ENERGY ANALYSIS REPORT

Holden Public Safety Building

1370 Main St

Holden, Massachusetts

September 2011

Prepared By:

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EXECUTIVE SUMMARY

The new Public Safety Building (PSB) in Holden Ma was constructed in 2010 and has been occupied since November of 2010. Over the early life of the building, energy usage has exceeded the expectations of some, and an independent third party evaluation was sought to evaluate energy consumption at the facility and to determine whether there are any low cost or no cost opportunities for energy conservation.

The review process was comprised of three major activities; first was a review of historical energy usage for the old police and fire buildings that were replaced by the new PSB. Second was a cursory review of building systems, energy end uses, and operating procedures. Third was a comparison of energy intensity for the PSB compared with other similar buildings throughout the country. Key findings are presented below:

- ✓ In an October, 2009 letter, the design engineers estimated that annual electric energy for just the HVAC system would by 488,860 kWh per year. Total electric consumption for the facility through the first 12 months of operation is projected to be 510,000 kWh, well within the bounds established by the design engineer.
- ✓ The new PSB has an Energy Utilization Index (EUI) of 66 kBtu per square foot of building area. This compared to an EUI of 84 for the old fire building, and 121 for the old police building. The EUI of 66 for the PSB places it in the 90th percentile for EUI among police and fire complexes in the country.
- ✓ Several key differences between the HVAC systems of the new PSB compared to the old police and fire buildings contribute to increased energy consumption. Specifically, the addition of a facility wide air conditioning system and large air handling systems that were not present in the old buildings do contribute to increased energy use but provide additional benefits such as improved indoor air quality.
- ✓ The geothermal heating and cooling system installed at the new PSB is significantly more energy efficient than a standard gas fired boiler for heating and centrifugal chiller unit for cooling.
- ✓ Review of operating procedures identified several no cost or low cost measures that should result in reduced energy use at the facility:
    - o Utilization of scheduling and setback capabilities holistically throughout the facility
    - o Adjustments to outside air economizer and sensors on AHU-1
    - o Adjustments to supply air and chilled water temperatures
    - o Variable air volume (VAV) box dead band control adjustments

Our conclusion from the study is that the new Public Safety Building is well designed and operated, and is very energy efficient compared to other buildings of similar use and size. Some operational measures can be undertaken to further reduce energy consumption, but overall the facility's energy consumption is within reasonable limits.

INTRODUCTION

GDS was retained by the Holden Municipal Light Department to conduct an energy audit of the new Holden Public Safety Building (PSB). The goal of this Energy Audit was to review energy use at the new facility and to determine whether the current energy intensity is within acceptable bounds based on benchmarking of similar facilities. A secondary goal of the audit was to determine whether there are any low or no cost operational efficiency measures that could be implemented to reduce energy costs.

Several major activities were undertaken as part of the audit process. First, an assessment of energy use from utility bills for the new Public Safety Building as well as the old fire and police department buildings was conducted to review seasonal usage patterns, breakdown the facility energy use by fuel type, and analyze the energy utilization index (kBtu per square foot of building area) for the old facilities and the new PSB. The second major activity was an on-site inspection of the facility to gather information on existing conditions and operating procedures of the major energy using mechanical equipment, building systems, and occupant usage characteristics. This included gathering physical information on the building and process equipment, such as equipment nameplate data, type, number and run hours of building systems, control equipment, process requirements, and so on. The site inspections allowed the auditors to gain an understanding of how the facility is currently being operated and maintained. The final activity was a preliminary review of current operating procedures, focusing on the BMS system use and settings and the sequence of operations

The new Holden Public Safety Building (PSB) began operation in November 2010. The building was built to replace the old fire and police department buildings. At approximately 31,500 ft^2, the PSB houses the Holden Police Department on the first floor and the Holden Fire Department on the second floor. The facility contains dormitories for firefighters, a radio dispatch area, holding cells, sally port, fire department apparatus bay, and a variety of office, recreational, and meeting areas.

The PSB utilizes ground source geothermal heat pumps for heating and cooling with a variable air volume (VAV) air distribution system, as opposed to the old police and fire buildings which had hydronic heating with no centralized cooling systems or provisions for outside air. Heating in the fire department apparatus bay is a radiant loop in the concrete floor; the facility also incorporates a hot water snow melt system in the winter months at the front entrance and in front of the fire apparatus bay. Geothermal heating is supplemented by high efficiency condensing gas boilers which also service hot water demands for the facility. The entire PSB is served off one electric meter, which also records electric use for the old fire department that is located right next to the new PSB. The old fire department is sub metered so electric use for both buildings is easily parsed. The PSB uses natural gas for minimal space heating purposes as well as for limited domestic hot water creation and snow melting operations in the winter months.

ENERGY USE BREAKDOWN

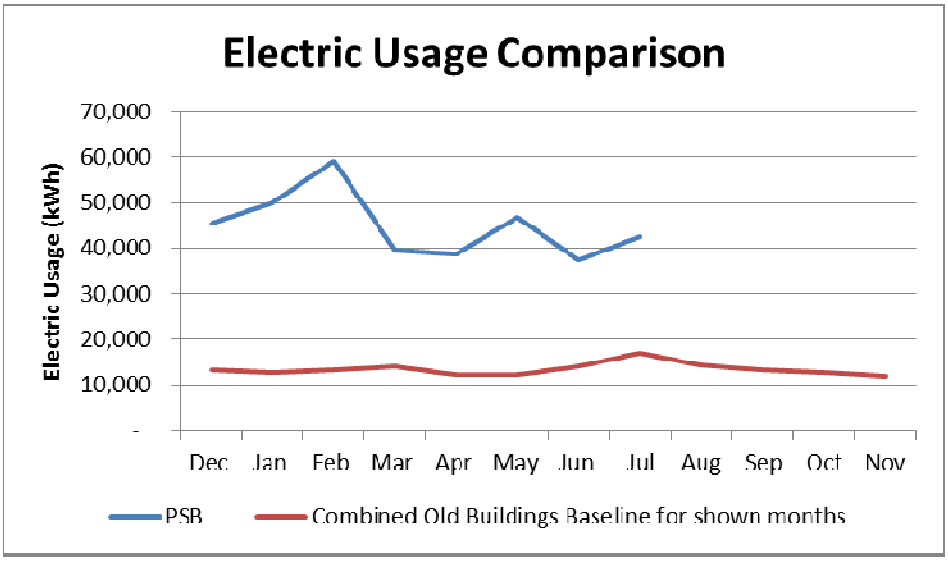
HISTORICAL ENERGY USE

Historical energy use for the old Fire and Police Department Facilities was reviewed to establish a baseline of energy use for the previous facilities. The past seven (7) months of energy use data for the new Public Safety Building was also reviewed and compared to the historical baseline. The Town of Holden supplied electricity records for the two old buildings from 2006 to 2010, fuel oil records from 2006 on, and natural gas records from 2008 on. The town also supplied electric and gas usage numbers for the new Public Safety Building to date. Findings presented below are based on this data provided by the Town.

