# Strategic Energy Management Plan
# 2020 Update

*for*

**UBCO**

Kelowna, BC

*Attention*

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# EXECUTIVE SUMMARY

UBCO is pursuing a greenhouse gas (GHG) emissions reduction target of **80% below 2013 levels by 2030**, based on <u>*gross*</u> GHG values. GHG emissions <u>*per $m^2$*</u> are also presented for context in light of the several new buildings which are expected to come online by 2030, adding substantial energy demand.

A list of demand-side management (DSM) projects were analyzed and presented to the UBCO Energy Team, who then grouped the projects into five bundles to represent annual implementation plans. Starting with the present fiscal period of FY2021, and proceeding through FY2025, Table 5Table A presents a five-year plan compiled from identified DSM projects. These figures provide an estimate for short-term potential energy and GHG emissions savings. Individual project descriptions can be found in Appendix A.

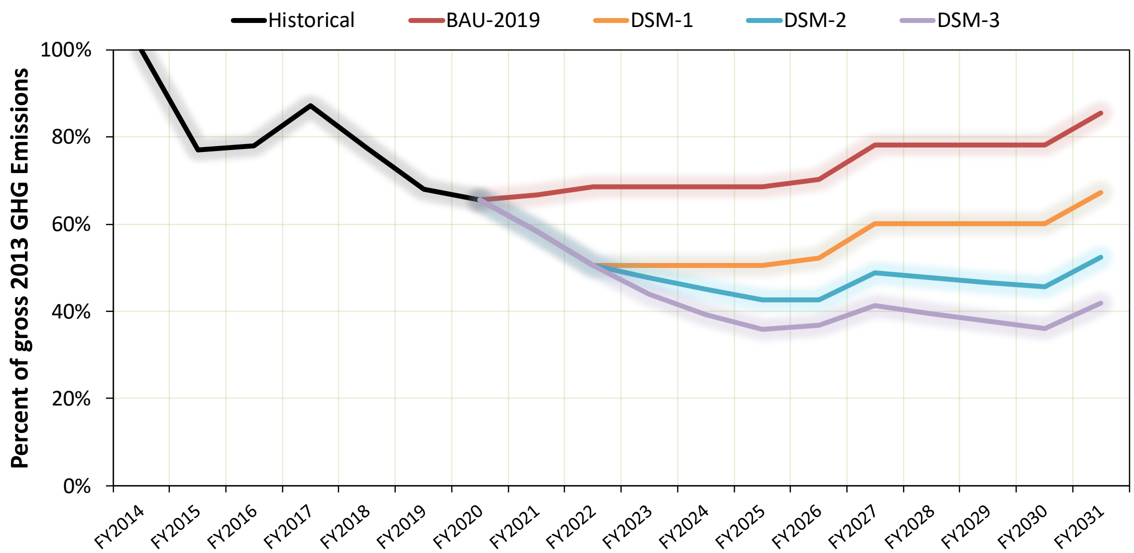
**Table A: Five Year DSM Plan Summary**

| Bundle | Budget | Annual Savings | NPV | IRR |
|---|---|---|---|---|
| FY2021 | $ 110,000 | $ 80,000 | $ 667,900 | 86% |
| FY2022 | $ 100,000 | $ 100,000 | $ 860,600 | 114% |
| FY2023 | $ 520,000 | $ 50,000 | ($30,700) | 12% |
| FY2024 | $ 500,000 | $ 40,000 | ($137,000) | 8% |
| FY2025 | $ 580,000 | $ 30,000 | ($301,500) | 4% |
| Future | $ 590,000 | $ 10,000 | ($497,300) | -6% |
| Residences | $ 173,500 | $ 25,900 | $ 64,500 | 18% |

To explore potential pathways towards meeting the 2030 GHG emissions target, three DSM scenarios were projected based on different implementation plans for the identified project bundles, as presented in Figure A.

- DSM-1: Is based on the implementation of project bundles FY2021 and FY2022, with no additional energy conservation efforts beyond that.
- DSM-2: Is based on the full implementation of project bundles FY2021 and FY2022, with savings from the remaining bundles (FY2023 – FY2025) linearly scaled to match an annual budget of $200k.
- DSM-3: Is based on the implementation of all project bundles (FY2021 – FY2025) as planned over the next five years, with the GHG emissions reduction over the remaining five years (up to FY2031) extrapolated.

**Figure A: 2030 Projections of DSM Scenarios**




The DSM-3 scenario is shown to be a pathway which brings the campus to an 80% GHG reduction based on *"per $m^2$"* emission values. It does not, however, achieve the Target based on *gross* GHG values.

It may be plausible to meet 2030 Target based on gross values by combining either the DSM-2 or DSM-3 scenarios with some degree of fuel-shifting. The LDES-ASHP fuel-shifting measure proposed here is shown to serve as a viable approach to accomplishing that goal. To facilitate any degree of success with the aforementioned pathways, it is critical that the Energy Team see the appropriate increase in annual spending budgets to meet the anticipated rise in project implementation costs.

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# 1 INTRODUCTION

In February of 2020, SES was engaged by UBCO to revise and update the five-year Strategic Energy Management Plan (SEMP). This work builds upon the 2018 SEMP also prepared by SES, and uses updated resources and technical evaluation to accomplish revised objectives.

This report presents our findings of the investigation and was prepared by Steffen Trangeled, P.Eng with support of Khaled Issa, EIT.

## 1.1 Objective

The primary objective of this SEMP edition is to explore potential pathways towards achieving UBCO's Energy Team (ET) Greenhouse gas (GHG) emissions targets by modelling projections over a 10-year horizon under different Demand Side Management (DSM) scenarios. The DSM measures presented were recommended following consultation with UBCO's Energy Team, and are grouped into bundles for implementation over a 5-year plan. This report is an extension on the 2018 SEMP, using updated resources such as utility data and campus growth projections.

## 1.2 Approach

The following approach was taken to gather information and produce this report.

- Review of the 2018 SEMP report.
- Review of owner supplied resources (as listed below).
- Discussion of recommended DSM measures with UBCO's Energy Team to select the most viable options to move forward with.
- Cost, energy savings, and emissions reduction estimates were done to an ASHRAE Level 1 standard.

The following resources were provided by UBCO:

- Campus energy summary with electricity and natural gas annual consumption data starting from FY12-13.
- Remote DDC access via Desigo/Insight (Siemens) and Enteliweb (Delta Controls), and trend log archives.
- Campus area growth projections and energy performance metrics for new academic and residential buildings.
- Campus equipment database updated to the year 2020.
- UBCO's Energy Team District Energy Systems (DES) strategy report (2019).
- Summary of DSM projects implemented by UBCO's Energy Team.
- Space type breakdown in academic buildings with lab areas.

## 1.3 Limitations of Liability

This document was prepared by SES Consulting Inc. for UBCO. An investigation has been performed to estimate the probable costs and energy impacts associated with each recommendation. Further detailed design work will be required for project implementation. All estimates of probable cost are made on the basis of SES's judgment and experience. SES makes no warranty, express or implied, that cost of the work will not vary from the SES's estimate of probable cost. SES accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

### 1.4 Acknowledgements

We thank Colin Richardson and Glen McIntyre for providing the needed resources, and for their support and direction during the analysis of DSM projects and the production of this report. We would also like to acknowledge Terrence Nimegeers for introducing us to the Siemens Desigo platform, and providing instructions on how to obtain HVAC operational trend logs.

## 2 BACKGROUND

UBCO's Energy Team has a mandate to achieve significant reductions in GHG emissions by the year 2030, through overseeing the implementation of an array of DSM measures that include: HVAC controls modifications, mechanical upgrades, equipment maintenance, and behaviour change strategies. The 2018 SEMP report outlined a path to reach UBCO's 2020 GHG reduction targets, primarily by means of DSM measures. The 2018 SEMP report also recognized that the 2030 GHG reduction targets are out of reach when relying solely on energy conservation measures.

This document re-examines the degree of GHG emissions reduction that would be possible via DSM measures. Data presented in this report's findings are intended to serve as budgetary planning tools for the upcoming five years of energy efficiency upgrades.

### 2.1 Summary of Recent Energy Projects

The following major projects have been completed since FY18-19:

- Science Exhaust Air Heat Recovery:
  - Heat was only partially recovered from the exhaust air connected to the Science building's main laboratory exhaust fans. A glycol run-around heat recovery system was installed to recover heat from the remainder of the exhaust air.
  - Completion date: July 2018.
  - Expected annual savings: 2,000GJ of natural gas.
- ASC Exhaust Heat Recovery:
  - A mechanical consultant was contracted to provide remedial actions needed to activate a glycol run-around loop that was previously installed to recover heat from the laboratory exhaust air, but was not operational due to deficiencies in the original design. The required actions were implemented and the system is operational.
  - Completion date: March 2019.
  - Expected annual savings: 68,800kWh of electricity, 860GJ of natural gas.
- Science Ventilation Upgrade - completed
- Library Data Centre Heat Recovery - completed

Projects that are ongoing:

- LDES Optimization:
  - In FY18-19, upgrades to the RHS and EME buildings were completed to allow for reduced return water temperatures, in order to increase the amount of groundwater heating provided to the LDES.
    - Expected annual savings: 350GJ of natural gas.
  - In FY19-20, two projects were carried out: (i) a connection was established between the LDES and MDES to improve the LDES heating capacity, and (ii) a low-flow pump was installed to meet minimum flow requirements for the LDES and improve geothermal heat extraction.
    - Expected annual savings: 30,000kWh of electricity, and 560GJ of natural gas.

  - Additional upgrades to the LDES are being investigated for future implementation.
- Lighting Upgrades:
  - Upgrades to existing campus lighting to LED lights and fixtures are still ongoing.
  - Expected annual savings: 250,000kWh of electricity.
- HVAC System Efficiency Maintenance:
  - HVAC Technician has been cleaning fouling and particulates from heat exchangers and other campus HVAC equipment. Identifying fouling rates in equipment is informing the maintenance schedule on an ongoing basis.
  - Expected annual savings: 50,400kWh of electricity, and 240GJ of natural gas.

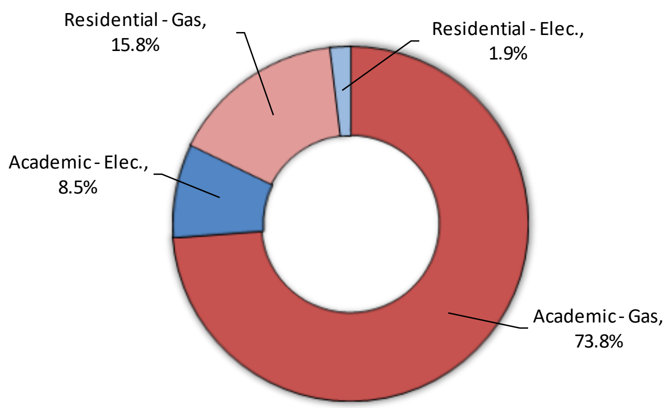
## 2.2 Existing Policies and Resources

- UBCO Okanagan Whole Systems Infrastructure Plan (2016) :
  - Guide for the strategic vision, such as the expansion of the Low-temperature District Energy System (LDES), and low-carbon fuel-switching.
- UBC Green Building Action Plan (2018):
  - GHG intensities (GHGI) for newly constructed buildings post 2019.
- UBC Okanagan Energy Team Annual Report for FY18-19 (2019):
  - Campus overall energy consumption trends and distribution of energy use.
  - LDES heating and cooling energy sources breakdown.
  - Medium-temperature District Energy System (MDES) thermal loads historical trends.
  - Summary of recently completed DSM projects.
- UBCO DES Strategy Plan – Part One (2019):
  - History and current state of the LDES and MDES.
  - Includes campus build-out, utility cost forecasting, operating and maintenance cost forecasting, purpose to define assumptions for Phase Two.
- UBC Okanagan Outlook 2040 (2019):
  - Campus growth projections with all new buildings up to the year 2040.

## 2.3 Energy Baselines

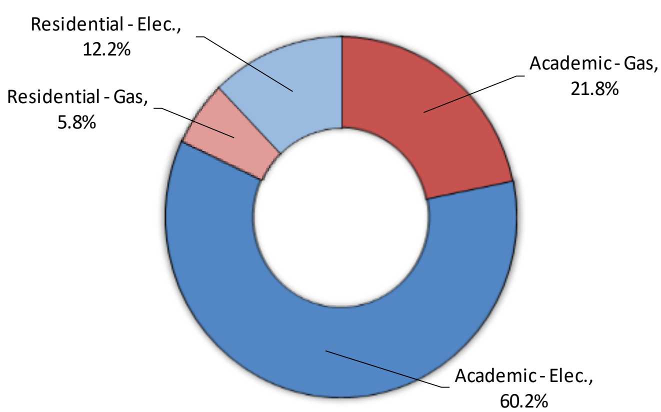
Since 2013, natural gas consumption has accounted for more than 89% of the total GHG emissions at UBCO (Figure 1), with the overwhelming majority coming from Academic buildings.

