



**FOR
ENDORSEMENT AND
FORWARDING**

CLOSED SESSION

TO: Executive Committee

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CONTACT INFO:

DATE: March 5, 2026 for March 12, 2026

AGENDA ITEM: 3(c)

ITEM IDENTIFICATION:

University of Toronto Facilities & Services Project Concept Report for the Climate Positive Campus – **Project LEAP 2.0 - Project Scope & Sources of Funding**

JURISDICTIONAL INFORMATION:

5.1 The Executive Committee is responsible for the preparation of the agenda for meetings of the Governing Council. As part of this responsibility, the Committee receives and reviews reports of other committees for transmittal to the Governing Council.

The Policy on Capital Planning and Capital Projects provides that capital projects with costs in excess of \$50 million (Approval Level 3) on the St. George campus, will first be considered by the Planning & Budget Committee, which shall recommend approval to Academic Board. Following consideration and by the Academic Board and approval for execution by the Business Board, such proposals are then brought forward to the Executive Committee for endorsement, and then forwarded to the Governing Council for approval. [Section 3(b)(ii)(1)(b) and (d)] The Policy further states that "any financing will be approved by the Business Board". [Section 3(c)].

GOVERNANCE PATH:

A. Total Project Cost, and Sources of Funding:

1. Planning and Budget [for recommendation] (February 11, 2026)
2. Academic Board [for recommendation] (February 26, 2026)

3. **Executive Committee [for endorsement and forwarding] (March 12, 2026)**
4. Governing Council [for approval] (March 26, 2026)

B. Execution of the Project:

1. Business Board [For approval] (March 4, 2026)

PREVIOUS ACTION TAKEN:

In 2021, the Climate Positive Campus Plan was presented to Governing Council.

HIGHLIGHTS:

The University of Toronto's commitment to become climate positive is strong—it is also forward-looking. Decisive and impactful action must be taken today.

On the University's journey to become climate positive, Facilities and Services is continuing the bold initiative called Climate Positive Leap (Low Emissions Accelerator Project), with Project Leap 2.0.

Project Leap 2.0 will eliminate more than 82% of current scope 1 and scope 2 carbon emissions (estimated total reduction of 3,117 metric tons per year) in five University of Toronto owned buildings.

Project Leap 2.0 goals:

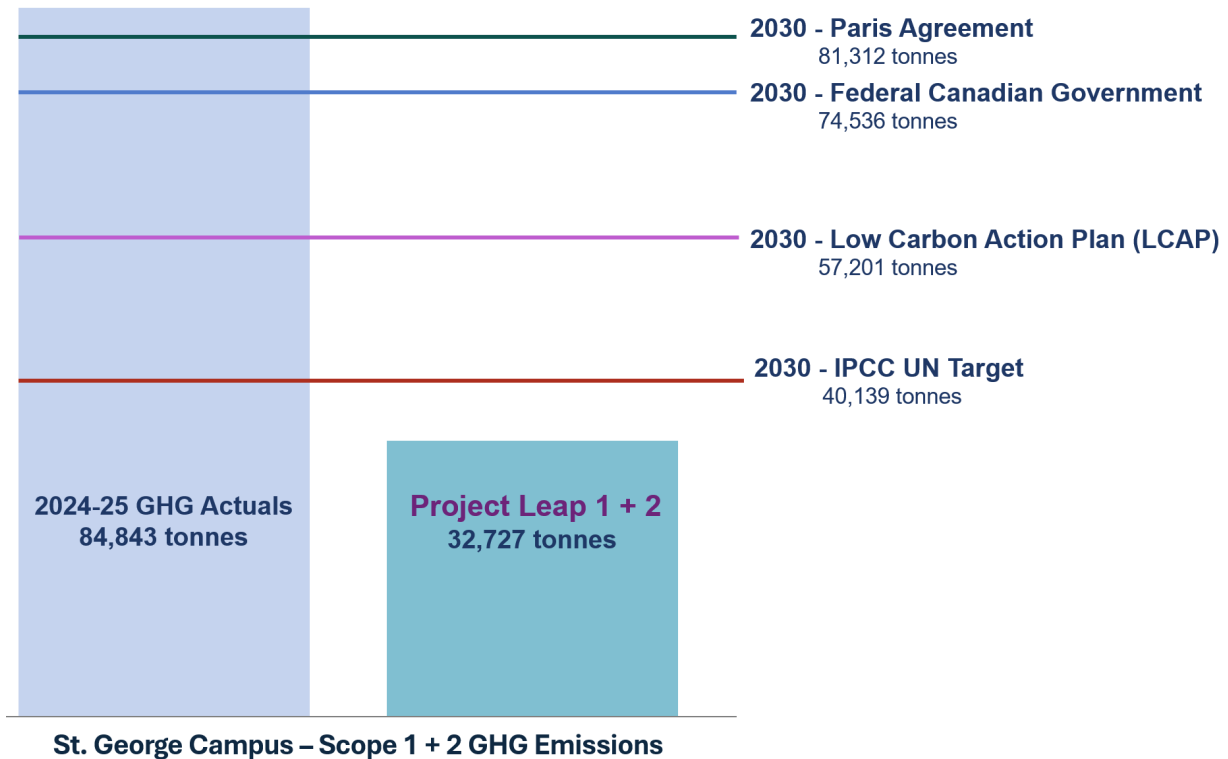
- Eliminate >3000 metric tons of CO2 annually, representing 80% of our 2023/24 Scope 1 and 2 emissions
- Reduce at least 40% energy use
- Add energy system resiliency in the buildings
- Address a significant portion of deferred maintenance needs in these buildings

Project Leap 2.0 scope:

Project LEAP 2.0 combines several items to a mutual advantage; Addressing deferred maintenance needs, expanding energy infrastructure to allow for future programmatic growth, and reducing our carbon emissions. The initiative impacts 5 buildings over 3 sites - Dentistry Building, Rehabilitation Sciences Building and the McCaul group of buildings (Health Sciences Building, Exam Centre, Old Admin Building). The Project Scope includes:

1. Climate Positive initiative
 - Decarbonization of building emissions by electrification of heating, humidification, domestic hot water and lab sterilization
 - Reduction of energy use through implementing heat recovery and heat pumps to reuse wasted heat
 - Improved efficiency and reliability of building heating and cooling ventilation through modernization of building automation systems
 - LED lighting retrofits
 - Installation of 150kW Solar PV panels
 - Insulation of ventilation spaces to reduce energy usage
2. Asset renewal for end of Life (Deferred Maintenance)
 - Reduction of steam network
 - Ventilation system renewal, and associated heating and cooling
 - Replacement of obsolete controls in critical spaces
 - Replacement of end-of-life electrical systems
3. Benefits to Dentistry program space
 - Increased electrical capacity for future expansion considerations
 - Additional ventilation and humidification to Clinic space (1 and pediatric)
 - Adding resiliency to Clinic 2 by enabling connection to building heating and cooling network over a standalone system
 - Connection of perimeter heating to emergency power

Project Leap 2.0 is fully aligned with the goals of the climate positive strategy, while also significantly mitigating deferred maintenance liabilities. In achieving the primary project objective of reducing net carbon emissions for the buildings retrofit by 82%, we will continue our transition away from fossil fuels as the primary heating source for our campus. The project allows the St George campus to surpass carbon reduction targets set out by all levels of government as well as the UN IPCC targets (commonly referred to as the science-based targets).



Schedule

The overall proposed project schedule is phased as follows:

- RFSQ Shortlist Announcement April 2024
- Issue of RFP to Short List June 2024
- Detailed Study March - September 2025
- Design October 2025 – March 2026
- Cycle 3 Governing Council Full Project Approval March 26, 2026
- Mobilization & Construction April 2026 – May 2028
- Anticipated Commissioning Period June 2028-May 2029
- Anticipated Guarantee Period June 2029-May 2054

This schedule assumes all municipal approvals can be achieved within the timelines.

FINANCIAL/RESOURCE IMPLICATIONS:

Discussion of overall costs and sources of funds can be found in the in-camera document for this project.

RECOMMENDATION:

Be It Recommended:

THAT the project scope of Project Leap 2.0, as identified in the Concept Reports (Faculty of Dentistry, March 19, 2023; McCaul Complex – July 8, 2022; 500 University – April 8, 2022) be approved in principle; and,

THAT the project be approved in principle to be funded through: Deferred Maintenance Funds.

DOCUMENTATION PROVIDED:

- Project Leap 2.0 Concept Reports and Technical Submissions
 - Faculty of Dentistry – March 19, 2023
 - McCaul Complex – July 8, 2022
 - 500 University – April 8, 2022



McCaul Complex Excerpts only

UNIVERSITY OF TORONTO

Project LEAP Concept Report

July 8th, 2022



ABBREVIATIONS

AHRI	Air Conditioning, Heating and Refrigeration Institute
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATS	Automatic Transfer Switch
BAS	Building Automation System
BAU	Business as Usual
BCIT	Bahen Centre of Information Technology
BESS	Battery Energy Storage System
BOP	Balance of Plant
CED	Central Electrical Distribution
CFM	Cubic Feet per Minute
CHW	Chilled Water
CMMS	Computer Maintenance Management Systems
CMRS	Central Management and Reporting System
COP	Coefficient of performance
Cogen	Cogeneration Plant
CSP	Central Steam Plant
CSP	Central Steam Plant
CW	Condenser Water
DHW	Domestic Hot Water
EMRS	Energy Management and Reporting System
GA	Global Adjustment
GSHP	Ground Source Heat Pump
GPM	US Gallons per Minute
HTHW	High Temperature Hot Water
Lbs/hr	Pounds per hour (Steam flow rate)
ISS	Ice Storage System
IESO	Independent Electricity System Operator
LDC	Local Distribution Company



LTHW	Low Temperature Hot Water
MSB	Medical Sciences Building
PPH	Pounds Per Hour (Steam)
OSHA	Occupational Safety and Health Administration
OWS	Operator Workstation
TH	Toronto Hydro
THESL	Toronto Hydro Electric System Limited
UMP	Site Utility Master Plan
UPS	Universal Power Supply
VFD	Variable Frequency Drive



3.5 McCaul (MC)

We have combined the following buildings under this group: 1) Health Sciences (HA), 2) Exam Centre and (EX), and 3) Old Administration Building (OA).

Health Sciences (HA) (154)

The Health Sciences Building dates from 1957 and has seven above grade stories plus a basement and a rooftop penthouse plant space. It has a mix of uses including administrative offices, classrooms, teaching labs, basement parking along with auditoriums on the first and sixth floors. It has two bridges, on the second and third floors, which link it to adjacent buildings: EX (255 McCaul Street) and OA (263 McCaul Street).

Exam Centre (EX) (155)

The Exam Centre Building dates from 1917 as industrial warehouse has four floors plus a partial basement space. After 2008 major renovation, U of T has repurposed the building function as a mix of uses including exam center on first to third floors, and administrative offices for facilities and services on fourth floor. It has two bridges, on the second and fourth floors, which link it to adjacent buildings: HA (155 College Street) and OA (263 McCaul Street).

Old Administration Building (OA) (156)

The Administration Building (building 156 - Health and Wellbeing of the University of Toronto is located at 263 McCaul Street. The rectangular shaped building was built in 1915 and was occupied by the Toronto Board of Education. The University acquired the building in 2003 and is now occupied by the University Department of Family and Community Medicine on the third and fourth floors, the Health and Well Being department on the 2nd floor and the Toronto School Board Sesquicentennial Museum and Archive on the first floor. The four-story building has a basement, and a total area is 3029 m². The building is connected to the adjacent buildings 154 and 155 by glass enclosed steel framed elevated walkways.

3.5.1 Existing Conditions

Heating

Third party steam enters the utility tunnel that joins OA and EX about in the middle below the outdoor parking. Steam enters at 200PSI in the utility tunnel and then continues travelling in the utility tunnel and enters EX and reduces to 100PSI and then again to 14PSI to feed existing boiler steam header in the EX Boiler Room. The steam header was originally fed from the disconnected old steam boilers left in place with all insulation removed. The steam header continues to feed:

- One feed from steam travels back via the utility tunnel to OA and converts to South & North HX's in basement and then continues with a steam line up to OA Penthouse MR to feed AHU steam coils. Same line feed steam unit heaters in bridge joining OA & EX. In addition, the steam also feeds DHW HX and is converted via 2 tanks.



- Two domestic hot water tanks located in basement heated by steam coils in tanks. Top tank (LP) supplies DHW up to the 4th floor and the bottom tank (HP) supplies from the 5th to the top floor.
- Another line travels in utility tunnel to OA basement and converts to hot water perimeter and hot to AHU plus convertor for small bridge 154 & 156
- Another steam line (2 lines for redundancy) travels to EX in basement mechanical room to 2 HXs one for perimeter and the other for AHUs. The hot water from the basement mechanical rooms HXs travel to the perimeter radiators and the air handlers on the roof
- There are 2 indoor parking garages in OA that have steam unit heaters
- There is one AHU in EX basement MR that is has steam coils

Gas DHW & Plumbing

Three gas fired domestic hot water heaters provide domestic hot water (DHW) for the buildings EX and OA. The DHW heaters are in the boiler room. Washroom facilities are located on each of the three floors and in the basement. A grey water system consists of rainwater cistern tanks, pumps in basement, and an expansion tank. The system was designed for saving portable water by using collected rainwater for flushing plumbing fixtures.

Chilled Water Systems

There is one air cooled glycol chiller on the roof of EX that supplies cooling to EX Air Handlers and there is another chiller in EX Basement with corresponding cooling tower on EX roof that feeds HA and OA. They are separate systems. For HA the primary chilled water is used in AHUs and then perimeter/Induction unit in summer. Chiller and chilled water pumps are in EX. Chilled water pumps are variable speed. Cooling coils has 3-way valves at AHUs. Chilled water operating temperature set between 44 to 48°F depending on OAT. Chiller can be OFF on schedule or based on low OAT. Most if not all AHUs in EX have VFD on supply and return fans.

Health Science Ventilation & BAS

The building had a major renovation in the early 2000s that included installation of several new AHUs in the rooftop penthouse along with a LED lighting retrofit in 2019. The building recently has completed a roof replacement project and does not have PV panels installed. Except for the steam system, the PRV is on a pneumatic control system. The building automation systems are on DDC controls that date from the time of the major renovation over 15-years ago.