The old Holden Police Department building electricity usage is fairly consistent over the five years of data that was analyzed, with a small peak evident in the summer months that likely represents small air conditioning loads. This building has a baseline annual use of approximately 100,000 kWh. The old Holden Fire Department building electricity usage is much more inconsistent. Electricity usage in this building increased every year, with a gap of nearly 40,000 kWh between 2006 and 2010. The baseline annual electricity usage is approximately 60,000 kWh, but this number varied widely in the past 5 years.

The new Public Safety Building only has 7 months of electric data available. These months alone have produced a total electric usage of nearly 320,000kWh – twice the annual electric consumption of the two old buildings combined. Electricity used by the old fire building (through the PSB meter) was not included in the analysis.

Figure 1: Electric Usage Comparison – Old Buildings vs. New PSB



The figure above shows a comparison between the PSB electric usage and the combined baseline electric usage of the two old buildings. The combined seasonal usage of the two old buildings is fairly consistent, with a small summer peak usage coming in the warmer summer months. Month to

month variations in the electric usage of the PSB building require further examination but may be attributable to operational refinements, occupancy, or other factors. Trending energy use of the new PSB is recommended to determine whether any seasonal trends emerge over the course of time. Overall, electric use of the PSB is considerably higher than the baseline electric usage from the two old facilities which is logical considering that space heating was switched from oil and gas in the old building to electric heat pumps, and the new facility has air distribution systems with a number of large fans that run almost constantly.

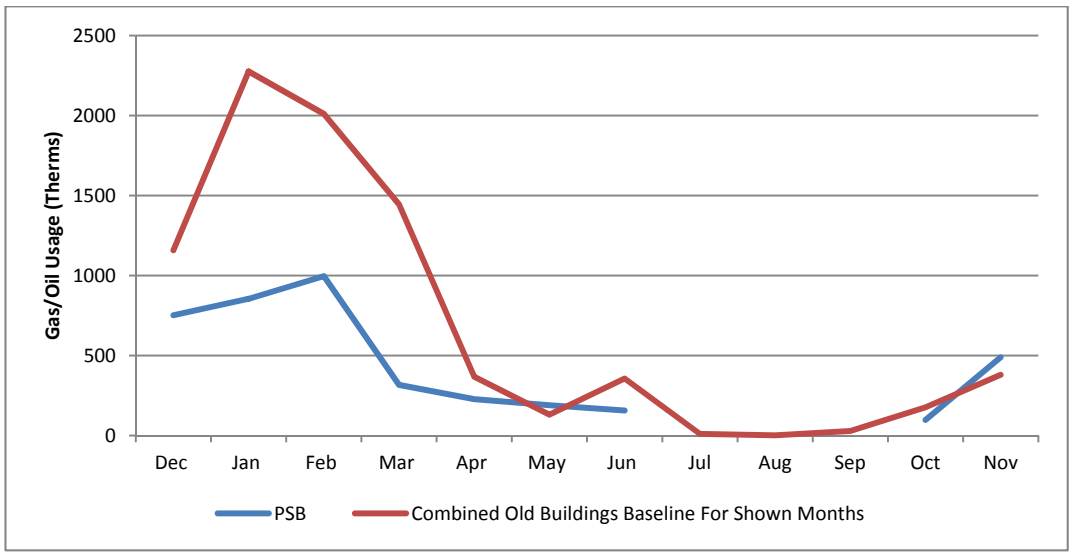
Natural Gas / Oil Energy Use

The police department building is the only one of the three that used fuel oil rather than natural gas. Fuel oil usage was fairly consistent for the Police Department over the five plus years of data that were given, with one high outlier in 2008. The annual baseline for oil usage over the five years was 3,622 Therms per year. The primary end use of fuel oil is heating and water heating.

Two full years of natural gas usage were provided for the old fire department building. The average annual usage for these two years was 4,686 Therms. The usage was very consistent over the two year period in that it peaked in cooler months, and was almost zero in warmer months. End uses for natural gas are also heating and water heating.

There is 9 months of data available for natural gas usage at the new Public Safety Building (PSB). Over these nine months, 4,084 Therms of natural gas was used to supplement the geothermal heating and primarily for hot water heating. The figure below shows a comparison of thermal energy usage in common units between the PSB and the two old facilities.

