# Investment Grade Energy Audit

## Camas School District

Liberty Middle School
Hayes Freedom High School
Camas High School
Camas Armory
Dorothy Fox Elementary School
JDZ/Doc Harris Parking Lots

## HVAC and LED Lighting Upgrade


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# EXECUTIVE SUMMARY

## Introduction and Background

Camas School District is interested in pursuing opportunities to reduce the energy usage of the heating, ventilating and air conditioning (HVAC) and lighting systems at their facilities while maintaining comfort and lighting standards within the schools. This report presents detailed findings of an investment grade level analysis of energy savings and implementation costs for several specific energy efficiency measures (EEMs) identified at these sites: Liberty Middle School, Hayes Freedom High School, Camas High School, Camas Armory, Dorothy Fox Elementary School, and the parking lots of JDZ Admin and Doc Harris.

## Incentives available for Energy Efficiency Projects

Clark PUD and Energy Trust of Oregon both offer incentives for owners to implement natural gas and electric saving measures. If the owner is interested in pursuing any of these opportunities they should discuss them with the local utility provider prior to purchasing equipment or issuing contracts for construction. Some projects will require inspections and verifications of savings before and/or after they are installed in order to qualify for incentives. All measures will require submitting official forms to the sponsoring agency prior to purchasing any equipment, except the new boiler project, which is currently a post-purchase incentive from the Energy Trust of Oregon.

## Grants available for Energy Efficiency Projects

The State of Washington is offering grants for municipally owned facilities to install energy efficiency improvements to their facilities. These grants are offered on a competitive basis, and the next round of applications is due no later than March 3, 2016. Another round of grants is anticipated in March 2017.

## Summary Table of EEMs

The overall project cost and savings summary is listed here.

| | | |
|---|---|---|
| **Total Project Installed Costs, including all fees, taxes, contingencies ,design, project management** | **$741,413** | |
| **Simple Payback (Using Grant Savings @ average state utility rates)** | **29.6** | **years** |

| | | |
|---|---|---|
| **Estimated Utility Incentives** | **$72,452** | |
| **Estimated Commerce Energy Grant** | **$185,353** | |
| **Net Owner Cost After Incentives and Grant** | **$483,608** | |
| **Net Simple Payback for Guaranteed Savings** | **26.5** | **years** |

The following table summarizes the energy savings and energy cost savings for each individual EEM in this report. The energy cost savings are calculated two different ways – one using the actual current utility rates, and one using the state-wide average rates that Commerce Department uses to compare grant applications.

## All Energy Efficiency Measures Summary Table

# EEM Summary Table - Projects for 2016 Commerce Grant

| | | | GUARANTEED ENERGY SAVINGS | | | GUARANTEED COST SAVINGS (@ Current Utility Rates) | | | | GRANT COSTS SAVINGS (@ State Average Rates) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **School** | **EEM #** | **EEM Description (Energy Efficiency Measures)** | **Electricity Saved / Year (kWh)** | **Electric Demand Saved / Month (kW)** | **Natural Gas Saved / Year (Therms)** | **Electric Costs Saved / Year ($)** | **Electric Demand Costs Saved / Year ($)** | **Natural Gas Costs Saved / Year ($)** | **Annual Utility Costs Saved / Year ($)** | **Electric Costs Saved / Year ($)** | **Natural Gas Costs Saved / Year ($)** | **Annual Utility Costs Saved / Year ($)** |
| Liberty MS | 1 | Retrocommission DDC System | 37,935 | | 1,938 | $1,821 | | $1,645 | $3,465 | $3,035 | $1,725 | $4,760 |
| Hayes Freedom HS | 2 | Retrocommission DDC System | 2,069 | | 551 | $99 | | $467 | $566 | $166 | $490 | $656 |
| Camas HS | 3 | Retrocommission DDC System | 1,777 | | 560 | $85 | | $233 | $318 | $142 | $498 | $641 |
| Camas HS | 4 | Add VFDs to (5) Large AHUs Serving Auditorium, Commons, Gym. | 80,812 | | | $3,879 | | | $3,879 | $6,465 | $0 | $6,465 |
| Camas HS | 5 | Add VFDs to Locker Room AHU 1001 and AHU 1002. | 10,799 | | 246 | $518 | | $102 | $621 | $864 | $219 | $1,083 |
| Camas Armory | 6 | New High Efficiency Boiler and Controls, + $10k Leak Repairs | 1,759 | | 2,872 | $84 | | $2,436 | $2,521 | $141 | $2,556 | $2,697 |
| Camas Armory | 7 | New High Efficiency Interior LED Lights | 14,653 | 4.4 | | $703 | $360 | | $1,063 | $1,172 | $0 | $1,172 |
| Dorothy Fox | 8 | New High Efficiency Interior LED Lights | 30,659 | 19.0 | | $1,472 | $1,286 | | $2,758 | $2,453 | $0 | $2,453 |
| JDZ / DH Parking Lots | 9 | New High Efficiency Parking Lot LED Lights | 8,820 | | | $423 | | | $423 | $706 | $0 | $706 |
| Camas HS | 10 | New High Efficiency Parking Lot LED Lights | 55,000 | | | $2,640 | | | $2,640 | $4,400 | $0 | $4,400 |
| **TOTALS** | | | **244,283** | **23** | **6,167** | $11,726 | $1,646 | $4,883 | **$18,255** | $19,543 | $5,489 | **$25,031** |

Note 1) For the Guaranteed Energy Savings Contract that the District may enter into with the ESCO, the actual utility rates have been used to determine the annual guaranteed cost savings in the table above, they are based upon the current actual utility rates.

Note 2) For the Commerce Department Grant that the District will be applying for, the Commerce Department has provided average state utility rates so that projects across the state can be evaluated on the same playing field, and they are used in the table above.

## Utility Rate Assumptions

For the Commerce Energy Grant application, we are directed to use the state average rates provided by the Commerce Department, so that the cost savings payback analysis for different grant applications from across the state are evaluated on an even playing field. These rates are only used for the Commerce Department Grant evaluation process, and these rates are:

| Grant Scoring Rates based on State Average | |
|---|---|
| **Natural Gas** | |
| Grant Rate | Washington State Average |
| $0.89000 | Charge per Therm |
| **Electricity** | |
| Grant Rate | Washington State Average |
| $0.0800 | Total Charge per kWh |

For the Guaranteed Energy Savings contract that the District may enter to with the ESCO, the actual current rates charged by the utility companies will be used during the measurement and verification of energy savings after the projects are installed, and will be used to determine if the guaranteed cost savings are being met. If the savings are not being met then the penalty paid to the District will be based upon these rates, which are listed here:

| Current Utility Rates Used for Guarantee | |
|---|---|
| **Natural Gas** | |
| Schedule 3 | Northwest Natural Gas Company |
| **$0.84836** | **Charge per Therm (used for guarantee)** |
| November 1, 2015 | Effective Date of Utility Rates |
| **Electricity** | |
| Schedule 34, Tier 2 | Clark Public Utilities |
| **$0.0480** | **Total Charge per kWh (blended annual rate used for guarantee)** |
| $0.0491 | Total Charge per kWh (September - March) |
| $0.0438 | Total Charge per kWh (April - August) |
| $6.77 | Total Charge per kW (Secondary Point-of-Delivery) |
| January 1, 2013 | Effective Date of Utility Rates |

## Next Steps for the Owner

**Review this report and decide which EEMs to implement.** The EEMs identified in this report affect different systems and have different budgets. If the owner has potential funding and commitment to implement any of these measures in the next few years then notify the serving utility company which measures are being considered. Indicate the timeframe you are considering and the potential budget.

**Apply for the Department of Commerce Grant.** Applications are due online March 3, 2016. Instructions and details can be found here:

**Clark PUD and Energy Trust of Oregon will notify you of the next steps to participate in their incentive program.** The particular EEMs that you are interested in implementing will determine what the next steps are, in order to qualify for incentives from the utility company. Normally you will be required to sign official paperwork from the utility company prior to issuing contracts to implement the EEMs, in order to qualify for the incentives.

## Other Energy Saving Opportunities not included in Summary Table

The following energy saving opportunities are not included in the summary table of this report, primarily because of the long paybacks. They are briefly described here, along with the reason why they are not included.

*Retrofit schools with LED/T8 and LED/T5HO lamps and drivers:* The District has many facilities with long operating hours that are good candidates for retrofitting to T8/T5HO/LED style lamps. They are not included in this grant application due to budget constraints, and they may be included in additional grant opportunities.

*Solar system to generate domestic hot water:* Glazed solar collectors could be mounted on the roofs and used to heat or pre-heat the domestic hot water. These systems have a payback over 40 years, and are not included in this grant application due to budget constraints.

*Solar system to generate electricity:* Glazed solar collectors could be mounted on the roofs and used to generate electricity. These systems have a payback over 40 years, and are not included in this grant application due to budget constraints.

*Upgrade additional parking lots with LED fixtures:* The District has additional school parking lots that are good candidates for upgrading to LED fixtures. They are not included in this report due to budget constraints, and they may be used in future grant applications.

*Upgrade exterior area lighting to LED fixtures:* The District has exterior building lights that are good candidates for upgrading to LED fixtures. They are not included in this report due to budget constraints, and they may be used in future grant applications.

*Demand controlled ventilation:* Installing and programing variable outdoor air supply based on $CO_2$ levels or occupancy reduces the amount of cooling or heating due necessary for excess outdoor air. High retrofit installations costs coupled with high existing occupancy rates result in long paybacks.

*Upgrade boilers and water heaters to full condensing units:* Full condensing boilers and water heaters offer the highest efficiency in natural gas fired units. This measure was evaluated for boilers at Skyridge Middle School and water heaters at Camas High School, however the resulting paybacks were too long due to high installation costs.

## Brief Description of Facility and Energy Using Systems

**Facility and Energy Using Systems Descriptions**:

**Liberty Middle School** is a 121,047 square foot facility that was originally built in 1935, with updates and additions in 1977, 1986 and 1996. In 2005, there was a major remodel of the HVAC system. Many of the existing air handling units were abandoned in place in the attic and replaced with rooftop AAON air handling units. There are currently (18) AAON units, (8) older built up units, and (2) makeup air units serving the school. Heat is provided by (3) full condensing high efficiency boilers. Direct expansion (DX) cooling coils are located in most of the AHUs for air conditioning.

The building is occupied by 60 teachers from 7:30 am to 3:30 pm. Approximately 800 students are in the building from 8 am and 2:45 pm. The building is also sometimes used for events on nights and weekends.

**Hayes Freedom High School** is a 20,500 square foot facility that was built in 2010. This building was designed to be very energy efficient, with in-slab heating, a full condensing boiler, daylighting, solar thermal water preheat, and photovoltaic solar panels. The building is served by (7) heat recovery ventilator (HRV) units. These Greenheck HRVs are 100% outside air with heat wheel heat recovery. There is no mechanical cooling in Hayes Freedom HS.

The building is occupied by 15 teachers from 7:30 am to 3:30 pm. Approximately 200 students are in the building from 8:20 am and 2:30 pm. The building is also occasionally used for events on nights and weekends.

**Camas High School** is a 248,464 square foot facility that was built in 2005, with updates and additions in 2011. The school is served by (76) small York air handling units, called classroom air handlers (CAHs), which serve the classrooms. There are also (10) larger Energy Lab Inc. AHUs that serve the large spaces such as the commons, auditorium, and gyms. There are (14) McQuay AHUs that serve the 2011 classroom and North Commons addition. In total, there are over 100 air handlers, as well as several exhaust fans. The parking lots and tennis courts are illuminated by pole-mounted, metal halide fixtures.

The building is occupied by 160 teachers from around 7 am to 4 pm. Approximately 2,100 students are in the building from 7:40 am and 2:10 pm. The building is frequently used for events on nights and weekends for sports events and extracurricular activities.

**Camas Armory** is a 14,432 square foot facility that was built in 1930s. This building was previously a school in the Camas School District but is now used as a gymnastics facility. The building is served by (1) Weil-McLain boiler. There are (4) fan coil units that use 100% return air which serve the main gymnasium. The remainder of the building is served by hot water radiators and convectors.

**Dorothy Fox Elementary School** is a 64,029 square foot facility that was opened in 1982. The lighting consists of mostly fluorescent T8, T5, and T12 lamps, with some CFLs also.

The building is occupied by 61 staff members from 8:30 am to 4:00 pm, and 481 students from 8:45 am to 3:30 pm, Monday through Friday.

**JDZ and Doc Harris Parking Lots** The James David Zellerbach building serves as the Camas School District administration office, as well as a venue for preschool programs. The Doc Harris Stadium is used for major sporting events. Only the parking lot lights were assessed for this energy analysis. The JDZ parking lot contains (4) high-pressure sodium floodlights mounted on two poles. The Doc Harris parking lot contains (8) high-pressure sodium fixtures mounted on four poles. These lights are operated from dusk until dawn all year.

## EEM 1: LIBERTY MIDDLE SCHOOL: RETROCOMMISSION DDC SYSTEM

During our investment grade energy audit review of the existing control system we spent time reviewing the as-built control sequences that were intended to save energy, and we interviewed the current operators about the current efficacy of the controls. We also reviewed trend data from the controls systems, and installed portable data loggers to analyze how the systems were operating. At this school we have already identified several opportunities to fine tune the system through retro commissioning to reduce energy usage. We anticipate finding other opportunities during our implementation of this work. The strategies we have already identified are listed below.

**Reprogram the Locker Room MAU Controls:** The Locker Room makeup air unit (MAU) has the ability to use return air or operate in 100% outside air mode with heat wheel heat recovery. Trend data indicates that when the unit operates, it operates in 100% outside air mode. This unit has variable speed drives on the supply and exhaust fans, however the drives are programmed to operate at 100% speed at all times. The unit operates from 5 am to 5 pm. This EEM proposes to reprogram the controls so the variable speed drives slow down to 50% speed during mild outside air temperatures and when humidity levels in the locker room are low. Additionally, the hours of operation of the unit can be reduced. This EEM proposes to operate the unit from 6 am to 5 pm.

**Reduce Hours of Operation of AHUs:** Most of the air handling units currently operate from 6 am to 5:30 pm. This EEM proposes to reprogram the controls so the units operate from 7 am to 3:30 pm. This new proposed schedule excludes the gym, cafeteria and locker room AHUs, because they need to operate differently for sports and after school programs.

**Reduce Hours of Operation of Hot Water Pumps:** The hot water pump was found to be operating excessively during the unoccupied hours. This EEM proposes to reprogram the pump to reduce the hours of operation.

**Refurbish air handlers 14 & 15:** The existing Pace Air Handlers were very high quality systems of their time, though they currently have some maintenance/operational issues that prevent them from operating as needed during extreme weather conditions. These air handlers will be inspected, repaired and refurbished so that they can provide full heating and cooling when needed.

The tables on the following pages illustrate the details of this EEM.

| Component | Current System | Proposed EEM Description |
|---|---|---|
| **MAU VFD Speed** | The variable frequency drives which control the fan speed for MAU 2 have been manually placed at 100% speed. This likely occurred because there was an issue with odor or moisture in the past. | The proposed system will implement new controls which will reduce the fan speed when outside air temperatures are mild and when the humidity levels in the locker room are low. |
| **Hours of Operation** | All units are programmed to operate Monday through Friday, September through June.<br>All typical AHUs are in "occupied" mode from 6 am to 5:30 pm, except for:<br>AC 11 (serving the cafeteria) which operates from 6:45am to 4:30 pm.<br>AH 14 and 15 (serving the gyms) which operate from 6am to 5pm.<br>MAU 2 (serving the locker room) which operates from 5am to 5pm. | The proposed system will continue to operate units Monday through Friday, September through June.<br><br>All typical AHUs will operate in occupied mode from 7 am to 3:30 pm.<br>AC 11 (serving the cafeteria) will operate from 6:45am to 4:00 pm.<br>AH 14 and 15 (serving the gyms) will operate from 7am to 5pm.<br>MAU 2 (serving the locker room) will operate from 6am to 5pm.<br><br>Optimal start routine will be fine-tuned and optimized so that the system automatically starts early enough to have the spaces comfortable by the time of occupancy. |
| **Hot Water Pump** | The hot water pump was found to be frequently operating during the unoccupied hours when outside air temperatures are mild. | The proposed system will utilize controls to reduce the hours of operation of the HW pump. |

**Baseline Systems**

**HVAC (Heating, Ventilation and Air Conditioning):**

Boilers:

There are (3) Aerco full condensing boilers that provide hot water for heating. The following table shows details about the boilers:

| Number | Type | Input MBH | Min Output MBH | Max Output MBH |
|---|---|---|---|---|
| B-1 | Aerco Condensing | 2000 | 1740 | 1880 |
| B-2 | Aerco Condensing | 2000 | 1740 | 1880 |
| B-3 | Aerco Condensing | 2000 | 1740 | 1880 |


**Full Condensing Boilers**

Air Handling Units:

There are (28) air handlers that condition the entire facility.

AAON Units: (18) of the air handling units are AAON units that were installed in 2006. Most of the AAON units are constant volume units with hot water heating and direct expansion cooling. There are two large variable air volume units with hot water preheat and direct expansion cooling in the unit and terminal units with hot water reheat.

**Typical Constant Volume AAON RTU**

**Typical Variable Volume AAON RTU**

Older Units: (8) of the air handling units are older built up units that appear to have been installed 30+ years ago. These units are constant volume with hot water heating. The two units serving the library have direct expansion cooling coils and dedicated outdoor condensing units.

**Older AHU Serving Gym**

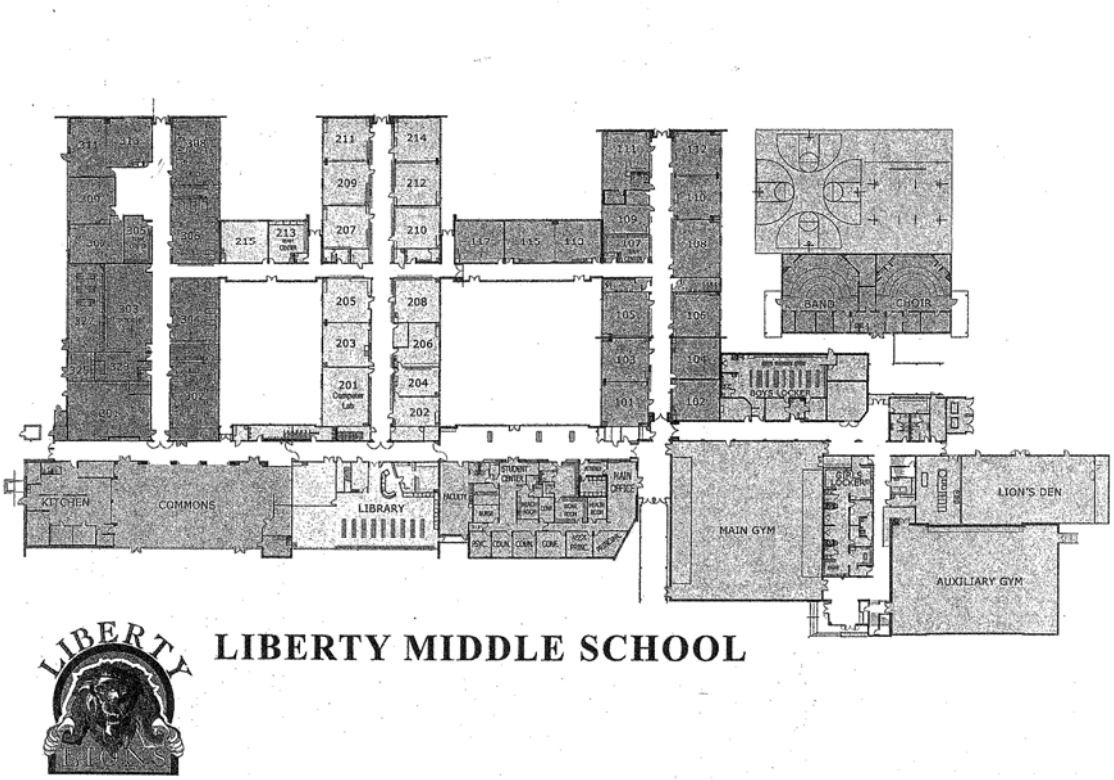
Makeup Air Units: (2) of the air handling units are makeup air units (MAUs) serving the kitchen and locker rooms. The kitchen MAU is often not used because, according to the kitchen staff, it is very loud and not normally needed. The kitchen MAU is constant volume and has the ability to use return air or operate in 100% outside air mode. The other MAU serves the locker rooms. The locker room MAU has the ability to use return air or operate in 100% outside air mode with heat wheel heat recovery. This unit has variable speed controlled supply and exhaust fan.

**MAU Serving Locker Rooms**

The following table shows details about the air handling units:

| Air Handler | Serves | CFM | Estimated SF HP | Estimated RF HP | Type |
|---|---|---|---|---|---|
| AC 1 | Science | 2310 | 1.5 | 1 | CAV |
| AC 2 | Science | 1450 | 1.0 | 0.5 | CAV |
| AC 3 | Science | 2350 | 1.5 | 1 | CAV |
| AC 4 | Science | 2170 | 1.5 | 1 | CAV |
| AC 5 | Classroom | 14990 | 10.0 | 7.5 | VAV |
| AC 6 | Classroom | 14990 | 10.0 | 7.5 | VAV |
| AC 7 | Admin | 2040 | 1.5 | 1 | CAV |
| AC 8 | Music | 3400 | 2.0 | 1 | Heat Pump |
| AC 9 | Music | 3000 | 2.0 | 1 | Heat Pump |
| AC 10 | Computer Lab | 1800 | 1.0 | 0.5 | CAV |
| AC 11 | Cafeteria | 10000 | 7.5 | 3 | CAV |
| AC 12 | Classroom | 3500 | 1.0 | 0.5 | CAV |
| AC 13 | Classroom | 1500 | 1.0 | 0.5 | CAV |
| AC 14 | Classroom | 1500 | 1.0 | 0.5 | CAV |
| AC 15 | Classroom | 2200 | 1.5 | 1 | CAV |
| AC 16 | Admin | 5600 | 4.0 | 2 | VAV |
| AC 17 | Classroom | 2000 | 1.0 | 0.5 | VAV |
| AC 18 | Upper Storage | 3800 | 2.0 | 1 | CAV |
| AH 1 | Media Center | 4150 | 3 | 1 | CAV |
| AH 2 | Meeting Area in M | 2800 | 2 | 0.75 | CAV |
| AH 3 | Project Lab | 2500 | 2 | 0.75 | CAV |
| AH 4 | Art Classroom | 1800 | 1 | 0.5 | CAV |
| AH 11 | Wrestling Rm | 5000 | 2 | 2 | CAV |
| AH 12 | Gym | 8000 | 2 | 2 | CAV |
| AH 14 | Gym | 9500 | 2 | 2 | CAV |
| AH 15 | Gym | 9500 | 2 | 2 | CAV |
| MAU 1 | Kitchen | 4400 | 3 | 3 | VAV |
| MAU 2 | Locker Rooms | 10070 | 10 | 7.5 | VAV |

**Map of School**



## EEM 2: HAYES FREEDOM HIGH SCHOOL: RETROCOMMISSION DDC SYSTEM

During our investment grade energy audit review of the existing control system we spent time reviewing the as-built control sequences that were intended to save energy, and we interviewed the current operators about the current efficacy of the controls. We also reviewed trend data from the controls systems, and installed portable data loggers to analyze how the systems were operating. At this school we have already identified several opportunities to fine tune the system through retro commissioning to reduce energy usage. We anticipate finding other opportunities during our implementation of this work. The strategies we have already identified are listed below.