Heating, cooling and ventilation are provided to the spaces via perimeter induction units that are original to the building and separated in a North-South configuration with regards to the AHUs that supply them (AHU 01 and AHU 02, respectively). The induction units have local wall- mounted thermostats that control space temperature via modulating control valve. Control via the local coil water temperature and the water circuits are switched seasonally between heating hot water and cooling chilled water. By Central switch over, not at the unit. CCMS control panel located in basement mechanical room has a summer and winter mode to switch over. Heating water and chilled water switch over valves located in basement mechanical room #091.



AHUs 03 & 04 serves most building spaces on floors 1-7, supplementing the induction systems. AHUs 05 & 06 serves the first and sixth floor auditoriums, respectively. AHU 08 serves the basement and the lobby is served by a fan coil unit in the basement for winter heating. A relatively small, newly installed, AHU serves a classroom space on the 7th floor and includes an air-to-air plate heat exchanger. All the AHUs, except for AHU 08, are in the penthouse plant room which acts as an air return plenum and incorporates exhaust and OA dampers as part of the envelope. AHUs 01 to 06 are on CCMS schedule fan shut-down during unoccupied time. Interior rooms have VAV Boxes (AHU 3 to 6). No reheat coils. Interior rooms have VAV boxes, no induction units.

All AHUs (1 to 6) located in PH Mechanical room at 8th floor. Return air from all the room from building supplying air to mechanical room (return air plenum) through return air Fans (RF1 and RF2). Return air fans supplying air to all AHUs through mixing damper and exhaust through exhaust air damper. RF1 and RF2 have VFD.

- AHU-1,2: supplying air to induction units at north and south
- AHU-3,4: supplying air to east and west side of building through VAV
- AHU-5: supplying air to 1st floor Room 106 and 108 (west of building)
- AHU-6: supplying air to auditorium at level 6, room 610.
- One air compressor located in PH mech room which is used for labs only

One HRV unit located in PH mechanical room which heat the fresh air with exhaust air and supplying to two classrooms on 7th floor.

- AHU-1: South Induction - SP 64.4°F
- AHU-2: North Induction - SP 64.4°F
- AHU-3: West Interior - SP 64.4°F
- AHU-4: East Interior - SP 63.5°F
- AHU-5: Auditorium 1st floor- SP 63.5°F
- AHU-6: Auditorium 6th floor-SP 63.5°F

The BAS is JCI

- JCI NAE controllers @ 3 are overloaded controllers (>120%)
- JCI access via launcher.

Health Sciences Third Floor Server Room

A third-floor data server room (room no.309) has two air-cooled Liebert units with the condenser located at EX Roof.



Exam Centre AHU's, Ventilation, & BAS

The five air-handling units and one air-cooled chiller are also installed on the roof. The boiler room located in basement and occupied two floor space, and a 500-ton chiller in the chiller room on ground floor serves the other buildings.

The main condensate return system is in the basement boiler room and consists of a condensate collection tank and two condensate pumps. Two heating exchangers (HE-1&HE-2) using steam as primary heating source to feed the hot water heating system and glycol heating system.

Chilled water pumps, and glycol heating pumps are equipped with VFDs, and the hot water pumps are running at constant speed.

The five AHUs are equipped with glycol heating coils, and cooling coils.

- AHU-1 serves level-1 basement space and provides cooling and ventilation.
- AHU-2 serves level-2 exam room RM200 and provides cooling and ventilation.
- AHU3 serves the lobby area and provides cooling and ventilation.
- AHU-4 serves the third-floor exam rooms and provides cooling and ventilation.
- AHU-4 serves the fourth floor F&S office and provides cooling and ventilation.
- The BAS is an ALC standalone system with local access only.

Old Admin AHU's & Ventilation & BAS

- Basement AHU has steam heating and DX for cooling which feeds 25% of 1st floor rooms.
- Two air compressors are in basement. One in service and one on STBY. Air compressor used for pneumatic control for AHUs.
- Small steam to glycol HE located in basement, used for heating radiators at the bridge to Building 154 through heating glycol circulation.
- This building has local control only. No CCMS, EMRS, and BAS.
- Two DCW booster pumps located in basement mech room have VFDs.
- AHU-2 at 2nd floor mech room:213 and AHU-3 at 3rd floor room 317.
- AHU-2 &3 have heating water from basement HE and 3-way valve at AHUs
- AHU-2,3 have chilled water from exam center and 3-way valve at AHUs.
- All AHUs have no VFDs for supply and Return Fans.
- Basement AHU-1: for some rooms (25%) at 1st floor
- 2nd floor AHU-2: For 2nd floor and partially 1st floor.
- 3rd floor AHU-3: For 3rd, 4th, 5th floors.



- No humidification in AHUs. No VAVs, and no reheat.
- All the rooms have hot water radiators. T-Stat controls radiator's heating output.
- There is no BAS in Old Admin

Exam Centre Electrical

Electrical Main Service

The building is supplied with a 2500A, 120/208V, 3 phase, 4 wire service from Toronto Hydro. The incoming service conductors enter from the Toronto Hydro vault and feeds the main switchboard. The incoming service conductors are housed in a protective enclosure.

Electrical Distribution

There are Toronto hydro meters, located within the main electrical room, for the Supply building and the Old Administration building.

Emergency Power

There is an existing Cummins, 225kW, 120/208V standby generator for the building.

Solar PV on Roof

There has been 67 kWac solar panels installed on the roof. Annual electricity generation is approximately 73,000 kWh tied into the building hydro meter.

Lighting

Throughout the building the lighting fixtures comprise of PL/CFL pot lights, under cabinet LED task lights, T5 fluorescent one or two-lamp fixtures. Some of T5 fixtures in stairwells recently have been converted to



3.5.2 Energy Conservation Measures (ECMs)

The following ECMs are proposed for further analysis at McCaul.

MC-ECM-01: Upgrade Lighting in EX & OA

a) Overview

This measure proposes that lighting be updated to more efficient in EX & OA.

EX Lighting

Throughout the building the lighting fixtures comprise of PL/CFL pot lights, under cabinet LED task lights, T5 fluorescent one or two-lamp fixtures. Some of T5 fixtures in stairwells recently have been converted to LED. Main lighting control is by Douglas control system dated back to 2008 major renovation.

Most of the lighting type in the building has not been converted to LED yet. This measure recommends all existing fluorescent based and compact fluorescent based T5 lamps and pot lighting to be replaced with LED equivalent.

OA Lighting

Most of the lighting type in the building has not been converted to LED yet. This measure recommends all existing fluorescent based and compact fluorescent based T8 lamps and pot lighting to be replaced with LED equivalent

b) Economics and Other Benefits

We have only included utility savings and have also taken into consideration both the cooling effect reduction and added heating load. We have not included any operational savings but do expect an operational cost reduction due to longer life LEDs.

Objectives Supported

- Eliminate CO2
- Address deferred maintenance
- Carbon tax avoidance

Principals Applied

- Balance carbon with cost
- Conservation first
- Foster innovative solutions
- Improve comfort and wellness

ECM ID	Electrical Savings						Thermal Savings			Saving Totals	
	kW ^{DR}	kW ^{GA}	kW ^{Pk}	kWh	tCO2e	\$	MMBtu	tCO2e	\$	tCO2e	\$
MC-ECM-01	0	24	24	121,090	4	\$7,107	-146	-11	-\$4,461	-7	\$2,647



c) Calculation Methodology

We have estimate LPD. The LED lamps are expected to reduce the LPD by 44%. This percentage reduction was then applied to the baseline energy model LPD.

d) Constructability

We have assumed the installation work will be done during regular working hours or during low occupancy periods. We propose to install this measure in many areas of the facility including in academic areas so that requires careful coordination. We will create a detailed communication and delivery plan due to the nature of this installation before work commences.

MC-ECM-02: McCaul Electrification

a) Overview

This ECM proposes the electrification of the grouped McCaul buildings EX, OA, and HA.

At a high level conceptually, decarbonizing of steam based heating by using Ground Source Heat pumps with exhaust air heat recovery from AHUs with electric boilers for peak heating (> 140°F). In addition, to centralize cooling for the proposed heat pump to use heat to recharge ground loop in summer. We also propose to convert the dedicated natural gas DHW to electric.

Scope of Work

- Install new Heat Pump 400-Ton @ 160F output in chiller room with 150-Ton geo exchange field in parking lot and garage
- Remove steam boilers in EX boiler room and install 1100kW electric boiler
- Supply hot water from boiler to:
 - To basement MR in OA to replace 2 x HX's (North and South Loops)
 - To PH MR in OA and in OA PH MR remove steam coils and install hot water coils 130°F

Objectives Supported

- *Build resilient low carbon systems*
- *Eliminate CO2*
- *Carbon tax avoidance*

Principals Applied

- *Balance carbon with cost*
- *Reach beyond our own assets*
- *Foster innovative solutions*



- Replace bridge steam heating unit with hot water fed from riser from EX to HA PH MR
- To 2 x HXs in basement EX MR
- To 3 x HX's in OA basement MR and replace 1 A HU steam coil located on basement with hot water
- To 2 x parking garage steam U/H's and replace with hot water
- To HA AHU's steam coils
- Connect the EX PH air cooled chiller to basement chiller in EX
- Install new elect 80 kW DHW and tanks in EX Boiler Room and replace 3 x gas fired DHW in same room
- Install exhaust air coils in AHUs in HA & EX PH and Roof Air handlers

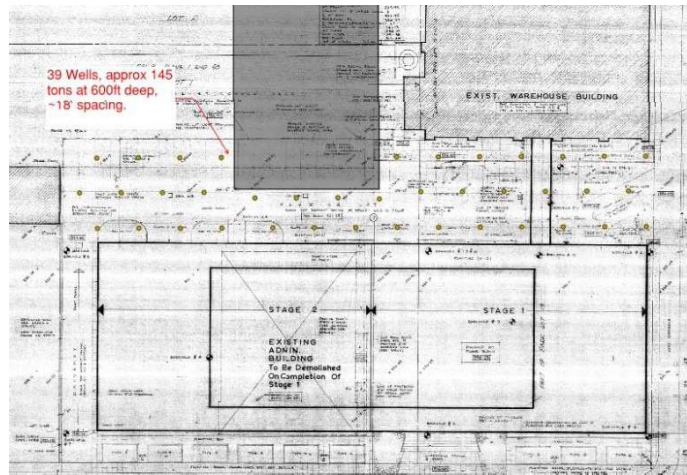


Figure 23: Proposed Location for Geo Field

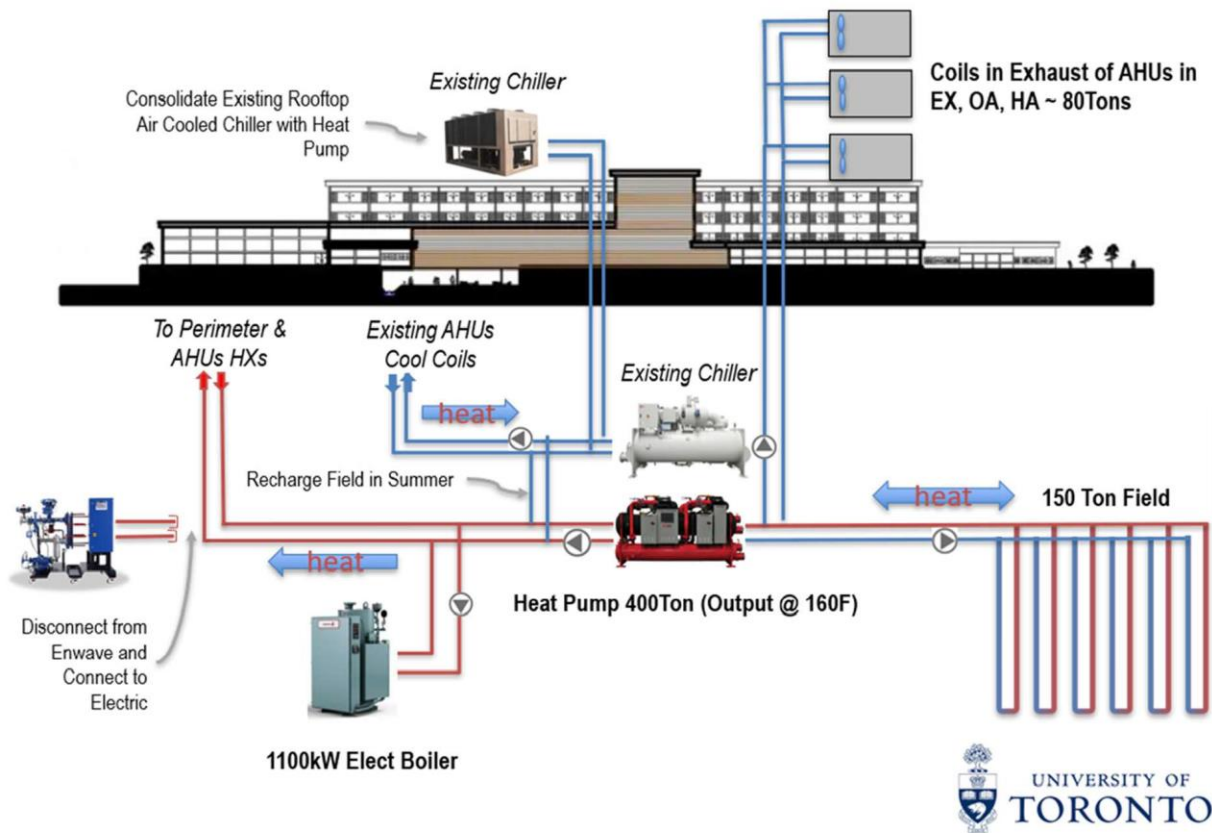


Figure 24: Proposed GSHP Schematic



- Connect exhaust coils in 155 & 154 to chiller room located in 155 basement with new heat pump chiller
- Install adiabatic or electric humidification in AHU's

Nodal Plant Option

This option has been omitted from the report as it may no longer be applicable.

MC-ECM-03: Battery Energy Storage System (BESS)

a) Overview

To further enable demand response and GA avoidance 3MWh hours of battery storage will be installed in the central heating plant. The batteries will be purchased in a self-contained unit and installed in a stacked manner near the electrical infrastructure. The 3MWh of capacity will provide 1MW of demand response capacity.