Figure 2: Gas/Oil usage Comparison

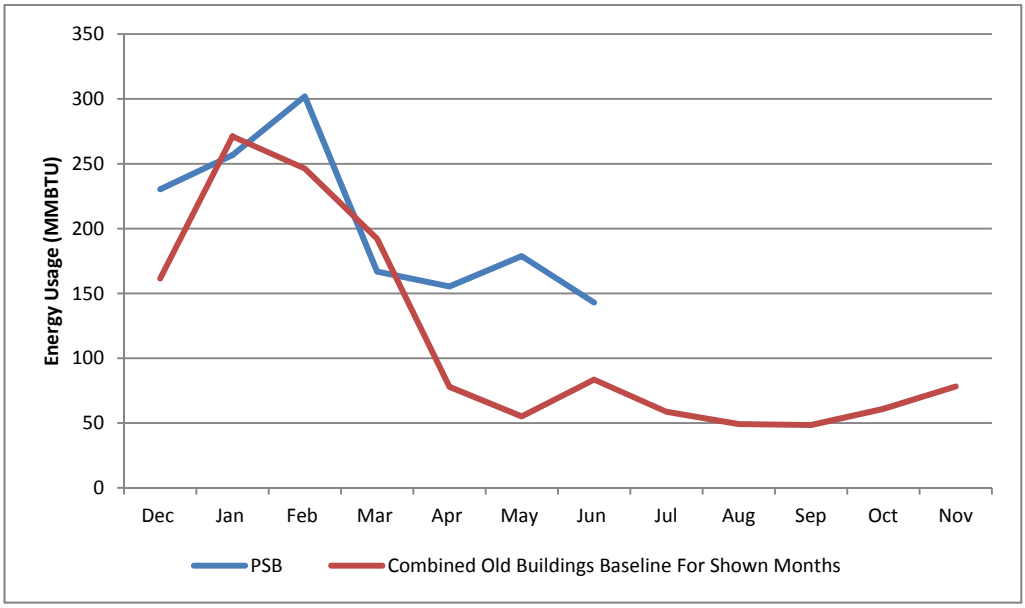


The PSB uses less than half as much thermal energy as the two old buildings did which is a likely result of the geothermal heating and cooling system which serve to decrease gas/oil usage and increase electric use.

Total Energy Use (Electric and Oil/Gas) Summary

Converting electricity, natural gas and oil to common units helps illustrate how total energy intensity compares between the old buildings and the new PSB. Figure 3 below shows the results of this conversion.

Figure 3: Energy Usage Comparison

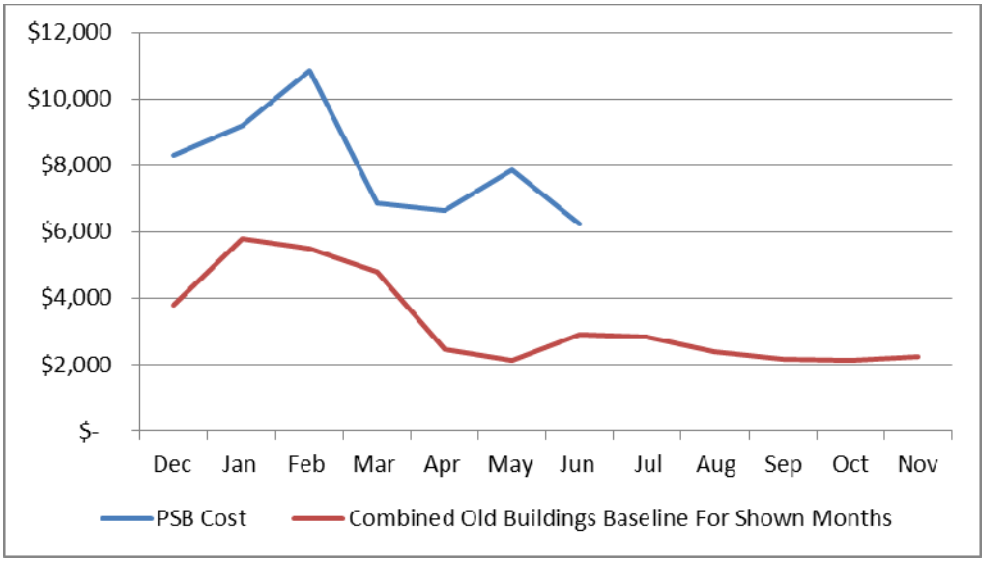


This comparison shows that total energy usage is roughly equivalent over the first several months the new PSB operated. As weather starts to warm up, energy usage in the old buildings went down significantly while energy usage in the PSB has declined at a slower rate – likely due to the increased cooling load in the new facility. Despite the fact that total energy use is roughly consistent, the operating costs of the PSB are much higher because the cost per MMBtu of electricity is nearly triple the cost per MMBtu for gas and oil, and the majority of energy use in the PSB is electric.

Energy Costs

Total baseline energy costs for the two old buildings and the PSB were reviewed. Energy costs for the old buildings were fairly evenly split between electric and gas/oil, whereas costs for the PSB are predominantly electric. Total baseline energy costs for the old buildings, and current costs for the PSB are shown in Figure 4 below.

Figure 4: Energy Cost Comparison



Despite the comparable energy usage (MMBtu), the cost to operate the PSB is much higher. At least one contributing factor to the increased cost of the PSB building is the fact that energy use is tilted more heavily towards electric than in the two old buildings. As shown in the table below, the cost per equivalent unit energy (MMBtu) for electricity is more than 4 times as expensive for electricity compared to natural gas.

Fuel Type	Average Cost Paid	Energy Content	Equivalent $/MMBtu
Electricity	$0.115/kWh	3,412 btu/kWh	$33 / MMBtu
Natural Gas	$1.13/Therm	100,000 btu/Therm	$11.27 / MMBtu

ENERGY UTILIZATION INTENSITY

Energy Utilization Intensity (EUI) is a metric that allows for comparison of energy usage among buildings of different sizes and that utilize different fuel types. An EUI is generally measured in units of thousand Btu's per square foot of building area (kBtu/sf). This allows for a straight comparison of energy usage between buildings that are used for similar purposes. GDS used the Buildings Technology Center website[1] as a tool for EUI comparison in this report. This site has information on EUIs for fire stations and police stations across the United States. The Buildings Technology Center shows the middle, 50th percentile, EUI for fire and police stations to be about 125 kBtu/sf. Facilities with a higher kBtu per square foot will rank below the 50th percentile while those with a lower intensity

[1] http://eber.ed.ornl.gov/benchmark/fire.htm

will rank above the median. The figure below illustrates the relationship between energy intensity and rank among similar buildings per the Buildings Technology Center. Efficiency rating is shown on the Y-Axis where a larger rating represents a more efficient building. Energy intensity is represented on the X-Axis. As energy intensity increases from left to right, the rating goes down:

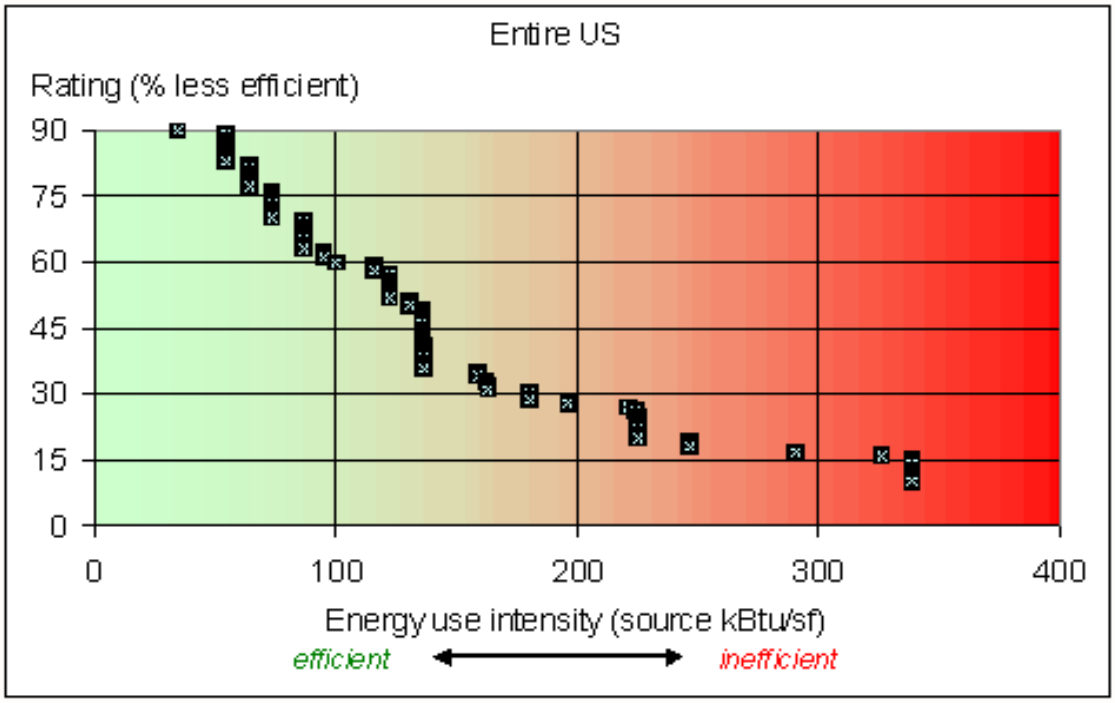


Figure 5: EUI distributions of fire/police stations

The following sections include analysis of EUI for the old fire and police buildings in addition to the new PSB.

OLD FIRE AND POLICE BUILDINGS

The old police department building had two floors, and was approximately 6,080 ft^2. To calculate an EUI, utility data from calendar year 2009 was used. This was the last full year of use for the building. During 2009, the police building used approximately 343,073 kBtu of electricity and 392,605 kBtu of oil. This led to a total energy use of 735,678 kBtu, giving the building an EUI of **121 kBtu/sf**. This EUI places the old police building in roughly the 55th percentile, meaning the building was more energy efficient than 55% of police and fire buildings in the United States.

The old fire department also had two floors, and was approximately 8,710 ft^2. To stay consistent with the calculation for the old police department, utility data from 2009 was also used to calculate the old fire department building's EUI. In 2009, the fire department used about 236,485 kBtu of electricity and 493,000 kBtu of natural gas. This gave the old fire building a total energy use of 729,485 kBtu. This energy use was similar to that of the old police building, but because the old fire building was larger, it had a much better EUI of approximately **84 kBtu/sf**. This put the fire building in

approximately the 75th percentile, meaning it was more energy efficient than 75% of the other fire and police buildings in the country.

PUBLIC SAFETY BUILDING

The PSB has two floors and a mezzanine mechanical attic. The PSB is approximately 33,500 ft^2 in size, making it much larger than the two old buildings combined. Calculating the Energy Utilization Intensity for the PSB was not as simple as it was for the two old buildings because the PSB has been in operation for less than a year, and a year of utility data is needed to calculate an EUI. GDS has both electric and natural gas usage data dating from December 2010 to July 2011 for the PSB. To estimate the electric energy use in kBtu for the remaining four months of the year, GDS used regression analyses correlating electric consumption to heating and cooling degree days to estimate energy consumption for the remainder of 2011. Similar methodology was employed for projecting gas usage.

We estimate the total energy use for the PSB to be 2,208,137 kBtu for the year. About 80% of this energy use will be attributed to the electric load, with another 20% being natural gas usage. Using this estimated usage, the PSB has an extremely low EUI of **66 kBtu/sf**, which places the PSB in the 90th percentile compared to similar facilities in the country. This means that the PSB has a lower energy intensity per square foot than 90% of the other fire and police buildings included in the benchmarking study.

ENERGY BENCHMARKING

ENERGY STAR® Portfolio manager is a benchmarking tool used to compare and contract energy use and intensity among buildings of similar type and use. Portfolio manager is also the tool by which buildings can earn and ENERGY STAR designation by scoring 75 or better; meaning the building is in the top 25% of similar buildings with respect to energy use.

For the benchmarking of the Public Safety Building, GDS relied on the office specific building type within the ENERGY STAR® Portfolio manager software. Energy Star has very specific criteria to be able to effectively use the program, and although the PSB building is not technically an office space, it is the category the PSB is closest to that will still receive an Energy Star rating. The PSB score will be lower than it should be because of this categorization. Other office buildings typically have shorter run hours and do not have the specialized systems and equipment present at the PSB.

To get a year's worth of energy data, GDS used estimated energy use for the months that the PSB has no data for. To make this work in the Portfolio Manager, the estimated data was entered for August 2010 to November 2010 because the program does not accept data entry for dates that have not happened yet. The Energy Star calculated Energy Use Index (EUI) is presented in this section along with a 12 month score that will provide an excellent starting point for tracking energy savings as upgrades, improvements and changes are made over the coming months and years. The EUI for the building was calculated both as a site EUI which resulted in a score of **65.5 kBtu/ft²/yr** for the PSB and a source EUI of **187.1 kBtu/ft²/yr**. Site EUI refers to the actual energy consumed on site

(i.e. 1 kWh of electricity equals 3,412 btu). Source EUI refers to the production intensity of energy. For example, electricity is produced at a generating station at an efficiency of roughly 40% then transmitted with loss to the end use. Thus, 1 kBtu of electricity used on site will have a much higher Source intensity than one kBtu of natural gas consumed on site.