**Reduce Hours of Operation of AHUs:** Most of the air handling units currently operate from 6 am to 3:30 pm. Trend data indicates that the hot water baseboard heating is the primary heat source used to warm the spaces for morning warm-up. Since the AHU's provide 100% outside air and are primarily meant to provide ventilation air to the spaces, the AHUs do not need to begin operation until occupants are in the building. This EEM proposes to begin AHU operation at 7 am instead of 6 am.

**Reduce Hours of Operation of Baseboard Heating:** The baseboard heaters utilize hot water from the boiler system as the primary source of heating for the school. (In the cafeteria, there is in-slab heating which also utilizes hot water from the boiler system. For simplicity, the in-slab heating has been included in with the baseboard heating analysis.) Data indicates that the baseboard heaters operate excessively during the unoccupied hours. Trend data shows that the indoor air temperature in the school begins to drop down after school ends, however the baseboard heating appears to begin operating around 2:30 am. During the logging period in December, January and February, the indoor air temperature never dropped below 62 deg F. This EEM proposes to reduce the operating hours of the baseboard heating.

**Reduce Hours of Operation of Hot Water Pumps:** The hot water pump was found to be operating excessively during the unoccupied hours. This EEM proposes to reprogram the pump to reduce the hours of operation.

**Optimize Hot Water Temperature Reset:** The boiler at Hayes is a full condensing boiler, however, trend data showed that the hot water return temperature is not always low enough for the boiler go to into condensing mode. This EEM proposes to implement a more aggressive hot water reset schedule in order to enable the boiler to operate more efficiently.

**Reduce Hours of Operation of Kitchen Exhaust Fan:** The kitchen exhaust fan was found to be operating from 2 am to 5 am, several days per week. Then the fan turns off until is it reactivated when kitchen staff arrive around 6 am. The fan appears to be operating erroneously. This EEM proposes to reprogram the kitchen exhaust fan to reduce the hours of operation.

The tables on the following pages illustrate the details of this EEM.

| Component | Current System | Proposed EEM Description |
|---|---|---|
| **AHUs** | All units are programmed to operate Monday through Friday, September through June.<br>All typical AHUs are in "occupied" mode from 6 am to 3:30 pm. | The proposed system will continue to operate units Monday through Friday, September through June.<br>All typical AHUs will operate in occupied mode from 7 am to 3:30 pm. |
| **Baseboard Heaters** | Baseboard heating operates excessively. This is possibly due to an issue with the nighttime heating setback temperature. | The proposed system will be reprogramed to reduce the hours of operation of the baseboard heaters. |
| **HW Pump** | The hot water pump operates excessively. This is probably due to the fact that the baseboard heaters operate excessively. | The proposed system will be reprogramed to reduce the hours of operation of the HW pump. |
| **Boiler** | The hot water return temperature is above 140 degF when outside air temperature are below 45 degF. | The proposed system will be reprogrammed with a more aggressive hot water reset schedule. To optimize savings, the more aggressive reset should be based on the maximum open hot water valve position. |
| **Kitchen Exhaust Fan** | The kitchen exhaust fan operates from 2am to 5am an average of 3-4 times per week. | The proposed system will be reprogrammed to eliminate the excessive operation of the kitchen exhaust fan. |

**Baseline Systems**

**HVAC (Heating, Ventilation and Air Conditioning):**

Boilers:

There is (1) HydroTherm KN-6 full condensing boiler that provides hot water for heating. The following table shows details about the boiler:

| Number | Type | Max Input BTUh | Min Input BTUh | Turndown | Output MBH | Min Eff |
|---|---|---|---|---|---|---|
| B-1 | Hydrotherm KN-6 | 600000 | 120000 | 20% | 510000 | 85% |


**Full Condensing Boiler**

Air Handling Units:

There are (7) air handlers that condition the entire facility.

Greenheck Units: All (7) of the air handling units are Greenheck units that were installed in 2010. These units are heat recovery ventilator (HRV) units. These HRVs are 100% outside air with heat wheel heat recovery. There is no mechanical cooling in any of the units.

**Typical Constant Volume AAON RTU**

The incoming outside air can either come directly from the outside, or can come preheated by the nearby photovoltaic solar panels. Data logging from December 2015 through February 2016, showed that the solar panel pre-heating contributed little to no heat to the incoming air. However, we suspect that on sunny days in the shoulder seasons, the solar panels do provide some preheating.

Exhaust Fans: There are several exhaust fans serving restrooms, fume hoods and the kitchen. The main kitchen exhaust fan is 1 HP and according to trend data, the kitchen exhaust fan operates excessively.

The following table shows details about the air handling units:

| Air Handler | Serves | CFM | SF HP | EF HP | Heat Wheel | VFD |
|---|---|---|---|---|---|---|
| HRV 1 | Science Classroom | 1200 | 1 | 0.75 | Yes | Yes |
| HRV 2 | Classroom | 1400 | 1.5 | 1 | Yes | |
| HRV 3 | Library and Admin | 1400 | 1.5 | 1 | Yes | |
| HRV 4 | Classroom | 1400 | 1.5 | 1 | Yes | |
| HRV 5 | Commons | 3000 | 2 | 1.5 | Yes | Yes |
| HRV 6 | Computer Classroom | 1200 | 1 | 0.75 | Yes | Yes |
| HRV 7 | Offices & East Classroom | 1200 | 1 | 0.75 | Yes | |
| EF 1 | Elec Room 120 | 250 | | 0.25 | | |
| EF 2 | Cust 135 | 150 | | 0.25 | | |
| EF 3 | MDF 136 | 800 | | 0.25 | | |
| EF 4 | Prep Room | 300 | | 0.25 | | |
| EF 5 | Fume Hood | 550 | | 0.25 | | |
| KEF 1 | Kitchen Hood Exhaust | 1375 | | 1 | | |
| KEF 2 | Dishwasher Hood | 350 | | 0.25 | | |
| KHS 1 | Kitchen Hood Supply | 825 | | 0.25 | | |

## EEM 3: CAMAS HIGH SCHOOL: RETROCOMMISSION DDC SYSTEM:

During our investment grade energy audit review of the existing control system we spent time reviewing the as-built control sequences that were intended to save energy, and we interviewed the current operators about the current efficacy of the controls. We also reviewed trend data from the controls systems, and installed portable data loggers to analyze how the systems were operating. At this school we have already identified several opportunities to fine tune the system through retro commissioning to reduce energy usage. We anticipate finding other opportunities during our implementation of this work. The strategies we have already identified are listed below.

**Implement Hot Water Temperature Reset:** The boilers at Camas High School are a full condensing, however, trend data showed that the hot water return temperature is not typically low enough for the boilers go to into condensing mode. This EEM proposes to implement a hot water reset schedule in order to enable the boiler to operate more efficiently.

**Implement Chilled Water Temperature Reset:** Currently, the chilled water temperature is maintained at 46 degF whenever outside air temperatures are above 60 degF. The air cooled chillers at Camas High School can operate more efficiently if the chilled water is allowed to reset to warmer temperatures when cooling demands are low. This EEM proposes to implement a chilled water reset schedule in order to enable the chiller to operate more efficiently.

**Reduce Average Hot Water Pump Speed:** There are two main hot water pumps which are already equipped with variable speed drives. The average speed of the hot water pumps is 63% speed. When new hot water temperature reset programming is implemented, the hot water pumps will be enabled to operate at lower speeds.

The tables on the following pages illustrate the details of this EEM.

| Component | Current System | Proposed EEM Description |
|---|---|---|
| **Hot Water Temperature** | The hot water supply temperature is currently set manually and it is maintained above 155 degF during most of the heating season. The differential between the supply water and return water temperature is typically 7 degF, resulting in a return water temperature of around 148 degF. This return water temperature is too high for the boilers to operate in condensing mode. | The proposed system will implement hot water supply temperature reset controls. This will enable the hot water supply temperature to vary with the hot water demand from the most open heating valve. This will ensure that the return water temperature is low enough for the boilers to go into condensing mode. |
| **Chilled Water Temperature** | The chilled water supply temperature is currently set at a constant 46 degF. | The proposed system will implement chilled water supply temperature reset controls. This will enable the chilled water supply temperature to vary with the chilled water demand from the most open cooling valve. This will ensure that chiller operates at optimal efficiency. |
| **HW Pump** | The hot water pumps currently operate at an average of 63% speed. | The proposed system will be reprogramed with hot water temperature reset. This will enable the hot water pumps to operate at a lower average speed. It is estimated that the average pump speed will be reduced by 5%. |

**Baseline Systems**

**HVAC (Heating, Ventilation and Air Conditioning):**

Boilers:

There are (5) Aerco full condensing boilers that provide hot water for heating. The following table shows details about the boilers:

| Number | Type | Input MBH | Output MBH | Min Eff |
|---|---|---|---|---|
| 501 | Aerco Condensing | 2000 | 1720 | 0.86 |
| 502 | Aerco Condensing | 2000 | 1720 | 0.86 |
| 503 | Aerco Condensing | 2000 | 1720 | 0.86 |
| 504 | Aerco Condensing | 2000 | 1720 | 0.86 |
| 505 | Aerco Condensing | 2000 | 1720 | 0.86 |

**Full Condensing Boilers**

Pumps:

There are (26) pumps that serve the hot water and chilled water systems in this school. The following table shows details about the pumps:

Pumps

| Number | Serves | HP |
|---|---|---|
| 501 | CHW | 25 |
| 502 | CHW | 25 |
| 503 | CHW ABC | 50 |
| 504 | CHW CDEF | 40 |
| 505 | Boiler | 1.5 |
| 506 | Boiler | 1.5 |
| 507 | Boiler | 1.5 |
| 508 | Boiler | 1.5 |
| 509 | Boiler | 1.5 |
| 510 | Boiler Loop | 10 |
| 901 | Coil Circ AHU 901 | 0.5 |
| 902 | Coil Circ AHU 902 | 0.5 |
| 903 | Coil Circ AHU 903 | 0.5 |
| 1001 | HW ABC | 20 |
| 1002 | HW CDEF | 15 |
| 1003 | Heat Recovery Run Around | 0.5 |
| 1004 | Coil Circ AHU 1002 | 1 |
| 1005 | Coil Circ AHU 1003 | 0.75 |
| 1101 | Coil Circ AHU 1102 | 1 |
| 1201 | Coil Circ CAH 1203 | 0.5 |
| 1202 | Coil Circ CAH 1214 | 0.5 |
| 1203 | Coil Circ CAH 1223 | 0.5 |
| 1204 | Coil Circ CAH 1226 | 0.5 |
| 1301 | Coil Circ CAH 1311 | 0.5 |
| 1302 | Coil Circ CAH 1312 | 0.5 |
| 1303 | Coil Circ CAH 1320 | 0.5 |

There are (100) air handlers that condition the entire facility.

CAHs: (76) of the AHUs are small York air handling units, called classroom air handlers (CAHs), which serve the classrooms. All of these units are constant volume with chilled water cooling and hot water heating. Each CAH has demand controlled ventilation.

**Typical CAH**

Large AHUs: (10) of the AHUs are Energy Lab Inc AHUs that serve the large spaces such as the commons, auditorium, and gyms. Most of these units are constant volume with chilled water cooling and hot water heating. The units that serve the Library and Administration areas (AHU 1201 and 1301) are variable air volume with hot water reheat at the terminal units.


**Typical Constant Volume AAON RTU**

MqQuay AHUs: There are (14) McQuay AHUs that serve the 2011 classroom and North Commons addition. These units are constant volume with chilled water cooling and hot water heating. Several of these units are 100% outside air with heat recovery because they serve science lab rooms.

Makeup Air Units: (2) of the air handling units are makeup air units (MAUs) serving the kitchen and locker rooms. The kitchen unit (AHU 1102) typically operates from 5:30am to 2:15pm, Monday through Friday. The kitchen MAU is constant volume and does not have any heat recovery. The locker room unit (AHU 1002) is constant volume and 100% outside air with a glycol heat recovery run around loop.


**AHU Serving Kitchen**

The following table shows details about the air handling units:

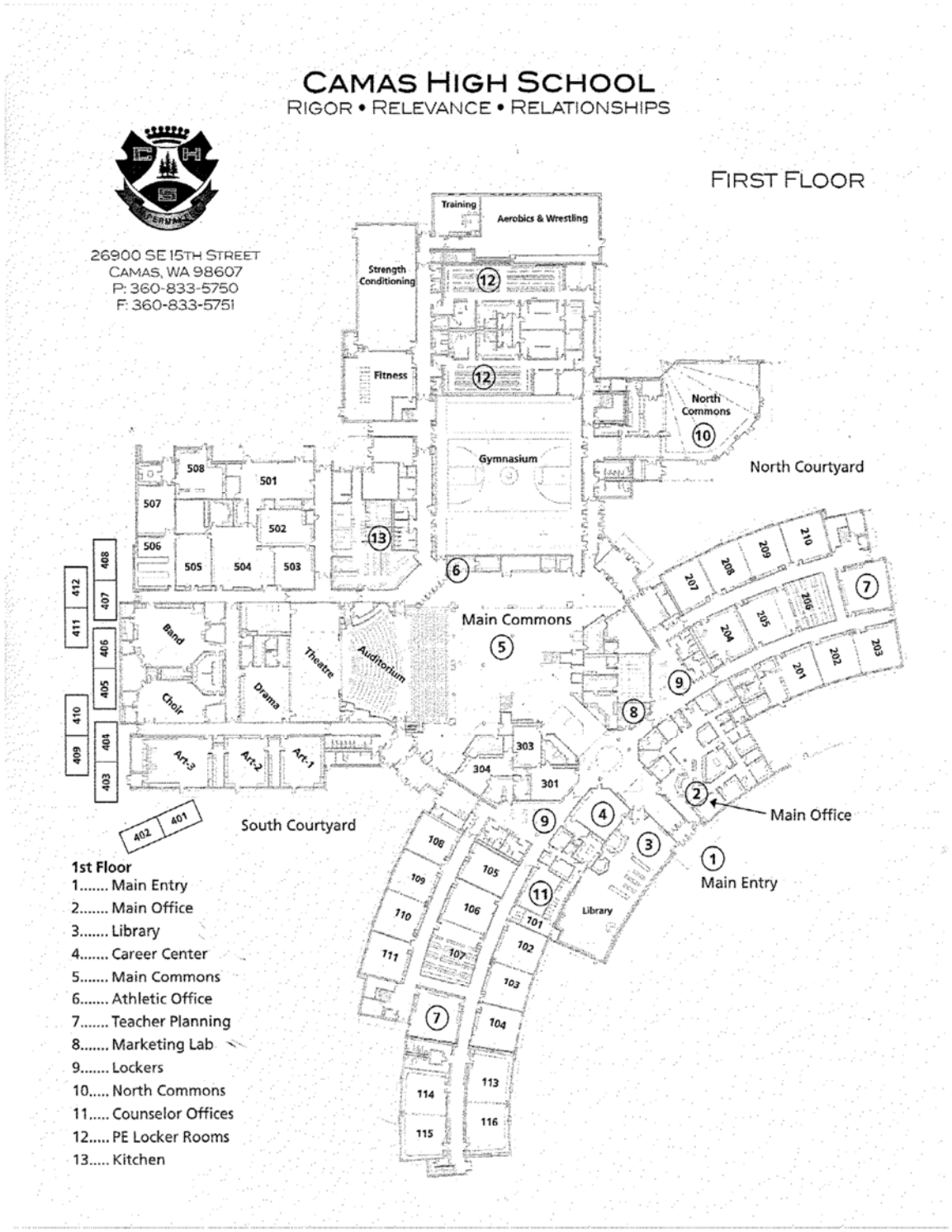
| Air Handler | Number | Serves | CFM | SF HP | RF HP | Type |
|---|---|---|---|---|---|---|
| AHU | 1201 | Library | 11000 | 15 | 7.5 | VAV, HW Reheat |
| AHU | 1301 | Admin | 8500 | 10 | 7.5 | VAV, HW Reheat |
| AHU | 901 | Aud/Commons | 4000 | 5 | 5 | CAV, Single Zone |
| AHU | 902 | Lower Gym | 30000 | 30 | 20 | CAV, Single Zone |
| AHU | 903 | Commons | 20000 | 20 | 15 | CAV, Single Zone |
| AHU | 1003 | Upper Gym | 16000 | 15 | 10 | CAV, Single Zone |
| AHU | 1101 | Auditorium | 12000 | 10 | 7.5 | CAV, Single Zone |
| AHU | 1001 | Lockers Exh | - | - | 7.5 | Locker Exhaust |
| AHU | 1002 | Lockers SA | 9400 | 7.5 | - | Locker Supply |
| AHU | 1102 | Kitchen | 9800 | 7.5 | - | Kitchen Supply |
| KEF | 1101 | Kitchen Vapor | 4090 | - | 3 | CAV |
| KEF | 1102 | Kitchen Grease | 5440 | - | 3 | CAV |
| KEF | 1301 | Pizza Oven | 1500 | - | 2 | CAV |
| KEF | 1302 | Convection Oven | 1500 | - | 2 | CAV |
| AHU | A1 | Classroom 113 | *2000* | 2 | 1 | CAV |
| AHU | A2 | Classroom 114 | *2000* | 2 | 1 | CAV |
| AHU | A3 | Chem prep | *2000* | 2 | 2 | CAV |
| AHU | A4 | Classroom 717 | *2000* | 2 | 1 | CAV |
| AHU | A5 | Classroom 714 | *3000* | 3 | 2 | CAV |
| AHU | A6 | Classroom 716 | *3000* | 3 | 2 | CAV |
| AHU | A7 | Classroom 116 | *2000* | 2 | 1 | CAV |
| AHU | A8 | Classroom 115 | *2000* | 2 | 1 | CAV |
| AH | D1 | N Commons | *2000* | *2* | *1* | CAV |
| AH | D2 | N. Kitchen | *2000* | *2* | *1* | CAV |
| AH | D1 | N Kitchen MAU | *2000* | *2* | *1* | CAV |
| AH | E1 | Training Room | *2000* | *3* | *1* | CAV |
| AH | E2 | Wrestling Room | *2000* | *3* | *1* | CAV |
| AH | F1 | Area E Room 508 | *2000* | *2* | *1* | CAV |
| CAH | 1001 | Aerobics | 4800 | 5 | 3 | CAV |
| CAH | 1002 | Weights | 2700 | 1.5 | 1.5 | CAV |
| CAH | 1003 | CR/Prep | 1575 | 1 | 0.5 | CAV |
| CAH | 1101 | Storage Print Shop | 2900 | 2 | 2 | CAV |
| CAH | 1102 | Bane | 4070 | 3 | 2 | CAV |
| CAH | 1103 | Hort | 1065 | 1.5 | 0.75 | CAV |
| CAH | 1104 | CADD | 2060 | 1 | 1 | CAV |
| CAH | 1105 | Video | 1240 | 0.75 | 0.75 | CAV |
| CAH | 1106 | Lab | 2000 | 1.5 | 1.5 | CAV |
| CAH | 1107 | Clean | 1000 | 0.75 | 0.5 | CAV |
| CAH | 1108 | Lab | 1250 | 1 | 0.75 | CAV |
| CAH | 1109 | Industrial Fab | 2200 | 1 | 1 | CAV |
| CAH | 1110 | Art | 2540 | 2 | 2 | CAV |
| CAH | 1111 | Choir | 3240 | 3 | 1 | CAV |
| CAH | 1112 | Graphic | 1350 | 1 | 0.75 | CAV |
| CAH | 1113 | Fine | 1670 | 1 | 0.75 | CAV |

| Air Handler | Number | Serves | CFM | SF HP | RF HP | Type |
|---|---|---|---|---|---|---|
| CAH | 1114 | Stage | 2850 | 2 | 2 | CAV |
| CAH | 1115 | Drama | 2285 | 2 | 1 | CAV |
| CAH | 1201 | Teacher Prep | 1950 | 1.5 | 1 | CAV |
| CAH | 1202 | Class | 1950 | 1.5 | 0.75 | CAV |
| CAH | 1203 | Biology | 2500 | 2 | 1.5 | CAV |
| CAH | 1204 | Class | 1500 | 1 | 1 | CAV |
| CAH | 1205 | Teacher Prep | 1500 | 1.5 | 1 | CAV |
| CAH | 1206 | Classroom | 1200 | 1 | 0.5 | CAV |
| CAH | 1207 | Computer Classroom | 2000 | 1.5 | 0.75 | CAV |
| CAH | 1208 | Classroom | 1200 | 1.5 | 1 | CAV |
| CAH | 1209 | Classroom | 1500 | 1 | 1 | CAV |
| CAH | 1210 | Classroom | 1200 | 1 | 0.75 | CAV |
| CAH | 1211 | Classroom | 1200 | 1 | 0.5 | CAV |
| CAH | 1212 | Classroom | 1200 | 1 | 0.5 | CAV |
| CAH | 1213 | Classroom | 1200 | 1 | 0.75 | CAV |
| CAH | 1214 | Biology | 2500 | 2 | 1 | CAV |
| CAH | 1215 | Classroom | 1200 | 1.5 | 0.75 | CAV |
| CAH | 1216 | Classroom | 1200 | 1 | 0.5 | CAV |
| CAH | 1217 | Computer Classroom | 2000 | 1.5 | 1 | CAV |
| CAH | 1218 | Classroom | 1200 | 1 | 0.75 | CAV |
| CAH | 1219 | Resource | 1000 | 1 | 0.5 | CAV |
| CAH | 1220 | Book Storage | 1200 | 1 | 0.5 | CAV |
| CAH | 1221 | Classroom | 1200 | 1.5 | 0.75 | CAV |
| CAH | 1222 | Classroom | 1200 | 0.75 | 0.75 | CAV |
| CAH | 1223 | Biology | 2500 | 2 | 1 | CAV |
| CAH | 1224 | Classroom | 1200 | 1 | 0.5 | CAV |
| CAH | 1225 | Physical | 1500 | 1.5 | 1 | CAV |
| CAH | 1226 | Life Skills | 1500 | 1.5 | 0.75 | CAV |
| CAH | 1227 | Offices | 1000 | 1.5 | 0.75 | CAV |
| CAH | 1228 | Physical Sci | 1500 | 1.5 | 1 | CAV |
| CAH | 1229 | Resource | 2000 | 1.5 | 1.5 | CAV |
| CAH | 1230 | Physical Sci | 1500 | 0.75 | 1 | CAV |
| CAH | 1301 | Journalism | 1000 | 1 | 0.5 | CAV |
| CAH | 1302 | Keyboard | 2100 | 1 | 2 | CAV |
| CAH | 1303 | ASB | 1000 | 1 | 0.75 | CAV |
| CAH | 1304 | Marketing | 2000 | 1.5 | 1.5 | CAV |
| CAH | 1305 | Staff Lounge | 1800 | 1.5 | 1 | CAV |
| CAH | 1306 | Business | 2000 | 1 | 1 | CAV |
| CAH | 1307 | Classroom | 1000 | 1.5 | 0.75 | CAV |
| CAH | 1308 | Physics | 1600 | 1 | 0.75 | CAV |
| CAH | 1309 | Classroom | 1000 | 1 | 0.5 | CAV |
| CAH | 1310 | Classroom | 1100 | 0.75 | 0.75 | CAV |
| CAH | 1311 | Foods | 2400 | 2 | 1.5 | CAV |
| CAH | 1312 | Child | 2000 | 1.5 | 1 | CAV |

| Air Handler | Number | Serves | CFM | SF HP | RF HP | Type |
|---|---|---|---|---|---|---|
| CAH | 1313 | Computer Classroom | 2000 | 1.5 | 1 | CAV |
| CAH | 1314 | Classroom | 1000 | 1 | 0.5 | CAV |
| CAH | 1315 | Classroom | 1000 | 1 | 0.75 | CAV |
| CAH | 1316 | Classroom | 1100 | 1 | 0.75 | CAV |
| CAH | 1317 | Classroom | 1100 | 1.5 | 0.75 | CAV |
| CAH | 1318 | Classroom | 1100 | 1.5 | 0.75 | CAV |
| CAH | 1319 | Classroom | 1100 | 1 | 0.75 | CAV |
| CAH | 1320 | Chemistry | 1500 | 1 | 0.5 | CAV |
| CAH | 1321 | Classroom | 1000 | 1 | 0.5 | CAV |
| CAH | 1322 | Computer Classroom | 2000 | 2 | 1 | CAV |
| CAH | 1323 | Classroom | 1100 | 0.75 | 0.75 | CAV |
| CAH | 1324 | Classroom | 1100 | 0.75 | 0.75 | CAV |
| CAH | 1325 | Classroom | 1500 | 1.5 | 1 | CAV |
| CAH | 1326 | Prep | 1500 | 1.5 | 1 | CAV |
| CAH | 1327 | Chemistry | 1800 | 1 | 1 | CAV |
| CAH | 1328 | Prep | 1500 | 1.5 | 0.75 | CAV |

Note: Values in *italics* are estimated.