There are multiple benefits to the battery storage systems as they can be charged overnight when electricity is both cheap and clean with a lower carbon content than the marginal during daytime operation. The conversion efficiency of the batteries is also very high at over 90%. Containerized solutions provide an advantage for noise mitigation and the ability to relocate generator in future to accommodate relocation of the Central Plant and/or Nodal Plant Design.

Objectives Supported

- *No material impact to utility budget*

Principals Applied

- *Reach beyond our own assets*
- *Foster innovative solutions*

Scope of Work:

Supply a containerized BESS solution 1MW @ 3 hours (3MWh) batteries with required HVAC, controls, etc.



Nodal Plant Option

This option has been omitted from the report as it may no longer be applicable.

MC-ECM-04: Combine Elect Service and Upgrade (+3MW)

a) Overview

As part of our strategy to electrify McCaul's 3 buildings we're proposing to change from the current Class B to a Class A rate. By electrifying the heating to electric should put us into the 1000kW minimum demand threshold for Class A. In addition, we would be required to tie all three buildings together electrically to achieve the new rate Class A.

The measure is in line with the overarching Nodal Strategy that our electrical service group has been taking elsewhere on campus. It allows for larger targeted demand response items for any storage systems on the node, which may indeed have a carbon effect since they will typically be used on peak days when the grid has a likely higher concentration of CO₂/kW as the gas-fired plant dispatched for generation.

Based on preliminary load sizing we expect there to be another 1.7MW of peak electric load. When combined with existing 0.8MW we would require approx. 3MW in total. We're proposing to build a customer owned HV substation service, consolidating the three existing buildings, proposed thermal (electric if decided) loads, and any future loads such as the Steward building. Other considerations include the renewal of the HA/EX/OA LV main electrical distribution systems, and emergency generators from diesel to renewable nature gas.

Objectives Supported

- *Build resilient low carbon systems*
- *No material impact to utility budget*

Principals Applied

- *Balance carbon with cost*
- *Reach beyond our own assets*
- *Foster innovative solutions*



Nodal Plant Option

This option has been omitted from the report as it may no longer be applicable.

MC-ECM-05: Electrify DHW

a) Overview

Three gas fired domestic hot water heaters provide domestic hot water (DHW) for the buildings EX and OA. The DHW heaters are in the boiler room.

We're proposing to install new 60-kW electric DHW boiler in HA basement mechanical room and feed 2 x DHW tanks.

Nodal Plant Option

This option has been omitted from the report as it may no longer be applicable.

Objectives Supported

- Build resilient low carbon systems
- Eliminate CO2
- Carbon tax avoidance

Principals Applied

- Balance carbon with cost
- Foster innovative solutions

MC-ECM-06: Upgrade BAS + DCV and Recommission in HA

a) Overview

The mechanical systems and their control equipment are in generally good condition but are now over 15 years old and would benefit from this measure.

- JCI NAE controllers @ 3 are overloaded controllers (>120%)
- JCI access via launcher.

This may entail upgrading of existing DDC points and addition of some new DDC points to allow the systems to follow the building loads more closely. The BTU meters which have not been working properly in the past two years for heating and cooling BTU meter is required to be calibrated, and re-commissioning.

- Upgrade BAS and connect to EBI for control

b) Economics and Other Benefits

Only utility savings have been included at this stage. We will need to understand what the differential operating costs are during the next detailed engineering phase.

Objectives Supported

- Eliminate CO2
- Address deferred maintenance
- Carbon tax avoidance

Principals Applied

- Conservation first
- Foster innovative solutions
- Improve comfort and wellness

ECM ID	Electrical Savings	Thermal Savings	Saving Totals
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	kW ^{DR}	kW ^{GA}	kW ^{Pk}	kWh	tCO ₂ e	\$	MMBtu	tCO ₂ e	\$	tCO ₂ e	\$
MC-ECM-06	0	0	0	61,003	2	\$1,806	2,827	212	\$86,450	214	\$88,256

c) Calculation Methodology

To be provided.



d) Constructability

No issues identified at this stage.

MC-ECM-07: Upgrade BAS + DCV and Recommission in EX

a) Overview

The mechanical systems and their control equipment are in generally good condition but are now over 15 years old and are recommended for upgrade. ALC BAS. local access only.

This may entail upgrading of existing DDC points and addition of some new DDC points to allow the systems to follow the building loads more closely. The BTU meters which have not been working properly in the past two years for heating and cooling BTU meter are required to be calibrated, and re-commissioning.

- Upgrade BAS and connect to EBI for control

Objectives Supported

- Eliminate CO2
- Address deferred maintenance
- Carbon tax avoidance

Principals Applied

- Conservation first
- Foster innovative solutions
- Improve comfort and wellness

b) Economics and Other Benefits

Only utility savings have been included at this stage. We will need to understand what the differential operating costs are during the next detailed engineering phase.

ECM ID	Electrical Savings						Thermal Savings			Saving Totals	
	kW ^{DR}	kW ^{GA}	kW ^{Pk}	kWh	tCO2e	\$	MMBtu	tCO2e	\$	tCO2e	\$
MC-ECM-07	0	0	0	33,844	1	\$1,002	158	12	\$4,822	13	\$5,824

c) Calculation Methodology

We have calculated savings based on a conservative 15% reduction of the HVAC loads as per the Energy Balance.

d) Constructability

Costing is based on previous BAS retrofits at the university. We will install this measure in many areas of the facility including in academic areas so that requires careful coordination. We will create a detailed communication and delivery plan due to the nature of this installation before work commences.



MC-ECM-08: Upgrade BAS + DCV and Recommission in OA

a) Overview

The mechanical systems and their pneumatic control equipment are in fair conditions locally, but they are not connected with any central energy management system. It is recommended that this BAS be connected to the central ERMS and building re-commissioning activities, such as system tune-up, setpoint calibrations, control sequence re-adjustment, and preventative maintenance corrections, etc., be performed.

Meanwhile, M&V&T program follows IPMVP protocol as a guidance, the savings can be properly quantified and accounted. The ongoing Cx activity ensures the persistent savings to be maintained over the time.

- Upgrade BAS and connect to EBI for control

Objectives Supported

- Eliminate CO2
- Address deferred maintenance
- Carbon tax avoidance

Principals Applied

- Conservation first
- Foster innovative solutions
- Improve comfort and wellness

b) Economics and Other Benefits

Only utility savings have been included at this stage. We will need to understand what the differential operating costs are between existing operation and proposed during the next detailed engineering phase.

ECM ID	Electrical Savings						Thermal Savings			Saving Totals	
	kW ^{DR}	kW ^{GA}	kW ^{PK}	kWh	tCO2e	\$	MMBtu	tCO2e	\$	tCO2e	\$
MC-ECM-08	0	0	0	12,479	0	\$369	58	4	\$1,778	0	\$2,147

c) Calculation Methodology

We have calculated savings based on a conservative 15% reduction of the HVAC loads as per the Energy Balance.

d) Constructability

Costing is based on previous BAS retrofits at the university. We will install this measure in many areas of the facility including in academic areas so that requires careful coordination. We will create a detailed communication and delivery plan due to the nature of this installation before work commences.



MC-ECM-09: Install Solar PV at HA

a) Overview

The roof of the penthouse has sufficient open area to support a photovoltaic array that would help offset the building's grid electricity usage. Per AMP's study, a total 342 PV panels for 120kWac capacity is proposed to be installed on the roof. The potential energy savings of rooftop solar PV is estimated at 139,725 kWh/annual.

Scope of Work:

- Approx. 342 panels
- 150kW, outdoor rated inverter installed on the roof
- Outdoor rated rapid shutdown box

Objectives Supported

- Build resilient low carbon systems
- Eliminate CO2
- Carbon tax avoidance

Principals Applied

- Reach beyond our own assets
- Foster innovative solutions
- Add renewable content



Figure 27: Proposed PV Layout

- Outdoor rated DC disconnect and combiner
- All local LDC requirements

b) Economics and Other Benefits

Savings are based on displacing the electric usage at the new electric rate. We will need to include operational costs with equipment renewal for invertors for example. This will be detailed in the next phase of development.

ECMID	Electrical Savings					Thermal Savings			Saving Totals		
	kW ⁰ _R	kWGA	kWPK	kWh	tCO2e	\$	MMBtu	tCO2e	\$	tCO2e	\$
MC-ECM-09	0	75	0	139,725	4	\$4,136	0	0	\$0	4	\$4,136

c) Calculation Methodology

Savings are based on AMP's study.

d) Constructability

Costing is based on typical rooftop installations with no added structural requirements. Systems can be scaled and/or removed if costs for structural prove prohibitive. We will need an approved parallel grid connection from Toronto Hydro.



MC-ECM-10: Install Solar PV on OA

a) Overview

According to the site situation and roof conditions, a small solar PV project is recommended based on a RETScreen Expert analysis. It is proposed to install 15kW of Solar PV on the roof of OA.

Scope of Work:

- 30kW, outdoor rated inverter installed on the roof
- Outdoor rated rapid shutdown box
- Outdoor rated DC disconnect and combiner
- All local LDC requirements

Objectives Supported

- Build resilient low carbon systems
- Eliminate CO2
- Carbon tax avoidance

Principals Applied

- Reach beyond our own assets
- Foster innovative solutions
- Add renewable content

b) Economics and Other Benefits

Savings are based on displacing the electric usage at the site based on synchronous grid operation.

ECM ID	Electrical Savings					Thermal Savings			Saving Totals		
	kWDR	kWGA	kWPk	kWh	tCO2e	\$	MMBtu	tCO2e	\$	tCO2e	\$
MC-ECM-10	0	9	0	16,900		\$500	0	0	\$0		\$500

c) Calculation Methodology

Savings are based on RETScreen for Toronto.

d) Constructability

Costing is based on typical rooftop installations with no added structural requirements. Systems can be scaled and/or removed if costs for structural prove prohibitive. We will need an approved parallel grid connection with Toronto Hydro.



MC-ECM-11: Upgrade Heating Radiators in OA

a) Overview

The perimeter radiant heating system (units and piping included) are approaching end of life. It is proposed to replace with new more energy-efficient models. The retrofit will require the system to connect and be designed with the LTHW system (135°F) and maintaining the same heating output, fan coil units appear to be a suitable alternative to the original units.

The additional opportunity of energy savings is controllability on the individual unit through temperature reset and occupancy sensing. There are approximately 24 units per floor for 5 floors, giving a total of 120 units for the entire building requiring conversion. Each unit has an output of 600 btu/ft/hr with a length of 4ft, providing 2400 btu/hr. An equivalent output of fan coil unit should be sized to replace each of the existing radiant units.

Nodal Plant Option

This option has been omitted from the report as it may no longer be applicable.

Objectives Supported

- *Address deferred maintenance*

Principals Applied

- *Foster innovative solutions*



UNIVERSITY OF TORONTO

Climate Positive: 500
University Deep Energy
Retrofit Proof of
Concept Report

External Version

April 8th, 2022



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ABBREVIATIONS

AHRI	Air Conditioning, Heating and Refrigeration Institute
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATS	Automatic Transfer Switch
BAS	Building Automation System
BAU	Business as Usual
CFM	Cubic Feet per Minute
CHW	Chilled Water
CMMS	Computer Maintenance Management Systems
CMRS	Central Management and Reporting System
COP	Coefficient of performance
CW	Condenser Water
DHW	Domestic Hot Water
EMRS	Energy Management and Reporting System
GA	Global Adjustment
GSHP	Ground Source Heat Pump
GPM	US Gallons per Minute
HTHW	High Temperature Hot Water
lbs/hr	Pound per Hour (Steam Flow Rate)
IESO	Independent Electricity System Operator
LDC	Local Distribution Company
LTHW	Low Temperature Hot Water
MSB	Medical Sciences Building
TH	Toronto Hydro
THESL	Toronto Hydro Electric System Limited
UMP	Site Utility Master Plan
UPS	Universal Power Supply
VFD	Variable Frequency Drive



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1.0 EXECUTIVE SUMMARY

1.1 Overview

In recognition that climate change remains one of the most pressing challenges of our time, the University of Toronto St. George campus has committed to becoming climate positive (having net negative emissions) by 2050. Our downtown Toronto campus—the university’s largest and oldest campus—makes up over 80% of the University of Toronto’s operational carbon footprint. Our impact on the institutional footprint and our key role in the community calls for going beyond net-zero carbon emissions to become climate positive by 2050. This means not only reducing the operating emissions under our control, but also mitigating additional carbon emissions to achieve net-negative emissions,

Our first step towards becoming climate positive is to invest in transformational infrastructure renewal as part of our 30-year carbon and energy campus master plan. We are moving towards a renewed, resilient and reliable utility infrastructure that will enable our campus to operate and thrive without disruption and mitigate the impacts of growth on our carbon footprint. Our 2050 plan follows the release of U of T’s tri-campus Low-Carbon Action Plan (2019-24), which focuses on U of T’s 2030 reduction target, and will position the institution to accelerate carbon reductions towards 2050.

While proud of our 2050 plan and commitment, we realize that we need to take decisive action now. As part of the launch of the Climate Positive Campus plan, the University is launching Deep Energy Retrofit Projects across campus to eliminate gas as a primary fuel for heating, and switch to low temperature hot water heating systems. In addition, optimizing ventilation, lighting retrofits, and adding renewable energy assets where possible while renewing aging assets.

The University of Toronto Energy Management team has conducted an energy audit of 500 University and identified key Energy Conservation Measures (ECMs).

500 University is a 13,091 m², 10 storey building located at University Avenue and Edward Street, 2 blocks South of University of Toronto St. George main campus. The building houses the Rehabilitation Sciences School and consists mainly of classrooms, large lecture halls, dry labs, and one wet lab.

Being an off-Campus building, it is not connected to the St. George Campus District Energy Systems (DES). The building was built in 1958 and was known as the Mutual of Omaha building at the time. Originally it was equipped with 2 gas fired boilers for heating the core fresh air supply and Domestic Hot Water while the perimeter heating was supplied with Dunham Baseboard Convectors. Air conditioning was supplied with dedicated AC units and a cooling tower.

500 University Key Objectives

- *Elimination of 432 net metric tonnes of CO₂, representing 80% of the annual Scope 2 thermal emissions*
- *No material impact to the building’s utility budget*
- *Added energy system resiliency by having dual fuel capability*
- *Addresses significant deferred maintenance priority*



Two duct shafts run along the height of the building near the elevator shaft that house the interior air supply and main return air ducts. The bulk of the fresh air supply is introduced by the interior AHU handling unit with a total volume of 60,000 CFM. The perimeter fan delivers 18,900 CFM to induction units while the main return fan has a maximum volume rate of 70,000 CFM.