Because of the source generation efficiency, the geothermal system at PSB negatively impacts the Energy Star grades. The source intensity of a facility that uses electricity as the primary energy source will have a higher source EUI than a similar facility that uses primarily fossil fuels.

The national average for an office was reported to be an EUI of 70 kBtu/ft^2/yr and a source EUI of 294 kBtu/ft^2/yr, which places the PSB above both the site national average and the source national average. Again it is important to point out that these averages are for regular office buildings, and would be higher for other police and fire buildings. The portfolio manager reported the PSB overall score of **72.** A score of 75 or higher would make the building eligible to receive the Energy Star certification and plaque.

Holden is encouraged to log-on and update their energy usage as time goes on, especially to replace all the estimated energy use numbers. Replacing the estimated energy numbers will give a much more accurate comparison of the PSB energy performance. This program is a good way to track progress and to gauge energy performance relative to other office buildings. A unique account has been set up for the building in Portfolio Manager and can be accessed at the site below with login information as indicated:

https://www.energystar.gov/istar/pmpam/index.cfm?fuseaction=login.login&fail=yes

User Name: holdenpsb Password: 1370mainst

BUILDING SYSTEMS / ENERGY END USES REVIEW

GDS conducted a preliminary review of design drawings, field conditions, and operating procedures to understand the building systems at the new PSB, how they are operated, and whether there are any low cost or no cost improvements that could be made to increase energy efficiency. This section includes a brief discussion of the building systems and energy end uses evaluated.

SPACE HEATING AND COOLING

A new ground source, open loop, geothermal system was installed for the PSB and serves the majority of the space heating and cooling demands. The system consists of two (2), 1,600 foot deep bore holes separated by approximately 75-feet. The two well pumps are each 7.5 HP and have run for approximately 1,580 hours and 1,130 hours respectively since the end of May when the building management system started recording run hours. The well pumps feed three staged “Florida” heat pumps that have run approximately 1,300, 800, and 800 hours since the end of May.

Conditioned air is circulated through the facility by one of two air handling units. AHU-1 serves 95% of the facility and AHU-2 serves only the Radio Dispatch area. AHU-1 is a variable air volume system with approximately 56 terminal (VAV) boxes throughout the facility. The AHU-1 supply fan is a 25 HP fan on a VFD set to maintain static pressure of 1.6” w.c. in the supply duct. Airflow to each space is controlled by maintaining this static pressure and modulating volume dampers at the VAV boxes; the VAV boxes do not have integral air distribution fans. The AHU-1 supply fan runs constantly.

AHU-1 has a 40 ton cooling coil that takes chilled water from the geothermal system. The cooling valve modulates as needed to maintain a supply air temperature of 65 deg F. AHU-1 is reported to have a dual enthalpy economizer however the BMS system does not record any %RH readings for outside air thus it appears either this sensor was not installed or is not functioning properly. Based upon our review it does not appear that the economizer mode is enabled to respond automatically to favorable outdoor air conditions. The outside air mixing damper instead appears to be set constantly at 10% to maintain Carbon Dioxide levels below the design threshold of 800 ppm. Enabling the dual enthalpy economizer is a low cost opportunity to reduce energy consumption by reducing cooling demands when outside air temperatures are favorable.

With any type of VAV system, improper balancing can result in a myriad of issues that cause increased energy consumption. Detailed examination of system balancing is beyond the scope of this review, however the building manager reported that a thorough balancing study was undertaken when the building was first commissioning. This report was not available for review.

Heating in most areas served by AHU-1 is via hot water reheat coils at the VAV boxes. The primary feed to the hot water supply loop is the geothermal system with contribution from the two high efficiency natural gas fired condensing boilers. The two boilers run infrequently (each less than 20 hours since inception) and are equipped with state of the air controls for temperature reset and lead/lag operation.

AHU-2 is a significantly smaller system dedicated to the Dispatch / Radio room. This unit provides heating through the geothermal supplied HW loop and cooling via a 3.5 ton dx coil at the unit connected to an exterior air cooled condenser.

The facility includes a large number of exhaust fans which contribute to overall energy consumption. In total, the facility contains approximately 18,000 CFM exhaust total (9,800 CFM in FDA bay) with a connected motor load of approximately 4.5 kW. The fans run intermittently and control varies from manual to automatic depending on the space. Based upon preliminary review, it appears the exhaust systems are properly balanced with makeup air to avoid creating any adverse negative pressures within the building.

Control of the pumps, air handling units, boilers, and boxes is via a Niagra Trinium Building Management System (BMS) that monitors status, schedule, temperatures, and set points for the system. A more thorough review of the BMS is included in the operating procedures section of this report.

Regarding space heating and cooling for the PSB, following are key points relating to energy consumption compared to the old buildings:

- ✓ The old fire and police buildings had hydronic heating systems and no air distribution. All of the fan energy used by the current systems represents additional load compared to what was utilized at the old facilities.
- ✓ The old facilities had no provision for outside air. Because the PSB always brings in a minimum 10% outside air, that air needs to be heated or cooled representing an additional load compared with the old buildings.
- ✓ The two standing column well pumps (15 HP total) represent an additional load beyond what was previously installed.

LIGHTING

Lighting systems in the PSB are extremely efficient with little noticeable room for improvement. Lighting throughout the building is comprised of a mixture of high efficient T-8 fluorescent and T-5 fluorescent fixtures with electronic ballasts, and compact fluorescent fixtures. Along with these highly efficient lighting fixtures, nearly every room in the PSB is equipped with either ceiling or wall mounted occupancy sensors. During the walk through of the building, GDS noticed that well over 75% of all lighting fixtures in the building were off.