**Map of School**



# CAMAS HIGH SCHOOL

RIGOR • RELEVANCE • RELATIONSHIPS

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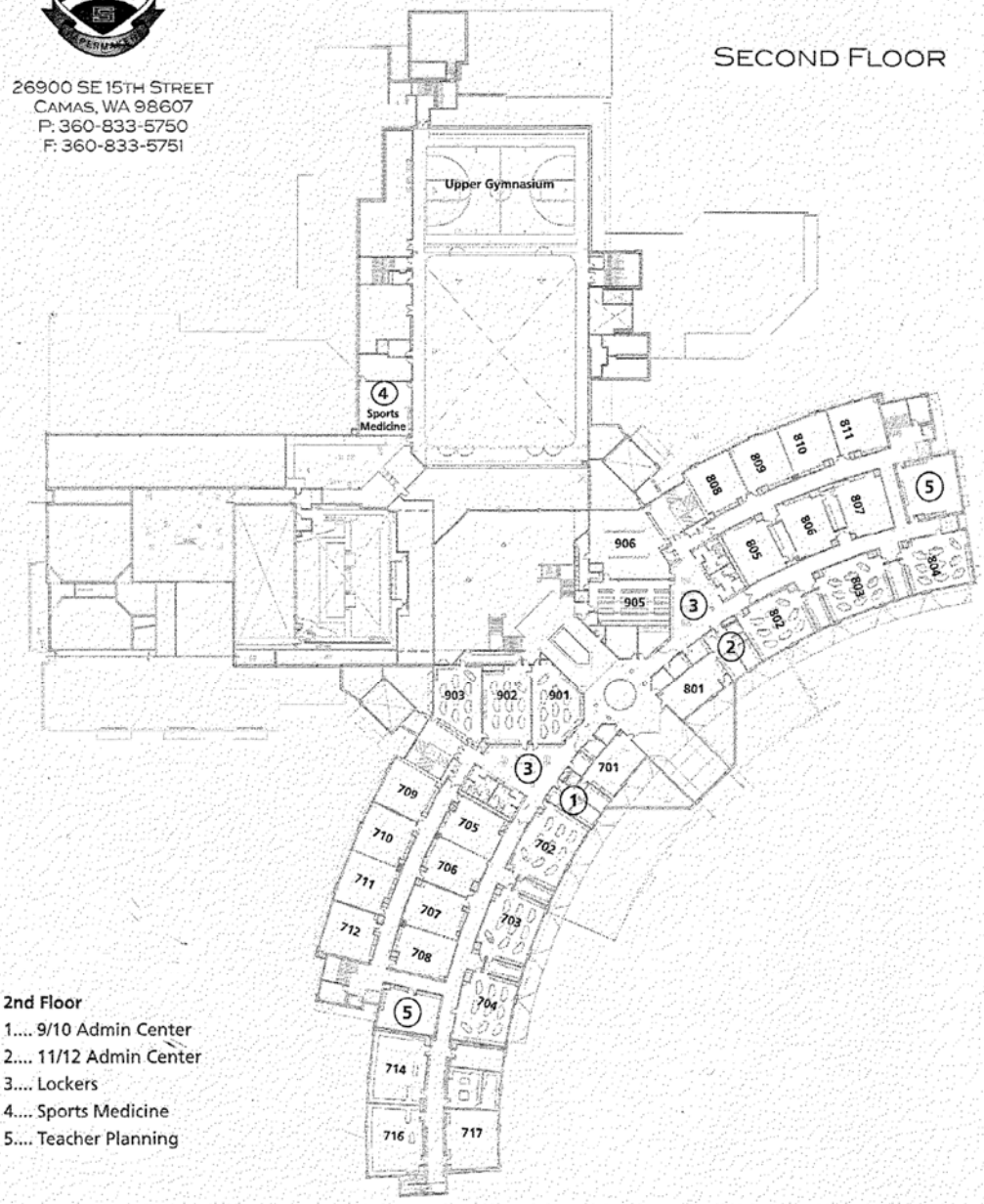
## SECOND FLOOR




**2nd Floor**

1.... 9/10 Admin Center
2.... 11/12 Admin Center
3.... Lockers
4.... Sports Medicine
5.... Teacher Planning

## EEM 4: CAMAS HIGH SCHOOL: ADD VFDS TO LARGE AHUS

There are several large air handlers at this school that are only capable of operating at full speed, regardless of heating or cooling loads or outside air temperatures. These units are good candidates for installing variable speed drives and modifying the controls so that the fan motors slow down when they are serving a light load during the day, and during milder weather.

**Add VFDs to (7) Large AHUs:** There are several large constant volume AHUs which serve the Gyms, Auditorium and Commons. This EEM proposes to install variable frequency drives on the supply and return fans of the large AHUs, enabling them to operate at reduced speeds during times of low loads.

The tables on the following pages illustrate the details of this EEM.

| Component | Current System | Proposed EEM Description |
|---|---|---|
| **AHU Fan Speed** | The constant volume large AHUs include:<br>AHU 901 (Auditorium/Commons)<br>AHU 902 (Lower Gym)<br>AHU 903 (Commons)<br>AHU 1003 (Upper Gym)<br>AHU 1101 (Auditorium) | The EEM proposes to install VFDs which will enable the fans to run at as low as 70% speed when outside air temperatures are around the building balance point. The fans are assumed to operate at full speed when outside air temperatures are very high and low. |

# EEM 5: CAMAS HIGH SCHOOL: ADD VFDS TO LOCKER ROOM AHU AND EXHAUST FAN

There are large fans used to supply and exhaust air from the locker rooms that are only capable of operating at full speed, regardless of heating or cooling loads or outside air temperatures. These are good candidates for installing variable speed drives and modifying the controls so that the fan motors slow down when they are serving a light load during the day, and during milder weather.

**Add VFDs to the Locker Room AHU and Exhaust Fan:** There is (1) large 100% outside air constant volume supply unit and (1) exhaust fan which serve the main locker rooms. There is a glycol runaround loop which is used to transfer heat from the outgoing exhaust air to the incoming supply air. The locker room is sized at 9400 CFM of exhaust air. This EEM proposes to install variable frequency drives on the supply and return fans of the large AHUs, enabling them to operate at reduced speeds during times of low loads.

The tables on the following pages illustrate the details of this EEM.

| Component | Current System | Proposed EEM Description |
|---|---|---|
| **AHU Fan Speed** | The constant volume large AHUs include:<br>AHU 1001 (Locker Room Supply)<br>AHU 1002 (Locker Room Exhaust) | The EEM proposes to install VFDs which will enable the fans to run at as low as 70% speed when outside air temperatures are around the building balance point. The fans are assumed to operate at full speed when outside air temperatures are very high and low. |

## EEM 6: ARMORY: NEW HIGH EFFICIENCY BOILER AND CONTROLS

This measure proposes to install a new high efficiency condensing boiler and controls at the Armory.

The existing boiler is a standard efficiency boiler. The new boiler will be capable of operating with an efficiency as high as 98%. Advanced controls will be installed to help minimize the return water temperature, which will increase the operating efficiency of the boiler.

The table below contains the details of our energy savings calculation.

| Existing System | Baseline System | Proposed System |
|---|---|---|
| **Boiler** | Standard efficiency, approx. 2,000,000 Btu/hr input, 1,600,000 Btu/hr output.<br><br>Assumed average annual operating efficiency of 75%. | New high efficiency condensing boiler, sized for an estimated 1,000,000 Btu/hr input. This will be finalized by an engineer during the design stage.<br><br>Assumed average annual operating efficiency of 91%. |
| **Hot Water Pumps** | (4) Standard efficiency inline circulating pumps located in the boiler room. | New pumps to be installed as part of this upgrade, along with new piping in the boiler room. |
| **Controls** | Outdated Paragon EC-128 time clock with relays in the boiler room, no longer providing night setback – systems operate 24/7. Manually turned on in the fall and manually turned off in the spring. | New controls will be integrated with District-wide Alerton control system, and programmed with an occupied and unoccupied operating time period. System will go into night low limit mode while unoccupied. |
| **Piping inside boiler room** | Multiple leaks in existing pipes and fittings. | Old piping to be removed and new piping installed inside the boiler room. |
| **Piping throughout the rest of the school.** | Several leaks have been observed by occupants over the years. Two consistent sources are in the hallway wall and under a radiator. | We have budgeted to repair up to three leaks inside the building. If additional leaks are discovered after implementation they will need to be repaired under a maintenance budget. |

**Baseline Systems**

**HVAC (Heating, Ventilation and Air Conditioning):**

Boilers:

There is (1) Weil-McLain boiler that provides hot water for heating. The following table shows details about the boiler:

| Name | Type | Max Input BTU/h | Min Input BTU/hr | Turn down |
|---|---|---|---|---|
| B-1 | Weil-McLain | 2396 | 1138 | 2:1 |

**Standard Efficiency Boiler**

Pumps:

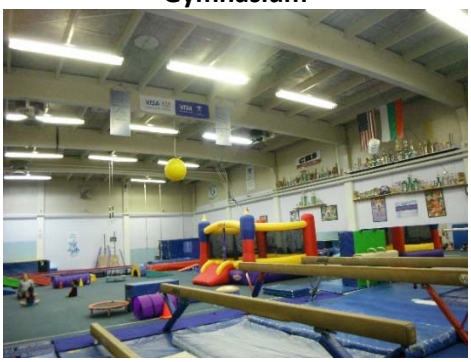
There are (4) fractional horsepower pumps which circulate hot water through (4) heating loops in the building.

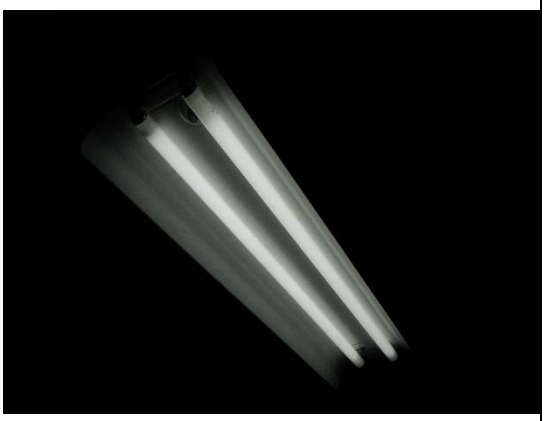
Air Handling Units:

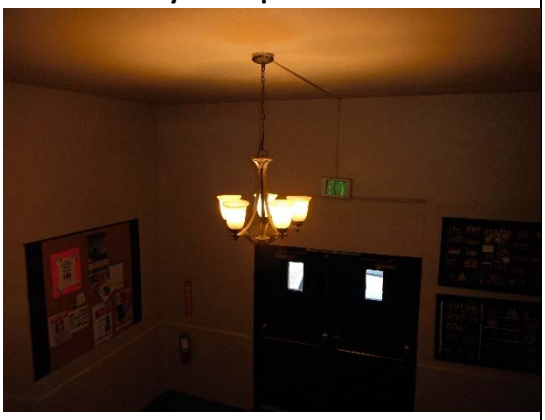
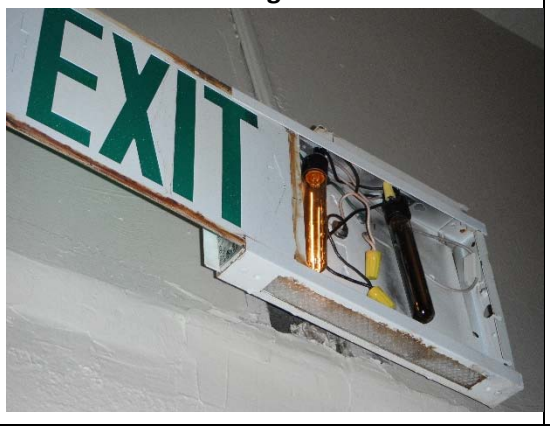
There are (4) ceiling mounted fan coil units in the gym which utilize 100% return (indoor) air. The rest of the facility relies on radiant heat from radiators and convectors throughout the building.

## EEM 7: ARMORY: INSTALL HIGH EFFICIENCY LED LIGHTS

This measure proposes to retrofit or replace approximately 140 existing light fixtures with new LED tubes and drivers or new LED fixtures designed to reduce energy and maintenance costs. These new lights will result in reduced electric usage whenever they are on.

| Location | Existing System | Proposed System |
|---|---|---|
| **Gymnasium**<br>  | 110-watt, 8' T12 fluorescent, (16) 2-lamp fixtures, and<br><br>32-watt, 4' T8 fluorescent, (1) 4-lamp fixture | Replace existing fixtures with (17) new 135-watt LED fixtures. |
| **Lower Hallway and Preschool Room**<br>  | (13) 23-watt CFLs, and<br><br>(22) 15-watt globe-style CFLs | Replace existing lamps with 8-watt screw-in LED lamps. |
|  <br>**Studio A and Laundry Room** | 110-watt, 8' T12 fluorescent, (4) 2-lamp fixtures | Replace existing 2 lamp fixtures with 60-watt 4-lamp LED fixtures (with replaceable 12.5-watt LED tubes). |
| (continued on next page) | | |

| Location | Existing System | Proposed System |
|---|---|---|
| **Studio B and Adacent Spaces**<br>  | 40-watt 4’ T12 fluorescent, (5) 4-lamp troffers | Replace existing fixtures with 60-watt 4-lamp LED fixtures (with replaceable 12.5-watt LED tubes). |
| **Studio B Track Lighting**<br>  | (31) 15-watt lamps in track-mounted fixtures | Replace existing lamps with 8-watt screw-in LED lamps. |
| **Maintenance Room**<br>  | 40-watt 4’ T12 fluorescent, (2) 2-lamp troffers | Replace existing fixtures with 30-watt 2-lamp LED fixtures (with replaceable 12.5-watt LED tubes). |
| (continued on next page) | | |

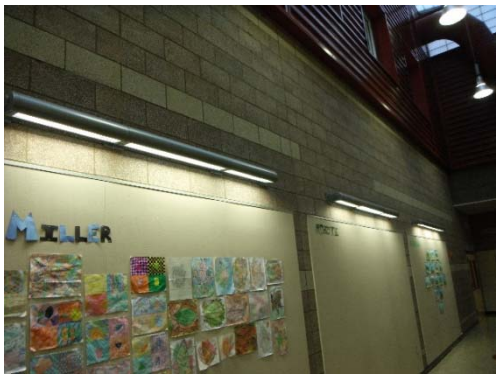
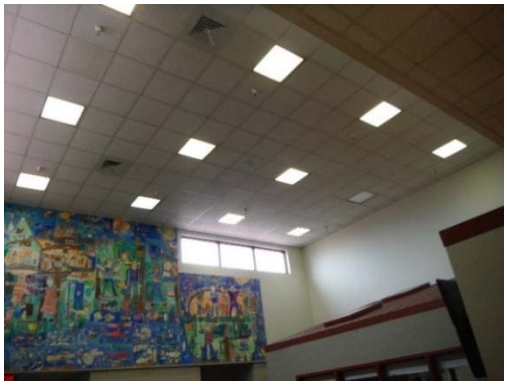
| Location | Existing System | Proposed System |
|---|---|---|
| **Miscellaneous Spaces** | 32-watt, 4’ T8 fluorescent lamps in (8) 4-lamp fixtures and (20) 2-lamp fixtures | Retrofit fixtures with 12.5-watt LED tubes and ballasts. |
| **Stairway and Upstairs Office**<br>  <br>  | (8) 23-watt CFLs in chandelier and ceiling fan fixture | Replace existing lamps with 8-watt screw-in LED lamps. |
| | | |
| **Exit Signs**<br>  | (5) 2-lamp, 25-watt incandescents, and<br><br>(1) 1-lamp, 7-watt CFL | Replace exit signs with new 1.5-watt LED exit signs. |
| (continued on next page) | | |

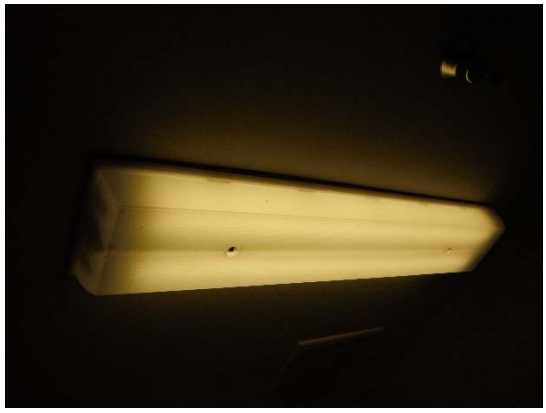
| Location | Existing System | Proposed System |
|---|---|---|
| **Locker Room**<br>  | 150-watt incandescent lamp | Replace existing lamp with 15-watt screw-in LED lamps. |

## EEM 8: DOROTHY FOX: INSTALL HIGH EFFICIENCY LED LIGHTS

This measure proposes to retrofit approximately 500 existing light fixtures with new LED tubes and drivers designed to reduce energy and maintenance costs. These new lights will result in reduced electric usage whenever they are on. The existing fixtures will remain in place, but the electric components (lamps, ballasts/drivers) will be retrofitted with new components as part of this upgrade.

| Location | Existing System | Proposed System |
|---|---|---|
|  **Classrooms** | 34-watt T12 and 32-watt T8 linear fluorescent lamps in 2'x4' troffer-style fixtures | Retrofit existing fixtures with 12.5-watt LED tubes and drivers. |
|  **Library** | 34-watt T12 linear fluorescent lamps in 2'x4' troffer-style fixtures | Retrofit existing fixtures with 12.5-watt LED tubes and drivers. |
|  **Cafeteria** | 32-watt T8 lamps in suspended fixtures | Retrofit existing fixtures with 12.5-watt LED tubes and drivers. |
| (continued on next page) | | |

| Location | Existing System | Proposed System |
|---|---|---|
| **Corridors, Assorted T8 Fixtures**<br>  <br>  | Mostly 32-watt 4’ T8 lamps; some 17-watt 2’ & 25-watt 3’ T8 lamps; assorted fixture types | Retrofit existing fixtures with 12.5-watt LED tubes and drivers; 8.5-watt & 10.5-watt LED U-tubes and drivers for 2’ and 3’ lamps. |
|  <br>**Corridors, 2’x2’ Fixtures** | 2’x2’ troffers with T12<br>U-tube lamps | Retrofit existing fixtures with 16.5-watt LED U-tubes and drivers. |
| **Offices** | 34-watt T12 and 32-watt T8 linear fluorescent lamps in 2’x4’ troffer-style fixtures | Retrofit existing fixtures with 12.5-watt LED tubes and drivers. |
| (continued on next page) | | |

| Location | Existing System | Proposed System |
|---|---|---|
| **Miscellaneous Spaces**<br>  <br>  <br>  | 34-watt T12 and 32-watt T8 linear fluorescent lamps in troffers, wrap-around, and vandal-resistant fixtures | Retrofit existing fixtures with 12.5-watt LED tubes and drivers. |

## EEM 9 JDZ & DOC HARRIS PARKING LOTS: INSTALL HIGH EFFICIENCY LED LIGHTS

This measure proposes to install approximately 10 new LED light fixtures designed to reduce energy and maintenance costs. These new lights will result in reduced electric use whenever they are on, which is dusk to dawn every night.

In addition to the energy benefits of LED lighting, the new lights are also more effective at spreading the light out evenly. This allows them to more evenly light the areas, resulting in few bright spots and fewer dim spots.

The existing lights will be replaced one for one, except in the parking lot of Doc Harris, where several new fixtures will be added to the existing pole to cost effectively increase the area of lighting coverage.

| Component | Baseline System | Proposed System |
|---|---|---|
| **JDZ Parking Lot** | (4) 400 watt High Pressure Sodium flood style fixtures mounted to wooden poles. | Install new LED fixtures on a one for one basis. |
| **Doc Harris Parking Lot** | (8) 250 watt high pressure sodium shoebox style fixtures | Install new LED fixtures on a one for one basis, plus two additional flood fixtures to existing poles for added coverage. |

## EEM 10 CAMAS HIGH SCHOOL PARKING LOTS: INSTALL HIGH EFFICIENCY LED LIGHTS

This measure proposes to install approximately 118 new LED light fixtures designed to reduce energy and maintenance costs. These new lights will result in reduced electric use whenever they are on, which is dusk to dawn every night.

In addition to the energy benefits of LED lighting, the new lights are also more effective at spreading the light out evenly. This allows them to more evenly light the areas, resulting in few bright spots and fewer dim spots.

