UBC Okanagan Energy Operations
Annual Report for FY20-21
April 2020 – March 2021

Report Date April 2021

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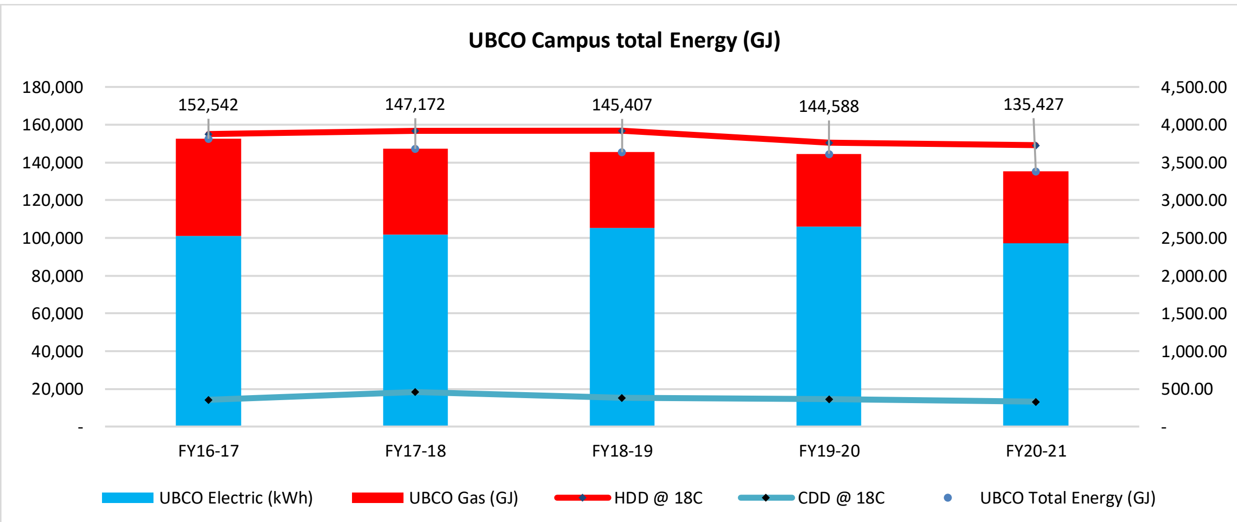
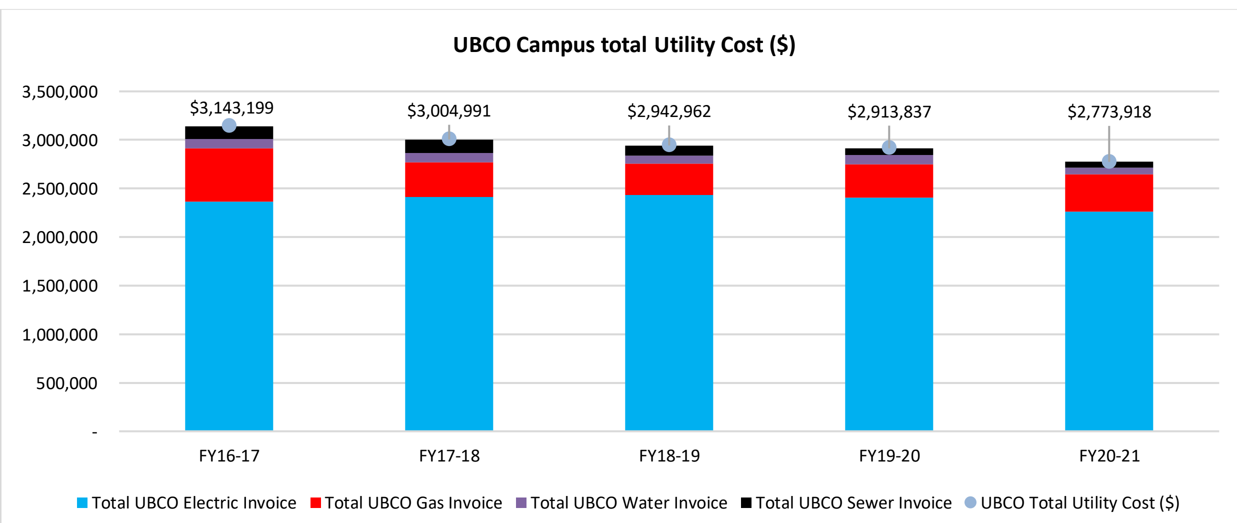
Executive Summary

UBC Okanagan total energy consumption over the last fiscal year (FY20-21) was 135,427 GJ compared to 144,588 GJ for FY19-20, a 6.34% year over year reduction leading to a 3.61% reduction in total campus energy utility cost from $2.75M in FY19-20 to $2.65M in FY20-21. The total campus energy consumption includes an 8.27% reduction in campus Electricity consumption i.e., from 29,409 MWh in FY19-20 to 26,977 MWh in FY20-21 and a 1.05% reduction in campus Natural Gas consumption i.e., from 38,716 GJ in FY19-20 to 38,310 GJ in FY20-21.

In FY20-21, Heating Degree-Days (HDD) fairly remained same at 3,729 degree-days compared to 3,764 degree-days in FY19-20 whereas Cooling Degree-Days (CDD) reduced by around 10% from 359 degree-days in FY19-20 to 330 degree-days in FY20-21.





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Greenhouse gas emissions were reduced by approximately 1.3% to 1,981.5 tCO_2e/ year mainly due to reduction in Natural Gas consumption by Residences as a result of SARS-CoV-2 (COVID-19).

Energy Team has been actively working on developing appropriate policies and guidelines that assist in meeting long-term campus energy and carbon goals through the following initiatives:

1. Strategic Energy Management Plan (SEMP) 2020: explore potential energy demand-side management scenarios (DSM) towards achieving GHG emission goals
2. High-Level Net-Zero Carbon District Energy (DE) Strategy: develop high-level options to reach a future state (with a view of modernization, renewal, and growth to serve both existing and new loads) anticipating Campus growth consistent with UBC Okanagan goals and aspirations
3. UBCO Net Positive Modelling Study – Archetype update and Analysis: update the five archetype models from the previous UBC Net Positive Modelling Study using Okanagan climate files and building archetypes that are representative of UBCO new construction with TEUI, TEDI, GHGI results for each archetype
4. Energy Monitoring and Data Management Platform: develop an intelligent data driven energy monitoring and management system for micro communities using statistical and advanced data analysis methods
5. Other: Technical reviews and setting goals, targets and strategies as early as possible for future campus expansions, updating the infrastructure HVAC Asset Management database and updating Technical Guidelines intended to provide minimum standards for campus projects.

In terms of energy efficiency studies/ projects, a few projects have been completed/ in progress like Science Lab Demand Controlled Ventilation, Recommissioning of Arts Building, Recommissioning of RHS Building, Recommissioning of EME Building, Recommissioning of UCH Building, lighting projects and other monitoring improvements. Energy Team related activities such as energy conservation measure implementation, equipment upgrade, personnel funding, new construction etc. in the past fiscal year received around $400,000 in FortisBC incentives.

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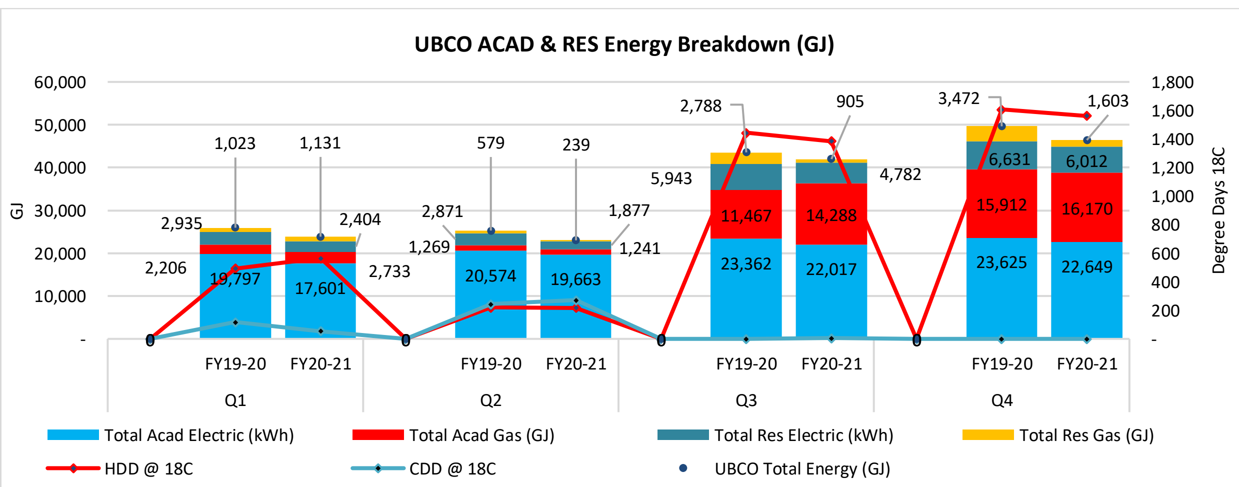
Following table presents total utility cost savings compared to Business-as-usual 2013 scenario, DSM-based utility savings, carbon tax savings, FortisBC funded staff position, energy efficiency incentives received by UBCO:

Parameter	**FY17-18**	**FY18-19**	**FY19-20**	**FY20-21**
Total Utility Cost Savings compared to BAU 2013[1]	$191,000	$260,700	$347,800	$923,000
DSM-based Utility Savings	$41,100	$66,300	$31,900	$36,200
DSM-based Carbon Tax Savings	$2,700	$4,000	$2,800	$1,900
External personnel funding	$60,000	$60,000	$60,000	$95,000
Energy Efficiency Incentive	$150,000	$176,000	$238,000	$305,000

The figure below shows that Residences Electricity and Natural Gas consumption reduced as a result of COVID-19 and a few energy conservation measures implemented in FY19-20. However, Natural Gas consumption for the Academic buildings was higher in Q3 and Q4 of FY20-21 because of increased LDES supply water temperature setpoint from 9°C to 15°C from November 2020 to January 2021. This test was conducted to understand the cost-benefit analysis of increasing the supply water temperature on heat loss in the LDES loop and increased COP for building-level heat pumps.



[1] Excludes DSM-based savings

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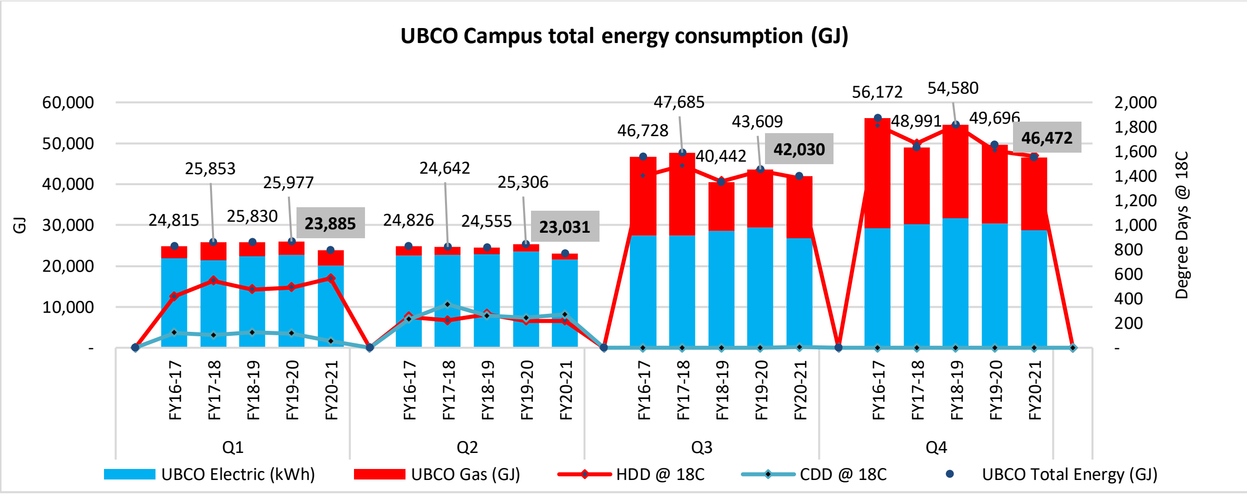

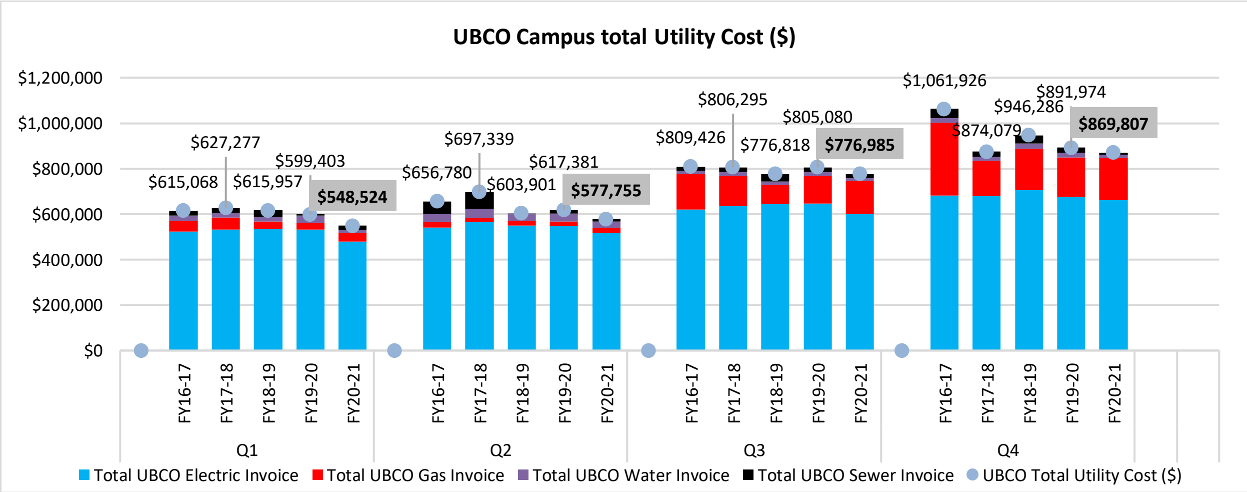

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Definition of Terms

AHU: Air Handling Unit
CAP: Climate Action Plan
CDD: Cooling Degree Day
COP: Coefficient of Performance
DCV: Demand Controlled Ventilation
DDC: Direct Digital Control
DE: District Energy
DHW: Domestic Hot Water
DSM: Demand-side Management
ECM: Energy Conservation Measure
EIR: Energy Input Ratio
EUI: Energy use intensity
GHG: Greenhouse Gas emissions, generally measured in equivalent tons of CO2.
GHGI: Greenhouse Gas Intensity
HDD: Heating Degree Day
HRV: Heat Recovery Ventilator
HVAC: Heating, Ventilation, and Air Conditioning
LDES: Low temperature District Energy System
MDES: Medium temperature District Energy System
MUA: Make Up Air
OAT: Outdoor Air Temperature
OPR: Owner's Project Requirement
RCx: Recommissioning
SEMP: Strategic Energy Master Plan
tCO2e: tonnes of carbon dioxide equivalent
TEDI: Thermal Energy Demand Intensity
TES: Thermal Energy Storage
TEUI: Total Energy Use Intensity
TG: Technical Guideline
VAV: Variable Air Volume
VRF: Variable Refrigerant Flow

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1 Energy Team

The Energy Team enables and facilitates energy management and carbon reduction projects at the University of British Columbia Okanagan campus. The Energy Team is an integral part of Campus Operations and Risk Management overseeing the utilities portfolio, working within a mandate of fiscal efficiency, operational excellence, environmental sustainability and innovative demonstrations.

The Energy Team champions appropriate policies and guidelines to assist in meeting campus energy goals. Often partnering with University departments, faculties and external stakeholders, Energy Team diligently works to reduce energy use and associated GHGs & costs, and optimize campus energy systems (District Energy Systems and Buildings).

Some of the key tasks include:

- Develop strategies, policies, guidelines and defined project requirements to optimize future campus energy consumption
- 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
- Implement detailed reporting to provide input into financial, infrastructure and operational planning
- Plan and implement energy conservation measures in existing campus facilities leveraging external funding opportunities to yield utility cost savings. Campus expansion and intensification emphasizes the importance of keeping energy creep under control
- Continuous measurement, verification, tracking and analysis of energy use on campus
- Meet annual savings targets of 500 MWh of electricity and 3000 GJ of gas compared to prior year
- 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.

The Energy Team currently consists of three members:

- Associate Director
- Energy Engineer
- Energy Analyst
- BMS Technician (Vacant)

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FortisBC has provided funding for the Energy Specialist position since 2016. In order to support increased energy management capacity, in FY19-20 the Energy Specialist funding was transitioned to financially supporting two positions.

2 Overall Campus Energy Performance

Campus energy consumption for FY20-21 totalled 135,427 GJ (483,670 MWh). As can be seen in Figure 1 below, electricity accounted for around 72% of total energy consumed on campus. Furthermore, electricity is more expensive than natural gas. Average electricity costs were $23.44/GJ ($83.70/MWh) last year and $10.18/GJ ($36.67/MWh) for natural gas. As a result, electricity accounted for around 85% of campus utility costs. While natural gas has a lower cost per unit of energy, its GHG emission intensity is eighteen times higher than those of electricity (0.18 tons CO_2/MWh for gas versus 0.0026 tons CO_2/MWh for electricity). As a result, about 97% 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 [2]. Note also that the emission factor currently used for the FortisBC electric grid is much lower than that for BC Hydro.

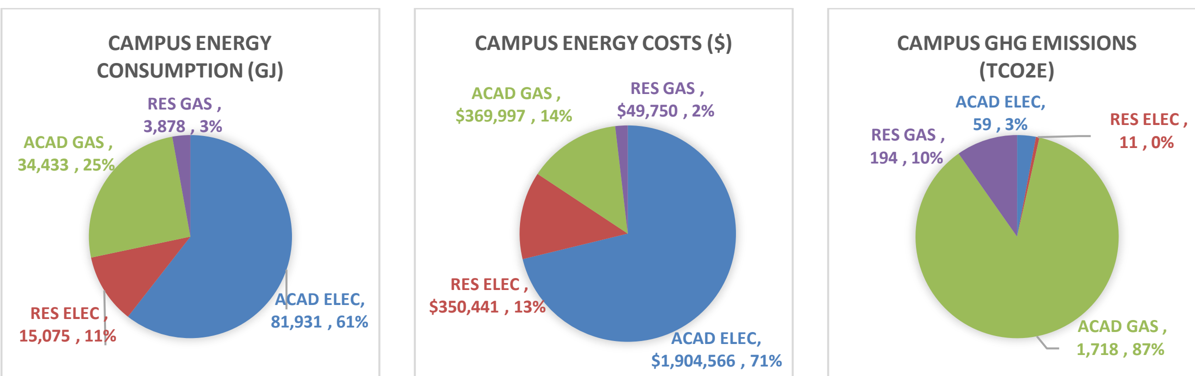

Figure 1: Campus Energy Consumption, costs and emissions by Source for FY20-21[3]

A quantitative model of the dependence of campus energy consumption on weather has not been developed at present. Qualitatively however, it can be 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.

An EUI reduction of 13% was observed from 1.03 GJ/m^2/yr. (286.10 kWh/m^2/yr.) in FY19-20 to 0.89 GJ/m^2/yr. (247.20 kWh/m^2/yr.) in FY20-21. This reduction can primarily be attributed to the following factors:

1. Reduced energy consumption as a result of reduced occupancy due to COVID-19
2. Improved EUIs for new construction buildings
3. Energy conservation measures implemented in FY19-20

[2] Electricity emission factor may change in future.
[3] Campus Energy consumption also includes electricity consumed by leased buildings. However, they represent less than 0.01% of total energy consumption and hence has not been shown in the Figure.

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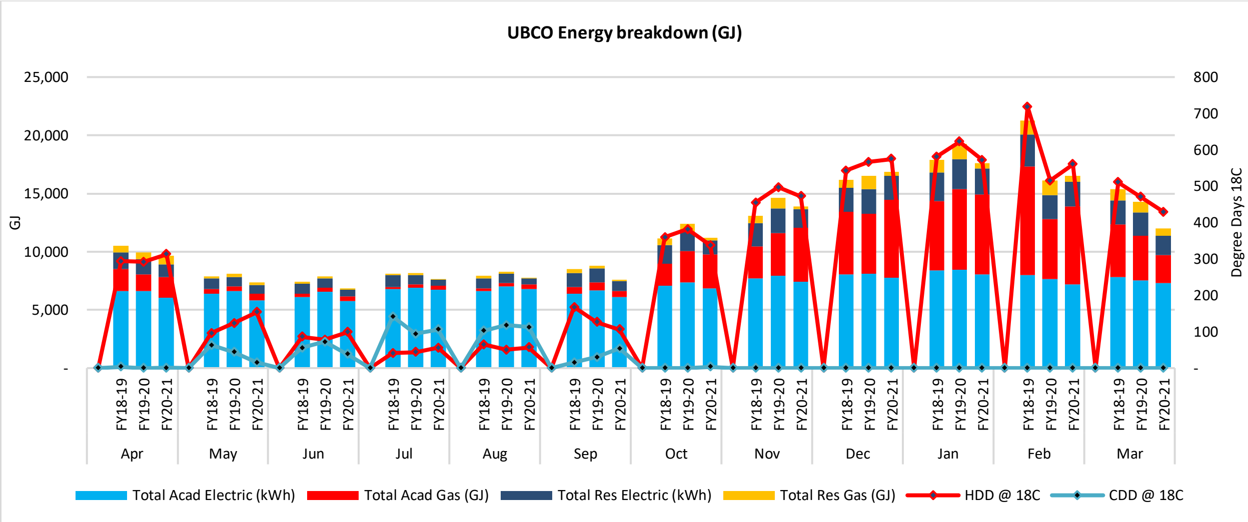

Figure 2: Campus Energy Consumption and Weather Comparison

2.1 Campus Energy Performance Trends

2.1.1 Costs

As shown in the Figure 3 below, campus utility costs were roughly flat year over year at about $2.65M. For FY20-21 the average cost of electricity on campus was $83.69/MWh compared to $81.69/MWh in FY19-20, a 2.4% increase. Costs for electricity is a blend of demand charge (27% of total electricity cost), energy charge (72% of total electricity) and fixed customer charge (1% of total electricity), the rate stated is a blended rate. The combined increase in electricity cost rates and a reduction in electricity consumption (due to COVID-19) resulted in a significant reduction in electricity costs from $2.40M in FY19-20 to $2.25M in FY20-21.

For FY20-21 the average cost of natural gas on campus was $10.18/GJ ($36.67/MWh) compared to $8.91/GJ ($32.08/MWh) in FY19-20, a 14.25 % increase. Although campus total gas consumption was lower in FY20-21 at 38,310 GJ compared to 38,716 GJ in FY19-20, total gas costs increased from $345K in FY19-20 to $390K in FY20-21, a 13% increase.

The utility costs is expected to be over $428k higher per year ($1.7M in total[4,5]) compared to 2013 Business as usual scenario without modernization efforts (High-performance building, equipment upgrade, recommissioning etc.) taken at the UBCO campus. Approximately $47k per year ($187k in total) of the savings are attributed to DSM projects funded directly by Energy Initiatives. These savings are shown in black in the Figure 5 below. The remainder of the savings, shown in purple 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

[4] Excludes DSM-based savings.
[5] This number is a little higher in FY20-21 compared to previous years due to COVID-19 as a result of reduced occupancy.

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individually measure such as new construction building projects, recommissioning, routine capital equipment upgrade or improved technical guidelines etc.

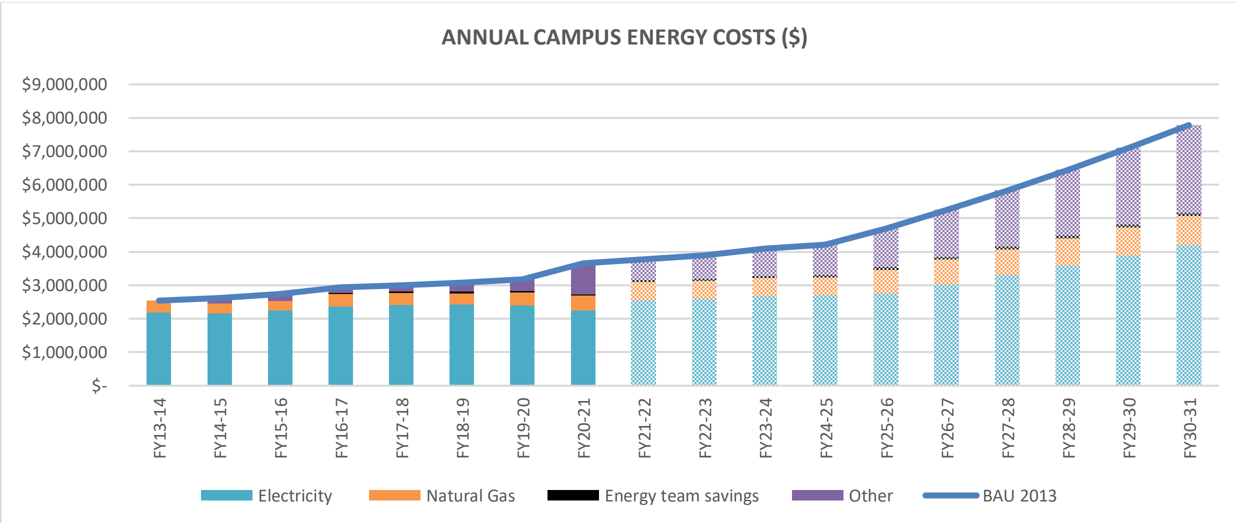

Figure 3: Campus Energy Costs Trend[6]

2.1.2 Greenhouse Gas Emissions

Campus greenhouse gas emissions were reduced by approximately 1.3% to about 1981 tons CO_2 per year using current emission factors as reported in "2018 B.C. Methodical guidance for quantifying greenhouse gas emissions" for public sector organizations, local governments and community emissions. 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. Note that the black and maroon portion of the columns are not emissions produced but rather are emissions avoided due to implemented energy conservation measures, routine capital equipment upgrade, efficient new construction buildings etc.

[6] 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 (kWh/m2/yr.) was maintained constant at the level of a defined reference year. For this report 2013 is generally used as the reference year.

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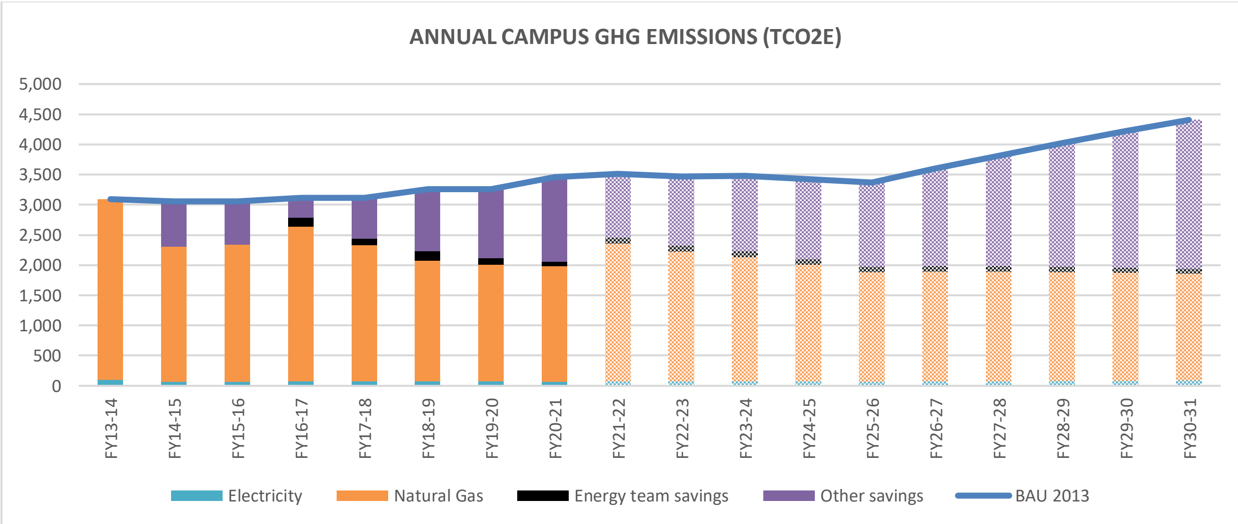


Figure 4: Campus GHG Emissions Trend

2.1.3 Electricity

Electricity consumption was down about 8.27% year over year to 26,977 MWh in FY20-21 from 29,409 MWh in FY19-20. This reduction in electricity consumption can be primarily attributed to COVID-19 and a few energy conservation measures implemented in FY19-20.

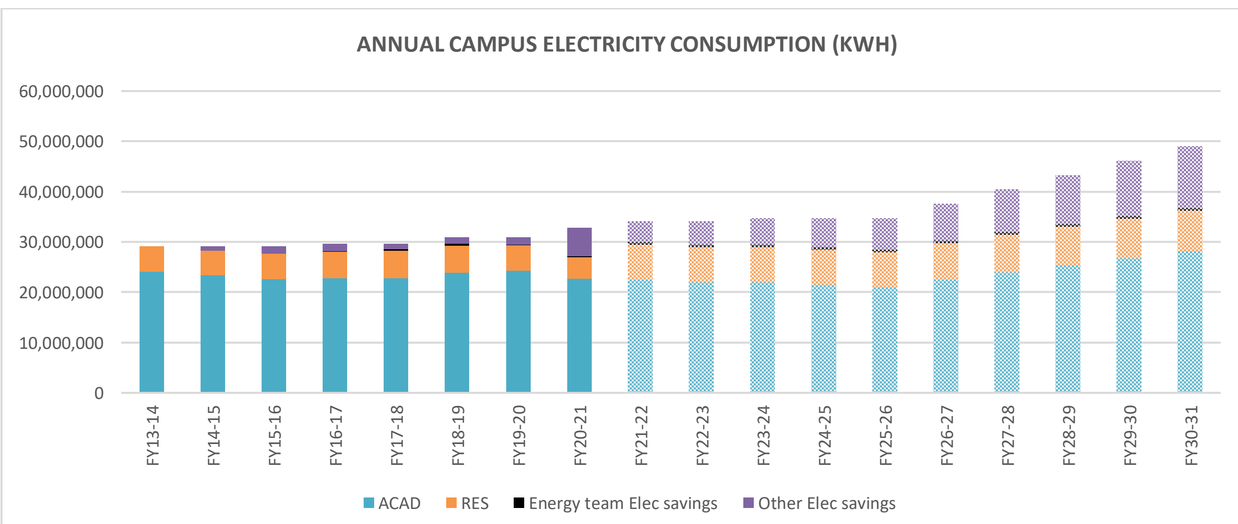


Figure 5: Campus Electricity Consumption Trend

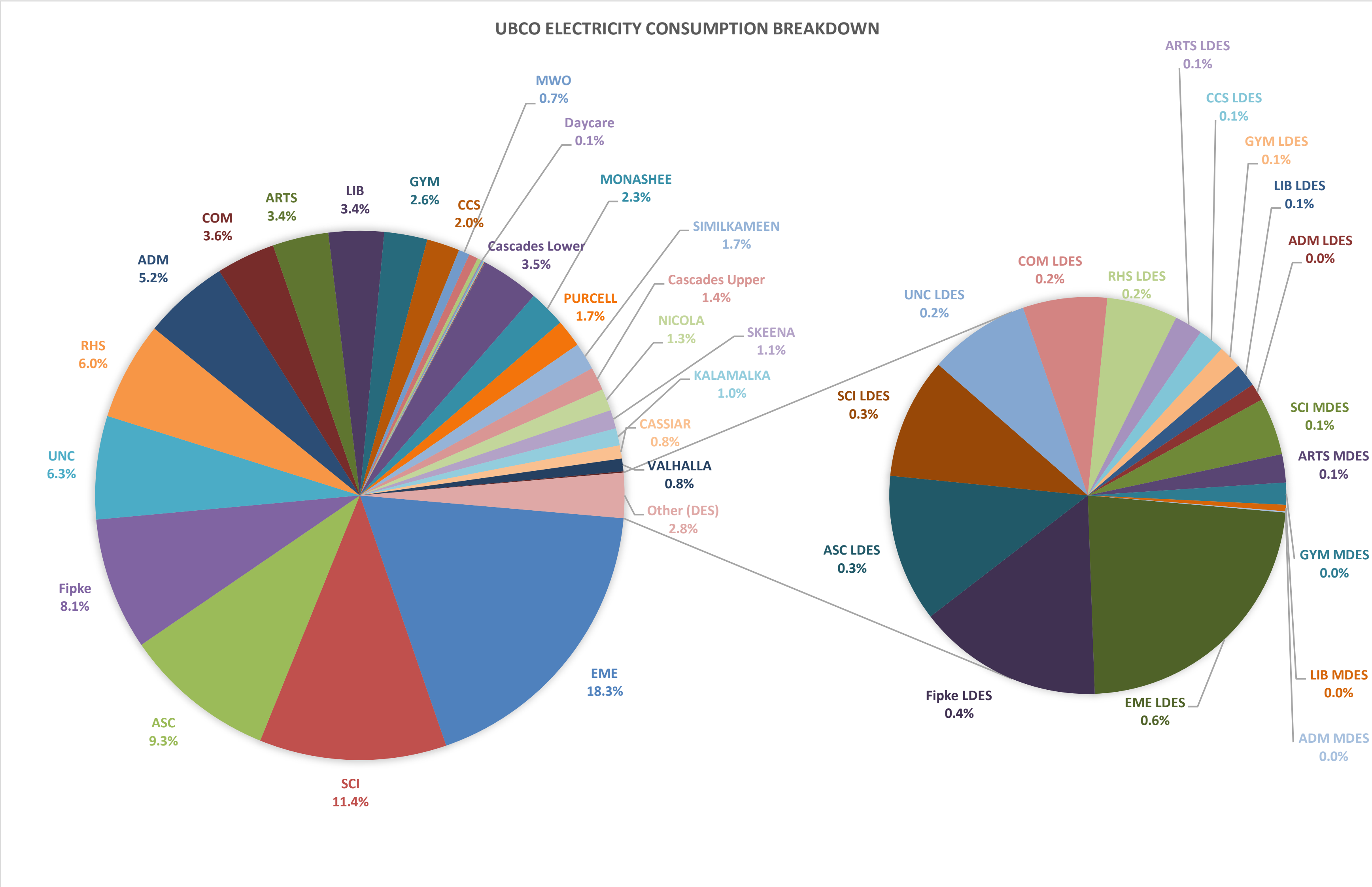


Figure 6: Electricity Consumption for Buildings and DES for FY20-21

EME, SCI, ASC, FIPKE, UNC, RHS and ADM are the Academic buildings which individually consume more than 5% of the total electricity consumption on campus. Campus District Energy Systems consume around 3% of the total energy consumption primarily for the required pumping operations in the LDES & MDES systems and rejecting heat from the LDES system in cooling season. Residences account for around 15.5% of the total electricity consumption. Refer to Figure 6 for more information on electricity consumption breakdown.