1991 Retrofit

In 1991, the building was equipped with electric duct heaters/reheat coils. At that time the perimeter heating had been already converted to induction units heating fed by the gas fired boilers in the penthouse mech room. Several Exhaust fans were also installed. A Carrier AHU (AC-1 AHU – Mixed air) with hydronic cooling and heating coils was installed in the cafeteria which remains. A carrier split system was installed in the kitchen (AC-2 133 MBH). A Carrier chilled water fan coil unit was installed in the lobby (AC-3 27MBH). A TRANE hot water heating unit was also installed in the Mechanical room (EHT-1 17.4 MBH). Electric heating units were installed in the shipping area (EHT-2 5KW) and two in the kitchen (EHT-3 & 4 2KW each) as well as several exhaust fans. Thermostats were installed throughout the building controlling all newly installed equipment including electric heaters, duct reheat units and induction units.

2002 Retrofit

In 2002, hot water source for heating loads was changed from gas boilers to steam converters (Heat Exchangers). The steam to hot water heat exchangers were located in a basement mechanical room and fed the original main header in the penthouse mechanical room. CVBs with basic air volume controls were installed throughout the building.

Retrofits to the AHUs and DHW were done since 2002 but no major changes to the building's energy systems were made. More details on the changes are in section 2.0.

No assessment of the building's air leakage rate is available. The building has single glazed windows that are believed to be original to the building. With reference to the baseline year used in this report 2018/2019, it has a TEUI of 360.80 ekWh/m².y, GHGI of 44.86 Kg CO₂e/m².y, and the building emits just over 587 tons of GHG annually, primarily scope 2.

Benchmarking

Considering that 500 University is primarily an office building with very few dry labs, the recommended target TEUI according to ASHRAE 100 should be 287 ekwh/m² (source energy (Table 7-2b, ASHRAE 100-2015) and 314 ekwh/m² according to NRCAN 2014 survey of office buildings (non-medical).

Proposed Energy Conservation Measures Overview:

The University of Toronto Energy Management team conducted an energy audit of the Faculty of Rehabilitation Sciences building and identified key Energy Conservation Measures (ECMs).

The goal of the ECMs identified is to demonstrate that the Deep Energy Retrofit program targets of reducing the GHG emissions by 80% and EUI by 40% can be achieved, and initiate a discussion for improvements and new innovative measures in the next stages of the project.



The ECMs selected are decarbonizing the steam heating plant by electrifying heating using a combination of electric boilers and heat pumps with gas fired boilers for peaking.

The building is estimated to exhaust approximately 22,000 CFM of conditioned air based on AHUs specs and OA intake field observations. The exhaust air is primarily accessible through main exhaust fans presenting an opportunity for heat recovery as a source of low-grade heat for the proposed water source Heat Pumps loop. Additional opportunity for feeding the space heating loop is attainable through replacing excess OA intake by the AHU-interior unit for free cooling with mechanical cooling using heat pumps. The space heating electrification ECM is expected to result in a net GHG reduction of ~416 tons or 71% of the building's total emissions, in addition to a 59% reduction in heating energy intensity.

A lighting retrofit is proposed to reduce the lighting energy consumption by 55% and 13 tons of Carbon or 2%. This retrofit will target replacing the T8s and CFLs lamps with LED lighting and lighting controls where feasible.

A Building Automation System (BAS) ECM is proposed that will see integrating the existing VFD controlled fans and VAVs into a single system that is BACnet compatible and complies with the university's controls standard. The measure aims to implement a control strategy that will take advantage of the VFD drives of the AHUs supply fans and return fan, in addition to utilizing the modulation capability of the VAVs (referred to in the mechanical drawings and this report as CVBs).

Finally, critical deferred maintenance items that will contribute to the energy efficiency of the building were selected. The Deferred maintenance items are replacing the cafeteria AHU and emergency generator that are approaching end of life. The emergency generator replacement DM measure proposes switching from Diesel to Gas supported by the availability of an express gas line that runs to the penthouse mechanical room close to the roof mounted emergency generator.

Proposed measures summary

The proposed conceptual ECMs are expected to meet the project's KPIs and result in a projected reduction in utilities cost in year 1 of ~\$171K based on 2022/2023 utility rates. The proposed measures are expected to achieve a TEUI of 231 ekwh/m².y or 36% reduction and a GHGI of 12 KG CO₂e/m².y. or 73% reduction. While the estimated TEUI and GHGI values don't meet the Project Charter and Project targets, they demonstrate that with refinement of the proposed measures, or an alternate more innovative approach, the targets can be achieved or exceeded.

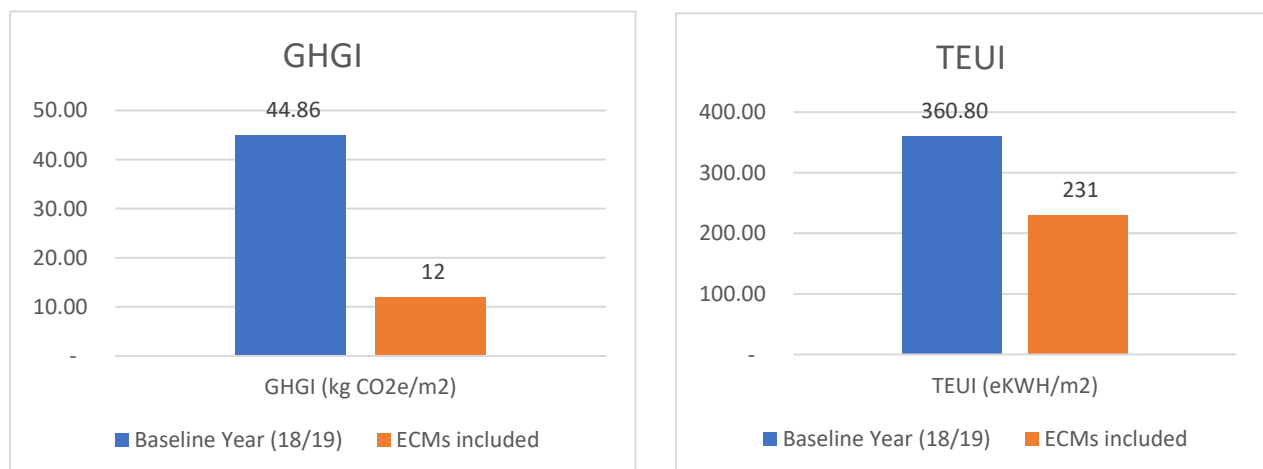


Figure 1 Energy metrics summary



Table 1 Summary of ECMs

ECM #	Location	Description	Measure	Outcome
RS-ECM-01	Basement and Penthouse Mech room	Heating Plant Electrification	Heat Pumps – 150 Tons with Gas Boilers for trim	Reduce the total GHG emissions by 70% (415 net Metric Tonnes)
RS-ECM-02	All Floors	Lighting Retrofit	Lighting: Re-lamp with LED lighting and implement lighting controls	55% saving on lighting energy – 328 MWH/year
RS-ECM-03	Full Building	Building Automation System (BAS)	Optimize ventilation, pumps, CVBs and fans controls	Advance the building towards full automation
RS-DM-01	Mech room 116	Cafeteria-AHU replacement	Deferred maintenance item: Replace the existing Cafeteria-AHU with new AHU equipped with VFD motors and DCV to integrate into new BAS system	Address a critical deferred maintenance item
RS-DM-02	Roof	Emergency generator replacement	Deferred maintenance item: Replace the existing Kohler Diesel generator with a 150 KW Gas fired emergency generator	Address a critical deferred maintenance item
RS-DM-03	Penthouse mech room	Repair and seal return duct to AHU-Interior	Deficiency repair item: Repair and seal supply duct to AHU-Interior	Address a deficiency

Table 2 Summary of ECMs - Units and Savings

ECM ID	Electrical Savings			Thermal Savings			Total Savings	
	KWH	tCO2e	\$	MMBTU	tCO2e	\$	tCO2e	\$
RS-ECM-01 Electrification of Heating	- 671,091	- 27.51	- 84,738.86	6,366.19	442.16	207,620.18	414.64	122,881.31
RS-ECM-02 Lighting Retrofit	328,041.24	13.45	41,421.87				13.45	41,421.87
RS-ECM-03 Building Automation & DCV	60,653.69	2.49	7,658.76				2.49	7,658.76
RS-DM-01 Cafeteria AHU								
RS-DM-02 Emergency Generator								
RS-DM-03 Air leak repair								
Sum	- 282,396.05	- 11.58	- 35,658.24	6,366.19	442.16	207,620.18	430.58	171,961.94



2.0 BUILDING SYSTEMS DISCUSSION:

2.1 Building Mechanical systems:

Heating capacity is supplied by Two steam to hot water heat exchangers HE-1&2. The water is supplied at 180 DEGF @ 15psi at the header (EWT 150 DEGF - LWT 190 DEGF).

Heat Exchanger HE-1 is typically on standby. the heat exchangers have a total maximum capacity of 7,400 lb/hr ~ 7.4 MMBTU (~7400 MBH).

The Hot Water from the steam to water heat exchangers located in the basement mechanical room feed all the main loads by supplying the hot water to the header located in the penthouse mechanical room.

The header feeds the following loads:

- Hot water to Glycol heat exchanger supplying hot Glycol for heating coil supply fan SF-1 providing the main fresh air supply AHU (AHU-interior) to the building and located in the mechanical penthouse.
- Hot water to Perimeter ventilation AHU (AHU-Perimeter) heating coil
- Hot water to Perimeter induction units water loop/riser
- Hot water to Washroom heaters
- Hot water to Ducts heating loop/riser feeding CVB reheat coils
- Hot water to Ground floor and lobby units
- Hot water to NE and SE Baseboard heaters
- Hot water supply to the Multi-purpose room AHU unit (AHU-1) heating coil
- Hot water supply to the Cafeteria/Lobby AHU unit (AC-1)

The summer and winter sequence initially intended to allow for pump backup is disabled – P-8 does not backup P-9 in the winter and P-9 does not backup P-8 in the summer.

Humidifier H-1 is a gas fired humidifier serving the interior AHU. The humidifier is not operational, and no humidification is currently supplied to the building.

The chiller plant is a dual compressor 300T McQuay Chiller. The chiller plant runs at about 50% capacity at peak cooling demand and feeds both AHUs cooling coils as well as the induction units water loop, multi-purpose room, and cafeteria. The Chiller is served by a new cooling tower on the 10th floor roof.

A roof top chiller is installed intended to serve AHU-interior was found not operational.

The perimeter and interior units have a common return fan 70,000 CFM and a common fresh air Louvre and plenum with each unit having a dedicated OA damper

Domestic hot water is provided by a Rheem-Ruud Universal 250MBH Natural gas 80% efficiency boiler and a 119 USGAL tank. DHW was supplied via 2 DHW tanks in the penthouse in 2002.



Both main supply fan SF-1 of the interior AHU (AHU-interior) and main return fan RF-1 are equipped with VFD drives.

Lighting is primarily a mix of T8s and, CFLs and recessed lights on most floors.

Ventilation System (Airside) Summary:

Multi-purpose room AHU-1 unit installed on the Ground floor:

Supply Fan - 5 HP (4000 CFM – Max Fresh Air 1600 CFM)

Return Fan RF-2 – 3600 CFM

HC: Water Heated coil - 200 MBH – 1 row (12 FPI)

EAT 40F LAT: 82 / EWT: 180F LWT: 160F@20 GPM

CC: Water cooled – 177 MBH – 5 rows (9 FPI)

EAT 83/68F LAT: 55/54 / EWT: 45F LWT: 55F@36 GPM

Ceiling Air AC-1 DX unit located in Room 4-18:

Supply Fan – 0.5 HP -1250 CFM

Condensing Unit Fan – 0.5 HP -1650 CFM

Interior AHU unit (in Mech penthouse):

Main Supply Fan - 75 HP - 60,000 CFM (VFD with CO2 sensor installed 2002)

HC-1: Glycol Heated coil - 2030 MBH (1 row – 11 FPI)

EAT 33F LAT: 57 / EWT: 150F LWT: 130F@172.8 GPM

CC-1: Water cooled - 1600 MBH (6 rows – 10 FPI)

EAT 60F LAT: 50 / EWT: 40F LWT: 52F@279 GPM

Perimeter unit (installed in Penthouse):

Supply Fan – 40 HP, 27.3 BHP, 25% min. OA, 18,900 CFM (installed in 2013)

HC: Water Heated coil – 613 MBH EAT 53F LAT: 82 / EWT: 160F LWT: 160F @ 58 GPM

CC: Water cooled EAT – 668 MBH (478 MBH sensible) 79/66F LAT: 54.9/53.6 / EWT: 42F @ 132 GPM

Main return fan (in Mech penthouse):



Fan: RF - 30 HP - 70,000 CFM

Feeds both AHU units.

Kitchen AHU (in room 116):

Carrier unit serving the kitchen

Supply and return fans. Served by the 300T chiller.

Return fan equipped with a damper allowing mixed air capability.

The AHU is equipped with a heating coil.

Terminal Constant Volume Fan Powered Boxes:

All terminal units are Tuttle & Bailey and equipped with a single row hot water coil and have a discharge capacity ranging from 200 to 1300 CFM.

Exhaust Fans:

Table 3 Exhaust Fans Summary

Fans	CFM
EF-1	150
EF-2	1000
EF-3	150
EF-4	100
EF-5	150
EF-6	150
EF-7	300
EF-8 (Fume Hood)	735
EF-9	900
EF-10	1000

2.1.1 Peak demand and baseload

Steam – Space Heating:

Based on the Steam utility bills, the peak monthly steam consumption 1,090,000 lbs (~1,301 MMBTU) for the month of Dec, 2017. Based on a regression analysis of the baseline year plotted against HDH, an estimate peak load of 2.35 MMBTU/HR and an average hourly load of 1.29 MMBTU/HR was estimated. The same analysis revealed that space heating loads are below 1.8 MMBTU/HR for 94% of the time. The



hourly analysis calibration to monthly bills showed higher error in the shoulder seasons and lower error 3 to 13% during the heating season.