The existing lights will be replaced one for one.

| Component | Baseline System | Proposed System |
|---|---|---|
| **Parking Lot** | (56) 400 watt Metal Halide flood style fixtures mounted to metal poles approx. 32' above the ground.<br><br>All of the lights turn on at dusk and turn off at dawn.<br><br>Approximately 1/3 of these lights operate all night long from dusk to dawn.<br><br>Approximately 2/3 of these lights turn off from midnight to 5am. | Install new LED fixtures on a one for one basis.<br><br>The new lights will continue to operate on the same schedule. |
| **Walkways** | (34) 175 watt metal halide style fixtures | Install new LED fixtures on a one for one basis. |
| **Tennis Courts** | (16) 250 watt metal halide style fixtures | Install new LED fixtures on a one for one basis. |
| **Sign and Flag** | (4) 175w metal halide style fixtures | Install new LED fixtures on a one for one basis. |

# APPENDIX

## 1.1 List of Contacts

**Contacts**

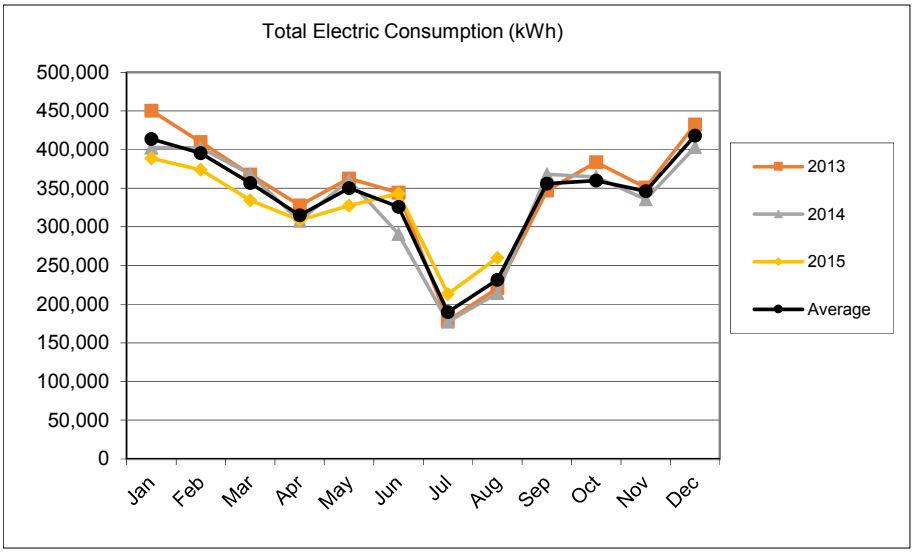
| |
|---|
| **Site Address**<br>Liberty Middle School - 1612 NE Garfield St, Camas, WA 98607<br>Hayes Freedom High School - 1919 NE Ione St, Camas, WA 98607<br>Camas High School - 26900 SE 15th St, Camas, WA 98607<br>Camas Armory - 838 NW 10th Ave, Camas, WA 98607<br>Dorothy Fox Elementary School - 2623 NW Sierra St, Camas, WA 98607<br>JDZ - 841 NE 22nd Avenue, Camas, WA 98607 |
| **Owner Contact**<br>Bryan McGeachy, Director of Operations<br>bryan.mcgeachy@camas.wednet.edu<br><br>Heidi Burkart, Resource Conservation Manager, Operations Coordinator<br>360-883-7402<br>Heidi.burkart@camas.wednet.edu |
| **Clark Public Utilities Contact**<br>Utility Representative<br>Bill Hibbs<br>360-992-3340<br>BHibbs@clarkpud.com |
| **Energy Trust of Oregon Contact**<br>Utility Representative<br>Kathleen Rienhardt-Waring<br>Phone: 503-310-0032<br>Kathleen.Rienhardt-Waring@icfi.com |
| **Energy Services Company Contact**<br>Abacus Resource Management Company<br>12655 SW Center Street, Suite 250<br>Beaverton, Oregon 97005<br>Main Phone: 503-277-5251<br><br>Steve Rubbert, President<br>Phone: 503-819-5593<br>stever@abacusrm.com<br><br>Rich Davis, Senior Energy Engineer<br>Phone: 503-936-7163<br>rich.davis@willdan.com<br><br>Lauren Bromley, Energy Engineer<br>Phone: 503-350-3461<br>laurenb@abacusrm.com |

## 1.2 Existing Energy Bills

There are six different buildings associated with this project. Each building has their own electric and gas meter(s). We summarize the total baseline of all buildings affected by this project, and then we provide details on each individual building.

All Buildings

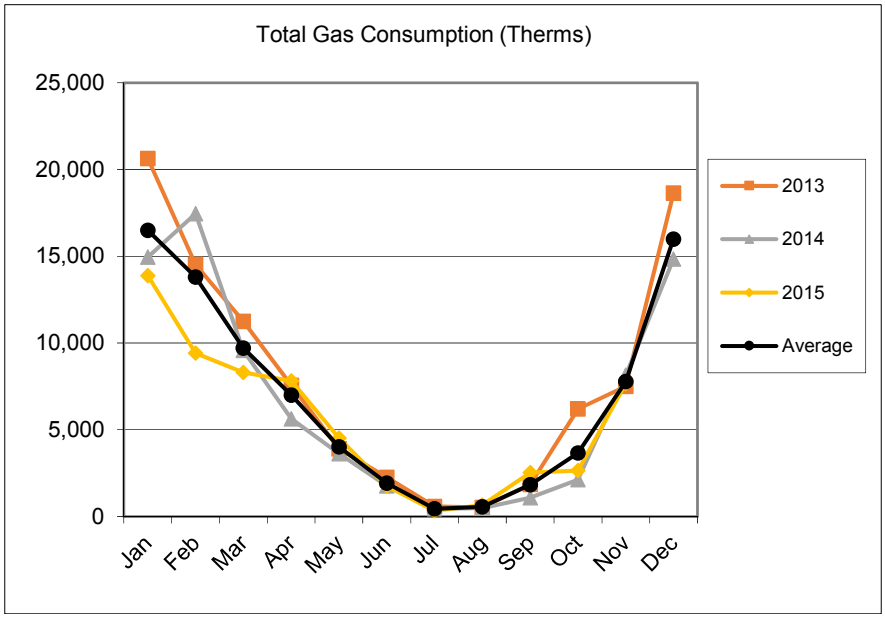
The electric usage is lowest in July and August when the buildings are generally not occupied, and higher in the winter months due to schools with electric heat sources.




| | Total Electric Consumption (kWh) | | | |
|---|---|---|---|---|
| Month | 2013 kWh | 2014 kWh | 2015 kWh | Average kWh (2013 - 2015) |
| Jan | 450,440 | 402,380 | 388,630 | **413,817** |
| Feb | 409,790 | 402,410 | 373,840 | **395,347** |
| Mar | 367,770 | 368,050 | 334,590 | **356,803** |
| Apr | 328,000 | 308,140 | 308,860 | **315,000** |
| May | 362,480 | 360,160 | 327,440 | **350,027** |
| Jun | 344,350 | 290,770 | 343,100 | **326,073** |
| Jul | 178,510 | 177,250 | 213,050 | **189,603** |
| Aug | 220,600 | 214,320 | 260,150 | **231,690** |
| Sep | 346,870 | 368,230 | N/A | **356,097** |
| Oct | 383,570 | 364,490 | N/A | **359,740** |
| Nov | 350,860 | 335,740 | N/A | **346,037** |
| Dec | 432,460 | 403,180 | N/A | **417,820** |
| **Totals** | **4,175,700** | **3,995,120** | **N/A** | **4,058,053** |

Note: The table above includes the meters for: Camas HS, Hayes Freedom HS, Liberty MS, Dorothy Fox ES, JDZ Admin, and Camas Armory Building. Individual building meters are found later in this section of the report.

The gas usage is higher in the winter due to space heating.

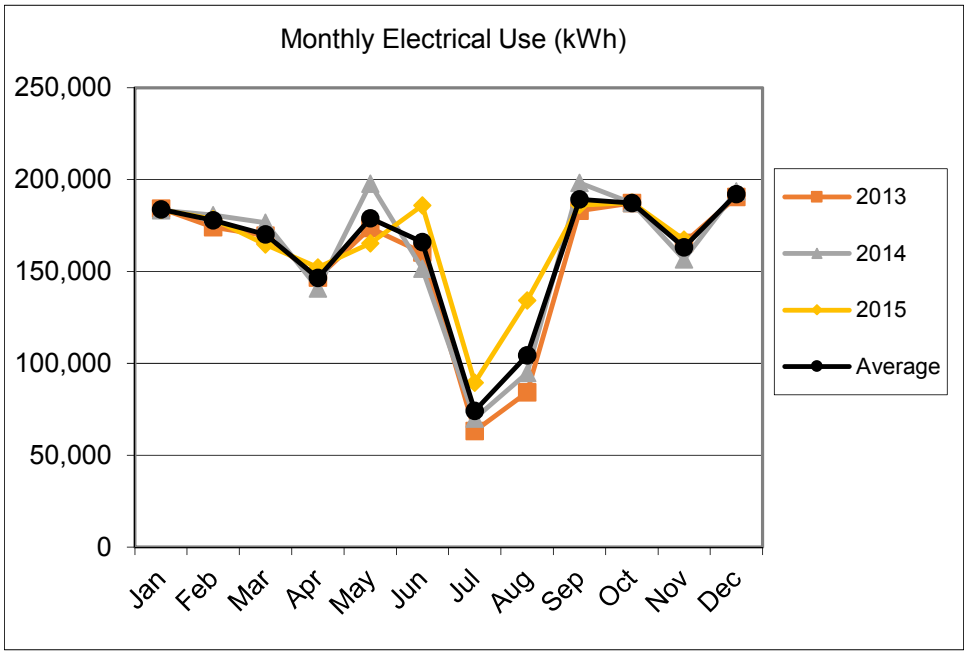



| | Total Gas Consumption (Therms) | | | |
|---|---|---|---|---|
| Month | 2013 Therms | 2014 Therms | 2015 Therms | Average Therms (2013 - 2015) |
| Jan | 20,634 | 14,962 | 13,879 | **16,492** |
| Feb | 14,532 | 17,453 | 9,411 | **13,799** |
| Mar | 11,260 | 9,583 | 8,309 | **9,718** |
| Apr | 7,569 | 5,632 | 7,825 | **7,009** |
| May | 3,905 | 3,629 | 4,515 | **4,016** |
| Jun | 2,262 | 1,768 | 1,760 | **1,930** |
| Jul | 583 | 446 | 319 | **449** |
| Aug | 517 | 492 | 663 | **557** |
| Sep | 1,842 | 1,091 | 2,533 | **1,822** |
| Oct | 6,208 | 2,120 | 2,650 | **3,659** |
| Nov | 7,509 | 8,146 | 7,670 | **7,775** |
| Dec | 18,642 | 14,849 | N/A | **15,993** |
| **Totals** | **95,462** | **80,172** | **N/A** | **83,218** |

Note: The table above includes the meters for: Camas HS, Hayes Freedom HS, Liberty MS, Dorothy Fox ES, JDZ Admin, and Camas Armory Building. Individual building meters are found later in this section of the report.

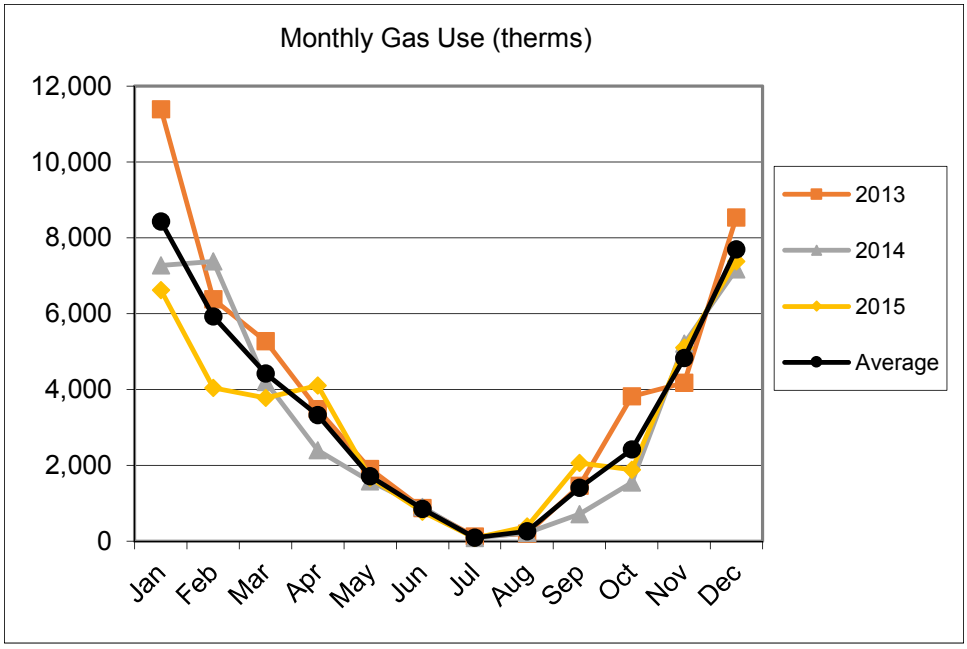
**Camas High School:**

The high school has two electric meters that will be affected by the proposed upgrades. The electric usage is lowest in July and August because the building is lowly occupied during these months. The electric usage is high in the shoulder months when the chiller operates to provide mechanical cooling, and high in the winter because of the long hours of operation for space heating.




| Month | 2013 kWh | 2014 kWh | 2015 kWh | **Average kWh 2013 - 2015** |
|---|---|---|---|---|
| Jan | 184,260 | 183,500 | 183,670 | **183,810** |
| Feb | 174,140 | 180,820 | 178,460 | **177,807** |
| Mar | 169,580 | 176,540 | 164,820 | **170,313** |
| Apr | 146,660 | 140,920 | 152,320 | **146,633** |
| May | 173,700 | 197,900 | 165,320 | **178,973** |
| Jun | 160,360 | 151,660 | 185,960 | **165,993** |
| Jul | 63,240 | 69,960 | 89,460 | **74,220** |
| Aug | 84,240 | 94,720 | 134,320 | **104,427** |
| Sep | 183,140 | 198,420 | 186,280 | **189,280** |
| Oct | 187,320 | 187,420 | 187,500 | **187,413** |
| Nov | 165,520 | 156,580 | 167,420 | **163,173** |
| Dec | 190,640 | 193,620 | | **192,130** |
| Totals | 1,882,800 | 1,932,060 | | **1,934,173** |

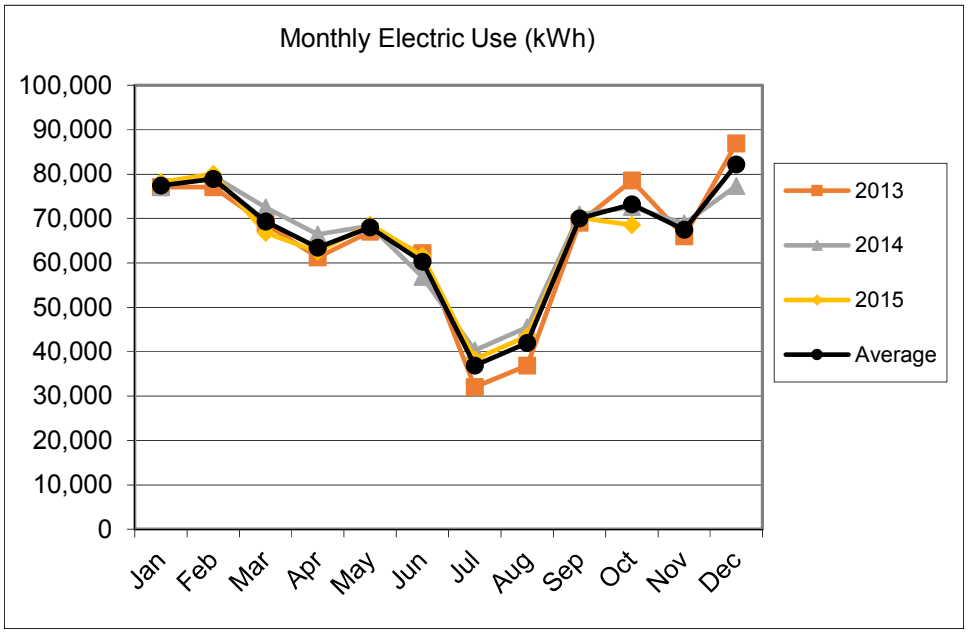
Camas High School has one natural gas meter that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads.




| Month | 2013 Therms | 2014 Therms | 2015 Therms | **Average Therms 2013 - 2015** |
|---|---|---|---|---|
| Jan | 11,393 | 7,276 | 6,620 | **8,430** |
| Feb | 6,378 | 7,378 | 4,040 | **5,932** |
| Mar | 5,275 | 4,201 | 3,777 | **4,418** |
| Apr | 3,483 | 2,394 | 4,101 | **3,326** |
| May | 1,909 | 1,573 | 1,672 | **1,718** |
| Jun | 869 | 900 | 781 | **850** |
| Jul | 121 | 84 | 84 | **96** |
| Aug | 194 | 215 | 387 | **265** |
| Sep | 1,465 | 718 | 2,058 | **1,414** |
| Oct | 3,822 | 1,544 | 1,880 | **2,415** |
| Nov | 4,180 | 5,216 | 5,109 | **4,835** |
| Dec | 8,536 | 7,174 | 7,379 | **7,696** |
| Totals | 47,625 | 38,673 | 37,888 | **41,395** |

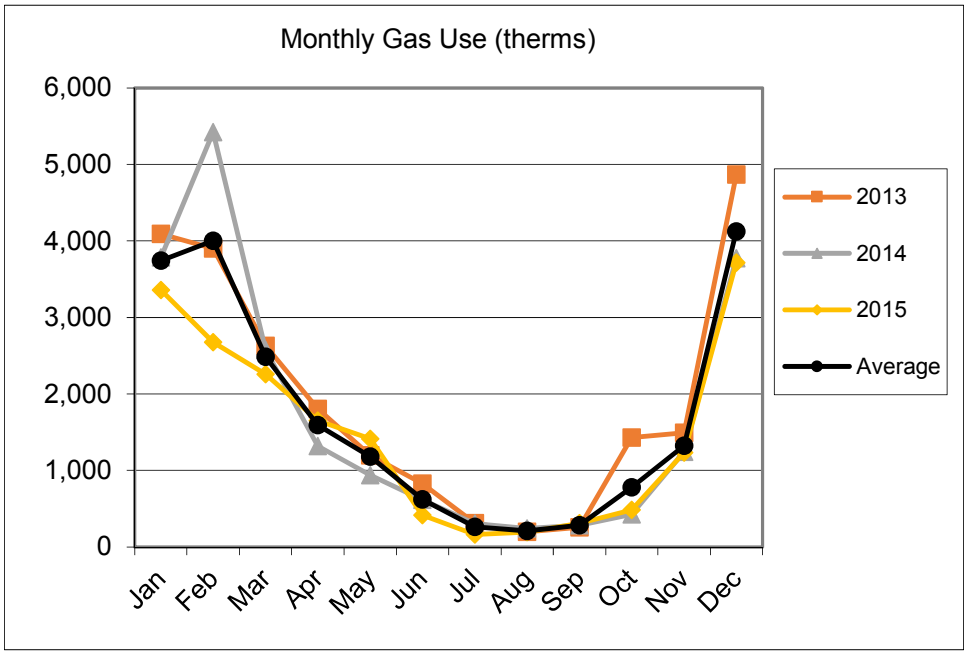
**Liberty Middle School:**

Liberty Middle School has two electric meters that will be affected by the proposed upgrades. The electric usage is lowest in July and August because the building is lowly occupied during these months. The electric usage is high in the shoulder months when the direct expansion cooling systems operate to provide mechanical cooling, and high in the winter because of the long hours of operation for space heating.




| Month | 2013 kWh | 2014 kWh | 2015 kWh | **Average kWh 2013 - 2015** |
|---|---|---|---|---|
| Jan | 77,080 | 77,080 | 78,160 | **77,440** |
| Feb | 77,080 | 79,480 | 80,040 | **78,867** |
| Mar | 68,800 | 72,480 | 66,800 | **69,360** |
| Apr | 61,240 | 66,440 | 62,560 | **63,413** |
| May | 67,000 | 68,360 | 68,640 | **68,000** |
| Jun | 62,240 | 56,840 | 61,600 | **60,227** |
| Jul | 32,080 | 40,280 | 38,320 | **36,893** |
| Aug | 36,920 | 45,480 | 43,480 | **41,960** |
| Sep | 69,040 | 70,920 | 70,200 | **70,053** |
| Oct | 78,520 | 72,560 | 68,520 | **73,200** |
| Nov | 65,960 | 68,920 | | **67,440** |
| Dec | 86,920 | 77,360 | | **82,140** |
| Totals | 782,880 | 796,200 | | **788,993** |

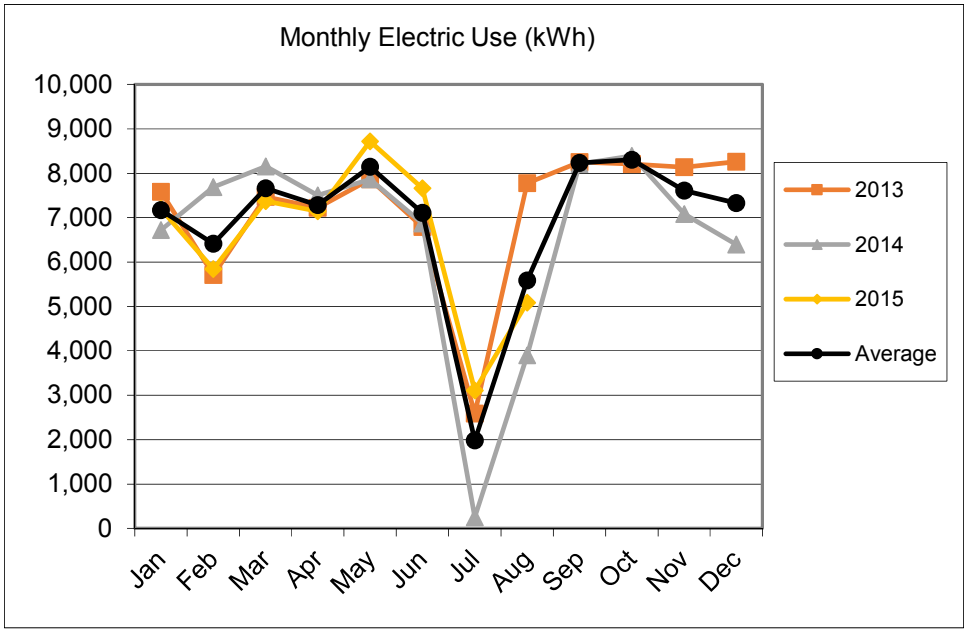
Liberty Middle School has one natural gas meter that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads.




| Month | 2013 Therms | 2014 Therms | 2015 Therms | **Average Therms 2013 - 2015** |
|---|---|---|---|---|
| Jan | 4,092 | 3,784 | 3,359 | **3,745** |
| Feb | 3,904 | 5,425 | 2,676 | **4,002** |
| Mar | 2,630 | 2,575 | 2,261 | **2,488** |
| Apr | 1,802 | 1,318 | 1,653 | **1,591** |
| May | 1,199 | 937 | 1,414 | **1,183** |
| Jun | 827 | 618 | 415 | **620** |
| Jul | 311 | 306 | 164 | **260** |
| Aug | 200 | 238 | 193 | **210** |
| Sep | 255 | 282 | 311 | **282** |
| Oct | 1,427 | 424 | 482 | **778** |
| Nov | 1,493 | 1,245 | 1,233 | **1,324** |
| Dec | 4,869 | 3,775 | 3,719 | **4,121** |
| Totals | 23,007 | 20,925 | 17,879 | **20,604** |

