's level. Figure 5 breaks out the regional data by usage type for EUI. As this graph shows, the much higher EUIs of Maintenance and Shop buildings at the statewide level are being driven primarily by the extremely high energy usage of shops in Region 4, the Northern Region (see Figure 9 for a pictorial depiction). This makes sense since shops typically are bringing in equipment to be worked on that is very cold and very heavy. Also, the equipment has to be heated with electric heaters for the engine, battery, and hydraulics in order to start them so that they can be brought into the shop for maintenance. Lastly, shops in the arctic are located in a darker winter area driving the need for more exterior lighting operation over the course of the year.

Figure 4: EUI by auditor region by building function



c. As can be seen in Figure 6, Region 1 has the highest ECI **for Public Assembly usage** in the state, primarily due to a very inefficient pool heated to a high temperature with electric boilers. This figure has not been normalized by climate, which explains why in some categories such as **Warehousing and Wholesale** the ECI increases progressively from Southeast to the Arctic Slope. Also, fuel prices vary significantly between and sometimes within regions; this, combined with the small number of records of a particular usage type in some regions, leads to some of the fluctuations, such as those found in Warehousing and Wholesale buildings in Regions 3 and 4.

Figure 5: ECI by auditor region by building function



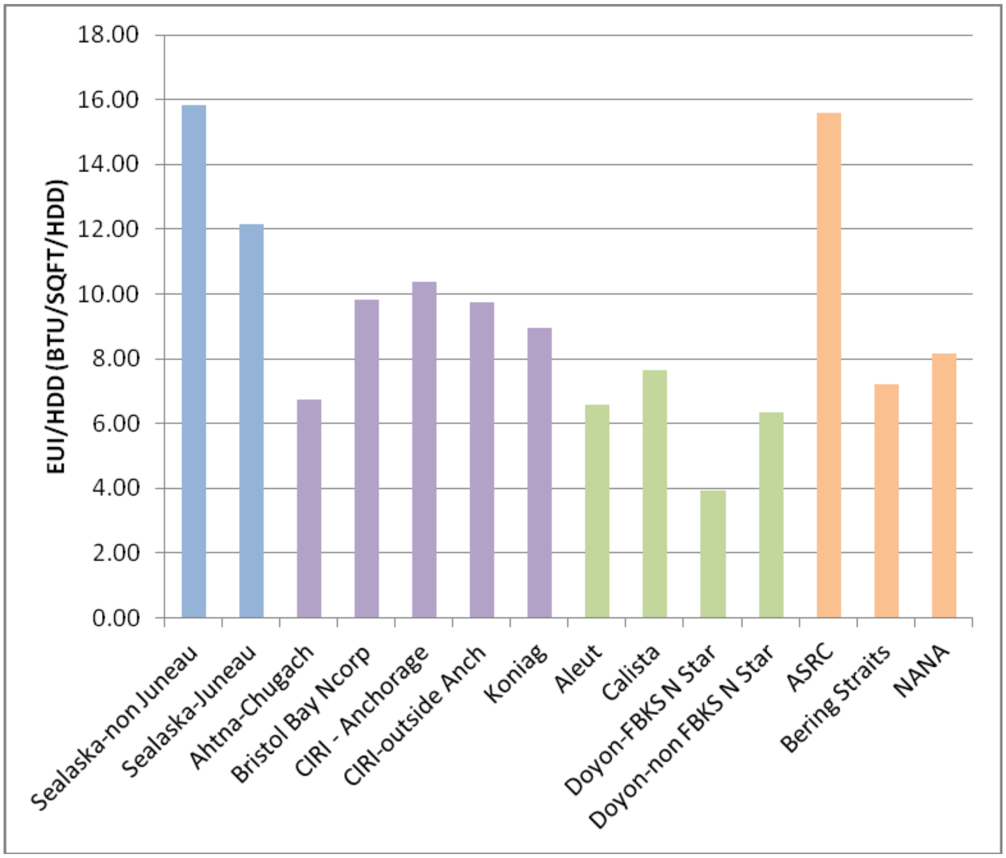
d. **ANCSA Regions—Energy Characteristics:** Figures 7 and 8 show that there are significant ranges for energy use and costs between auditor regions when looking at the EUI and ECI of building usage types, CCHRC also analyzed data at the ANCSA region level. ANCSA regions were used because they are typically climatically and culturally similar, and are familiar ways of dividing up the state. For the purposes of this analysis, large urban areas were also separated out from the rest of the ANCSA region, as they often have unique energy characteristics and typically higher occupant densities. The regional sampling was already more evenly distributed than the building usage type sampling was, and separating out cities from ANCSA regions allows for a finer look at patterns that may exist. Energy cost, use, and general building characteristics are summarized in Figure 7. For the geographic locations of the ANCSA Regions please refer to Figure 9.

Figure 6: Energy Characteristics by ANCSA Region

	ANCSA Region[1]	Audited Buildings	EUI (BTUs/SF)			ECI ($/SF)			SF			Age in Years		
			AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
	All Regions	327	149,372	33,102	1,973,345	$4.45	$0.68	$32.96	41,864	1,200	361,698	33	2	82
REG 1	Sealaska - non Juneau	23	163,231	37,951	1,061,667	$5.91	$1.31	$32.96*	38,258	8,748	99,282	43	9	75
	Sealaska - Juneau only	15	139,808	54,489	478,202	$4.57	$1.81	$15.71	76,865	8,220	190,738	32	5	60
REG 2	Ahtna-Chugach	8	107,550	82,519	132,604	$4.39	$3.13	$6.34	25,422	8,234	53,700	37	19	54
	Bristol Bay NC	12	132,258	92,113	229,113	$7.00	$4.03	$11.50	24,043	6,499	78,073	34	11	53
	CIRI - Anchorage	49	165,322	61,094	367,053	$2.92	$1.24	$8.69	67,597	3,061	361,698	34	12	58
	CIRI - outside Anchorage	47	152,993	70,820	357,164	$3.04	$1.07	$6.33	46,473	3,312	206,687	34	8	63
	Koniag	10	105,763	72,972	161,592	$3.14	$2.09	$5.54	26,405	3,126	60,876	41	28	67
REG 3	Aleut	14	83,365	59,131	117,140	$4.43	$2.48	$6.90	15,833	2,448	49,296	27	3	72
	Calista	20	121,955	36,664	345,294	$7.01	$2.12	$15.07	24,078	2,200	75,829	27	2	77
	Doyon - FNSB	43	89,946	43,911	222,849	$2.90	$1.25	$8.05	68,417	3,796	234,412	35	4	67
	Doyon - outside FNSB	41	111,355	33,102	241,932	$4.93	$1.69	$12.46	23,198	3,340	76,683	34	8	82
REG 4	ASRC	28	358,315	112,563	1,973,345	$5.59	$0.68	$19.53	17,049	1,200	51,665	27	4	36
	Bering Straits	15	131,871	73,978	224,875	$7.24	$4.31	$11.16	22,443	1,684	44,343	26	8	41
	NANA Corp	2	156,200	93,444	218,956	$7.75	$5.88	$9.62	29,775	11,325	48,225	31	26	35

* Colored cells indicate highs and lows

Figure 7: Average Thermal EUI per HDD, by ANCSA Region, all audited buildings



The data in Figure 7 suggest that ASRC buildings use more energy than in many regions. This may be at least partially accounted for in the longer darkness period in the Arctic and the impact of extreme cold on equipment and engines that drive the need for electric head bolt heater operation, which drives up the cost of energy significantly. The data in Figure 10 looks solely at energy consumed for space heating. Note that even after accounting for the colder climate ASRC buildings continue to have the highest average thermal EUI/HDD. It also suggests that buildings in the Sealaska geographic area outside of Juneau are roughly equally energy inefficient. A further conclusion might be that in places with cheap energy, there is less pressure to construct efficient structures. However, there is a fairly low correlation statewide between EUI per HDD and energy price[7].Another factor is that similar buildings have the same lighting and equipment energy use, but this is weighted differently when the HDD correction is applied.

Figure 8 shows that there are significant ranges for energy use and costs even within ANCSA regions, The current data set is not sufficient to make comparisons at this level of detail for all usage types. However, due to the high percentage of schools that were audited, CCHRC was able to do a preliminary analysis case study of schools at the ANCSA geographic region-level. The case study can be found in Appendix A.

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[7] See Appendix H, Figure K for scatter plot and R^2 value.

White Paper Disclaimers

This audit was performed using ARRA funds, managed by the AHFC. This material is based upon work supported by the Department of Energy under Award number is EE-0000217.

This report contains generalized recommendations that, in the opinion of the auditors, will cause public facility owners to realize energy savings over time. Some recommendations may need to be designed by a registered engineer, licensed in the State of Alaska, in the appropriate discipline. Lighting recommendations should all be first reviewed by running a lighting analysis to assure that the recommended lighting upgrades will comply with State of Alaska Statues as well as IES recommendations.

Payback periods may well vary from those forecast due to the uncertainty of the final installed design, configuration, equipment selected, and installation costs of recommended EEMs, or the operating schedules and maintenance provided by the owner. Furthermore, EEMs are typically interactive, so implementation of one EEM may impact the cost savings from another EEM. Neither the auditor, Richard S. Armstrong, PE, LLC, AHFC, or others involved in preparation of this report will accept liability for financial loss due to EEMs that fail to meet the forecasted payback periods.

Each audit meets the criteria of an ASHREA Level 2 audit, and is valid for one year. The life of the IGA may be extended on a case-by-case basis, at the discretion of the AHFC.

IGAs are the property of the State, and may be incorporated into AkWarm-C, the Alaska Retrofit Information System(ARIS), or other state and/or public information system. AkWarm-C is a building energy modeling software developed under contract with AHFC.

"This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

Throughout the project and in this White Paper "Investment Grade Audit" is used to refer to an ASHRAE level II audit.

Background

The following section includes, but is not limited to, information on the individuals involved in performing the IGAs, systems, programs, and data normalization approach.

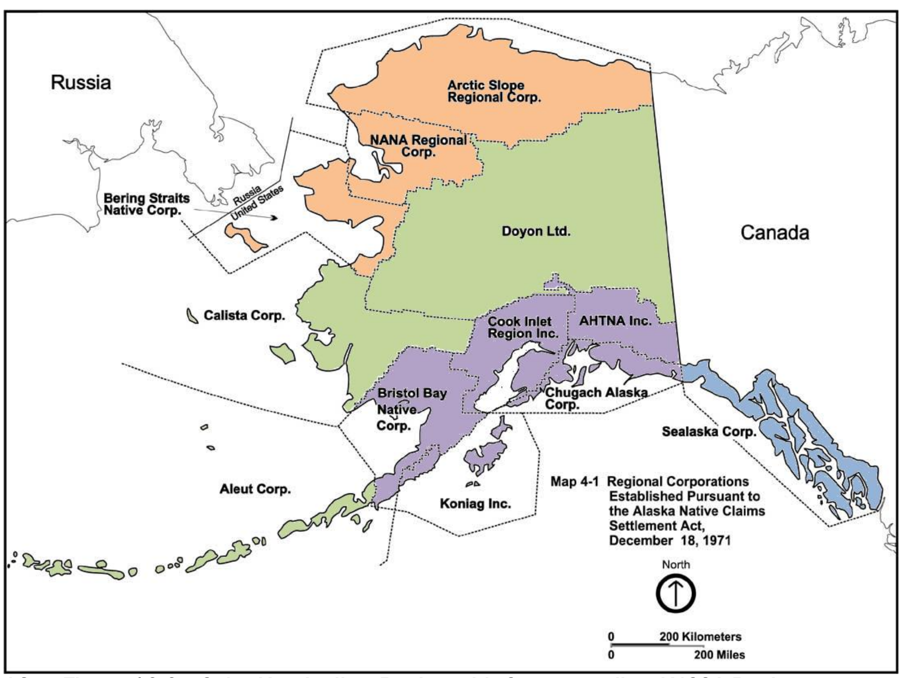
1. TSPs Assigned Regions

The AHFC-selected TSPs were directed to select buildings to be audited, confirm benchmark utility data, and perform or subcontract and manage the IGA. Auditors working under the TSPs are a Certified Energy Auditor (CEA), a Certified Energy Manager (CEM), or the equivalent. TSP firm profiles are located in Appendix C: Firm Profiles, Statement of Qualifications and resumes for the lead TSPs are located in Appendix D: Lead TSP Resumes.

Figure 9 below shows the four separate Auditor Regions.

Organization	Project Manager	Auditor Region[8]
Alaska Energy Engineering, LLC	Jim Rehfeldt, PE, CEM	Region 1, Southeast
Central Alaska Engineering Company	Jerry Herring, PE, CEA	Region 2, Southcentral
NORTECH	Peter Beardsley, PE, CEA	Region 3, Interior, West, Aleutians
Richard S. Armstrong, PE, LLC	Richard S. Armstrong, PE, CEM, CEA	Region 4, Northern

Figure 8: AHFC Designated TSP Regions*



*See Figure 10 for Color Key Auditor Region with Corresponding ANCSA Regions

[8] See Figure 10 for further information on regions.

Figure 10: Auditor Region with Corresponding ANCSA Regions

Auditor Region	ANCSA Region
Region 1	Sealaska Corporation - outside Juneau
	Sealaska Corporation - Juneau only
Region 2	Ahtna-Chugach
	Bristol Bay Native Corporation
	Cook Inlet Regional, Inc. (CIRI) - Anchorage Municipality only
	CIRI - outside Anchorage Municipality
	Koniag
Region 3	Aleut
	Calista
	Doyon - Fairbanks North Star Borough only
	Doyon - outside Fairbanks North Star Borough
Region 4	ASRC
	Bering Straits Regional Corporation
	NANA Regional Corporation

2. Investment Grade Audit

An IGA is one of the most detailed energy audits on the market for commercial facilities. The primary goal of an IGA is to learn about a building's energy consumption and identify potential energy and cost saving measures in the building through better facilities management practices, as well as to identify energy efficiency upgrades and replacements. It can be used to guide facility managers in prioritizing improvements and typically identifies low cost measures that can be implemented right away.

Through the audit process, a CEA or CEM takes a comprehensive look at all components of a facility, not just the traditional shell components or lighting and HVAC systems. The CEA or CEM also looks deeper into the operation and maintenance (O&M) of the building and reviews occupant behavior, schedules, controls, and indoor air quality (IAQ), just to name a few. The auditor does not outline how the building was designed to perform, but rather investigates and reports on how it actually is performing and the energy costs that are associated with this performance. This is done by using a building modeling software, such as AkWarm-C (discussed later). Please see Appendix H for more IGA information.

3. Energy Utilization Index (EUI)

The primary benchmarking statistic is the EUI. The EUI is calculated from the utility bills and provides a snapshot of the quantity of energy actually used by the building on a square foot and annual basis. The calculation converts the total energy use for the year from all sources in the building, such as heating fuel and electrical usage, into British Thermal Units (BTUs). This total annual usage is then divided by the number of square feet of the building. The EUI units are BTUs per square foot per year.

The EUI is useful in comparing a building's energy use to that of other similar buildings in Alaska and in the Continental United States. However, it is not adjusted for climate variations.

The EUI can be compared to the average energy use found in a 2003 study by the U.S. Energy Information Administration of commercial buildings (abbreviated CBECS, 2006). That report found an overall average energy use of about 90,000 BTUs/SF per year while studying about 6,000 commercial buildings of all sizes, types, and uses that were located all over the Continental U.S.

In a recent and unpublished state-wide benchmarking study sponsored by the AHFC, schools in Fairbanks averaged 62,000 BTUs/SF and schools in Anchorage averaged 123,000 BTUs/SF annual energy use[9]. The Fairbanks schools use half the energy of Anchorage schools even though they are located in a much colder climate.

4. Energy Cost Index

Another useful benchmarking statistic is the Energy Cost Index (ECI), which is the cost for energy used in the building on a square foot basis per year. The ECI is calculated from the cost for utilities for a year period. The ECI permits comparison of buildings on total energy cost per square foot even though they may be located in areas with differing energy costs and differing heating and cooling climates. The cost of energy, including heating oil, natural gas, and electricity, can vary greatly over time and geographic location and can be higher in Alaska than other parts of the country.

5. Heating Degree Day Correction and Normalization

Each region has its own unique climate and weather pattern. Some areas of the State experience only a few hours of daylight during the winter and numerous days below freezing. For example, the data show that buildings in the Arctic Slope Regional Corporation (ASRC) geographic area have higher average EUI than other regions, and that buildings in the Aleut Corporation geographic area have the lowest average EUI of all regions. However, these numbers do not take into account the fact that these regions have significantly different climates. As a result the data was normalized in order to make the data more comparable.

Normalization was done by dividing the thermal energy portion of the EUI by the annual number of HDD of an area. HDD are the number of degrees that the daily average temperature falls below 65°F. For example, if the average temperature in a particular area is 20° F on November 13th, there are 45 HDDs for that date. Using the sum of HDDs over the course of an average year in calculations allows one to look at non-climatic factors that may be influencing thermal energy consumption and costs. The EUI per annual HDDs by ANCSA region can be found in Figure 17.

Even after normalizing the data it was found that the HDD range across the State is from a low of 7,000 HDD in Southeast to a high of 20,370 HDD in the Arctic Slope, with an average of 12,434 HDD statewide.

The normalized data, with HDD factored in, still does not take into account (1) engine heaters have to be operated in extreme cold climates and not at all in the Southeast, and (2) lights have to be operated much longer on the North Slope where the sun does not come above the horizon from November 18 until January 23 each year, providing only civil twilight for part of each day. Another factor is that heat gain from lighting, people, and equipment is

[9] These averages were found to be slightly different for the specific group of buildings that underwent detailed audits.

fully beneficial in colder climates and only partly beneficial in climates with fewer degree days.

6. Alaska Retrofit Information System (ARIS)

AHFC, in conjunction with the Cold Climate Housing Research Center (CCHRC), created ARIS to house data pertaining to buildings in Alaska that was collected statewide through commercial and residential audits.

ARIS is also home to over 65,000 unique residential units, including information on over 40,000 residential units that were rated in either the Weatherization or Home Energy Rebate Program and over 24,000 new homes certified as meeting or exceeding the Building Energy Efficiency Standard (BEES). With the completion of this project, now nearly 400 public facilities have extensive construction data and energy use in this database.

It is AHFC's goal to continue to expand data collection on public facilities. Consistent data input and means to correlate construction details of many buildings in a similar manner will be imported into the ARIS database. Furthermore, under HB 306, all state-owned facilities are now required to track their energy use and ARIS is the vehicle for doing so. AHFC plans to open this option to school districts, borough and municipal governments as well.

The IGA data was collected and entered into the AkWarm-C© software to standardize all information gathered. The AkWarm-C© (further explained in the next section) file was then uploaded to ARIS.

For the IGAs, the ARIS database was analyzed to determine comparative benchmark performance evaluations by cost per square foot, by energy use per square foot, by region, by building type, by student, and by student by HDD. This comparative performance evaluation was completed to help normalize the massive amount of data required to determine trends and identify potential for improvement.

7. AkWarm-Commercial Modeling Software

Once the auditor completed a building site visit they would then enter data from the building into AkWarm-C, to model a building's energy use. The AkWarm-C program was developed by AHFC to assist the auditors preparing IGAs to model their buildings and estimate operating costs and payback for recommended improvements. AkWarm-C can be used at no cost and can model both residential and commercial buildings.

AkWarm-C uses an energy library that is maintained by AHFC. The library contains energy costs by user type, climate data and utilities. Calculations for payback on various EEMs are calculated for a building using these specific costs and climate. The current version can be downloaded free from the link following:

www.analysisnorth.com/AkWarm-C/AkWarm-C2download.html

8. Benchmark Data Collection: December 2010 through April 2011

Through this process, AHFC attempted to collect standard benchmark data which includes information such as building square footage, year built, renovations and additions since construction, number of occupants, hours of operation, two years of energy bills, and construction drawings.

Benchmarking building energy use consists of obtaining and then analyzing two years of energy bills. The original utility bills are necessary to determine the raw energy usage and charges as to evaluate the utility's rate structure. The metered usage of electrical and natural gas consumption is measured monthly, but heating oil, propane, wood, and other energy sources are normally billed upon delivery and provide similar information. During benchmarking, information is compiled in a way that standardizes the units of energy and creates energy use and billing rate information statistics for the building on a square foot basis. The objectives of benchmarking are listed below.

- Understand patterns of use
- Understand building operational characteristics
- Comparison with other similar facilities in Alaska and across the country
- Offer insight into potential energy savings

Through the benchmarking effort, AHFC was able to collect full or partial benchmark data on almost 1,200 facilities statewide by contracting with Central Alaska Engineering Company and NORTECH Engineering.

Secondly, AHFC used this information to begin a building inventory that identifies publically-owned facilities and their current conditions statewide. The State has records on State-owned facilities and school districts, regional educational attendance area REAA-owned facilities, but does not have a statewide basis of all municipally owned facilities.

After the benchmark data was collected, TSPs analyzed the data by ANCSA region. The facilities that provided complete benchmark data were prioritized and the highest energy users were selected to receive an ARRA-funded IGA, administered by the AHFC. AHFC housed this information in ARIS where it could be analyzed. AHFC and the TSP teams sorted through the data and chose the highest using facilities for audits. Though this inventory was not complete, AHFC was able to get a fairly good sampling of buildings across usage types.

It is estimated that there are around 5,000 publically owned buildings in Alaska.

Appendices

Appendix A	Case Studies
Appendix B	Organizational Chart
Appendix C	Firm Profiles, Statement of Qualifications
Appendix D	Lead TSP Resumes
Appendix E	AHFC Program Process
Appendix F	Building Use
Appendix G	List of Audited Buildings
Appendix H	Education Facility Statistical Analysis Details
Appendix I	Glossary

Appendix A
Case Studies

Case Studies and Lessons Learned

Each TSP developed case studies and lessons learned based on their personal findings that they felt were worth highlighting. The case studies following describe particular findings in more detail to provide a better understanding of the specific scenario. Some simply identify lessons learned through the process:

Submitted by: **CCHRC**

Title: **Energy Usage and Costs in Audited Schools**

Of the 327 total public buildings whose audits had been submitted to ARIS, at the time of this report, 183 were classified as actual schools[10] with representation from every ANCSA geographic region. This amounts to approximately 38 percent of the 479 public schools listed in the DEED's Average Daily Membership report. Over 10 million square feet of school buildings were audited, with total annual costs of $34,328,000, for approximately 1.1 trillion BTUs of energy. A linear extrapolation of these numbers for all public schools shows that there is approximately 26 million square feet of school buildings in Alaska, with an annual cost of just under $90 million for 2.9 trillion BTUs of energy.

The audit data was matched with enrollment numbers from DEED's 2012 average daily membership statistics. Of the original 183 audits classified as schools, 175 were satisfactorily matched with enrollment. This level of data coverage and number of buildings was sufficient to conduct preliminary analyses of the differences in energy consumption and costs for schools between geographic regions and to highlight some of the potential causes of these differences.

Analysis was conducted at both the ANCSA region level and an Auditor Region level (as described previously). Data at the ANCSA geographic region level is moderately well-distributed, with at least five records from each region except for NANA. It is important to keep in mind that the analyses that follow are primarily based on averages taken from all of the schools in a particular region; consequently those regions with a higher number of audited schools will likely have more reliable data than those with fewer audited schools. The exact breakdown of data by ANCSA geographic region can be seen in the table below.

Figure 11: Number of Schools by Region

Auditor Region	ANCSA Region	Matched Audited Schools
	All Regions	175
Region 1	Sealaska Corporation - outside Juneau	8
Region 1	Sealaska Corporation - Juneau only	7
Region 2	Ahtna-Chugach	6
Region 2	Bristol Bay Native Corporation	12
Region 2	CIRI - Anchorage Borough only	22
Region 2	CIRI - outside Anchorage Borough	26
Region 2	Koniag	7
Region 3	Aleut	5
Region 3	Calista	11
Region 3	Doyon - Fairbanks North Star Borough only	27
Region 3	Doyon - outside Fairbanks North Star Borough	28
Region 4	ASRC	5
Region 4	Bering Straits Regional Corporation	10
Region 4	NANA Regional Corporation	1

[10] Schools were defined by the energy rating software as buildings whose primary space usage was "Academic/technical classroom instruction, such as elementary, middle and high schools, and classroom buildings on college/university campuses. Buildings on education campuses for which the main use is not classroom are included in the category related to their use."

School Building Energy Use

EUI varied significantly between schools, ranging from about 36,700 BTU/SF in Aniak to 278,000 BTU/SF in Nuiqsut, with a statewide average of 114,405 BTU/SF. School building owners, operators, and designers can compare their energy use with those in their region using Figure 12.

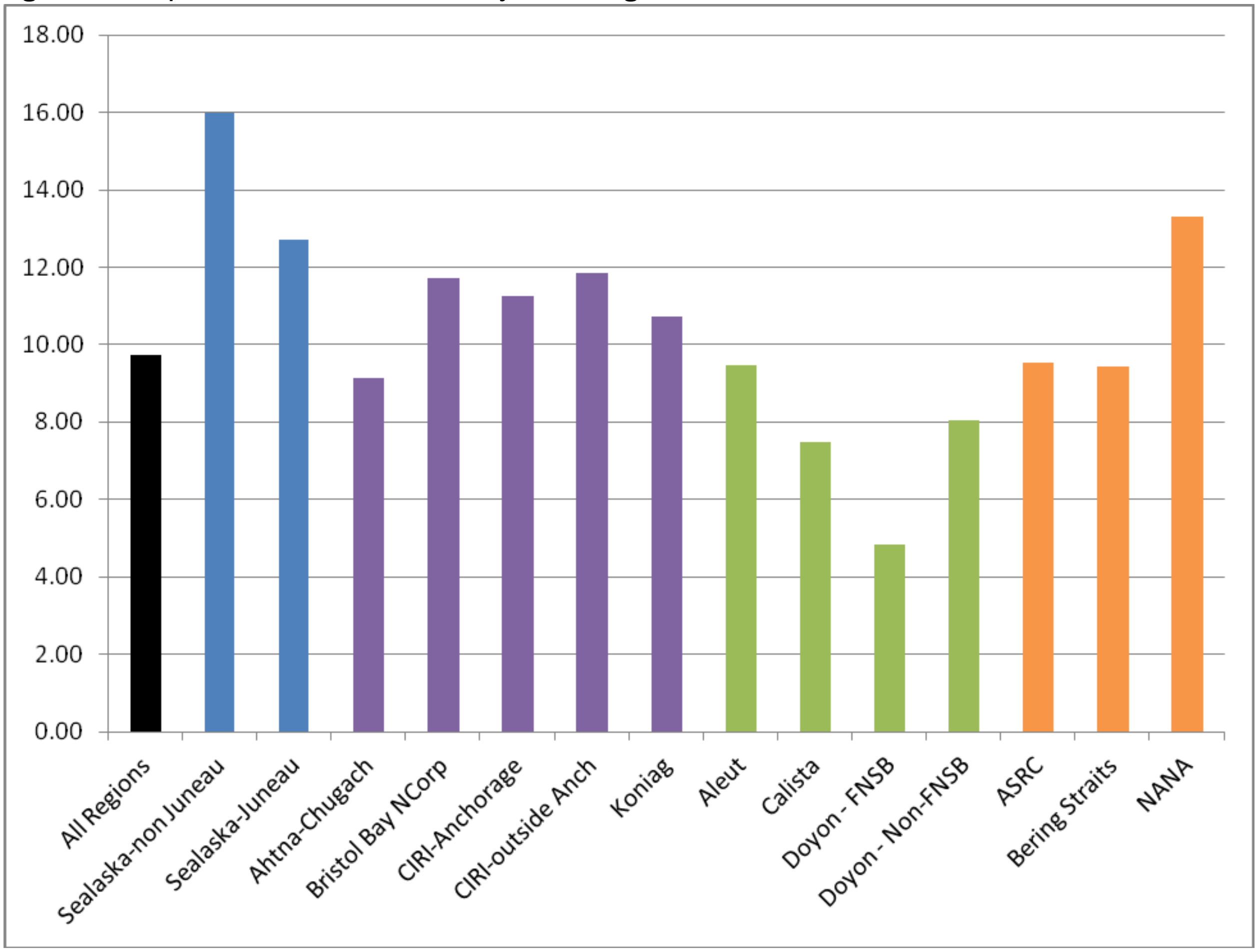
Figure 12: EUI and EUI/HDD of Audited Schools by ANCSA region

ANCSA Region	Audited Buildings	EUI (BTU/SF)			EUI/HDD (BTUS/SF/HDD)		
		AVG	MAX	MIN	AVG	MAX	MIN
All Regions	183	114,405	278,055	36,664	9.73	26.53	2.75
Sealaska-non Juneau	12	131,674	224,862	58,852	15.99*	26.53	6.90
Sealaska-Juneau	7	99,576	153,300	54,489	12.72	19.92	6.79
Ahtna-Chugach	6	112,661	132,604	82,519	9.14	13.00	5.52
Bristol Bay NCorp	12	132,258	229,113	92,113	11.73	20.26	8.28
CIRI-Anchorage	23	121,637	146,311	102,443	11.27	13.53	9.45
CIRI-outside Anch	26	128,948	235,115	84,800	11.86	25.59	6.47
Koniag	7	92,265	106,426	72,972	10.72	12.46	8.55
Aleut	5	92,062	117,140	77,061	9.46	13.21	7.09
Calista	11	99,531	201,333	36,664	7.49	15.09	2.75
Doyon - FNSB	28	70,282	112,671	43,911	4.82	7.89	3.08
Doyon - Non-FNSB	30	117,935	241,932	50,866	8.05	16.30	3.49
ASRC	5	190,893	278,055	116,433	9.54	13.65	6.17
Bering Straits	10	136,526	224,875	73,978	9.42	16.16	5.31
NANA	1	218,956	218,956	218,956	13.30	13.30	13.30

* Colored cells indicate highs and lows

Analysis was done on several variables to evaluate their effects on energy use per square foot (EUI). Climate is certainly a significant factor, which can be taken into account using the EUI per HDD chart shown in Figure 13.

Figure 13: EUI per HDD of Audited Schools by ANCSA region



This chart indicates significant differences by ANCSA region, with schools in the Fairbanks North Star Borough on average using less than half of the energy per HDD of an equal sized building in the Sealaska Bristol Bay, NANA and CIRI regions. In order to narrow down the possible causes of this difference, building age and building size were analyzed to determine if there was a significant correlation between high energy use and older buildings or increased energy use with smaller building size. The variables were not found to have significant correlation with EUI or EUI per HDD[11].

School Energy Prices and Total Costs

Another variable that could affect the EUI per HDD of a school building is energy price. The price per million BTUs (MMBTU) varies widely throughout the state due to differences in fuel type and transportation access. The range is from about $97/MMBTU for one school in the YK Delta to about $13/MMBTU for one school using district steam. These price differences will obviously significantly affect the annual energy costs of a school. Figure 14 allows building operators, designers, and owners to compare energy costs to regional averages.