The steam is supplied at 200 psi to the building and dropped to 100 psi before reaching the Steam to HW heat exchangers.

A regression analysis of the baseline year revealed a monthly baseload of ~239 MMBTU and is assumed to be the summer reheat load since steam is not used in the building for any other application other than space heating.

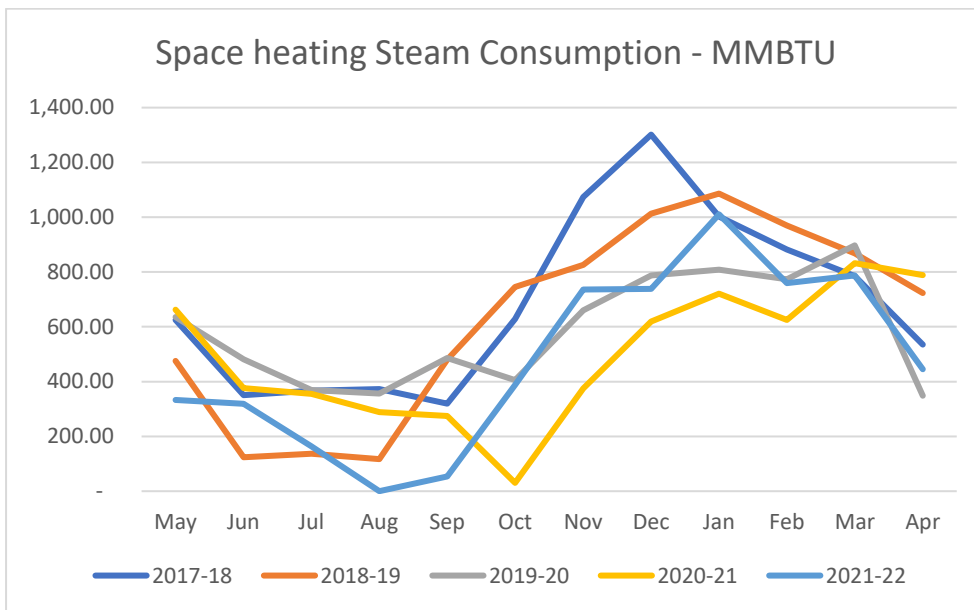


Figure 2 Space Heating Consumption profile

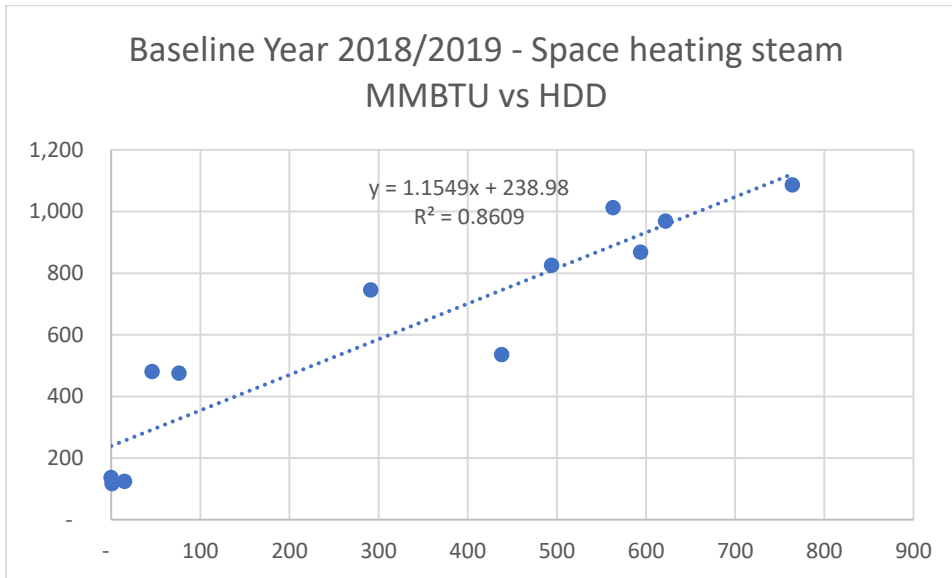


Figure 3 Space Heating - Steam Regression Analysis of Baseline Year

Gas – DHW:

Gas is used primarily for DHW. The express gas line that runs to the Penthouse mechanical room was originally used to feed the two dual fuel boilers that were retired and replaced by third party steam for space heating in 2002. The line now feeds only the Rheem water heater in the penthouse mechanical room. Gas monthly consumption average is ~400m3.

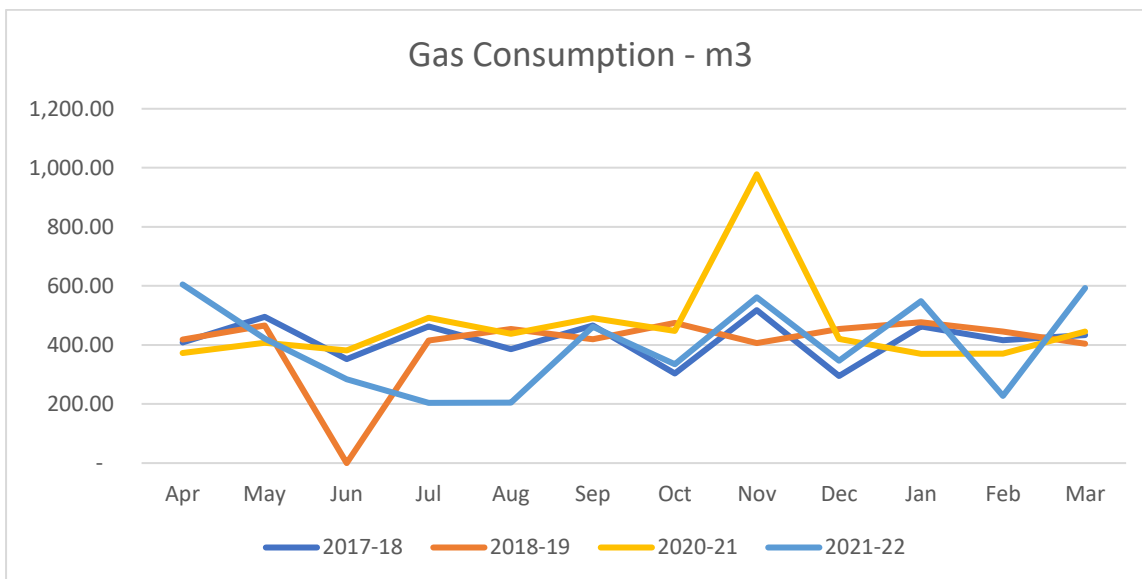


Figure 4 DHW - Gas Consumption Profile



2.2 Electrical System:

The building is hydro connected and served by a 13.8 KV service feeding 2 x 1,000 KVA (13.8KV to 120/208V) transformers. The Main switchboard is a 4,000 A 3P split bus and receives 120/208V from the transformers secondary.

TX2 transformer and bus serve the risers with a 2,400A main breaker, the 150T chiller splitter, cooling tower fan, AHU-interior supply fan and penthouse panel P1.

TX1 transformer and bus serve the other loads including penthouse MCC, panel DP-DPA, fire pumps, penthouse other life safety and elevators ATS loads, pump control panel, RP-GH, 120KVAR capacitor bank, panel BA, RP-GC, basement MCC, and main 300T chiller.

Emergency power is provided through a 150kW, 120/208V generator.

With reference to the baseline year, electrical consumption peaks in the summer at ~274 MWH and Peak demand of ~500 KVA or 50% of one transformer capacity.

A regression analysis of the baseline year revealed a baseload of ~185 MWH.

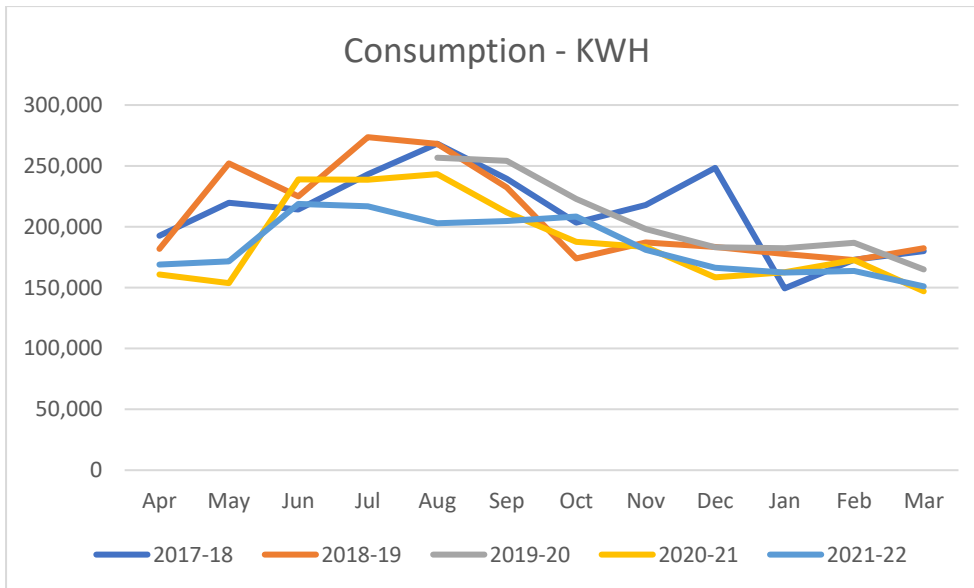


Figure 5 Electrical Consumption Profile

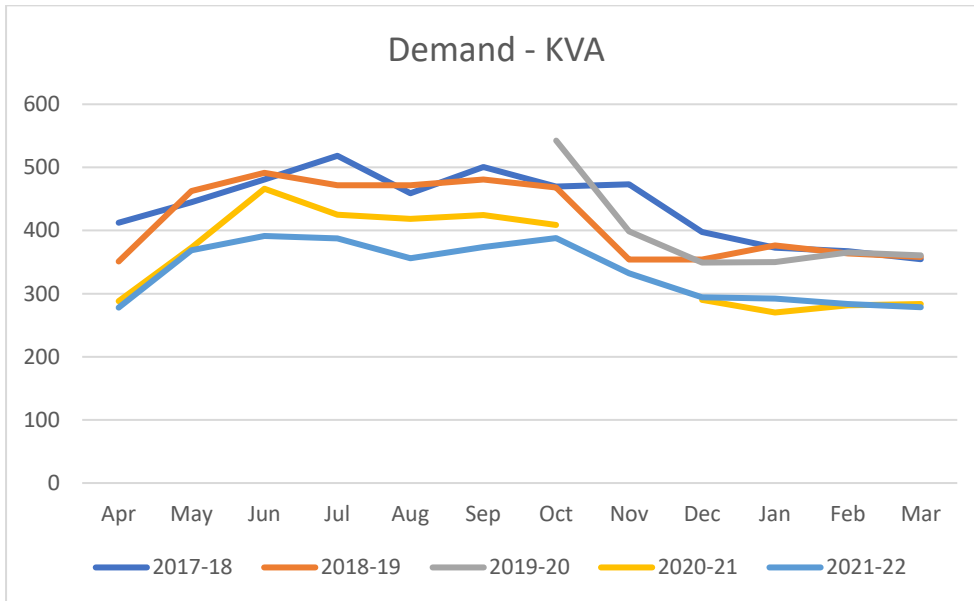


Figure 6 Electrical Demand Profile

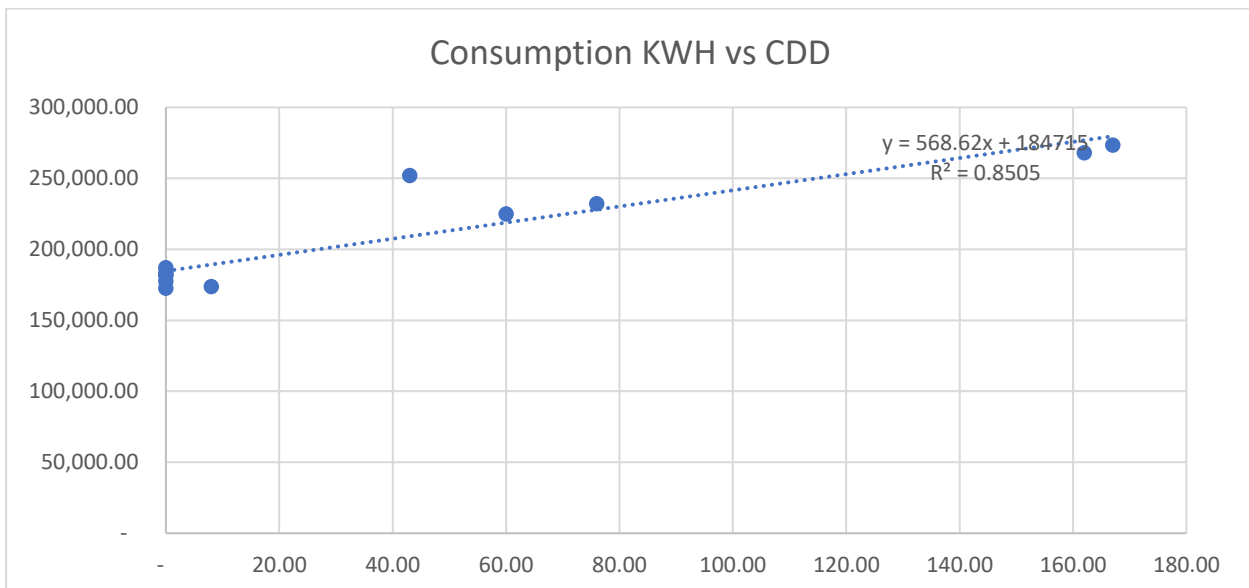


Figure 7 Electrical Consumption Regression Analysis

2.3 Water System:

The water consumption follows a pattern of increasing consumption in the summer months by 2.4 times compared to the winter months with reference to the baseline year. The consumption increase coincides with the cooling season and is likely attributed to the cooling tower evaporation volume. A new cooling



tower was installed in 2022 and an updated set of data from 2022-2023 would be more representative of current consumption, and possible opportunities to reduce the cooling tower consumption further.