**Figure 1: GHG total emissions % breakdown from 2013 - 2019**




The UBCO campus energy sources include: electricity, natural gas, and geothermal wells. Electricity and natural gas are provided by FortisBC. The campus also receives gas from Shell Energy. In FY19-20, the campus consumed a total of 37,400 MWh of energy, divided between academic and residential buildings as shown in Figure 2.

**Figure 2: Campus energy consumption in FY19-20.**




Electricity accounts for the majority of energy consumption on campus, and is used to power the operation of ventilation equipment, chilled water systems, lighting, as well as plug loads.

Gas on campus is consumed by the following systems:

- Medium Temperature District Energy System (MDES).
- Low Temperature District Energy System (LDES)
- Buildings standalone space and potable water heating systems.
- Other relatively minor loads for cooking, laboratories, and processes.

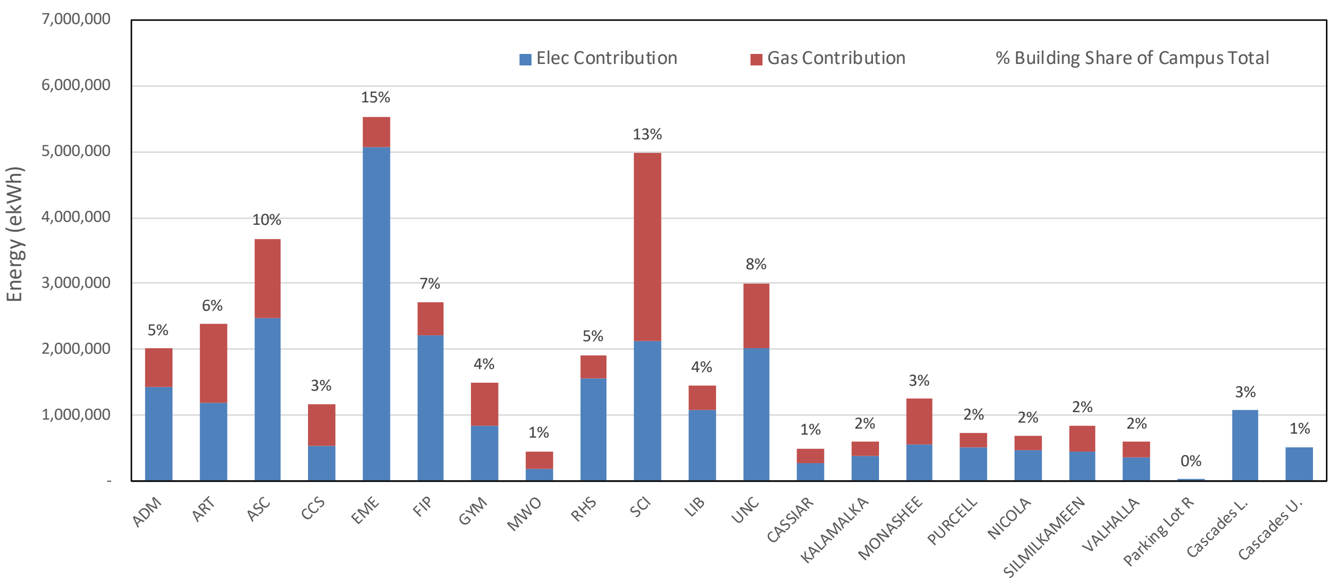
The MDES central heating pant relies on natural gas fired boilers to produce heating water that serves five academic buildings. The MDES also delivers heat to the LDES through a heat exchanger in the geo-exchange building.

The LDES distributes slightly conditioned water (6°C – 32°C) to 11 academic buildings, each equipped with water-source heat pumps for heating and cooling. Heating sources for the conditioned water include: geothermal wells, natural gas fired boilers, and the MDES. Cooling is also provided by cooling towers, and is supported by the open-loop geothermal exchange system.

## 2.4 Building Breakout

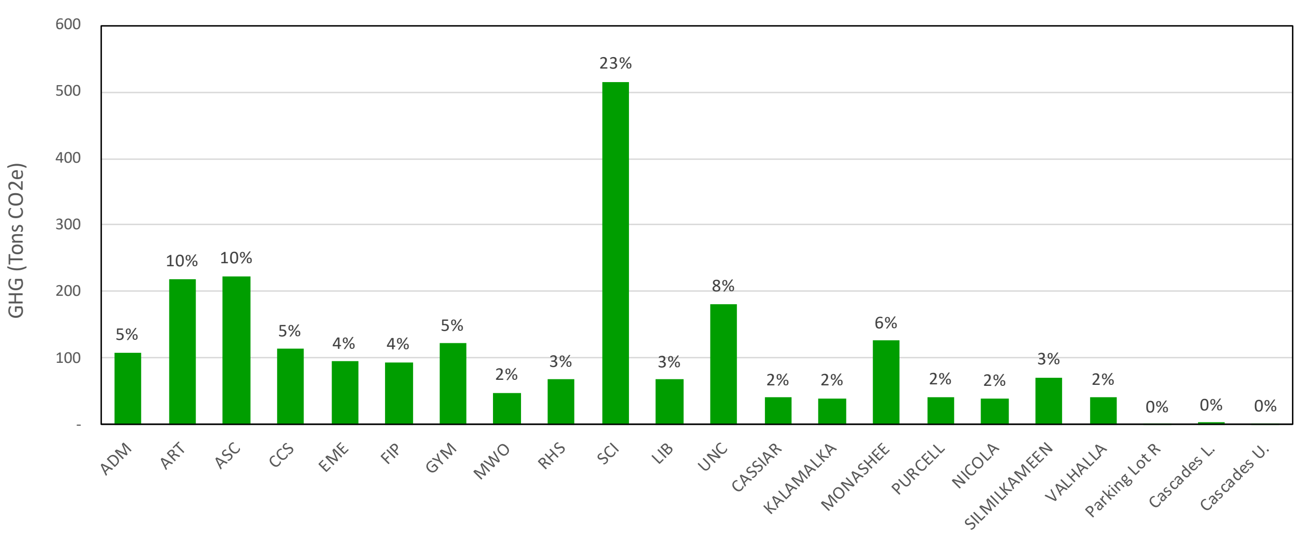
Electricity and natural gas consumption per building is shown in Figure 3 for academic and residential buildings, respectively. In addition to locally consumed electricity and natural gas, contributions from the MDES and LDES to the per-building energy consumption are also included in the presented values. For most buildings, electricity accounts for a larger portion of the total energy consumed.

**Figure 3: Buildings energy consumption breakdown at UBCO (FY19-20).**




Similarly, Figure 4 shows the GHG emissions breakdown by building. This helps to identify candidates for DSM measures that are focused on reducing natural gas consumption and GHG emissions. These buildings include: SCI, ASC, ART, and UNC. The SCI building has a relatively higher reliance on natural gas, and as a result, produces more than twice the GHG emissions from any other building on campus.

**Figure 4: Buildings GHG emissions breakdown at UBCO (FY19-20).**



## 2.5 Energy Cost

Table 1 presents the energy (utility) and emission pricing rates used for subsequent calculation.

**Table 1: Utility Rates**

| Natural Gas | | Electricity | |
|---|---|---|---|
| Utility Provider | FortisBC | Utility Provider | FortisBC |
| Utility Rate Schedule | Rate 2 | Utility Rate Schedule | Large Commercial Service |
| Utility Consumption Rate 2020 | $ 8.64 /GJ | Marginal Consumption Rate 2020 | $ 0.0560 /kWh |
| GST | 5.0% | GST | 5.0% |
| PST | 7.0% | PST | 0.0% |
| Consumption Rate Escalation starting 2021 | 3.3% /yr | Peak Demand Charge | $ 9.280 /kW |
| Carbon Tax 2020 | $ 45.00 /tonne | Est. Consumption Rate Escalation Starting 2021 | 3.3% /yr |
| Carbon Tax 2021 | $ 50.00 /tonne | Est. Consumption Cost 2030 | $ 0.0803 /kWh |
| Carbon Price 2020-2021 | $ 25.00 /tonne | | |
| Carbon Tax/Price Escalation starting 2022 | $ 5.00 /tonne | GHG Factor | 2.59E-06 tonne/kWh |
| Net Consumption Cost 2030 | $ 18.33 /GJ | | |
| GHG Factor | 4.99E-02 tonne/GJ | | |

As a direct comparison of the cost of electricity versus natural gas: the blended energy cost of natural gas in FY19-20 was $34/MWh, and the blended cost of electricity was $80/MWh. This totaled approximately $0.30M (37,234 GJ) and $2.17M (27,063 MWh) CAD annually for natural gas and electricity, respectively.

# 3 FUTURE OUTLOOK

## 3.1 GHG Targets

UBCO's Energy Team is pursuing a GHG emissions reduction target of **80% below 2013 levels by the year 2030**, based on gross GHG values. Nevertheless, GHG emissions per $m^2$ are also presented for added context, especially in light of the expected increase in campus space over the 2020 – 2030 period. For existing campus buildings, the greenhouse gas emissions intensity (GHGI) for FY19-20 was calculated to be: 18.4 $kgCO_2e/m^2$ for academic buildings, and 8.9 $kgCO_2e/m^2$ for residential buildings. Newly constructed buildings, after FY19-20, are assigned GHGIs based on the 2018 UBC Green Building Action Plan (4.1$kgCO_2e/m^2$ and 5.5 $kgCO_2e/m^2$ for academic and residential buildings, respectively). Figure 5 provides a visual representation of the FY19-20 GHG emissions versus the 2030 target.

**Figure 5: Comparing FY19-20 emissions total to 2030 GHG reduction target.**

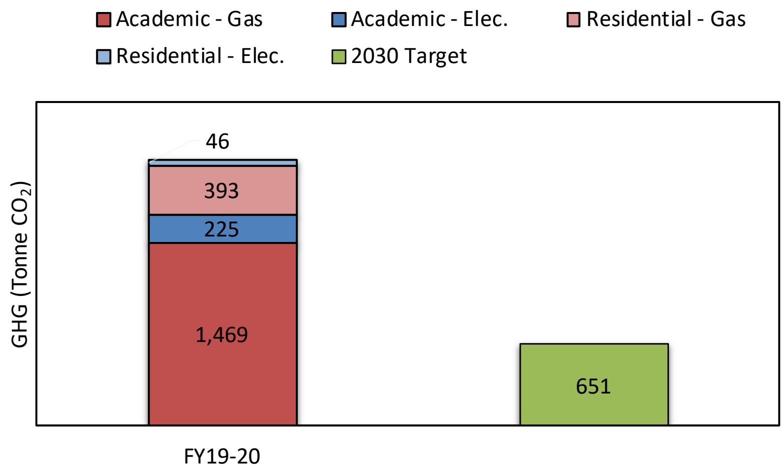
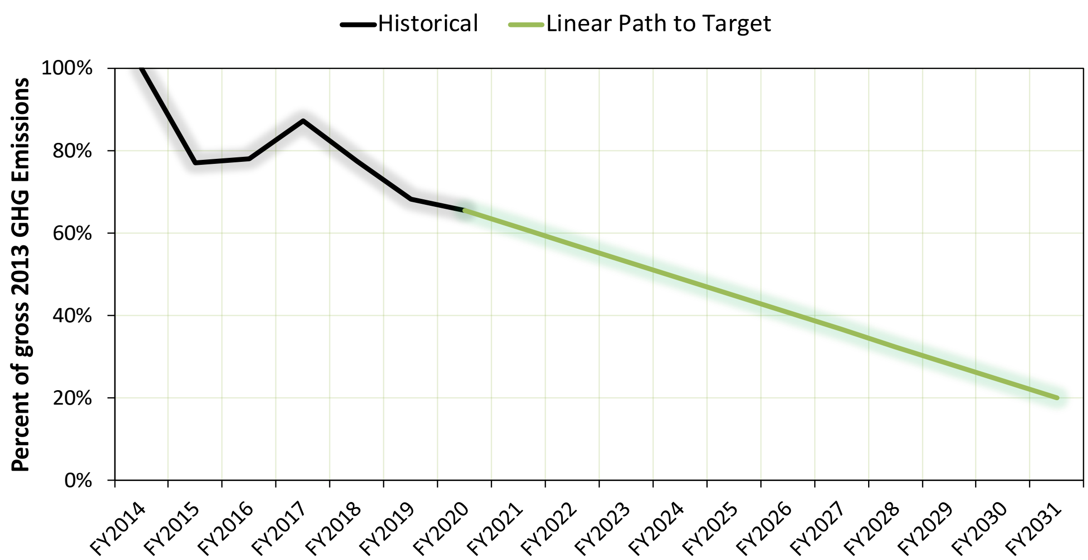


Figure 6 presents a linear projection of the GHG emissions drop required to meet the 2030 goal. This amounts to reducing the FY19-20 emissions by 70%, or at a rate of 7% (approx. 150 Tonne $CO_2$ or 2,960GJ) per year over the 2020 – 2030 period.