2.1.4 Natural Gas

Consumption of natural gas was reduced from 38,716 GJ in FY19-20 to 38,310 GJ in FY20-21, a 1% year over year reduction. Natural gas consumption for the residences reduced from 7,862 GJ to 3,877 GJ (around 50% reduction) primarily due to reduced occupancy, a direct impact of COVID-19. However, 140-ton Variable Refrigerant Flow (VRF) heat pump was installed at Monashee Residence during the summer season of 2020. This led to significant drop in gas consumption for the building. A 66% gas reduction was observed for Monashee Residence compared to 43% reduction for other Residences for the period. Refer to Section 7.22 for detailed information.

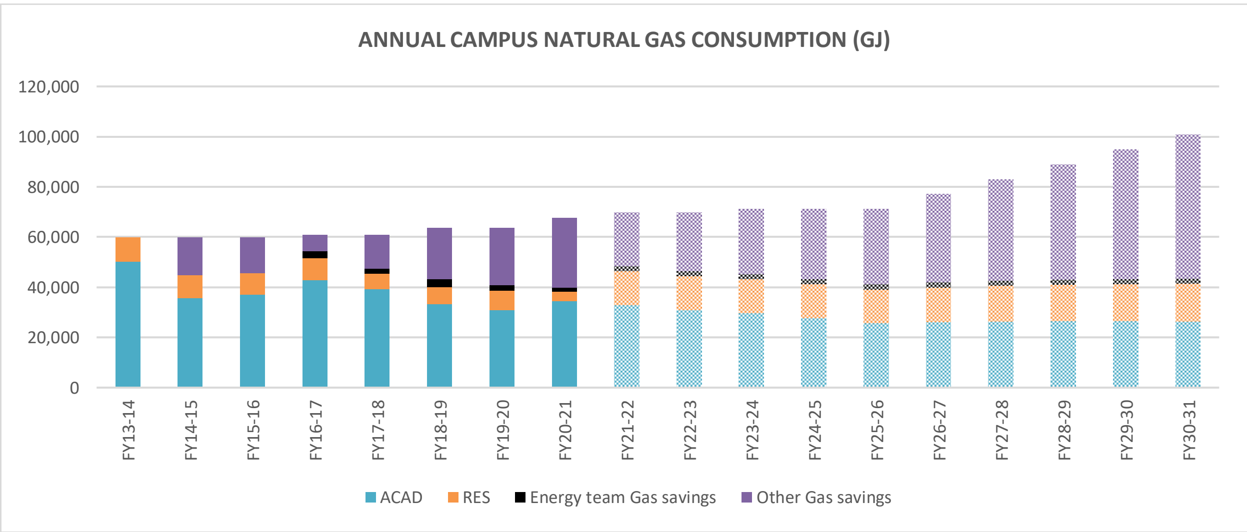


Figure 7: Campus Natural Gas Consumption Trend

The Figure 8 below shows the distribution of gas consumption on campus. The gas consumed within the building is shown separately from the gas consumed by the two campus District Energy Systems (DES). The DES gas consumption is represented as “Other” in the figure below and is attributed to the buildings based on relative building thermal consumption from the DES.

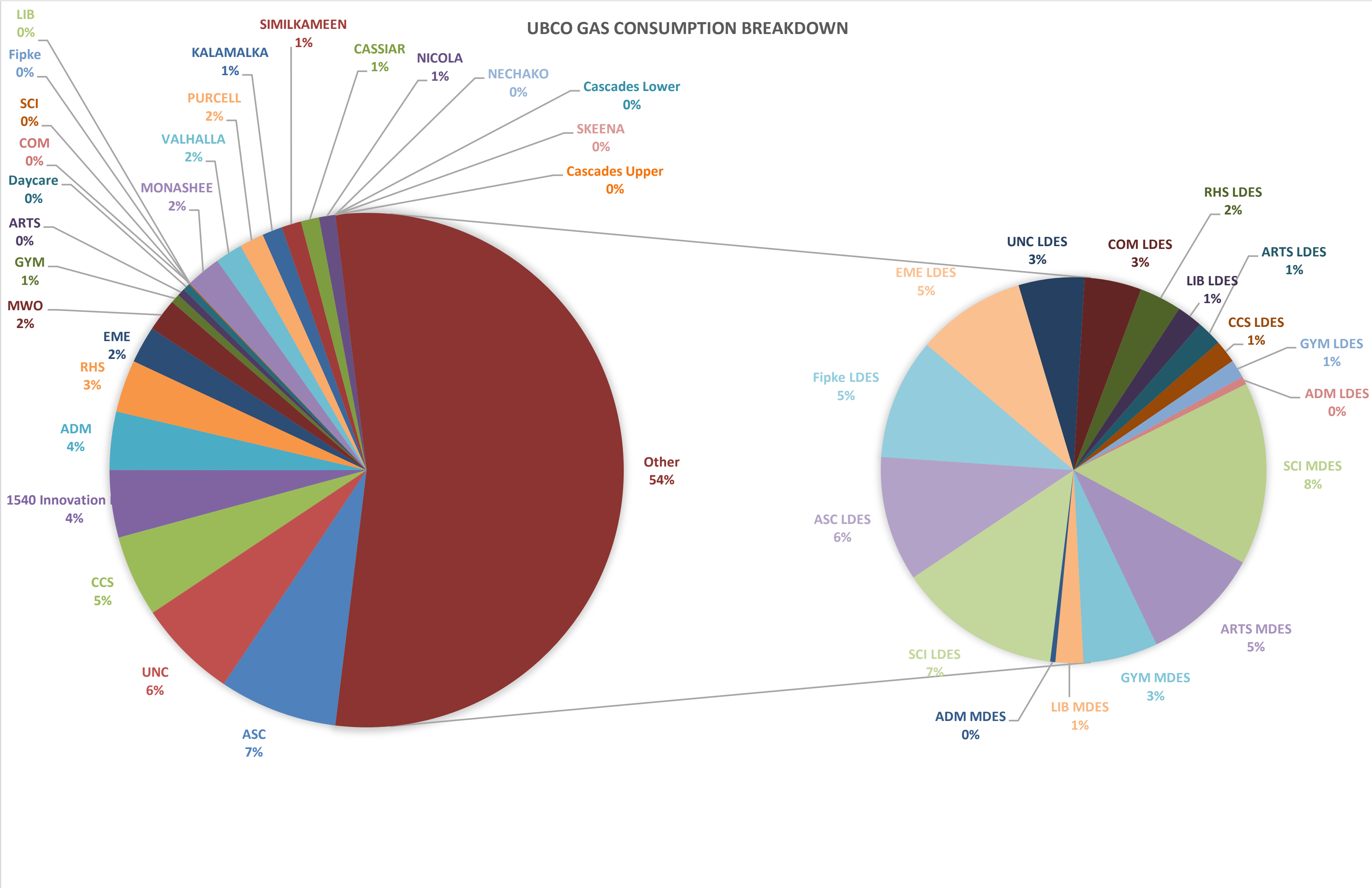
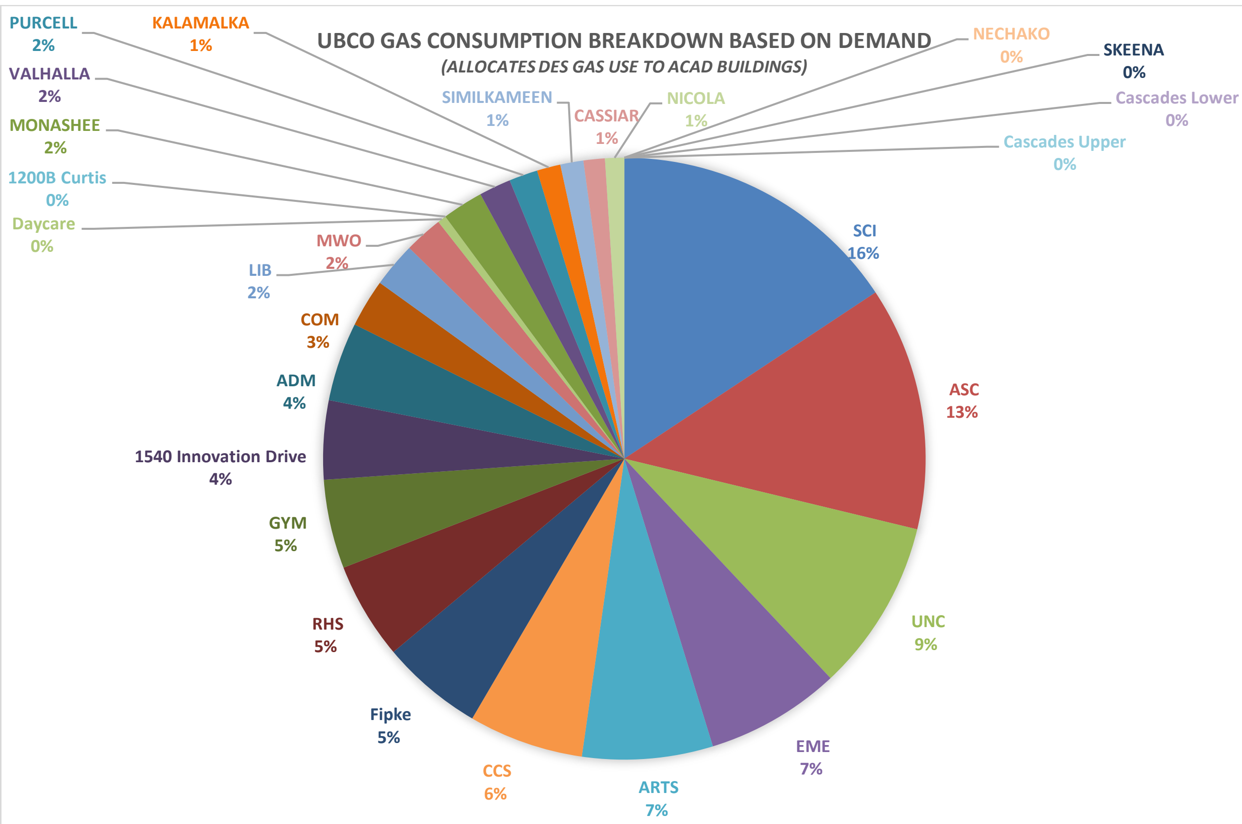


Figure 8: Gas Consumption of Buildings and DES for FY20-21

ASC, UNC, CCS, are the Academic buildings which individually and directly consume more than 5% of the total campus Natural Gas because of the standalone equipment in the buildings (gas boilers, gas water heaters). As can be seen in the figure, a large fraction (around 54%) of natural gas on campus is consumed by the two district energy systems' plants by gas boilers (LDES = 35.40% and MDES = 18.60%). Residences consume around 10% of the total gas consumption. Refer to Figure 8 for more information on gas consumption breakdown.

Figure below provides the gas consumption breakdown and allocates DES (LDES, MDES) gas consumption to the respective building based on demand. SCI, ASC, UNC, EME, ARTS, CCS, Fipke, RHS, and Gym consume more than 5% of the total gas consumption on campus.



EME gas consumption increased by more than 100% compared to FY19-20 levels from 320 GJ to 888 GJ in FY20-21 as a result of Heat Recovery Ventilator (HRV) demand. If the heating valves for any HRV are at 100% and Outdoor Air Temperature (OAT) is less than 7°C, the system reverts to building boilers for heating of this loop. The heating demand for the HRV's was driven to 100% because of heat wheel failures, causing the heating coil to be overwhelmed.

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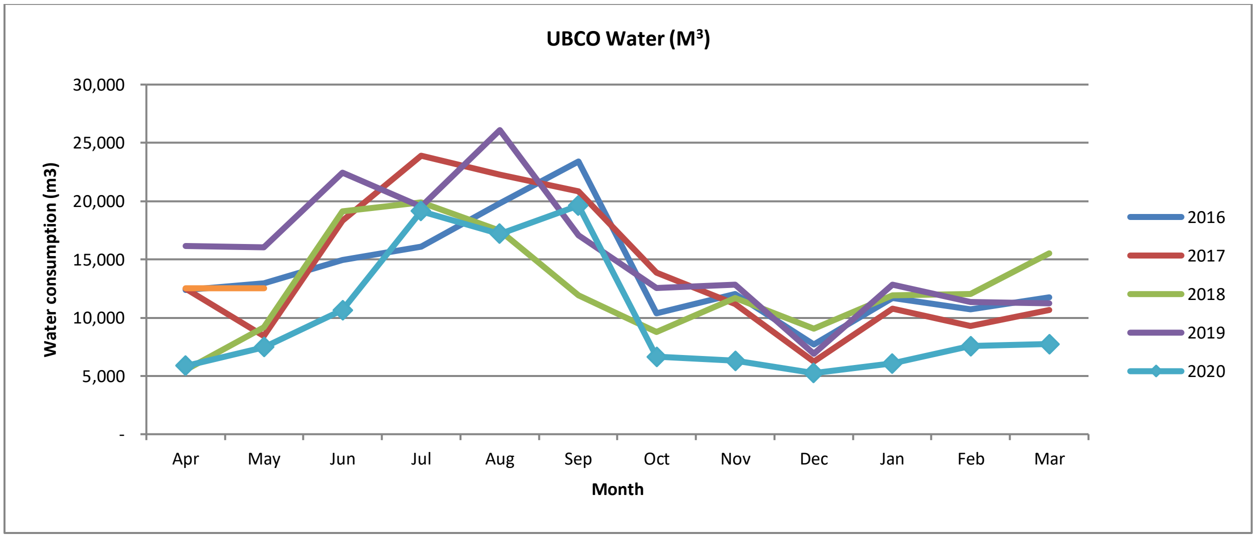
2.1.5 Water and Sewer

Water consumption purchased from Glenmore Ellison Improvement District (GEID) for campus[7] use reduced by 35.5% from 185,035 m^3 in FY19-20 to 119,433 m^3 in FY20-21 with Academic buildings consuming 55% of the water. Sewer production also reduced by 26.6% from 77,515 m^3 in FY19-20 to 56,851 m^3 in FY20-21. Figure 9 below provides water and sewer trends for the campus.



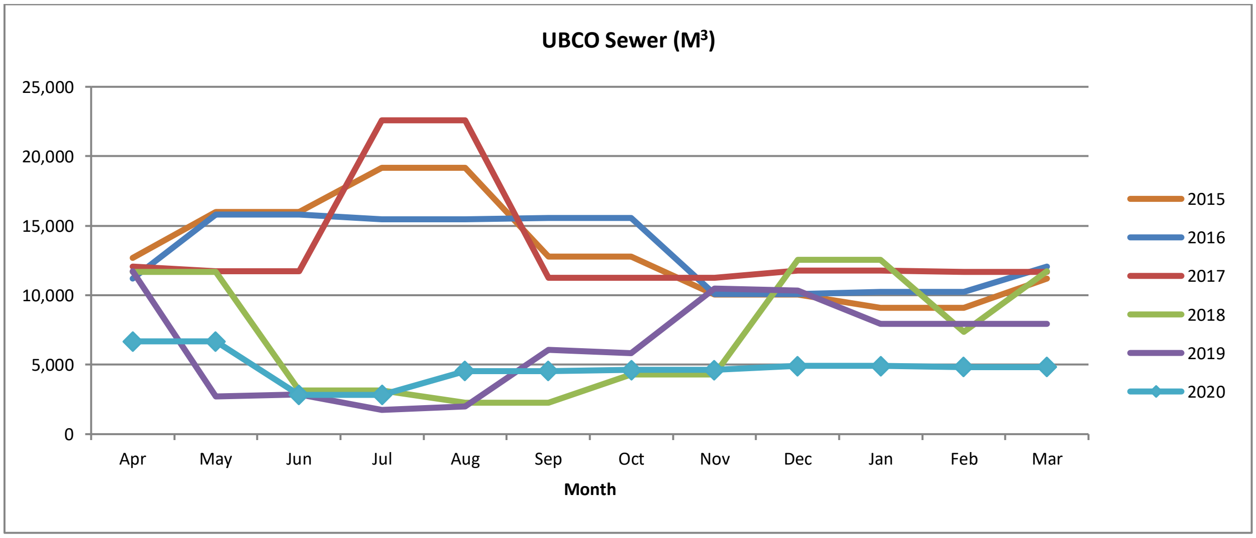


Figure 9: Water and Sewer consumption trend for UBCO campus

[7] Note that this consumption doesn't account for West Campus water use for irrigation. It only includes Academic and Residence building water consumption.

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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 0.89 GJ/m^2/yr. (247 kWh/m^2/yr.) for FY20-21, a 13% reduction over the prior year. The average EUI for academic buildings on campus was 338 kWh/m^2/yr. while it was 93 kWh/m^2/yr. for residences. Median Site EUI for Educational College/ Universities is 266 kWh/m^2/yr. and Residence Halls is 183 kWh/m^2/yr. in United States (*Energy Star Portfolio Manager: U.S. Energy Use Intensity by Property Type*). The academic buildings on an average have a higher 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 5-year trend for the breakdown of EUI per energy source for the Academic, Residences and overall campus.

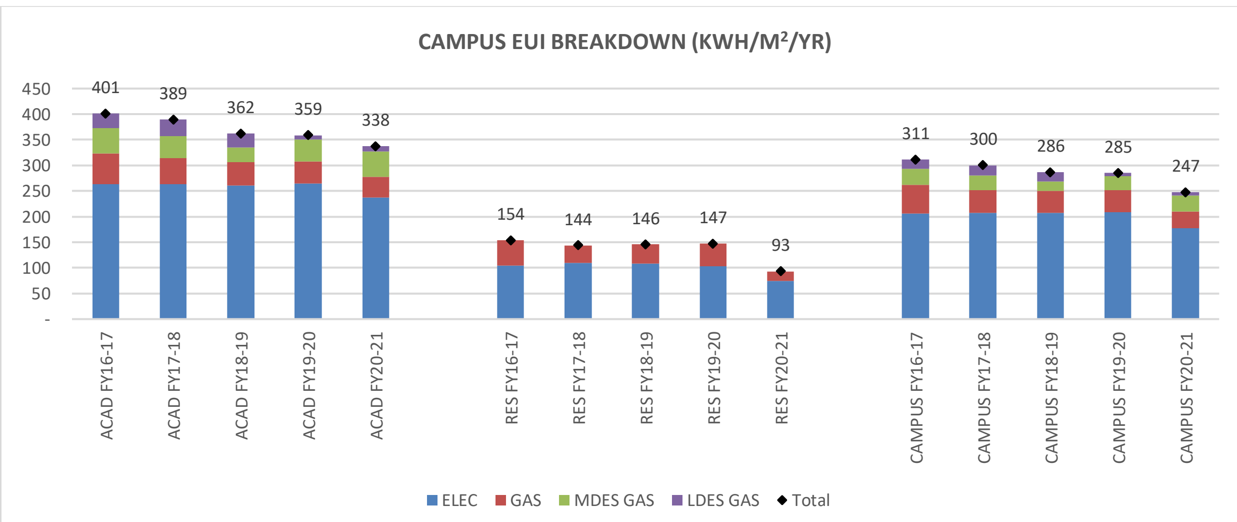

Figure 10: Campus Energy Use Intensities trend

A study is currently underway to update TEUI, TEDI, GHGI for five archetype models from the previous UBC Net Positive Modelling Study using Okanagan climate files and building archetypes that are representative of UBCO new construction. As per preliminary findings, following table provides a summary of the different metrics for the baseline scenario:

	Student Residence (100% Residential)	**Campus Rental Housing (contains Commercial Retail Units)**	**Lab Building (Low fume hood density)**	**Lab Building (High fume hood density)**	**Classroom/ Office**
TEUI (kWh/m^2/yr.) (GJ/m^2/yr.)	142 (0.51)	181 (0.65)	315 (1.13)	443 (1.59)	163 (0.59)
TEDI (kWh/m^2/yr.) (GJ/m^2/yr.)	30 (0.11)	30 (0.11)	66 (0.24)	107 (0.39)	20 (0.07)
DHW (kWh/m^2/yr.) (GJ/m^2/yr.)	25 (0.09)	39 (0.14)	12 (0.04)	15 (0.05)	13 (0.05)
GHG (kgCO$_2$e/m^2/yr.)	9	12	14	22	6

As can be seen in the following Figure 11, the ASC and SCI buildings have the highest EUI on campus, primarily because of the laboratories in these buildings. A project is underway in the

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Science building to reduce lab ventilation rates. Refer to section 5.1 of this report for more information. Similar project will be carried out for the ASC and FIPKE buildings in the current fiscal year. Also, FortisBC funded Recommissioning activities were performed for the EME, RHS and MWO buildings. In terms of total energy consumption, EME, SCI, ASC, FIPKE, and UNC have high consumption compared to their peer academic buildings. EME has significantly higher area footprint leading to high energy consumption. SCI, ASC and FIPKE are the lab intensive buildings on campus and UNC has a commercial kitchen leading to increased energy consumption.

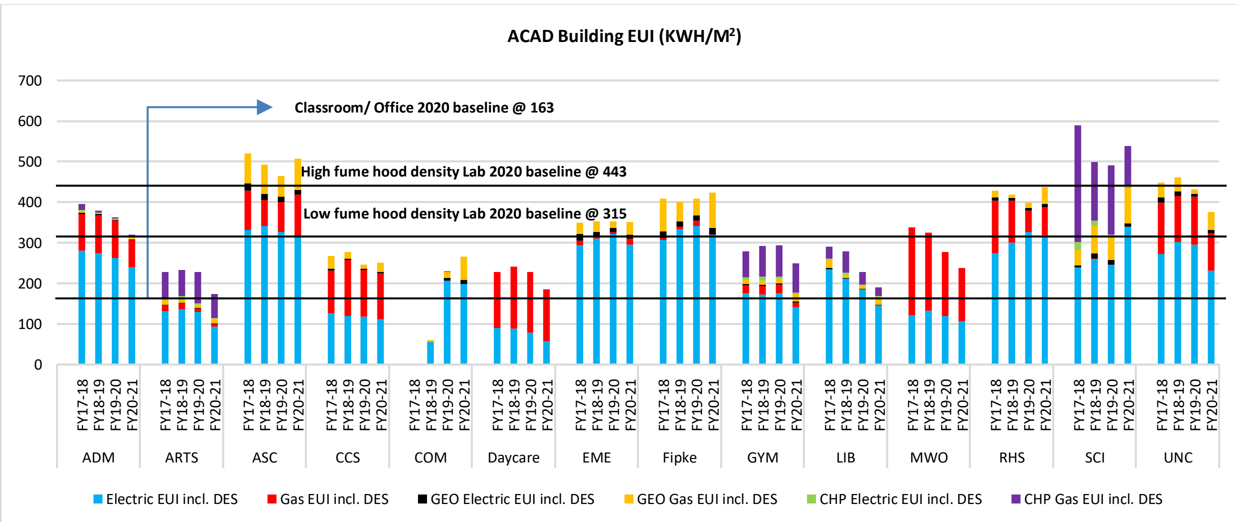

Figure 11: Energy Use Intensity for Campus Academic Buildings

Figure 12 provides a comparison between total energy consumption for the various Academic buildings on campus.

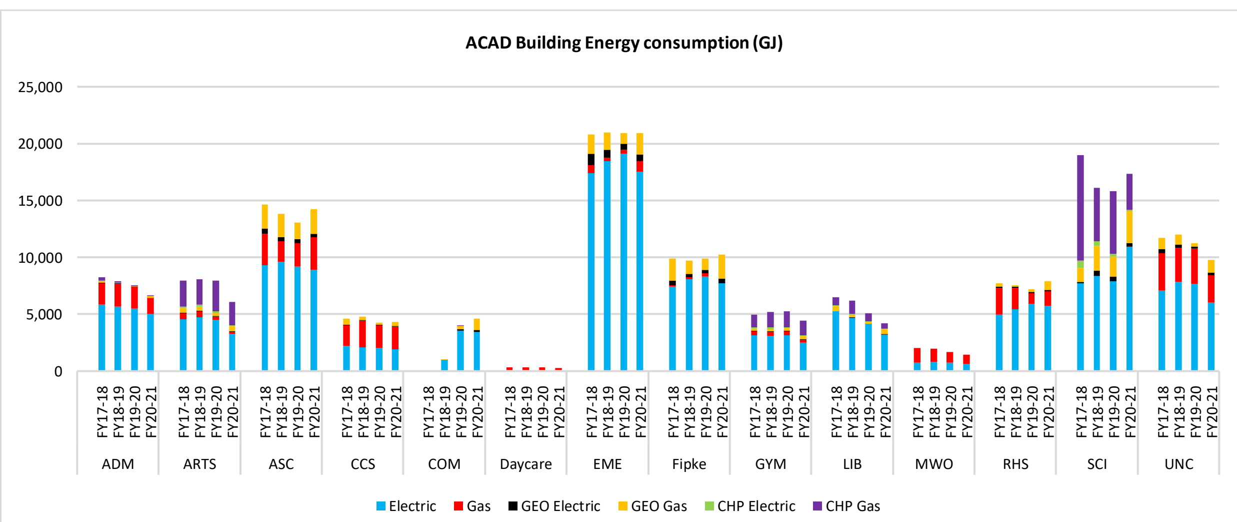

Figure 12: Energy Use for Campus Academic Buildings

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Due to their lower intensity occupancy and use, residence EUIs are significantly lower than those of academic buildings. As mentioned earlier, a reduction in overall intensity was observed in FY20-21 due to reduced occupancy as a result of COVID-19. A significant reduction in natural gas consumption for Monashee is evident in the Figure 13 and 14 due to VRF heat pump project in 2020. An estimated $87,000 rebate was received from FortisBC for this project.

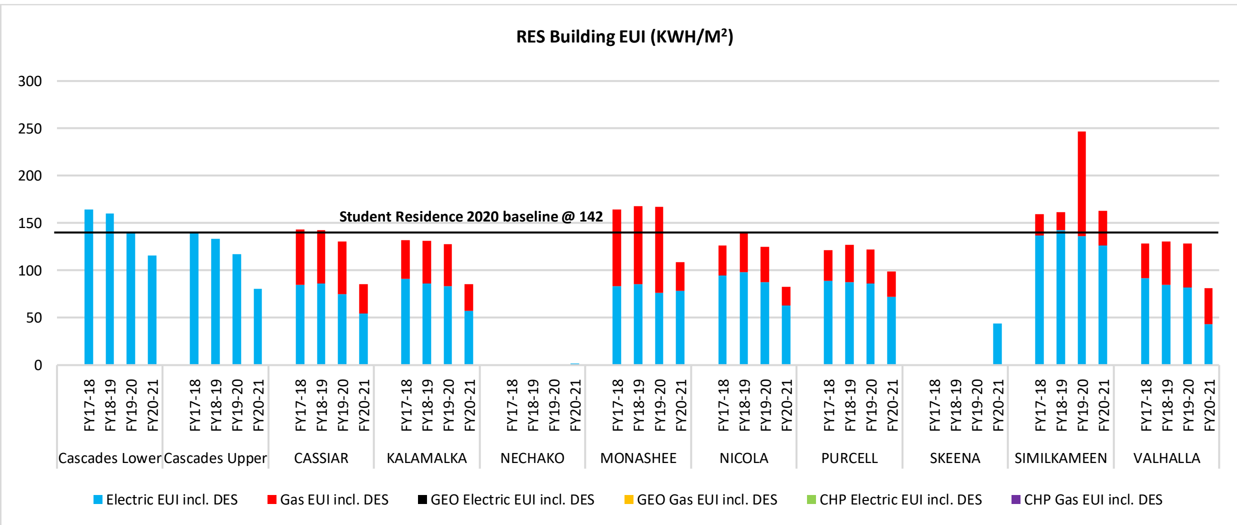

Figure 13: Energy Use Intensity for Campus Residence Buildings

Figure 14 provides a comparison between total energy consumption for the various Residence buildings on campus.

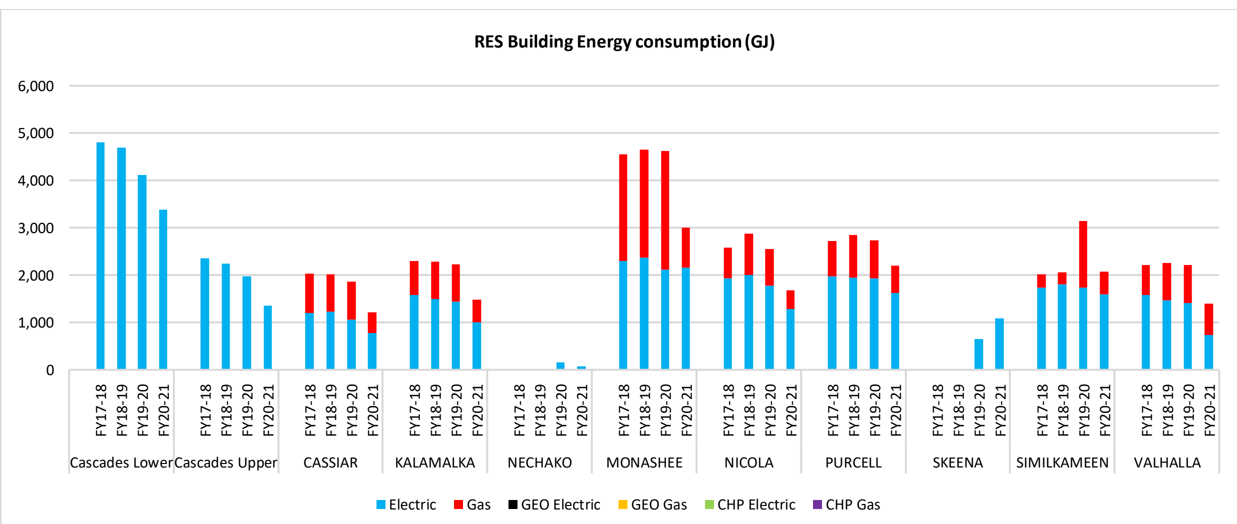

Figure 14: Energy Use for Campus Buildings

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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.

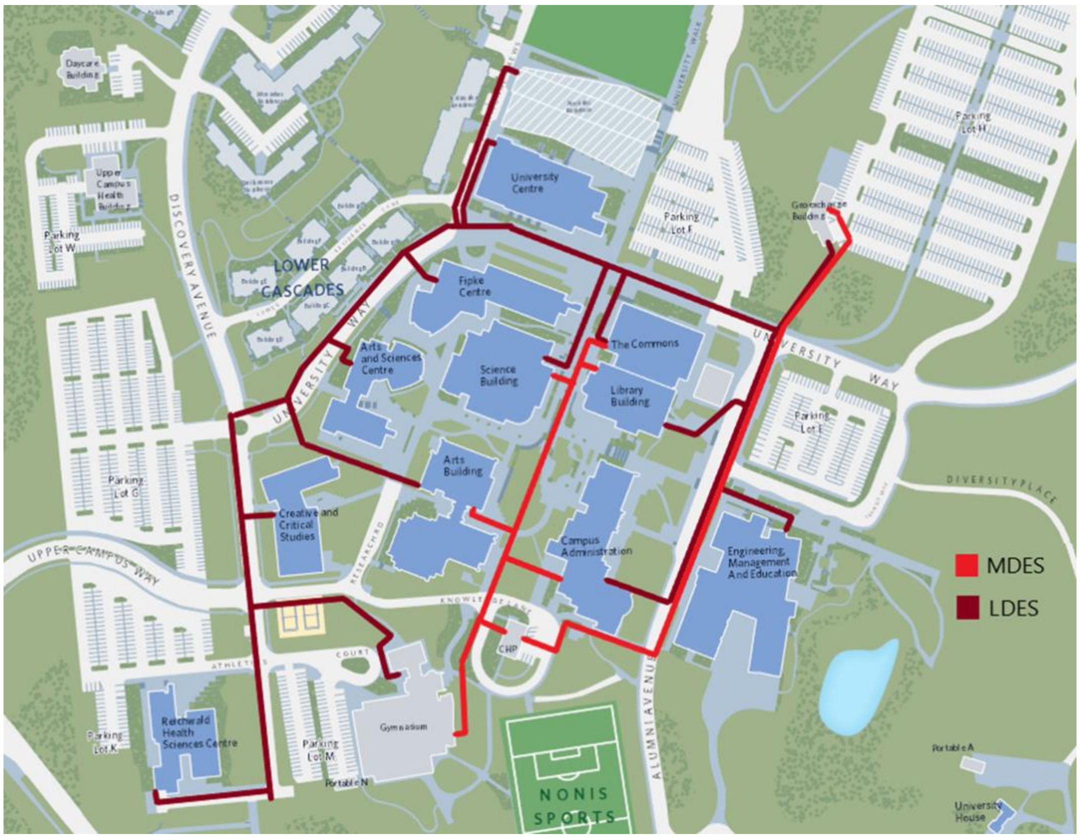

Figure 15: Map of the current status of District Energy Systems

3.1 MDES - Medium Temperature District Energy System

The medium temperature district energy system (MDES) delivers hot water to the five legacy academic buildings on campus (ADM, ARTS, GYM, LIB and SCI with total floor area of 35,500 m^2). Heat is supplied to the building mechanical plant from boilers in the Central Heating Plant (CHP) building at 80°C (176°F) supply water through a 150mm (6”) insulated carbon steel piping over 200 trench meters (656 feet). The boilers in the CHP building consist of:

- 1 x 440 kW (1,500 MBtu/h) natural gas input condensing dual-return boilers
- 2 x 967 kW (3,300 MBtu/h) natural gas input condensing dual-return boilers
- 2 x 1.9 MW (6,500 MBtu/h) natural gas input atmospheric boilers

While three 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. However, there is now a thermal connection between the campus medium (MDES) and low (LDES) temperature district energy systems. By using the MDES return water as a heat source for the LDES, colder water can be returned to the boilers in the central heating plant, increasing their efficiencies. This system was installed in the fall of 2019 and operating parameters and strategies are still being optimized.