PLUG LOADS / APPLIANCES

The PSB has a significant amount of plug loads and appliances which make a contribution to the electric use of the building. The facility operates a large number of computer monitors and LCD and plasma televisions as part of the dispatch and monitoring responsibilities. Additional plug loads include clothes washers and driers, ice machines, a hose washer, refrigerators, microwaves, dishwashers, stoves, ovens, coffee makers, copiers, printers, smart boards, a central vacuum, water coolers, vending machines, and other miscellaneous plug loads that are not plugged in all the time.

Although these end uses represent a small portion of overall energy consumption in the building, they should still be monitored to be sure they are being used effectively.

MISCELLANEOUS LOADS

In addition to the variety of plug loads and appliances discussed above, several unique energy end uses are present at the PSB. There are multiple, small, seldom used compressed air systems for the fire apparatus exhaust systems and vehicle maintenance. There is an oxygen refill machines for firefighter SCBA, and rarely used welding motors. The facility also runs a 2.4 kW block heater on the emergency generator to keep the block always above 80 degrees for rapid response, and a Universal Power Supply (UPS) that consumes a constant 7.5 kW of power for emergency backup purposes.

WATER HEATING

Domestic hot water is produced using a combination of waste heat from the geothermal heat pumps and a gas fired boiler. The domestic hot water is generally used in wash rooms and for washing clothes. Hot water can also be used to clean trucks and cars, but it is assumed cold water is generally used in these applications. Again, hot water production makes up a very small portion of the energy consumption, and is not likely to become an issue unless building occupancy grows from where it currently is. The two boilers have run combined for less than 20 hours since May, when data began being tracked.

ENERGY AND COST BREAKOUT BY END USE

GDS prepared calculations of annual consumption for current systems and energy end uses at the PSB to estimate the current breakdown of energy use at the facility. These calculations used simplifying assumptions for annual run hours and appliance and fixture wattages. An estimated breakdown of electric energy use at PSB is shown in the figure below.

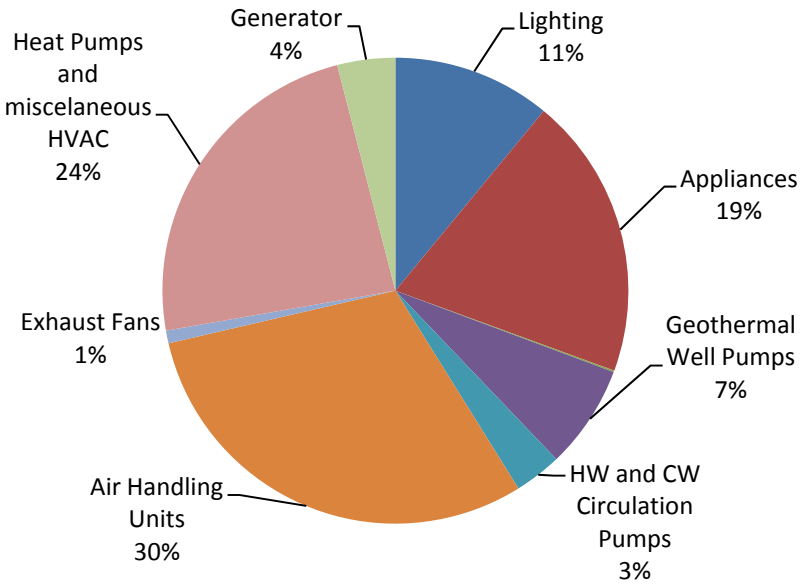
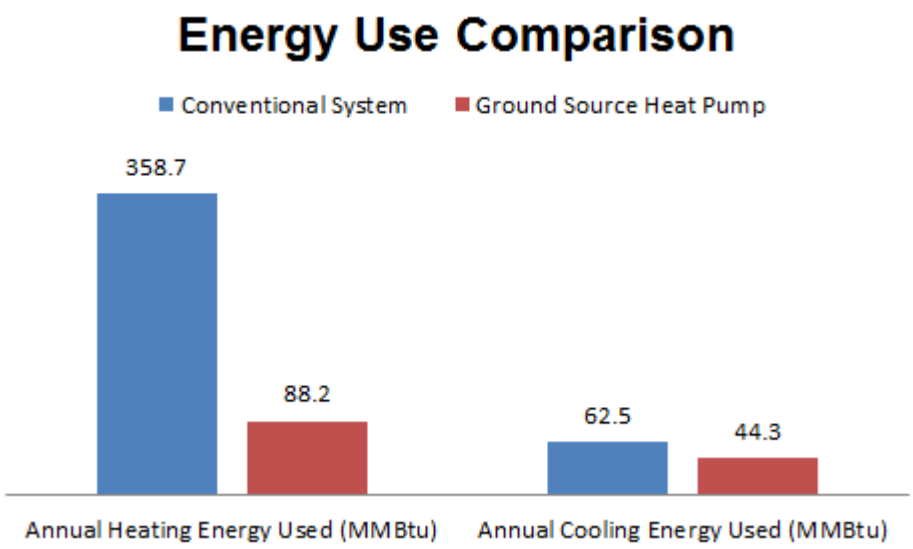


Figure 6: Estimated Energy Use Breakdown

GEOTHERMAL SYSTEM COMPARISON

GDS was asked to evaluate the energy performance of a geothermal system compared with standard efficiency heating and cooling systems to demonstrate the inherent efficiencies with a geothermal system. Our analysis considered only the input energy needed to the heating and cooling loads of the system. For example, the analysis discussed below does not include the fan energy of the systems. It is assumed that all HVAC systems are exactly as in place currently at PSB except that hot water for reheat is supplied by standard efficiency gas boilers and chilled water is provided by a code minimum efficiency centrifugal chiller instead of the geothermal system.

Detailed energy modeling of the facility was not conducted, and precise design heating and cooling loads were not available so simplifying assumptions were used to estimate the building's heating and cooling loads (output Btu's). Then, based on the efficiency and EER of the standard heating and cooling systems, the energy input (fuel consumed) to each respective system was estimated. The chart below further illustrates the difference in input energy (fuel used) between a conventional system and a geothermal system to meet the exact same building loads (output Btu's/year).



