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Energy Efficiency of Public Buildings in Alaska: Schools

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The Cold Climate Housing Research Center (CCHRC) conducted an analysis of the energy use and energy costs of public schools in Alaska. The majorities of public schools in the state are represented in this analysis, with investment-grade energy audit[1] data for approximately 38% of schools and benchmarked utility data for an additional 29%.[2] Each year, $49 million in public monies are spent on energy for the 67% of schools analyzed in this data. The cost of energy for schools can be a burden to communities throughout the state. These energy costs are likely to rise with the price of oil predicted to increase 41% by 2040[3] and Southcentral Alaska facing potential natural gas shortfalls without significant new developments.[4]

Each year schools are required to spend at least 70% of their budget on direct instruction, or obtain a waiver from the Alaska Department of Education and Early Development (DEED). Between 2001 and 2011, on average about half of the 53 school districts in Alaska have had to obtain a waiver for this requirement.[5] DEED has found that typically schools with operations and maintenance costs over 20% need this waiver, and money spent on energy is a significant component of these costs.[6] Reducing the energy costs required to maintain a comfortable school environment would free up more funding to be spent where it is needed most—on direct student instruction.

An analysis of 156 energy audits conducted by the Alaska Housing Finance Corporation (AHFC) in 2012 on public schools throughout Alaska showed that on average, schools could save approximately $33,300 per year on energy by implementing the cost-effective energy efficiency retrofits identified by the auditors. The auditor-estimated upfront capital cost of these retrofits averaged approximately $125,000, which would lead to an annual return on investment of 26%, paying itself off in a period of just under four years. Reducing energy costs has the potential to increase the funding available for education and provides a measure of long-term fiscal security in the face of uncertain future energy costs.

This paper investigates the differences in energy use and costs using 2012 audit and benchmark data from 67% of the schools as well as interviews with energy conservation and facilities managers in school districts throughout the state. In 2013, CCHRC analyzed the factors affecting the energy efficiency of schools in order to identify the most cost-effective ways for buildings to reduce their long-term energy needs.

[1] Investment-grade energy audits are ASHRAE level 2 audits that use fuel bills, building plans and various measurements to identify cost effective energy efficiency measures that can be implemented. This data is stored in AkWarm energy models in the Alaska Retrofit Information System (ARIS) database.
[2] Benchmark data includes two years of energy costs and usage from fuel bills.
[3] U.S. Energy Information Administration, "Annual Energy Outlook 2014", website: http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2014).pdf
[4] Stokes, Peter J. "Cook Inlet Natural Gas Supply: 2014 and Beyond". RDC Annual Meeting. Available at: http://www.akrdc.org/membership/events/conference/2013/presentations/stokes.pdf
[5] October 29th 2012 State Board of Education Information Packet, available at: http://education.alaska.gov/State_Board/pdf/12_oct_packet.pdf
[6] Ibid.

Research Finding Highlights:

- $49 million in public dollars per year are spent on energy in the 67% of schools with available data.
- Energy use and costs vary significantly within a school district, suggesting greater opportunities for cost-effective retrofits in those schools paying more for energy.
- Ventilation is typically the largest source of thermal energy loss in a school building.
- On average, audited schools in Fairbanks used less than half the amount of energy for space heating per square foot than audited schools in other urban school districts when climate has been factored out.
    - Incentive systems for energy management appear to be one of the biggest factors in this difference.
    - The level to which valuing energy efficiency has been institutionalized and operational efficiencies have been maximized also are likely contributing factors to differences in overall school energy efficiency.
- Schools in rural areas of the state tend to have lower electric use per square foot than those in urban areas.
- Ventilation and air leakage are often the largest source of thermal energy loss for schools.
- There is little correlation of building energy efficiency with the age of the building, local fuel price, the relative difference in geographic area construction cost factors, or available fuel type. This means that older buildings and buildings in remote areas are not necessarily less energy efficient, and even newer schools in areas with high fuel prices are not necessarily more energy efficient.

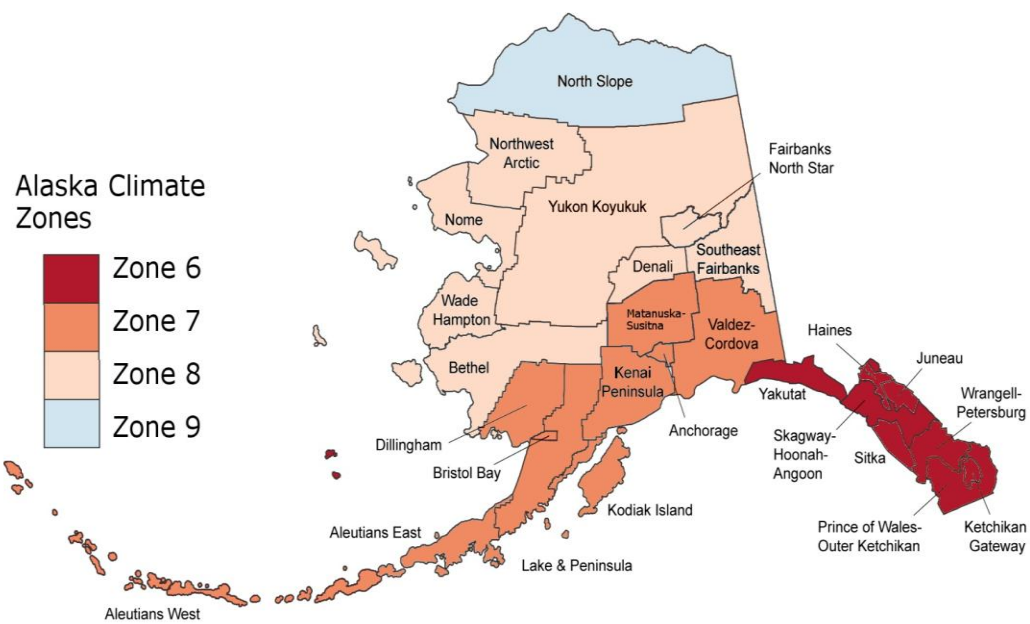
Energy Efficiency Metrics

The following four metrics are used in this paper to compare the efficiency of energy use and costs in public schools in Alaska:

- **ECI**: Energy Cost Index. The total amount of money spent on energy in a year divided by the square footage of the building.
- **EUI**: Energy Use Intensity. The total amount of energy used annually by a building, including heating fuel, electricity, and any other energy source, divided by the square footage of the building.
- **Electric EUI**: The total electrical use of a building in kilowatt-hours per year divided by the square footage of the building.
- **Thermal EUI / HDD**: The Energy Use Intensity for *space heating only* normalized by heating degree days. This measure normalizes the EUI by climate, allowing for comparisons across climate zones.

As climate varies significantly within a state as large as Alaska, it is useful to look at school energy metrics broken down regionally—in this case the Alaska Building Energy Efficiency Standard (BEES) climate zones were used (Figure 1).