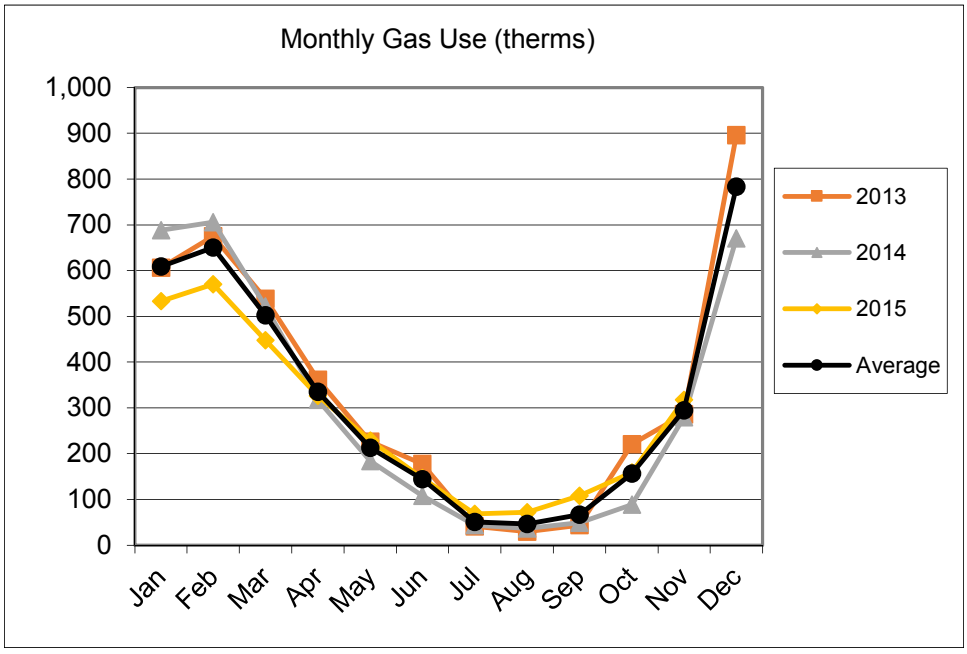
**Hayes Freedom High School:**

Hayes Freedom High School has one electric meter that will be affected by the proposed upgrades. The electric usage is lowest in July and August because the building is lowly occupied during these months. The electric usage is relatively constant throughout the rest of the year because this building does not have mechanical cooling.




| Month | 2013 kWh | 2014 kWh | 2015 kWh | **Average kWh 2013 - 2015** |
|---|---|---|---|---|
| Jan | 7,580 | 6,720 | 7,200 | **7,167** |
| Feb | 5,710 | 7,690 | 5,840 | **6,413** |
| Mar | 7,470 | 8,150 | 7,370 | **7,663** |
| Apr | 7,220 | 7,500 | 7,140 | **7,287** |
| May | 7,860 | 7,860 | 8,720 | **8,147** |
| Jun | 6,790 | 6,870 | 7,660 | **7,107** |
| Jul | 2,590 | 250 | 3,110 | **1,983** |
| Aug | 7,780 | 3,900 | 5,090 | **5,590** |
| Sep | 8,250 | 8,210 | | **8,230** |
| Oct | 8,210 | 8,390 | | **8,300** |
| Nov | 8,140 | 7,080 | | **7,610** |
| Dec | 8,260 | 6,400 | | **7,330** |
| Totals | 85,860 | 79,020 | | **82,827** |

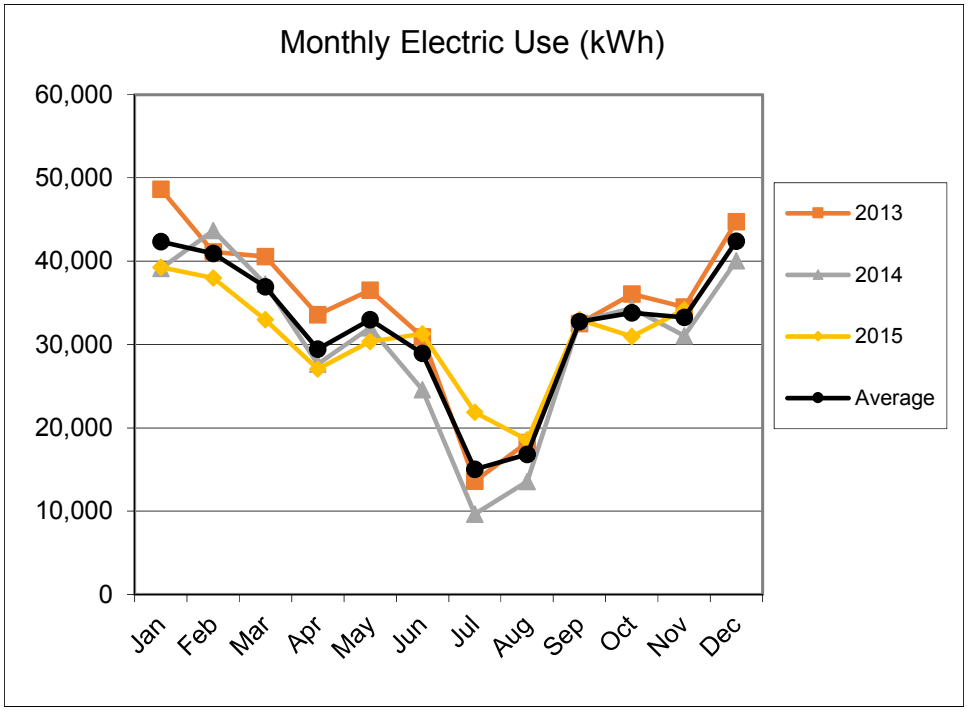
Hayes Freedom High School has one natural gas meter that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads.




| Month | 2013 Therms | 2014 Therms | 2015 Therms | **Average Therms 2013 - 2015** |
|---|---|---|---|---|
| Jan | 606 | 688 | 533 | **609** |
| Feb | 675 | 705 | 570 | **650** |
| Mar | 539 | 522 | 448 | **503** |
| Apr | 361 | 317 | 327 | **335** |
| May | 226 | 183 | 229 | **213** |
| Jun | 177 | 108 | 147 | **144** |
| Jul | 41 | 43 | 68 | **51** |
| Aug | 30 | 37 | 72 | **46** |
| Sep | 44 | 49 | 108 | **67** |
| Oct | 220 | 89 | 159 | **156** |
| Nov | 285 | 280 | 318 | **294** |
| Dec | 896 | 670 | | **783** |
| Totals | 4,100 | 3,692 | | **3,850** |

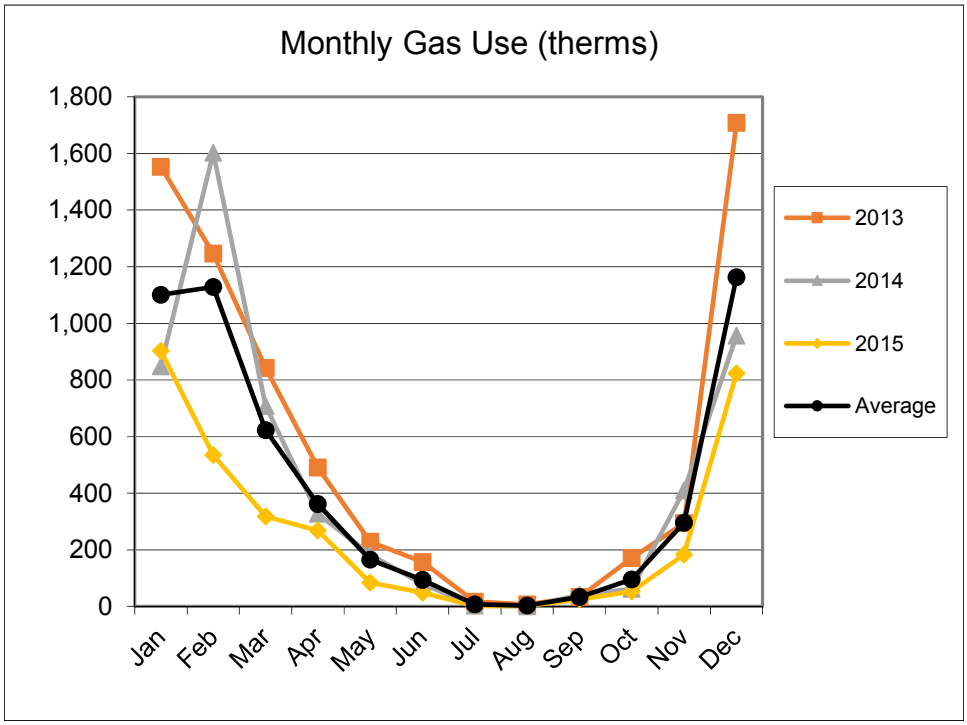
**Dorothy Fox Elementary School:**

Dorothy Fox Elementary School has one electric meter that will be affected by the proposed upgrades. The electric usage is lowest in July and August because the building is lowly occupied during these months. The electric usage is highest in the winter because the building is heated by electric water source heat pumps.




| Month | 2013 kWh | 2014 kWh | 2015 kWh | **Average kWh 2013 - 2015** |
|---|---|---|---|---|
| Jan | 48,640 | 39,120 | 39,280 | **42,347** |
| Feb | 41,120 | 43,680 | 38,000 | **40,933** |
| Mar | 40,560 | 37,240 | 33,000 | **36,933** |
| Apr | 33,600 | 27,640 | 27,040 | **29,427** |
| May | 36,520 | 32,000 | 30,360 | **32,960** |
| Jun | 30,920 | 24,560 | 31,280 | **28,920** |
| Jul | 13,600 | 9,640 | 21,880 | **15,040** |
| Aug | 18,260 | 13,580 | 18,580 | **16,807** |
| Sep | 32,520 | 32,800 | 33,000 | **32,773** |
| Oct | 36,040 | 34,360 | 30,960 | **33,787** |
| Nov | 34,520 | 31,040 | 34,160 | **33,240** |
| Dec | 44,720 | 40,040 | | **42,380** |
| Totals | 411,020 | 365,700 | | **385,547** |

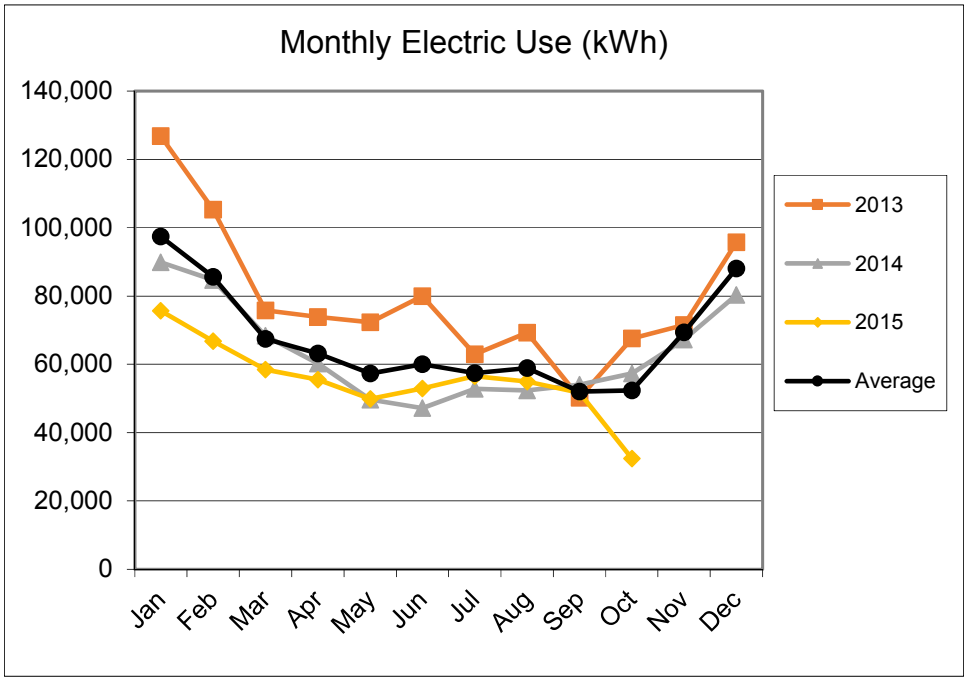
Dorothy Fox Elementary School has one natural gas meter that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads.




| Month | 2013 Therms | 2014 Therms | 2015 Therms | **Average Therms 2013 - 2015** |
|---|---|---|---|---|
| Jan | 1,553 | 849 | 904 | **1,102** |
| Feb | 1,246 | 1,602 | 536 | **1,128** |
| Mar | 843 | 708 | 318 | **623** |
| Apr | 491 | 327 | 269 | **362** |
| May | 229 | 183 | 84 | **166** |
| Jun | 157 | 79 | 49 | **95** |
| Jul | 17 | 4 | 2 | **8** |
| Aug | 8 | 1 | 2 | **4** |
| Sep | 33 | 41 | 26 | **33** |
| Oct | 171 | 62 | 53 | **96** |
| Nov | 295 | 410 | 184 | **296** |
| Dec | 1,709 | 957 | 823 | **1,163** |
| Totals | 6,752 | 5,223 | 3,249 | **5,075** |

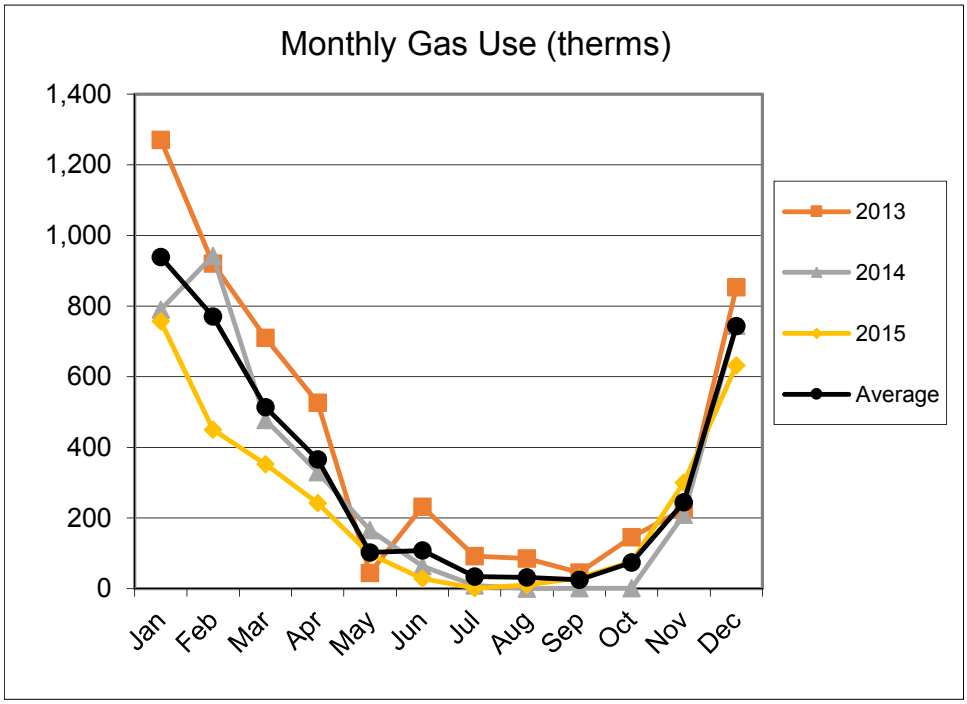
**JDZ Administration Building:**

The JDZ building has two electric meters that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads served by electric boilers.




| Month | 2013 kWh | 2014 kWh | 2015 kWh | **Average kWh 2013 - 2015** |
|---|---|---|---|---|
| Jan | 126,880 | 89,840 | 75,680 | **97,467** |
| Feb | 105,300 | 84,740 | 66,820 | **85,620** |
| Mar | 75,760 | 68,320 | 58,400 | **67,493** |
| Apr | 73,840 | 60,240 | 55,520 | **63,200** |
| May | 72,320 | 49,680 | 49,840 | **57,280** |
| Jun | 80,000 | 47,120 | 52,960 | **60,027** |
| Jul | 62,960 | 52,800 | 56,480 | **57,413** |
| Aug | 69,200 | 52,400 | 54,960 | **58,853** |
| Sep | 50,160 | 54,080 | 51,680 | **51,973** |
| Oct | 67,520 | 57,280 | 32,360 | **52,387** |
| Nov | 71,520 | 67,200 | | **69,360** |
| Dec | 95,760 | 80,320 | | **88,040** |
| Totals | 951,220 | 764,020 | | **809,113** |

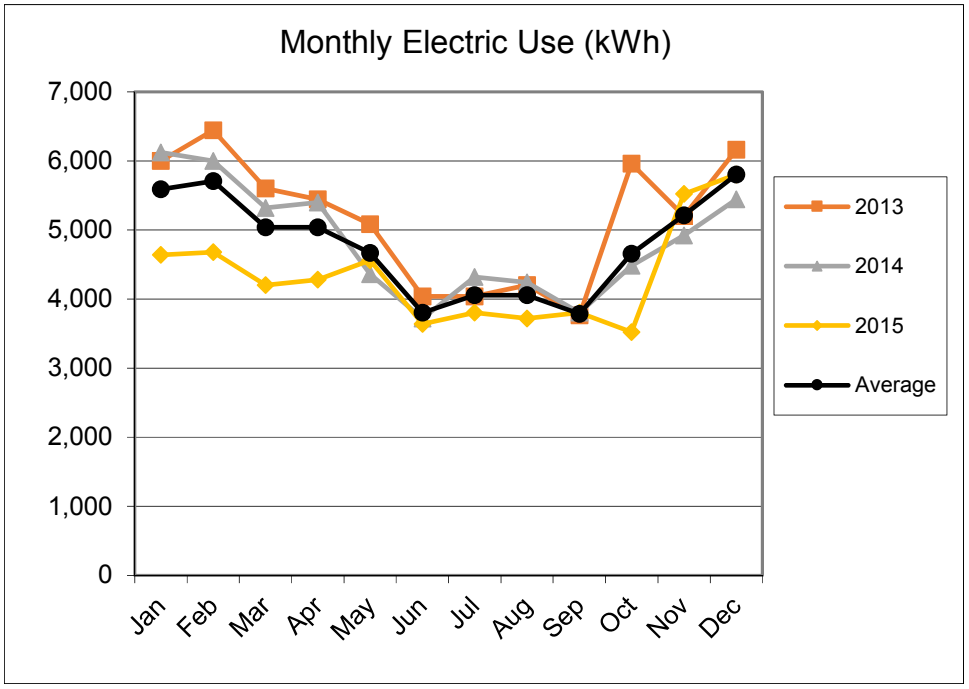
The JDZ building has one natural gas meter that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads.




| Month | 2013 Therms | 2014 Therms | 2015 Therms | **Average Therms 2013 - 2015** |
|---|---|---|---|---|
| Jan | 1,271 | 790 | 757 | **939** |
| Feb | 920 | 942 | 450 | **771** |
| Mar | 710 | 477 | 353 | **513** |
| Apr | 527 | 330 | 243 | **366** |
| May | 45 | 166 | 98 | **103** |
| Jun | 232 | 63 | 28 | **108** |
| Jul | 92 | 10 | 1 | **34** |
| Aug | 86 | 0 | 10 | **32** |
| Sep | 45 | 1 | 30 | **26** |
| Oct | 146 | 1 | 76 | **74** |
| Nov | 225 | 210 | 300 | **245** |
| Dec | 853 | 745 | 632 | **743** |
| Totals | 5,152 | 3,735 | 2,977 | **3,955** |

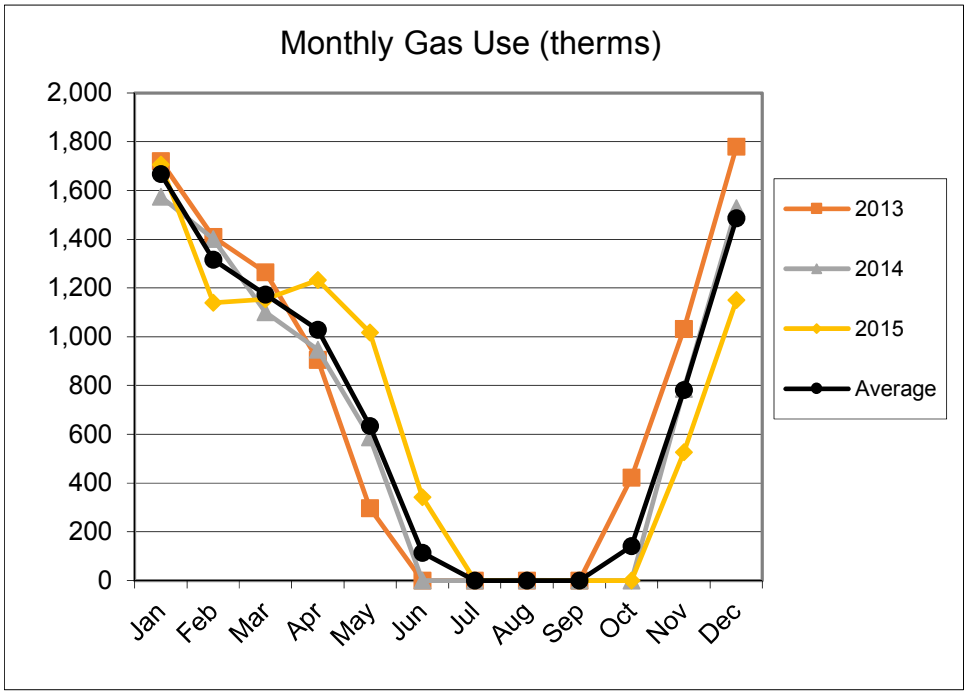
**Camas Armory Building:**

The Camas Armory Building has one electric meter that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads served by electric resistance heaters.




| Month | 2013 kWh | 2014 kWh | 2015 kWh | **Average kWh 2013 - 2015** |
|---|---|---|---|---|
| Jan | 6,000 | 6,120 | 4,640 | **5,587** |
| Feb | 6,440 | 6,000 | 4,680 | **5,707** |
| Mar | 5,600 | 5,320 | 4,200 | **5,040** |
| Apr | 5,440 | 5,400 | 4,280 | **5,040** |
| May | 5,080 | 4,360 | 4,560 | **4,667** |
| Jun | 4,040 | 3,720 | 3,640 | **3,800** |
| Jul | 4,040 | 4,320 | 3,800 | **4,053** |
| Aug | 4,200 | 4,240 | 3,720 | **4,053** |
| Sep | 3,760 | 3,800 | 3,800 | **3,787** |
| Oct | 5,960 | 4,480 | 3,520 | **4,653** |
| Nov | 5,200 | 4,920 | 5,520 | **5,213** |
| Dec | 6,160 | 5,440 | 5,800 | **5,800** |
| Totals | 61,920 | 58,120 | 52,160 | **57,400** |

The Camas Armory Building has one natural gas meter that will be affected by the proposed upgrades. The usage is higher in the winter due to increased space heating loads.




| Month | 2013 Therms | 2014 Therms | 2015 Therms | **Average Therms 2013 - 2015** |
|---|---|---|---|---|
| Jan | 1,720 | 1,575 | 1,706 | **1,667** |
| Feb | 1,409 | 1,401 | 1,139 | **1,316** |
| Mar | 1,264 | 1,101 | 1,153 | **1,173** |
| Apr | 905 | 946 | 1,233 | **1,028** |
| May | 297 | 587 | 1,018 | **634** |
| Jun | 0 | 0 | 341 | **114** |
| Jul | 0 | 0 | 0 | **0** |
| Aug | 0 | 1 | 0 | **0** |
| Sep | 0 | 0 | 0 | **0** |
| Oct | 422 | 0 | 0 | **141** |
| Nov | 1,031 | 786 | 526 | **781** |
| Dec | 1,779 | 1,527 | 1,151 | **1,486** |
| Totals | 8,827 | 7,924 | 8,267 | **8,339** |

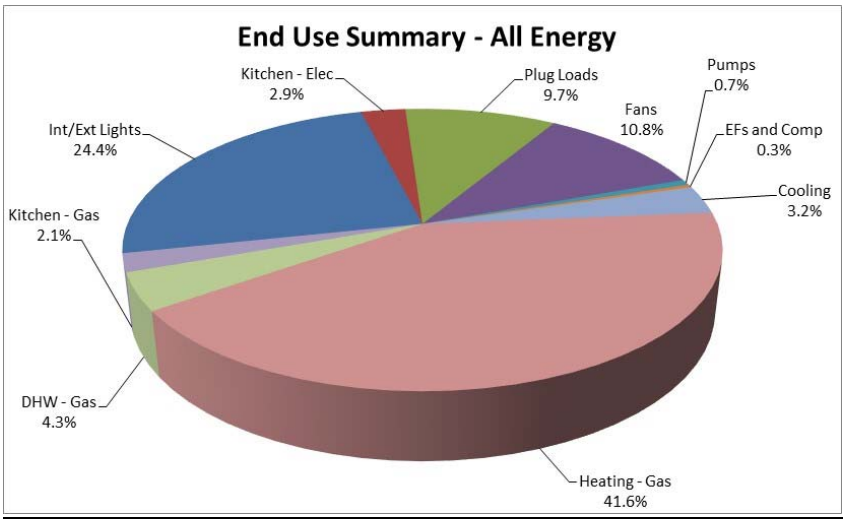
## 1.3 Existing Energy End Use Analysis

As the first step in our investment grade energy audit, we first determine where the existing energy in the facility is being used. This step is essential to take in order to accurately determine what the potential energy savings can be. The results of this analysis are presented here.

