Clackamas Community College

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MEP Facility Condition Assessment and Master Planning Project Narrative

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TABLE OF CONTENTS

Executive Summary

Clackamas Community College Oregon City Campus, originally built in 1966, is located on 165 acres and is a pinnacle of higher education in Oregon City, Oregon just 20 minutes south of Portland. Many of the existing buildings on the campus contain the original infrastructure relative to the year that they were constructed; some of which are more than 50 years old. Mazzetti along with the Clackamas Community College Team identified 17 specific buildings to be included as part of this Facility Condition Assessment and Master Planning Project. Buildings not part of this work included Harmony East and West, the Wilsonville Campus, the Holden Industrial Technology Center, the DeJardin Science Addition, Pauling C, Barlow B and C, the Wacheno Welcome Center, Lewelling, and the Environmental Learning Center's Pavilion and Lakeside Hall. These buildings are either newer to the college inventory or are smaller in nature and were not included in this work.

The Master Plan work project included three phases.

1. **Facility Condition Assessment** – A process where the team visually inspected, evaluated, and analyzed the existing MEP infrastructure components to understand the configurations, conditions, and rate them based on a set scoring criteria. A cost analysis was completed based on like-for-like replacement. All collected information was input into a web-based software developed by Mazzetti called M+Assessment.

2. **Energy Analysis** – An energy analysis was completed for ten of the older buildings identified by the CCC Team. The Department of Energy's eQuest software was used to build an energy model of each of the ten buildings using as-built drawings and site investigation findings. The models were then calibrated to the existing utility bill information to give accurate baseline models. Energy Conservation Measures (ECM's) were then studied with the energy models along with cost information to provide recommended alternate designs over the like-for-like replacements outlined in the FCA.

3. **MEP Master Planning** – Using the results from the FCA and Energy Analysis phases, recommendations and associated cost were established. It was found that for these 17 buildings much of the equipment needed replacement with needs ranging from immediately to within the next 15 years. The recommendations from the analysis can be found in the table below.

Building	FCA Costs	Additional Costs for Recommended ECM's	FCA + Recommended ECM Costs	Annual Energy/ Operating Cost Savings	ROI from Additional Recommended ECM Costs
Barlow Building A	$8,556,200	$739,100	$9,295,300	$45,700	16.2
Bill Brod	$4,795,809	$427,600	$5,223,409	$25,600	16.7
McLoughlin	$3,614,961	$729,300	$4,344,261	$34,000	21.5
Pauling A&B	$1,331,860	$251,600	$1,583,460	$12,900	19.5

Building	FCA Costs	Additional Costs for Recommended ECM's	FCA + Recommended ECM Costs	Annual Energy/ Operating Cost Savings	ROI from Additional Recommended ECM Costs
Randall Hall	$3,383,800	$853,000	$4,236,800	$42,400	20.1
Clairmont Hall	$2,985,072	$298,100	$3,283,172	$18,000	16.6
Dye Learning	$1,505,900	$423,600	$1,929,500	$21,200	20.0
Niemeyer	$2,269,353	$642,300	$2,911,653	$38,500	16.7
Roger Rook	$813,380	$434,300	$1,247,680	$18,600	23.3
Streeter Hall	$1,032,146	$235,000	$1,267,146	$17,800	13.2
Arts Center	$595,319	-	$595,319	-	-
DeJardin	$665,264	-	$665,264	-	-
Gregory Forum	$1,076,162	-	$1,076,162	-	-
Streeter Annex	$310,323	-	$310,323	-	-
Training Center A	$1,382,798	-	$1,382,798	-	-
Training Center B	$778,418	-	$778,418	-	-
Barlow CUP	$4,346,800	-	$4,346,800	-	-
TOTAL	**$39,502,838**	**$9,812,266**	**$49,315,104**	**$290,770**	**18.3**

The findings show that the college has $39.5 million in mechanical, electrical and plumbing like-for-like replacement 2022 costs for the buildings reviewed in the FCA. To add ECM's to gain energy efficiencies identified would add $9.8 million to this cost for a total of $49.3 million. Calculating the energy savings associated with the ECM's, an annual savings of $290,770 would be realized with a rate of return at 18.3 years.

Decentralization from the central utility plant (CUP) was also analyzed as an element of the energy conservation measures. Decentralization will replace the central heating and cooling systems with dedicated heating and colling systems installed at each building. Maintaining the aging CUP with the steam boilers, chillers and all underground piping systems carries a high cost, therefore having smaller dedicated systems at each building is preferred by the college. There would also be energy savings associated with this option by not needing to run a large chiller if only one building is occupied and by using high efficiency condensing hot water boilers instead of steam boilers. The decentralization analysis shows that the cost to decentralize (adding dedicated cooling and heating systems at each building) is approximately equal to retaining the CUP (replacing the aging CUP equipment) at $4,346,800. There would also be an estimated $30,000 savings per year in energy costs associated with decentralization.

Glossary

AHU – Air Handling Unit

BMS – Building Management System

CAV – Constant Air Volume

CCC – Clackamas Community College (also known as Clackamas)

CHW – Chilled Water

DDC – Direct Digital Controls

DOAS – Dedicated Outside Air System

DX – Direct Expansion (type of cooling)

EA – Energy Analysis

ECM – Energy Cost Measure

FCA – Facility Condition Assessment

HHW – Heating Hot Water

HVAC – Heating, Ventilation, and Air Conditioning

MEP – Mechanical, Electrical, Plumbing (and Fire Protection where applicable)

PV – Photovoltaics

ROM – Rough order of Magnitude

RTU – Rooftop Unit

S.F. – Square Foot

VAV – Variable Air Volume

VRF – Variable Refrigerant Flow (type of HVAC system)

Introduction

Overview

Clackamas Community College Oregon City Campus, originally built in 1966, is located on 165 acres and is a pinnacle of higher education in Oregon City, Oregon just 20 minutes south of Portland. The campus contains 22 buildings that serve many functions varying from classrooms, office/administrative spaces, laboratories, training centers, automotive shops, gymnasiums, support services and other miscellaneous uses. Many of the existing buildings on the campus contain the original infrastructure relative to the year that they were constructed.

Mazzetti along with the Clackamas Community College Team identified 17 specific buildings to be included as part of the Facility Condition Assessment and Master Planning Project. The selections were based on building age, infrastructure conditions, and current energy performance.

The project included the following three phases.

- Facility Condition Assessment (FCA)
- Energy Analysis
- MEP Master Planning

1. Facility Condition Assessment (FCA)

FCA Process

The FCA began with the Design Team assembling and reviewing available building as-builts/record documents. The as-builts allowed the team to obtain an understanding of the existing building systems and allowed the team to create a workplan for collecting the data.

Working with the college, the Mazzetti team developed six categories that each piece of equipment/system was evaluated and scored.

- **Fire Life Safety**: How does the installation, condition, operation affect overall Fire Life Safety?
- **Code/Regulatory**: Does the installation, condition, and operation comply with current codes and regulations?
- **Condition**: Does the current condition affect service and performance?
- **Capacity**: Does the equipment maintain adequate capacity to meet current and possible future use?
- **Sustainability**: Does the equipment comply with current energy/sustainability goals of the owner?
- **Resiliency**: What is the ability to find parts availability should the equipment fail.

Each of these categories were rated on a scale of 1 to 5, where 5 indicates the equipment is in great condition. A weighed average of these scores was created to provide a unique score for each piece of equipment. There was a default set for Fire Life Safety, Code/Regulatory, and Condition for all equipment such that if either of these categories is rated a score 1 or 2, the weighted average will default to the lowest of either of these four as the three of these categories are critical to the operation of the college. See Appendix B – Scoring Criteria.

Prioritizing Projects and Budgets:

To identify project priority of projects for planning and budgeting purposes the team elected for the following three definitions:

- Immediate to 5-year projects: These projects have a weighted score ranging from 0 to 3.5. These projects represent an urgent need to make corrections. These components/systems are critical to the facilities operation, or it is defined as a life safety hazard, in which case, that particular asset would be identified as immediate regardless of the scoring.
- Projects to be implemented within 5 to 10 years: These projects have a weighted score ranging from greater than 3.5 but less than 4.2. These components/systems are near the end of their useful life/are critical to the operation of the facility.

- Projects to be implemented within 10 to 15 years: These systems are within 10 years of their useful life and functional/are not critical to the operation of the facility, or these systems were generally in good condition even though they were close to end of useful life.

Pricing:

All pricing was prepared by Mazzetti through trade partners and adjusted for inflation, soft costs, and engineering adjustments that needed to be made for systems selections. These costs are to be used for rough order of magnitude (ROM) planning purposes only and not for exact construction amounts. The information was based on local historical data for projects with similar scope. The team attempted to create basic replacement scopes for each type of equipment that was similar in function without knowing exactly how the replacements would occur or the codes/regulations at the time of the replacement. To the best of the team's ability if replacement of equipment required a temporary unit, the cost is included in the budgeted number.

M+ Assessment

The Design Team utilized an application created by Mazzetti called M+Assessment. M+Assessment allows for the collection of data for assets, rating the equipment based on six categories, and pricing allowing for future planning and budgeting.

M+Assessment is a cloud-based software solution that can be used on any iPhone, Android, tablet and computer. This app provides dynamic solutions and flexibility for the user. The user has the ability to instantaneously create project budgets and lists by simple searches that are exportable in Excel format.

The software provides the most recent updated information any time the user signs in. It is a living document where data inputs such as escalation can be edited and automatically updates through all assets. As projects are completed, the user must update information within the software.

17 Buildings Analyzed

Buildings		
1. Barlow Central Utility Plant	7. Clairmont Hall	13. DeJardin Hall (original)
2. Barlow Building A	8. Dye Learning	14. Gregory Forum
3. Bill Brod Community Center	9. Niemeyer	15. Streeter Annex
4. McLoughlin Hall	10. Roger Rook Hall	16. Training Center A
5. Pauling A&B	11. Streeter Hall	17. Training Center B
6. Randall Hall	12. Arts Center	

Table 1 - Building's Analyzed

The focus of the study included only the Oregon City Campus buildings and renovations that were not part of the 2014 Bond improvements. Therefore, buildings not part of this work included Harmony East and West, the Wilsonville Campus, the Holden Industrial Technology Center, the DeJardin Science Addition, Pauling C, Barlow B and C, and the Wacheno Welcome Center. Smaller facilities were also left out of the study, including Lewelling, the maintenance building, and the Environmental Learning Center's Pavilion and Lakeside Hall.

1. Central Utility Plant (Barlow CUP)

CUP (Central Utility Plant) Building Overall:

The Central Utility Plant (CUP) building is a 39,200 S.F., two level building residing in the northwest portion of the Barlow Hall Building. The building and equipment was built in 1970. The main utilities for the campus are served from the CUP equipment and tunnel system and include services out to the following buildings: Barlow Hall, Randall Hall, Mcloughlin Hall, Bill Bod Community Center, Pauling A/B/C, and Niemeyer. These services include steam condensate return, chilled water, domestic water, electrical power, natural gas, and data.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Cooling Systems:

The main chilled water system is served by a McQuay 700-Ton, water-cooled, centrifugal chiller (CH-1) that was installed in 1995 and had its entire control system replaced in 2022. This chiller is located on level 1 of the chiller room. A primary chilled water pump (PCHWP-1), located on level 2 with 1,600 gpm and 25' of head, serves the primary chilled water loop that is piped through the mechanical room and into the utility tunnels. There is an expansion tank (ET-2), also located on level 2 next to PCHWP-1. Barlow's Secondary Chilled Water Pump (SCHWP-01), on level 2 of the central plant, is directly piped to Barlow Hall serving the cooling coils in AHU's in the building. Other buildings served chilled water from the CUP have individual Secondary Chilled Water Pumps serving building cooling coils and air handlers from their service starting location in the tunnels. Details of these are under the applicable sections of each building.

The cooling tower (CT-01) is a concrete, built-up, induced draft cooling tower located outside to the north of the central plant. The condenser water piping is routed from the tunnel to the central plant. The condenser water pump (CWP-01), the chemical treatment filter pump (CWP-02), and the pool pump (PP-01) are all located in the utility tunnel in the central plant area. The chemical treatment skid (CTS-01) is located adjacent to the chiller on level 1 of the central plant.

Heating Systems:

The main steam heating system is served by two Burnham, fire-tube, 350 HP Boilers (B-01 and B-02). These boilers produce steam at 15 psi, which is routed to either AHU preheat coils or heat exchangers that serve hot water (heating hot water and domestic hot water) throughout the campus. The condensate from this is then collected and transferred through the utility tunnel back to the central plant to the deaerator (D-01) located on level 2. A condensate receiver (CP-01) collects condensate from the traps and boiler in the tunnel.

There is a secondary heating hot water system in the central plant that serves Barlow Hall. The heat exchanger (HX-01), heating hot water pump (HHWP-01), expansion tank (ET-01), and condensate receiver (CP-02) on level 2 of the central plant that is directly piped that serves the heating coils in AHU's or reheat coils in terminal units.

There are also secondary heating hot water system steam heat exchangers located in the utility tunnels that serve individual buildings served by the CUP. Details of these are under the applicable sections of each building.

Mechanical HVAC:

The following are located on a platform above the office:

- A packaged outdoor air handling unit (AC-01) that serves the plant office area,
- A heat pump mini split (AC-02) with the FCU in the office wall
- A decommissioned steam humidifier (H-01)
- Two condensing units that serve the data center (CU-01 and CU-02).

In addition, there is a packaged window unit (AC-03) that serves the hotel-office space and the wall pack air conditioner (AC-04) that serves the electrical room. An exhaust fan (E-01) serves the air compressor room.

2. Barlow Building A (Main Building)

Barlow Building Overall:

The Barlow Hall Building (built in 1970) is a 52,000 s.f., two level building that consists of three distinct building separations and the central plant. The three separations are the Barlow A, B and C Buildings. Barlow A (including an addition) houses administrative offices, IT and classrooms. The 1st level of the Barlow B (north wing) serves the Auto Collision Repair shop and the 2nd level offices and classrooms. Barlow C (south wing) is Auto Service shop and classroom. The main utilities for the building are served directly from the central plant adjacent to building A to the north for HVAC, water, and fire protection. This Masterplan only addresses Barlow A and the CUP as Barlow B and C were updated during the 2014 bond work. See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The HVAC systems are broken down into 3 separate scopes of work for this assessment. Barlow A is served by a built-up penthouse Dual Duct AHU. The Barlow A addition is served by an outdoor dual duct AHU and a HVU located on the roof. Barlow B 2nd floor is served by a VAV AHU on the roof of Barlow B.

For Barlow A, the Cold/Hot Deck AHU (AHU-01) is located in the built-up mechanical penthouse located on the roof. This serves the hot and cold deck supply ductwork which goes into a shaft directly underneath the AHU in the middle of the building. These have dual duct terminal boxes that modulate each damper to maintain temperature at the zone level. The built-up AHU has a (1) return plenum, (2) filter, (3) heating fan plenum, (4) heating fan, (5) relief plenum, (6) heating coil, (7) return/recirculated air, (8) outside air louver, (9) mixed air plenum, (10) cooling supply fan, (11) perforated plate, and (12) cooling coil.

The general exhaust fan (EF-01) is also located in the penthouse and serves the general exhaust for the toilets, janitor closets and other building pressurization exhaust.

On the roof of Barlow A is also a packaged rooftop unit (AC-01) that serves the data center. There is also a heat pump split condensing unit (AC-02) that serves additional building loads.

For the Barlow A Addition, the Cold/Hot Deck AHU (RTU-01) is located on the roof of that buildout. This serves the hot and cold deck supply ductwork which goes into a shaft directly underneath the AHU and serves levels 1 and 2. These have dual duct terminal boxes that modulate each damper to maintain temperature at the zone level. Also, the shop portion of level one is served by the heating/ventilation unit (RTU-02) that is located on the roof next to RTU-01. Both of these units are deteriorating, have antiquated controls, and are in bad overall condition.

There is not a dedicated exhaust fan for the Barlow A-Addition.

For the Barlow B level 2, the VAV AHU (AHU-04) is located on the roof of that buildout. This serves supply ductwork which is connected to the floor below the AHU. These have hot water

For the Barlow B level 2, the VAV AHU (AHU-04) is located on the roof of that buildout. This serves supply ductwork which is connected to the floor below the AHU. These have hot water terminal reheat boxes that modulate to maintain temperature at the zone level. This unit is deteriorating, has antiquated controls, and are in bad overall condition.

There is not a dedicated exhaust fan for the Barlow B level 2; however, there are relief hoods on this roof that serve level 2 for building pressurization relief.

Mechanical Piping:

The main steam piping and primary chilled water are served from the central utility plant to Building A mechanical penthouse for the dual duct AHU.

The Barlow A Addition has its own dedicated secondary chilled water pump (SCWHP-01) that is located in the tunnel. This then serves RTU-01 on that building.

The Barlow B AHU is a DX unit and does not have chilled water. However, there is hot water reheat that serves terminal boxes in the area from the heat exchanger in the central plant.

Electrical Systems:

Barlow Building serves as a point of electrical service distribution for the majority of the adjacent buildings as this is where the Medium Voltage primary service (PGE) feeders are being routed to. From here, individual feeders are being distributed to surrounding buildings.

Barlow specifically is equipped with a 5000A, 480V, 3-Phase, 4-Wire rated service, located in Boiler/Chiller Electrical Utility Entrance Room. Power is being distributed via a 9-Section Main Distribution Switchboard that serves Motor Control Center, Chillers, and various downstream sub-distribution boards and branch circuit panelboards at 480/277V and 208/120V.

Barlow Building is also equipped with a 150kW Diesel Generator that serves Telecommunication and other selected loads.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or loose on the wall.