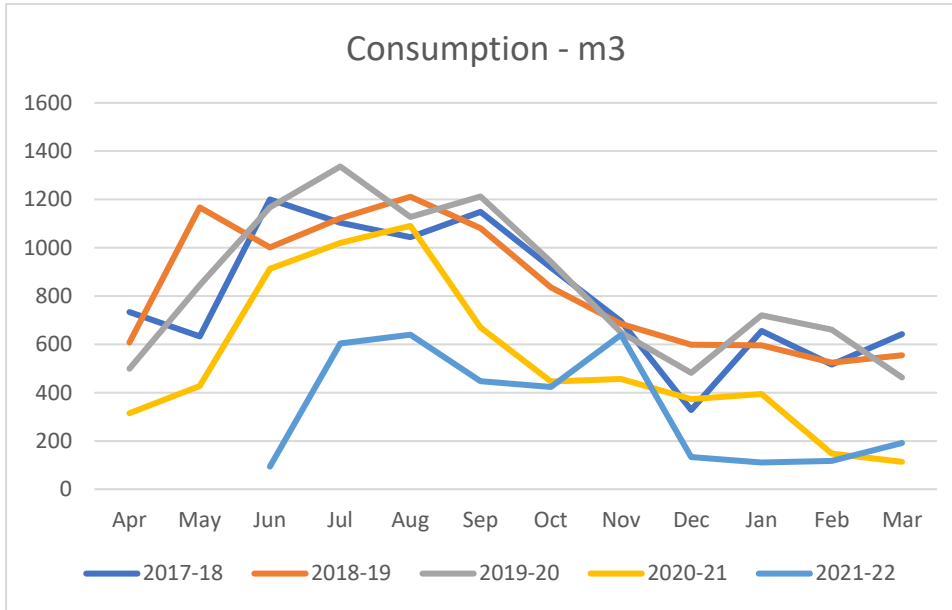


Figure 8 Water Consumption Profile

3.0 Building Performance Analysis

The building's TEUI (Total Energy End Use Intensity) is higher than the average office building, it is currently at 360 eKWH/m2 as mentioned in the benchmarking discussion. The higher TEUI could be attributed to the age of the building envelope which is built less airtight and insulated compared to an average modern building, close to constant air volume configuration, and older lighting fixtures. The GHGI is 44.86 kgCO_{2e}/m², equivalent to 587 tons of GHG per year which is mainly scope 2 and attributed to purchased third party steam.

Table 4 Building Performance Metrics Summary

Energy Metric	Units
TEUI (kWh/m2.yr)	360.80
TEDI (kWh/m2.yr)	169.07
GHGI (kgCO _{2e} /m ²)	44.86

Energy End-use breakdown:

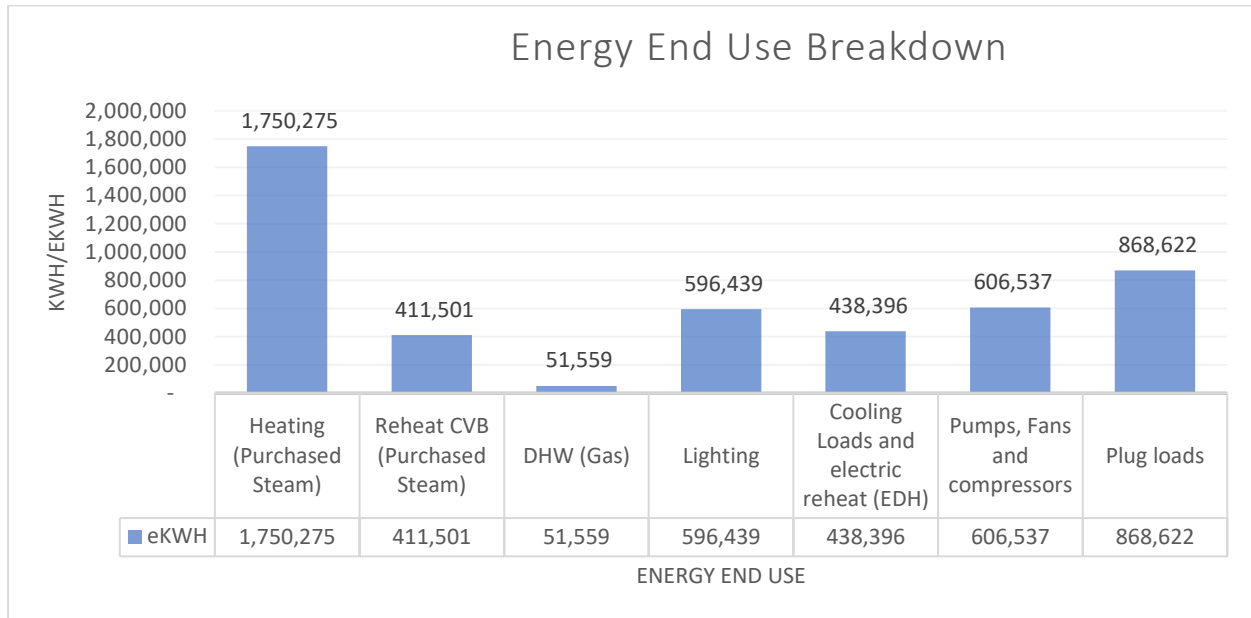


Figure 9 Energy End Use Breakdown

The energy end use breakdown shows that space heating is the highest energy load representing 37% of the total annual energy consumption. A summer reheat load represents 9% of the total annual energy consumption. Together the total annual heating energy represent 46% of the total annual energy consumption and 81% of the building's emissions or 475 tons.

High lighting loads are typical in commercial buildings. The lighting load is the fourth highest energy end use and represents 13% of the total annual energy use and 24 tons annually of Carbon.

Rates Structure:

500 University is off the main campus and is fed by Toronto Hydro and Enbridge for gas. Steam is supplied by third party and delivered to the loads as hot water via onsite steam to hot water heat exchangers. The gas rate has significantly increased in the second half of 2022 through the cost adjustment charge resulting in an average annual blended rate of just over \$0.58. The blended rate includes the Federal carbon tax charge. Third party steam unit rates have increased in the last fiscal year bringing the blended rate to \$29.47 in the year 2021-2022. The blended rate includes the Federal carbon tax charge. The blended average rate of electricity is \$0.126/KWH and the building is a class B customer with a peak of ~500 KVA (baseline year).

The utilities blended rates and emissions rates below were applied to the selected baseline year 2018-2019 fiscal year to calculate the savings of the proposed ECMs. The baseline is a pre-COVID year and is considered representative of future energy demand.



Table 5 Utilities Rates and Emissions values

Utilities Rates			Emissions	
Hydro Blended Rate	0.126	\$/Kwh	41	gCO2e/Kwh
Enbridge Gas Unit Rate	0.159	\$/m3	1933	gCO2e/m3
Enbridge Gas Annual Fixed Charges	1,638.64	\$	182	gCO2e/ekwh
Enbridge Carbon Tax rate	0.09	\$/m3		
Enbridge blended rate	0.58	\$/m3		
Enbridge Gas Unit Rate W/O Carbon cost	0.49	\$/m3		
Enbridge annual carbon escalation to 2030	0.03	\$/m3		
Steam Unit Rate	17.07	\$/MMBTU	64,370	g CO2e/MMBTU
Steam Annual Fixed Charges	68,498.88	\$	220	gCO2e/ekwh
Steam Carbon Tax Rate	3.12	\$/MMBTU	76.6	g CO2e/lbs
Steam blended Rate	29.47	\$/MMBTU		
Steam Unit Rate W/O Carbon cost	26.35	\$/MMBTU		
Steam annual carbon escalation to 2030	0.97	\$/MMBTU		
Water	4.48	\$/m3		

The information used to develop our understanding of the existing system are as follows:

1. 500 University renovation project – 01-241
 - a. Drawing M-01 to M-16 – Revision 4 (February 2002)
2. 500 University renovation project – 2001-0485
 - a. Drawing E1-01 – Revision 4 (December 2001)
3. University of Toronto Utilities Division F&S Single Line Diagram
 - a. Drawing 0152-SLD-01 – Revision 01 (February 2023)
4. Rushby Energy Solutions University of Toronto Lighting Audit – Rehabilitation Sciences – (February 2002)
5. University of Toronto EM team Site visit performed on February 08, 2023

3.0 DETAILED PROPOSED ENERGY CONSERVATION MEASURES:

A high-level schematic summarizing understanding of current building systems and proposed ECM01 is attached in Appendix A



3.1 ECM-01 Heating Plant Electrification

This Energy Conservation measure aims to replace the heating plant currently running on third party steam with 150 Tons of Water to Water heat pump capacity as option 1. The proposed capacity will provide the building’s total heating requirements to a temperature of -10 DegC or 1.8 MMBTU/HR. At temperatures lower than -10 DEGC (or >1.8 MMBTU/HR), a Two 1500 MBH gas fired high efficiency boilers will provide heating to the maximum projected annual load of the baseline year 2018/2019 of 2.35 MMBTU/HR. Annually this translates to Heat pump coverage of 6,871 MMBTU (2,013,272 eKWH) or 93% of the total building annual heating demand, including summer reheat. The remaining building demand of 505 MMBTU (147,965 eKWH) or 7% peak demand will be provided by the high efficiency gas boilers. This 93% electrification of the heating plant will result in a net of 415 tCO2e or 70% of the total building CO2e emissions.

The estimated grid emissions used to calculate the electricity (Scope 2) emissions is 41 gCO2e/KWH to reflect Ontario’s projected higher emissions.

The heat pump plant is assumed to operate at an average of 3.0 COP in heating mode utilizing rejected heat from Mechanical cooling of the interior return air and exhaust air heat recovery.

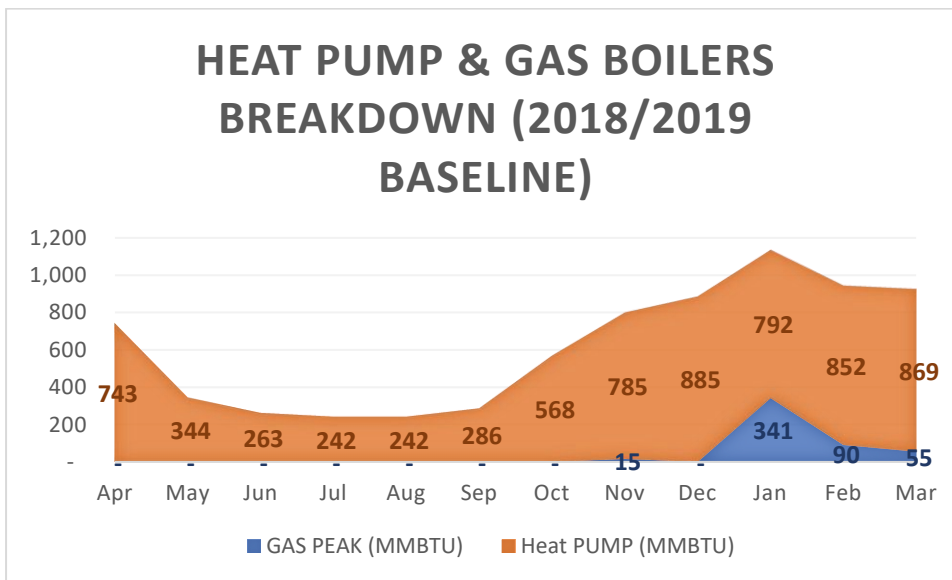


Figure 10 Heat Pump and Backup Gas Boilers Monthly Consumption Breakdown

While the interior unit AHU heating coil is supplied with low temperature hot glycol at 150 DEGF, the perimeter AHU unit receive high temperature water (160 DEGF) directly from the hot water supply header as well as the other loads including the perimeter induction units. A conversion to LTHW may require further investigation of the terminal loads including replacing the perimeter AHU coils.

The building peak demand based on 2018/2019 baseline year is ~500KVA. The available electrical spare capacity is ~450 KVA (95% max loading of a single transformer of the transformer pair). Based on the



data available, 150 Tons of heat pump capacity running as low as 2-3 COP would not significantly load the system beyond the 950 KVA maximum allowed loading.

Further assessment of the summer condition needs to be considered when reheat energy is required by the heat pumps while the chillers are running simultaneously.

Economics and assumptions

The heating plant heat pumps are expected to displace 93% of the total baseline year heating demand while the gas boilers will be used for trimming covering 7% of the baseline year demand.

A second option for implementing this measure contemplates an Air-to-Water heat pump system.

Constructability

In case of option 1 (Water-to-Water heat pump system), the system can be installed in the Penthouse Mechanical room. The LTHW can be connected to the hot water supply header.

In case of option 2 (Air-to-Water heat pump system), 2 locations are proposed, the penthouse mechanical room or an enclosure to house the heat pumps on the roof. The penthouse mechanical room will require re-opening a louvre to provide sufficient outside air flow rate to the Air Source Heat pumps. The LTHW can be connected to the hot water supply header.

The backup gas boilers can be installed in the same locations where the original dual fuel boilers used to be in the penthouse mechanical room and connect to the supply and return headers nearby as well as the original flue stack. A gas connection is available in the mechanical room.

The construction will disrupt the heat supply especially in the final stage when connecting to the existing piping. The final stage of this measure's construction will need to be off the heating season with the final commissioning during the heating season.

