Technical Analysis Study

Oregon Institute of Technology - Wilsonville

HVAC DDC System Upgrade Project

27500 SW Parkway Ave., Wilsonville, OR 97070

Project Number: **CU_101553**

Study sponsored by:

Energy Trust of Oregon - Existing Buildings Program

Submitted by:

Karl Friesen and Associates, LLC dba KFAA Engineering

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Disclaimer

This energy analysis is funded by Energy Trust of Oregon to help the participant (customer) identify energy savings potential at their facility. TRC is the Program Management Contractor for the Existing Buildings Program. TRC will work with the Allied Technical Assistance Contractor (ATAC) to review the accuracy of this study. If the energy efficiency upgrades (measures) recommended in this report may be eligible for Energy Trust incentives and if the participant wishes to implement the eligible measures, TRC will support and provide guidance to the participant on Energy Trust's incentive application process and requirements throughout the life of the project.

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.

In no event will Energy Trust of Oregon, TRC or the ATAC be liable for (i) the inability of the participant to achieve the estimated energy savings or any other estimated benefits included herein, or (ii) for any damages to participant's site, including but not limited to any incidental or consequential damages of any kind, in connection with this report or the installation of any identified energy efficiency measures.

1 Key Contact Information

Participant (Customer) Contact	
Contact Name	Sara Mansfield
Title	Campus Operations Manager
Phone	503-821-1291
Email	sara.mansfield@oit.edu
Allied Technical Assistance Contractor (ATAC) Contact	
Contact Name	Karl Friesen, PE
Title	Principal
Phone	503-686-1176
Email	karl@karlfriesen.com
Energy Advisor (TRC) Contact	
Contact Name	Eric Bessel
Phone	206-586-6764
Email	ebessel@trccompanies.com

2 Project and Measure Summary

2.1 Energy Use and Savings Summary

Facility description	
Site Name	Oregon Institute of Technology - Wilsonville
Facility Type (e.g., office, grocery etc.)	Govt Offices and technical college
Year Built	2000
Number of Floors	4
Total Building Area (sq.ft.)	162,745
Area Affected by Proposed Measure(s) (sq.ft.)	162,745
Energy Usage	
Average Annual Electric Usage (kWh)	2,506,150
Average Annual Gas Usage (therms)	3,272
Energy Use Intensity, EUI (kBtu/sq.ft.)	55
Electric Utility Provider	PGE
Gas Utility Provider	NW Natural
Estimated Savings (%)	
Estimated Electricity Savings (%)	31.4%
Estimated Gas Savings (%)	-31.9%

1) Note that the % savings gas and electric is nearly the same, making it appear as if the amount of electricity being saved is just showing up as more natural gas usage. However, since there is such a dramatic difference between the natural gas and electricity usage (on a BTU basis 96% electricity and 4% Natural Gas), there is no comparability between these % savings figures.
2) The energy savings estimates are not incremental. The firm costs and the energy savings estimate both reflect the upgrade of the entire HVAC DDC system and no other measures were evaluated.

2.2 Energy Efficiency Measure (EEM) Summary – Custom Track

The following energy efficiency measure(s) (EEMs) are recommended for the participant's site and are potentially eligible for custom incentives under the Existing Buildings program:

- EEM 1 – Upgrade the existing HVAC Control system to improve occupant comfort and obtain energy savings

The current control system is aged, out of calibration, not expandable, or capable of implementing more modern energy savings strategies based on the age of the systems operating the building. It is to be replaced with a new state of technology DDC system.

The table below includes a list of recommended EEMs that may be eligible for Custom Incentives:

Custom Measures	Measure Descriptions	Energy Savings		Cost Savings		Estimated Program Eligibility Cost[3] ($)	Estimated Project Cost - Without Incentive[4] ($)	Simple Payback[5] - Without Incentive (years)
		Estimated Annual Electric Savings (kWh)	Estimated Annual Gas Savings (therms)	Estimated Annual Energy Cost Savings[1] ($)	Estimated Annual Non-Energy Benefits[2] ($)			
EEM 1	**DDC Control System Upgrade**	786,200	-1,044	$60,264	$0	$386,696	$386,696	6.4
Total		**786,200**	**-1,044**	**$60,264**	**$0**	**$386,696**	**$386,696**	**6.4**

1. *Cost savings are based on Energy Trust's average utility rates for electricity and gas. Actual rates and cost savings may differ.*
2. *Non-energy cost benefits are related to cost savings due to avoided maintenance, reduced water costs, etc.*
3. *Program Eligibility Cost is used to estimate cost-effectiveness under the Program. This could be the incremental cost for end-of-life replacement or full costs for early replacement measures. Program eligibility costs typically include equipment and labor costs. Costs such as permitting, shipping, crane use, painting, warranties, concrete pads, engineering, and design are ineligible to include in the program costs.*
4. *Project Cost includes all costs the participant would incur towards the EEM such as equipment, labor, permitting, shipping, and all other applicable costs.*
5. *Simple payback is estimated using current utility rates and project costs, which could vary over time.*

2.3 Energy Efficiency Measure (EEM) Summary – Standard (Prescriptive) Track

The following energy efficiency measure(s) (EEMs) are recommended for the participant's site and are potentially eligible for standard (prescriptive) incentives under the Existing Buildings program:

- None were identified by the customer contact as under consideration for funding at this time. At some point in the future lighting and RTU, upgrades may be under consideration for the building, however, these are not prescriptive measures.