The domestic water distribution is of galvanized steel construction. There is light corrosion & minor leaking occurring.

Existing hose-bibbs are not freeze-proof.

The drainage system is of cast-iron construction and has observed slow drainage & backups.

There is an air compressor serving the high school Auto shop.

The domestic hot water is being generated in a steam to domestic hot water exchanger with steam supplied by the central utility plant steam boilers as the primary domestic hot water source.

Fire Protection System(s):

The fire protection system is composed of empty fire hose cabinets with fire extinguishers.

There is also an out of date Halon system in the Data Center. The main controller of this system was replaced in 2022.

3. Bill Brod – Community Center

Bill Brod Community Center Overall:

The Bill Brod Community Center (built in 1975) is a 28,449 s.f., three level building that consists of a main level, mechanical penthouse, and basement. The main level houses the kitchen, cafeteria, conference rooms, Associated Student Government, and other student support offices. The basement houses electrical, mechanical and storage rooms. The main utilities for the building are served through the utility tunnel. The tunnel level is the same as the basement level.

Note: The basement level also houses mechanical equipment that serves the Wacheno Welcome Center. The Wacheno equipment is not part of this report.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The primary HVAC system is a built-up air handler in the Penthouse. Originally, the system consisted of two supply fans: SF-401 for the outside air/cold deck, and SF-402 for the return air/hot deck. In 1998 the system was modified to convert SF-402 from a supply fan to a return fan, thus providing an economizer mode. The air handler's current configuration consists of (1) supply fan, (2) return fan, (3) cooling coil, (4) filters, (5) return air duct, (6) return air damper, (7) outside air damper, (8) mixed air plenum, (9) relief damper, (10) return air shaft, (11) supply air plenum, (12) supply air duct, and (13) return air plenum. Heating is provided by hot water coils in the terminal units and fan powered boxes at the individual zones.

The building general exhaust fan (EF-401) serves the restrooms and portions of the kitchen area. Exhaust fan (EF-402 that serves the Food Serving Line. Both fans are located on the roof.

The kitchen hoods are served by two exhaust fan/makeup air unit pairings. Installed as part of the original construction in 1971, the combo serving the Kitchen Serving Line hood consists of supply fan (SF-403) that is an evaporative cooler located on the roof and Exhaust fan (EF-403) provides the exhaust. Heat is provided to this system by steam heating coil (HC-403). Currently the evaporative cooling and heating functions of this unit are non-functional. The Kitchen hood in the food preparation area is served by the combination exhaust fan and gas fired makeup air unit (RME-1) which was installed in 1993. Currently this unit has non-functioning gas heat.

Supply Fan (SF-404) provides transfer air from the basement/utility tunnel to the High Voltage Room.

The roof top package DX unit with gas heat (AC-1) provides heating and cooling to a portion of the cafeteria that was added in 1980.

The restrooms added in 1993 are served by (FCU-1), an electric heating only fan coil and by (EF-2), an inline exhaust fan.

Mechanical Piping:

The main steam piping and primary chilled water are served from the central utility plant into the tunnel mechanical room in the basement.

The steam piping serves a domestic hot water heat exchanger (T-401) in the basement, heating coil (HC-403) in the penthouse and heating water heat exchanger (HX-1), also in the penthouse.

The low-pressure steam condensate from the heat exchangers as well as the steam heating coil is routed to a separate condensate receiver station (CP201) on the tunnel level. This condensate is then pumped back to the central utility plant.

Heating water pumps (HWP1 and HWP-2) in the penthouse circulate the heating water between the (HX-1) and the terminal units and fan powered boxes.

The primary chilled water serves a secondary chilled water pump (P401) located in the penthouse that pumps the chilled water to cooling coil (CC-401).

Electrical systems:

The Community Center is one of the surrounding buildings whose electrical service is connected to the main service hub/switchgear located in Barlow Hall Building. Medium voltage feeders are routed to the Community Center connecting to a set of step-down transformers, located in the utility tunnel, providing an 800A, 480V, 3-Phase, 4-Wire rated service for the building. Downstream distribution also included a 225kVA step-down transformer (480V-208/120V) and associated branch circuit panels for 480/277V and 208/120V services. Refer to electrical floor plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or loose on the wall.

The domestic water distribution is partially of galvanized steel & partially of copper. There is light corrosion & minor leaking occurring. Some repairs have been made on the water system with new copper pipe.

The drainage system is cast-iron construction and is nearing its end of useful life.

There is an existing, exterior located aboveground grease-waste interceptor serving the kitchen.

The existing hot water is generated by the central utility plant.

Fire Protection System(s):

The building has a fire sprinkler system. There are some existing fire hose-cabinets that contain fire extinguishers.

4. McLoughlin

McLoughlin Building Overall:

McLoughlin Hall (built in 1972) is a 52,292 s.f. three level building that consists of classrooms, auditorium, computer labs, study areas, and department offices. The main utilities for the building are served through the utility tunnel.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The HVAC systems are broken down into 3 separate zones for this building. The North Zone Dual Duct AHU, the South Zone Dual Duct AHU, and the Bookstore DX Packaged System (additional buildout).

The Cold/Hot Deck supply fans (SF211/SF212 and SF221/SF222) are located in the built up mechanical rooms located on the roof of the building. Both of these serve the hot and cold deck supply ductwork and have their own dedicated ductwork which goes into a shaft directly underneath the AHU in the middle of the building. SF211/SF212 is located in Penthouse N301 and SF221/SF222 is located in Penthouse N302. These AHU's have almost identical configurations, but their design information may be slightly different due to them being built up for the mechanical room they are located in. Each built-up AHU has a (1) filter, (2) return plenum, (3) heating supply fan, (4) relief plenum, (5) relief louver, (6) heating coil, (7) return/recirculated air, (8) outside air louver, (9) mixed air plenum, (10) cooling supply fan, (11) filter, and (12) cooling coil.

The bookstore is served by a packaged rooftop unit RTU-01 located on the roof above that space. It's a 4T packaged Bryant unit that is roughly 30 years old. This unit has packaged DX cooling and heating water reheat coils (HC-1 through HC-4) in ceiling space below.

The general exhaust fans (EF211, EF221 and EF222) for the building are located in the corresponding mechanical room penthouse and in the SW stairwell. They serve the general exhaust for the toilets, janitor closets and other building pressurization exhaust.

The two data closet rooms in the building have dedicated exhaust for these spaces. These are noted as EF1A and EF1B.

There is a dedicated room served by a split system heat pump. The outdoor unit is located on the roof near Penthouse N301.

Mechanical Piping:

The main steam piping and primary chilled water are served from the central utility plant into the tunnel mechanical room on the foundation/tunnel level of McLoughlin Hall.

The steam piping serves a steam to heating hot water heat exchanger (HX-01) in the tunnel. From here, there is a dedicated heating hot water pump (P-1) that serves (4) reheat zones for a portion of the building (bookstore) that was renovated in 1990. The low pressure steam condensate from the heat exchangers as well as the steam heating coils on the AHU's are routed to a separate condensate receiver station (CP201) on the tunnel level. This condensate is then pumped back to the central utility plant.

The primary chilled water serves a secondary chilled water pump (P201) in this space as well. The piping is then distributed throughout the building to the (2) Penthouses where the built up Hot/Cold Deck AHU's are located and then serves the chilled water coil.

Electrical systems:

McLoughlin building electrical service is being routed through Randall Hall via the service tunnel. Medium voltage feeders are extended to McLoughlin and terminate into (3) 1-Phase, 15kV transformers, providing a 800A, 480V, 3-Phase, 4-Wire rated service, located in the Electrical Utility Room in the tunnel. Downstream distribution consists of a 225kVA step-down transformer (480V - 208/120V) and associated branch circuit panels placed throughout for 480/277V and 208/120V loads. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or showing signs of early wear.

The domestic water distribution is of galvanized steel construction.

The domestic hot water is generated by the CUP as a primary source, the secondary source of hot water generation is a solar hot water heater, the tertiary method is a domestic hot water booster heater.

Fire Protection System(s):

There are existing sprinklers in the basement storage area, but the 1st and 2nd floor do not have a fire sprinkler system. There are fire extinguishers located within hose-cabinets in some locations.

5. Pauling A and B

Pauling Center Buildings A and B Overall:

The Pauling Center is a group of three buildings interconnected by breezeways. All three buildings were built in 1982. Pauling A is a 6,400 SF single level building that consists of classrooms. Pauling B is a 10,300 S.F. single level building that consists of classrooms and staff offices. Pauling C consists of classrooms and staff offices. Pauling C was recently updated and is not a part of this report. The main utilities for the buildings are served through the utility tunnel. Although these systems are served through the utility tunnel, there is no direct access to the tunnel from any of the buildings. None of the three buildings has a basement level.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

Both of the buildings are served by roof top multizone air handlers; Building A by (ACU-03) with seven zones and Building B by (ACU-04) with ten active zones and two future. These units have the same configuration, consisting of a (1) return fan and relief damper, (2) outside air intake and mixing plenum, (3) filter, supply fan, (4) hot and cold decks, (5) heating water recirc pump and (6) zone dampers. The air flow to the zones in Building B are further controlled individual variable and constant volume air control valves (VAV-1) through (VAV-10).

Building A has one exhaust fan (EF-9) that serves the toilets. Building B has four exhaust fans. (EF-6) serves the toilets, (EF-2a) serves the darkroom, and (EF-2b), (EF-3b) serve fume hoods in Prep Room 131. These fans are located on the roof of their respective building.

Mechanical Piping:

The main steam piping and primary chilled water piping are served from the central utility plant through the utility tunnel. The utility tunnel houses the steam to heating water heat exchanger (HX-1), the heating water pump (HWP-1), the secondary chilled water pump (CHP-1), and the steam condensate pump (CP-10). The equipment in the tunnel serves all three Pauling buildings.

Electrical systems:

Pauling Center A and B are part of the group of buildings that are served/fed from the medium voltage switchboard located in the Bill Rod Community Center building. The medium voltage feeders are extended and terminates into a 500kVA (12.5kV - 480V) transformer, providing a 800A, 480V, 3-Phase, 4-Wire rated service for the building, located above ground on the exterior of Pauling A. Downstream distribution consists of (4) step-down transformers (30kVA, 75kVA, 75kVA, 112.5kVA) and associated branch circuit panels placed throughout for 480/277V and 208/120V loads. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or showing signs of wear. The domestic water distribution is of copper construction.

The existing electric water heater is newer.

Floor drain trap primers are missing.

There are existing compressed air and gas to tunnels at teaching stations with the pipe buried under-slab.

Fire Protection System(s):

There is an existing wet-pipe sprinkler system within the building and there are also fire extinguisher cabinets.

6. Randall Hall

Randall Building Overall:

The Randall Hall Building (built in 1972) is a 60,775 S.F., three level building that consists of a gymnasium, weight room, locker rooms, training rooms, wrestling room, classrooms and the athletic department offices. The main utilities for the building are served through the utility tunnel. The basement level (training, weightroom and locker rooms) is the same level as the tunnel system.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The HVAC systems are broken down into 3 separate zones for this building. The Gymnasium, the Multizone Areas, Exercise Room and Old Wrestling Room (additional buildout).

The supply fan AHU's (SF304A and SF304B) are located in the stair towers mechanical rooms. Both of these serve the gymnasium supply air and have their own dedicated ductwork overhead. SF304A is located in the SE stair tower and SF304B is located in the NW stair tower. These AHU's have similar configurations but are laid out differently due to them being built up for the mechanical room they are located in. The built-up AHU has a (1) outside air intake, (2) return air plenum, (3) filter, (4) steam preheat coil, (5) chilled water coil, (6) cooling supply air plenum, and (7) supply air fan.

The Multizone air handling units (MZ301, MZ302, and MZ303) are stationed in different locations. MZ301 serves the ground floor and MZ302 serves the first floor. Both of these units are located in the Utility Tunnel Mechanical room. MZ303 serves the 2nd floor and is located in the 2nd floor NE stair tower. The return fans (RF301, RF302, RF303) serve each of the Multizone units, respectively.

These Multizone AHU's have similar configurations but are laid out differently due to them being built up for the mechanical room they are located in. The built-up AHU has a (1) return plenum, (2) return fan, (3) relief air plenum, (4) relief louver, (5) outside air louver, (6) mixed air plenum, (7) filter, (8) supply fan, (9) steam coil and (10) cooling coil.

The exercise room is served by a packaged rooftop unit AC-01 located on the roof above that space. It's a 15T packaged Trane unit that is 30 years old. This unit has packaged DX cooling and gas heat.

The general exhaust fans (EF301 and EF302) for the building are located on the 2nd floor mechanical room (stair tower) and serve the general exhaust for the locker rooms, toilets, and other building pressurization exhaust.

Laundry is on the ground floor (R114). This space is served by MZU 301 and each dryer has a dedicated exhaust fan.

The Trans Vault supply fan (SF307) is located in the tunnel mechanical room. This unit is noted as potentially being an exhaust fan but after inspection this is ducted from the OA intake ductwork so it should be updated to be a supply fan the Asset ID.

Mechanical Piping:

The main steam piping and primary chilled water are served from the central utility plant into the tunnel mechanical room on the ground floor of Randall Hall.

The steam piping serves a steam to domestic hot water heat exchanger (HX1) in this space and domestic hot water is distributed from tank storage and circulating pumps throughout the building. The low pressure steam condensate from the heat exchanger as well as the steam heating coils on the MZU's are routed to (2) separate condensate receiver stations (CP301 and CP302) on the ground level. CP301 is located in the tunnel and serves the south portion of the tunnel. CP302 is located in the tunnel mechanical room and serves the adjacent Multizone units as well as the domestic hot water heat exchanger condensate. This condensate is then pumped back to the central utility plant.

The primary chilled water serves a secondary chilled water pump (P301) in this space as well. The piping is then distributed throughout the mechanical room to the (2) Multizone units in the basement and then the piping goes up to level 2 and serves the last Multizone unit and the other (2) Gymnasium Air handling units.

Electrical systems:

Randall Hall is one of the surrounding buildings that is fed/served by the medium voltage service hub located in Barlow Hall building located in the Electrical Utility Room in the tunnel. The medium voltage feeders are extended and terminate into (3) 1-Phase 12.5kV transformers, providing a 600A, 480V, 3-Phase , 4-Wire rated service. Downstream distribution consists of a 150kVA and 75kVA step-down transformer and associated branch circuit panels placed throughout for 480/277V and 208/120V loads. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The building has existing domestic hot/cold water, natural gas, sanitary drain & vent and storm drainage infrastructure. The piping is mostly of the original construction, however multiple renovations over the years have had pipes removed, relocated and added.

The domestic hot water is being generated in a steam to domestic hot water exchanger with steam supplied by the central utility plant steam boilers as the primary domestic hot water source. Within the underground utility tunnel, there is an abandoned in place solar hot water generation skid no longer used. This was intended to be the secondary source of hot water to the building. As a tertiary option, there is also a 3 element electric booster heater and 200 gallon storage tank. The intent, if both CUP (steam boiler) and solar hot water are not available, the booster heater & recirculating pump will maintain the required temperature for a period of time. The hot water &

cold water exposed piping is insulated and appeared to be copper under the insulation at the equipment. The distribution is galvanized metallic piping.

There is an existing thermostatic mixing valve & recirculating pump located between the solar skid and the electric booster heater that appears to be in good condition. This serves to protect the domestic hot water bearing fixtures, such as Gymnasium showers & lavatories.

The building incorporates a natural gas fuel source to power gas clothing dryers within the ground floor laundry.

The storm drainage system is gravity-flow via rainwater leaders, both primary and overflow drains are present on the roof. Noticeable overgrowth was present in some areas at the time of the site visit.

Fire Protection System(s):

The building is protected by a wet-standpipe fire protection system on the ground floor only. This along with the dual-check valve assembly & tamper switch are located within the underground utility tunnel, Fire hose cabinet locations have fire extinguishers.

7. Clairmont Hall

Clairmont Building Overall:

The Clairmont Hall Building (built in 1969) is a 21,320 s.f., single level building that consists of classrooms, offices, and lab spaces. The building is not served from heating or cooling from the utility tunnel. In 2023 Clackamas Volunteers in Medicine complete a tenant improvement and moved into the north portion of the space.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building is on the rooftop with (21) Packaged RTU's (RTU-1 through RTU-21) with gas pack heating and DX cooling. These units are single zone constant volume RTU's and most of them were installed in 1995, 1997 or 2003.

These serve supply ductwork and have their own dedicated ductwork which goes into the building to serve their zones. Each of these RTU's has a (1) outside air damper, (2) filter section, (3) gas fired pre-heating, (4) dx cooling coil, and (5) supply fan. There is not a diagram for example.

The general exhaust fans (EF-1 and EF-2) for the building are located on the roof. They serve the general exhaust for the toilets, janitor closets, and building pressurization relief.

There is (1) one relief hood (RH-1) on the roof for additional building pressurization relief.

Mechanical Piping:

There is no mechanical piping on the Clairmont Building.

Electrical systems:

(New system installed in 2016)

Clairmont is one of the surrounding buildings that are fed, electrically, by the service entrance Main-Hub located at Barlow Hall Building. A set of Medium Voltage feeders are being routed across the campus and terminated into a step-down transformer located outside of Clairmont building, providing a 1200A, 208V, 3-Phase, 4-Wire service. Downstream distribution consists of branch circuit panel placed throughout the building serving equipment, lighting, and receptacle loads. Refer to electrical floor plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with stainless steel trim. New fixtures existing are in excellent condition & older existing fixtures are in good condition.

The domestic water distribution is of galvanized steel construction. There is light corrosion & minor leaking occurring. Some repairs have been made with newer copper.