**Liberty Middle School**

| End Uses | | | | | | |
|---|---|---|---|---|---|---|
| Fuel Type | Category | Energy Usage | Unit | % of Total Energy Use | % of Electric Use | % of Gas Use |
| Elec | Int/Ext Lights | 334,816 | kWh | 24.4% | 46.9% | |
| Elec | Kitchen - Elec | 39,450 | kWh | 2.9% | 5.0% | |
| Elec | Plug Loads | 133,926 | kWh | 9.7% | 18.7% | |
| Elec | Fans | 148,317 | kWh | 10.8% | 20.8% | |
| Elec | Pumps | 9,111 | kWh | 0.7% | 1.3% | |
| Elec | EFs and Comp | 4,663 | kWh | 0.3% | 0.7% | |
| Elec | Cooling | 44,319 | kWh | 3.2% | 6.2% | |
| Gas | Heating - Gas | 19,522 | therms | 41.6% | | 87% |
| Gas | DHW - Gas | 1,999 | therms | 4.3% | | 9% |
| Gas | Kitchen - Gas | 988 | therms | 2.1% | | 5% |

| | | | | | Modeled Percent of Actual Uility Bills |
|---|---|---|---|---|---|
| End-Use Estimates | Electricity (kWh) | 714,602 | EUI ($kBtu/ft^2/yr$) | 38.7 | 91% of Elec bills |
| | Gas (therms) | 22,510 | | | |
| Utility Bills | Electricity (kWh) | 788,993 | | 40.4 | 102% of Gas bills |
| | Gas (therms) | 21,966 | | | |

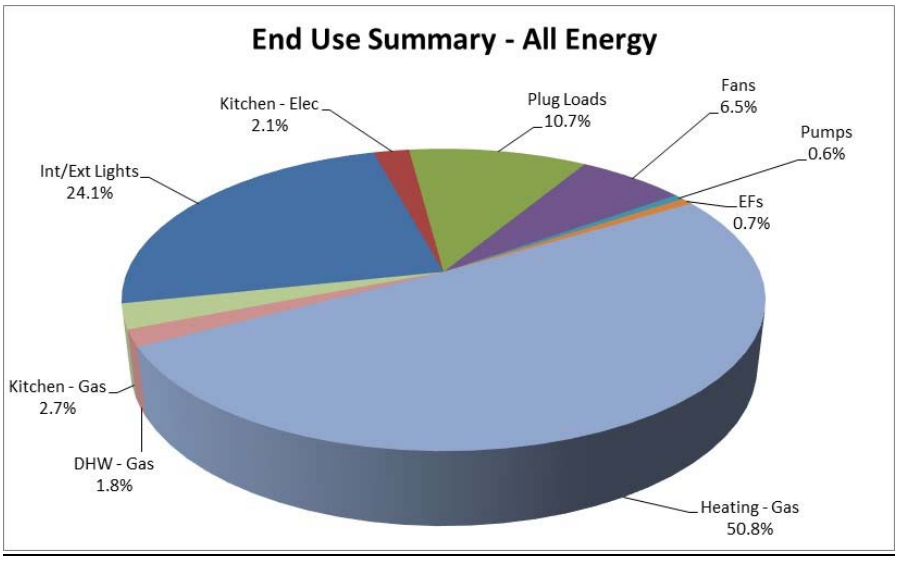


## Hayes Freedom High School

| End Uses | | | | | | |
|---|---|---|---|---|---|---|
| Fuel Type | Category | Energy Usage | Unit | % of Total Energy Use | % of Electric Use | % of Gas Use |
| Elec | Int/Ext Lights | 46,715 | kWh | 24.1% | 53.9% | |
| Elec | Kitchen - Elec | 4,141 | kWh | 2.1% | 5.0% | |
| Elec | Plug Loads | 20,762 | kWh | 10.7% | 24.0% | |
| Elec | Fans | 12,519 | kWh | 6.5% | 14.4% | |
| Elec | Pumps | 1,125 | kWh | 0.6% | 1.3% | |
| Elec | EFs and Compressor | 1,373 | kWh | 0.7% | 1.6% | |
| Gas | Heating - Gas | 3,357 | therms | 50.8% | | 92% |
| Gas | DHW - Gas | 118 | therms | 1.8% | | 3% |
| Gas | Kitchen - Gas | 175 | therms | 2.7% | | 5% |

| | | | | |
|---|---|---|---|---|
| End-Use Estimates | Electricity (kWh) | 86,636 | EUI (kBtu/ft$^2$/yr) | 32.2 |
| | Gas (therms) | 3,650 | | |
| Utility Bills | Electricity (kWh) | 82,827 | | 32.8 |
| | Gas (therms) | 3,896 | | |

| Modeled Percent of Actual Uility Bills |
|---|
| 105% of Elec bills |
| 94% of Gas bills |

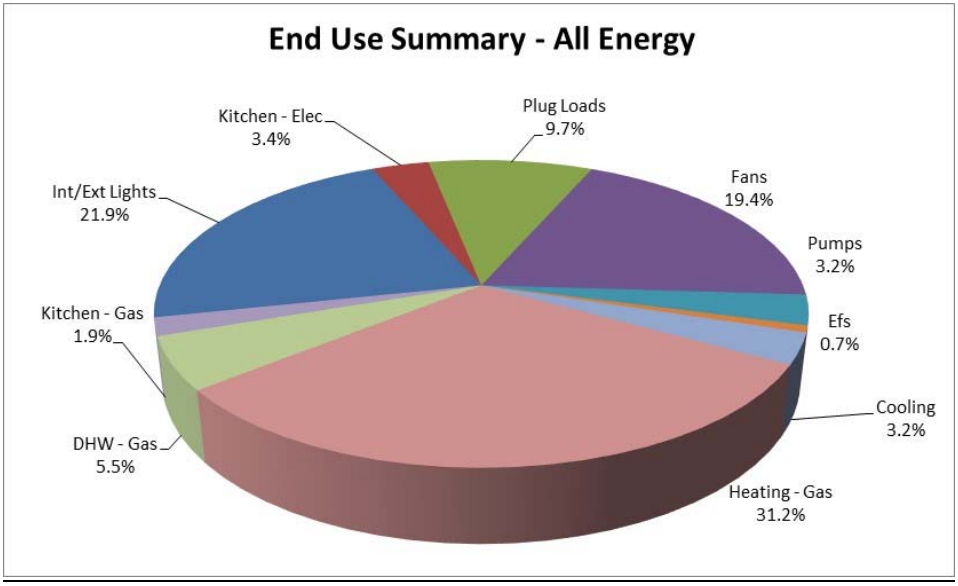


## Camas High School

| End Uses | | | | | | |
|---|---|---|---|---|---|---|
| Fuel Type | Category | Energy Usage | Unit | % of Total Energy Use | % of Electric Use | % of Gas Use |
| Elec | Int/Ext Lights | 622,551 | kWh | 21.9% | 35.6% | |
| Elec | Kitchen - Elec | 95,726 | kWh | 3.4% | 5.0% | |
| Elec | Plug Loads | 276,690 | kWh | 9.7% | 15.8% | |
| Elec | Fans | 552,143 | kWh | 19.4% | 31.5% | |
| Elec | Pumps | 90,639 | kWh | 3.2% | 5.2% | |
| Elec | EFs and Compressor | 19,956 | kWh | 0.7% | 1.1% | |
| Elec | Cooling | 92,505 | kWh | 3.2% | 5.3% | |
| Gas | Heating - Gas | 30,281 | therms | 31.2% | | 81% |
| Gas | DHW - Gas | 5,374 | therms | 5.5% | | 14% |
| Gas | Kitchen - Gas | 1,837 | therms | 1.9% | | 5% |

| | | | | |
|---|---|---|---|---|
| End-Use Estimates | Electricity (kWh) | 1,750,209 | EUI ($kBtu/ft^2/yr$) | 39.1 |
| | Gas (therms) | 37,492 | | |
| Utility Bills | Electricity (kWh) | 1,914,516 | | 42.7 |
| | Gas (therms) | 40,821 | | |

| Modeled Percent of Actual Uility Bills |
|---|
| 91% of Elec bills |
| 92% of Gas bills |

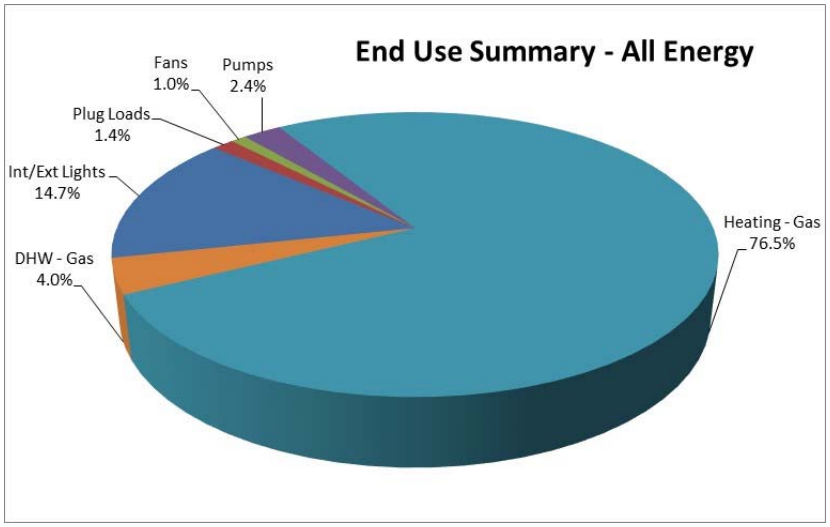


## Camas Armory

| End Uses | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fuel Type | Category | Usage | Unit | % of Total Energy Use | % of Electric Use | % of Gas Use | Btu/ft$^2$/yr |
| Elec | Int/Ext Lights | 45,088 | kWh | 14.7% | 75.4% | | 10,660 |
| Elec | Plug Loads | 4,220 | kWh | 1.4% | 7.1% | | 998 |
| Elec | Fans | 2,984 | kWh | 1.0% | 5.0% | | 705 |
| Elec | Pumps | 7,510 | kWh | 2.4% | 12.6% | | 1,776 |
| Gas | Heating - Gas | 8,013 | therms | 76.5% | | 95.0% | 55,520 |
| Gas | DHW - Gas | 419 | therms | 4.0% | | 5.0% | 2,902 |

| | | | | |
|---|---|---|---|---|
| End-Use Analysis | Electricity (kWh) | 59,803 | EUI (kBtu/ft$^2$/yr) | 72.6 |
| | Gas (therms) | 8,431 | | |
| Utility Bills | Electricity (kWh) | 57,400 | | 71.6 |
| | Gas (therms) | 8,376 | | |

| Modeled Percent of Actual Uility Bills |
|---|
| 104.2% of Elec bills |
| 100.7% of Gas bills |



## 1.4 Measurement And Verification Plan

### Proposed M&V Methodology

The M&V for these projects shall be Option A for lighting measures – stipulated savings approach, and Option B for HVAC measures – short term measurements and calculated savings approach.

For the lighting measures the energy savings have been calculated using utility approved fixture wattages for the existing lights, and manufacturer provided wattages for the proposed lights. The difference between the two is the demand savings (kW). The annual energy savings are calculated by multiplying the demand savings (kW) times the annual hours of operation. For the different lighting systems affected, the agreed upon hours of year of operation are as follows:

Exterior dusk to dawn: 4,380 hours per year
Exterior dusk to midnight, 5 am to dawn: 1,000 hours per year

Armory Lights: 2440 hours per year on average – ranging from 3136 in the main performance area to 510 in the rarely used spaces.

Dorothy Fox Lights: 1310 hours per year on average – ranging from 1330 in the classrooms and 1520 in the corridors and offices, to 304 in the rarely used spaces.

After the new lights are installed, the savings calculation sheets shall be updated to reflect the actual quantity of lights installed (if they vary), and they actual final wattages of the fixtures and equipment installed, after the final design is completed. The same stipulated operating hours will be used to calculate the measured annual energy savings.

The lighting savings will be measured during the first year only.

For the HVAC measures the energy savings have been calculated using engineered calculations for the baseline energy, and engineered estimates for the proposed energy. Actual measurements will be made for the post construction upgrades, and these measurements will be applied to the engineering calculations to extrapolate over the course of a typical weather year, to determine the measured savings for these measures. For the different HVAC systems affected, the following systems will be measured after the upgrade:

New VFDs:

Operating profile of affected motors will be recorded over different weather and occupancy patterns from trend logs and/or recorded with portable data recording devices.

Existing VFDs and Motors being Retro Commissioned:

Operating profile of affected motors (VFD and constant speed) will be recorded over different weather and occupancy patterns from trend logs and/or recorded with portable data recording devices.

New Boiler and Condensing Boilers being Retrocommissioned:

Operating profile of affected boilers will be recorded over different weather and occupancy patterns from trend logs and/or recorded with portable data recording devices. For the new boilers installed the combustion efficiency will be measured over different load conditions.

We anticipate conducting this M&V for several months, over a time period long enough to cover typical weather and occupancy conditions that we experience in a typical year. The measurements made over this time period will be used to extrapolate the energy savings over the course of a typical year, and this will be the measured energy savings.

If there are significant changes to the weather or occupancy patters, then we would make adjustments to the measured energy savings to take into account these changes. These could be based on very cold winter weather, increased Mega-Events being held throughout the year, or if a water leak develops, or the owner operates the system in a manner other than agreed upon.

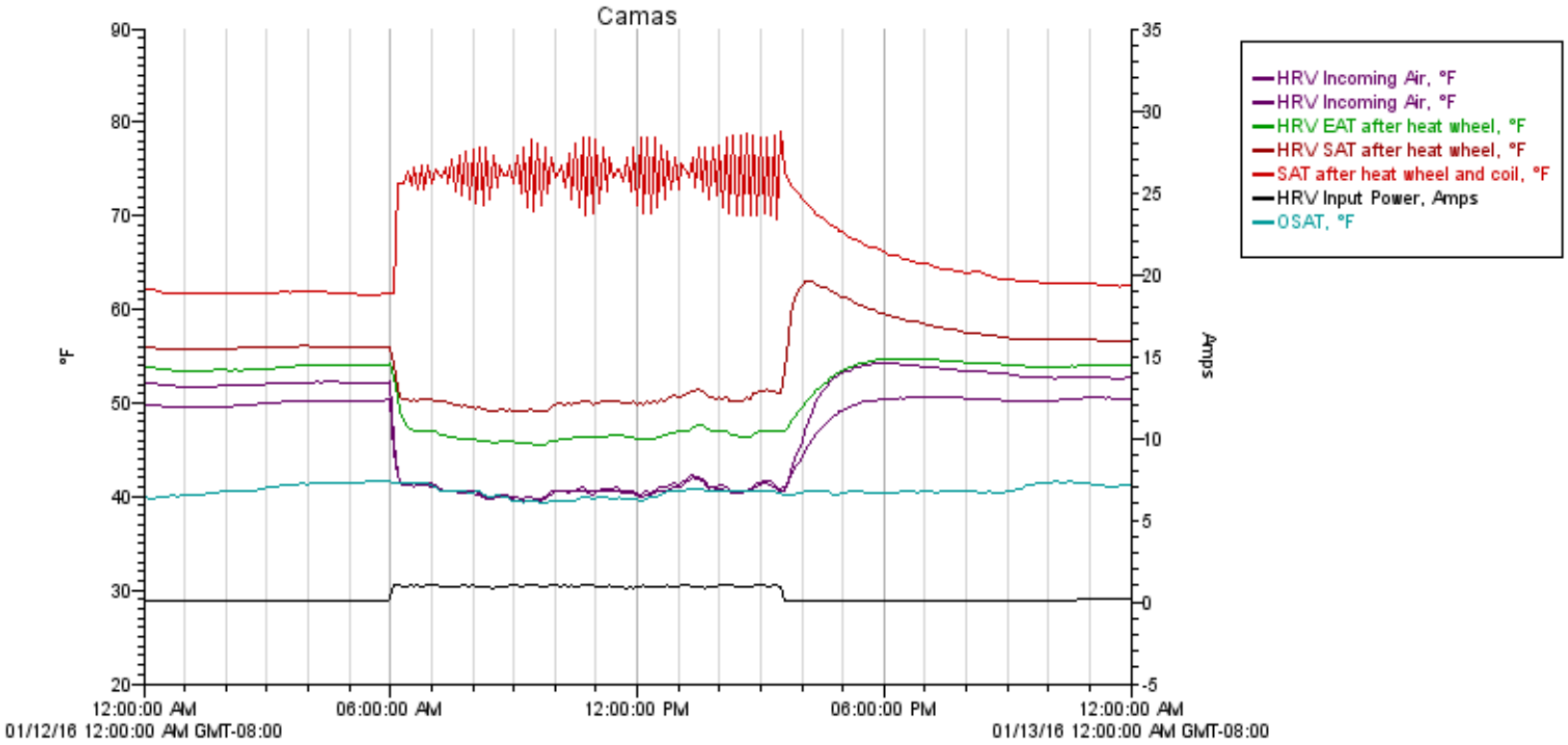
The non-lighting savings will be measured each year the contract is in effect (presumable three years).

## 1.5 Results Of Data Logging During The Conduct Of This Energy Study

During the course of conducting this energy audit, we interviewed staff, observed and made instantaneous measurements while on-site, and we installed portable data logging devices to measure different parameters over time.

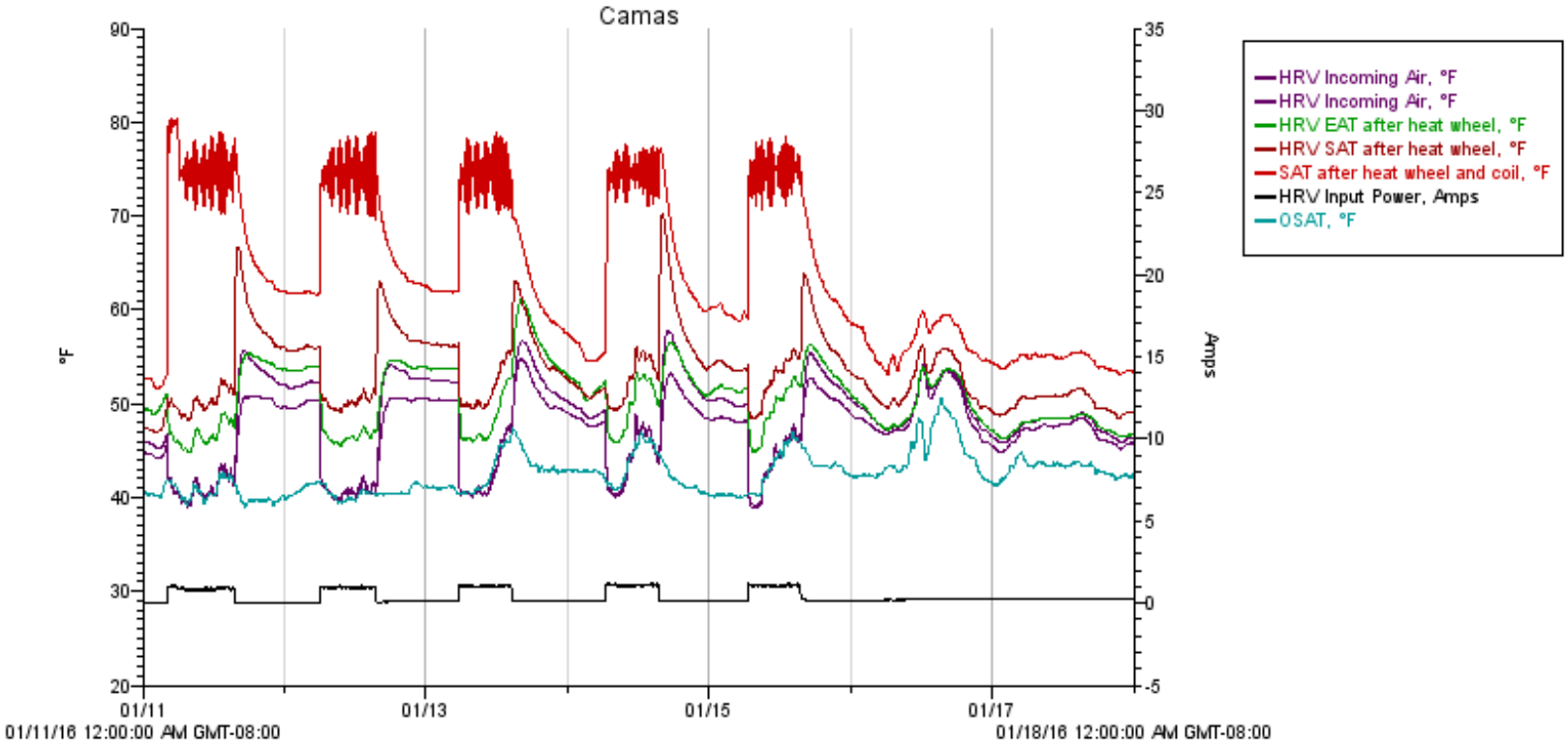
We used the results of these measurements over time to estimate how much energy the various systems use over the course of a typical year. The results of some of these recordings are presented here for documentation of conditions as they occurred during the winter of 2015-2016.

