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facilities.ok@ubc.ca

UBC Okanagan Energy Team Annual Report April 2017 – March 2018

May 11 2018

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Definition of Terms

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/m2 are the units used for EUI.

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

LDES: Low temperature district energy system. One of two district energy loops on campus, this loop currently operates between approximately 10^{o}C and 30^{o}C. Heating and cooling for this loop is provided by boilers, geothermal 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 mid-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
- Champion the implementation of an Okanagan Campus energy policy
- 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 Energy Performance for Year

Overall campus electrical consumption increased year over year by about 200 MWhr or less than 1%. This increase can be attributed to a number of factors including construction of the TLC and successful implementation of a number of gas-electric conversion projects as well as increased consumption by residences. Electricity costs for FY2017-2018 were $2.3M (including savings due to rebate of 2/3 of GST) and averaged $0.082/kWhr.

Overall campus gas consumption decreased year over year by about 6600 GJ, a reduction of 13%. Gas costs for FY2017-2018 were $380,000. The average gas cost for the year was $8.52/GJ including carbon offset costs and savings due to rebate of 2/3 of GST. The gas consumption reductions were the result of a number of projects that are described in the individual buildings section below.

2.1 Overall Campus Energy Performance Plots

The plots below give an overview of overall campus energy performance. The data series shown can be described as follows:

- Campus Actual/Forecast: Historical energy consumption data is used until FY2017-18. For future years, energy consumption is predicted as follows:
  - Academic: known building expansions are included (TLC, Okanagan Commons and Skeena). For subsequent years, a constant FTE/m^2 ratio is assumed (equal to FY2019-2020 ratio). Campus expansion is thus based on FTE predictions obtained from Campus Planning. New academic buildings are assumed to have an EUI the same as the average academic building the year before. Energy reduction targets of 500 MWHr electricity per year and 3000 GJ per year of gas until 2020 and 2000GJ of gas post 2020 are also included.
  - Residences: planned residence expansions are included. A constant FTE/m^2 ratio is assumed for years after 2020 (ie after the completion of Skeena/Okanagan Commons Residences). The historical EUI for existing residences is used for future years for both existing and new residence buildings.
- 2013 Baseline: Campus energy consumption is set to equal what it was in 2013.
- BAU 2013: The campus business as usual energy consumption baseline is calculated based on the 2013 campus EUI and the campus building area for the given year. This gives the energy consumption the campus would have if it maintained its EUI at the same value as 2013.

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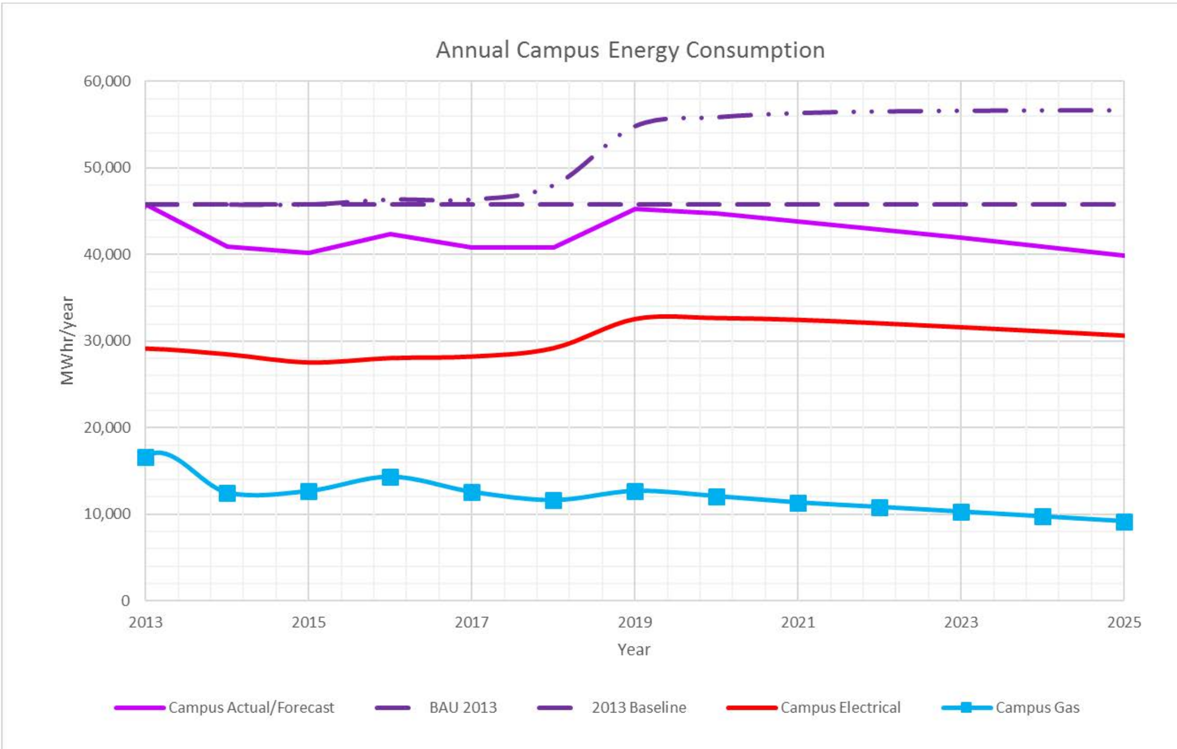
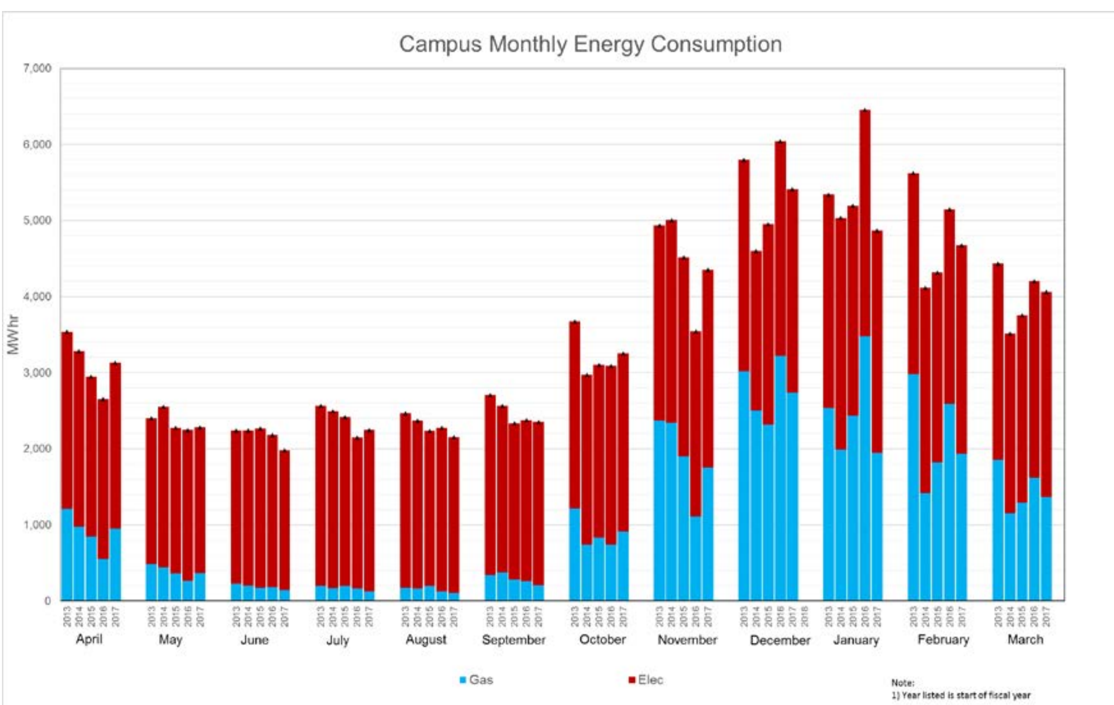


Note: Dates listed refer to start of fiscal year. ie FY2017-2018 = 2017



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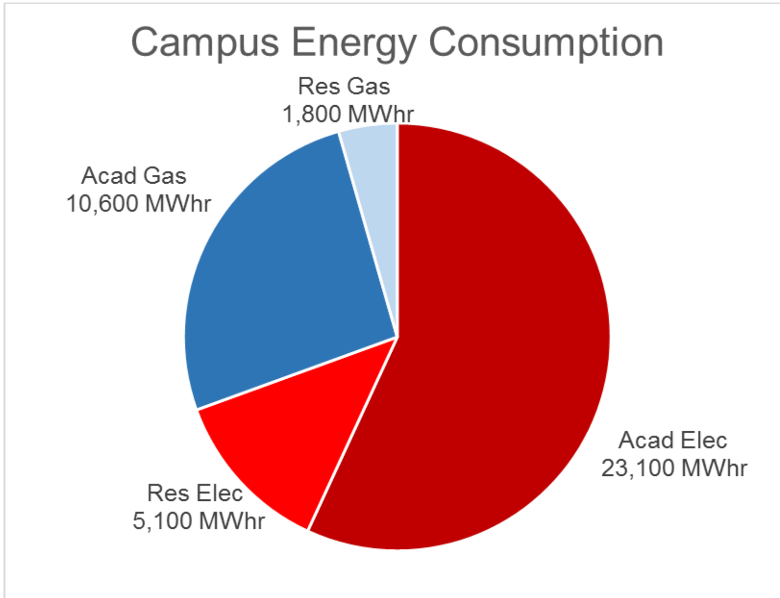

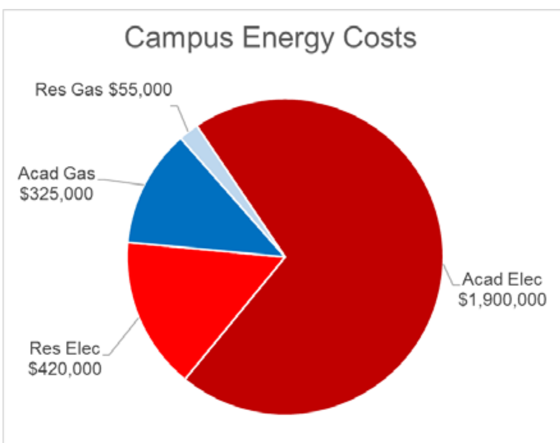

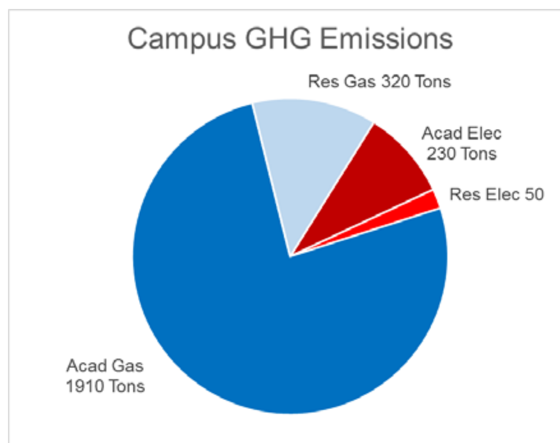

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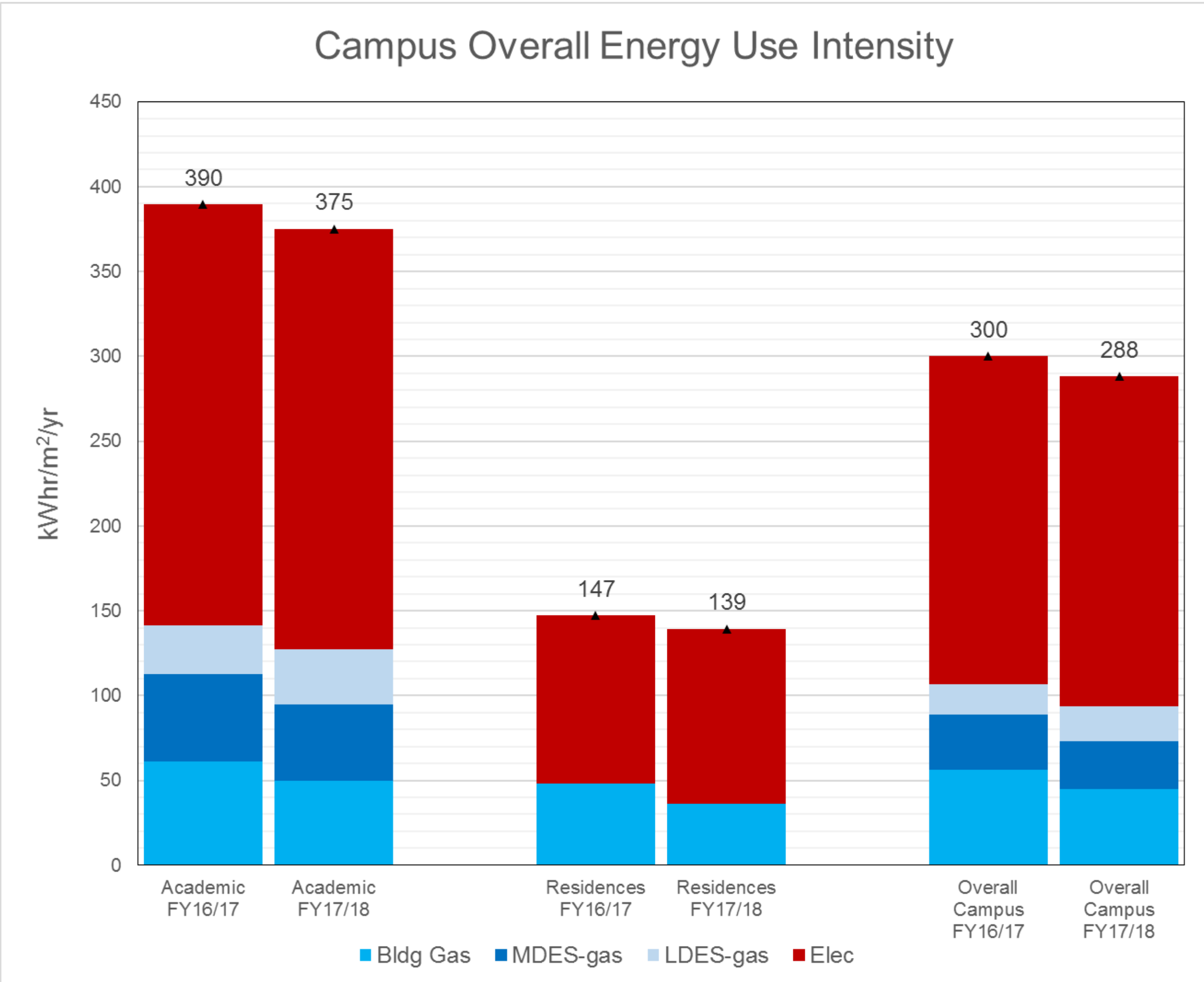
2.2 Energy Use Intensity

Energy use intensity (EUI) is the amount of energy used per unit of floor area. The overall campus EUI was 288 kWhr/yr/m^2 for FY2017-2018, a 4% 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 average EUI for academic buildings on campus was 375 kWhr/yr/m^2 while it was 139 kWhr/yr/m^2 for residences. The chart below shows the breakdown of EUI per energy source.



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3 Campus District Energy Systems

The UBC Okanagan campus is served by two district energy systems. The characteristics and performances of these systems are described below.

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 'MDES Operating Efficiencies' table below, the central heating plant operates at a thermal efficiency of about 78%. Thermal losses from the MDES distribution piping lead to about a 85% distribution efficiency (ie about 15% of heat sent through the MDES pipes is lost through conduction to the surrounding soil). The resulting total system efficiency is about 66%. Thus, for every three GJ of natural gas input to the central heating plant boilers, about two GJ of heat is delivered to the buildings served by the system. This equates to an energy input ratio (EIR) of 1.5.

MDES Operating Efficiencies

	FY 16/17	FY 17/18
Boiler Plant Efficiency	78%	78%
Piping Distribution Thermal Efficiency	86%	84%
Total System Efficiency	67%	66%

The 'Total MDES Heating' plot below shows the thermal energy delivered to campus buildings by the MDES. As can be seen in the plot, there was a year over year reduction in heat consumed from the MDES. A total of 9000 GJ was delivered by the MDES in FY17-18 compared to about 10500 GJ the prior year. The heating degree-days for both years were roughly similar at about 3800 HDD18^{o}C. The 'CHP Gas Consumption' plot is also given below and represents the gas consumed by the central heating plant that supplies the MDES.

The MDES load is believed to have been reduced due to energy conservation measures that were implemented within the buildings as well as a number of measures that were implemented to increase utilization of the low-temperature district energy system (LDES). These measures are discussed in their respective sections below.

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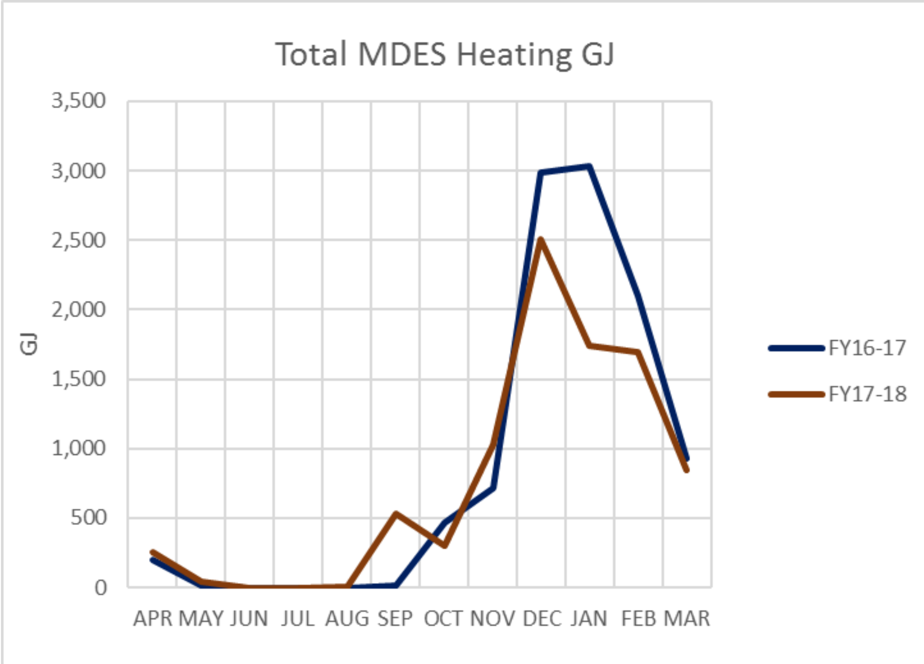

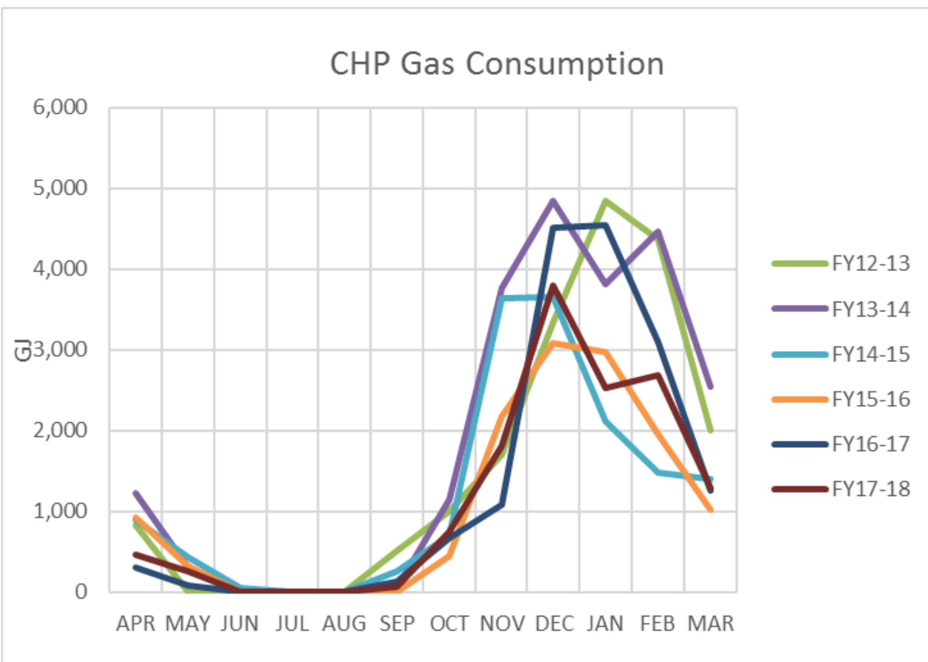

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3.2 LDES - Low Temperature District Energy System

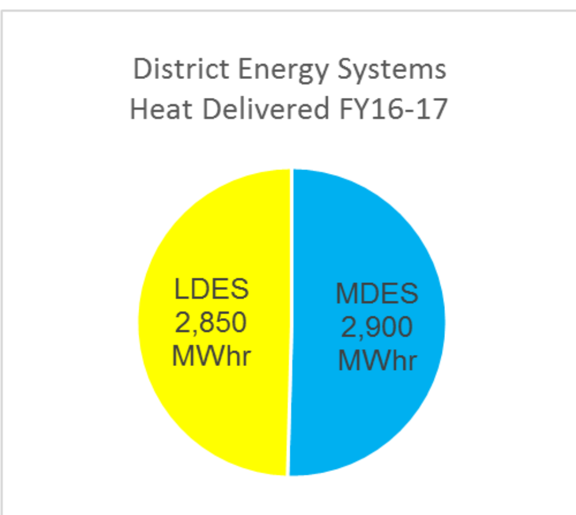
The low temperature district energy system (LDES) on campus delivers roughly ambient (8ºC-35ºC) water to most academic buildings on campus. This system provides heating and cooling to buildings via heatpumps within the buildings. Several buildings that are connected to the LDES utilize the system for heating only and use building-level chillers for 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.

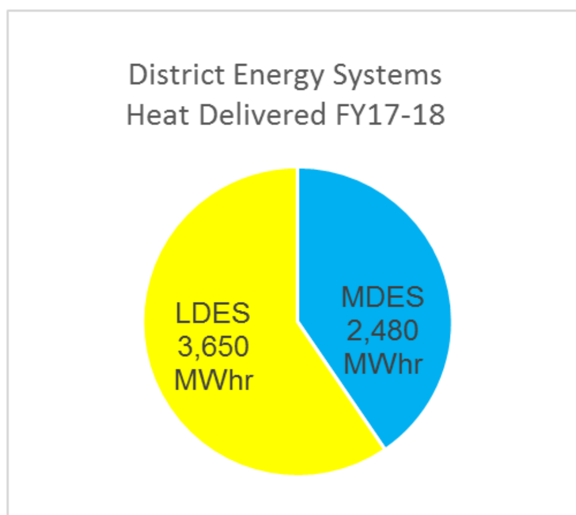
Electrical consumption of the LDES system was almost 900MWhr for FY2017-2018, or about 15% higher year over year. This increase is due mainly to increased heating loads on the system and use of geothermal pumps for heating as described in the heating section below.

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 geothermal groundwater system. Due the water temperature requirements of a number of buildings, the LDES supply water temperature has historically been too hot to utilize groundwater heating. However, the completion of major building plant upgrades in Fipke, ASC and UNC has changed this situation and some groundwater heating was utilized this past winter. To allow further reductions of LDES temperatures, addition of glycol within both EME and RHS is required. These projects are now both expected to be completed by the next heating season.

The Fipke, ASC and UNC plant upgrades and a number of other projects transferred significant heating loads to the LDES from the MDES as well as a number of independent boilers within buildings. This load shift resulted in the LDES delivering 3650 MWhr of heat in FY17-18 compared to 2850MWhr GJ in FY16-17. The relative amounts of heating energy delivered by the two district energy systems is shown graphically in the 'District Energy Systems Heat Delivered' pie charts below.





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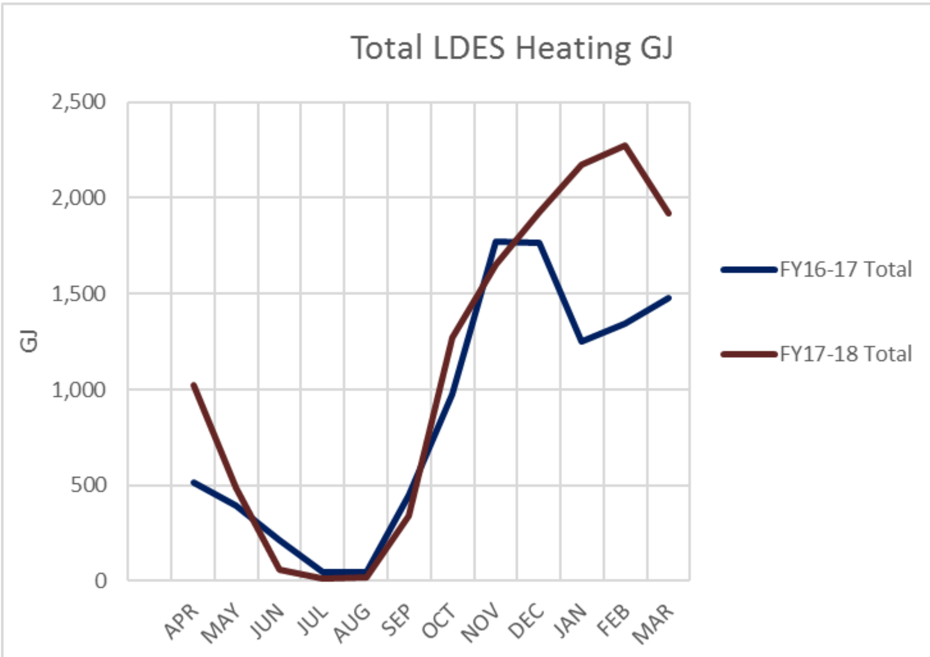
The total monthly thermal heating energy delivered by the LDES system for the past two years is given below in the 'Total LDES Heating' plot. This plot clearly illustrates the increased loads placed on the LDES in FY2017-2018. As a result of the increased LDES loads, gas consumption of the LDES boilers increased from 8600GJ in FY2016-2017 to 9900GJ in FY2017-2018. This increase can be seen in the 'LDES Gas Consumption' plot below.



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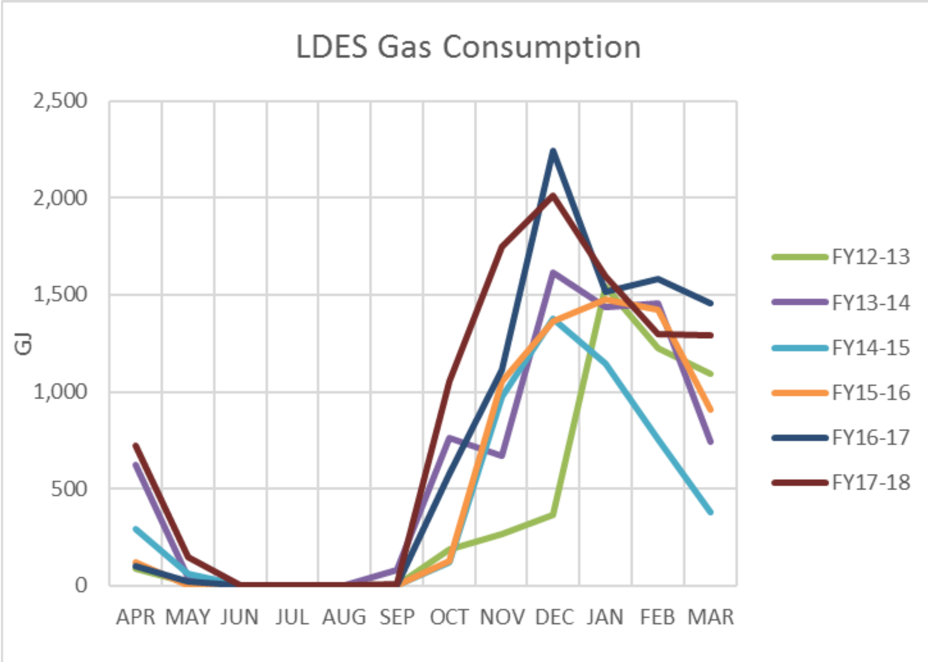
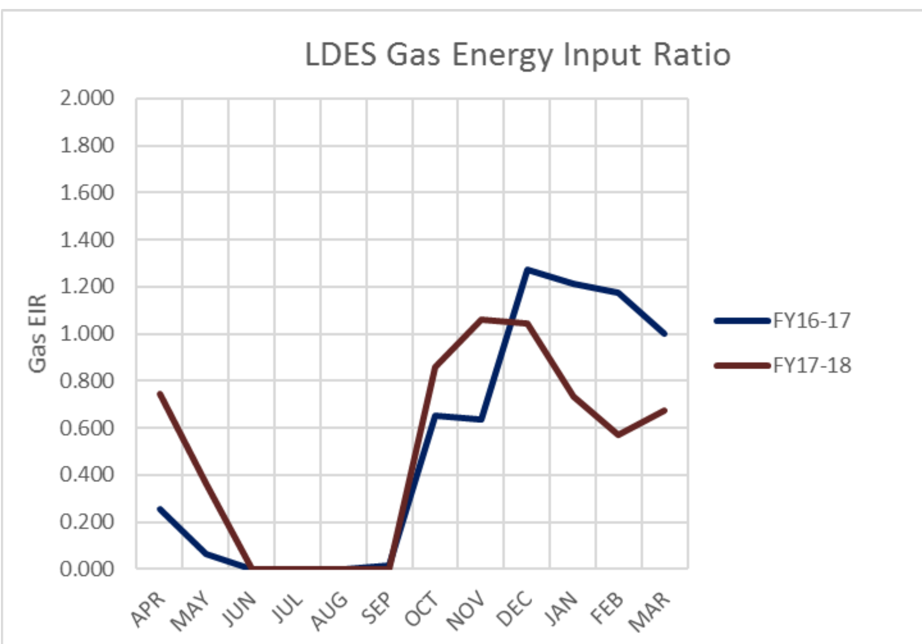


The energy input ratio (EIR) of the LDES calculates the amount of energy consumed by the system as a fraction of the amount of energy delivered. With both the increased thermal loads and the increased gas consumption of the LDES, the average LDES natural gas EIR decreased to 0.77 for FY2017-2018 compared to 0.90 the year before. The ‘LDES Gas Energy Input Ratio’ plot below shows the monthly values for the past two fiscal years.



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The fact that the LDES gas EIR is less than 1 (ie gas efficiency of greater than 100%) demonstrates the advantages of utilizing the LDES. The reasons for this EIR, which indicates that the LDES uses less than half the gas per unit of heat delivered than the MDES, include:

- No system delivery heat losses to the ground since during heating season LDES water temperatures are colder than ground temperatures
- Energy can be shared between buildings; excess heat from one building can be rejected to the LDES to be utilized in another building
- Boiler efficiencies are maximized due to low water temperatures
- Possibility of using geothermal heat

In the ‘LDES Gas Energy Input Ratio’ plot above, it can be seen that the LDES EIR tends to increase in colder months. This is due to reduced energy sharing between buildings once all buildings are in heating mode and thus have no surplus heat to share. It can also be seen that a lower EIR occurred in winter FY2017-2018 compared to the prior year. This reduction is due to some use of geothermal heating in FY2017-2018. The amount of heat obtained from groundwater sources was limited both by the need to complete upgrades in EME and RHS as well as system limitations to sustained groundwater injection capacity.

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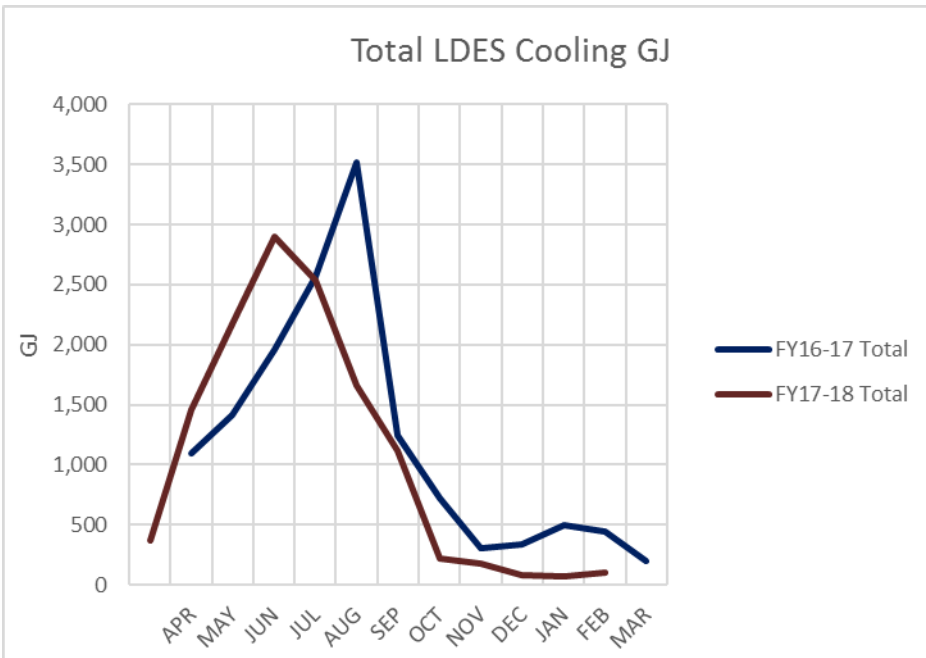
3.3 LDES – Cooling

In addition to heating, the low temperature district energy system provides cooling to several academic buildings on campus. The monthly system loads are shown in the 'Total LDES Cooling' plot below. Total cooling provided by the LDES was 3570 MWhr in FY2017-2018 compared to 3970 MWhr the year prior. In order to increase LDES cooling capacity a third cooling tower was constructed during FY2017-2018 with final commissioning taking place in spring 2018.



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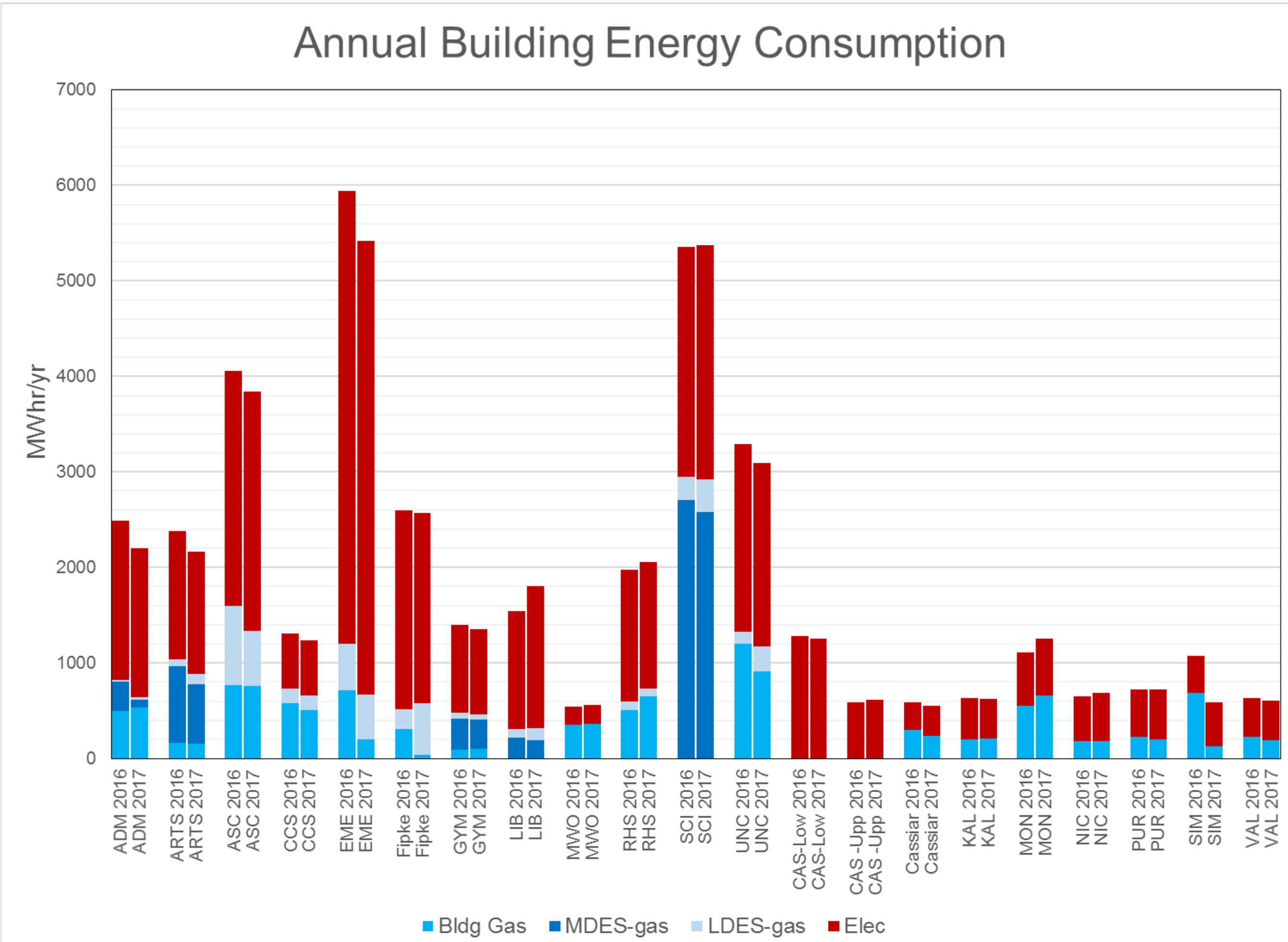
4 Performance by Building

Due to the wide array of building types on campus, energy performance varies widely building by building. The 'Annual Building Energy Use' chart below shows the breakdown of energy use per energy source for each building on campus. The next chart shows the same energy use breakdown but normalized per unit of building floorspace giving the 'Energy Use Intensity' values.



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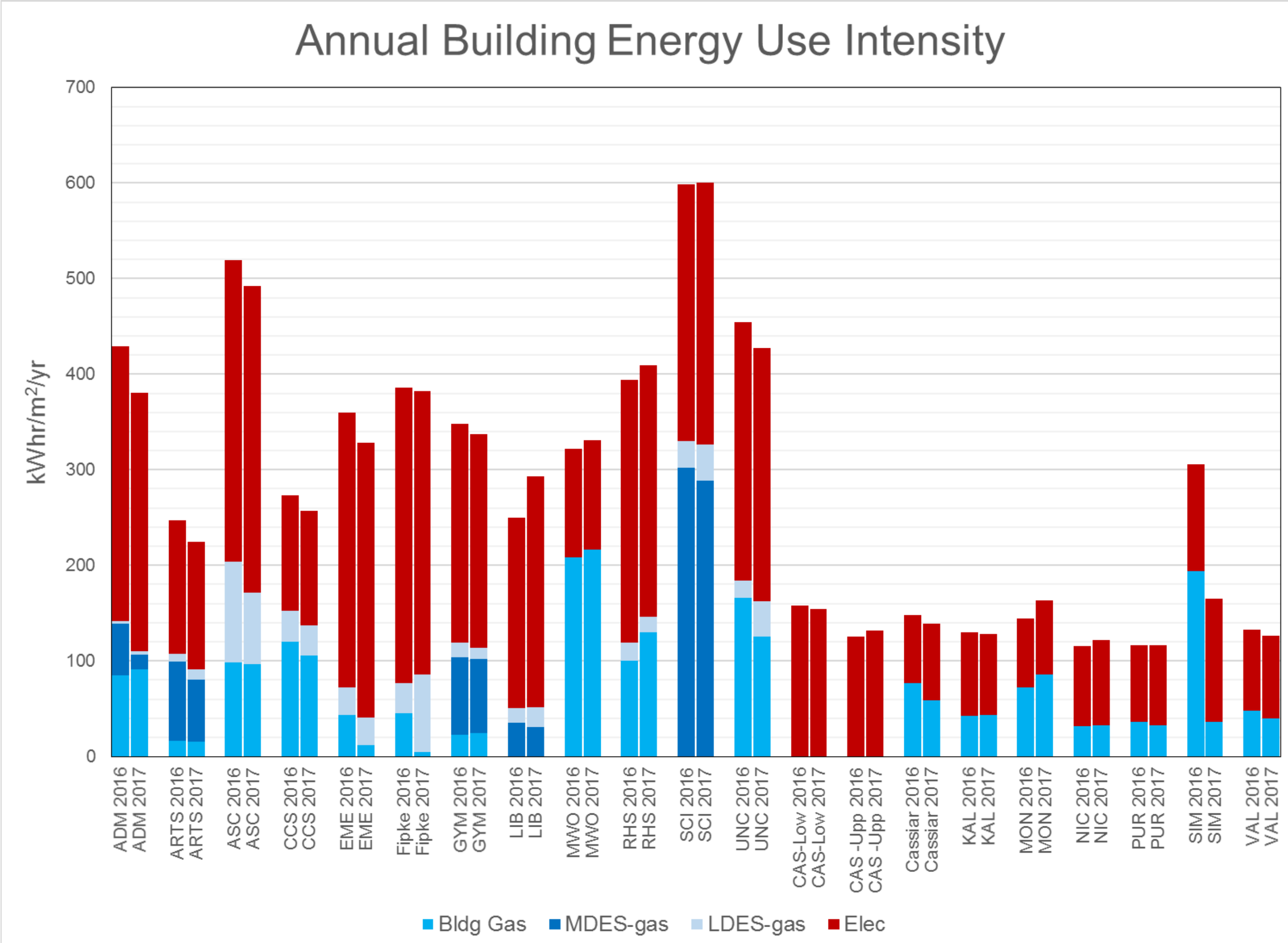

It can be seen in the chart above that the EUI of academic buildings tend to be higher with the Science building have the highest EUI, consuming almost 600 kWhr/yr/m^2.

The energy consumption of a given building is due to a number of different factors such as occupancy, type of use, installed technology, age and state of repair. As such, some buildings can be expected to have higher EUI's. Nonetheless, a high EUI value for a building relative to other buildings of similar types indicates that a building may be a higher-priority target for energy conservation measures.

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5 Energy Conservation Projects

5.1 Projects Completed in FY2017-2018

5.1.1 LDES Optimization

Currently the effectiveness of the LDES is compromised due to Phase I buildings not being able to operate with supply water temperatures appropriate for geothermal heating of the LDES. In order to effectively utilize both the heating and cooling capacity of the geothermal system and increase the cooling capacity of the cooling towers, upgrades to several buildings on campus were required. Federal government funding ($1,200,000) was been utilized to complete the upgrades on three buildings: Fipke, UNC and ASC. For these buildings, an upgrade of the central plant to a 4-pipe glycol system with hot and cold tanks has been completed. Due to these upgrades, a reduction in the winter operating temperatures of the LDES was observed and some groundwater heat was utilized. Further utilization of groundwater heating requires upgrades in the RHS and EME buildings to be completed along with some further LDES upgrades and optimizations.

5.1.2 Cooling Plant Expansion

Funding from the federal government (approximately $1,000,000) was received for installation of an additional cooling tower for the LDES system. This tower will increase the air-cooled capacity of the LDES system. Construction was mostly completed in the fall of 2017 with final commissioning being completed at the time of writing (Spring 2018).

5.1.3 Lighting Upgrades

5.1.3.1 Fixture Replacements in ADM

Federal government funding of $227,000 was used for upgrading the lighting in the ADM building. This lighting upgrade is expected to save approximately 78,000 kWhr per year and was completed in August 2017.

5.1.3.2 Fluorescent Tube Replacements

Due to reduced costs and available utility incentives, replacement of a large number of fluorescent T-8 tubes with LED tubes was completed. Including the available FortisBC incentive, 15W LED tubes were installed for a total cost of about $6/tube including parts and labour. When used to replace a 32W T-8 tube, this cost is paid back in about a year. An auxiliary staff person was hired for two months to install a large quantity of these tubes along with UBCO maintenance staff. Over 7000 tubes were installed which are expected to account for savings of over 300,000 kWhr of electricity per year or about $25,000/yr. These tubes were installed in the Arts building, Library, CCS building, Science building and bookstore.

5.1.4 Science Building Third Floor Heating Upgrade

Previously, heat was provided to the third floor of the science building from the central heating plant alone. By connecting the 3rd floor heating systems to the LDES, the central heating plant will be able to remain off for longer during shoulder seasons. This measure has been completed and is estimated to save $6000 per year in energy costs and 45 tons of GHG emissions.

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5.1.5 EME Domestic Water Electrification

Heating for domestic hot water in this building was previously provided by the building's main boilers. As a result, these large boilers were required to operate during the summer months in order to provide domestic hot water. In order to provide hot water more efficiently, a separate dedicated electric water heater has been installed in EME. To further increase efficiency, the domestic hot water system has been connected to the building's heatpumps in order to capture waste heat to preheat the domestic water. This system is in operation and is expected to save approximately $4000 per year as well as 1200 GJ of natural gas and 59 tons of GHG emissions per year.

5.1.6 ADM Domestic Water Boiler Upgrade

The low-efficiency domestic hot water gas-fired boiler that primarily serves the commercial kitchen in the ADM building was replaced with a 117kW high-efficiency gas fired condensing unit.

5.1.7 MWO Boiler Replacement

The low-efficiency 190kW boiler in the MWO building was replaced with two 117kW high-efficiency condensing boilers. FortisBC gas incentives of about $7000 were received for this project.

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5.2 Projects Underway at End of FY2017-2018

5.2.1 LDES Optimization

In order to increase the amount of groundwater heating that is provided to the system, upgrades to the RHS and EME buildings are required. The upgrade in EME has already begun and the design work for RHS is expected to begin in late spring 2018. 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.

5.2.2 Peak Load Management

Electricity costs for the campus are a mixture of charges for energy consumption (kWhr) and peak demand (kW). As such, reducing electrical demand at peak times can have significant impacts on campus energy costs. This project was pursued as a partnership between SES consultants and Siemens to develop and implement peak load management algorithms. Initial control sequences have been developed and are in place. These sequences will be modified as experience indicates is appropriate. Further peak load management strategies may be developed in the future that respond to the needs of the local Fortis supply grid.

5.2.3 Recommissioning HVAC Systems

The energy team has been systematically recommissioning campus HVAC systems. Some examples of recommissioning activities are:

5.2.3.1 HVAC System Efficiency Maintenance

During the year, the energy team's HVAC Efficiency Technician has been cleaning heat exchangers and other campus HVAC equipment. Improved operational efficiencies are expected as the technician has found and cleaned significantly fouled equipment.

5.2.3.2 CO_2 Sensor Calibration

Carbon dioxide sensors are used in various locations across campus to ensure occupants receive good indoor air quality (IAQ) by increasing ventilation rates on demand. Numerous carbon dioxide sensors across campus are slated for recalibration or replacement. Recalibration of sensors that have drifted high and are bringing in more outdoor air than necessary will result in substantial energy savings.

5.2.3.3 Cold Weather Operation

During the previous year, periods of particularly cold weather occurred. During these periods, disproportionate increases in gas consumption were noted. The reason for these increases was found to be operational procedures put in place to minimize risk of frozen pipes in buildings. Improved control sequence upgrades were investigated and implemented to avoid this issue. Further improvements to cold weather operation are still being investigated and will be completed as time and funding allow.

5.2.3.4 Equipment Rescheduling

UNC AHU-4 was rescheduled to run only during utilized hours; estimated annual savings of 29,700 kWh and 27GJ of Gas. EME HRV-4 was scheduled to run during normal building operating hours; estimated annual savings of 260,000kWh and 212GJ of Gas.

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5.2.4 Science Ventilation Upgrade

Various building changes that have accrued over time have reduced the optimization of the ventilation in this building which includes a large number of laboratories. In order to improve the ventilation to this building the following upgrades are being implemented:

- Analyze current airflows
- Add occupancy controls to laboratories to allow for reduced ventilation rates where and when possible
- Upgrade high-flow fumehoods to variable volume control
- 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 incentives and $55,681 in FortisBC gas incentives. This project is expected to be complete in the summer of 2018.

5.2.5 Science Exhaust Air Heat Recovery

Currently a portion of, but not all, of the exhaust air connected to the Science building's main laboratory exhaust fans have heat recovery systems installed. Provincial funding to install heat recovery for the remaining portion of the exhaust air has been received. A glycol run around heat recovery system is under construction is expected to be complete by July 2018.

5.2.6 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 are planned for completion in the summer of 2018.

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6 Building Performance Plots

6.1 Administration

A large fraction of the building heating load was transferred from the MDES to the LDES. This was the result of a heating system upgrades that allowed more efficient distribution of heat throughout the building which in turn allowed for greater use of the building's heatpumps. Increased electrical consumption of the heatpumps was offset by savings due to a major lighting upgrade within the building.

The makeup air unit serving the cafeteria has an air-source heatpump that has been out of service for the majority of the heating season. This unit is to be repaired this spring and as a result it is expected that there will be an increase in electrical consumption and a decrease in gas consumption in the building.

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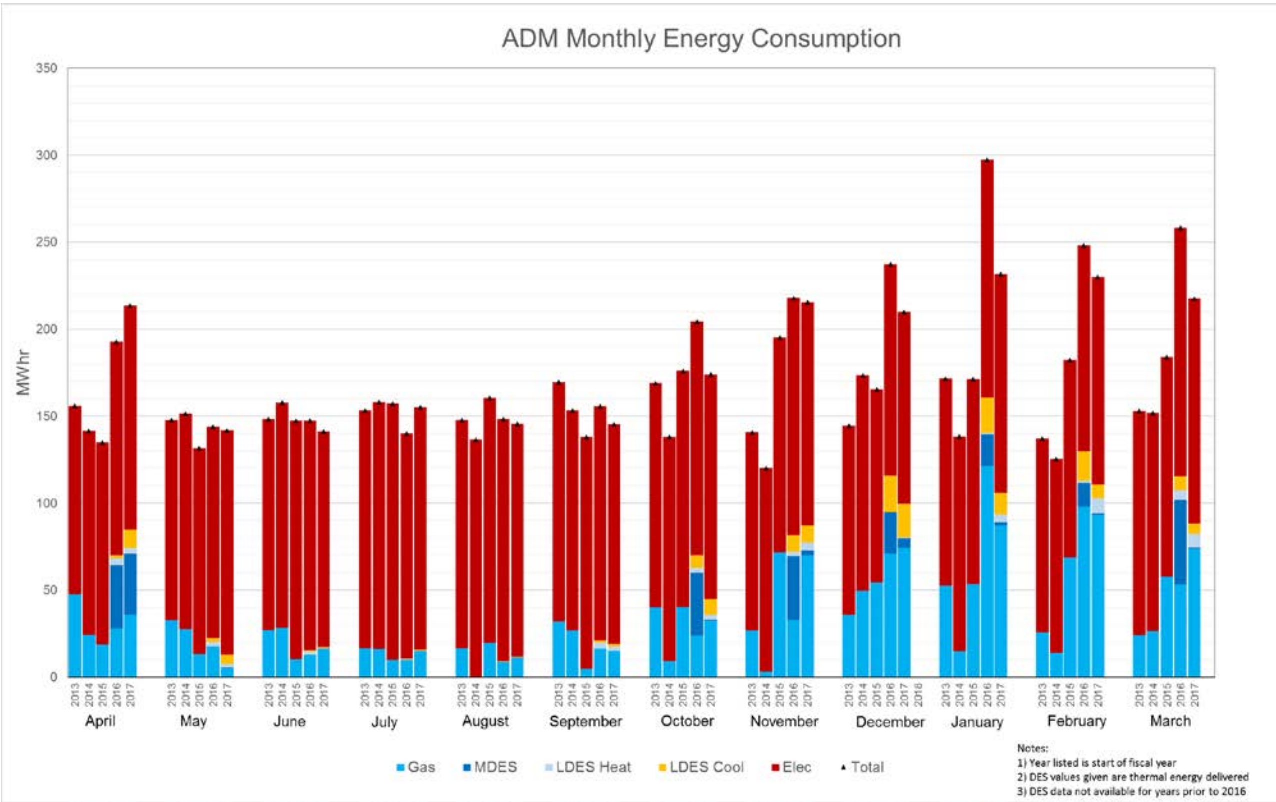
ADM Building Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	1,523	3%
Natural Gas	530	-7%
MDES	47	78%
LDES-Heat	38	-49%
LDES-Cool	83	7%



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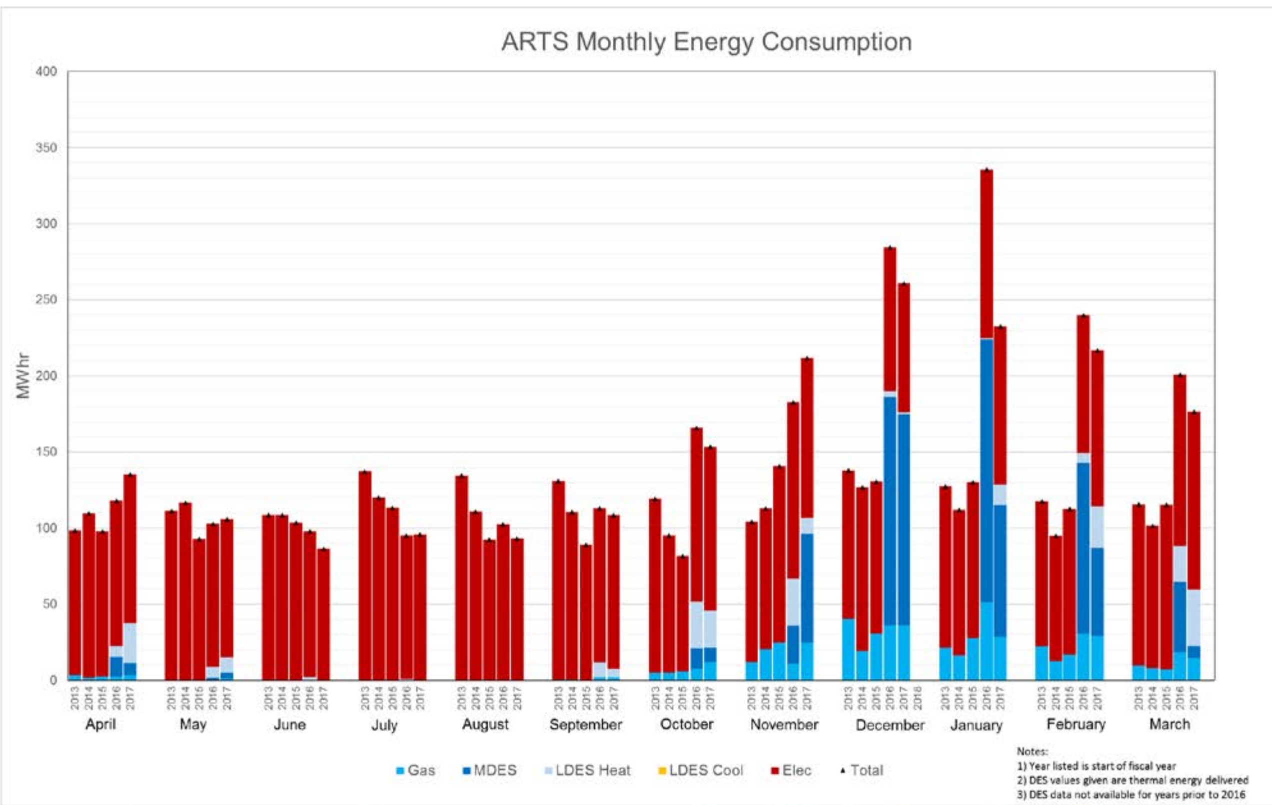
6.2 Arts

The success of efforts to increase capacity of the building's heatpumps can be seen by the increase in LDES heat consumption along with a corresponding drop in MDES consumption.

ARTS Building Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	1,186	3%
Natural Gas	151	5%
MDES	384	28%
LDES-Heat	156	-27%
LDES-Cool	-	-



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6.3 Arts and Science Building

Electrical and gas consumption within the Arts and Science building was roughly flat year over year.

A major plant upgrade took place in this building during FY2017-2018. As a result of this renovation, significant heating load was transferred from the building's boilers to the LDES. The overall building natural gas consumption did not decrease due to a large increase in gas consumption by steam boiler's in the building that service laboratory process loads. These laboratory process loads were dramatically increased and thus increased the steam boiler gas consumption from about 700GJ in FY2016-2017 to 1400GJ in FY2016-2017. When this increase in gas consumption is taken into consideration, the base building gas consumption shows a considerable decrease year over year. It should also be noted that the plant upgrade was not fully operational until January 2018 and therefore its benefits were only partially realized for FY2017-2018.

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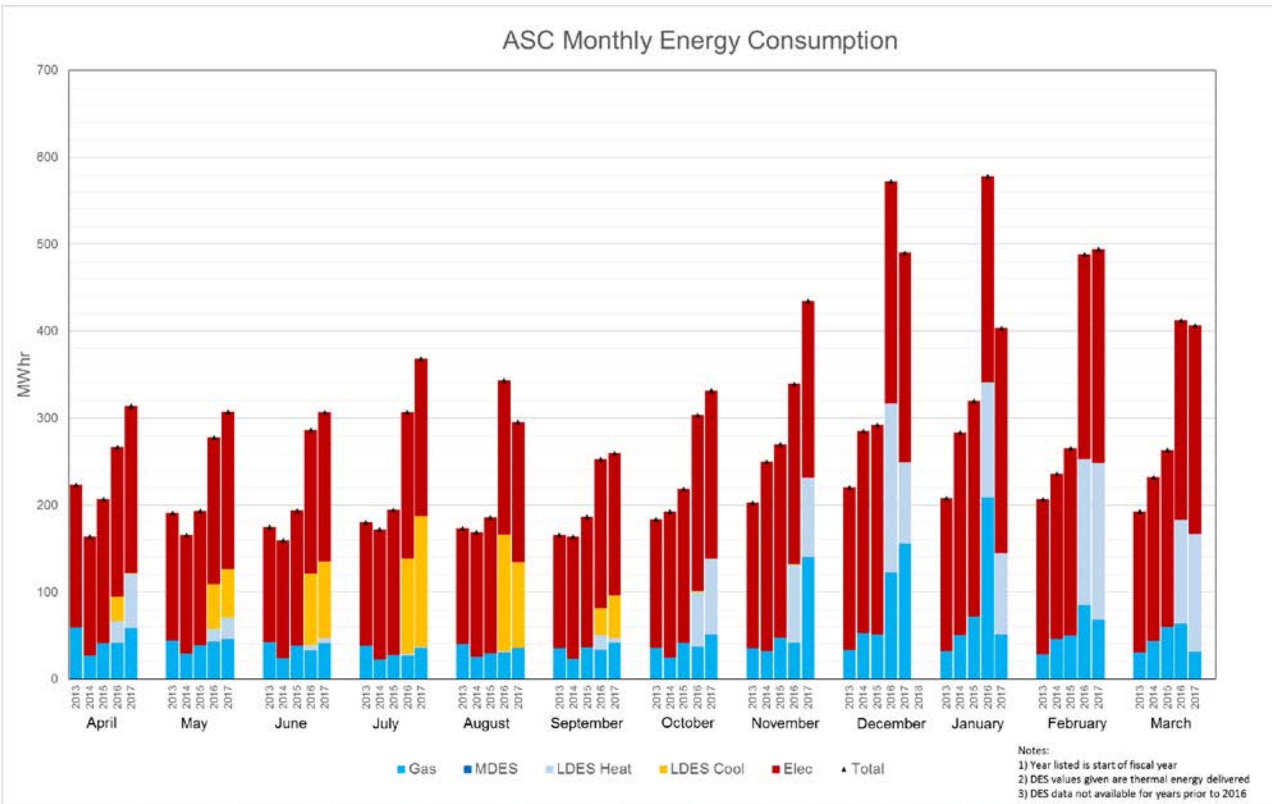
ASC Building Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	2,432	-2%
Natural Gas	756	2%
MDES	-	-
LDES-Heat	783	6%
LDES-Cool	442	-1%



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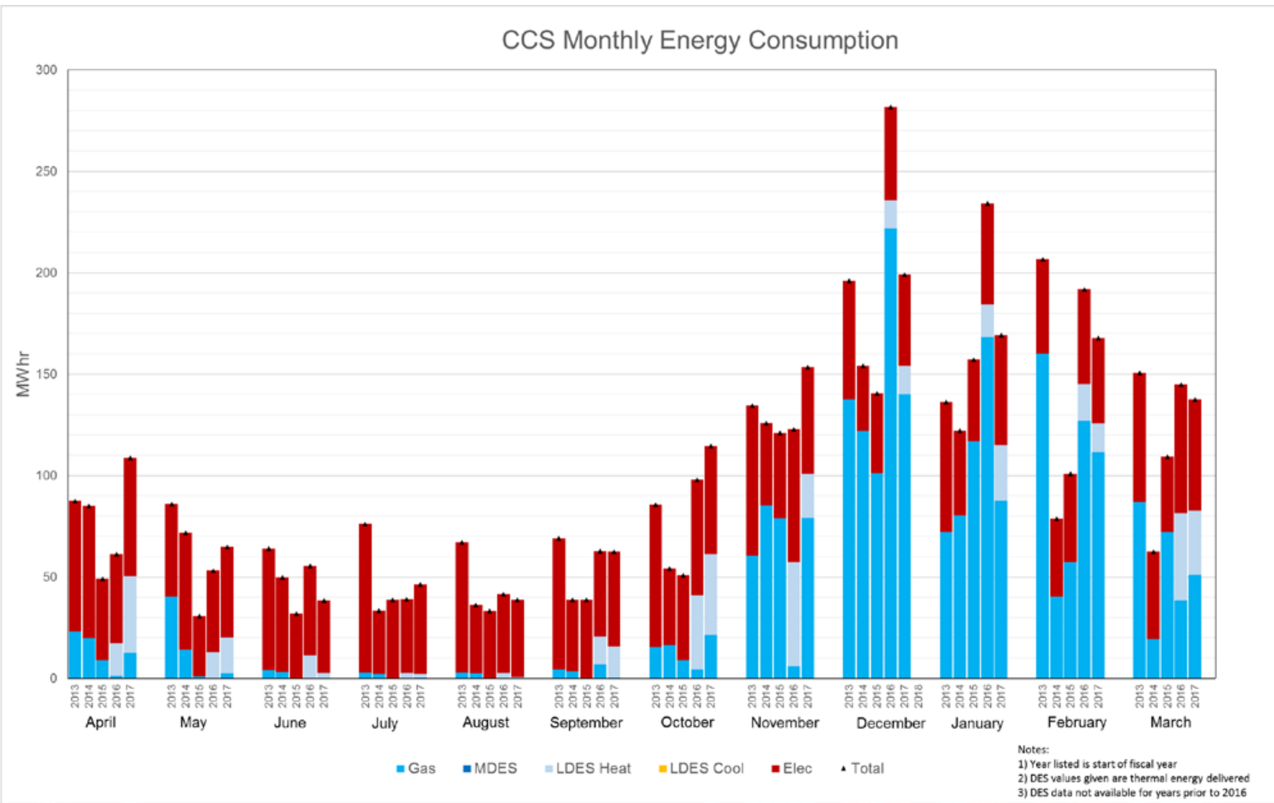
6.4 Creative and Critical Studies

Reduced heating loads in this building are believed to be because of improved operational procedures during cold weather that were implemented during FY2017-2018.

CCS Building Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	570	1%
Natural Gas	506	12%
MDES	-	-
LDES-Heat	225	5%
LDES-Cool	-	-



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6.5 EME

Large changes in energy consumption patterns were seen in EME as the result of a number of energy conservation projects. These included:

- Domestic Hot Water Boiler Separation: The domestic water for EME was formerly provided via the building's main boilers. These boilers are low-efficiency units that have particularly poor performance at low output levels which occur when providing domestic hot water during the cooling season. To avoid this inefficiency, provisions were made to first preheat domestic hot water with heat rejected from the building's heatpump plant and use electric hot water tanks for final heating. Additionally it was found that the building's domestic hot water recirculation system had excessive flow rates. To reduce energy losses from the recirculation system, the system's pump was set to only run intermittently.
- Building Heatpump Plant Upgrades: Changes were made to the main building heatpumps to allow them to operate more efficiently. The heatpumps not only operate more efficiently but can now handle heating load for the building that was formerly met using the building's boilers.
- Building recommissioning: Multiple issues were identified such as heating/cooling water mixing, CO_2 sensor malfunctions etc.

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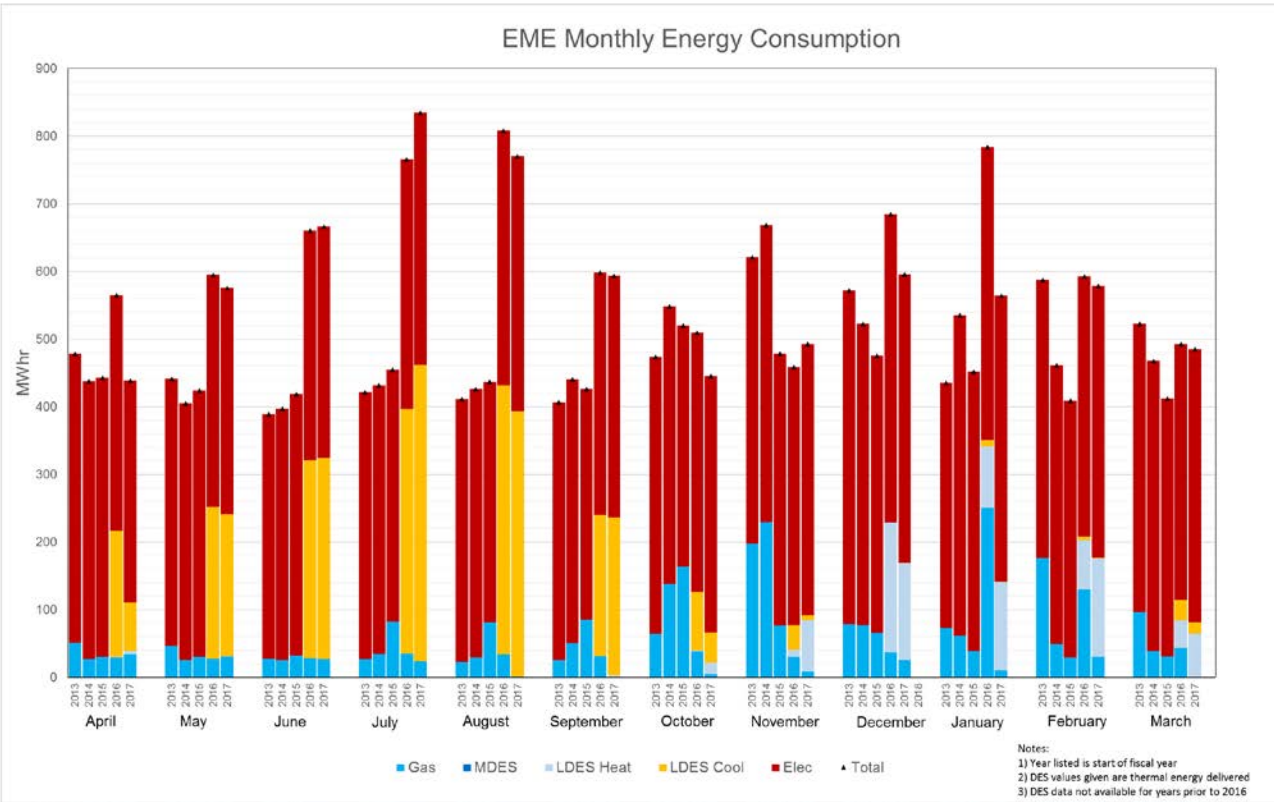
EME Building Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	4,547	0%
Natural Gas	196	73%
MDES	-	-
LDES-Heat	585	-44%
LDES-Cool	1,713	7%



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6.6 Fipke

Large shifts in energy consumption patterns in Fipke can be tied to the major plant upgrade that took place in Fipke in FY2017-2018. The LDES cooling consumption was reduced since the plant was out of commission for a large portion of the cooling season and cooling was not available to parts of the building during this time. The reduction of electricity consumption is probably also a result of reduced heatpump usage during this time.

The large reduction in gas consumption as well as the large increase in LDES heat use is a direct result of the plant upgrade which successfully increased the utilization of the building's heatpumps.

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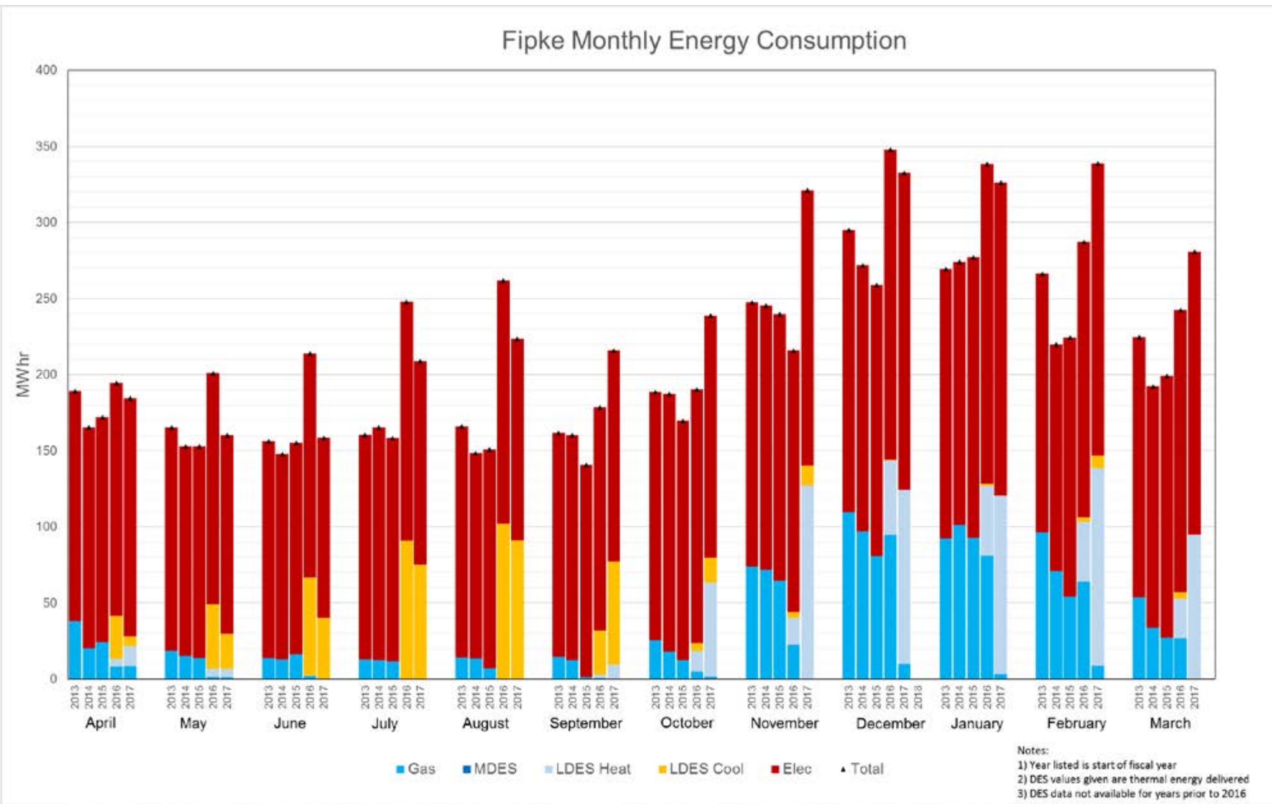
Fipke Building Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	1,942	5%
Natural Gas	33	89%
MDES	-	-
LDES-Heat	673	-230%
LDES-Cool	342	9%



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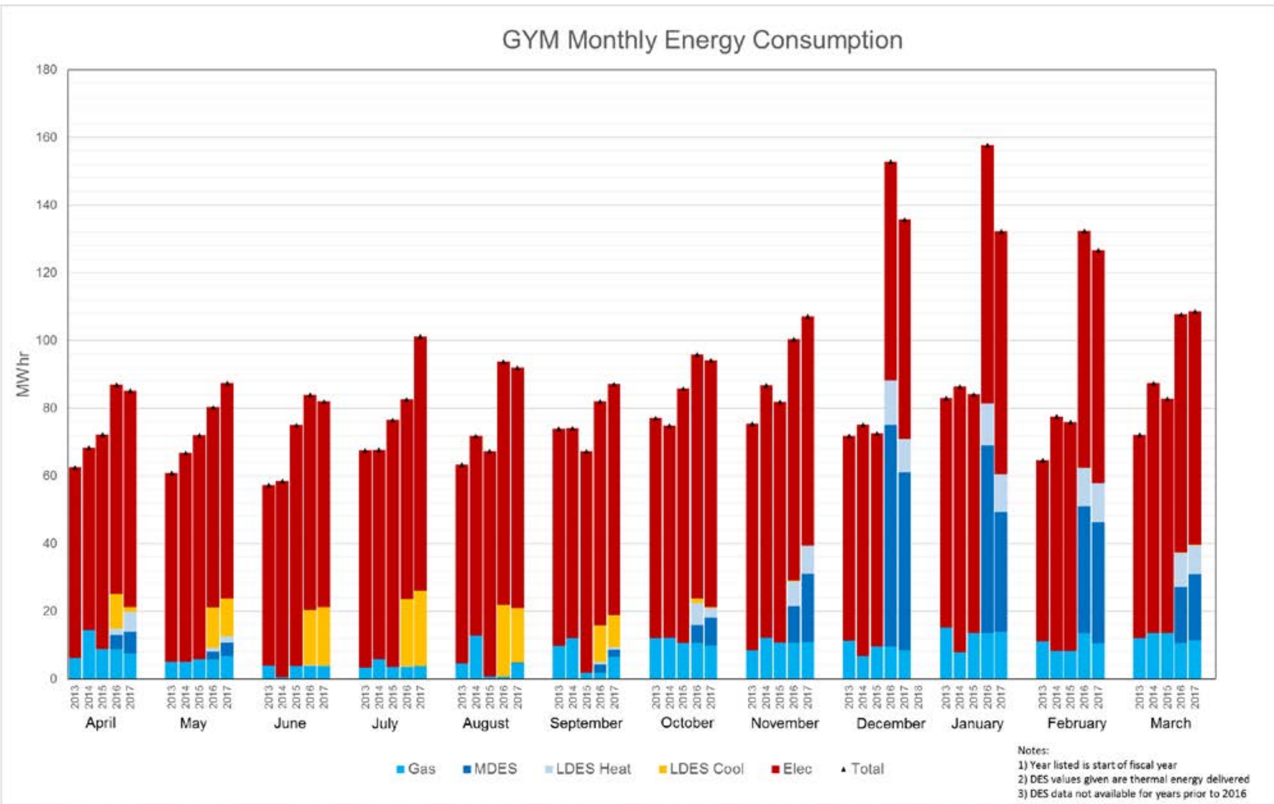
6.7 Gym

Gym Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	818	-1%
Natural Gas	98	-5%
MDES	184	8%
LDES-Heat	61	6%
LDES-Cool	78	15%



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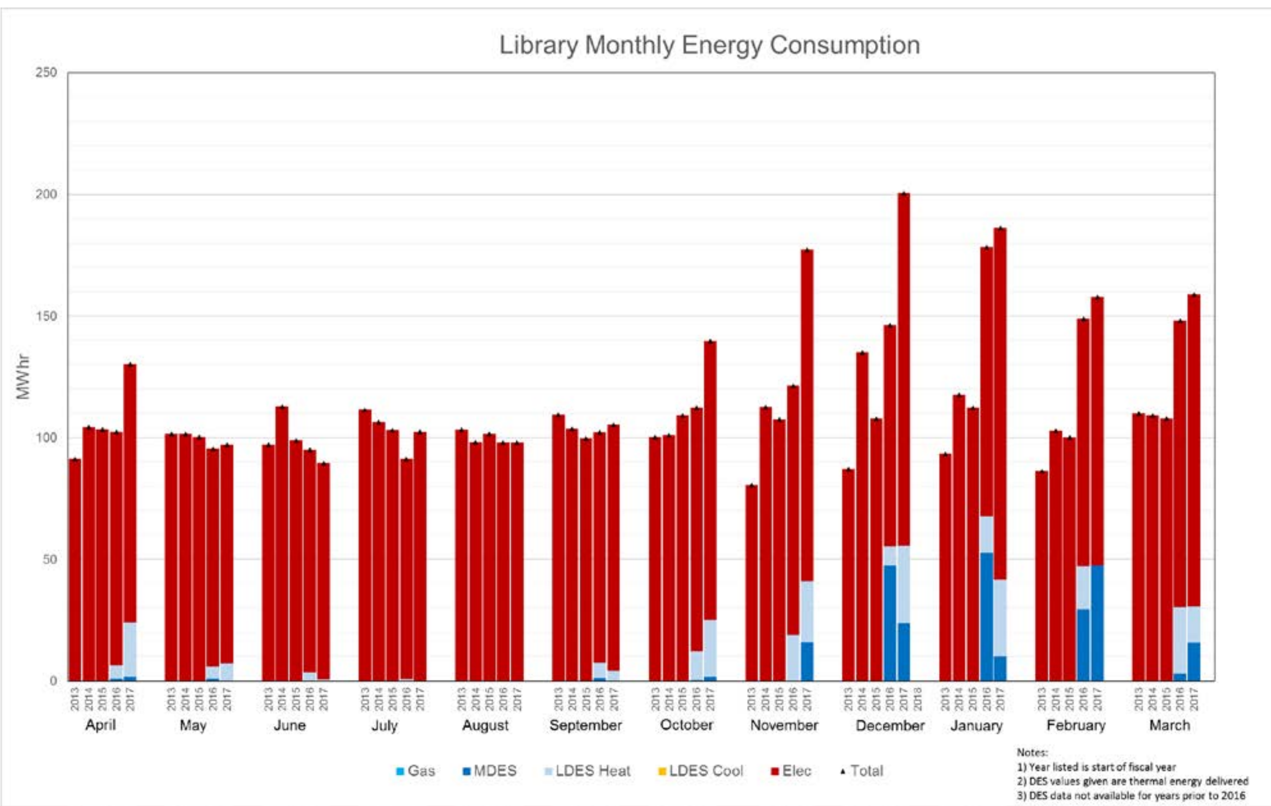
6.8 Library

Electrical consumption on the library building increased 15% year over year increase. The increase in electrical load can be attributed to construction of the new Teaching and Learning Centre adjacent to the library as the construction site power is fed off of the Library power meter.

Library Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	1,366	-15%
Natural Gas	-	-
MDES	117	15%
LDES-Heat	161	-35%
LDES-Cool	-	-

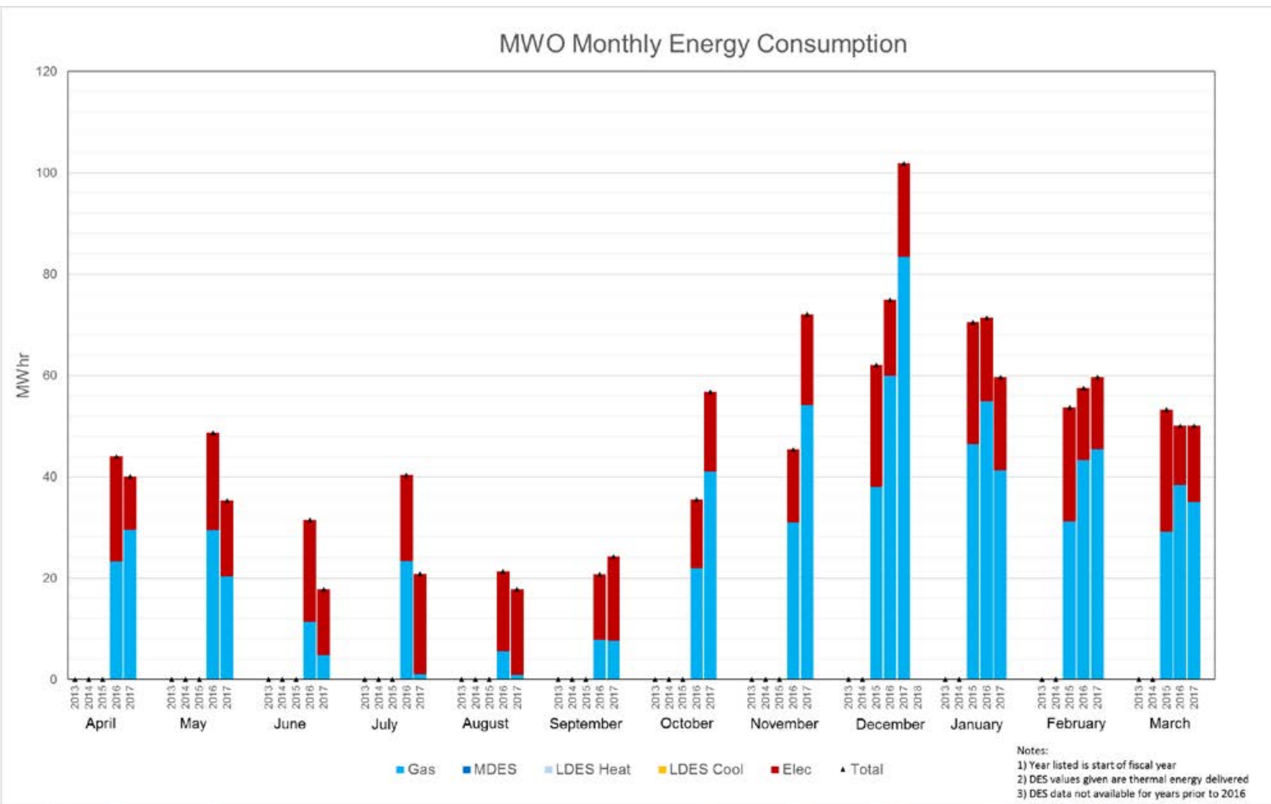


6.9 MWO

Electrical consumption at MWO was flat year over year at about 190 MWhr. Gas consumption increased about 5% to 1300 GJ. The increased gas consumption is attributed to substantially higher occupancy in the building. The occupancy related increase of gas consumption was tempered by the replacement of the existing boilers with higher-efficiency units.

MWO Annual Energy Summary

Energy Type	Consumption	Savings vs. Prior FY
Electrical	190 MWhr	-
Natural Gas	1300 GJ	-5%
MDES	-	-
LDES-Heat	-	-
LDES-Cool	-	-



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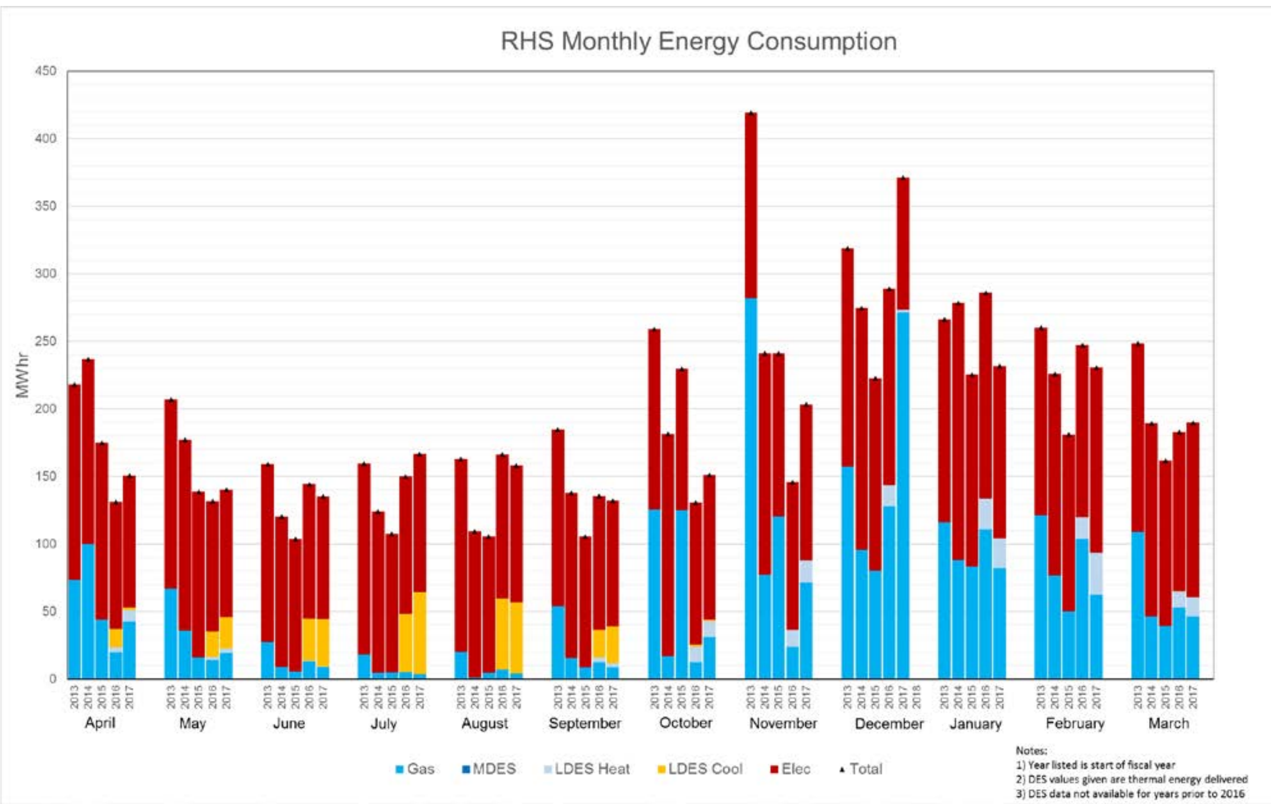
6.10 Reichwald Health Sciences

Electrical consumption showed a reduction of about 5% compared to the year before. Natural gas consumption about 30% higher compared to the year before. The increase in gas consumption was due to a control valve failure during the winter that resulted in the building's boilers carrying heating loads that would have otherwise been met by the building's heatpumps. Despite this, LDES heating consumption for all of FY2017-2018 rose about 15%.

RHS Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	1,294	5%
Natural Gas	652	-29%
MDES	-	-
LDES-Heat	113	-15%
LDES-Cool	202	-11%



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6.11 Science Building

Electrical consumption in the Science building was down nearly 5% from the prior year. Heat consumption from the MDES was also down nearly 5%.

A number of projects are underway in the Science building:

- The 3rd Floor was connected to the building's heatpumps, previously heating to the 3rd floor was only available from the MDES.
- A heat recovery project is underway to recover heat from the laboratory exhaust system via a glycol run around loop.
- Lab Ventilation project: The laboratory air change rates are being reduced to be in alignment with UBC Technical Guidelines.
- Occupancy fume hood controls are being considered for three labs.
- For three test labs, a system that controls the ventilation rate based off of lab air quality chemical analysis is being tested.
- Extensive cleaning of terminal heating equipment strainers has been undertaken. Due to excessively fouled systems, it is expected that heating system improvements will result from this cleaning.
- Lighting LED retrofits have been installed.

When analyzing the annual energy consumption of the Science building it must be considered that a number of the above projects are in the midst of implementation. For others, the construction phase substantially impacted building operation. For example LDES heating was disabled while the connection to the 3rd floor was under construction.

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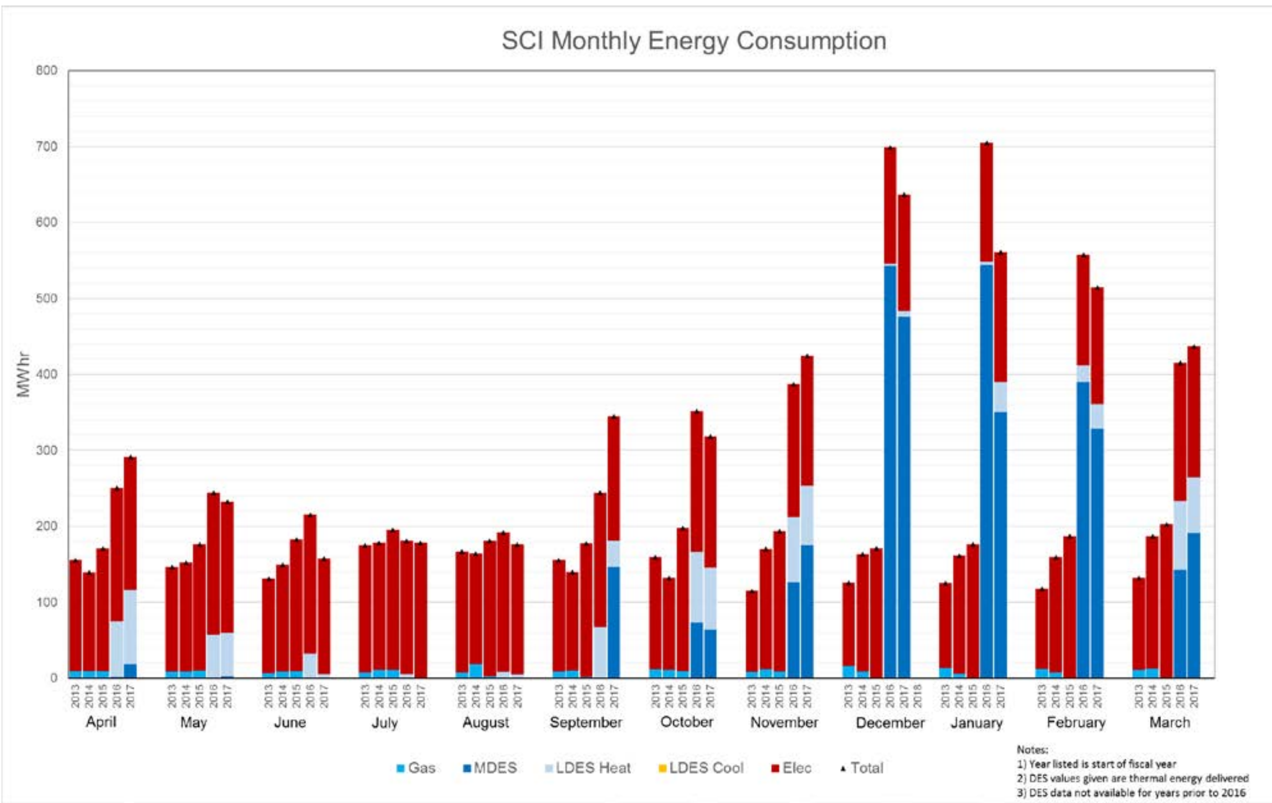
Science Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	2,008	4%
Natural Gas	1	-7%
MDES	1,752	4%
LDES-Heat	512	5%
LDES-Cool	-	-



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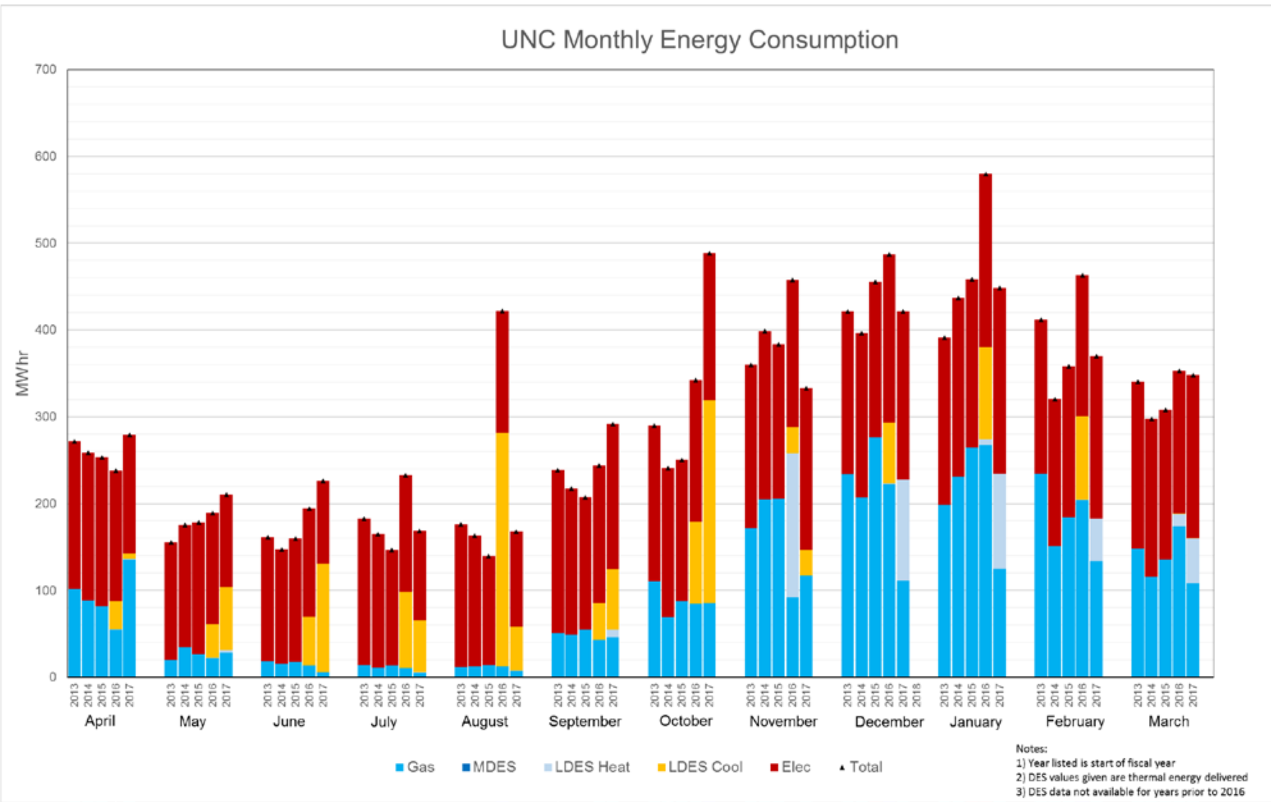
6.11.1 University Centre

Electrical consumption in UNC was slightly down year over year while gas consumption was down by about 25%. This reduction in natural gas usage can be attributed to the plant upgrade in the building which shifted load from the building's boilers to the LDES. Shifts in energy consumed from the LDES occurred for the same reason. A large fraction of the cooling reduction can be attributed to a lack of cooling available during the summertime plant upgrade.

UNC Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	1,856	2%
Natural Gas	908	24%
MDES	-	-
LDES-Heat	340	-81%
LDES-Cool	648	30%



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6.12 Residences

Electrical consumption in the residences was approximately 5100 MWhr, a 4% increase from the prior year. In contrast, natural gas consumption was down about 30%. The majority of the gas decrease can be attributed to failed gas-fired makeup air units in the Similkameen building. While these units were out of commission for the winter, gas usage was drastically reduced. Over the same period electrical usage in Similkameen increased, most likely due to electrical baseboard heaters compensating for a lack of heat from the non-functional gas-fired units.

Residences Annual Energy Summary

	Consumption MWhr	Savings vs prior FY
Electrical	5,096	-4%
Natural Gas	1,803	24%
MDES	-	-
LDES-Heat	-	-
LDES-Cool	-	-