UBC Okanagan Energy Team Annual Report for FY18-19 April 2018 – March 2019

Report Date June 2019

Facilities Management
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Definition of Terms

BAU: The 'Business as Usual' reference case is the total cost or amount of energy that would be consumed by the campus if the energy use intensity (kWhr/yr/m^2) was maintained constant at the level of a defined reference year. For this report 2013 is generally used as the reference year.

EIR: The 'Energy Input Ratio' is the amount of energy input into the system per unit of energy output. In general, this equates to the inverse of efficiency.

EUI: Energy use intensity is the annual energy consumption of a building per unit of floor area. In this report kWhr/yr/m^2 are the units used for EUI.

GHG: Greenhouse gas emissions, generally measured in equivalent tons of CO_2.

LDES: Low temperature district energy system. One of two district energy loops on campus, this loop distributes ambient temperature water between approximately 5°C and 30°C. Heating and cooling for this loop is provided by boilers, geo-exchange water and cooling towers.

MDES: Medium temperature district energy system. This loop provides hot water for heating; heat is provided by boilers in the Central Heating Plant.

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1 Energy Team

The Energy Team was identified as a part of the campus Whole Systems Implementation Plan and was identified in the Utilities 15/16 Priorities and growth ask. The team currently consists of four members:

- Colin Richardson - Energy Systems Manager
- Glen McIntyre - Energy Specialist
- Terrence Nimegeers - Building Management Systems Technician
- Steve Casey - HVAC Efficiency Technician

The BMS Energy Technician and Energy Specialist positions began in the spring of 2016 while the HVAC Efficiency Technician position began in May 2017. The Energy Specialist position is partially funded by FortisBC.

The goal of the campus energy team is to track and reduce campus energy use, costs and GHG emissions. These goals are achieved through implementing energy projects, system monitoring, equipment recommissioning and improved operational efficiencies. Some of the key tasks of the team include:

- Implementing detailed reporting to provide input into financial, infrastructure and operational planning as well as verification of results of energy projects
- Maintaining energy conservation measures in existing campus facilities to yield utility cost savings. Campus expansion and intensification will emphasize the importance of keeping energy creep under control
- Act as a technical review team providing input and recommendations for retrofits, new construction projects, infrastructure expansion and campus policy and technical guidelines. By providing input to help ensure new projects are built to meet future requirements, the risk of costly future upgrades is minimized
- Develop strategies, policies, guidelines and defined project requirements to optimize future campus energy consumption
- Continue to meet annual savings targets of 500 MWh of electricity and 3000GJ of gas compared to prior year
- Apply for energy efficiency rebates
- Co-ordinate energy projects with other stakeholder groups in order to optimize efficiencies. For example, by optimizing mechanical system operation, the following can all occur simultaneously: increased energy efficiency, increased equipment lifespan, reduced number of repairs required, reduced risk of system failures and improved indoor air quality.

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2 Overall Campus Energy Performance

Campus energy consumption for FY18-19 totalled 41 700 MWhr. As can be seen in Figure 1 below, electricity accounted for the majority of energy consumed on campus. Furthermore, electricity is more expensive than natural gas. Average electricity costs were $80/MWhr last year compared to $33/MWhr for natural gas. As a result, electricity accounted for over 85% of campus utility costs. While natural gas has a lower cost per unit of energy, its GHG emission factors are eighteen times higher than those of electricity (0.18 tons CO_2/MWhr for gas versus 0.01 tons CO_2/MWhr for electricity). As a result, about 90% of campus GHG emissions are the result of natural gas consumption. The low emission factor used for electricity is due to electricity supplied to UBC Okanagan mostly being sourced from hydroelectric generators.

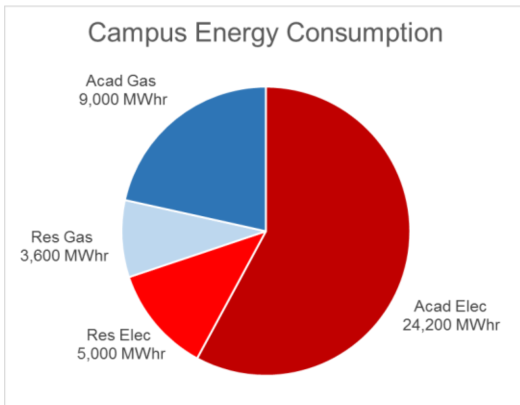

Figure 1: Campus Energy Consumption by Source

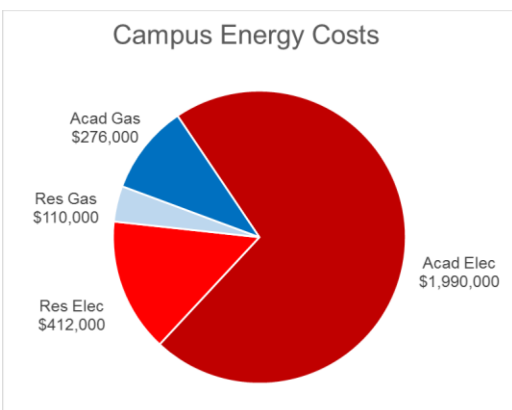

Figure 2: Campus Energy Costs by Source

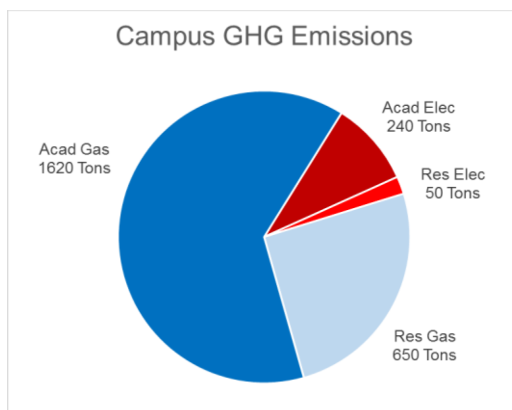

Figure 3: Campus GHG Emissions by Source

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A quantitative model of the dependence of campus energy consumption on weather has not been developed at present. Qualitatively however, it can bee seen in the figure below that variations in natural gas consumption track heating degree day variations while electricity usage has less dependence on weather variations.

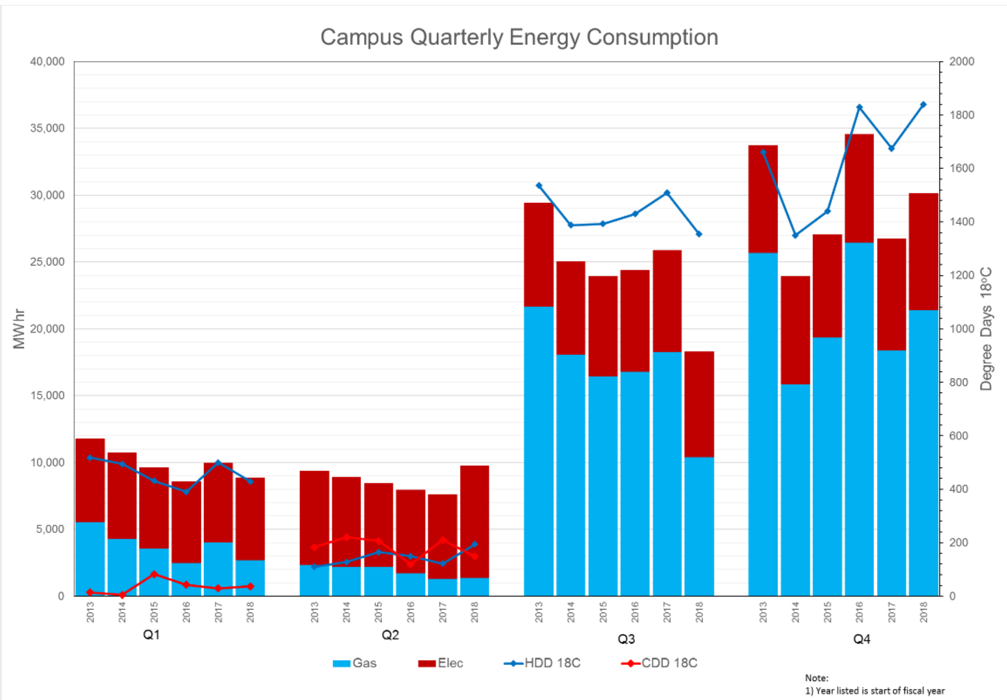

Figure 4: Campus Energy Consumption and Weather Comparison

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2.1 Campus Energy Performance Trends

2.1.1 Costs

As shown in the figure below, campus utility costs were roughly flat year over year at slightly less than $2.8M. Electricity cost rates were reduced by a reduction of provincial sales tax on electricity. For FY18-19 the average cost of electricity on campus was $80.37/MWhr compared to $82.43/MWhr in FY17-18. This rate reduction offset an increase in electricity consumption keeping overall electricity costs approximately constant at $2.3M.

Natural gas costs have continued to be low compared to historical trends but increased about 7% year over year, rising to $33.01/MWhr in FY18-19 from $30.78/MWhr in FY17-18. These natural gas rates include carbon offset costs. The combined increase in gas cost rates and reduced consumption resulted in a slight overall gas cost reduction for FY18-19; approximately $413k compared to $435k for FY17-18.

Without energy conservation measures implemented in the last 3 years, it is expected that utility costs would be $350k higher. Approximately $75k of these savings are attributed to projects funded directly by the energy team. These savings are shown in light green in the figure below. The remainder of the savings, shown in beige in the figure, are attributed to measures funded by other sources (federal SIF program, BC AVED funding etc) or cumulative measures that are difficult to individually measure such as recommissioning.

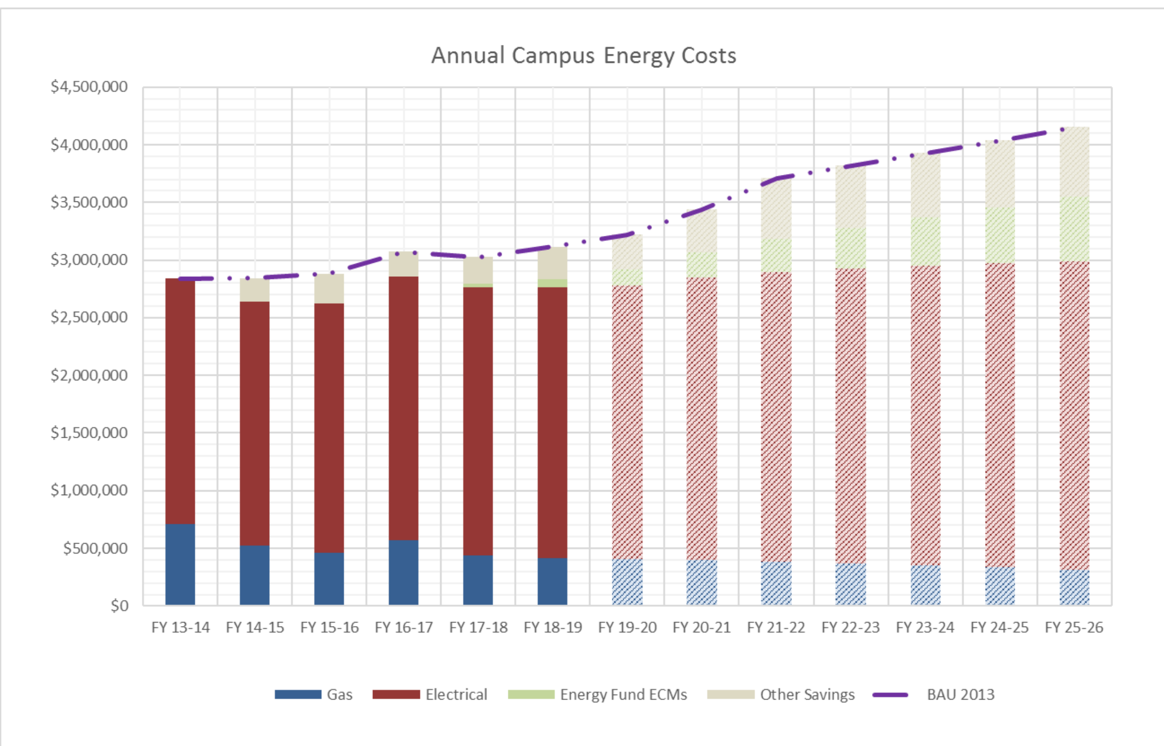

Figure 5: Annual Campus Energy Costs

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2.1.2 Greenhouse Gas Emissions

Campus greenhouse gas emissions were reduced to approximately to 2550 tons CO_2/yr, a reduction of about 300 tons CO_2/yr. As the majority of campus GHG emissions are due to natural gas usage, these reductions can primarily be attributed to reductions in natural gas consumption.

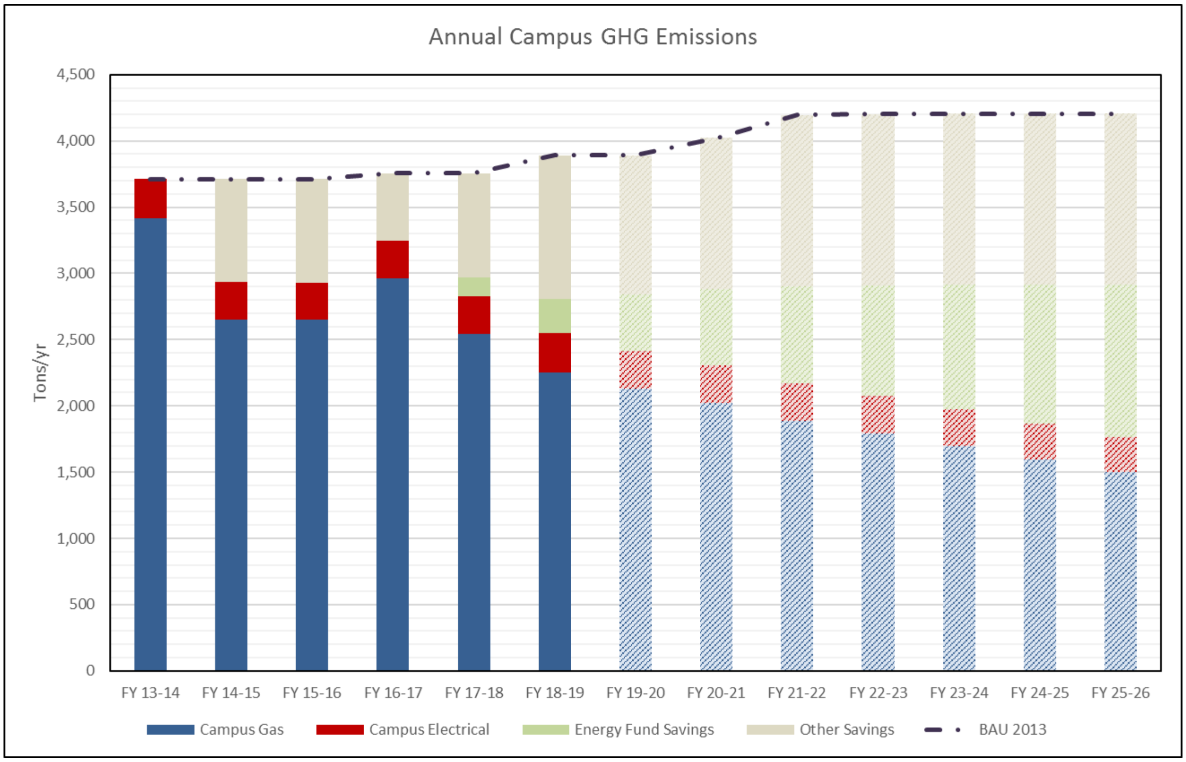

Figure 6: Annual Campus GHG Emissions

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2.1.3 Electricity

Electricity consumption was up about 3% year over year to 29 192 MWhr. This increase can be attributed to: campus intensification, construction of the new Commons/TLC building and electrification projects that reduced natural gas but increased electricity consumption. Increases due to these factors were partially mitigated by electricity conservation measures such as lighting upgrades.

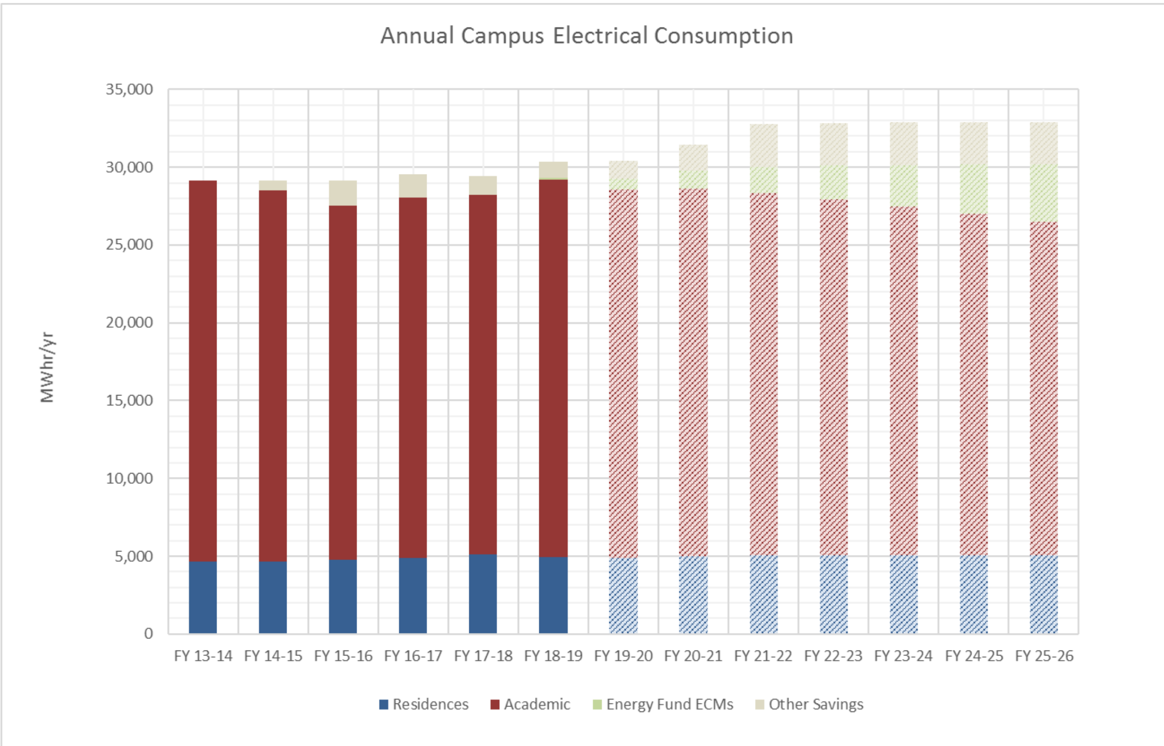

Figure 7: Campus Electricity Consumption Trend

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2.1.4 Natural Gas

Consumption of natural gas was reduced from 50 800 GJ in FY17-18 to 45 100 GJ in FY18-19, an 11% year over year reduction. This reduction is the result of a number of projects. These include:

- Load shifts from building boilers and the central heating plant to heatpumps and the LDES system
- Utilization of groundwater heating for the LDES
- Science building ventilation optimization
- Science building exhaust heat recovery implementation
- ASC exhaust heat recovery implementation

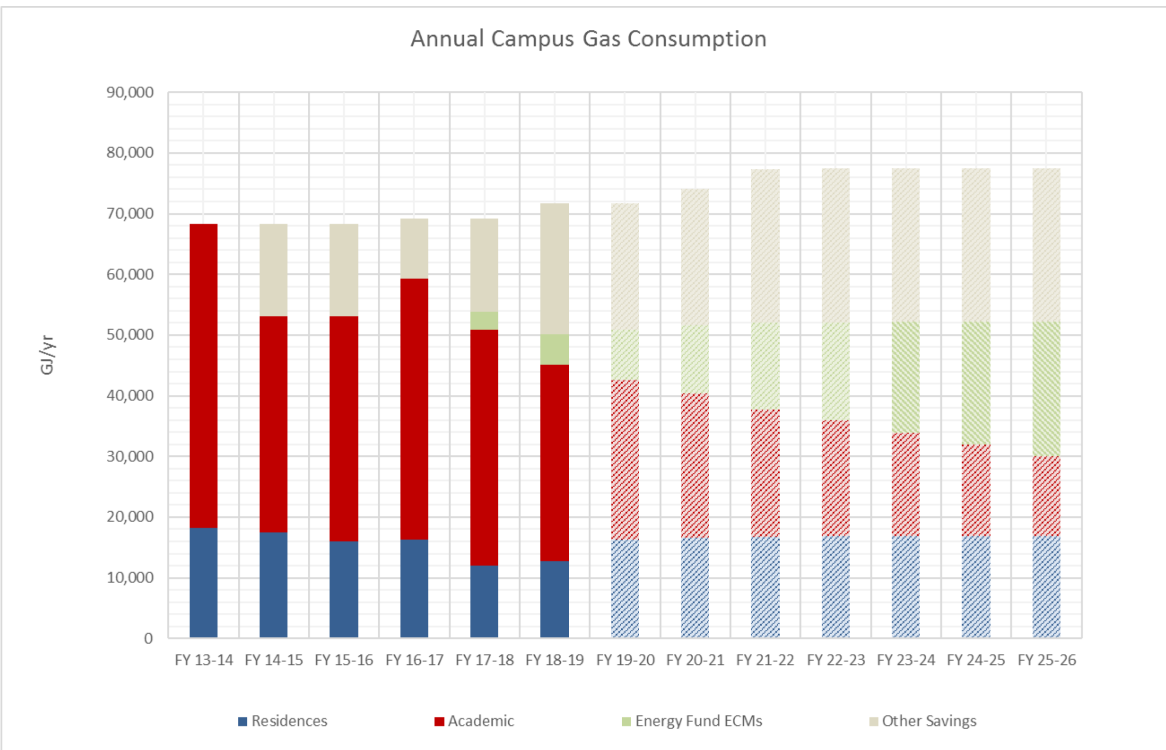

Figure 8: Campus Natural Gas Consumption Trend

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2.2 Distribution of Campus Energy Use

Energy use intensity (EUI) is the amount of energy used per unit of floor area. The overall campus EUI was 278 kWhr/yr/m^2 for FY18-19, a 3% reduction over the prior year. The academic buildings on campus have a higher average EUI than residence buildings due to their more intensive use and the higher energy use of facilities such as laboratories (increased ventilation air, process loads, equipment etc). The charts below show the breakdown of EUI per energy source for the campus and individual buildings.

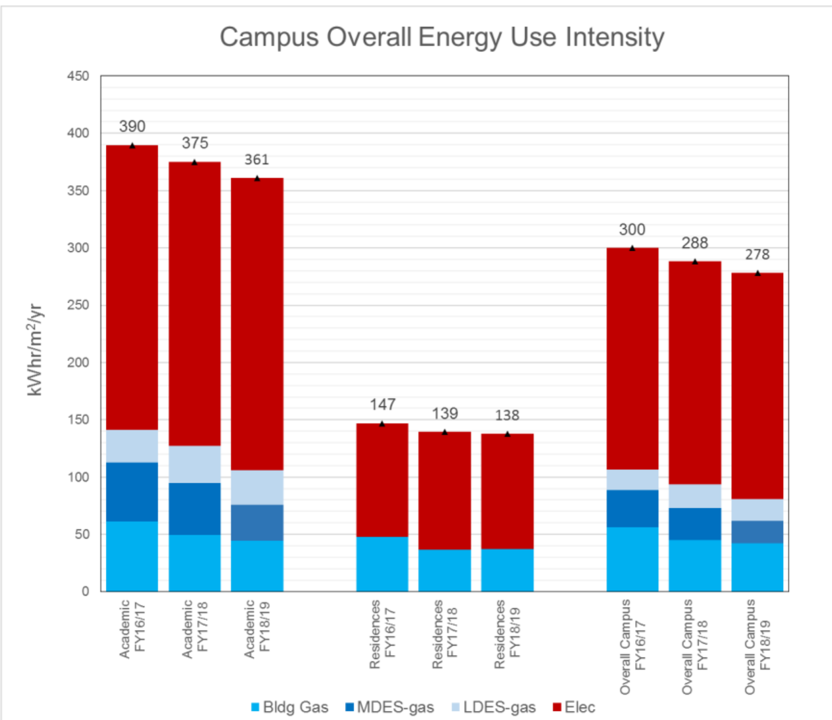

Figure 9: Campus Energy Use Intensities

The average EUI for academic buildings on campus was 361 kWhr/yr/m^2 while it was 138 kWhr/yr/m^2 for residences. For the last two years, the EUI for academic buildings has been reduced by just under 4% per year. For residences, FY17/18 saw an EUI reduction of over 5% while for FY18/19 the EUI was relatively unchanged. The significant drop in energy use in the residences in FY17/18 was due to a reduction in ventilation air provided in the Similkameen residence due to broken equipment.

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As can be seen in the following figure, the Science building has the highest EUI on campus but has shown significant reductions in gas usage for heating (via both the MDES and LDES). Other energy intensive buildings include Arts&Science, which is also a lab-intensive building as well as UNC which has a commercial kitchen. Due to their lower intensity occupancy and use, residence EUIs are significantly lower than those of academic buildings.

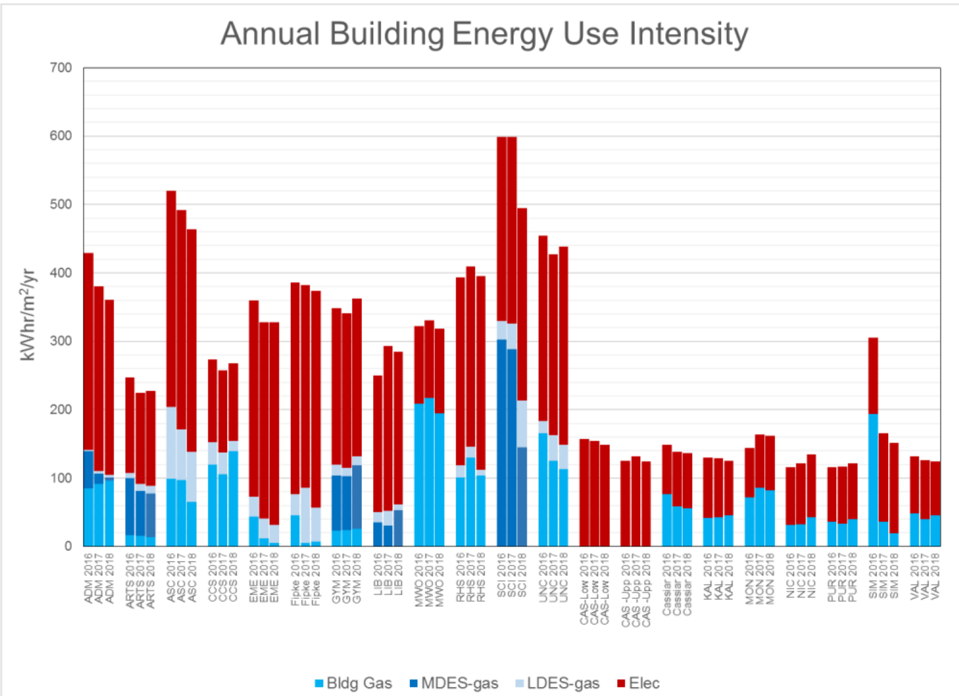

Figure 10: Energy Use Intensity for Campus Buildings

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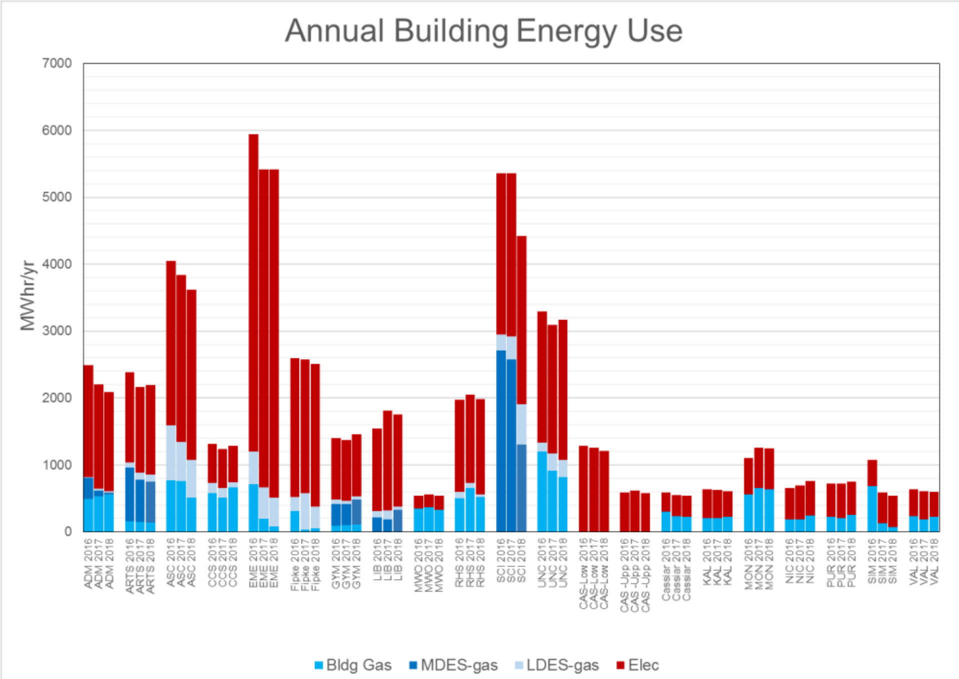

Figure 11: Energy Use for Campus Buildings

As can be seen in the preceding figures, gas usage was reduced over the last two years in the ASC, Fipke and UNC buildings. These reductions are the result of heatpump plant upgrades in the buildings that reduced usage of boilers within the buildings. Energy consumption in ASC was further reduced by commissioning of a previously non-functioning ventilation heat recovery system.

The largest energy savings were seen in the Science building. These savings are the result of multiple projects including: connection of the 3rd floor to the building's heatpump system, demand controlled ventilation upgrades and a new exhaust air heat recovery system.

For residences, the most significant change was a reduction of gas usage in Similkameen. This reduction is due to the failure of a gas-fired makeup air unit. A replacement unit is expected to be in operation for the next heating season so an increase in Similkameen gas consumption is expected for FY19-20.

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3 Campus District Energy Systems

The UBC Okanagan campus is served by two district energy systems. The characteristics and performance of these systems are described below. Over the past several years, in order to reduce GHG emissions, heating loads have been shifted from the MDES to the LDES. As such the fraction of heat delivered by the LDES has increased. As can be seen in the figures below, while the relative amount of heat delivered by the LDES has increased compared to the MDES, the LDES uses proportionally less gas than the MDES. This is due to the LDES using higher efficiency boilers, energy sharing between buildings and utilization of groundwater as a heating source.

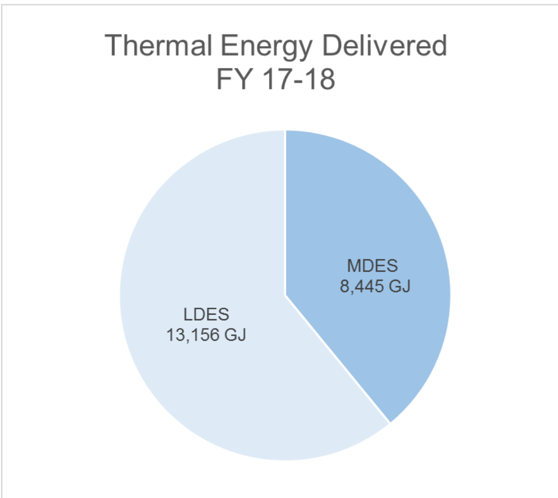

Figure 12: FY17-18 District Energy System Heat Delivered

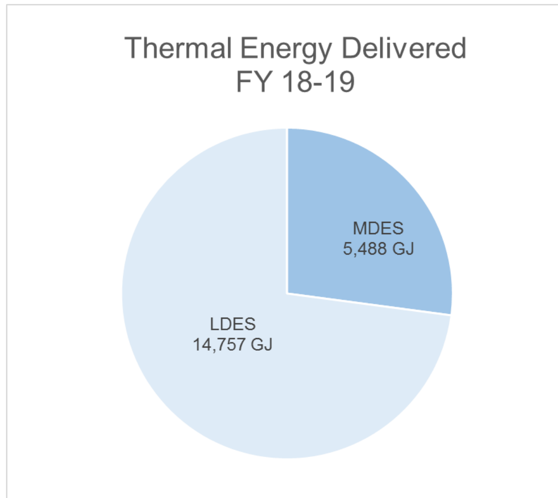

Figure 13: FY18-19 District Energy System Heat Delivered

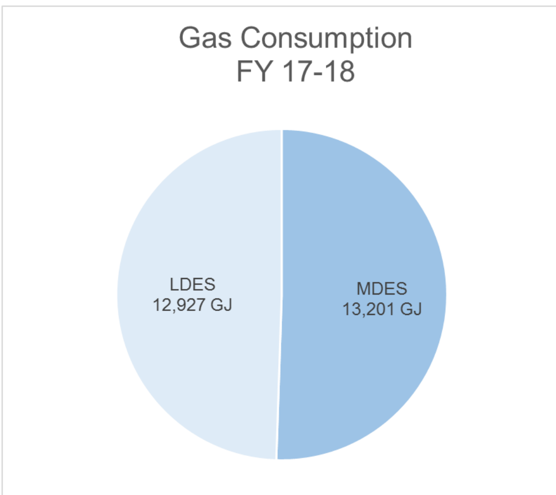

Figure 14: FY17-18 District Energy System Gas Usage

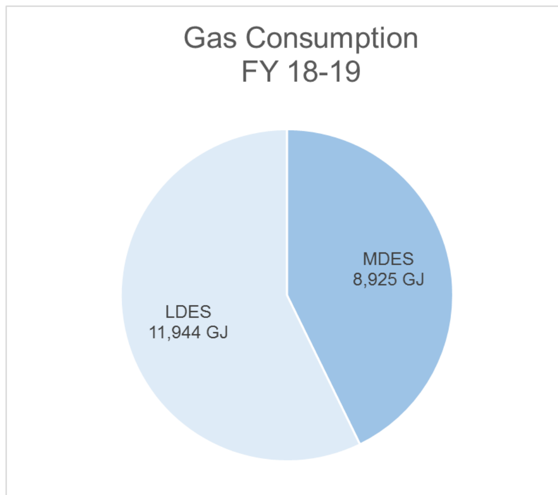

Figure 15: FY18-19 District Energy System Gas Usage

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3.1 MDES - Medium Temperature District Energy System

The medium temperature district energy system (MDES) delivers hot water to the five original academic buildings on campus (Admin, Arts, Gym, Library and Science). Heat is supplied to the system from boilers in the central heating plant. While some of these boilers are high-efficiency condensing units, their efficiencies are compromised due to the high water temperatures required by the buildings that the system serves.

As can be seen in the figure below, the MDES operates at a 55-70% efficiency. This efficiency compares the boilers' natural gas input to the thermal energy delivered measured at the buildings. The boiler plant operates at about 80% efficiency with the remainder of the heat being lost from the underground distribution piping. As can be seen in the figures below, there has been a year over year reduction in MDES system efficiency. This is due to the heat losses to the ground being roughly constant while the amount of heat delivered by the MDES has been reduced due to both energy conservation measures and load switching to the LDES. Thus while the total losses remain constant, the percentage losses increase. Significant energy conservation measures such as heat recovery in the Science building have also reduced the heat loads on the MDES. The large reduction in heating loads placed on the MDES can be seen in the following table:

Table 1: MDES Thermal Loads

Year	MDES Heat Delivered to Buildings	MDES Central Heating Plant Gas Consumption
FY16-17	10 500 GJ	14 700 GJ
FY17-18	8 500 GJ	13 200 GJ
FY18-19	5 500 GJ	8 900 GJ

As expected, the reduction of loads on the MDES system has reduced the gas consumption of the central heating plant as seen in the table above and 'MDES – Central Heating Plant Gas Consumption' figure below.

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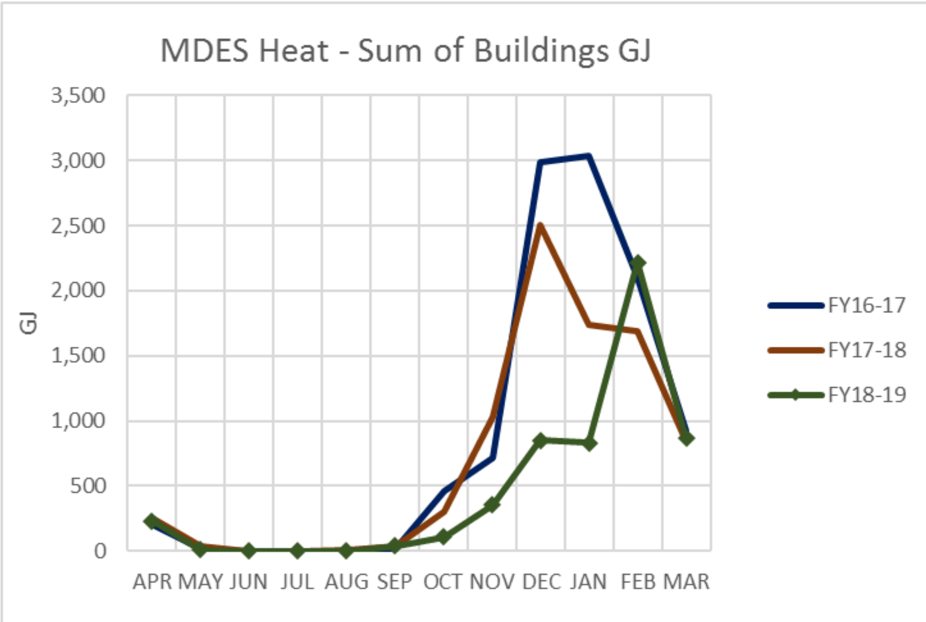

Figure 16: Thermal Energy Delivered by MDES

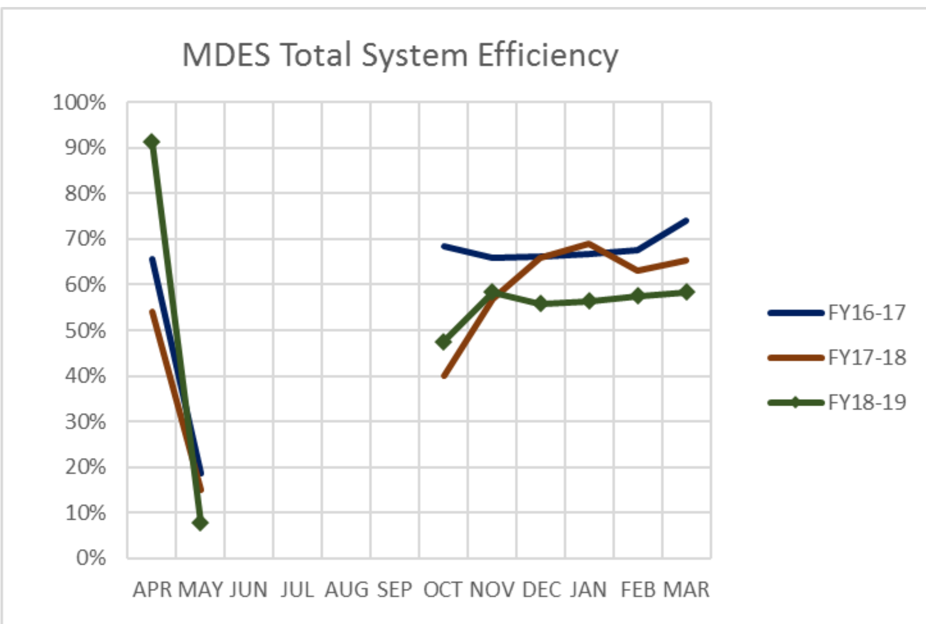

Figure 17: MDES System Efficiency

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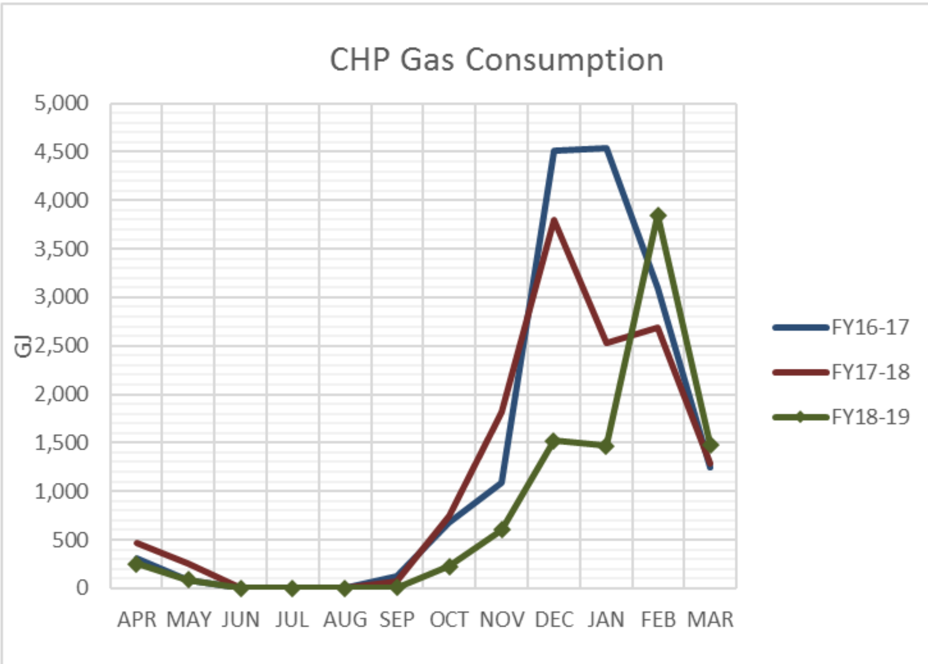

Figure 18: MDES - Central Heating Plant Gas Consumption

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3.2 LDES - Low Temperature District Energy System

The low temperature district energy system (LDES) on campus currently delivers roughly ambient (8ºC-25ºC) water to most academic buildings on campus. Heatpumps within the building can use this ambient temperature water as a source for either heating or cooling. For heating, at the present time all buildings connected to the LDES also have independent boilers or MDES connections for supplemental and backup heating. Several buildings that are connected to the LDES utilize the system for heating only and use building-level chillers for cooling.

The figure below shows the amount of heating/cooling used from the different LDES sources in FY18-19. In the figure, the energy amounts shown as "Shared" account for heating/cooling that the LDES plant did not need to generate due to heat being transferred between buildings when some buildings are in cooling whilst others are in heating and vice versa. This shared energy results in a savings as the central LDES plant does not need to generate the heating/cooling. The "Shared" values shown however do not account for heating/cooling diversity within buildings. For example heat extracted from a data centre and reused within a building would show up as a reduced building heat load whereas if the heat was transferred into the LDES loop and used by another building it would be accounted for as a "Shared" energy source.

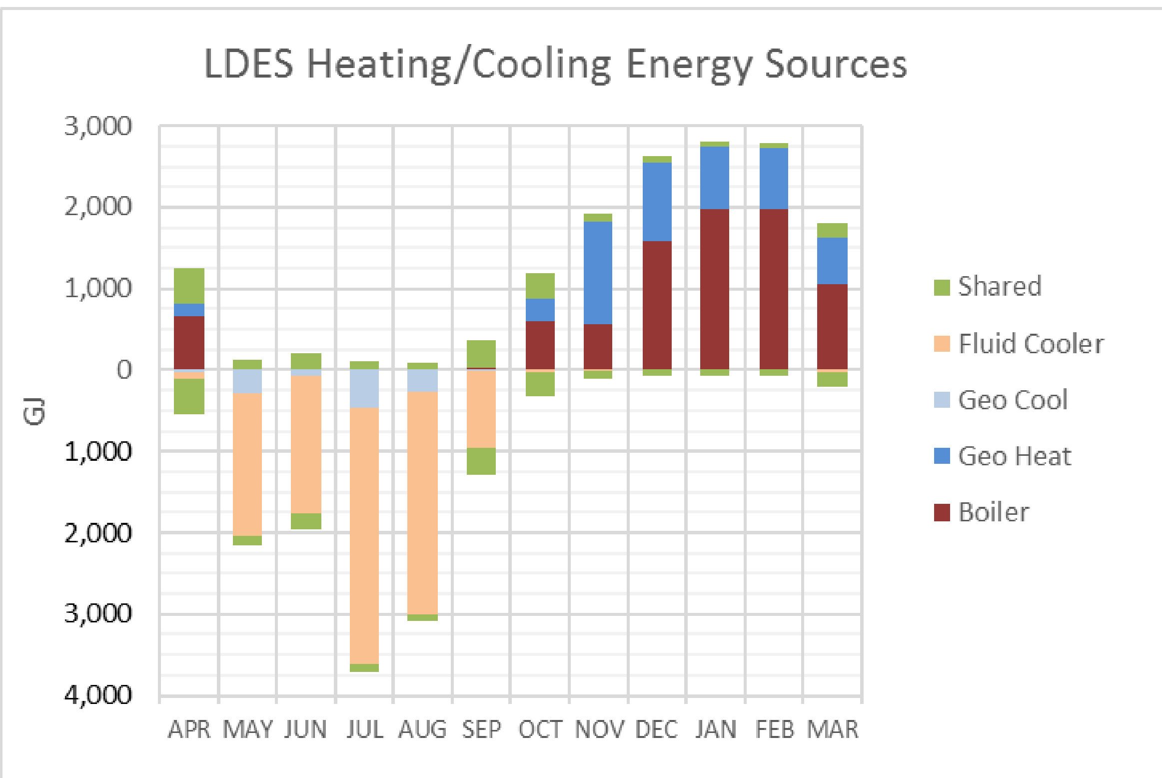

Figure 19: LDES Heating and Cooling Sources FY18-19

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3.2.1 LDES – Heating

Heat is provided to the LDES from two gas-fired boilers: one high-efficiency condensing boiler and one low-efficiency atmospheric boiler. In addition to these boilers, heat can be provided to the LDES from a geo-exchange groundwater system. Due to the water temperature requirements of a number of buildings, the LDES return water temperature has historically been too warm to utilize groundwater heating. However, upgrades in limiting buildings have been completed that allow for return water temperatures compatible with utilizing groundwater as a heat source. The amount of heat extracted from groundwater is shown in the figure below. As can be seen in the figure, over 1000GJ of heat was extracted from groundwater in November 2018 with the amount being reduced as the heating season progressed. This reduction is due to capacity limits with the groundwater injection system. It was found that the flow rate of water that the injection system could handle declined over time as the system was used continuously. Ways to increase the capacity of the system for continuous season-long water injection are being investigated in order to increase the amount of groundwater available for heat extraction.

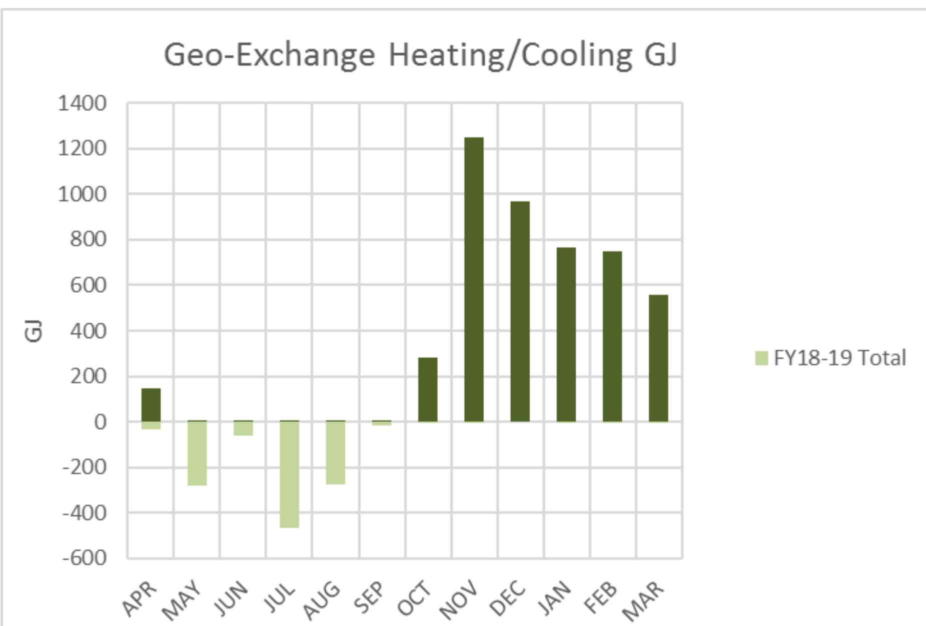

Figure 20: Quantities of Heat Extracted From Groundwater

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Utilization of groundwater heating requires electricity use in order to run the required pumps. The figure below shows the amount of electricity used by the required pumps as a fraction of the amount of heat extracted (or heat injected during the cooling season) from the groundwater. This value is defined as the Energy Input Ratio or EIR. As can be seen in the chart, during the heating season electricity use varied from less than 10% to greater than 15% of the value of heat extracted. Optimization efforts to reduce this ratio are underway. Of particular importance is the LDES return water temperature. The colder the return water temperature is, the more the groundwater can be cooled before being returned to the ground and correspondingly the greater the amount of heat that can be extracted from a given amount of groundwater is. As such, efforts are underway to reduce the LDES return water temperatures from campus buildings.

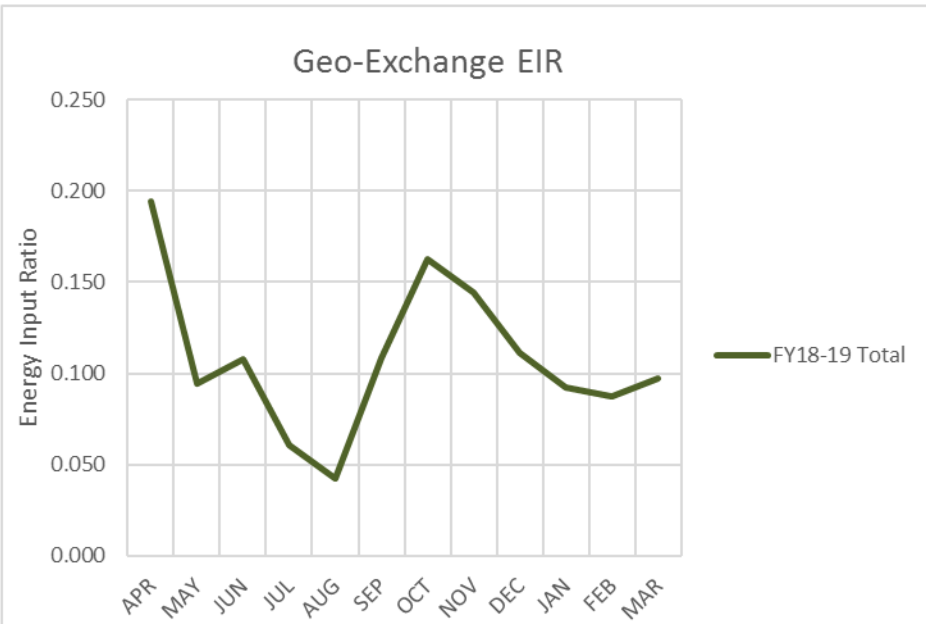

Figure 21: Groundwater Heat Extraction Energy Input Ratio

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3.3 LDES – Cooling

In addition to heating, the low temperature district energy system provides cooling to several academic buildings on campus. Note that not all buildings connected to the LDES utilize the system for cooling, several of the older academic buildings utilize the system for heat only and have air-source chillers to supply their cooling needs.

Cooling loads on the LDES totalled 12 400 GJ for FY18-19, a 3% decrease from 12 900 GJ in FY17-18. While some cooling is provided by the groundwater system, the majority of LDES cooling is provided by cooling towers attached to the system. Groundwater cooling is intentionally limited in order to reduce wear and maintenance on the groundwater extraction and infiltration systems and preserve their use for heating, where a much greater potential for GHG emissions reductions exists. The figure below shows the cooling towers EIR which is defined as the amount of electricity consumed by the towers as a fraction of the amount of heat they reject.

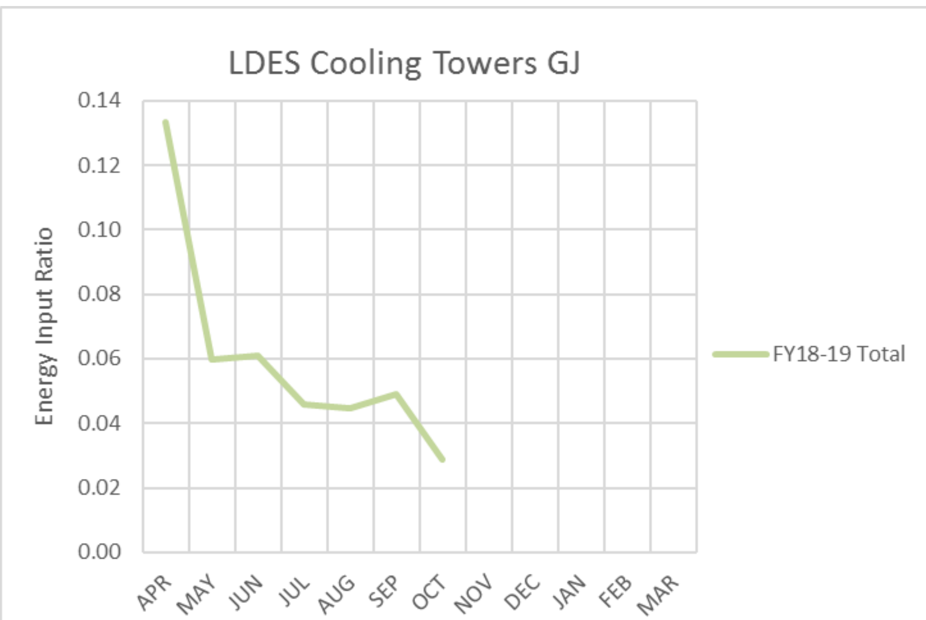

Figure 22: LDES Cooling Towers Energy Input Ratio

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4 Energy Policies and Strategic Development

The energy team is involved with development of strategies for optimizing future campus energy use. In order to set and meet achievable goals the team is working on development of campus strategies, technical guidelines as well as requirements for campus projects.

4.1 Campus District Energy Strategy

A strategy to guide possible further development of the District Energy Systems on the Okanagan campus is under development. The first phase in developing the strategy is expected to be completed in the fall of 2019. Further work on development of the campus District Energy Strategy will depend on the outcome of the first phase and confirmation of funding for the work. The strategy is intended to guide how district energy systems on campus evolve to meet the requirements of an expanding campus and will inform other plans and strategies such as the campus Climate Action Plan.

4.2 Technical Guidelines

Technical Guidelines are intended to provide minimum standards for campus projects. There are a large number of guidelines that cover both UBC as a whole and some specific to the Okanagan campus. The energy team is working to update several that are specific to energy performance and monitoring. Guidelines that have been updated so far include: Monitoring Based Commissioning, Indoor Thermal Environment and General HVAC Requirements.

4.3 Owner's Project Requirements

The UBC technical guidelines define minimum standards for all projects on campus as applicable. However, in addition to these generally applicable requirements, there are specific requirements for individual projects; these requirements are highlighted in the 'Owner's Project Requirements' document. The energy team provides input to the OPR to ensure that requirements for energy efficiency are met.

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5 Energy Conservation Projects

5.1 Projects Completed in FY2018-2019

5.1.1 Science Exhaust Air Heat Recovery

Previously, only a portion of the exhaust air connected to the Science building's main laboratory exhaust fans had heat recovery systems installed. A glycol run around heat recovery system was installed in July 2018 to recover heat from the remainder of the exhaust air. This measure is expected to save approximately 2000 GJ/yr of natural gas usage.

5.1.2 ASC Exhaust Heat Recovery

While a glycol run around system was installed in order to recover heat from laboratory exhaust air, it has not been operational for some time due to deficiencies in the original construction. A mechanical consultant was contracted to evaluate the system and has provided recommended remedial actions required in order to activate and operate the system. The required actions were completed in the summer of 2018 and the system is now operational.

5.1.3 Lighting Upgrades

Upgrades of campus lighting to LED fixtures is ongoing. In order to reduce the manpower required to complete lighting replacements, an indoor man-lift was purchased. During FY18-19, UBCO staff replaced about 2000 flourescent tubes with LED versions and upgraded 24 streetlights to LEDs. These and other assorted lighting upgrades on campus are expected to save about 150 000 kWhr per year of electricity.

5.2 Projects Underway at End of FY2018-2019

5.2.1 Science Ventilation Upgrade

Due to the large number of laboratories in the building and their associated high ventilation rates, the Science building is the largest consumer of natural gas on campus (almost all of which is consumed indirectly through both campus district energy systems). Reducing the ventilation rates to avoid unnecessary over-ventilation is a key energy conservation measure. Measures taken to date include:

- Upgrading fumehoods to variable volume control to allow for reduced airflow when the hood's sash is down
- Installation of air quality sensors and controls to adjust ventilation rates based on air quality/chemical contamination
- Add occupancy controls to laboratories to allow for reduced ventilation rates where and when possible
- Add variable-frequency drives to the building's Strobic exhaust fans.

This project is currently estimated to save $52,000 in energy costs per year (2,600 GJ of gas and 415,000 kWhr of electricity). The project has been approved for $25,815 in FortisBC electrical

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incentives and $55,681 in FortisBC gas incentives. As this project has progressed, additional fumehoods have been identified as opportunities for upgrades and these upgrades are expected to be complete by July 2019.

5.2.2 Library Data Centre Heat Recovery

The data centre in the Library produces a significant amount of heat year-round and there are plans to expand it. In order to utilize the heat produced by the data centre during cold weather, a hydronic connection is being made between the library data centre and the new adjacent Commons (TLC) building's central heating/cooling plant. With this connection, cooling for the data centre will be provided by the Commons' central plant with the heat being available for use in the Commons building. This system is expected to save 480 GJ of natural gas and 53 MWhr of electricity consumption annually. Completion of this project is expected for June 2019.

5.2.3 LDES Optimization

In order to increase the amount of groundwater heating that is provided to the system, upgrades to the RHS and EME buildings were completed in FY18-19 allowing for reduced return water temperatures. Other operational upgrades to the LDES circulation system are being investigated as well as upgrades to the groundwater system. The nature and timing of these upgrades will depend on the availability of funding.

5.2.4 HVAC System Efficiency Maintenance

The energy team has employed an HVAC Efficiency Technician since the spring of 2017. This technician has been cleaning heat exchangers and other campus HVAC equipment. Improved operational efficiencies were expected and are being noted as the technician has found and cleaned significantly fouled equipment. Trends in the fouling of equipment are being used to optimize cleaning schedules as systems with faster/slower fouling rates are identified.

Some examples of work completed include:

- Significant fouling of terminal equipment was found in terminal devices in the Science building. Cleaning of this equipment will result in improved occupant comfort and more efficient usage of the building's heatpumps.
- The LDES/Science building heat exchanger was found to have significant particulate buildup that was impairing flow. Cleaning of the heat exchanger increased flow to the building's heatpumps increasing their capacity by a factor of 4/3.
- Material buildup was found to be less significant in the Arts building than in Science. However AHU-3 in Arts was found to have a plugged heating coil. Cleaning of this coil is expected to improve system efficiencies and increase occupant comfort.
- Insufficient water flow due to particulate fouling in the LDES/Fipke heat exchanger. Correction of this issue should positively impact required HVAC system capacity upgrades in the building.

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5.3 New Construction Projects

Two new major buildings are currently under construction on campus. Both of these are residence buildings. Additionally, the Commons building attached the library opened in January 2019.

5.3.1 Commons Building

The new Commons building (formerly referred to as the Teaching and Learning Centre) opened for use in January 2019. Fortis energy efficiency incentives of $115k were approved for this project. Current estimates are that the Commons building will consume less than half the energy compared to a minimally code compliant reference building. Final commissioning of this building is still ongoing.

5.3.2 Skeena Residence

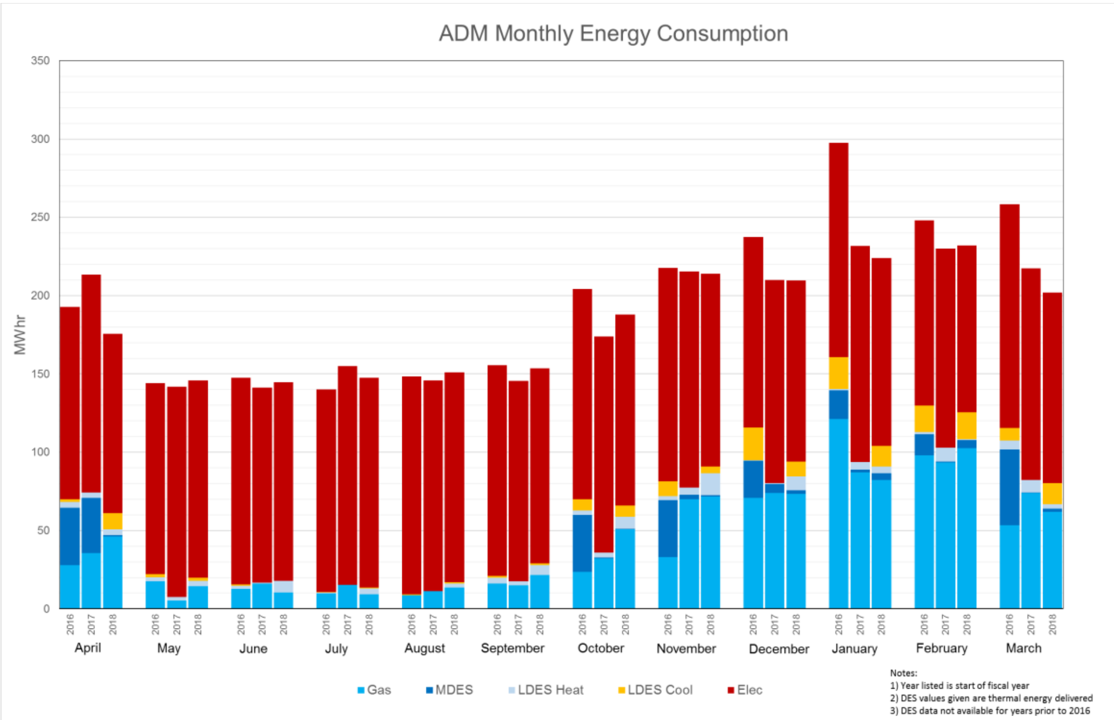
The Skeena Residence is a new residence building that is planned to be the first Passive House Certified building on campus. The energy team has provided detailed feedback on the design of this building. Completion of this building is expected for the summer of 2020. Based on the expected energy performance, FortisBC incentives of $167k have been approved. Additional incentives from the provincial government for high-performance new buildings may also be obtained for this building but have not yet been confirmed.

5.3.3 Nechako Housing Commons

The Nechako building is a new residence building with a large cafeteria and other campus amenities included. While the energy team has provided detailed feedback on the design of this building, as a residence building decisions for this building are the responsibility of UBC Student Housing and Hospitality Services. Completion is expected for summer 2021. Based on the modelled energy performance of this building, $157k of FortisBC incentives have been approved.

6 Monthly Energy Performance Data for Campus Buildings

6.1 Administration



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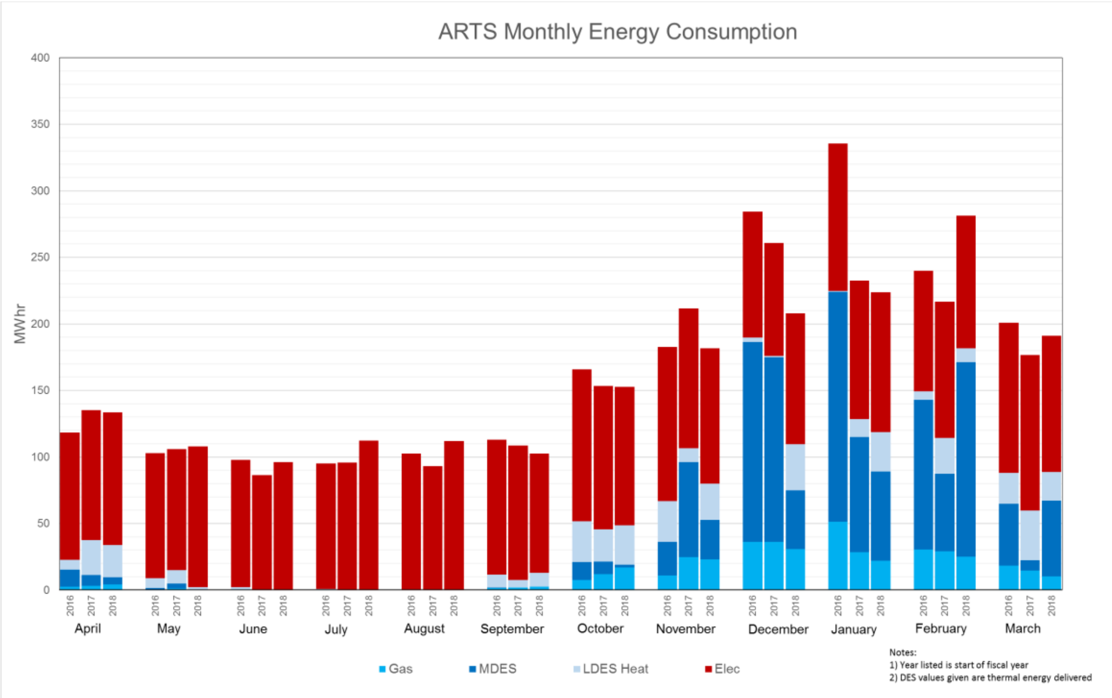
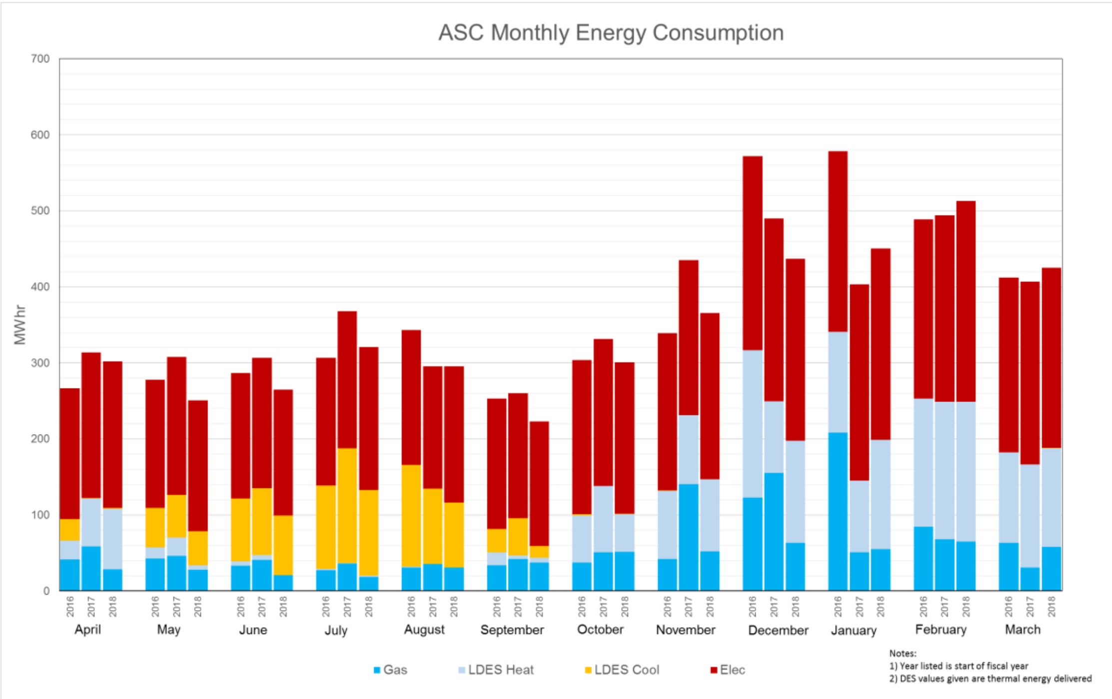
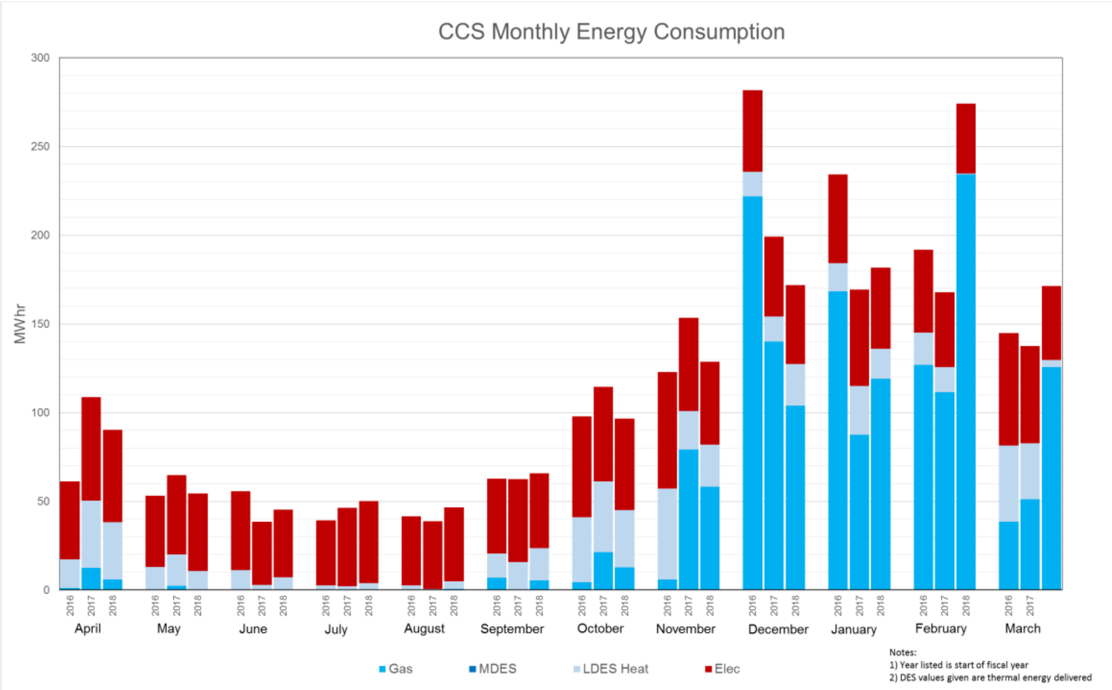
6.2 Arts



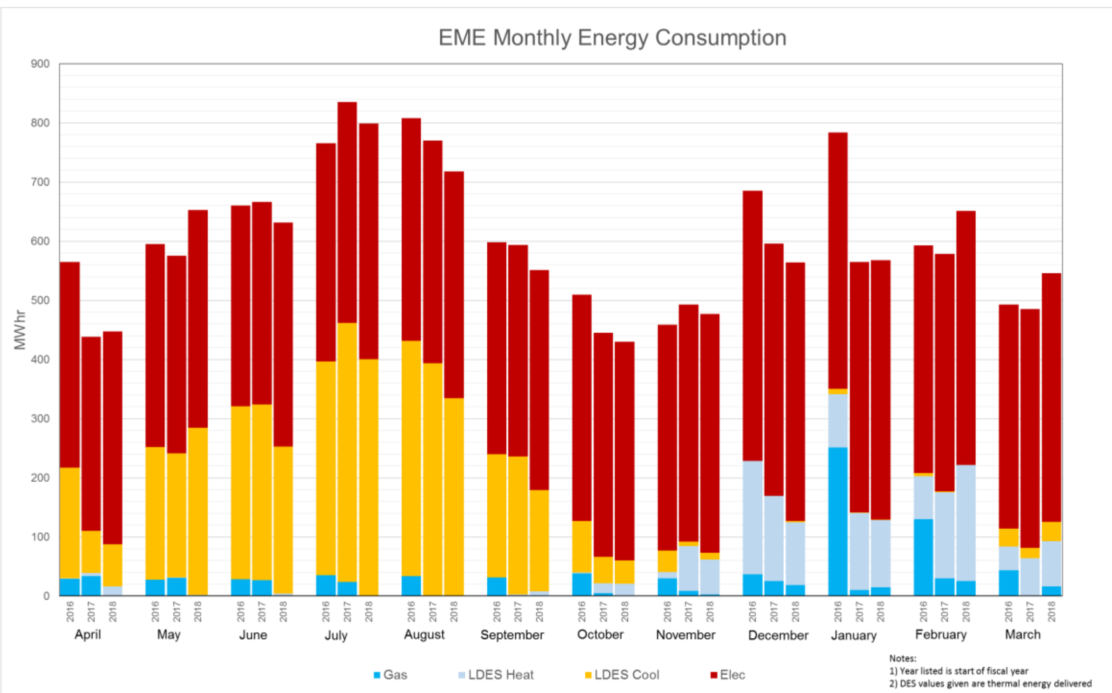
6.3 Arts and Science Building



6.4 Creative and Critical Studies



6.5 EME



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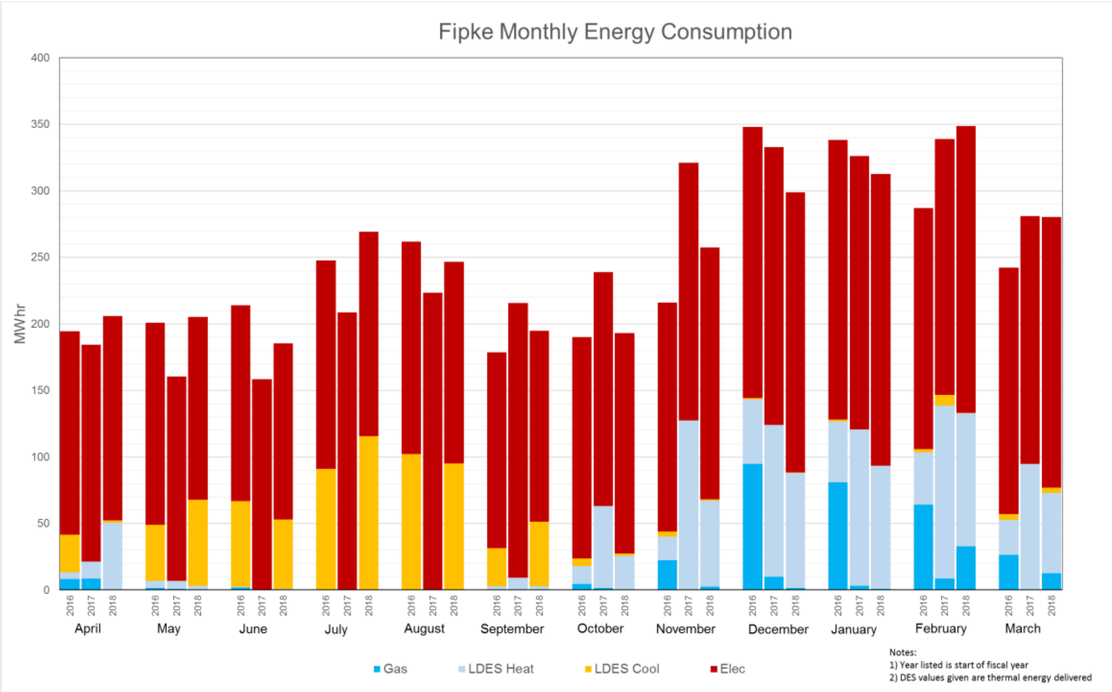
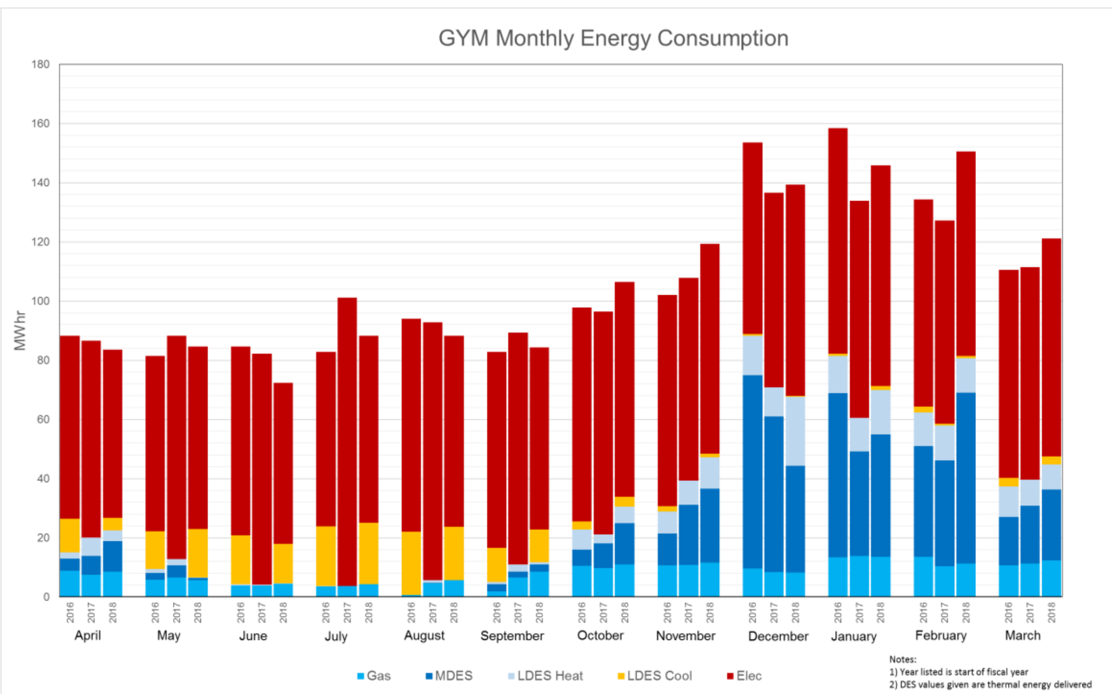
6.6 Fipke



6.7 Gym



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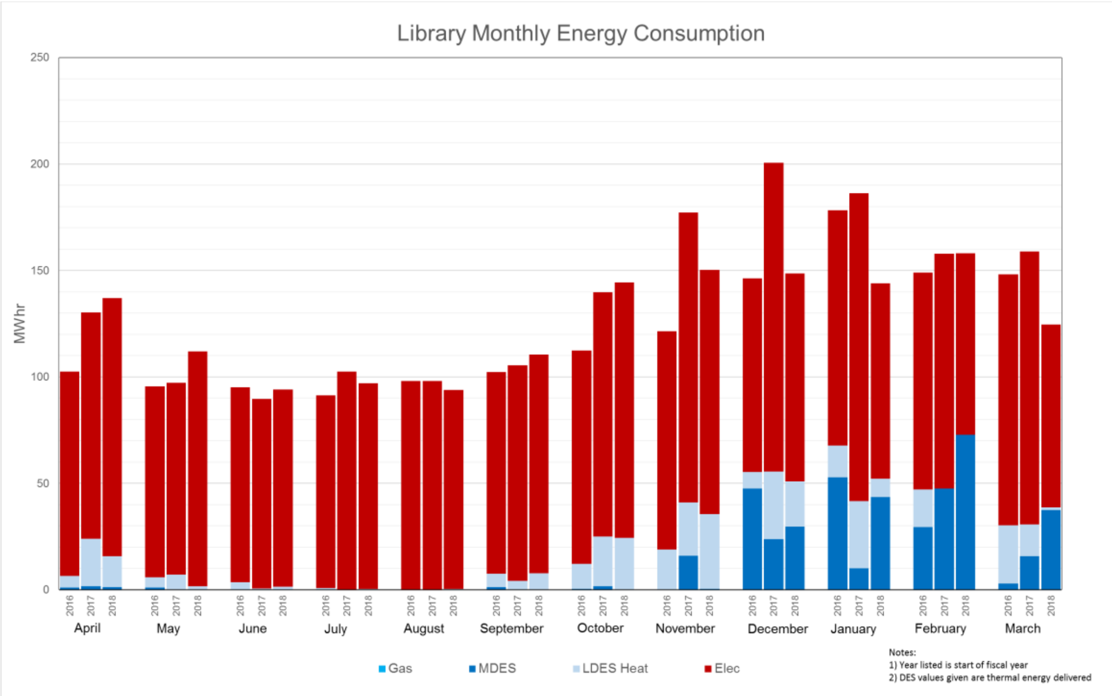
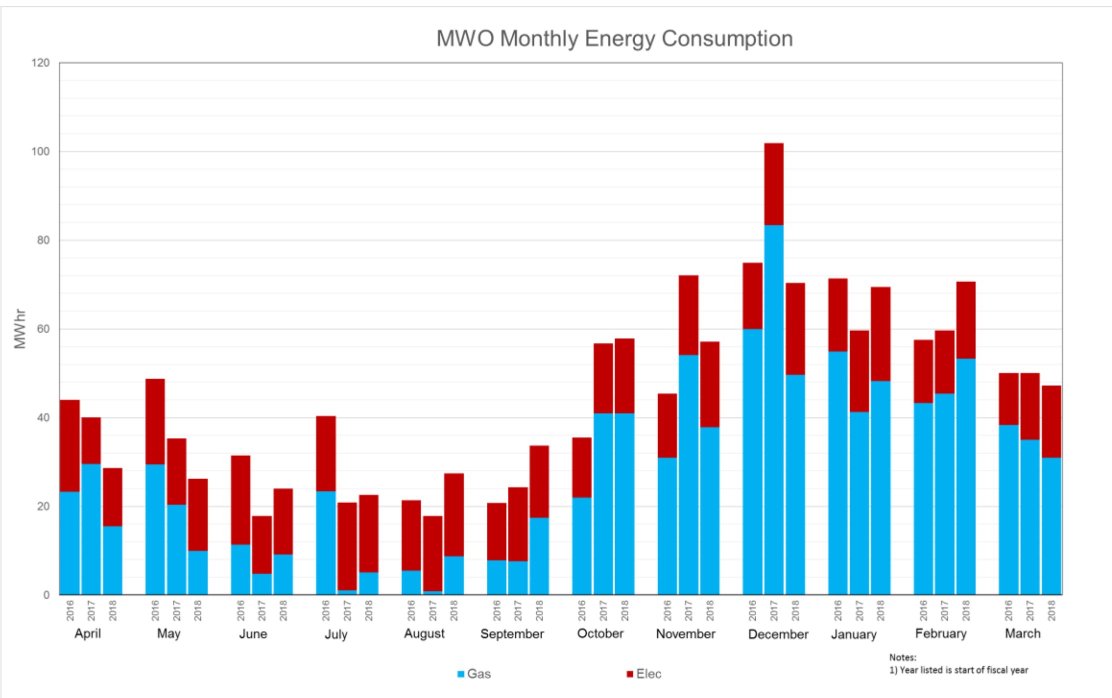
6.8 Library



6.9 MWO



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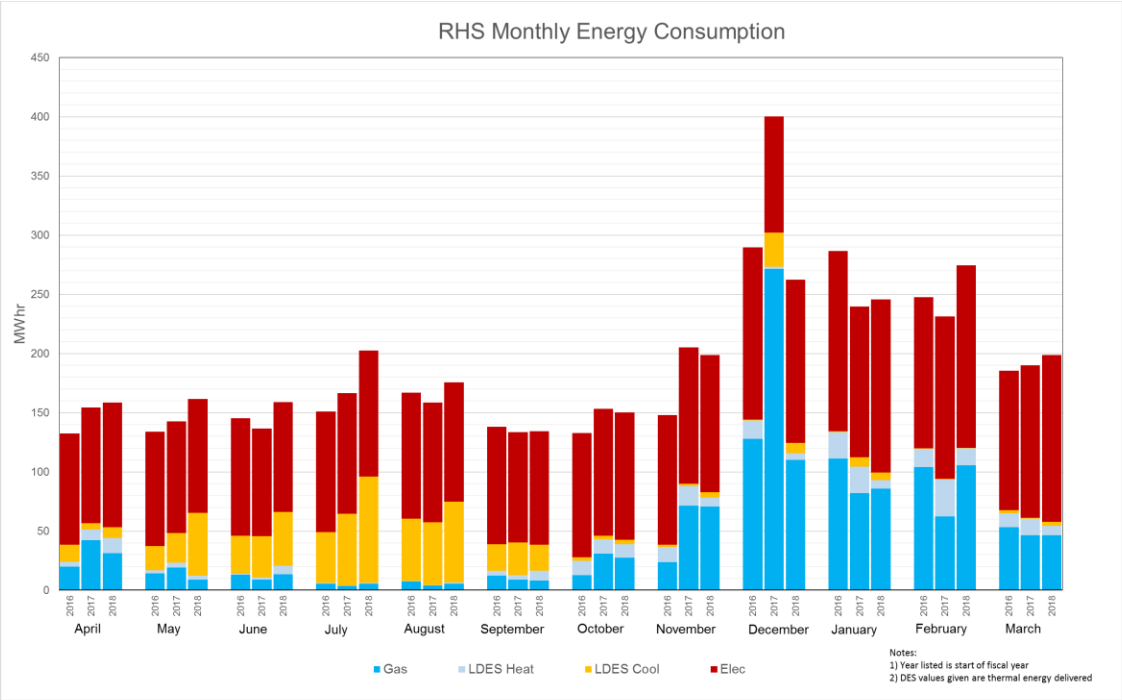
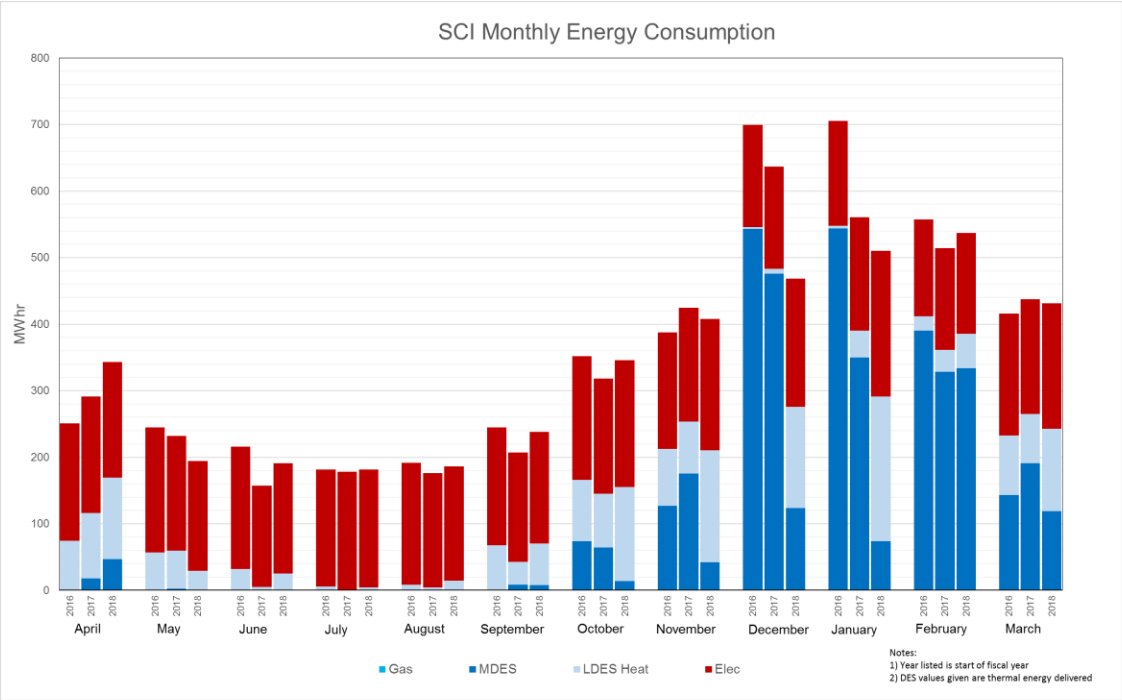
6.10 Reichwald Health Sciences



6.11 Science Building



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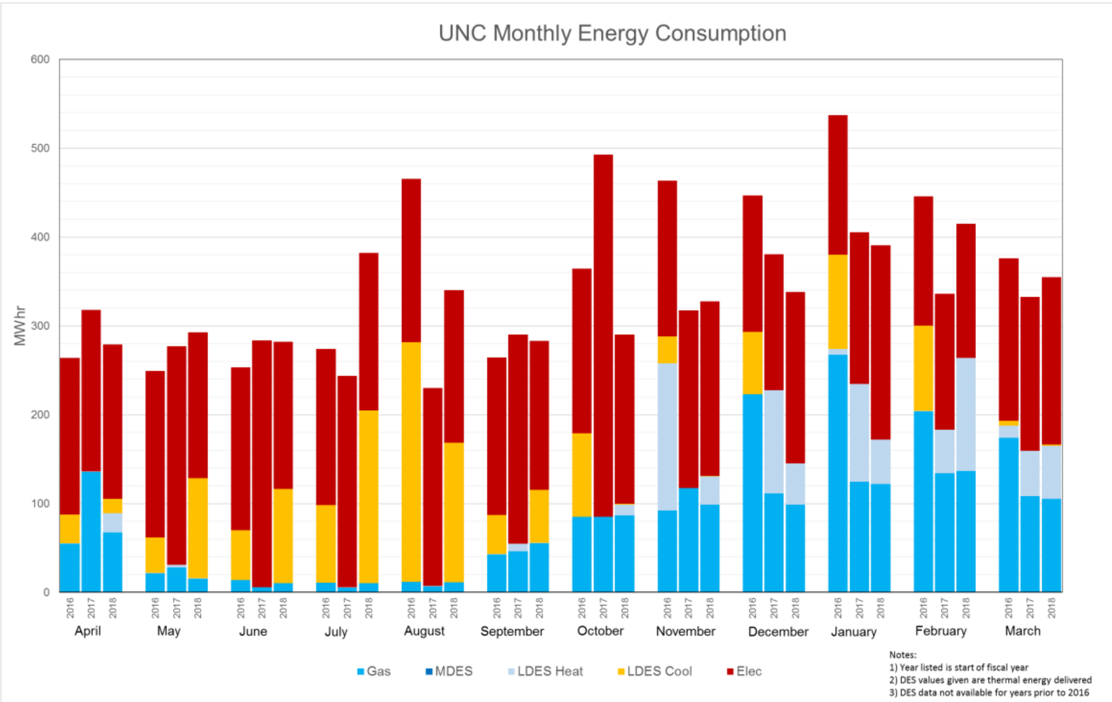
6.11.1 University Centre



6.12 Residences