Heating loads are inherently greater than cooling loads in the Northeast as a function of outdoor air temperatures and the fact that the temperature differential between a heating design day and interior building temperature is much greater than that between a cooling design day and interior building temperature. In both heating and cooling modes, the geothermal system consumes significantly fewer Btu's of input energy to produce the same amount of usable heating or cooling energy. This large difference in Btu consumption produces significant cost savings for the implementation of a geothermal system, even though the price per Btu of electricity is so much higher than that of natural gas.

Calculations to estimate these consumption values were obtained from the Massachusetts technical reference Manual, a tool utilized by the State's Investor Owned Utilities. The heating and cooling loads utilized as the basis for this analysis are based on a number of simplifying assumptions and are

not intended to represent the precise energy loads for the system. This analysis is designed simply to illustrative the differences in efficiency between a conventional system and a geothermal system.

OPERATING PROCEDURES REVIEW

GDS conducted a preliminary review of operating procedures, both as design and currently in practice, for the PSB to understand how the facility is being operated and whether there are any opportunities for energy conservation. The two primary resources for this review were the Sequence of Operations Document (M09101) and the facility BMS system. GDS was granted read only access to the BMS system and was able to review current conditions as well as historical trending. Below is a summary of key items identified during the review.

SCHEDULING

Utilizing the scheduling for the building serves two important functions; first, set points in individual zones can be adjusted during unoccupied periods to reduce heating and cooling loads and avoid cooling or heating the space unnecessarily. The second key function of the scheduling feature is that the air handling units are designed to shut off during unoccupied periods (M09101 D.5).

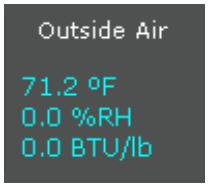
Currently, the second floor office is set up with a schedule as follows: occupied from 6am-5pm Monday-Friday and unoccupied at all other times. The fire department dorms also have a schedule, unoccupied from 6am-8pm daily and occupied at other times. Schedules are set for AHU-1, AHU-2 or the Apparatus Bay but they are set as occupied 24/7 so there is never an unoccupied period. No schedule is set up for the first floor so those zones will always be heated or cooled to the “occupied” set point.

Setting up schedules for the first floor (and potentially sub-areas of the first floor) and any other areas where scheduling is not currently enabled is a no cost opportunity to conserve energy. Most of the VAV boxes are already programmed with occupied and unoccupied set points, so a schedule just needs to be developed for these spaces to send these commands to the boxes. Allowing these areas to set back to higher cooling temperatures, or lower heating temperatures, will conserve reheat energy and can reduce the total volume of air that needs to be supplied because the zone dampers will close when the space temperature is satisfied. This can reduce the speed and energy consumption of the supply fan.

Further review of AHU-1 operation is needed before a schedule can be developed, primarily because the dormitories are occupied at most times when the first floor will be occupied so there may not be much opportunity to shut down the units entirely. Similarly, occupancy of the radio dispatch room may preclude any setback in this area.

ECONOMIZER MODE AND RH SENSOR

Based upon our review, it appears the economizer mode is not functional. During the site inspection meeting, it was reported that AHU-1 has a dual enthalpy economizer however the BMS does not recognize any outside relative humidity. Either the RH sensor was not installed or is not functioning properly. The figure to the right is part of a screenshot from the BMS that shows 0% RH but does report an accurate outside air temperature. Installing a RH sensor, or repairing the sensor that was



installed and integrating that reading into the economizer set point is a low cost opportunity to realize significant energy savings by utilizing outdoor air for heating or cooling whenever conditions are favorable.

The sequence of operations states that when the outside air temperature is between 55 deg F and 75 deg F the air handlers should operate at 100% outside air. Typically, economizers are set such that if the outside air temperature is less than the return air temperature then more outside air is brought in to reduce the mechanical cooling load. The economizer for PSB does not appear to be active; rather it appears that the outside air damper is permanently fixed at 10% to manage CO2 levels. The current configuration of the system is best illustrated in the figure below that shows the relationship between AHU-1 return air temperature, outside air temperature, mixed air temperature, and supply air temperature for the morning of September 9th, 2011.