3 Historical Energy Usage

Month	Electric Use (kWh)					Natural Gas Use (therms)				
	2017	2018	2019	2020	3-year Average	2017	2018	2019	2020	3-year Average
January	279,000	259,500	229,500	212,100	245,025	129	435	425	118	277
February	242,100	244,800	275,100	202,500	241,125	134	786	462	550	483
March	213,300	215,700	199,500		209,500	118	687	453		419
April	207,300	193,650	180,000		193,650	123	721	343		396
May	228,000	199,350	170,700		199,350	355	357	197		303
June	197,400	178,800	193,800		190,000	329	263	107		233
July	200,400	218,400	171,000		196,600	166	221	118		168
August	219,000	194,700	167,100		193,600	125	159	115		133
September	185,700	190,800	160,200		178,900	95	409	388		297
October	196,500	175,800	183,300		185,200	173	129	187		163
November	243,000	210,600	220,500		224,700	130	556	117		268
December	264,600	262,500	218,400		248,500	124	147	125		132
Annual Energy Usage										
Annual energy usage	2,676,300	2,544,600	2,369,100	NA	2,506,150	2,001	4,870	3,037		3,272
Rolling energy Usage[1]	Month 24-36	Month 12-24	Month 0-12			Month 24-36	Month 12-24	Month 0-12		
	2,659,500	2,544,900	2,279,100			2,959	4,536	2,818		
Annual energy usage (kBtu)	9,131,536	8,682,175	8,083,369		8,550,984	200,052	486,883	303,627		327,130
Energy Performance of the facility										
Conditioned space area (sqft)					162,745					
Total Energy Use (kBtu per year, based on 3-year Average)										8,878,114
Energy Use Intensity, EUI (kBtu/sqft/year)										55
Median EUI for facility type in the US[2]										52.4

1. *Electrical usage has dropped 31% and natural gas use has gone down 25% since Covid. So only pre-Covid data was used for this evaluation.*
2. *The building EUI 55, is only 4% higher than the national average for Vocational School facility type per the below link to the USDOE Energy Star EUI ratings although this figure is a little misleading since a) this building is reasonably newer than most college type buildings and has LED lighting, b) local weather is less severe (less extremely hot or cold weather) compared with the majority of the buildings in the average mix, and c) based on the effect of maintaining 24/7 operations which pushes the building to force the TU based electric resistance heat to carry the heating load vs n gas heat which presses the EUI down on a BTU basis (compared with both the older building and predominate dual fuel buildings contained in the national average calculational mix).*

**Median EUI source: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/what-energy*

4 Facility & Equipment Description

Facility Operations

- The facility is a four-story office building that functions as a technical institute that was originally constructed in 2000 with a renovation in 2011. The building consists of two rectangular wings with the biggest one running in a north-to-south configuration and the smaller one running in an SW to NE orientation. The school's main entrance is a set of air-lock style double doors located on its north façade with a matching set of egress doors located on its south façade. The facility has spaces common to structures of this type that include:
  - Vestibule/lobby
  - Offices/Classrooms/Labs
  - Conference rooms
  - Library
  - Supply/copy rooms
  - Kitchen/Breakrooms
  - Restrooms
  - Storage
  - Eating/lunch/break room spaces

- Operating hours: 7 AM to 11 PM – Monday - Sunday
- Total hours facility is occupied per year: 5,840 hours
- Total hours facility is unoccupied per year: 2,920 hours

Building Envelope

- **Wall assembly**: 2x6, 24 in o.c. medal framing, ¾" fiberboard sheathing (R-2), R-19 batt insulation with a red brick exterior finish.
- **Window assembly**: Double pane, aluminum frame wo/ break, U=0.47 and SHGC=0.81, coverage is approximately 40% of all facades.
- **Roof construction**: 24 in o.c. metal framing with built-up style roof with 3" polyurethane R-18 insulation.

Site Pictures

Figure 1: North Facade Entrance

Figure 2: Lobby Entrance

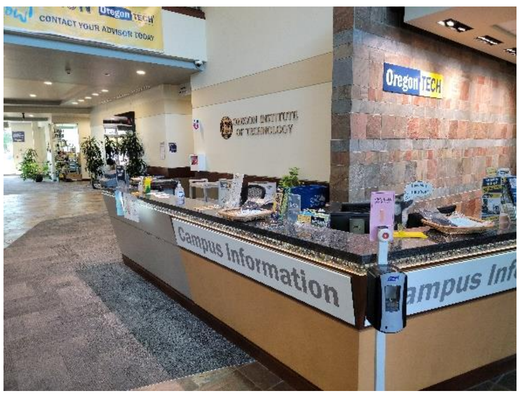

Figure 3: Information Desk

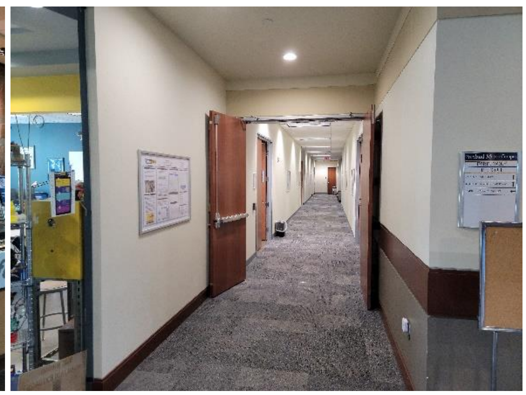

Figure 4: Typical Hallway

Figure 5: Office

Figure 6: Break Room

Figure 6: Library

Figure 7: Computer Lab

Figure 8: Classroom

Figure 9: Classroom

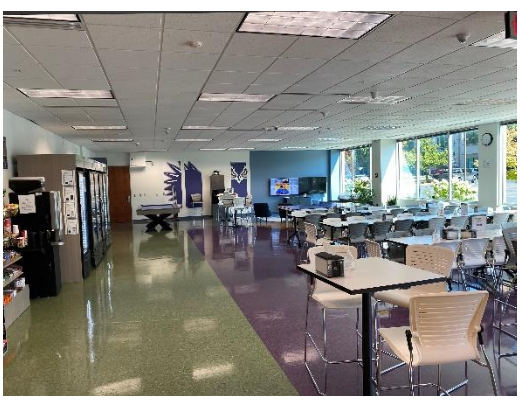

Figure 10: Cafeteria

Figure 11: Study Carrels

Figure 12: Air Handler (AC-1)

Figure 13: Air Handler (AC-2) Compressors

Figure 14: Split Systems

Figure 15: Exhaust Fan

Figure 16: MLS Hood 455

Figure 17: Hoods/Bench Lab 424

Figure 18: Hoods Lab 427

Figure 19: Chemical Storage Exhaust

Figure 20: Stair Pressurization Fan

Figure 21: Make-Up Air Unit

HVAC System

ROOF TOP UNITS										
Tag	Tons	CFM	Compressor Motor HP	Condenser Fan Motor HP	Evaporator Fan Motor HP	Return Fan Motor HP	Cooling Total (MBH)	Heating Input (MBH)	Electrical	Comments
AC-1	115	43,000	(4) 25	(9) 1	(1) 50	(1) 30	1221	500	460/60/3	Each unit serves Fan Powered Terminal Units (FTUs) and
AC-2	115	43,000	(4) 25	(9) 1	(1) 50	(1) 30	1221	500	460/60/3	Terminal Units (TUs) both with electric reheat serving
AC-3	115	43,000	(4) 25	(9) 1	(1) 50	(1) 30	1221	500	460/60/3	vertical zones that consist of an area of each floor.

SPLIT SYSTEMS					
Tag	Serves		Tons	Condenser Fan Motor	Electrical
Condensing Unit (Outdoor)	Fan Coil (Indoor)	Area			
CU 1-1	FC 1-1	1st Floor Electrical Room	2	(1) 0.33	208/60/1
CU 1-2	FC 1-2	Elevator Room	2	(1) 0.33	460/60/1
CU 1-3	FC 1-3	Main Server Room	2	(1) 0.33	208/60/1
CU 1-4	FC 1-4	Control Room	2	(1) .75	208/60/1
CU 2-1	FC 2-1	2th Floor Electrical Room	2	(1) 0.33	208/60/1
CU 2-4	FC 2-4	Project Server Room	2	(1) 0.33	208/60/1
CU 3-1	FC 3-1	3rd Floor Electrical Room	2	(1) 0.33	208/60/1
CU 4-1	FC 4-1	4th Floor Electrical Room	2	(1) 0.33	208/60/1

MAKE-UP AIR UNITS					
Tag	Serves	CFM	Supply - HP	Heating Input (MBH)	Electrical
MAU-1	MLS	4,000	3	300	460/60/1
MAU-2	Chem Lab	4,000	3	300	460/60/1

FANS			
Tag	Serves	CFM	HP
EF-1	West Restroom	4300	1
EF-2	North Restroom	4500	1.5
Hood 455 -(EF-1)	MLS Hood 455	-	0.25
EF-3	Janitor	200	1/50
EF-5	Hoods / Bench Lab 424	-	1
EF-7	Hoods - Lab 427	-	1
SF-1	Stairway	740	0.25
SF-2	Stairway	740	0.25
Mark-1	Chemical Storage	-	0.25

Controls (For Relevant Equipment)

- Set points (winter/summer) of various areas: 72 deg F – winter / 72 deg F - summer.
- Supply and return air temperatures (winter/summer): Supply 70-120 deg F (Winter range capability) / Supply 55-60 deg F (Summer).
- Economizer: Yes, but not working efficiently
- Current HVAC equipment schedules: 24/7 operation
- Controls are an older Alerton DDC system which is original with the building construction from 2000 with some upgrades in 2011 when OIT took over the building.

Internal Loads

- Occupancy: Project dependent and the number of staff can vary between 75-100 people working every day
- Lighting: LED Fixtures predominately throughout

Previous Energy Efficiency Upgrades

- LED lighting upgrade from T-8s has been mostly completed

5 Detailed EEM Description – Custom Track

5.1 EEM 1 – DDC upgrade

5.1.1 EXISTING EQUIPMENT DESCRIPTION

The existing HVAC control system is an older DDC system, with typical difficulties with older electronic systems, out-of-calibration sensors, temperature sensing/damper positioning delays/accuracy uncertainties, and slower system responses from older technologies. Plus, a lack of ability to add functionality (more inputs/outputs) as well as the lack of adequate controller memory capabilities which limit the ability to upgrade the operating programming for more sophisticated, optimizing strategies.

These shortcomings can lead to increased (and decreased) space temperatures to uncomfortable ranges on a sporadic basis including temperature setpoint overshoot/undershoot from less capable older PID loop control algorithms. As well as overheating of spaces from a lack of the ability to alter operations based on changes such as seasonal/daily solar gain intensity especially problematic as weather patterns continue to shift with changes in our climate.

These issues are economically compounded by decreased natural gas use of rooftop unit gas heat vs the TU box electric reheat. This is due to excess nighttime HVAC operations which keep the reheat coils operating while the rooftop unit gas morning warmup cycle is limited by the building already being warm when the morning warmup should be operating. It is uncertain whether these extended after-hours elevated temperatures are due to past re-programming for a temporary condition that was not removed afterward, or whether this operation is part of the system's supervisory controller technology related challenges.

The data logging identifies the above-mentioned issues of minimal to no after-hours/unoccupied operational setback temperature regimes in place. So, the HVAC system is operating in most spaces even during "normally" unoccupied hours on weekends and in the middle of the night. With afterhours 'occupied' temperatures ranging from 72°F to 76°F, with only slight setbacks of down to only 68°F to 71°F. Some spaces were observed to have higher weekend temperatures which could indicate some nominal amount of weekend cooling setbacks.

It was also observed in the data logs that no outside air control using occupancy or CO2 levels to adjust the outside air flows is being done. This makes sense given the existence of no CO2 monitors or occupancy sensors on the system.

These low CO2 readings may in part be due to lower occupancy levels during COVID, but the data loggers identify relationships between temperature and humidity that are typical for a lack of outside air modulation of any kind. So, at no time is the system reducing levels of outside air which can in turn reduce the need for heating and/or cooling energy for the building. Plus, regardless of the lack of CO2 monitoring to use as inputs to drive minimum outside air flows the existing system is also not shutting down outside air flows at night or on weekends when no or the very minimum of fresh air is needed.

All these inadequacies lead to inconsistent operations and missing abilities to include optimization strategies in the overall facility operations. And as currently configured, not allowing the operator to effectively monitor and manage the HVAC system in an energy-efficient manner, by utilizing more up-to-date energy savings strategies, which leads to increased energy use.

5.1.2 PROPOSED MEASURE DESCRIPTION

Replacing the existing user interface and supervisory controller as well as replacing the existing TU box and RTU controllers will provide much more energy-efficient building control. Including the implementation of more aggressive unoccupied temperature setback regimes, CO2 monitoring and outside air control, and improved zone temperature monitoring and control all of which is to be implemented under this EEM. This latter option will be done via the addition of accurate DDC-based new TU outlet temperature sensors, and connection to existing electric resistance start-stop relays.

With the implementation of these measures, the building operation will be improved in several ways:

a. With improved feedback of space conditions and actual 'firm' control of the HVAC system components with much better schedule implementation, temperature sensing and modulation, and provide outside air supplies to better match the varying needs all allowing the terminal unit operations to provide feedback which will be used to implement RTU supply air reset strategies, implementing occupied/unoccupied temperature setback regimes in the various spaces in the building, all of which will reduce heating/cooling energy use of the building.
    i. Setback temperatures will aim towards 60°F during the heating season and 82°F in the cooling season.
        - These setback temperatures are to be automatically adjusted upwards (and downwards) to partial setback levels (65°F heating and 78°F colling) when the coldest days (below 22°F to 25°F) and warmest days (above 93°F to 95°F) occur to allow both freeze protection, and assurance for the staff that occupants will be comfortable upon arrival to the spaces regardless of the outdoor conditions. These coldest/warmest days modified unoccupied setback strategies will eliminate the need for the operations staff to be tempted to override the system for the 'just in case' situation, and then potentially leave this override in place over time.
    ii. Optimal start/stop routines will be implemented shifting some to the electric reheat back up to the rooftop units for morning warmup. This sequence allows for a more aggressive unoccupied setback strategy to be implemented, so the HVAC system will have warmed up (cooled down) the building before occupants arrive without starting/stopping earlier/later than needed.
    iii. The use of occupant override buttons (minimum of two per floor) in select spaces is to be implemented based on the needs in some areas to accommodate periodic, sporadic non-schedulable after-hours or weekends use (control contractor/owner/tenant discussions will be needed to determine the most convenient/useful locations for this capability).
b. The new control system will allow for tighter room temperature to setpoint deviations based on more accurate sensors, and more accurate damper positioning, driven by up-to-date PID loop control around established setpoints. Thus, reducing wasteful and uncomfortable overshoot and undershooting of setpoints.
c. The outside air control will be improved by installing a minimum of four (4) CO_2 sensors per floor "strategically placed" to help determine when the spaces may need more or less outside, fresh air.
    i. A detailed follow-up area by area, conference room, and other higher-density occupant locations configuration layout review will need to be done by the contractor during the design process to accomplish this objective. The objective is to pinpoint the most beneficial locations. Strategically placed CO_2 sensors will be areas that are anticipated to have groups of people gathering /greater occupant densities) to monitor, assess and maintain proper CO_2 and outside air levels. The CO_2 levels will aim for readings of a maximum of 800-850 ppm range on a steady basis). Along with a complete shutdown of outside airflow during unoccupied periods except as required for Labs and other special afterhours occupancy needs.
d. It should be noted that these strategies will need to be put in place with setpoint and other input parameter flexibility. So that during the system checkout process and over the coming months/year or so of system shakeout, either the operations team or the DDC contractor technicians can adjust/fine-tune or optimize this approach without having to re-program the sequence of operation setup.

d. With all control system upgrades, a nominal review of the building air balancing (re-balancing) may be needed to ensure proper airflow regimes are re-established and maintained during occupied and unoccupied timeframes. This based on occupant feedback and past balancing studies and prior setup/re-setup documentation and data available. This is anticipated and scoped in this EEM to at most be only a 'partial' or specific areas rebalancing effort vs a whole building re-balancing. Aimed primarily to reflect changes from the original design/previous balancing efforts in just certain spaces due to new walls breaking up spaces, desks placed directly under diffusers or new internal gains added to spaces over time. In addition, the normal DDC contractor QC checkout processes may identify improperly operating reheat coils, dampers or other mechanical system components which will/amy need to be addressed before the full benefits of this upgrade can be obtained. These sorts of identified repaired elements are considered to be outside this upgrade scope budget, since sorts of repairs are not a cost line item under consideration for this energy study. These types of costs are more overall building maintenance cost elements which will need to be addressed.

Performance or Operating Parameters of the Equipment	Model Input Pathway	Baseline Condition	Proposed Condition
Occupied Temperature	Temperature controls	Cooling SP: 72 °F	Cooling SP: 72°F
		Heating SP: 72 °F	Heating SP: 72°F
Night time Temperature Setback	Temperature controls	Cooling SP: 74 °F (Some spaces have higher setbacks so modeled some of them at 78F)	Cooling SP: 84°F in building setpoint and 84°F used in modeling to account for excess outside air temperature reset strategies as well as for other reasons as explained in the TAS report.
		Heating SP: 70 °F (Some spaces have lower setbacks so modeled some of them at 67F)	Heating SP: 60°F in building setpoint and 62°F used in modeling to account for excess outside air temperature reset strategies as well as for other reasons as explained in the TAS report.
Economizer	Economizer inputs	Max 60°F - Min 60°F	Max 70°F - Min 55°F
Outside air control	Outside air control for occupancy is not currently being utilized.	40 cfm/person Outside air flows are based on fixed design settings (except during economizer operating modes).	35 cfm/person Additional CO2 monitoring in higher density areas and allow for tighter lower levels of outside airflow control to establish a maximum range of 800-850 ppm – the minimum CO2 levels will range from 400 to 500 ppm during no/low populated/occupied times based on naturally occurring background CO2 levels without people's breathing influencing the CO2 levels. With more CO2 sensors, mainly located in potentially higher density areas, damper positions can close off more of the time and entirely during unoccupied periods and operate as low as needed to maintain the above target CO2 levels.
Fan Operation and Optimal Start/Stop	Fan operation hours	Typical: 24/7 operation The hours are adjusted to replicate the erratic behavior of energy use in different months. Extended or always on during colder months	Optimal start/stop control to be implemented. Based on extended at at time less predictable extneded building operations to account for student/staff needs for certain areas, this was modeled as 3 hours before and 2 hours after normal operating hours. This optimal controls will increase morning gas warmup and decrease electric reheat usage. (Sundays off and Saturdays with reduced schedule of 10 AM to 2 PM to account for partial occupancy)

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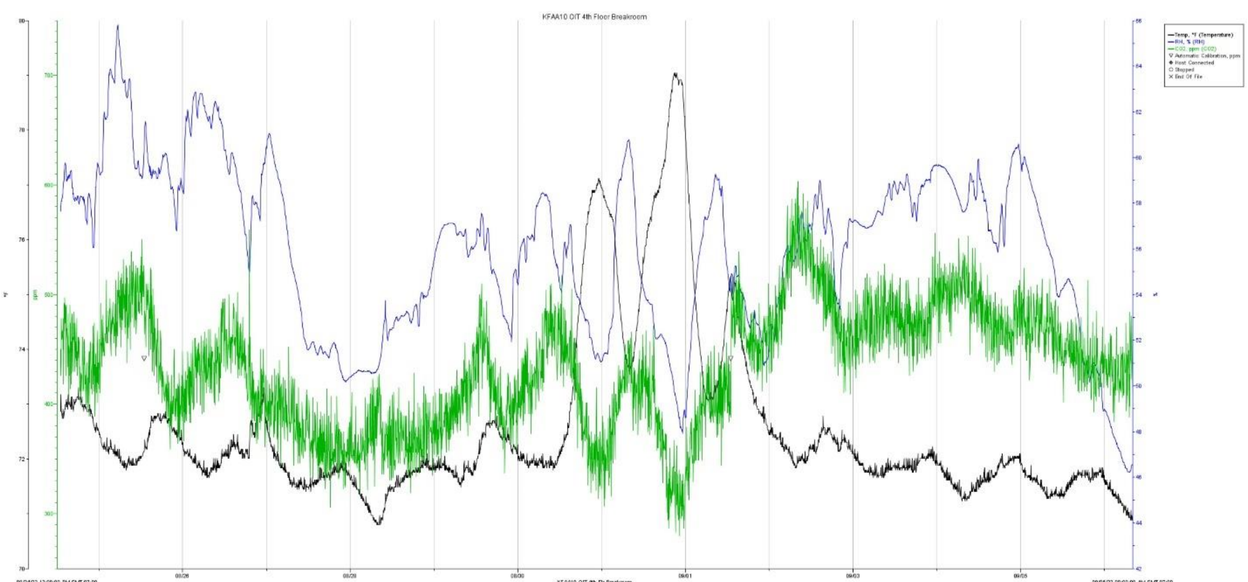
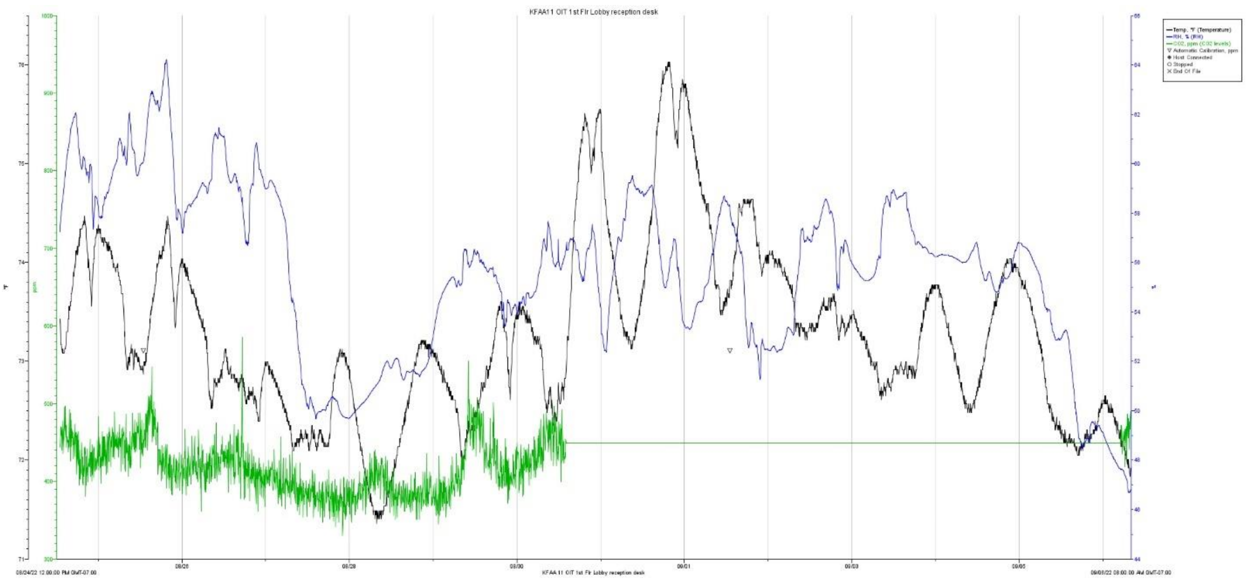
5.1.3 SAVINGS METHODOLOGY

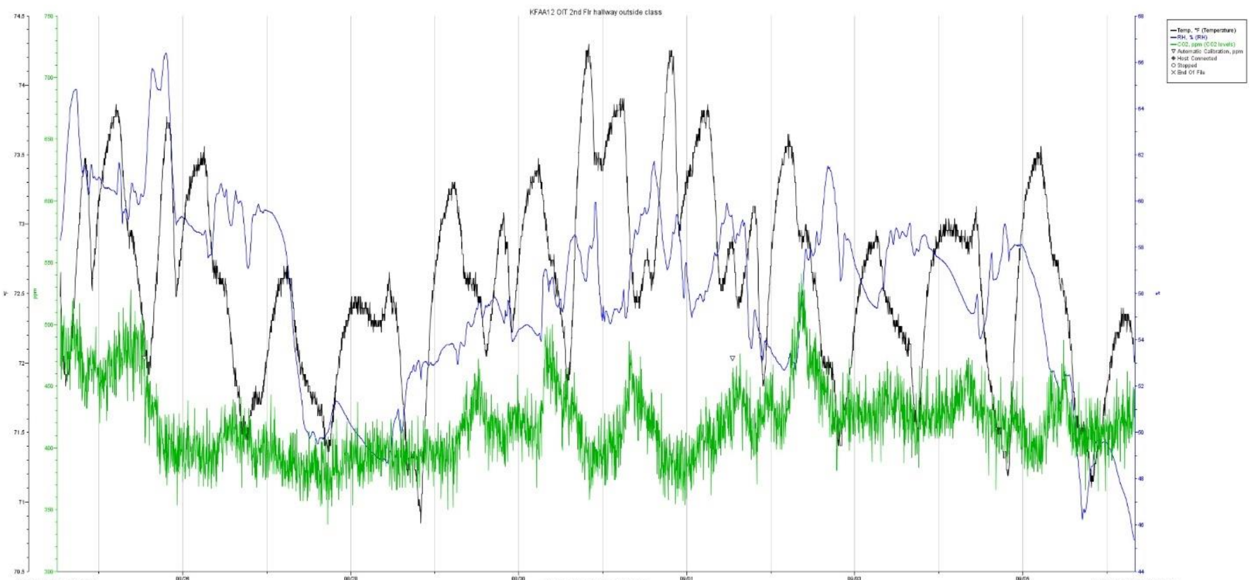
EEM savings were calculated by making appropriate adjustments to the temperature setpoints, setbacks, fan schedule operation, and outside air flow rate via the eQuest model to reflect the improvements mentioned. Data logging was installed in the building for two weeks to obtain HVAC operations details for insertion into the report. In addition, two-building walkthroughs were performed to obtain building operational inputs into this modeling process. Finally, the model was manipulated to reflect the actual building operations as close as possible given the constraints of the models and their limitations.

<u>Data logs that are referenced in the above are included on the following pages.</u>

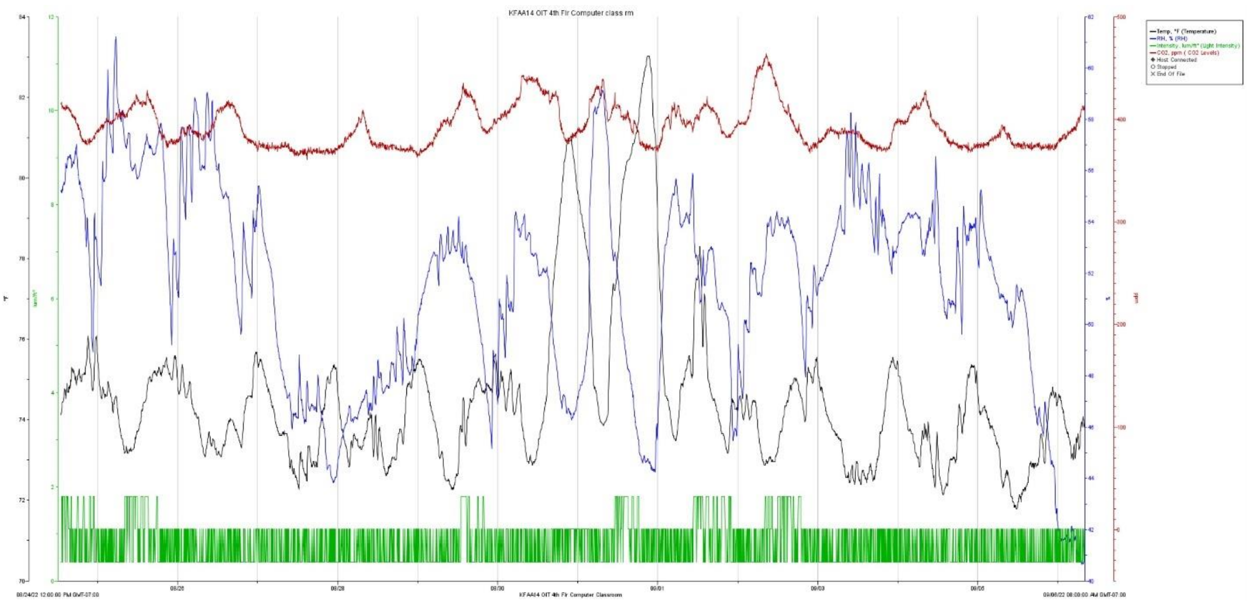
The first three logs, are quite similar to each other on how the spaces are being controlled, show that the HVAC system has pretty consistent temperatures which go up to 72-74F, and has moderate setbacks in 68-70F with some days occupying temperatures starting way before occupancy. Weekends do have some nominal setbacks which have been adjusted in the model via adjusting some spaces with higher setbacks. Inconsistent correlation between RH and temperature indicates inconsistent outside air control, i.e., not driven by any particular HVAC need other than perhaps economizer operation during some parts of the year. The CO2 levels also are consistently lower which indicates overventilation.




KFAA11 OIT 1st Flr Lobby reception desk
Temp, °F (Temperature)
RH, % (RH)
CO2, ppm (CO2 levels)
Automatic Calibration, ppm
Host Connected
Stopped
End Of File
08/24/22 12:00:00 PM GMT-07:00
09/05/22 08:00:00 AM GMT-07:00


KFAA12 OIT 2nd Flr hallway outside class
Temp, °F (Temperature)
RH, % (RH)
CO2, ppm (CO2 levels)
Automatic Calibration, ppm
Host Connected
Stopped
End Of File
08/24/22 12:00:00 PM GMT-07:00
09/05/22 08:00:00 AM GMT-07:00

The following data log shows similar inconsistent operational patterns like those above but generally. With more varied temperatures observed indicate that some spaces are indeed better controlled while some spaces are not well controlled at all. However, consistently, the HVAC control system is always maintaining occupied temperatures with little to no unoccupied setbacks.



5.1.4 NON-ENERGY SAVINGS ESTIMATES

This measure will improve occupant comfort and improve energy usage through the strategies identified. In addition, this system upgrade will reduce overall HVAC system management and maintenance time costs.

This upgrade will allow the operations team to access the system quickly and easily to investigate/troubleshoot issues from the facility lead's office desktop, or handheld devices wirelessly while around the facility or for the HVAC service team while on or off-site. Or the system can be accessed from any PC allowed by the facility management team via the web-enabled user interface. This will save troubleshooting time currently spent driving to the building by these off-site management functions. None of these non-energy savings benefits in management or maintenance time have been included in this cost-benefit analysis, however, they are benefits.

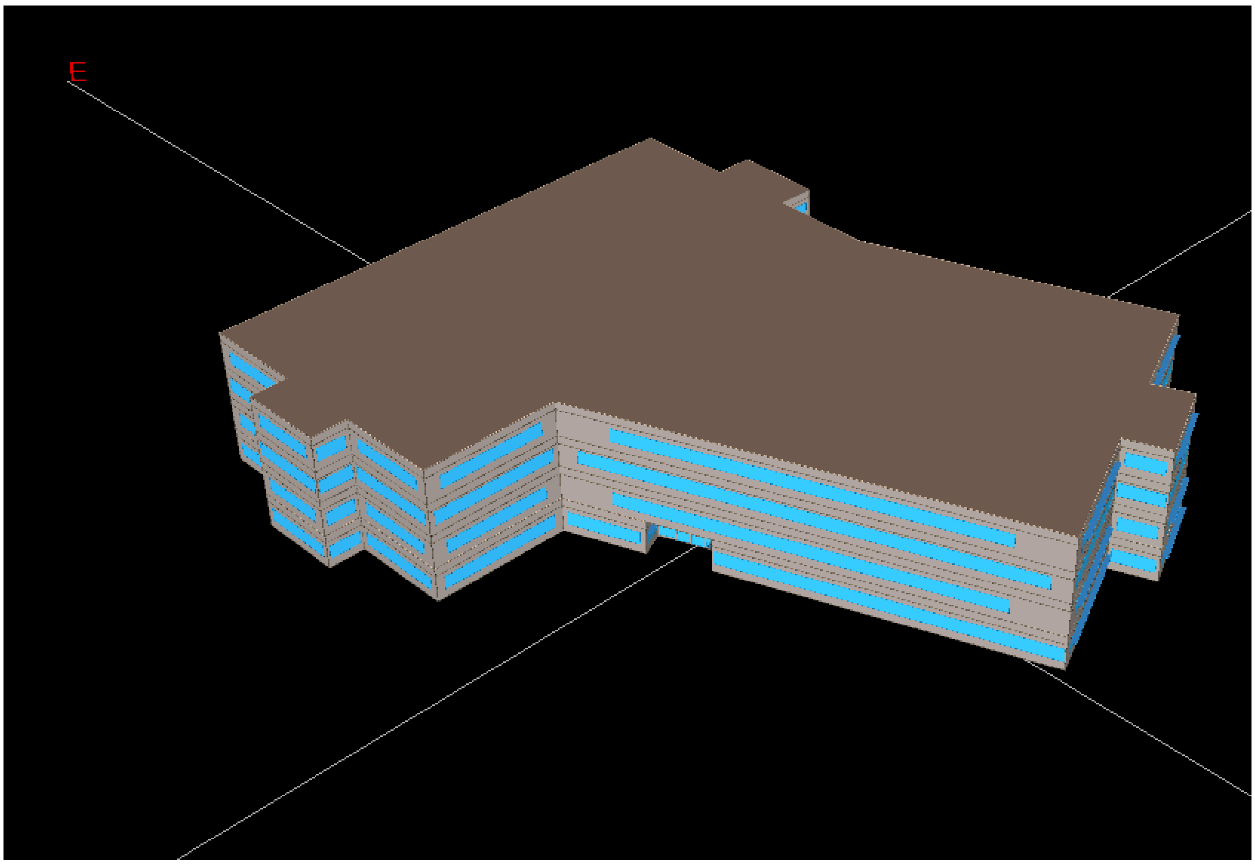
EEM 1 - Estimated Savings, Cost & Incentive summary		
Annual Energy Usage & Savings estimate	Baseline Electric Usage (kWh)	2,480,700
	Proposed Electric Usage (kWh)	1,694,500
	Electric Savings (kWh)	786,200
	Electric Cost Savings ($)	61,245
	Baseline Natural Gas Usage (therms)	3,300
	Proposed Natural Gas Usage (therms)	4,345
	Natural Gas Savings (therms)	(1,044)
	Natural Gas Cost Savings ($)	(981)
	Annual Energy Cost Savings ($)	60,264
	Annual Non-Energy Savings ($)	-
Measure Cost & Incentives	Program Eligibility Cost[1]	386,696
	Project Cost without incentive[2]	386,696
	Estimated Energy Trust Incentives ($)	170,875
	Project Cost with Incentive	215,821

1. Estimated Project Cost includes all costs the participant would incur towards the proposed measure such as equipment, labor, permitting, shipping, and all applicable costs.

6 Calculation Methodology Description

6.1 Calculation Software

A CAD model of the building was developed and inserted into the eQuest model *v3.65 build 7175.* along with building construction and energy data, including building construction materials, architectural dimensions, and geometry.



All these inputs as well as details from the data log observations, control/mechanical service technician feedback, as well as the lead facility person's input, was inserted into the model, so we were able to develop an accurate energy simulation compared with the billing data from the last 3 years provided by the ETO (both electric and natural gas consumption). The simulation model was iteratively calibrated (see below) around these various inputs. The EEM savings were calculated by modifying the wizard inputs using the EEM wizard. A TMY3 weather file " USA_OR_Portland.Intl.AP.726980_TMY3.BIN" was used for the project.

6.2 Energy Model Calibration

Month	Electric Use (kWh)			Natural Gas Use (therms)		
	Baseline/ Billed	Model	% Deviation	Baseline/ Billed	Model	% Deviation
January	245,025	262,200	7%	277	375	26%
February	241,125	211,000	-14%	483	320	-51%
March	209,500	211,800	1%	419	354	-18%
April	193,650	180,600	-7%	396	316	-25%
May	199,350	181,200	-10%	303	303	0%
June	190,000	199,900	5%	233	299	22%
July	196,600	194,500	-1%	168	126	-33%
August	193,600	205,000	6%	133	135	1%
September	178,900	170,900	-5%	297	125	-137%
October	185,200	174,200	-6%	163	265	39%
November	224,700	209,000	-8%	268	312	14%
December	248,500	280,400	11%	132	370	64%
Total	**2,506,150**	**2,480,700**	**-1%**	**3,272**	**3,300**	**1%**

DDC Upgrade														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Baseline Modeled kwh	262,200	211,000	211,800	180,600	181,200	199,900	194,500	205,000	170,900	174,200	209,000	280,400		2,480,700
Modeled Saved kwh	107,500	79,400	64,600	47,200	48,100	47,100	54,600	53,000	43,700	49,000	75,500	116,500		786,200
														31.7%
Baseline Modeled Therms	375	320	354	316	303	299	126	135	125	265	312	370		3,300
Modeled Saved Therms	(69)	(81)	(112)	(117)	(110)	(92)	(53)	(70)	(67)	(110)	(76)	(90)		(1,044)
														-31.6%
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**		
Electric Data Drop from Equest	**154.7**	**131.6**	**147.2**	**133.4**	**133.1**	**152.8**	**139.9**	**152.0**	**127.2**	**125.2**	**133.5**	**163.9**		1,694.50
N Gas Data Drop from Equest	**44.36**	**40.07**	**46.64**	**43.25**	**41.25**	**39.08**	**17.90**	**20.47**	**19.19**	**37.51**	**38.75**	**46.00**		434.5
													E MBTU	2682.5
													NG MBTU	-104.4
						38.20 new EUI after after above EEM Upgrade								

7 Lighting and Solar Opportunities

This facility has LED lights predominately throughout so has already mostly been upgraded to the most current technologies.

In addition, this building is a viable candidate for solar with approximately most of its roof in full sun throughout the day with no shading from adjacent buildings, trees, or equipment. Architectural walls surrounding the three primary HVAC RTUs can create some shading as well as exhaust fans and server focused smaller cooling unit condensers do take up some of the potential solar application locations.

8 Next Steps for the Participant

8.1 Apply for Energy Trust Incentives for Recommended EEMs

8.1.1.1 OBTAIN BIDS FOR EEM(S) YOU WISH TO IMPLEMENT AND SIGN THE INCENTIVE APPLICATION

- The participant will evaluate the recommended EEMs contained in the TAS and estimated incentives in the accompanying 110C and select the EEMs they wish to implement.
- The participant must obtain bids from contractors for the EEM(s) they wish to implement and send a copy of the final bid to the Energy Advisor.
- The PMC will review the contractor's proposed scope and costs to determine compliance with Existing Building program requirements, alignment with the EEMs as described in this TAS, and ensure that the EEMs still meet the cost-effectiveness criteria.
- If the bids are found satisfactory and subject to Existing Buildings program requirements in effect at that time and incentive budget availability, PMC may issue Form 120C (or 320C) - Incentive Offer form for participant review and signature. This offer to reserve incentives will detail the approved measures and estimated incentives that the participant is applying to receive, as well as Energy Trust's terms and conditions for Existing Buildings program incentives, including any per-site, per-year limits.
- To apply for a reservation of Energy Trust custom incentives, the customer must return the signed Incentive Offer to the PMC by the submittal deadline listed in the Incentive Offer application and **BEFORE** issuing purchase orders or beginning the project work. If the participant moves forward with purchase orders or installation before signing and returning the Incentive Offer application, the measures will no longer be eligible for Energy Trust incentives.

Notify TRC upon Installation of EEM(s) and Submit Completion Documentation

- The participant must notify the PMC once the installation of EEMs is completed along with final invoices before the project's incentive reservation expiration date which will be included in the Incentive Offer.
- A post-installation verification of the installed EEMs could be required.
- All required documentation must be provided to the PMC and post-installation verifications (if required) must be completed before incentive payments can be issued.

8.2 Apply for Energy Trust Solar Incentives

Please review the details of any solar opportunities, if included in this report. If you wish to find out more, please fill out Energy Trust's solar interest form included here - https://energytrust.org/solar-request-analysis-bid/. Energy Trust will match you with qualified solar Trade Ally contractors in your area. The solar Trade Allies will help you assess your rooftop or property potential for solar power, provide a bid with estimated incentives, tax credits, annual solar power generation, and utility cost savings information, and answer any questions you may have.

9 Appendix A – EUL Reference

SB 1149 Appendix A is the default reference used for technology EULs. If a technology is more accurately captured by a different EUL source, the alternative source may be cited.

Equipment/Measure	(Years)
Building Envelope	
Double glazed windows (complete units)	30
Retrofit double glazing	20
Triple glazed windows (complete units)	30
Adding storm windows	15
Solar shade films	12
Insulated metal doors	20
Cavity insulation (wall, floor or ceiling)	30
Reduction of window or door area	30
Rigid roof deck insulation	25
Caulking, weather stripping & sealing	10
Exterior door self closers	5
HVAC Components	
Boilers	30
Boiler burners	20
Boiler tune-up optimization	5
Replacement steam traps	6
Ground source heat pump systems	25
Rooftop gas/oil pkgd units	15
Fans, central	25
Air conditioner, rooftop/split	15
Air-to-air packaged heat pumps	15
Water-to-air packaged heat pumps	15
Variable Refrigerant Flow / Ductless Heat Pump	15
Coils, DX, water or steam	25
Radiant/unit heaters, all types	20
Thermostatic valve	15
Furnaces, gas/oil	20
Chillers, reciprocating	25
Chillers, centrifugal & absorption	30
Cooling towers	25
Heat Recovery Systems	20
Heat Exchangers	25
Damper systems & VAV conversions	20
Low leak dampers	15
Air economizers	15
Automatic boiler flue dampers	15
Ductwork & Piping (new)	30
Duct and pipe insulation/sealing	15
Valve and damper actuators, Valves	15

Equipment/Measure	(Years)
HVAC Controls	
DDC systems	15
Local controls: timers, prog. thermostats	15
CO_2, auto faucet or other sensors	10
Pumps, Motors & Drives	
Pumps, base mounted	25
Pumps, inline	20
Premium efficiency motors	25
Variable frequency drives	20
Domestic Hot Water	
Heat pump water heaters	15
Gas or propane water heaters	20
Solar water heaters	15
Faucet flow restrictors, aerators	10
Lighting	
Lighting fixtures, non-LED	25
LED lighting fixtures (integrated)	20
Lighting fixture rebuild kits [a]	20
T-LED lamps and retrofits [c]	15
Exterior LEDs	18
Field/Stadium LEDs	25
Electronic ballasts	15
Dimming systems	12
Occupancy sensors	10
Lighting control systems (electronic)	15
Linear fluorescent fixture de-lamping [b]	9
Reduced wattage linear fluorescent lamps [c]	9
Screw-in replacement CFL lamps	5
Screw-in replacement LED lamps	12
Kitchen Equipment	
Refrigeration system upgrades	15
Walk-in fan EC motors	15
Reach-in refrigerators/freezers	18
Ice machines	10
Walk-in door self-closers	10
Kitchen cooking equipment	25
Kitchen hood fan VFD and control	18
Other Measures	
Pool covers	10
Solar PV systems	25
Retro-commissioning	5
Vending machine controls	10
Computer power management controls	5