The drainage system is of cast-iron construction and past its useful life.

The existing hot water is generated by two older water heaters.

Fire Protection System(s):

There are existing fire extinguisher cabinets with extinguishers located throughout the building.

8. Dye Learning

Dye Learning Resource Center Overall:

The Dye Building (built in 1991) is a 29,215 s.f., single level building that consists of the library, classrooms, tutoring area, computer lab and staff offices. The gas, water and fire protection utilities are served through underground lines that enter along the west side of the building.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building consists of two cooling only packaged rooftop units (RTU-1) and (RTU-2). Both RTUs have a (1) return fan, (2) relief damper, (3) mixing damper, (4) outside air damper, (5) filter section, (6) DX cooling, and (7) supply fan.

Heating is provided at the zone level by the VAV boxes with hot water coils. (RTU-1) serves the north half of the building and (RTU-2) serves the south half.

Exhaust fan (EF-1) serves the toilets and (EF-2) serves the janitor closet and storage room. Both fans are located on the roof.

The electrical room is cooled by a ductless split system (FC-1) with the condenser (CU-1) on the roof.

Mechanical Piping:

Heating water for the building is generated by a gas fired sectional cast iron boiler (B-1). Pump (P-1) circulates the heating water to the VAV boxes.

Electrical systems:

Dye Learning Center building is one of the group of buildings that are served/fed by the Bill Brod Community Center medium voltage switchboard. The service feeders are routed from Bill Brod Community Center and terminates into a 500kVA pad-mounted transformer (12.5kV - 480V), providing a 600A, 480V, 3-Phase, 4-Wire rated service for the building. Downstream distribution includes (2) 75kVA step-down transformer (480V-208/120V) and associated branch circuit panels placed throughout for 480/277V and 208/120V loads. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Stainless steel sinks at kitchenettes and a mop sink in the janitor’s closet. Some fixtures are damaged and/or showing signs of early wear.

The domestic water distribution is of copper construction. There is light corrosion & minor leaking occurring.

Fire Protection System(s):

There is an existing dry-pipe fire suppression system with adjacent air compressor within the boiler room.

Fire Department connections are outside the boiler room.

There are also existing fire extinguisher cabinets located throughout the building.

9. Niemeyer

Niemeyer Building Overall:

The Niemeyer Building (built in 2005) is a 46,370 S.F., two level building that consists of classrooms, a studio theater, art gallery, vocal and instrumental rehearsal, dressing rooms, scene workshop, support spaces, and department offices. CUP steam through piping from the utility tunnel to the building is used to create hot water (via a heat exchanger) for reheat through the building. Air conditioning does not use chilled water from the CUP. Water and fire protection come up from underground in the area.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building is on the rooftop with (3) VAV AHU's (RTU-1, RTU-2, and RTU-3) with hot water reheat at the zone level. RTU-1 serves the studio theatre and is direct ducted into that space for temperature control. RTU 2 & 3 serve the rest of the building zone with VAV terminal units. There is radiant in-floor heating on the west and south portion of the building that is served through manifolds in the area. These were out-of-use which was causing additional unwanted energy use from the original design of the building.

The packaged RTU's are located on a built-up structural platform on the roof of the building. These serve supply ductwork and have their own dedicated ductwork which goes into the building to serve their zones. shaft directly underneath the AHU in the middle of the building. Each of these RTU's has a (1) return fan w/VFD, (2) relief damper, (3) mixing damper, (4) outside air damper, (5) filter section, (6) gas fired pre-heating, (7) dx cooling coil, (8) supply fan w/VFD, (9) terminal units with reheat.

There is an electric steam humidifier (H-1) that serves and is dedicated to the piano storage room.

The general exhaust fans (EF-1 and EF-2) for the building are located on the roof. They serve the general exhaust for the toilets, janitor closets and other building pressurization exhaust.

The elevator machine room and the dimmer room both have dx split units (AC-1 and AC-2) heat pumps that serve each space individually. The outdoor units are located on the roof under the structural platform for the RTU's.

Mechanical Piping:

The main steam piping is served from the central utility plant into the tunnel mechanical room on the foundation/tunnel level of Niemeyer.

The steam piping serves a steam to heating hot water heat exchanger (CX-01) in the tunnel. From here, there is a dedicated heating hot water pump (HWP-1) that serves multiple reheat zones as well as the radiant heating loop. The radiant floor heating loop has a dedicated pump (HWP-2) that circulates water out to the radiant heating manifolds. The low pressure steam condensate from the heat exchanger is routed to a separate condensate receiver station (CP-1) on the tunnel level. This condensate is then pumped back to the central utility plant.

Electrical systems:

Niemeyer Building electrical service is rated at 1600A at 480V, 3-Phase, 4-wire, provided by a pad-mounted transformer located exterior to the building. The service distribution consists of (3) step-down transformers (225kVA, 300kVA, and 75kVA) and associated branch circuit panels placed throughout for 480/277V and 208/120V loads.

The building is also equipped with a 30kW diesel backup generator that serves life safety loads and minimal selected equipment loads.

Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Seemingly in good condition other than light occupant abuse. Some flush valves have slow/weak flow despite 90 PSI supplied to building.

The domestic water distribution is of copper construction. There is an existing gas-fired water heater supplying the domestic hot water.

During medium to heavy rains, the rainwater flows into the overflow drains.

There is a small air compressor serving a prop shop.

Fire Protection System(s):

There is an existing wet pipe fire protection system with sprinklers throughout the building. The loading dock is served by an "anti-freeze" protected branch.

There are existing fire extinguisher cabinets with extinguishers throughout the building.

10. Roger Rook

Roger Rook Hall Overall:

The Roger Rook Hall (built in 2003) is a 29,172 s.f. two level building. The building consists of classrooms, creating writing lab, staff office and an open office area. In 2022 the first floor was renovated to house members of the Executive Team, the Foundation, the Diversity Equity and Inclusion offices and a dividable community room. This is a stand-alone building and has no services coming from utility tunnel. The gas, water and fire protection utilities are served through underground lines that enter along the east side of the building.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building is a package rooftop unit with gas heat (RTU-1) with electric reheat at the zone level. This RTU has a (1) return fan w/VFD, (2) relief damper, (3) mixing damper, (4) outside air damper, (5) filter section, (6) gas fired pre-heating, (7) dx cooling coil, (8) supply fan w/VFD, and (9) terminal units with electric reheat.

The building has one exhaust fan (EF-1) which serves the public toilets, janitors closets and newly installed staff breakroom in the 2022 remodel and is located on the roof. This EF was replaced and upsized as a result of the 2022 remodel project.

The elevator equipment room is served by a ductless split system (AHU-1) with the condenser (CU-1) located on the roof.

Mechanical Piping:

There is no mechanical piping in this building.

Electrical systems:

Roger Rook is one of the buildings that share a service feed with the Dejardin Building, downstream from a Main Distribution board located exterior to the building. The service is rated at 800A, 480V, 3-Phase, 4-Wire and consists of a 112.5kVA step-down transformer with associated branch circuit panels serving 480/277V and 208/120V loads.

The building was set up for connection to a backup generator system. However, this generator no longer exists, and associated distribution were re-routed accordingly. As part of the 2022 remodel, an inverter was installed to provide back up power to egress lighting and exit signs.

Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or showing signs of early wear.

The domestic water distribution is of copper construction.

The existing gas-fired water heaters are nearing end of useful life.

A previous FCA report documented excessive sewer gas at HVAC rooftop equipment. Existing VTR has extension.

Fire Protection System(s):

There is an existing wet-pipe sprinkler system protecting the building. The roof top mechanical space canopy is protected by dry heads.

There are also fire extinguisher cabinets with extinguishers throughout the building.

11. Streeter Hall

Streeter Hall Overall:

Streeter Hall (built in 1990) is a 15,757 s.f., single level building that consists of a math and computer lab, classrooms, and staff offices. This is a stand-alone building and has no services coming from utility tunnel. The gas, water and fire protection utilities are served through underground lines. The gas line enters the building on the west side and the water line enters on the south.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building consists of a cooling only packaged rooftop unit (RTU-1). This RTU has a (1) return fan, (2) relief damper, (3) mixing damper, (4) outside air damper, (5) filter section, (6) DX cooling, and (7) supply fan.

Heating is provided at the zone level by VAV boxes with hot water coils.

Exhaust fan (EF-1) serves the toilets and the janitor closet. This fan is located on the roof.

Mechanical Piping:

Heating water for the building is generated by a gas fired sectional cast iron boiler (B-1). Pump (P-1) circulates the heating water to the VAV boxes.

Electrical systems:

Streeter Hall service derived from a 500kVA pad-mounted transformer (12.5kV - 480V), providing a 600A, 480V, 3-Phase, 4-Wire rated service for the building. Downstream distribution consists of (2) 75kVA step-down transformers and associated branch circuit panels placed throughout for 480/277V and 208/120V loads. A sub-feed from this building is also brought over to serve the Annex building. Refer to electrical floor plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim.

The domestic water distribution is of copper construction.

The drainage system is of cast-iron construction. Trap primers failing in some areas.

The existing hot water is generated by an electric hot water heater.

Fire Protection System(s):

There is an existing dry-pipe fire suppression system protecting the building.

There is a glycol system for the mechanical canopy that connects Streeter Hall and Streeter Annex that is supplied from Streeter Annex.

There are fire extinguisher cabinets with extinguishers within, as well as some attached to walls.

12. Art Center

Art Center Building Overall:

The Art Center Building (built in 2003) is a 12,000 s,f., single level building that consists of studio classrooms, studio work spaces, offices, and adjacent outbuilding with pottery/brick ovens. The building is not served from the utility tunnel. Water and fire protection come up from underground.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building is on the rooftop with (1) VAV AHU's (RTU-1) with gas preheat and electric reheat at the zone level and (1) Heating/Ventilation Unit (HVU-1) with gas heat. RTU-1 serves the west wing of the building and HVU-1 serves the south wing. These serve supply ductwork and have their own dedicated ductwork which goes into the building to serve their zones.

RTU-1 has a (1) relief damper, (2) powered exhaust fan w/VFD, (3) mixing damper, (4) outside air damper, (5) filter section, (6) gas fired pre-heating, (7) dx cooling coil, (8) supply fan w/VFD, (9) terminal units with electric reheat.

HVU-1 has (1) supply fan, (2) filter section, and (3) gas fired heating ducted directly into the south wing areas.

The general exhaust fans (EF-1 through EF-8) for the building are located on the roof. They serve the general exhaust for the toilets, janitor closets, and studio classrooms.

There are two relief hoods (RH-1 and RH-2) on the roof for additional building pressurization relief.

Mechanical Piping:

There is no mechanical piping on the Art Center Building.

Electrical systems:

The Art Center building electrical service is fed from Randall Hall Building. The service is rated at 400A, 480V, 3-Phase, 4-Wire with a downstream 150kVA step-down transformer (480V-208/120V). Both 480/277V and 208/120V services are provided throughout via branch circuit panels (Refer to Electrical floor plans and one-line diagram for additional information).

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or loose on the wall.

The domestic water distribution is of copper construction.

The drainage system is of cast-iron construction. Trap primers failing in some areas.

There is compressed air, natural gas, oxy-acetylene, brazing gas, solids separators & other specialty systems.

Fire Protection System(s):

There is an existing wet-pipe fire suppression system protecting the building.

There are fire extinguisher cabinets with extinguishers within, as well as some attached to walls.

13. DeJardin Hall

DeJardin Hall Overall:

DeJardin Hall (built in 2003) is an 18,602 S.F., two level building. The building consists of classrooms, science labs, and offices. This is a stand-alone building and has no services coming from the utility tunnel. The gas, water and fire protection utilities are served through underground lines that enter along the north side of the building. The DeJardin Hall Science Addition was opened in 2019 and is not included in this study.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building is a package rooftop unit with gas heat and DX cooling (RTU-1) with electric reheat at the zone level. This RTU has a (1) return fan w/VFD, (2) relief damper, (3) mixing damper, (4) outside air damper, (5) filter section, (6) gas fired pre-heating, (7) dx cooling coil, (8) supply fan w/VFD, (9) terminal units with electric reheat, and (10) air control valve with corresponding electric reheat coil.

The building has four exhaust fans. EF-1 serves the public toilets and janitor's closets and is located on the roof. EF-2 serves the science labs and fume hoods and is located on the roof. EF-3 serves the compressor room and is located in that room. EF-4 serves a private toilet and is located in the ceiling above Clinical Classroom 228.

The elevator equipment room is served by a ductless split system (AHU-1) with the condenser (CU-1) located on the roof.

The Sprinkler Riser room has an electric baseboard heater providing freeze protection.

Mechanical Piping:

There is no mechanical piping in this building.

Electrical systems:

Dejardin is one of the group of buildings that are served by the Medium Voltage switchboard located in the Bill Brod Community Center. In addition, the service feed to Dejardin is shared with the Roger Rook Building via a 1000kVA service transformer (12.kV- 480V). The service size dedicated to Dejardin is rated at 800A, 480V, 3-Phase, 4-Wire. Distribution consists of a downstream 150kVA step-down transformer (480V-208/120V) and associated branch circuit panels placed throughout for 480/277V and 208/120V loads. Refer to electrical floor plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or showing signs of early wear.

The domestic water distribution is of galvanized steel construction. There is light corrosion & minor leaking occurring.

The drainage system is of cast-iron construction and observed slow drainage and backups have been reported.

There are air compressors and vacuum systems serving the labs that are currently not in use.

Fire Protection System(s):

There is an existing wet-pipe fire suppression system protecting the building.

There are fire extinguisher cabinets throughout the building.

14. Gregory Forum

Gregory Forum Overall:

The Gregory Forum (built in 1991) is a 10,200 s.f. single level building that consists of meeting rooms, office, kitchen, and lobby. This is a stand-alone building and has no services coming from utility tunnel. The gas, water and fire protection utilities are served through underground lines. The gas line enters the building on the west side and the water line enters on the east.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building consists of a cooling only packaged rooftop unit (RTU-1). This RTU has a (1) return fan, (2) relief damper, (3) mixing damper, (4) outside air damper, (5) filter section, (6) DX cooling, and (7) supply fan.

Heating is provided at the zone level by a combination of variable volume, constant volume, and dual duct fan powered boxes with hot water coils. The three dual duct boxes serve the lobby with mix of supply air from the RTU with general return air from the building.

There are three exhaust fans. Exhaust fan (EF-1), located on the roof, serves the vending machine and storage rooms. Exhaust fan (EF-2), located above the kitchen ceiling, serves the kitchen and storage rooms. Exhaust fan (EF-3) located on the roof, serves the toilets and the janitor closet.

Mechanical Piping:

Heating water for the building is generated by a gas fired sectional cast iron boiler (B-1). Pump (P-1) circulates the heating water to the VAV boxes.

Electrical Systems:

Gregory Forum building is one of the group of buildings that is served/fed by the Bill Brod Community Center medium voltage switchboard. The service feeders are routed to the Gregory Forum building and terminate into a 500kVA transformer (12.5kV - 208/120V), providing a 1200A , 208/120V, 3-Phase, 4-Wire service. Downstream distribution consists of a 75kVA step-up transformer (208V- 480/277V) and associated branch circuit panels place throughout for 480/277V and 208/120V loads. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Some fixtures are damaged and/or showing signs of early wear.

The domestic water distribution is of copper construction and heat-traced and insulated in unconditioned spaces.

The existing gas-fired water heaters are nearing end of useful life.

Fire Protection System(s):

There is an existing dry-pipe fire suppression system. A recent report showed the piping system to be corroded and failing.

Existing fire department connection is near the entrance.

There are also existing fire extinguisher cabinets with extinguishers within.

15. Streeter Annex

Streeter Hall Annex Overall:

Streeter Hall Annex (built in 2002) is a 7,000 S.F. single level building that consists of computer classrooms, data center, a resource room and staff offices. It is connected to the main Streeter Hall building by a breezeway. This is a stand-alone building and has no services coming from utility tunnel. The gas, water and fire protection utilities are served through underground lines that enter on the north side of the building.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The main HVAC for the building consists of a single cooling only packaged rooftop unit (RTU-1). This RTU has an (1) power exhaust fan, (2) relief damper, (3) mixing damper, (4) outside air damper, (5) filter section, (6) dx cooling coil, (7) supply fan, (8) terminal units with electric reheat.

Exhaust fan (EF-1) serves the toilets and the janitor closet. This fan is located on the roof.

Mechanical Piping:

Heating water for the building is generated by a gas fired sectional cast iron boiler (B-1). Pump (P-1) circulates the heating water to the VAV boxes.

Electrical systems:

The Streeter Annex building electrical service is a sub-feed from the Streeter Hall building main distribution. A 200A, 480V, 3-Phase, 4-Wire feed provided with a downstream 75kVA step-down transformer along with a set of branch circuit panels serving 480/277V, and 208/120V loads. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim.

The domestic water distribution is of copper construction.

The drainage system is of cast-iron construction.

The existing hot water is generated by an electric hot water heater.

Fire Protection System(s):

There is an existing wet-pipe fire suppression system protecting the building.

There is a glycol system for the mechanical canopy that connects Streeter Hall and Streeter Annex that is supplied from Streeter Annex.

16. Training Center A

Training Center A Building:

The Training A Building (built in 1994) is an 18,365 S.F. single level building that consists of classrooms, offices, workshops spaces, and lab spaces. The building is not served from the utility tunnel. Water and gas come up from underground in the area.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The building is broken down into two different types of HVAC systems, the North and South. The North HVAC for the building serves the classrooms by (11) FCU's (FCU-1 through FCU-11) with gas furnace heating and DX cooling. These units are single zone constant volume FCU's installed in the attic space with direct ducted OA from and exterior louver. They each have their own individual condensing unit (CU-1 through CU-11) and are located outside to the south of the building.

The FCU's serve supply ductwork and have their own dedicated ductwork which goes into the classrooms to serve their zones. Each of these FCU's has a (1) outside air damper, (2) filter section, (3) gas fired heating, (4) dx cooling coil, and (5) supply fan. There is not a diagram for example.

The South HVAC for the building serves the labs and a storage space by (7) Radiant Heaters (RH-1 through RH-7) with a direct gas connection and OA intake to from the exterior wall. These labs have no form of mechanical cooling.

The general exhaust fan (EF-1) for the building is located in the attic space and is ducted up to roof heads with bird screen for relief. This unit serves the general exhaust for the toilets, janitor closet, and building pressurization relief. The other exhaust fan (EF-2) is located on the roof and serves the paint storage room.

Mechanical Piping:

There is no mechanical piping on the Training A Building.

Electrical systems:

The Training Center A building electrical service is provided from the Utility Transformer located to the Southside of the building. The service is a 800A, 208V, 3-Phase, 4-Wire rated system with a set of branch circuit panels serving the building loads. In addition, a 75kVA step-up transformer (208V – 480V) was installed at a later date to accommodate larger HVAC equipment loads. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Seemingly in good condition other than light occupant abuse.

The domestic water distribution is of copper construction. Backflow preventers are present in the utility room. Hard-piped drain reduced pressure zone backflow preventer.

The domestic hot water is produced by a 50-gallon electric water heater, recirculating pump existing.

There is natural gas service to the building serving existing furnaces & other equipment.

Fire Protection System(s):

There is an existing sprinkler system for flammable liquid/hazmat storage rooms.

There are fire extinguisher cabinets throughout.

17. Training Center B

Training B Building:

The Training B building (built in 1997) is a 9,934 S.F., single level building that consists of welding shop, metalworking, class labs, offices, and support spaces. The building is not served from the utility tunnel. Water, gas, and fire protection come up from underground.

See Appendix C – FCA Supporting Files for link to MEP diagrams.

Mechanical HVAC:

The building is broken down into two different types of HVAC systems for the east and west portions of the building. The gas fired 100% OA HVAC Unit (MAU-)1 serves the east section of the building consisting of the welding shop. This unit is a single zone variable volume MAU installed in a mechanical room with direct ducted OA from an exterior louver. This shop has no form of mechanical cooling and utilizes portable swamp coolers and floor fans in the warmer months of the year.

The west section of the building consisting of class labs and offices spaces is served by HVU-1, a gas fired heat and dx cooling mixed air system. This unit is a single zone variable volume HVU installed in a mechanical room with direct ducted OA from an exterior louver. There is also a condensing unit (CU-1) located outside that serves the classrooms for mechanical cooling which is connected to a coil in the HVU ductwork after the unit.

The exhaust fans (EF-1 through EF-4) for the building are located in the mezzanine level or high up in the space and are ducted up to roof heads with bird screen for relief. Exhaust fan EF-1 serves the welding space and is a utility upblast fan without a roof head at the roof level. Exhaust fan EF-2 serves the general exhaust and is an in-line fan for the toilets and janitor closet. Exhaust fan EF-3 serves the track burners and is an in-line fan in the shop space above head. Exhaust fan E-4 serves the exterior booth and is a prop fan attached to the top of the booth.

The roof heads (RH-1 through RH-7) are either connected to the exhaust fan discharges or for general building pressurization relief and are roof mounted.

There is a gas-fired unit (UH-1) that was added to provide additional heating for the Welding Shop space at some point between the present and original construction.

Mechanical Piping:

There is no mechanical piping on the Training B Building.

Electrical systems:

The Training Center B building electrical service is provided from the Utility Transformer located to the Southwest corner of the building. The service is a 2000A, 480V, 3-Phase, 4-Wire rated system with a set of branch circuit panels serving the building loads. There are (1) 300kVA and

(2) 30kVA Step-Down transformer provided for serving 208/120V loads. The majority of the electrical equipment is located in a centralized electrical room. Refer to electrical plans and one-line diagram for additional information.

Plumbing System(s):

The plumbing fixtures are of porcelain construction with chrome trim. Seemingly in good condition other than light occupant abuse.

The domestic water distribution is of copper construction. Backflow preventers are present in the utility room. Hard-piped drain reduced pressure zone backflow preventer.

The domestic hot water is produced by a 40-gallon electric water heater, aqua stat & timer existing.

There are hard-piped Acetylene, oxygen, compressed air, C02, argon & assorted mixed gases for welding within the shop, controlled with automatic gas-manifolds.

There is natural gas service to the building.

Fire Protection System(s):

There is an existing wet-pipe fire suppression system protecting the building.

There are fire extinguisher cabinets throughout.

2. Energy Modeling Narrative

The Facility Condition Assessment provides timeframe and costs for undertaking a like-for-like replacement of aging infrastructure. Clackamas Community College was forward thinking in the process and included within the scope of the project to analyze alternate energy efficiency design options in lieu of the like-for like replacement.

The scope for this task included performing energy analysis on 10 of the buildings for a range of different energy efficient alternate design and measures that we have termed ECM's (energy conservation measures).

Mazzetti and the college then determined which 10 buildings would be of most benefit to analyze and could have the most potential energy savings for the campus. The buildings chosen were the six buildings connected to the central utility plant, and four other buildings that are high energy use buildings. The buildings have been listed below:

Connected to Central Plant:

- Barlow
- McLoughlin Hall
- Randall Hall
- Bill Brod Community Center
- Pauling A&B
- Niemeyer (connected via boiler only)

Outlying buildings:

- Dye Learning
- Roger Rook
- Clairmont Hall
- Streeter Hall

Energy models were then created for these buildings using the software package eQuest. This software package was chosen due to the college staff being familiar with this software and the ability to use the models in future projects and analyses.

Each of the 10 buildings are then created in 3-dimensions within the software using a combination of construction drawings and site investigation. The five buildings connected to the central chiller were combined into one model, so that the part load operation of the chiller could be accurately modeled. The envelope properties, occupancy, lighting, equipment, HVAC and controls were then input. The buildings were simulated using a Portland TMY3 weather file, on an hour-by-hour basis for an entire year to produce the predicted energy consumption of the buildings.

The results are then compared to a year's worth of utility bills (electricity and gas), to help calibrate the models, to account for any unknown's or inefficiencies in the buildings that have occurred over time. The utility bills from 2019 were chosen for this calibration, to avoid the disruption caused by the pandemic in 2020.

Once the models were calibrated, Mazzetti and the college developed a list of ECM's for each building to be analyzed.

The ECM's were broken into five categories:

- HVAC (Air Side) Systems
- Decentralization and Water Side Systems
- Lighting and Lighting Controls
- Photovoltaics
- Envelope Improvements

Two of the major themes discussed were the college's goals to decentralize buildings from the central utility plant and decarbonize the campus.

A description of decentralization and the reasons are described under the ECM descriptions in the next section.

Decarbonization is the reduction of carbon emissions by reducing energy usage and reliance on high carbon emitting energy sources. Building codes in states around the US (including California, Washington and New York) are aggressively changing energy codes to reduce carbon emissions from all new and existing buildings. The State of Oregon is expected to be adopting similar code changes in the following years.

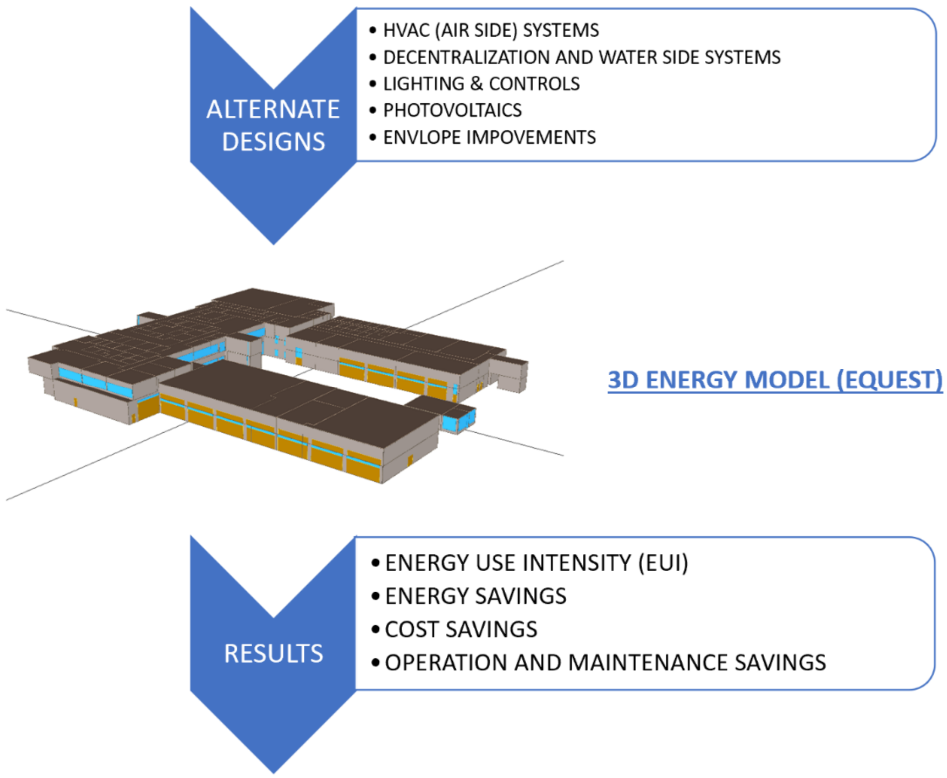
The college expressed that decarbonization was important to strive towards in future planning of the campus. Many of the ECM's developed have focused on this objective by:

- Reducing building energy use

- Electrifying the buildings (reducing reliance on natural gas, and instead using electricity from cleaner girds).

- Installing renewable energy measures (photovoltaics).

The next Section in the report provides a detailed description of the ECM's chosen and agreed upon by Mazzetti and the college to investigate via the energy analysis.



Disclaimer:

Computer building energy simulation provides an estimate of building performance. This estimate is based on a necessarily simplified and idealised version of the building that does not and cannot fully represent all the intricacies of the building once built. As a result, simulation results only represent an interpretation of the potential performance of the building. No guarantee or warrantee of building performance in practice can be based on simulation results alone.

3. Energy Conservation Measure (ECM) Descriptions

The following Section provides a description of the energy conservation measures (ECM's) which have been analyzed for the Clackamas Community College campus.

The ECM measures were developed in collaboration with Clackamas staff early in the project. Mazzetti discussed each building in detail with the team, including the type of equipment, controls, ease of maintenance and ideas for more energy efficiency solutions.

Each ECM has been numbered in accordance with the DOE Standard for energy conservation numbering, but with the building name included.

1. HVAC (Air Side) ECM's

The HVAC ECM's look at replacing the existing air side systems (air handling units) with new systems using more advanced technology and controls strategies. Many of the buildings throughout the facility use old technology such as dual duct systems, which are inefficient, difficult to operate and maintain, and limit the energy efficient controls strategies that can be implemented.

The new systems proposed are to improve thermal comfort to the occupants, provide easier to maintain systems, and reduce the energy consumption of the systems. As each unit is replaced (either via a like-for-like replacement per the FCA or an upgraded system) the controls will be upgraded from pneumatic to DDC and integrated into the campus BAS system.

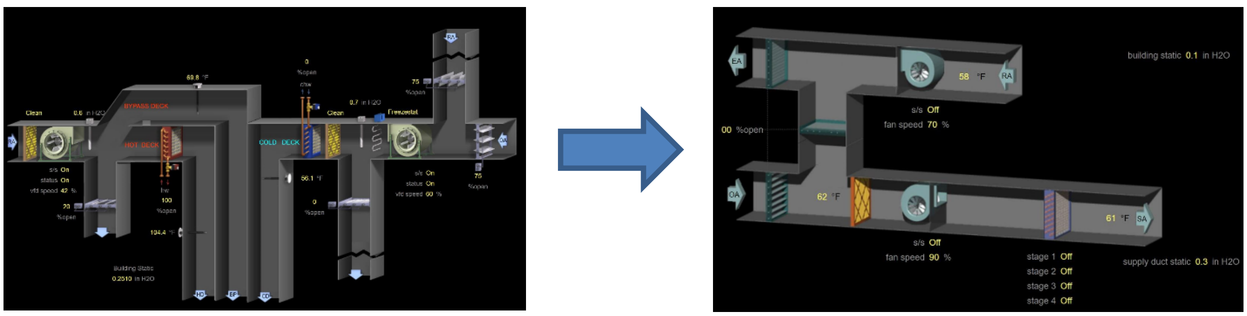


Figure 1 - Replace Multizone/Dual Duct Systems with VAV Reheat Systems

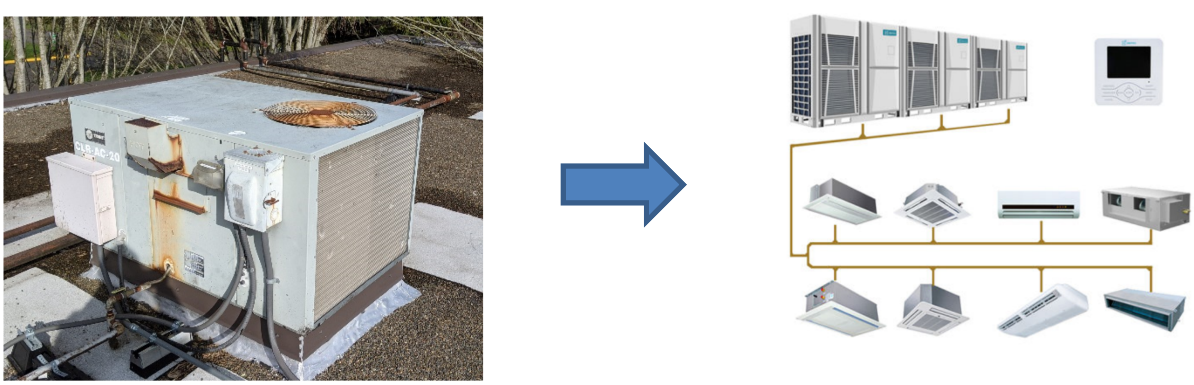


Figure 2 - Replace Rooftop Units with Variable Refrigerant Systems (VRF)

The following table provides a brief description of the proposed HVAC ECM's for each building. A detailed description of the ECM including all associated work can be found in Appendix A.

Building	HVAC ECM
Barlow **(ECM-BAR-4.01)**	Replace the dual duct/multizone systems (RTU-1, RTU-2 and the Penthouse RTU) with more efficient variable air volume (VAV) systems including new advanced DDC controls.
McLoughlin **(ECM-MCL-4.01)**	Replace the dual duct/multizone systems (north and south Penthouse AHU's) with more efficient variable air volume (VAV) systems including new advanced DDC controls.
Randall **(ECM-RAN-4.01)**	Replace the multizone systems (RTU-MZ-301, 302 and 303) with more efficient variable air volume (VAV) systems including new advanced DDC controls.
Bill Brod Community Center **(ECM-BIL-4.01)**	Replace the makeup air units and kitchen hood with new variable volume capable systems.
Pauling **(ECM-PAU-4.01)**	Replace the dual duct systems (RTU-3 and RTU-4) with more efficient variable air volume (VAV) systems including new advanced DDC controls.
Niemeyer	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).
Dye Learning	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).
Roger Rook	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).
Clairmont Hall **(ECM-CLA-4.01)**	Replace all RTU's with new variable refrigerant (VRF) systems with a dedicated outside air (DOAS unit) for ventilation.
Streeter Hall	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).

Table 2 - HVAC (Air Side) ECM's

2. Decentralization and Water Side ECM's

Decentralization

The Clackamas Community College campus contains a central utility plant within the Barlow Hall building. This central utility plant includes a water-cooled chiller, cooling tower, pumps, steam boilers and other associated equipment that provides chilled water and steam to six buildings (Barlow, McLoughlin, Randal, Bill Brod, Pauling and Niemeyer) via underground piping.

Decentralization is the removal of this central plant and installing dedicated plants at each building. There are many reasons a campus may choose to centralize or decentralize, but in Clackamas' case they have raised significant concern about the ability to maintain the aging central plant, including all the piping systems out to the buildings. In addition, the campus also has a unique situation where frequently they only need to operate a few buildings. For this situation, the campus must switch on the central plant for just those few buildings. With only one (or a few) buildings on line, the load is not large enough for the central plant to operate, and a second building needs to be brought on just to produce enough load for the central plant to operate and therefore wasting large amounts of energy.

The following table summarizes the path to decentralization.

System	Decentralization ECM
Hot Water System	
Barlow/McLoughlin/Randall **Bill Brod/Pauling/Niemeyer.** **(ECM-BAR-1.01A & B)** **(ECM-MCL-1.01A & B)** **(ECM-RAN-1.01A & B)** **(ECM-BIL-1.01A & B)** **(ECM-PAU-1.01A & B)** **(ECM-NIE-1.01A & B)**	<u>Option A: Decentralization and Decarbonization</u> Install a combination of high efficiency condenser boilers and high efficiency air cooled electric heat pumps (including new DDC controls) at each of the six buildings. The heat pumps will be used as an all-electric option for providing the heating water to the building (and help the facilities goal of decarbonization), and the condensing boilers will be used as backup and to help meet the load in peak conditions. The existing domestic hot water tank in Barlow and the Bill Brod Community Center will be replaced with high efficiency electric water heaters (~92% efficient). Demolish the steam boilers in Barlow, including all associated equipment. Remove heat exchanger at each building that convert steam to hot water. <u>Option B: Decentralization</u> This option was the same as Option 1, except the focus on decarbonization (heat pumps) was removed to reduce the installation costs. All heating from the new system will be from Condensing Boilers.

Chilled Water System	
Barlow/McLoughlin/Randall: **(ECM-BAR-1.01A)** **(ECM-MCL-1.01A)** **(ECM-RAN-1.01A)**	Install a new high efficiency air cooled chiller and pumps to serve both the new and existing AHU's (including new DDC controls). The buildings will be disconnected from the central chilled water plant.
Bill Brod/Pauling: **(ECM-BIL-1.01A)** **(ECM-PAU-1.01A)**	Install a new high efficiency air cooled chiller and pumps to serve both the new and existing AHU's (including new DDC controls). Existing chilled water piping will be inspected and reused where possible. The buildings will be disconnected from the central chilled water plant. OR Replace AHU's CHW Coils with DX coils including new DDC controls). Consider variable speed compressors for more accurate control. Existing chilled water piping will be demolished and the building will be disconnected from the central chilled water plant. Final decision on DX versus Air Cooled Chiller to be made during the design process once building loads have been analyzed. Costs have been based on the Air Cooled Chiller option as this is the more expensive option.

Table 3 - HVAC (Water Side) Decentralization ECM's

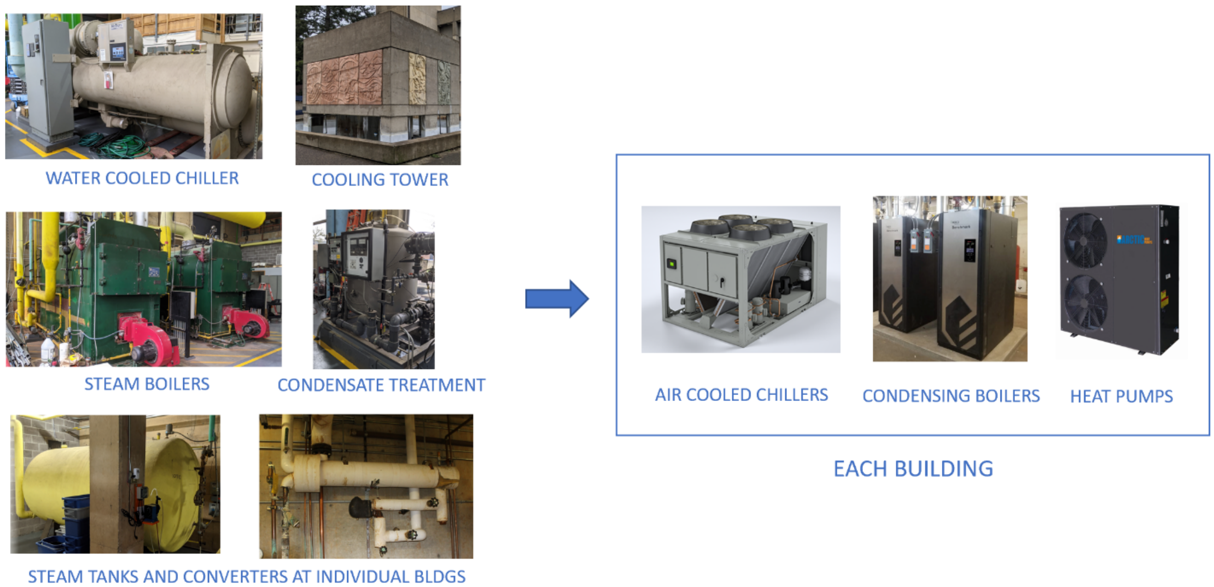


Figure 3 – Decentralization

Water Side Upgrades

For the four of ten buildings not connected to the central plant (Dye Learning, Roger Rook, Clairmont Hall and Streeter Hall), and the chilled water side of Niemeyer, upgrades to their water side systems have been analyzed.

Each building currently contains DX systems for cooling and hot water boilers, gas reheat or electric heat for heating.

Clackamas emphasized that they were not satisfied with DX cooling from a comfort control perspective, and therefore the option of replacing the DX systems with a chilled water system using an air-cooled chiller and pumps was investigated.

For the hot water systems, replacing the hot water boiler with a combination of condensing boilers and heat pumps (per previous section) was analyzed. If the building was already utilizing electric heat, it was not analyzed.

Below is a description of the work for each building.
Note: It is assumed that the upgrades would occur at the same time as the air side equipment replacements per the FCA analysis. For example, if an air handling unit was being replaced as part of the FCA, instead of replacing the unit with a packaged DX unit, the unit would be replaced with a chilled water coil, which could then be connected to a new air-cooled chiller system.

System	Water Side Upgrades
Hot Water System	
Dye Learning / **Streeter Hall** **(ECM-DYE-1.01A & B)** **(ECM-STR-1.01A & B)**	<u>Option A: Condensing Boilers & Heat Pumps (Decarbonization)</u> Install a combination of high efficiency condenser boilers and high efficiency air cooled electric heat pumps (including new DDC controls) to serve the RTU's and VAV reheat coils. The heat pumps will be used as an all-electric option for providing the heating water to the building (and help the facilities goal of decarbonization), and the condensing boilers will be used as backup and to help meet the load in peak conditions. Demolish the existing hot water boiler and pumps. <u>Option B: Condensing Boilers Only</u> This option was the same as Option 1, except the focus on decarbonization (heat pumps) was removed to reduce the installation costs. All heating from the new system will be from Condensing Boilers.
Chiller Water/DX System	
Niemeyer **(ECM-NIE-1.03)**	Replace DX coils in RTU-1, 2 and 3 with CHW coils and install a new high efficiency air cooled chiller and pumps (including new DDC controls).
Dye Learning / Roger Rook / Streeter Hall **(ECM-DYE-1.03)** **(ECM-ROG-1.03)** **(ECM-STR-1.03)**	Install a new high efficiency air cooled chiller and pumps to serve the new CHW coils (including new DDC controls).

Table 4 - HVAC (Water Side) ECM's

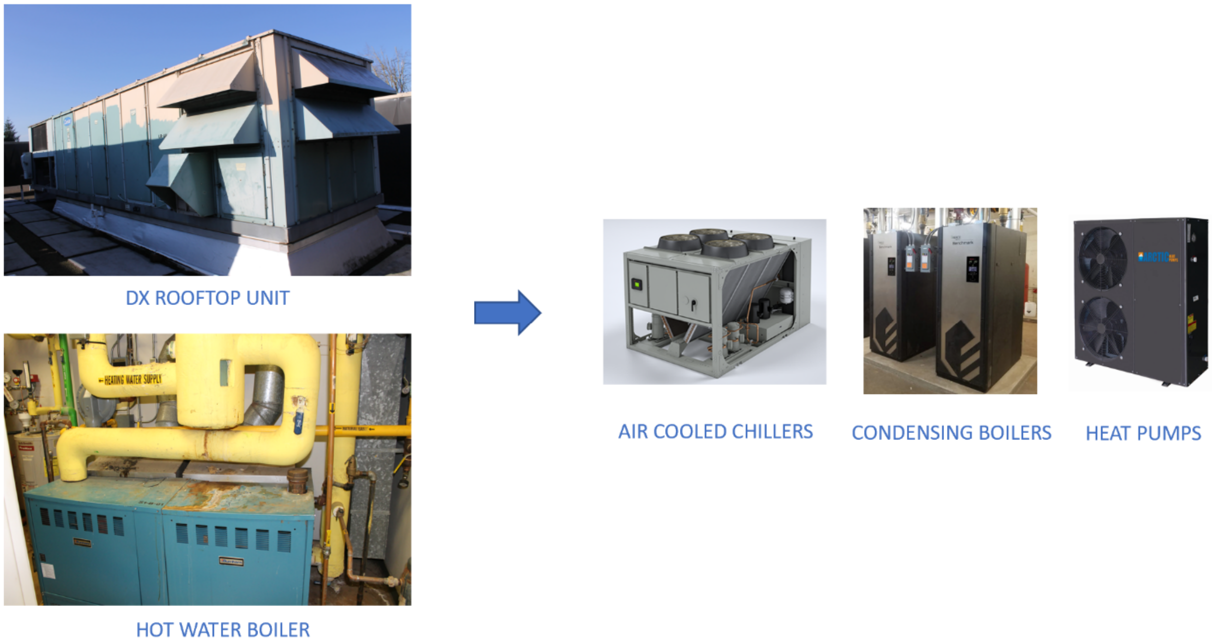


Figure 4 - Water Side System Improvements

3. Lighting ECM'S

For each of the buildings, the current lighting types and controls were assessed. This was achieved by reviewing the construction drawings for each building and comparing to site observations.

In nearly all cases buildings had inefficient lighting types with lighting densities varying from 0.75-3 W/ft^2 and had no automatic controls.

It is proposed to replace all these light fixtures with energy efficient LED and provide automated controls including daylight and occupancy sensors. This will reduce the lighting power density to an average of ~0.6 W/ft^2 for each building and automatically switch off the lights when not required. These newer lighting systems will result in improved lighting quality and comfort, whilst simultaneously reducing energy consumption.

For each building two different lighting options have been proposed.

Building	Lighting ECM
Barlow (ECM-BAR-5.01A or B) **Randall Hall (ECM-RAN-5.01A & B)** **McLoughlin (ECM-MCL-5.01A & B)** **Bill Brod (ECM-BIL-5.01A & B)** **Pauling A&B (ECM-PAU-5.01A & B)** **Niemeyer (ECM-NIE-5.01A & B)** **Dye Learning (ECM-DYE-5.01A & B)** **Roger Rook (ECM-ROG-5.01A & B)** **Streeter Hall (ECM-STR-5.01A & B)** **Clairmont Hall (ECM-CLA-5.01A & B)**	Option A: Building Lighting Control System with Network Capabilities This option includes a new programmable and network-able lighting control system for the building. The lighting control systems will have the ability to provide dimming, daylight harvesting, photocell sensing, occupancy/vacancy sensing, and timeclock setting features for individual spaces and/or zones. Option B: LED Light Fixtures with Integral Controls This option proposed a One-to-One replacement of the existing light fixtures with new LED fixtures that are equipped with built-in/integral occupancy/vacancy sensors. The integral sensors allow for automatic control capabilities (Dimming, Occupancy/Vacancy, and Daylight Harvesting). This option does not have programmable and network-able capabilities.

Table 5 – Lighting ECM's

4. Solar PV ECM'S

A solar PV system was assessed for each building. The system was sized based on both the available roof area and the base electricity consumption for the buildings and assumed all electricity produced will be used for the building and not fed back to the grid. Further options of a central or expanded solar system to serve multiple buildings and connection to the grid can be explored. The Solar PV systems generate electricity for use in the buildings, which helps in achieving the energy reduction and sustainability goals of the campus, as well as contributing to the decarbonization strategy.

Randall Hall has a non-functioning solar thermal system serving the domestic hot water. This was installed due to the high "hot water" use associated with the athletic showers. The solar panels associated with this system have be removed, however all plumbing piping/equipment are still in place with piping capped at the roof penetration. It is recommended to repair this system. Solar Thermal was also assessed as an option for the other buildings, but with the move towards electrifying the buildings, and the difficulty in maintaining and operating Solar Thermal systems, Solar PV was considered the best option for these buildings and provided superior energy savings.

Building	Solar PV System Size
Barlow (ECM-BAR-11.01)	208 kW
McLoughlin (ECM-MCL-11.01)	209 kW
Randall (ECM-RAN-11.01)	240 kW
Bill Brod Community (ECM-BIL-11.01)	114 kW
Pauling (ECM-PAU-11.01)	67 kW
Niemeyer (ECM-NIE-11.01)	185 kW
Dye Learning (ECM-DYE-11.01)	117 kW
Roger Rook (ECM-ROG-11.01)	124 kW
Clairmont Hall (ECM-CLA-11.01)	85 kW
Streeter Hall (ECM-STR-11.01)	64 kW

Table 6 - Solar PV ECM's

5. Envelope ECM'S

It was discussed with Clackamas that the building envelope (including the wall/roof insulation and glazing) was in particularly bad condition on the Bill Brod Community Center. The energy model was therefore used to test the energy efficiency gain of upgrading the insulation and glazing to current building code requirements, including sealing the building to reduce infiltration. Note: it is likely that the Bill Broad Community Center will be replaced as part of the future (and currently unfunded) Wacheno Phase 2 project.

Building	Envelope ECM
Bill Brod (ECM-BIL-6.01)	Building Envelope (Wall/Roof/Glazing) improvements to current code requirements.

Table 7 – Envelope ECM's

4. Energy Modeling Results and Cost Analysis

Current Energy Use

As per detailed in the Energy Modeling Narrative section of the report, the models were first developed using as-built documents and field observations and then calibrated to the utility bills.

The results of the current building's energy uses have been displayed in Figure 5. The energy use has been split into electricity and natural gas and displayed as Energy Use Intensity (EUI). EUI is the annual energy use (kBtu) normalized over the buildings floor area (kBtu/square foot).

The five buildings connected to the central plant chiller are shown as one results, as they were combined into one model as previously outlined.

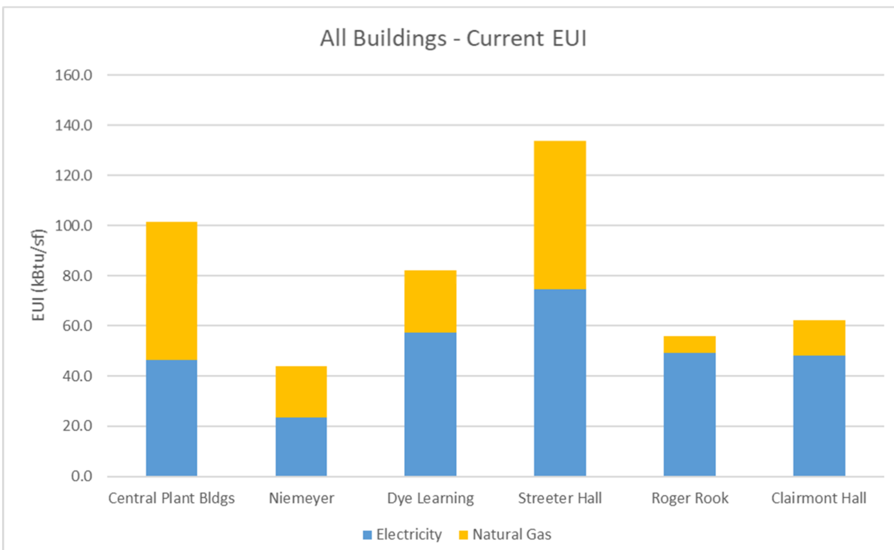


Figure 5 - Current building energy uses

The results indicate that Streeter Hall and the five buildings connected to the central plant chiller have the highest energy use intensity and therefore the greatest potential for improvement. Streeter Hall has a relatively small floor area compared to the other buildings, and the five connected buildings make up the majority of the floor area. Therefore, the central plant buildings should be the focus for making the biggest campus impact.

The energy use intensity results can also be used to compare Clackamas Community College's energy use performance to similar functioning buildings in the same climate area. Figure 6 has been produced to show this comparison. The EUI of all 10 buildings were combined into one which resulted in an overall campus EUI of 87. This was then compared to:

- The Median EUI of college campus buildings located in the same climate area of Oregon as measured and collated by CBECS (Commercial Building Energy Consumption Survey)

- An approximate target EUI for a new college building design in the same area.

The comparisons show that as a campus, Clackamas' energy use is slightly higher than the typical college campus, and significant improvements would be required to bring the campus in-line with new building designs.

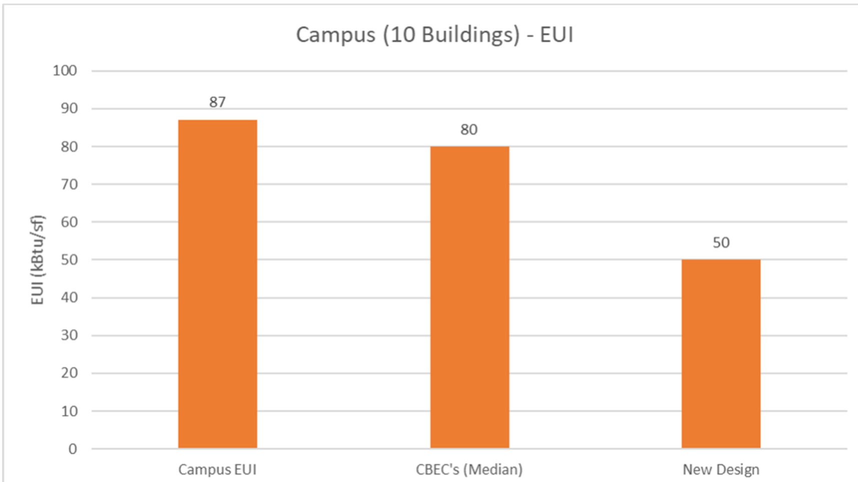


Figure 6 - EUI comparisons

ECM Energy Results and Cost Analysis

The results for the ECM's for each building have been displayed with four metrics:

Metric	Description
EUI Savings	The energy savings for each ECM in terms of EUI (energy use intensity).
Additional First Cost	For each ECM, a ROM first cost was calculated. These costs were calculated in a similar fashion to the FCA costs, where contractor costs were used and extrapolated over different size equipment or square footage. As the ECM's are design alternates to like-for-like replacement, the first costs have been displayed as the additional cost over directly replacing the equipment as derived in the FCA. For example, the cost displayed for a condensing boiler is the cost premium over replacing the existing boiler system with like-for-like. The same escalation and soft cost factors have been applied to each first cost calculation. For large multi-year projects such as decentralization, adjustments to these

	factors will need to be made once project schedules are known. (Lighting and PV differ in they are direct first costs, as like-for-like replacements have not been analyzed for these systems)
Annual Energy & Operational Cost Savings	The annual energy savings were calculated by converting the energy savings into an energy cost savings using the utility rates provided by Clackamas. The operational cost savings were estimated based on using typical median maintenance cost/s.f. for a college facility for the different systems being compared. This data was gathered from research done by the 'Consulting Specifying Engineer'. The above two costs were then combined for the annual Energy and Operational costs for each ECM.
Return on Investment (ROI)	The return on investment has been calculated using the simple payback method and is the return on investment of the cost premium over selecting the ECM (design alternate) over like-for-like replacement. (Lighting and PV differ in they are direct return on investment based on the installation costs, as like-for-like replacements have not been analyzed for these systems)

Table 8 - Results Description

The tables below show the results for each of the buildings. The first three rows show an overview of the building:

- FCA First Costs (Total for Building): the full cost to replace everything outlined in the FCA for the building like-for-like).

- FCA First Cost (Baseline for ECM's): The cost to replace all MEP systems being considered in the ECM's like-for-like)

- Current EUI: The current EUI of the building. (as discussed previously Barlow, McLoughlin, Randall, Bill Brod, and Pauling A&B were all modeled in the same energy model and so their combined current EUI has been shown).

Barlow Building A					
FCA First Cost (Total for Barlow)		$8,556,200			
FCA First Cost (Baseline for ECM's)		$1,214,813			
Current EUI		101.4			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-BAR-1.01A	HVAC (Water Side) Opt A. Decentralize & Decarb (Heat Pumps)	16.6	$133,400	$5,400	24.7
ECM-BAR-1.01B	HVAC (Water Side) Opt B. Decentralize	3.7	$11,100	$5,300	2.1
ECM-BAR-4.01	HVAC (Air Side)	30.4	$2,145,700	$34,800	61.7
ECM-BAR-5.01A	Lighting Opt A. Network Lighting Controls	17.2	$624,000	$22,000	28.4
ECM-BAR-5.01B	Lighting Opt B. Integrated Lighting Controls	17.2	$208,000	$22,000	9.5
ECM-BAR-11.01	PV	15.3	$624,000	$18,400	33.9

Table 9 - Barlow Building A Results

Randall Hall					
FCA First Cost (Total for Randall)		$3,383,800			
FCA First Cost (Baseline for ECM's)		$1,108,552			
Current EUI		101.4			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-RAN-1.01A	HVAC (Water Side) Opt A. Decentralize & Decarb (Heat Pumps)	36.1	$154,100	$8,900	17.3
ECM-RAN-1.01B	HVAC (Water Side) Opt B. Decentralize	3.5	$13,000	$6,200	2.1
ECM-RAN-4.01	HVAC (Air Side)	9.4	$1,686,900	$36,300	46.5
ECM-RAN-5.01A	Lighting Opt A. Network Lighting Controls	7.4	$720,000	$15,000	48.0
ECM-RAN-5.01B	Lighting Opt B. Integrated Lighting Controls	7.4	$240,000	$15,000	16.0
ECM-RAN-11.01	PV	15.3	$720,000	$21,200	34.0

Table 10 - Randall Hall Results

McLoughlin					
FCA First Cost (Total for McLoughlin)		$3,614,961			
FCA First Cost (Baseline for ECM's)		$993,232			
Current EUI		101.4			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-MCL-1.01A	HVAC (Water Side) Opt A. Decentralize & Decarb (Heat Pumps)	11.3	$120,600	$6,100	19.8
ECM-MCL-1.01B	HVAC (Water Side) Opt B. Decentralize	4.3	($2,400)	$6,100	-0.4
ECM-MCL-4.01	HVAC (Air Side)	23.9	$1,634,700	$31,200	52.4
ECM-MCL-5.01A	Lighting Opt A. Network Lighting Controls	5.4	$627,600	$9,400	66.8
ECM-MCL-5.01B	Lighting Opt B. Integrated Lighting Controls	5.4	$209,200	$9,400	22.3
ECM-MCL-11.01	PV	15.3	$627,000	$18,500	33.9

Table 11 - McLoughlin Results

Bill Brod Community Center					
FCA First Cost (Total for Bill Brod Community Center)		$4,795,809			
FCA First Cost (Baseline for ECM's)		$398,090			
Current EUI		101.4			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-BIL-1.01A	HVAC (Water Side) Opt A. Decentralize & Decarb (Heat Pumps)	14.2	$85,800	$3,400	25.2
ECM-BIL-1.01B	HVAC (Water Side) Opt B. Decentralize	4.2	$18,900	$3,200	5.9
ECM-BIL-4.01	HVAC (Air Side)	13.3	$9,900	$5,600	1.8
ECM-BIL-5.01A	Lighting Opt A. Network Lighting Controls	5.1	$341,400	$6,700	51.0
ECM-BIL-5.01B	Lighting Opt B. Integrated Lighting Controls	5.1	$113,800	$6,700	17.0
ECM-BIL-6.01	Envelope	9.1	$176,400	$2,400	73.5
ECM-BIL-11.01	PV	15.4	$342,000	$10,100	33.9

Table 12 - Bill Brod Community Center Results

Pauling A&B					
FCA First Cost (Total for Pauling)		$1,331,860			
FCA First Cost (Baseline for ECM's)		$441,807			
Current EUI		101.4			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-PAU-1.01A	HVAC (Water Side) Opt A. Decentralize & Decarb (Heat Pumps)	20.7	$56,300	$1,500	37.5
ECM-PAU-1.01B	HVAC (Water Side) Opt B. Decentralize	2.5	$16,800	$1,400	12.0
ECM-PAU-4.01	HVAC (Air Side)	33.6	$678,200	$13,100	51.8
ECM-PAU-5.01A	Lighting Opt A. Network Lighting Controls	6.6	$201,900	$5,500	36.7
ECM-PAU-5.01B	Lighting Opt B. Integrated Lighting Controls	6.6	$67,300	$5,500	12.2
ECM-PAU-11.01	PV	15.3	$201,000	$6,000	33.5

Table 13 - Pauling A&B Results

Niemeyer					
FCA First Cost (Total for Niemeyer)		$2,269,353			
FCA First Cost (Baseline for ECM's)		$208,986			
Current EUI		43.9			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-NIE-1.01A	HVAC (Water Side) Opt A. Decentralize & Decarb (Heat Pumps)	14.5	$34,600	$5,700	6.1
ECM-NIE-1.01B	HVAC (Water Side) Opt B. Decentralize	5.6	($74,400)	$9,000	-8.3
ECM-NIE-1.03	HVAC (Water Side) Replace DX with Air Cooled Chiller	0.0	$278,300	$0	N/A
ECM-NIE-4.01	HVAC (Air Side)	N/A	N/A	N/A	N/A
ECM-NIE-5.01A	Lighting Opt A. Network Lighting Controls	5.9	$762,600	$13,500	56.5
ECM-NIE-5.01B	Lighting Opt B. Integrated Lighting Controls	5.9	$254,200	$13,500	18.8
ECM-NIE-11.01	PV	11.2	$555,000	$16,000	34.7

Table 14 - Niemeyer Results

Dye Learning Center					
FCA First Cost (Total for Dye Learning)		$1,505,900			
FCA First Cost (Baseline for ECM's)		$59,000			
Current EUI		82.2			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-DYE-1.01A	HVAC (Water Side) Opt A. Condensing Boilers and Heat Pumps (Decarb)	17.5	$85,000	$1,400	60.7
ECM-DYE-1.01B	HVAC (Water Side) Opt B. Condensing Boilers	3.3	$15,000	$700	21.4
ECM-DYE-1.03	HVAC (Water Side) Replace DX with Air Cooled Chiller	-0.7	$174,100	($400)	N/A
ECM-DYE-5.01A	Lighting Opt A. Network Lighting Controls	8.2	$348,100	$10,100	34.5
ECM-DYE-5.01B	Lighting Opt B. Integrated Lighting Controls	8.2	$116,100	$10,100	11.5
ECM-DYE-11.01	PV	15.5	$351,000	$10,400	33.8

Table 15 - Dye Learning Results

Roger Rook					
FCA First Cost (Total for Roger Rook)		$813,380			
FCA First Cost (Baseline for ECM's)		$0			
Current EUI		55.9			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-ROG-1.01A	HVAC (Water Side) Opt A. Condensing Boilers and Heat Pumps (Decarb)	7.3	$99,400	$300	331.3
ECM-ROG-1.01B	HVAC (Water Side) Opt B. Condensing Boilers	1.5	$50,700	$300	169.0
ECM-ROG-1.03	HVAC (Water Side) Replace DX with Air Cooled Chiller	0.2	$186,400	$200	932.0
ECM-ROG-5.01A	Lighting Opt A. Network Lighting Controls	7.2	$372,700	$7,600	49.0
ECM-ROG-5.01B	Lighting Opt B. Integrated Lighting Controls	7.2	$124,300	$7,600	16.4
ECM-ROG-11.01	PV	15.3	$372,000	$11,000	33.8

Table 16 - Roger Rook Results

Streeter Hall					
FCA First Cost (Total for Streeter Hall)		$1,032,146			
FCA First Cost (Baseline for ECM’s)		$45,500			
Current EUI		133.7			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-STR-1.01A	HVAC (Water Side) Opt A. Condensing Boilers and Heat Pumps (Decarb)	60.6	$70,500	$700	100.7
ECM-STR-1.01B	HVAC (Water Side) Opt B. Condensing Boilers	12.5	$10,500	$1,300	8.1
ECM-STR-1.03	HVAC (Water Side) Replace DX with Air Cooled Chiller	-0.1	$96,700	$0	N/A
ECM-STR-5.01A	Lighting Opt A. Network Lighting Controls	13.7	$193,300	$10,800	17.9
ECM-STR-5.01B	Lighting Opt B. Integrated Lighting Controls	13.7	$64,500	$10,800	6.0
ECM-STR-11.01	PV	15.2	$192,000	$5,700	33.7

Table 17 - Streeter Hall Results

Clairmont Hall					
FCA First Cost (Total for Clairmont)		$2,985,072			
FCA First Cost (Baseline for ECM’s)		$1,125,255			
Current EUI		62.2			
ECM #	ECM Description	EUI Savings	Additional Cost	Energy/ Operation Cost Savings	ROI
ECM-CLA-4.01	HVAC (Air Side)	21.9	$367,200	$9,900	37
ECM-CLA-5.01A	Lighting Opt A. Network Lighting Controls	7.8	$256,600	$7,000	36.7
ECM-CLA-5.01B	Lighting Opt B. Integrated Lighting Controls	7.8	$85,600	$7,000	12.2
ECM-CLA-11.01	PV	15.2	$255,000	$11,000	23.2

Table 18 - Clairmont Hall Results

To help interpret the total cost and EUI implications of choosing multiple ECM's for a building, graphs of this scenario has been created below (using Randall as an example).

Figure 7 shows the full cost of replacing all equipment identified in the FCA as $3,383,800. It then shows the additional cost (on top of the FCA cost) for each of the ECM measures. The bar on the right shows the total cost of upgrades to the buildings if all the equipment in the FCA was replaced, plus implementing all the ECM measures.

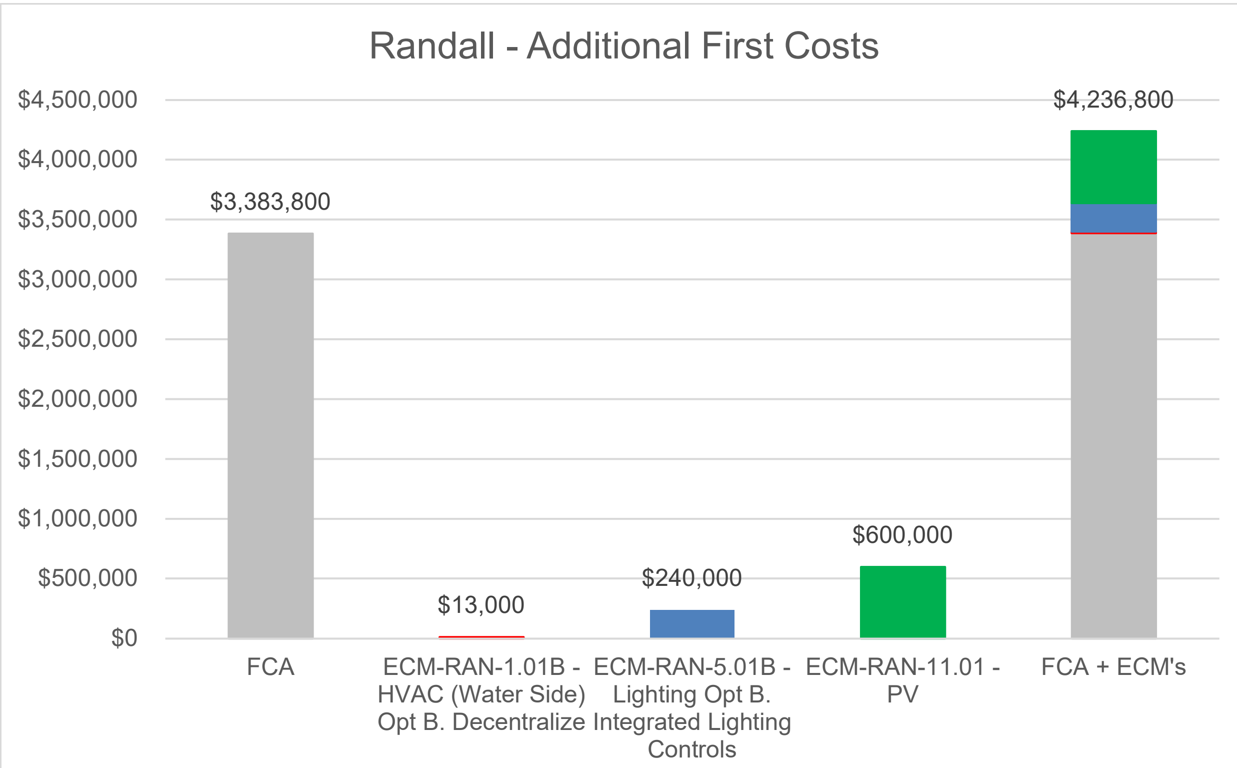


Figure 7 - Randall ECM Additional Costs

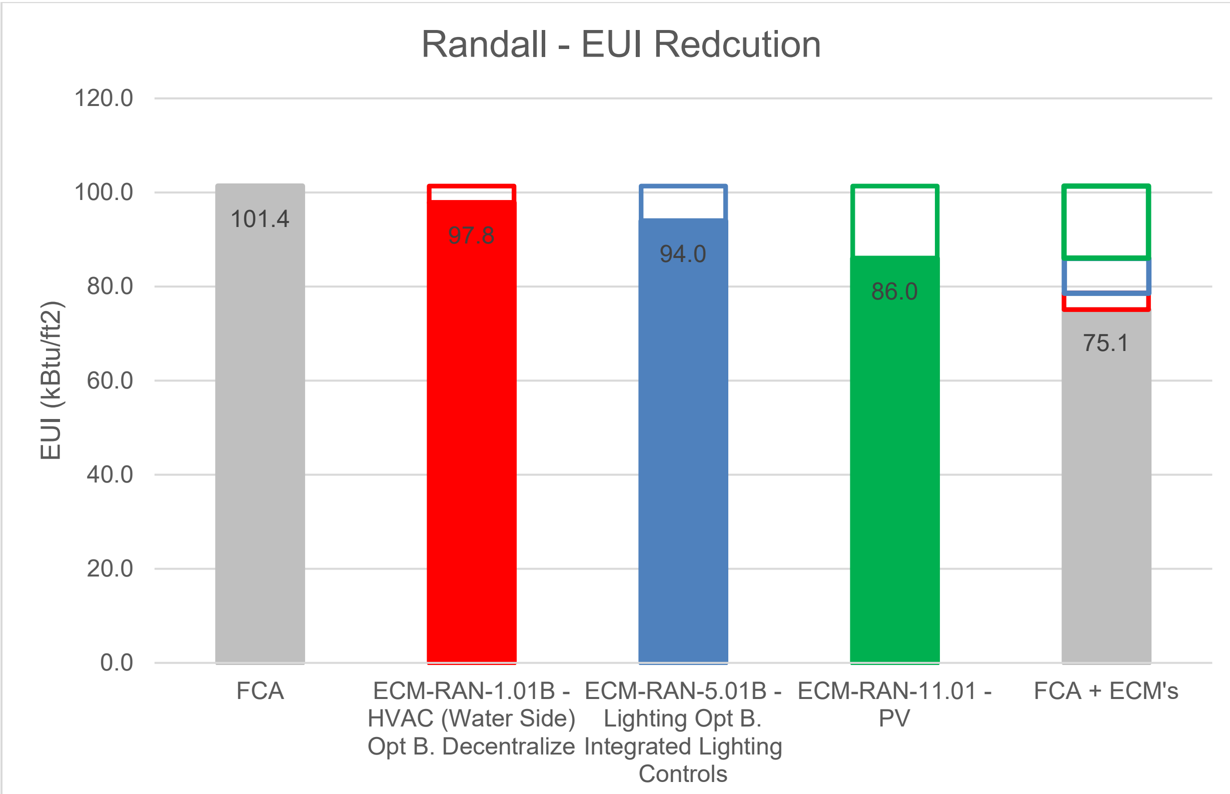


Figure 8 - Randall EUI Reduction from ECM's

5. Recommendations

The previous section displayed the energy modeling results of each of the buildings, including first cost, effect on EUI and energy/operational cost savings.

To help compare the alternates and choose which ECM's to pursue, we have developed summary tables of the return on investment (ROI) of each of the options. The first table display's the buildings connected to the central plant and the second table shows the outlying four buildings.

The ROI figures have been colored based on initial recommendations.
Red = Not recommended
Orange = Recommended only if full building re-model or renovation is undertaken
Green = Recommended

An explanation on the reasoning for the recommendations has been provided after the tables.

Note: As previously discussed, the ROI is based on the cost difference between replacing like-for-like (FCA costs) versus the energy efficient alternates as discussed previously.

ECM #	ECM Measure	Barlow	Randall	McLoughlin	Bill Brod	Pauling	Niemeyer
ECM-1.01A	HVAC (Water Side) Opt A. Decentralize & Decarb (Heat Pumps)	24.7	17.3	19.8	25.2	37.5	6.1
ECM-1.01B	HVAC (Water Side) Opt B. Decentralize	2.1	2.1	0.0	5.9	12.0	0.0
ECM-1.03	HVAC (Water Side) Replace DX with Air Cooled Chiller	-	-	-	-	-	*
ECM-4.01	HVAC (Air Side)	61.7	46.5	52.4	1.8	51.8	-
ECM-5.01A	Lighting Opt A. Network Lighting Controls	28.4	48.0	66.8	51.0	36.7	56.5
ECM-5.01B	Lighting Opt B. Integrated Lighting Controls	9.5	16.0	22.3	17.0	12.2	18.8
ECM-6.01	Envelope	-	-	-	73.5	-	-
ECM-11.01	PV	28.3	28.3	28.2	28.2	27.9	28.9
* Energy use of alternate ECM is higher than like-for-like replacement. ROI not accessible. Measure is for improved temperature controls and comfort, not an energy saving decision.							

Table 19 - Summary of ECM ROI's (Buildings Connected to Central Plant)

ECM #	ECM Measure	Dye Learning	Roger Rook	Streeter	Clairmont
ECM-1.01A	HVAC (Water Side) Replace Existing Boiler w Heat Pumps & Condensing Boilers (Decarb)	60.7	-	100.7	-
ECM-1.01B	HVAC (Water Side) Replace Existing Boiler w Condensing Boilers Only	21.4	-	8.1	-
ECM-1.03	HVAC (Water Side) Replace DX with Air Cooled Chiller	*	*	*	*
ECM-4.01	HVAC (Air Side)	-	-	-	37.1
ECM-5.01A	Lighting Opt A. Network Lighting Controls	34.5	49.0	17.9	36.7
ECM-5.01B	Lighting Opt B. Integrated Lighting Controls	11.5	16.4	6.0	12.2
ECM-6.01	Envelope	-	-	-	-
ECM-11.01	PV	28.1	28.2	28.1	19.3
* Energy use of alternate ECM is higher than like-for-like replacement. ROI not accessible. Measure is for improved temperature controls and comfort, not an energy saving decision.					

Table 20 - Summary of ECM ROI's (Building Not Connected to Central Plant)

ECM-1.01A: HVAC (Water Side) Replace Existing Boiler w Heat Pumps & Condensing Boilers (Decarb)

The energy savings and path to decarbonization are excellent with this option, but the heat pumps would need to be air the air-cooled variety for this building type and function, and multiple heat pumps would need to be purchased to satisfy each building (including condensing boilers for backup). This ECM has not been recommended due to the large first costs which are producing unreasonable payback periods. A hybrid approach could be taken where most of the heat is produced via condensing boilers, and one or two heat pumps are installed to reduce the reliance on natural gas to head towards decarbonization with a reduced first cost.

ECM-1.01B: HVAC (Water Side) Replace Existing Boiler w Condensing Boilers Only

This option is recommended to help the facility towards it's decentralization goals.

On the hot water side, installing the condensing boilers provides a significant energy savings over the centralized steam system and would remove all the maintenance requirements of the steam system and its associated equipment, as well as all the steam distribution piping. The return on investment periods are excellent considering the costs to replace all the aging steam boilers, equipment and piping would be removed.

On the chilled water side, the energy savings are minimal. The new air-cooled chillers will be less efficient than the current water cooled chillers in the central plant, but they will provide the flexibility to operate each building individually, and not operate a central chiller just for one building. There will be more equipment to maintain with this option, but the equipment will be simpler and there will be no distribution piping systems from the CUP to the outer buildings to be maintained.

ECM-1.03: HVAC (Water Side) Replace DX with Air Cooled Chiller

This ECM was analyzed due to Clackamas concern with the DX systems and their ability to maintain tight comfort control. The energy results show that an Air Cooled System actually performs slightly less efficient than the DX system, due to the additional pumping systems required, and the fact the Air Cooled chiller would only be serving one or two cooling coils in each building. It is also difficult to source an air cooled chilled of such small size. This ECM is not recommended.

ECM-4.01: HVAC (Air Side)

In almost all options the new HVAC systems analyzed provided large energy savings, better comfort control and reduced maintenance. The downside with most of the HVAC options is they require a whole system replacement, including the air handling units, ductwork and terminal units. This becomes cost prohibitive as the construction work would be required throughout the entire building, and therefore this option is recommended only if a major renovation or remodel of the building was occurring.

The Bill Brod Community Center is an exception to this, as the measure was just focused on the kitchen hoods. It is recommended to further pursue this option.

ECM-5.01A/B: Lighting

The energy results show that good energy savings can be achieved through the replacement of lighting with LED and upgrading the lighting controls.

Option 1 provides a new programmable and network-able lighting control system which is consistent with the other new buildings on the campus. This option is however much more expensive than Option 2 and only recommended is a full building remodel/renovation was occurring.

Option 2 provides a method to quickly achieve a One-to-One replacement of the existing light fixtures with new LED fixtures that are equipped with built-in/integral occupancy/vacancy sensors. This option is recommended if the Facility wanted to upgrade their lighting without a full building remodel/renovation.

Both Options yield the same energy/cost savings.

ECM-6.01: Envelope

Replacing the envelope is a significant first cost which will not pay pack from the associated energy savings. It is recommended to undertake this option only if a full building remodel/renovation is occurring (in which case building code regulations may dictate this upgrade).

ECM-11.01: PV

Installing PV is a great option for reducing Clackamas' reliance on the electricity grid, providing a source of renewable energy and heading towards Clackamas' goal of decarbonization.

There are many options for how the PV is installed (on each building, or one common system for the campus), and whether sized for just the campus/building, or feeding back into the grid.

The results show there are significant energy savings/carbon reductions that can be realized through PV. The first costs show that the payback period is between 20-30 years, but this is a conservative estimate as we do not yet have a design to work with.

PV panels in Oregon have been shown to have payback periods between 10-20 years on average and therefore we recommend that PV panels are still considered for the site and work undertaken with a PV manufacturer to determine the best fit for the campus.

Summary

Table 21 and Figure 9 and displays a summary of the costs associated with each building based on the recommendation outlined above (including buildings not including in the energy modeling portion of the project).

The table shows the total cost to replace all equipment like-for-like per the FCA documentation in the first column. It then shows the additional of adding in all the recommended ECM's, the savings associated with those and the resultant ROI.

Building	FCA Costs	Additional Costs for Recommended ECM's	FCA + Recommended ECM Costs	Annual Energy/ Operating Cost Savings	ROI from Additional Recommended ECM Costs
Barlow Building A	$8,556,200	$739,100	$9,295,300	$45,700	16.2
Bill Brod	$4,795,809	$427,600	$5,223,409	$25,600	16.7
McLoughlin	$3,614,961	$729,300	$4,344,261	$34,000	21.5
Pauling A&B	$1,331,860	$251,600	$1,583,460	$12,900	19.5
Randall Hall	$3,383,800	$853,000	$4,236,800	$42,400	20.1
Clairmont Hall	$2,985,072	$298,100	$3,283,172	$18,000	16.6
Dye Learning	$1,505,900	$423,600	$1,929,500	$21,200	20.0
Niemeyer	$2,269,353	$642,300	$2,911,653	$38,500	16.7
Roger Rook	$813,380	$434,300	$1,247,680	$18,600	23.3
Streeter Hall	$1,032,146	$235,000	$1,267,146	$17,800	13.2
Arts Center	$595,319	-	$595,319	-	-
DeJardin	$665,264	-	$665,264	-	-
Gregory Forum	$1,076,162	-	$1,076,162	-	-
Streeter Annex	$310,323	-	$310,323	-	-
Training Center A	$1,382,798	-	$1,382,798	-	-
Training Center B	$778,418	-	$778,418	-	-
Barlow CUP	$4,346,800	-	$4,346,800	-	-
TOTAL	**$39,502,838**	**$9,812,266**	**$49,315,104**	**$290,770**	**18.3**

Table 21 - Summary of Costs Based on Recommended ECM's

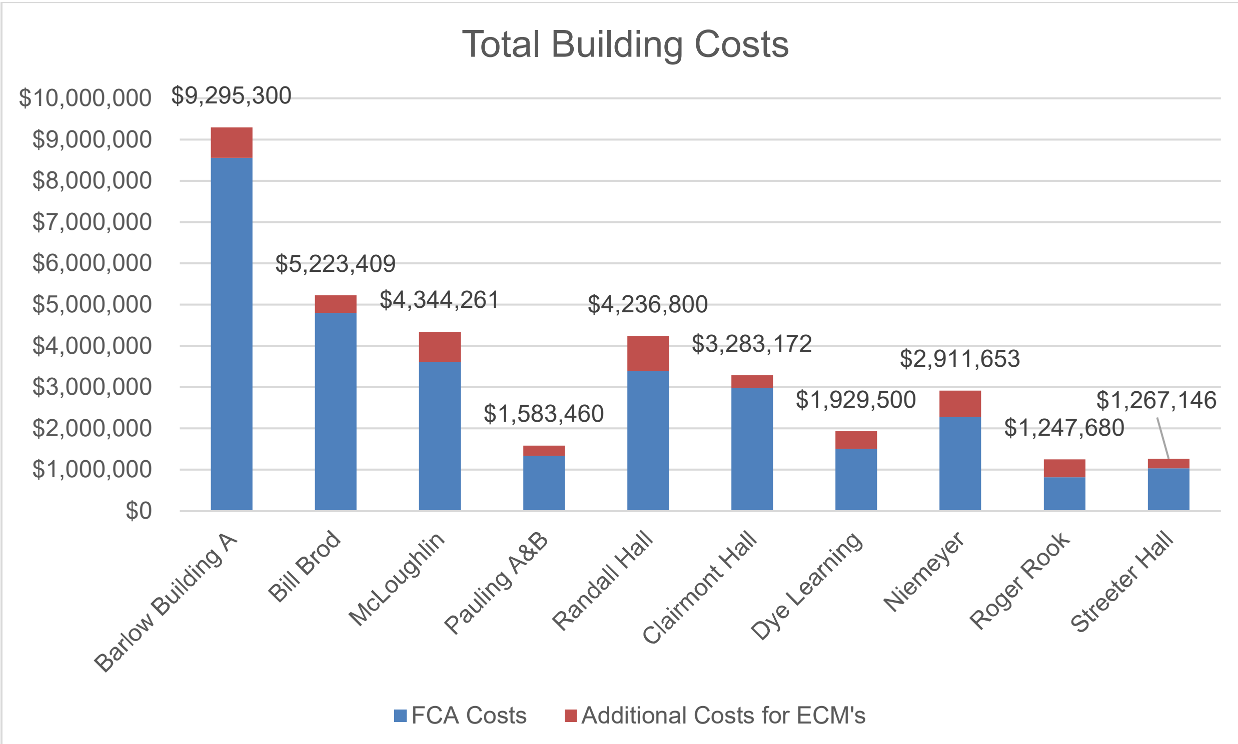
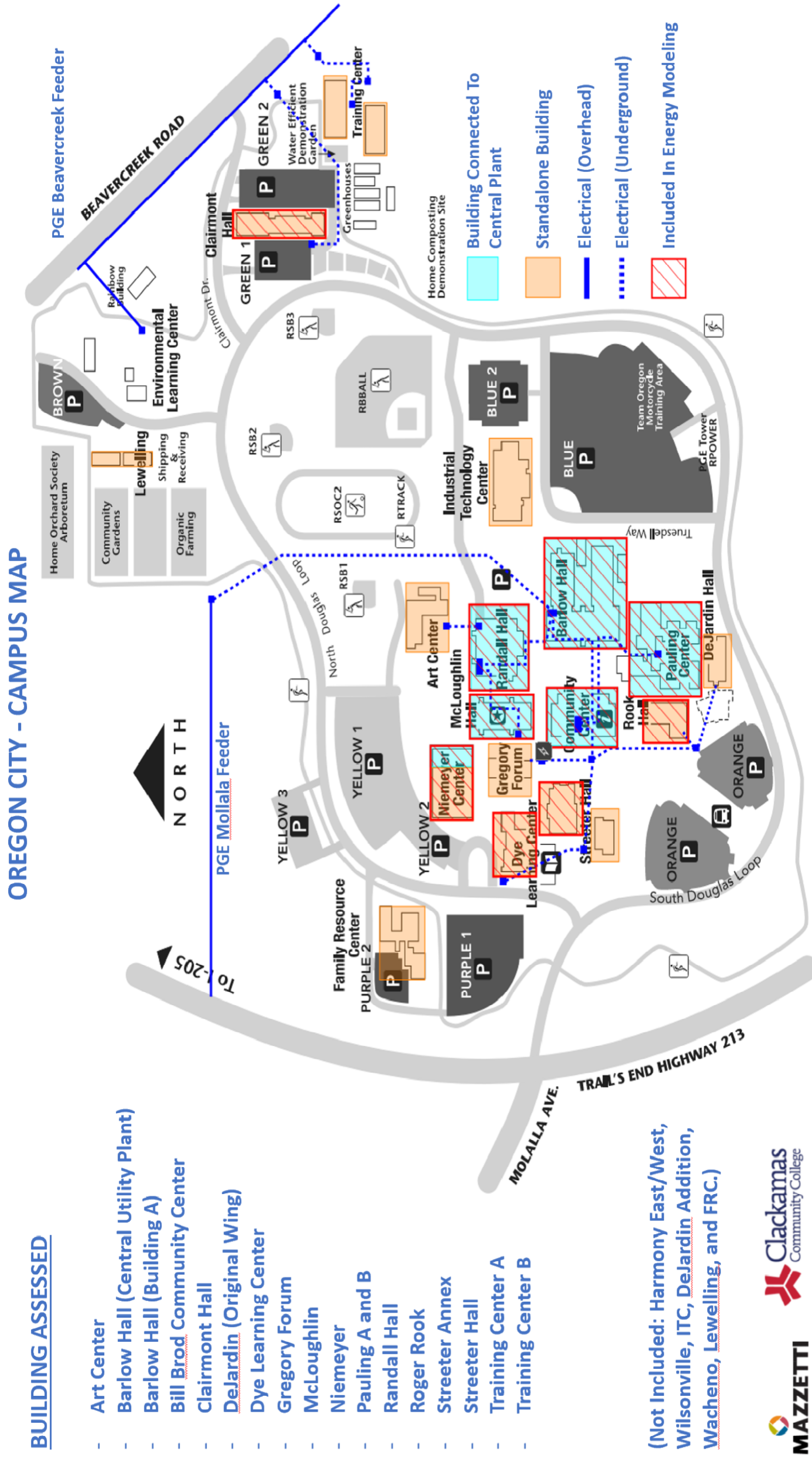


Figure 9 – Total Building Costs including FCA Costs and recommended ECM Costs

Appendix A – Campus Map



Appendix B – Scoring Criteria

CATEGORY	SCORING (1 THROUGH 5) 1	2	3	4	5
FIRE LIFE SAFETY	CRITICAL OR IMMINENT RISK. REQUIRES IMMEDIATE ATTENTION TO RESOLVE.	STRONG LIFE SAFETY RISK. REQUIRES RESOLUTIONS WITHIN THE NEXT 1.5 YEARS.	MODERATE LIFE SAFETY RISK. REQUIRES RESOLUTIONS WITHIN THE NEXT 3 YEARS.	SLIGHT LIFE SAFETY RISK. REQUIRES RESOLUTION WITHIN 5 YEARS.	NO LIFE SAFEY RISK.
CONDITION	UP TO 5 YEARS BEYOND USEFUL SERVICE LIFE. FREQUENT EXTENDED DOWNTIME FOR REPAIR OR MAINTENANCE. REQUIRES IMMEDIATE ATTENTION TO RESOLVE.	UP TO 5 YEARS BEYOND USEFUL SERVICE LIFE. NOT EXPERIENCING FREQUENT EXTENDED DOWNTIME FOR REPAIR OR MAINTENANCE. REQUIRES RESOLUTION WITHIN THE NEXT 3 YEARS.	UP TO HALF-WAY THROUGH USEFUL SERVICE LIFE. OCCASIONAL DOWNTIME FOR REPAIR OR MAINTENANCE. REQUIRES ATTENTION WITHIN THE NEXT 5 YEARS.	UP TO HALF-WAY THROUGH USEFUL SERVICE LIFE, OCCASIONAL DOWNTIME FOR REPAIR OR MAINTENANCE. REQUIRES ATTENTION WITHIN THE NEXT 10 YEARS.	COMPONENT/SYSTEM HAS BEEN INSTALLED NEW WITHIN THE LAST 5 YEARS. NO KNOWN ISSUES.
REGULATORY CODE	AHJ HAVE ISSUED WRITTEN CITATION OR DOES NOT COMPLY WITH CODE. REQUIRES IMMEDIATE ATTENTION TO RESOLVE.	DEFICIENT IN CODE OR PARTIALLY COMPLIES AND DOES NOT PRESENT FLS ISSUE. REQUIRES RESOLUTION WITHIN THE NEXT 3 YEARS.	DEFICIENT IN CODE OR PARTIALLY COMPLIES AND NOT PRESENT FLS ISSUE. REQUIRES RESOLUTIONS WITHIN THE NEXT 5 YEARS.	GRANDFATHERED IN, COMPLIED WITH CODE AT TIME OF INSTALL, BUT DOES NOT MEET CURRENT CODE. DOES NOT PRESENT FLS ISSUE.	MEETS CURRENT CODE.
CAPACITY	CANNOT MEET CURRENT LOADS AND/OR GROSSLY OVER CAPACITY. REQUIRES IMMEDIATE ATTENTION.	SYSTEM IS AT CAPACITY AND DOES NOT PROVIDE ADEQUATE STANDBY NOR FUTURE CAPACITY. REQUIRES RESOLUTION IN 3 YEARS.	SYSTEM IS AT CAPACITY AND DOES NOT PROVIDE ADEQUATE STANDBY NOR FUTURE CAPACITY. REQUIRES RESOLUTION IN 5 YEARS.	SYSTEM IS AT CAPACITY AND DOES NOT PROVIDE ADEQUATE STANDBY NOR FUTURE CAPACITY. REQUIRES RESOLUTION IN 10 YEARS.	NO CAPACITY ISSUES AND SYSTEM MAINTAINS ADEQUATE STANDBY CAPACITY, PLUS ADDITIONAL TO HANDLE FUTURE LOADS.
ENERGY EFFICIENCY AND SUSTAINABILITY	SIGNIFICANT ENERGY IMPROVEMENT POSSIBLE. SIGNIFICANT IMPACT ON OCCUPANTS AND ENVIRONMENT. IMMEDIATE RETURN ON INVESTMENT.	SIGNIFICANT ENERGY IMPROVEMENT POSSIBLE. SIGNIFICANT IMPACT ON OCCUPANTS AND ENVIRONMENT. RETURN ON INVESTMENT WITHIN 3 YEARS.	GOOD ENERGY IMPROVEMENT. SIGNIFICANT IMPACT ON OCCUPANTS AND ENVIRONMENT. RETURN ON INVESTMENT WITHIN 5 YEARS.	REASONABLE ENERGY IMPROVEMENT. MODERATE IMPACT ON OCCUPANT AND ENVIRONMENT. RETURN ON INVESTMENT WITHIN 7-10 YEARS.	NEGLIGIBLE IMPROVEMENT IN ENERGY EFFICIENCY AND NO ENVIRONMENTAL ISSUES CONSIDERED.
RESILIENCY	DOES NOT MEET THE CURRENT INDUSTRY STANDARDS. REQUIRES IMMEDIATE ATTENTION.	DOES NOT MEET CURRENT INDUSTRY STANDARDS. REQUIRES ATTENTION WITHIN 3 YEARS.	DOES NOT MEET CURRENT INDUSTRY STANDARDS. REQUIRES ATTENTION WITHIN 5 YEARS.	DOES NOT MEET CURRENT INDUSTRY STANDARDS. REQUIRES ATTENTION WITHIN 10 YEARS.	MEETS OR EXCEEDS CURRENT INDUSTRY STANDARDS.

Appendix C – FCA Supporting Files

For FCA supporting files please see M+ Assessment website.

https://assessment.mazzetti.com/

Go to: Clackamas Community College -> Oregon City Campus -> Building -> Files

Appendix D – Detailed ECM Description

1. HVAC ECM's

The following table provides a description of the proposed HVAC ECM's for each building.

Building	HVAC ECM
Barlow **(ECM-BAR-4.01)**	RTU-1, RTU-2 and the Penthouse RTU are past useful life expectancy, use old inefficient dual-duct technology and have pneumatic controls which are failing. It is proposed to replace these units with new more efficient variable air volume (VAV) units. The units will provide energy savings by being able to wind down airflow (significant fan and heating savings), will have advanced optimization controls, and more efficient motors. The scope will include: - Replacing the three AHU's. The new AHU's will have supply and return fans (fan wall technology), hot water pre-heat coil (if required), chilled water coil, air mixing sections and filtration. During design it will be examined whether the units can be replaced in the same position, or whether a new location is necessary. - DDC controls will be installed and include optimized programming for air-side economizer, supply air temperature reset and static pressure reset. - The cooling duct from the existing dual duct system will be examined and reused where possible for the new system. The existing hot duct will be removed. - The dual duct terminal boxes will be replaced with new VAV terminal units with reheat. New hot water piping will be routed to each VAV box to provide reheat. All boxes will include DDC controls.
McLoughlin **(ECM-MCL-4.01)**	North and South Penthouse AHU's are past useful life expectancy, use old inefficient dual duct/multi-zone technology and has DDC controls which are failing. It is proposed to replace these units with new more efficient variable air volume (VAV) units. The units will provide energy savings by being able to wind down airflow (significant fan and heating savings), will have advanced optimization controls, and more efficient motors. The scope will include: - Replacing the two AHU's. The new AHU's will have supply and return fans (fan wall technology), hot water pre-heat coil (if

	required), chilled water coil, air mixing sections and filtration. During design it will be examined whether the units can be replaced in the same position, or whether a new location is necessary. - DDC controls will be installed and include optimized programming for air-side economizer, supply air temperature reset and static pressure reset. - The cooling duct from the existing dual duct system will be examined and reused where possible for the new system. The existing hot duct will be removed. - The dual duct terminal boxes will be replaced with new VAV terminal units with reheat. New hot water piping will be routed to each VAV box to provide reheat. All boxes will include DDC controls.
Randall **(ECM-RAN-4.01)**	RTU-MZU-301, 302 and 303 are past useful life expectancy, use old inefficient multizone technology and have pneumatic controls which are failing. MZU-302 has been converted to DDC using Electric to Pneumatic technology and MZU-301 has been converted to DDC using all electric actuation technology as of December 2022. It is proposed to replace these units with new more efficient variable air volume (VAV) units. The units will provide energy savings by being able to wind down airflow (significant fan and heating savings), will have advanced optimization controls, and efficient motors. The scope will include: - Replacing the three AHU's. The new AHU's will have supply and return fans (fan wall technology), hot water pre-heat coil (if required), chilled water coil, air mixing sections and filtration. During design it will be examined whether the units can be replaced in the same position, or whether a new location is necessary. - DDC controls will be installed and include optimized programming for air-side economizer, supply air temperature reset and static pressure reset. - The existing ducts will be inspected and re-used where possible. VAV terminal hot water reheat boxes will be installed within the ducts, and new hot water piping routed to the boxes.
Bill Brod Community Center **(ECM-BIL-4.01)**	The VAV AHU, Makeup AHU and Kitchen hood are past useful life expectancy and have pneumatic controls which are failing. It is proposed to replace the VAV AHU with a new variable air volume (VAV) unit. The unit will provide energy savings by having advanced optimization controls, and efficient motors. The scope will include:

	- Replacing the AHU. The new AHU will have supply and return fans (fan wall technology), chilled water coil, air mixing sections and filtration. During design it will be examined whether the units can be replaced in the same position, or whether a new location is necessary. - DDC controls will be installed and include optimized programming for air-side economizer, supply air temperature reset and static pressure reset. - The existing ducts and hot water piping will be inspected and replaced/repaired where necessary. It is proposed to replace the Makeup air units and Kitchen Hood with new variable volume capable systems. The kitchen hood will have automatic sensors which indicate when not in use, and can wind down/turn off. The Makeup air unit will modulate according to the airflow required by the hood. Both will save significant fan energy savings, as well as cooling and heating savings. The makeup air unit will have chilled water and heating water coils and have new DDC controls.
Pauling **(ECM-PAU-4.01)**	RTU-3 and RTU-4 AHU's are past useful life expectancy, use old inefficient dual-duct technology and have pneumatic controls which are failing. These RTU's have been converted to DDC and utilize electric to pneumatic controls. It is proposed to replace these units with new more efficient variable air volume (VAV) units. The units will provide energy savings by being able to wind down airflow (significant fan and heating savings), will have advanced optimization controls, and efficient motors. The scope will include: - Replacing the two AHU's. The new AHU's will have supply and return fans (fan wall technology), hot water pre-heat coil (if required), chilled water coil, air mixing sections and filtration. - DDC controls will be installed and include optimized programming for air-side economizer, supply air temperature reset and static pressure reset. - The cooling duct from the existing dual duct system will be examined and reused where possible for the new system. The existing hot duct will be removed. - The dual duct terminal boxes will be replaced with new VAV terminal units with reheat. New hot water piping will be routed to each VAV box to provide reheat. All boxes will include DDC controls.

Niemeyer	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).
Dye Learning	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).
Roger Rook	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).
Clairmont Hall **(ECM-CLA-4.01)**	All RTU's are past useful life expectancy and controls are failing. It is proposed to replace the RTU's with a variable refrigerant (VRF) system. The system will include VRF fan coil units for each space, with heat recovery condenser units located on the roof. These systems provide high efficiency cooling and heating and use heat recovery to provide simultaneous heating and cooling. A separate dedicated outdoor air (DOAS) unit will provide the minimum ventilation requirements for the space. The system is a highly efficient all electric option, which will help in both decentralizing and decarbonizing the facility.
Streeter Hall	No ECM. (As per the FCA, the units should be replaced like for like, with energy savings being realized due to newer efficient equipment and optimized controls).

2. Decentralization and Water Side ECM's

The following table lists the ECM's required for decentralization:

System	Decentralization ECM
Hot Water System	
Barlow/McLoughlin/Randall **Community/Pauling/Niemeyer.** **(ECM-BAR-1.01A & B)** **(ECM-MCL-1.01A & B)** **(ECM-RAN-1.01A & B)** **(ECM-BIL-1.01A & B)** **(ECM-PAU-1.01A & B)** **(ECM-NIE-1.01A & B)**	Option A: Decentralization and Decarbonization Install a combination of high efficiency condenser boilers and high efficiency air cooled electric heat pumps (including new DDC controls) to serve the AHU's and VAV Reheat coils in each of the six buildings. The heat pumps will be used as an all-electric option for providing the heating water to the building (and help the facilities goal of decarbonization), and the condensing boilers will be used as backup and to help meet the load in peak conditions. Existing hot water piping will be inspected and reused where possible. The building will be disconnected from the central steam plant. Randall: Install new hot water coils in the two gymnasium AHU's (ASU_304_A and B) to allow these units to be disconnected from the central steam plant. Niemeyer: Replace gas heating in RTU-2 and 3 with hot water coils. Barlow: The exiting domestic hot water tank (~80% efficient) will be replaced with high efficiency electric water heaters (~92% efficient). The data center will be analyzed to understand how much heat could be recovered and possibly used for pre-heating the DHW. The method for achieving this will be studied during the masterplan phase. Bill Brod Community Center: The exiting domestic hot water tank (~80% efficient) will be replaced with high efficiency electric water heaters (~92% efficient). Demolish the steam boilers in Barlow, including all associated equipment. Remove heat exchanger at each building that convert steam to hot water. Option B: Decentralization This option was the same as Option 1, except the focus on decarbonization (heat pumps) was removed to reduce the installation costs. All heating from the new system will be from Condensing Boilers.

Chilled Water System	
Barlow/McLoughlin/Randall: **(ECM-BAR-1.01A)** **(ECM-MCL-1.01A)** **(ECM-RAN-1.01A)**	Install a new high efficiency air cooled chiller and pumps to serve both the new and existing AHU's (including new DDC controls). Existing chilled water piping will be inspected and reused where possible. The buildings will be disconnected from the central chilled water plant.
Bill Brod/Pauling: **(ECM-BILL-1.01A)** **(ECM-PAU-1.01A)**	Install a new high efficiency air cooled chiller and pumps to serve both the new and existing AHU's (including new DDC controls). Existing chilled water piping will be inspected and reused where possible. The buildings will be disconnected from the central chilled water plant. OR Replace AHU's CHW Coils with DX coils including new DDC controls). Consider variable speed compressors for more accurate control. Existing chilled water piping will be demolished and the building will be disconnected from the central chilled water plant. Final decision on DX versus Air Cooled Chiller to be made during the design process once building loads have been analyzed. Costs have been based on the Air Cooled Chiller option as this is the more expensive option.

The following table lists the Water Side ECM measures:

Building	Water Side ECM's
Niemeyer **(ECM-NIE-1.03)**	Replace DX coils in RTU-2 and 3 with CHW coils. Install a new high efficiency air cooled chiller and pumps to serve both the new CHW coils and new RTU-1 (including new DDC controls).
Dye Learning **(ECM-DYE-1.01A & B)** **(ECM-DYE-1.03)**	<u>Option A: Condensing Boilers & Heat Pumps (Decarbonization)</u> Install a combination of high efficiency condenser boilers and high efficiency air cooled electric heat pumps (including new DDC controls) to serve the RTU's and VAV reheat coils. The heat pumps will be used as an all-electric option for providing the heating water to the building (and help the

	facilities goal of decarbonization), and the condensing boilers will be used as backup and to help meet the load in peak conditions. Existing hot water piping will be inspected and reused where possible. Demolish the existing hot water boiler and pumps. Option B: Condensing Boilers Only This option was the same as Option 1, except the focus on decarbonization (heat pumps) was removed to reduce the installation costs. Air Cooled Chiller Install a new high efficiency air cooled chiller and pumps to serve the new CHW coils (including new DDC controls).
Roger Rook **(ECM-ROG-1.03)**	Install a new high efficiency air cooled chiller and pumps to serve the new CHW coil (including new DDC controls).
Streeter Hall **(ECM-STR-1.01A & B)** **(ECM-STR-1.03)**	Option A: Condensing Boilers & Heat Pumps (Decarbonization) Install a combination of high efficiency condenser boilers and high efficiency air cooled electric heat pumps (including new DDC controls) to serve the VAV reheat coils. The heat pumps will be used as an all-electric option for providing the heating water to the building (and help the facilities goal of decarbonization), and the condensing boilers will be used as backup and to help meet the load in peak conditions. Existing hot water piping will be inspected and reused where possible. Demolish the existing hot water boiler and pumps. Option B: Condensing Boilers Only This option was the same as Option 1, except the focus on decarbonization (heat pumps) was removed to reduce the installation costs. Air Cooled Chiller Install a new high efficiency air cooled chiller and pumps to serve the new CHW coils (including new DDC controls).

Appendix E – Description of Referenced Cost Data

The below tables outline the various costs that were referenced throughout the analysis. The next page shows the cost analysis provided by Fortis to help derive some of the costs.

Utility Costs		
Electricity	$0.083	/kWh
Natural Gas	$0.63	/Therm

MEP Cost Data		
Cost for New Building	$540	/sqft
Cost for Mechanical System (VAV) in New Building	$54	/sqft
Cost for Lighting Opt A. Network Lighting Controls	$12	/sqft
Cost for Lighting Opt B. Integrated Lighting Controls	$4	/sqft
Cost for new PV System	$2.5	/W

O&M Savings		
O&M Savings for New HVAC System over the Dual Duct/Multizone Systems	$0.40	/sqft
O&M Savings for Decentralized System over maintaining the CUP and Distribution Systems	$0.10	/sqft
O&M Savings for new LED Lighting over existing Lighting	$0.02	/sqft
Additional O&M Costs for installing PV	($0.02)	/sqft

FORTIS CONSTRUCTION INC.

Clackamas Community College

EXECUTIVE SUMMARY - COST MODELS

PROJECT: TBD **11/12/2021**
LOCATION: Oregon
OWNER: CCC

		Building			
	Building Area	50,000 sqft			
	Description	Total	$/sqft	% Total	Notes
01	DEMOLITION	$ 100,000	$2.00	0%	Minor clearing only
02	SITEWORK	$ 1,250,000	$25.00	5%	
03	FOUNDATIONS	$ 475,000	$9.50	2%	
04	SUBSTRUCTURE	$ 307,500	$6.15	1%	
05	SUPERSTRUCTURE	$ 3,750,000	$75.00	14%	Seismic/retrofit = $45 to $60/sf
06	EXTERIOR SKIN	$ 3,100,000	$62.00	11%	
07	ROOFING	$ 750,000	$15.00	3%	
08	INTERIOR CONSTRUCTION	$ 2,850,000	$57.00	11%	
09	CONVEYING	$ 290,000	$5.80	1%	One elevator
10	SPECIAL CONSTRUCTION	$ 100,000	$2.00	0%	No specialty owner equipment
11	PLUMBING/PROCESS PIPING	$ 850,000	$17.00	3%	No labs
12	FIRE PROTECTION	$ 237,500	$4.75	1%	
13	MECHANICAL	$ 2,700,000	$54.00	10%	VAV w/water reheat
14	ELECTRICAL	$ 2,100,000	$42.00	8%	Telecom, AV, Security
15	JOBSITE MANAGEMENT	$ 2,000,000	$40.00	7%	
16	SITE REQUIREMENTS	$ 300,000	$6.00	1%	
	SUBTOTAL	$ 21,160,000	$423.20	78%	
	MARKUPS				
5.00%	Escalation	$ 1,058,000	$21.16	4%	Range 3-5% annually
10.00%	Design Contingency	$ 2,116,000	$42.32	8%	
3.00%	Construction Contingency	$ 730,020	$14.60	3%	
0.00%	Permit Fees - By Owner	$ -	$0.00	0%	
1.20%	Liability Insurance	$ 300,768	$6.02	1%	
1.20%	Sub Bond Program	$ 46,848	$0.94	0%	
0.70%	Payment and Performance Bond	$ 177,881	$3.56	1%	
1.00%	All Risk Insurance	$ 255,895	$5.12	1%	Non-wood structure
2.60%	Fee	$ 671,981	$13.44	2%	
0.40%	Preconstruction Services	$ 84,640	$1.69	0%	
1.50%	Solar / Alternative Energy	$ 399,031	$7.98	1%	
	TOTAL BUILDING	**$ 27,001,064**	**$540.02**	**100%**	