[11] See Appendix H, Figures I and J for scatter plots and R^2 values of these two variables

Energy price data, in terms of dollars per million BTUs, was plotted against EUI to determine if there was a significant correlation. Surprisingly, for both the State as a whole, and for individual ANCSA regions there was very little correlation between the energy efficiency of a building and the price of energy for that building[12]. With the significant savings possible from EEMs and facility operation management it is surprising to see this disconnect in areas of the state with high energy prices. There are a number of possible causes for this disconnect between EUI and price that can be acted on, such as[13]:

- Lack of a commissioning process for structures
- No energy policies for the organization or facility
- No energy coordinator responsible for the structure
- Inadequate data collection or monitoring
- Insufficient funding for EEMs
- Lack of education or authority for the facility manager to institute EEMs

A more in-depth analysis of the individual structure, and a careful examination of the structure's IGA report would be required in order to determine the most cost effective steps to implement.

[12] See Appendix H, figure J for scatter plot and R^2 value
[13] For more details on these possible causes, see IGA Common EEM Recommendations 1-11

Figure 14: ECI, School Size, and Annual Energy Costs of Schools by ANCSA Region

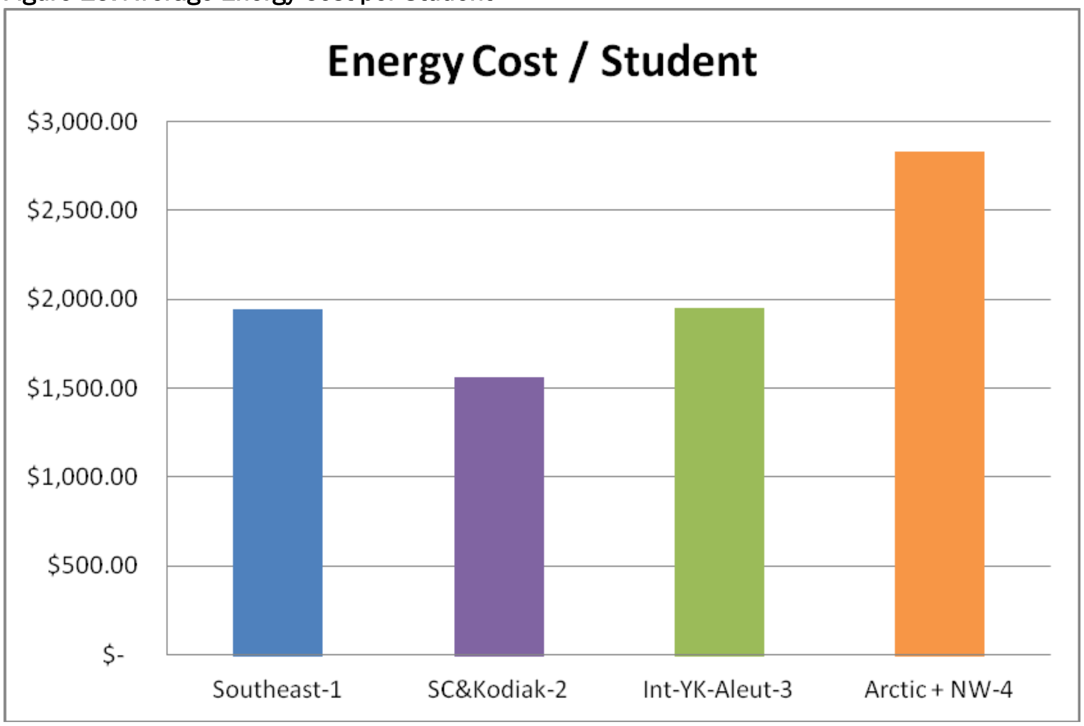
ANCSA Region	Audited Buildings	SF			Annual Energy Cost / School ($)			ECI ($/SF)		
		AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN
All Regions	183	54,976	361,698	5,213	$187,584	$853,643	$11,379	$4.33	$12.46	$1.60
Sealaska-non Juneau	12	51,458	99,282	13,670	$291,186	$730,480	$42,195	$5.48	$11.39	$2.08
Sealaska-Juneau	7	120,779	190,738	58,669	$386,260	$784,690	$165,130	$3.37	$5.69	$1.81
Ahtna-Chugach	6	22,178	52,956	8,234	$87,099	$165,712	$33,782	$4.56	$6.34	$3.13
Bristol Bay NCorp	12	24,043	78,073	6,499	$147,589	$319,819	$60,405	$7.00	$11.50	$4.03
CIRI-Anchorage	23	89,614	361,698	18,580	$175,437	$673,463	$45,291	$1.96	$2.44	$1.60
CIRI-outside Anch	26	67,141	206,687	9,245	$169,238	$434,285	$32,601	$2.86	$6.33	$1.69
Koniag	7	32,427	60,876	8,450	$97,615	$200,457	$18,973	$3.20	$5.54	$2.09
Aleut	5	29,283	49,296	10,939	$139,139	$272,730	$31,511	$4.54	$5.63	$2.88
Calista	11	32,333	75,829	7,326	$233,828	$853,643	$34,251	$6.55	$11.26	$2.60
Doyon - FNSB	28	79,838	234,412	5,213	$188,519	$477,626	$11,379	$2.32	$3.39	$1.67
Doyon - Non-FNSB	30	29,387	76,683	7,538	$142,836	$424,802	$31,804	$5.61	$12.46	$1.74
ASRC	5	40,185	51,665	35,558	$260,979	$352,033	$193,037	$6.63	$8.92	$4.12
Bering Straits	10	27,394	44,343	17,116	$211,760	$315,700	$102,489	$7.88	$11.16	$5.87
NANA	1	48,225	48,225	48,225	$463,778	$463,778	$463,778	$9.62	$9.62	$9.62

* Colored cells indicate highs and lows

Average Energy Use and Costs *Per Student*

In addition to looking at energy use and costs at the building level, it is useful to examine them on a per student basis since public school funding is allocated based on the number of students in attendance[14] as well as several other factors. There is considerable variation of the mean yearly energy costs per student between auditor regions, with a difference of $1,270 per student between Region 2 and Region 4. This means that a school with 247 students (the mean enrollment per school in Alaska) in Region 4 could be paying approximately $313,000 *more* in annual energy costs than a similarly sized school in Region 2.

Figure 15: Average Energy Cost per Student

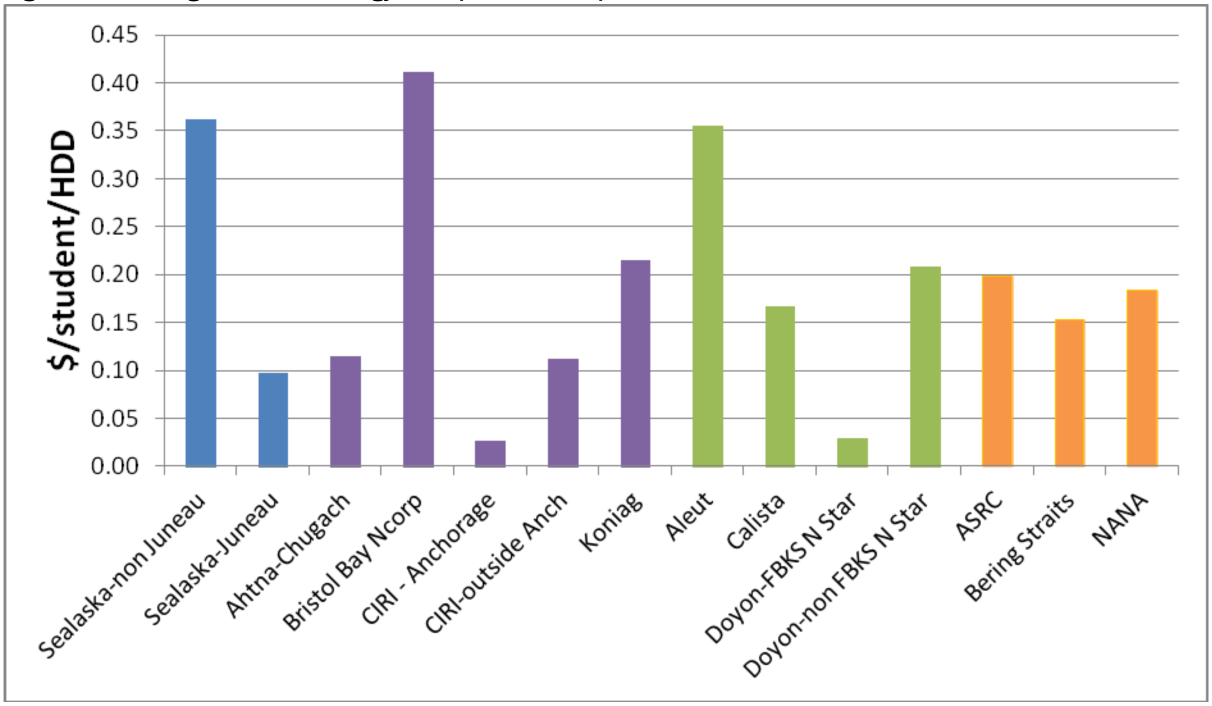


There are many potential causes of this variation; CCHRC looked at climate, energy prices, building age, building size, and school enrollment to determine the general effect of these factors on the average energy cost per student.

While the climate of an area will certainly affect the thermal energy costs of buildings in that area, it is not a factor that can be changed on a local scale. Thus, for school administrators, policymakers, or energy professionals, it is more useful to look at the average heating energy costs per *annual HDD.*

[14] AS 14.17.410. Public School Funding

Figure 16: Average Thermal Energy Cost per Student per HDD



By normalizing the data using HDDs, the above graph shows particular ANCSA geographic regions that have much higher annual energy costs per student than are explainable by their climate alone to be identified.

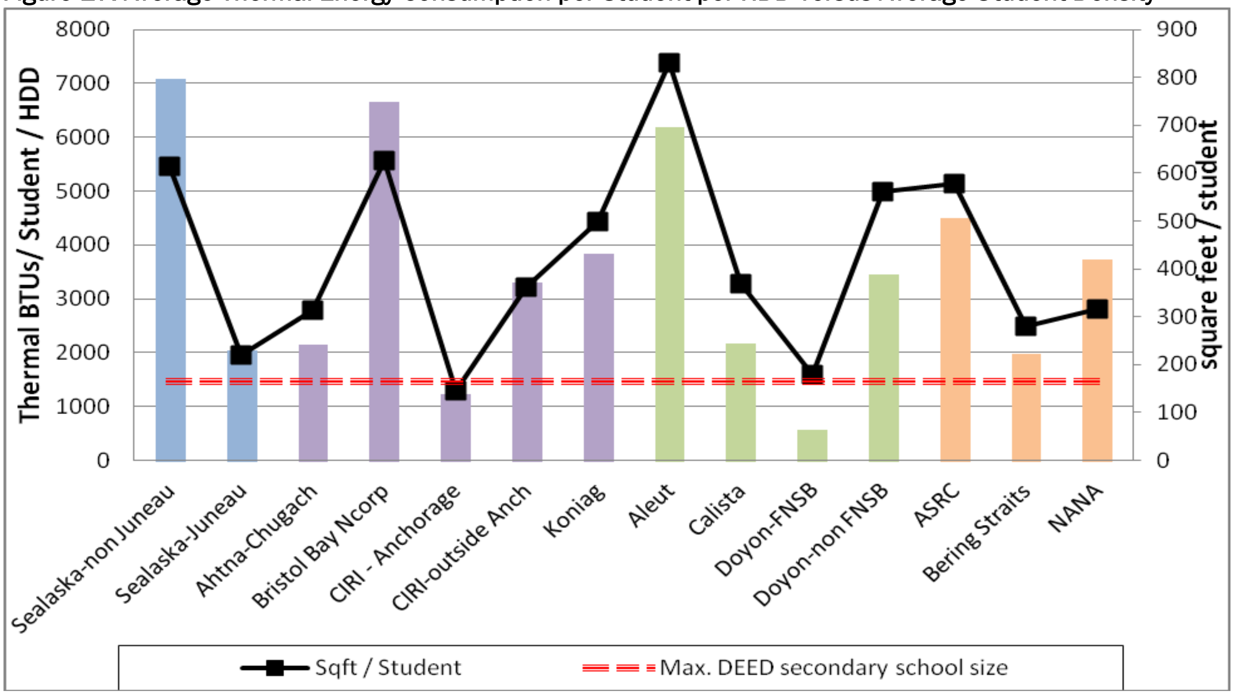
Similar to the analysis done at the building level, building age, building size, and energy prices were found to have very little correlation to the energy use and energy cost per student metrics[15].

Student Density

One clear difference between urban and rural schools is the total number of students enrolled. Of the 183 schools audited for this report enrollments ranged from a minimum of 7 students in False Pass to a maximum of 2,150 students at East Anchorage High School. The audit data allows further investigation of these differences by looking at the average amount of square footage of building space that exists per student in a given ANCSA geographic region. This student density data shows that there is a strong correlation between average energy consumption per student and square footage of building space per student[16], with urban areas having fewer square feet per student as well as very low energy consumption per student, and some rural areas having a very large amount of space devoted to each student and correspondingly high amounts of energy consumption per student. The average student density shows a similar correlation with energy costs per student, although it is not as closely linked, likely due to varying energy costs between regions[17].

[15] See Appendix H for more details
[16] The R-squared value for a linear regression of these two variables is 0.68. See Appendix H, figure E, for the scatter plot
[17] The R-squared value for a linear regression of these two variables is 0.59. See Appendix H, figure F, for the scatter plot and figure G for the regional breakdown.

Figure 17: Average Thermal Energy Consumption per Student per HDD versus Average Student Density



It should be noted that DEED has a space allocation guideline that recommends a maximum limit on the gross square feet per student that can be built. As of 2005, the maximum square footage per student was 165 for secondary schools, and 114 for elementary schools[18]. Only audited schools in Anchorage and the Fairbanks North Star Borough meet these criteria, and the rest of the schools in the State have too large a school compared to the number of students—sometimes by a factor of 450 percent in excess of the standards.

For the purposes of this study, primary (elementary) and secondary (high school) schools were considered together. This should lead to a slightly lower square footage per student than the secondary schools on their own. The secondary school's maximum is shown on the above graph in red, which highlights the fact that the only K-12 schools *in this study* that have average student densities below this maximum in the State are in Anchorage. A more in-depth evaluation of the audited Anchorage primary and secondary schools shows that the average square feet per student for primary schools is 136, and the average for secondary schools is 159.

Though there is a very high correlation between energy consumption per student and student density, there are still gaps in which schools in a region appear to have either lower or higher energy consumption than would be predicted by their student density. This difference seems to be accounted for fairly well by the energy efficiency of buildings found within a region, as measured by average EUI per HDD found in Figures 12 and 13. For example, the Fairbanks North Star Region and the Aleut region's energy use per student is below the square footage per student because these areas have significantly lower EUIs than the average. Conversely, Sealaska non-Juneau and Bristol Bay ANCSA regions have much higher energy use per student than their square footage per student would suggest because they have higher than average building EUIs.

[18] Mearing, Tim. "EED Space Guidelines: History and Overview". Department of Education and Early Development. Alaska, 2005.

1. Conclusions

The preliminary data shows that on an ANCSA regional level there is a significant range of school building energy efficiency levels as measured by EUI per HDD. It appears that this variability is not caused by having older buildings or larger buildings. The extremely low correlation between energy efficiency and energy price of the ANCSA regions highlights the need for energy policies, energy managers, and adequate energy data collection so that schools can efficiently allocate scarce resources where they will provide the most benefit to students.

Schools also need to be aware of energy use and costs per student, as funding is based on the enrollment. However, one of the primary alterable factors that is driving energy consumption and energy cost per student in a school is the square footage of heated or ventilated space per student. While the fact that having more students in the same space will save energy consumed per student may seem obvious, the observation that this factor appears to have a much stronger influence than either energy cost or building age provides valuable insight to policy makers as well as building and energy professionals.

As the majority of the schools that were audited have more space per student than the DEED recommendations, this study points to a large potential area for energy and cost savings that could be achieved by finding innovative ways to ensure that the amount of heated building space is in line with enrollment numbers. While school administrators and building operators cannot control the number of students enrolled, there are several potential options for reducing energy use and cost per student by reducing the heated and ventilated areas in regions that may be subject to declining enrollments, including:

- Consolidation of community functions in buildings, utilizing unused space for other community functions such as post offices, municipal or tribal offices, or clinics.
- Modular design features[19], such as:
  - Design floor plans and roof lines for adding capacity if and when needed
  - Zoned setback temperatures to reduce temperatures in unoccupied or unused areas
  - Demand controlled ventilation systems to ensure that schools are ventilating based on the actual occupancy and not the designed maximum occupancy
  - Zoned ventilation to reduce ventilation of unoccupied or unused areas
  - Lighting occupancy sensors
  - Systems for shutting down computers, appliances, and other systems when not in use

In this preliminary analysis of the school audits, two issues stand out. The first is declining enrollment, which seems common in rural schools. For this the suggestions offered above are a good place to start. The other issue can be seen clearly in Figure 13where schools in Southeast Alaska and the Southcentral area have EUI per HDDs that are roughly double those in the Fairbanks North Star Borough. While the authors are not sure of the exact causes for such higher energy use in areas that are also urban and have similar student densities to FNSB, they would recommend further research on this topic and suggest that significant energy saving potential does exist.

Please see Appendix H: Education Facility Statistical Analysis Details for more information.

[19] See *IGA Common EEM Recommendations* for more detailed descriptions

Submitted by: Richard S. Armstrong, PE, LLC

Title: Air Handler Damper Operator Positioning

Observation

There have been numerous observations of Outside Air (OSA)/return air damper actuators that have been disconnected, become loose and inoperative, rusted in place, or have been set to defeat the control system.

Impact

The damper actuators modulate to provide more or less OSA and return air to the mixing box of the air handler to assure adequate OSA during occupied periods. This is done to provide cooling as needed, to close off the OSA when the space is not occupied or when the air handler is off, or to open further when carbon dioxide (CO_2) sensors or other pollutant sensors determine the need for more OSA. Improper control of the OSA dampers, especially when the OSA dampers are found to be fully open continuously, burns huge amounts of thermal energy since the air handler coil has to heat all of the OSA to the programmed set point whenever the air handler is operating. This causes the boilers to work much harder and burn excessive amounts of fuel.

Recommended Change

The operation of the damper actuators and damper positions should be observed by trained technicians to assure that the dampers close tightly when the air handler is off or in pre-heat mode (unless an air flush is required). Likewise, leaving the OSA dampers closed continuously during occupied times causes the building to be stuffy, and sometimes hot, as well as potentially cause Indoor Air Quality (IAQ) problems—depending on the volume of the spaces, sources of pollutants, and occupant loads. CO_2 sensors have been proven to be excellent indicators of human metabolic activity, and can be used to program the DDC control system to maintain pre-set maximum CO_2 levels to assure a healthy environment for the building occupants.

Volatile Organic Compounds sensors can determine if other common air pollutants are present and need to be flushed.

Building technicians need to be aware of the functions and operational drivers for the damper actuators, and not change original commissioned settings unless they are fully aware of the designed control parameters.

Lesson Learned

Uninformed maintenance operators who intentionally disable control damper operators or control rods, or revise the positions of the control arms, create long term problems such as wasting significant amounts of energy, creating IAQ problems, creating overheating issues, and wasting money.

Submitted by: **Richard S. Armstrong, PE, LLC**

Title: **Lighting Continuously Operating**

Observation	The lights in the gymnasium and the wall packs on the north side of an audited school were found to be left on 24 hours a day, 7 days a week (24/7). The plant manager's diagnosis was either faulty system control hardware or incorrect programming in the DDC controls system. The problem reportedly persisted in spite of the plant manager's basic knowledge of the direct digital control (DDC) system and attempts to override it using the lighting contactor HOA switch.
Impact	The 24 metal halide fixtures in the gym use 95,659 kWh and the seven exterior wall packs use 5,684 kilowatt hour (kWh) annually while operating 24/7. If the gym lights were only on during its operating hours and the exterior lighting were only on during hours of darkness, the savings would be 51,501 kWh, or $14,935 per year.
Recommended Change	Correct the lighting control problem and replace the metal halide lights in the gym with newer technology LED fixtures or T5-HO florescent fixtures, both of which have instant-on capability that permits the use of occupancy sensors. There would be a lower power draw for either technology. And, with the occupancy sensors, the lights would only be on while the space was occupied. The occupancy sensors could be programmed to remain on longer after no occupancy is detected in order to avoid nuisance lighting shut-off if occupants are out of range of a given sensor. LED lighting upgrades for the exterior lights would likewise result in lower energy consumption since lower lighting levels are appropriate due to the scotopic lighting nature of the fixtures as compared to the photopic nature of HPS systems. See discussion of photopic and scotopic vision in the following links: http://www.ecofitlighting.com/led-photopic-scotopic.html http://www.led-industries.com/Scotopic_vs_Photopic.pdf
Lesson Learned	If a control system is too complex for the local remote villages to diagnose, maintain, or manage, operators tend to either over-ride it using the hand-off-auto (HOA) controls or just leave components like lights, air handlers and pumps on continuously—at great expense to the owner.

Submitted by: **Richard S. Armstrong, PE, LLC**

Title: **HOA Switches on Contactors and Motor Starters**

Observation

Air handlers in various observed buildings were found to be operating continuously because the hand-off-auto (HOA) control on the air handler motor starter was left in the “hand” position. Likewise, lighting contactors were sometimes found in the “hand” position, thereby overriding the time clock or direct digital control (DDC) scheduler, as well as the outside photocell that would have shut off lights during non-scheduled or daylight periods.

Impact

Operation of an air handler 24/7 means the motor is continuously on 168 hours per week instead of 40 hours per week, cutting life expectancy of the motor and increasing electrical consumption by four times over operating the equipment only during occupied times, assumed to be 40 hours per week in this example. Additionally, the operation of the air handler means it is pressurizing the building continuously with OSA, thus over ventilating the facility and wasting huge amounts of thermal energy. The cost and energy impact of this is totally dependent on the cost of power, size of the motor, thermal environment, and the cost to overhaul motors and replace belts. Likewise operating exterior lights around the clock rather than just during scheduled hours or darkness hours will burn twice as much power and cut the life of the lamp in half or more.

Recommended Change

The typical cause of finding the HOA switch being left in the “hand” position is a lack of the operator’s understanding of what that setting is actually doing, and the impact it has on operations and energy cost. Maintenance personnel who do not understand how to troubleshoot control systems that cycle the air handler on and off based on a time clock schedule or some other algorithm, find that simply turning the air handler to “hand” gets the device running rather than troubleshoot the failure of the equipment to start.

The origin of the problem can be as simple as a failure to change the time clock or time setting in the DDC control scheduler to the current time, possibly because of daylight savings time or holidays, a dead battery or loss of power to the time clock, or some other reason. The selection of the HOA position to “hand” bypasses the control system’s ability to cycle the equipment according to schedule, or occupancy sensors, or other control input function.

Lesson Learned

It is essential that equipment operators in commercial facilities understand the function of the motor starters and lighting contactors, as well as the impact that the HOA selector on motor starters has on cost of operation. Training is essential to assure understanding of these operational concepts.

Submitted by: **Richard S. Armstrong, PE, LLC**

Title: **Subsidized Energy Cost Impacts**

Observation	During some of the audits it became apparent that there is indifference to energy consumption. Lights are left burning 24/7, thermostats are set to abnormally high positions, thermostats are not setback when unoccupied, doors and windows are left open, compressor air lines are leaking and not repaired, and air handlers are operating continuously instead of during occupied times only.
Impact	The obvious impact of these energy wasting activities is that the cost of operating and maintaining the facility is driven up to unsustainable levels—costing the State, Municipality, or Borough an excessive amount of money to operate.
Cause	One potential cause of this issue is subsidized energy payments made by the government. There appears to be very little incentive to contain the cost of energy for facility operation because that energy cost is subsidized or completely paid for by others.
Recommended Change	Owners of public facilities should be incentivized to control and minimize the cost of energy, or lose their subsidy entirely. Benchmarked energy consumption and costs should be established and published, with energy cost and consumption compared to similar facilities in order to provide operators with a better understanding of their stewardship of public assets.
Lesson Learned	Public subsidy programs intended to reduce the cost of energy on facility owners can actually increase the energy consumption when the majority of the actual cost of operations does not come out of the pocket of the users and operators.

Submitted by: **Alaska Energy Engineering LLC**

Title: **Lighting Retrofits Economics**

Observation

The intent of a lighting upgrade is to reduce the electrical energy required to maintain proper light levels. This also reduces the amount of heat generated by the lighting. In our predominantly heating climate, up to 85 percent of the lighting heat is beneficial toward heating the building. When the lighting produces less heat, the heating system must supply more heat to make up the difference. A lighting retrofit analysis must consider the added heating energy when determining the economics of a lighting retrofit.

Impact

Up to 85 percent of the energy savings from a lighting retrofit can be transferred to the heating system, decreasing the overall energy savings during heating periods.

Recommended Change

Lighting retrofit analyses must account for the loss of lighting heat and how much of it is transferred to the heating system.

Lesson Learned

When evaluating a lighting retrofit from the perspective of total building energy use, the following must be considered:

1. The amount of lighting heat that is beneficial to the building must be assessed on a case-by-case basis. There is no standard value for all installations. For example:
   a. Gymnasium lighting typically causes the upper parts of the gym to be 3-5 degrees Fahrenheit (°F) warmer. It is likely that much of the lighting heat is lost through the roof and of little value to heating the rest of the building.
   b. Lighting heat that is captured by a ceiling return plenum is useful whenever the ventilation systems are adding heat to maintain a supply air temperature, assuming the amount of outside air (OSA) compared to return air is creating the need to add heat.

In areas where the heat from lights has a similar cost as heat from the heating system, there is little economic incentive to upgrade the lighting unless little of the lighting heat is beneficial. Most areas of the State of Alaska have a higher cost for electricity than for heating fuel, but should be considered on a case-by-case basis.

On the other hand, more efficient lighting reduces the need for cooling during shoulder seasons, and allows for better temperature control in buildings.

Submitted by: **Alaska Energy Engineering, LLC**

Title: **Necessity for Energy Awareness**

Observation

In auditing numerous buildings throughout Alaska, it was observed that institutional knowledge of the building energy systems coupled with energy awareness by the occupants and maintenance staff is essential to the building operating in an energy efficient manner. Buildings where this does not occur are not as energy efficient.

One school district hired an experienced maintenance person with a high level of energy awareness. The previous maintenance was poorly performed. Effective measures taken by the new maintenance person are listed below.

1. Performed proper maintenance of the systems
2. Turn off ventilation systems and lighting when they are not needed
3. Standardized thermostat set points
4. Educated building users on use of the building and how they can contribute toward energy savings

Additionally, the maintenance person convinced the administration to incorporate energy efficiency measure (EEMs) identified in an energy audit into a planned renovation project.

Impact

Building energy use decreased by 25 percent and will decrease more once the renovation project is complete.

Recommended Change

Hire competent maintenance and operations personnel who also have a high level of energy awareness. Provide appropriate training so they are knowledgeable about all aspects of the design, operation, and maintenance of the building systems.

Lesson Learned

Building owners have a strong incentive to educate their staff on energy performance and how their actions have a direct effect on energy performance. Most building users and maintenance staff have an interest in energy efficiency and will contribute toward improving a building's energy efficiency. Providing training to maintenance staff and giving occupants specific recommendations will improve the building energy performance.

Submitted by:	**Alaska Energy Engineering, LLC**
Title:	**Energy Policy Benefits**
Observation	One school district was found to have a formal energy policy that makes all users responsible for energy efficiency. Integral with this policy are established guidelines for ventilation system operating schedules and thermostat set points.
Impact	The schools in this district have much lower Energy Use Index (EUI) than other comparable schools. The guidelines give operating personnel clear direction on operating the buildings. Moreover, users accept the policy and do not put pressure on operating personnel to make changes.
Recommended Change	Develop and implement an energy policy that achieves the energy efficiency goals of the facility.
Lesson Learned	Buildings are dynamic places with many users and operational needs. An energy policy can provide guidelines for operation of the building to meet these needs while maintaining control of energy consumption.

Submitted by: **Alaska Energy Engineering, LLC**

Title: **Reduce Exhaust Air Flow**

Observation

It was observed that many buildings have high exhaust air flows that result in bringing more makeup air into the building than what is required to maintain adequate Indoor Air Quality (IAQ). These exhaust-dominated buildings over ventilate the building, increasing energy costs.

Impact

High exhaust rates can lead to over-ventilation of the building and higher energy costs. Every cubic feet per minute (CFM) of air that is exhausted must be replaced with a CFM of outside air (OSA) that must then be heated to ambient temperatures.

Recommended Change

Designers should optimize exhaust air requirements with the ultimate goal of keeping exhaust air flows near, but not above what is needed for maintaining adequate IAQ. Potential strategies include the following:

1. Establish reasonable exhaust rates based on actual usage of the building.
2. For central exhaust systems, utilize variable air flow to reduce exhaust from intermittently occupied rooms and other spaces. This will result in a lower average exhaust rate.
3. Where applicable, control local exhaust fans from occupancy sensors—along with the lights—so the air is exhausted when the room is in use and for a set period after each use.
4. Where applicable, control local exhaust fans from timers rather than switches so the exhaust fans are not unintentionally left on.

Lesson Learned

Designers rightly give close consideration to ensuring a building has adequate IAQ. Exhaust air systems require the same attention to ensure they are optimally sized and controlled so they do not remove excessive amounts of warm air from the building.

Submitted by: **Alaska Energy Engineering, LLC**

Title: **Ice Arena Energy Circle**

Observation

The design and operation of an ice arena has resulted in a wasteful energy consumption cycle. A propane powered Zamboni exhausts water vapor and combustion pollutants such as CO, carbon dioxide (CO_2), NO_2, and combustion particles into the building. This makes the ice arena experience poor Indoor Air Quality (IAQ) due to Zamboni operation. Not only does this reduce the air quality in the building for the occupants, it is the catalyst for the cycle of conflicting energy demands.

As the humidity goes up and hits the 55 percent set point, the propane-powered dehumidifiers are automatically started. They run to try to maintain the humidity level between 45 percent and 55 percent. As the exhaust air from the Zamboni concentrates in the arena, the CO_2 levels trigger the exhaust fans to bring in OSA to improve air quality for the occupants. The outside air (OSA) in Juneau is typically much higher in humidity than the desired humidity set points inside the arena. Once the OSA is brought into the building, the humidity sensors then trigger the propane-powered dehumidifiers to run once again. This cycle repeats itself every 20 minutes on hockey game days when the Zamboni runs between each period.

Impact

The energy consumption is significantly higher than normal for an ice arena.

Recommended Change

1. Replace the propane powered Zamboni with an electric model. Electric models cost more but have lower energy costs and do not create air quality problems within the building.
2. Add refrigeration heat recovery. The refrigeration equipment that makes ice currently discharges the heat outdoors. Simultaneously, the building is heated by fuel oil boilers. Adding heat recovery to the refrigeration systems will eliminate the need for boiler heat, without increasing refrigeration energy use.
3. Waste Heat Dehumidification: With an electric Zamboni, the facility will need much less dehumidification. Replacing the two large dehumidifiers with a smaller unit that can dehumidify using refrigeration waste heat will eliminate propane consumption for dehumidification.

Lesson Learned

The decision to use a propane-powered Zamboni did not consider the energy impacts to the other building systems. A refrigeration heat recovery system will easily pay for itself and reduce long-term energy costs.

