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THE UNIVERSITY OF BRITISH COLUMBIA

Energy Team
The University of British Columbia |
Okanagan Campus
1060 Diversity Place | Kelowna BC | V1V 1V7 Canada

UBC Okanagan Campus
Energy Team
Quarterly Report
April 2022 – June 2022

Report Date: 2022-09-07

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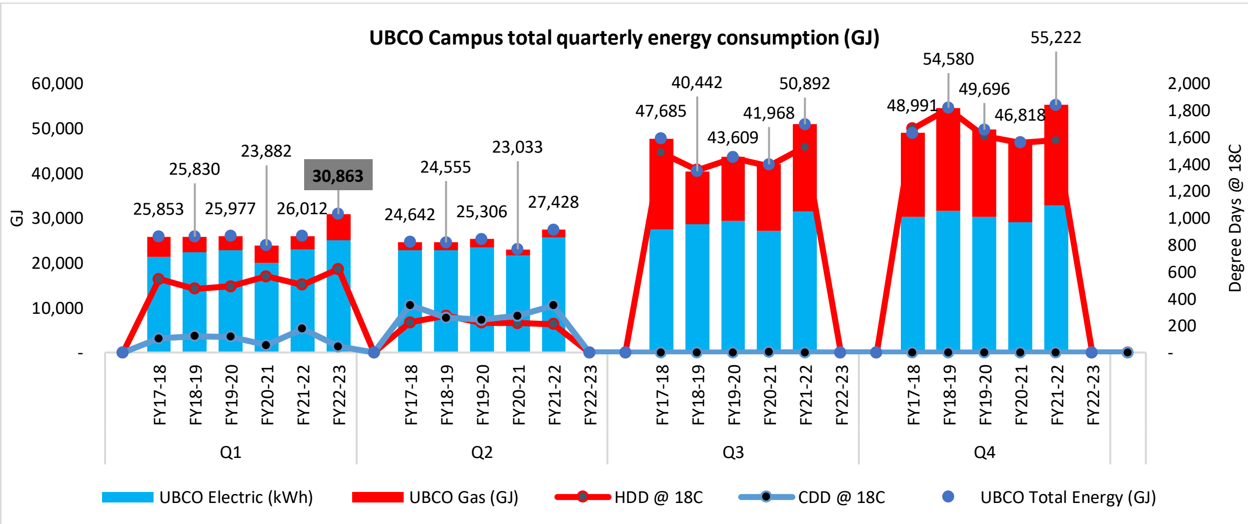
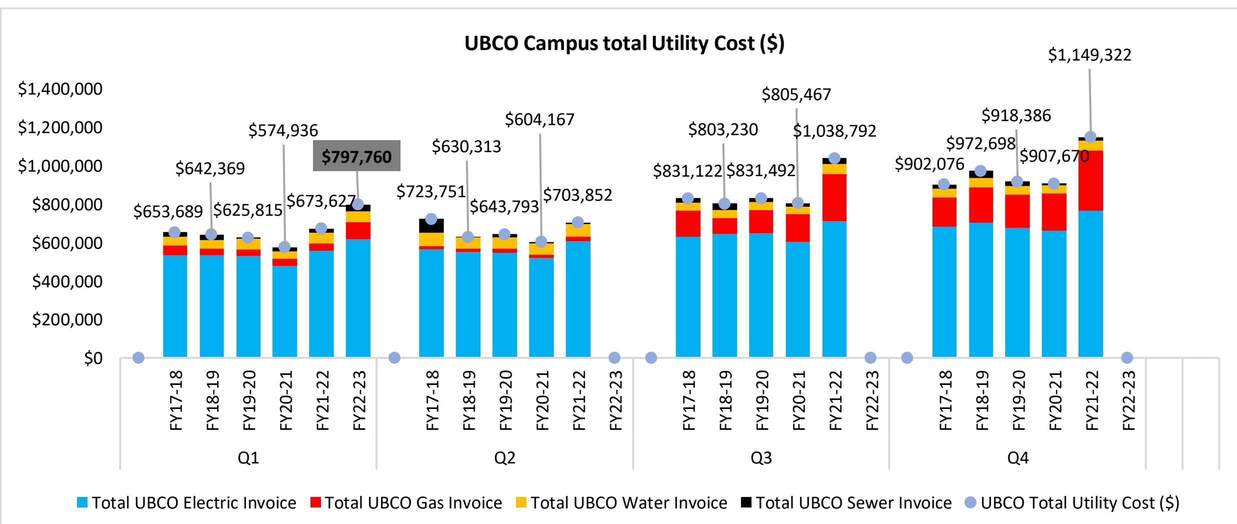
1. Overview of the First Quarter of FY 2022-2023

UBCO Campus total energy consumption over the past quarter (Q1 2022) was 30,864 GJ compared to 26,012 GJ for Q1 last fiscal year (Q1 2021), a 19% year over year quarterly increase leading to a 19% increase in total campus energy utility cost. This total energy consumption includes a 9% increase in campus Electricity consumption i.e. from 6,397 MWh in Q1 2021 to 6,942 MWh in Q1 2022 and an increase of 97% in campus Gas consumption i.e. from 2,983 GJ in Q1 2021 to 5,873 GJ in Q1 2022.





In Q1 2022, a 24% increase in Heating Degree-Days (HDD) was observed i.e. from 503 degree-days in Q1 2021 to 621 degree-days in Q1 2022 and reduction in Cooling Degree-Days (CDD) was observed i.e., from 175 degree-days in Q1 2021 to 45 degree-days in Q1 2022.

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The increase in energy consumption is in direct correlation with the heating degree days experienced during the period along with following key factors:

Electricity:

- As UBCO community transitioned back to campus, a 41% increase (380 MWh) in Residences electricity consumption was observed i.e. from 934 MWh in Q1 2021 to 1,315 MWh in Q1 2022. This can be primarily attributed to operations and commissioning of new Residence building Nechako (300 MWh Q1 2022 vs 68 MWh during Q1 2021 construction). Other Residences increased by an average of 20%.
- A 3% (162 MWh) increase in electricity consumption for Academic buildings was observed. This can be primarily attributed to operations and commissioning of the research laboratory building Innovation Precinct 1 (124 MWh Q1 2022 vs 6 MWh Q1 2021 consruction). Other notable buildings are ARTS (37% increase i.e. by 90 MWh), CCS (31% increase i.e. by 36 MWh), LIB (18% increase i.e. by 40 MWh), ADM (16% increase i.e. by 50 MWh)
- Interestingly, a few academic buildings observed reduction of electricity consumption. These buildings are CHP (84% i.e. by 107 MWh), GEO (30% i.e. by 44 MWh), SCI (6% i.e. by 44 MWh).

Natural Gas:

- A 162% increase (1,150 GJ) in Residences gas consumption was observed i.e. from 709 GJ in Q1 2021 to 1,859 GJ in Q1 2022. This can be primarily attributed to operations and commissioning of new Residence Nechako (384 GJ) and increased Gas consumption in Cassiar (178% increment i.e. by 95 GJ), Nicola (173% increment i.e. by 93 GJ). Other Residences show an increment of around 66% gas consumption.
- A 77% (1,740 GJ) increase in gas consumption for Academic buildings was observed primarily by District Energy plants (LDES and MDES) (770 GJ in Q1 2021 to 2219 GJ in Q1 2022 i.e. by 1,449 GJ). Other notable buildings are ARTS (by 153 GJ[1]), EME (by 68 GJ[2]), ADM (100% i.e. by 153 GJ), ASC (35% i.e. by 185 GJ).
- Interestingly, a few academic buildings observed reduction of gas consumption. These buildings are UNC (54% i.e. by 151 GJ), RHS (41% i.e. by 52 GJ).

[1] ARTS gas consumption in Q1 2021 was around 0 GJ
[2] EME gas consumption in Q1 2021 was around 3 GJ

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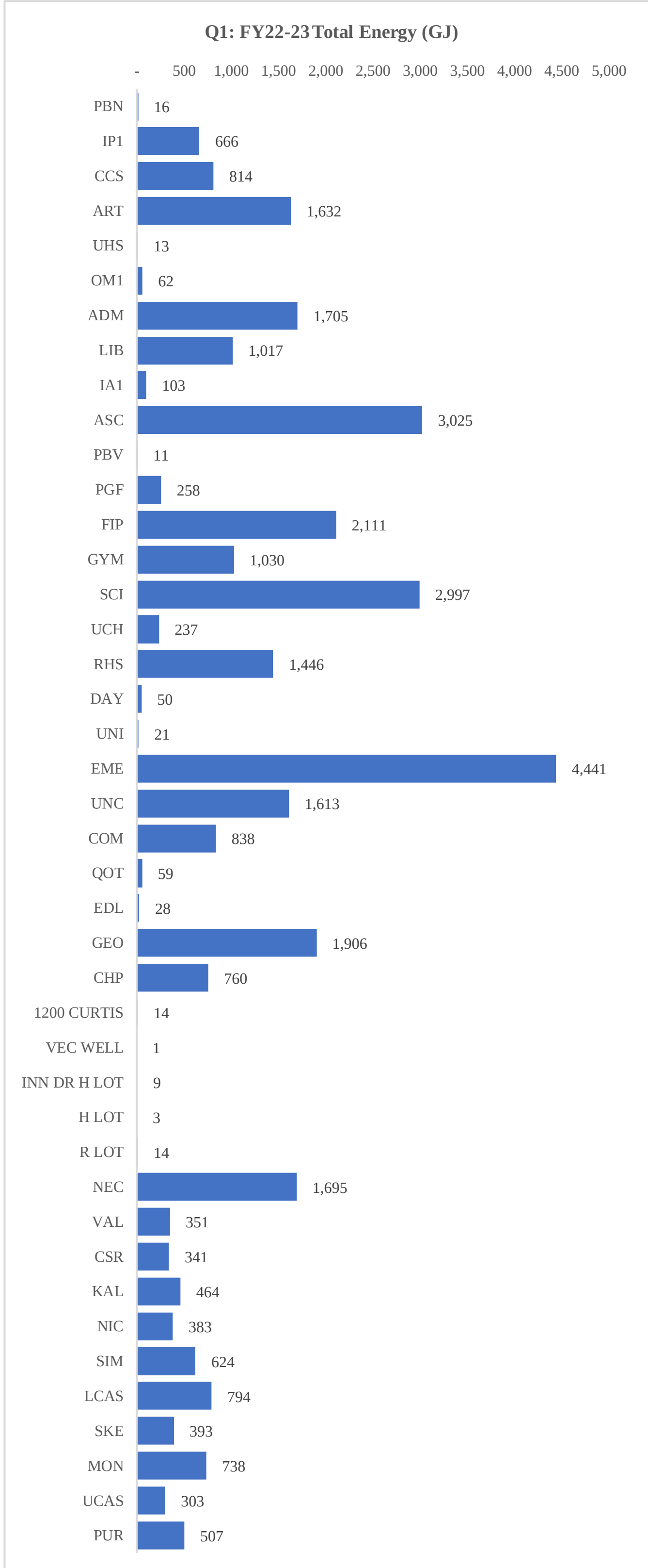
Type	BUILDING	% TOTAL ENERGY CHANGE
ACAD	PBN	1384%
ACAD	IP1	307%
ACAD	CCS	59%
ACAD	ART	48%
ACAD	UHS	47%
ACAD	OM1	39%
ACAD	ADM	29%
ACAD	LIB	23%
ACAD	IA1	22%
ACAD	ASC	15%
ACAD	PBV	13%
ACAD	PGF	10%
ACAD	FIP	10%
ACAD	GYM	8%
ACAD	SCI	5%
ACAD	UCH	2%
ACAD	RHS	1%
ACAD	DAY	1%
ACAD	UNI	0%
ACAD	EME	-1%
ACAD	UNC	-2%
ACAD	COM	-3%
ACAD	QOT	-10%
ACAD	EDL	-18%
DES	GEO	224%
DES	CHP	-35%
OTHER	1200 CURTIS	253%
OTHER	VEC WELL	200%
OTHER	INN DR H LOT	4%
OTHER	H LOT	1%
OTHER	R LOT	-12%
RES	NEC	586%
RES	VAL	56%
RES	CSR	55%
RES	KAL	46%
RES	NIC	36%
RES	SIM	32%
RES	LCAS	27%
RES	SKE	23%
RES	MON	21%
RES	UCAS	14%
RES	PUR	5%



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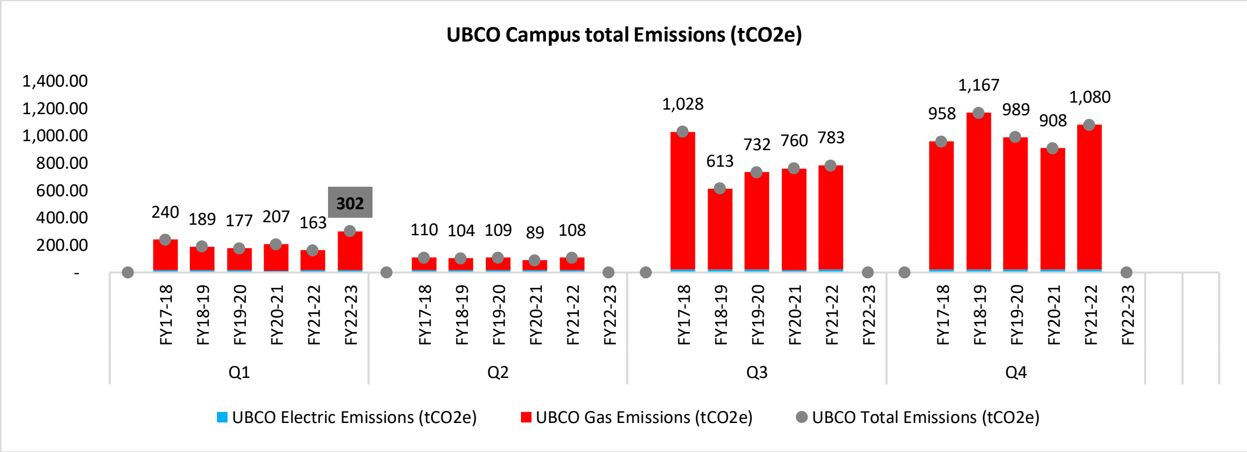

The figure above shows quarterly trend of total GHG emissions for UBC Okanagan campus from FY17-18 to FY22-23 assuming electricity emission intensity factor of 2.587 tCO_2e/GWh[3]. Note that the increase in total GHG emission from Q1 2021 to Q1 2022 is 139 tCO2e.

Section 2.11. of this report provides a more in depth analysis on the UBCO campus total emissions as public sector organizations will be using a new set of integrated grid emission factor for electricity use.

2. Policy Development

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.

2.1. Strategic Energy Management Plan (SEMP) 2020

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:

- Campus-wide lab demand-controlled ventilation – Occupancy Controlled Ventilation (Completed for SCI building)
- Recommissioning of existing controls at ARTS building (Completed)
- Demand controlled ventilation for campus AHUs and/ or MUAs (Project underway)
- Night-time precooling (Completed)
- Recommissioning of existing controls at campus buildings (Q3 2022)

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

The main campus is expected to grow with the addition of the Innovation Precinct. This motivated further analysis and consideration of district energy strategy with a view of modernization, renewal, and growth to serve both existing and new load.