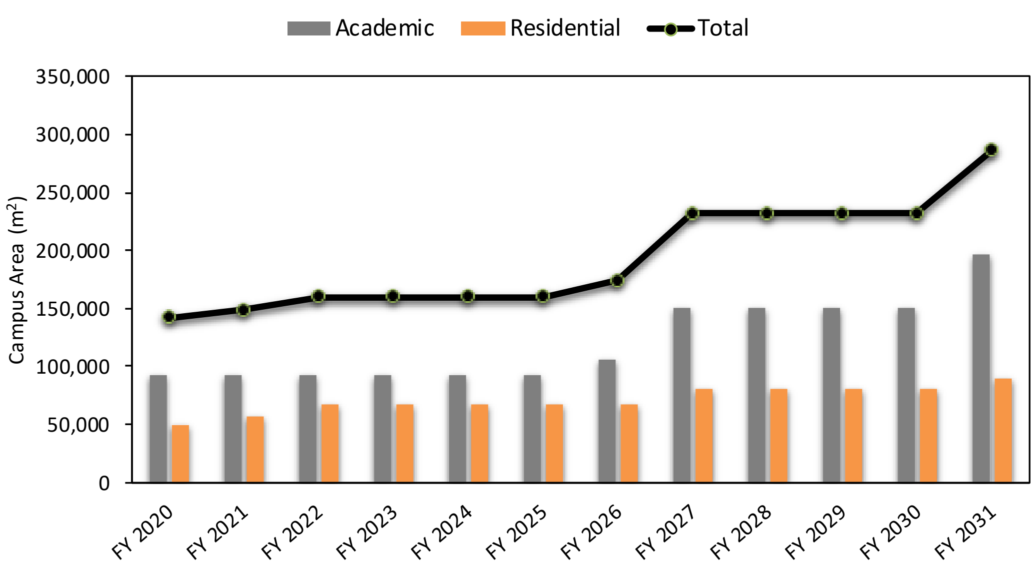
**Figure 6: Historical and linearly projected drop to meet 2030 emissions target (Gross).**




## 3.2 Campus Growth

The challenge to meet this 2030 GHG target is further exacerbated by the projected campus expansion, shown in Figure 7, which by FY30-31 is anticipated to increase by 102%.

**Figure 7: Projected increase in UBCO campus space from FY19-20 to FY30-31**



### 3.3 Business As Usual

The ‘Business-As-Usual’ (BAU) scenario assumes that all existing buildings (BAU-Existing) will continue to perform with the same greenhouse gas emissions intensity (GHGI) as that of FY2020.

Buildings constructed post FY2020 (BAU-New) have GHGIs assigned based on the UBC Green Building Action Plan (2018). With no additional climate actions taken beyond FY2020, BAU-2019 projects GHG emissions will reach 85% (or 41% on a per $m^2$ basis) of the 2013 levels, as shown in Figure 8. This falls short of the 20% target by the year 2030. The increase in GHG emissions in this scenario is solely from new construction.

**Figure 8: BAU-2019 GHG emissions projection for existing and new campus buildings (Gross).**

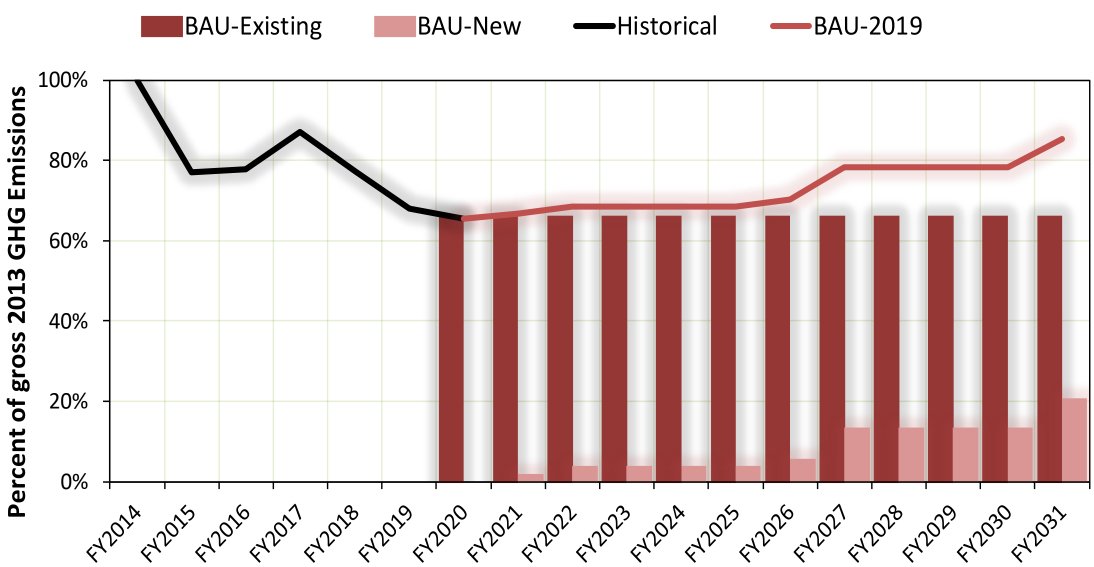
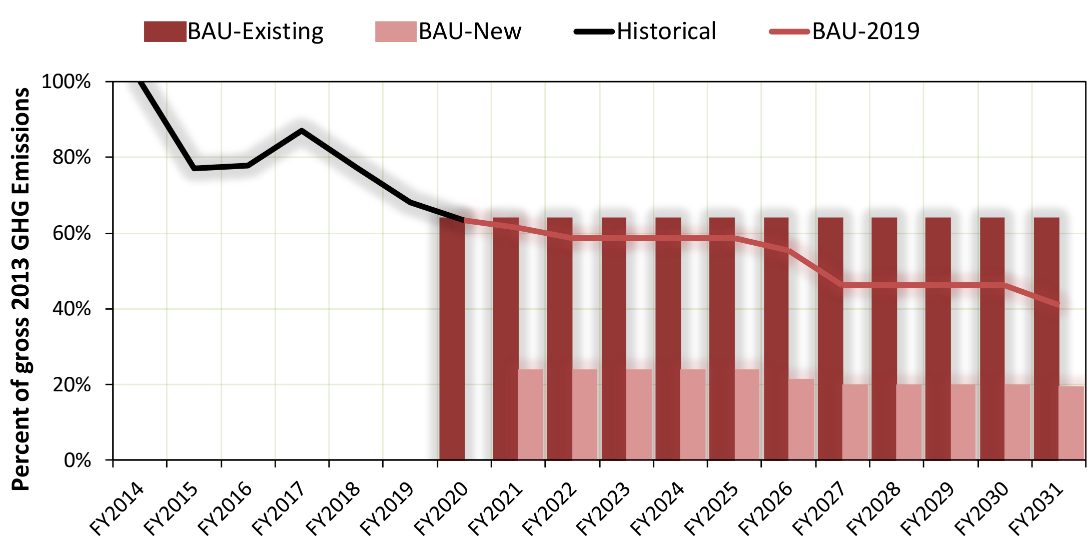



**Figure 9: BAU-2019 GHG emissions projection for existing and new campus buildings (Per $m^2$).**



# 4 IDENTIFIED DSM MEASURES

For the purpose of identifying and analyzing a volume of Demand-Side Management (DSM) opportunities, an extensive list of energy projects was developed in partnership with UBCO's Energy Team. These projects were validated by SES at a high-level (ASHRAE Level 1) with estimated costing and energy savings. Newly identified measures are presented in addition to some outstanding items from the 2018 SEMP which remain viable. The numerical analysis of recommended DSM measures is based on the energy consumption from FY19-20 as a baseline. Potential utility funding incentives were not included in cost estimates gets, due to the general uncertainty. However, incentive programs should be pursued where applicable, as they can provide significant offset to capital costs. Furthermore, interactions and inter-dependencies between ECMs were not captured in the analysis of individual measures for the purpose of flexible selection and bundling, therefore, final savings may differ from values given here, depending on the makeup of select project bundles

## 4.1 Project List

The list of individual projects has been categorized by measure type and described below. See ***Appendix B*** for the detailed descriptions of all individual measures and their potential for energy and emission savings.

### 4.1.1 DCV

This group of measures proposes to reduce outdoor-air and total-air ventilation rates to ASHRAE minimums unless required by a known measurement of occupancy in the spaces served.

Multiple technologies and strategies are available to measure occupancy in ventilated spaces including:

- AHU level CO2 sensors, generally installed in the common return air duct.
- Floor level CO2 sensors, generally installed in the return air ducts consolidating return air paths from multiple zones on a given building floor.
- Zone level CO2 sensors, generally installed in the return air duct of individual ventilation zones.
- WIFI-enabled device counting, using *Sensible Building Science* technology to measure the human occupancy via the monitoring of WIFI-enabled devices.
- Room level occupancy detection, generally installed on the wall or ceiling of occupied spaces using low-resolution infrared sensors to provide a binary signal of room occupancy or not.
- Room level occupancy counting using high-resolution infrared cameras, generally mounted within the occupied space with a view to occupants to provide a numerical signal of occupancy.
- Entry level occupancy counters, generally installed above individual doorways to count the number of human entrances and exits.
- Space level manual switches or automatic detection, generally installed in the immediate vicinity of a device or sub-space within a larger space. Examples include workshop tools and laboratory fume hoods.

*Note: Due to the COVID-19 pandemic, new internal (or external) ventilation codes and requirements may come into conflict with certain applications of DCV.*

### 4.1.2 Air-Side Heat Recovery

This group of measures proposes to recover heat from exhausted ventilation air. There are several mechanisms by which this could work including:

- Passive heat recovery involving a pumped water/glycol loop between an exhaust-air stream and a fresh-air stream. This application is often suitable when the air streams are not in immediate proximity to one another, or multiple streams are to be connected, or differing sizes of stream are to be matched.

- Passive heat recovery involving a direct thermal-transfer mechanism between matching exhaust and fresh air streams. Examples include a rotating heat wheel or stationary heat exchanger. This is often a suitable replacement option for RTUs and AHUs with near-matching return air stream compared with supply.

### 4.1.3 Cooling load transfer onto the LDES

This group of measures aims to offset natural gas at the MDES and LDES plants by moving building cooling loads from local chillers to the LDES instead. Buildings that will be targeted are connected to the LDES for heating only (5 in total). GHG savings would be gained over the heating and shoulder seasons as the undesired heat can be recovered into the LDES for use by other buildings, and thereby offsetting natural gas consumption.

### 4.1.4 DHW Control Upgrade

This measure proposes demand-based control of domestic hot water (DHW) circulation and tank heating in academic buildings with non-electric DHW heat sources. Currently, energy consumed for DHW heating is driven by supply temperature setpoints and schedule requirements regardless of end-user demand, or the temperature of the recirculation line. To facilitate demand-based control, we recommend the following:

- Install temperature sensors on the recirculation line return pipes. This allows for reducing the speed or disabling of the recirculation pumps when the return water temperature is above a certain setpoint.
- A flow sensor on make-up water pipes to monitor demand for DHW.
- Scheduled (variable) control of tank temperature setpoints.

Based on a US Department of Energy research study, temperature-based recirculation control typically leads to annual electricity (pumping) and thermal energy savings up to 15% (of the DHW system), while still ensuring that occupants are not waiting long periods of time for hot water at the tap[1].

### 4.1.5 RCx of Existing Control Systems

These measures capture energy savings that can be achieved by recommissioning (RCx) existing control systems in academic buildings. Over the years, campus spaces undergo changes due to renovations, re-scheduling, and evolving occupant needs. This can negatively impact the energy efficiency of the buildings' HVAC systems, especially if the building controls systems were never thoroughly commissioned at construction. Through a rigorous investigative approach of detecting operational deficiencies and system integration issues, RCx ensures that the existing building HVAC systems are aligned with current space needs.

This re-optimization process should be ongoing and integrated as part of the buildings' life cycle to ensure the persistence of benefits. The RCx process can address inefficiencies from:

- Equipment operating over extended periods of time when the building spaces are unoccupied.
- Excessive simultaneous heating and cooling.
- Supply air and water temperature setpoints that are no longer optimal or have been manually overridden.
- Ineffective utilization of free-cooling.
- Improper building pressurization.

### 4.1.6 Re-Design of Lab Ventilation Rates

This measure proposes to reduce overall ventilation rates in laboratory spaces, both wet and dry types. Savings are achieved by standardizing the total air-changes per hour (ACH) during occupied hours (example 8.0 ACH), and

[1] DHW Controls Upgrade Control Strategies to Reduce the Energy Consumption of Central Domestic Hot Water Systems, Advanced Residential Integrated Energy Solutions, US Department of Energy, June 2016.

applying a lower standard (example 4.0 ACH) during unoccupied hours as recommended by ASHRAE standards for laboratories. Methods for determining occupancy can be adopted from Sec 4.1.1 of this report.

### 4.1.7 Upsize of Terminal HW Coils

Terminal HW coils in legacy campus buildings were initially designed for high temperature operations. This measure proposes to lower the design HW temperature of terminal coils by increasing their overall size (increasing heat transfer) to perform equally at a lower supplied HW temperature.

This retrofit will improve the energy performance of heatpumps serving the building hydronic systems by lowering the required “temperature lift” (temperature difference between the source and load sides). Design flow considerations must be carefully explored to ensure proper rates can be maintained to satisfy the buildings’ heating loads.

While this measure may play a vital role in the grand scheme of de-carbonizing space heating at UBCO, applicable equipment is difficult to identify in mass and less-sensible to analyze in isolation. Thus, no specific projects of this nature are presented in the annual bundles below.

This measure is ideal to consider in conjunction with an interior space renovation, especially if the serving ventilation equipment is near end-of-life.

### 4.1.8 Upsize of Building Heatpump Stations

During periods of high heat load (winter), the HW heating capacity of some buildings is limited by the capacity of currently installed heatpump units. When this limit is reached, the buildings may revert away from LDES heating onto local gas-fired boilers which increases GHG emissions.

By adding capacity to the building heatpump stations, this limiting factor can be mitigated to allow extended operation of the LDES system.

The addition of the LDES and MDES for heating favors lower temperatures for a more efficient operation of the DES. Upsizing the heatpump energy transfer stations enables the extraction of the same amount of heat at lower supply, and consequently, return HW temperatures. A lower HW return temperature enhances the heat extraction from geothermal wells by the LDES, and increases the efficiency at which the MDES condensing boilers operate.

While this measure may play a vital role in the grand scheme of de-carbonizing space heating at UBCO, applicable equipment is difficult to identify in mass and less-sensible to analyze in isolation. Thus, no specific projects of this nature are presented in the annual bundles below.

### 4.1.9 Deep Retrofit of Ventilation Systems

The majority of mechanical ventilation systems at UBCO’s academic buildings are conventional in design with limited opportunities for substantial energy reduction. Most systems can be characterized as multi-zone distribution with centralized air movement and centralized cooling. Several alternative ventilation designs exist which separate outdoor air from recirculated air which is moved within the zone. Furthermore, terminal conditioning devices to satisfy both heating and cooling loads at a zone level dramatically reduce the simultaneous heating and cooling inherent to systems with central cooling and zone heating.

Such “deep retrofits” involve more than simply changing a piece of rooftop or mechanical room equipment, because it affects how air is delivered, and how thermal conditioning is managed. These retrofits may involve significant tenant disruption and high capital cost to replace air distribution or hydronic systems. Examples include:

- Constant volume to variable air volume terminal upgrades
- A dedicated outdoor air system (DOAS) with either:
    - 4-pipe terminal fancoils
    - 2 or 4 pipe terminal water-to-air heatpumps
    - Terminal VRF units
- Single zone breakouts with heat recovery ventilators (HRV)

This measure is ideal to consider in conjunction with an interior space renovation, especially if the serving ventilation equipment is near end-of-life.

While these measures may play a vital role in the grand scheme of de-carbonizing space heating at UBCO, applicable equipment is difficult to identify in mass and less-sensible to analyze in isolation. Thus, no specific projects of this nature are presented in the annual bundles below.

### 4.1.10 Residence Building RCx

This measure includes both the recommissioning (RCx) of existing control systems at Residence buildings as well as the addition or expansion of control systems to extend functionality. Sub-measures include:

- Installation of DDC systems to facilitate control and ongoing commissioning of HVAC and DHW.
- Occupancy detection in common areas for HVAC control.
- Optimizing setpoints for packaged terminal air conditioning (PTAC) units during unoccupied periods.
- Energy efficient education campaigns.
- Isolation of DHW tanks during the summer season.

### 4.1.11 Other

This group of measures stem from the 2018 SEMP and involve miscellaneous measures across campus.

- Nighttime pre-cooling of ventilated spaces.
- Hydronic additives for increased thermal transfer (Endotherm).

### 4.1.12 Air-Source Heatpumps for LDES

This measure sits apart from the above by being a mode of direct fuel-shifting, as opposed to methods of demand-reduction.

***Heatpumps using CO2 Refrigerant***

Mayekawa is a Japanese manufacturer with a Canadian division in the process of certifying $CO_2$ heatpump products in Canada. The Mayekawa Unimo air-source heatpump (ASHP) is a 2-pipe modular unit using $CO_2$ (aka R744) refrigerant. It comes in one size (~40kW output), and can be controlled to supply either 65°C or 90°C hot water (HW).

The principle benefit of the $CO_2$ refrigeration cycle is the ability to deliver high temperature water and the ability to “lift” the temperature (from source to load) by very high amounts. However, another notable performance characteristic includes the requirement of high load-side temperature difference (dT). A minimum 25° dT is required, but even higher is preferred. For example; if supplying HW at 90°C, the maximum return water temp may be 65°. Performance is largely dependent on this load-side dT, and less dependent on lift (variable with OAT) as compared to conventional refrigerants.

While this high dT requirement is a major barrier to many commercial heating applications, the LDES loop provides a uniquely compatible case for the $CO_2$ technology due to its high volume, high flow rate, and very low returning water temperature.

Beyond heating performance, the Unimo products promise a simple and low cost installation compared to ASHPs using traditional refrigerants. A bank of Unimo units would be relatively simple to design, control, and install, thanks in part to the very low water flow requirements.

***Heatpumps Using 410a Refrigerant***

Several manufacturers from Italy and the USA offer ASHP products available in UBCO’s market, including the Aermec NRK line.

For comparative purposes it should be noted that the NRK option is physically larger with more complex controls and operation. It would also, however, be able to run in cooling mode during summer months to supplement or offset the existing LDES cooling system if desired. The cooling operation has not been analysed here.

## 4.2 Implementation Impact

Table 2 presents an estimate of costs and savings based on the DSM measure categories.

**Table 2: Impact of recommended measures by category**

| Measure Category | Capital Cost | Annual Savings | GHG Savings (tonne) | Capital / GHG ($/tonne) |
|---|---|---|---|---|
| DCV | $ 52,000 | $ 87,200 | 300 | $ 173 |
| Air-Side HR | $ 4,980,000 | $ 160,860 | 645 | $ 7,722 |
| LDES Cool Transfer | $ 515,000 | $ 3,360 | 13 | $ 39,615 |
| DHW Controls Upgrade | $ 95,000 | $ 7,100 | 29 | $ 3,287 |
| RCx Existing Control Systems | $ 415,000 | $ 129,580 | 113 | $ 3,660 |
| Re-Design Lab Ventilation Rates | $ 90,000 | $ 79,200 | 248 | $ 363 |
| Mechanical Upgrades | $ 283,000 | $ 3,060 | 25 | $ 11,365 |
| Residence RCx | $ 173,500 | $ 25,900 | 42 | $ 4,121 |
| Other | $ 72,000 | $ 4,500 | 11 | $ 6,486 |

A high variability in the capital costs per tonne of GHG savings are observed, with DCV and Re-Design of Lab Ventilation projects appearing the most attractive by this metric.

***Potential Impact of ASHP for LDES***

This report has analysed a conceptual ASHP addition to the LDES plant at a high level (ASHRAE Level 1 calculations).

A bank of 12 Unimo units is proposed, yielding a maximum heating capacity of 550 kW at 0° OAT. Such a system is expected to show a net utilization of ~50% over the course of an average climate year for Kelowna.

**Table 3: Impact of Unimo Heatpump to LDES**

***Energy***

| Annual Savings | | |
|---|---|---|
| Gas GJ | Gas GJ | Elec kWh |
| 6,740 | 93% | (629,524) |

***Financial***

| Capital Cost | First Year Savings | Payback | Incremental NPV | Incremental IRR |
|---|---|---|---|---|
| $ 2,100,000 | $ 47,168 | 0 yr | ($1,611,200) | 0% |

***Environmental***

| Annu. Save GHG ton | % Save GHG ton | Life Expectancy | Lifetime GHG Save | Incremental $ / GHG | NPV $ / GHG |
|---|---|---|---|---|---|
| 335 | 92% | 25 | 8,363 | $ 251 | ($ 193) |

The particularly high capital cost reflects primary equipment which is very new to our market, namely the CO2 ASHPs. These equipment costs are likely to come down as adaptation occurs and this system type proliferates as an HVAC electrification solution in BC and Canada.

The same general concept for an LDES plant addition using ASHPs has been analysed using an alternative product with a conventional refrigerant. A bank of 6 x "NRK700NA" units is proposed, yielding a maximum heating capacity of 720 kW at 0° OAT. Such a system would show a net utilization of ~40% over the course of an average climate year.

**Table 4: Impact of NRK Heatpump to LDES**

*Energy*

| Annual Savings | | |
|---|---|---|
| Gas GJ | Gas GJ | Elec kWh |
| 7,245 | 99.5% | (473,540) |

*Financial*

| Capital Cost | First Year Savings | Payback | Incremental NPV | Incremental IRR |
|---|---|---|---|---|
| $ 1,600,000 | $ 62,475 | 18 yr | ($961,700) | 3% |

*Environmental*

| Annu. Save GHG ton | % Save GHG ton | Life Expectancy | Lifetime GHG Save | Incremental $ / GHG | NPV $ / GHG |
|---|---|---|---|---|---|
| 360 | 99% | 25 | 9,002 | $ 178 | ($ 107) |

As presented in Table 4, NRK option shows a shorter fiscal payback period and allows for more complete offset of natural gas and associated GHG emissions. The improved performance of this (NRK) project as compared with the CO2 technology is due to the equipment performance under the specific system temperatures analysed for the LDES application. Other applications may show an advantage to either refrigerant technology.

These results are not compiled along with DSM measures into the 10-year plan as presented in sections below, but should be considered as an alternative approach (fuel shifting) to lower the gross GHG emissions.

# 5 FIVE YEAR PLAN

A list of DSM projects fitting the above measure descriptions were analyzed and presented to the UBCO Energy Team, who then grouped the projects into five bundles to represent annual implementation plans. Starting with the present fiscal period of FY2021, and proceeding through FY2025, Table 5 presents a five-year plan compiled from identified DSM projects. These figures provide an estimate for short-term potential energy and GHG emissions savings. Individual project descriptions can be found in Appendix A.

*(The five fiscal-year bundles in the following tables and charts represent the first five years of DSM-3 projection which is defined in Section 6.3)*

**Table 5: Recommended Annual ECM Bundle - Energy Summary**

| | Electricity | | Natural Gas | |
|---|---|---|---|---|
| Bundle | kWh Savings | Incremental Reduction | GJ Savings | Incremental Reduction |
| FY2021 | 376,000 | 1% | 5,000 | 10% |
| FY2022 | 507,000 | 2% | 6,000 | 12% |
| FY2023 | 41,000 | 0% | 4,000 | 9% |
| FY2024 | 71,000 | 0% | 3,000 | 8% |
| FY2025 | 101,000 | 0% | 2,000 | 6% |
| Future | 56,000 | 0% | 1,000 | 3% |
| Residences | 280,000 | 1% | 1,000 | 3% |

Generally, the project bundles were organized by GJ savings. The annual incremental reduction in gas consumption signals diminishing returns, as DSM measures considered to be 'low-hanging fruit' are progressively implemented. The incremental reduction in electricity consumption is negligible by comparison.

## 5.1 Financial Case

The annual investment profile by projects bundle is presented in Table 6. Net present values (NPV) for project bundles were calculated based on the underlying measure's life expectancy, which averages to approximately 15 years for the entire five-year plan. An annual fuel cost escalation rate of 3.3% was used along with a Discount Rate of 12.5%. The NPV represents the net value of accumulated savings beyond that of a hypothetical investment at the discount rate. The internal rate of return (IRR) represents the net annual return rate on investment.

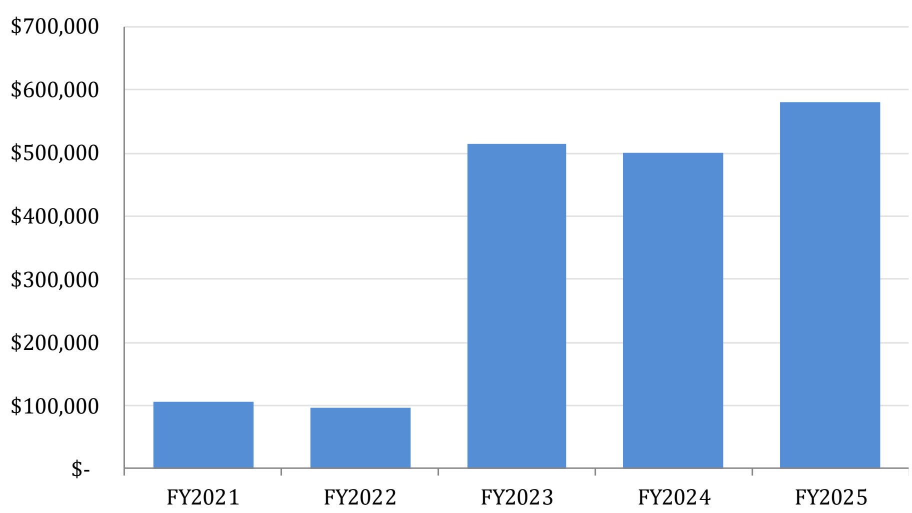
Measures affecting the Residence buildings alone are presented as a separate bundle. The Future Projects Bundle is compiled of measures considered least attractive but still plausible for future consideration.

**Table 6: Recommended Annual ECM Bundle - Financial Summary**

| Bundle | Budget | Annual Savings | NPV | IRR |
|---|---|---|---|---|
| FY2021 | $ 110,000 | $ 80,000 | $ 667,900 | 86% |
| FY2022 | $ 100,000 | $ 100,000 | $ 860,600 | 114% |
| FY2023 | $ 520,000 | $ 50,000 | ($30,700) | 12% |
| FY2024 | $ 500,000 | $ 40,000 | ($137,000) | 8% |
| FY2025 | $ 580,000 | $ 30,000 | ($301,500) | 4% |
| Future | $ 590,000 | $ 10,000 | ($497,300) | -6% |
| Residences | $ 173,500 | $ 25,900 | $ 64,500 | 18% |

Figure 10 presents the investment profile associated with the projects' bundles, and it highlights a drastically lower investment budget for the first two years of project bundles.

**Figure 10: Five-Year DSM Bundle Capital costs**



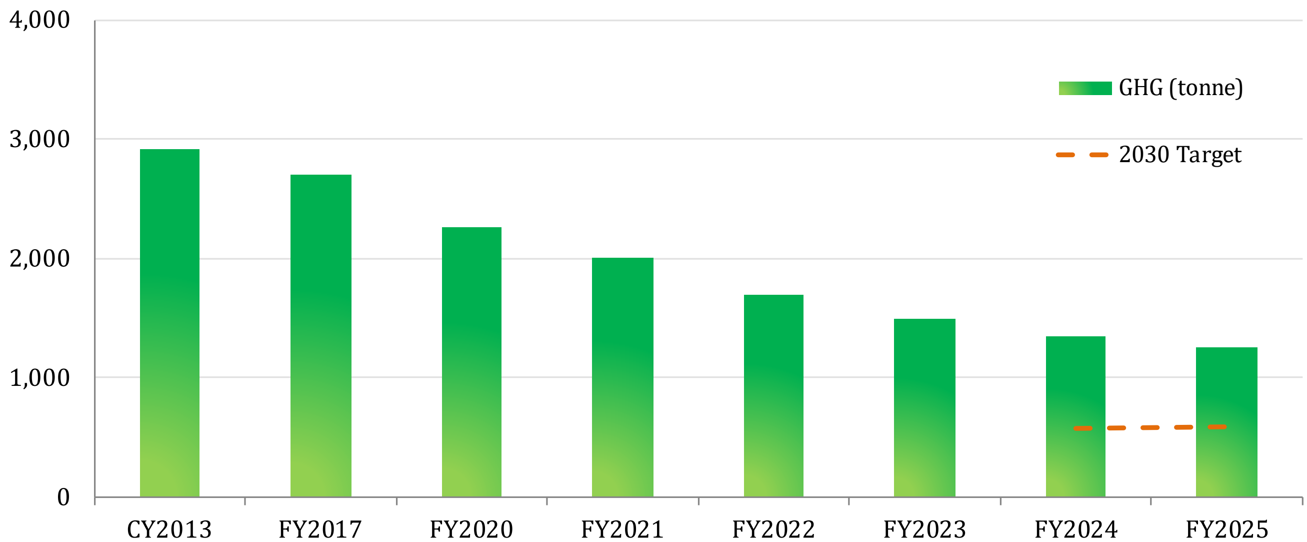
## 5.2 GHG Impact

The impact of the selected ECM bundles on campus GHG emissions is presented in Table 7 and Figure 11. While the selected bundles would achieve a relatively drastic reduction in emissions over the five-year period, meeting the 2030 target would necessitate additional measures. Insights into the degree of effectiveness of the extra measures required to meet the 2030 GHG reduction target can be discerned from the DSM scenarios analysis in Section 6.

**Table 7: Comparison of DSM Bundles GHG Reduction Performance**

| Bundle | GHG Savings (tonne) | $/GHG |
|---|---|---|
| FY2021 | 254 | $ 433 |
| FY2022 | 310 | $ 323 |
| FY2023 | 202 | $ 2,573 |
| FY2024 | 143 | $ 3,501 |
| FY2025 | 99 | $ 5,835 |
| Future | 26 | $ 22,605 |
| Residences | 42 | $ 4,121 |

**Figure 11: Five-Year DSM Bundle GHG Reductions**




# 6 THE 2030 HORIZON

To explore potential pathways towards meeting the 2030 GHG emissions target, three projection scenarios for Demand Side Management (DSM) were analyzed based on different implementation plans for the identified project bundles.

## 6.1 DSM-1 Projection

DSM-1: Is based on the implementation of project bundles FY2021 and FY2022, with no additional energy conservation efforts beyond that. Savings are assumed to apply to existing buildings (DSM-2-E), whereas new buildings (DSM-2-N) perform based on the assigned GHGIs from the GBAP.

There is a relatively sharp initial drop in GHG emissions, as shown in Figure 12 and Figure 13. This is followed by a period of no additional savings, and an increase in GHG emissions due to the planned campus expansion. For the DSM-1 scenario, the projected total emissions for FY2031 reaches 67% (or 32% on a per $m^2$ basis) of the FY2014 figures.

**Figure 12: DSM-1 GHG emissions projection for existing and new campus buildings (Gross).**

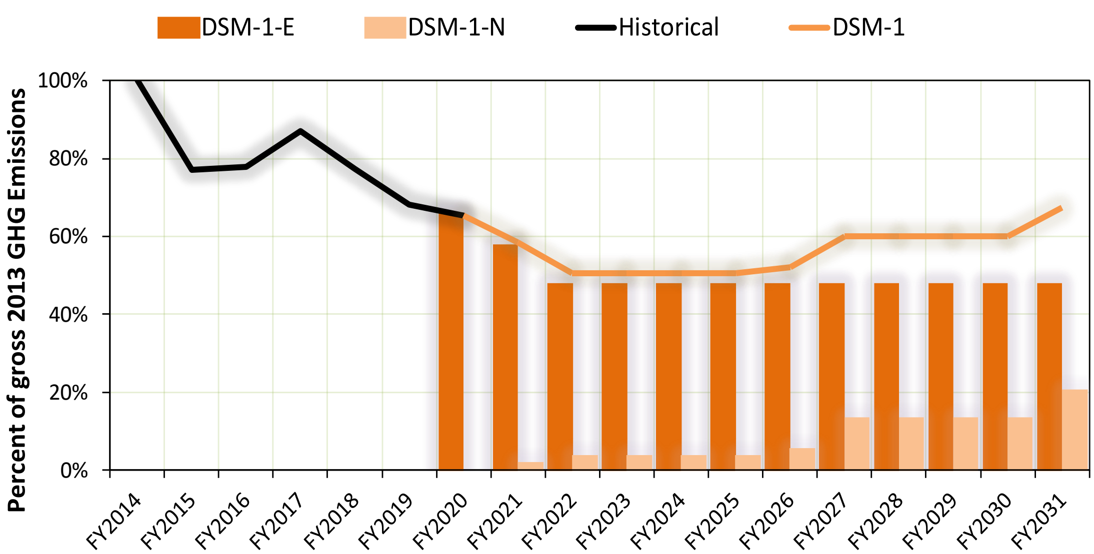
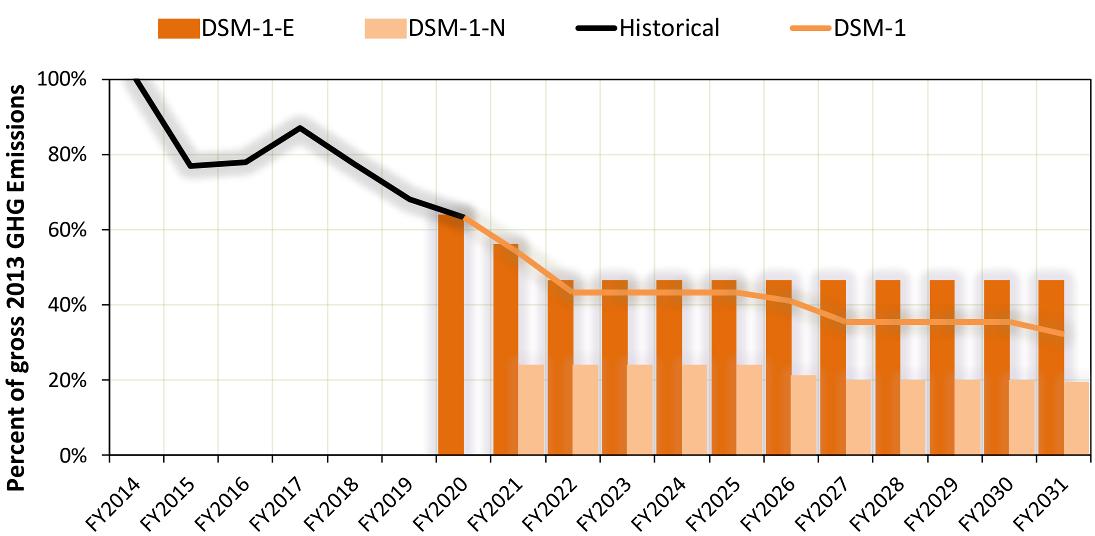



**Figure 13: DSM-1 GHG emissions projection for existing and new campus buildings (Per $m^2$).**



## 6.2 DSM-2 Projection

DSM-2: Is based on the full implementation of project bundles FY2021 and FY2022, with savings from the remaining bundles (FY2023 – FY2025) linearly scaled to match an annual budget of $200k.

Similar to DSM-1, this scenario (Figure 14 & Figure 15) will result in a sharp initial drop in GHG emissions as a result of the implementation of project bundles FY2021 and FY2022. The rate of emissions reduction decreases over the following years due to the capped expenditure. The GHG emissions from the newly added buildings causes an overall increase from FY2026 to FY2031. By 2030, emissions under the DSM-2 scenario are projected to only reach 52% (or 25% on a per $m^2$ basis) of the FY2014 levels.

**Figure 14: DSM-2 GHG emissions projection for existing and new campus buildings (Gross).**

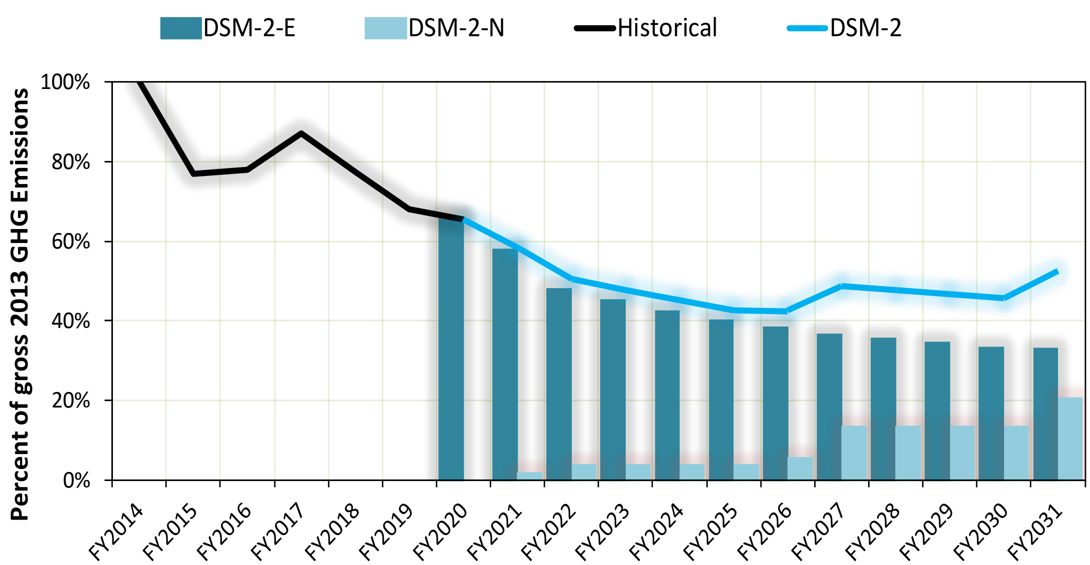
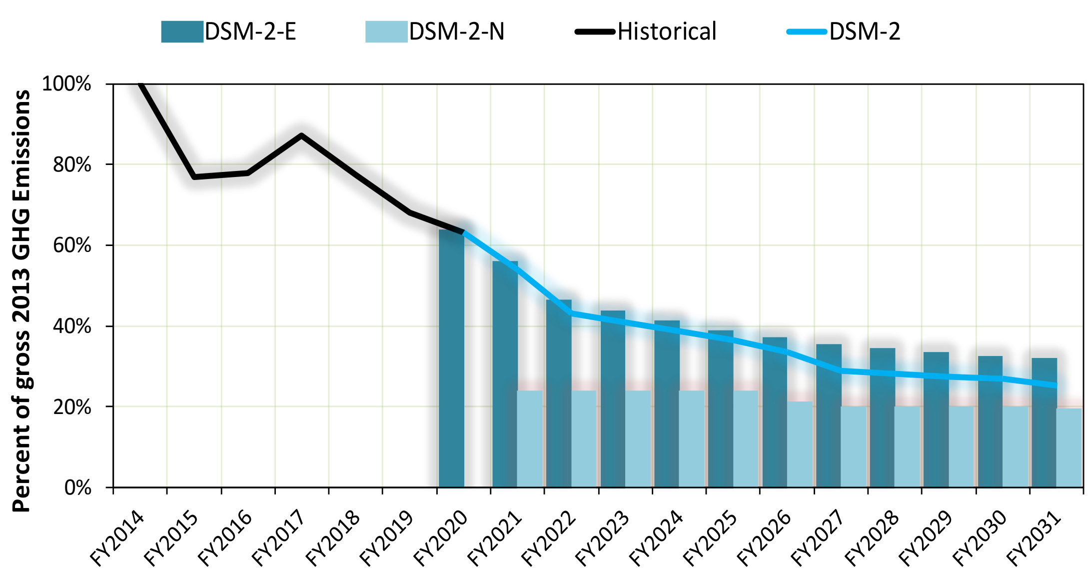



**Figure 15: DSM-2 GHG emissions projection for existing and new campus buildings (Per $m^2$).**



## 6.3 DSM-3 Projection

DSM-3: Is based on the implementation of all project bundles (FY2021 – FY2025) as planned over the next five years, with the GHG emissions reduction over the remaining five years (up to FY2031) extrapolated.

Under this scenario, DSM measures can achieve reductions in GHG emissions that reach 42% (or 20% on a per $m^2$ basis) of the FY13-14 values, as show in Figure 16 and Figure 17.

**Figure 16: DSM-3 GHG emissions projection for existing and new campus buildings (Gross).**

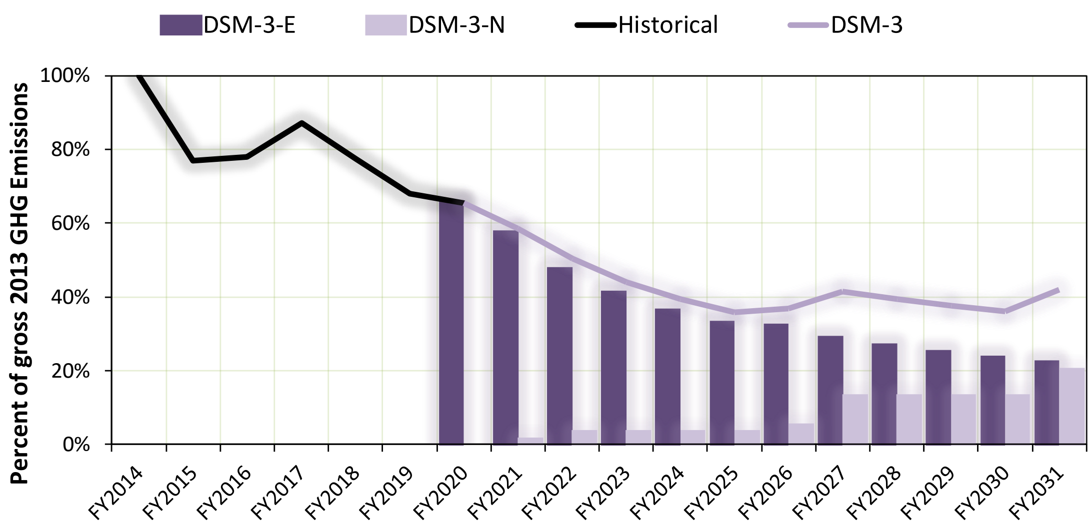
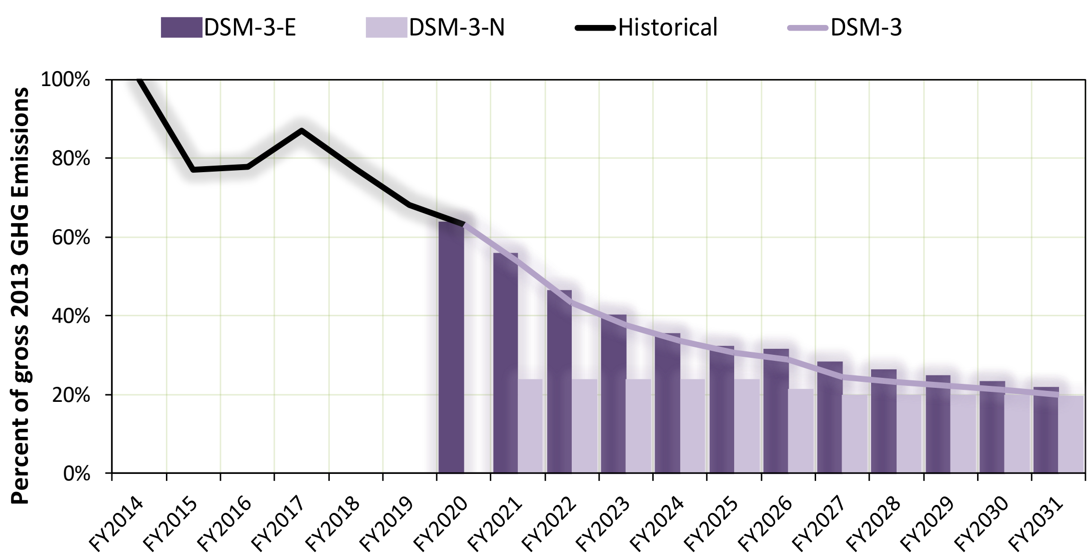



**Figure 17: DSM-3 GHG emissions projection for existing and new campus buildings (Per $m^2$).**



## 6.4 Summary of GHG Projections

A presentation of all the evaluated scenarios (BAU-2019, DSM-1, DSM-2, and DSM-3) is shown in Figure 18 and Figure 19 for gross and per $m^2$ values, respectively.

**Figure 18: GHG emissions projections of all scenarios over a 10-year horizon (Gross)**

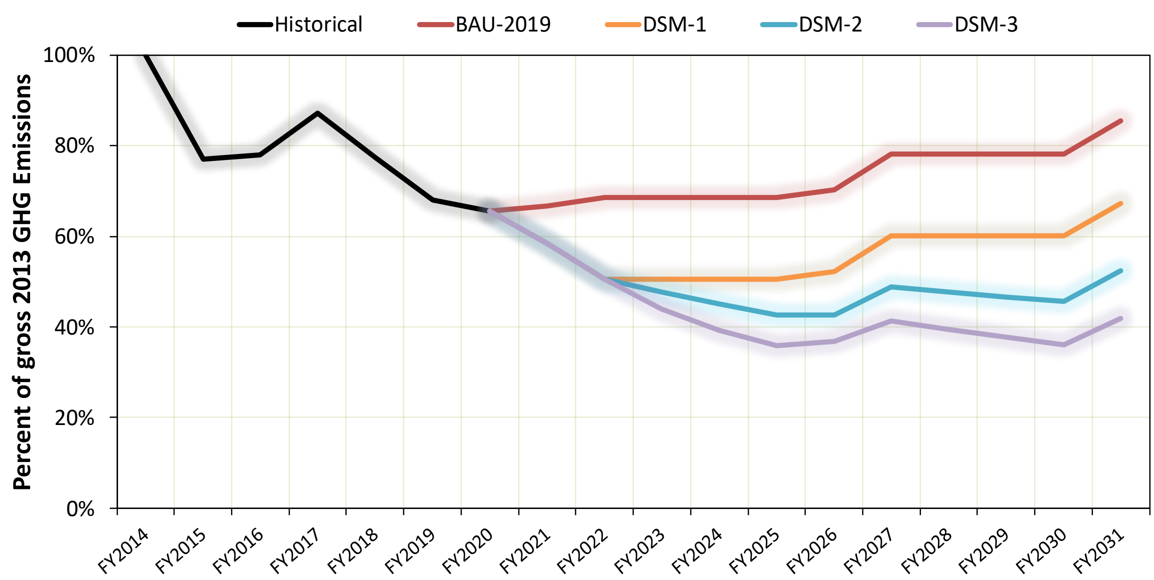
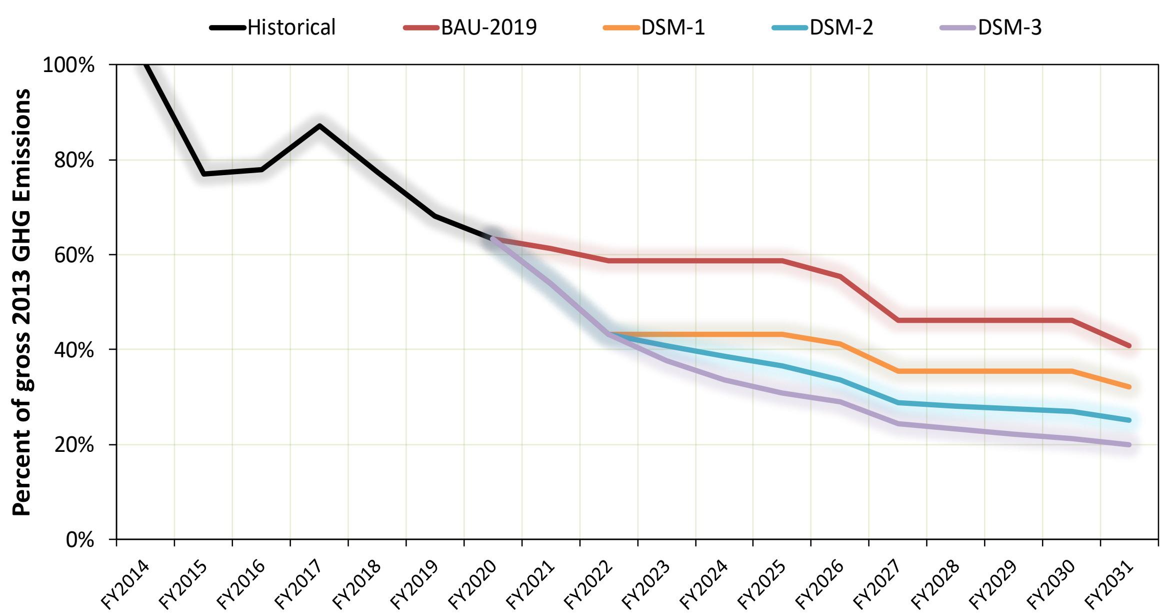



**Figure 19: GHG emissions projections of all scenarios over a 10-year horizon (Per $m^2$)**



For DSM-1, only projects in bundles FY2021 and FY2022 would be implemented. Initially, the GHG emissions savings will outperform the BAU-2019 scenario, however, it only achieves a 2030 reduction of 67% based on 2013 levels (or 32% on a per $m^2$ basis).

The DSM-2 pathway, which scales back the implementation of bundles FY2023 – FY2025 based on budget limitations, will mitigate some of the increase in GHG emissions due to campus expansion, however, this scenario can't keep up with the rate of emissions reduction required to meet the 2030 target. Under DSM-2, projected GHG emissions are expected to reach 52% of the 2030 target, or 25% on a per $m^2$ basis.

The DSM-3 scenario involves the implementation of all five annual project bundles as outlined in the Five Year Plan, with GHG emissions savings for the remaining five years extrapolated. Out of all the pathways examined, DSM-3 represents the most aggressive approach to reducing campus GHG emissions via DSM measures, with an anticipated 2030 drop to 42% of the 2013 levels. DSM-3 can achieve the required 7% annual GHG reduction to meet the 2030 target until the effects of the anticipated campus expansion come into play post 2025.When normalized by the campus area and corresponding growth, the per $m^2$ projections for DSM-3 can reach the 2030 target of 20% relative to 2013.

Based on gross GHG emissions figures, all examined DSM scenarios would fall short of the 2030 emissions target. Therefore, moving forward, a significant reduction in natural gas consumption that at least matches the DSM-3 scenario is required. This will also have to be complemented, to varying extents, by additional GHG reduction approaches that include: electrification of heat sources, expansion of the LDES to increase heating reliance on the DES, and fuel-switching.

# 7 CONCLUSION

This Report has examined multiple potential pathways for UBCO to reach their 2030 Target for GHG reduction through DSM measures. The recommended measure bundles laid out in the *Five Year Plan* can achieve significant reductions in natural gas consumption, however, they still fall short of the 2030 target of accomplishing an 80% reduction based on 2013 emission levels.

After FY2020, if no additional DSM measures are implemented (BAU-2019), the GHG emissions are projected to miss the 2030 target emissions by 65%. Since 2013, UBCO has achieved more than 30% reduction in GHG emissions, mainly driven by campus-scale implementation of energy conservation measures and the expansion of the DES. With the progressive implementation of 'low-hanging fruit' options, there are diminishing returns when it comes to long-term GHG savings per dollar spent on project implementations.

The DSM-3 scenario is shown to be a pathway which brings the campus to the 2030 Target based on the *"per-square-meter"* emission values. It does not, however, achieve the Target based on *gross* GHG values. A DSM scenario has not been identified which alone meets 80% reduction of gross GHG values by 2030.

It may be plausible to meet 2030 Target based on gross values by combining either the DSM-2 or DSM-3 scenarios with some degree of fuel-shifting. The LDES-ASHP fuel-shifting measure proposed here is shown to serve as a viable approach to accomplishing that goal, albeit high in capital cost. To facilitate any degree of success with the aforementioned pathways, it is critical that the Energy Team see the appropriate increase in annual spending budgets to meet the anticipated rise in project implementation costs.

SES is pleased to have taken part in this planning exercise, and invites any questions or comments regarding the contents of this report and its supporting documents.

# 8 PROJECT ENGINEER'S APPROVAL

The information, calculations, and recommendations contained in this document have been reviewed for accuracy and completeness by **Steffen Trangeled, P.Eng**


*[P.Eng stamp, sign, and date in the box above.]*

**Bundle FY2021**

| ECM # | Measure | Incremental Cost | Incremental Payback | Annual Savings | | | |
|---|---|---|---|---|---|---|---|
| | | | | $ | GJ | kWh | GHG |
| A1 | Lab DCV - Occupancy Controlled Ventilation | $90,000 | 1.1 | $79,200 | 4,950 | 317,100 | 248 |
| A2 | RCx of Existing Controls at ART | $15,000 | 3.1 | $4,900 | 130 | 58,900 | 7 |
| | **TOTAL** | **$ 105,000** | **1.2** | **$ 84,100** | **5,080** | **376,000** | **254** |

**Bundle FY2022**

| ECM # | Measure | Incremental Cost | Incremental Payback | Annual Savings | | | |
|---|---|---|---|---|---|---|---|
| | | | | $ | GJ | kWh | GHG |
| B1 | ASC-MUA-2 DCV | $12,000 | 0.6 | $21,500 | 1,520 | 46,200 | 76 |
| B2 | FIP-MUA-1 DCV | $8,000 | 0.8 | $9,500 | 610 | 34,600 | 31 |
| B3 | FIP-MUA-2 DCV | $8,000 | 1.5 | $5,200 | 330 | 19,500 | 16.5 |
| B4 | SCI-AHU-7 DCV | $12,000 | 0.5 | $26,000 | 1,770 | 71,200 | 88.5 |
| B5 | SCI-AHU-8 DCV | $12,000 | 0.5 | $25,000 | 1,770 | 71,200 | 88.5 |
| B6 | Nighttime PreCooling | $15,000 | 9.4 | $1,600 | - | 29,300 | 0.1 |
| B7 | RCx of Existing Controls at ASC | $15,000 | 1.8 | $8,500 | 130 | 123,700 | 6.8 |
| B8 | RCx of Existing Controls at FIP | $15,000 | 2.2 | $6,900 | 50 | 111,000 | 2.8 |
| | **TOTAL** | **$ 97,000** | **0.9** | **$ 104,200** | **6,180** | **506,700** | **310** |

**Bundle FY2023**

| ECM # | Measure | Incremental Cost | Incremental Payback | Annual Savings | | | |
|---|---|---|---|---|---|---|---|
| | | | | $ | GJ | kWh | GHG |
| C1 | FIP Strobic System Heat Recovery | $500,000 | 10.1 | $49,500 | 3,980 | - | 199 |
| C2 | RCx of Existing Controls at GYM | $15,000 | 4.7 | $3,200 | 70 | 41,400 | 4 |
| | **TOTAL** | **$ 515,000** | **9.8** | **$ 52,700** | **4,050** | **41,400** | **202** |

**Bundle FY2024**

| ECM # | Measure | Incremental Cost | Incremental Payback | Annual Savings | | | |
|---|---|---|---|---|---|---|---|
| | | | | $ | GJ | kWh | GHG |
| D1 | EME Strobic System Heat Recovery | $170,000 | 12.9 | $13,200 | 1,060 | - | 53 |
| D2 | ADM AHU-4 Heat Recovery | $220,000 | 15.3 | $14,400 | 1,160 | - | 58 |
| D3 | DHW Controls Upgrade | $95,000 | 13.4 | $7,100 | 580 | - | 28.9 |
| D4 | RCx of Existing Controls at ADM | $15,000 | 3.1 | $4,800 | 60 | 71,200 | 3.2 |
| | **TOTAL** | **$ 500,000** | **12.7** | **$ 39,500** | **2,860** | **71,200** | **143** |

**Bundle FY2025**

| ECM # | Measure | Incremental Cost | Incremental Payback | Annual Savings | | | |
|---|---|---|---|---|---|---|---|
| | | | | $ | GJ | kWh | GHG |
| E1 | SCI AHU-2 Heat Recovery | $200,000 | 24.4 | $8,200 | 660 | - | 33 |
| E2 | SCI AHU-3 Heat Recovery | $120,000 | 17.4 | $6,900 | 560 | - | 28 |
| E3 | ART AHU-1 Heat Recovery | $240,000 | 29.3 | $8,200 | 660 | - | 32.9 |
| E4 | RCx of Existing Controls at UNC | $20,000 | 2.9 | $7,000 | 110 | 101,200 | 5.7 |
| | **TOTAL** | **$ 580,000** | **19.1** | **$ 30,300** | **1,990** | **101,200** | **99** |

**Future Project Bundle**

| ECM # | Measure | Incremental Cost | Incremental Payback | Annual Savings | | | |
|---|---|---|---|---|---|---|---|
| | | | | $ | GJ | kWh | GHG |
| F1 | LIB-CH-1 LDES Cooling Load Transfer | $150,000 | 267.9 | $560 | 40 | - | 2 |
| F2 | LIB-CH-2 LDES Cooling Load Transfer | $125,000 | 250.0 | $500 | 40 | - | 2 |
| F3 | SCI-CH-1 LDES Cooling Load Transfer | $145,000 | 103.6 | $1,400 | 110 | - | 5.5 |
| F4 | SCI-CH-2 LDES Cooling Load Transfer | $95,000 | 105.6 | $900 | 70 | - | 3.5 |
| F5 | Endotherm for Hydronic Heating/Cooling Systems | $57,000 | 19.7 | $2,900 | 220 | 2,200 | 11.0 |
| F6 | RCx of Existing Controls at LIB | $15,000 | 4.3 | $3,500 | 40 | 54,100 | 2.1 |
| | **TOTAL** | **$ 587,000** | **60.1** | **$ 9,760** | **520** | **56,300** | **26** |

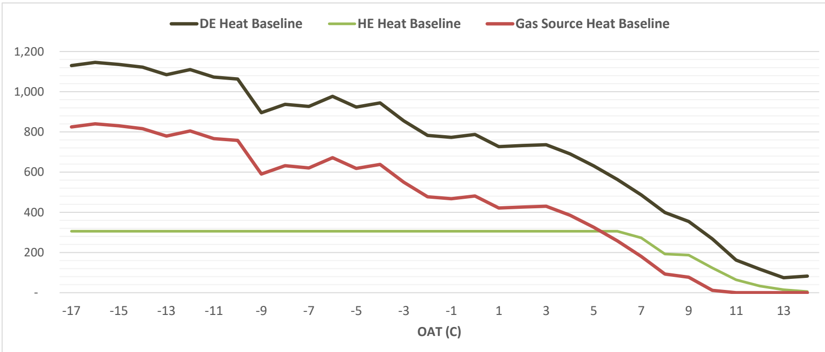
**Residence Project Bundle**

| ECM # | Measure | Incremental Cost | Incremental Payback | Annual Savings | | | |
|---|---|---|---|---|---|---|---|
| | | | | $ | GJ | kWh | GHG |
| R1 | Cassiar Recommissioning | $10,000 | 7.7 | $1,300 | 70 | 9,000 | 4 |
| R2 | Cassiar DDC Integration | $25,000 | 19.2 | $1,300 | 40 | 13,800 | 2 |
| R3 | Kalamalka Recommissioning | $50,000 | 9.4 | $5,300 | 180 | 53,500 | 9.1 |
| R4 | Similkameen Recommissioning | $5,500 | 3.4 | $1,600 | 50 | 18,000 | 2.5 |
| R5 | Nicola Recomissioning | $24,000 | 5.1 | $4,700 | 190 | 42,800 | 9.6 |
| R6 | Purcell Recommissioning | $16,000 | 3.1 | $5,200 | 110 | 68,800 | 5.7 |
| R7 | Valhalla Recommissioning | $43,000 | 6.6 | $6,500 | 190 | 74,500 | 9.7 |
| | **TOTAL** | **$ 173,500** | **6.7** | **$ 25,900** | **830** | **280,400** | **42** |

# UBCO SEMP 2018 to 2023
## Appendix B: Measure Descriptions

| Project # | Project Description | Description of Finding | Energy Conservation Measure | Implementation Notes | Annual GHG Savings (tonne) | Capital Cost |
|---|---|---|---|---|---|---|
| A1 | Lab DCV - Occupancy Controlled Ventilation | | | | 248 | $ 90,000 |
| A2 | RCx of Existing Controls at ART | | | | 7 | $ 15,000 |
| B1 | ASC-MUA-2 DCV | The ventilaton unit does not utilize space CO2 sensors to adjust the amount of fresh outdoor air entering the building based on actual air quality in the spaces. The unit is scheduled to run 24/7, has a heating coil connected to the LDES and a heating/cooling coil connected to the strobic heat recovery system. | Install space CO2 sensors to monitor indoor air quality and modulate the fan speed based on actual demand for fresh outdoor air. | Space CO2 sensors should be installed in areas of high occupant density. When lowering the supply fan speed, consider how this may impact building pressurization. | 76 | $ 12,000 |
| B2 | FIP-MUA-1 DCV | The ventilaton unit does not utilize space CO2 sensors to adjust the amount of fresh outdoor air entering the building based on actual air quality in the spaces. The unit is scheduled to run 24/7, has a heating coil connected to the LDES and a heating/cooling coil connected to the strobic heat recovery system. | Install space CO2 sensors to monitor indoor air quality and modulate the fan speed based on actual demand for fresh outdoor air. | Space CO2 sensors should be installed in areas of high occupant density. When lowering the supply fan speed, consider how this may impact building pressurization. | 31 | $ 8,000 |
| B3 | FIP-MUA-2 DCV | The ventilaton unit does not utilize space CO2 sensors to adjust the amount of fresh outdoor air entering the building based on actual air quality in the spaces. The unit is scheduled to run 24/7, has a heating coil connected to the LDES and a heating/cooling coil connected to the strobic heat recovery system. | Install space CO2 sensors to monitor indoor air quality and modulate the fan speed based on actual demand for fresh outdoor air. | Space CO2 sensors should be installed in areas of high occupant density. When lowering the supply fan speed, consider how this may impact building pressurization. | 17 | $ 8,000 |
| B4 | SCI-AHU-7 DCV | The ventilaton unit is 100% OA and does not utilize space CO2 sensors to adjust the amount of fresh outdoor air entering the building. The unit is scheduled to run 24/7, has a heating coil connected to the LDES/MDES and a cooling coil served by stadalone chillers. | Install space CO2 sensors to monitor indoor air quality and modulate the fan speed based on actual demand for fresh outdoor air. | Space CO2 sensors should be installed in areas of high occupant density. When lowering the supply fan speed, consider how this may impact building pressurization. | 89 | $ 12,000 |
| B5 | SCI-AHU-8 DCV | The ventilaton unit is 100% OA and does not utilize space CO2 sensors to adjust the amount of fresh outdoor air entering the building. The unit is scheduled to run 24/7, has a heating coil connected to the LDES/MDES and a cooling coil served by stadalone chillers. | Install space CO2 sensors to monitor indoor air quality and modulate the fan speed based on actual demand for fresh outdoor air. | Space CO2 sensors should be installed in areas of high occupant density. When lowering the supply fan speed, consider how this may impact building pressurization. | 89 | $ 12,000 |
| B6 | Nighttime PreCooling | The summer months in Kelowna can have relatively cool evenings with quickly warming mornings. Electricity tends to peak during this startup cooling. | Using the exsiting weather predictor available on campus, use a pre-cooling strategy, similar to the existing morning warmup strategy. | The eligible systems and spaces are going to be limited. | | $ 15,000 |
| B7 | RCx of Existing Controls at ASC | | | | 7 | $ 15,000 |
| B8 | RCx of Existing Controls at FIP | | | | 3 | $ 15,000 |
| C1 | FIP Strobic System Heat Recovery | Currently the strobic system, which is composed of three fans, exhausts air to the atmosphere without any heat recovery. Heat in the building is served by sandalone boilers and heat from the LDES. | Install a glycol runaround loop to recover heat from the exhaust. This heat can be used to pre-heat supply air to another unit. | | 199 | $ 500,000 |
| C2 | RCx of Existing Controls at GYM | | | | 4 | $ 15,000 |
| D1 | EME Strobic System Heat Recovery | EME strobic system is composed of two exhaust fans (LEF-1 and LEF-2) that serve lab fumehoods and general exhaust. Air is rejected to the atmosphere without any heat recovery. | Recover exhaust heat using a glycol runaround loop. Heat recovered can be used to preheat incoming outdoor air. | | 53 | $ 170,000 |
| D2 | ADM AHU-4 Heat Recovery | This unit serves office spaces. Currently the exhaust air is rejected to the atmosphere without any heat recovery. The unit is equipped with heating and cooling coils. Heat in the building is served by a mix from the LDES and MDES loop. Cooling is supplied by standalone chillers. | Install a glycol runaround loop to recover heat from the exhaust. This heat can be used to pre-heat supply air to another unit. | | 58 | $ 220,000 |
| D3 | DHW Controls Upgrade | Domestic hot water (DHW) heating and re-circulation in academic buildings is dirven by supply temperature setpoint and schedule requirements. | Apply demand-based control by installing a flow sensor on the makeup water pipe, and using a switch to enable the recirculating pump when flow is detected and the DHW return temperature is below an adjustable setpoint (50C). | | 29 | $ 95,000 |
| D4 | RCx of Existing Controls at ADM | | | | 3 | $ 15,000 |
| E1 | SCI AHU-2 Heat Recovery | This unit serves lab and office areas. Currently the exhaust air is rejected to the atmosphere without any heat recovery. Unit is equipped with heating and cooling coils. Heat in the building is served by a mix from the LDES and MDES loop. Cooling is supplied by standalone chillers. | Install a glycol runaround loop to recover heat from the exhaust. This heat will be used to pre-heat supply air to the unit. | | 33 | $ 200,000 |
| E2 | SCI AHU-3 Heat Recovery | This unit serves the animal room and is 100% OA. Currently air is rejected to the atmosphere by EF-3 without any heat recovery. AHU-2 is equipped with heating and cooling coils. Heat in the building is served by a mix from the LDES and MDES loop. Cooling is supplied by standalone chillers. | Install a glycol runaround loop to recover heat from the exhaust. This heat will be used to pre-heat supply air to AHU-3. | | 28 | $ 120,000 |
| E3 | ART AHU-1 Heat Recovery | This unit serves office spaces. Currently the exhaust air is rejected to the atmosphere without any heat recovery. The unit is equipped with heating and cooling coils. Heat in the building is served by a mix from the LDES and MDES loop. Cooling is supplied by standalone chillers. | Install a glycol runaround loop to recover heat from the exhaust. This heat can be used to pre-heat supply air to another unit. | | 33 | $ 240,000 |
| E4 | RCx of Existing Controls at UNC | | | | 6 | $ 20,000 |
| F1 | LIB-CH-1 LDES Cooling Load Transfer | Building has a standalone chiller and is connected to the LDES for heating only. | Switching the cooling load from the standalone chiller onto the LDES will allow diverting the undesired heat for use by other buildings. | | 2 | $ 150,000 |
| F2 | LIB-CH-2 LDES Cooling Load Transfer | Building has a standalone chiller and is connected to the LDES for heating only. | Switching the cooling load from the standalone chiller onto the LDES will allow diverting the undesired heat for use by other buildings. | | 2 | $ 125,000 |
| F3 | SCI-CH-1 LDES Cooling Load Transfer | Building has a standalone chiller and is connected to the LDES for heating only. | Switching the cooling load from the standalone chiller onto the LDES will allow diverting the undesired heat for use by other buildings. | | 6 | $ 145,000 |
| F4 | SCI-CH-2 LDES Cooling Load Transfer | Building has a standalone chiller and is connected to the LDES for heating only. | Switching the cooling load from the standalone chiller onto the LDES will allow diverting the undesired heat for use by other buildings. | | 4 | $ 95,000 |
| F5 | Endotherm for Hydronic Heating/Cooling Systems | | EndoTherm is an energy saving additive for hydronic heating and chilled systems (non-potable) which is proven to reduce energy consumption by 1-5%. It works by reducing the surface tension of the system water which improves heat transfer, creating a condition that is optimal for efficiency gains in the HVAC system. Buildings hit temperature setpoints quicker and systems are required to run less frequently to maintain temperature, saving significant amounts of energy. | | 11 | $ 57,000 |
| F6 | RCx of Existing Controls at LIB | | | | 2 | $ 15,000 |
| R1 | Cassiar Recommissioning | | Optimize PTAC unoccupied setpoints, Common area HVAC motion control, Energy efficiency education campaign, Isolate DHW tanks in the summer, | | 4 | $ 10,000 |
| R2 | Cassiar DDC Integration | Systems are currently on standalone controls. | Install a new DDC system and connect existing RTUs, HRVs, DHW tanks and recirc pump, new HVAC motion sensors, and any low voltage lighting in the building. Implement the following energy efficient DDC control strategies if they are not already rogrammed:<br>• Summer shutdown - shutdown or cycle RTUs/HRVs<br>• Demand controlled ventilation<br>• HRV staging/damper control optimization<br>• Supply air temperature reset optimization<br>• Free cooling<br>• Scheduling where appropriate<br>• Night time and holiday lighting sweeps | | 2 | $ 25,000 |
| R3 | Kalamalka Recommissioning | | Install DDC system, to control HVAC and DHW, Common area HVAC motion control, Optimize PTAC unoccupied setpoints, Energy efficiency education campaign, Isolate DHW tanks in the summer | | 9 | $ 50,000 |
| R4 | Similkameen Recommissioning | | Summer DHW Tank Isolation, Common Area Baseboard Motion Control, Energy Efficiency Campaign | | 3 | $ 5,500 |
| R5 | Nicola Recomissioning | | Interface Delta DDC - new control strategies, Common area HVAC motion control, Isolate DHW tanks in the summer, Optimize PTAC unoccupied setpoints, Energy efficiency education campaign, Connect solar DHW system to DDC and ensure DHW heating is staging properly | | 10 | $ 24,000 |
| R6 | Purcell Recommissioning | | Interface Delta DDC - new control strategies, Isolate DHW tanks in the summer, Optimize PTAC unoccupied setpoints, Common area HVAC motion control, Energy efficiency education campaign | | 6 | $ 16,000 |
| R7 | Valhalla Recommissioning | | Install DDC system, to control HVAC and DHW, Common area HVAC motion control, Optimize PTAC unoccupied setpoints, Energy efficiency education campaign, Isolate DHW tanks in the summer, | | 10 | $ 43,000 |

## Baseline



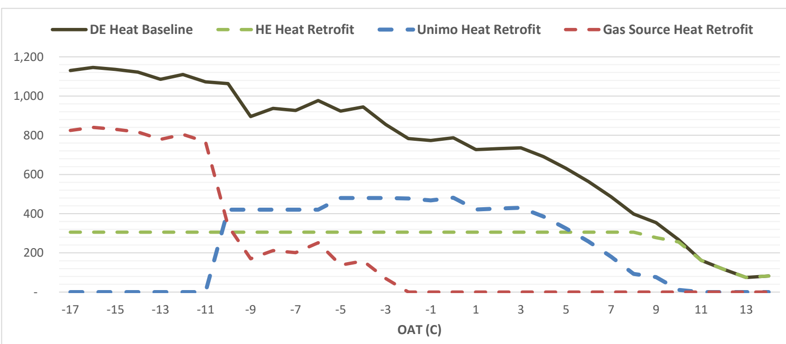

| Gas GJ | eT CO2 |
|---|---|
| 7,280 | 363 |

## Unimo ASHP Retrofit

Heatpump Performacne Data

| OAT | HWST | Heat Capacity | COP |
|---|---|---|---|
| | @9C inlet | @9C inlet | @9C inlet |
| C | C | kW | |
| -10 | 65 | 35 | 2.5 |
| -5 | 65 | 40 | 2.5 |
| 0 | 65 | 46 | 2.7 |
| 5 | 65 | 53 | 3.0 |
| 10 | 65 | 68 | 4.0 |
| 15 | 65 | 77 | 4.3 |

| # of Units | 12 |
|---|---|




*Energy*

| Annual Savings | | |
|---|---|---|
| Gas GJ | Gas GJ | Elec kWh |
| 6,740 | 93% | (629,524) |

*Financial*

| Capital Cost | First Year Savings | 0 Payback | Incremental NPV | Incremental IRR |
|---|---|---|---|---|
| $ 2,100,000 | $ 47,168 | 0 yr | ($1,611,200) | 0% |

*Environmental*

| Annu. Save GHG ton | % Save GHG ton | Life Expectancy | Lifetime GHG Save | Incremental $ / GHG |
|---|---|---|---|---|
| 335 | 92% | 25 | 8,363 | $ 251 |

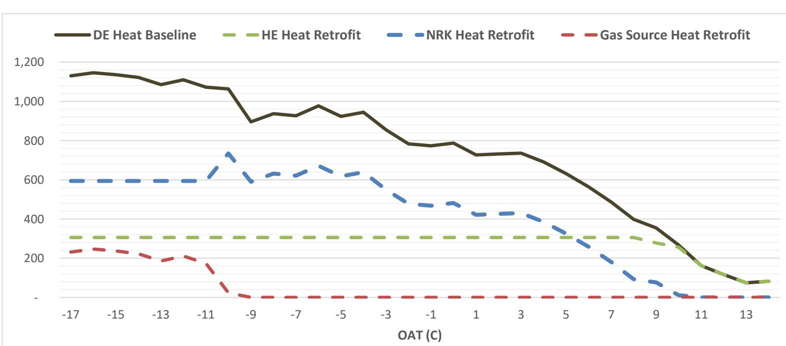
**Weighted Equipment Utilization**
**51%**

## NRK ASHP Retrofit

Heatpump Performacne Data

| OAT | HWST | Heat | Input | COP |
|---|---|---|---|---|
| C | C | kW | kW | kW/kW |
| -20 | 25 | 97 | 34.5 | 2.81 |
| -10 | 25 | 120 | 33.9 | 3.54 |
| 0 | 25 | 117 | 32.8 | 3.57 |
| 7 | 25 | 165 | 34.3 | 4.81 |
| 10 | 25 | 170 | 34.4 | 4.94 |

| # of Units | 6 |
|---|---|




*Energy*

| Annual Savings | | |
|---|---|---|
| Gas GJ | Gas GJ | Elec kWh |
| 7,245 | 99.5% | (473,540) |

*Financial*

| Capital Cost | First Year Savings | 0 Payback | Incremental NPV | Incremental IRR |
|---|---|---|---|---|
| $ 1,600,000 | $ 62,475 | 18 yr | ($961,700) | 3% |

*Environmental*

| Annu. Save GHG ton | % Save GHG ton | Life Expectancy | Lifetime GHG Save | Incremental $ / GHG |
|---|---|---|---|---|
| 360 | 99% | 25 | 9,002 | $ 178 |

**Weighted Equipment Utilization**
**40%**