Submitted by: **NORTECH Engineering**

Title: **Power of Accountability**

Observation

A common issue found with many buildings audited was high energy use from improper operation and/or bad energy use habits. Four similarly sized buildings built in the last ten years were found to have energy efficient technology in place, but benchmarking showed them to consume more energy than comparable buildings. While some building operators and occupants attempt to be energy conscious, some do not realize how expensive their buildings are to operate or just do not make an effort as there are no financial incentives or recognition to lower energy use.

Impact

Money and resources will continue to be wasted if building operators and occupants are not aware of energy use and continue to use energy inefficiently. The cost to operate a building will continue to rise with the rising use and cost of fuels.

Cause

Two reasons for this issue are building operators and occupants not realizing the cost of building operation or a lack of financial incentives or recognition to lower energy use. Even if building operators know energy use is high, bills are paid by accounting without further analysis. Accountants do not know what the bills represent in terms of building cost of operation, and do not understand if use is high or low from season to season. Buildings that actually do lower energy use do not get proper recognition. Also, new buildings may originally operate at high efficiencies, but as building performance starts to deteriorate, the necessity to determine the cause of decreased performance and to immediately fix the problem is not there as more money is allocated to make up for increased utility costs. Increasing cost awareness of maintenance personnel would be beneficial to most buildings, but without a clear incentive to distribute additional money towards maintenance, the potential to save energy and money may not be realized.

Recommended Change

Utility bills need to be seen by individuals who understand how the buildings work to identify and make any corrective action due to energy increases as soon as possible. Also, institutional owners need to provide more incentives to building operators and occupants to lower energy consumption. Schools in districts such as the Anchorage School District (ASD) incorporate competitions which allow building managers that save the most money in building operation to get supplemental money towards the school budget. School districts in other states also incorporate an Energy Specialist to monitor building energy behavior in order to ensure minimal operation costs.

Lesson Learned

Building operators and occupants will not effectively lower energy use as long as a third party is paying the bills without the operator's prior review. Building operators and occupants must realize the cost of building operation and the long term effects of a poorly operated and maintained building. Job descriptions should include energy accountability. Financial incentives have proven to help save money and energy use.

Submitted by: NORTECH Engineering

Title: Building Design

Observation

A wide variety of observations have been made concerning a particular school in rural Alaska indicating an all-around failure to manage design, construction, operations and maintenance in a new school. This has resulted in a building that is among the most expensive in the State of Alaska to operate. This building is less than five years old and most users are dissatisfied with their experience at this building. The audit and subsequent research identified the following issues with the building:

Issues pertaining to design include:

- The building has a central commons area with a wall made almost entirely of glass and a large cupola.
- The building is oriented in a manner that results with an equal amount of windows on the north side as on the south side of the building. The prevailing winds in this part of Alaska originate from the North, this causes the following:
  - The north side of the building is cold in the winter.
  - The south side of the building is overheated in the winter.
- Snow blows into the roof through vents and melts through the ceiling
- Control system is more complicated than the operator understands

Issues pertaining to construction include:

- An inaccessible crawlspace that is heated to 60°F all year
- Reported gap of 6" above windows in commons area
- Wind howls through the ceiling space and "screaming noises" are heard
- Drafts felt through wall electrical outlets
- Improperly programmed controls
- SIP panel gaskets not installed

Issues pertaining to building operation include:

- AHU schedules are bypassed and operate 24 hours a day, seven days a week (24/7)
- Occupancy sensors for lights are overridden
- OSA dampers do not modulate and are set manually to 100 percent open during the day and 40 percent open at night

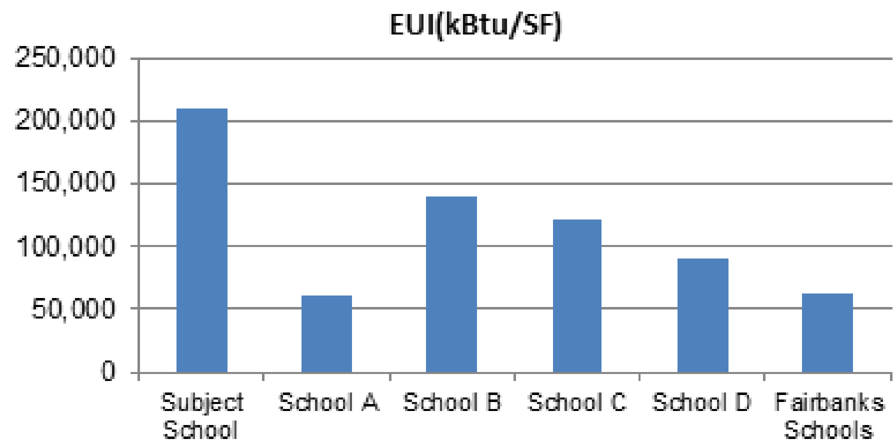
Issues pertaining to maintenance include:

- Kitchen make-up air (MUA) unit runs continuously in manual mode due to broken sensors and an overheating room
- None of the fixtures in the commons area had all of the lamps working.
- Parking lot light sensor broken, lights stay on

Impact

The most noticeable impact of the numerous failures at this building is the excessive energy use and associated costs. For example, Energy Use Index (EUI) is at 209 BTU/SF per year, Energy Cost Index (ECI) is $10.84/SF per year, which results in greater than $820,000/YR in energy cost.

The cost of energy in rural communities is two to four times higher than locations on the Railbelt like Fairbanks and Anchorage which amplifies the annual cost associated with energy wasted at this building. This building has annual energy costs of 150 percent the cost of a school in Fairbanks which is three times larger and has over twice as many students. Within this building's School District, it has the highest EUI of the buildings audited. The graph below shows the EUI of this school in relation to other buildings in the same region and the Fairbanks School average. Two other buildings in this region that were built in the same time frame and of similar size have EUIs of 91 BTU/SF and 61 BTU /SF. The average EUI in the district is 141 BTU/SF. This school has an EUI of 209 BTU/SF which is nearly twice the average EUI and over three times the EUI of the lowest.



Recommended Change

Building owners must be aware of the outcome during the construction process. The most costly construction problems are very expensive to repair and some issues can't be remedied. Future designers must be more aware of the location of the building when designing aesthetically pleasing features. Energy loss can be decreased by simple programming, repair, and understanding of the energy management system. Keeping an unoccupied temperature as low as possible and decreasing the rate of incoming OSA to the correct minimum standard is the most important way for this building to decrease energy usage.

The standard recommended approach for building orientation, long elevation on E-W axis, may need to be re-evaluated in extremely windy and cold locations with little sun in the winter. A building in this dark, windy climate should not have the same window to wall ratio on the north side as it has on the south side. The north windows have zero solar gain through most of the winter and even poor natural lighting during long periods as well. Designers need to recognize when they are designing for an extreme environment.

Lesson Learned

Designing and constructing a building properly in rural Alaska for Arctic performance is the most important aspect of having an energy efficient building. A poorly designed, constructed building will burden the owners, in this case a financially struggling school district, with high energy costs for the lifetime of the building, regardless of the operators training level.

Submitted by: **NORTECH Engineering**

Title: **Design Comparison of Two Poorly Maintained & Operated Buildings**

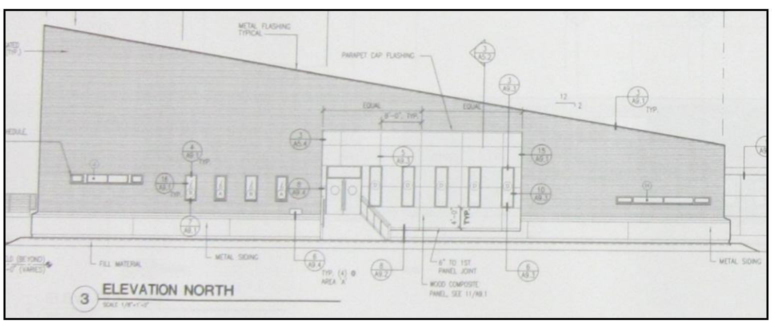
The intention of this case study is to show that the largest factors related to energy efficiency are in building design, even with a poorly maintained and operated building (O&M is the largest factor in a well-designed building). The focal point of this case study pertains to poor Arctic design that results in a dramatically higher EUI than normal. Both buildings are poorly maintained and operated with the following opportunities to save significant amounts of energy:

- No setback temperature
- Bypassed DDC schedules and set points
- No full time maintenance person
- Corridor lights that remain on continuously

Despite these similar O&M problems, the EUI of School B (the poorly designed building) is four times higher than School A. Price per student would be much worse for School B if both schools had comparable enrollment. The design issues are illustrated below.

School A EUI: 54,000	School A: $1,122/Student	School A: 171 students
School B EUI: >200, 000	School B: $1,986/ Student	School B: 414 students

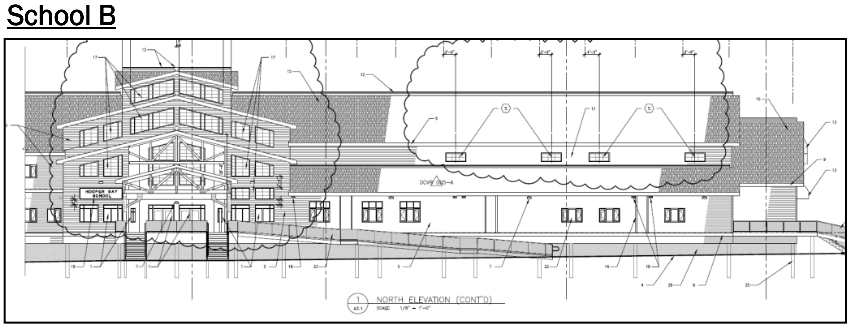
School A



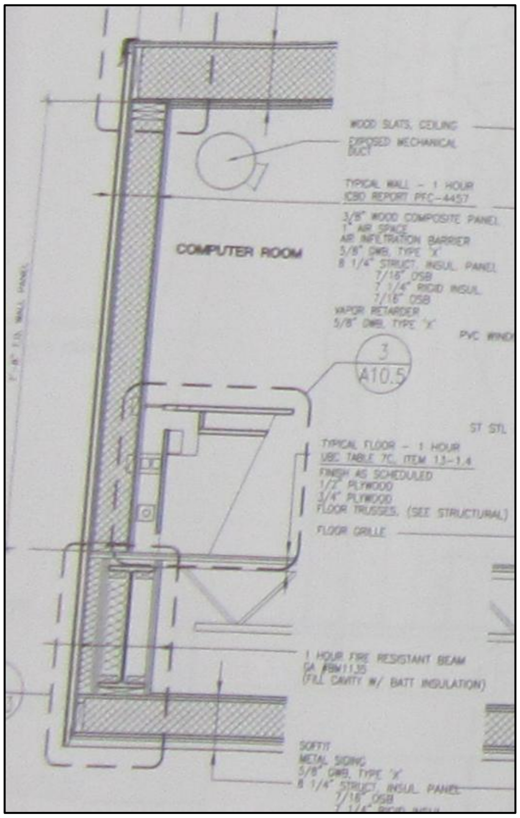
School A
Primarily insulated wall on North side
No classrooms with windows
Few windows

School B
Huge storefront windows on North side
Two stories of classrooms
Many windows

School B

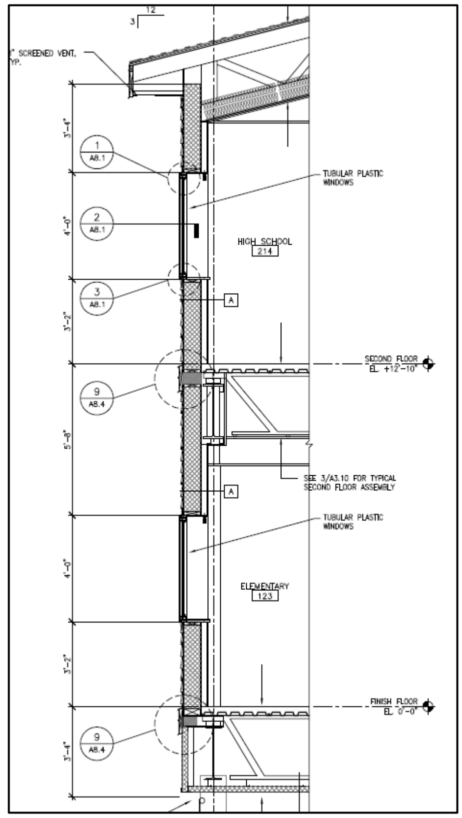


School A



- 7.25" Rigid Insulation
- Hot, sealed roof
- Well insulated metal doors with small windows.
- Arctic Entry

School B



- 5.5" rigid insulation
- Cold, vented roof
- Full glass metal doors
- No arctic entry

Submitted by: **NORTECH Engineering**

Title: **Interior Lighting—LED Versus Fluorescent**

Observation

While exterior LED retrofits have found acceptance among maintenance personnel, most maintenance managers are reluctant to change to LED lighting in interior applications. Maintenance managers indicated that this is because the LED lamps produce fewer lumens than existing fluorescent technology and do not produce enough lumens to meet the Illuminating Engineer Society's (IES) current illumination recommendations. Additionally, the technology is perceived as new, unproven and expensive and the occupied office and classroom spaces are more critical than exterior lighting.

In contrast, the city of Fairbanks has decided to replace all traditional lighting with LED lamps, including interior lighting. Despite an LED lighting consultant recommending that the City not change their T-12s to LEDs in a number of office areas based on insufficient lumen output, the City replaced the T-12s with LEDs anyway. The City found the light output and light quality met or exceeded the original lighting based on the occupants' comments regarding satisfaction with the lighting upgrade.

Impact

Despite obvious energy and costs savings and the higher quality light from LED lamps, interior LED retrofits are often not undertaken based on the reduction in lumen output. Despite these perceptions, most people working at locations with interior LED lighting found the brightness and quality of light equal or better than the original lighting.

Cause

IES recommendations are based on the amount of light striking an object (illuminance) and are measured in lumens per square foot (foot-candles) using a standard light meter. The human eye reacts to light reflected (luminance) from an object and recent research has determined that standard light meters do not accurately measure the human eye's sensitivity to certain wavelengths of light. From this data, correction factors for different light sources have been developed that convert traditional lumens into lumens perceived by the eye. As seen in the table below, the lumens/watt that elicits a response from the photoreceptors (cones and rods) in the eye are highest for LED lighting due to the wavelengths of light that are emitted.

Light Source	Watt	Total Lumens	Standard Lumens/ Watt	Correction Factor	Pupil Lumen s	Pupil Lumens/ watt
Low Pressure Sodium	250	32500	130	0.2	9250	37
High Pressure Sodium	365	37000	101	0.62	25530	70
Metal Halide	455	36000	79	1.49	48960	108
T8 Fluorescent	36	2800	78	1.13	3080	85
High Quality LED	15	1500	100	1.9	2475	165
Note: This study used high quality LED lamps emitting a broad spectrum of visible light wavelengths						

Recommended Change	Several pilot studies should be undertaken in Alaska facilities and classrooms to validate the recent research and reported conditions at City of Fairbanks facilities. Alaska-specific research is recommended due to the high seasonal variability of natural lighting and the impacts this has on the perception and importance of interior lighting.
Lesson Learned	While recent research and anecdotal evidence suggests that LED lighting is more than adequate for interior lighting, conventional lighting design criteria and current perceptions are preventing the installation of LED lighting in many interior applications. Until the current science is validated and energy managers overcome their reluctance to utilize LEDs for interior lighting, the potential energy and cost savings of complete LED retrofits will not be realized.

Submitted by: **NORTECH Engineering**

Title: **Poor O&M**

Observation	Many on-site visits indicated that buildings were being operated and maintained poorly. In addition, dangerous conditions were created through improper repairs. Operation issues observed: • Inconsistent heating set points • Incorrect air-handling units (AHU) set points • Mechanical devices left in "hand" or manual mode • Disconnected boiler control systems Maintenance issues observed: • Exposed and unprotected wiring running across the floor • Wiring connections not made to code requirements • Lighting fixtures with exposed wiring holding up the fixtures in an occupied area • Tools left on floor with incomplete repairs • Protective guards left off AHUs • Duct work made from plywood with a smoke detector attached • Clogged air filters in AHUs • Exposed wires running to replaced water pumps • Poor access to mechanical equipment due to use as storage
Impact	The lack of proper Operation and Maintenance (O&M) prevents buildings from operating at efficient levels. Improper maintenance leads to energy wasting habits such as occupants opening windows despite extreme low temperatures in the winter due to uncontrolled heat output from mechanical systems. Correcting these issues presents significant opportunities to reduce energy use and save money.
Cause	The failure of trained personnel to perform rudimentary repairs correctly and the lack of understanding of the control systems are the biggest contributors to this problem. Only the most critical repairs are being made to keep the building functional and these are often quick fixes that do not bring systems back to design levels or address the root cause of the problem. Repairs and maintenance that can significantly reduce energy use are not prioritized due to lack of understanding and/or funding.
Recommended Change	Operators need to be trained to handle the sophistication level of their building and the training levels should increase as the controls of buildings gets more complex. Building owners need to invest more funding into maintenance for their facilities. Experienced maintenance personnel should be present either on-site or readily available from a district office to make any needed repairs. District managers should periodically inspect each facility to understand and prioritize repairs and maintenance requirements that are going to help keep the operational cost of the

building low. Conversely, designers should be aware of O&M limitations for the specific location of a planned building. Owners and designers need to work together to make sure that the complexity of the building is matched by the operations and maintenance personnel and funding that will be reasonably available.

Lesson Learned

Low quality maintenance leads to high building operational costs. The investment for hiring and adequately training maintenance personnel is much lower than the long term energy and repair costs associated with an improperly operated building.

Submitted by:	**NORTECH Engineering**
Title:	**Inadequate Metering of Energy Sources**

Observation

Several facilities throughout the State of Alaska showed a lack of energy management due to inadequate metering. Instances include facilities:

- Heating multiple buildings with a single heating plant and no sub-metering
- Receiving annual fuel deliveries and not recording monthly usage
- Annual fuel deliveries to one tank that serves multiple plants and buildings

Utilizing multiple energy sources to serve multiple plants and buildings

Impact

Although Energy Use Index (EUI) numbers indicate the potential for savings, adequately determining energy savings and payback periods is impossible without knowing the energy used by a specific plant or building. An audited facility with one of the highest EUI is a facility with multiple buildings, heating plants, and energy sources that does not properly track energy usage. Some building operators show an understanding of energy conservation without the quantification that metering can provide while others lack an awareness or accountability of energy usage.

Cause

Buildings in rural Alaska generally receive only a few fuel deliveries a year, typically during the summer. Since fuel and energy meters are rarely present, fuel is not monitored to document how much, and where, the fuel is used during any given period. This issue is compounded when the number of buildings, fuel tanks, and energy sources are increased without a sufficient number of meters. Since the predominant concern regarding fuel usage for building operators in rural Alaska is simply to ensure they have enough, proper attention is not given to in-depth monitoring and metering.

Recommended Change

Effective metering will allow comparison of facilities of similar occupancy in order to understand relative energy use between buildings. This can be done by:

- Keeping adequate records of deliveries
- Monitoring monthly levels in fuel tanks
- Installing fuel meters on fuel lines
- Installing British Thermal Unit (BTU) meters on supply lines to each building

Lesson Learned

Owners of public facilities must be aware of the amount of energy being used in their facility in order to manage it properly. Proper metering will allow for energy management to be performed and help to quantify potential savings.

Submitted by: **NORTECH Engineering**

Title: **Controlling OSA Levels**

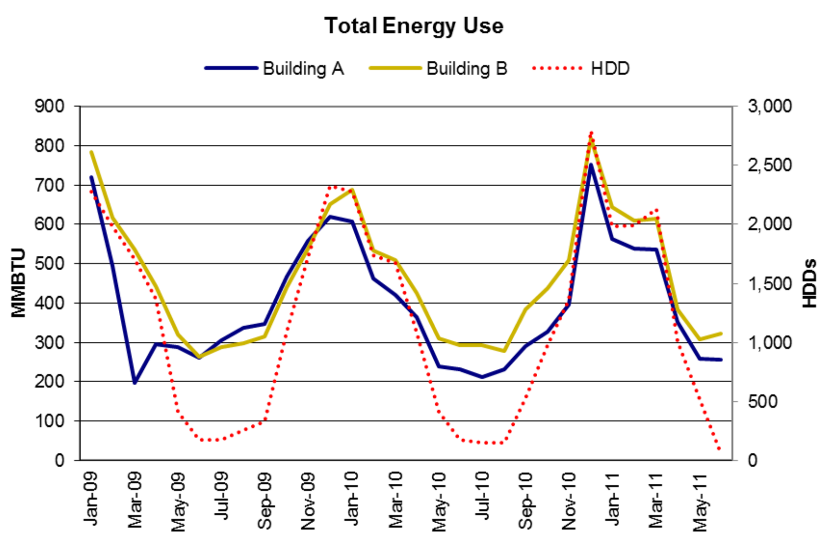
Observation

Two recently constructed emergency services buildings in Fairbanks, Alaska have Energy Use Indexes (EUIs) of 158 Thousand British Thermal Unit (KBTU)/SF and 236 KBTU/SF respectively. Both EUIs are larger than that of an older City of Fairbanks building (building usage is different, but occupancy hours are the same as the compared building). During on-site visits these buildings were noticeably over ventilated with a large amount of outside air (OSA) being brought in to replace exhausted air, which resulted in the high EUIs.

Impact

The large amount of exhaust air requires a large amount of OSA, which results in high energy use for space heating. The cost to operate these buildings is very high as heating large quantities of OSA (-20F to -40F) to a comfortable temperature (+68F to +72F) is very expensive in the cold winter months. This equates to about $0.06/CFM of outside air during a -20F day, or about $1000 annually per 100 cubic feet per minute (CFM) of OSA.

The graph below shows how energy use in the two buildings is affected by heating degree day (HDDs). The energy use trend almost perfectly follows the HDD trend in the winter months. The graph shows none of the apparent fluctuations of energy use that are normally seen from varying occupancy, building uses or schedules in normal buildings. This correlation of energy use and HDDs is an indication that primary energy use in these building is directly related to heating OSA that makes up for the excessive exhaust rates.



Cause

Excessive levels of OSA are a byproduct of the buildings' designs that use constant exhaust volumes as if each building were fully utilized on a 24/7 schedule. The designed exhaust rates require a high amount of OSA in order to keep the building slightly pressurized and avoid unwanted air infiltration, regardless of the actual building occupancy.

Recommended Change	Both of the subject buildings are operating as designed, but have an excessive amount of exhaust air volume relative to the small number of occupants and operating schedule. The exhaust air rates in the two buildings need to be reevaluated as many areas in these buildings are not occupied 24 hours per day or even used regularly. Exhaust rates should be minimized to the lowest allowable rates and allow for OSA from AHUs to be controlled by the DDC systems and vary with occupancy. Building B has a constant volume AHU which should be redesigned to have the flexibility to vary based on usage and/or follow air quality regulations.
Lesson Learned	Higher exhaust levels require more OSA. While a building's CO_2 levels may not require a large amount of OSA, OSA will always be needed to make up for exhausted air levels. Exhaust rates need to be managed and matched to meet building operation needs rather than being left at maximum design capacity. Controlling the OSA rates presents a large potential for reducing energy consumption and cost.

Submitted by: **NORTECH Engineering**

Title: **Opportunity to Fund Training and Commissioning**

Observation

The subject school is located in the Interior and the structure was constructed in 1959. The facility had multiple remodels and a major renovation was completed in 2010. The renovation included:

- A new HVAC system, excluding boilers
- A new lighting and electrical system
- Added insulation to the walls and ceiling
- New doors and windows
- A DDC system

Mechanical problems and maintenance issues were discovered during the audit of the building. Some of the major issues are illustrated by:

- The need to replace boilers within two years of renovation
- A large, unexplained base electrical load
- Permanently bypassed control schedules due to a singular weather event
- Installing fluorescent lamps when LEDs may have been appropriate
- Refusal to use remote monitoring

Impact

The lack of commissioning and proper training left the building in the hands of operators that do not understand the building's capabilities and functions. This lack of understanding has shortened the lifespan of mechanical equipment resulting in preventable repair costs and electric bills that continue to be higher than expected following the renovation.

Cause

The primary reasons for these issues are improper understanding and operation of the building and a lack of maintenance and commissioning. According to a member of the design team the boilers were removed from the building and then reinstalled instead of being replaced during the renovation due to budget constraints. According to on-site personnel, boiler replacement may have been due to thermal shock. The design team indicates that the boilers could not have been thermally shocked by the new mechanical system. Regardless of the reason, this boiler replacement should not have been necessary had the building been functioning correctly.

Building operators spoke with building designers about installing LEDs, but the idea was rejected by the designer. On-site personnel claim the idea was rejected because the designer said the lighting levels would be too low, while the designer claims it was due to the project not being cost effective. Several buildings have gone against recommendations such as this and have been satisfied with the lighting levels provided by LEDs. The recent installation of T5 fixtures throughout the building reduces the potential for a future cost effective upgrade to LEDs.

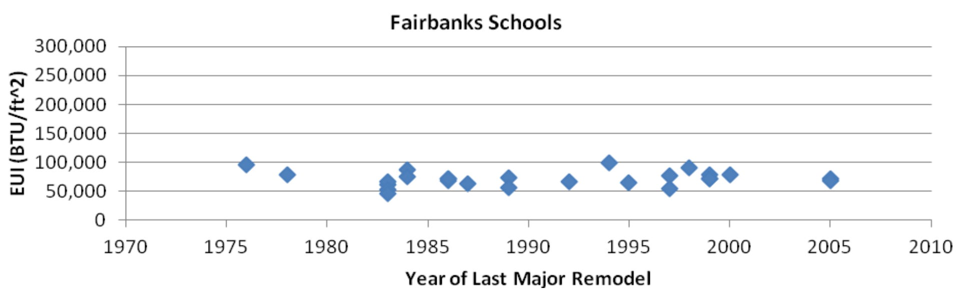
Recommended Change	This building clearly indicates the potential for savings that can be achieved through more efficient operations following proper commissioning and training. Both the owner and designer documented construction funding constraints, but the building owner is spending money on replacement equipment and energy that is not necessary. In order to prevent these problems in the future, owners should incorporate commissioning into the construction cost of a building. This should also include development of a standard maintenance program, which includes logs and equipment manuals, and a reliable on-site maintenance person should be trained and hired. This building and other un-commissioned buildings should be commissioned in the next 12 months and re-commissioned every 3-5 years.
Lesson Learned	Owners and operators of new buildings have an opportunity to invest in training and commissioning as a way to reduce operations and maintenance costs. A little bit more money spent during the construction phase will help insure that a building operates properly and efficiently and will save money on repairs and energy in the future. Additionally, building designers should be consulted during commissioning of buildings constructed in the last 10 years to obtain plans, manuals, and design knowledge that may not have been transferred to owners. Building designers should also be told of problems found during commissioning and re-commissioning so that future designs can be improved.

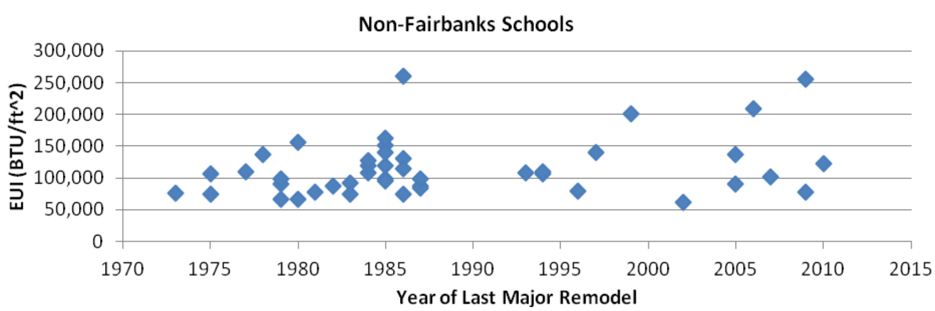
Submitted by: NORTECH Engineering

Title: Energy Use Based on Age

Observation

Preliminary benchmarking data and anecdotal experience led auditors to expect that EUIs are generally increasing over time due to potential over ventilation based on stricter minimum air and exhaust standards. Review of NORTECH's audit data does not prove this hypothesis. None of the charts below show a clear relation between Energy Use Index (EUI) and the date built or last major remodel. The charts below compare EUI to year for Fairbanks schools and non-Fairbanks schools. The average EUI for Fairbanks schools appears consistent and low over time because of properly implemented maintenance and energy management programs along with trained personnel. The average for non-Fairbanks schools shows a much wider variability in EUI in schools of all ages.





Lesson Learned

This data indicates that factors other than the age of the building have a larger impact on the EUI of that building. During this data review, NORTECH determined that controlling the data set for a more thorough analysis of the specific age-related factors that may contribute to overall energy use is not possible due to the number of potential design and operation variables that can result in higher than expected energy use. The most significant design, operation, and maintenance variables that impact the EUI are discussed in other case studies. If undertaken in the future, analysis of energy use relative to building age should focus on buildings that are operating as designed based on recent re-commissioning events.

Submitted by: **Central Alaska Engineering Company**

Title: **Addition of Pool Cover to Swimming Pools**

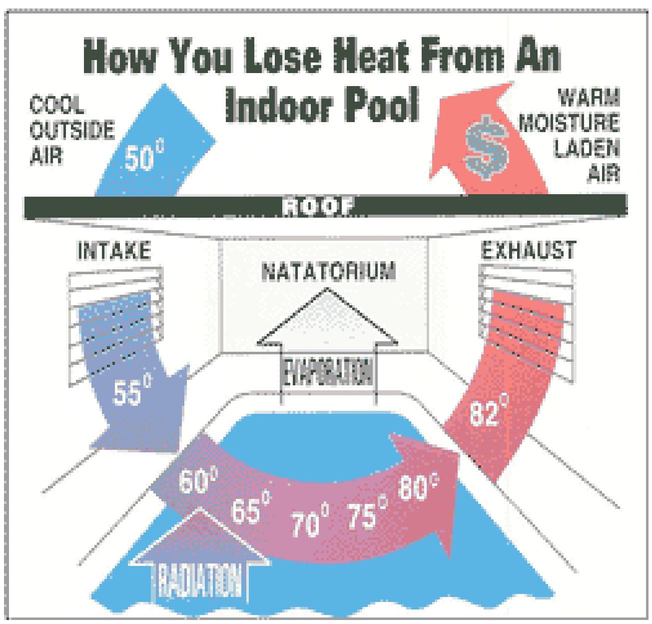
Observation

All of the buildings audited by Central Alaska Engineering Company that contained swimming pools were noted to not make use of a pool cover in the off-hours. Pools were heated and uncovered on a continual basis, requiring the HVAC system of the building to provide ventilation regularly in order to maintain a controlled humidity or room temperature. The air that is removed from areas with a pool is often very humid and warm, therefore taking a large portion of purchased energy out of the building.

Impact

As pool water evaporates into the air of an enclosed building, energy is taken from the pool. This requires pool heating systems to run constantly to keep up with the temperature demand and also requires the ventilation system of the pool area to operate continuously to de-humidify the room in order to maintain a good quality of indoor air. According to the U.S. Department of Energy (DOE), "Swimming pools lose energy in a variety of ways, but evaporation is by far the largest source of energy loss." (DOE, 2011) Figure 1.0, shown below, provides a visual example of how energy is lost from an indoor swimming pool.

Figure 1.0: Indoor Pool Energy Loss Example



Recommended Change

It is recommended that indoor pools be provided with pool covers and these covers be used during times when the pool is closed or unoccupied. According to the U.S. DOE, "Covering a pool when it is not in use is the single most effective means of reducing pool heating costs. Savings of 50 percent–70 percent are possible. Pool covers on indoor pools not only can reduce evaporation but also the need to ventilate indoor air and replace it with unconditioned outdoor air as often. Exhaust fans can also be shut off when an indoor pool is covered and the relative humidity controlled, which saves even more energy." (DOE, 2011) this also helps prevent degradation to the building envelope, further reducing maintenance costs.

Lesson Learned

Many people who operate a pool or work in a pool environment are opposed to inclusion of a pool cover at their facility for the obvious reason; it takes work to cover and uncover the pool. The audit team determined that installing a pool cover is considered by the pool managers to be a complicated task as well as there is a general lack of incentives to save energy by those who would be required to perform the task. As most pool employees are not owners, they are not as concerned with the energy cost associated with running a pool. Thermally insulated pool covers are estimated to cost nearly $3.00 per square foot, not including shipping or installation fees. This price estimate generally includes a warranty of up to 5 years. Motors can be used to automate the cover placement and removal processes to reduce time and effort required by facility staff members, making a pool cover a more attractive option for facility operators that may be opposed to further complicating the task of maintaining a pool. Strong administrative authority is required to enforce a pool cover policy.

Submitted by: **Central Alaska Engineering Company**

Title: **Klatt Elementary Condensing Boiler Installation**

Observation

Klatt Elementary in the Anchorage School District (ASD) was determined to be a well built and functional school with a well maintained Siemens direct digital control (DDC) system controlling the mechanical operations. This school also features two (2) modern natural gas fired AERCO BMK high-efficiency condensing boilers, installed in 2009, that provide heated water to the building's hydronic system. Heated air is supplied to the building using heating coils on five (5) air-handling units (AHUs) interconnected with the hydronic loop from the condensing boilers.

Impact

Klatt Elementary was provided with modern high-efficiency condensing gas boilers as a flagship project for ASD replacing 26 year old gas fired Weil McLain sectional boilers. From the utility data provided, the installation of these boilers and the degree of control provided by the DDC system has reduced the annual natural gas use of this building by 24.6 percent, based on the average annual consumption over the three-year periods of 2007-2009 and 2010-2012. Figure 1.0 shows the difference in natural gas used in Hundreds of Cubic Feet (CCF) and Annual Cost for Klatt Elementary's natural gas usage over the three-year averages mentioned earlier. Cost savings over this period were shown to be $9,945 annually, corresponding to a 21.5 percent reduction in actual cost paid for the natural gas used.

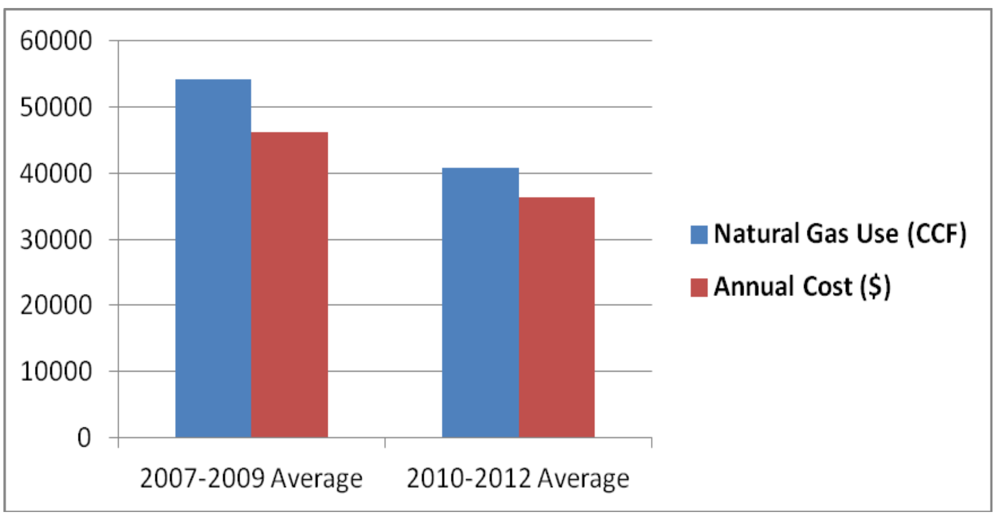


Figure 1.0: Average Annual Energy Use and Cost Comparison

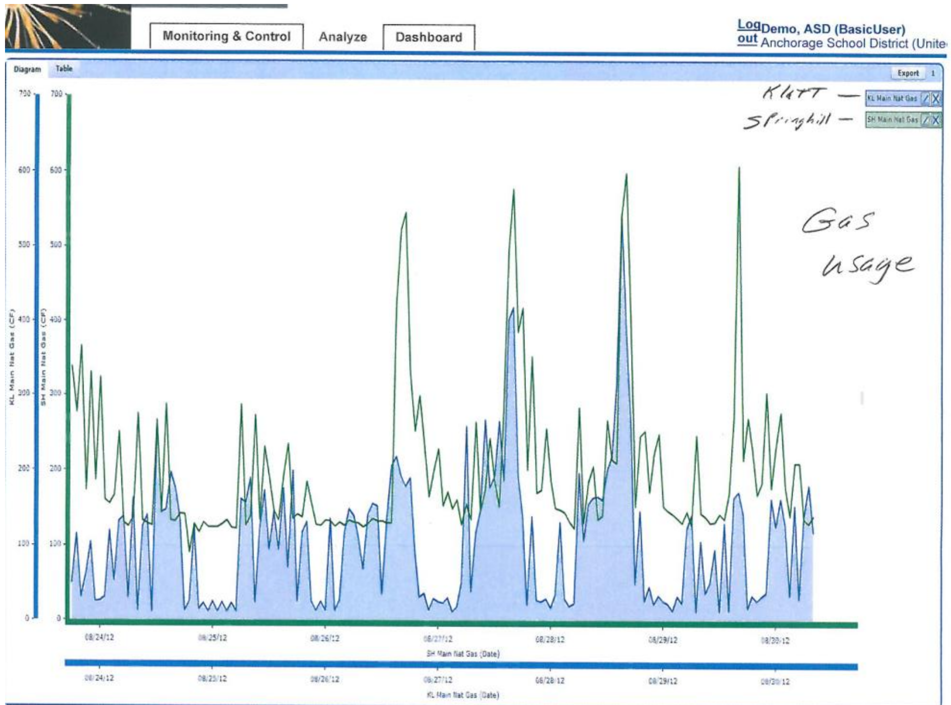


Figure 2.0: Gas Consumption for Klatt and Springhill Elementary Schools

Figure 2.0 above shows the gas consumption of two identical schools, Klatt and Springhill Elementary, comparing usage between the condensing boilers at Klatt to the old Weil McLain sectional boilers at Springhill for a one week period in August. This graph demonstrates the reduction in gas usage available during the shoulder season between the two systems in use.

Recommended Change

Modern condensing boiler technology can greatly reduce the energy consumption of a building, assuming natural gas as the fuel is available. In the case of the ASD, natural gas is currently supplied to all of the buildings in the school district (with the exception of their Relocatable Classrooms). Older gas fired sectional boilers can operate at less than 80 percent efficient where condensing boilers operate at 86 percent with 160 degree F (°F) return temperature. Where condensing boilers payout in comparison to the older sectional boiler technology is during the shoulder seasons where condensing boilers can operate up to 93 percent efficient with 100°F return temperature and firing at 50 percent input. Refer to the efficiency curve attached on the following page as Figure 3.0.

Lesson Learned

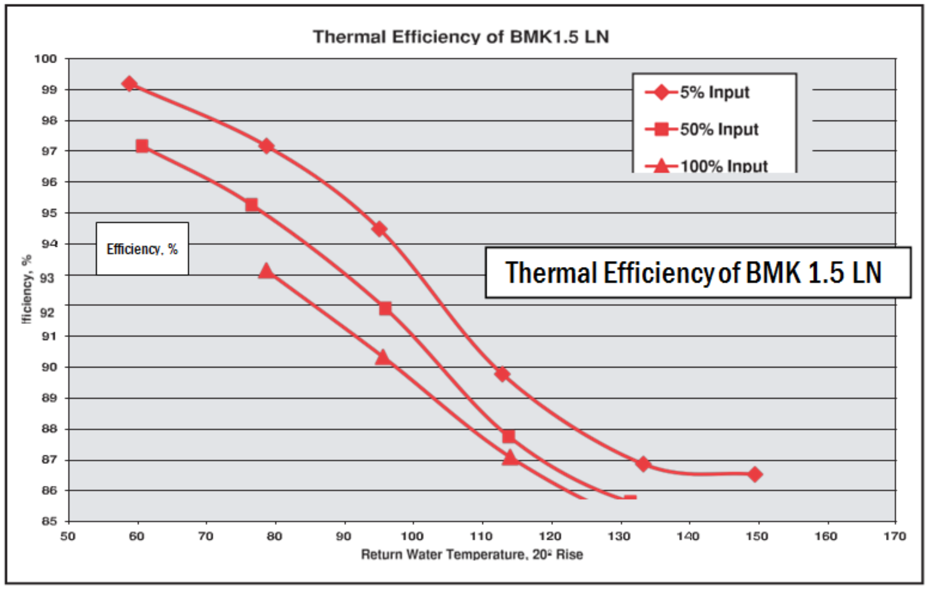


Figure 3.0: Thermal Efficiency Curve for the AERCO BMK 1.5

Installation of a new modern condensing gas boiler system in a building can provide a potentially large savings in energy consumption. However, buildings that have boilers still within their useful life or well-maintained boilers that are generating efficiencies of up to 88 percent will prove to have a very long payback period, often in excess of 35 years. A major part of the driving factor behind this is the Public Sector high initial cost of such an upgrade and the relatively low cost of natural gas. In the case of Klatt Elementary, this upgrade cost Anchorage School District $250,000 as a pilot project. Other buildings will have to take these factors in to account when pushing towards an upgrade of this measure. Also, the public sector installation costs must be made more reasonable to improve the payback period. Other issues impacting the decision are the life expectancy of a gas fired condensing boiler using a stainless steel boiler section and the annual maintenance cost differences for the more complex technology which will be determined over time.

Submitted by: **Central Alaska Engineering Company**

Title: **Kenai Elementary School Windows**

Observation

This elementary school in the Kenai Peninsula Borough School District is an old building built in 1949 that is a good candidate for several energy retrofits. This school has old shell and tube gas fired boilers that were originally designed to burn coal. These boilers are well past their useful life. This school also has an HVAC system that is pneumatically controlled, has several areas that still use outdated lighting systems, and the windows over the majority of the building are in poor condition. This school was recently re-roofed, effectively reducing the annual energy cost of the building. This case study is focusing mainly on the window replacement opportunity presented.

Impact

The school windows and doors are deteriorated and in some cases have poor seals or a lack of weather stripping. As a large portion of this school's walls are windowed, there are many areas where solar gain and heat loss problems are common issues. The south facing rooms have window mounted air conditioning units to provide cooling during sunny days. All of the classrooms have unit ventilators in place to provide heat and ventilation. Figures 1 and 2 depict a view of the school, showing the amount of windows typical of this building.

Figure 1: View of South Facing Windows with A-C Units

Figure 2: View of Single Pane Windows and North Facing Windows

Recommended Change

Replacing the windows in the school with modern Low-E, Argon-filled energy efficient windows were evaluated as an energy efficiency measure (EEM). Replacing windows will help to reduce solar gain issues and help the building retain heat in the cooler months and also help to reduce unwanted air infiltration into the building. However looking at Table 1 the simple payback is 180.5 years, meaning replacing windows is not a cost effective measure to implement.

Table 1 depicts the estimated cost, savings and payback period for a project of this scale. Cost estimates were generated using the Program Demand Cost Model for Alaskan Schools, 12th Edition, Updated 2011, developed for the energy efficiency measure Department of Energy (DOE), Education Support Services/Facilities.

Table 1: Expected Results of Window Replacement

Estimated Cost	Annual Savings	Simple Payback
$422,673	$2,342 per year	180.5 years

Lesson Learned

Due to lengthy simple payback period, n**ew windows are often expensive and hard to justify on energy savings alone**. However, replacing windows in a building with new, modern windows will have a great effect on the thermal comfort and draft reduction in the building, and will help to reduce the issues with high solar gain on one side of a building and high heat loss on the other side.

Though not cost effective based on energy savings alone, replacing windows can be beneficial by making the building more aesthetically pleasing to the. It could also demonstrate good stewardship of the environment by potentially reducing energy waste and the associated CO_2 production. These are considerations the building owner will have to weigh.

Submitted by: **Central Alaska Engineering Company**

Title: **Gymnasium Lighting Systems**

Observation

Several of the schools that were audited by Central Alaska Engineering Company were noted to have an old and outdated lighting system in the gymnasium. Typically these lights were made up of High-Pressure Sodium (HPS), Metal-Halide (MH), or T12 fluorescent lamp systems. Most of the facilities had manual controls for these lights. It was often noted that gymnasiums are under-lit in terms of lumen per square foot, most likely caused by lamp depreciation. Many of the gym light systems using High-Intensity Discharge (HID) fixtures were not suited for rapid starting and therefore left on even when not in use.

Impact

In today's standards, the types of lights found in gymnasiums were deemed to be very high consumers of energy. The most common types MH and HPS bulbs found are often well in excess of 250 Watts of power consumption. Additionally, these lighting systems are often left on for long periods of time which leads to a large waste of energy. Coupling the long run time of the bulbs and the high power use per bulb, gymnasiums were often found to be using an excessive amount of energy. Extended use of bulbs also leads to light quality degradation. Replacing the bulbs based on the quality or quantity of light produced is often a very low priority due to the cost of a typical HPS or MH bulb and labor to make the change.

Recommended Change

There has been recent advancement with high lumen output lighting. In particular, T5 High Output fluorescent lights are readily being used in many modern gymnasiums. These modern lights are capable of being installed on occupancy sensors and multi-level switching for instant start. With these advanced controls and the reduction in use of power, many schools have ample opportunity to implement this change.

Lesson Learned

It is often the case that the cost to upgrade a gymnasium lighting system reaches a point where the Simple Payback period of the retrofit becomes excessive. This is mainly due to the high cost of the installation. In school districts throughout Alaska, the cost of installation can vary from $7.11/SF to $19.54/SF depending on location and final scope of work. A higher installation price is typically associated with a remote building location where an often higher than normal electric price can help to maintain a somewhat reasonable payback period.

Submitted by: **Central Alaska Engineering Company**

Title: **Anchorage School District (ASD) Relocatable Classrooms**

Observation

ASD uses portable buildings (Relocatable Classrooms) to add space for classrooms as student enrollment grows beyond the capacity of a school. These Relocatable Classrooms can also be removed as enrollment declines, even though this was not observed to happen often. Once the Relocatable Classrooms are in place, they were noted to be left on site even if the need was minimum, used only for a music class an hour or two daily for an example.

Impact

These ASD Relocatable Classrooms are heated with electric baseboard. ASD has made the decision to not use available natural gas to heat these units. In addition, many of the units observed are under insulated, have old wood framed windows which are in poor condition, and utilize old T12 fluorescent lighting systems. The electric baseboard heat systems were noted to be putting out excessive heat even while unoccupied during the summer with manual thermostats and no temperature setback capability.

Figure 1: View of Chinook Elementary Relocatable Classroom

Electrical use data was provided by the ASD so that the average electrical use could be determined for the Relocatable Classrooms which are sub-metered. It can be concluded that these units are estimated to consume 17,450 kWh annually on average and can be entered as a stand-alone plug-load in AkWarm-C with no associated shell components. Table 1, shown below, summarizes the data gathered from both Hanshew Middle and Mears Middle Schools. It can be seen that the Relocatable Classrooms at Mears Middle School have a higher average electrical usage than those Relocatable Classrooms at Hanshew Middle School. This could be due to different hours of use and different ages of the buildings.

Table 1: Relocatable Classroom Electrical Use Data

School	Number of Relocatable	Avg. Annual Electrical Usage for Building Group (kWh)	Average Annual Electrical Use per Relocatable (kWh)	Average Electrical Use per Relocatable (kWh)
Mears	9	172,040	19,116	17,433
Hanshew	6	94,500	15,750	

Recommended Change

Table 2 depicts the estimated cost, savings and payback period for the evaluated EEM's.

Table 2: Priority List – EEMs

Rank	Feature	Improvement Description	Annual *Maint.* Energy Savings	Installed Cost	Savings to Investment Ratio, SIR**	Simple Payback (Years)
1	Setback Thermostat: Relocatable Rooms	Implement a Heating Temperature Unoccupied Setback to 60º F for the Relocatable Classroom space.	$726	$6,000	1.49	8.3
2	Ceiling w/ Attic (CWA)	Add R-21 blown cellulose insulation to attic with Standard Truss.	$154	$2,803	1.14	18.2
3	Exposed Floor (AGF)	Install R-10 rigid board insulation	$155	$2,928	1.09	18.9
4	Air Tightening	Perform air sealing to reduce air leakage by 6 percent.	$60	$500	1.05	8.3
5	Exterior Door: ED	Remove existing door and install standard pre-hung U-0.16 insulated door, including hardware.	$150	$2,967	1.05	19.7
6	Window/Skylight: WNSF	Replace existing window with U-0.26 vinyl window	$133	$2,025	1.01	15.2
7	Lighting: Interior Lights	Replace with 20 FLUOR (2) T8 4' F32T8 28W Energy-Saver Program HighLight HighEfficElectronic and Remove Manual Switching and Add new Occupancy Sensor, Daylight Sensor, Multi-Level Switch	$35 (*$350*)	$12,000	0.38	31.2
	TOTAL		$1,414 ($350)	$29,224	0.88	16.6
	*Including upgrade to nat. gas heating		$2,033 ($350)	$39,434	0.86	16.5

*The last row in this table exemplifies the expected savings that could be realized by switching the portable building's heating system
from electric baseboards to natural gas.

**Savings to Investment Ratio (SIR) is a life-cycle cost measure calculated by dividing the total savings over the life of a project (expressed in today's dollars) by its investment costs. The SIR is an indication of the profitability of a measure; the higher the SIR, the more profitable the project. An SIR greater than 1.0 indicates a cost-effective project (i.e. more savings than cost). Remember that this profitability is based on the position of that EEM in the overall list and assumes that the measures above it are implemented first.

Lesson Learned

With all of these energy efficiency measure (EEMs) in place, the annual utility cost can be reduced by $1,414 per year, or 30.3 percent of the buildings' total energy costs. These measures are estimated to cost $29,224, for an overall simple payback period of 16.6 years. The building direct digital control (DDC) system does not control the Relocatable Classrooms and are not monitored by the ASD. A pilot program was being developed to enable remote monitoring and control to provide temperature setback capabilities of these units so that they are not excessively heated by the electric baseboard system during non-occupied hours.

Submitted by: **Central Alaska Engineering Company**

Title: **Copper River School District – Slana K-12 School**

Observation

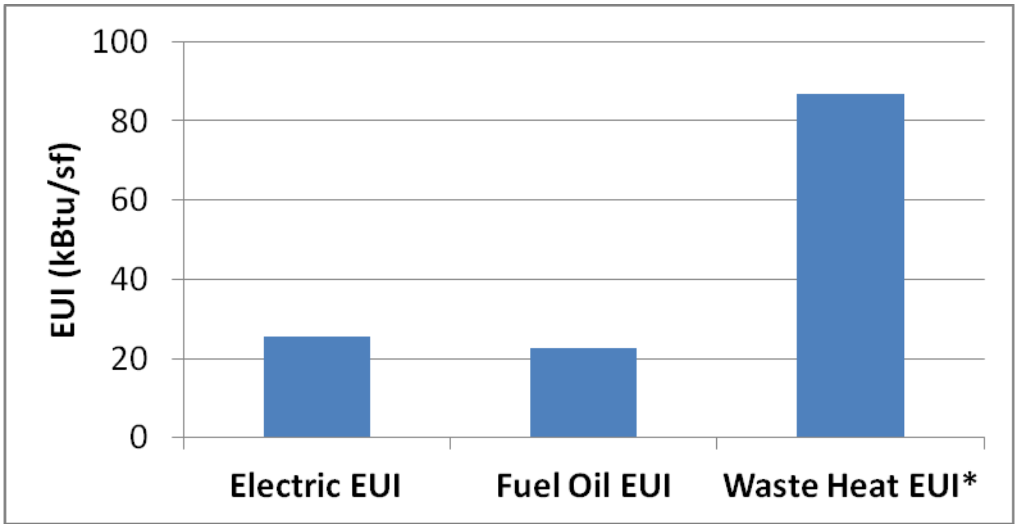
This school uses a waste heat recovery system from the on-site town generators as a supplemental heating source for its oil fired boilers. Waste heat is unmetered and typically flows throughout the school constantly, even if the building circulators are turned off, due to ghost flow issues. As a result, this school has a very low fuel oil usage compared to other schools in the district. Boilers at the facility are often unused for most of the year and are only used in the winter months when the outdoor temperature is well below freezing. This building also has an AHU that is designed to provide ventilation to the crawlspace as well as fresh air to the gym, but the entire system was observed to be turned off due to high electricity costs. This building was noted to be paying an average of $0.80 per kilowatt hour (kWh) in 2010 and 2011, which is considerably higher than other district buildings which utilize a different utility company and clearly higher than the majority of the buildings on the road system. This building also has two outdoor classroom portable buildings, both of which are completely shut down and only used for cold storage. This school also has an oil-fired domestic hot water heater and several outdated lighting systems, some of which were placed on occupancy sensors.

Impact

The continual flow of waste heat into the school is causing the school to be over-heated much of the year. Often the occupants leave windows open during the day in order to attain some degree of cooling. This is primarily caused by the pump in the generator shed being left on throughout the year, allowing the hydronic flow to continue in spite of the school's main hydronic circulating pump being shut down. The school is also paying for the electricity required to operate the waste heat circulating pump. In the interest of saving money spent on electricity, the school has opted to run the gymnasium AHU sparingly under manual control. As the air-handling units (AHU) is designed to also provide ventilation to the crawlspace of the building, having the AHU off allows for undesirable conditions below the building which can lead to IAQ issues. The relatively high cost for electricity also brings into question whether or not the school is actually paying for the waste heat indirectly through the electric rate schedule.

Figure 1.0, shown on the following page, depicts the Energy Use Index (EUI) break-down of this building. From this figure, it can be seen that the reported average fuel oil EUI is lower than the reported average electric EUI. This shows that the waste heat is indeed working as designed by taking a large heating load off of the school boilers. The only large fuel oil consumer in this building that runs continually is the domestic hot water heater. As there is no monitoring of the amount of heat supplied by the waste heat system, the waste heat EUI was estimated using the average EUI of schools within the district.

Figure 1.0: Average Annual EUI Breakdown



*estimated based on similar building total energy usage

Recommended Change

It is recommended that a BTU meter be installed on the waste heat loop to monitor and to be able to determine the value of the displaced fuel oil. This will allow the school to have an accurate record of the amount of energy taken from the generator waste heat system. It is also recommended that the waste heat circulating pump be shutdown in conjunction with the school's main hydronic circulating pump to prevent the ghost flow problems and associated over heating of the school classrooms. The schools domestic hot water tank is also recommended to be replaced with a new side-arm hot water maker to take advantage of the waste heat loop, allowing the school to further reduce its fuel oil EUI.

If the electric rate being charged by the utility cannot be renegotiated to a satisfactory rate, then the operation of the school generator should be re-examined for competitiveness. At the current rate, installation of renewable energy may also be competitive at this location.

Lesson Learned

This school has an abnormally high electric cost. It is believed by the auditing team that the school district is indeed paying for the waste heat through the increased electric cost, though there is no formal metering or custody transfer of the waste heat energy. That being said, waste heat is an extremely effective alternative heating system and helps to greatly reduce the fuel oil used by this school as long as the energy costs are reasonable compared to the cost of the displaced fuel oil.

Submitted by: **Central Alaska Engineering Company**

Title: **Building Setback Temperature**

Observation

Many of buildings audited by Central Alaska Engineering Company did not maintain a low heating temperature setback during non-occupied hours. In schools, it was common to find a building that was excessively heated during the summer when the school's use by the public is at a minimum. It was also often the case that the thermostat controls were tied into a pneumatically controlled HVAC system that used a mechanical time clock to control setback operations, making repeatable setback temperatures possible. However, these mechanical time clocks are not easily changed for daylight savings adjustment and are easily defeated by removal of the clock pins. Where advanced direct digital control (DDC) systems are in place, a low cost energy savings is available by re-programming the system to optimize the temperature setback during non-occupied hours.

Impact

While any amount of temperature setback is beneficial, especially during non-occupied hours, control systems were not often set to a temperature setback that would most benefit the school. Every degree of heat applied to a building will have a certain amount of energy use associated with it. If a building is heated to a lower temperature than normal during non-occupied hours, there can often be a substantial energy savings opportunity. The amount of savings will be dependent on the building configuration, size and location.

Recommended Change

It is recommended that building heating setback temperatures be evaluated for effectiveness and be lowered to the greatest extent possible. So long as the reduced temperature is not set too low such that the ability of the heating system cannot recover timely or below internal dew point on that specific day, there can be considerable savings realized in most buildings with a sophisticated enough control system. This change will require the building owner to determine the relative humidity in the building. This can be monitored by the building's DDC system. And this will allow for the building setback temperature to be adjusted on a seasonal basis and allow for greater savings.

Lesson Learned

There are economic reasons why the thermostatic controller set points should be setback during off peak use hours. However, one important control data input concerns the water dew point of the air. The water dew point of the inside air varies with the seasons. As outside air (OSA) temperatures rise, the inside air dew point also rises. The staff is likely to complain about mildew and mold smells if the temperature is dropped below the dew point and condensation occurs. In keeping with this mildew and mold concern, it is recommended that the control system monitor the relative humidity within the building to select how far back the temperature can be safely set during low use periods.

Other parameters relating to the building setback temperature include warm-up time required to reheat the building and preventing any water pipes near the building perimeter from freezing. During extreme cold periods, raising the setback temperature limit and time appropriately is required to prevent possible problems. Optimization would require paying attention to these parameters and will vary by building.

Submitted by: **Central Alaska Engineering Company**

Title: **Seasonal Shutdown of Refrigeration Systems**

Observation

Many of the buildings that were audited by Central Alaska Engineering Company were noted to not practice seasonal shutdown of the various refrigeration systems throughout the building, including refrigerators, freezers, and vending machines. This appeared to be a school by school decision and not a district wide administrative control.

Impact

Refrigeration systems operate continuously to provide cooling for a particular purpose (mainly used for food services). During the summer months when schools are generally not occupied, refrigeration systems do not need to be running when not used. Perishable foods that require refrigeration are generally removed during the summer recess, leaving the refrigeration systems to provide needless cooling. The refrigeration system will produce heat as a by-product to the refrigeration process when it is running. This heat is distributed to the surrounding environment. In the summer months in particular, this will help to increase the inner temperature of the building which may cause building cooling systems to run needlessly. More importantly, the compression cycle required to provide refrigeration will consume electricity constantly.

Recommended Change

At the end of the occupied season, being the end of the school year for most cases, all refrigerators and vending machines should have their perishable foods removed and their systems unplugged. This will not have any adverse effects on the system and will reduce the amount of power consumed by the unit over the year. It is a no or low cost measure to perform seasonal shutdown of the refrigeration equipment and an adoption of a new facility policy may be required for administrative control. Employees can be educated of the benefits of this practice during regularly scheduled staff meetings or similar events. Savings of this measure will be immediately realized, particularly in facilities where there is no seasonal shutdown procedures being performed at all. During annual start-up, this is an excellent time to schedule regular maintenance of refrigeration systems.

Lesson Learned

For most facilities there seems to be no incentive for the employees to be driven to perform energy saving procedures. There are some areas where programs have been put into place to incentivize staff to be conscious of such practices, and as a result such programs have had a role in reducing the energy consumption of the facility. Buy in by the staff is required to implement administrative controls to unplug refrigeration systems while not in use.

For most facilities there seems to be no incentive for the employees to be driven to perform energy saving procedures. There are some areas where programs have been put into place to incentivize staff to be conscious of such practices, and as a result such programs have had a role in reducing the energy consumption of the facility. Buy in by the staff is required to implement administrative controls to unplug refrigeration systems while not in use.

Submitted by: **Central Alaska Engineering Company**

Title: **Redoubt Elementary School, Kenai Peninsula Borough School District**

Observation

This elementary school in the Kenai Peninsula Borough School District is a well-built school that is a good candidate for several energy retrofits. This school has older AO Smith gas fired tank-type boilers that are 34 years old and well past their useful life. There is also an HVAC system that is pneumatically controlled. This building also has several areas that still use outdated lighting systems. This case study focuses on the impact of changing out the old gas boilers with new high efficiency condensing boilers.

Impact

The tank-type boilers that are in the elementary school were measured to operate at less than 76 percent efficiency. This is low by today's standards and allows for a high loss of energy out the stack. The pneumatically controlled HVAC system that is in place does not permit remote monitoring or changes to the heating system of the building. Because of the lack of demand based control, heat and ventilation is provided to areas of the school even when not occupied. This causes the boilers to fire up and provide hydronic heat to certain areas of the building even when not occupied.

Recommended Change

The current boilers are recommended to be replaced with a modern condensing boiler package and the current natural gas domestic hot water heater be replaced with an indirect-fired hot water maker. The addition of new high efficiency condensing gas boilers as well as a variable speed DDC system on pump and fan motors is estimated to provide an energy savings of $8,250 annually. The pneumatic control system is recommended to be replaced with a modern direct digital control (DDC) system which would allow the building to be heated more efficiently and have improved temperature set-back control during unoccupied times. A new variable speed DDC system on pump and fan motors that can be monitored and controlled as needed at an off-site location as well as allow for demand-control would greatly help manage the energy use of the building. Figure 1.0 depicts the estimated annual cost and savings associated with a retrofit project addressing the building space heating, water heating, and ventilation systems.

Lesson Learned

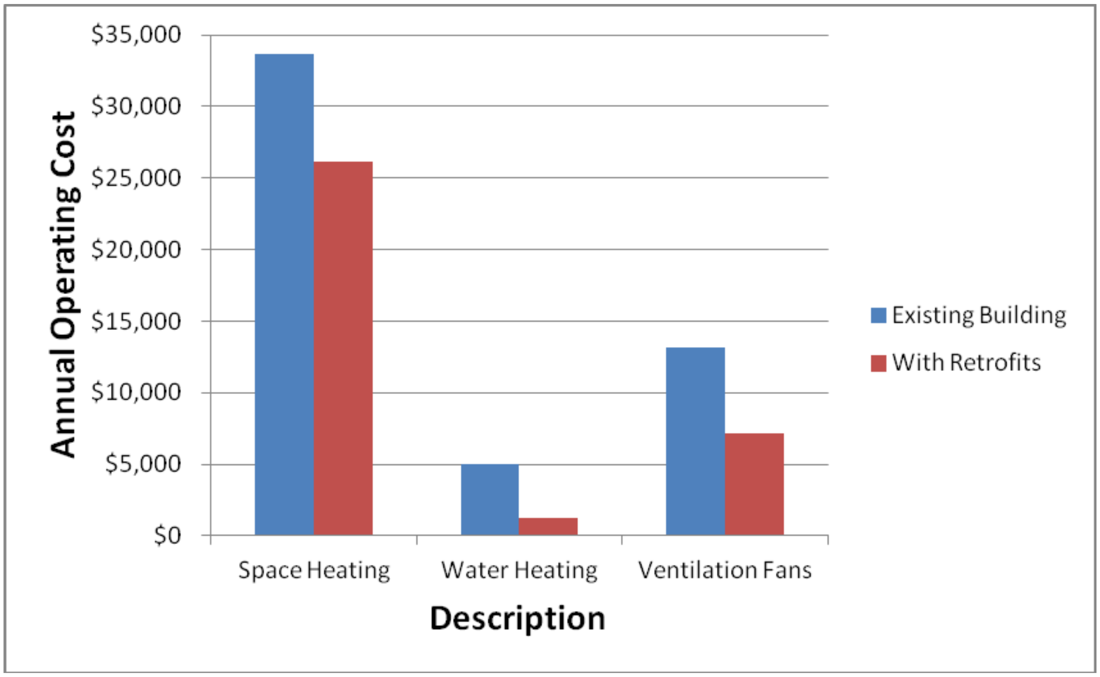


Figure 1.0: Annual Estimated Costs Before and After Retrofit

There are many schools that are being maintained on a regular basis, but not upgraded to take advantage of new technology or energy management techniques. Incorporation of a new energy management plan with provisions for the education of the building operators and occupants will have the greatest benefit. New boilers are often expensive and hard to justify on energy savings alone with their resulting lengthy Simple Payback. As this is often an issue, it can be beneficial to combine upgrade projects to take advantage of additional savings and improve the combined payback period for the upgrade project.

From the energy audit, it was also recommended that the school's various lighting systems be upgraded to modern lighting systems, including the use of occupancy sensors, LED lighting, and new energy saver model fluorescent bulbs. The use of occupancy sensors will allow areas such as classrooms, the gym, and offices that are unoccupied to remain minimally lit and save a portion of the energy used by the school. Coupling these sensors with lower wattage lighting in non-classroom areas helps to reduce the payback period of the lighting upgrade to make projects like this feasible.

Submitted by: **Alaska Housing Finance Corporation**

Title: **Low Hanging Fruit VS Deep Retrofit**

Observation

In discussing the potential to implement energy efficiency projects with building owners and managers, Alaska Housing Finance Corporation (AHFC) discovered that building owners were more likely to address the low hanging fruit recommended in the audit rather than take a holistic, deep retrofit approach.

In the Investment Grade Audits (IGAs) completed throughout this project, almost all audits had energy efficiency measure (EEMs) with minimal upfront costs, that can be implemented quickly and easily and that payback in typically a very short period of time. These attractive measures are typically referred to as low *hanging fruit*. Examples of these include upgrading lighting, installing programmable thermostats and occupancy sensors. In addition to these measures, audits include more robust recommendations that address the structure and functionality of the building such as installing additional insulation and replacing boilers. However, implementing these measures oftentimes requires a deeper level of retrofit and engineering, requiring more time and resources.

Impact

A facility owner should know that blending the quick payback options with the longer payback options, allows the “low hanging fruit” to help offset the higher costs of a deep retrofit. This approach improves a building’s energy efficiency for a longer period of time. It may reduce the number of construction and financing projects as well as the disruptions to the buildings occupants. To accomplish this, a more holistic, all-systems engineering approach and financial analysis will be required to develop a project. Additionally, upgrades with lower ROIs and SIRs may require justification for any future, unknown, potential funding source only a few years after the low hanging fruit upgrades are completed.

Recommended Change

As facility owners and managers evaluate their buildings for potential energy savings, they should considerer a holistic approach. Combining EEMs with both short and long term paybacks will yield, in many cases, much greater savings than only working with the low cost, short payback items. Further reductions in maintenance costs, fewer comfort complaints and long term energy savings are enhanced, and both short and long term payback items become cost effective.

Lesson Learned

Coupling low hanging fruit and more robust audit recommendations enables deep retrofits to be more cost effective. Collectively the deep retrofit approach benefits building owners in the long run because EEMs with higher ROIs or SIRs balance out those EEMs with lower ROIs or SIRs. This will increase the life of the building, provide more sustainable systems, and develop responsible building ownership and maintenance.

Submitted by: **Alaska Housing Finance Corporation**

Title: **Facility Owners Determine Level of Audit Details**

Observation	AHFC reviewed and categorized the top 5 energy efficiency measures (EEMs) from each Investment Grade Audit (IGA). With more than 40 auditors and engineers working to complete 327 IGAs, some variations and trends were expected. Through this process, several observations were made: • Some auditors tended to consistently identify the same top EEMs across all buildings with little variation • Some auditors only provided a few recommendations, which were typically the low hanging fruit • Other auditors identified an upwards of 20 EEMs, including ones with higher up-front costs and longer payback Though all auditors are required to follow a standardized audit process for AHFC projects, auditors have different methods for choosing what EEMs show up in the actual report.
Impact	A facility owner can set the terms of the contract to address a deep retrofit assessment, by discussing the terms of the work. For example an owner can require that all EEM's with paybacks of 40 years or less be considered and evaluated in the audit. If the facility owner plans to undertake a deep retrofit of the building, they should communicate this desire to ensure the auditor provides complete information to do so. If a facility wants a quick reduction in energy use, then an audit recommending limited projects may be appropriate. See case the study Low Hanging Fruit VS Deep Retrofit for further implications.
Lesson Learned	It is the responsibility of the facility owner to establish the level of detail presented in the audit report and the top listed EEMs. A building owner should determine the purpose and results desired of the audit and require the end report satisfy those specifications.

Submitted by: **Renewable Energy Alaska Project**

Title: **Best Practices for Engaging in Energy Efficiency**

Observation

Through the outreach process Renewable Energy Alaska Project (REAP) identified multiple barriers in facilities moving forward to address energy efficiency measure (EEMs) listed in the audits. While most public facilities recognize that energy efficiency and conservation are important resources to save energy and money, it is not always viewed as an investment opportunity from the building manager or owner perspective. Furthermore, when the opportunity was clear, many managers or owners show little interest in investing in projects even though an audit illustrates the cost-effectiveness of an investment.

Impact

REAP found that often there is no sense of urgency to implement EEMs recommended in the Investment Grade Audit (IGA). Several reasons for this include:

1. An uncertainty in financing the project
2. A sense that there are sufficient grants for capital improvements
3. The notion that the EEMs will provide equal benefits by being incorporated within the Capital Improvement Projects (CIPs) through the upcoming years

Such barriers result in fewer facilities implementing EEMs in the short term. Without pursuing energy saving measures, public facilities remain beholden to volatile and rising energy costs for their building's energy use for the foreseeable future.

Recommended Change

Addressing EEMs in the short term enables facility owners to start seeing those savings from reduced energy bills right away. Whereas if the building owner waited to address these thought CIP or receive a grant, they would be missing out on potentially years of reduced energy costs.

By investing in EEMs, the facility can use the savings in energy costs to pay for the implementation costs. This will allow the facility to pay the loan back with energy savings and realize savings in the future for other uses. It is recommended that facility owners, operators and finance personnel assemble to assess the audit recommendations and next steps. The facility is encouraged to contact AHFC for technical and programmatic assistance and their Technical Services Provider (TSP) for follow up regarding the energy audit. The Alaska Energy Efficiency Revolving Loan Program (AEERLP) is a unique opportunity and should not be treated as other loans.

Lesson Learned

An audit that shows EEMs that will pay for themselves and continue to save money for other uses is not necessarily enough to motivate owners to act. Further, schools and other public facilities may not have a clear path to taking out a loan for infrastructure upgrades. Facility owners that work together with their staff and AHFC personnel have a greater ability to overcome these barriers and realize energy savings much more quickly than waiting for grants and appropriated funds that may never come.

Submitted by: **Renewable Energy Alaska Project (REAP)**

Title: **The Significance of Leadership by Key Staff**

Observation	Moving forward with energy efficiency measure (EEMs) works best when the key staff takes ownership of the project and have the authority to make it happen.
Impact	Forward movement, including audit review and pursuit of the next steps, is more likely to happen when the project is in the hands of key staff with leadership and authority. Throughout the audit process, Alaska Housing Finance Corporation (AHFC), REAP, and Technical Services Providers were mainly in contact with the maintenance personnel and thought they can be inclined to use the audit as an outline for the upcoming Capital Improvement Projects (CIPs). However, it is not typically their role to address and fund projects facility wide. In many cases, AHFC-funded energy audits end up with staff members that were unsure of the entity's next step in addressing EEMs. Identifying the right person internally may be an issue in itself. In the case of one municipality it took communication with six people in order to get the message to a decision maker because there was no leader or approach informing all relevant personnel of this opportunity.
Recommended Change	As outreach efforts continue it is vital to identify the appropriate leader or group of leaders for the project. The leader should have authority to pursue the next steps, the background to understand the building's energy use and audit recommendations, and the impetus to identify barriers and move the project forward. It is also recommended that the leader work closely with relevant staff and management to identify clear goals and tasks.
Lesson Learned	In order for energy efficiency projects to be addressed in a facility, key decision makers and staff need to be involved in this process.

Submitted by: **Renewable Energy Alaska Project**

Title: **Sparking Energy Awareness through Friendly Competition**

Observation

In order to encourage energy efficiency and conservation in public buildings, REAP and AHFC implemented the first year of the Challenge, a competition to see who can reduce their energy use the most in a six month time period.

The Challenge focused on public facilities, with the goal of raising awareness about energy efficiency and conservation, spreading the word about the Alaska Energy Efficiency Revolving Loan Program, and saving the State of Alaska and municipality's money. The contest generated over ten pieces of earned media. Radio ads lauding the energy savings and Challenge winners served to educate the public of the potential for energy efficiency and conservation measures.

Participants worked from October 1, 2011 through March 31, 2012 to see what difference they could make on their energy use from the previous year. It should be noted that most of the participants were already pursuing EE&C measures, which appeared to be the drive for entering the Challenge.

Impact

Due to energy efficiency and conservation efforts, the ten participants shaved over $40,000 of their energy bills from the previous year (based on 2010 utility rates).

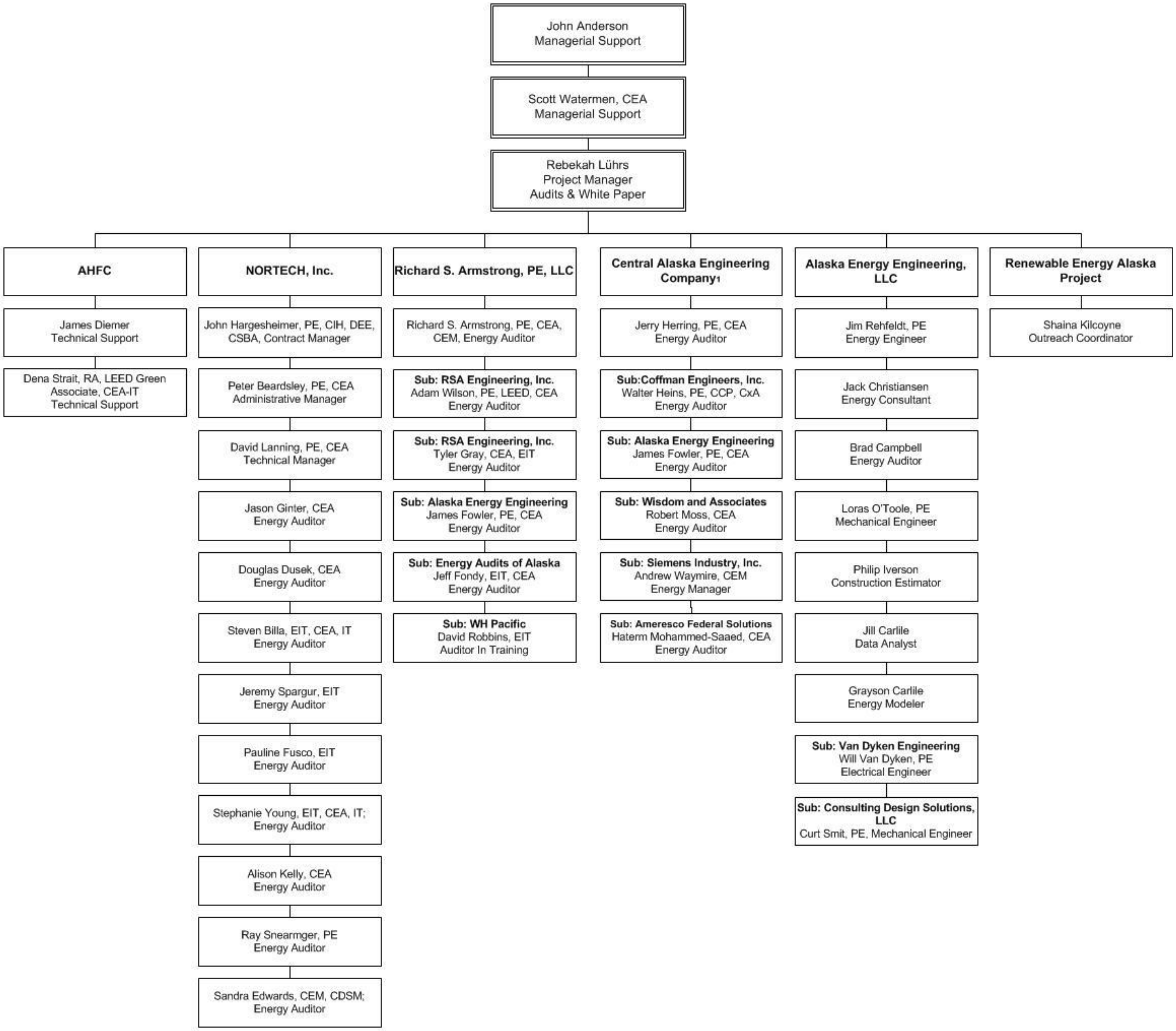
Diverse participants approached the Challenge in a variety of ways. Some of the schools chose one class to lead the project. Students posted creative reminders through the school to close blinds and keep arctic entry doors closed. One class learned how to calculate heating degree-days. Other participants sealed leaky doors and dimmed lights midday taking advantage of the sunlight. Another facility began to track their energy usage in order to identify trends and anomalies. Participants were encouraged to make it the goal of their facility users to make energy saving practices habitual so energy can be saved when the Challenge ends and at home.

Lesson Learned

Friendly competitions can spark interest and get people to think about ways to reduce energy even when they do not pay the utility bills (directly). Contests and other methods may be used to bridge this gap and teach more people about saving energy. Furthermore, studies show that energy saving habits in the workplace are often carried over into the home.

Appendix B
Organizational Chart

Organizational Chart



[1] CAEC worked with a total of 16 auditors and engineers, however, only the lead auditors are listed here

Appendix C
Firm Profiles, Statement of Qualifications

Richard S. Armstrong, PE, LLC

Alaska Energy Engineering LLC

Central Alaska Engineering Company

Nortech Engineering INC

Richard S. Armstrong, PE, LLC

Overview

Richard (Dick) S. Armstrong, PE, LLC was formed in 2001 to provide services for selected clients after Dick Armstrong retired from RSA Engineering, LLC. The firm has only one employee, and utilizes RSA Engineering for projects requiring additional manpower. The firm specializes in smaller projects, such as Investment Grade Energy Audits, plan reviews, claims audication, inspection, commissioning, troubleshooting, and general cold climate engineering. The majority of projects involve cold climate engineering, which is Dick's specialty.

Organization

Dick Armstrong, P.E., is the sole staff member at Richard S. Armstrong, P.E., LLC. Dick is a professional mechanical engineer, a professional electrical engineer, as well as, a CEA, a CEM, and a Certified Building Inspector. He is also a fellow of ASHRAE. A list of his licenses and certifications is below:

- Registered Professional Mechanical Engineer, (P.E.), in Alaska, California, Washington, & Hawaii
  - ME-5023, Alaska
  - ME-023484, California
  - PE-#22358, Washington
  - PE-05896, Hawaii

- Registered Professional Electrical Engineer, (P.E.), in Alaska, California, Washington, & Hawaii
  - EE-6023, Alaska
  - EE-011933, California
  - PE#-#22358, Washington
  - PE-05896, Hawaii

- AEE Certified Building Commissioning Professional, #56713
- AEE Certified Energy Manager, CEM 13557
- AEE Certified Energy Auditor, CEA 178
- AEE Certified Green Building Engineer, CGBE 594
- ICC Certified Combination Building Inspector, ICC 32770
- ICC Certified Plan Review Engineer, ICC 32770
- ICC Certified Combination Residential Inspector, ICC 32770
- BEES Compliance Certificate #1312

Services

RSA, PE, LLC provides these services for the following systems:

- Conceptual Planning and Design
- Plan Review
- Construction Administration
- Inventory & Condition Surveys
- Energy Audits
- Expert Witness Services
- Claims Adjudication Consulting
- Commissioning

For:

- Heating, ventilation, and air conditioning systems
- Fire protection, detection, and suppression
- Fuel systems
- Power generation and distribution
- Security systems
- Lighting
- Communications

Projects

RSA, PE, LLC has provided site investigation, design, plan review, investment grade energy audits, and construction administration services for a wide variety of facilities throughout Alaska, as well as, in Antarctica and Greenland. These projects have included the following:

- Wastewater treatment
- Power Plants
- Schools
- Fueling Systems
- Warehouses
- Hotels/Housing
- Maintenance Facilities
- Military Facilities

RSA Engineering, Inc.

Overview

RSA Engineering, Inc. (RSA) is an Alaskan consulting firm specializing in mechanical and electrical engineering in cold climates. RSA was founded in June 1983 and has grown from one person to 46 staff members since inception. RSA is a shareholder owned corporation, with a majority of our employees as shareholders. This promotes employee concern for efficient operations as well as customer satisfaction.

RSA has provided the full range of consulting services for a wide variety of projects throughout Alaska for over 25 years. This experience includes facilities for local governments, federal government agencies, and private industry. RSA's project engineers have experience in all types of facilities and systems in cold climates. Our staff members are familiar with the time, planning, and coordination required for designing in arctic, maritime, and seismic locations, as well as remote and inaccessible areas. We complete over 300 projects a year, with nearly half of those projects in rural, arctic areas of Alaska. RSA is looked upon as an expert in arctic design.

RSA's design philosophy is to employ designs that are efficient and budget conscious with respect to the mechanical and electrical systems. RSA is very familiar with the high cost of fuel and electricity in remote communities and strives to select equipment and systems that are not only energy efficient but also easy to service. The lead mechanical and electrical engineers at RSA have the experience to specify appropriate systems during the programming and project concept phases that will fall within the construction budget.

Organization

RSA's depth of personnel provides the client with qualified people who will be available to quickly respond to the project schedule. Each engineer or staff person has a backup available. The staff at RSA includes:

- Mechanical Engineers (P.E.)* 9
- Mechanical Engineers 5
- Electrical Engineers (P.E.)* 7
- Electrical Engineers 8
- Designers/ Drafters 13
- Administrative 4

* One engineer is licensed in both mechanical and electrical engineering.

Services

RSA provides these services for the following systems:

- Conceptual Planning
- Design
- Construction Administration
- Inventory & Condition Surveys
- Energy Audits

For:

- Heating, ventilation, and air conditioning systems
- Fire protection, detection, and suppression
- Fuel systems
- Power generation and distribution
- Security systems
- Lighting
- Communications

Projects

RSA has provided site investigation, design, and construction administration services for a wide variety of projects throughout Alaska, as well as, in Antarctica and Greenland. These projects have included the following:

- Airports
- Churches
- Community Centers
- Fueling Systems
- Hospitals & Clinics
- Hotels/Housing
- Maintenance Facilities
- Military Facilities
- Ports & Harbors
- Power Plants
- Prisons & Correctional Facilities
- Public Safety Facilities
- Recreation Facilities
- Schools
- Warehouses
- Water Supply, Treatment, Distribution

Central Alaska Engineering Company

CAEC is an engineering consulting firm in business for over 20 years providing practical solutions to the design challenges facing Alaska's many different industries. CAEC provides a full range of energy audits, engineering studies, design and construction management services for municipal, borough, state, federal and private clients.

Overview

CAEC was established in 1991 by Jerry P. Herring, PE, CEA, Principal Mechanical Engineer. The business was relocated from Anchorage to Soldotna in 1996 where the office is maintained on Brown's Lake. The CAEC office and shop are powered with solar and wind renewable energy in a co-generation scheme with Homer Electric Association.

Organization

CAEC is a small business and uses sub-consultants when necessary as required to complete projects. Merrick Jackinsky, Mechanical Engineer EIT, is the company engineer in training preparing to take his P.E. test. CAEC is a HUBZone Certified company by the US Small Business Administration, HUBZONE Certified # 42200; SBA # P1333287).

Services

- Certified Energy Auditing, Public Sector and Commercial Utility Benchmarking
- Mechanical and Electrical Engineering Design Services Utilizing AutoCAD Design/Drafting
- Heating, Ventilation and Air-Conditioning
- Pumping, Plumbing and Piping
- Renewable Energy, Power Generation, Cogeneration and Waste-heat Recovery
- Project and Construction Management
- Infrared Imaging and Building Diagnostic Services

Energy Auditing Projects

Central Alaska Engineering Company was chosen to be a TSP for the REAL System managed by the AHFC utilizing ARRA funding. Utility energy benchmarking was completed by ANSCA region and CAEC successfully benchmarked 16,082,293 SF of public sector facilities in the Ahtna, Aleut, Bering Strait, Bristol Bay, Chugach, CIRI, and Koniag regions to be able to rank and prioritize the high energy consuming buildings. CAEC then managed ASHRAE Level 2 Investment Grade Energy Audits completed on 127 public sector facilities totaling 6,324,383 SF. AkWarm-C was used for the energy modeling evaluations. EEMs identified potential energy savings in the facilities audited, estimated the cost of the measure, and estimated the Simple Payback and Savings to Investment

Ratio for the potential investment. All utility benchmark and audit reports were uploaded to the ARIS for further data analysis.

General Engineering Projects

- Crowley Marine Barge CO2 Fire Suppression System
- Chevron Steelhead Platform BOP Upgrade Project
- KNWR Solar Pump Power
- Sterling Elementary Heating System Upgrade
- HEA Bradley Lake Air Compressor Upgrade
- Kenai City Hall HVAC Project

Commercial Building Projects

- Kenai Automotive Transmission Shop
- Atka Airport SRE Building
- Soldotna Animal Shelter HVAC Upgrade
- Soldotna State Forestry Command Center HVAC
- Saint George Airport SRE Building
- Seward True Value Expansion
- Saint Paul Airport SRE Building

Apartment/Hotel/Lodge Projects

- Soldotna Senior Housing Project
- Soldotna Hillcrest Terrace Housing Project
- Togiak Senior Housing
- Togiak Teacher Housing
- Manokotak Teacher Housing
- Kipnuk Teacher Housing
- Napaskiak Teacher Housing

Alaska Energy Engineering LLC

Overview

Alaska Energy Engineering LLC (AEE) was formed in 1997 to provide energy engineering services to clients throughout Alaska. The firm specializes in the analysis and optimization of energy systems for building, facilities, and systems. The firm works directly with facility owners and as a member of multi-disciplined project and design teams. The firm combines academic engineering knowledge, practical experience, and personal relationships into a high quality, beneficial experience for the client and engineer.

Organization

James Rehfeldt, P.E., is the principal engineer of the firm. James is a professional mechanical engineer, CEM, and a commissioning authority. A list of his licenses and certifications is below:

- Registered Professional Mechanical Engineer, ME-8987, Alaska
- AEE Certified Energy Manager, CEM 16781

Services

AEE provides the services following:

Mechanical Engineering Services

- Technical studies and analysis
- Building load and ventilation calculations
- Condition assessments
- Mechanical/HVAC/energy system design
- Peer reviews
- Construction services

Energy Engineering Services

- Energy audits
- Energy modeling and analysis
- Conceptual design / optimization analysis
- Life cycle cost analysis

Projects

AEE has provided conceptual design, energy system optimization, mechanical system design, energy audits, and commissioning services for a wide variety of facilities throughout Alaska. These projects have included the following:

- Office Buildings
- Libraries
- District Plants
- Laboratories
- Aquatic Centers
- Industrial Facilities
- Schools
- Utility Systems
- Health Centers
- Assisted Living Facilities
- Mooring Facilities
- Restaurants
- Water and Wastewater Treatment
- Fueling Systems

NORTECH, INC.

Overview

NORTECH, Inc. Environment, Energy, Health & Safety Consultants is an Alaskan Corporation founded in 1979. NORTECH is an independent professional consulting firm that provides services in a broad range of fields relating to environmental engineering, civil engineering, industrial hygiene, safety and sustainable design and energy studies.

We offer consulting services either independently, as prime, subconsultant, or as part of a multi-disciplinary team. Serving the public, private, industrial, and professional sector, we routinely task ourselves with a broad view of problems and avoid the trial and error approach. We seek to provide appropriate cost conscious solutions to our clients' requirements, taking full account of the human community and environmental dimensions of the project. At the same time, we are at the forefront of the application of technological developments in our fields.

We use modern methods of providing professional services, including consultant teaming, information technology, and computer-aided analysis and design to save project cost and time, and to provide accurate detailed results. Our firm's standardized quality assurance procedures ensure that work is carried out to be the best quality, completed on time and within budget.

Services (energy)

NORTECH provides the energy services following:

- Third party Energy and Sustainability Studies
- Preliminary Energy-Use Analysis
- ASHRAE Level 1, 2 and 3 Energy Assessments
- Energy Modeling
- ASHRAE Building Energy Quotient (bEQ) Labeling
- LEED O+M Certification
- Energy Metering plans and Energy Use Monitoring
- Commissioning, Re-Commissioning, and Retro-Commissioning
- Professional Engineering Design and Project Management
- Renewable Energy – Bio-mass, Solar and Wind Energy Projects
- Grant and Loan Program Assistance
- Indoor Air Quality (IAQ) Monitoring and Consultation
- Indoor Environmental Quality (IEQ) Monitoring and Consultation
- Life Cycle Cost economic studies

Organization

We currently staff offices in Fairbanks, Anchorage and Juneau, Alaska. Our firm has grown in the past few years to a team of 32 individuals.

Projects

NORTECH has provided over 130 Investment Grade Audits under contract to the AHFC and the Alaska Energy Authority. These projects have encompassed more than 4.5 million square feet across all regions and climate zones of Alaska. Buildings have included:

- City Buildings and Community Centers
- Hospitals and Health Clinics
- Hotels and Lodging Facilities
- Industrial/Storage Facilities
- Office Buildings
- Public Safety/ Pools
- Public Works Facilities Recreational & Entertainment Facilities
- Research Facilities
- Schools
- Transportation Facilities
- Water Treatment Plants
- Washeterias
- Ice Arenas

Appendix D
Lead TSP Resumes

TSP	Firm
Richard S. Armstrong, PE, CEM, CEA	Richard S. Armstrong, PE, LLC
Jim Rehfeldt, PE, CEM	Alaska Energy Engineering LLC
Jerry Herring, PE, CEA	Central Alaska Engineering Company
Peter Beardsley, PE, CEA	Nortech Engineering INC

Richard S. Armstrong, P.E.
2522 Arctic, Suite 200, Anchorage, AK 99503
(P) 907-276-0521; (C) 907-229-0331; darmstrong@rsa-ak.com

EDUCATION

MBA in Management, Cum Laude, Fairleigh Dickinson University, Rutherford, New Jersey, 1974

Bachelor of Science Mechanical Engineering, Top Third of Class, Fairleigh Dickinson University, Teaneck, New Jersey, 1969

EXPERIENCE SYNOPSIS

4/00 to Present	Principal Mechanical/Electrical Engineer for RSA PE LLC and Consultant to RSA Engineering, Inc.
6/83 to 4/00	President, Principal Mechanical Engineer, RSA Engineering, Inc.,
7/81 to 6/84	Director, Division of Design and Construction, State of Alaska, DOT/PF
6/79 to 7/81	Director, Division of General Design and Construction, State of Alaska, DOT/PF
3/78 to 6/79	Pipeline Services Supervisor, Alyeska Pipeline Service Company
1/77 to 3/78	Support Services Supervisor, Southern District, Alyeska Pipeline Service Company
6/75 to 1/77	Support Services Manager, Section One, Alyeska Pipeline Service Company
6/74 to 6/75	Camp Construction Superintendent, Glennallen Camp, Alyeska Pipeline Service Company
6/67 to 6/74	Unit Head, Quality Assurance Engineering, Singer-Kearfott Division (Aerospace Navigational Equip Manufacturer)
6/61 to 6/67	Quality Control Analyst, Ford Motor Company

PROFESSIONAL LICENSES/ CERTIFICATIONS

Registered Professional Electrical Engineer, EE-6023, Alaska
Registered Professional Mechanical Engineer, ME-5023, Alaska
Registered Professional Electrical Engineer, E 011933, California
Registered Professional Mechanical Engineer, M 023484, California
Registered Professional Elec. & Mech. Engineer, #22358, Washington
Registered Professional Elec. & Mech. Engineer, PE-05896, Hawaii
International Conference of Building Officials Certified Combination Dwelling Inspector, Light Commercial Inspector, #32-US-32008975
Alaska Craftsman Home Program Airtightness Certified Technician
BEES Compliance Certificate #1312
AEE Certified Building Commissioning Professional, #56713
AEE Certified Energy Manager, CEM #13557
AEE Certified Energy Auditor, CEA #157
AEE Certified Green Building Engineer, #594
ICC Certified Combination Building Inspector #32770
ICC Certified Building Plans Examiner, #32770
ICC Certified Combination Residential & Dwelling Inspector, 32770
Pilot Licenses – Private Airplane Single Engine Land & Sea, Complex, High Performance
Pilot Licenses – Commercial Airplane Single & Multi-engine Land Instrument

PROFESSIONAL AFFILIATIONS	Board of Directors (89-94) President (87-88), VP (86-87), Secretary (85-86), Treasurer (84-85), Membership Chairman (83-85), American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Regional Vice Chairman, ASHRAE Energy & Technical Affairs (88-89, 89-90) Professional Member, International Conference of Building Officials (ICBO)
APPOINTMENTS	Architects, Engineers, Land Surveyors Board of Registration, State of Alaska, 1992-96 (Chairman 1994-95), Emeritus Member, 1997 Arbitrator, American Arbitration Association, 1991-Present Municipality of Anchorage Code Adoption Committee, 1992, 1994, 2001 State of Alaska Code Consolidation Committee, 1992-93 University of Alaska, Engineering Advisory Board, 2005-2011 Merrill Airport Advisory Board, 2004-Present The Superior Group, Board of Directors, 2009-Present Providence Hospital Foundation Board, 1995-2001
HONORS AND AWARDS	ASHRAE Fellow, 1996 Alaska Engineer of the Year, 1993
RESEARCH PAPERS PUBLISHED	Utilities and Systems for the New U.S. South Pole Station, Amundsen-Scott Station, Antarctica, American Society of Civil Engineering Eighth International Specialty Conference on Cold Region Engineering, Fairbanks, Alaska, August, 1996 HVAC Design Considerations for Cold Climates, ASHRAE Journal, September, 1993 Design and Construction Problems in Bush Schools, March, 1980 Estimate Analysis, October, 1980
SEMINARS PRESENTED	APDC Fall Forum – International Codes, APDC Meeting, Anchorage, Alaska, November, 2003 Design Considerations for Residential Heating Systems in Arctic Regions, ASHRAE Summer Meeting, Vancouver, B.C., Canada, June, 1989 Building Technology: Mechanical Issues, a Seminar Presented as Part of a Northern Design Course by the American Institute of Architects (AIA), Anchorage Chapter, October, 1996-2003 Mechanical and Electrical Technology (AET 142), a 4 credit college course offered by the University of Alaska Anchorage, Community and Technical College, Division of Applied Technologies, 2002-2003
PROFESSIONAL EXPERIENCE	**RSA Engineering, Inc.** **Consultant/Principal Mechanical/Electrical Engineer**, 2000 to Present Dick provides mechanical and electrical consulting services on selected projects. These services include plan reviews, energy audits and analysis, expert witness services, Commissioning services, pre-design or inventory and condition site visits, design, as well as construction administration. **RSA Engineering, Inc. / RSA Engineering** **President, Principal Mechanical Engineer**, 1983 to 2000 While President of the firm, Dick provided day-to-day direction to 33 engineers, designers, and clerical people in the operation of the corporation. As a Principal Mechanical Engineer, Dick provided direction to other mechanical staff, as well as managing his own projects. These projects cover the range of facilities including housing, power plants, schools, commercial, industrial, institutional and residential. Several relevant projects include: South Pole Station Replacement Fuel Facility – U.S. Navy, ACE Hangar Complex - Merrill Field, National Park Service Kennecott Mine Utilities Study, Unalakleet Fish Processing Plant, Valdez Baler Ventilation, Valdez Emergency Operations Center, Alaska Railroad New Passenger Terminal, Anchorage International Airport Code Upgrade, Cominco Red Dog Permanent Accommodation Complex, National Park Service Glacier Bay Maintenance Facility Remodel, and Dekastri Export Terminal Offshore Mechanical. **State of Alaska - Department of Transportation & Public Facilities**

Director, Division of Design & Construction, Central Region, 1981-1984
Directed a 500 person division which designed, inspected and administered contracts for the construction of state highways, harbors, airports and public buildings in central Alaska. Administered over $150 million in projects annually. Served as Contracting Officer for Central Region construction projects. Staff consisted of licensed professional engineers and architects, as well as engineers in training and support people. The majority of transportation related design work was performed in-house, while consultants did most of the buildings designs. Duties also included right-of-way acquisition and certification, legal actions involving right-of-way and construction, and contractor claim adjudication. Personnel records verify consistently outstanding performance in meeting goals and timetables.

State of Alaska - Department of Transportation & Public Facilities
Director, Division of General Design and Construction, 1979-1981
Managed a 65 person division that administered design and construction contracts for public buildings statewide. Responsible for administration of architect/engineer selection, design contracts, bidding and award of construction contracts, construction contract administration, construction inspection, design changes and claims adjudication. Established procedures for above functions and ensured they were followed. Responsible for planning, coordinating, reviewing and monitoring work performed by the three regions (Southeast in Juneau, Central in Anchorage and Interior in Fairbanks) as well as Headquarters in Anchorage. Expedited the design phase which got construction contracts advertised and built on schedule.

James A Rehfeldt, P.E.
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(P) 907-789.1226; (F) 907-523-1082; jim@alaskaenergy.us

EDUCATION	Masters Study; Pennsylvania State University; 1995-96 B.S. Mechanical Engineering; Univ. of Wisconsin; 1984

EXPERIENCE SYNOPSIS

1997 to Present	Alaska Energy Engineering LLC; 1997-present
2003 to 2007	US Coast Guard Civil Engineering Unit Juneau
1989 to 1995	
1996 to 1998	Murray & Associates PC; 1996-1998
1985 to 1987	Vernon Akin and Associates

PROFESSIONAL LICENSES/ CERTIFICATIONS

Registered Professional Mechanical Engineer, ME-8987, Alaska
AEE Certified Energy Manager, CEM #16781

PROFESSIONAL EXPERIENCE

Alaska Energy Engineering LLC
Principal Mechanical/Energy Engineer, 1997 to Present
Provide mechanical and energy consulting services on selected projects. These services include conceptual design, energy analysis, life cycle cost analysis, energy audits, and commissioning. Work is performed on facilities throughout Alaska and includes office buildings, libraries, district plants, laboratories, aquatic centers, industrial buildings, schools, utility systems, health centers, assisted living facilities, , and restaurants.

United States Coast Guard Civil Engineering Unit Juneau, 1989 to 1995 and 2003 to 2007

Mechanical engineer performing multi-disciplined engineering tasks including project development, analysis, design, cost estimating and construction technical representative for mechanical and civil engineering projects at Coast Guard facilities throughout Alaska. Project manager of multi-disciplined design contracts including development of project scope and constructability reviews of plans and specifications. Performing extensive multi-disciplined facility audits.

Technical representative to the contracting officer for all aspects of construction administration including plan and specification constructability reviews prior to bidding, approving construction schedules, contract administration, submittal review, construction inspection, negotiation and processing of change orders, negotiation of contractor claims, final inspection, and project closeout.

Murray & Associates, P.C., 1996 to 1998

Mechanical engineering designer and project manager specializing in engineering design, energy analysis, construction administration and inspections, and engineering analysis of mechanical systems for commercial and institutional buildings throughout Southeast Alaska.

Vernon Akin and Associates, 1985 to 1987

Mechanical engineer-in-training specializing in project design and construction administration of mechanical systems for commercial and institutional buildings.

Jerry P. Herring, PE, CEA
32215 Lakefront Drive, Soldotna, AK 99669
Phone: 907-260-5311
Email: jherring@akengineer.com

EDUCATION	Bachelor of Science Mechanical Engineering, University of Alaska, Fairbanks, 1983
EXPERIENCE SYNOPSIS	1991 to Present — Principal Mechanical Engineer for Central Alaska Engineering Company 1983 to 1991 — Mechanical Engineer for ARCO Alaska
PROFESSIONAL LICENSES/ CERTIFICATIONS	Registered Professional Mechanical Engineer, ME-8287, Alaska AEE Certified Energy Auditor, CEA #1484 Building Performance Institute Certified Building Analyst Professional #5014711 ICC Certified Combination Dwelling Inspector #1097420 AHFC Approved Energy Rater #990075 BEES Compliance Certificate #74 Pilot License – Private Single Engine Land & Sea, Complex, High Performance
PROFESSIONAL AFFILIATIONS	Member, American Society of Heating, Refrigerating and Air-Conditioning Engineers Member, American Society of Mechanical Engineers Member, Association of Energy Engineers Member, International Code Council Member, Illuminating Engineering Society Board Member, CCHRC Past Board Member, Kenai Peninsula Builders Association Past Board Member, Alaska State Home Builders Association
SEMINARS PRESENTED	**Association of Energy Engineers Fundamentals of Energy Auditing** Presented the AEE Preparatory Training Program for the Certified Energy Auditor test in Anchorage, Fairbanks and Juneau. Course included pre-audit work, data collection procedures, test equipment familiarization, utility benchmarking, Simple Payback and Savings to Investment Ratio calculations. This course provided the technical knowledge required to perform comprehensive commercial energy audit work.
PROFESSIONAL EXPERIENCE	**Central Alaska Engineering Company** **Principal Mechanical Engineer, 1991 to Present** Jerry established Central Alaska Engineering Company in 1991 upon receiving his professional mechanical engineering license. CAEC specializes in providing engineering design services including heating, ventilation, piping and plumbing design, renewable energy projects, commercial energy auditing, residential energy ratings and BEES certification. Central Alaska Engineering Company was chosen to be a TSP for the REAL System managed by the

AHFC utilizing ARRA funding. Utility energy benchmarking was completed by ANSCA region and CAEC successfully benchmarked 16,082,293 SF of public sector facilities in the Ahtna, Aleut, Bering Strait, Bristol Bay, Chugach, CIRI, and Koniag regions to be able to rank and prioritize the high energy consuming buildings. CAEC then managed ASHRAE Level 2 Investment Grade Energy Audits completed on 127 public sector facilities totaling 6,324,383 SF. AkWarm-C, a building energy modeling program, was used for the energy modeling evaluations. EEMs identified potential energy savings in the facilities audited, estimated the cost of the measure, and estimated the Simple Payback and Savings to Investment Ratio for the potential investment. All utility benchmark and audit reports were uploaded to the ARIS for further data analysis.

Jerry has developed energy auditing expertise and is all about the production of the ***Negawatt Power*** as defined by *the theoretical unit of power representing an amount of energy saved which is the direct result of energy conservation or increased efficiency*

ARCO Alaska
Mechanical Engineer, 1983 to 1991
Progressed through various levels of increasing responsibility while employed for ARCO Alaska at Prudhoe Bay. Gained valuable Arctic construction, petroleum production and processing experience while completing a variety of projects supporting North Slope oil production, gas and water handling. Worked as a Facilities Engineer at the Crude Oil Topping Unit, Flow Stations 2 and 3. As Project Mechanical Engineer, projects worth several million dollars were managed to upgrade capacity of the facilities and to address safety deficiencies. Duties were completed on several multi-million dollar upgrade projects at Prudhoe Bay to increase production and defer decline as a Construction Engineer, field construction supervision and contract administration.

Peter Beardsley, PE, CEA
2400 College Road, Fairbanks, AK 99709
Phone: 907-452-5688
Email: peter@nortechengr.com

EDUCATION

B.S. Environmental Engineering, Rensselaer Polytechnic Institute, Troy, NY, 1997

EXPERIENCE SYNOPSIS

Mr. Beardsley, PE has worked in the environmental field since 1992 and in Alaska since 1998.

PROFESSIONAL LICENSES/ CERTIFICATIONS

Registered Civil Engineer, Alaska 2003 (CE-10934)
Engineer-in-Training, New York, 1997
Certified Energy Auditor, 2011
40-hr HAZWOPER Training 1998-Current
State of Alaska DEC Qualified Sampler 1998-Current
EPA AHERA Asbestos Inspector 1999-Current
IFCI Tank Decommissioning 1998-2000

PROFESSIONAL EXPERIENCE

Commercial Energy Audits
Mr. Beardsley has been directly involved with more than 125 of NORTECH's energy audits of commercial and municipal buildings in communities from the eastern Interior to the Aleutian chain. He was also responsible for a benchmarking effort that included nearly 1,000 buildings across Alaska. His work on these audits included identifying buildings for audits from benchmarking data, completing audit field work, reporting, and working with building owners to develop energy use reduction strategies and implement recommended EEMs.

Environmental Site Assessments
Mr. Beardsley has conducted many Phase I and Phase II investigations around the state of Alaska. He has been in responsible charge of NORTECH's Phase I ESA program for the last nine years and many of these projects have developed into remedial design and long-term monitoring projects. Mr. Beardsley has designed and evaluated active remediation systems including multiphase extraction, horizontal well, pump and treat, and air sparge systems. Mr. Beardsley has also designed long-term groundwater and soil monitoring plans, monitored natural attenuation programs, and institutional controls for a variety of sites.

Worker Safety and Environmental Noise Compliance
Mr. Beardsley has conducted several safety compliance audits, including noise, air quality, and mechanical safety components, at several facilities in Fairbanks, including the water and wastewater plants. He has also conducted environmental noise compliance monitoring for Fairbanks Gold Mining, Inc.

Indoor Air Quality and Hazardous Materials Investigations
Mr. Beardsley has extensive experience in indoor air quality monitoring, including carbon monoxide/dioxide and mold investigations. He has also conducted many investigations for asbestos, lead-based paint, and other hazardous materials, including mercury and PCBs.

Appendix E
AHFC Program Process

AHFC Program Process

After the details are collected, inventory is taken, and the engineering assessment of energy savings is complete, the auditor then projects future costs based on the actual energy use that is modeled in the facility. Finally all of this is assimilated in a report with recommendations and prioritized improvements. The findings provide facility owners with a list of EEMs that could potentially be developed into projects. The TSP passed the completed audit on to the facility owner and then the outreach piece begins.

1. Details of Outreach Process Established for IGA Recipients

With 327 IGAs completed thus far in public facilities statewide, AHFC developed an outreach component to provide IGA-recipient facilities with technical assistance, direction, tools, funding and resources to address the improvements and recommendations listed on the IGA.

To lead this effort, AHFC contracted with the Renewable Energy Alaska Project (REAP). Working closely with AHFC Staff, REAP was tasked to individually follow up with all facility owners/contacts. REAP staff identified the appropriate person to communicate for each facility, provided and verified that they received the IGAs, provided informational packets with resources on next steps, and also shared the funding opportunities available through the AEERLP. The process is outlined below.

a. **Send Outreach Packet:** REAP sent out a hard copy of the draft IGAs with a packet that included a cover letter, IGA Benefits and Resources sheet, Scope and Project implementation sheet, AEERLP Brochure, and an AEERLP Question/Answer Sheet.

b. **Contact Facility:** A week after these were sent, Shaina Kilcoyne, the AHFC Outreach Coordinator from REAP directly called the person working with the auditor during the audit process. On this call she verified that they had received the audit and outreach packet, discussed where they were in the process, and asked if they needed any additional assistance. If they had not yet reviewed the audit(s) they were encouraged to do so and promised a follow-up call. In cases where facilities were interested in moving forward with the AEERLP, Shaina worked to set up additional follow up such as in-person presentations, meetings, or conference calls.

c. **High Priority Facility Follow Up:** Further follow up was set up for facilities interested in more information about the AEERLP. Either REAP or AHFC staff met with key staff and discussed opportunities for fully utilizing the audit and potential funding options. Through this process AHFC and REAP staff were able to meet with over a dozen facility staff.

d. **General outreach and Education:** REAP also provided additional outreach by hosting tables at conferences and fairs, educating and informing community leaders (such as mayors, city council members, and borough officials), worked with DEED to further promote energy efficiency in their audited facilities, and promoted the program to energy efficiency stakeholders statewide.

e. **Educational Venue:** REAP hosted the Great Alaska Energy Challenge (Challenge) which engaged public facilities in a friendly energy efficiency competition, which also served as a venue to further educate participants and the public on opportunities available for implementing EEMs through media and direct communication.

2. Investment Grade Audit

The purpose of the IGA is to perform an in-depth review of the selected building so that a realistic analysis can be provided to define potential energy upgrades, along with potential paybacks for each upgrade, defined as EEMs. It is important to note that the same EEM may produce more or less energy savings, depending on the location in which it is implemented. For example, daylight variations over the STATE vary greatly. As we move further North, there is less daylight in the winter time, making exterior lighting upgrades more attractive in northern areas than in southern areas of the state. For this reason, it is important to review each building individually.

a. **Eligibility for AHFC funded audit:** Only buildings that were benchmarked were eligible to receive an AHFC-funded IGA. More information on building eligibility can be found in the Process and Methodology section.

b. **Site visit:** The building is visited by a CEA or a CEM to confirm the building construction against plans. If there are not as-built plans available, then the auditor must as-built the existing building in order to perform an energy consumption simulation. The auditor interviews building occupants and maintenance people to understand occupant schedules, problems with the building, or suggested upgrades that will improve the building.

c. Building shell features such as wall thickness and insulation, attic insulation, window condition, floor construction, and door condition and insulation are all observed and noted on the model. Lighting is reviewed for potential upgrade, with new lighting suggested, where appropriate, either through relamping and re-ballasting using newer technology devices or replacing the lighting fixtures.

d. Pumps and motors are reviewed for potential upgrade to premium motors or variable frequency drive (VFD) fans and pump motors. Fan and pump operation is observed to see if the controls need upgrading. Boilers and furnaces are examined to see if it would be appropriate to replace these heat generation devices. Additionally, appliances are reviewed for potential upgrade. A review of the approximately 50 EEMs presented later in this report are a good indication of the types of building features that are examined during an IGA.

e. The model resulting data is compared to the most recent two years of energy consumption data, and input assumptions are adjusted as needed to bring the model as close as possible to the actual energy consumption. Once the model and actual energy consumptions are relatively close (10 percent agreement is generally the target), then EEMs can be analyzed for potential payback. Other energy modeling software was permitted to be used, such as Trane Trace, but that software was found to be typically more complex to use than AkWarm-C.

f. Factors affecting audit findings and recommendations are listed below.

i. In order to calculate a payback time for any given improvement, the auditor must input the estimated cost to implement the recommended change. This cost estimate can vary considerably depending on how the owner wishes to implement the EEM. For example, the cost to relamp and reballast a light fixture could be estimated using the building maintenance person to install the replacement components on a time available basis, or the process could be done using an outside contractor that needs to be mobilized to the site, including state or federal Davis bacon wages and conditions, and all travel expenses. The two approaches will result in vastly different overall costs, so an overly expensive approach may result in not having a reasonable payback, thus resulting in the EEM being discarded. Therefore, reasonable estimates are essential in order to arrive at any realistic payback schedules for project adoption. The caveat here is that the owner needs to determine how he/she intends to implement each EEM, and make an independent cost estimate before proceeding.

ii. Cost of fuel and electrical energy: Locations that had relatively low energy utility rates produced longer payback periods for energy upgrades, so EEMs were harder to justify than in locations where the cost of energy was very high, such as in some remote northern villages. Locations in Southeast Alaska with hydroelectric power as inexpensive as $.08/kWh did not show as quick a payback for lighting or other electrical upgrades as places with energy costs approaching $.80/kWh. Alaska Heating fuel costs range from less than $.70 per 100,000 BTUs, to over $8.oo per 100,000 BTUs.

iii. AIR Infiltration assumptions during modeling: All energy models require the auditor to input the estimated infiltration rate for the building. This can be done relatively precisely if a blower door test is performed on the building, as is typically done with small houses. A blower door test on a larger building (typically larger than 5,000 SF) is much more difficult to perform, and has less reliable results. To prove the theory, the AHFC building on Boniface and Tudor in Anchorage was given a blower door test. The test took almost 8 hours to set up and take down, and the results could be challenged because so many openings had to be sealed for the test, but are normally open during operation.

iv. Time of year for audit: Operation of buildings in the summer that may be vacant, such as schools, can present EEM opportunities that would not be obvious to an auditor who performed the site visit during the winter. One example was an auditor who discovered that a school closed for the summer was operating all of the walk-in freezers and coolers over the entire summer period, even though they were empty of food. In other places, boilers were found to be left operational all summer, along with the circulation pumps, even though there was no chance for freeze-up and the building was sufficiently warm due to the ambient weather conditions. Likewise, audits in the summer can miss operational issues like classrooms that had lights burning even though there were no classes being taught at the time, or thermostats turned up with windows open at the same time.

3. AHFC's AEERLP

As defined in 15 AAC 155.605, the AEERLP program may finance energy efficiency improvements to buildings owned by regional educational attendance areas; municipal governments, including political subdivisions of municipal governments; University of Alaska; and political subdivisions of the State. Loans may be used to finance EEMs via Energy Performance Contracts (EPC) or Non-EPC construction contracts approved by AHFC. Both of the loan instruments (EPC and non-EPC) allow facility owners to finance the implementation of EEMs without up-front capital investment or specific appropriations.

Loan amounts are determined by the projected energy savings outlined by a specific scope of work. As a public corporation, AHFC exercises due diligence to ensure the borrower's ability to repay.

AHFC can finance a loan for up to 15 years—interest rates generally being higher with the longer loan term. While a community may be eligible for a 10-year term, they may opt for a shorter term to attain a lower interest rate. Visit http://www.ahfc.us/loans/akeerlf_loan.cfm for more AEERLP information.

4. Retrofit Energy Assessment for Loan Program

In order to establish a technical assistance process for identifying and implementing projects, AHFC developed the Retrofit Energy Assessment for Loan (REAL) Program. REAL establishes a standard for facilities to successfully identify and implement comprehensive and effective energy efficiency retrofits that lead to measureable short-term and long-term energy savings and improved building performance. The REAL Manual outlines the process for facilities to identify potential projects to implement energy efficiency improvements.

Currently the REAL Program is under a redraft based on lessons learned during this project. Check the AHFC website to see if an updated version of the REAL Manual has been published.

5. The goals and objectives of REAL are listed below.

a. Provide technical assistance to facility owners interested in identifying cost effective EEM's and moving forward with addressing energy efficiency improvements.

b. Create a standardized process to assist the facility owner through the process of benchmarking, getting an audit, and choosing between using an energy performance contract or managing the project internally.

c. Reduce energy use for public facilities by providing funding for comprehensive, integrated energy efficiency retrofits that go beyond lighting and heating system upgrades.

d. Establish EUI data, specific to the State, that describe the size-related energy consumption for buildings with specific energy end uses.

e. Identify effective EEMs specific to Alaska's public buildings (office buildings, warehouses, water plants, schools, etc).

f. Establish qualifications for a CEA/CEM[20] and for energy service companies (ESCO) who may prepare IGAs for AHFC-funded projects. To assist publically owned facilities in identifying projects, through use of DOE ARRA funds (administered through AHFC) to benchmark over 1,200 facilities and fund IGAs in 327 Municipal, State, or School District owned public buildings. The IGAs were performed after the buildings were benchmarked. TSPs were contracted to implement the benchmark data collection and complete IGAs using this REAL Program.

6. Eligible Building Types

Facilities eligible to be selected for audit by a TSP were required to meet the following criteria to be considered for AHFC-funded IGAs:

a. Within the State of Alaska

b. Public facility buildings owned by schools or local governments

c. Benchmarking must have been completed

d. Provide a complete inventory of all buildings owned excluding minor buildings (such as pump houses) to the TSPs. Eligible buildings must have been benchmarked to the greatest extent possible

7. Buildings Selected for Audit

The TSPs selected buildings for audit that typically met the eligible criteria listed above, and appeared to be good candidates for potential energy upgrades. For example, new buildings were typically not selected for audit based on the assumption that newer building's design would already include most of the current energy savings designs. AHFC ran an allocation formula based on population, fuel costs and HDDs, and a budget was given to each TSP for each of their assigned ANCSA regions. Audits were then assigned, to the extent of the budget, to those buildings with the highest EUIs. Part of the original selection of the TSPs included their submission of audit cost fees by building type, by building size ranges, and by ANSCA region. More information is listed in Appendix E: Building Use.

[20] Recommend that AHFC also recognize ASHRAE certified Building Energy Assessment Professional (BEAP) as qualified CEA/CEM.

Appendix F
Building Use

Building Usage Type and Size	Examples
Education - K-12 Single classroom/portable School less than 30,000 SF School greater than 30,000 SF *NOTE: For schools, special services (such as cafeteria, stage, shop, lab) are often the defining characteristic of school building loads. Otherwise, size may just be a function of how many classrooms are included.*	Academic/technical classroom instruction, such as elementary, middle and high schools, and classroom buildings on college/university campuses. Buildings on education campuses for which the main use is not classroom are included in the category related to their use.
Health Care - Nursing/Residential Care	Nursing care facilities; Residential Developmental Handicap, mental health and substance abuse facilities; Community Care facilities of the elderly; other residential care facilities.
Mall Strip Mall Enclosed Mall	Shopping malls composed of multiple connected establishments.
Office Less than 20,000 SF 20,000-50,000 SF Greater than 50,000 SF	Buildings used for general office space, professional office, or administrative offices. Medical offices are included here.
Public Assembly *NOTE: No natural size break in how these building configured, and use is highly variable. There are commonalities with many school space functions.*	Buildings in which people gather for social or recreational activities, whether in private or non-private meeting halls.
Public Order and Safety *NOTE: Prisons are complex systems with little relation, in energy use, to any other building type.*	Buildings used for the preservation of law and order or public safety. Includes police/fire stations, jails/penitentiary, courthouse or probation office.
Residential - Multi-Family **2-4 Units**	A structure that is divided into living quarters for 2, 3 or 4 families or households in which one household lives above or beside another. This category also includes houses originally intended for occupancy by 1 family (or for some other use) that have since been converted to separate dwellings for 2-4 families. Typical arrangements in these types of living quarters are separate apartments downstairs and upstairs or one apartment on each of 3 or 4 floors. A unit in a building with 5 or more housing units - a structure

5+ Units	that contains living quarters for 5 or more households or families and in which one household lives above or beside another.
Residential – Single Family **Single-Family Detached** **Single Family Attached**	A single-family house is contained within walls extending from the basement (or the ground floor, if no basement) to the roof. Attached houses are considered single-family houses as long as they are not divided into more than one housing unit and they have independent outside entrances.
Warehousing and Wholesale	Wholesale Distributors (farm products, petroleum products, foods and beverages, personal and household goods, motor vehicle parts, building materials, etc.)Buildings used to store goods, manufactured products, merchandise, raw materials or personal belongings (such as self-storage).
Accommodation Services External door Motel-type, less than 4 stories Internal Door Hotel-type Up to 4 stories Greater than 4 stories	Dormitories, Senior Living, Traveler accommodations (not including Nursing/Residential Care).
Food Service and Drinking Places	Full service restaurants; limited-service eating places; special food services, drinking places (alcohol).
Health Care - Hospitals Less than 50,000 SF Greater than 50,000 SF	General medical and surgical hospitals; psychiatric and substance abuse hospitals; specialty hospitals.
Retail – food	Grocery stores; specialty food stores; beer/wine/liquor stores
Retail - non-food	Non-food retail (not in a mall); gasoline stations; services such as repair shops, beauty parlors.
Other	Buildings that are industrial or agricultural with some retail space; buildings that have several different commercial activities that, together, comprise 50 percent or more of the floor space, but whose largest single activity is agricultural, industrial/manufacturing, or residential; and all other miscellaneous buildings that do not fit into any other category. Also special-purpose buildings like water/wastewater treatment and distribution, museums, data centers.

Appendix G
List of Audited Buildings

REGION	#	BUILDING	CITY	FIRM
ASRC	4	Nunamuit School	Atqasuk	RSA, PE, LLC
ASRC	4	Meade River School	Kaktovik	RSA, PE, LLC
ASRC	4	Harold Kaveolook School	Nuiqsut	RSA, PE, LLC
ASRC	4	Trapper School	Point Lay	RSA, PE, LLC
ASRC	4	Cully School aka Kali School	Barrow	RSA, PE, LLC
ASRC	4	NSB Public Works Building	Barrow	RSA, PE, LLC
ASRC	4	Inupiat Heritage Ctr	Anaktuvuk Pass	RSA, PE, LLC
ASRC	4	Anaktuvuk Pass Fire Dept	Barrow	RSA, PE, LLC
ASRC	4	NSB Search and Rescue Building	Atqasuk	RSA, PE, LLC
ASRC	4	Atqasuk Fire Dept	Barrow	RSA, PE, LLC
ASRC	4	Barrow Fire Dept	Barrow	RSA, PE, LLC
ASRC	4	NSB Fire Dept	Kaktovik	RSA, PE, LLC
ASRC	4	NSB Public Safety	Point Hope	RSA, PE, LLC
ASRC	4	Point Hope Fire Dept	Wainwright	RSA, PE, LLC
ASRC	4	Wainwright Fire Dept	Barrow	RSA, PE, LLC
ASRC	4	Barrow Municipal Bus Barn	Barrow	RSA, PE, LLC
ASRC	4	Barrow Shop III/TDS Facility	Barrow	RSA, PE, LLC
ASRC	4	DMS Equipment Storage Shop Building	Barrow	RSA, PE, LLC
ASRC	4	Heavy Equipment Shop Building	Barrow	RSA, PE, LLC
ASRC	4	NSB Bus Storage Facility	Barrow	RSA, PE, LLC
ASRC	4	NSB Light Equipment Shop	Kaktovik	RSA, PE, LLC
ASRC	4	Public Works Warm Storage/Vehicle Maint Facility	Nuiqsut	RSA, PE, LLC
ASRC	4	Maintenance and Operations Shops	Atqasuk	RSA, PE, LLC
ASRC	4	USDW Building (Public Works Building)	Barrow	RSA, PE, LLC
ASRC	4	Barrow Shipping and receiving	Barrow	RSA, PE, LLC
ASRC	4	C Street Shops Warehouse	Point Hope	RSA, PE, LLC
ASRC	4	USDW Building (Public Works Building)	Point Lay	RSA, PE, LLC
ASRC	4	Point Lay Warm Storage	Atqasuk	RSA, PE, LLC
Bering Straits Reg Corp	4	Teller School	Teller	RSA, PE, LLC
Bering Straits Reg Corp	4	Koyuk-Malemute School	Koyuk	RSA, PE, LLC
Bering Straits Reg Corp	4	Brevig Mission K-12 School	Brevig Mission	RSA, PE, LLC
Bering Straits Reg Corp	4	Elim Aniguiin School	Elim	RSA, PE, LLC
Bering Straits Reg Corp	4	John Apangalook School	Gambell	RSA, PE, LLC
Bering Straits Reg Corp	4	Shaktoolik School	Shaktoolik	RSA, PE, LLC
Bering Straits Reg Corp	4	Shishmaref School	Shishmaref	RSA, PE, LLC
Bering Straits Reg Corp	4	Stebbins K-12 School (Tukurngailnguq School)	Stebbins	RSA, PE, LLC

Bering Straits Reg Corp	4	Unalakleet Elementary	Unalakleet	RSA, PE, LLC
Bering Straits Reg Corp	4	Wales School	Wales	RSA, PE, LLC
Bering Straits Reg Corp	4	Nome City Hall & Senior Ctr	Nome	RSA, PE, LLC
Bering Straits Reg Corp	4	Nome Community Recreation Ctr	Nome	RSA, PE, LLC
Bering Straits Reg Corp	4	Icy View Fire Station	Nome	RSA, PE, LLC
Bering Straits Reg Corp	4	Nome Public Works	Nome	RSA, PE, LLC
Bering Straits Reg Corp	4	Nome Volunteer Fire Station	Nome	RSA, PE, LLC
Bristol Bay Native Corp	2	Egegik K-12	Egegik	CAEC
Bristol Bay Native Corp	2	Ekwok K-12 School	Ekwok	CAEC
Bristol Bay Native Corp	2	Koliganek K-12	Koliganek	CAEC
Bristol Bay Native Corp	2	Manokotak K-12 School	Manokotak	CAEC
Bristol Bay Native Corp	2	Newhalen K-12	Newhalen	CAEC
Bristol Bay Native Corp	2	Nondalton K-12	Nondalton	CAEC
Bristol Bay Native Corp	2	Perryville K-12	Perryville	CAEC
Bristol Bay Native Corp	2	Tanalian K-12	Tanalian	CAEC
Bristol Bay Native Corp	2	Twin Hills K-12	Twin Hills	CAEC
Calista	3	Mountain Village Community Ctr	Mountain Village	NORTECH
Calista	3	Aniak High School	Aniak	NORTECH
Calista	3	Auntie Mary Nicoli Elementary	Aniak	NORTECH
Calista	3	Crow Village Sam School	Chuathbaluk	NORTECH
Calista	3	Hooper Bay K-12 School	Hooper Bay	NORTECH
Calista	3	Kotlik K-12 School	Kotlik	NORTECH
Calista	3	Zachar Levi School	Lower Kalskag	NORTECH
Calista	3	Ignatius Beans School	Mountain Village	NORTECH
Calista	3	Russian Mission K12 School	Russian Mission	NORTECH
Calista	3	Scammon Bay K12 School	Scammon Bay	NORTECH
Calista	3	Jack Egnaty Sr. School	Sleetmute	NORTECH
Calista	3	Gusty Michael School	Stony River	NORTECH
Calista	3	Lower Yukon SD Main Office	Mountain Village	NORTECH
Calista	3	Kuspuk School District Office	Aniak	NORTECH
Calista	3	Bethel City Hall	Bethel	NORTECH
Calista	3	Bethel Courthouse	Bethel	NORTECH
Calista	3	Mountain Village City Office	Mountain Village	NORTECH
Calista	3	City of Hooper Bay Public Safety	Hooper Bay	NORTECH
Calista	3	Bethel City Shop	Bethel	NORTECH
Calista	3	Hooper Bay Washeteria	Hooper Bay	NORTECH
CIRI - ANC Borough only	2	Airport Heights ES	Anchorage	CAEC
CIRI - ANC Borough only	2	Bartlett Pool	Anchorage	CAEC
CIRI - ANC Borough only	2	Baxter Elementary School	Anchorage	CAEC

CIRI - ANC Borough only	2	Bayshore Elementary School	Anchorage	CAEC
CIRI - ANC Borough only	2	Bear Valley ES	Anchorage	CAEC
CIRI - ANC Borough only	2	Benson High School	Anchorage	CAEC
CIRI - ANC Borough only	2	Bowman Elementary School	Anchorage	CAEC
CIRI - ANC Borough only	2	Chinook Elementary	Anchorage	CAEC
CIRI - ANC Borough only	2	East High School	Anchorage	CAEC
CIRI - ANC Borough only	2	Inlet View ES	Anchorage	CAEC
CIRI - ANC Borough only	2	Kasuun ES	Anchorage	CAEC
CIRI - ANC Borough only	2	Klatt Elementary School	Anchorage	CAEC
CIRI - ANC Borough only	2	Mountain View ES	Anchorage	CAEC
CIRI - ANC Borough only	2	Muldoon ES	Anchorage	CAEC
CIRI - ANC Borough only	2	Northwood ABC School	Anchorage	CAEC
CIRI - ANC Borough only	2	O Malley Elementary School	Anchorage	CAEC
CIRI - ANC Borough only	2	Rabbit Creek Elementary School	Anchorage	CAEC
CIRI - ANC Borough only	2	Rogers Park Elementary School	Anchorage	CAEC
CIRI - ANC Borough only	2	SAVE Alternative High School	Anchorage	CAEC
CIRI - ANC Borough only	2	Service High School Pool	Anchorage	CAEC
CIRI - ANC Borough only	2	Service High School, 9-12	Anchorage	CAEC
CIRI - ANC Borough only	2	West High School Pool	Anchorage	CAEC
CIRI - ANC Borough only	2	Birchwood ES	Chugiak	CAEC
CIRI - ANC Borough only	2	Chugiak High School	Chugiak	CAEC
CIRI - ANC Borough only	2	Girdwood School	Girdwood	CAEC
CIRI - ANC Borough only	2	Martin Luther King Career Ctr	Anchorage	CAEC
CIRI - ANC Borough only	2	Student Nutrition Ctr	Anchorage	CAEC
CIRI - ANC Borough only	2	Anchorage Senior Ctr	Anchorage	CAEC
CIRI - ANC Borough only	2	Chugiak Senior Ctr	Chugiak	CAEC
CIRI - ANC Borough only	2	Transit Admin Building	Anchorage	CAEC
CIRI - ANC Borough only	2	Combined MOA Transit Maintenance Building and Paratransit Admin Building	Anchorage	CAEC
CIRI - ANC Borough only	2	ASD Operations Building	Anchorage	CAEC
CIRI - ANC Borough only	2	Loussac Library	Anchorage	CAEC
CIRI - ANC Borough only	2	Ben Boeke Ice Arena	Anchorage	CAEC
CIRI - ANC Borough only	2	Dempsey Anderson Ice Arena	Anchorage	CAEC
CIRI - ANC Borough only	2	Fairview Community Recreation Ctr (Old and New Combined)	Anchorage	CAEC
CIRI - ANC Borough only	2	Mt View Community Recreation Ctr	Anchorage	CAEC
CIRI - ANC Borough only	2	Spenard Recreation Ctr	Anchorage	CAEC
CIRI - ANC Borough only	2	Sullivan Arena	Anchorage	CAEC
CIRI - ANC Borough only	2	Anchorage Police Dept Headquarters Building	Anchorage	CAEC
CIRI - ANC Borough only	2	APD Training / MISD	Anchorage	CAEC

CIRI - ANC Borough only	2	Fire Station #11	Eagle River	CAEC
CIRI - ANC Borough only	2	Fire Station #1 & Fire Station Admin Offices	Anchorage	CAEC
CIRI - ANC Borough only	2	Fire Station #12 and Dispatch	Anchorage	CAEC
CIRI - ANC Borough only	2	ASD Facility Maintenance Building	Anchorage	CAEC
CIRI - ANC Borough only	2	ASD Bus Garage	Anchorage	CAEC
CIRI - ANC Borough only	2	New Transit Maintenance Building	Anchorage	CAEC
CIRI - ANC Borough only	2	Northwood Street Maintenance	Anchorage	CAEC
CIRI - ANC Borough only	2	ASD Warehouse	Anchorage	CAEC
CIRI - outside ANC Borough	2	Chapman Elementary School	Anchor Point	CAEC
CIRI - outside ANC Borough	2	Homer High School	Homer	CAEC
CIRI - outside ANC Borough	2	Paul Banks Elementary	Homer	CAEC
CIRI - outside ANC Borough	2	West Homer Elementary	Homer	CAEC
CIRI - outside ANC Borough	2	Hope Elementary/High School	Hope	CAEC
CIRI - outside ANC Borough	2	Houston High School	Houston	CAEC
CIRI - outside ANC Borough	2	Kenai Central High School	Kenai	CAEC
CIRI - outside ANC Borough	2	Kenai Elementary	Kenai	CAEC
CIRI - outside ANC Borough	2	Kenai Middle School	Kenai	CAEC
CIRI - outside ANC Borough	2	Moose Pass School	Moose Pass	CAEC
CIRI - outside ANC Borough	2	Nikiski NS Elementary School	Nikiski	CAEC
CIRI - outside ANC Borough	2	Nikolaevsk	Nikolaevsk	CAEC
CIRI - outside ANC Borough	2	Palmer High School	Palmer	CAEC
CIRI - outside ANC Borough	2	Port Graham	Homer	CAEC
CIRI - outside ANC Borough	2	Susan B. English School	Seldovia	CAEC
CIRI - outside ANC Borough	2	Seward High School	Seward	CAEC
CIRI - outside ANC Borough	2	Ninilchik School	Soldotna	CAEC
CIRI - outside ANC Borough	2	Redoubt Elementary School	Soldotna	CAEC
CIRI - outside ANC Borough	2	Skyview High School	Soldotna	CAEC
CIRI - outside ANC Borough	2	Soldotna Elementary School	Soldotna	CAEC
CIRI - outside ANC Borough	2	Soldotna High School	Soldotna	CAEC
CIRI - outside ANC Borough	2	Sterling Elementary	Sterling	CAEC
CIRI - outside ANC Borough	2	Glacier View K-12	Sutton	CAEC
CIRI - outside ANC Borough	2	Talkeetna Elementary School	Talkeetna	CAEC
CIRI - outside ANC Borough	2	Trapper Creek Elementary School	Trapper Creek	CAEC
CIRI - outside ANC Borough	2	Wasilla HS	Wasilla	CAEC
CIRI - outside ANC Borough	2	Kenai Senior Ctr	Kenai	CAEC
CIRI - outside ANC Borough	2	Vintage Point	Kenai	CAEC
CIRI - outside ANC Borough	2	City Hall	Kenai	CAEC
CIRI - outside ANC Borough	2	MSBSD - Palmer Admin Office (Post Improvements)	Palmer	CAEC
CIRI - outside ANC Borough	2	KPB Admin Building	Soldotna	CAEC

CIRI - outside ANC Borough	2	Soldotna City Hall	Soldotna	CAEC
CIRI - outside ANC Borough	2	Palmer Public Library	Palmer	CAEC
CIRI - outside ANC Borough	2	Soldotna Public Library	Soldotna	CAEC
CIRI - outside ANC Borough	2	North Peninsula Recreation Ctr	Kenai	CAEC
CIRI - outside ANC Borough	2	Palmer MTA Ice Arena	Palmer	CAEC
CIRI - outside ANC Borough	2	Soldotna Sports Ctr	Soldotna	CAEC
CIRI - outside ANC Borough	2	Recreation Ctr	Kenai	CAEC
CIRI - outside ANC Borough	2	Kenai Airport Terminal	Kenai	CAEC
CIRI - outside ANC Borough	2	Public Safety Building	Kenai	CAEC
CIRI - outside ANC Borough	2	Mackey Lake Fire Substation	Soldotna	CAEC
CIRI - outside ANC Borough	2	Soldotna Fire Station	Soldotna	CAEC
CIRI - outside ANC Borough	2	Soldotna Police Station	Soldotna	CAEC
CIRI - outside ANC Borough	2	Sterling Fire Substation	Soldotna	CAEC
CIRI - outside ANC Borough	2	Wasilla Police Station	Wasilla	CAEC
CIRI - outside ANC Borough	2	City of Soldotna Maintenance Garage	Soldotna	CAEC
CIRI - outside ANC Borough	2	KPB School District Warehouse and Storage	Soldotna	CAEC
Doyon - FBKS NS Borough only	3	Anderson Elementary	Eielson AFB	NORTECH
Doyon - FBKS NS Borough only	3	Ben Eeilson Jr/Sr High School	Eielson AFB	NORTECH
Doyon - FBKS NS Borough only	3	Crawford Elementary	Eielson AFB	NORTECH
Doyon - FBKS NS Borough only	3	Anne Wein Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Arctic Light Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Barnette Magnet School	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Denali Elementary School	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Hunter Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Hutchison High	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Joy Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Ladd Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Lathrop High School	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Nordale Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Pearl Creek Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Randy Smith Middle School	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Salcha Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Tanana Middle School	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Two Rivers Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	University Park Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Weller Elementary	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Weller Module	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	West Valley High School	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Wood River Elementary	Fairbanks	NORTECH

Doyon - FBKS NS Borough only	3	Badger Elementary	North Pole	NORTECH
Doyon - FBKS NS Borough only	3	North Pole Elementary	North Pole	NORTECH
Doyon - FBKS NS Borough only	3	North Pole High School	North Pole	NORTECH
Doyon - FBKS NS Borough only	3	North Pole Middle School	North Pole	NORTECH
Doyon - FBKS NS Borough only	3	Ticasuk Brown Elementary	North Pole	NORTECH
Doyon - FBKS NS Borough only	3	Wescott Pool	North Pole	NORTECH
Doyon - FBKS NS Borough only	3	Fairbanks NS Borough School District Administrative Ctr	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Fairbanks City Hall	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	FNSB Administrative Office	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Hamme Pool	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Big Dipper	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Carlson Ctr	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Fairbanks Main Fire Station	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Fairbanks Police Station	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Fire Station 3	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Fire Training Ctr	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Old City Hall	Fairbanks	NORTECH
Doyon - FBKS NS Borough only	3	Public Works Facility	Fairbanks	NORTECH
Doyon - outside FBKS NS Borough	3	GILA Auto Shop	Galena	NORTECH
Doyon - outside FBKS NS Borough	3	Allakaket School	Allakaket	NORTECH
Doyon - outside FBKS NS Borough	3	Anderson School	Anderson	NORTECH
Doyon - outside FBKS NS Borough	3	Blackwell Pre-12 School	Anvik	NORTECH
Doyon - outside FBKS NS Borough	3	Arctic Village School	Arctic Village	NORTECH
Doyon - outside FBKS NS Borough	3	Beaver School (Cruikshank)	Beaver	NORTECH
Doyon - outside FBKS NS Borough	3	Delta Elementary	Delta Junction	NORTECH
Doyon - outside FBKS NS Borough	3	Delta High School	Delta Junction	NORTECH
Doyon - outside FBKS NS Borough	3	Fort Greely School	Fort Greely	NORTECH
Doyon - outside FBKS NS Borough	3	GILA Composite	Galena	NORTECH
Doyon - outside FBKS NS Borough	3	GILA Gymnasium	Galena	NORTECH
Doyon - outside FBKS NS Borough	3	GILA Iditarod Hall	Galena	NORTECH
Doyon - outside FBKS NS Borough	3	Sidney Huntington Elementary	Galena	NORTECH
Doyon - outside FBKS NS Borough	3	Sidney Huntington Jr-Sr High School	Galena	NORTECH
Doyon - outside FBKS NS Borough	3	David-Louis Memorial School	Grayling	NORTECH
Doyon - outside FBKS NS Borough	3	Cantwell School	Healy	NORTECH
Doyon - outside FBKS NS Borough	3	Tri Valley School	Healy	NORTECH
Doyon - outside FBKS NS Borough	3	Holy Cross School	Holy Cross	NORTECH
Doyon - outside FBKS NS Borough	3	Huslia Elementary/High School	Huslia	NORTECH
Doyon - outside FBKS NS Borough	3	Kaltag School	Kaltag	NORTECH
Doyon - outside FBKS NS Borough	3	McGrath School	Mcgrath	NORTECH

Doyon - outside FBKS NS Borough	3	Nenana City School	Nenana	NORTECH
Doyon - outside FBKS NS Borough	3	Top of the Kuskokwim School	Nikolai	NORTECH
Doyon - outside FBKS NS Borough	3	Walter Northway School	Northway	NORTECH
Doyon - outside FBKS NS Borough	3	Nulato School	Nulato	NORTECH
Doyon - outside FBKS NS Borough	3	Ruby School	Ruby	NORTECH
Doyon - outside FBKS NS Borough	3	Innoko River School	Shageluk	NORTECH
Doyon - outside FBKS NS Borough	3	Tanacross School	Tanacross	NORTECH
Doyon - outside FBKS NS Borough	3	Maudrey J. Sommer K12 School	Tanana	NORTECH
Doyon - outside FBKS NS Borough	3	Tok Athletic Facility	Tok	NORTECH
Doyon - outside FBKS NS Borough	3	Tok School	Tok	NORTECH
Doyon - outside FBKS NS Borough	3	John Fredson School	Venetie	NORTECH
Doyon - outside FBKS NS Borough	3	Denali Borough School District Office	Healy	NORTECH
Doyon - outside FBKS NS Borough	3	IASD District Office	Mcgrath	NORTECH
Doyon - outside FBKS NS Borough	3	Anderson City Hall	Anderson	NORTECH
Doyon - outside FBKS NS Borough	3	Delta Junction City Hall	Delta Junction	NORTECH
Doyon - outside FBKS NS Borough	3	Nenana City Hall	Nenana	NORTECH
Doyon - outside FBKS NS Borough	3	Delta Public Works/Rescue Squad	Delta Junction	NORTECH
Doyon - outside FBKS NS Borough	3	Nenana Civic Ctr	Nenana	NORTECH
Doyon - outside FBKS NS Borough	3	Delta Junction Fire Station	Delta Junction	NORTECH
Doyon - outside FBKS NS Borough	3	Anderson Fire and Public Works	Anderson	NORTECH
Doyon - outside FBKS NS Borough	3	Nenana Fire Hall	Nenana	NORTECH
Doyon - outside FBKS NS Borough	3	GILA Headquarters	Galena	NORTECH
Koniag	2	Chiniak School	Chiniak	CAEC
Koniag	2	East Elementary School	Kodiak	CAEC
Koniag	2	Kodiak Middle School	Kodiak	CAEC
Koniag	2	Main Elementary School	Kodiak	CAEC
Koniag	2	Peterson Elementary School	Kodiak	CAEC
Koniag	2	Larsen Bay School	Larsen Bay	CAEC
Koniag	2	Ouzinkie School	Ouzinkie	CAEC
Koniag	2	Kodiak Island Borough Admin Bldg	Kodiak	CAEC
Koniag	2	Bayside Fire Station	Kodiak	CAEC
Koniag	2	Women's Bay Volunteer Fire Dept	Kodiak	CAEC
NANA Regional Corporation	4	Alaska Technical Ctr Dormitory	Kotzebue	RSA, PE, LLC
NANA Regional Corporation	4	Buckland School	Buckland	RSA, PE, LLC
Sealaska Corp - Juneau only	1	Dzantiki Heeni Middle School	Juneau	AEE
Sealaska Corp - Juneau only	1	Floyd Dryden Junior High School	Juneau	AEE
Sealaska Corp - Juneau only	1	Juneau Douglas High School	Juneau	AEE
Sealaska Corp - Juneau only	1	Mendenhall River Elementary School	Juneau	AEE
Sealaska Corp - Juneau only	1	Riverbend Elementary	Juneau	AEE

Sealaska Corp - Juneau only	1	Thunder Mountain High School	Juneau	AEE
Sealaska Corp - Juneau only	1	Bartlett Hospital	Juneau	AEE
Sealaska Corp - Juneau only	1	Municipal Building	Juneau	AEE
Sealaska Corp - Juneau only	1	Juneau Airport Terminal	Juneau	AEE
Sealaska Corp - Juneau only	1	Augustus Brown Pool	Juneau	AEE
Sealaska Corp - Juneau only	1	Centennial Hall	Juneau	AEE
Sealaska Corp - Juneau only	1	Juneau Police Dept	Juneau	AEE
Sealaska Corp - Juneau only	1	Capital Transit Bus Barn	Juneau	AEE
Sealaska Corp - Juneau only	1	Hazmat/Salt Storage	Juneau	AEE
Sealaska Corp - outside Juneau	1	Craig High School	Craig	AEE
Sealaska Corp - outside Juneau	1	Hoonah City Schools	Hoonah	AEE
Sealaska Corp - outside Juneau	1	Hoonah Gym and Pool	Hoonah	AEE
Sealaska Corp - outside Juneau	1	Hydaburg Elementary School	Hydaburg	AEE
Sealaska Corp - outside Juneau	1	Kake Schools	Kake	AEE
Sealaska Corp - outside Juneau	1	Pelican City K-12 School	Pelican	AEE
Sealaska Corp - outside Juneau	1	Petersburg Middle/High School	Petersburg	AEE
Sealaska Corp - outside Juneau	1	Sitka High School	Sitka	AEE
Sealaska Corp - outside Juneau	1	Skagway K-12 School	Skagway	AEE
Sealaska Corp - outside Juneau	1	Wrangell High School	Wrangell	AEE
Sealaska Corp - outside Juneau	1	Yakutat Jr. Sr. High School	Yakutat	AEE
Sealaska Corp - outside Juneau	1	Ketchikan High School	Ketchikan	AEE
Sealaska Corp - outside Juneau	1	Mt. Edgecumbe Cafeteria, Bldg 290	Sitka	AEE
Sealaska Corp - outside Juneau	1	Mt. Edgecumbe Gym and Classrooms, Bldg 1331	Sitka	AEE
Sealaska Corp - outside Juneau	1	Petersburg Medical Ctr	Petersburg	AEE
Sealaska Corp - outside Juneau	1	Sawmill Cove Admin Building	Sitka	AEE
Sealaska Corp - outside Juneau	1	Treadwell Ice Arena	Douglas	AEE
Sealaska Corp - outside Juneau	1	Metlakatla Activity Ctr	Metlakatla	AEE
Sealaska Corp - outside Juneau	1	Thorne Bay Gym	Thorne Bay	AEE
Sealaska Corp - outside Juneau	1	Wrangell Pool	Wrangell	AEE
Sealaska Corp - outside Juneau	1	Douglas Fire Hall/Library	Douglas	AEE
Sealaska Corp - outside Juneau	1	Mt. Edgecumbe High School Girls Dorm, Bldg. 293	Sitka	AEE
Sealaska Corp - outside Juneau	1	Douglas Shop	Douglas	AEE
Sealaska Corp - outside Juneau	1	Mt Jumbo Shop/Gym	Douglas	AEE

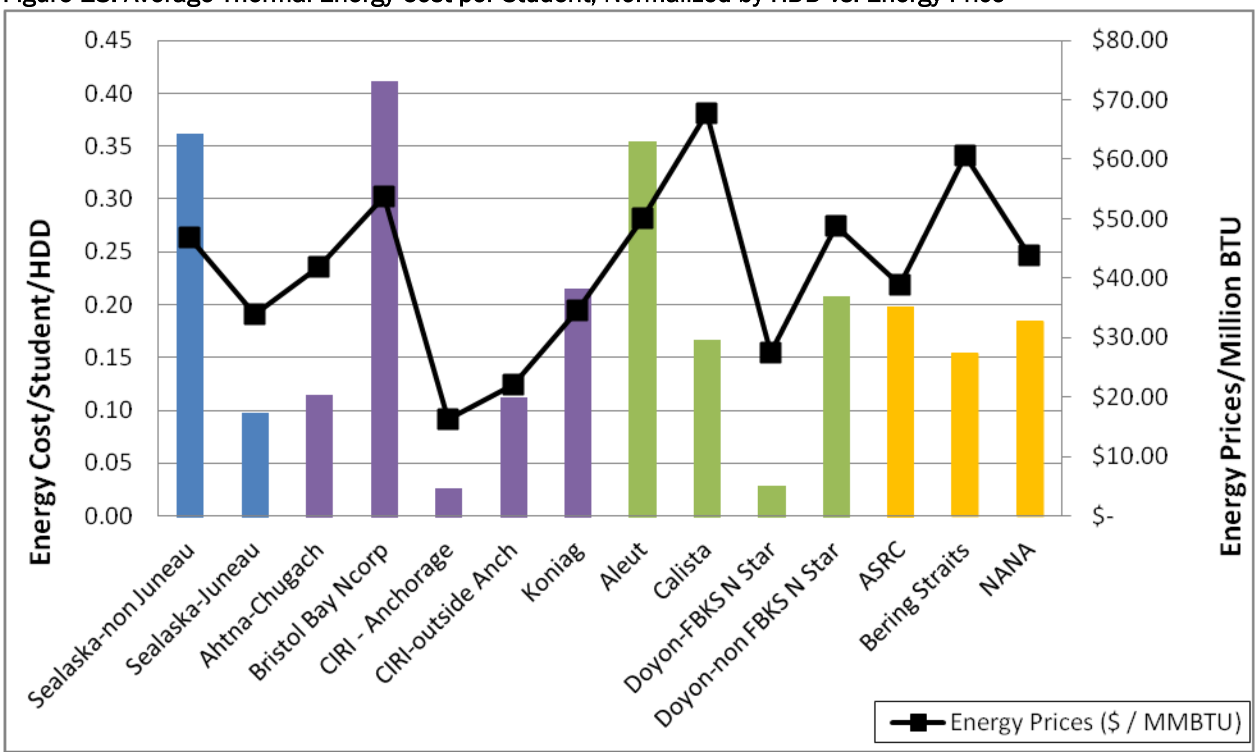
Appendix H
Education Facility Statistical Analysis Details

Please note: This section is meant to provide supporting details for the CCHRC **Case Study: Energy Usage and Costs in Audited Schools**—it is not intended as a stand-alone section.

1. Energy Prices

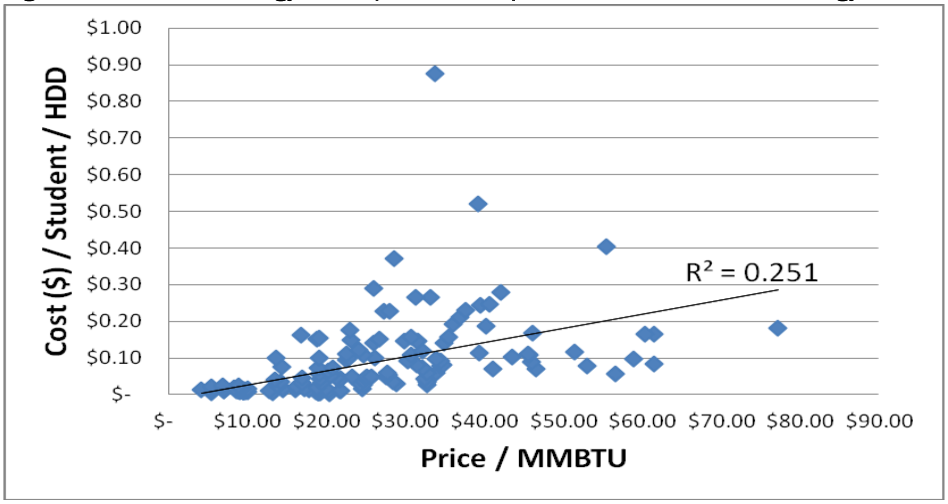
Part of the difference in school energy costs between regions is likely based on varying energy prices. Figure 18 shows the cost per million BTUs[21] of energy consumed (including space heating, cooling, and hot water heating) compared with the average energy cost per student for each HDD. While there appears to be some slight correlation between these variables, it is not consistent as can be seen in the scatter plot in Figure 19 on the following page. Thus, while energy prices will have some effect on average energy costs per student regionally, it doesn't appear to be the main driving factor.

Figure 18: Average Thermal Energy Cost per Student, Normalized by HDD vs. Energy Price



[21] British Thermal Units: The amount of energy required to raise the temperature of one pound of water one degree Fahrenheit. For reference one gallon of fuel oil contains between 130,000 and 140,000 BTUs

Figure 19: Thermal Energy Costs per student per HDD versus Price of Energy

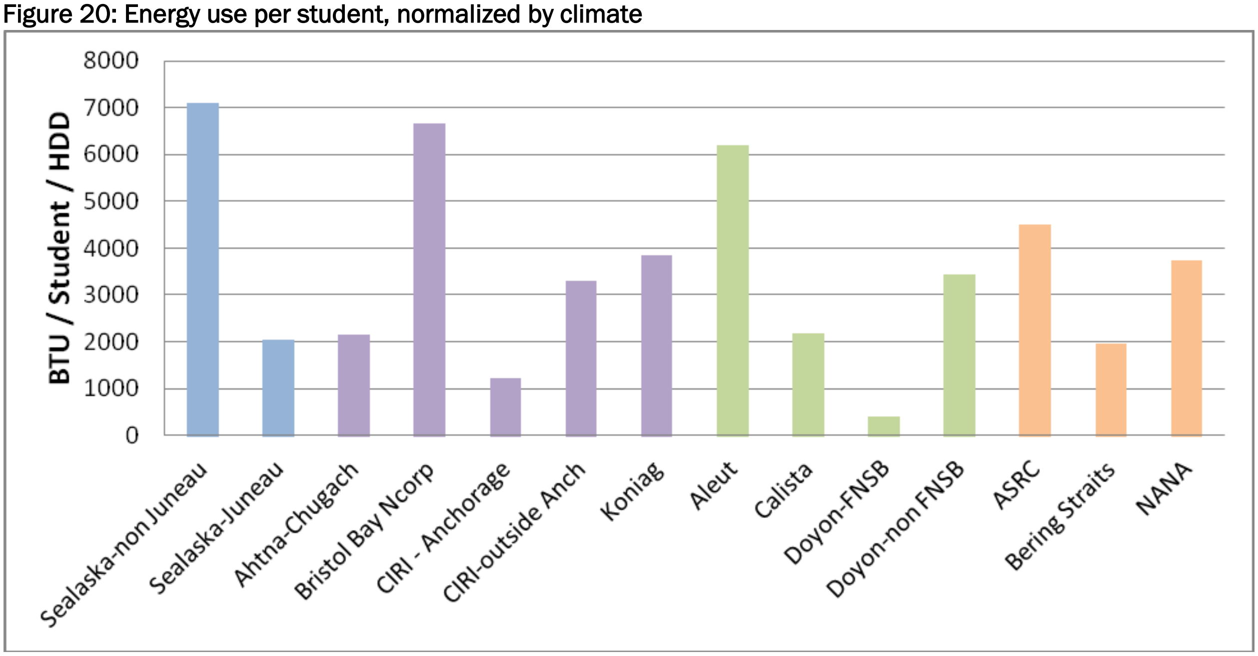


Each data point represents one school. Upper bound outlier audit data points have been thoroughly reviewed and validated.

2. Average Energy Consumption per Student

Since energy prices do not appear to be the primary factor driving costs per student, CCHRC analyzed the thermal energy consumption per student normalized by HDDs, which then removes the effect of varying energy prices. The following graph shows that there are significant differences between ANCSA geographic regions, with schools outside of Juneau in the Sealaska region on average using over *fourteen times* as much energy per student as schools in the Fairbanks North Star Borough.

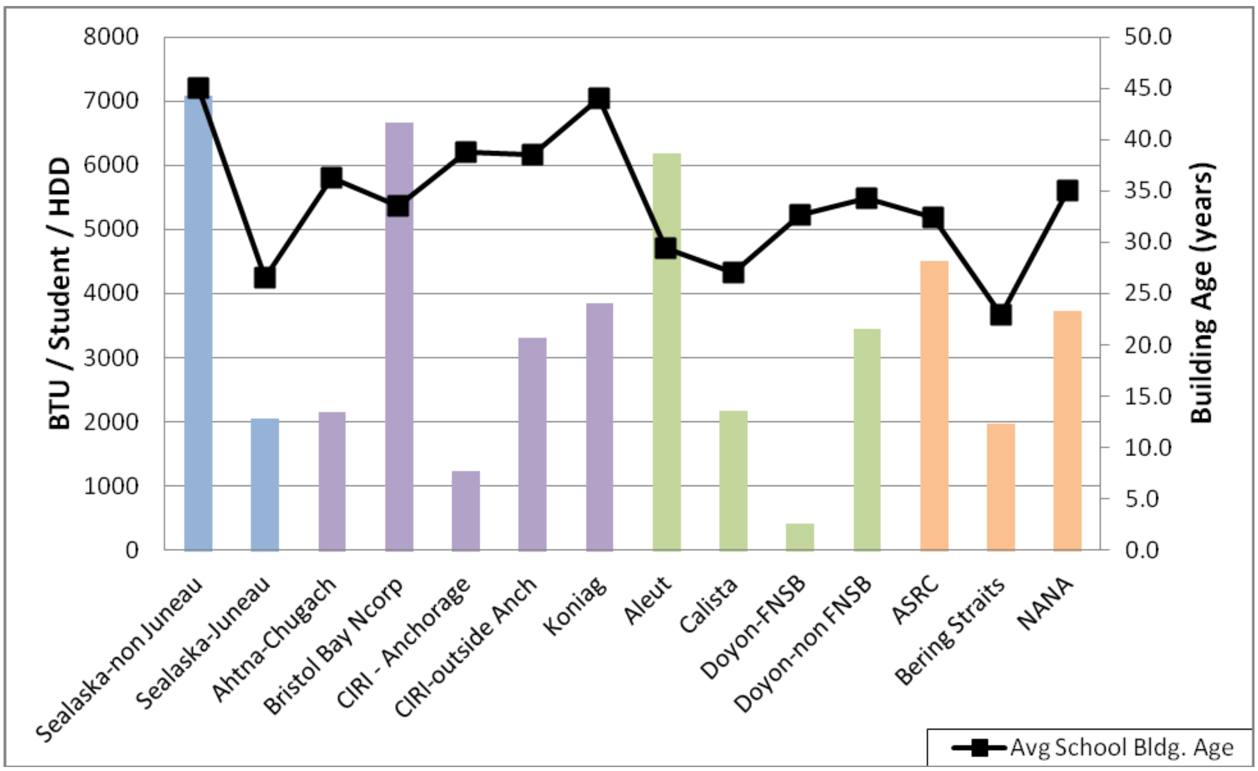
Figure 20: Energy use per student, normalized by climate



3. Building Age

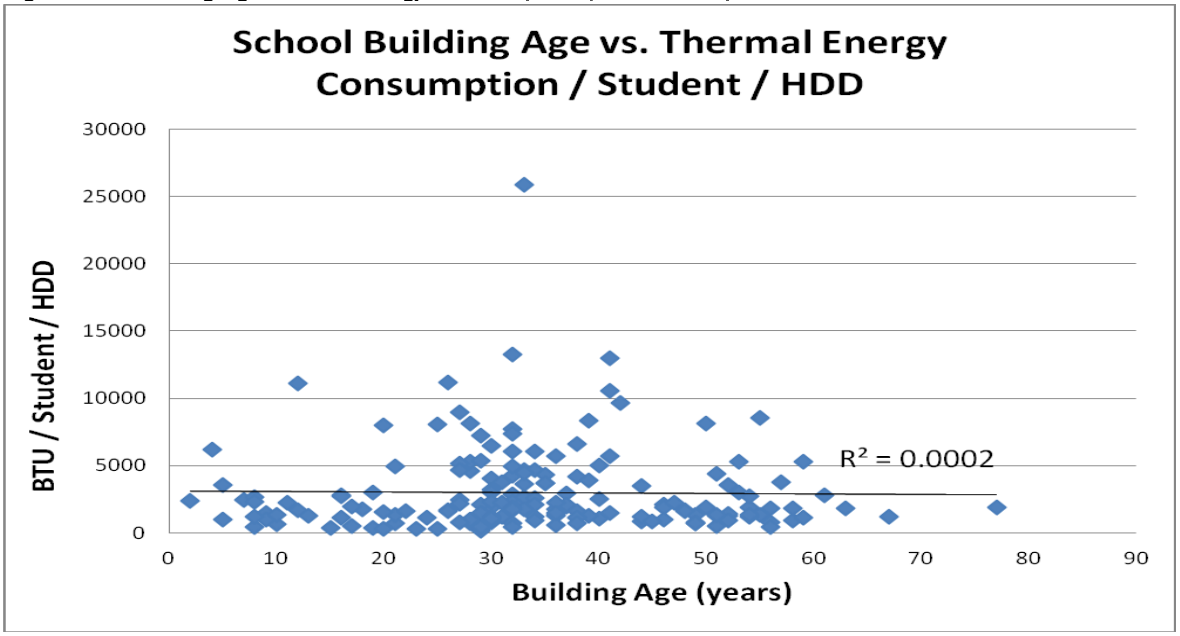
Building age is often correlated with energy efficiency, as over time new technologies and practices have developed that can reduce energy consumption[22]. Thus, the age of schools in a region was a strong candidate for explaining the differences in average energy consumption per student between regions; if urban schools were on average built more recently than rural schools, it would be expected that they would use less energy. However, the Figures 21 and 22 show that there is very little correlation between the average age of schools in a region and the amount of energy consumed per student.