[3] 2020 B.C. BEST PRACTICES METHODOLOGY FOR QUANTIFYING GREENHOUSE GAS EMISSIONS https://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2020-pso-methodology.pdf

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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

A decision was made by the UBC steering committee to proceed with district energy utility services where district scaled water source heat pumps provide hot and cold water to the buildings. 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 worked with DE consultant to advance the schematic design and development of the cluster plant in the ICI building. The cluster plant at the ICI building was accepted and approved by UBC executive team. Energy Team has been working diligently with UBC Properties Trust and their consultant in implementation of cluster plant at the ICI building and its associated connection with adjacent buildings. UBCO Energy Team also worked with consultant to perform a high-level concept design to outline preliminary requirements and indicative capital costs for a potential Lower Innovation Precinct Cluster Plant (LIPCP).

In terms of DE decarbonization, the key strategy for decarbonization features the integration of air source heat pumps (ASHP) in a transition to a future state that is affordable, sustainable, and resilient in service to connected customers. 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.

A schematic design and economic assessment of an Air Source Heat Pump (ASHP) and thermal energy storage (TES) plant near the GEO building was conducted in subsequent DE strategy phase. Currently, work is underway to advance this strategy, explore other low carbon heating sources/ technologies through a study planned for FY22-23 and install ASHP (Phase 1 of DE decarbonization strategy) by FY23-24.

In order to advance DE Strategy, Energy Team has engaged UBCO Project Services to kick off two parallel projects which include:

- Phase 1 of DE decarbonization strategy i.e. installation of ASHP and

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- Installation of ICI 4-pipe infrastructure to serve heating and cooling demands of surrounding buildings from ICI cluster plant.

2.2.1. Geo-Exchange Air Source Heat Pump Study

A feasibility study to investigate the ASHP addition for Phase 4A of the TES/ASHP integration, which will provide 700 kW of thermal heating capacity to the LDES. In addition to the ASHP addition, the study will also include the addition of two 1,200 kW backup boilers. A market review of ASHPs is expected to be undertaken to get an understanding of what products and technologies are currently available in the market. The technical performances of different options will be evaluated by comparing different metrics between units including thermal capacities, efficiencies, turndowns, costs and more. The study is currently underway with an expected completion by end of September 2022.

2.2.2. ICI 4-pipe infrastructure Study

This study will focus on feasibility and preliminary design of the piping infrastructure required to:

1. Extend the ICI Building's 4 pipe infrastructure from the future ICI cluster plant's piping stubbs up Knowledge Lane to Discovery Avenue.
2. Extend the ICI Thermal Storage 4 pipe infrastructure from the ICI stubbs to the proposed location of the HW and CHW Thermal Storage tanks.
3. Extend the existing LDES 2 pipe infrastructure from Alumni Avenue to connect to Discovery Avenue

The final report is expected to include recommendations for specific piping materials & pathways and also include a Class D cost estimate. This study is currently underway and is expected to be completed by Q3 2022.

2.3. 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. 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.

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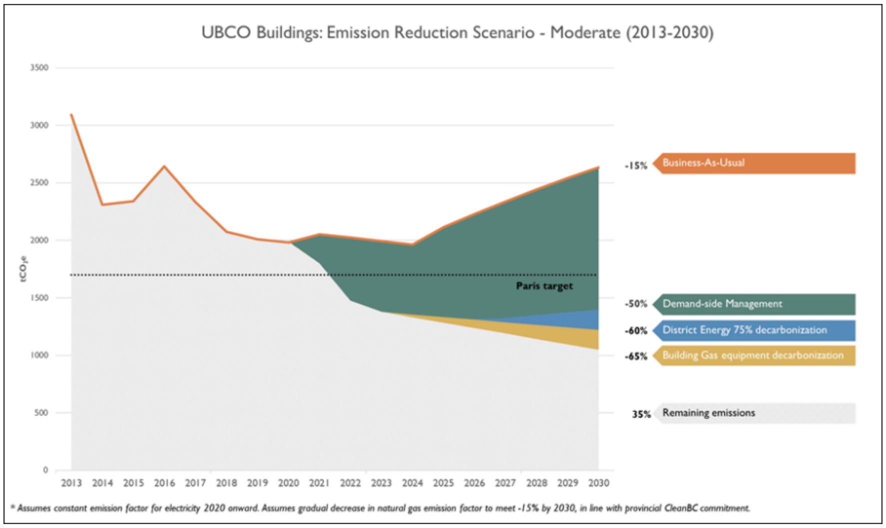

Based on the strategy, a moderate (realistic) target of 65% emission reduction[4] from 2013 levels by 2030 is recommended. This can be achieved by partial decarbonization of the central plant, implementing projects that will reduce energy demand, and connecting select existing buildings to central energy supply systems (district energy). The Campus Action Plan 2030 plan has been signed off by the UBC executive committee. Further work is being performed to keep track of the progress. Following are few of the potential challenges to achieving CAP 2030 targets:

- Addition of high-intensive research facilities
- Market economy: Rising costs of new construction buildings might impact implementation of energy efficiency measures as a result of value engineering
- Need for a low carbon energy supply to replace deteriorating Geo-exchange infrastructure
- New construction Residences and leased buildings needs to be aligned with UBCO CAP targets.

2.4. UBCO Net Positive Modelling Study – Archetype update and Analysis

Energy Team worked with RDH Building Science Inc. to update the five archetype energy models (Student Residence (no kitchen), Campus Rental Housing (with Commercial Retail Units and suite kitchen), Low intensity lab building, High intensity lab building, Classroom/Office building) from the previous 2016 UBC Net Positive Modelling Study and reflect UBC Okanagan campus typologies and climate zones based on current UBCO construction practices.

This work included formulating ECM bundles to identify achievable energy and greenhouse gas emission targets (TEUI, TEDI, GHGI) specific to UBCO, and then completing costing and financial analysis to identify the most cost-effective strategies to achieve those targets. Applicability of the proposed strategies to existing building retrofits was also considered.

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[4] Note that when conducting the scenario analysis, the electricity emission factor used in 2020 was 2.587 tCO_2e/GWh and assumed constant till 2030. However, in Q1 FY21-22 this factor has been retroactively updated by Ministry of Environmental and Climate Change Strategy to 35 tCO_2e/GWh for 2013 and 40.1 tCO_2e/GWh for 2020. This modelling results do not reflect this change.

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A subsequent work to compare these parameters TEUI, GHGI, TEDI values for various archetypes from the study to other relevant standards and codes was completed in August 2022.

Table below provides a snapshot of various Enclosure and Mechanical ECMs recommended by RDH for each archetype. The ECMs were selected based on the previous UBC Net Positive Modelling Study, other project experience, and with cost-effectiveness and market readiness in mind.

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ECMs	Student Residence	Campus Housing	Science Lab (low-density)		Lab (high-density)		Classroom/ Office
			Lab	Non-lab	Lab	Non-lab	
Enclosure							
Fixed windows, U-0.14, SHGC-0.37, VT 63%		x	x		x		x
Operable windows, U-0.17, SHGC-0.37, VT 63%	x	x					
Reduced SHGC to 0.25, VT 57%	x	x	x		x		x
Electrochromic glazing	x	x	x		x		x
Walls R-30	x	x	x		x		x
Roof R-45	x	x	x		x		x
Airtightness – 0.6 ACH @ 50Pa	x	x	x		x		x
Operable exterior shades (E/S/W-facing façade)	x	x	x		x		x
Fixed exterior shades (E/S/W-facing façade)	x	x	x		x		x
Reduced window-to-wall ratio	x	x	x		x		x
Mechanical							
90% efficient centralized HRV with bypass ventilating suites	x	x					
90% efficient centralized HRV with bypass (CRU only for Campus Housing)		x		x		x	x
Reduced corridor make-up air to corridors (10 cfm/unit)	x						
Reduced corridor make-up air to corridors (15 cfm/unit)		x					
Corridor supply air temperature nighttime setback of 18°C	x	x					
Nighttime free cooling air flush	x	x	x	x	x	x	x
Variable speed FCUs with ECM motors (decoupling of DOAS and FCU if applicable)	x	x	x	x	x	x	x
Radiant heating/cooling ceiling panels (instead of FCUs)			x		x		x
Aircuity sensors to reduce lab ventilation rate (minimum 4 ACH occupied / 2 ACH unoccupied)			x		x		
Make-up air provided to lab from non-lab space			x		x		
Variable speed rooftop fan for lab stack exhaust			x		x		
Water-source heat pump for DHW top-up (from 120F to 140F) using DES hot water loop as source	x	x	x	x	x	x	x
DHW heat recovery	x	x	x	x	x	x	x

This study also provided various energy targets for UBCO building archetypes which are expected to be used to develop Green Building Action Plan Targets for UBCO campus.

2.5. 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

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develop an intelligent data-driven energy monitoring and management system for micro-communities using statistical and advanced data analysis methods. Currently, work is underway to connect the backend of the dashboard (R platform) with the existing Siemens Desigo system (UBCO is using this system to maintain campus operations through trend log reviews) to create a parallel database which can be further used for energy monitoring.

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 and various intensity parameters.

2.6. 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. Due to Facilities Management Engineers workload and other issues, progress on this project has been slow. Additional resources have been hired in the CORM department to fast track this project as it will be a critical input to the asset management module of the Enterprise Maintenance Management System that UBCO will be adopting in FY22-23.

2.7. VLAN upgrade

The intent of this project is to segregate the controls equipment for each building on campus into individual VLANs. This project has been undertaken and currently in progress for three key reasons which include communication control, increased security as well as plan for future additions as more equipment in the controls industry operates primarily with IP interfaces. This includes meters, lighting, chillers, and zone HVAC controllers.

The current network infrastructure is a hybrid configuration with a flat “facilities” VLAN that covers multiple building, in addition all new construction since the Commons (TLC) building has been configured into individual VLANs. This project will migrate the older buildings into their individual VLANs, eventually removing the “facilities” VLAN entirely. Once the VLAN migration is complete, the Desigo server is intended to become the central hub for communication control, avoiding broadcast information between buildings and many firewall rules needed to accommodate facilities network access for all BMS systems. The project is substantially complete.

2.8. 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 conducting technical reviews and setting goals, targets, and strategies as early as possible for future campus expansions such as new construction ICI building, Childcare, OM2. A detailed summary for each new building has been presented in Section 4. of this document.

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In August 2021, UBC Executive team took a significant step towards sustainable development on campus by approving first cluster plant and provisions for thermal storage within the ICI building currently in design with occupancy anticipated for Jan 2025. This cluster plant is expected to serve thermal demand to surrounding buildings potentially CCS, ADM, EME, GYM including ICI (South and east of main campus). This will provide significant savings with respect to deep building retrofits and new campus buildings.

ICI is intended to include spatial provisions and corridors to allow plant expansion into a nodal thermal energy plant that serves future developments around the ICI building. This "cluster" plant will produce heating water (HW) and chilled water (CHW) using the LDES and MDES interfaces, before distributing HW and CHW to the ICI building and the building cluster downstream of the ICI. Energy Team has been working with UBC Properties Trust and their consultant for successful design and construction of cluster plant at the ICI building.

2.9. 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.

2.10. District Energy Plant efficiency study

Energy Team has been working to analyze performance of DE system and building plant to help optimize overall system performance. The scope of work under this study includes:

- **Energy Trend Analysis:** Validate existing trend logs for each building showing heating water consumption, gas consumption, district energy consumption, and electrical energy.
- **Develop Coefficients of Performance:** Develop a real-time coefficient of performance trends for the central heating plant, district energy plant, and building level heat pumps.
- **Develop Cost Trends:** Using the energy use profile, coefficients of performance, and utility rates, calculate the real-time costs of operation for each building, and for the plants.

Energy Team is working internally to carry out this study which has been kick started with SCI, EME and COM as the three buildings. Energy Team fast tracked a portion of this study to optimize operations of cooling towers. After a careful review of existing operations, Energy Team has put together an add-on sequence of operation (SOO) to

- make cooling towers run more efficiently,
- automate staging of various cooling sources, and
- increase operational capacities of existing cooling towers

This SOO update is expected to provide potentially 300 tons of additional cooling capacity from existing cooling towers. A similar exercise will be carried out in Q3 FY22-23 to review District Energy heating season performance and investigate optimization opportunities.

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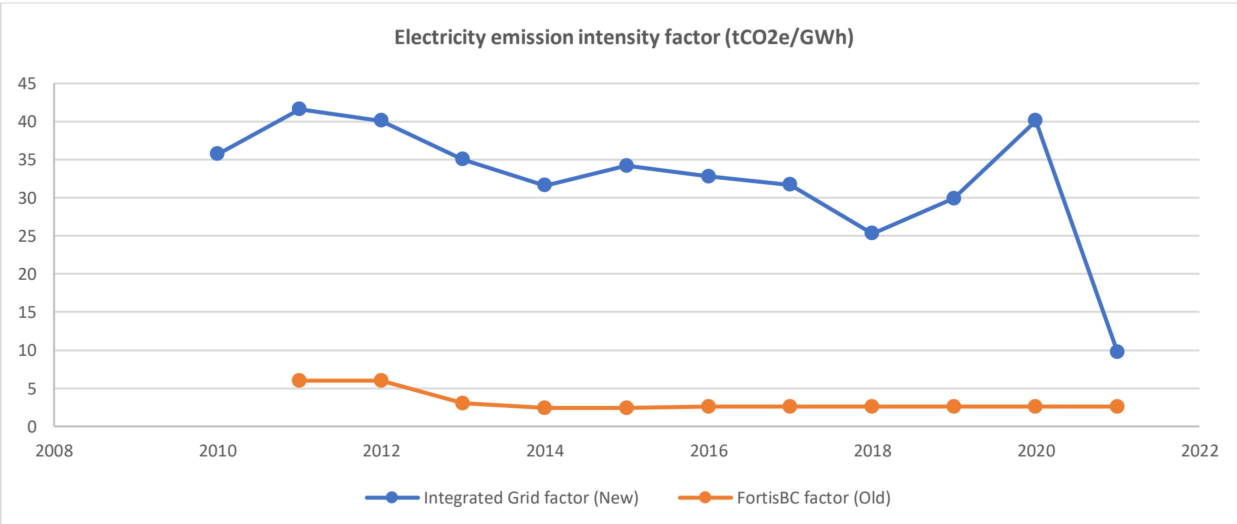
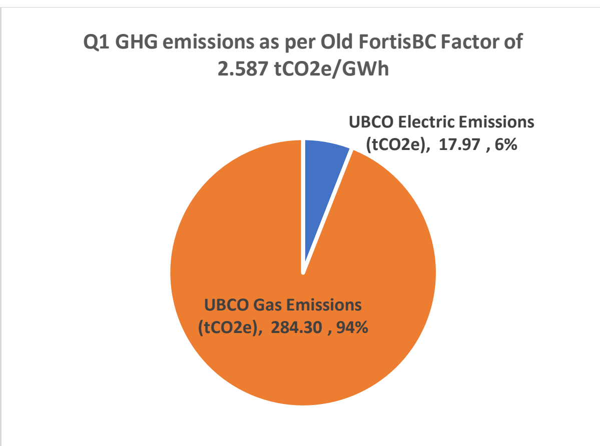
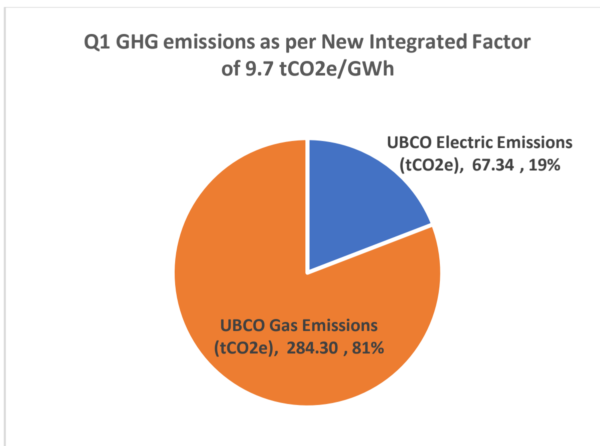
2.11. Electricity emission intensity factors modelling for UBCO

The GHG emission trend for the campus primarily follows Natural Gas consumption trend because electricity emission intensity factor for the FortisBC grid in British Columbia is very low at 2.587 tCO_2e/GWh.



However, in 2020, Ministry of Environment and Climate Change Strategy published a new set of greenhouse gas (GHG) emission intensity factors for electricity use from 2016 to 2020 along with hindcasted grid factors for 2010 to 2016[5]. The charts below show the increase in GHG emissions when considering new integrated electricity emissions factor.





[5] The new set of emission intensity factor is based on a different methodology. Prior to that, the Ministry of Environment and Climate Change Strategy published, in the B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions, provider-based emission intensity factors for electricity purchased from BC Hydro and FortisBC. These factors reflected the emissions intensity of each utility provider's electricity generating fleet. The methods differ in their scope in that the current estimates include all power producers in B.C., as well as considering imported electricity for in-province consumption.

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2.12. Smoke and Indoor Air Quality (IAQ) Particulates

Currently smoke mitigation measures are initiated and implemented manually via a procedure. Air quality can be very localized, and current air quality notifications may not be specific to the local conditions at UBCO campus. The intent of this project is to install sensors to measure the air quality specifically at the campus buildings and provide automatic notification that air quality is poor at the UBCO campus.

Existing indoor air quality monitoring via the BMS currently is mainly limited to CO2. Some buildings also include relative humidity sensing, as well as CO and NO_2 for loading bays.

Wildfires are a common occurrence in the British Columbia, which has a high potential to bring wildfire smoke through Campus and into the buildings. Currently there are procedures in place to respond to wildfire conditions, such as changes to ventilation operation and changes to filtration, however we currently have no quantitative measurements to determine how successful these measures are.

The intent of this project is to implement additional outdoor air quality monitoring on campus to provide quantitative data to initiate air quality mitigation controls. Using a portable indoor meter can determine how successful our measures are in responding to poor outdoor air quality on campus. This information can be evaluation and processes adjusted accordingly.

3. Energy Conservation Projects

In order to reduce utility costs, energy consumption and GHG emissions, energy conservation measures (ECMs) are regularly implemented on campus. In terms of actual studies/ projects, the following projects have been completed/ in progress over the last quarter.

3.1. 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 RCx study was completed in Q3 2021 which identified 92 MWh electricity and 490 GJ gas consumption.The following 5 out of 8 ECMs have been selected for implementation.

- ECM-1: Outdoor air temperature (OAT) lockout optimization
- ECM-2: Free cooling optimization
- ECM-3: Demand control ventilation (DCV) optimization
- ECM-4: Supply air pressure (SAP) setpoint reset
- ECM-6: Room occupancy sensor (OS) scheduling

The implementation of these ECMs is currently underway and was completed in Q1 2022.

3.2. UBCO ASC FIPKE 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

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and strategies will be considered for reduction and standardization of air changes during both occupied and unoccupied hours.

UBCO Energy Team worked to collect background data for this project and had submitted an incentive application for SES Consulting to perform an engineering study for this project to better determine the cost and benefits of this project.

The incentive application for engineering study was approved by FortisBC in September 2021. The scope of work is to estimate the financial and energy savings impact associated with Laboratory rooms DCV ECM (Reduced air-changes per hour in appropriate zones served by the aforementioned ventilation systems with controls recommissioning including new sensors, switches, and programming changes) for air handlers FIPKE AHU-2, FIPKE MUA-1, FIPKE MUA-2, FIPKE MUA-3, FIPKE MUA-4, ASC MUA-1, ASC MUA-2, and ASC MUA-3.

The study is currently underway and is expected to be completed in Q3 2022.

3.3. Night time flush

Night ventilation, or night flushing, is a passive cooling technique that utilizes the outdoor diurnal temperature swing and the building's thermal mass to pre-cool a building through increased outdoor airflow at night, allowing radiant cooling to take place during the day when the building is occupied.

By using the natural cooling effect of the night and the cooler air at night simply allowing the cool night air to circulate a structure during the night allows the loss of the heat buildup, or heat mass gathered by the structure during the day. In order to achieve this cooling one simply needs to allow the night air to circulate the building. The cool night air carries away the heat absorbed by the structure during the day. The very nature of concrete or other high specific heat capacity materials makes them perfect to use in conjunction with Night Flushing as the structure will take a long time to absorb enough heat during the day to change its temperature and thereby not only decreasing the cost of maintaining a stable internal climate during the day, but would also drastically decrease the cost of cooling as most of the heat absorbed during the day is lost during the night via Night Flushing. Thermal mass is a property enabling structures to absorb, retain and then release heat energy, this coupled with a high specific heat capacity means that buildings made up of concrete need to absorb a substantial amount to heat to effect a change in temperature.

The summer months in Kelowna can have relatively cool evenings with quickly warming mornings. Electricity tends to peak during this startup cooling. For summer months where the evenings are cool and it is anticipated that significant mechanical cooling load will exist throughout the day, a pre-cooling strategy will be implemented utilizing the existing weather predictor, similar to the existing morning warmup strategy.

Energy Team has contracted the implementation of this measure to Siemens Canada Ltd. The night flush mode is intended to pre-cool buildings with fresh air during unoccupied hours with the goal of delaying the need for mechanical cooling throughout the summer period. Following are the Air Hanldling Units affected by this night flush measure:

- Arts AHU1-8, RTU1-3

- EME AHU1-8 - enable and verify night cooling operation for AHU-1-8 in existing SSTO operation
- Gym AHU1
- Library AHU1-6
- Admin AHU1-9
- EME HRV4 – high head lab, occupied by wifi occupancy only, no existing scheduling exists or setback heating or cooling modes

This project is expected to be completed by Q2 2022.

3.4. Recommissioning study for the EME building

UBCO Energy Team is planning to recommission EME building and has put forward a FortisBC/ BCHydro incentive application to perform a Continuous Optimization study for the EME building. BC Hydro approved consultant Falcon Engineering will be contracted to provide support in performing this recommissioning for the EME 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. The study is expected to start in October 2022 with an anticipated completion date of December 2023.

3.5. Science Heat recovery study

UBCO Energy Team is working with CURA Engineering to conduct a study to recover heat from the existing rooftop laboratory exhaust via glycol runaround heat recovery system. CURA Engineering identified to UBC Okanagan that the existing glycol runaround heat recovery system that interconnects recovered laboratory exhaust energy to the air handler AHU-1 system's outside air preheat ducting appeared to have spare capacity, because the exhaust coil's discharge air temperature held at 9.7˚C at an outdoor air temperature of -6˚C.

CURA suggested the potential of expanding the existing heat recovery system and coupling the existing exhaust coil runaround heat recovery either to air handler AHU-2 or AHU-3 preheat, or as potential source energy for the Multistack heat pump to displace input energy received from the campus' LDES system. Calculations verify that when the glycol runaround systems data points were acquired at -6˚C, the outside air preheat flow for AHU-1 was 18,188 CFM (8,585 L/S) while the exhaust air flow at the rooftop recovery coil air flow was 26,313 CFM (12,420 L/S); verifying that the exhaust air stream had additional flow and energy available that could not be transferred to AHU-1's preheat coil

An incentive application under FortisBC's Custom Efficiency Program has been submitted to conduct the study and potentially take advantage of the funding sources available. This study is expected to be completed by Q4 2022 with implementation in the next fiscal year.

3.6. Project to install Siemens AQGARD IAQ monitoring system for SCI building

UBCO Energy Team has engaged UBCO Project Services to manage this project to install Siemens AQGARD IAQ monitoring system using multi-parameter Demand Control Ventilation (mp-DCV) System, to reduce energy and operating costs, while improving the indoor air quality (IAQ) in the Science Building.

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The new Siemens AQGARD will monitor selected 10 rooms in the SCI building, as well as the AHU's feeding them. The system will sense for CO2 (occupancy based DCV) and IAQ (TVOC's and micro-Particles in the PM 0.3-2.5 range). The system will maximize ventilation at all times when needed and will modulate ventilation based on a high-select between sensed contaminants, occupancy and temperature / thermal load.

This project is expected to achieve energy savings of around 124 MWh Electricity and 1100 GJ Natural Gas with an estimated ROI of just over 3.4 years.

3.7. Power factor analysis

UBCO Energy Team has been working on analyzing the power factor of all the campus-level and building-level electricity meters. Power factor is a measure of how effectively electricity is being used and is the ratio between Real Power (kW) to Apparent Power (kVA).

Power factor can be corrected by installing capacitors in parallel with the connected equipment or circuit. These can be applied at the equipment, distribution board or at the origin of the installation. They improve the overall electrical efficiency of your electrical supply, so less electrical current is needed to achieve the same result. There are numerus advantages to installing power factor correction devices to your electrical supply. They include:

- A reduction in electricity bills
- Increased load carrying capabilities in your existing circuits
- Reduction of I2R losses in transformers and distribution equipment
- overall reduced power system loses
- Extended equipment life
- Reduced electrical burden on cables and electrical components.

Table below provides an average power factor for all the UBCO buildings from January 2021 to March 2022 analyzed at 15 minute interval.

Building	**Average Power factor**
ASC	96%
ART[6]	93%
ADM	95%
CHP	94%
FIP	92%
CCS	95%
DAY	94%
EDL	93%
EME	94%
GEO	56%
GYM	95%
LIB	90%

[6] Calculations suggest a power factor of 31%. However, Energy Team believes due to a 3:1 stepdown transformer, the 3:1 conversion factor was not added back in to the ARTS demand point during the VLAN upgrade project.

PGF	66%
RHS	85%
SCI	98%
UNC (Current power factor = 90%; Jan 2021 = 38% <*OUTLIER*>)	87%
UCH	54%
OM1	92%
PORT A (Relatively small load)	258%
PORT V (Relatively small load)	78%
Quonset	89%
U HS	88%
Lower A	100%
Lower B	100%
Lower C	97%
Lower D	101%
Lower E	101%
Lower F	101%
Lower G	100%
Upper H (Data not available)	NA
Upper I (Data not available)	NA
Upper J (Data not available)	NA
Upper K (Data not available)	NA
CAS	99%
IP1 (Data not available)	NA
IPA (Data not available)	NA
Kalamalka	96%
MON	95%
NEC	100%
NIC	96%
PUR	97%
SIM	99%
SKE	97%
COM	91%
VAL	94%

Based on this analysis, Energy Team recommends to verify power factor for ASC, ARTS buildings and improve power factor for GEO, PGF, and UCH buildings.

3.8. Plant Growth Facility LED lighting upgrade

Plant Growth Facility (PGF) reached out to UBCO Energy Team to assist them with a solution for failure of high pressure sodium lighting. Subsequently the Energy Team has been working with researcher at UBCO PGF, Samantha Olivier and lighting vendors to develop a business case for UBCO Plant Growth Facility lighting replacement from existing High Pressure Sodium to LED fixtures.

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Below are some of the reported challenges the PGF has been experiencing with existing lighting fixtures:

- Existing lamps have an end of useful life of around 10,000 hours and are failing prematurely.
- Existing lighting does not meet lighting requirements in the winter periods.
- HPS lamps are very inefficient

The project has a simple payback of around 3.5 years and will be little higher when considering interactive heating/cooling effects. The total cost of the project is around $50,000 (including installation) after FortisBC rebates. This project is expected to be implemented in the near future based on funding availability from UBCO.

3.9. Monitoring improvements

A few monitoring improvements are continuously being implemented by the UBCO Energy Team. For example, resolving the WIFI occupancy reporting issue, working with Siemens to fix the Desigo deficiencies list, resolving integration between Advantage Navigator and Desigo backend to maintain BMS database, adding missing trends on the key hydronic graphics etc.

4. 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.

4.1. 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, detailed designs for the building and providing inputs on the building mechanical, electrical systems and energy-related standards/ benchmarks.

4.2. Office Modular II (OM2)

UBCO is currently working on a project proposing a new modular structure to address immediate space needs resulting from growth in UBC Okanagan's faculty and program staffing. The proposed building will be located directly north of Office Modular 1 (OM1). The new Office Modular 2 (OM2) building's design, footprint, and function will closely match that of OM1. OM2 will also have washrooms provided that will service the occupants of OM1 and OM2. Project Services has prepared the basis of design document. Energy Team has been working with Project Services to apply for an eligible incentive for the Office Modular building through FortisBC.

4.3. 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

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collisions. Energy Team has beenworking with Construction Management Office to apply for an eligible incentive for the renovations through FortisBC.

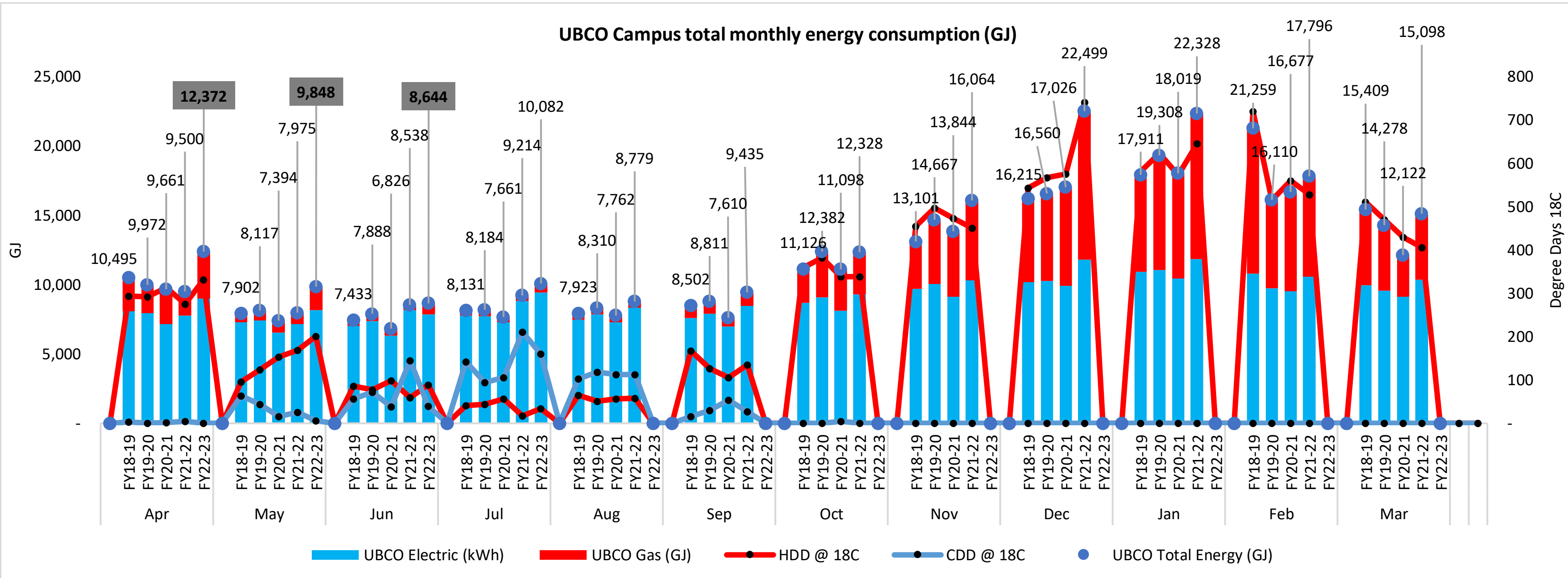
4.4. Childcare (Daycare Extension)

The Child Care Facility is a proposed new $3.294M facility, expected to be 520 GSM (5,600 GSF), located adjacent to the existing UBC Okanagan Daycare Building at 1262 Discovery Avenue and operated by the University Children's Learning Centre Society (UCLCS or 'the Centre'). Through the development of a new facility and outdoor play space adjacent to the existing Centre, the Child Care Facility will add 37 new childcare spaces (12 infant/toddler and 25 3-5 year) to the Centre's 57 childcare spaces (22 infant/toddler and 35 3-5 year) accommodated in the Daycare Building.

Energy Team has been involved in reviewing Design Brief of the project and will be working to apply for an eligible incentive for the this extension through FortisBC.

5. Monthly Energy Performance Graphs

This section presents various figures which show and compares the month over month energy consumption from FY 18-19 to FY 22-23[7].



[7] For section 5, any year listed in the graph is start of the fiscal year.

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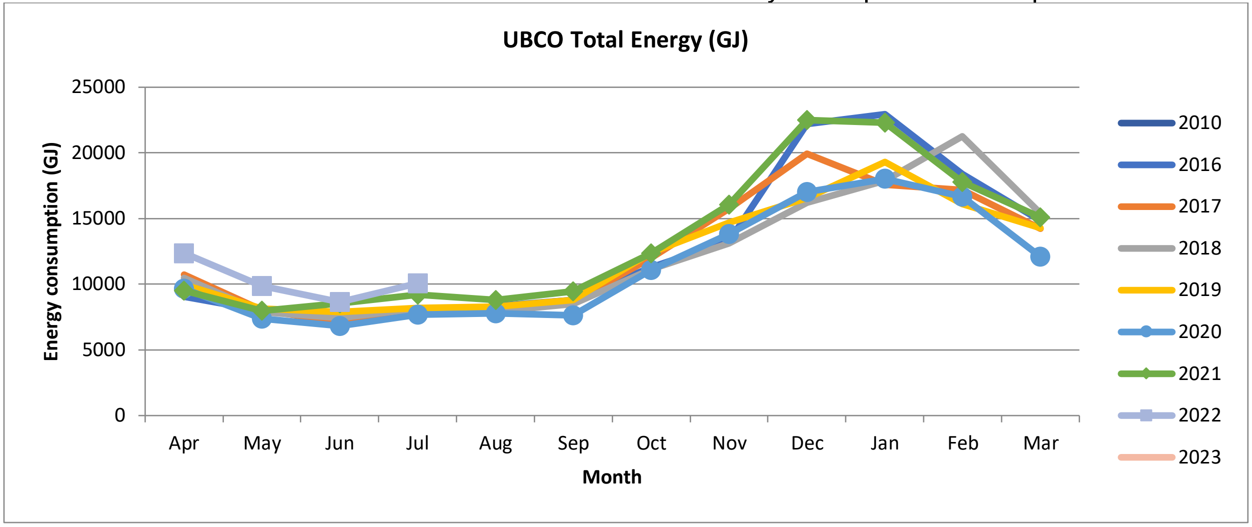

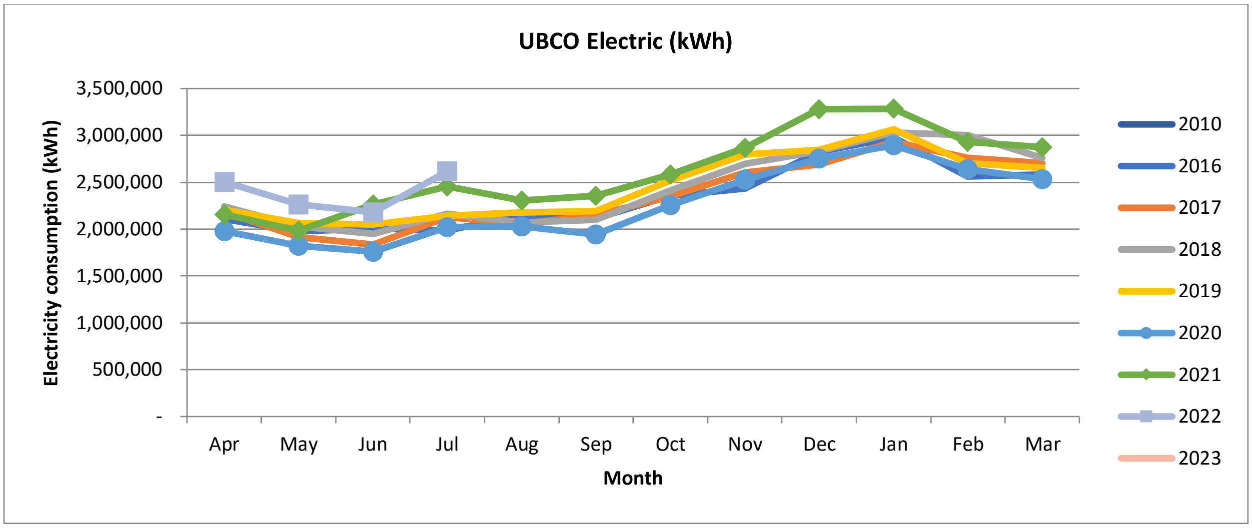

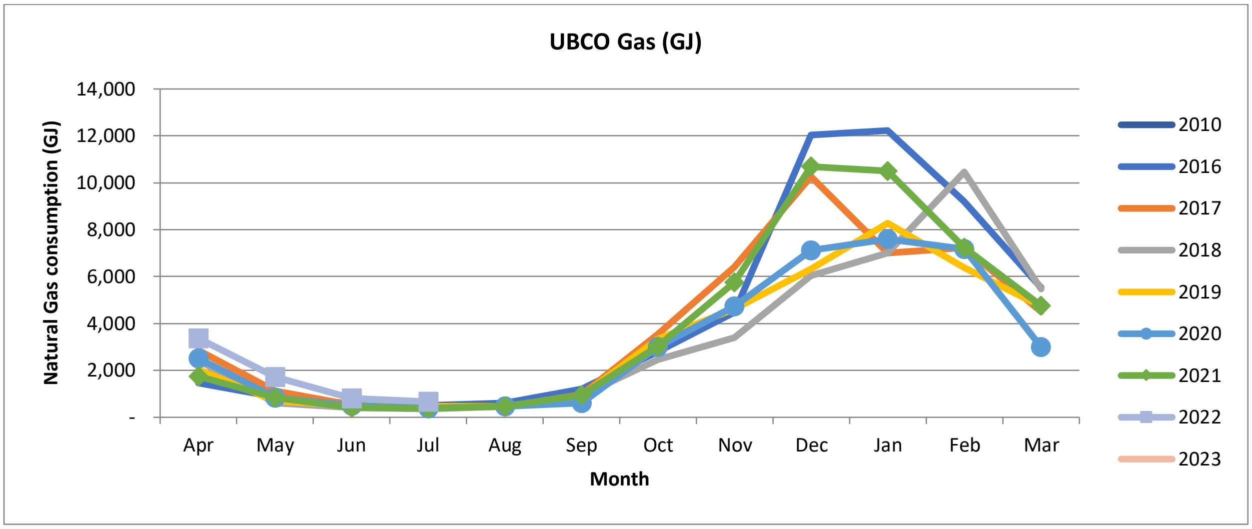

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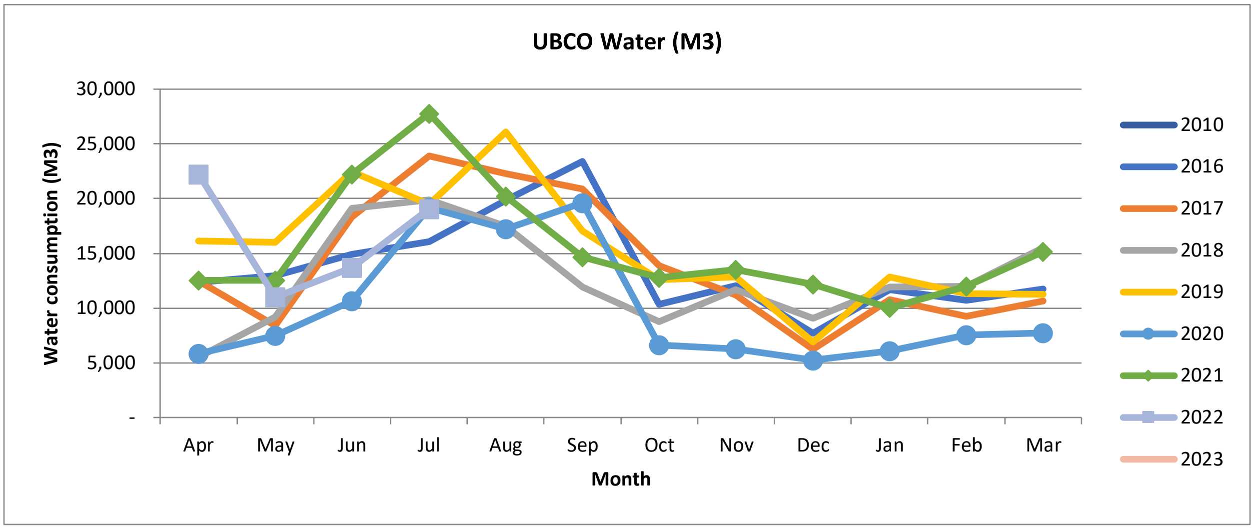

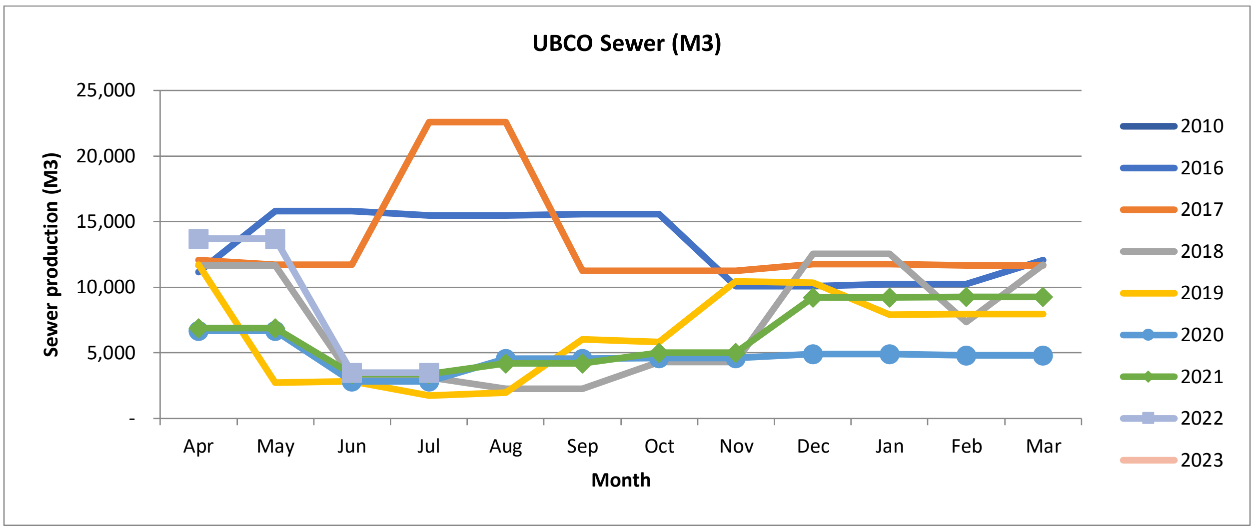

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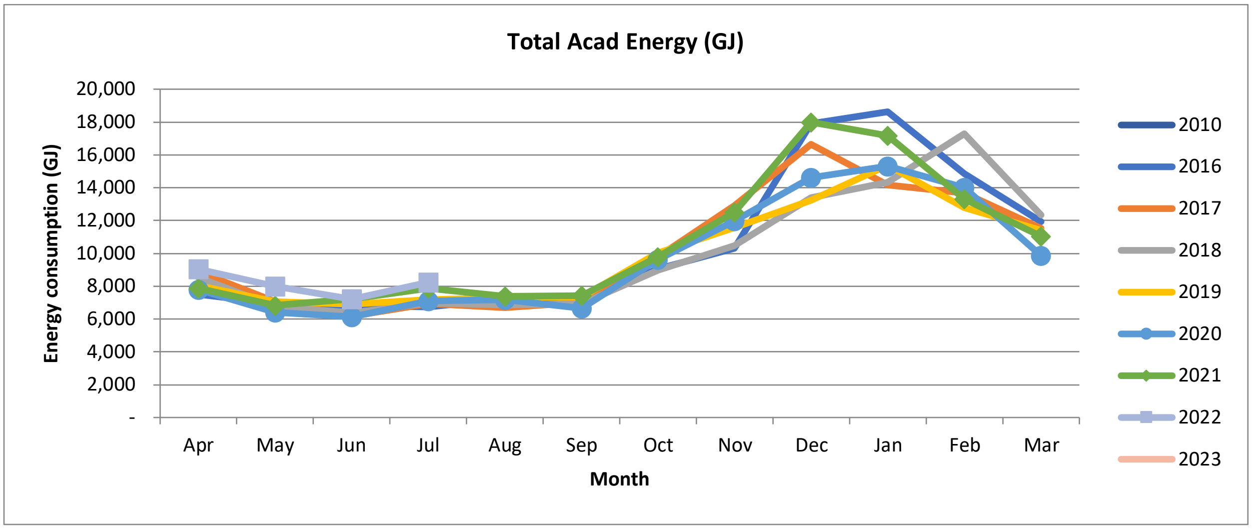

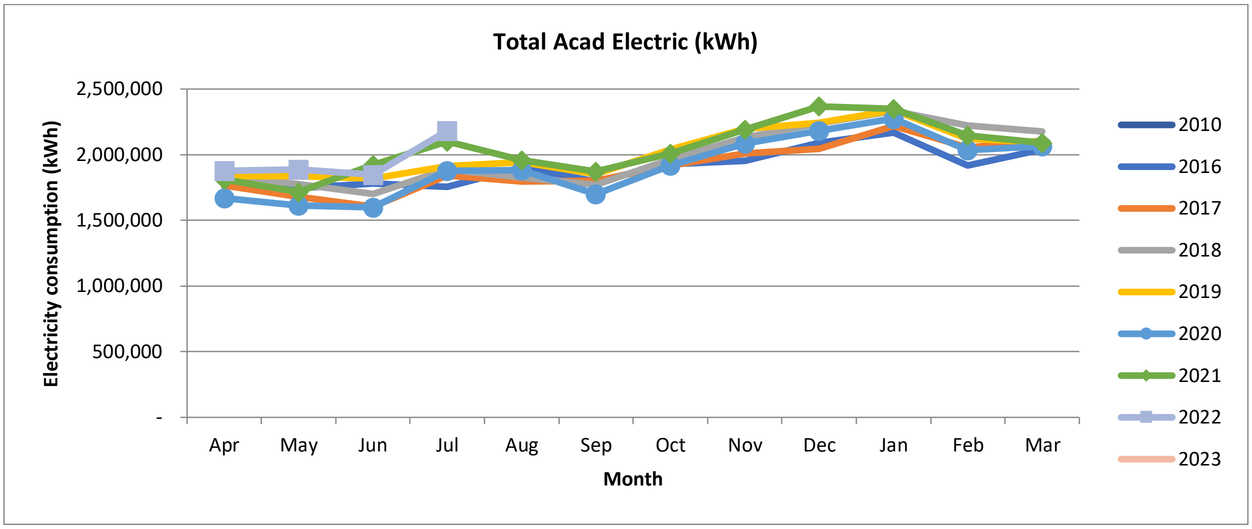

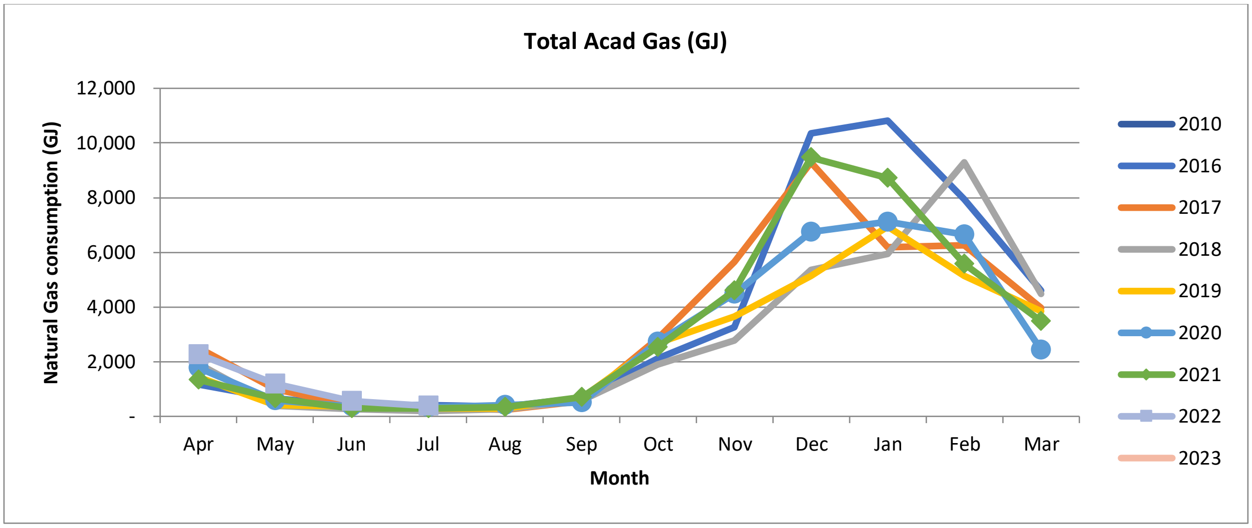

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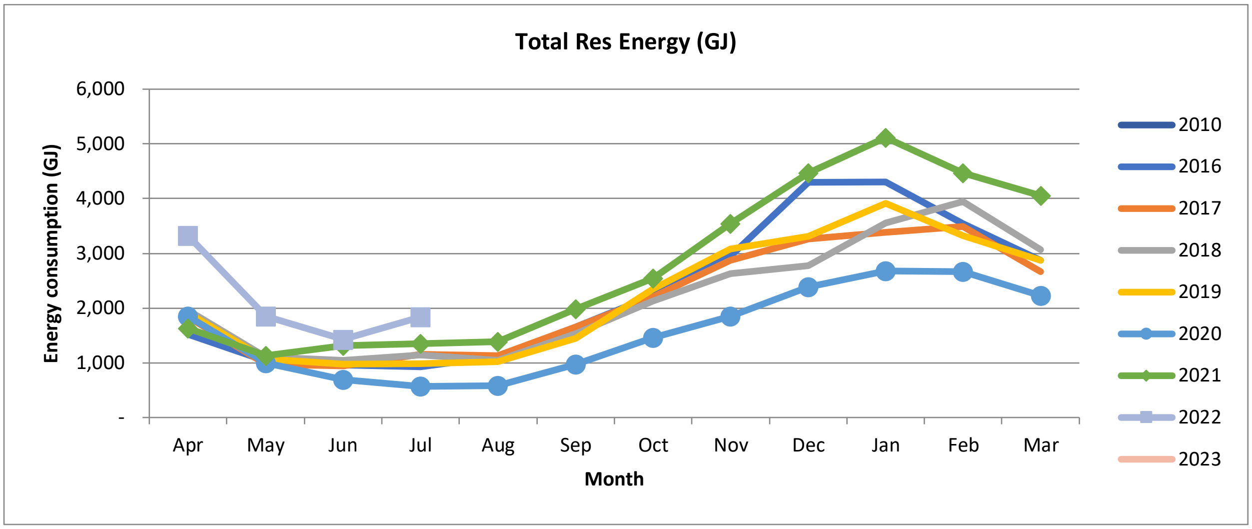

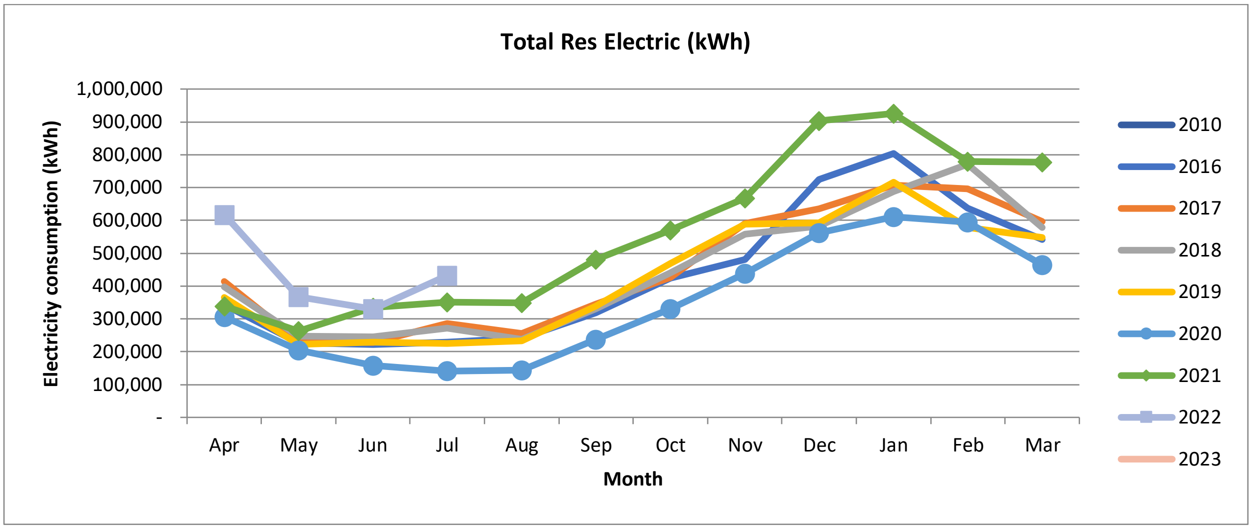

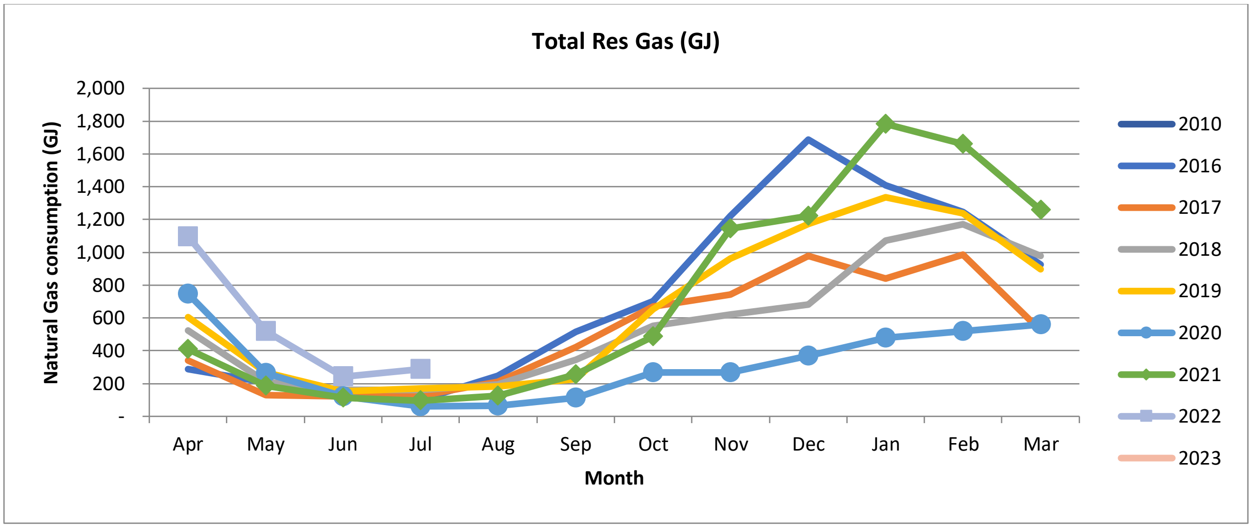

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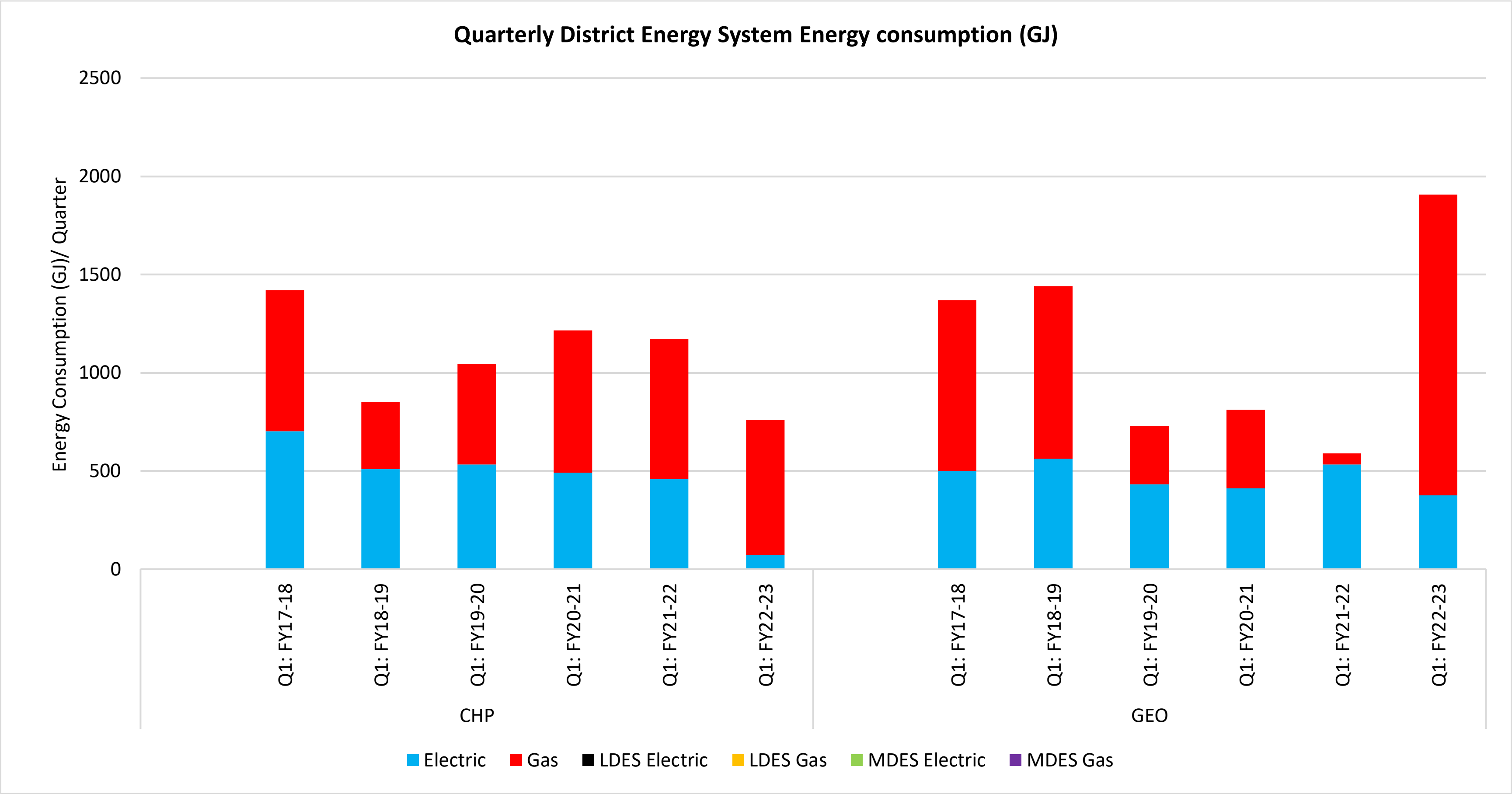

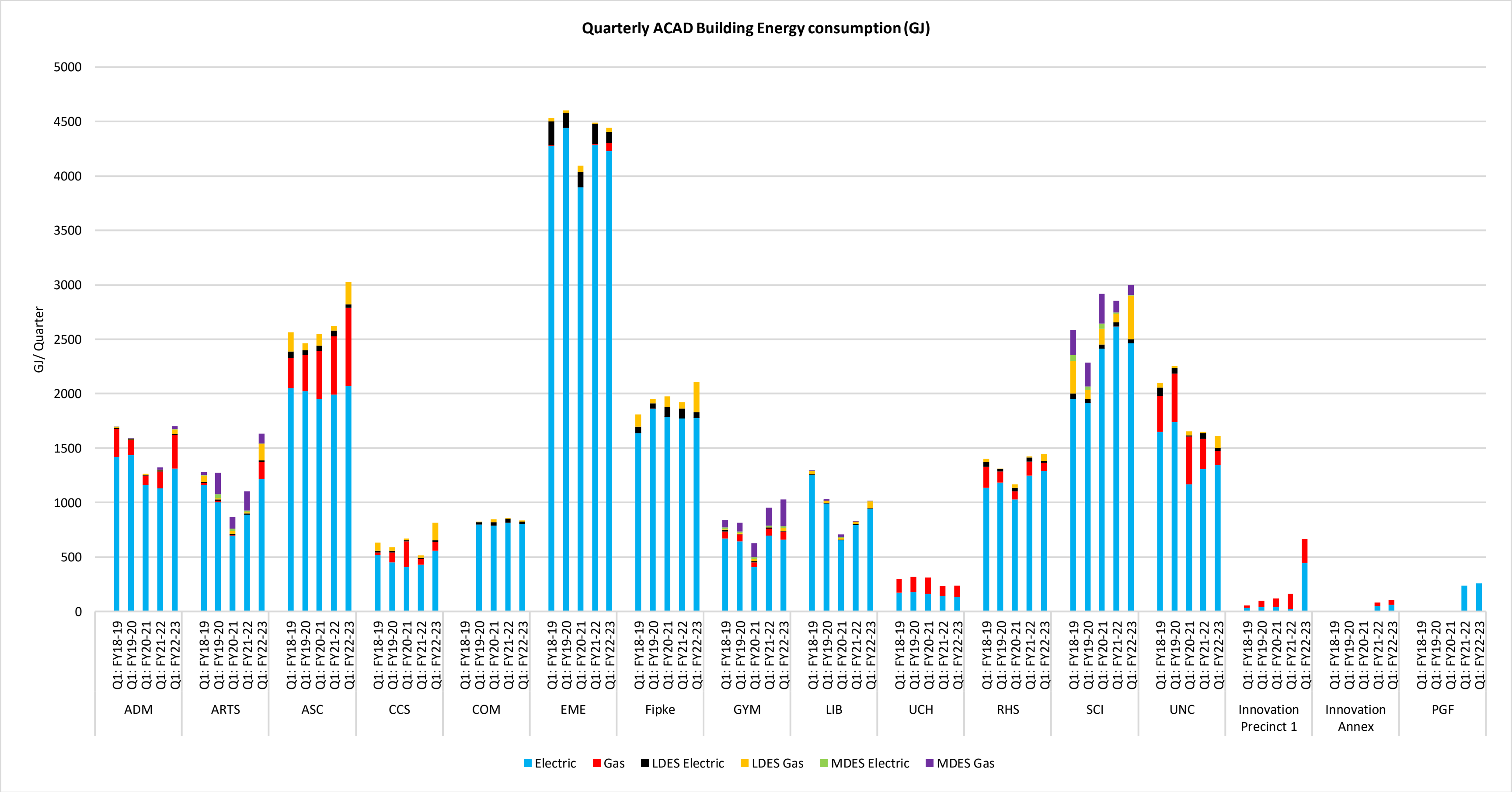
Quarterly ACAD Building Energy consumption (GJ)
GJ / Quarter
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Q1: FY18-19
Q1: FY19-20
Q1: FY20-21
Q1: FY21-22
Q1: FY22-23
ADM
ARTS
ASC
CCS
COM
EME
Fipke
GYM
LIB
UCH
RHS
SCI
UNC
Innovation Precinct 1
Innovation Annex
PGF
Electric
Gas
LDES Electric
LDES Gas
MDES Electric
MDES Gas

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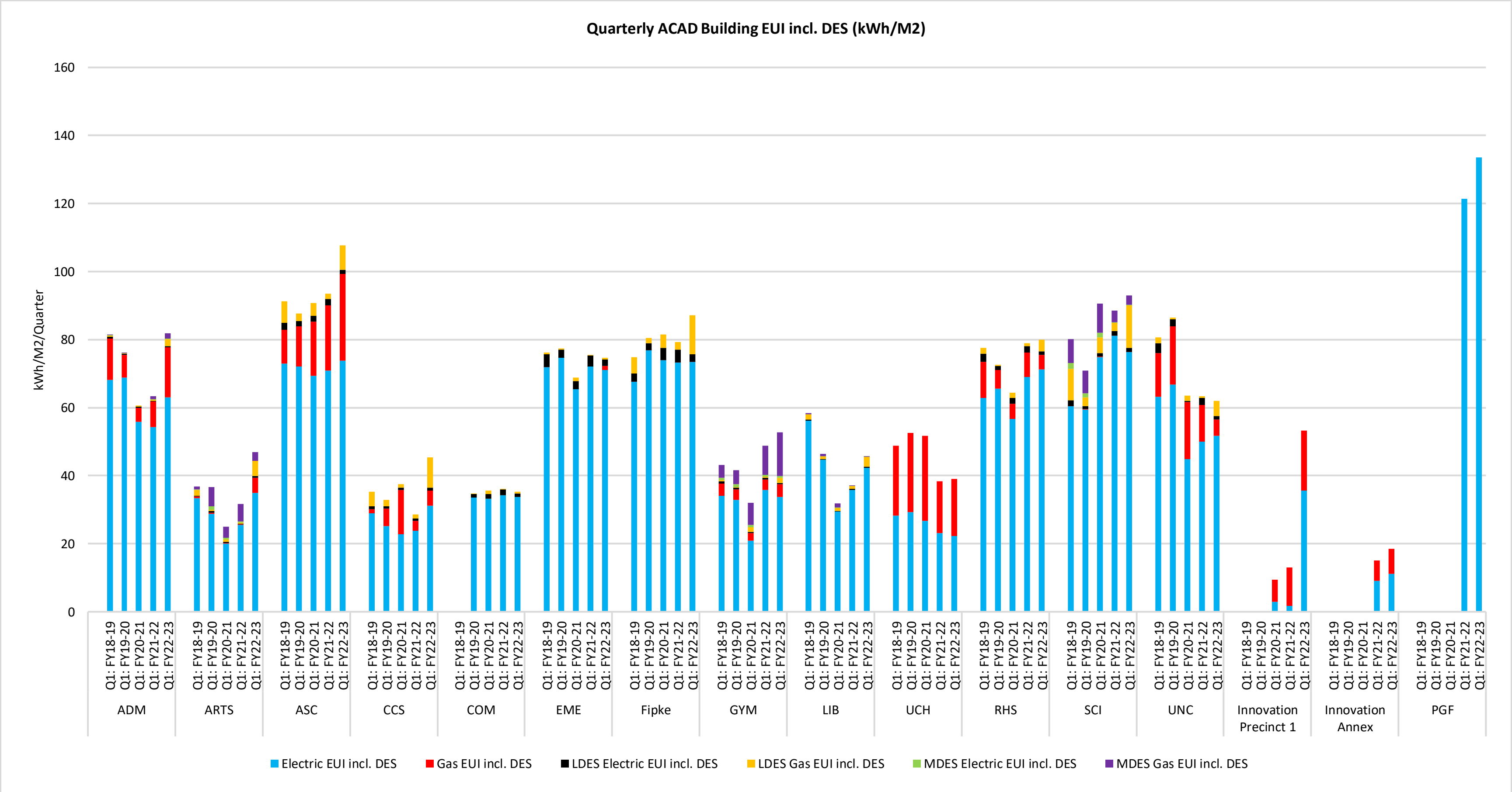

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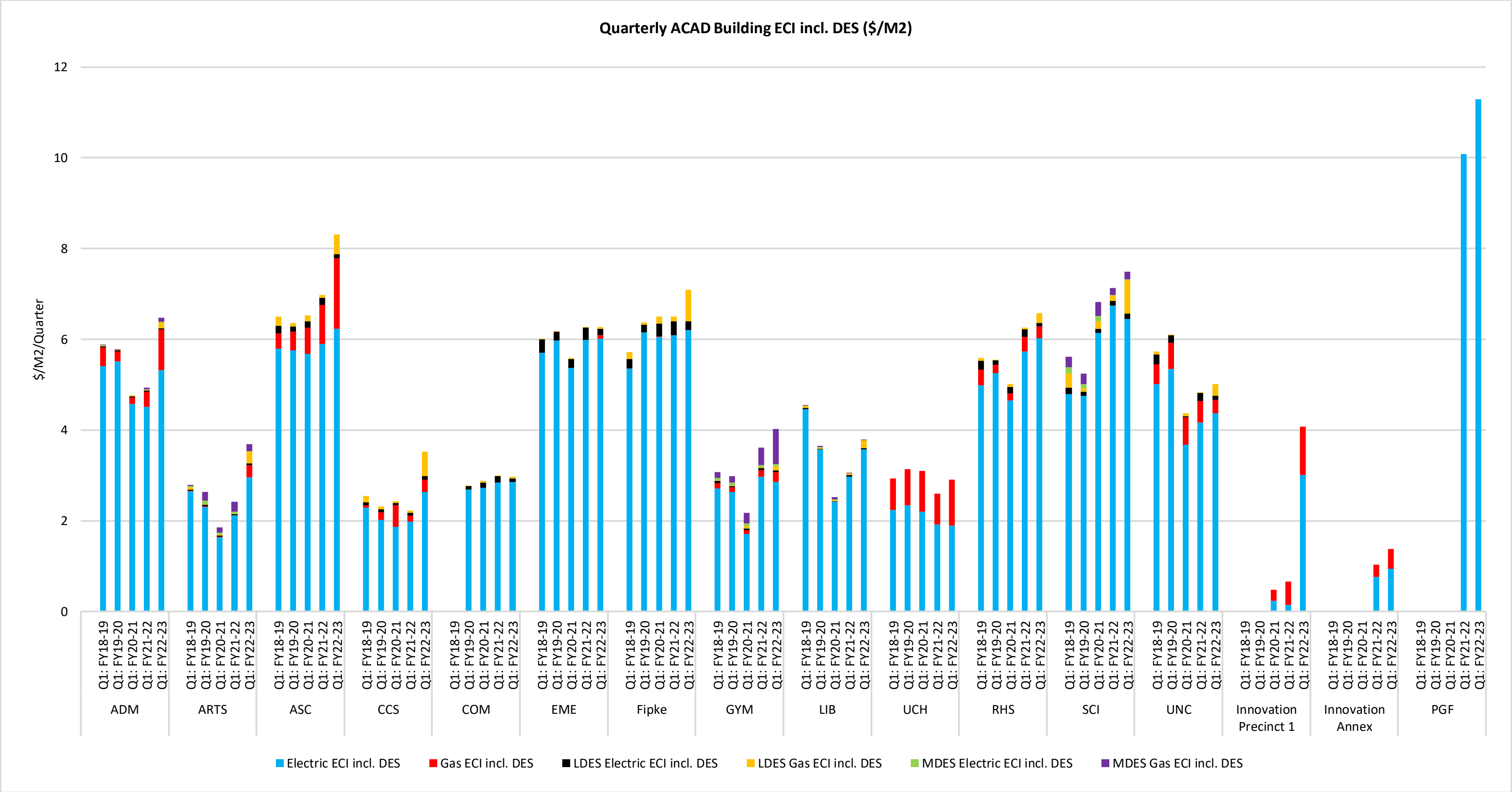

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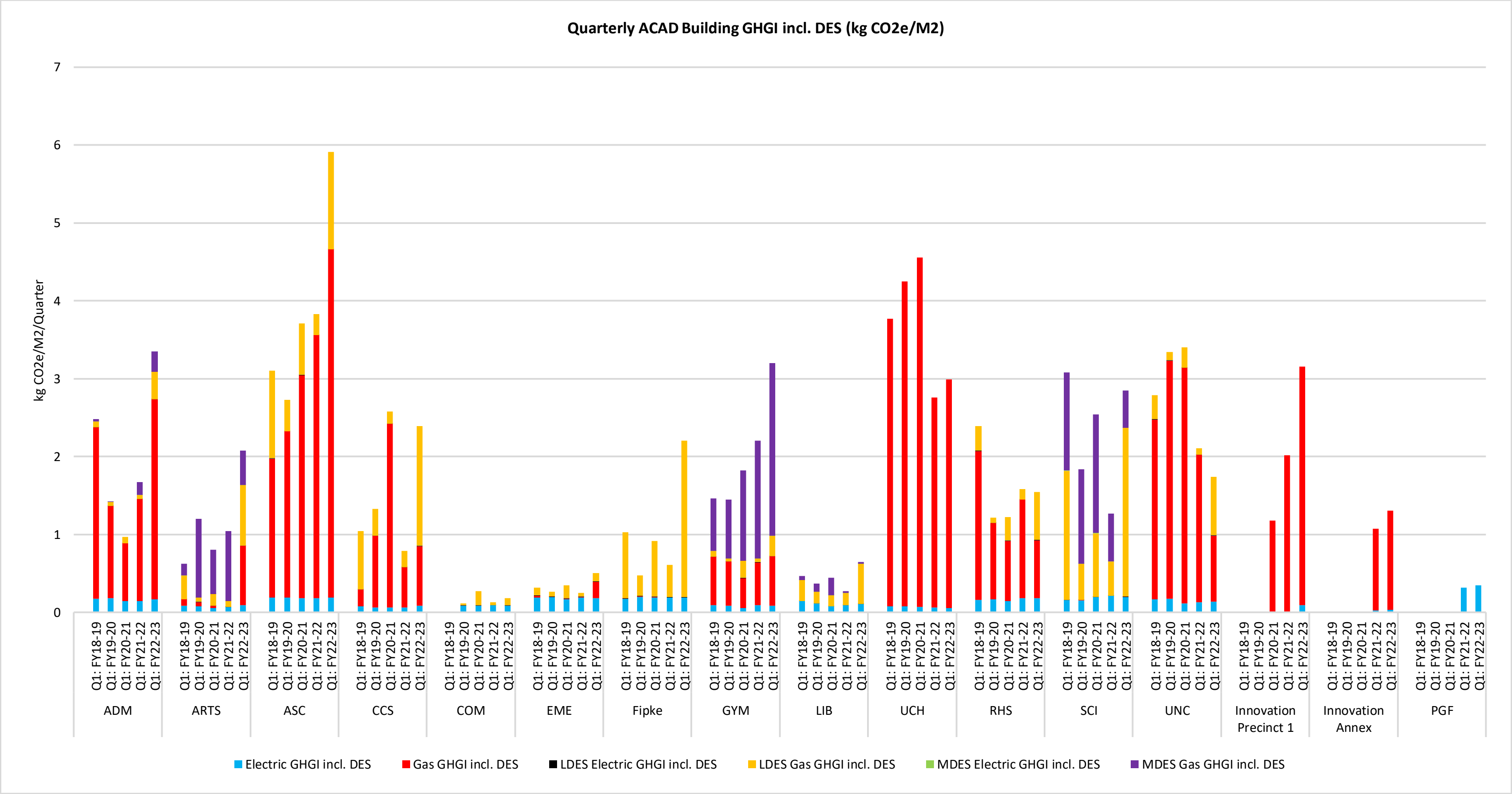

* Assuming electricity emission factor of 2.587 tCO_2e/GWh (old FortisBC grid factor)

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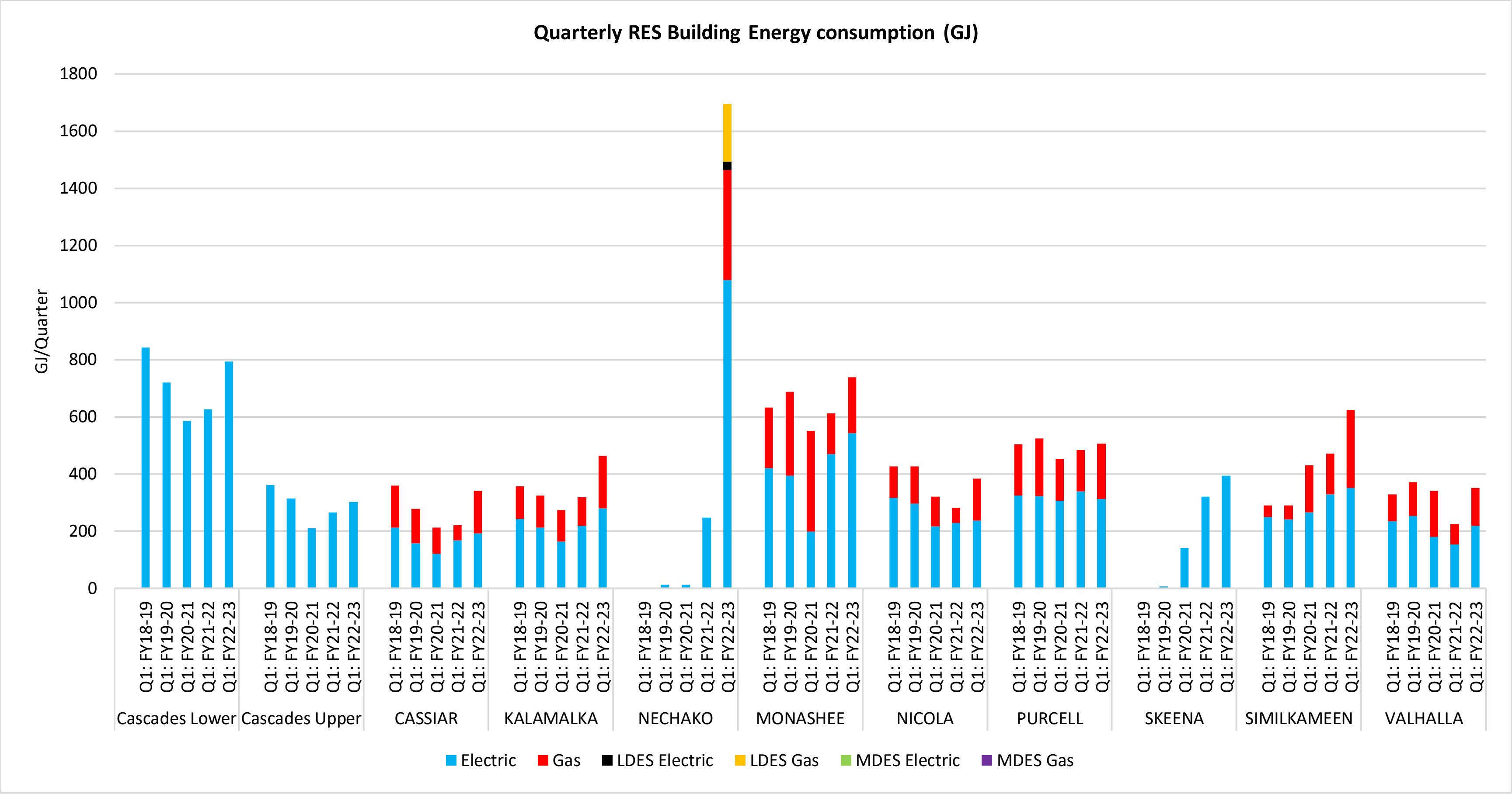

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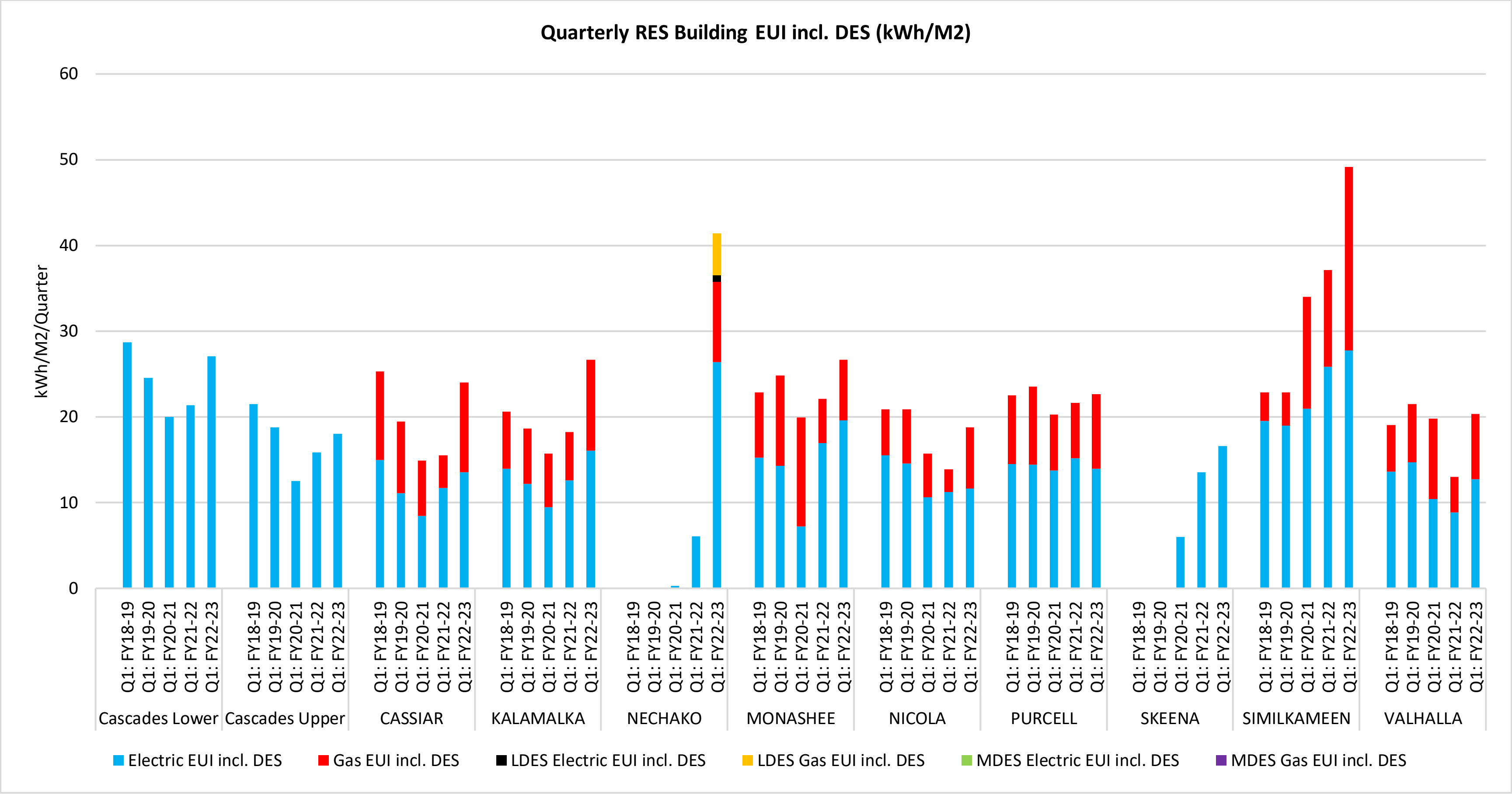

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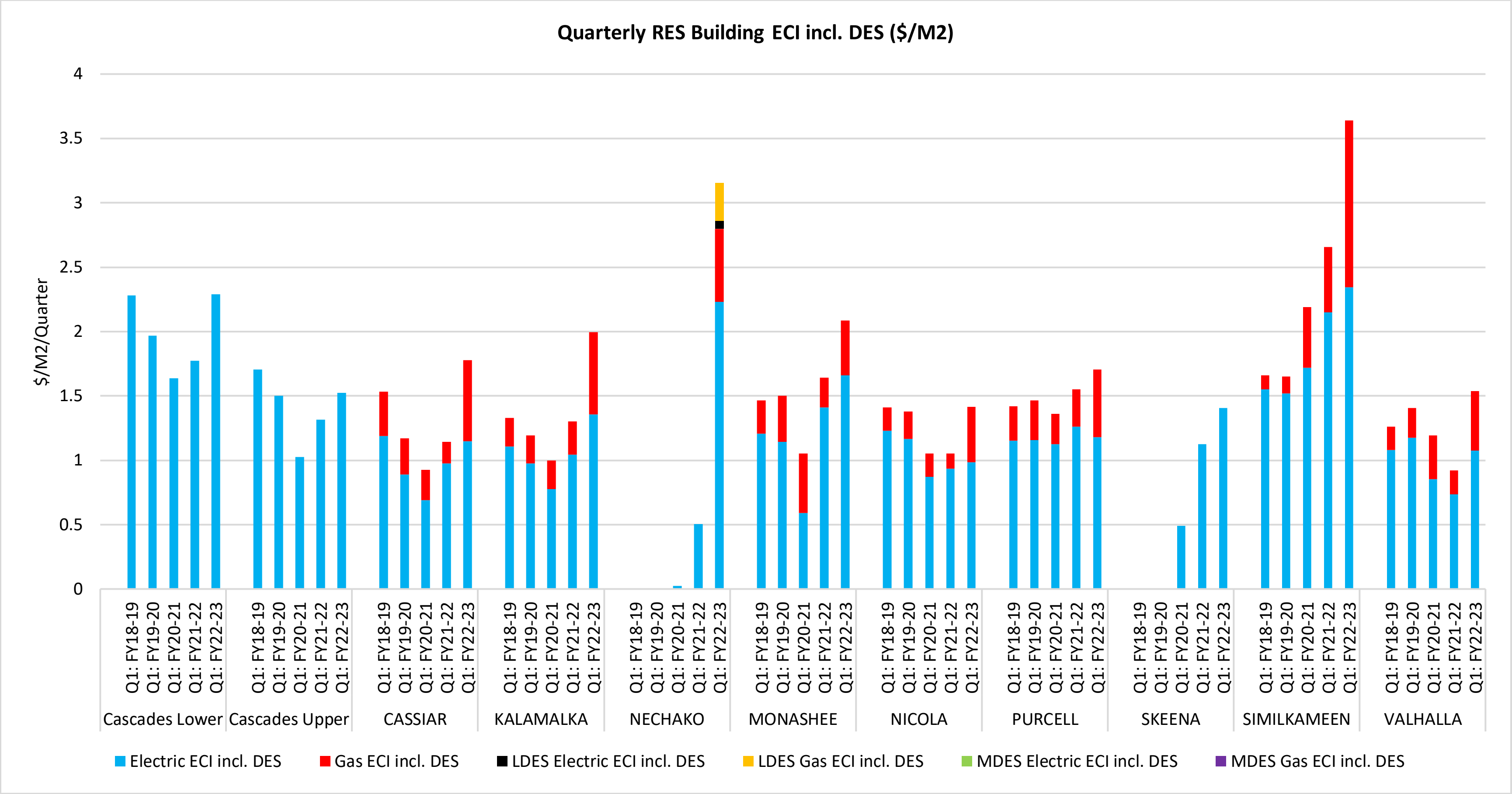

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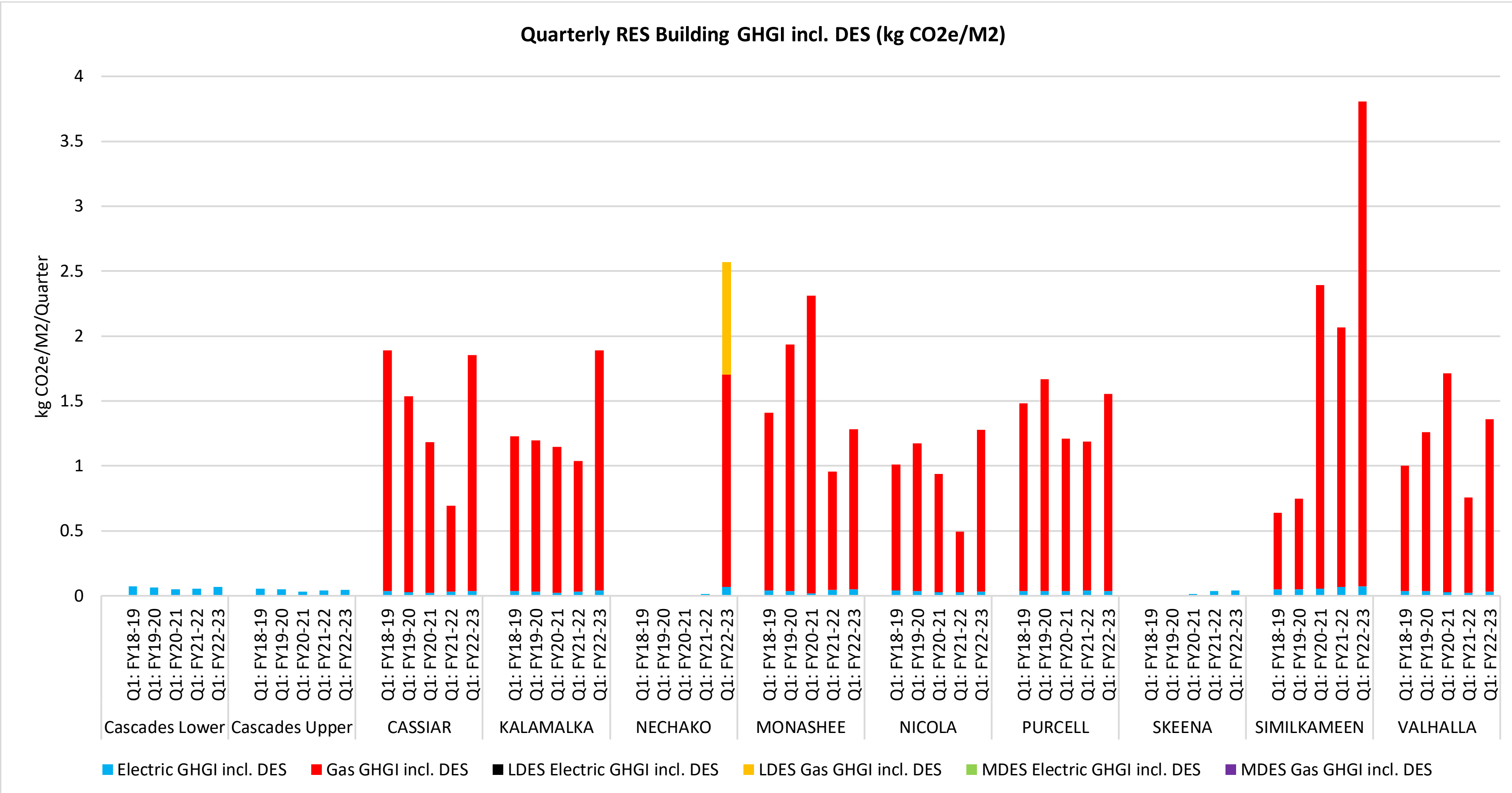

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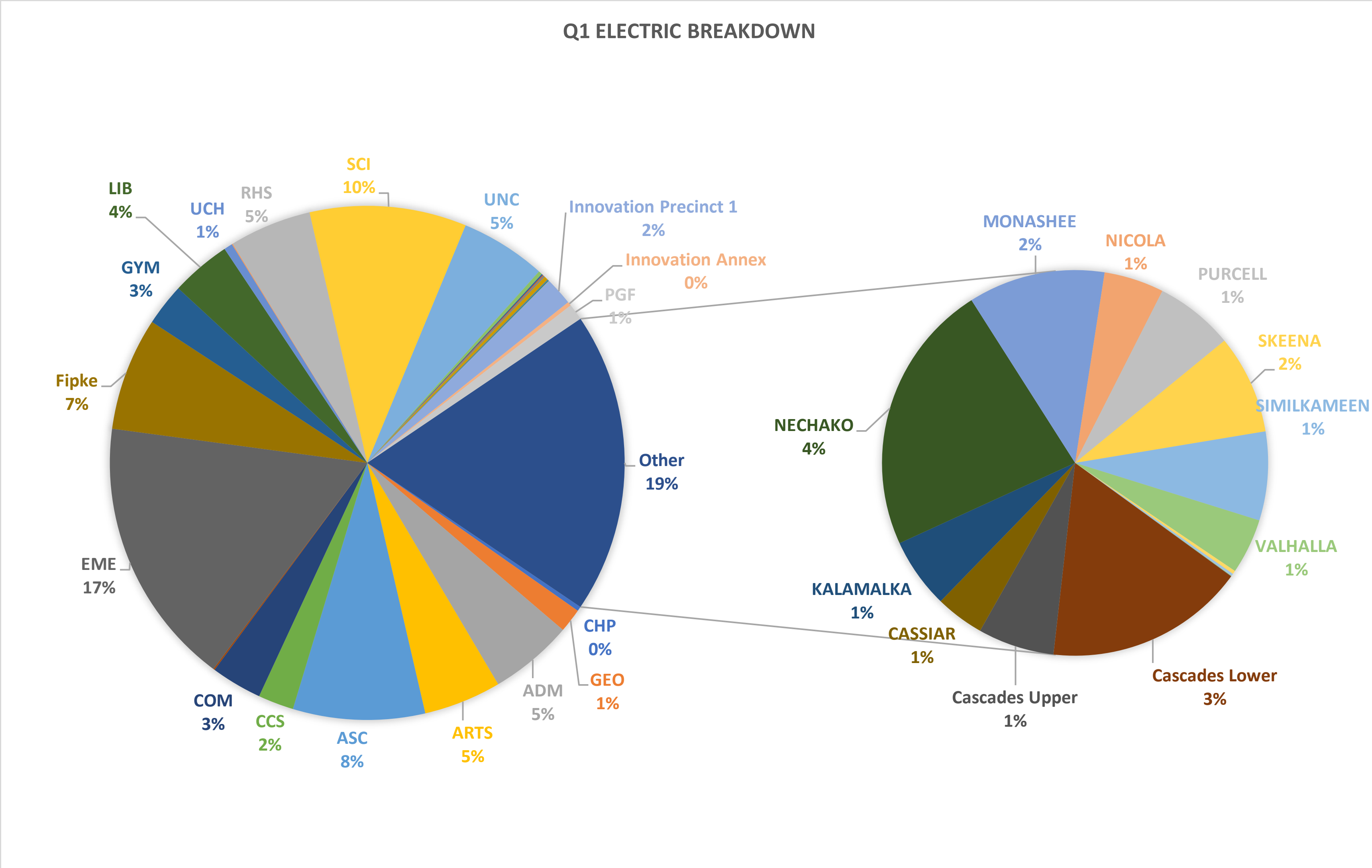
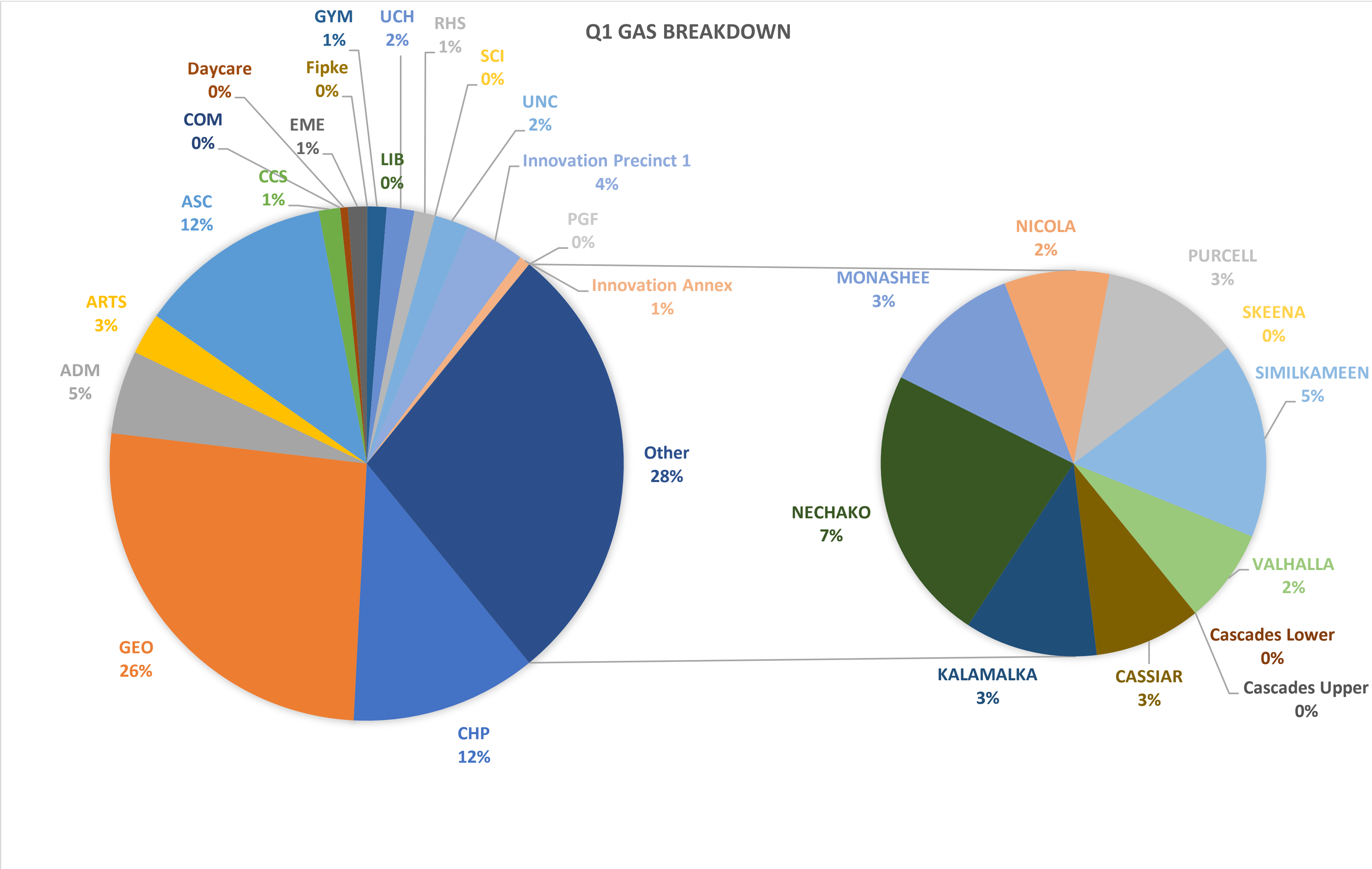


Note: Building electricity and gas consumption values shown are for consumption within the building. Indirect gas consumption via MDES & LDES is not included.



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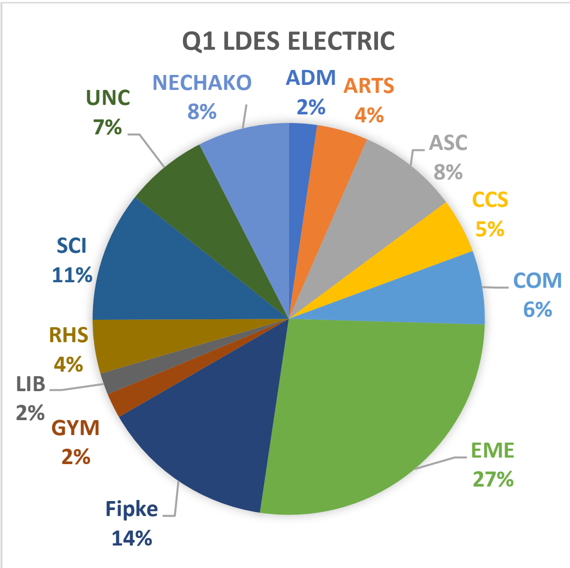
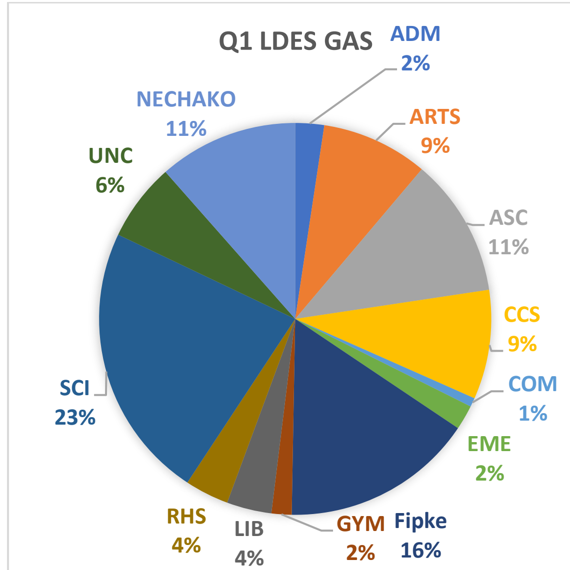
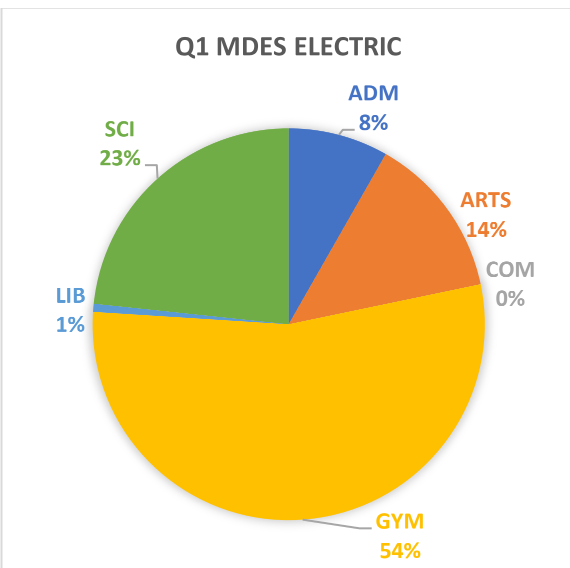
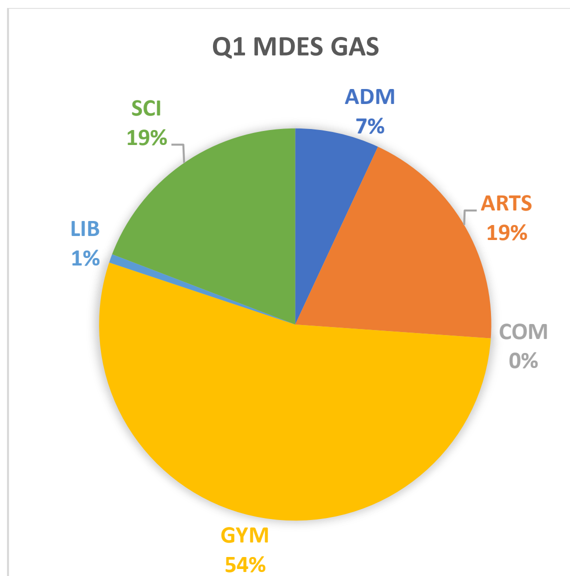

Q1 LDES ELECTRIC
ADM 2%
ARTS 4%
ASC 8%
CCS 5%
COM 6%
EME 27%
Fipke 14%
GYM 2%
LIB 2%
RHS 4%
SCI 11%
UNC 7%
NECHAKO 8%


Q1 LDES GAS
ADM 2%
ARTS 9%
ASC 11%
CCS 9%
COM 1%
EME 2%
Fipke 16%
GYM 2%
LIB 4%
RHS 4%
SCI 23%
UNC 6%
NECHAKO 11%


Q1 MDES ELECTRIC
ADM 8%
ARTS 14%
COM 0%
GYM 54%
LIB 1%
SCI 23%


Q1 MDES GAS
ADM 7%
ARTS 19%
COM 0%
GYM 54%
LIB 1%
SCI 19%

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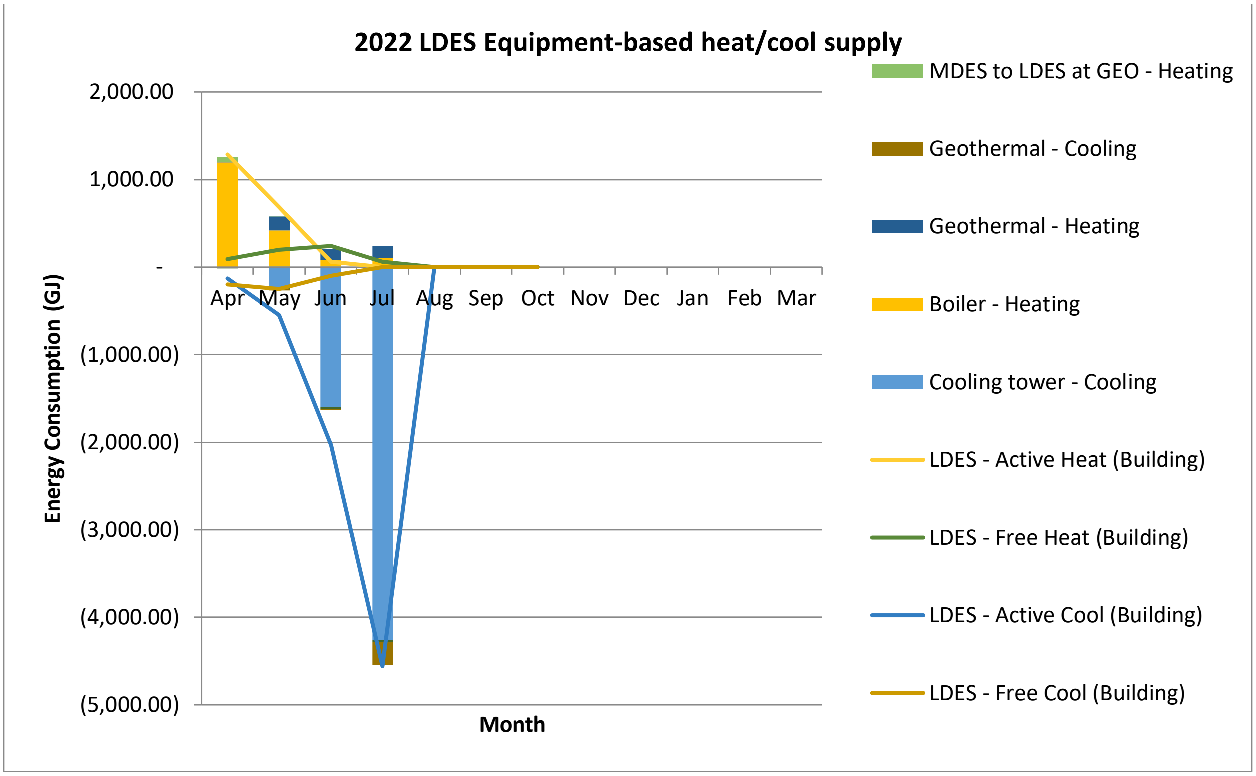

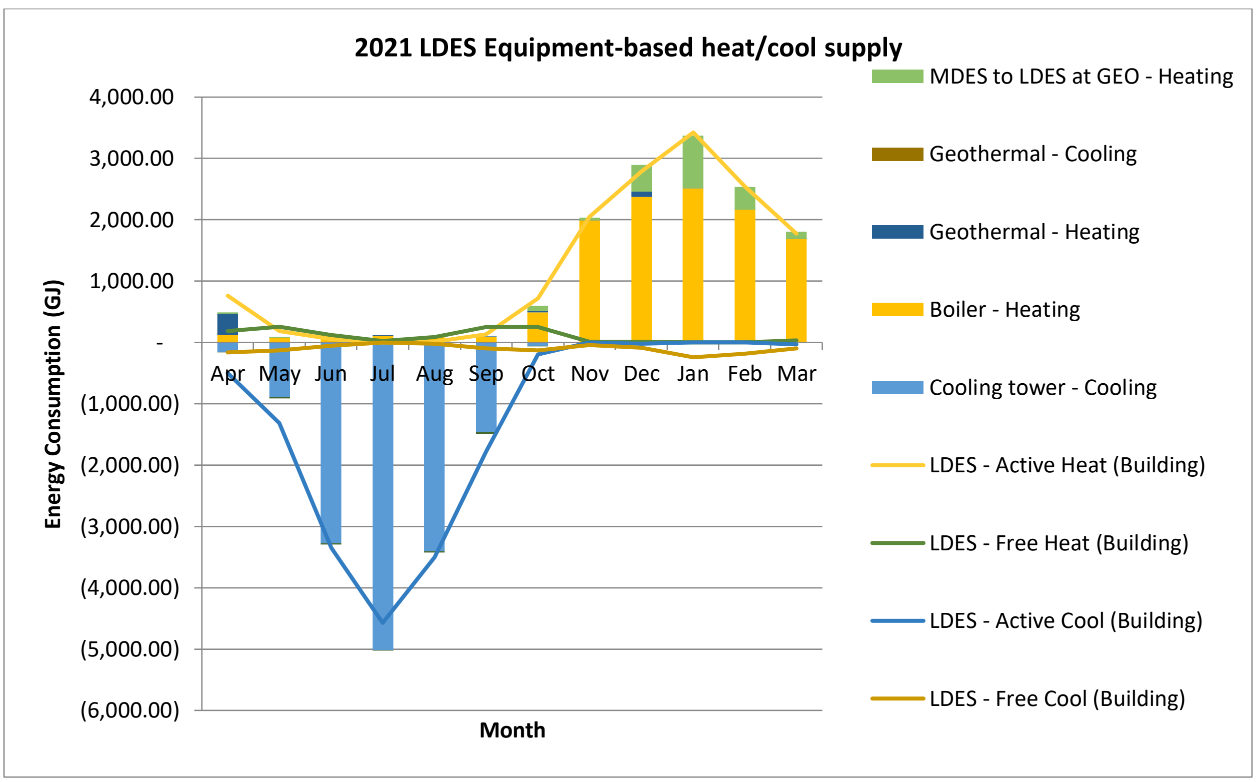

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