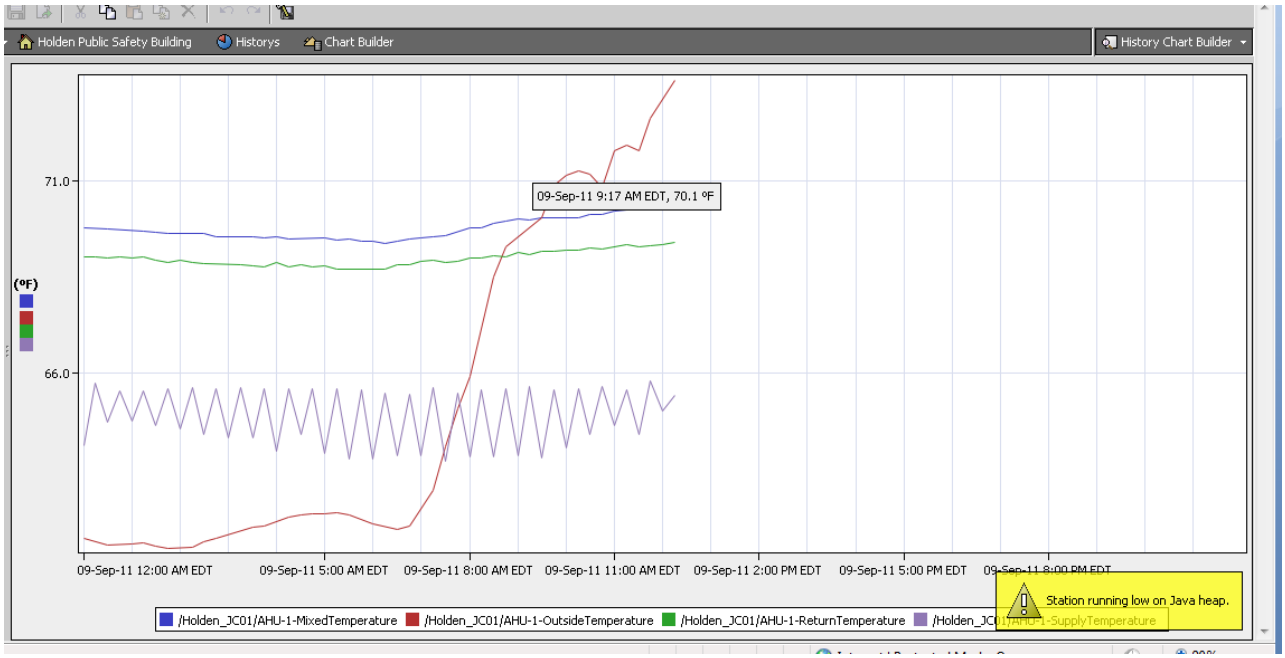


Figure 7: AHU-1 Trending from 9/9/11: RA, MA, SA, OA

Supply air temperature is shown in purple and is steady, per design, around 65 deg F. Return air temperature is also steady around 69 deg F. One oddity of this figure is that the mixed air temperature is higher than the return air temperature. This is likely attributable to sensor drift and/or the tolerance of the sensors which are typically tested to +/- 0.5 deg F. The total difference between return air and mixed air is less than 1 degree, within the tolerance of the sensors. Metering the air stream temperatures with data loggers would be one method to confirm the accuracy of the sensors.

Outside air temperature is represented by the red line in the graph. From midnight until roughly 9am, the outside air temperature was much lower than the return air temperature. If the economizer were working properly, the outside air damper should have opened to allow more outside air into the system and eliminating the need for chilled water. If this system were working properly, the mixed air temperature would be closer to the supply air temperature of 65 deg F. The fact that the mixed air temperature mirrors the return air temperature, and has for the length of history saved in the BMS, is

indicative of the fact that the outside air damper is fixed at 10% open and is not allowed to modulate in response to outside weather conditions. Utilizing the capabilities of the economizer is a low cost way to improve energy utilization of the system.

CHILLED WATER / SUPPLY AIR TEMPERATURE

Currently, the system is sending 50-55 deg F chilled water to the air handler to produce 65 deg F supply air temperature; however the sequence of operations calls for a discharge air temperature of 55 deg F. 65 deg F supply air is not likely to achieve a sufficient level of dehumidification in the facility. If there are any issues or concerns with humidity within the building, adjusting the chilled water to 45 deg F and supply air temperature to 55 deg F should be a consideration. Also, reducing supply air temperature to increase dehumidification would make the space feel more comfortable to occupants and may enable temperature set points to be reduced while maintaining comfortable conditions. Supply air temperature reset controls are another option for automatically adjusting the supply air temperature in response to space temperature demands and outdoor air conditions.

SPACE TEMPERATURE CONTROL DEADBAND

Most of the Variable Air Volume (VAV) boxes at the PSB are set with a “dead band” or temperature range of 2 degrees, meaning the cooling set point is 72 degrees and the heating set point is 70 degrees. A snapshot of some representative VAV settings from the BMS is included below for reference:

ID	Occ Cmd	Room Temp	Clg Sp	Clg Sp Active	Htg Sp Active	Flow	Flow Sp	Damper	Supply Temp	Htg Valve	Valve Calibrate
TB-101	Occupied	70.2 °F	72.0 °F	72.0 °F	70.0 °F	208.2 cfm	200.0 cfm	40.0 %	64.6 °F	0.0 %	Inactive
TB-102	Occupied	70.4 °F	72.0 °F	72.0 °F	70.0 °F	277.0 cfm	280.0 cfm	56.0 %	64.4 °F	0.0 %	Inactive
TB-103	Occupied	71.5 °F	72.0 °F	72.0 °F	70.0 °F	75.8 cfm	75.0 cfm	31.0 %	65.3 °F	0.0 %	Inactive
TB-104	Occupied	72.8 °F	72.0 °F	72.0 °F	70.0 °F	495.6 cfm	491.2 cfm	64.0 %	64.8 °F	0.0 %	Inactive
TB-105	Occupied	69.6 °F	72.0 °F	72.0 °F	70.0 °F	99.7 cfm	100.0 cfm	37.0 %	65.5 °F	90.0 %	Inactive
TB-106	Occupied	74.0 °F	74.0 °F	74.0 °F	72.0 °F	398.1 cfm	542.3 cfm	100.0 %	64.6 °F	0.0 %	Inactive
TB-107	Occupied	68.9 °F	72.0 °F	72.0 °F	70.0 °F	288.0 cfm	280.0 cfm	66.0 %	64.3 °F	100.0 %	Inactive
TB-108	Occupied	69.7 °F	72.0 °F	72.0 °F	70.0 °F	213.4 cfm	200.0 cfm	47.0 %	64.4 °F	56.2 %	Inactive
TB-109	Occupied	70.2 °F	72.0 °F	72.0 °F	70.0 °F	261.0 cfm	250.0 cfm	53.0 %	64.6 °F	74.8 %	Inactive
TB-110	Occupied	67.7 °F	72.0 °F	72.0 °F	70.0 °F	289.1 cfm	275.0 cfm	57.0 %	64.2 °F	100.0 %	Inactive

Of the 10 boxes included in the summary above, 5 have heating valves that are open trying to re-heat the space to back to within the dead band range. However, no hot water is being circulated to these boxes in cooling mode thus no active re-heat is occurring.

For VAV boxes that control both heating and cooling, a control setting recommendation is for the VAV box to maintain a dead band of at least 5°F between heating and cooling set points. VAV terminal units should be programmed to operate at the minimum airflow setting without addition of reheat when the zone temperature is within the set dead band. This way, the reheat coil is only activated once the temperature falls out of this range allowing for less stringent reheat demands due to very slight temperature fluctuations.

STATIC PRESSURE RESET

For AHU-1 at the PSB, the fan speed is controlled to maintain static pressure of 1.6 inches water column. Most energy codes require that this set point be adjusted automatically to minimize fan energy. The required controls will maintain the pressure in the duct only as high as necessary to meet the airflow requirements for all zones. These static pressure reset controls are readily achievable in systems with direct digital controls and can provide significant fan energy savings, because buildings operate at partial-load conditions most of the time. Another common benefit is reduced fan noise. Further study would be needed to design and specify rest controls for PSB; that is beyond the scope of this review.