Figure 21: Building Age versus Energy Consumption per student per HDD



22 Examples include better insulation, tighter buildings, better windows, more efficient motors, boilers, and lighting, as well as more sophisticated controls.

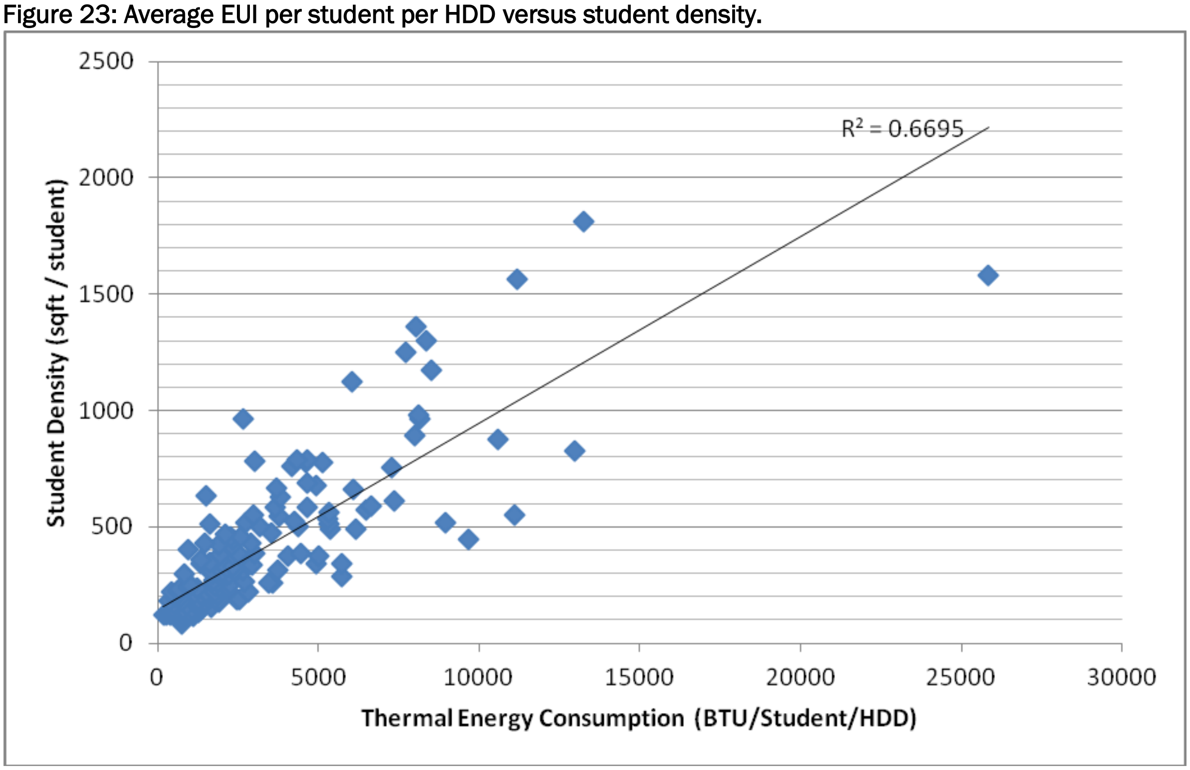
Figure 22: Building Age versus Energy Consumption per student per HDD Scatter Plot



Each data point represents one school. Upper bound outlier audit data points have been thoroughly reviewed and validated.

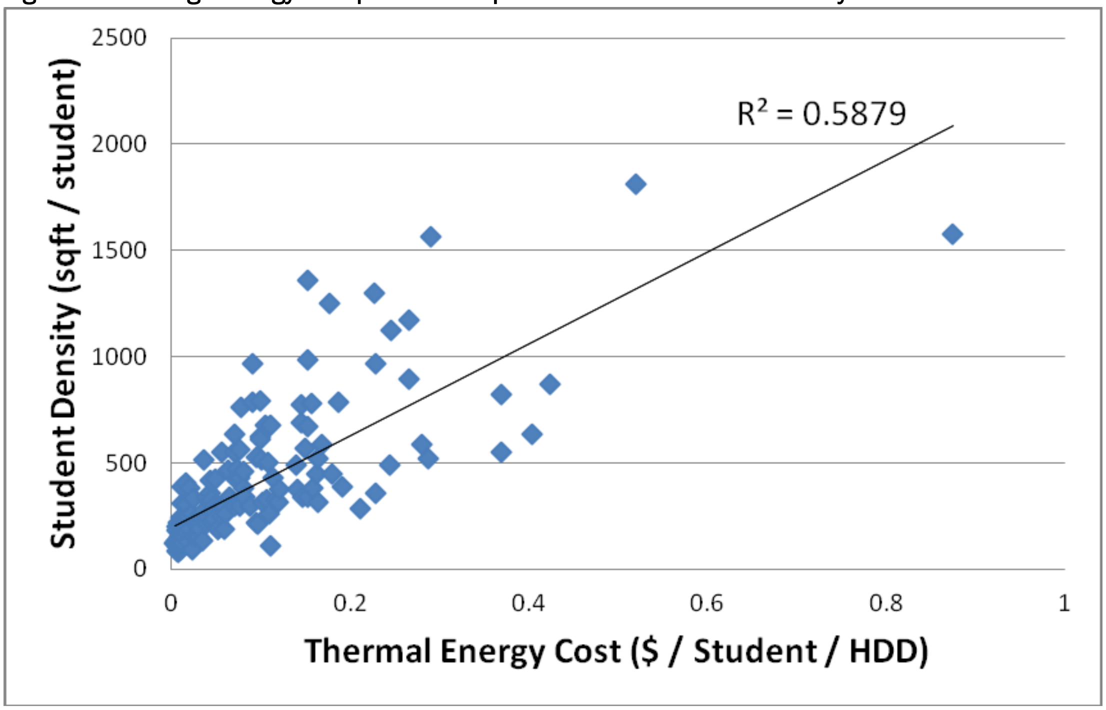
This lack of correlation between building age and energy consumption suggests that there is some other factor that is driving energy consumption per student.

Figure 23: Average EUI per student per HDD versus student density.



Each data point represents one school. Upper bound outlier audit data points have been thoroughly reviewed and validated.

Figure 24: Average energy cost per student per HDD versus student density



Each data point represents one school. Upper bound outlier audit data points have been thoroughly reviewed and validated.

Figure 25: Average thermal energy cost per student per HDD versus student density – by ANCSA geographic Region

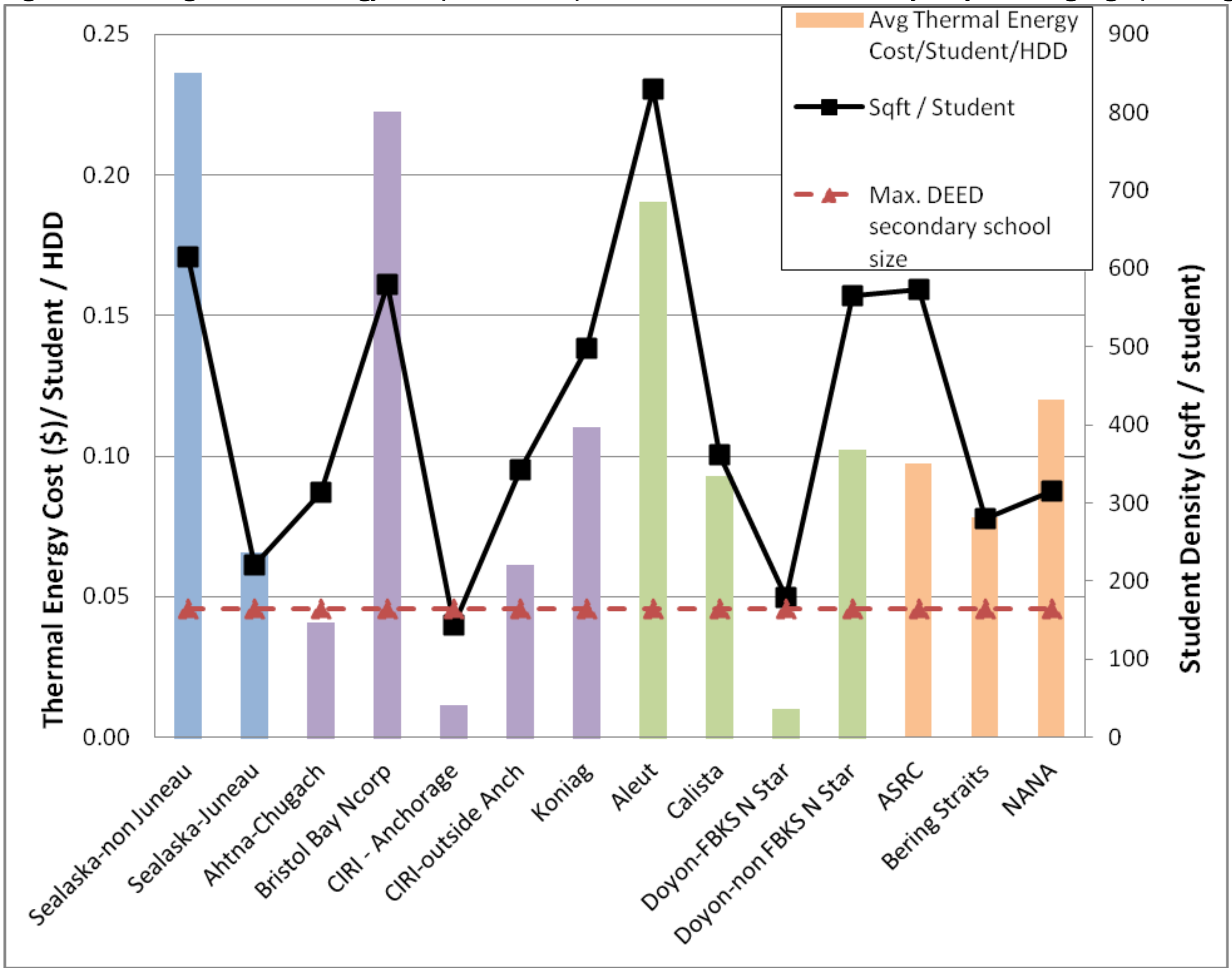
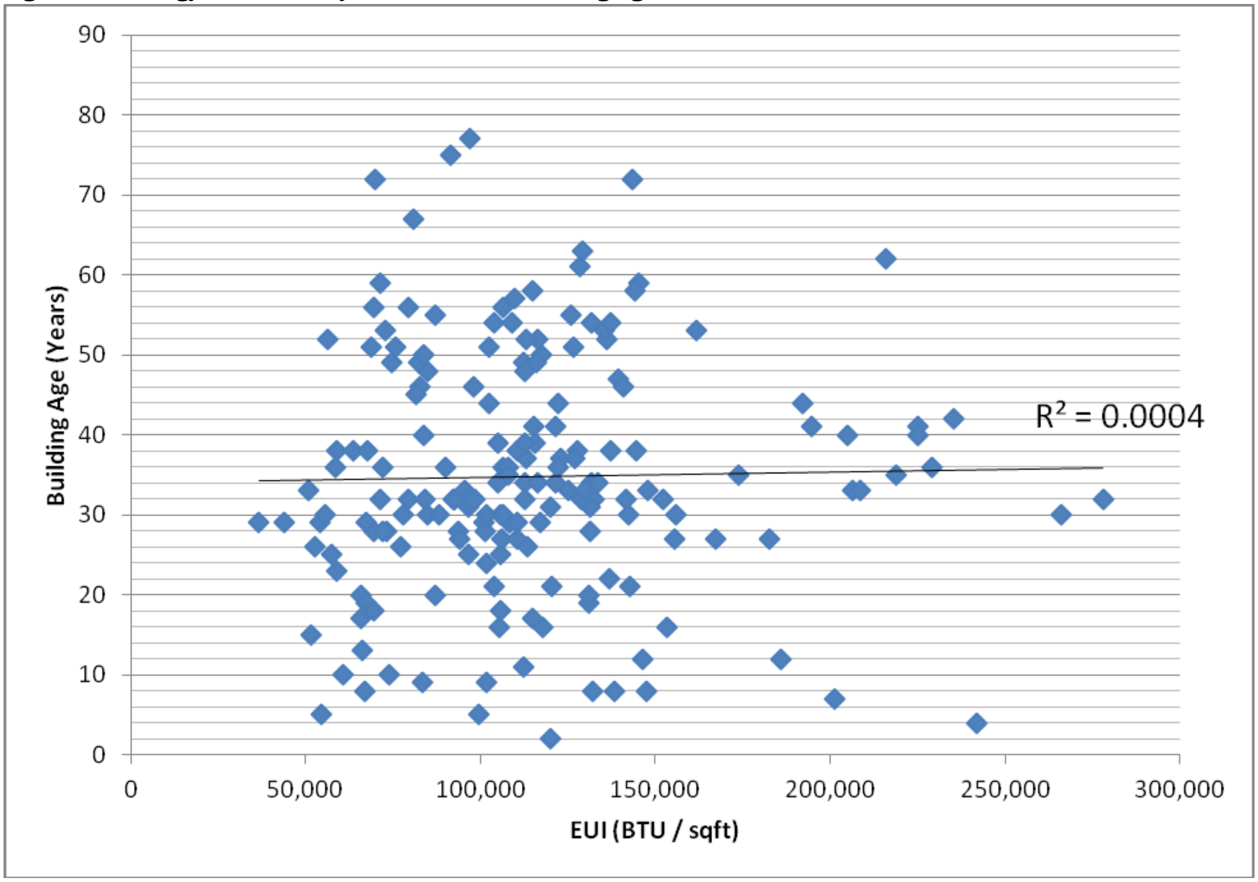
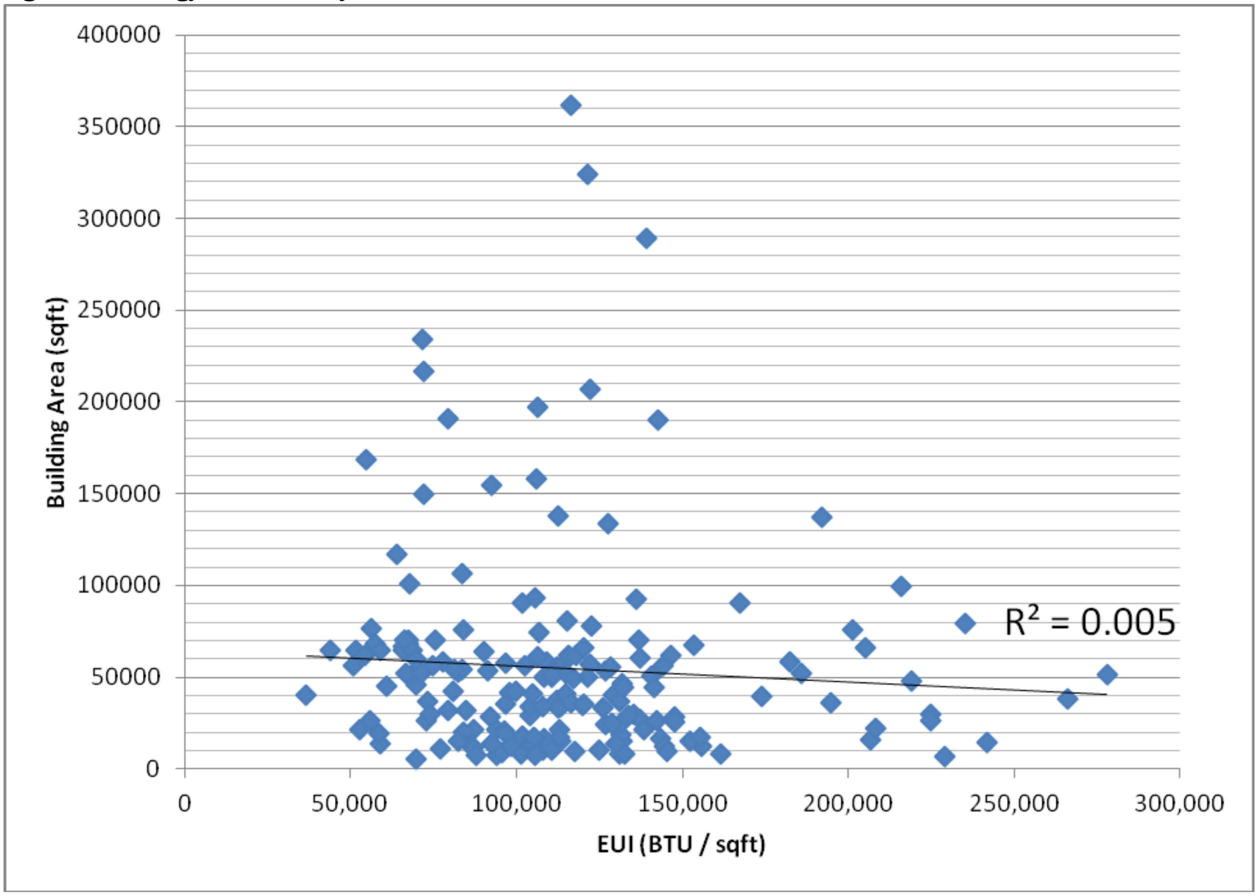


Figure 26: Energy Use Intensity of Schools vs. Building Age



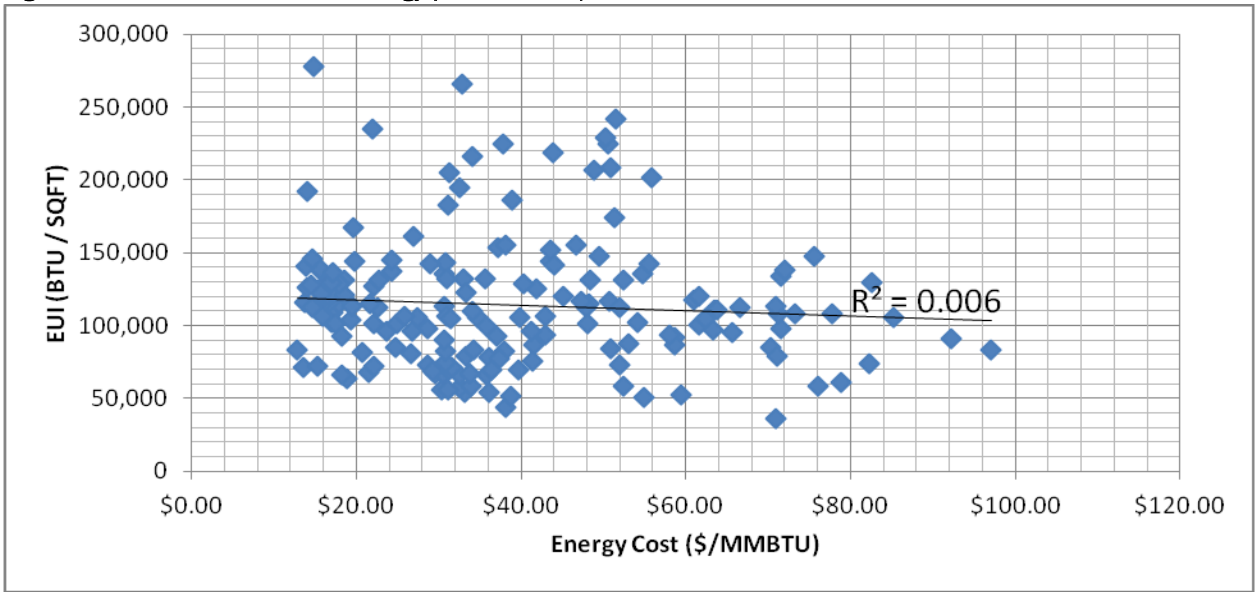
An R^2 value of 1 indicates perfect correlation. In this case, the R^2 value of 0.0004 indicates very little correlation.

Figure 27: Energy Use Intensity of Schools vs. School Size



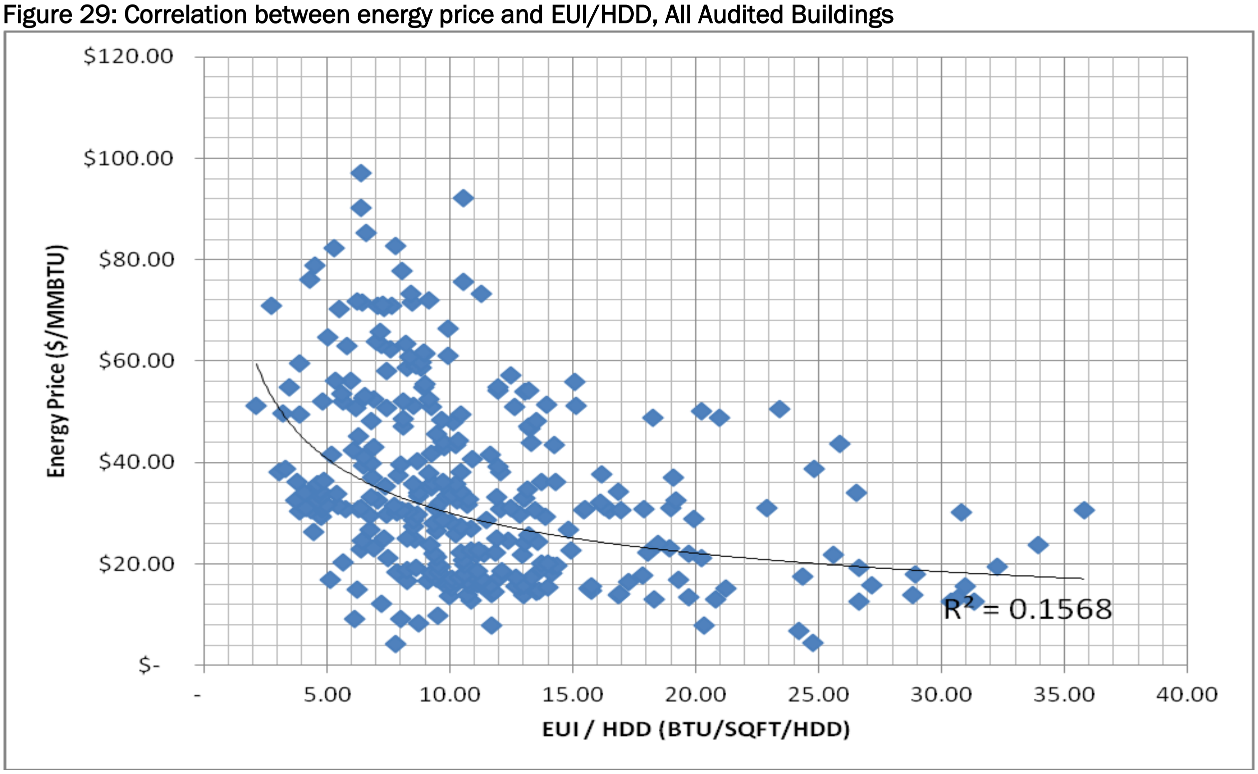
An R^2 value of 1 indicates perfect correlation. In this case, the R^2 value of 0.005 indicates very little correlation.

Figure28: Correlation between energy price and EUI/HDD, Schools ONLY



Each point represents one of the audited buildings. An R^2 value of 1 indicates perfect correlation. In this case, the R^2 value of 0.006 indicates very little correlation.

Figure 29: Correlation between energy price and EUI/HDD, All Audited Buildings



Each point represents one of the audited buildings. An R^2 value of 1 indicates perfect correlation. In this case, the R^2 value of 0.1568 indicates only a slight correlation. Outlier data was cleaned from this graph, and an exponential line of best fit was used as it appeared to model the data better than a linear line.

Appendix I
Acronym and Abbreviation Reference List

Acronym and Abbreviation Reference List

24/7	24 hours a day, 7 days a week
°F	degrees Fahrenheit
AEE	Alaska Energy Engineering, LLC
AEERLP	Alaska Energy Efficiency Revolving Loan Program
AGF	Exposed floor
AHFC	Alaska Housing Finance Corporation
AHU	air-handling units
AkWarm-C	AkWarm-Commercial
ANCSA	Alaska Native Claims Settlement Act
ASD	Anchorage School District
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ARIS	Alaska Retrofit Information System
ARRA	American Recovery and Reinvestment Act
ASRC	Arctic Slope Regional Corporation
BTU	British Thermal Unit
CAEC	Central Alaska Engineering Company
CCF	centum (100) cubic feet
CCHRC	Cold Climate Housing Research Center
CEA	Certified Energy Auditor
CEM	Certified Energy Manager
CFM	cubic feet per minute
Challenge	Great Alaska Energy Challenge
CIRI	Cook Inlet Regional, Inc.
CIP	Capital Improvement Project
CO_2	carbon dioxide
CWA	ceiling with attic
DDC	direct digital control
DEED	Department of Education and Early Development
DOE	Department of Energy
ECI	Energy Cost Index
EEM	energy efficiency measure
EIA	Energy Information Administration
EPA	Environmental Protection Agency

EPC	Energy Performance Contractor or Contract
ESCO	Energy Service Company
EUI	Energy Use Index
GPF	gallons per flush
GPM	gallons per minute
HDD	heating degree day
HID	high-intensity discharge
HOA	hand-off-auto
HPS	high-pressure sodium
IAQ	indoor air quality
IECC	International Energy Conservation Code
IES	Illuminating Engineer Society
IGA	Investment Grade Audit
kWh	kilowatt hour
LEED	Leadership in Energy and Environmental Design
LED	light emitting diode
MH	metal-halide
MMBTU	million BTUs
MUA	make-up Air
O&M	operation and maintenance
OSA	outside air
Paper	Energy Use in Alaska's Public Facilities White Paper
PPM	parts per million
REAA	Regional educational attendance area
REAL	Retrofit Energy Assessment for Loans
REAP	Renewable Energy Alaska Project
ROI	return on investment
RSA	RSA Engineering, Inc.
SD	school district
SF	square foot
SIR	saving to investment ratios
TSP	Technical Services Provider
VAV	variable air volume
VFD	variable frequency drive
VOC	volatile organic compounds

Appendix J
Glossary

Glossary

ASHRAE Level 2 Audit	An ASHRAE Level 2 audit includes the following: interviews with the building operator and managers, review of the building's utility bills, evaluation the building's energy systems to identify energy efficient improvements, quantification of energy consumption to baseline to identify seasonal variations, evaluation of all conditions that affect energy consumption and occupancy comfort, and development of a report that summarizes the findings and lists recommended energy efficiency measures (EEMs).
BTU	A British Thermal Unit is the amount of heat required to raise the temperature of one pound of liquid water by 1°F at a constant pressure of one atmosphere.
DDC	Direct digital control is the automated control of building processes such as heating and lighting via a device such as a computer. The building processes can be control *on-* or *off-* site.
Demand charge	Demand charge is the not the actual cost of the energy used, but the cost of having a required capacity available at all times. The demand charge is determined by the maximum demand required of a user during a defined period. Demand charges vary by the serving utility, according to their tariff.
Energy Cost Index (ECI)	The annual amount of money spent per square foot of building space for thermal and electrical energy. It should be noted that both the energy use index as well as the ECI index will be influenced by the differences in climate and size between buildings, as well as local energy costs.
Energy cost per student/HDD (schools only)	The energy cost for students in schools was derived by taking the total energy cost in a school, divided by the number of students and divided by the local heating degree days in the area (i.e.: energy cost/student/Heating Degree Day (HDD); similar to the benchmark data for criteria (d) above.
Energy use per student (schools only)	This is the total energy use per student per year for comparison to other schools. In order to normalize this data the total thermal energy use per student per year (excluding electricity use) is then divided by the number of HDD, to give energy use per student per year per HDD[23].
Energy Efficiency Measure (EEM)	An investment that provides a reduction in the energy costs and use in a building of an amount sufficient to recover the total cost of purchasing and installing such measure over an appropriate period of time.
Energy Use Index (EUI)	EUI is a measure of the annual amount of energy used in BTUs per square foot of building space. This figure is often used to compare the energy

[23] **Student Enrollment:** This value was provided by the Department of Education, and represented the *average* student enrollment of a given school over the school year

	consumption of buildings within similar climate zones.
HVAC	Heating, Ventilation, and Air-Conditioning
HDD (base 65)	Heating Degree Days are the number of degrees that the daily average temperature falls below 65° F.
Savings to Investment Ratio (SIR)	Savings over the life of an EEM divided by investment capital cost. Savings includes the total discounted dollar savings considered over the life of the improvement. Investment in the SIR calculation includes the labor and materials required to install the measure.
Low Hanging Fruit	Energy efficiency measure (EEMs) with minimal upfront costs, that can be implemented quickly and easily and that payback in typically a very short period of time.
Set Point	Target temperature that a control system operates the heating and cooling system.
Technical Service Provider (TSP)	A Technical Service Provider is the term used to define any of the four contractors under AHFC that performed or subcontracted for the performance of energy audits for the AHFC.