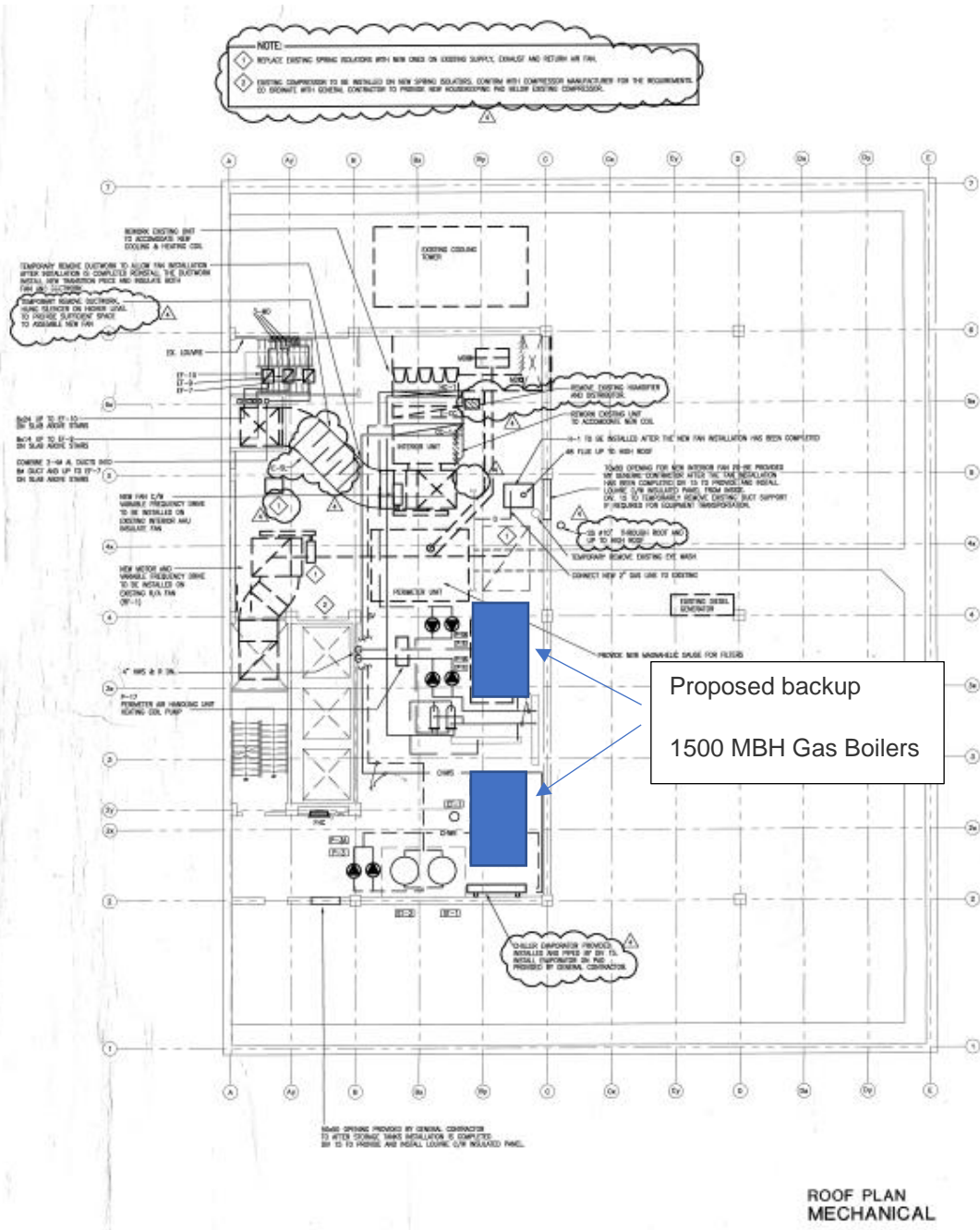


Figure 11 Backup Gas Boilers Proposed Locations



3.2 ECM 02 – Lighting Upgrade

A lighting retrofit is proposed to reduce the current LPD by about 55% using a combination of LEDs and lighting controls. This retrofit will need to be planned so as to avoid disrupting the operation in the building. Some stakeholders may wish to test the LED color temperature first before the full installation.

This retrofit is expected to save 328 MWH or 55% of the current 596 MW annual lighting load and eliminate 13.5 tonnes of CO₂e annually.

The building is currently fitted with 4ft T8 32W two lamp fixtures and CFL recessed/pot fixtures.

Lighting controls are absent on all floors, and feasible to implement.

A lighting audit conducted in 2021 by Rushby Energy Services was the basis of the lighting calculations.

Economics and assumptions

Constructability

The lighting audit specifies where occupancy sensors can be installed.

We have assumed the installation work will be done during regular working hours or during low occupancy periods. We propose to install this measure in many areas of the facility including in academic areas so that requires careful coordination. We will create a detailed communication and delivery plan due to the nature of this installation, before work commences.

3.3 ECM 03 – Building Automation System (BAS)

The measure recommends demand control ventilation, BAS optimization, and recommissioning. These include an upgrade to the building automation system as well as attention to building operation including building pressurization. The upgraded BAS will see integrating the existing VFD controlled fans into a single system that is BACnet compatible and complies with the university's controls standard. This measure will convert related pumps to VFD pumps where applicable to fully benefit from the existing VFD fan controls. In addition, to benefit from the supply fans VFD drives, the terminal units CVB boxes, will require controls upgrade to respond automatically to setbacks, and local thermostats. The CVB boxes are currently adjusted manually acting as constant flow boxes. The new BAS system will integrate with the University's EMRS system.

Economics and assumptions

Constructability



CCMS controlled equipment will need to be transitioned to the new BAS system with possible disruption to the equipment operation, such as pumps and fans.

We have assumed the installation work will be done during regular working hours or during low occupancy periods. We propose to install this measure in many areas of the facility including in academic areas so that requires careful coordination. We will create a detailed communication and delivery plan due to the nature of this installation, before work commences.

4.0 DEFERRED MAINTENANCE ITEMS NOT ADDRESSED IN THE PROPOSED ECMS PACKAGE:

4.1 Cafeteria AHU:

The packaged Carrier air handling unit serving the cafeteria and located in mechanical room 116, was installed in 1990 and houses a supply fan, cooling coils and a filter section. The unit has only 5 years of useful life remaining based on 35 years of equipment life.

Photos



Rehabilitation Sciences Building - D304043



Rehabilitation Sciences Building - D304043

Figure 12 Cafeteria AHU - DM

A replacement with demand control ventilation and VFD drive to be integrated into the building's BAS is recommended.

4.2 Emergency Generator:

The Diesel emergency generator located on the roof is a 150 KW unit (188KVA) is in poor condition although no major deficiency was reported. The generator is estimated to have 1 year of useful life left based on a 30 years equipment life.

A conversion to a high efficiency emergency gas generator and the elimination of the diesel storage tanks is recommended. A gas connection is already available on the roof and might need coordination with the other loads to prioritize supply to the generator.



Rehabilitation Sciences Building - D509002



Rehabilitation Sciences Building - D509002

Figure 13 Emergency Power Generator

4.3 AHU Interior Supply Duct Air Leak:

An AHU supply duct suspected air leak near the Pneumatic control panel was observed during the site visit by the university energy manager. The leak is recommended to be addressed by maintenance staff if feasible or as part of the retrofit. Air duct sealing technologies can be used to address this leak.

5.0 LOW CARBON ACTION PLAN

The addition of 500 University retrofit to the U of T Low Carbon Action Plan (LCAP) will contribute 432 tCO₂e reduction or avoidance at a tri-campus level by end of calendar 2024. This contribution supports the U of T in meeting or exceeding its 2030 commitments to mitigate the impacts of climate change thru a 37% GHG reduction relative to a 1990 baseline.



6.0 MANDATORY REQUIREMENTS

6.1 Outcomes / Performance Metrics

The following is a list of performance-based metrics:

- Minimum reduction of 80% of the candidate buildings annual scope 1 & 2 emissions and meet the Project Charter which specifies the Energy Use Intensity (“EUI”) target for each building. The (“**Project Charter**”) defines the energy targets for the projects. Sample Project Charters are found in Appendix D to this RFSQ.
- The utility budget (natural gas, fuel oil, electricity, and water), excluding carbon tax, remains the same or is reduced. Utility rates are fixed to the base year rates.
- Maximize the Net Present Value (“NPV”) using the U of T’s Lifecycle Cost Analysis (“LCCA”) template
- Maximize Greenhouse Gases (“GHG”) reduction
- Project life not to exceed 20 years
- Address Deferred Maintenance (“DM”) on a building-by-building basis
 - Rehabilitation Sciences: Min requirement – Replace the emergency generator
- Perform conversions to low temperature hot water LTHW (<57°C) in support of our Carbon and Energy Master Plan to electrify and decarbonize our campus
- Provide updated as-built drawing sets for all buildings affected
- Provide complete Operations and Maintenance (“O&M”) manuals for full scope of the Project
- Provide comprehensive training on all systems to U of T staff
- Meet the requirements of the Tri-Campus Energy Modelling & Utility Performance Standard for all building retrofits as established by the Project Charters (see Appendix D for sample project charters)
- Comply with all applicable U of T standards including, but not limited to, Facilities & Services design, performance standards, and Environmental Health & Safety standards
- Ensure continuity of critical operations and research in laboratory facilities
- Address provisions for future expansion if applicable
- Modernization and Integration of building the Building Automation System (“BAS”) into U of T’s Centralized Management and Reporting System (“EMRS”) portal

6.2 U of T Design Standards

All designs must be compliant with all U of T design standards unless exemptions are approved by the Project Steering Committee.

The latest U of T Design Standards are located here:

<https://www.fs.utoronto.ca/projects/design-standards-and-project-forms/>

<https://ehs.utoronto.ca/resources/standards/>

These shall include but are not limited to:



- Mechanical Design Standard
- Electrical Standards
- Building Commissioning Design Standard
- Building Automation System Design Standard
- Fume Hoods & Fume Hood Exhausts Standard
- Laboratory Design Standard and Guidelines



7.0 FINANCIAL ANALYSIS

Omitted.



APPENDIX A – AHU CONTROLS DIAGRAMS SNAPSHOTS

UofT UNIVERSITY OF TORONTO - 500 UNIVERSITY

82.63 deg F OAir Temperature

SUMMER/WINTER MODE

Winter

Dont touch this button unless you are certain you know what you are doing.

It will switch the building between its two modes of operation.