Figure 1: Alaska Climate Zone Map



Variability of Energy Use and Costs in Alaska

Figures 2 and 3 below show the differences in energy efficiency of schools in the four different BEES climate zones. While slight differences between climate zones can be seen, the large variability in energy efficiency and energy costs that occurs even within the same climate zone is evident in these two tables. For example, Zones 6, 7, and 8 all have similar ranges from approximately $2 per square foot to $12 per square foot—meaning some schools in the same general climate are spending six times as much on energy. Similarly, EUIs in these regions all have a maximum that is around seven times as much as the minimum.

Figure 2: Building Size and ECI of Schools by Climate Zone

SCHOOLS		SQUARE FOOTAGE $_{A+B}$[7]				ECI_A			
BEES Climate Zone	# OF $RECORDS_{A+B}$	AVG	MEDIAN	MAX	MIN	AVG	MEDIAN	MAX	MIN
6	26	45,820	23,082	190,738	2,320	$4.01	$2.98	$11.39	$1.81
7	196	60,968	50,986	361,698	5,405	$3.49	$2.53	$11.50	$1.60
8	85	47,980	40,081	234,412	3,796	$4.91	$4.33	$12.46	$1.67
9	6	42,745	38,796	55,545	35,558	$7.03	$7.33	$9.08	$4.12

Figure 3: EUI and Electric EUI of Schools by Climate Zone$_{A+B}$

SCHOOLS		EUI (thousands of BTU / SQFT)				ELECTRIC EUI (KWH / SQFT)			
BEES Climate Zone	# OF RECORDS	AVG	MED	MAX	MIN	AVG	MED	MAX	MIN
6	26	88.3	78.6	224.9	29.7	7.0	6.3	17.0	3.3
7	196	107.6	102.4	290.0	30.9	8.3	8.2	24.0	0.7
8	85	102.0	92.5	245.8	36.7	6.8	6.9	11.5	1.4
9	6	195.1	195.0	278.1	116.4	11.3	9.9	18.2	7.4

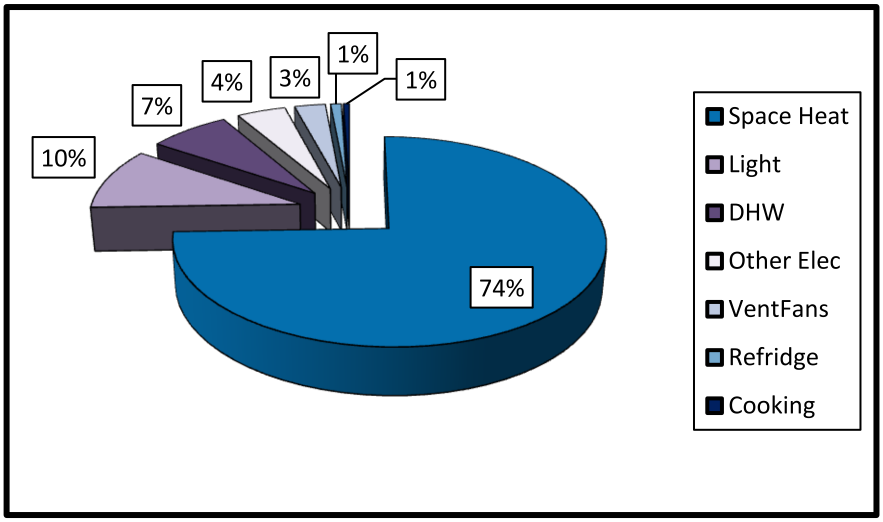
Energy End Uses – Space Heating

CCHRC analyzed energy end uses in an attempt to determine what is driving the high variability in energy use and costs in schools. Figure 4 shows that on average nearly three-quarters of the energy used in a public school building is for space heating. As space heating constitutes the majority of the energy use, it is also the area with the most potential for energy savings. There are several programs and initiatives in school districts in Alaska to increase energy efficiency by incentivizing user behavior.

While energy for lighting and electrical plug loads can typically be reduced by changing user behavior, space heating is not likely to be significantly affected.

[7] $_{A+B}$ means that the data used for this section comes from both energy **A**udits and utility **B**enchmarks. Sections marked with the subscript $_A$ came from energy audit files only.

Figure 4: Schools - Energy Consumption by End Use[A]

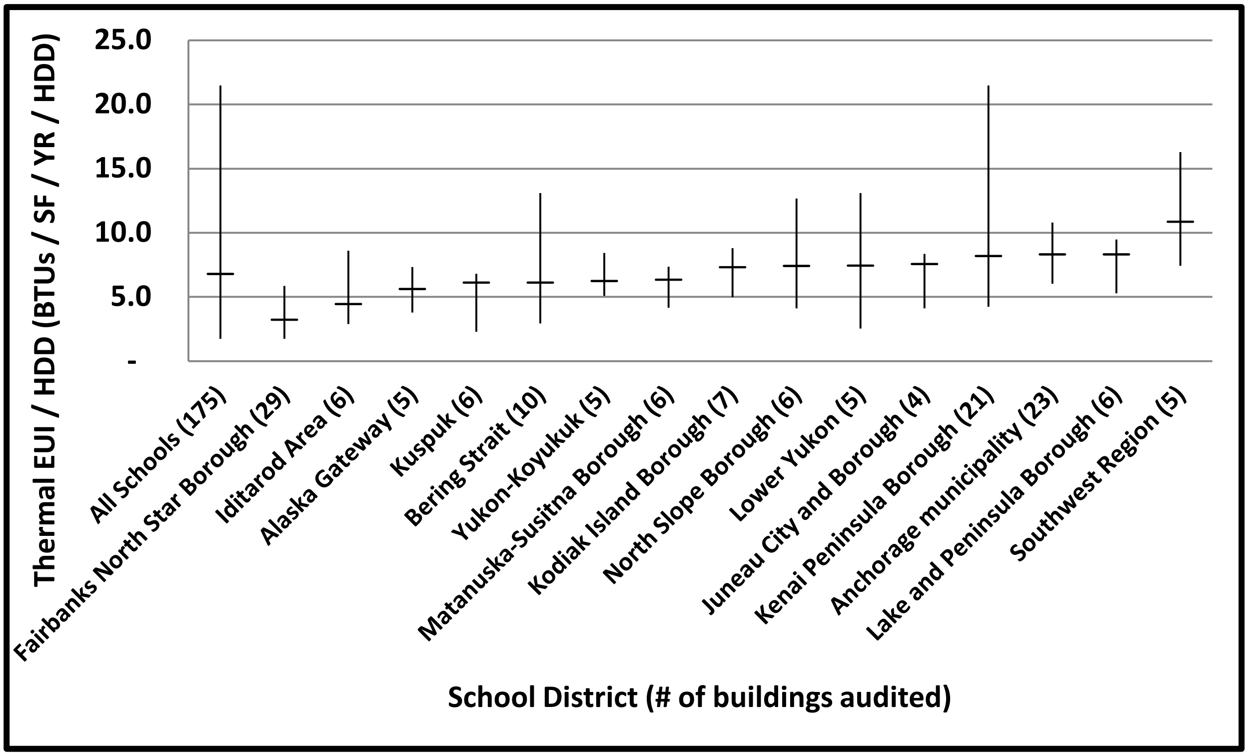


Since space heating is typically the largest energy use in a school building, and different climates will have different heating loads, the best metric for comparing the energy efficiency of schools across the state is Thermal EUI/HDD. By normalizing the space heating load by the heating degree days and the square footage of a building, one can more reasonably compare both large and small schools and schools located in the Arctic versus those in more temperate regions of Alaska.

Figure 5 shows the Thermal EUI/HDD for school districts that had four or more energy audits performed. It should be noted that these schools were not randomly selected; AHFC's investment grade audit program[8] typically chose the least energy efficient buildings in each district, as potential energy cost savings would be higher. As these audits were not evenly distributed, some districts received audits for a much higher percentage of their buildings than others. The central bar in this figure represents the median, and the vertical line represents the maximum and minimum usage in each district. The range highlights how variable energy efficiency is even within a school district. A large range likely indicates that there is one or more very poorly performing school in that district which probably has significant opportunities for cost effective retrofits or operational changes. Small ranges, on the other hand, may indicate that the district is closely watching energy use and focusing resources on the low-hanging fruit for energy efficiency measures. Gains are still possible in such cases, but often require greater capital investment.

[8] AHFC conducted 327 investment grade energy audits on public buildings in Alaska through the State Energy Program. See http://www.ahfc.us/efficiency/energy-programs/energy-efficiency-public-facilities/ for details.

Figure 5: Median Thermal EUI/HDD by School District[A]



Of the school districts with at least four audited buildings, the Fairbanks North Star Borough district uses significantly less energy than other districts with access to the road or ferry system (Figure 5). In fact, districts in Anchorage, Juneau, and the Kenai Peninsula use more than two times the energy per square foot on average for an equivalent amount of heating as Fairbanks schools.

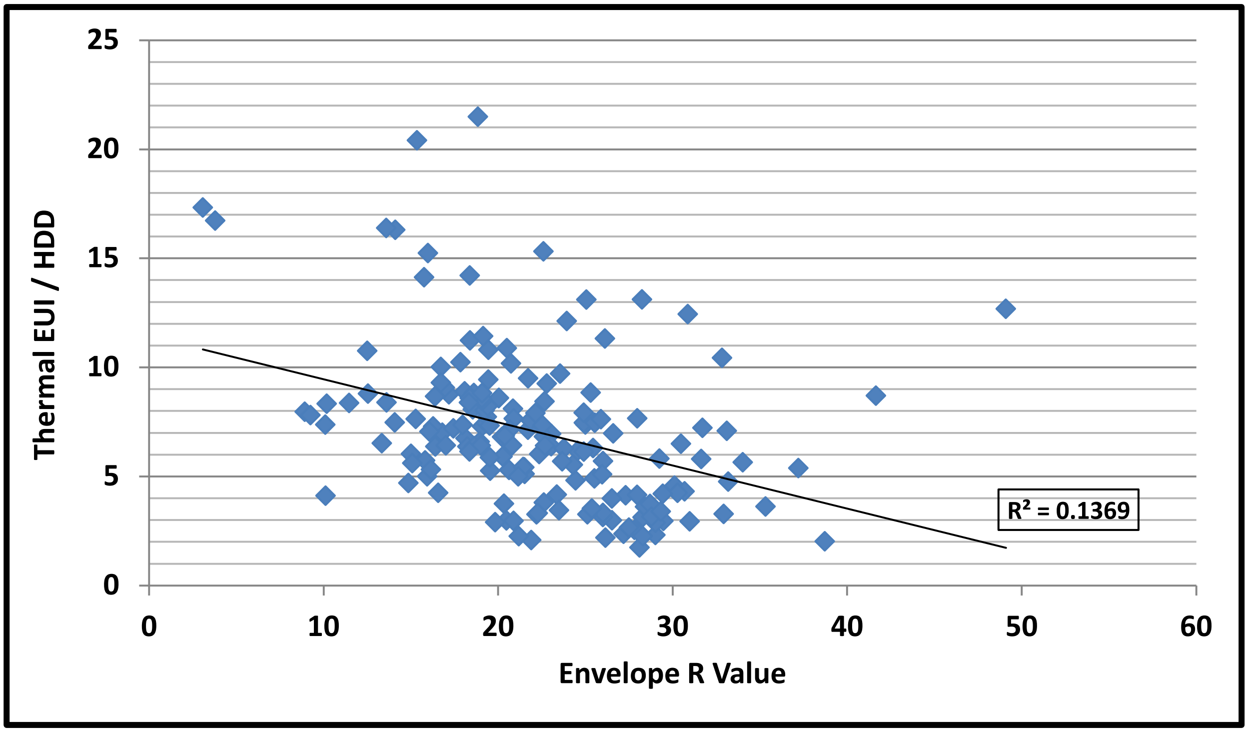
A variety of factors were analyzed to investigate the cause of the significant variation in energy use between school districts. CCHRC performed regression analyses looking for correlation between thermal EUI / HDD and: building age, years since the last remodel, the current geographic area construction cost factors for building a facility in remote locations[9], primary fuel type, building size, and the price of fuel. For all school buildings, there was no significant correlation found between any of these variables[10]. This means that the primary driver of energy efficiency is not age of buildings, current geographic area construction cost factor, or energy prices.

One variable that did show some correlation to thermal EUI / HDD is building insulation level, measured by R value. The R values for the entire envelope assembly were calculated and compared to the Thermal EUI / HDD values on a school-by-school basis. As one would expect, Figure 6 shows a general trend of buildings with higher insulation values having a lower thermal EUI / HDD. There is also significant variation within this trend, and there are many outliers.

[9] Cost factors come from the Program Demand Cost Model for Alaskan Schools published by the Alaska Department of Education and Early Development available at https://www.eed.state.ak.us/facilities/pdf/cost_model_instructions.pdf

[10] See *Energy Efficiency of State, Tribal, and Municipal Buildings: Metrics and Analysis* for details..

Figure 6: Schools - Thermal EUI/HDD vs. Envelope R-value[A]



Envelope R value does not account for most of the variation in thermal EUI / HDD for school buildings. Of the 74% of energy used for space heating in schools, between 55% and 58% is lost through air transport from ventilation and leakage (Figure 7). In commercial buildings, the rate of air exchange due to mechanical ventilation is almost always higher than the air infiltration rates[11]. Indeed, when the total annual amount of ventilation was compared to the annual thermal energy per HDD for school buildings, a much more significant correlation was found (Figure 8). While envelope insulation values are an important part of the energy efficiency picture, accounting for 42-45% of heat loss, the tight correlation between ventilation and thermal energy per HDD points to ventilation rates as being the single biggest driver of energy usage in schools. Additional factors that play a role in the variation of energy use include different indoor temperature setpoints and setbacks and different hours of operation.

[11] Price, Phillip N., A. Shehabi, and R. Chan. 2006. *Indoor-Outdoor Air Leakage of Apartments and Commercial Buildings.* California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2006-111.

Figure 7: Space heating loss by component for large & small schoolsA

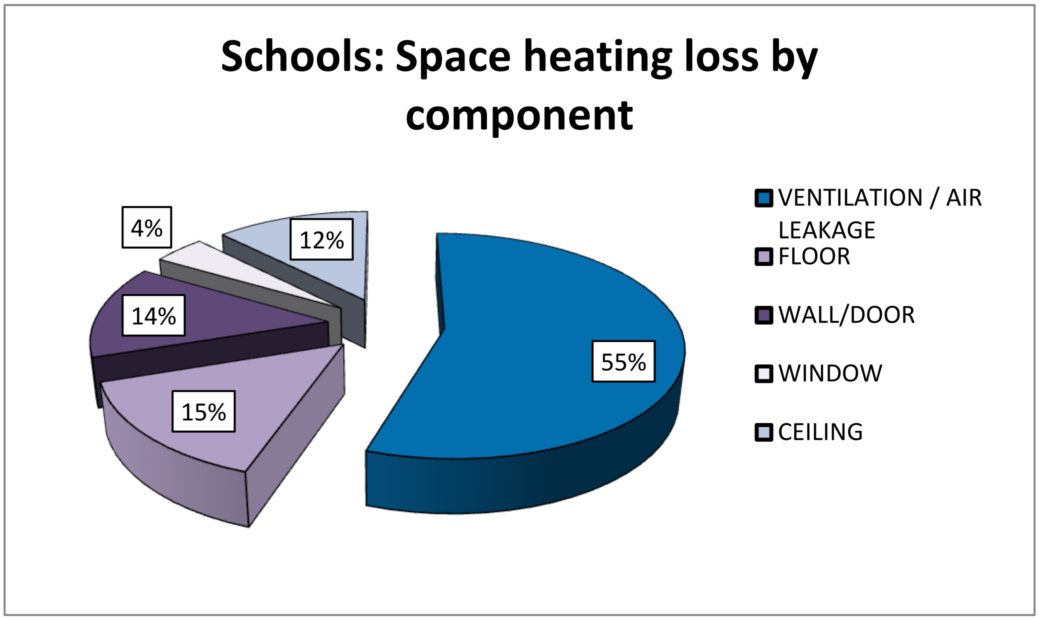
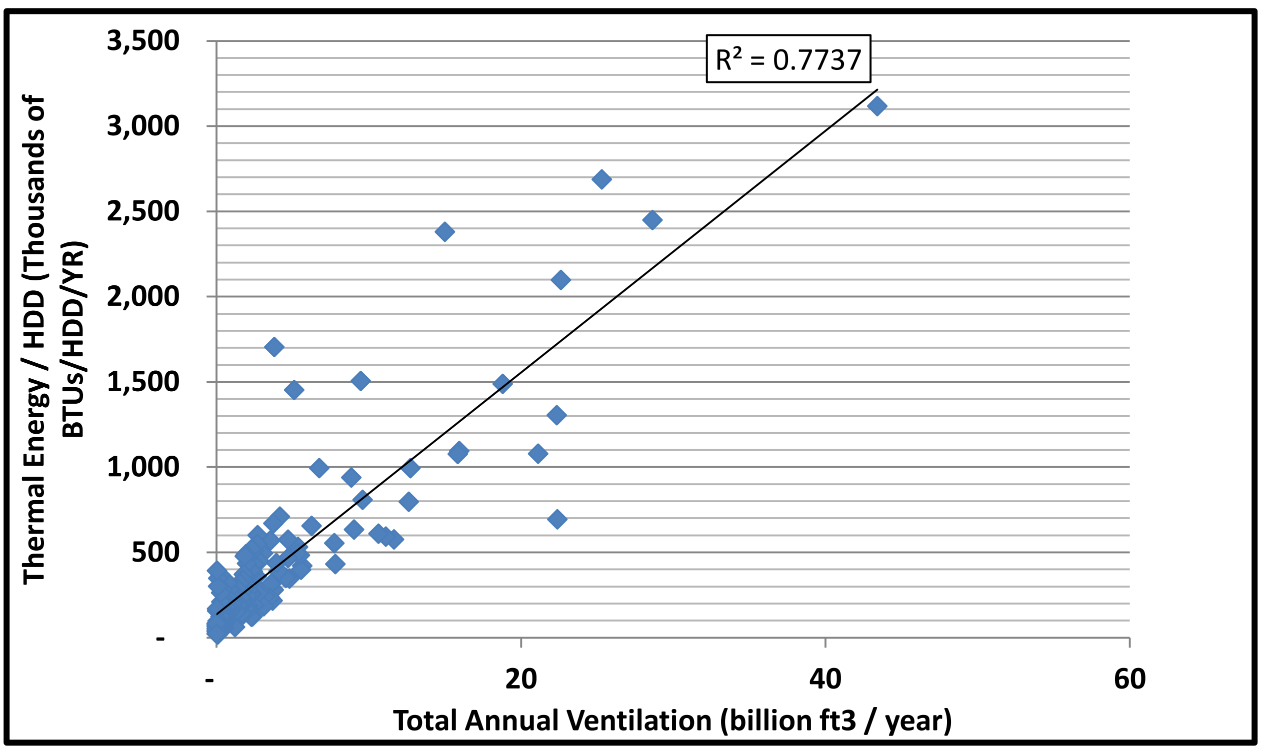


Figure 8: Schools: Annual thermal energy / HDD vs. Total Annual Ventilation



Figures 9 and 10 highlight the variation found in thermal EUI/HDD. Figure 9 compares the thermal EUI/HDD of three urban school districts with different performance characteristics. Similarly, Figure 10 compares the thermal EUI/HDD of three rural school districts with different energy performance characteristics.

Figure 9: Comparison of Urban School Districts - Envelope R-value vs. Thermal EUI/HDDA

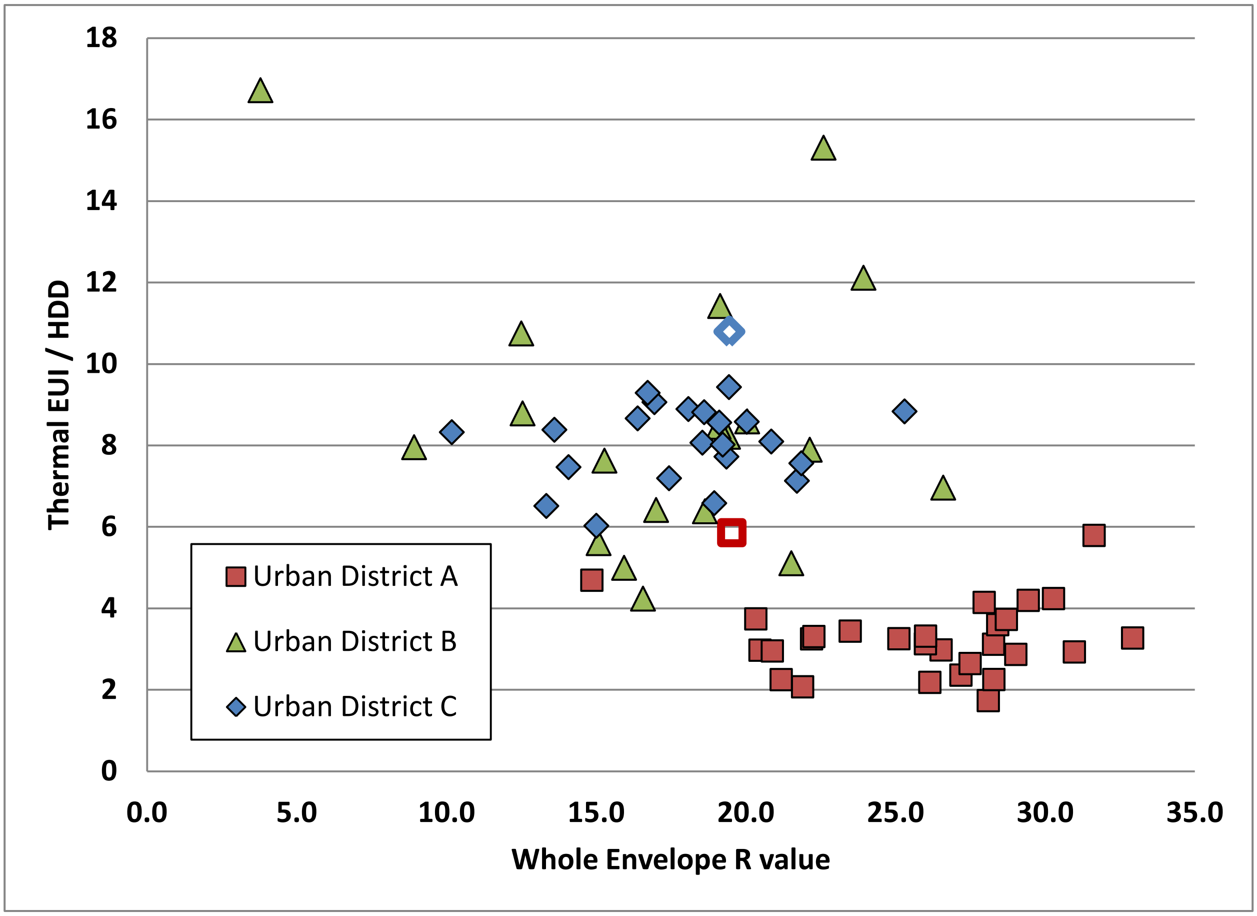
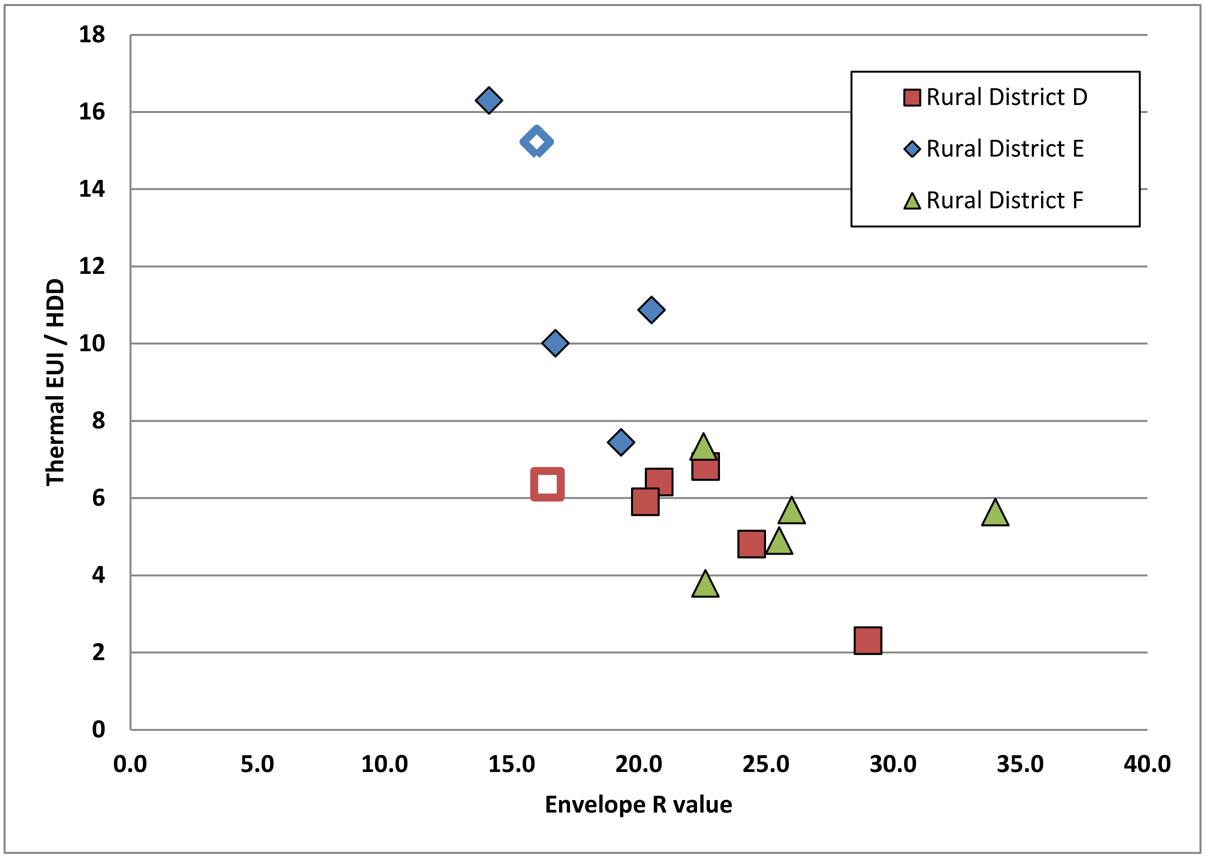


Figure 10: Comparison Rural School Districts: Envelope R-values vs. Thermal EUI/HDDA



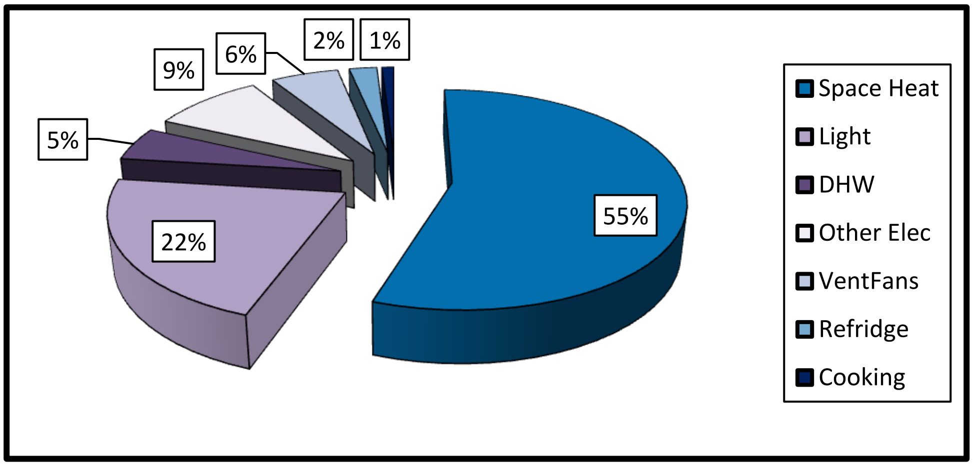
In both of these comparisons, the highest-performing district is offset horizontally to the right, meaning they have better insulation values. A more energy efficient district having better insulation values is to be expected. More interesting is that the higher-performing districts are also offset vertically, meaning that a building with the *same* levels of insulation in the better performing districts are actually using significantly less energy per heating degree day than the buildings in the lower-performing districts. This is highlighted by the hollow points in the above graphs. In each case, the two buildings being compared have roughly the same whole envelope R value, but the school in the higher-performing district is using almost half the energy per heating degree day to heat each square foot of building space. The strong correlation found in Figure 34 and the information from the interviews suggest that the primary cause of this discrepancy is differences in ventilation strategies. Other contributing factors are air leakage and operation of the buildings. A more detailed discussion of these differences can be found in the case study on school energy conservation below.

Energy End Uses - Electricity

Due to Alaska's cold climate, space heating is by far the largest energy use and cost in the state's public buildings. The next largest energy use is lighting. Due to the higher cost of electricity, lighting accounts for over 20% of energy costs, even though it is only 10% of energy use of the average school. Figure 11 shows the average breakdown in energy costs by end use for schools.

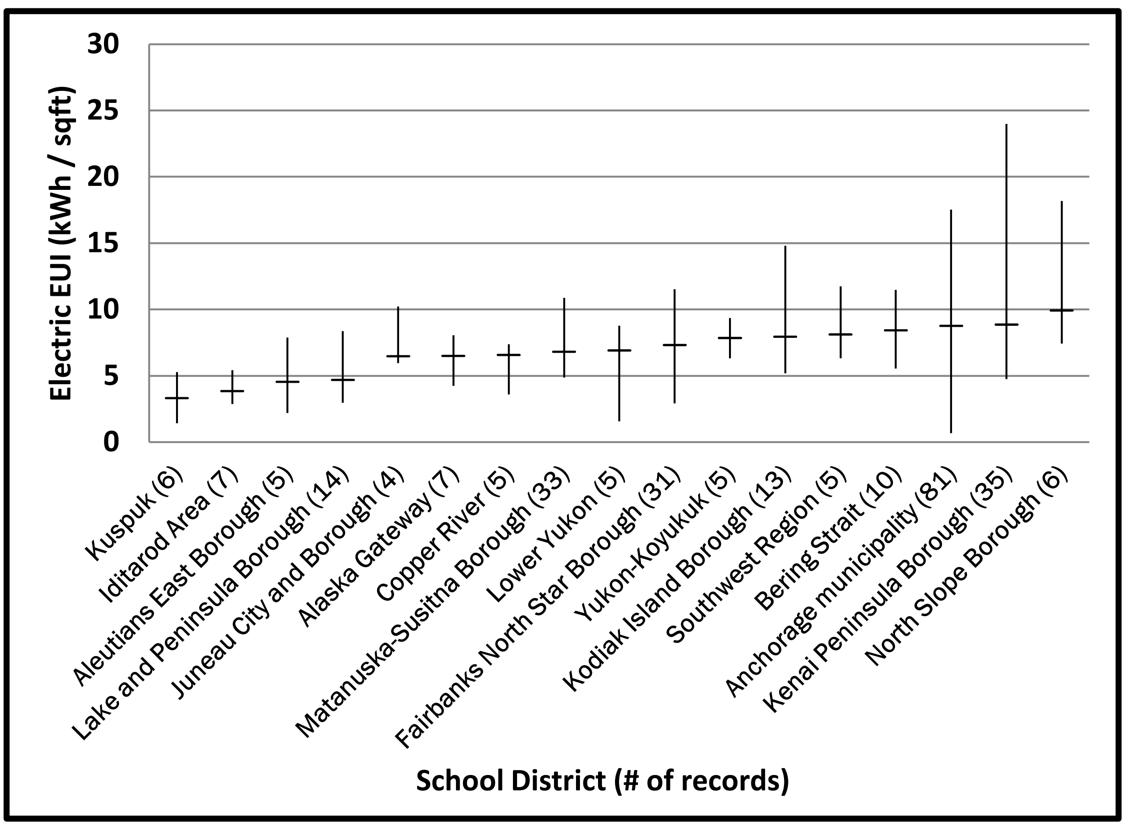
Figure 11: Schools–Energy Cost by End UseA

Figure 11: Energy Cost by End Use for Schools



The electricity use between school districts varies significantly (Figure 12). The horizontal bars represent the median for each school district, and the vertical lines represent the ranges found in different schools.

Figure 2: Median Electric Utilization Index by School DistrictA+B



Interestingly, this data appears to show that the districts with the least electrical use are all located in rural areas. In fact, when comparing the Electric EUI across districts, the four most efficient electricity users are all located in rural areas. CCHRC recommends further research to determine the underlying cause of this electricity conservation and determine if it could be replicated in other areas.

Case Study - School Energy Conservation

In an attempt to better understand the underlying reasons behind the differences in thermal EUI/HDD among school districts, CCHRC conducted in-depth interviews with Facility Department personnel and Energy Conservation Managers in six school districts[12] throughout the state during the winter of 2012. Interviews were designed to look at the institutional policies and practices that may partially account for the differences in energy usage between districts.

The following matrix provides an overview of key factors in the way school districts manage energy consumption and costs in their district:

[12] Information from one of the school districts is not presented here because of data collection anomalies

Figure 13: Key Energy Management Factors for Selected School Districts

School District	# Audited schools / # un-audited benchmark / # Schools in district	Average thermal EUI / HDD (Btu/SF/ HDD)	Electric EUI (kWh / SF)	Year Energy Focus Started	Incentives	Personnel
Alaska Gateway	5 / 2 / 7	5.5	6.5		Money saved through EEMs more likely to be approved for use for future facilities / maintenance projects	Small staff; well-trained
Anchorage	23 / 58 / 94	8.2	9	2007	25% of money saved through energy efficiency goes to budget of individual school; no incentive for facilities and maintenance	High turnover due to funding cuts; insufficient number of DDC[13] programmers
FNSB	29 / 2 / 34	3.3	7.5	~15 years ago	Positive feedback loop: money saved through EEMs[14] goes back into facilities / maintenance budget	Well-trained; sufficient number of DDC programmers
Mat-Su	6 / 27 / 42	6.3	7	2005	All money saved through energy conservation goes back into district general fund	Well-trained; insufficient number of DDC programmers
Southwest Region	5/ 0 / 8	12	8.3	2005/ 2006	Money saved through EEMs more likely to be approved for use for future facilities / maintenance projects	Insufficient number of community-based trained professionals

During the course of these interviews, CCHRC identified four common factors that appear to play major roles in the energy efficiency of the different school districts: the type of incentive system (if any) that was

[13] Direct Digital Control (DDC) systems are automated controls for building components such as HVAC and lighting, and typically entail controllers, logic, time schedules, set-backs, timers, alarms, and possibly trend logs. These systems can potentially save significant amounts of energy, but must be programmed and readjusted to meet changing occupancy schedules.
[14] Energy efficiency measures; these include any change to equipment, control systems, or practices which reduce the amount of energy used to provide the same level of comfort or utility.

in place, the existence of systems and staff to maximize operational efficiency, equipment standardization, and whether or not energy efficiency had been institutionalized.

Incentive System

While each district operates under different conditions, including differences in climate, the interviews suggest that the biggest driving forces behind the differences in energy efficiency are the incentive systems. For example, based on the data available, Fairbanks has the lowest thermal EUI/HDD of any district in the state. While this may be due to several factors, the most significant difference between Fairbanks and other school districts found in the interviews is that every dollar saved through energy efficiency measures goes back into the facilities and maintenance budget, creating a strong incentive to reduce energy use. This system provides an incentive for all levels in the organization—in times of tough budget cuts around the state, saving money spent on energy has meant that in general facilities and maintenance positions have been retained in the FNSB school district. This system also allows for energy efficiency measures to continue to be implemented with a limited budget, as facility managers are motivated to implement measures that will quickly pay for themselves, freeing up more money to be spent on personnel and projects rather than on fuel over time. This combination of utility and facility budgets also allows for long-term planning as to how best to implement energy efficiency over time.

In contrast, when money is saved in the Southwest Region, Alaska Gateway, or the Mat-Su school districts, it first goes back into the general fund. In Anchorage, if money is saved on energy, 25% of those funds go to the school where energy was reduced, and the rest goes back into the district general fund. This type of incentive system tends to spur school principals and district managers to implement programs to change user behavior and reduce plug loads in schools. In a commercial-scale building, changing plug loads and user behavior has less potential for energy reduction than optimizing operational controls and implementing mechanical retrofits. Thus, while this type of incentive system is a good second phase to reducing energy use, it has the potential to reduce already limited funding for more cost-effective energy saving measures if it is implemented before operational efficiencies and the low-hanging fruit of energy efficiency measures have been maximized.

Operational Efficiency

Operational efficiency involves attention to the function of the building's systems. This can include tuning heating and ventilation rates and schedules to occupancy and needs, establishing off-use setbacks, adjusting lighting use, identifying waste and leakage, and training staff on proper operation. As discussed earlier, space heating provides the largest avenue for energy savings, with ventilation controls being a key factor in the differences in thermal EUI/HDD for schools (Figures 9 and 10). There is considerable research showing the need to adequately ventilate enclosed spaces in order to maintain proper indoor air quality[15], and interviewees indicated that schools were designed to meet these standards. In Alaska's climate, this often means that air is being brought in at temperatures below zero and warmed to 70 degrees at a significant energy cost. It is essential that operations staff ventilate to meet the needs of

[15] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (2010). ASHRAE Standard 62.1. Atlanta, GA.

students when the building is occupied, but minimize the amount of ventilation during periods of low/no occupancy.

One common remark from every interview was that schools in Alaska are heavily used by the community. Many schools have some level of occupancy until late into the evening on a regular basis, although often only a small number of people and only certain sections of the school. One of the key factors that all interviewees pointed out was the importance of controlling ventilation so that during these periods of low-occupancy only the area directly occupied is being ventilated. This requires that buildings have well-partitioned HVAC zones, adequate control systems, and the staff to properly operate these systems. A common complaint among school districts with higher thermal EUI/HDD numbers was that they had either a large number of different DDC systems, or inadequate levels of trained DDC system staffing in each community of their district to achieve optimized ventilation rates for ever-changing school occupancy schedules. Additionally, more than one interviewee pointed to poor zoning as the cause of one of their inefficient buildings and, conversely, well-partitioned zones as responsible for high performing buildings. For example, one recently constructed large high school had a minimum number of zones, so when the dutiful administration member arrives two hours before students, the HVAC system starts operating for the offices, gym, and cafeteria as if they were at full occupancy. This leads to a constant exchange of a huge volume of outside air that needs to be heated when only one person is in the office.

Analysis of historical energy data is beyond the scope of this paper. However, interviewees in districts with energy conservation managers all pointed to significant energy cost savings in the past several years relative to a base year. Since operational efficiency appears to play such a large role in energy consumption and costs for schools, having a position dedicated to tracking energy data and detecting inefficiencies for remediation is integral to lowering overall energy use. Several energy conservation managers pointed to a case in which they saved significant amounts of money simply by identifying cases of overbilling by the utilities.

Institutionalized Energy Efficiency

Another key difference between districts was the level to which energy efficiency had been institutionalized, or integrated into organizational culture and policy. For example, the FNSB school district requires that energy efficiency opportunities be examined during any maintenance project. This policy tends to reduce the cost of energy retrofits as they may be integrated into regularly scheduled repair or replacement projects. For example, when a roof or siding has reached the end of its life cycle, more insulation can be added before installing the new component. Other districts did their energy retrofits primarily on an ad hoc basis, when grant funding or bond money was available. This policy difference may be part of the reason that FNSB buildings have much higher envelope R values than those in other urban school districts (Figure 9), even though all of these districts have buildings of a similar average age.

Including energy conservation staff in the design process for new buildings is also essential to institutionalizing energy efficiency. When these staff are not an integral part of the process, relatively new buildings have been found to be less energy efficient than schools that are over 30 years old. For example, both the Southwest Region and Mat-Su school districts have built a school within the past 10 years that has proven to be one of the biggest energy users in their district, and in each case there was little to no involvement of energy conservation staff in the design.

Retro-commissioning

Finally, more than one of the interviewees indicated that because of budget constraints leading to significant deferred maintenance, some buildings were in need of retro-commissioning. Retro-commissioning is a commissioning process for existing buildings whose performance, appliances, or characteristics may have changed or been altered over time. It ensures that the HVAC system and other building components are working as intended to meet the building occupants' needs in the most efficient manner and that staff are trained to operate and maintain the building correctly. According to a meta-analysis by the Lawrence Berkeley National Laboratory, the median payback on retro-commissioning an existing building is 1.1 years, with a median energy savings of 16% and a commissioning cost of $0.30 per square foot.[16] The non-energy benefits of retro-commissioning are also estimated to be quite high—in one example from the Lawrence Berkeley study, four elementary schools avoided an estimated $100,000 in repair costs by correcting problems in a retro-commissioning effort[17]. An earlier case study found that buildings with annual energy costs greater than $2 per square foot and those with deferred maintenance are the best candidates for saving money.[18] Since every school district except Anchorage[19] has an average ECI of greater than $2 per square foot and some schools have issues with deferred maintenance, retro-commissioning is likely to be very cost effective.

Equipment Standardization

Due to the limited maintenance budgets and staffing that many school districts face, it appears that equipment standardization likely plays both a direct and indirect role in affecting energy efficiency. Directly, both interviews and the results in the "White Paper on Energy Use in Public Facilities"[20] indicate that more complex energy-saving technologies are sometimes overridden or improperly used because operations and maintenance staff are not familiar with them, cancelling out the benefits of the systems. Examples include direct digital control systems being switched to manual mode, negating the energy savings of setting back temperatures and ventilation rates at night, and maintenance workers bypassing motion sensors for lighting because of a lack of time to learn how to fix a new system. Indirectly, if maintenance staff can do their jobs more quickly due to familiarity with equipment, more time is available to implement energy efficiency measures. A long-term effort to standardize equipment likely contributes to the ability of the Alaska Gateway School District to perform so well even with only three maintenance personnel for seven schools.

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[16] Mills, Evan. 2009. *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*. Lawrence Berkeley National Laboratory. Retrieved November 20, 2012 from http://escholarship.org/uc/item/7dq5k3fp

[17] Ibid.

[18] Gregorson, Joan. (1997). Commissioning Existing Buildings. *ESource Tech Update.* Retrieved November 19, 2012 from http://www.cecer.army.mil/kdsites/hvac/commissionpedia/publications/Papers/Tu9703%20ES%20Commissioning%20Existing%20Buildings.pdf

[19] Anchorage has an average ECI of $1.96 per square foot

[20] Armstrong, Richard, Luhrs, Rebekah, Diemer, James, Rehfeldt, Jim, Herring, Jerry, Beardsley, Peter, et. al. (2012). *A White Paper on Energy Use in Alaska's Public Facilities*. Alaska Housing Finance Corporation. Available online at: http://www.ahfc.us/iceimages/loans/public_facilities_whitepaper_102212.pdf

Because DDC systems are particularly important in optimizing the operational efficiency of ventilation and heating systems, CCHRC recommends that these be standardized as much as possible within a school district or even within a region. Several interviewees pointed to the difficulty of having multiple systems and not necessarily having sufficient numbers of staff trained to operate each system.

Interview Highlights

The following are interesting additional insights obtained through the interviews:

- A LEED Silver certified[21] school in one district was one of the highest energy users in the district due to a lack of separate zones and design flaws.
- One school with high electricity costs had a full LED lighting retrofit done, which paid back in less than one year. Money for this project was taken straight out of the annual budget for utilities at the start of the fiscal year under the assumption that it would pay back before the end of the annual billing cycle.
- An energy conservation manager saved approximately $250,000 per year by uncovering a billing oversight.
- Exterior LED retrofits in one school district saved 1,800 man-hours annually by reducing the amount of labor needed to replace lamps.
- One school district has an internal standard of R-75 for any future roof retrofits and new construction.

Recommendations

Energy costs can comprise a significant portion of school budgets. As energy costs rise, schools will need to find ways to cost-effectively reduce energy consumption to avoid reducing the instructional budget even further. If done efficiently, energy management has the potential to increase the funding available for instruction in the near-term. Based on the analyses in this report, the authors feel that these recommendations will help schools reduce their energy costs in a targeted, effective manner.

Short Term:

- **Get an energy audit for all buildings.** On average schools can save $33,300 per year on energy costs through making cost effective changes.
- **Implement the cost-effective energy efficiency measures recommended by the auditors.** The average return on investment is 26%, or a less than 4-year simple payback.
- **Create a district-wide energy policy.** This policy should direct staff to pay attention to energy use and look for means to cut costs. It should also provide a means of recognizing staff members that have been successful in reducing energy costs.

[21] Leadership in Energy & Environmental Design (LEED) is a third-party certification program verifying buildings as "green" to different levels. See http://www.usgbc.org/leed for more details.

- **Consider retro-commissioning buildings with energy costs greater than $2 per square foot.** This is a good way to ensure that building systems are working properly, and typically energy cost savings quickly overtake the initial expenditure
- **Install a building monitoring system.** These systems allow staff to track energy usage of different building systems and diagnose inefficiencies before they cause equipment maintenance problems. AHFC has developed an inexpensive building monitoring package that has already allowed them to find significant energy cost savings.

Long Term:

- **Focus energy reduction efforts on space heating.** The majority of energy consumption and costs in a school are for space heating.
  - **Aggressively manage ventilation.** Ventilation is the largest component of space heating.
    - **Ensure there are sufficient staff trained to properly operate DDC systems.** These systems allow ventilation to be properly matched to occupancy of the building so cold air is not excessively brought into the building.
    - **Install Demand Controlled Ventilation systems in new construction.** These systems automatically adjust the ventilation rates based on building occupancy.
    - **Where feasible, include well-partitioned and independently controlled HVAC zones to account for different occupancy or scheduling in various building areas.**
- Incentivize Energy Efficiency
  - **Combine the utility budget with the maintenance and operations budget.** This provides an incentive for all maintenance and operations staff to find the most cost-effective way to reduce energy use. Often facilities and maintenance departments that save energy costs do not see any of the savings and receive little recognition for their efforts. Combining budgets allows maintenance and operations staff to implement energy efficiency measures in combination with facility upgrades and routine maintenance, making them more cost effective.
  - **Track monthly energy consumption and costs.** Energy patterns cannot be seen with the naked eye. Keeping a database of monthly energy use and cost by fuel type allows anomalies to be detected and the effectiveness of energy reduction efforts to be verified. An incentive system only works if people can see the results of their efforts. AHFC provides an online energy tracking tool in the ARIS database free of charge for public facilities in Alaska.
  - **Ensure that operations and maintenance staff are properly trained in energy efficient operation of lighting and HVAC systems.**
- **Include operations and maintenance staff trained in energy efficiency in design decisions.** These people will be responsible for the energy costs of the building, and thus should be part of design for new construction.
- **Standardize Equipment.** This will allow operations and maintenance staff to effectively use energy-saving equipment and reduce maintenance time. Of particular importance is standardizing DDC

systems as much as possible, as these are complex systems that can reduce energy costs significantly if properly used.

- **Energy Management.** Consider hiring an energy conservation manager to track energy use, to benchmark buildings and create a plan to reduce energy costs starting with the most poorly performing buildings first. This benchmark data can be compared to other public buildings in Alaska using AHFC's ARIS database, allowing schools to see how their energy performance compares to districts around the state.