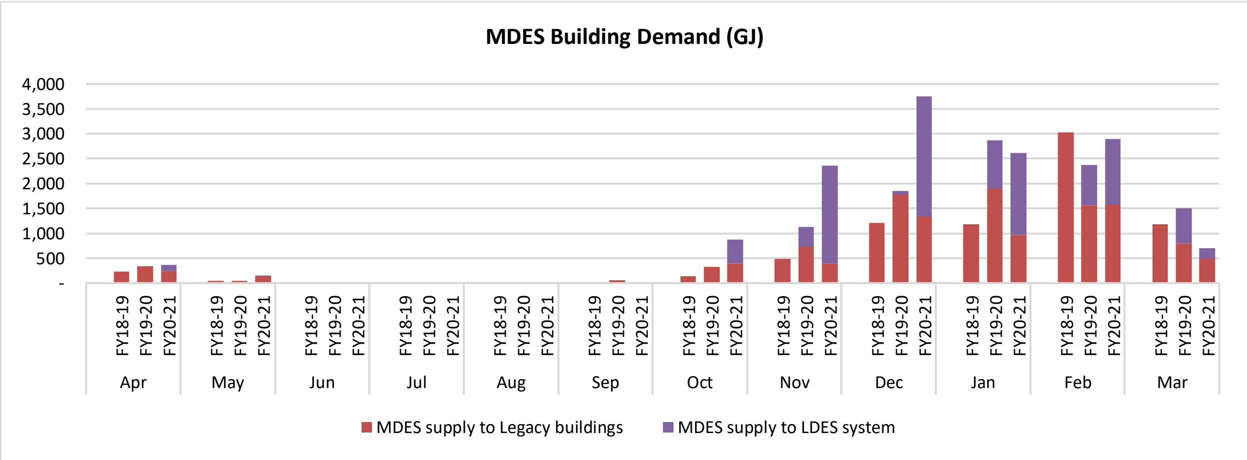

Figure 16: Thermal Energy demand from the MDES plant

Significant heating loads have been transferred off of the MDES and onto the LDES in the last several years to take advantage of the higher efficiency of the LDES system. Although, these load shifts have reduced both the thermal loads on the MDES as well as the gas consumed by the central heating plant. A test was conducted to understand the cost-benefit analysis of increasing the supply water temperature on heat loss in the LDES loop and increased COP for building-level heat pumps. For this test, LDES supply water temperature setpoint was increased from 9°C to 15°C from November 2020 to January 2021 which increased the total gas consumption 14,326 GJ in FY19-20 to 17,136 GJ in FY20-21 (Refer to Figure 16). Note that due to the MDES-LDES connection, approximately 60% of the gas consumed in the central heating plant can now associated with the LDES (Refer to Figure 17).

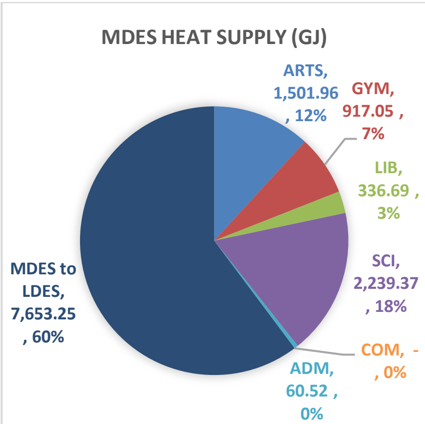

Figure 17: Heat Supplied from the MDES plant to various demand buildings for FY20-21

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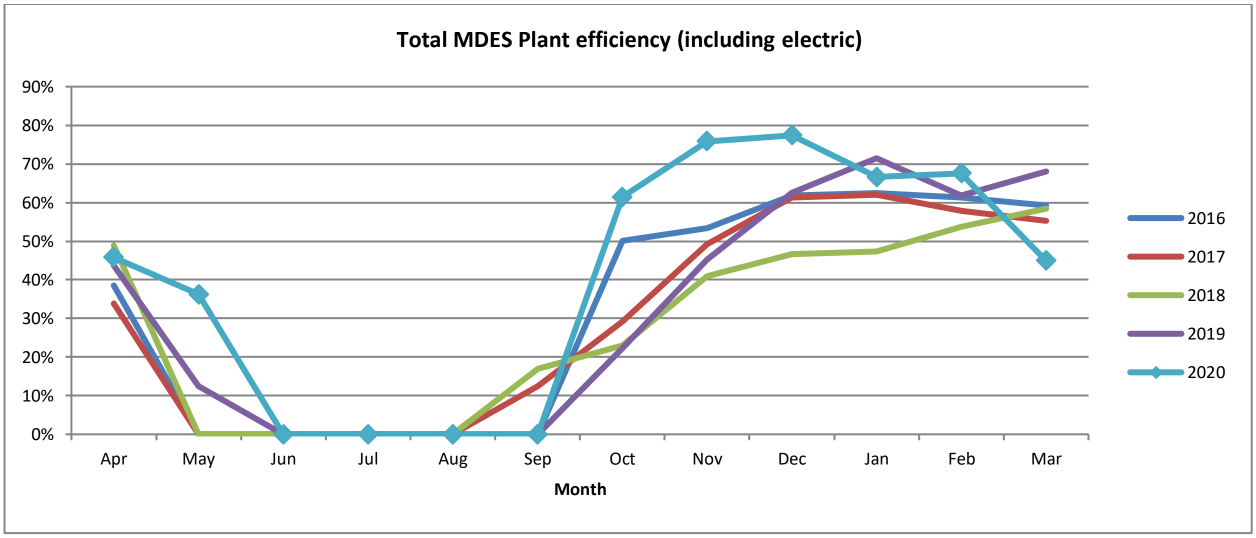

Figure 18: MDES plant efficiency

3.2 LDES - Low Temperature District Energy System

The low temperature district energy system (LDES) on campus currently delivers ambient temperature water in the range of 8°C to 25°C (46°F to 77°F) to most academic buildings (EME, CCS, FIPKE, GYM, RHS, LIB, SCI, ADM, UNC, COM, ARTS, ASC) on campus through a PVC pipeline[8]. Heat pumps within the building further use this ambient temperature water as a source for either heating or cooling. Domestic hot water (DHW) pre-heat exists on a case-by-case basis. 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.

In the LDES system, heat is injected or rejected from the loop with a combination of gas boilers, connection with MDES, open-loop groundwater geo-exchange, and fluid coolers. The Groundwater Geo-exchange system contains 4 supply wells that can extract up to a total of 150 lps (2,378 gpm) of groundwater which goes through double-walled shell and tube heat exchangers to extract/ reject heat. The groundwater is then returned to the local aquifer via 2 infiltration basins that can handle 30 lps (476 gpm) of water. LDES system also contains one 1.2 MW (4000 MBtu/h) condensing natural gas boilers. In addition to this boiler, heat exchangers that connect the MDES and LDES plants were installed and made operational in 2019. These heat exchangers allow the dual-return condensing boilers in the MDES central plant to utilize the low temperature LDES water to achieve high boiler efficiencies. In order to reject heat from the system, three hybrid fluid coolers are used that have a nominal cooling capacity of 1.4 MW (400

[8] LDES is not connected to all the Residences (except for the upcoming Nechako Commons) and MWO, DAYCARE and 1540 INN DR Academic buildings.

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tons) each. These are wet cooling towers that utilize evaporative cooling to cool water below the outdoor dry bulb air temperature.

A study was completed in April 2020 on the Geo-exchange feasibility of vadose zone to aquifer recharge groundwater flow direction and mounding modelling. Based on Recommendation # 5 of this report, due to uncertainty in subsurface recharge capacity if the Geo-exchange system is considered to be ready for decommissioning, close all Campus wells according the Groundwater Protection Regulation.

LDES system utilizes a low cost 2 pipe network supplying ambient water to building heat pumps which generate hot and cold water for use within the building. Three 93 kW (125 horsepower) pumps located within the LDES plant circulate water around the LDES loop. The piping network consists of over 2,000 trench meters (6,560 feet) of 400mm (16") PVC uninsulated pipework that is buried below the frost line. Insulation on the distribution piping is not required due to the relative temperatures of the LDES water and the ground.

- Pipes 100 to 300 mm (4 to 12") dia. - AWWA C900 SDR 25 or Series 160 DR 26
- Pipes 350 to 1200 mm (14" to 48") dia. - AWWA C905 SDR 25 or Series 160 DR 26

Every building connected to the current LDES system has its own building scale heat pump system to transfer heat into hydronic heating and/or cooling systems.

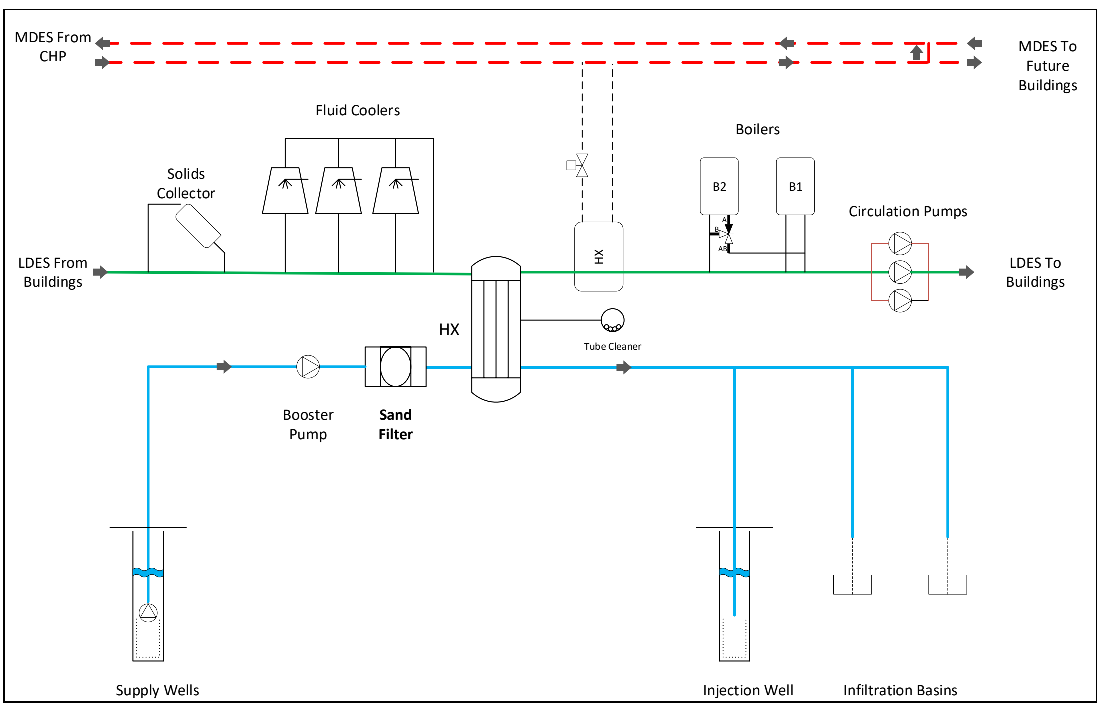

Figure 19: LDES plant block diagram

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The Figure 20 below shows the amount of heating/cooling demand from the LDES-connected buildings. The columns above the x-axis represent the heating demand from LDES-connected buildings whereas columns below the x-axis represent the cooling demand from the LDES-connected buildings. In the figure, the energy amounts shown as "Free Heat" or "Free Cool" account (in black) 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 (around 7%) results in energy savings as the central LDES plant does not need to generate the heating/cooling. The "Free" 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 "Free" energy source. An increment in heating demand and a decrement in cooling demand was observed in FY20-21 compared to FY19-20.

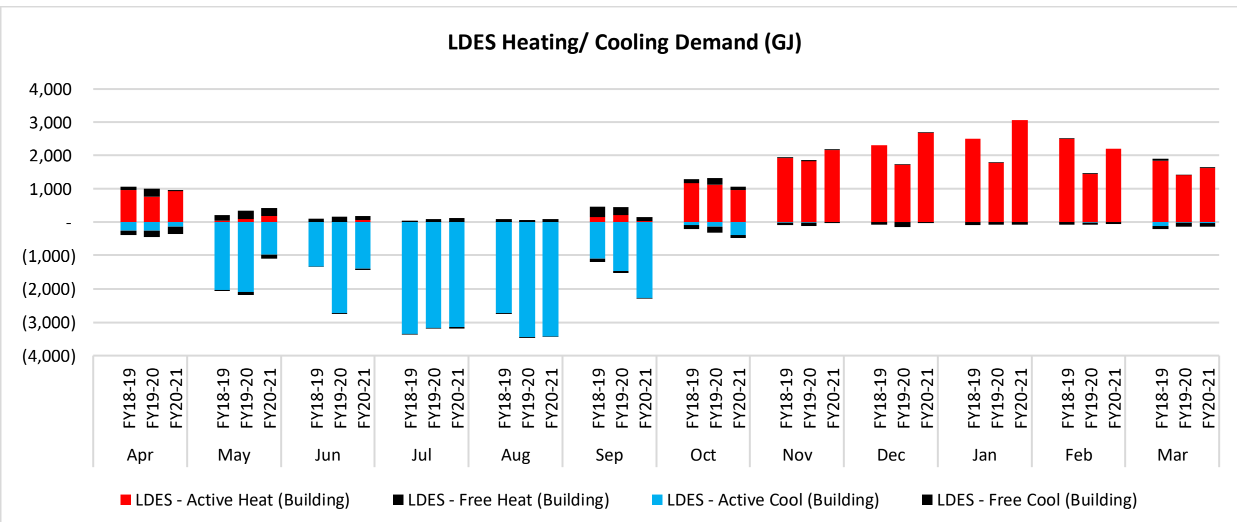

Figure 20: Thermal Energy demand from the LDES plant

Figure 21 shows the various sources of heat injection and rejection in FY20-21 and Figure 22 shows the breakdown heating or cooling supply between various buildings from LDES plant.

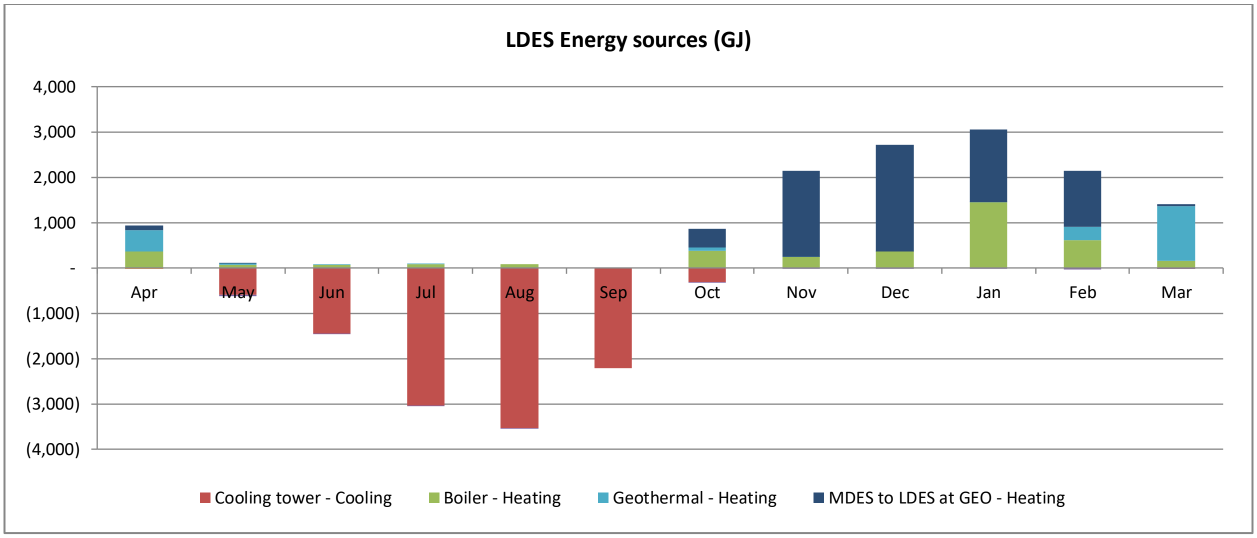

Figure 21: LDES Heating and Cooling Sources for FY20-21

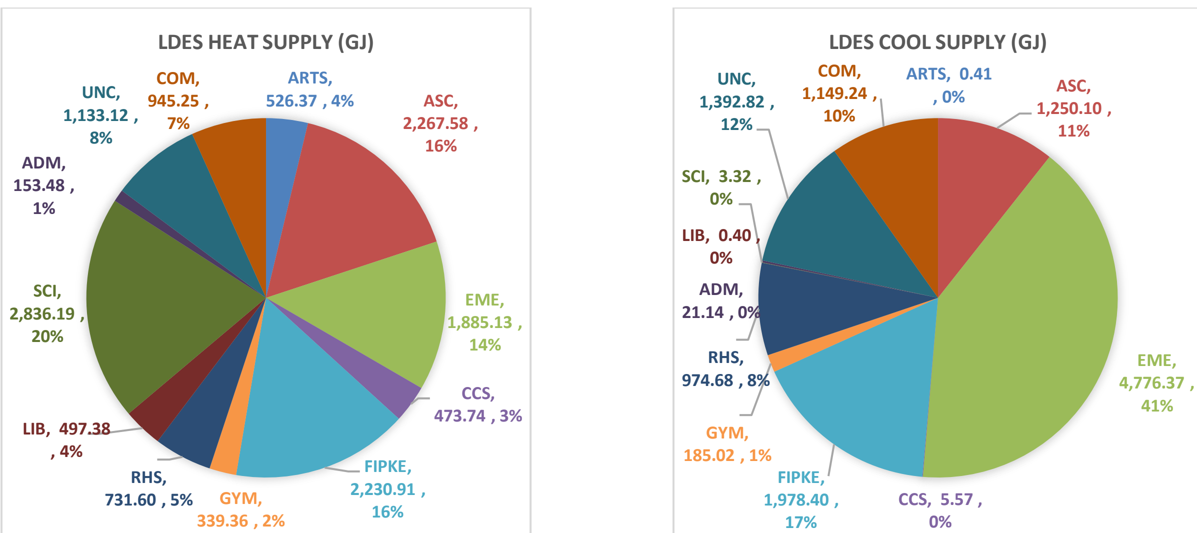

Figure 22: Heat Injected/ Rejected from LDES plant to/from various buildings for FY20-21

3.2.1 LDES – Heating

Heat is provided to the LDES through three different sources 1) a heat exchanger connection to the central heating plant, 2) a high-efficiency condensing boiler, and 3) an open loop groundwater geo-exchange 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. Approximately 2,064 GJ of heat was extracted from geo-exchange system in FY20-21 compared to 6,447 GJ of heat extraction in FY19-20 due to heat loss test from November 2020 to January 2021 (Refer to Figure 23).

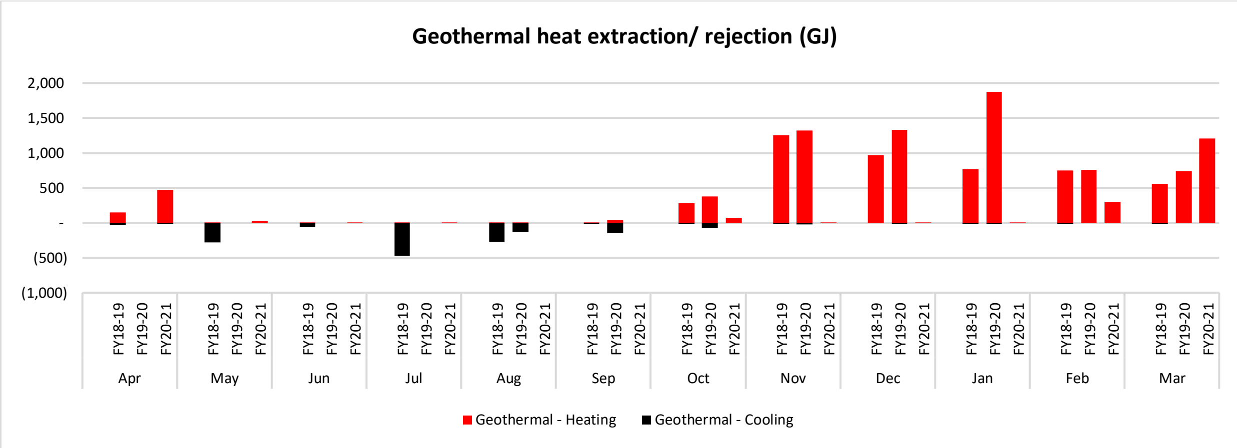

Figure 23: Quantities of Heat extracted/ rejected from Groundwater geo-exchange system

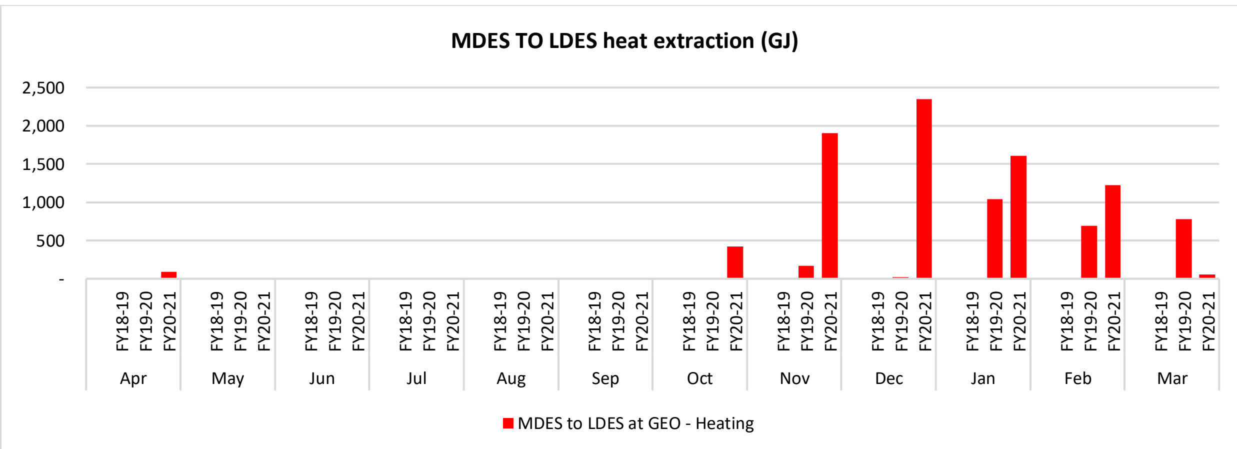

Figure 24: Quantities of Heat extracted from MDES to LDES system

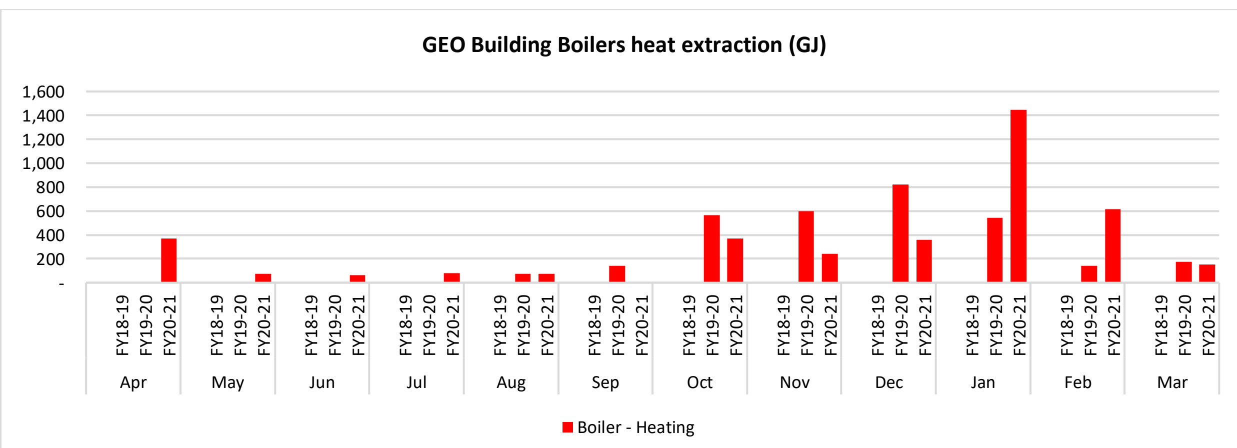

Figure 25: Quantities of Heat extracted from MDES to LDES system

Figure 23, Figure 24, Figure 25 present the historical comparison of various LDES heating sources. MDES to LDES and GEO building boilers heat extraction went up in FY20-21 to compensate for the increased heating requirement as a result of increased LDES supply water temperature setpoint from 9°C to 15°C.

Figure 26 shows the heating efficiency for the LDES system. In general, the heating efficiency is less than 100% however, due to open-loop Geo-exchange system efficiency of the system goes above 100%. Refer to 2020 values from October to February where efficiency is below 100% as the open loop system was not operational.

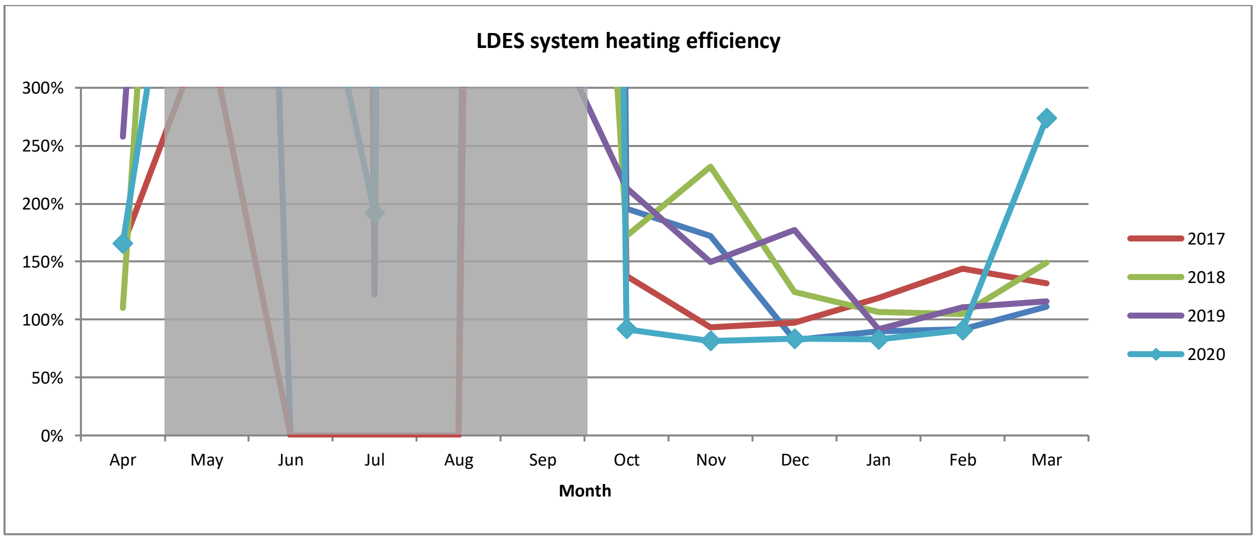

Figure 26: LDES System heating efficiency[9][10]

3.2.2 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 12,568 GJ for FY20-21, a 12.6% decrease from 14,386 GJ in FY19-20. A large portion of this decrease can be primarily attributed to 10% reduction in cooling degree days and reduced occupancy as a result of COVID-19.

Almost all 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

[9] Refer to months between October to April for heating system efficiency
[10] Due to measurement error and heat rejection from LDES during summer months, LDES heating efficiency is more than 300%. In order to highlight the LDES heating efficiency during heating season, x-axis is capped at 300%.

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extraction and infiltration systems and preserve their use for heating, where a much greater potential for GHG emissions reductions exists.

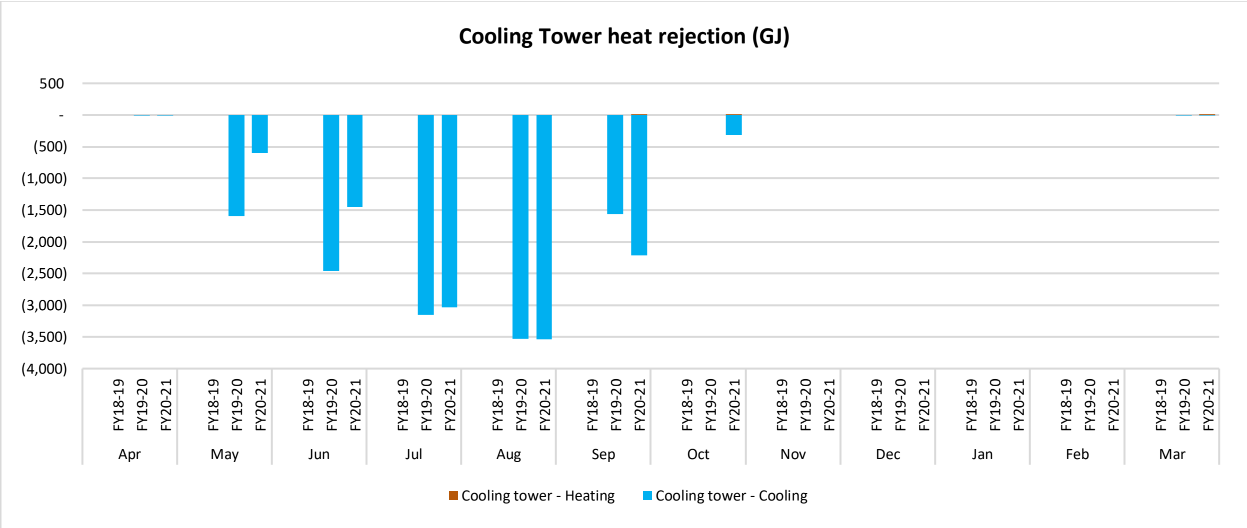

Figure 27: Quantities of Heat rejected by cooling towers

The Figure 27 above shows the heat rejected by the cooling towers in the LDES system. Figure 28 below shows the cooling COP of the LDES system which is around 10 during peak cooling season.

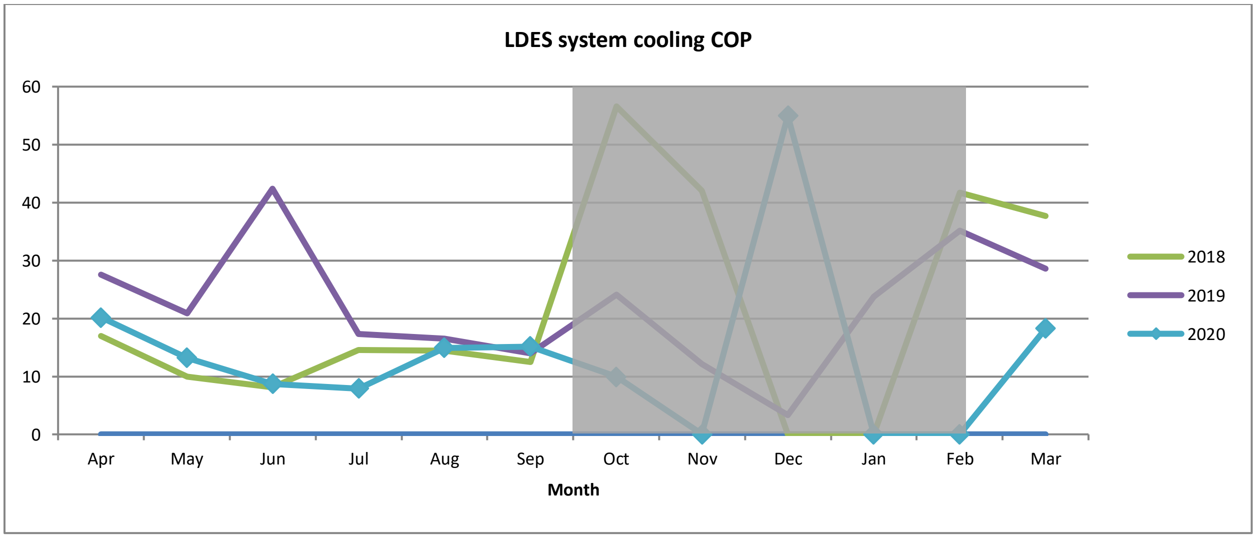

Figure 28: LDES Cooling Towers Heat Rejection Energy Efficiency[11]

[11] Refer to months between March to October for cooling system efficiency

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4 Energy Policies and Strategic Development

UBCO Energy Team is involved with development of strategies for optimizing future campus energy use. Appropriate policies and guidelines assist in meeting campus energy goals and as such are championed by the Energy Team. Significant developments in energy-related campus guidelines and policies that occurred in the past quarter are described below.

4.1 Strategic Energy Management Plan (SEMP) 2020

Strategic Energy Master Plan (SEMP) evaluates demand-side measures i.e., options to reduce loads including heating, cooling and electrical loads. A 5-year SEMP was created in 2016 and again in 2018 with the intention of continuing with updates every 2 years. For the 2020 update a longer 10-year horizon was chosen for the SEMP along with a more detailed look at projects recommended for implementation in the first 5 years. A list of demand-side management (DSM) projects was analyzed and grouped into five bundles to represent annual implementation plans starting with the present fiscal period of FY2021, and proceeding through FY2025, as presented in Table below.

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%

SES Consulting projected three DSM scenarios based on different implementation plans for the identified project bundles, as presented in Figure below:

- DSM-1: This is based on the implementation of project bundles FY2021 and FY2022, with no additional energy conservation efforts beyond that.
- DSM-2: This 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: This 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.

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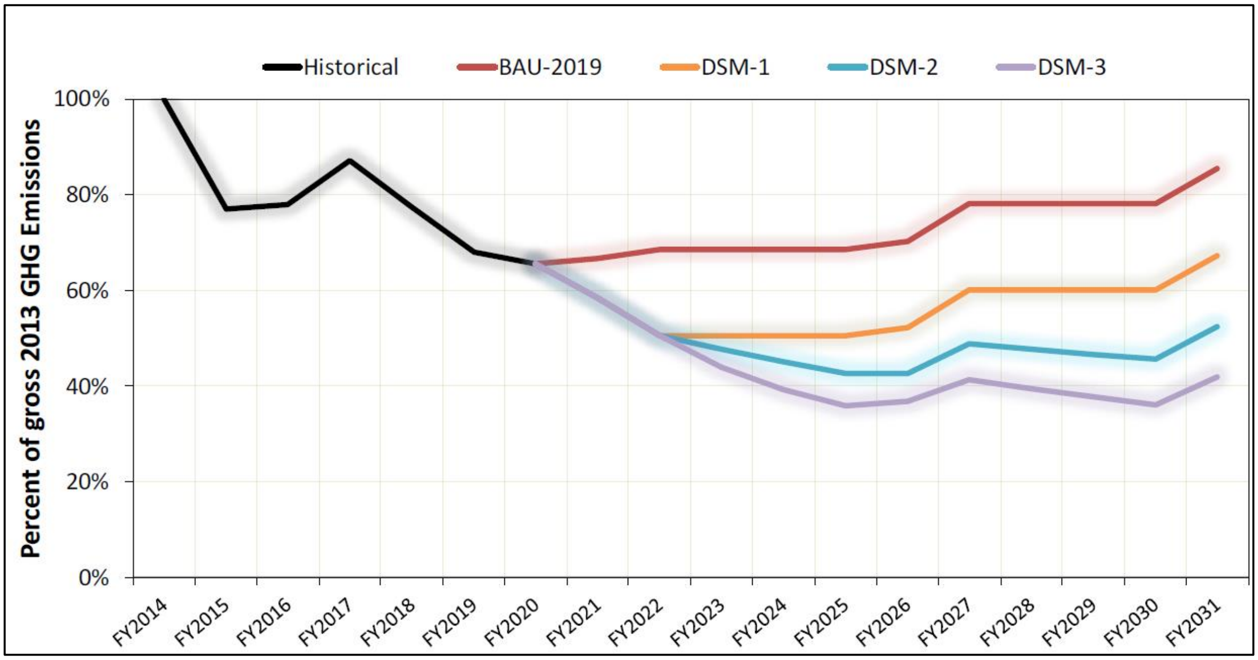

Figure 29: SEMP 2020 Modelled DSM scenarios

DSM-2 has been the chosen strategy to set and meet the goals with respect to carbon emissions reduction. The same has been used in the CAP emissions scenario modeling as discussed further in this report.

Energy Team is working on implementing the Energy Conservation Measures (ECMs) identified as per the SEMP 2020. Following are the identified measures for the first two years:

1. Campus-wide lab demand-controlled ventilation – Occupancy Controlled Ventilation (Underway)
2. Recommissioning of existing controls at ARTS building (Underway)
3. Demand controlled ventilation for ASC MUA-2
4. Demand controlled ventilation for FIP MUA-1
5. Demand controlled ventilation for FIP MUA-2
6. Demand controlled ventilation for SCI AHU-7
7. Demand controlled ventilation for SCI AHU-8
8. Night-time precooling
9. Recommissioning of existing controls at ASC building
10. Recommissioning of existing controls at FIP building

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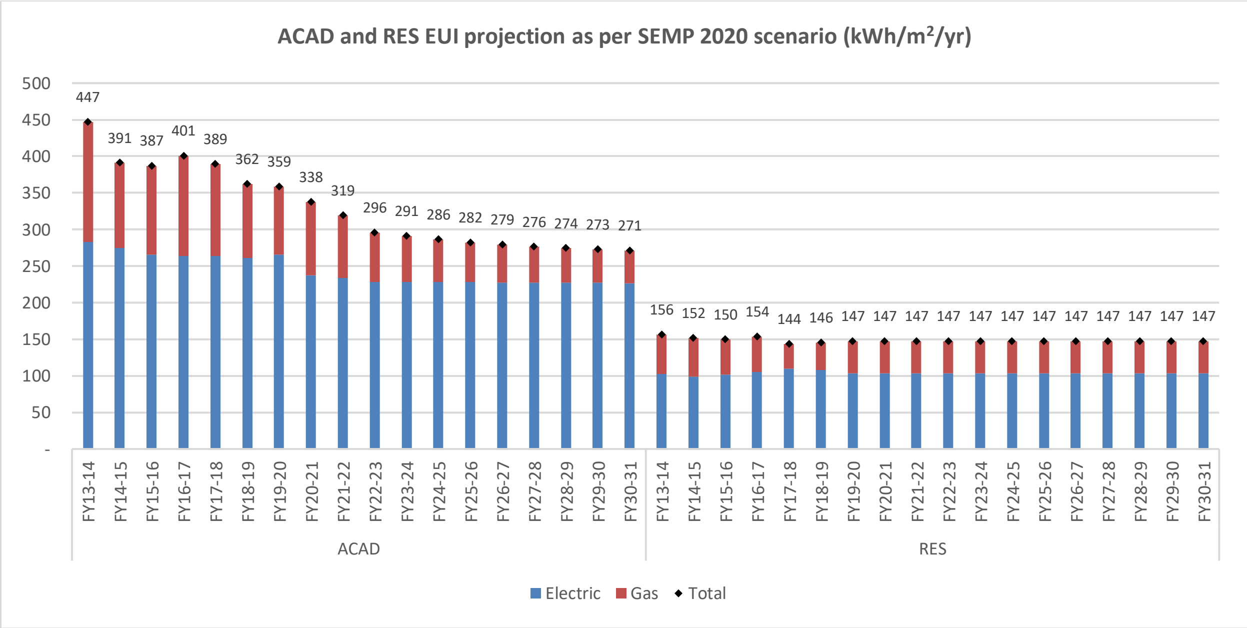

Figure 30: ACAD and RES EUI projection as per SEMP 2020

4.2 High- Level Net-Zero Carbon District Energy (DE) Strategy

The UBC Okanagan (UBCO) campus doubled in size between 2008 and 2010 and may again be on a path of significant growth with the addition of the Innovation Precinct. This has motivated further analysis and consideration of district energy strategy with a view of modernization, renewal, and growth to serve both existing and new load.

The strategy is intended to guide how district energy systems on campus evolve to meet the requirements of an expanding campus. The strategy considers:

- Capital and operational costs
- Greenhouse gas emissions
- Adaptability to regulatory and technology changes
- Phaseability
- Resiliency

The first phase of this project was completed in the fall of 2019 and included a synopsis of the current state and generated a reference case using packaged heating and cooling equipment within buildings. The second phase of this project was completed in July 2020 and compared different district energy system options against this reference case. The options being compared included a 4-pipe cold and medium temperature DES, a low temperature DES and a hybrid between the two.

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As discussed in Section 3.2. the existing strategy[12] to distribute heat from the existing LDES system is to install building scale heat pump system in every building to transfer heat into hydronic heating and/ or cooling systems. Employing this strategy to date has provided many benefits as follows:

- Energy Efficiency and Carbon
    - Compatible with many low carbon and waste heat resources
    - Enables energy sharing within and between buildings
    - Minimal distribution heat losses
    - Optimizes boiler efficiency
- Campus and Building Operations
    - Centralized maintenance
    - Simple and low-cost pipe infrastructure
    - Reduced space requirements for building mechanical equipment
    - Takes advantage of campus system diversity
    - Provides for both heating and cooling

Current LDES benefits aside, the investment in smaller scale heat pump equipment in every connected building has higher capital and operating cost relative to district energy alternatives with more scale (Refer to Figure 31). As such, transition is focused on aggregating load, preserving benefits, and improving performance. Outcome of the DE Strategy Phase 2 identified hybrid cluster plant approach i.e. “Zone-scale heat pumps generating hot & chilled water and distributing through a 4-pipe system to all new buildings within the associated building cluster. LDES connection between the distributed plants” (Strategy # 4) as a low cost strategy for the campus and best positioned to achieve carbon emission reduction goals. District energy utility service simplifies building operations, maximizes resilience, and provides a foundation for the integration of waste heat, renewable energy, and other low carbon energy sources.

[12] Refer to Figure 31 for cost details for this Strategy # 3

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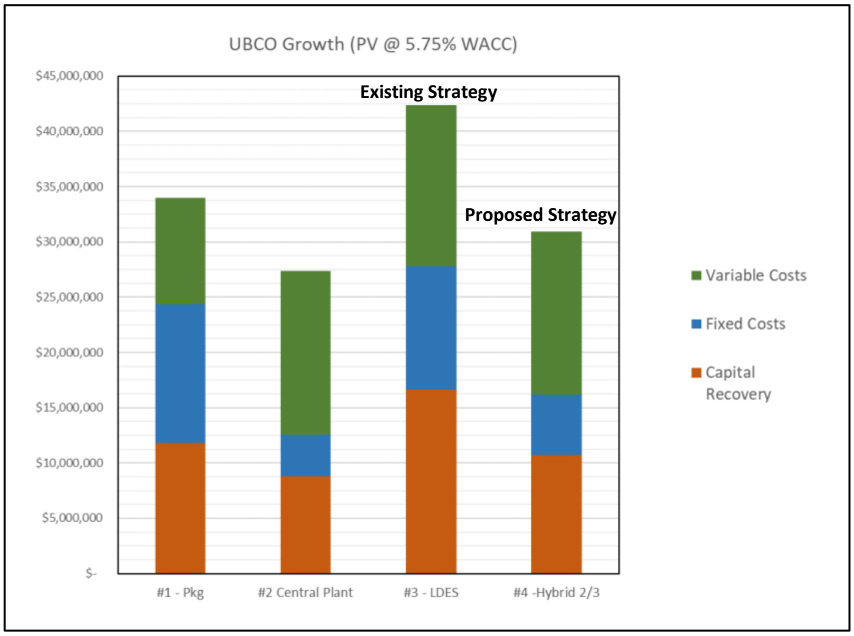

Figure 31: Cost comparison of various alternatives for new building growth

The district energy strategy progressed in three stages and was reviewed by a Whole Systems Steering Committee consisting of three AVP-level representatives from the offices of Finance and Operations (Okanagan), Campus and Community Planning (Vancouver), and Infrastructure and Development (Vancouver), and five director-level representatives from the offices of Integrated Planning and Chief Budget Officer (Okanagan), Campus Operations and Risk Management (Okanagan), Campus Planning and Development (Okanagan), Energy and Water (Vancouver), and Sustainability and Engineering (Vancouver).

A decision was made by the UBC Whole Systems Steering Committee to proceed with utility services as a distributed central plant District Energy System. With the distribution and energy transfer station strategy set, the focus turned to DE decarbonization, as well as a strategy for service to the new Interdisciplinary Collaboration and Innovation (ICI) building on the main campus.

The ICI building was determined to be a good location for a zone scale plant (Cluster plant or mini plant) for the following reasons:

- First opportunity
- Avoid cost and land use of standalone plants in individual buildings
- Proximity to MDES/LDES mainlines
- Proximity to future growth and existing buildings

Energy Team has been working with the DE Consultant dJoule LLC to advance the schematic design and development of the cluster plant in the ICI building. Figure 32 below provides

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schematic of the ICI cluster plant. In the ICI cluster plant, electric chillers reject condenser heat to the LDES. Dedicated heat recovery chillers intercept waste heat and cool the LDES to provide space heat and domestic hot water (DHW). Hot and chilled water TES provide for peak capacity, electric demand response, and the integration of more waste heat and renewable energy. MDES is designed for backup, peaking, and polishing as needed.

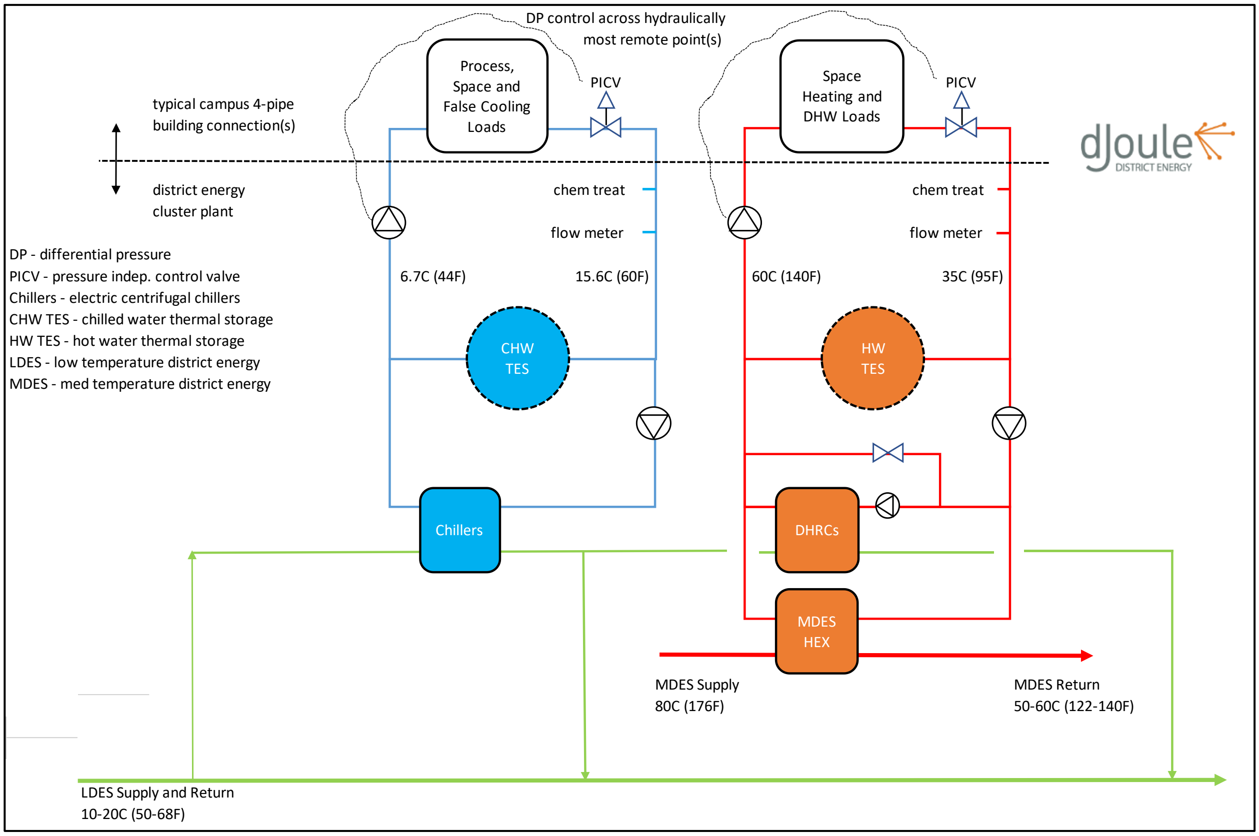

Figure 32: ICI Cluster plant proposed high-level design

UBCO has engaged Integral Group, the mechanical designer for ICI building to perform two parallel schematic design options for the building mechanical plant. These two designs are:

1. ICI Cluster plant connected to District Energy System (Strategy # 2) – ICI cluster plant connected to district energy and planned to expand to serve multiple future buildings on campus
2. ICI Building plant connected to District Energy System (Strategy # 3) – ICI plant connected to district energy for ICI building only

Based on the design requirements, Integral Group identified the various equipment and provisions required for the two options. Currently, based on work done by Integral Group, costing work is being carried out by Sawchuk in order to determine the cluster plant cost

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premiums. A decision will be taken accordingly whether to move forward with the Cluster plant or employ the UBCO's existing energy transfer strategy.

Phase 3 of the DE strategy was completed in Q3 of FY20-21 highlighted UBCO district energy decarbonization strategy in a transition to a future state that is affordable, sustainable, and resilient in service to connected customers (Refer to Figure 33). Important new elements included high lift heat pumps and thermal storage adjacent to the GEO building to displace natural gas use. Plus, service to a first cluster plant in the ICI building from which surrounding buildings are served.

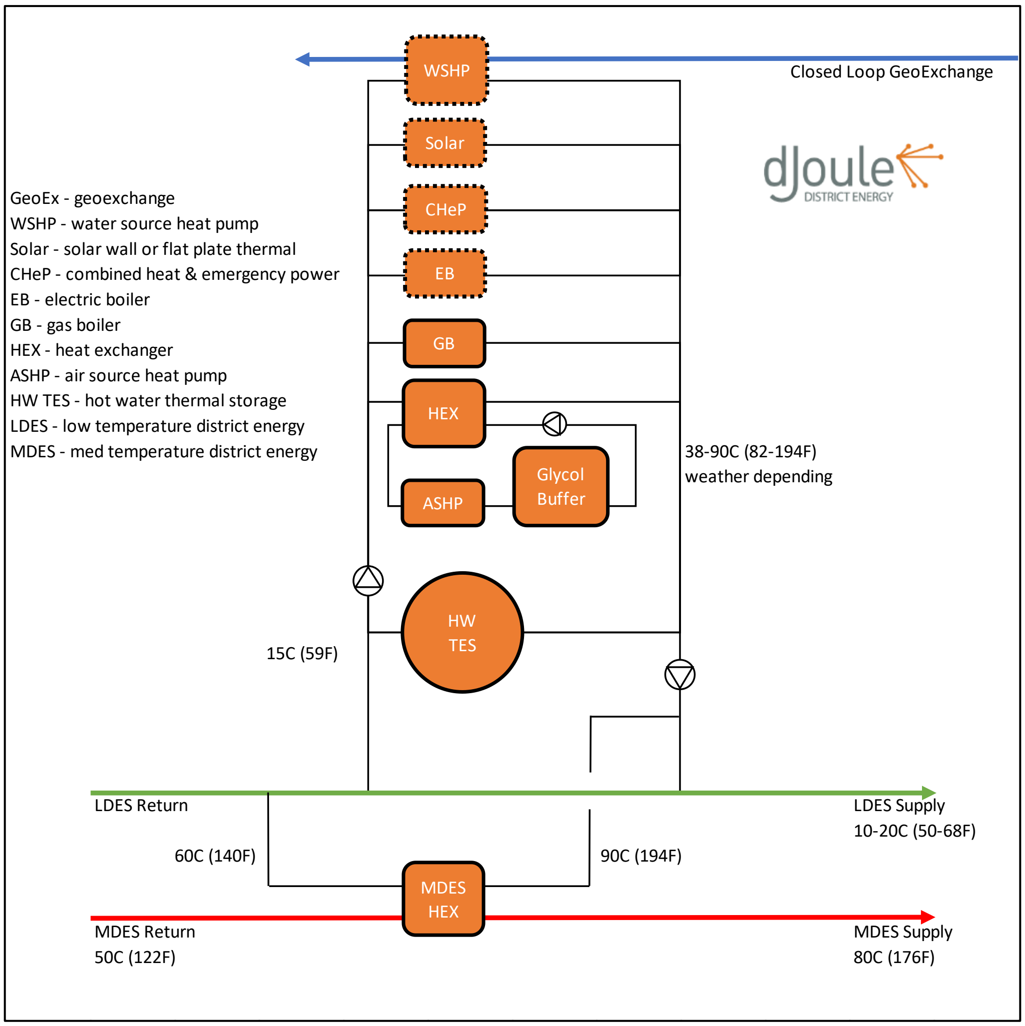

Figure 33: Key DES decarbonization strategies

The key strategy for decarbonization features the integration of air source heat pumps (ASHP) and hot water thermal energy storage (TES). This approach is designed for baseload down to outside air temperatures as low as -5C (23 deg F) before gas boiler heat is required. These hours represent less than 10% of the annual operating hours in a year.

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Future options considered include closed-loop geo, solar thermal, dispatchable combined heat and emergency power, and electric boilers. All strategies would be opportunistically deployed based on the weather and grid conditions.

The next phase of the DE strategy included schematic design and economic assessment of an Air Source Heat Pump (ASHP) and thermal energy storage (TES) plant near the GEO building.

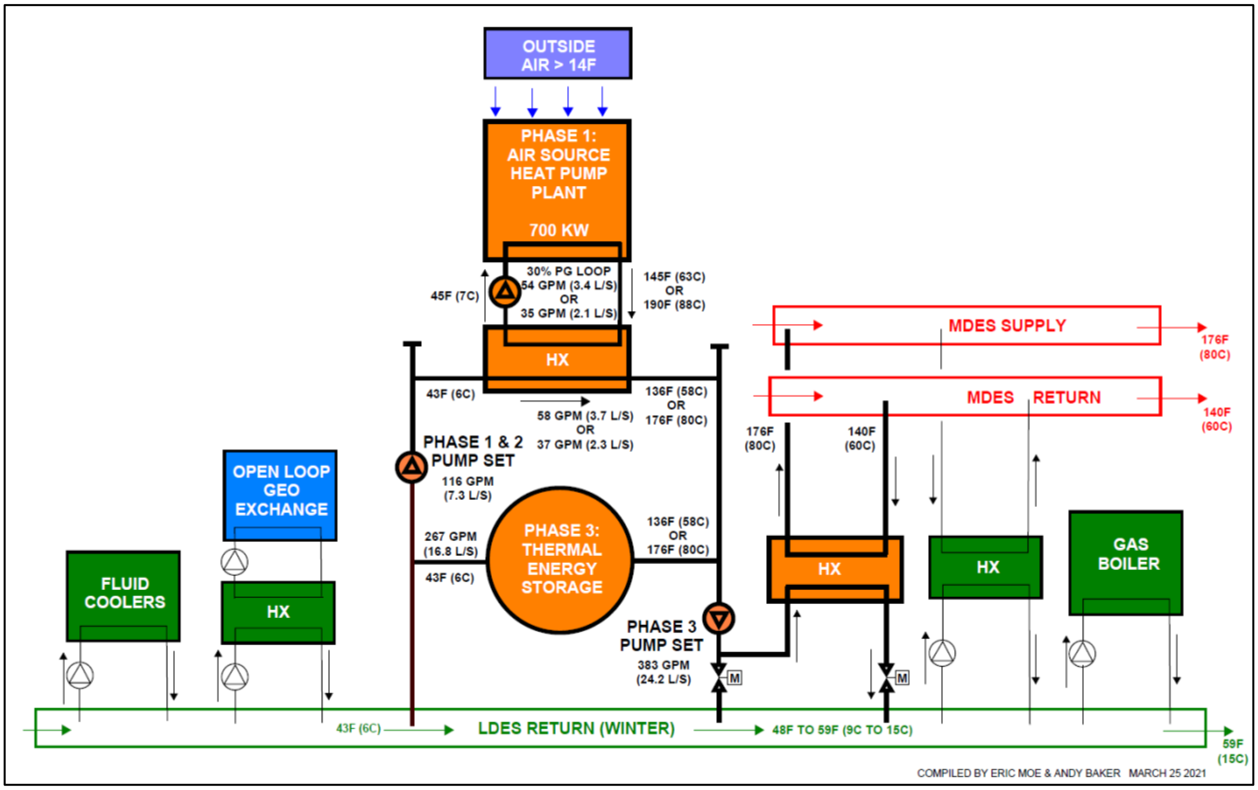

Figure 34: DE Decarbonization schematic design

The ASHP/TES plant envisioned would be completed in three phases (Refer to Figure 34 for Schematic design). The first and second phases each involve the installation of 700 kW (2.4 MMBtu/h) heat pump systems featuring high temperature output and natural refrigerant. The third phase provides 3.5 MW (12 MMBtu/h) capacity TES with 128,000-gallon capacity for 8 hours dispatch to enhance performance, capacity, and resilience and to enable stored low carbon heat to be injected into both the LDES and MDES system. TES at this scale will reduce the need for new gas boilers to replace aging equipment. Upon completion of this project UBCO will be able to choose when it consumes power for heat production to reduce operating cost and grid carbon. It may be able to operate as an electricity prosumer and be paid for demand response with no impact on service to connected customers.

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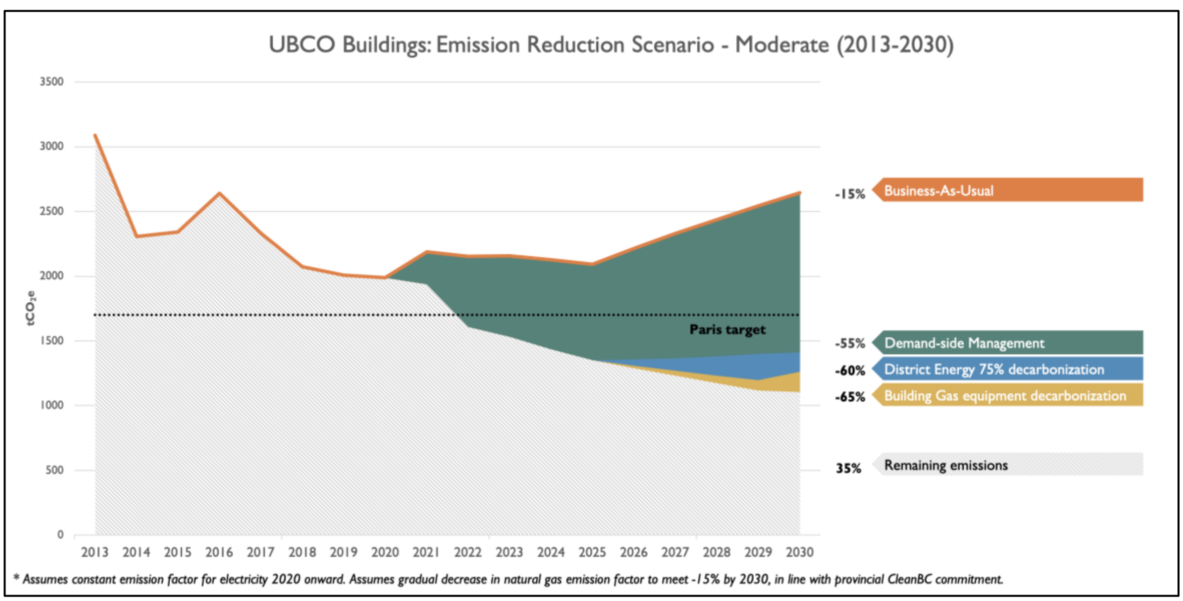
The first phase of ASHP Plant has been proposed to consist a total of twelve (12) Mayekawa Unimo air to water heat pumps located outside adjacent to a central container to house supply and return headers, plate heat exchanger, electrical power distribution panel, controls, and storage of spare parts. The central container will be a standard 40-foot-long steel unit, insulated and equipped with space heater and active ventilation to allow occupancy in winter for maintenance.

Through these three phases, it is expected to reduce existing DES carbon emissions from the current level by 40, 80, and 90% respectively by minimizing operation of natural gas boilers in both the CHP and GEO buildings for a total carbon emission reduction of 742 tonnes per year[13]. This work was further utilized to recommend goals in the CAP 2030 report.

4.3 Low Carbon Energy Strategy

Energy Team was tasked by the Whole Systems Steering Committee with developing a High-Level Net-Zero Carbon District Energy (DE) Strategy that would help inform realistic carbon emission reduction targets. The strategy included the completion of pro forma for various alternate energy supply options, as well as a sensitivity analysis and rough "order of magnitude" costs for each option as discussed in Section 4.2. The result was the selection of an option that was deemed to be the lowest cost for the campus, as well as the best option to achieve UBC carbon reduction goals, simplify building operations, maximize resilience, and provide a foundation for the integration of waste heat, renewable energy, and other low carbon energy sources in the future.



[13] This analysis does not account for additional conservation in district energy connected buildings or the elimination of gas heat sources in individual buildings.

Figure 35: DE Decarbonization schematic design

Based on the strategy, a moderate (realistic) target of 65% emission reduction from 2013 levels by 2030 is recommended. This can be achieved by partial decarbonization of the central plant, implementing projects that will reduce energy demand, and connecting select existing buildings to central energy supply systems (district energy).

4.4 UBCO Net Positive Modelling Study – Archetype update and analysis

Energy Team has been working with RDH Building Science Inc. to update the five archetype models from the previous UBC Net Positive Modelling Study using Okanagan climate files and building archetypes that are representative of UBCO new construction with TEUI, TEDI, GHGI results for each archetype.

It will also include updating the ECM bundles to be specific to UBCO, as well as updating the costing and financial analysis for the new construction archetypes, and will also determine the applicability of each bundle to existing building retrofits. This work is currently underway and expected to be completed by Q2 of FY21-22.

4.5 Energy Monitoring and Data Management Platform

Energy data for the campus is obtained from a number of sources including utility bills, manual meter readings, and building digital control systems. UBCO Energy Team has engaged with the UBCO School of Engineering to develop a custom data management system for the campus. This project aims to develop an intelligent data-driven energy monitoring and management system for micro-communities using statistical and advanced data analysis methods.

In the meantime, Energy Team has developed a utility tracking tool using advanced programming language knowledge python and excel to track overall campus utility consumption (Electricity, Natural Gas, Water, Sewer) as well as building-level consumption at the monthly, quarterly, and annual interval. The tracking is being done for three different parameters i.e., utility consumption, utility cost, and carbon emissions associated.

4.6 UBCO HVAC Infrastructure Asset Management Database

Energy Team has been working with the Facilities Management to advance and update the Infrastructure HVAC Asset Management database and potentially linking this up with the major capital retrofit projects on campus in the near future. This also includes consolidating campus-wide DDC points, physical meters, and manual metering points in one location and further developing a meter tree. This will further be input to the Data Analytics platform which Energy Team has been working on with UBCO School of Engineering.

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4.7 Future Campus Construction

In order to ensure that future campus energy goals and targets are met, it is important that new buildings constructed on campus are designed and built to be consistent with the Whole Systems Infrastructure plan as well as other campus plans and goals. As such, the Energy Team has been involved in providing technical reviews and setting goals, targets, and strategies as early as possible for future campus expansions such as new construction ICI building.

4.8 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 that are specific to the Okanagan campus.

In 2021 with a view to streamline the process, a new Joint Working Group including UBC Vancouver and UBC Okanagan facilities teams has been formed. The Working Group has been set up to provide potential TG updates, collaborate between campuses and between disciplines. The Energy Team has been involved in facilitating regular meetings for the Joint Working Groups and working to update several that are specific to energy performance and monitoring.

Major update to HVAC TG: UBC's Climate Action Plan (CAP) has set a target of 100% reduction in GHG emissions below 2007 levels by 2050[14]. In support of this plan, natural gas shall not be used as the primary heating source in domestic water heating and in new and replacement air handling and space heating equipment, including but not limited to rooftop units, unit heaters, space heaters, etc. Natural gas may be used as a backup heating source at the unit wherever required to ensure heating requirements can be met. Refer to "Section 22 30 00 Plumbing Equipment" for Domestic water heating and "Section 23 05 00 HVAC – General Requirements" for Heating, Ventilating, and Air Conditioning (HVAC).

4.9 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. Energy Team is leading OPR creation to ensure that requirements for energy efficiency are met. In FY20-21, Energy Team has worked to create OPR for new construction ICI building, and Energy transfer station (Cluster plant).

[14] Please note that these targets are for UBC Vancouver campus.

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5 Energy Conservation Projects

In order to reduce utility costs, energy consumption and GHG emissions, energy conservation measures (ECMs) are regularly implemented on campus. Energy Team has been working on an ECM template to track potential Energy Conservation Measures identified on campus from various sources such as SEMP, RCx studies, staff inputs, etc. This will act as a one-stop source for any potential energy conservation implementation project and enable the team to select and bundle future retrofit/ modernization projects.

Significant financial support for these projects has been made by FortisBC through various incentive programs. When point of sale rebates are included, over $305,000 of energy efficiency incentives were received this past fiscal year. In addition to these rebates $95,000 was received from FortisBC to support the campus Energy Team staff position. An application was made to FortisBC to transition the Energy Specialist funding to funding for two positions, an Energy Analyst and a Thermal Energy Manger. The application was approved which increased the FortisBC support for Energy Team staff to $130,000 per year. In terms of actual studies/ projects, the following projects have been completed/ in progress over the last year.

5.1 UBCO Science Laboratory Rooms Demand Controlled Ventilation (DCV)

SES Consulting identified this measure in their 2020 SEMP report for the FY20-21 implementation. The ventilation rate of non-critical laboratory spaces is not strictly controlled, causing significantly higher air changes per hour than required for occupant health and comfort. The use of upgraded controls equipment and strategies will be considered for reduction and standardization of air changes during both occupied and unoccupied hours. For the campus-wide laboratories, this measure is expected to save 317,100 kWh Electricity and 4,950 GJ Natural Gas per year equivalent to 250 tonnes CO_2e[15].

UBCO Energy Team had put forward an incentive application to perform an engineering study for this project to better determine the cost and benefits of this project. However, due to a delay in the application processing from FortisBC, the project went forward without support from FortisBC.

Siemens Controls is the prime contractor working on this project which is being managed by UBCO's Project Services along with the help of the Energy Team. Following labs have been identified for this first phase of the project:

- Priority 1 Labs: 121, 142, 143, 145, 358, 374
- Priority 2 Labs: 119, 127, 141
- Priority 3 Labs: 336, 338, 345, 347, 355, 363 (second phase of the project)

[15] This number is for the campus-wide lab DCV upgrade. SCI building would be a portion of this.

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The construction start date is the first week of February 2021 and the work is currently in progress, expected to be completed in the first quarter of FY21-22.

The work is currently underway to implement the similar measure in the lab-intensive ASC and FIPKE buildings.

5.2 Recommissioning study for the Arts building

UBCO Energy Team has put forward an incentive application to perform a Recommissioning (RCx) study for the ARTS building. SES Consulting has been contracted to provide support in performing this recommissioning for the ARTS building. This study is expected to identify deficiencies in the operation of the buildings that were wasting energy, increasing equipment wear and tear, or decreasing occupant comfort. This is the study and further measure implementation is expected to save 58,900 kWh Electricity and 130 GJ Natural Gas per year equivalent to 7 tonnes CO2e.

5.3 Recommissioning study for the RHS building

FortisBC funded recommissioning (RCx) study for Reichwald Health Sciences Centre (RHS) Building was completed by Prism Engineering in March 2020. This study identified deficiencies in the operation of mechanical systems and related controls, and determined opportunities for corrective action and other improvements that reduce energy consumption and demand as well as increase building comfort. The report identified electricity savings of 4.7 MWh, Natural gas savings of 1,958 GJ, and GHG reductions of 97 tCO_2e. The main issues identified are summarized as follows:

- The heat pump system is designed to meet the building heating needs at design temperature. There was an issue with the heat pump staging resulting in only 4 of 10 compressors operating. As a result, the boiler has been relied on heavily to provide supplemental heating. A review of the system found that the heat pump system is sized for design conditions, this presents an opportunity to significantly reduce GHG emissions in the building
- Many zones such as lecture theatres, offices, multipurpose rooms, etc. have highly variable occupancy. Currently the zones operate according to a building schedule. Energy consumption can be reduced through demand control ventilation (DCV) to align ventilation with occupancy.
- Other recommended measures

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ECM	Measure	Demand Savings (kW)	Electrical Savings (kWh)	Fuel Savings (GJ)	Total Cost Savings ($)	Budget Retrofit Costs ($)	Simple Payback (yrs)
5.1	Revise Heat pump control	-71	-122,446	1,949	-$2,500	$12,900	n/a
5.2	Revise Boiler Plant Control	-	53,537	0	$3,748	$3,800	1.2
5.3	Revise Theatre AHU Standby Mode	-	8,009	0	$561	$3,900	8.0
5.4	Zone Isolation	-	23,013	0	$1,611	$9,100	6.5
5.5	Reduce Atrium AHU-1 Operation	-	30,273	0	$2,119	$2,700	1.5
5.6	schedule DHW pump	-	1,261	9	$161	$600	4.3
5.7	Holiday Calendar	-	11,071	0	$775	$1,100.00	1.6
	Total		**4,717**	**1,958**	**$6,500**	**$39,250**	**6.1**
	2018 Data		**1,351,543**	**2187**	**$130,831**		
	% Savings		0.3%	90%	5%		

Johnson Controls has been contracted to implement some of the RCx recommendations as per the study which include the reprogramming and onsite testing. The RCx measures implementation is currently underway and will be reviewed once completed.

5.4 Recommissioning study for the UCH building

FortisBC funded recommissioning (RCx) study for Upper Campus Health (UCH) building was completed by Prism Engineering in February 2020. This study identified deficiencies in the operation of mechanical systems and related controls, and determined opportunities for corrective action and other improvements that reduce energy consumption and demand as well as increase building comfort. The report identified electricity savings of 8.7 MWh, Natural gas savings of 176 GJ, and GHG reductions of 8.8 tCO_2e. The main issues identified are summarized as follows:

- The main AHU was observed to be operating with excessive outdoor air and unable to maintain its supply air temperature setpoint. End to end checks and verification of functionality is required
- VAV boxes were overridden and calling for heating during unoccupied periods
- OS warm-up was not configured correctly resulting in excessive heating operation
- The heating plant is enabled excessively during unoccupied periods
- The building control system was observed to lose communication frequently. This hindered the ability to review the system, and may explain some of the deficiencies observed. It is recommended that the communication issue be addressed
- Other recommended measures

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ECM	Measure	Demand Savings (kW)	Electrical Savings (kWh)	Fuel Savings (GJ)	Total Cost Savings ($)	Budget Retrofit Costs ($)	Simple Payback (yrs)
5.1	Adjust Weekly Schedule and OS Warm-up	-	3,325	-32	-$10	$500	
5.2	Implement Standby Mode	-	500	10	$130	$3,500	26.9
5.3	Schedule Environment Canada Office	-	1,450	9	$195	$800	4.1
5.4	Restore VAV Box Control	No energy savings or costs associated with this measure					
5.5	Recommission AHU	-	0	71	$260	$3,000	11.5
5.6	Revise Boiler SWT setpoint	-	0	29	$250	$700	2.8
5.7	Revise Heating Plant Enable		3,000	0	$530	$500	0.9
5.8	Revise NSB Control		0	60	$300	$1,400	4.7
5.9	Holiday Schedule		520	29	$200	$200	1.0
	Total		**8,795**	**176**	**1,855**	**10,600**	**5.7**
	2018 Data		201,123	1,146	$28,202		
	% Savings		4%	15%	7%		

Kimco Controls Ltd. has been contracted to implement some of the RCx recommendations as per the study which include the reprogramming and onsite testing. The RCx measures implementation is currently underway and will be reviewed once completed.

5.5 Recommissioning study for the EME building

FortisBC funded recommissioning (RCx) study for Engineering, Management and Education (EME) building was completed by Prism Engineering in December 2020. This study identified deficiencies in the operation of mechanical systems and related controls, and determined opportunities for corrective action and other improvements that reduce energy consumption and demand as well as increase building comfort. The report identified electricity savings of 494.6 MWh, Natural gas savings of 233 GJ, and GHG reductions of 11.6 tCO_2e. The main issues identified are summarized as follows:

- Zones such as lecture theatres, offices, multipurpose rooms, etc. have highly variable occupancy. Currently the zones operate according to a building schedule, or no schedule at all. Energy consumption can be reduced through demand control ventilation (DCV) to align ventilation with occupancy.
- Due to load variation in the building, during heating months some heat pumps are used for cooling. The natural gas boilers fire to meet the shortage of heat pump heating capacity. Increased free cooling would allow more units to be in heating.
- DDC graphics are missing some equipment and trends
- Other recommended measures

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ECM	Measure	Demand Savings (kW)	Electrical Savings (kWh)	Fuel Savings (GJ)	Total Cost Savings ($)	Budget Retrofit Costs ($)	Simple Payback (yrs)
5.1	Adjust Weekly Schedule & Revise Optimal Start	-	49,434	-	$4,078	$100	0.0
5.2	Holiday Schedule	-	9,639	-	$795	$100	0.1
5.3	Implement AHU Standby Mode & Demand Controlled Ventilation	-	114,145	-	$9,417	$7,000	0.7
5.4	Schedule HRV-1 & HRV-2	-	154,196	-	$12,721	$100	0.0
5.5	Implement HRV-3 Schedule	-	137,817	-	$11,370	$100	0.0
5.6	Implement HRV-3 Static Pressure Reset	-	4,451	-	$367	$2,000	5.4
5.7	Enable Exhaust Fan 26	-	-	-	-	$300	-
5.8	Control EF-22 and EF-23 On Room Temperature	-	-	-	-	$500	-
5.9	Increase LDES Free Cooling	-	0	-	$2,045	$34,800	17.0
5.10	Revise LDES CV Control	-	24,983	233	$2,061	$1,000	0.5
5.11	Revise DDC Graphics	-	-	-	-	$3,000	-
	Total		**494,665**	**233**	**$42,855**	**$49,000**	**1.1**
	2018 Data		4,699,552	7,919	$418,321.27		
	% Savings		11%	3%	10%		

Siemens Controls Ltd. has been contracted to implement some of the RCx recommendations as per the study which include the reprogramming and onsite testing. The RCx measures implementation is currently underway and will be reviewed once completed.

5.6 Nechako Commons Kitchen Equipment

Nechako Commons is a new residence building with a large cafeteria and other campus amenities included. Energy Team has been working with the Project Manager UBC Properties Trust and contractors to apply for eligible FortisBC incentives for the kitchen equipment[16]. Energy Team identified additional $10,000 of eligible rebate for Nechako Commons cafeteria which brings the total to $24,000 of rebate for the appliances in Nechako Commons.

5.7 Lighting Upgrades

Upgrades of campus lighting to LED fixtures is ongoing. The majority of LED upgrades that are believed to be cost effective have been implemented. However, availability of cost-effective LED lamps continues to increase. As this occurs further areas on campus are targeted for upgrades. Upgrades also occur during renovations. FortisBC rebate for the LED upgrades completed in FY20-21 was around $7,000 in point-of-sale rebate and around $6,000 in prescriptive rebate which is expected to save over 100,000 kWh (conservative estimate) per year.

[16] Food services (Nechako kitchen and convenience store) was out of scope of the modelled energy performance of the building based on which FortisBC's new construction rebate application was approved.

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5.8 Monashee Mechanical Upgrade

140-ton Variable Refrigerant Flow (VRF) heat pump was installed at Monashee Residence during the summer season of 2020. This led to significant drop in gas consumption for the building. A 66% gas reduction was observed for Monashee Residence compared to 43% reduction for other Residences for the period. This project was eligible for FortisBC incentive and received $87,000 in rebate for the purchase of VRF heat pumps.

5.9 Monitoring improvements

A few monitoring improvements were implemented by the UBCO Energy Team which included resolving the WIFI occupancy reporting issue, working with Siemens to fix the Desigo deficiencies list and add missing trends on the key hydronic graphics.

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6 New Construction Projects

The Energy Team is involved in the design and construction process for new construction on campus. The Energy Team's goal is to ensure that the design and construction of new buildings on campus are consistent with the campus Whole Systems Plan in terms of energy targets and sources. The Energy Team also co-ordinates the pursuit of energy efficiency incentives from FortisBC. The two new major buildings Skeena and Nechako residence buildings have already been discussed in Annual FY 19-20 report. A total of $324K incentive have been approved by FortisBC for the construction of these two residence buildings.

6.1 Interdisciplinary Collaboration and Innovation (ICI)

The UBC Okanagan Campus (UBCO) is proposing a new building to facilitate world-leading, interdisciplinary/ transdisciplinary research and academic programming, and to advance its mandate as a partner in regional development. Tentatively titled the Interdisciplinary Collaboration and Innovation (ICI) building and is expected to be up to 13,364 gross square meters. Energy Team has been involved in advocating the creation of Owner's Project Requirements (OPR) for the ICI building, reviewing the schematic designs for the building and providing inputs on the energy-related standards/ benchmarks.

6.2 Innovation Precinct 1 (1540 Innovation Drive) Renovations

In 2017, UBC purchased 1540 Innovation Drive – a 1.36-acre land parcel with 24,400 sq. ft. warehouse/office building – at the north end of the university's future Innovation Precinct. This property is of strategic importance as it will be the first example that pairs commercial activity with UBC Okanagan research and learning. It will facilitate innovation and co-location partnerships with local technology companies, support graduate student needs, and help address the shortage of academic space at UBC Okanagan.

The building is being renovated to accommodate research laboratory facilities for Engineering faculty, studio space for Faculty of Creative and Critical Studies Master of Fine Arts students, an industry-UBC partnership research centre, and shared collaborative space.

Energy Team identified $10,000 of prescriptive rebate that equipment installed in Innovation Precinct # 1 was eligible for. We have been working with the Project Manager UBC Properties Trust and contractors Falcon Engineering to apply for an eligible FortisBC incentive for the renovations.

6.3 University House Renovations

UBCO is currently working on renovating its existing U-House building. The intent is to co-locate CORM departments as much as possible and maximize opportunities for collaboration and productive collisions. The scope of work is currently being developed and Energy Team will be working to apply for an eligible incentive for the renovations through FortisBC.

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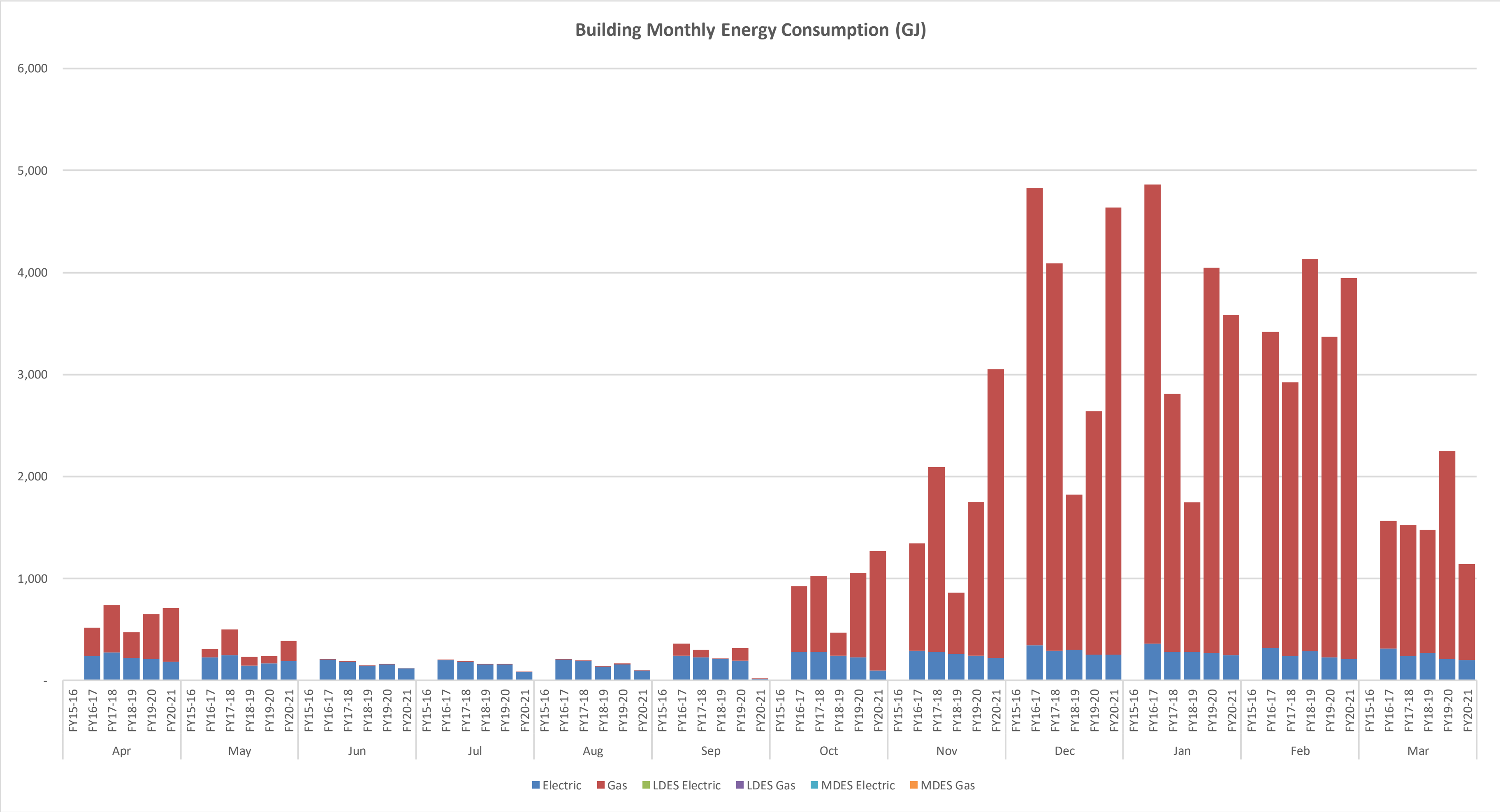
6.4 UBC Okanagan's Downtown site

The UBC Okanagan Campus (UBCO) is proposing a new building. Planning is underway for UBC Okanagan's downtown Kelowna site with a number of community-accessible facilities being considered, including a new public gallery, creative innovation spaces, and a public engagement and learning suite.

In partnership with UBC Properties Trust, UBC is planning a new building at 550 Doyle Avenue. Once design and approvals are in place, construction is expected to begin in mid-2022.

7 Monthly Energy Performance Data for Campus Buildings

7.1 Central Heating Plant building (DES)



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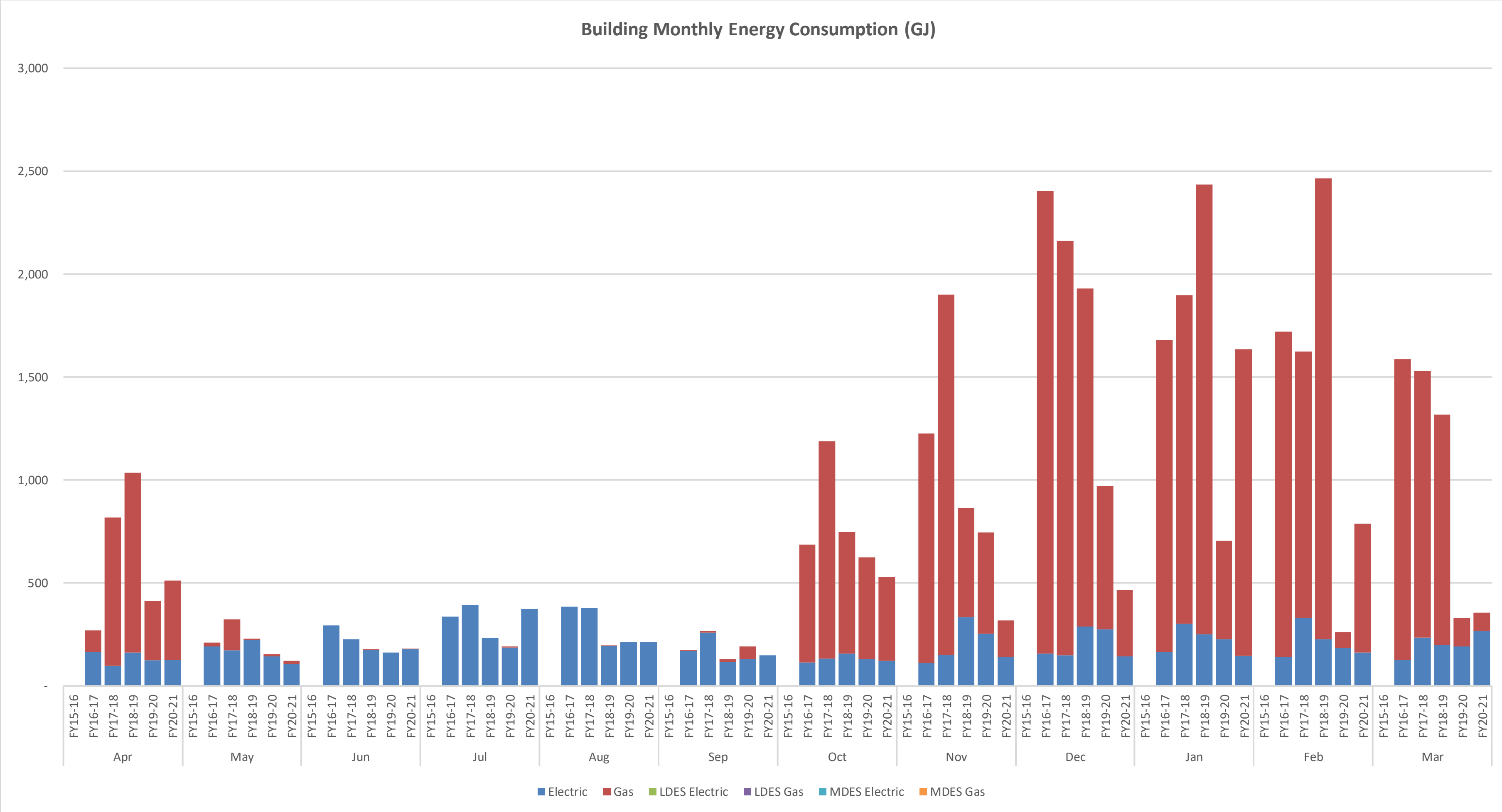
7.2 Geo-Exchange building (DES)



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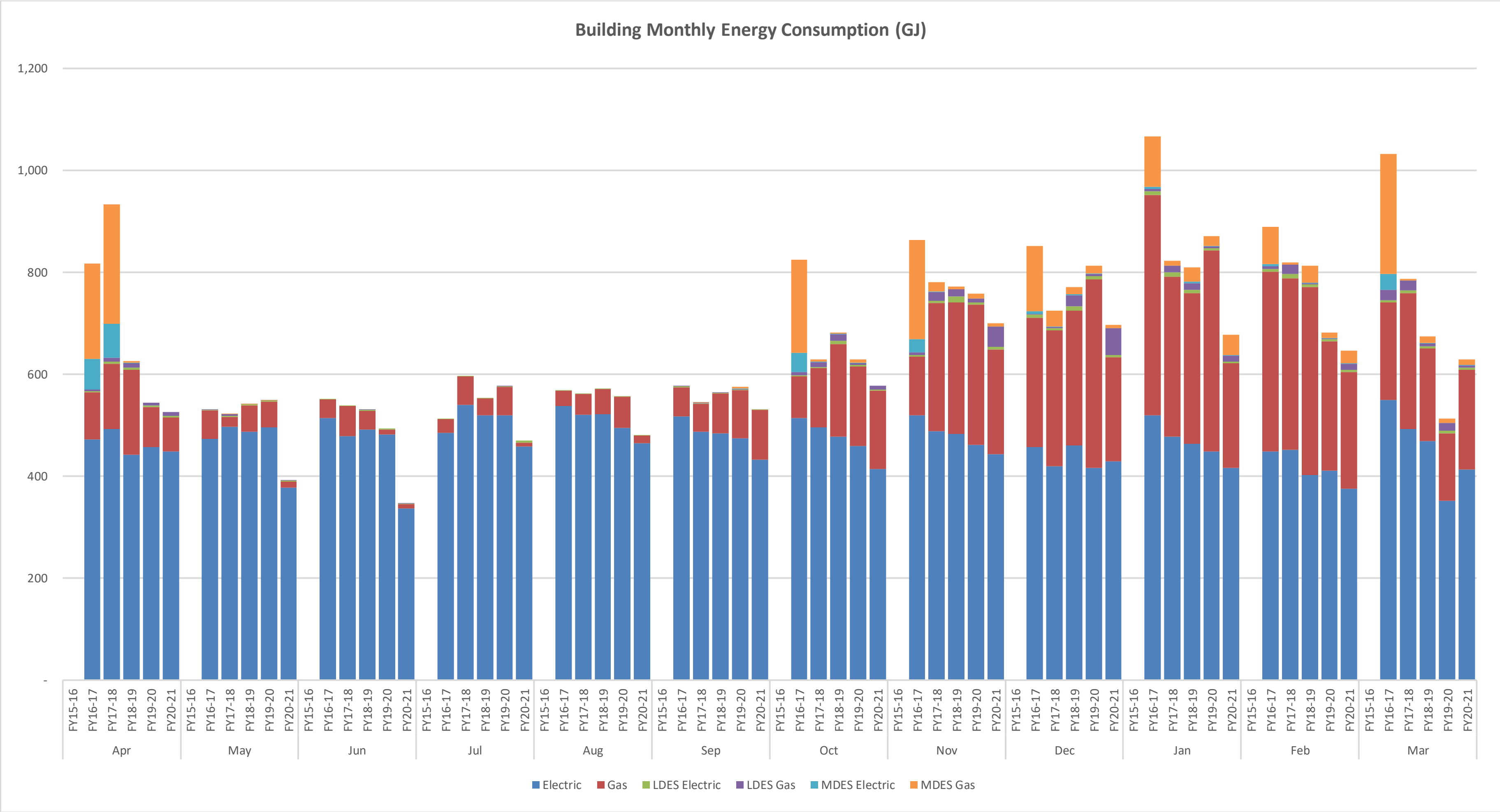
7.3 Administration building (ACAD)



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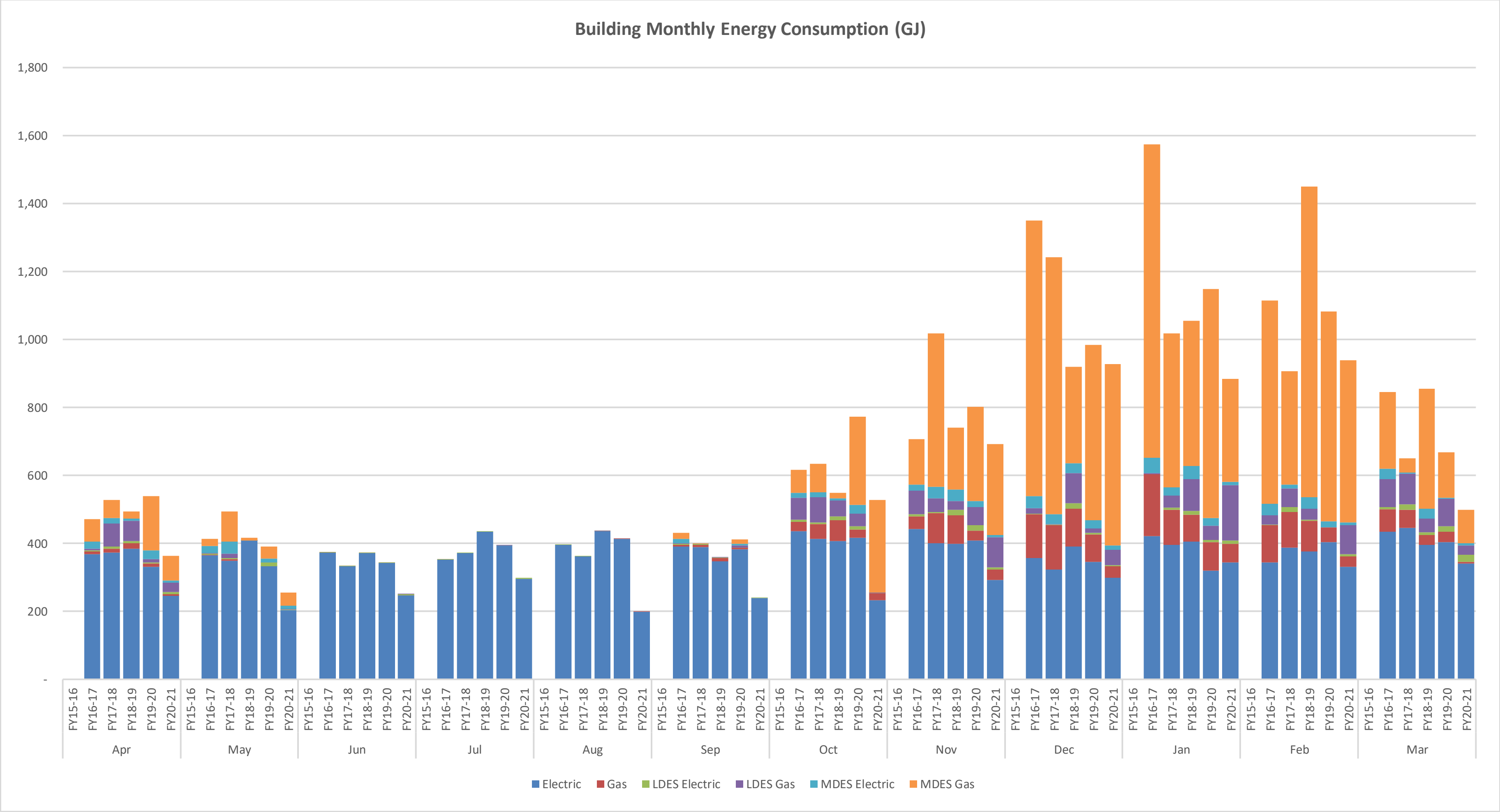
7.4 Arts building (ACAD)



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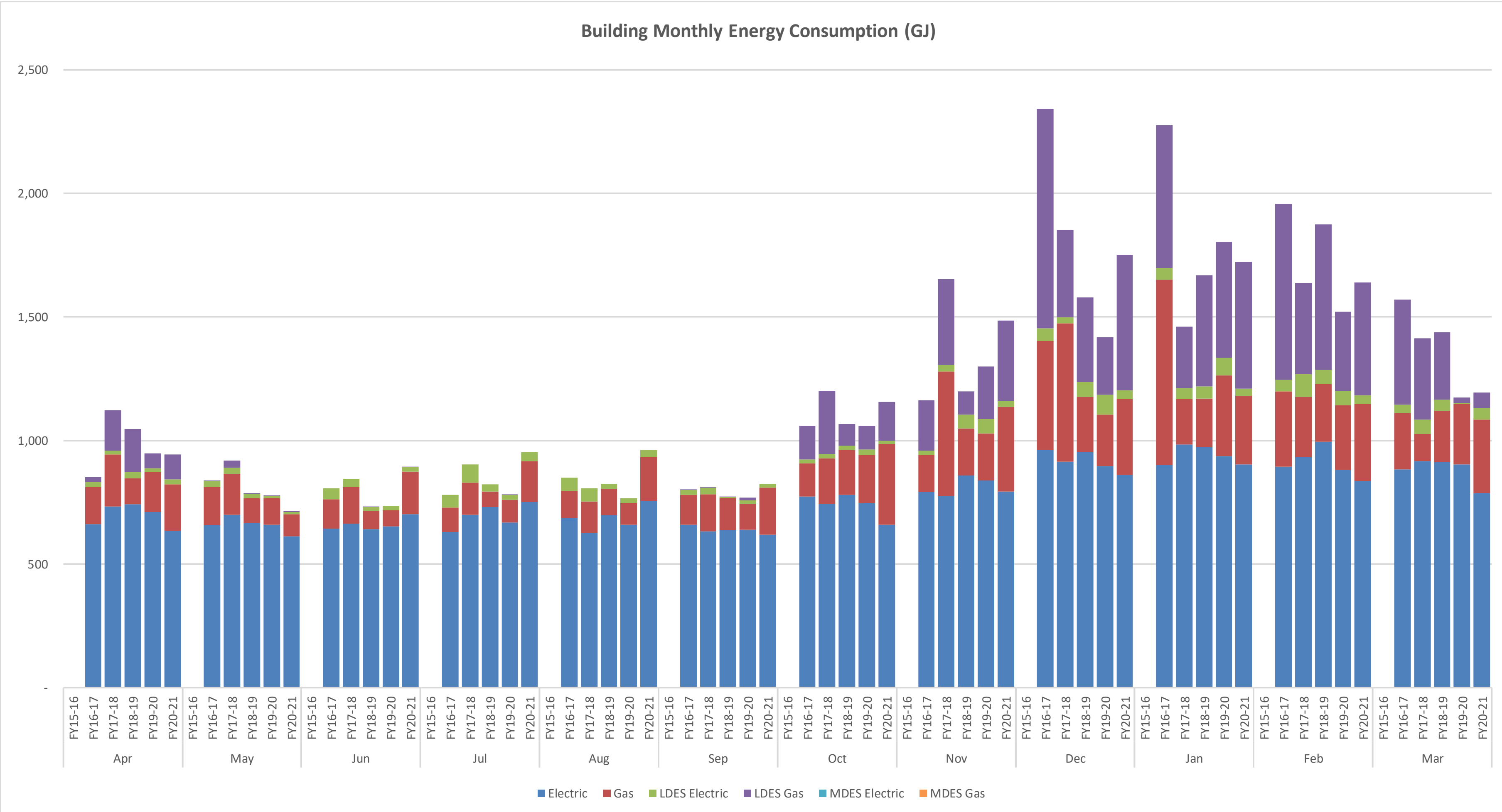
7.5 Arts & Science Centre building (ACAD)



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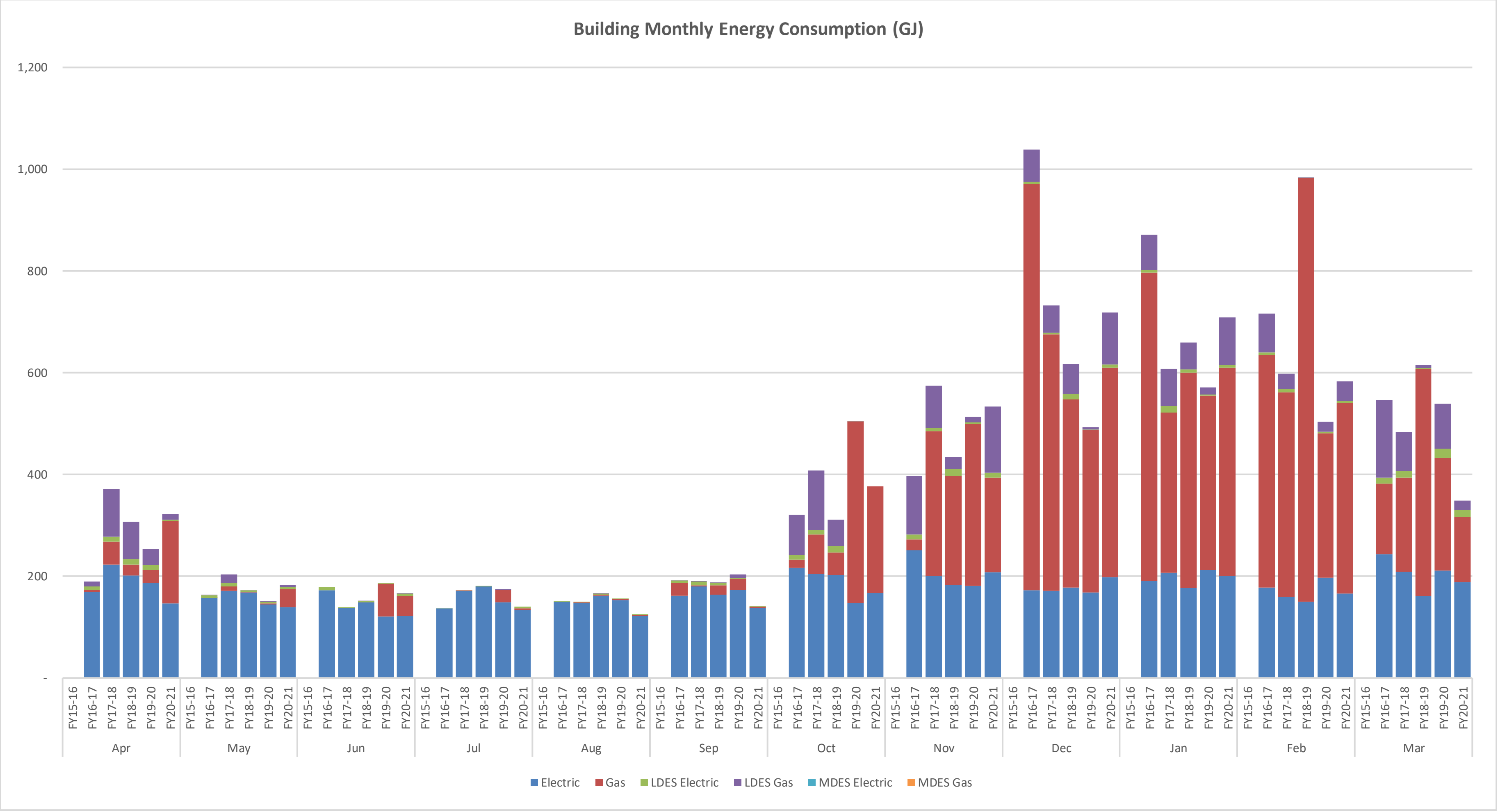
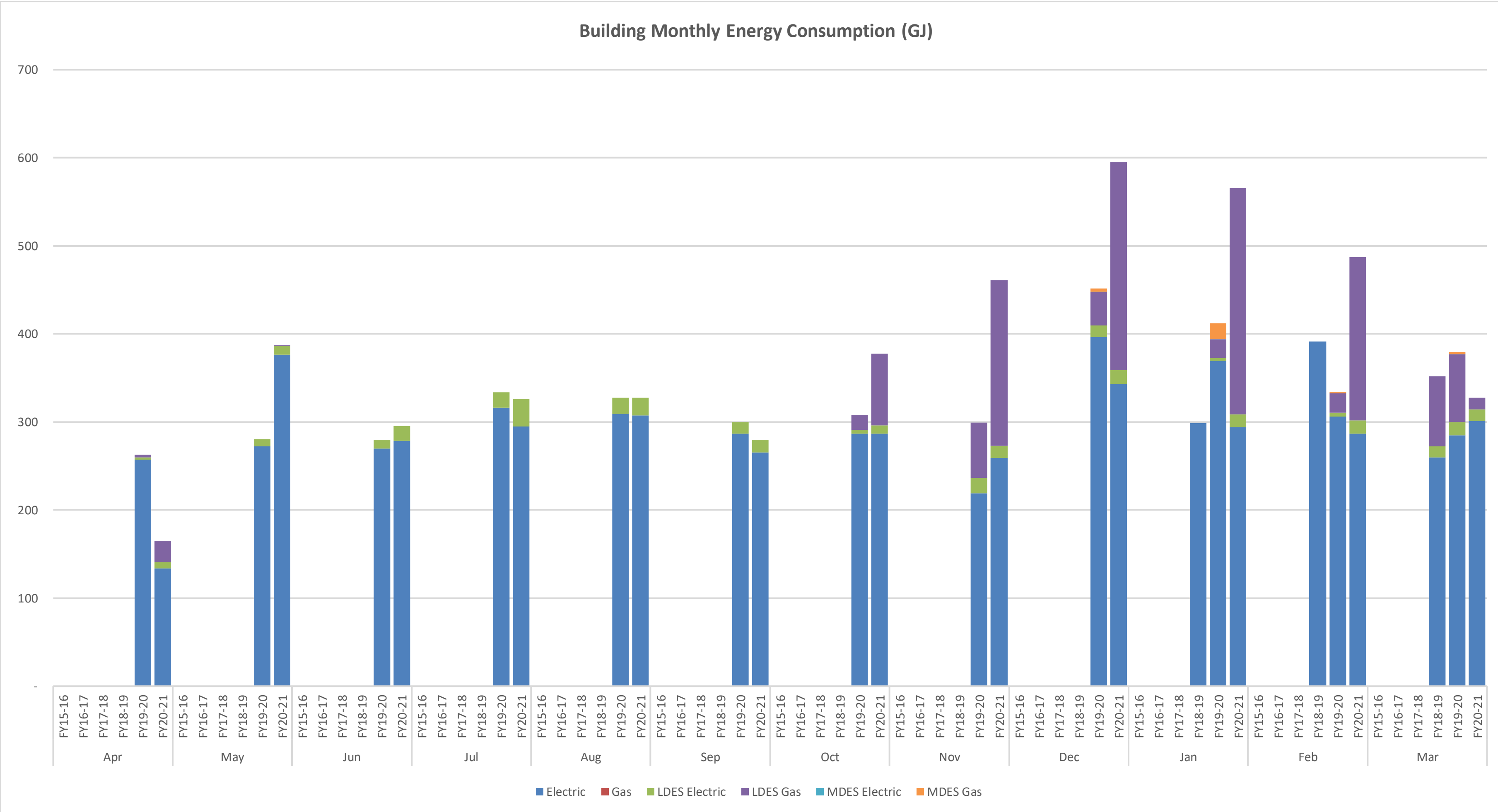
7.6 Creative and Critical Studies building (ACAD)



7.7 Teaching & Learning Centre (Commons) building (ACAD)



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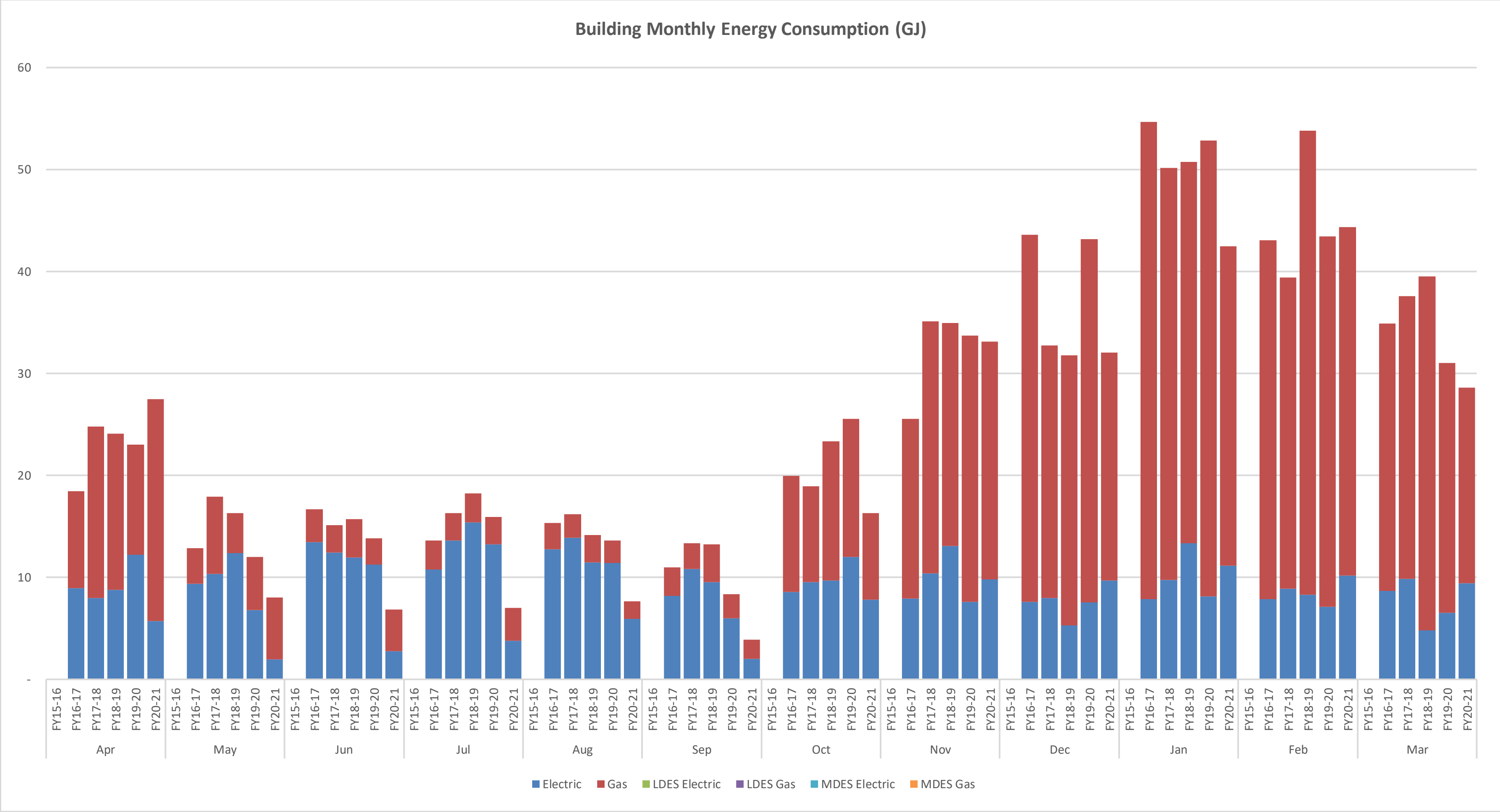
7.8 Daycare building (ACAD)



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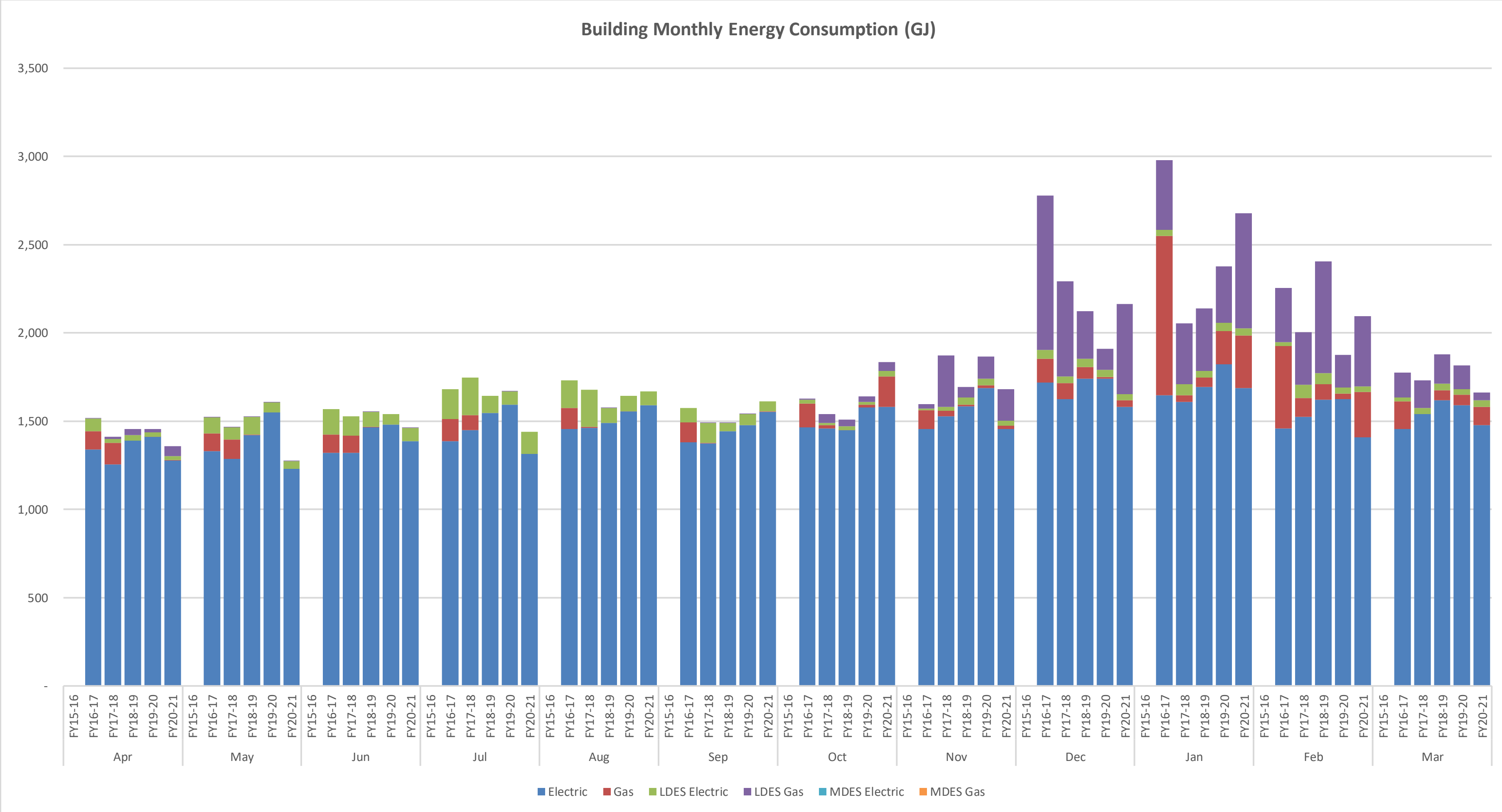
7.9 Engineering, Management and Education building (ACAD)



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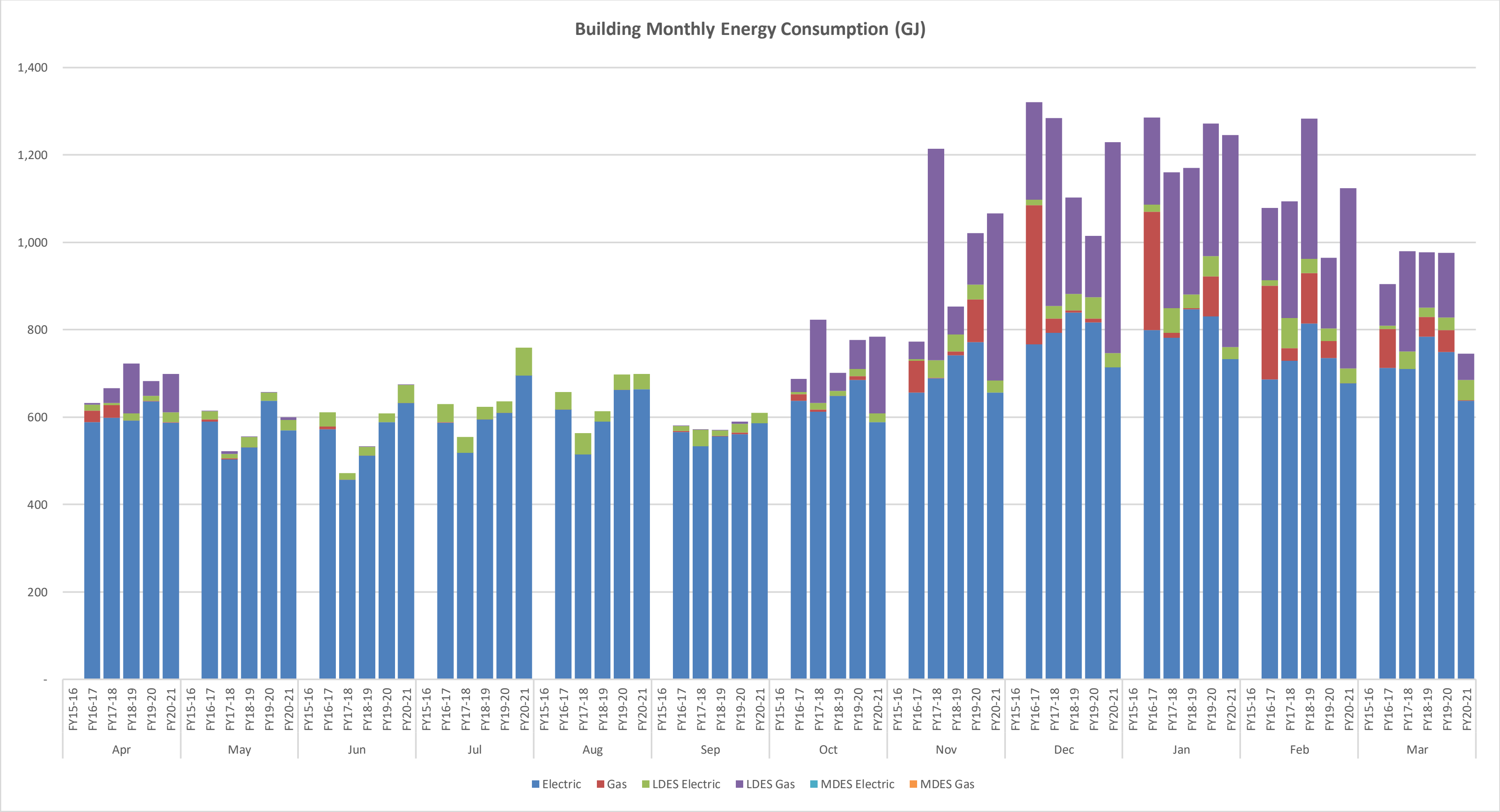
7.10 Fipke building (ACAD)



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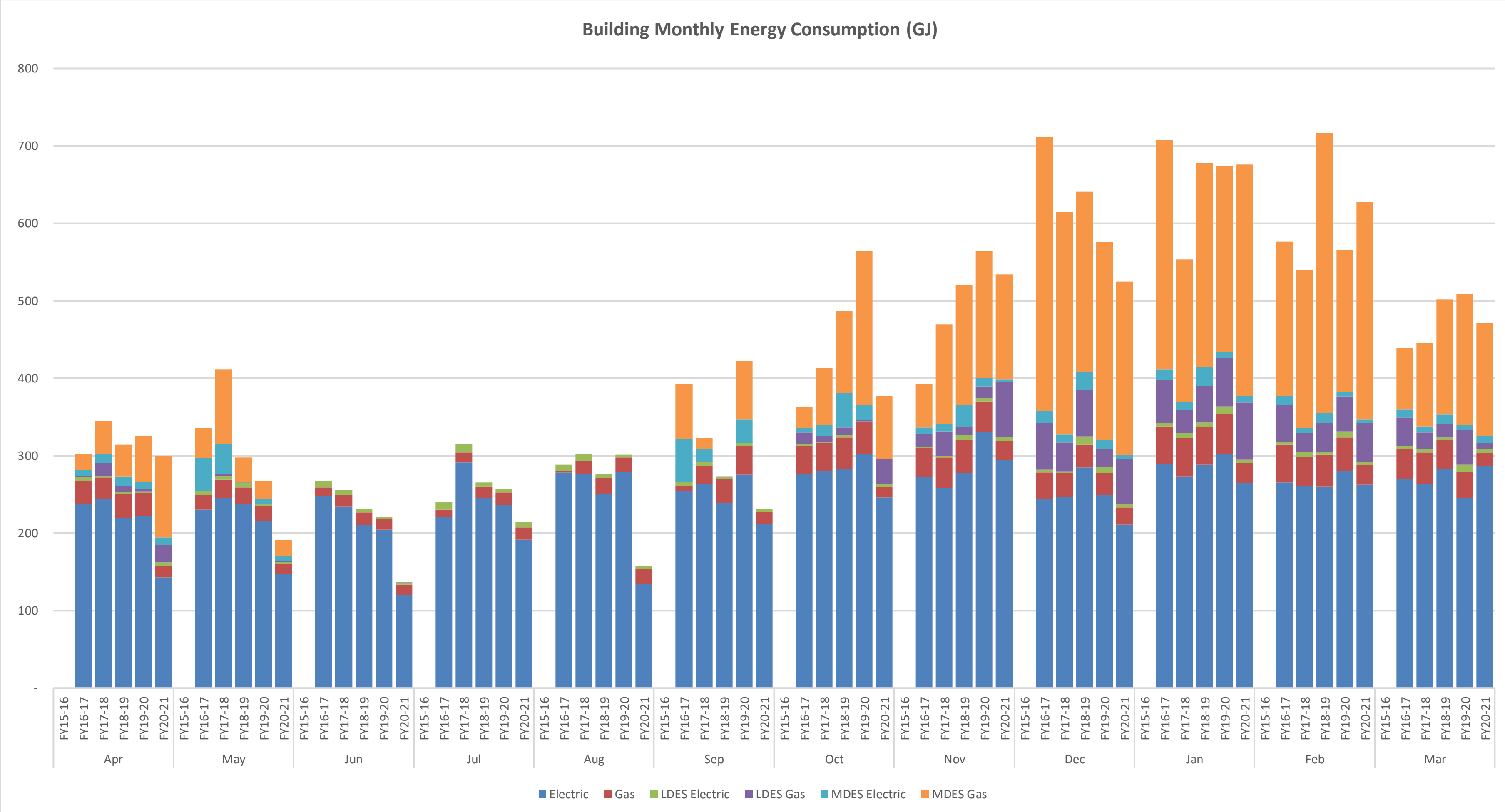
7.11 Gymnasium building (ACAD)



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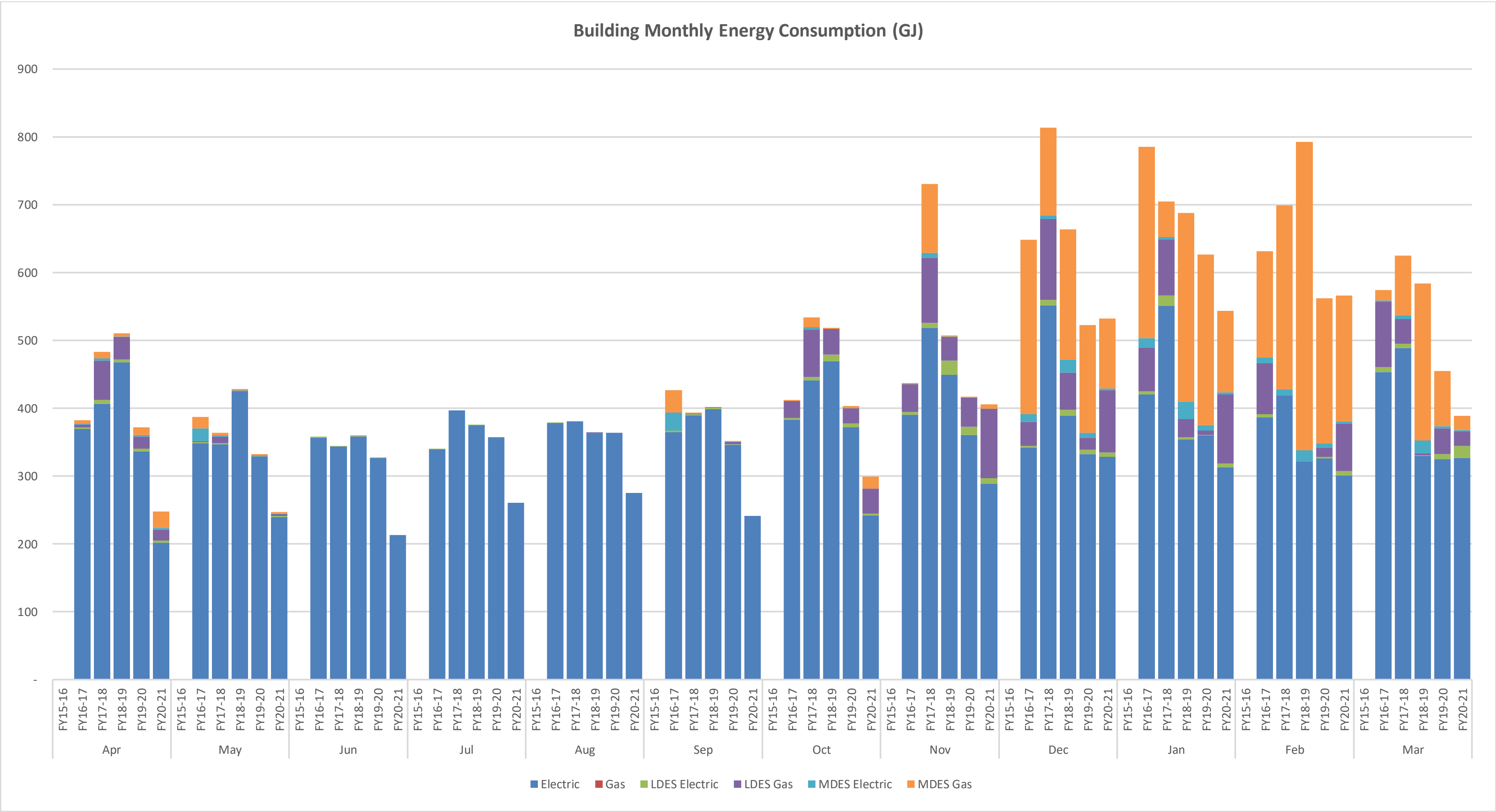
7.12 Library building (ACAD)



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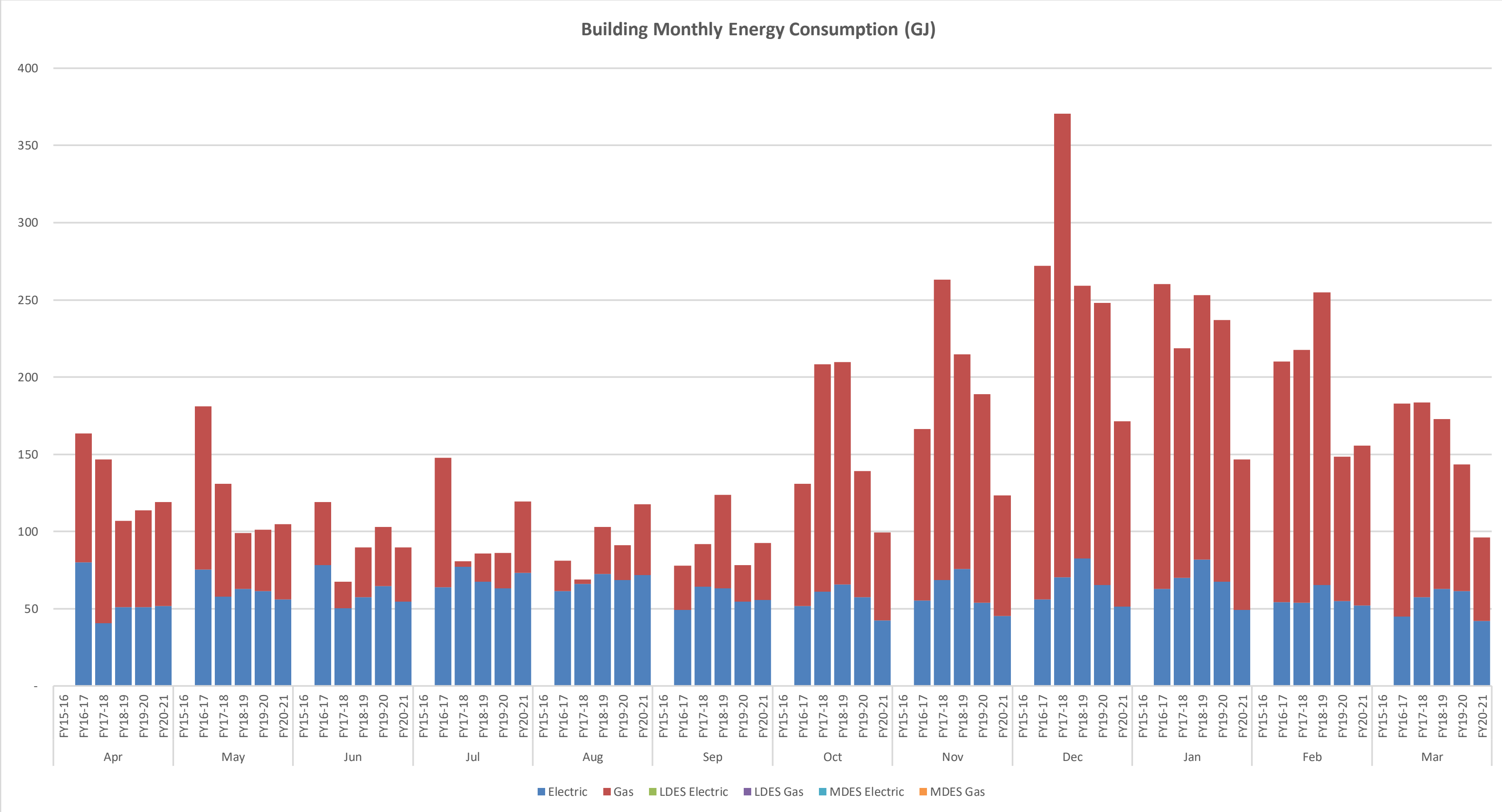
7.13 Upper Campus Health building formerly known as Mountain Weather Office (ACAD)



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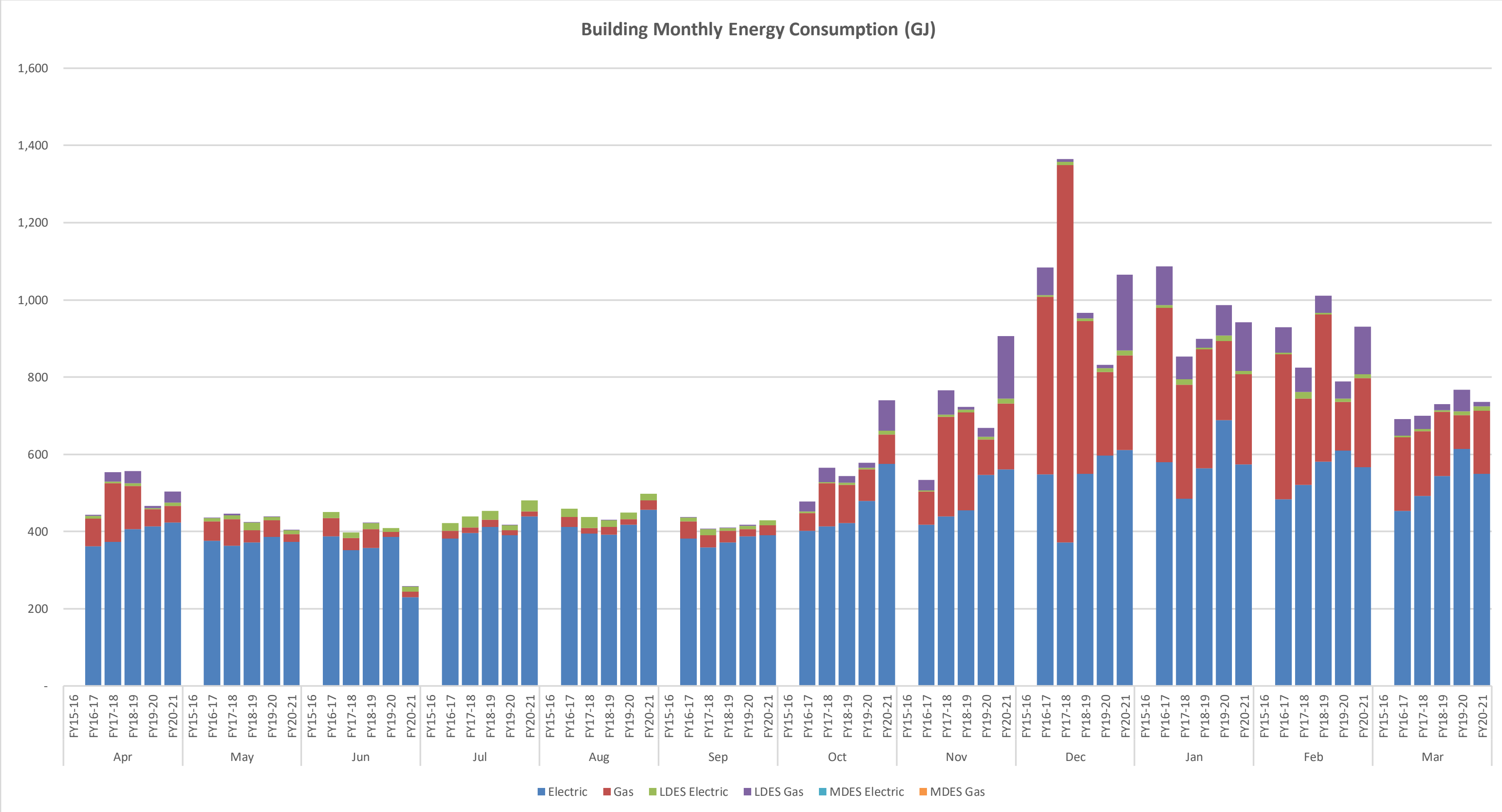
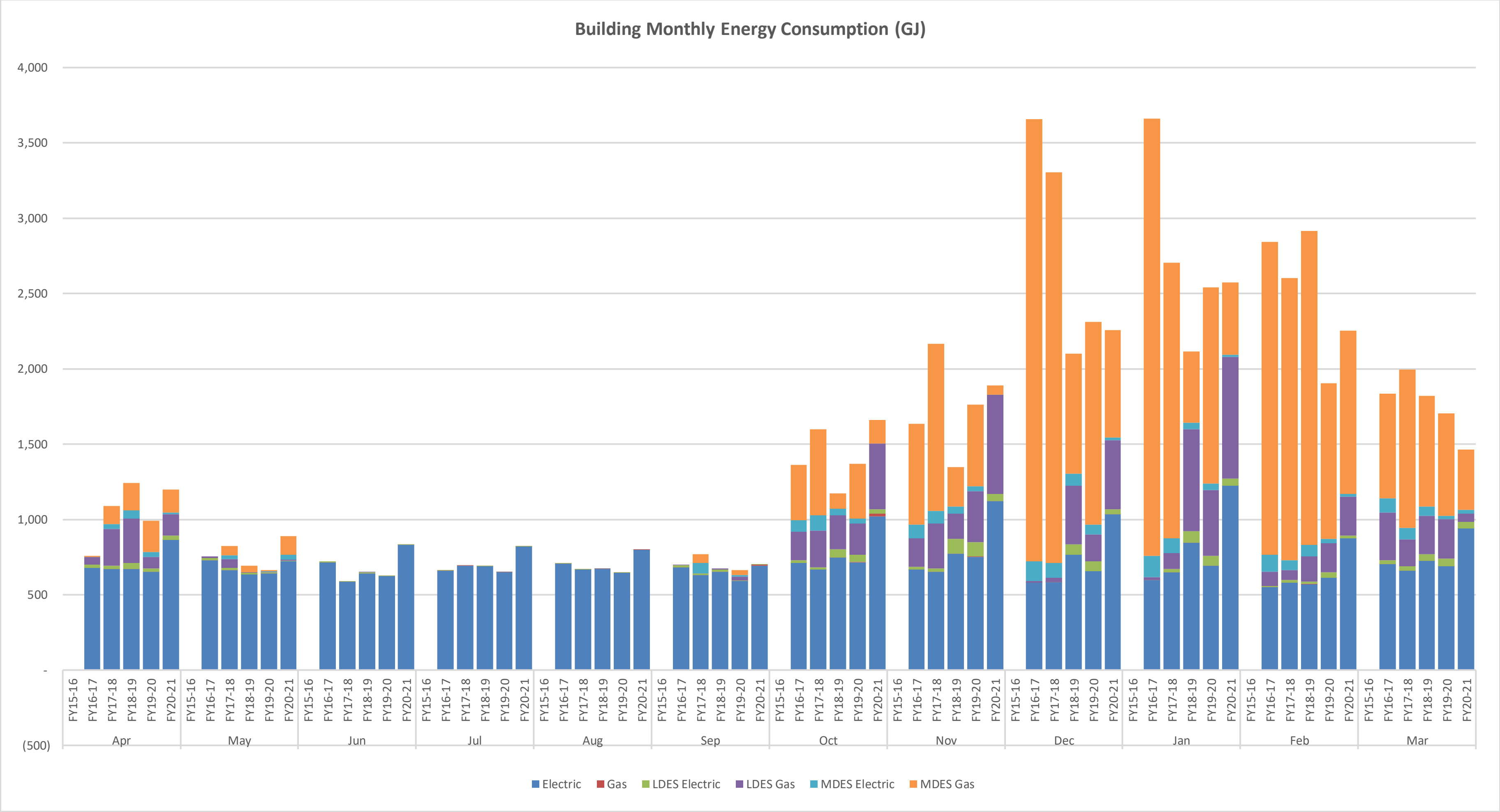
7.14 Reichwald Health Sciences Centre building (ACAD)



7.15 Science building (ACAD)



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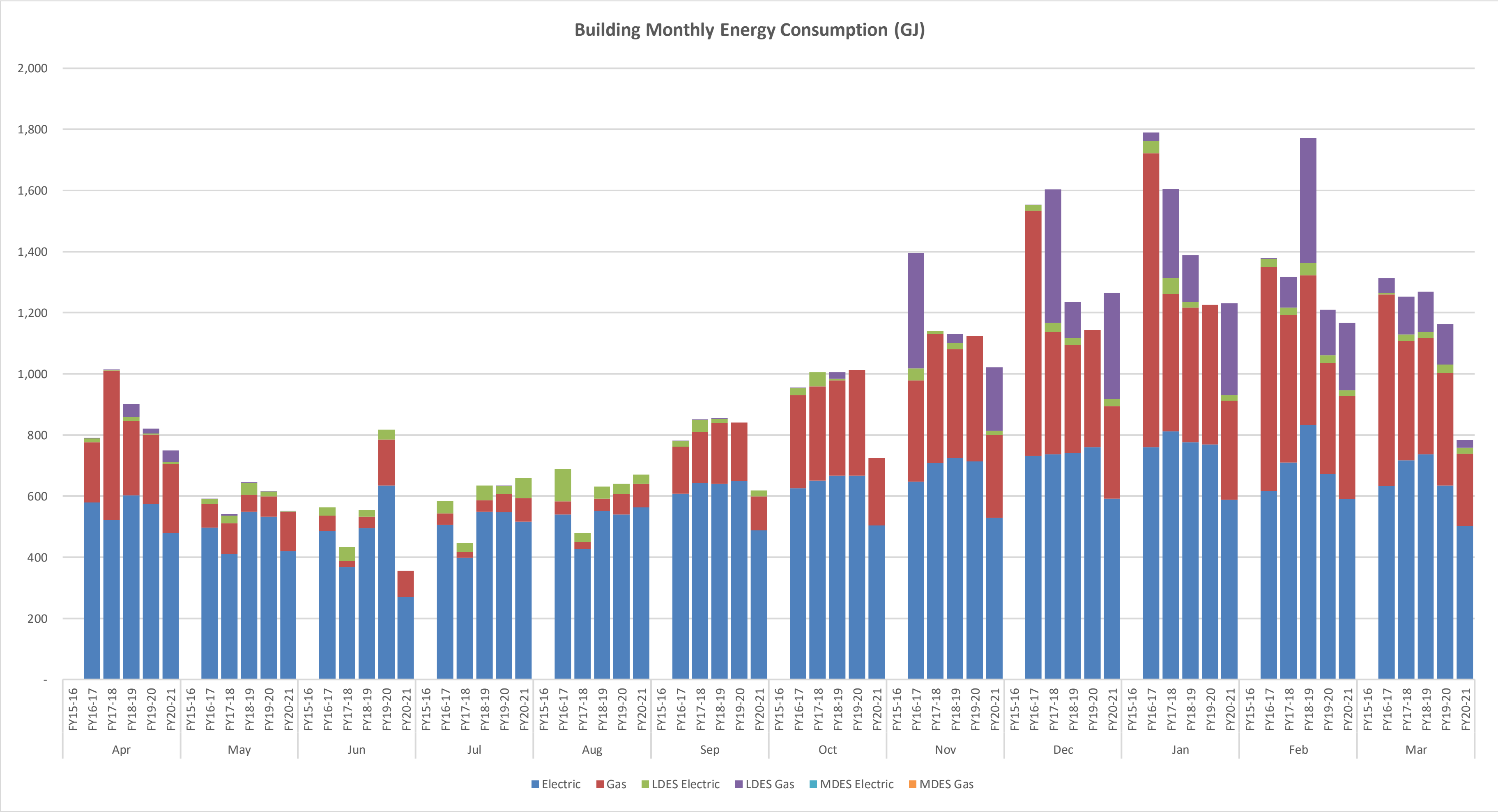
7.16 University Centre building (ACAD)



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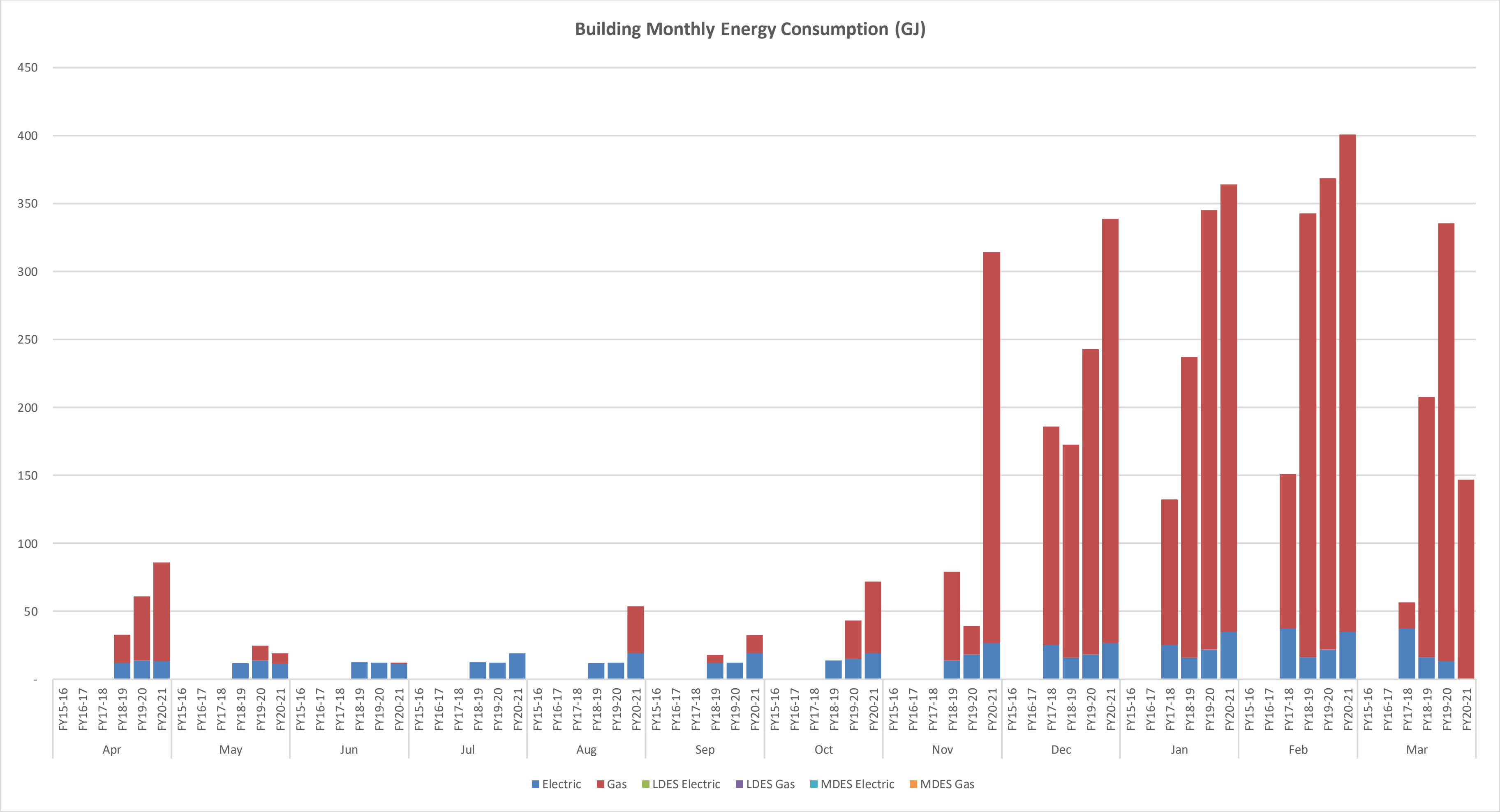
7.17 1540 Innovation Drive (IP#1) building (ACAD)



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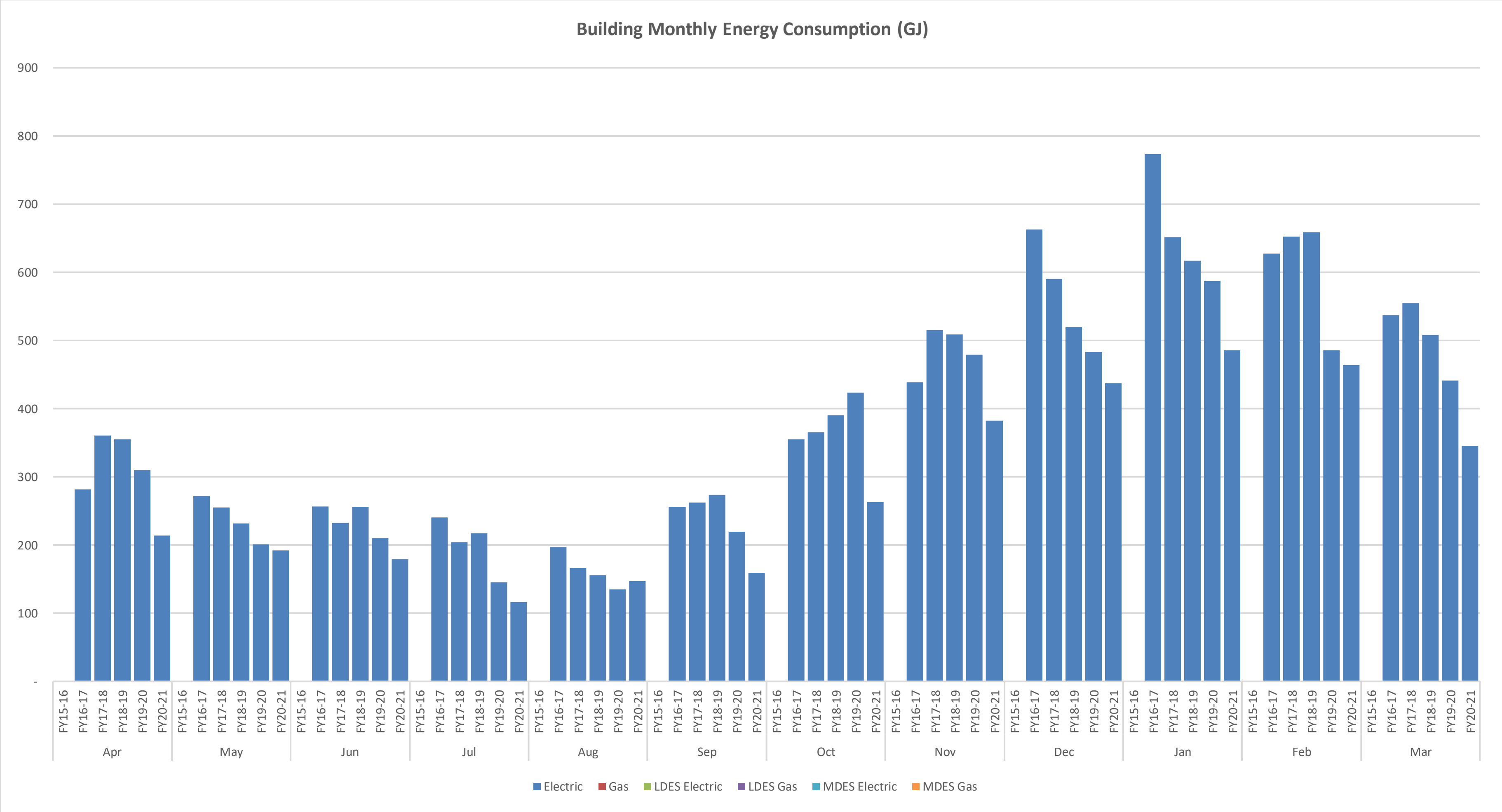
7.18 Lower Cascades Residence building



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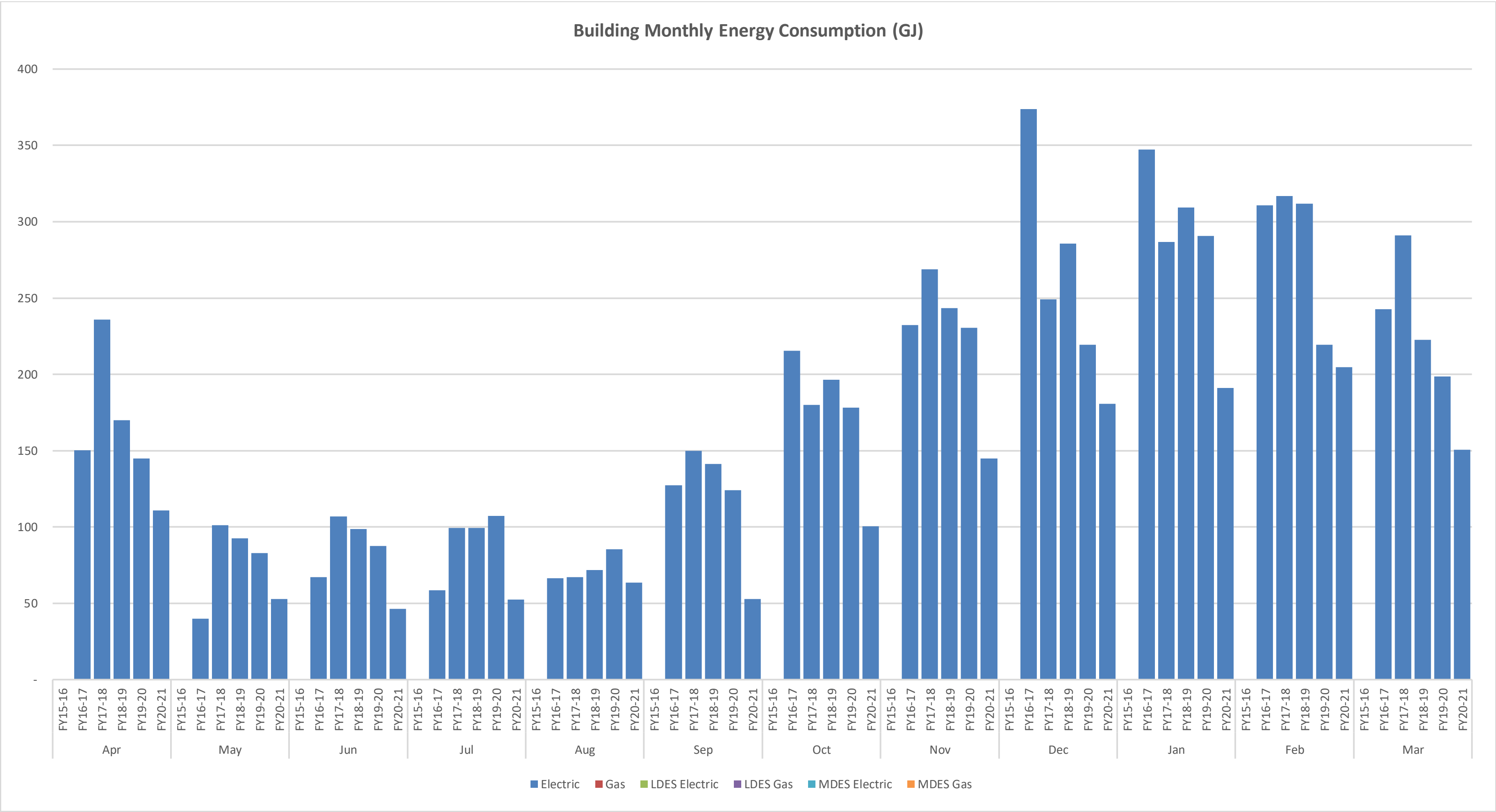
7.19 Upper Cascades Residence building



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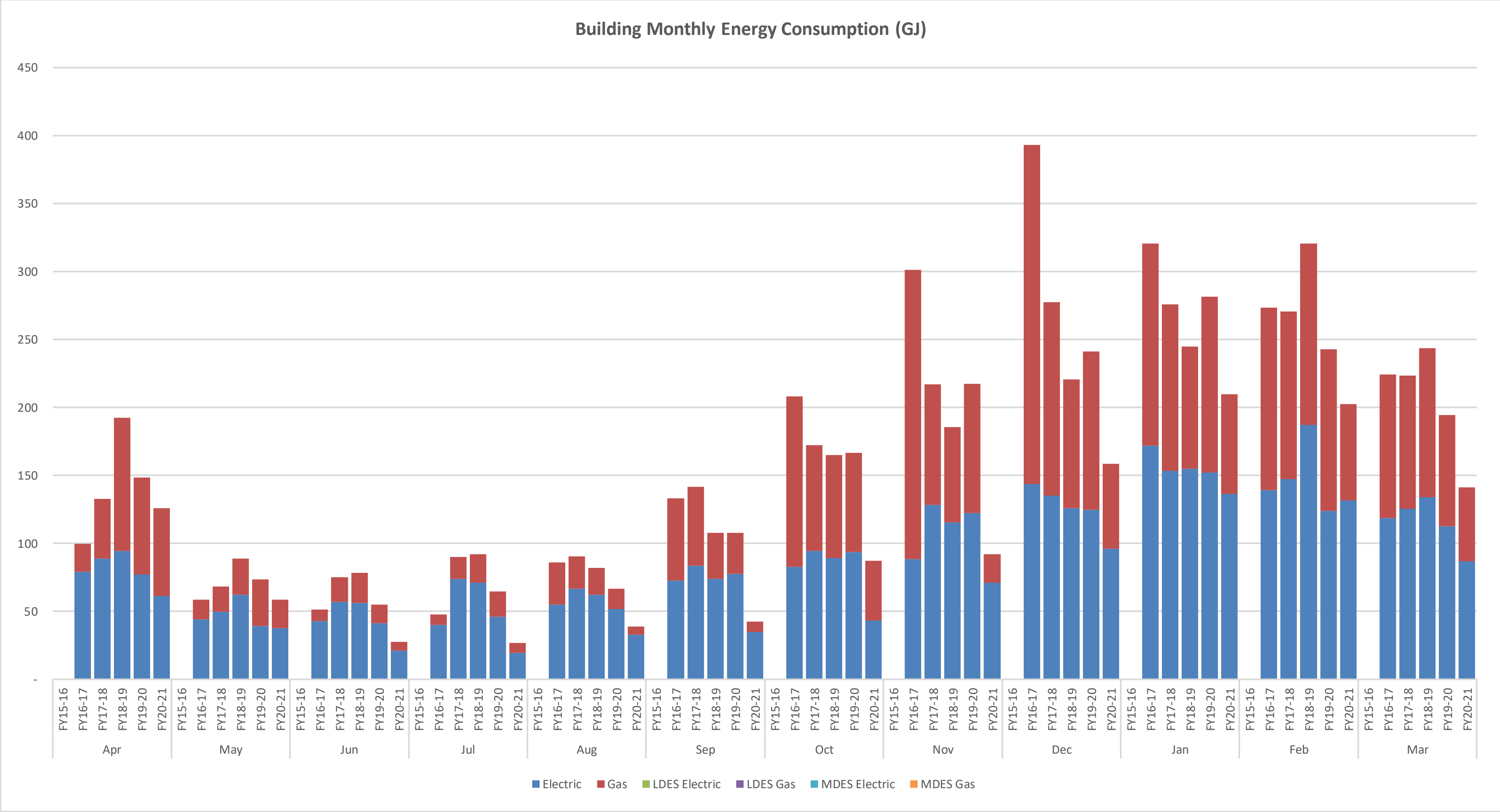
7.20 Cassiar Residence building



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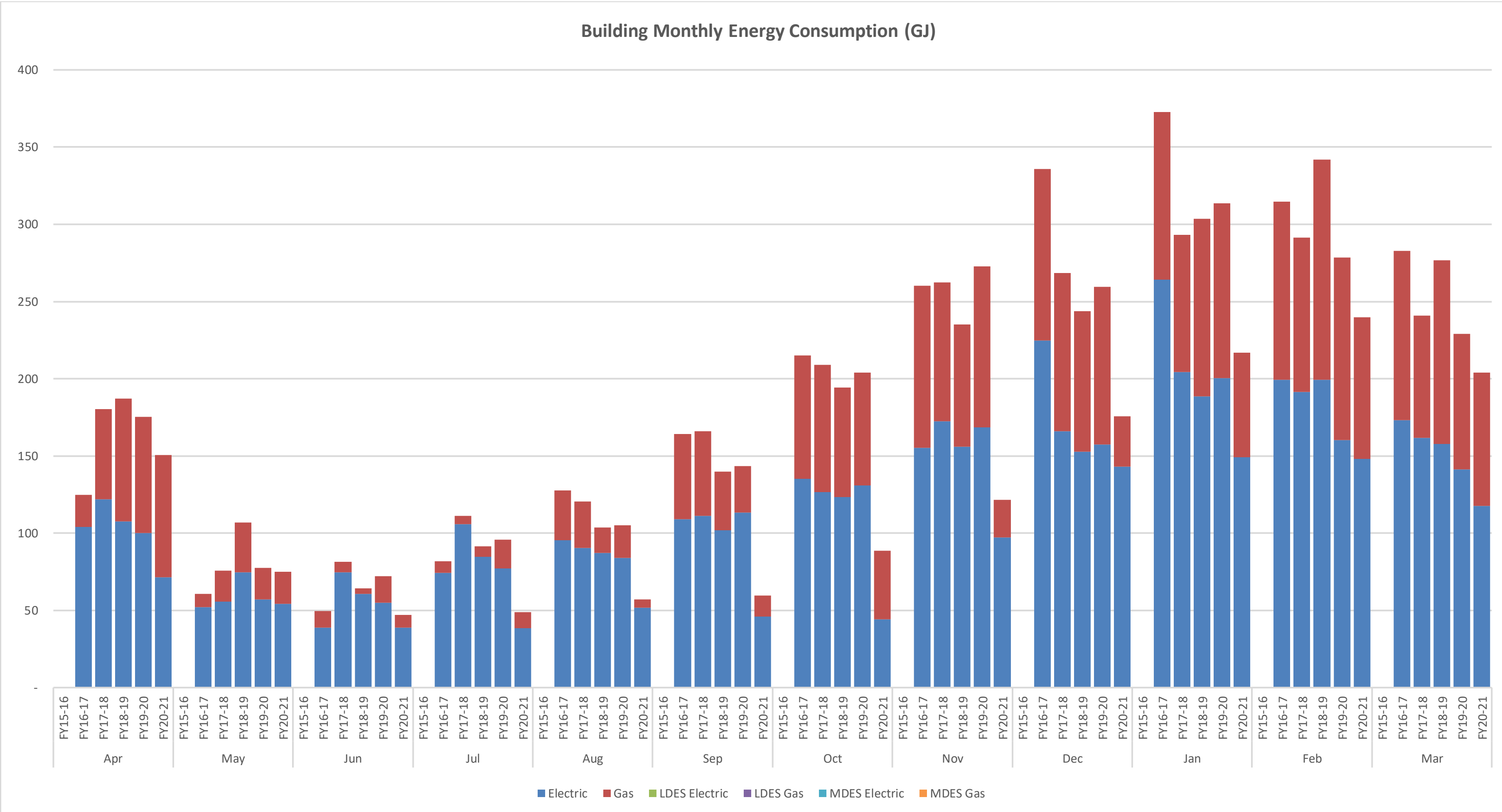
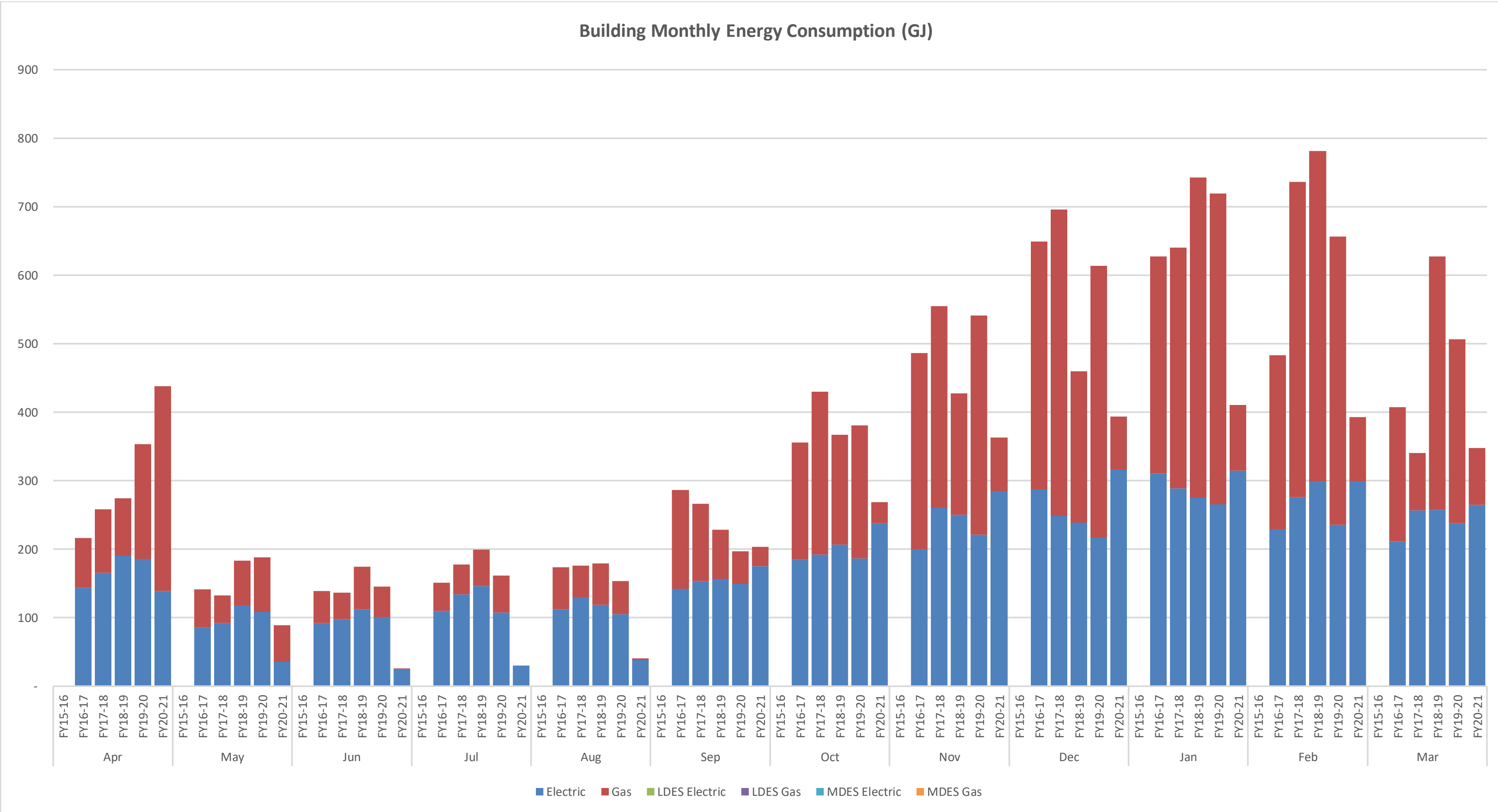
7.21 Kalamalka Residence building



7.22 Monashee Residence building



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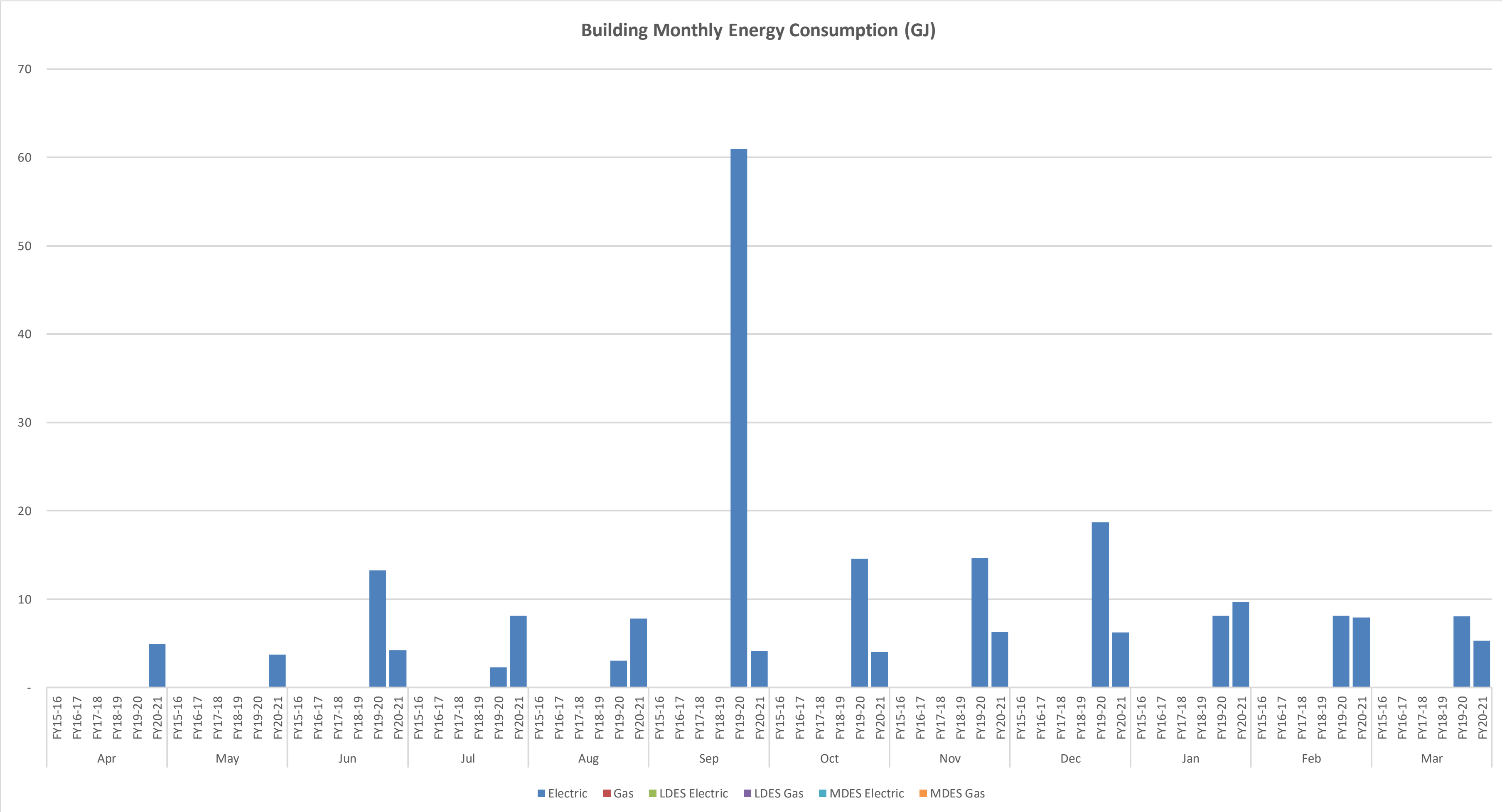
7.23 Nechako Commons Residence building



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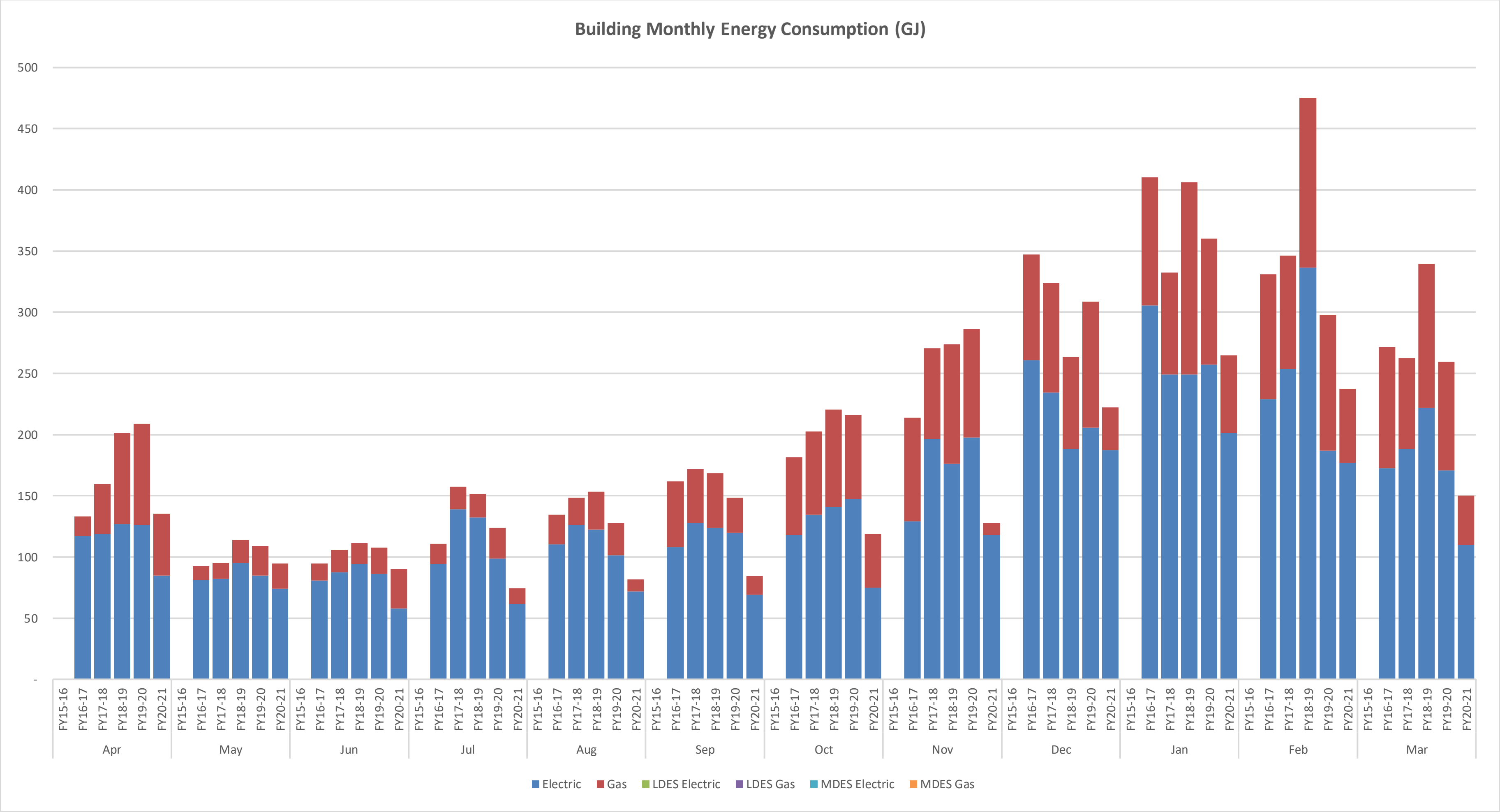
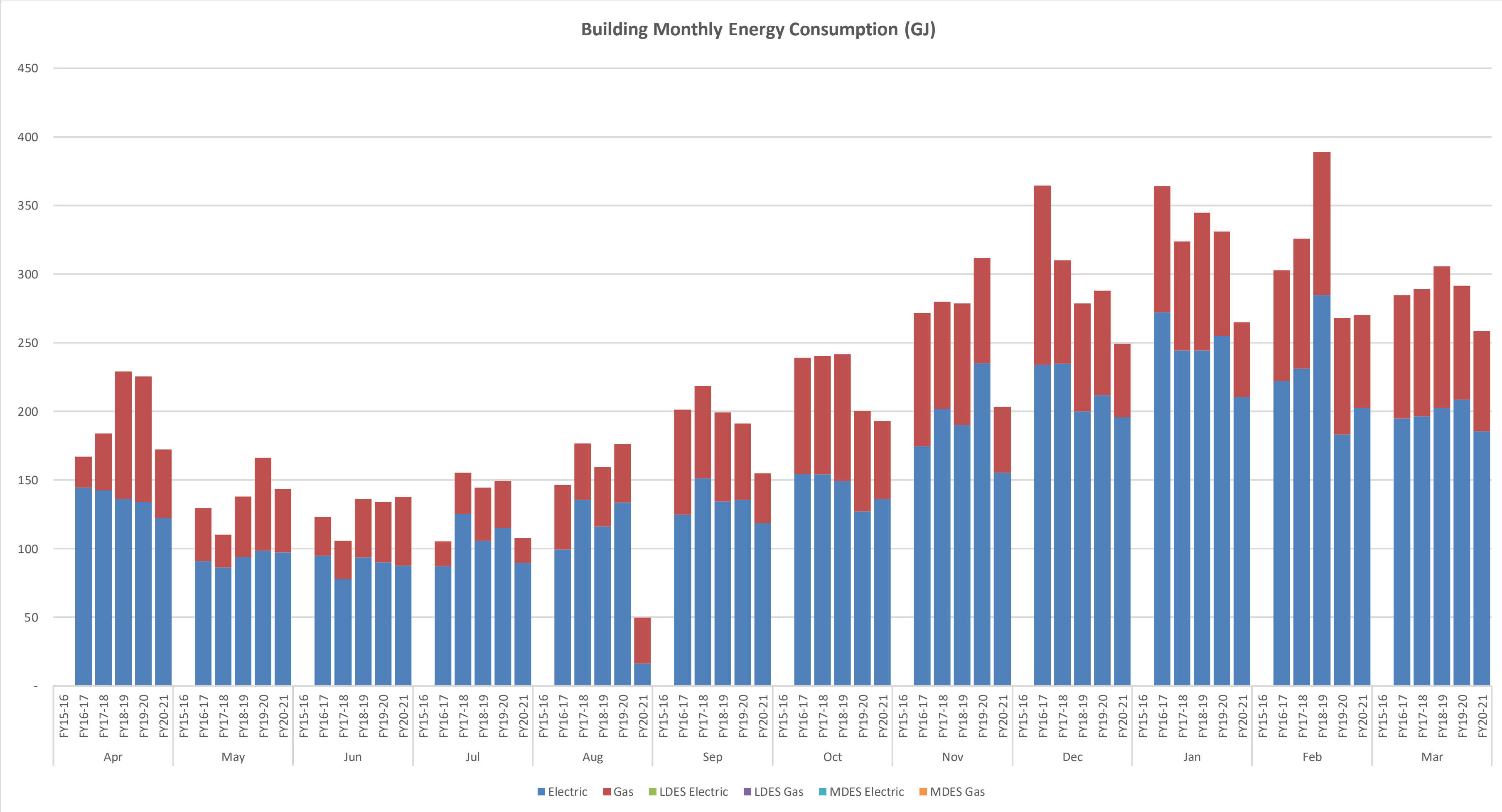
7.24 Nicola Residence building



7.25 Purcell Residence building



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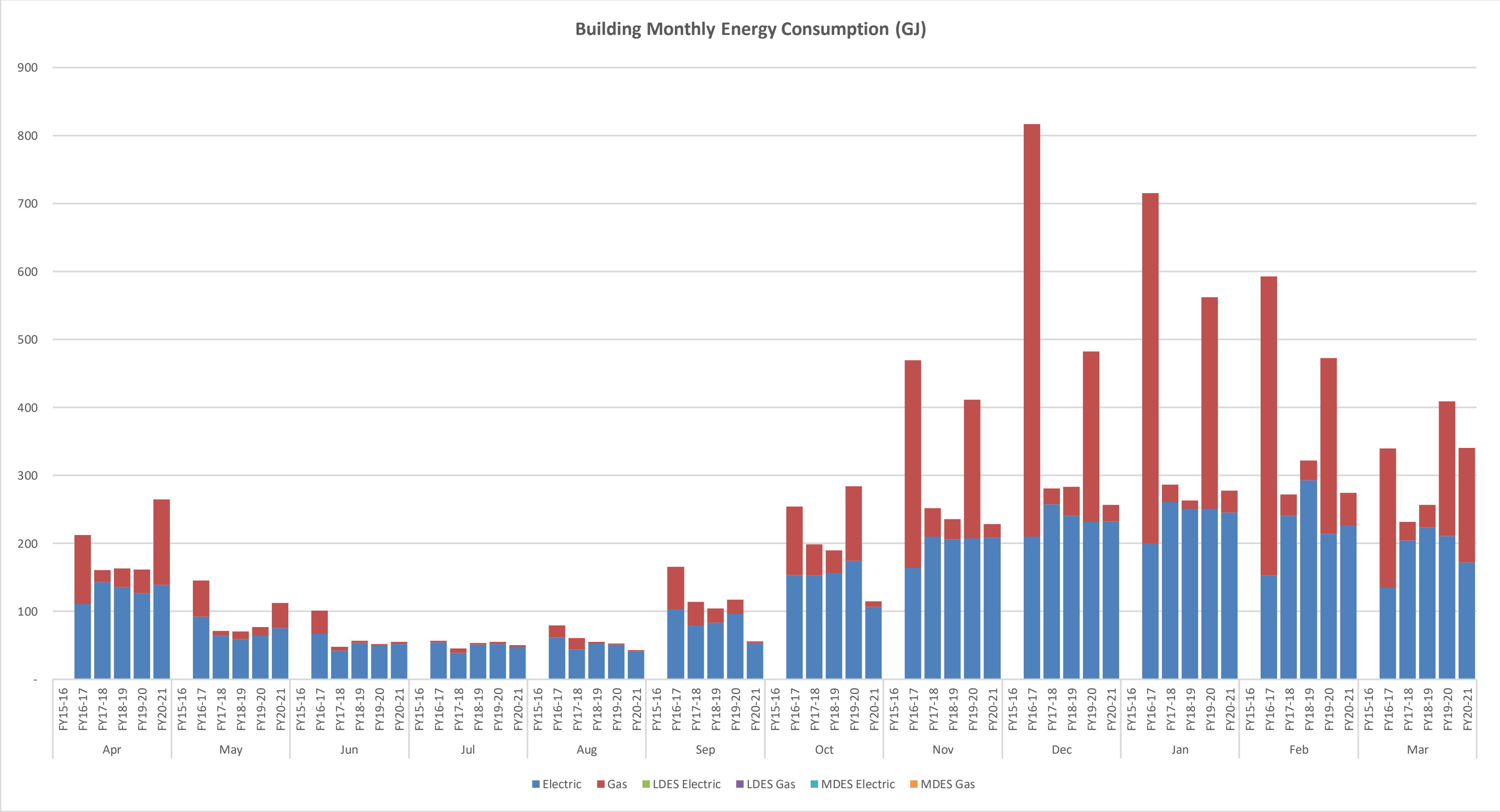
7.26 Similkameen Residence building



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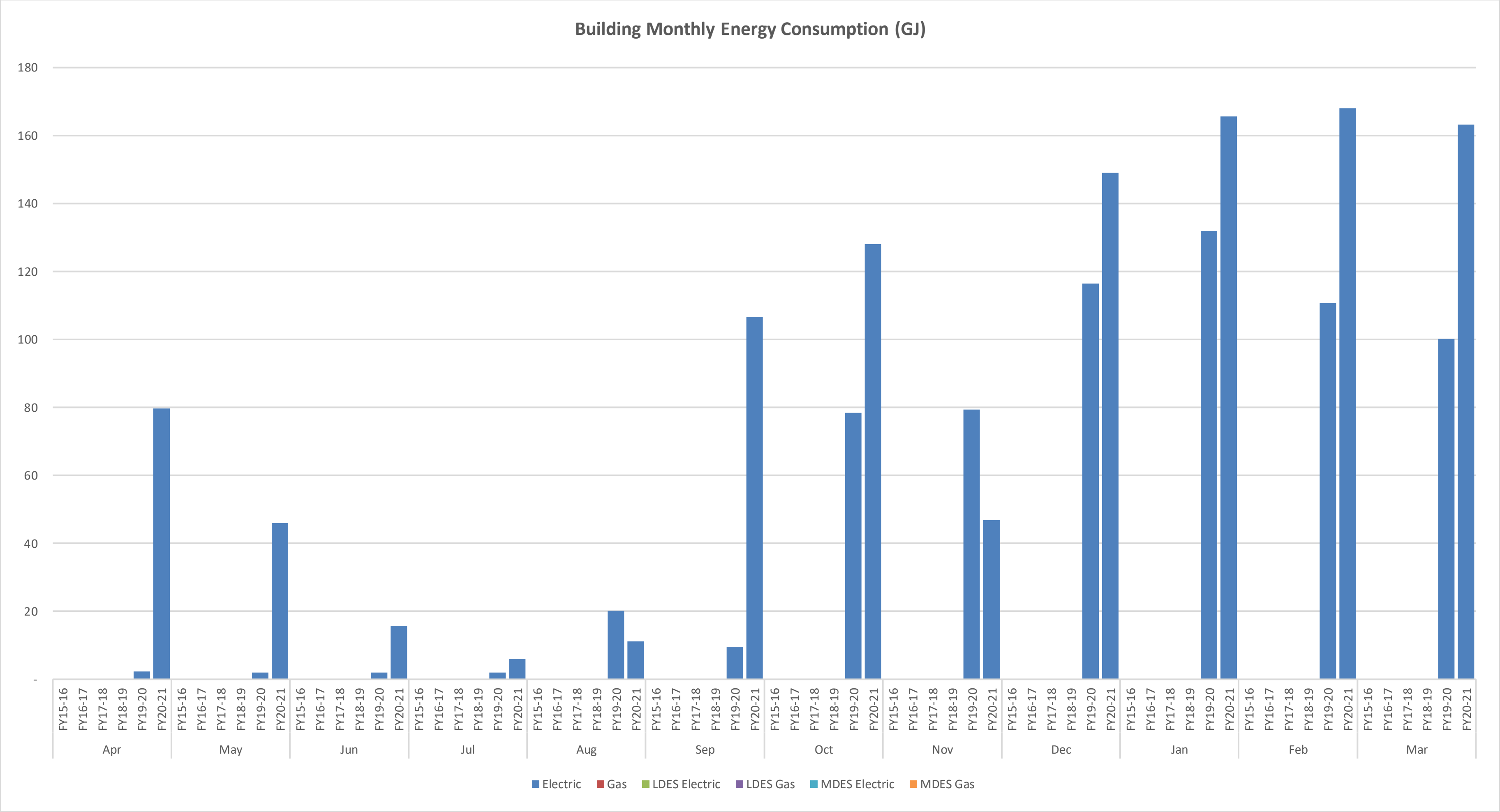
7.27 Skeena Residence building



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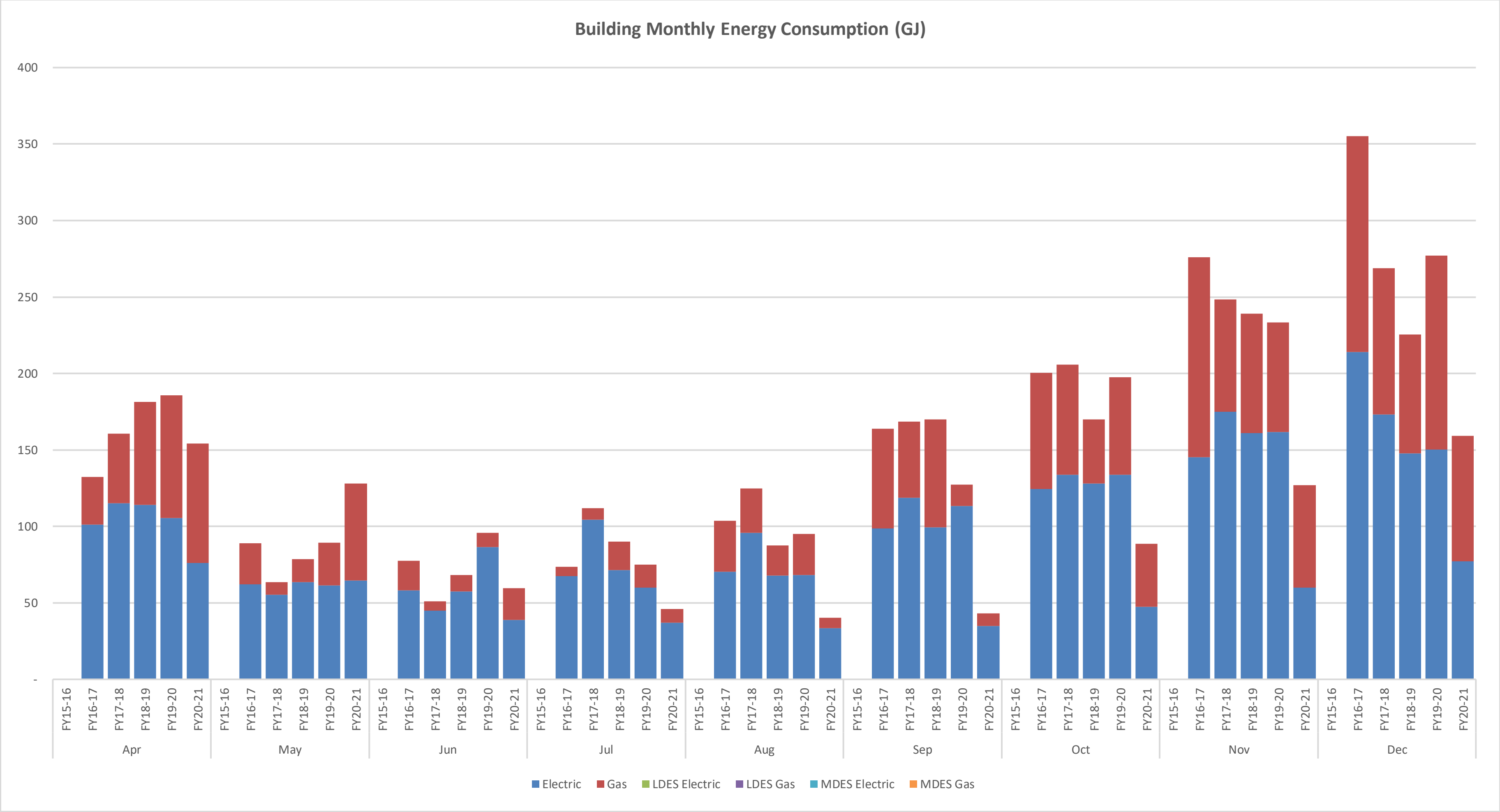
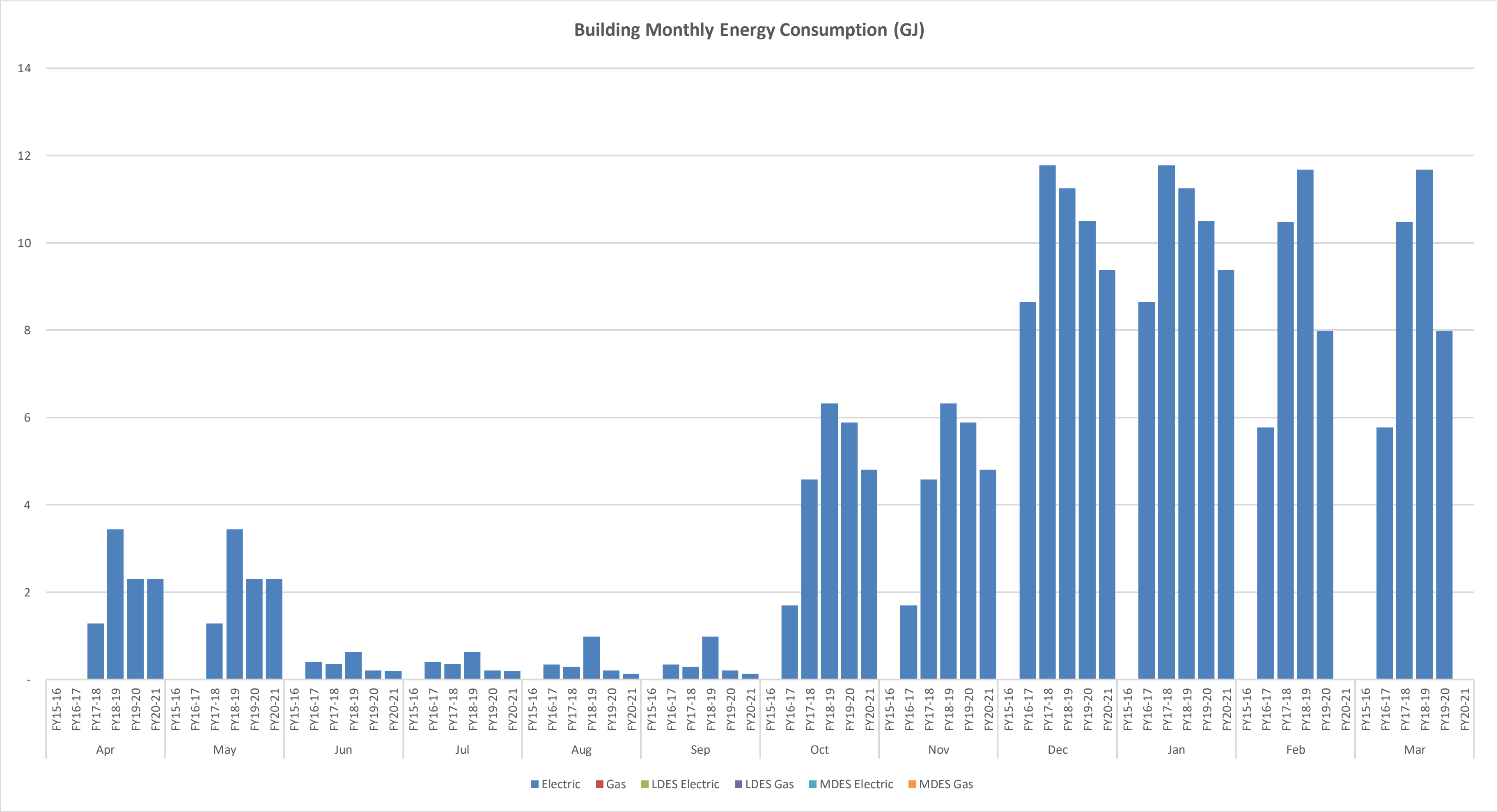
7.28 Valhalla Residence building



7.29 1200B Curtis building



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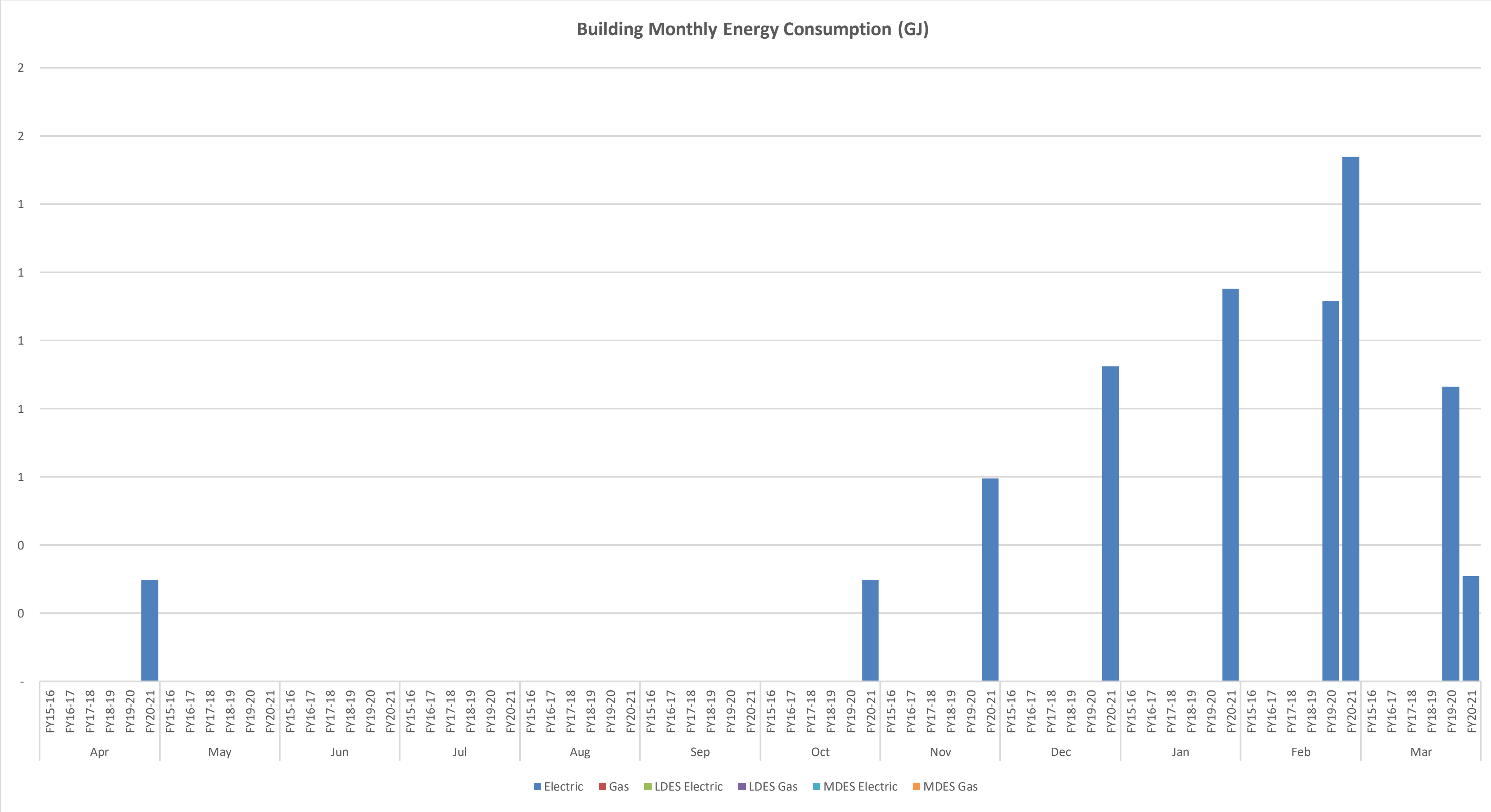
7.30 3430 Pumphouse building



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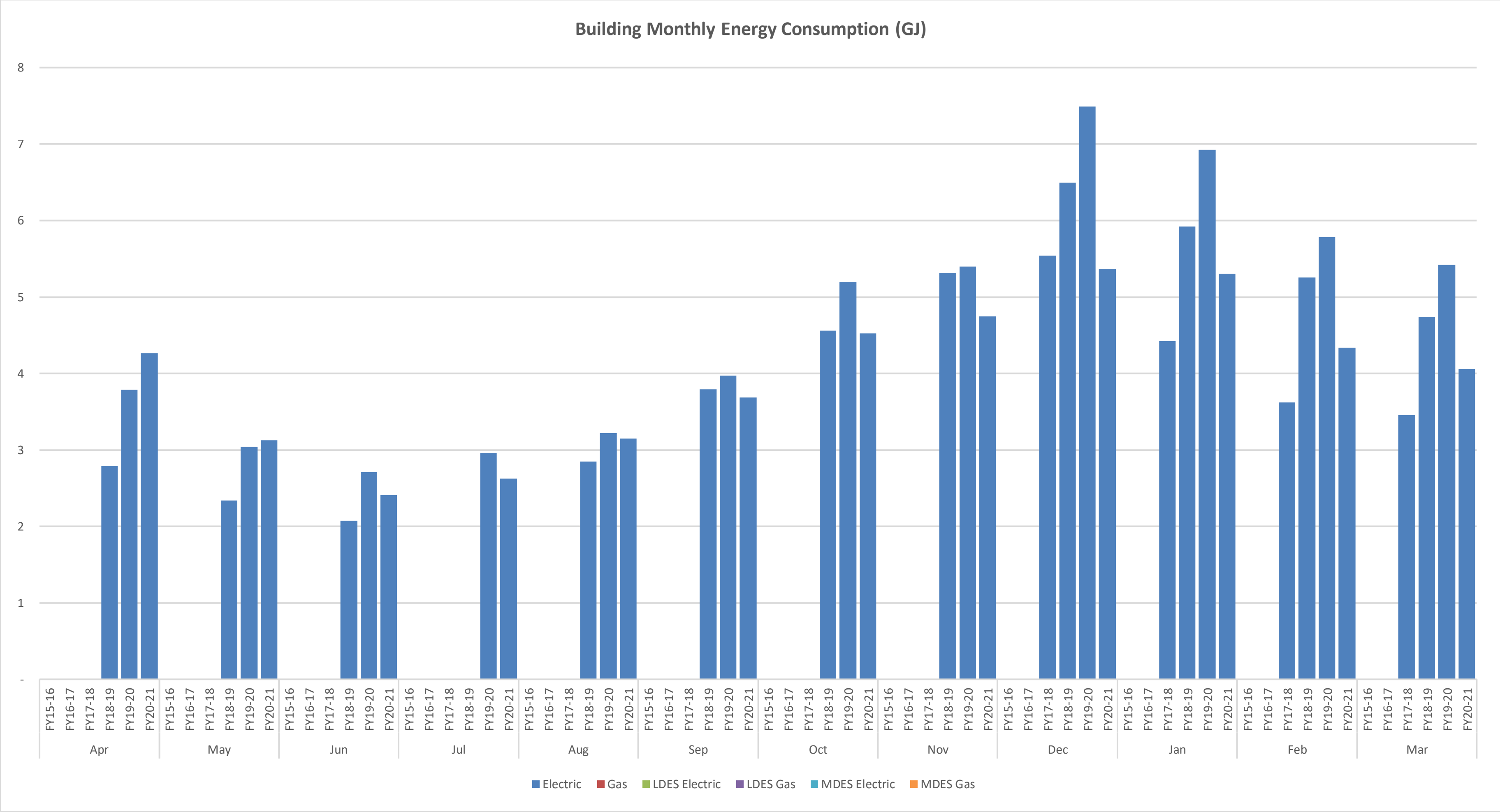
7.31 Innovation Drive H Lot (Includes Trailer)



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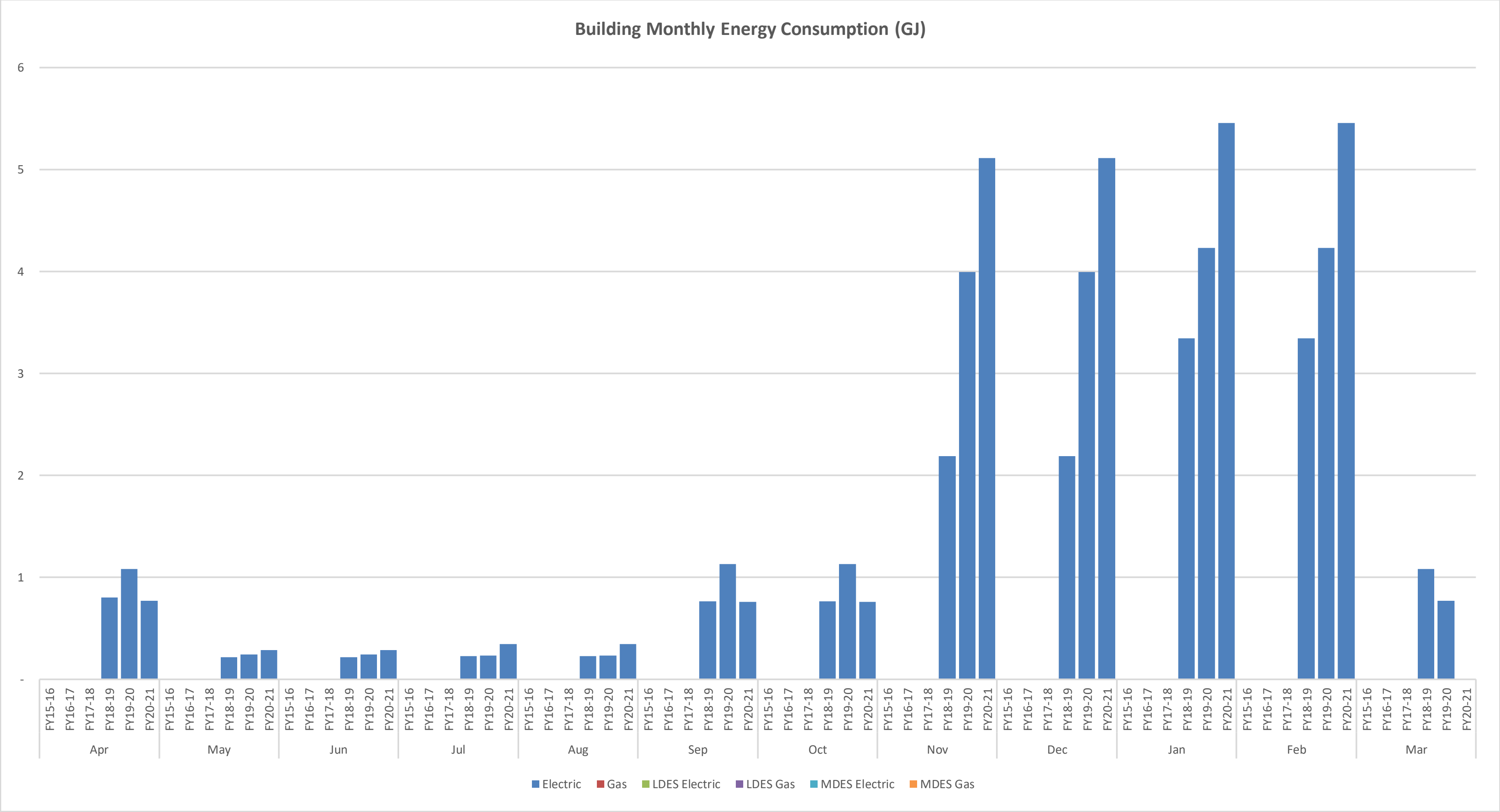
7.32 H Lot (Overflow parking)



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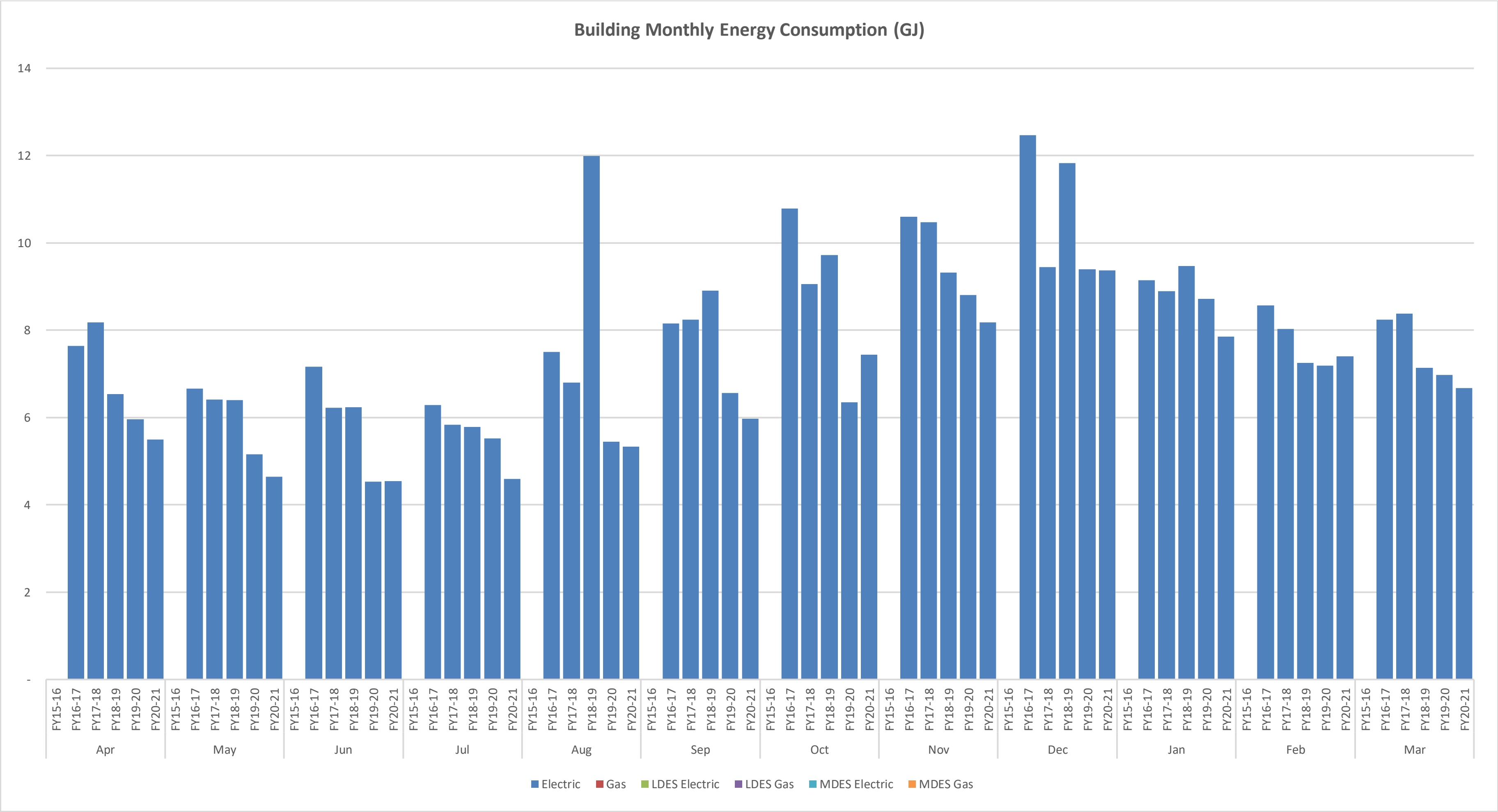
7.33 Parking Lot R



7.34 Geo-exchanger external (Quonset, U-House, U-House Portable) building