PENTHOUSE SYSTEMS

- GLYCOL HEATING PLANT - PENTHOUSE
- REHEAT COIL HYDRONIC - PENTHOUSE
- CHILLED WATER SYSTEM - PENTHOUSE

AIR SYSTEMS

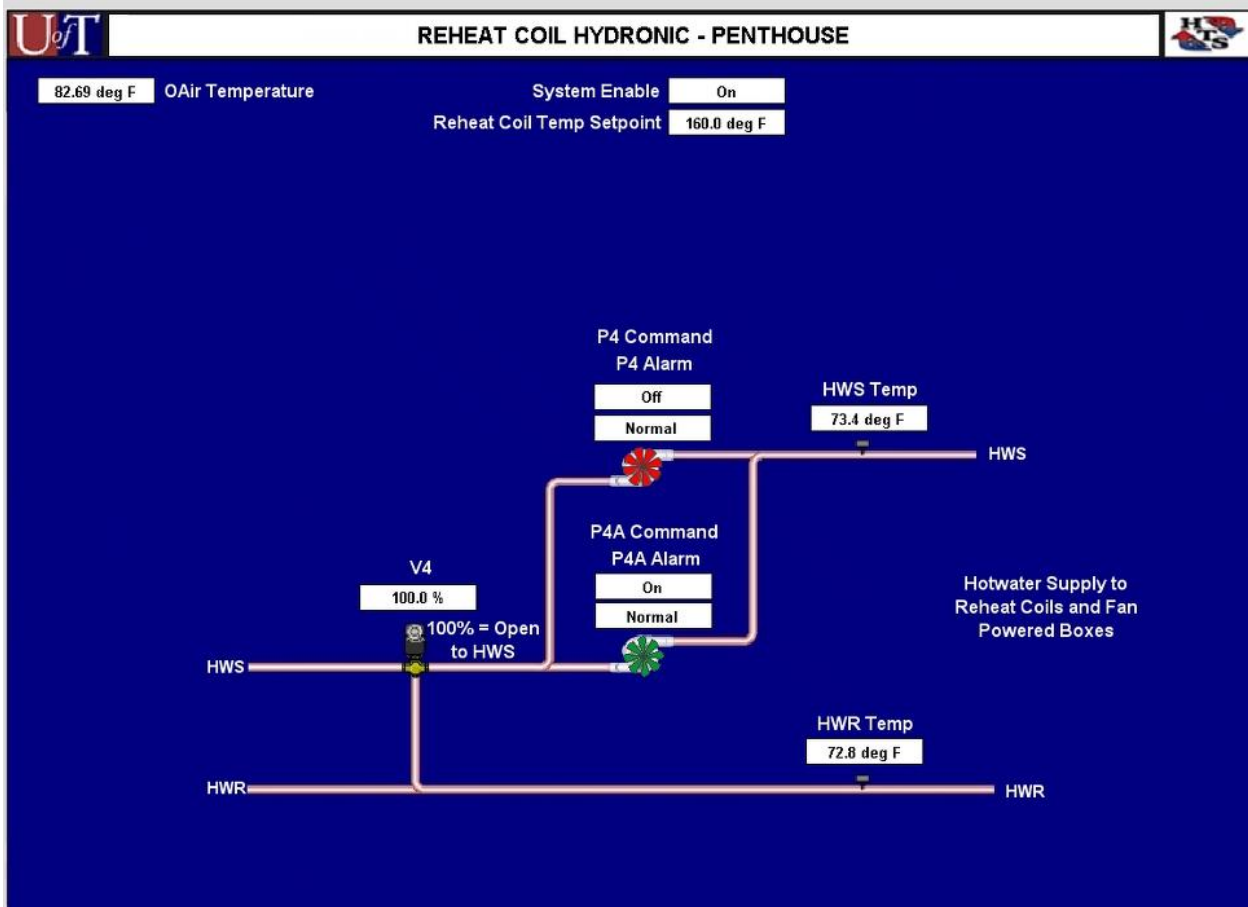
- AHU-1
- AHU INTERIOR
- AHU-1 PERIMETER
- EXHAUST FANS
- AC-1

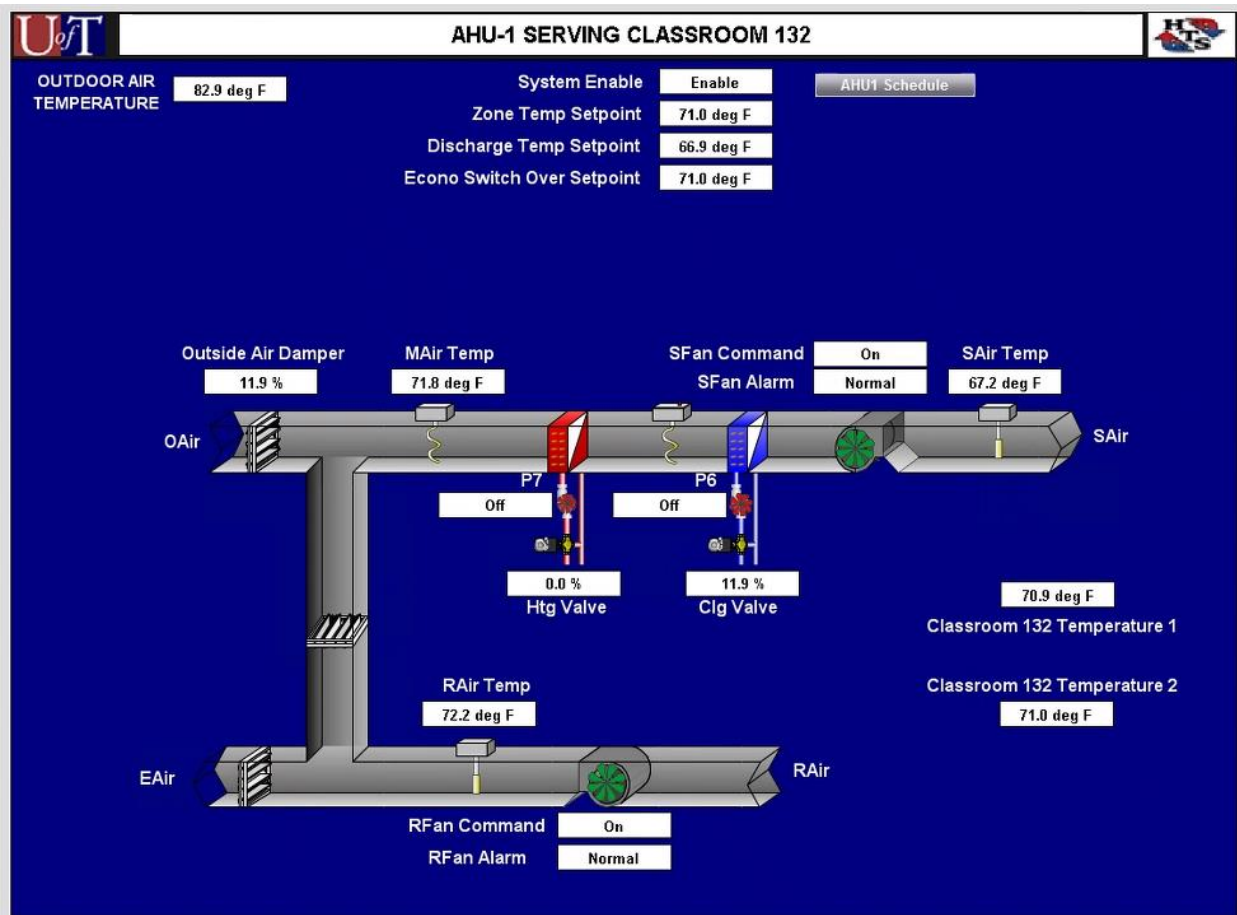
FLOOR SYSTEMS

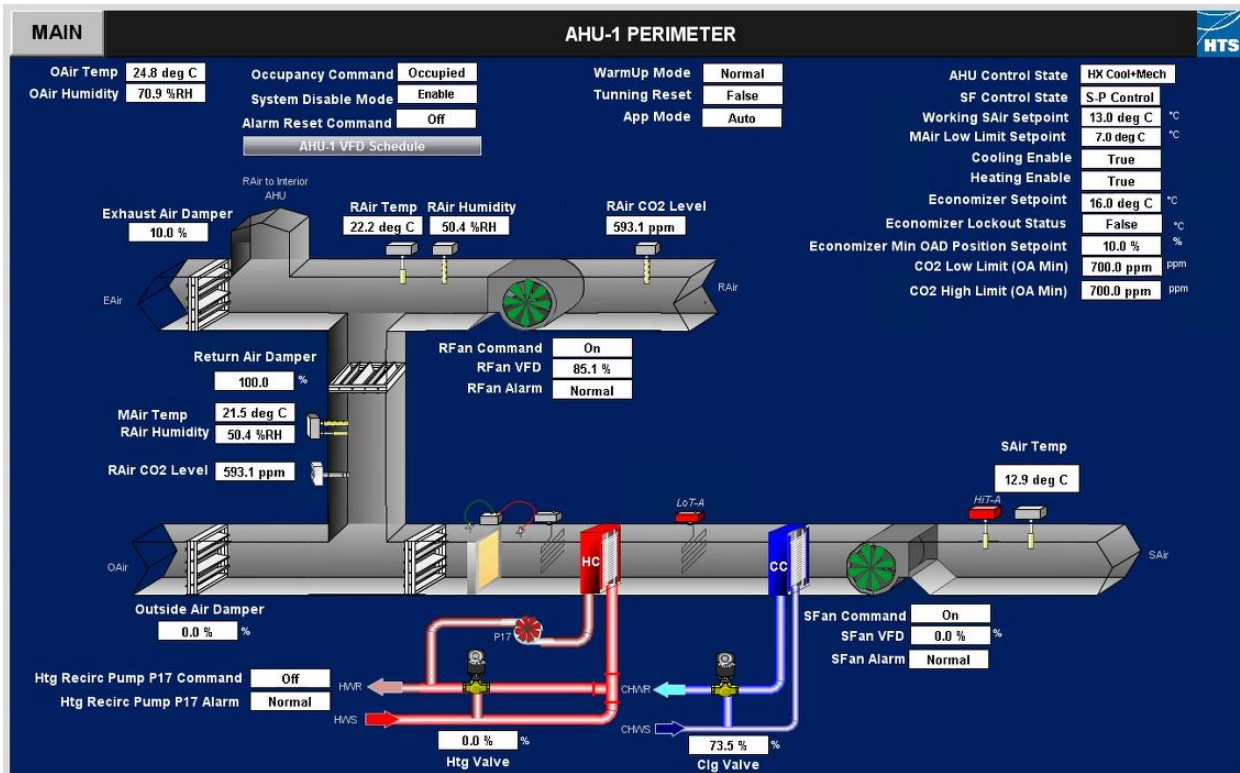
- 10TH FLOOR
- 9TH FLOOR
- 8TH FLOOR
- 7TH FLOOR
- 5TH FLOOR
- 4TH FLOOR
- 3RD FLOOR
- 2ND FLOOR
- 1ST FLOOR
- BASEMENT FLOOR

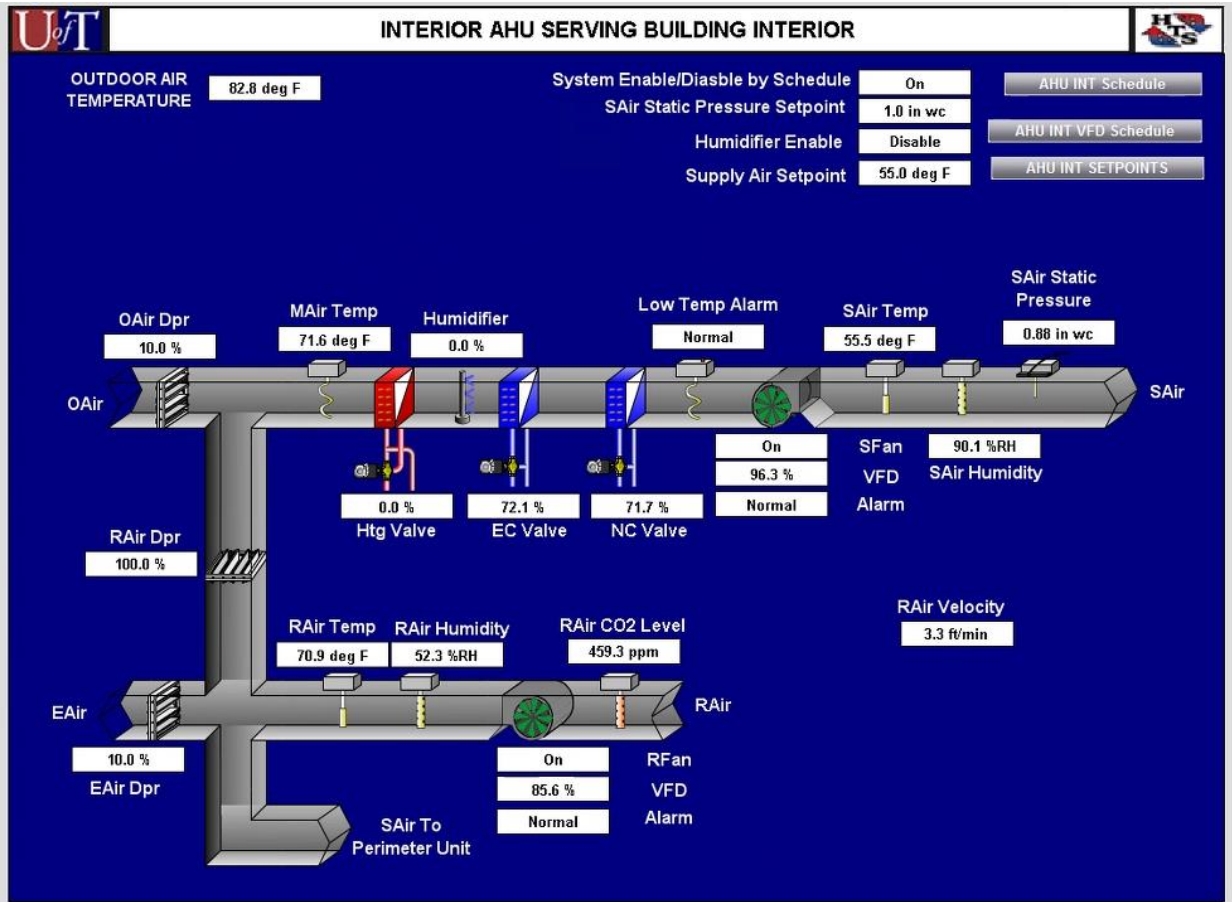
BASEMENT SYSTEMS

- HEATING PLANT - BASEMENT
- INDUCTION WTR SYSTEM - BASEMENT
- CHILLED WATER SYSTEM - BASEMENT
- BACKFLOW PREVENTER - BASEMENT











Name: Perimeter_AHU.1
Status: Normal
Date: 2/18/2023 12:23:46 PM **Priority:** 108
Value: Online

Description:
JCI - SNC16120 ---AHU1 (bldg152)
Alarm Message Text:
< Returned to Normal Status >

VAV 4-1-45
Normal

Occupancy: 3.0 (1=Unoccupied, 2=Standby, 3=Occupied)
Common Setpoint: 72.0 deg F

Fan Command: On

From AHU: 29.9 % open Damper Position

Reheat Valve: 100.0 %

SAir

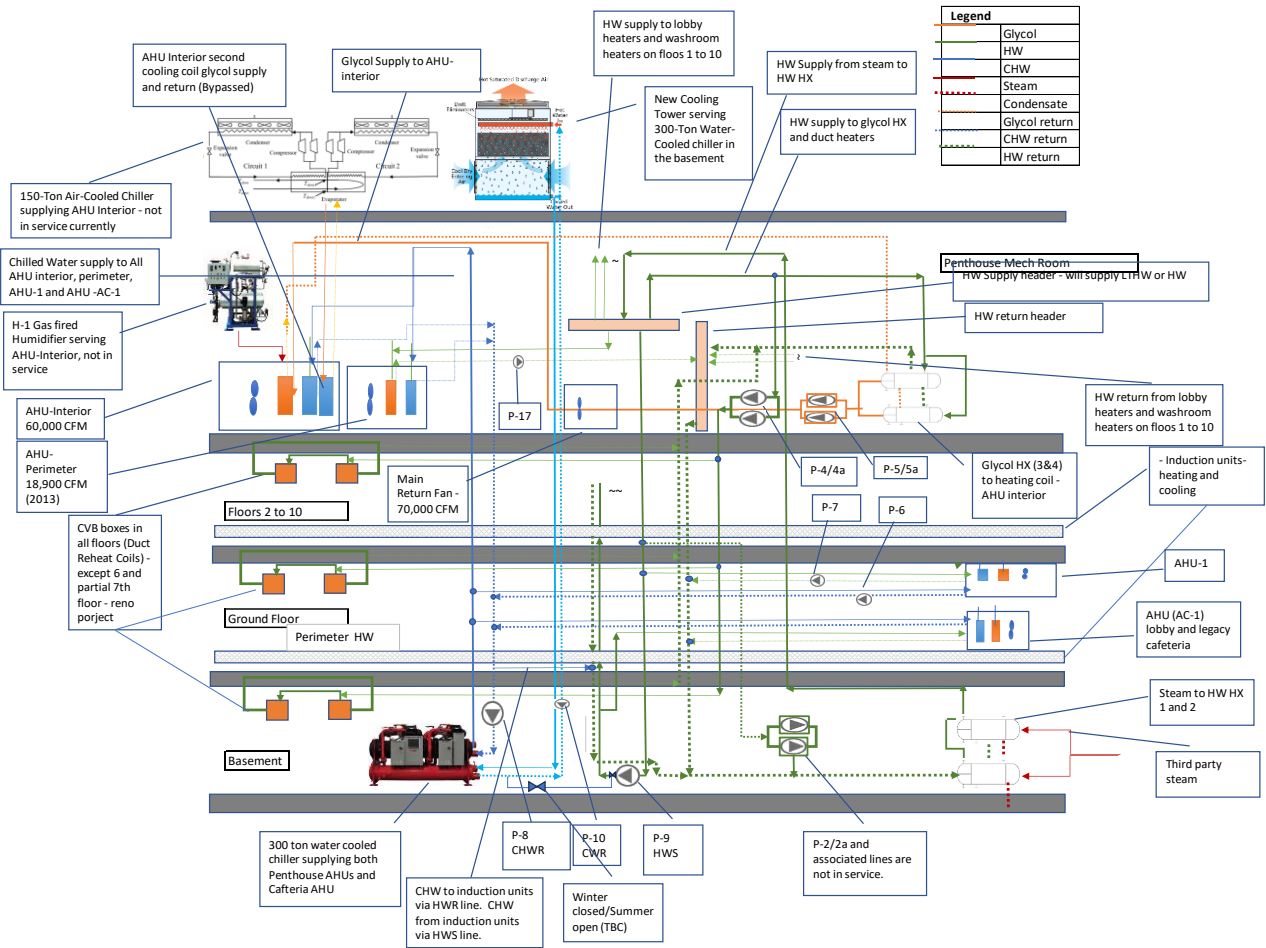
Supply Flow: 84.2 cfm
Supply Flow SP: 88.0 cfm

Zone Temp: 65.8 deg F
W/C Adj: 0.9 deg F



APPENDIX B – EXISTING CONDITIONS AND PROPOSED ECM MEASURES SCHEMATIC

Existing Conditions Schematic:



Proposed ECMs Schematic:

