*This is a supplemental report to be used to enhance the modules for Commercial Building Energy Audits. This was not developed through CREATE or with NSF funding. Please see below to provide proper credit to those that developed it.

Feb 02, 2024

Prepared by:

Community College Building

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Abbreviations

AFUE Annual Fuel Utilization Efficiency

AHU Air Handling Unit

BTU British Thermal Unit

CFM Cubic Feet (per) Minute

CMU Concrete Masonry Unit

CV Constant Volume

DAT Discharge Air Temperature

DDC Direct Digital Control(s)

DegF Degrees Fahrenheit

DOE Department of Energy

DHW Domestic Hot Water

dP Discharge Pressure

dT Delta T (Temperature difference)

DX Direct Expansion

EEM Energy Efficiency Measure

EFLH Estimated Full Load Hours

ETO Energy Trust of Oregon

EUI Energy Use Index

HC Heating Coil

HP Horsepower

Hr Hour

HVAC Heating Ventilating & Air Conditioning

HW Heating Water

HWP Heating Water Pump

IAC Industrial Assessment Center

kBtu 1,000 Btus

kW Kilowatt

kWh Kilowatt-hours

lbs Pounds

LPD Lighting Power Density

MBH kBtu/hr (1,000 BTU/hr)

MAT Mixed Air Temperature

OAT Outside Air Temperature

RAT Return Air Temperature

RF Return Fan

SAT Supply Air Temperature

sf Square Feet

SF Supply Fan

SOO Sequence of Operations

SP Static Pressure

TMY3 Typical Meteorological Year

TU Terminal Unit

VAV Variable Air Volume

VFD Variable Frequency Drive

W Watts

Yr Year

Disclaimer

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

The intent of this energy analysis is to estimate energy savings associated with the recommended energy efficiency upgrades. This report is not intended to serve as a detailed engineering design document. Any description of proposed improvements that may be diagrammatic in nature are for the purpose of documenting the basis of cost and savings estimates for potential energy efficiency measures only. Detailed design efforts may be required by the participant to implement measures recommended as part of this energy analysis. While the recommendations in this study have been reviewed for technical accuracy and are believed to be reasonably accurate, all findings listed are estimates only. Actual savings and incentives may vary based on final installed measures and costs, actual operating hours, energy rates and usage.

Preface

The Commercial Building Energy Audit (CBEA) program is funded by the DOE and structured within the framework of its predecessor and parent program, the Industrial Assessment Center (IAC). The purpose of the CBEA is to provide customers with free energy assessments of commercial buildings, thereby increasing energy efficiency while simultaneously expanding the workforce of building efficiency professionals through the application of student participation from partnered colleges and universities. The scope of such audits is limited in nature, for the express purpose of identifying no-cost and low-cost energy savings opportunities, and a general view of potential capital improvements. This is accomplished by means of utility usage and billing evaluation, along with observation and analysis of energy using systems. The findings and recommendations within this report represent the conditions observed at the time of this site survey. Conditions and equipment usage are subject to change, and therefore the conclusions expressed within this report may not be evident in the future. The CBEA audit team has endeavored to meet what it believes is the applicable standard of care ordinarily exercised by others in conducting this energy audit. No other warranty, express or implied, is made regarding the information contained in this report.

MESC Funding Opportunities

The Office of Manufacturing and Energy Supply Chains (MESC) aims to support scale-up and deployment of the nation's energy manufacturing capacity, for all equipment and products that are required to make the technologies that generate clean energy, transport that energy, store that energy, and decarbonize traditional energy sources while we transition. MESC seeks to bolster both enterprises and communities, to pave the way for a smooth and equitable energy transition.

Related Contacts

Building Efficiency Measure (EEM) Summary

These energy efficiency measures (EEMs) are suggested for the facility. Cost savings are based on average utility rates for electricity and natural gas. Actual rates and cost savings will differ. Non-energy cost benefits are related to cost-savings due to as-avoided maintenance. Simple payback is estimated using current utility rates and estimated project costs, which may vary over time.

Table 1: EEM Summary

Measure Number	Measure Description	Annual Energy and Cost Savings					Measure Cost and Simple Payback	
		Electricity Savings		Gas Fuel Savings		Total Cost Savings	Measure Cost	Simple Payback Year
		kWh	kW	Therms	MMBtu			
EEM 1	Lighting Upgrade	44221	13	-	-	$ 669	$ 45,400	67.9
EEM 2	Occupancy Sensors	31585	-	-	-	$ 375	$ 2,500	6.7
EEM 3	Occupancy Sensor VAV Control	46833	-	1327	133	$ 2,013	$ 6,000	3.0
EEM 4	Boiler Temperature Control	-		2392	239	$ 2,567	$ 2,500	1.0
EEM 5	System Scheduling	178931	-	2970	297	$ 5,313	$ 1,500	0.3
EEM 6	AHU SP Reset	22961				$ 273	$ 1,000	3.7
Totals		324529	13	6689	669	$ 11,211	$ 58,900	5

Building Description

The facility is located on a community college campus located near Portland, Oregon. Constructed in 2003, the facility is a 2 building, approximately 72,000 sq. ft. The exterior is masonry construction, windows are thermally efficient double pane with aluminum frames. Approximate window/wall ratio is 20%. The roof is flat with a light color membrane roofing. The facility serves as student center, library, multipurpose rooms, and classrooms. The general occupant schedule is typical for community colleges, generally assumed to be 4 am – 9 pm weekdays. This facility is generally unoccupied on weekends and holidays.

Best Practices

This audit is per ASHRAE Level 2 requirements. The building's energy cost and efficiency were assessed by analyzing 2023's utility data.

Utility analysis was used to produce reports on the monthly consumption of both electricity and natural gas. The output from these reports was used to benchmark this building against the median EUI for buildings of its size and type in the local vicinity.

The mechanical and lighting schedules were used to generate outlines of energy usage in terms of demand and energy consumption.

A site visit conducted on December 21, 2023 provided a walk-through survey of the facility including its construction, operation, and maintenance, and major energy consuming equipment. Feedback from the customer related to facility performance and comfort was used to inform the survey and the resulting recommendations within this report.

The data was then used to identify no-cost and low-cost measures for improving energy efficiency. Because calculations at this level are minimal, savings and costs are approximate.

Energy Cost Analysis

Table 2: 2023 Utility Data

2023 Electrical Data							
Month	kWh	kWh Charge	Charge / kWh	kW	kW Charge	Charge/kW	Fees
Jan	65429	$2,663	$0.04	231	$2,163.13	$9.4	$1,177.45
Feb	54476	$1,210	$0.02	231	$2,162.21	$9.4	$609.28
Mar	59022	$783	$0.01	231	$2,183.71	$9.5	$432.68
Apr	63636	$620	$0.01	231	$2,213.66	$9.6	$356.60
May	77756	$45	$0.00	231	$2,926.00	$12.7	$45.79
Jun	70155	$45	$0.00	231	$2,699.59	$11.7	$41.83
Jul	87167	$45	$0.00	231	$2,786.21	$12.1	$43.15
Aug	81096	$45	$0.00	192	$2,674.14	$13.9	$41.44
Sep	67685	$45	$0.00	192	$2,208.62	$11.5	$34.34
Oct	62053	$975	$0.02	231	$2,703.81	$11.7	$284.58
Nov	49789	$1,146	$0.02	175	$2,130.07	$12.2	$594.10
Dec	42278	$1,654	$0.04	231	$2,114.61	$9.2	$472.00
TOTALS	780,542	$ 9,275	$0.012	2,638	$28,965.76	$10.98	$4,133

2023 Natural Gas Data					
Month	Therms	MMBTU	Cost	Cost /MMBtu	Other Charges
Jan	2,351	235	$2,317	$9.86	$326
Feb	2,918	292	$3,034	$10.40	-$570
Mar	2,403	240	$2,360	$9.82	$333
Apr	1,984	198	$2,014	$10.15	$279
May	1,337	134	$1,463	$10.94	$195
Jun	1,463	146	$1,570	$10.73	$211
Jul	1,041	104	$1,211	$11.63	$156
Aug	974	97	$1,154	$11.85	$147
Sep	1,224	122	$1,367	$11.17	$180
Oct	1,238	124	$1,193	$9.64	$62
Nov	2,460	246	$2,833	$11.52	$146
Dec	2,722	272	$3,215	$11.81	$167
TOTALS	22,115	2,212	$23,731	$10.73	$1,632

The facility has an EUI (Energy Utilization Index) of 67.7 kBtu/sf. The Energy Star Performance Scorecard rates the facility at 78 out of 100.

Figure 1: 2023 Electrical Use

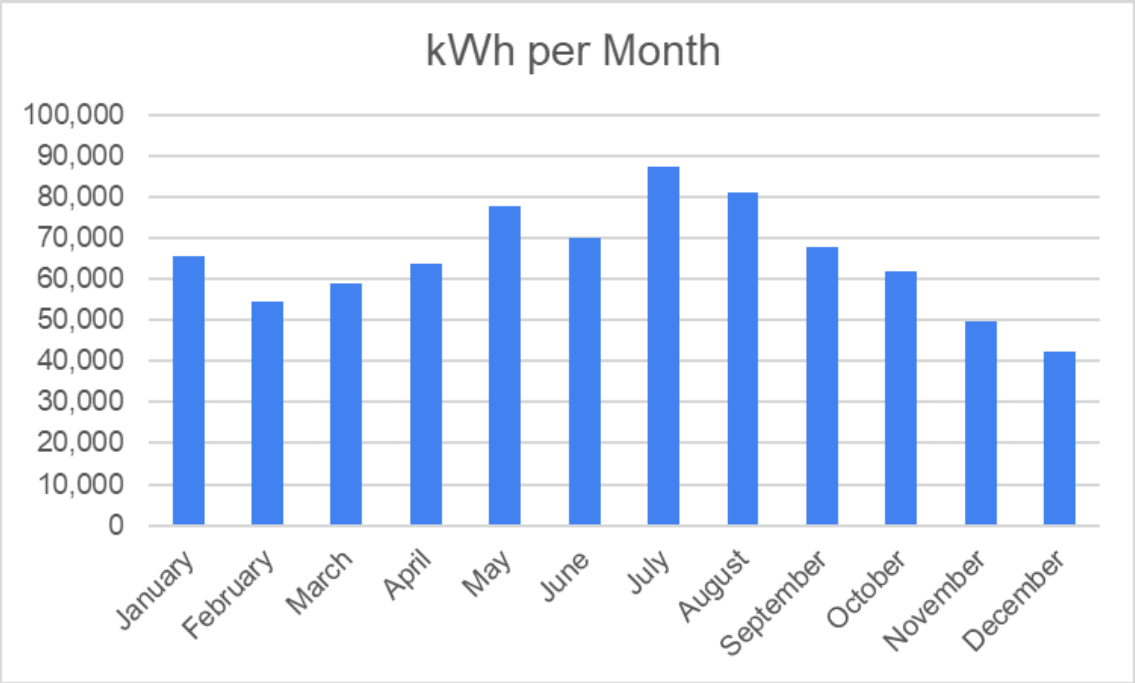


Figure 2: 2023 Natural Gas Use

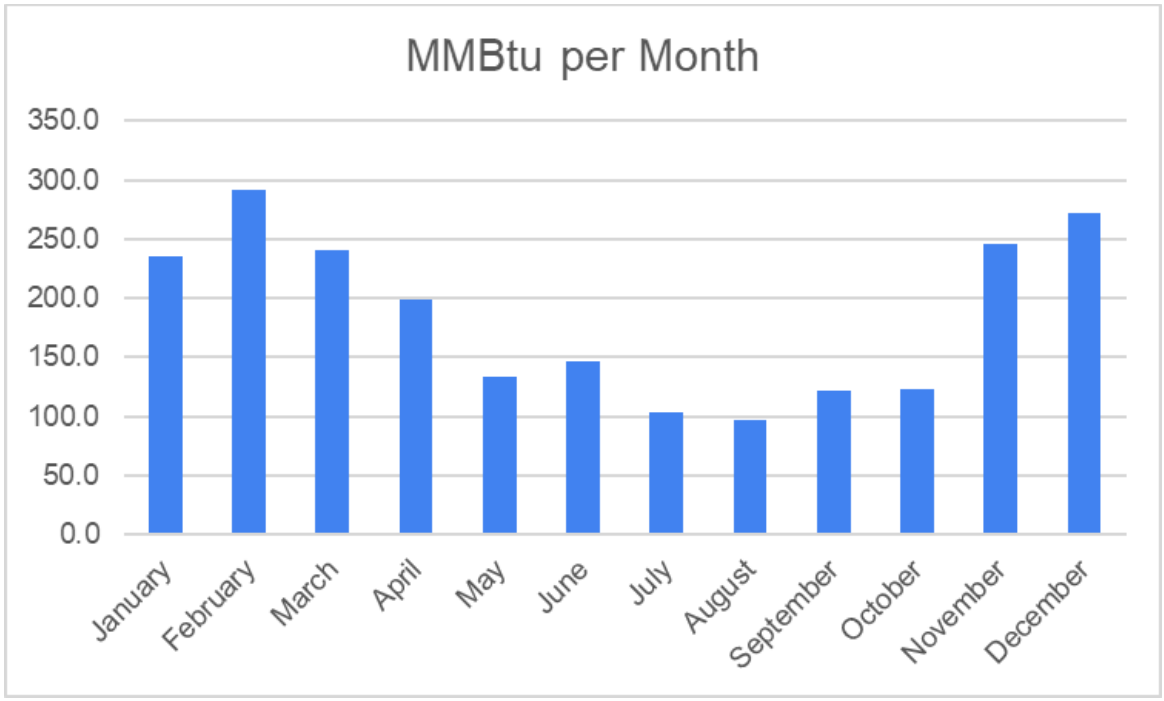


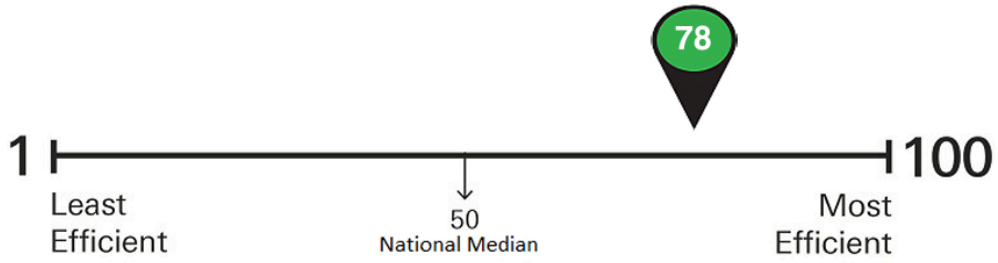
Figure 3: Energy Performance Scorecard

ENERGY STAR® Energy Performance Scorecard

78

out of 100

For Year Ending	December 31, 2023
Property Address	
Primary Function	University/College
Gross Floor Area (ft²)	72,000
Year built	2003
Energy Use per sq. ft.*	68.4 kBtu



What is the ENERGY STAR Score?
The ENERGY STAR score rates commercial building's energy performance relative to similar buildings nationwide. Expressed as a number on a simple 1-100 scale, the score rates performance on a percentile basis: a building with a score of 50 performs better than 50% of its peers. Higher scores mean better energy efficiency, resulting in less energy use and fewer greenhouse gas emissions. If a 1-100 score for a specific building type has not been developed, Site Energy Use Intensity (EUI) will be displayed on this scorecard.

Learn more at:
energystar.gov/scorecard

*Site energy use

EPA United States Environmental Protection Agency

Date Generated: January 29, 2024

Lane Community College

U.S. DEPARTMENT OF ENERGY

Oregon State University

Major Energy Consuming Equipment

Mechanical

Air Handling Units

AHU-1, 2 and 3

There are three air handlers located in the second-floor mechanical room. These three units provide and distribute the conditioned air throughout the building. AHU-1 serves the Administrative and Media Centers, AHU-2 serves the First Floor and AHU-3 serves the second floor. They each have a supply and return fans with variable speed to modulated air flow. Hot water coils provide heating. The heating water is controlled by 2-way valves to modulate heating water flow. Chilled water coils provide cooling. The chilled water flow is controlled at the units by 2-way valves to vary the chilled water flow. Each unit has full economizer control along with capability for demand-controlled ventilation.

Table 3: Air Handling Units

Rooftop Air Handling Units					
Tag	Area Served	Air Flow CFM	Supply Fan HP	Return Fan HP	Min OA CFM
AHU-1	Admin/Media	34500	50	15	10950
AHU-2	All Floors	14000	20	7.5	5350
AHU-3	All Floors	14000	20	7.5	6650

Boilers

B-1, B-2, and B-3

The boilers are located in the second-floor mechanical room. The units are high efficiency condensing boilers which provide heating water to the roof mounted air handlers and to reheat coils in the variable air volume terminal units throughout the facility. Variable speed pumps distribute the heating hot water through a primary piping/secondary piping distribution system.

Table 4: Boilers

Boilers				
Tag	Service	Manufacture	Type	Capacity MBH
B-1	Building Heating	AERCO BMK	Condensing	1000
B-2	Building Heating	AERCO BMK	Condensing	1000
B-3	Building Heating	AERCO BMK	Condensing	1000

Chillers

There are two air cooled chiller scroll packaged chillers located in an enclosed mechanical yard adjacent to the facility. The chillers provide chilled water to the three air handling units inside the mechanical room. These chillers have replaced the original evaporative air-cooled chiller that was originally installed at the time of construction. One chiller is 90 Tons nominal capacity, and the other chiller is 125 Tons nominal capacity. Both chillers are Trane CGAM type units.

TRANE

Model Number Descriptions

Digits 1-4— Chiller Model

CGAM= Air-Cooled Scroll Packaged Chiller

Digits 5-7— Unit Nominal Ton

020 = 20 Tons
026 = 26 Tons
030 = 30 Tons
035 = 35 Tons
040 = 40 Tons
052 = 52 Tons
060 = 60 Tons
070 = 70 Tons
080 = 80 Tons
090 = 90 Tons
100 = 100 Tons
110 = 110 Tons
120 = 120 Tons
130 = 130 Tons

Digit 18— Freeze Protection (Factor-Installed Only)

X = Without freeze protection
1 = With freeze protection (External T-Stat control)

Digit 19— Insulation

A = Factory insulation - all cold parts
B = Insulation for high humidity/ low evap temp

Digit 20— Factory Charge

1 = Full factory refrigerant charge (R-410A)
2 = Nitrogen charge

Digit 21— Evaporator Application

A = Standard cooling (40 to 65°F/4.4 to 18°C)

Table 5: Air Cooled Chillers

Air Cooled Chillers				
Tag	Service	Manufacturer	Type	Nominal Capcity Tons
Chiiler 1	Air Handling Units	TRANE	Packaged Scroll	90
Chiller 2	Air Handling Units	TRANE	Packaged Scroll	125

The pumping system is comprised on two chilled water loops. The primary loop circulates through the chilled water through the chiller. The secondary loop circulates chilled water to the air handling units. All the chilled water pumps are variable speed.

Table 6: Pumps

Pumps				
Tag	Service	Type	Capacity	
			Flow (GPM)	Motor HP
HWP-1	Boiler B-1	In-Line	45	0.75
HWP-2	Boiler B-2	In-Line	45	0.75
HWP-3	Boiler B-3	In-Line	45	0.75
HWP-4	Building	In-Line	135	7.5
HWP-5	Building	In-Line	135	7.5
HWP-6	AHU-1 HW Coil	In-Line	30	0.5
HWP-7	AHU-2 HW Coil	In-Line	14.5	0.33
HWP-8	AHU-3 HW coil	In-Line	17.9	0.33
CHWP-1	Chilled Water	In-Line	310	15
CHWP-1	Chilled Water	In-Line	310	15

Terminal Units

Variable air volume terminal units provide zone control and hot water reheat.

Split system AC units

Split system air conditioning units provide cooling to electric rooms, telecom spaces, and elevator equipment rooms. The outdoor condensing units are located on the roof.

General Exhaust Fans

Roof mounted exhaust fans provide general exhaust for restrooms.

Domestic Hot water

There is a single high efficient condensing hot water heater located in the mechanical room. It provides domestic hot water for the entire building. Water is tempered with a mixing valve located in the boiler room and recirculated throughout the system with a recirculation pump.

Solar PV Array

A 500 kW solar array is located at ground level across the main drive and near the facility. The solar pv system provides electrical for this facility and other facilities located on the campus.

Lighting

The lighting in the classrooms and offices consist of a combination of cable hung linear fluorescent direct/indirect fixtures with F32T8 lamps and ceiling recessed fixtures. The entrance lobby are recessed square fixtures with 32watt lamps. In the main floor hallway there are linear suspended pendant type fixtures. Stairwells are lit with surface wall mounted fixtures with F32T8 lamps. Mechanical rooms and general utility area lighting consist of fluorescent strip light fixtures with F32T8 lamps.

Lighting is controlled by manual wall switches.

Detailed Energy Efficiency Measures

EEM 1 Lighting Updates

EXISTING CONDITIONS

The lighting in the general offices and classrooms is the original lighting that was installed in 2003. The classroom lighting consists of a combination of 2 ft x 4 ft ceiling recessed fixture and 4 ft suspended fixtures with F32 T8 lamps (32 watts per lamp). Offices and common areas are a mixture of recessed round fixtures with 18 watt compact fluorescent bulbs (CFL).

PROPOSED MEASURE DESCRIPTION

Replace the F32 lamps with LED lamps. Replaced CFL bulbs with LED. This measure assumes LED replacement lamps have 9.2 watt/foot per current manufacturer data.

CALCULATIONS

Energy (kWh) = Fixture Watt/1000 x No. of Fixtures x "ON" Hrs per year

Demand (kW) = Lighting total watt/1000 kW/watt

Hours "ON" is assumed to be 3380 hours per year.

Estimated Cost = $100/Fixture

Existing Conditions							
Fixture Plan Designation	Fixture Type	Space Type	Watt/fixture	Qty	Total Watt per Fixture Type		
A24, A27	2 lamp, 4ft T8	Classrooms, Offices	64	232	14848		
A7, A28, A14	1 lamp 8 ft T8	Classrooms, Offices	59	71	4189		
A7, A17, A28, D, B, F	1 lamp 4 ft T8	Classrooms, Offices	34	146	4964		
A20	1 lamp 12 ft T8	Classrooms, Offices	59	5	295		
				454		24296	Total Watts
Recommended Change							
A24, A27	Replace T8 with LED, 2 lamp 4ft	Classrooms, Offices	26	232	6032		
A7, A28, A14	Replace T8 with LED, 1 lamp 8ft	Classrooms, Offices	33	71	2343		
A7, A17, A28, D, B, F	Replace T8 with LED, 1 lamp 4ft	Classrooms, Offices	18	146	2628		
A20	Replace T8 with LED, 1 lamp 12ft	Classrooms, Offices	42	5	210		
				454		11213	Total Watts

Hours "ON"	3380	hrs	
			Calculations
Existing Energy =	82120.48	kWh	: Lighting Fixture Watt X No. of Fixture x "ON Hrs
Existing Energy Cost = $	976		
			Demand (kW) = Lighting total Watt/1000
Proposed Energy =	37899.94	kWh	
Proposed Energy Cost = $	450		
			Estimated Cost/Fixture = $ 50
Existing Demand =	24		
Existing Demand Cost =	267		
Proposed Demand =	11		
Proposed Demand Cost = $	123		Total Cost = $ 45,400

Hours "ON"	3380 hrs		
Existing Energy =	82120.48 kWh	Lighting Fixture Watt X No. of Fixture x "ON Hrs	
Existing Energy Cost = $	976		
		Demand (kW) = Lighting total Watt/1000	
Proposed Energy =	37899.94 kWh		
Proposed Energy Cost = $	450		
		Estimated Cost/Fixture = $	50
Existing Demand =	24	Total Cost = $	45,400
Existing Demand Cost =	267		
Proposed Demand =	11		
Proposed Demand Cost = $	123		

EEM #1 Estimated Savings			
Annual Energy Usage & Savings Estimate	Baseline Electric Usage (kWh)		82120
	Proposed Electric Usage (kWh)		37900
	Electric Savings (kWh)		44221
	Electric Cost Savings ($)	$	525
	Demand Savings (kW)		13
	Electric Demand Savings ($)	$	144
	Baseline Natural Gas Usage (Therms)	-	
	Proposed Natural Gas Usage (Therms)	-	
	Natural Gas Savings (Therms)	-	
	Natural Gas Savings ($)	-	
	Annual Energy Cost Savings	$	669
Measure Cost & Simple Payback	Project Cost	$	45,400
	Simple Payback (Cost/Savings)		67.9

EEM 2 Occupancy Sensors

EXISTING CONDITIONS

Existing offices and classrooms do not have occupancy sensors for lighting control Lights are controlled by manual wall switches.

PROPOSED MEASURE DESCRIPTION

Install occupancy sensors in classrooms and offices for lighting control.

CALCULATIONS

Spreadsheet calculations were developed to determine energy savings. Existing lighting plans and site investigation was used to determine the existing lighting wattage.

Existing Conditions
Facility does not have Occupancy Sensors

Fixture Plan Designation	Existing Conditions Fixture Type	Space Type	Watt/fixture	Qty	Watt per Fixtur	
A24, A27	2 lamp, 4ft T8	Classrooms, Offices	64	232	14848	
A7, A28, A14	1 lamp 8 ft T8	Classrooms, Offices	59	71	4189	
A7, A17, A28, D, B, F	1 lamp 4 ft T8	Classrooms, Offices	34	146	4964	
A20	1 lamp 12 ft T8	Classrooms, Offices	59	5	295	
				454	24296	Total Watts

"ON" Time Existing= 3380 hrs

Proposed reduces "ON" Time from 10 hrs/day 5 days per week to 8 hrs/day

"ON" Time proposed = 2080 hrs
Existing Energy = 82120 kWh
Existing Energy Cost = $ 976

Proposed Energy = 50536 kWh
Proposed Energy Cost = $ 600

Calculations

Energy (kWh) = Lighting Fixture Watt X No. of Fixture x "ON Hrs

Estimated Cost/Sensor = $50

Total Sensors = 50
Total Cost = 2500

EEM #2 Estimated Savings			
Annual Energy Usage & Savings Estimate	Baseline Electric Usage (kWh)		82120
	Proposed Electric Usage (kWh)		50536
	Electric Savings (kWh)		31585
	Electric Cost Savings ($)	$	375
	Baseline Natural Gas Usage (Therms)		
	Proposed Natural Gas Usage (Therms)	-	
	Natural Gas Savings (Therms)	-	
	Natural Gas Savings ($)	$	-
	Annual Energy Cost Savings	$	375
Measure Cost & Simple Payback	Project Cost	$	2,500
	Simple Payback (Cost/Savings)		6.7

EEM 3 Occupancy Based Control of VAV System

EXISTING CONDITIONS

The air handling system at the facility is a variable air volume system with hot water reheat. Flow station control of the terminal box dampers are designed to maintain flow rate between a minimum air flow setpoint and maximum airflow setpoint. The minimum airflow setting is based on design calculations for outside air per ASHRAE 62 requirements. The requirements assume an occupancy rate based on the space type. Site inspections and per conversations with the staff, many of the spaces are not fully occupied all the time, yet the minimum outside air does not go below minimum settings based on actual occupancy.

PROPOSED MEASURE DESCRIPTION

Provide Occupancy Based Control (OBC) using monitored zone temperature and occupancy to determine actual terminal unit flow rate.

SAVINGS METHODOLOGY

Pacific Northwest National Laboratory studies have shown that systems can achieve energy savings of 18% by utilizing advanced occupancy sensors for variable volume damper control. ("Energy Savings for Occupancy-Based Control of VAV Systems" by Jian Zhang PhD., and Guopeng Liu PhD, PE, LEED AP October 21, 2015). Based on this study and current energy use, occupancy sensor control can achieve as much as 46,833 kWh electrical and 133 Mbtu natural gas energy savings.

EEM #3 Estimated Savings				
		Electric Savings (kWh)		46833
		Electric Cost Savings ($)	$	556
			-	
		Natural Gas Savings (MMBtu)		133
		Natural Gas Savings ($)	-	
		Annual Energy Cost Savings	$	556
Measure Cost & Simple Payback		Project Cost	$	6,000
		Simple Payback (Cost/Savings)		10.8

Energy Savings for Occupancy-Based Control of VAV Systems

Jian Zhang Ph.D. and Guopeng Liu Ph.D, PE, LEED AP
Pacific Northwest National Laboratory

Presented at Building Energy Simulation Forum
Energy Trust of Oregon
Portland OR
Oct 21, 2015

U.S. DEPARTMENT OF ENERGY

PNNL-SA-113934

Results – Baseline vs Advanced OS for Lighting and HVAC

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

	National Weighted Average Site Energy Use (kBtu/sf-yr)						Energy Savings	
	Interior Lights	Cooling	Heating	Fans	Pumps	Whole Building	kBtu/sf-yr	%
Baseline	9.8	6.9	9.0	2.1	2.3	**47.8**	-	-
Common OS	9.2	6.5	7.4	1.9	2.2	**45.0**	**2.8**	**5.9%**
Advanced OS	8.9	5.9	3.0	1.5	2.2	**39.3**	**8.5**	**17.9%**

- Major Savings from reduction to reheat energy
- Significant improvement from OBC with common OS to advanced OS

Lane Community College

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Oregon State University

EEM 4 Boiler Temperature Control – HW Return Reset

EXISTING CONDITIONS

The boiler control is currently operating the heating water return through the boilers at a fixed temperature of approximately 160°F. This prevents the boilers from operating efficiently during periods when the load is reduced, and the heating water return can be reset to levels to optimize condensing boiler efficiency.

PROPOSED MEASURE DESCRIPTION

Replace the existing boilers with high efficiency condensing boilers.

SAVINGS METHODOLOGY

Based on the most recent utility data, approximately 90% of the total natural gas use in the facility goes to space heating and reheat. The remaining 10% is to domestic hot water use.
Baseline Natural Gas Use = .90 x 2215 MMBtu
Baseline Natural Gas Use = 1994 MMBtu

Condensing boilers improve efficiency to 92% for a 12% savings in natural gas energy use.
Proposed Energy Use = 1754 MMBtu
Energy Savings = 240 MMBtu

The estimated savings do not include potential utility incentives.

EEM #4	Estimated Savings	
Annual Energy Usage & Savings Estimate	Baseline Electric Usage (kWh)	-
	Proposed Electric Usage (kWh)	-
	Electric Savings (kWh)	-
	Electric Cost Savings ($)	-
	Baseline Natural Gas Usage (MMBtu)	1994
	Proposed Natural Gas Usage (MMBtu)	1754
	Natural Gas Savings (MMBtu)	239
	Natural Gas Savings ($)	$ 2,567
	Annual Energy Cost Savings	$ 2,567
Measure Cost & Simple Payback	Project Cost	$ 2,500
	Simple Payback (Cost/Savings)	1.0

Based on utility data:			
Naturlag Gas Energy Use =	2215	MMBtu	Based on recent utillity data
90% Nat Gas Heating Baseline Energy Use	1993.5	MMBtu	90% Total Gas use goes to cast iron boilers
Proposed Energy Use =	1754.28	MMBtu	12% Energy Savings
Natural Gas Energy Savings =	239.22		

An alternative method used eQUEST energy simulation to estimate natural gas use with the boilers at 80% efficient and then with reset assuming they operate as condensing boilers with efficiency varying up to 95% efficient depending on heating water return temperature.

eQUEST Summary:

Baseline natural gas use = 2348 MMBtu
Proposed natural gas use = 1926 MMBtu
Energy Savings = 422 MMBtu
This method resulted in a more significant energy savings and therefore the more conservative method is proposed to demonstrate savings and payback.

EQUEST Report Baseline Energy Use

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	330.7	236.6	163.2	119.8	109.6	43.7	28.5	24.1	66.4	131.4	269.2	328.0	1,851.2
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.7	6.2	7.1	6.7	6.7	6.1	5.9	6.2	5.3	6.1	5.9	6.2	75.1
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	337.4	242.8	170.3	126.5	116.3	49.8	34.4	30.4	71.7	137.5	275.0	334.1	1,926.3

EQUEST Report EEM Energy Use

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	394.1	287.2	201.2	151.6	138.2	57.8	39.2	32.9	87.1	166.6	325.8	391.6	2,273.3
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.7	6.2	7.1	6.7	6.7	6.1	5.9	6.2	5.3	6.1	5.9	6.2	75.1
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	400.7	293.3	208.3	158.3	145.0	63.9	45.1	39.1	92.4	172.8	331.6	397.7	2,348.4

EEM 5 System Rescheduling

EXISTING CONDITIONS

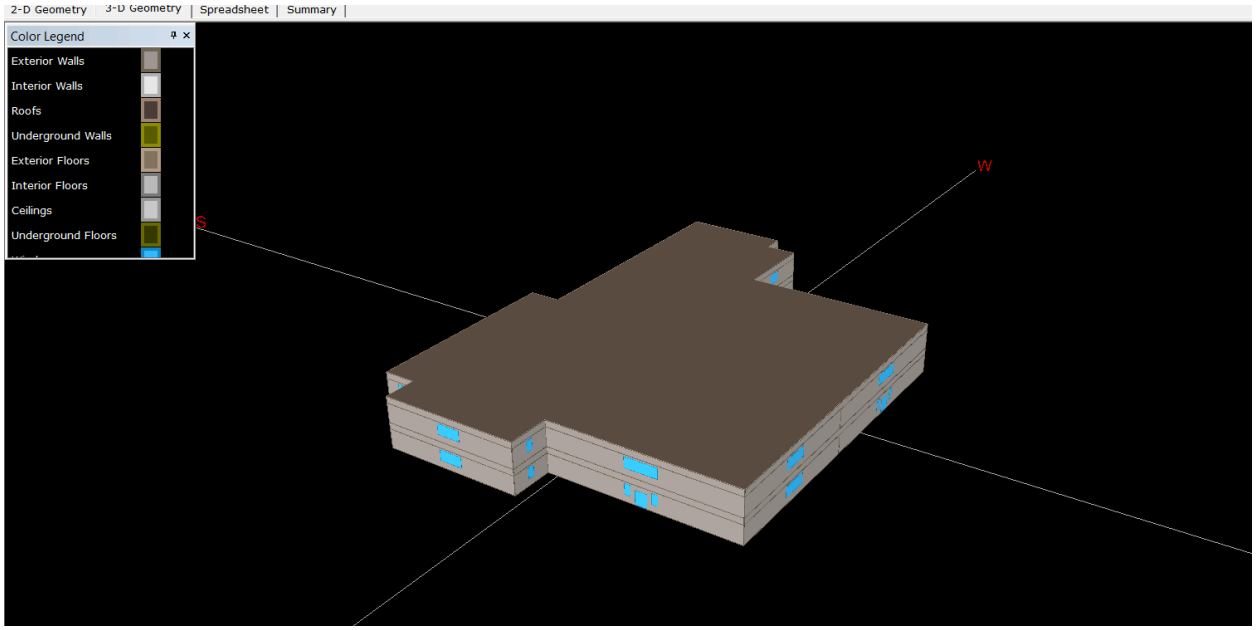
The facility HVAC is currently scheduled to run 23 hours daily (12 am – 11pm) but the building is occupied generally from 7 am – 10 pm.

PROPOSED MEASURE DESCRIPTION

Reschedule the building automation system (BAS) to setback the HVAC during non-occupied periods.

SAVINGS METHODOLOGY

The DOE Energy Modeling software, eQUEST was used to estimate energy savings. eQUEST is based on DOE-2, Building Energy Use and Cost Analysis Tool, a widely used and accepted building energy analysis tool used to predict energy use. DOE-2 uses the building description, construction, use, HVAC system type, local weather data and building scheduling to perform an hourly (8760) simulation of the building.



Two energy models were developed. The baseline energy model was developed based on building construction, location, schedule, and system types and calibrated to latest energy use based on 2023 annual utility data.

This method resulted in a more significant energy savings and therefore the more conservative method is proposed to demonstrate savings and payback.

Baseline Energy Use (Based on eQUEST Model)

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	7.60	6.87	8.58	10.54	9.85	16.01	24.19	22.27	14.13	10.69	7.36	7.60	145.69
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	2.81	2.48	2.75	2.70	2.81	3.00	3.60	3.57	2.82	2.81	2.66	2.78	34.80
Pumps & Aux.	4.52	4.08	4.52	4.38	4.52	4.38	4.52	4.52	4.38	4.52	4.38	4.52	53.23
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	16.49	14.91	17.03	16.34	17.03	16.31	16.51	17.55	15.26	17.03	15.77	15.95	196.17
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	34.69	31.38	36.20	34.64	36.20	34.55	34.74	37.66	31.62	36.20	33.04	33.18	414.12
Total	66.11	59.73	69.09	68.59	70.41	74.24	83.55	85.58	68.21	71.25	63.20	64.04	844.01

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	394.1	287.2	201.2	151.6	138.2	57.8	39.2	32.9	87.1	166.6	325.8	391.6	2,273.3
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.7	6.2	7.1	6.7	6.7	6.1	5.9	6.2	5.3	6.1	5.9	6.2	75.1
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	400.7	293.3	208.3	158.3	145.0	63.9	45.1	39.1	92.4	172.8	331.6	397.7	2,348.4

EQUEST Report EEM Energy Use Rescheduling Building Operation Hours

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	4.41	4.03	6.09	6.92	7.25	13.47	19.04	18.65	11.41	6.74	4.22	4.32	106.54
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	3.06	2.49	2.74	2.55	2.67	2.58	2.52	2.74	2.36	2.65	2.62	2.85	31.82
Pumps & Aux.	3.52	3.21	3.73	3.52	3.68	3.58	3.55	3.84	3.28	3.67	3.36	3.42	42.35
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	13.24	12.02	13.89	13.19	13.77	13.30	13.24	14.31	12.24	13.77	12.65	12.82	158.45
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	27.27	24.69	28.58	27.24	28.51	27.30	27.27	29.75	24.82	28.51	25.99	26.09	326.02
Total	51.49	46.44	55.02	53.42	55.88	60.23	65.63	69.29	54.10	55.34	48.83	49.49	665.17

Gas Consumption (Btu x000,000)

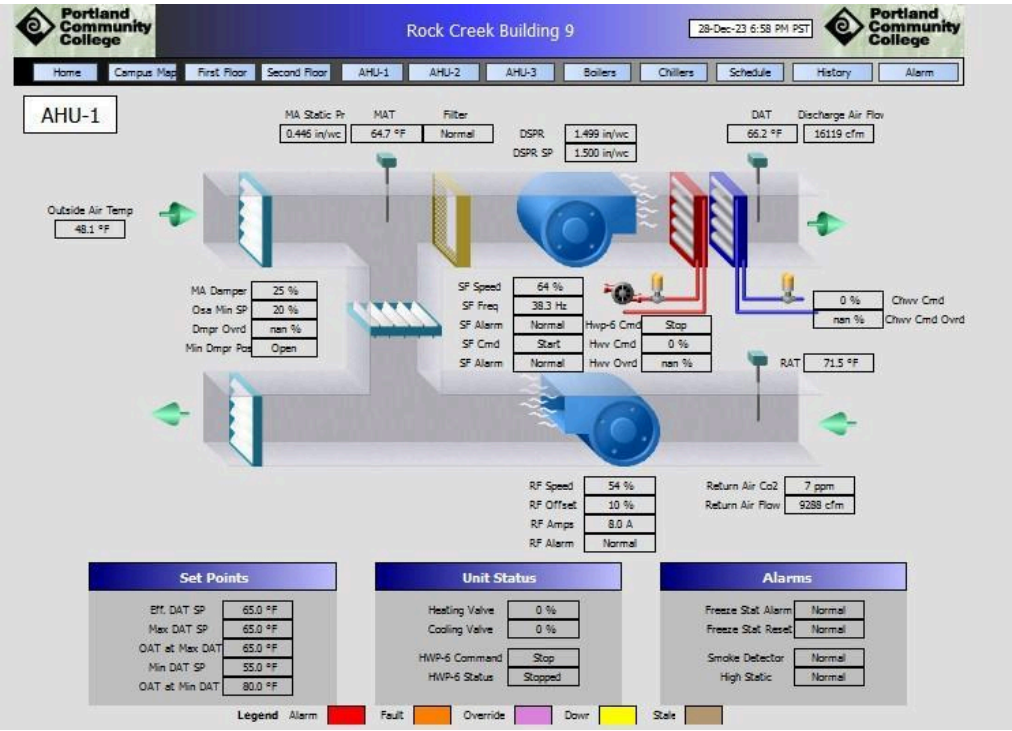
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	316.2	231.5	183.3	151.3	140.2	73.8	33.4	40.2	90.6	157.7	260.6	297.0	1,975.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	6.7	6.2	7.1	6.7	6.7	6.2	5.9	6.2	5.3	6.1	5.9	6.2	75.2
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	322.8	237.7	190.4	158.0	147.0	80.0	39.3	46.4	95.8	163.8	266.5	303.2	2,051.0

EEM #5 Estimated Savings			
Annual Energy Usage & Savings Estimate	Baseline Electric Usage (kWh)		844101
	Proposed Electric Usage (kWh)		665170
	Electric Savings (kWh)		178931
	Electric Cost Savings ($)	$	2,126
	Baseline Natural Gas Usage (MMBtu)		2348
	Proposed Natural Gas Usage (MMBtu)		2051
	Natural Gas Savings (MMBtu)		297
	Natural Gas Savings ($)	$	3,187
	Annual Energy Cost Savings	$	3,187
Measure Cost & Simple Payback	Project Cost	$	1,500
	Simple Payback (Cost/Savings)		0.5

EEM 6 AHU Static Pressure Reset

EXISTING CONDITIONS

AHU-1, 2 and 3 are variable air volume systems that serve the facility. In a variable air volume system (VAV) the zone dampers open or close depending on the requirements of the zone. The SP on the systems is at a fixed value of 1.5” WC.



When multiple zone dampers close, the static pressure in the system increases. If the static pressure (SP) exceeds a certain value, then the pressure controller sends a signal to the fan speed control to reduce fan speed and reduce air flow back to the set pressure. The design airflow and SP setpoint are based on design conditions. Typically the static pressure is set to satisfy the most demanding zone, often resulting in setpoints higher than necessary. When zone loads are reduced, the SP setpoint should be adjusted or reset, to lower values. This will result in energy savings due to lower SP, less air flow and lower brake horsepower at the fan. Using the fan laws a reduction in 1" WC can provide a reduction of approximately 35% savings in Bhp.

$$\text{Fan Law 1: } \frac{CFM_2}{CFM_1} = \frac{RPM_2}{RPM_1}$$

$$\text{Fan Law 2: } \frac{SP_2}{SP_1} = \left(\frac{RPM_2}{RPM_1}\right)^2$$

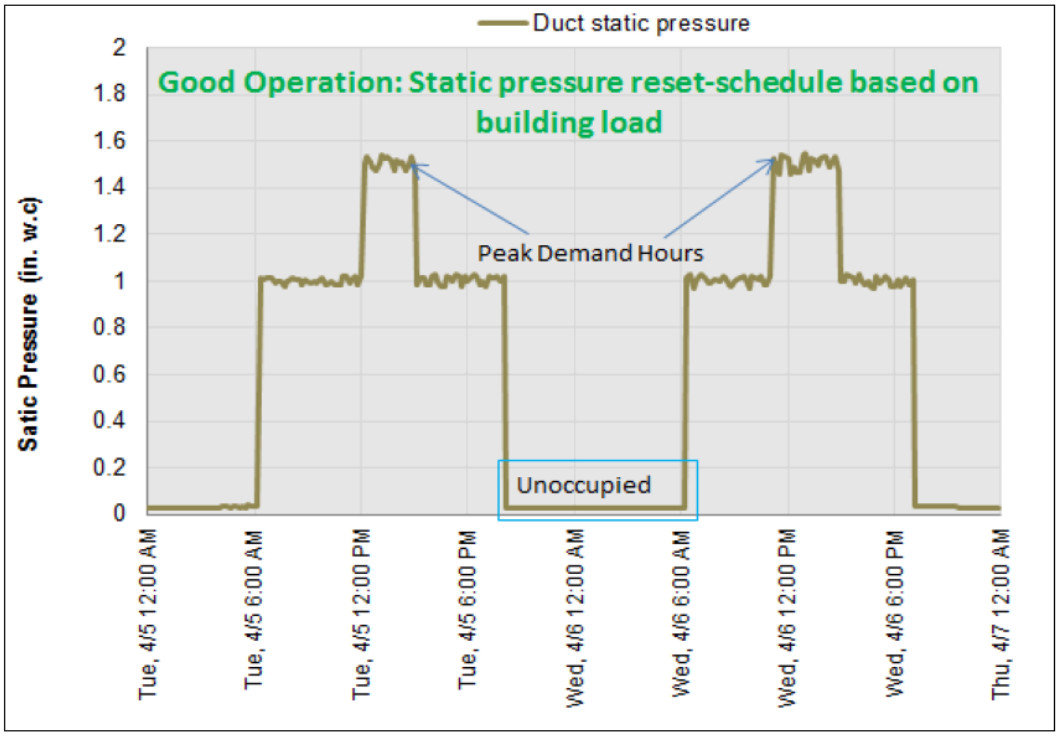
$$\text{Fan Law 3: } \frac{HP_2}{HP_1} = \left(\frac{RPM_2}{RPM_1}\right)^3$$

If SP_2 = 1" WC, and SP_1 = 2" WC, then the reduction in energy savings can be shown as follows:

$$\frac{HP_2}{HP_1} = \left(\frac{SP_2}{SP_1}\right)^{\frac{3}{2}} = \left(\frac{1"}{2"}\right)^{\frac{3}{2}} = 35.3\%$$

PROPOSED MEASURE DESCRIPTION

Instead of operating at a fixed static pressure, this measure proposes that the system controls reset the static pressure to lower levels as the building loads decrease. Below is a graphic from Pacific Northwest Natural Laboratory showing how the reset schedule can be implemented.



SAVINGS METHODOLOGY

The following Fan Part Load Performance Curves for VAV with fixed SP and VAV with SP reset were used to determine percent power based on percent air flow (CFM). For purposes of this analysis, it is assumed that airflow (CFM) will vary based on the percent of time that the system is at partial loading as follows:

100% Load	Occurs 1% of the time
75% Load	Occurs 42% of the time
50% Load and lower	Occurs 45% of the time

AHU-1 100% design = 34,500 CFM
AHU-2 100% design = 14,000 CFM
AHU-3 100% design = 14,000 CFM

CALCULATIONS

Assume motor efficiency = 90%
Assume hours = 23 hours per day, 7 days per week and 52 weeks per year

AHU-1

Percent Load	% Power VAV Fixed SP	Airflow	Bhp	kW Input	Percent of Time	Hours	kWh	
100%	100%	34,500	41.4	34.32	0.01	84	29	
75%	48%	25875	19.9	16.47	0.42	3516	24326	
50%	20%	17250	8.3	6.86	0.57	4772	18668	
							43023	Total kWh
	VAV SP Reset							
100%	100%	34,500	41.4	34.32	0.01	84	29	
75%	35%	25875	14.5	12.01	0.42	3516	17738	
50%	10%	17250	4.1	3.43	0.57	4772	9334	
							27100	Total kWh
							15922	kWh Savings

AHU-2 and AHU-3

100%	100%	28,000	18.3	15.17	0.01	84	13	
75%	48%	21000	8.8	7.28	0.42	3516	10753	
50%	20%	14000	3.7	3.03	0.57	4772	8252	
							19017	Total kWh
	VAV SP Reset							
100%	100%	28,000	18.3	15.17	0.01	84	13	
75%	35%	21000	6.4	5.31	0.42	3516	7840	
50%	10%	14000	1.8	1.52	0.57	4772	4126	
							11979	Total kWh
							7038	kWh Savings

EEM #6 Estimated Savings			
Annual Energy Usage & Savings Estimate	Baseline Electric Usage (kWh)		62040
	Proposed Electric Usage (kWh)		39080
	Electric Savings (kWh)		22961
	Electric Cost Savings ($)	$	273
	Demand Savings (kW)	-	
	Electric Demand Savings ($)	-	
		-	
		-	
	Natural Gas Savings (MMBtu)	-	
	Natural Gas Savings ($)	-	
	Annual Energy Cost Savings	$	273
Measure Cost & Simple Payback	Project Cost	$	1,000
	Simple Payback (Cost/Savings)		3.7

Appendix

Appendix 1 Photos

Figure A: Air Handling Units

Figure B: Condensing Boiler

Figure C: Air-Cooled Chiller

Figure D: Solar

Figure E: Domestic Water

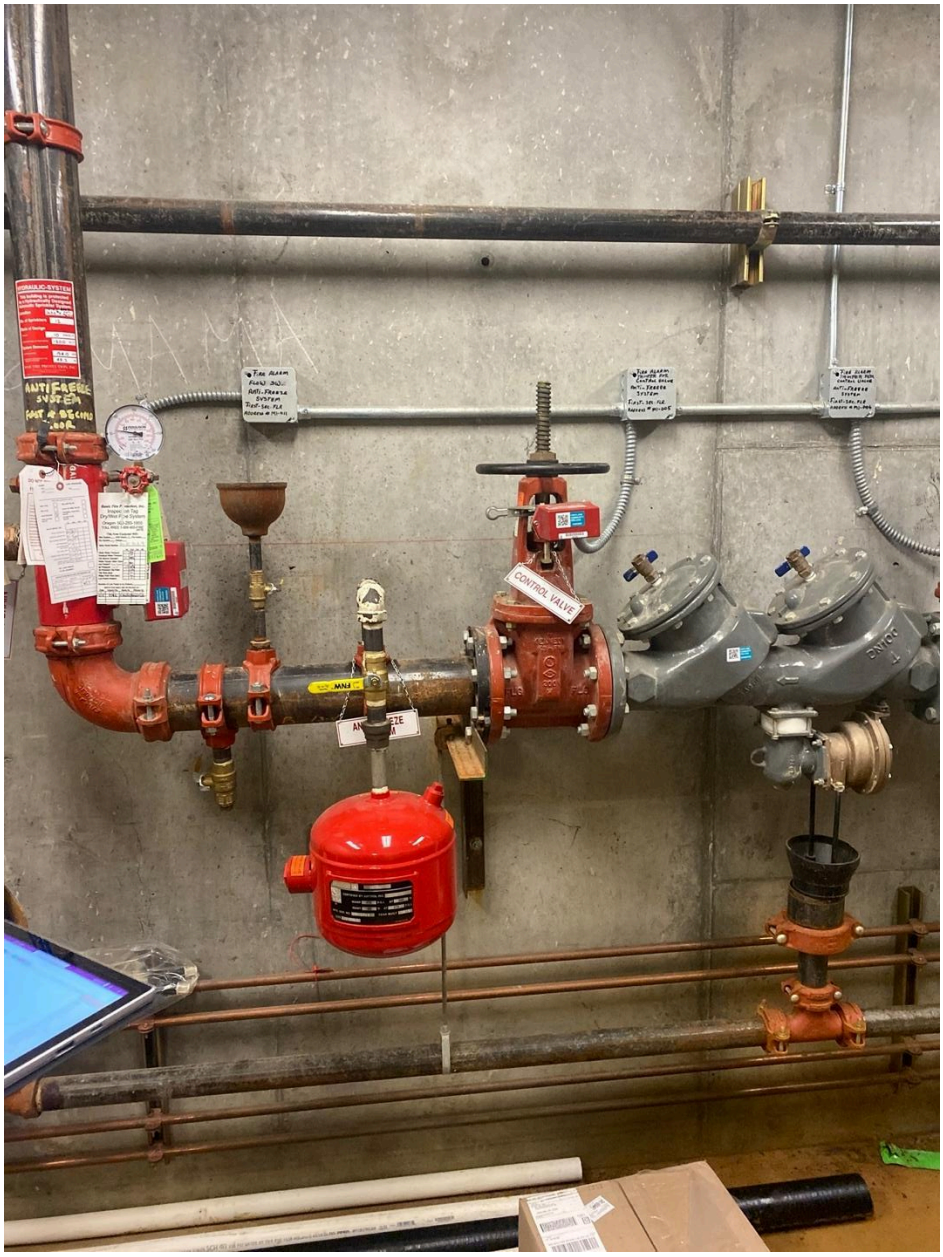


Figure F: Hot Water Pumps

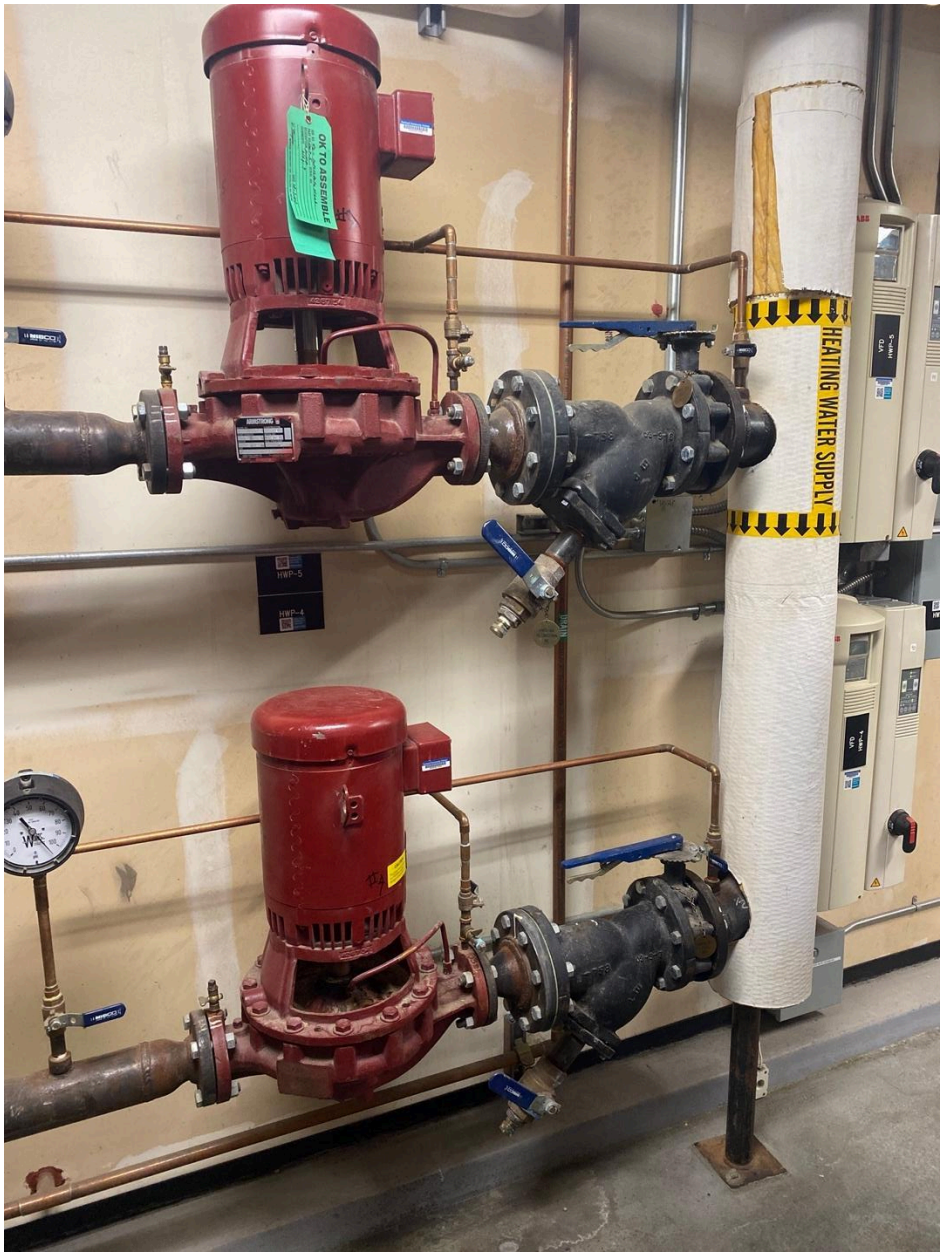


Figure G: Chilled Water Pumps


CHWP-4