**Hayes Freedom High School**



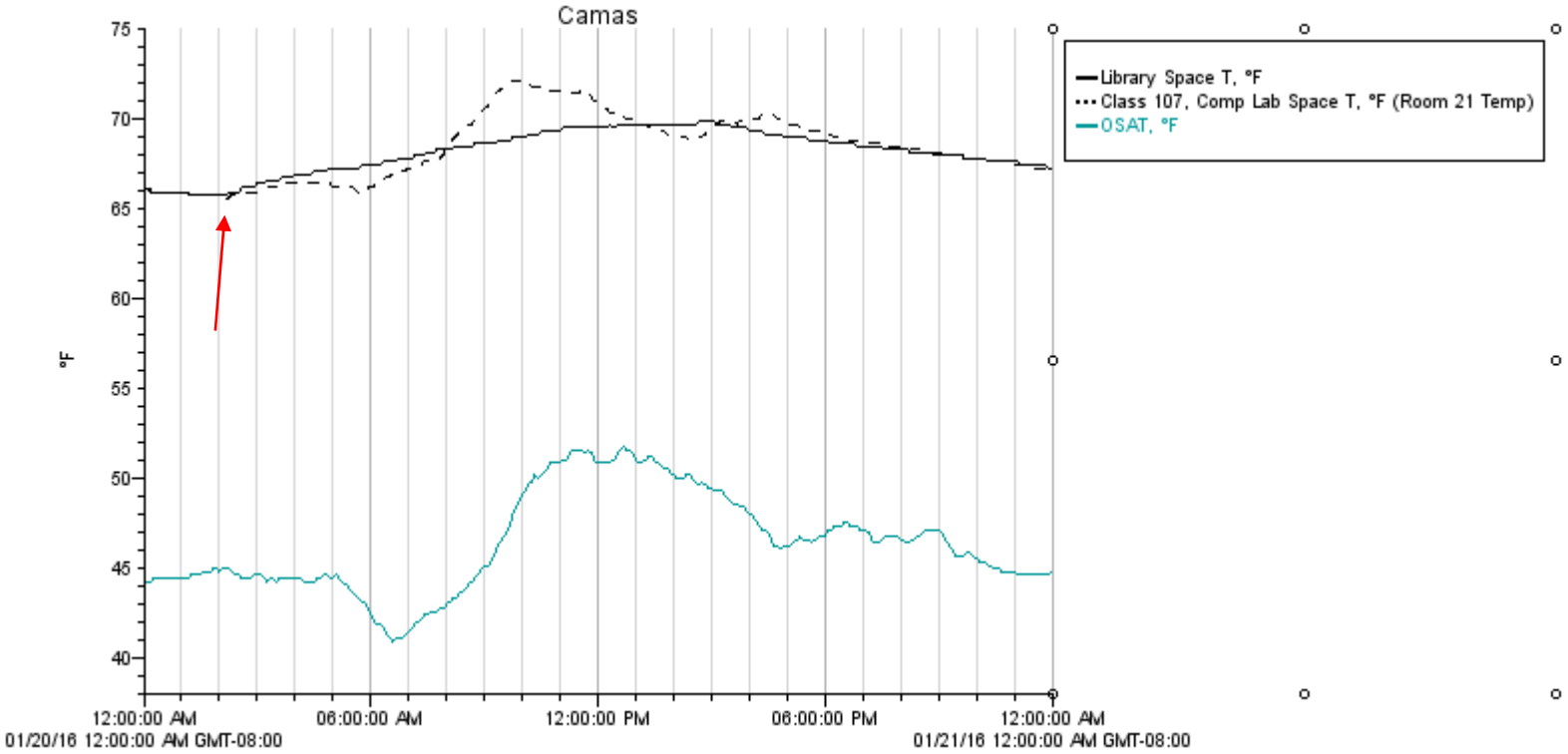

Graph shows one day of performance of HRV 5 at Hayes Freedom High School. The unit begins operation at 6am and operates until 3:30pm (black line). The supply air temperature (red line) only gets as high as 78 degF and there is no distinctive supply air temperature increase for morning warmup when the unit begin operation. All of this indicates that the HRVs' primary function is to provide tempered outside air, not to be the primary source of heating for the building. This means that the HRVs should operate strictly when people are in the building and ventilation air is required.

**Hayes Freedom High School**



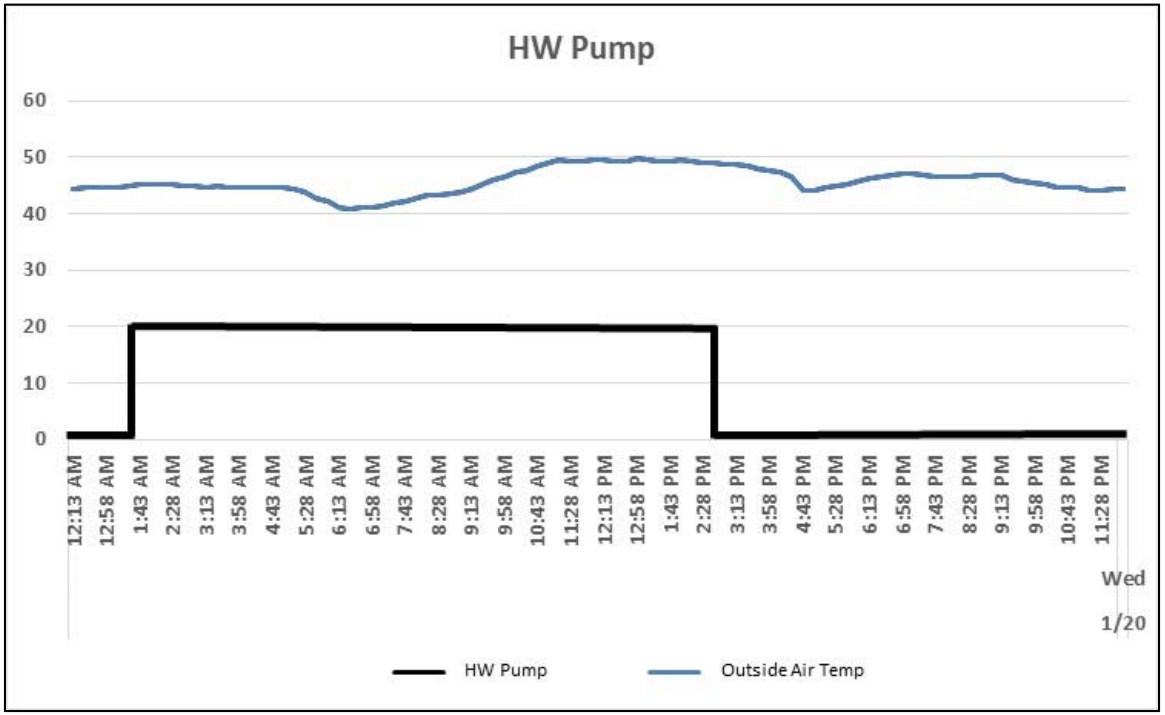

Graph shows one week of performance of HRV 5 at Hayes Freedom High School. This graph is included to confirm that the one day of operation shown on the previous page is typical.

**Hayes Freedom High School**



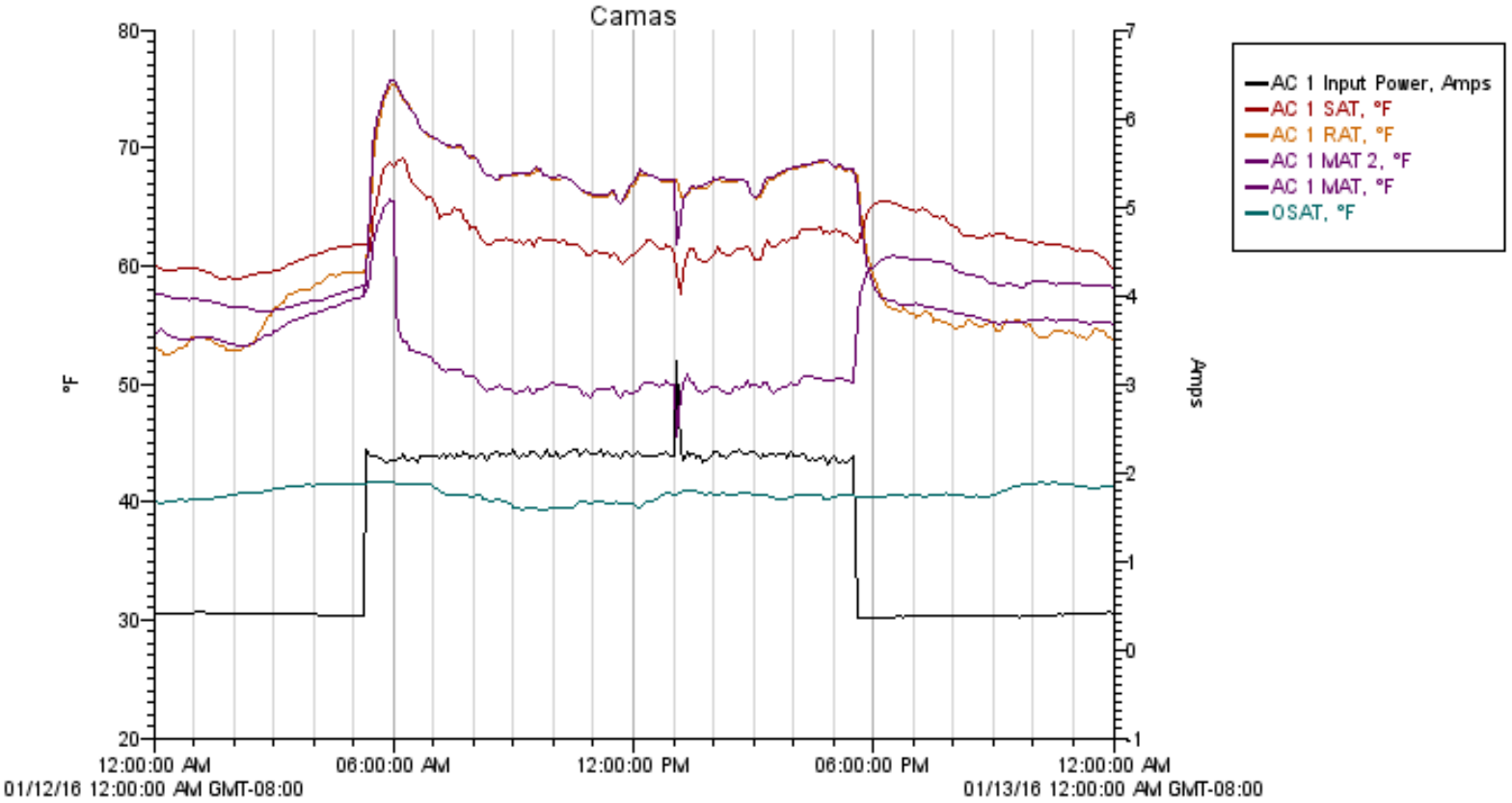

Graph shows one day of space temperatures in two classrooms at Hayes Freedom High School. Note that even with outside air temperatures of as low as 40 degF (teal line), the space temperatures (black lines) never drop below 65 degF. The temperature inside the building is slowly dropping after midnight, until about 2:30 am (see red arrow above) when the space temperatures begin to rise. This occurs even though the outside air temperature is declining. This indicates that the hot water radiant heating system began to operate at this time.

**Hayes Freedom High School**



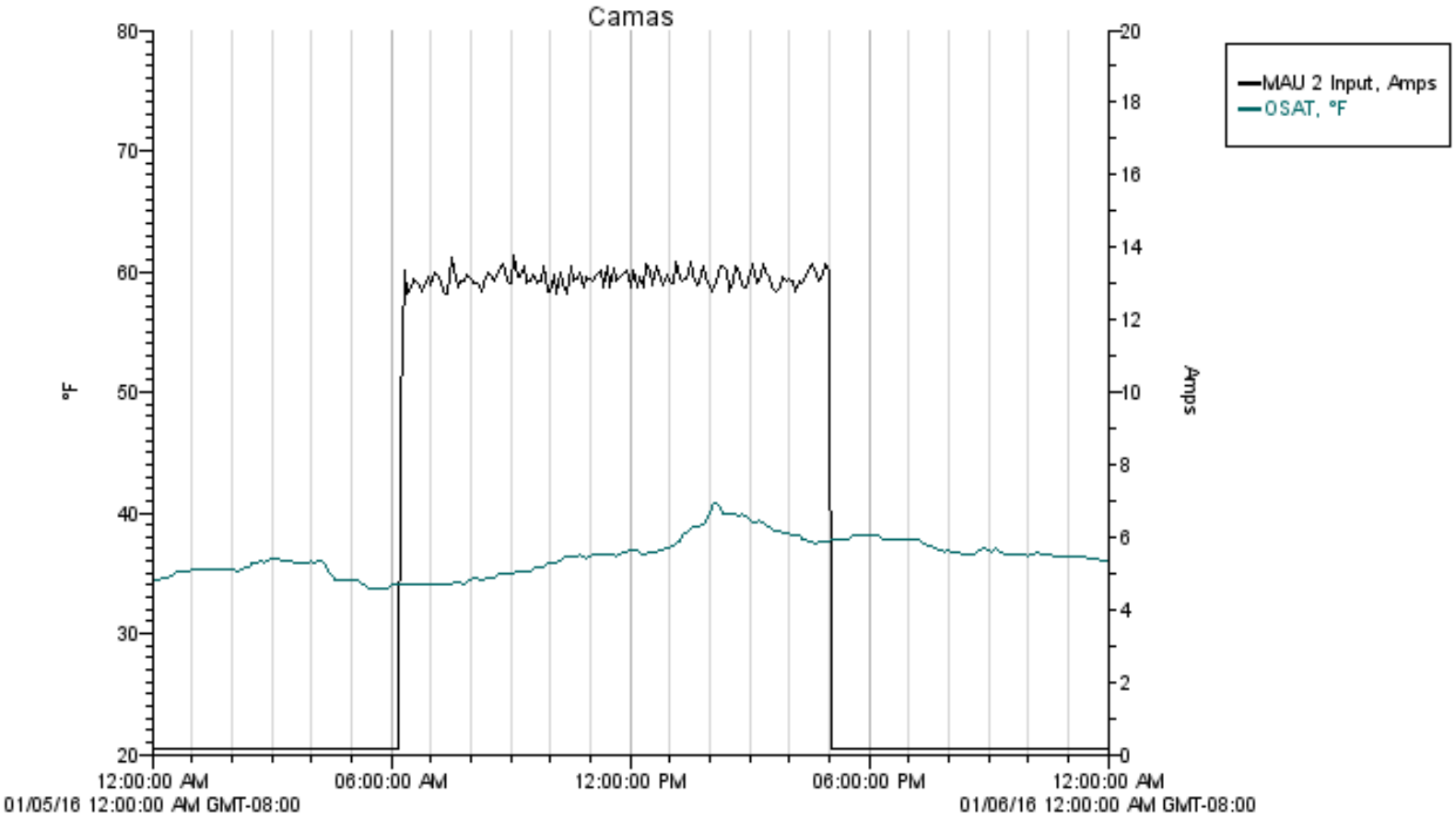

Graph shows one day of hot water pump operation at Hayes Freedom High School. Note that even with outside air temperatures around 45 degF, the pump begins operation before 2 am.

**Liberty Middle School**



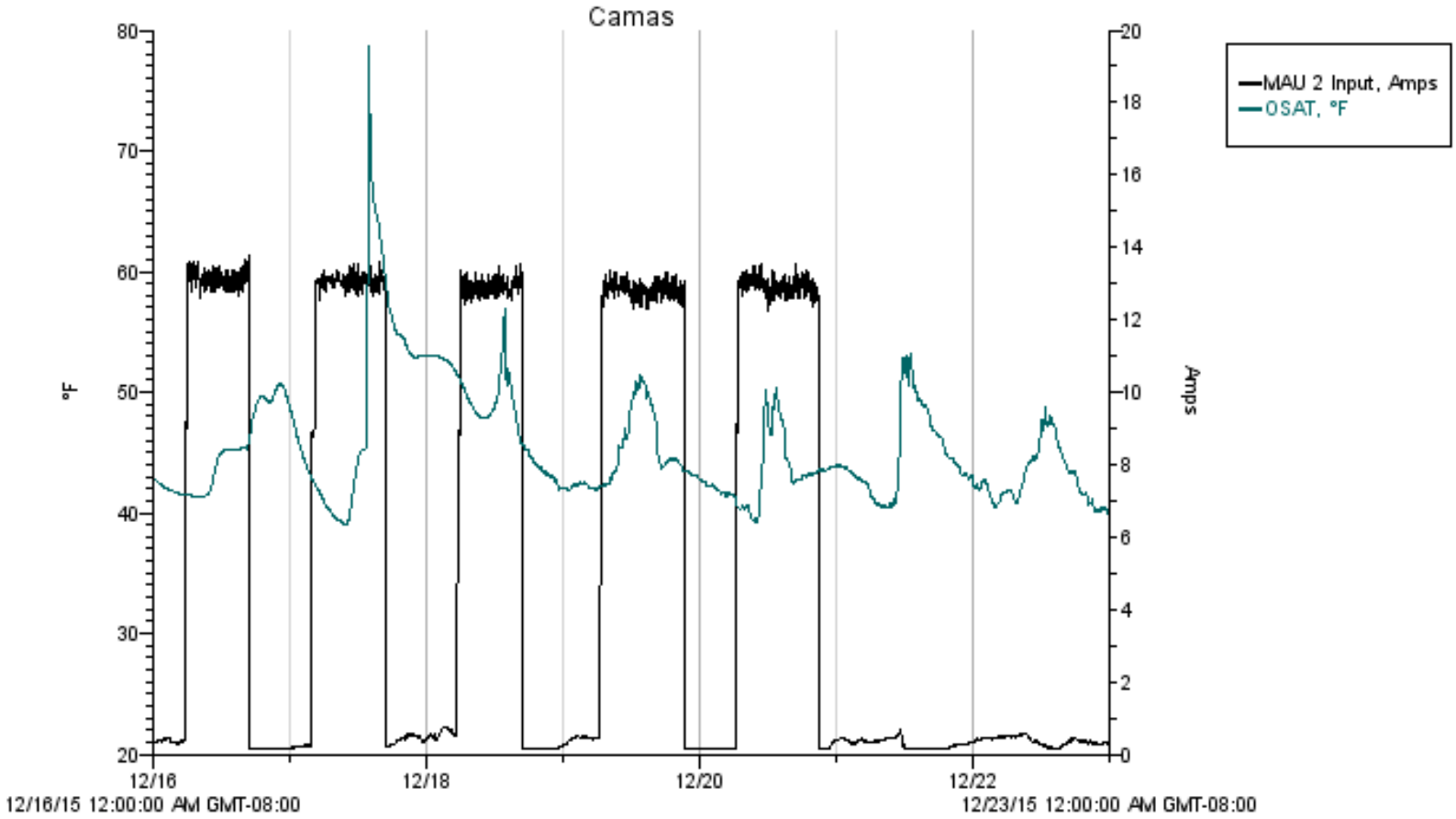

Graph shows one day of performance of AC 1 at Liberty Middle School. On this day, the unit began operation at 5am (black line). The unit operates in morning warmup mode from about 5 am until 6 am, then the unit operates to maintain indoor air temperatures until 5:30 pm. The unit provides outside air during the currently scheduled “occupied period” from 6 am to 5:30 pm.

**Liberty Middle School**



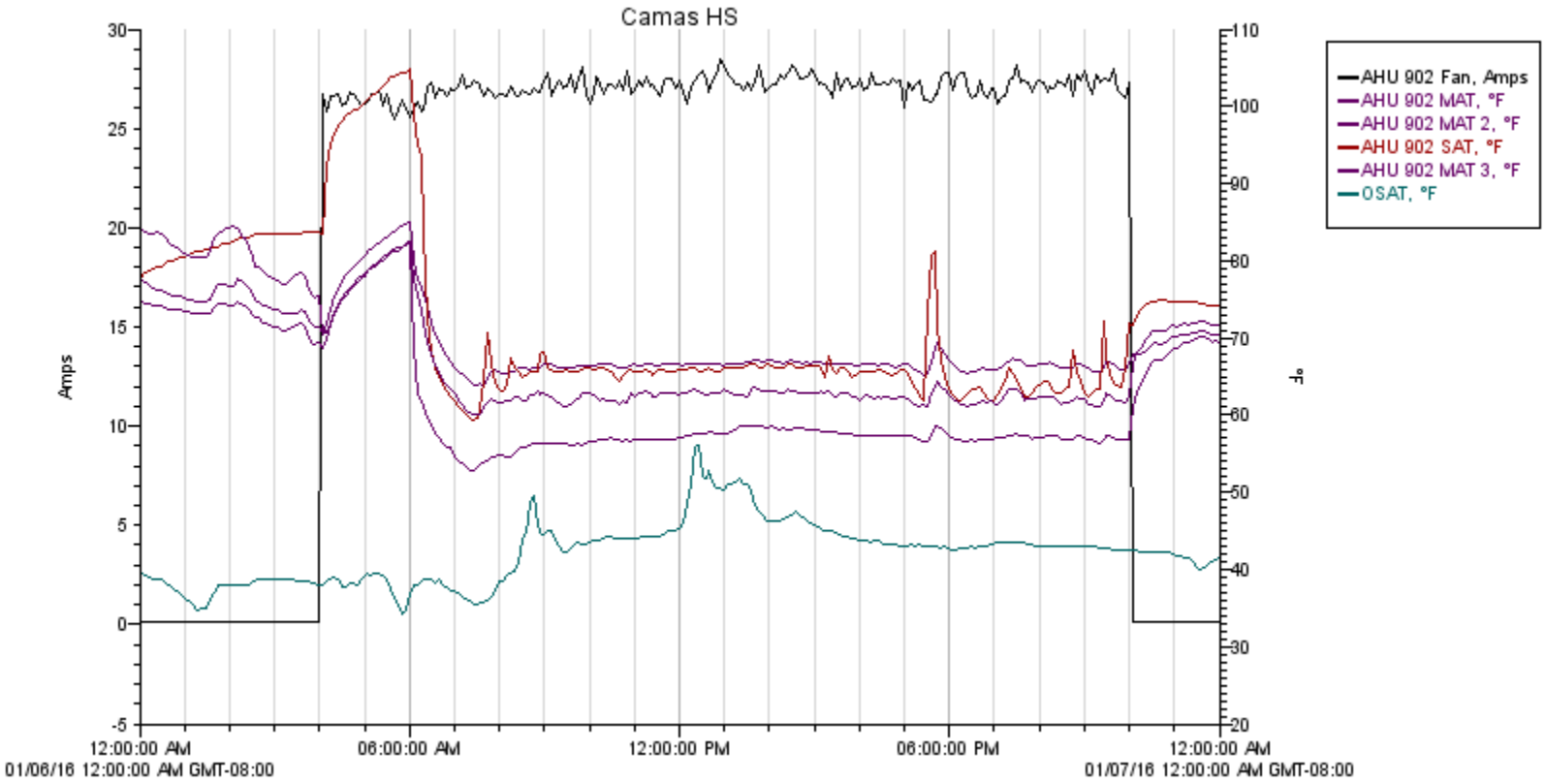

Graph shows one day of performance of the locker room makeup air unit at Liberty Middle School. On this day, the unit began operation at 6am (black line) and operates at full speed throughout the day, until 6pm.

**Liberty Middle School**



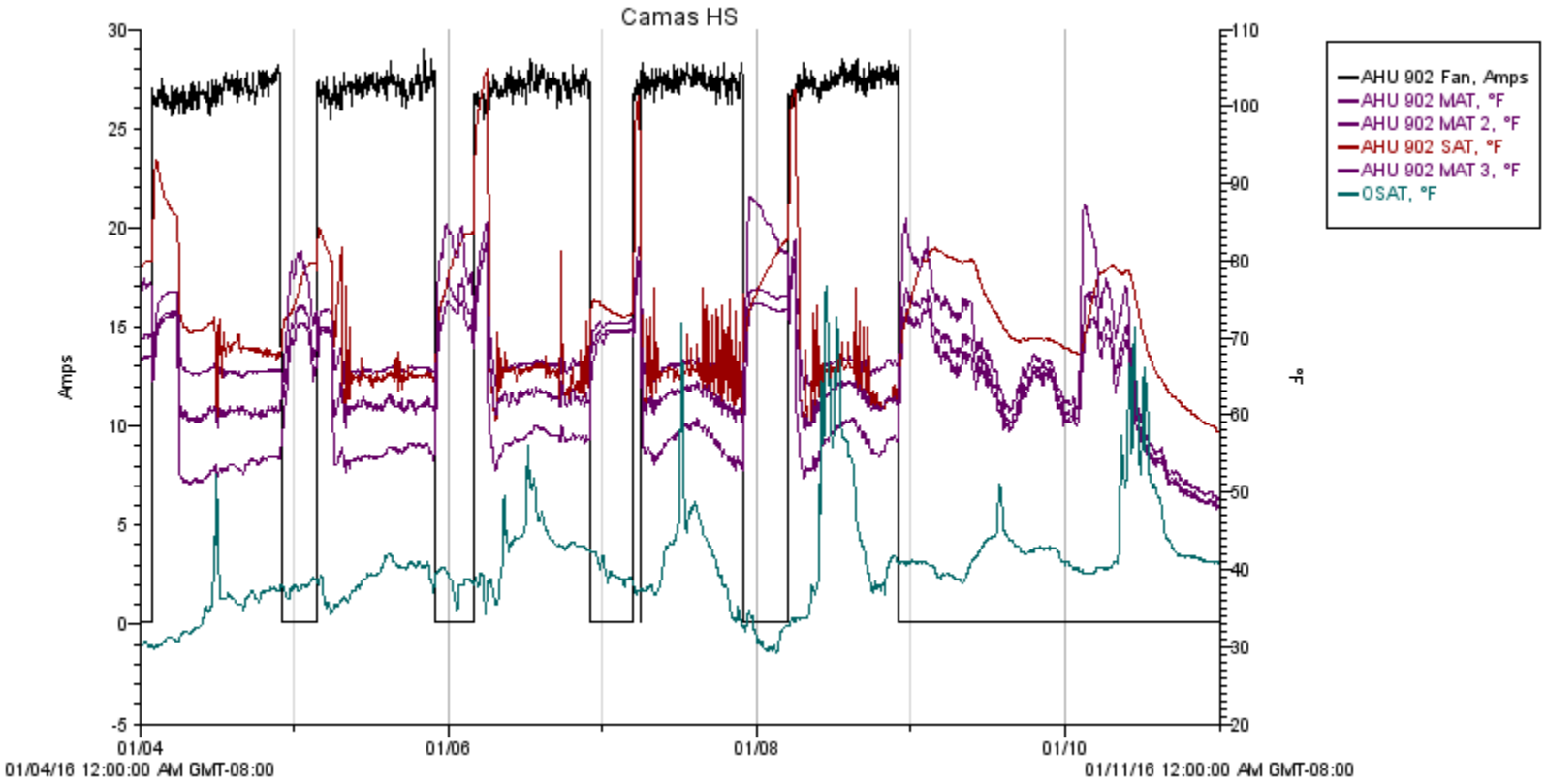

Graph shows one week of performance of the locker room makeup air unit at Liberty Middle School. The unit operates each day from around 6am to around 6pm. This graph is included to confirm that the one day of operation shown on the previous page is typical.

**Camas High School**



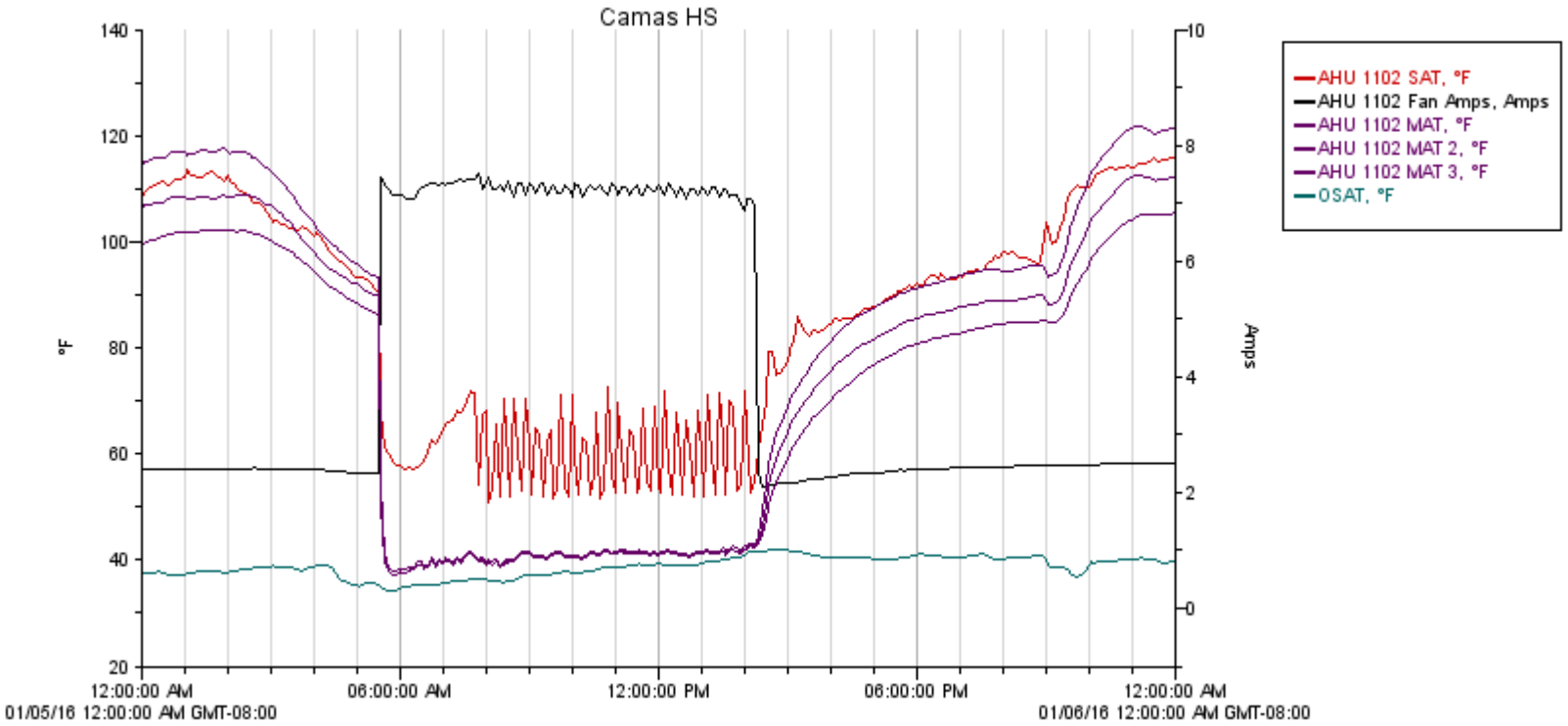

Graph shows one day of performance of AHU 902 which serves the main gym at Camas High School. On this day, this constant volume unit began operation at 4 am (black line). The unit operates in morning warmup mode from about 4 am until 6 am, then the unit operates to maintain indoor air temperatures until 10 pm. The unit provides outside air during the currently scheduled “occupied period” from 6 am to 10 pm.

**Camas High School**




Graph shows one week of performance of the AHU 902 which serves the main gym at Camas High School. The unit operates each day from around 5 am to around 10 pm. This graph is included to confirm that the one day of operation shown on the previous page is typical.

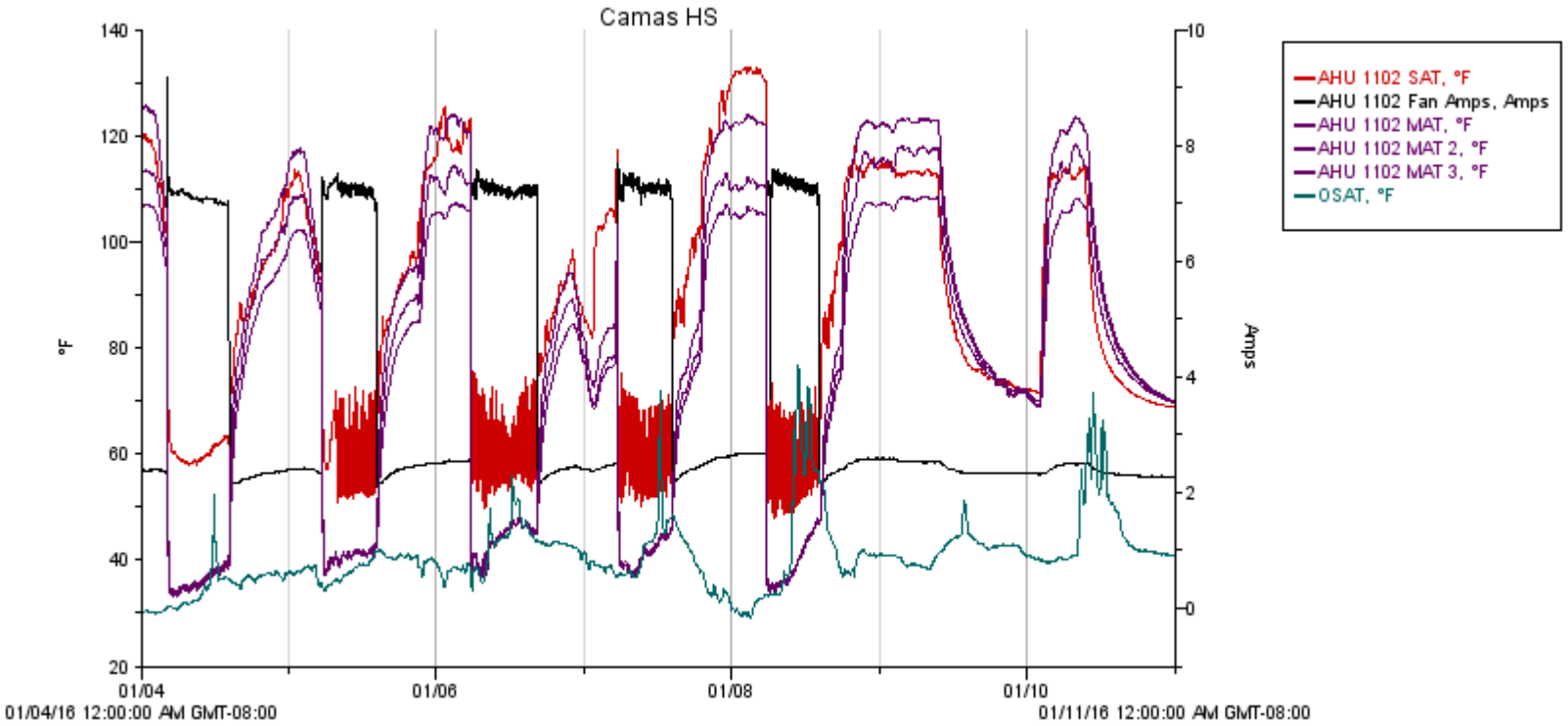
**Camas High School**




Graph shows one day of performance for AHU 1102 which serves the kitchen at Camas High School. The kitchen unit is 100% outside air, which is why the "mixed air" (purple lines) matches the outside air line (teal line). The kitchen unit operates from around 5:30 am to around 2:30 pm, Monday through Friday (black line). The supply air temperature (red line) varies around 55 to 65 degF during the day.

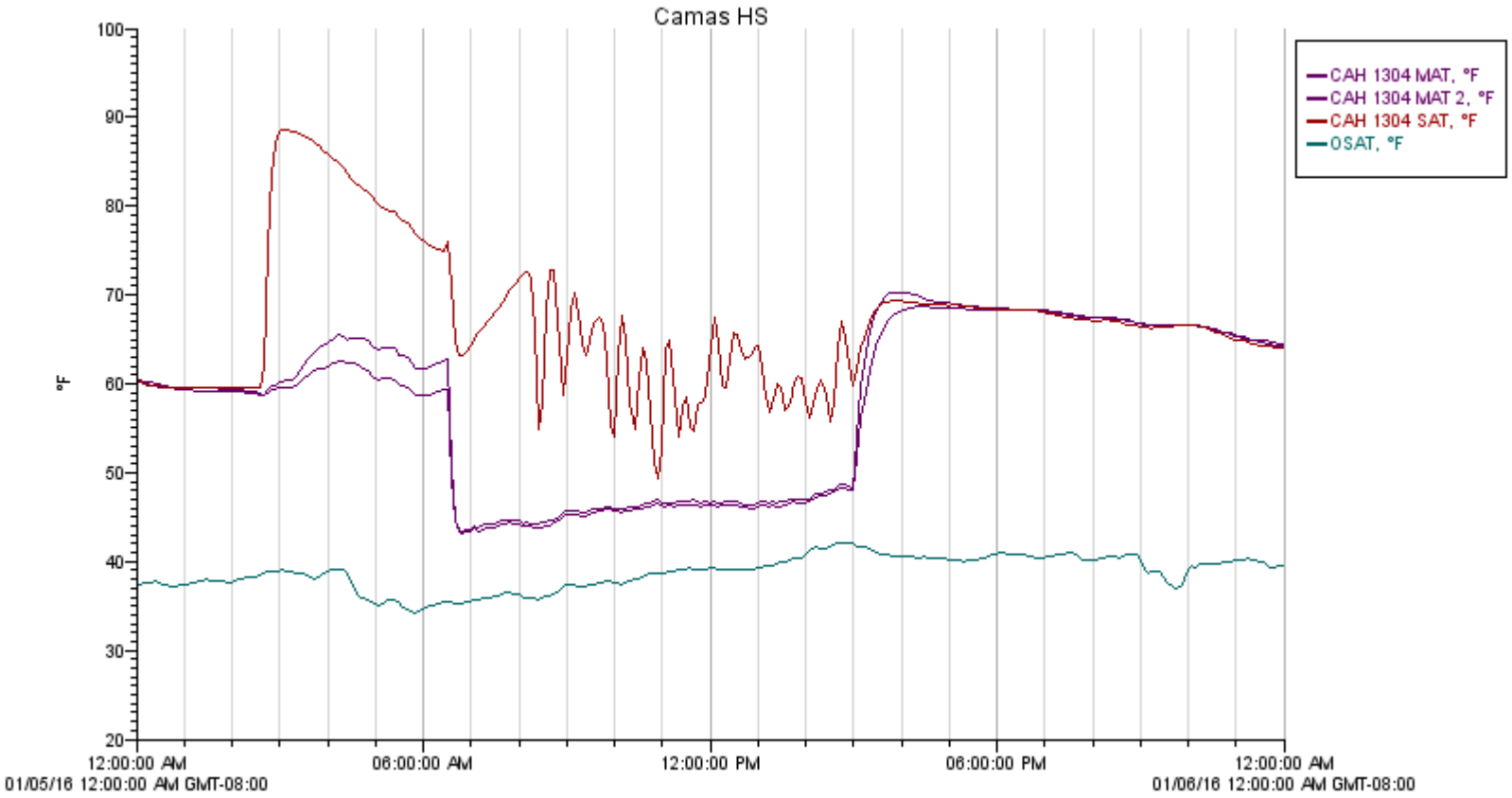
The data loggers indicate that during the unoccupied hours, the temperatures within the AHU increase to up to 115 degF. This typically indicates that there is a leaking or malfunctioning hot water valve.

**Camas High School**



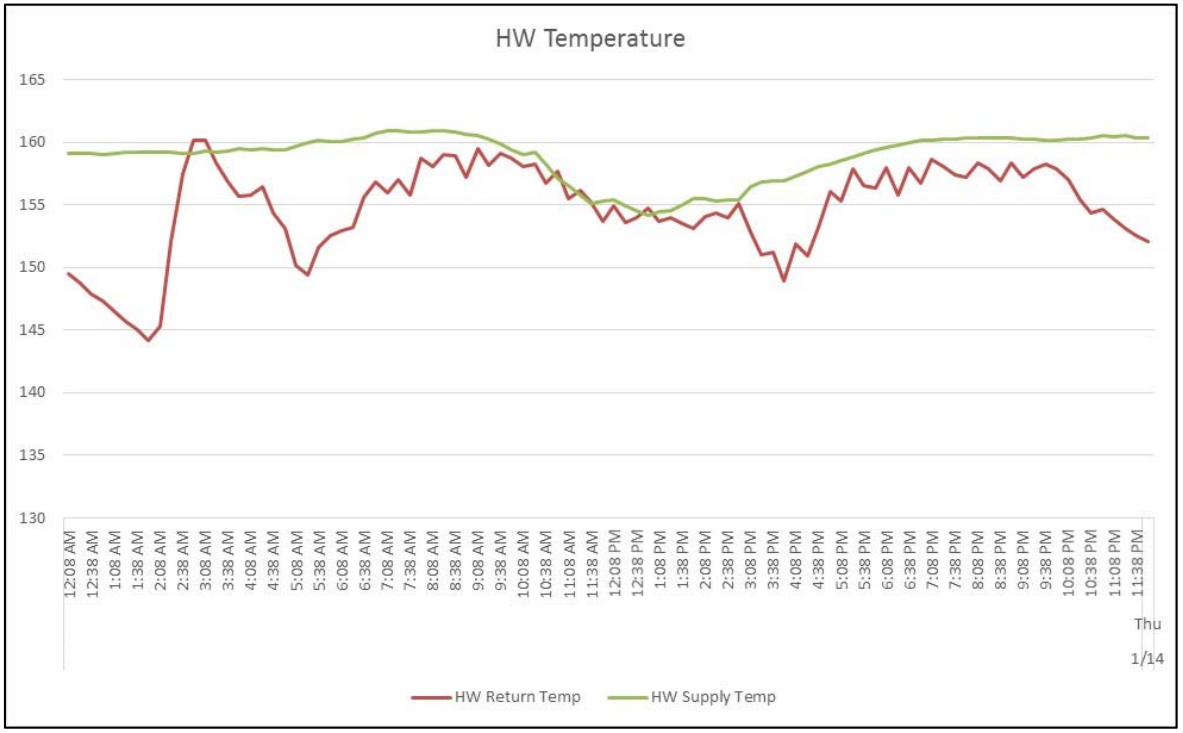

Graph shows one week of performance of the AHU 1102 which serves the kitchen at Camas High School. The unit operates each day from around 5:30 am to around 2:30 pm. This graph is included to confirm that the one day of operation shown on the previous page is typical. The temperatures inside the AHU during the unoccupied hours indicate that hot water is running through the heating coils when the unit is off.

**Camas High School**



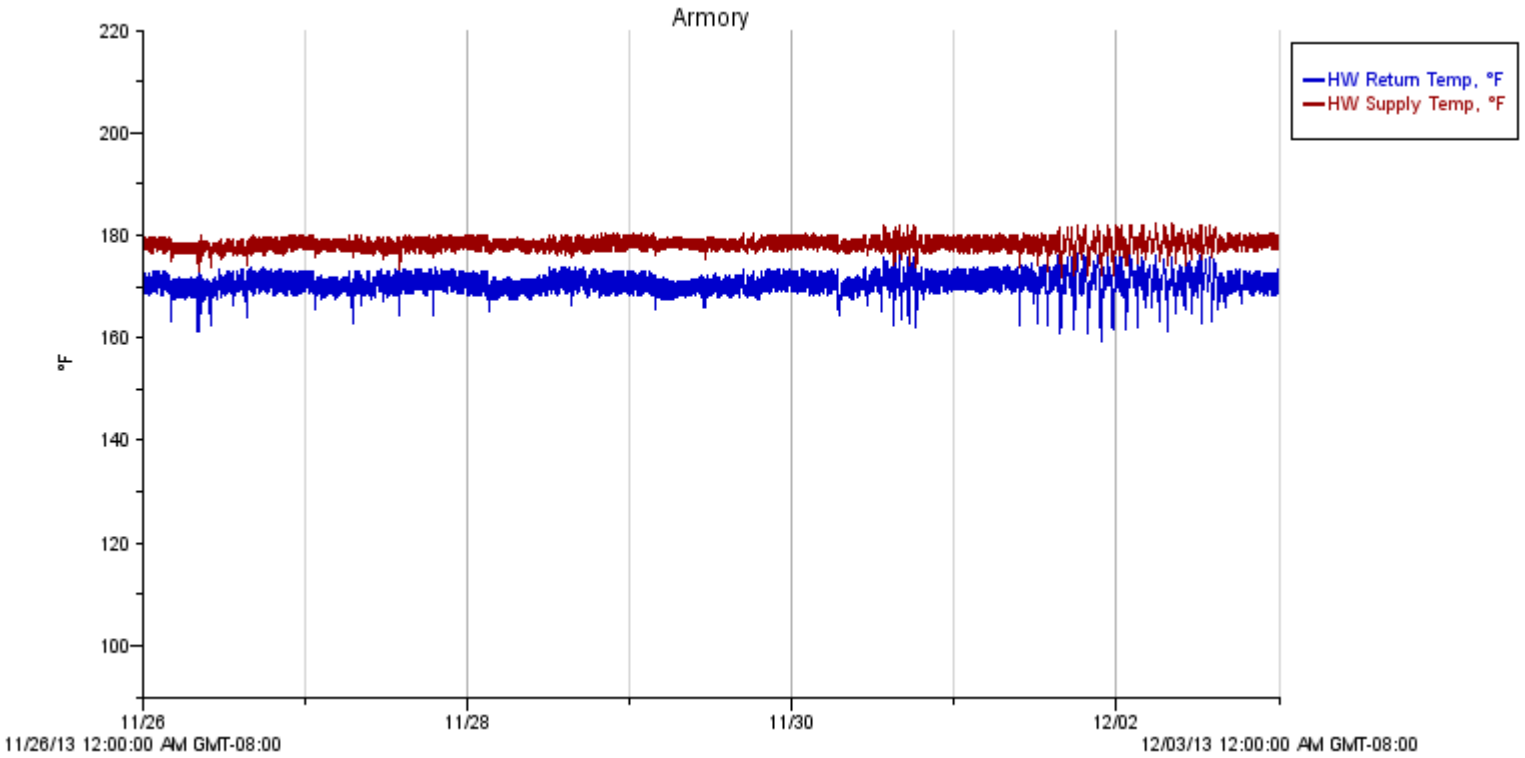

Graph shows one day of performance of one of the classroom air handlers (CAH 1304) at Camas High School. On this day, the unit operated in morning warmup mode with no outside air from 3 am to 6:30 am. Then unit then provided outside air and maintained space temperatures from 6:30 am until 3 pm.

**Camas High School**




Graph shows one day of performance of the hot water supply and return temperature at Camas High School. Note that the hot water supply temperature varies between 160 and 155 degF depending on outside air, however the return water temperature is coming back at between 2 to 10 degF less than the supply water temperature, resulting in return water temperatures which are always above 150 degF. Condensing boilers require return water temperatures below 130 degF in order to go into condensing mode, so the boilers at the high school are often operating as standard efficiency boilers.

**Camas Armory**




Graph shows one week of performance of the hot water system at the Camas Armory. Because of the lack of controls, the boiler currently operates 24 hours per day, 7 days per week. The boiler does not have supply water temperature reset; it provides 178 degF water at all times. Typically, the return water temperature is 5 to 10 degF less than the supply water temperature.