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THE UNIVERSITY OF BRITISH COLUMBIA

Energy Team
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UBC Okanagan Campus
Energy Team
Quarterly Report
October 2022 – December 2022

Report Date: 2022-01-31

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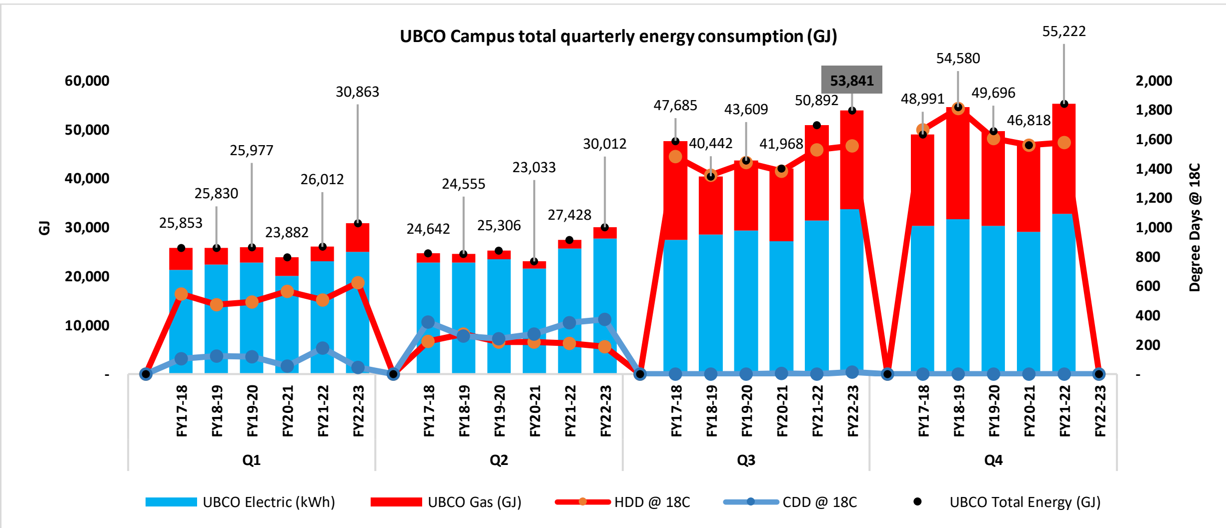
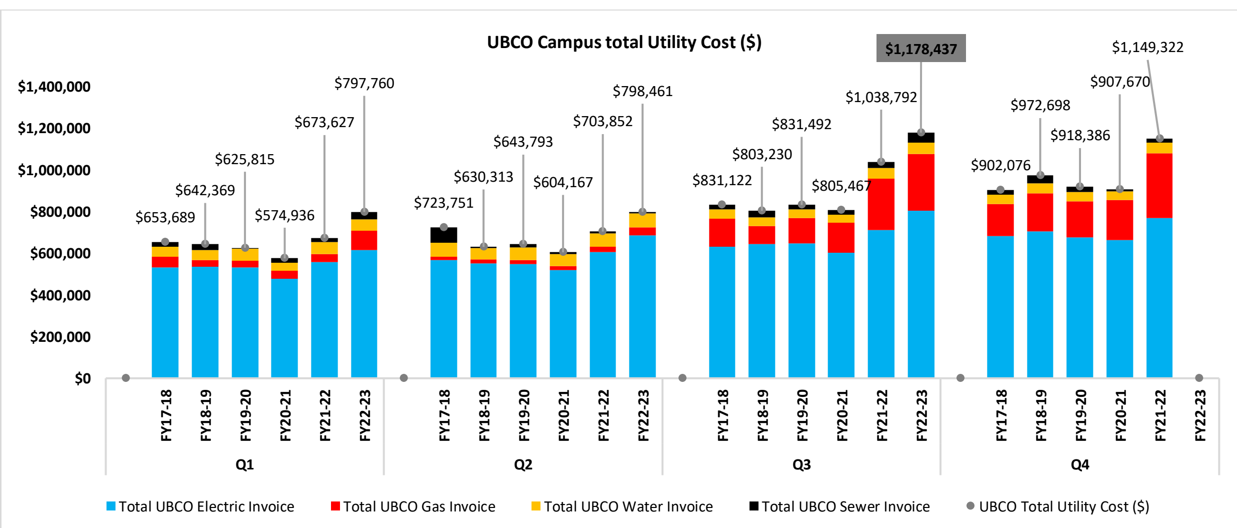
1. Overview of the Third Quarter of FY 2022-2023

UBCO Campus total energy consumption over the past quarter (Q3 2022) was 53,841 GJ compared to 50,892 GJ for Q3 last fiscal year (Q3 2021), a 6% year over year quarterly increase leading to a 12% increase in total campus energy utility cost. This total energy consumption includes a 7% increase in campus Electricity consumption i.e. from 8,730 MWh in Q3 2021 to 9,378 MWh in Q3 2022 and an increase of 3% in campus Gas consumption i.e. from 19,463 GJ in Q3 2021 to 20,081 GJ in Q3 2022.





In Q3 2022, Heating Degree-Days (HDD) was observed to be similar to previous year i.e. 1,529 degree-days in Q3 2021 vs 1,555 degree-days in Q3 2022.

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The increase in energy consumption can be attributed to the following key factors:

Electricity:

- A 21% increase (439 MWh net) in Residences electricity consumption was observed i.e. from 2,140 MWh in Q3 2021 to 2,579 MWh in Q3 2022. This increment was observed in almost all the Residences primarily Lower Cascades (37% increase i.e. by 126 MWh), Upper Cascades (26% increase i.e. by 45 MWh), Nechako (17% increase i.e. by 73 MWh), Nicola (27% increase i.e. by 40 MWh). Similkameen observed a reduction in electricity consumption by 5% i.e. by 9 MWh.
- A 3% (214 MWh net) increase in electricity consumption for Academic buildings was observed. This can be primarily attributed to U House (194% i.e. by 11 MWh), RHS (17% i.e. by 75 MWh), FIP (10% i.e. by 56 MWh), Innovation Precinct 1 (20% increase i.e. by 31 MWh), CCS (22% i.e. by 25 MWh), COM (18% i.e. by 43 MWh), GEO (18% i.e. by 21 MWh), Innovation Annex (18% i.e. by 5 MWh).
- A few academic buildings observed reduction of electricity consumption. These buildings are CHP (75% i.e. by 166 MWh), ARTS (8% i.e. by 27 MWh), SCI (3% i.e. by 23 MWh) due to a combination of recommissioning, retrofit and efficiency measure implementation projects.

Natural Gas:

- A 31% increase (875 GJ net) in Residences gas consumption was observed i.e. from 2,852 GJ in Q3 2021 to 3,726 GJ in Q3 2022. This can be primarily attributed to operations and commissioning of new Residence Nechako's kitchen (390 GJ), SIM (34% i.e. by 160 GJ).
- A 2% reduction (256 GJ net) in Academic gas consumption was observed i.e. from 16,612 GJ in Q3 2021 to 16,355 GJ in Q3 2022. Gas consumption increased significantly in a few buildings EME (306% increase by 530 GJ), ASC (55% increase by 386 GJ), ARTS (25% increase by 93 GJ).
- A few academic buildings observed reduction in gas consumption. These buildings are CHP (4% decrease by 260 GJ), GEO (5% decrease by 282 GJ), FIP (80% decrease by 287 GJ), UCH (36% decrease by 90 GJ), UNC (21% decrease by 174 GJ).

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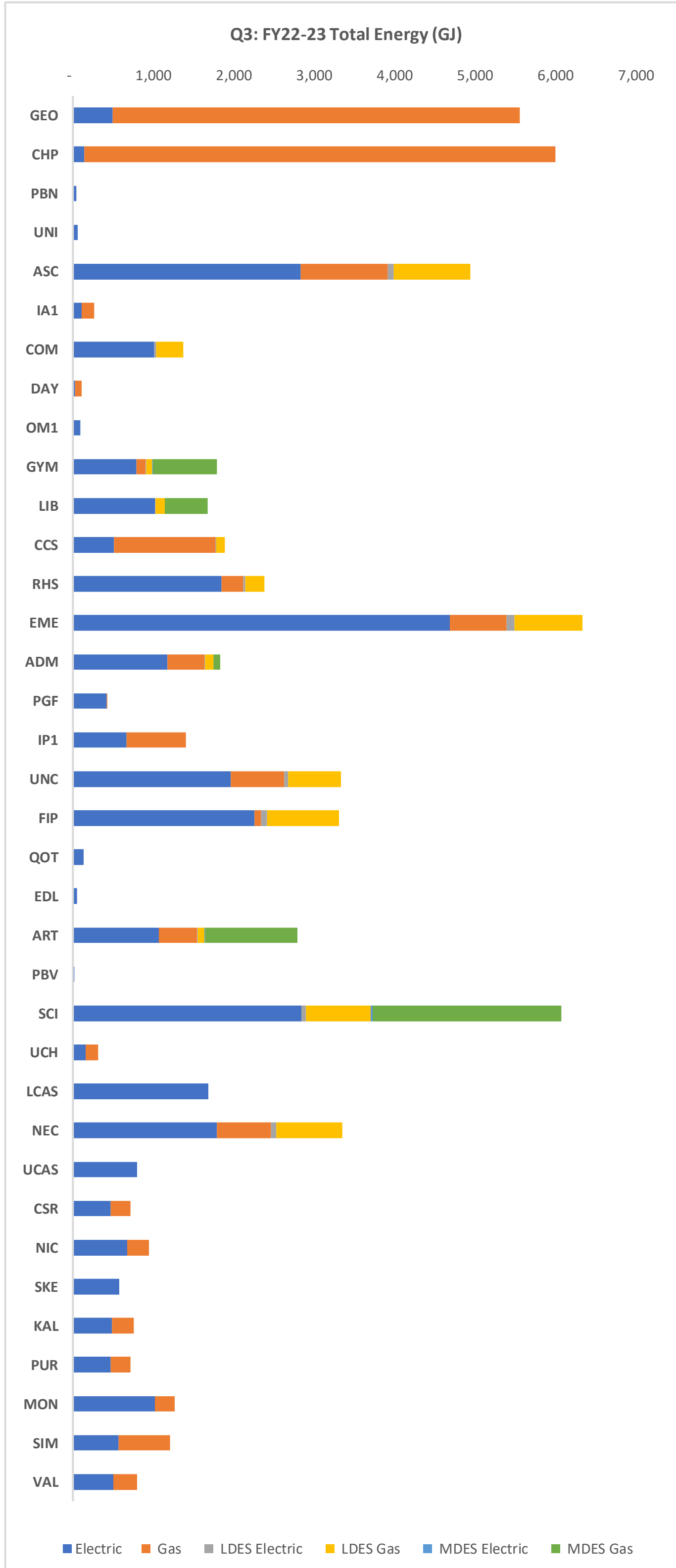
Type	Building	% Total energy change
DES	GEO	-4%
DES	CHP	-10%
ACAD	PBN	3190%
ACAD	UNI	194%
ACAD	ASC	22%
ACAD	IA1	20%
ACAD	COM	16%
ACAD	DAY	13%
ACAD	OM1	12%
ACAD	GYM	12%
ACAD	LIB	10%
ACAD	CCS	9%
ACAD	RHS	8%
ACAD	EME	8%
ACAD	ADM	4%
ACAD	PGF	3%
ACAD	IP1	2%
ACAD	UNC	0%
ACAD	FIP	-1%
ACAD	QOT	-2%
ACAD	EDL	-2%
ACAD	ART	-4%
ACAD	PBV	-5%
ACAD	SCI	-12%
ACAD	UCH	-20%
RES	LCAS	37%
RES	NEC	35%
RES	UCAS	26%
RES	CSR	23%
RES	NIC	19%
RES	SKE	17%
RES	KAL	17%
RES	PUR	17%
RES	MON	14%
RES	SIM	12%
RES	VAL	10%



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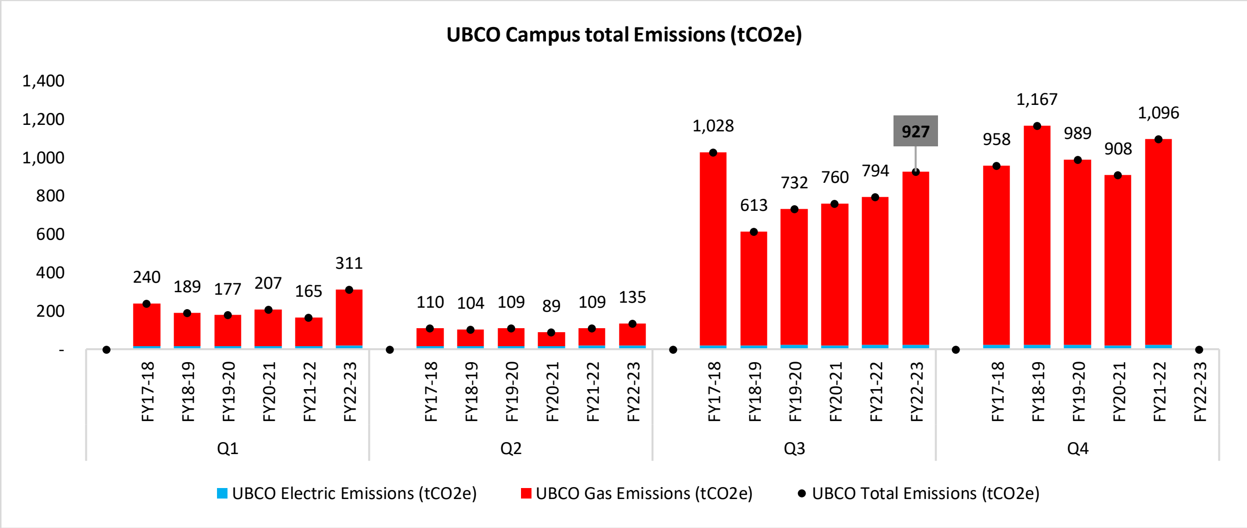
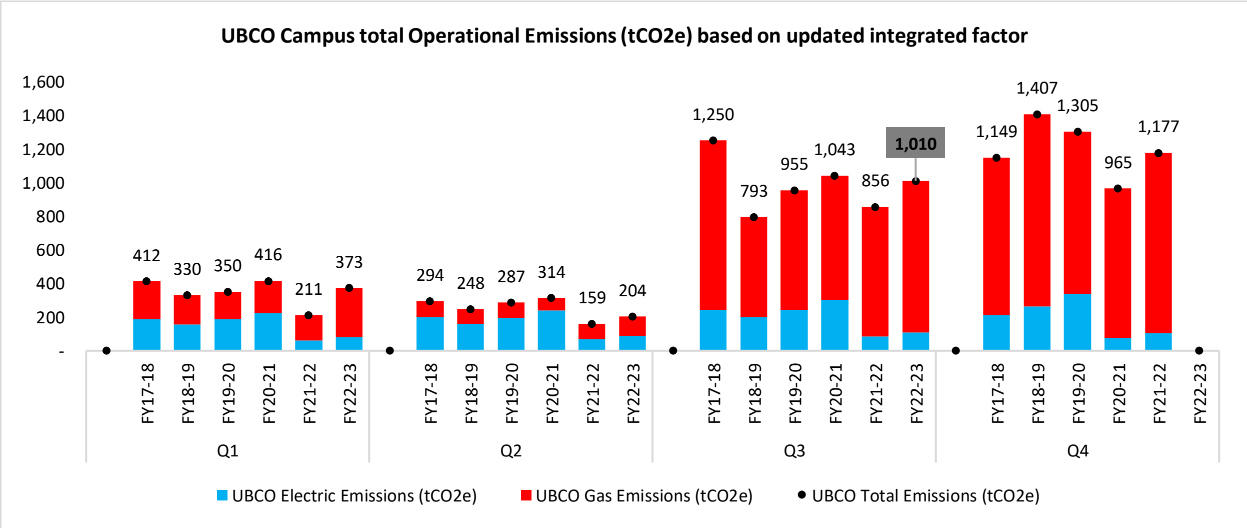


The figure above shows quarterly trend of total GHG emissions for UBC Okanagan campus from FY17-18 to FY22-23 assuming electricity emission intensity factor of 2.587 tCO_2e/GWh[1]. Total operational GHG emissions for the UBCO campus increased by 17% from 794 tCO2e in Q3 FY21-22 to 927 tCO2e in Q2 FY22-23. UBCO purchased 2000 GJ of RNG resulting in reduction of 100 tCO_2e.



The figure above shows quarterly trend of total GHG emissions for UBC Okanagan campus from FY17-18 to FY22-23 based on integrated grid emissions factor which is currently at 11.5 tCO_2e/GWh.

[1] 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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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-based Demand controlled ventilation for campus AHUs and/ or MUAs (Project completed for SCI building)
  - Occupancy-based Demand controlled ventilation for campus AHUs and/ or MUAs (Study completed for ASC FIP, project to be implemented in FY23-24)
  - IAQ-based Demand controlled ventilation for campus AHUs and/ or MUAs (Project underway for SCI building)
  - IAQ-based Demand controlled ventilation for campus AHUs and/ or MUAs (Study underway for EME building)
- Recommissioning of existing controls at ARTS building (Completed)
- Night-time precooling (Completed)
- Waste heat recovery from strobic exhaust for SCI building (Study underway)
- Recommissioning of existing controls at EME building (Project underway)
- LED lighting upgrade for Plant Growth Facility (Project underway)

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.

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.

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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). Similar to LIPCP, Energy Team is working on a high-level concept design for a potential Upper Innovation Precinct Cluster Plant to serve new and existing residences.

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 and install ASHP (Phase 1 of DE decarbonization strategy) by FY24-25.

In order to advance DE Strategy, Energy Team has engaged UBCO Project Services and/ or direct consultants to kick off four parallel projects which include:

- Phase 1 of DE decarbonization strategy i.e. installation of ASHP and boilers for heating redundancy and
- Phase 2 of DE decarbonization strategy i.e. Thermal Energy Storage
- Installation of ICI 4-pipe infrastructure to serve heating and cooling demands of surrounding buildings from ICI cluster plant.
- High level concept design for an Upper Innovation Precinct 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 was undertaken to get an understanding of what products and technologies are currently available in the market. The technical performances of different options were evaluated by comparing different metrics between units including thermal capacities, efficiencies, turndowns, costs and more. Table below provides a list of product recommendations which were found to be acceptable options:

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Manufacturer	Unit	Notes
Trane (Basis of Design)	2 x ACX-140	• Unit offers best $/kW. • Second best in GHG reductions. • 2 x units required (Require additional space from Phase 4b area) • R410A refrigerant • Local after sales technical/maintenance support.
HecoClima	VHA-4346 HP	• Best heating COP (lowest operating costs) • 1 x unit total required (fits within proposed Phase 4a site area) • R410A refrigerant • No local support
HecoClima	VHA-4346 HP (454b)	• Best heating COP (lowest operating costs) • 1 x unit total required (fits within proposed Phase 4a site area) • R454b refrigerant (Lower GWP) • No local support • Min -10°C ambient (lower GHG emission reduction)
Aermec	NRB H 1800	• Greatest GHG emission reductions. • 2 x units required • Large unit footprint (Requires more space than proposed site of Phase 4a) • High Comparable $/kW and budget costs. • R410A refrigerant • Local after sales technical/maintenance support.

Electrical requirement and costing exercises were also conducted as part of this study. Based on the proposed mechanical systems in terms of overall electrical demand, there is sufficient available spare capacity on the existing 1,200 A, 600V geo-exchange service to support the mechanical works without requiring a utility service upgrade with FortisBC.

The implementation of boiler portion of the project is currently underway. Air-Source heat pump portion of the project has been delayed due to budget constaints and will likely be implemented in next 2-3 years.

2.2.2. Thermal Energy Storage (TES) Study

This study will focus on recommending a few TES tanks, recharge strategy along with developing a concept design to install a changeover TES tank including system schematic markups. It will also include sensitivity analysis and a Class D cost estimate to implement the TES tank.

This study is currently underway and is expected to be completed by end of March 2023.

2.2.3. ICI 4-pipe infrastructure Study

A study to advance ICI cluster plant connection to existing adjacent buildings was completed in October 2022 by an Engineering consultant. This study investigated the feasibility and cost associated with the installation by only using pre-insulated Logstor steel piping. The estimate showed a significant portion of the costs coming from the high cost of supplying and installing the carbon steel Logstor Twin Pipe product for the heating and chilled water piping.

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This exsting study is being extended to investigate alternative piping systems that may be more cost effective than the carbon steel Logstor Twin Pipe product and can be used for expansion of the 4-pipe campus district energy system from the Interdisciplinary Collaboration & Innovation Cluster Plant to several surrounding buildings on campus.

This study is currently underway and is expected to be completed by end of March 2023.

2.2.4. High-level concept design for an Upper Innovation Precinct Cluster Plant

This study is being carried out to explore thermal system configurations to meet the demands of two (2) existing residence buildings, Skeena (2020) and Purcell (2011), and two (2) yet-to-be constructed residence buildings. Energy and Carbon performance of four potential thermal system configurations are being evaluated:

- "Business-As-Usual" configuration with standalone systems per residence
- Standalone system configuration with Low Temperature District Energy System (LDES) connection per residence
- Cluster Plant configuration distributing Low Temperature Heating Water (LTHW),
- Cluster Plant configuration distributing Medium Temperature Heating Water (MTHW).

This study is currently underway and is expected to be completed by end of March 2023.

2.3. Campus-Wide High Voltage Master Electric Plan

Energy Team is working with engineering consultant to analyze the current campus wide high voltage electrical distribution systems and develop a strategy to best support the campus's future needs including:

- Prepare for campus buildout and the addition of new buildings including the Innovation Precinct expansion plans.
- The electrification of existing buildings
- Enhance the energy resiliency for advanced research applications.
- Provide energy savings to the campus
- Implementing revenue generating services that produce a return on investment. (ie. Providing infrastructure for electric vehicle charging)
- Allow capability for future onsite generations, combined heat and power, battery storage , local PV
- Highlighting critical loads including heating, cooling, and research related items
- Providing resiliency and redundancy to the campus's electrical systems.
- Achieving UBCOs goal of net zero carbon emissions by the year 2050.
- Analyze the options of continuing with Fortis owned primary transformer vs transitioning to UBC owned primary transformers.

This study is currently underway and is expected to be completed by Q1 FY23-24.

2.4. Indoor Air Quality monitoring

In response to COVID-19, UBCO increased ventilation rates in buildings across campus while maintaining comfortable indoor air temperature and humidity. In order to re-engage the occupancy

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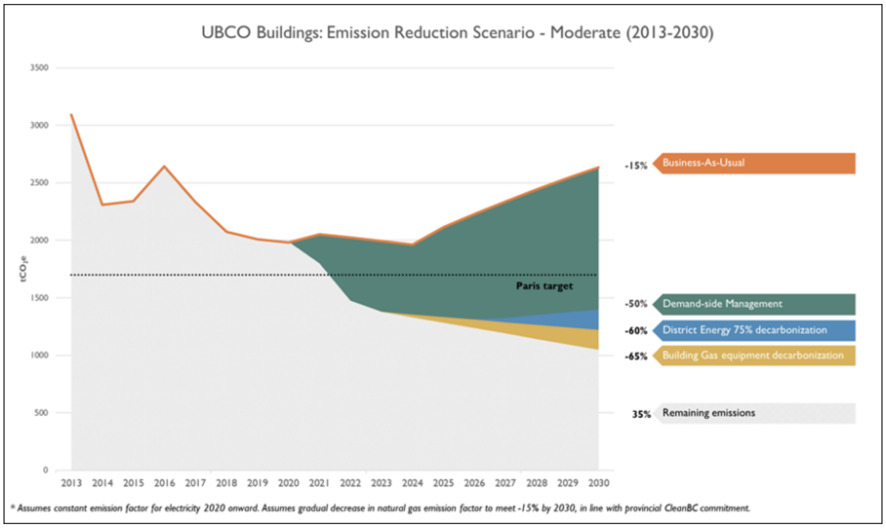
sensors/ Wi-Fi-based controls, Energy Team has been tasked with developing a monitoring tool for CO_2 sensors on campus and create a procedure to continue measurement and verification of air quality on campus.

2.5. 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.



Based on the strategy, a moderate (realistic) target of 65% emission reduction[2] 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] 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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- Grid electricity emission factor

2.6. 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.

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. This study also provided various energy targets for UBCO building archetypes.

Parameter	**Student Residence**	**Campus Housing**	**Dry Lab**	**Wet Bldg**	**Class / Office**
TEUI kWhr/m^2/yr	97	137	217	290	127
TEDI kWhr/m^2/yr	12	13	43	50	8
GHGI* kgCO_2/m^2/yr	6	9	13	16	6
Peak Heating W/m^2	14	10	28	31	29
Peak Cooling W/m^2	14	21	40	53	39
Peak Electric W/m^2	9	11	23	31	19

Energy Team has been working with UBCO leadership to adopt proposed energy targets for net positive ready buildings for Okanagan campus. These targets have been approved and will be included in the UBCO Green building action plan targets.

2.7. 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 and various intensity parameters EUI, ECI etc.

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However, due to the BMS integration challenges during project and limited resource constaints, a display platform has been developed which shows BMS sensor trends for utility meters, KPIs tracked in excel, and also creates a parallel database.

2.8. 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 FY24-25.

2.9. 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.

2.10. 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.

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.

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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.

2.11. 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.

2.12. 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 by reviewing hydronic schematic for campus buildings and developing COP trends for each building and central plant. 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 is being carried out to review District Energy heating season performance and investigate optimization opportunities. An average 7.5% efficiency gain for boilers in Geo-Exchange building has already been observed based on recommendations provided by Energy Team. This translates to around 750 GJ of natural gas savings.

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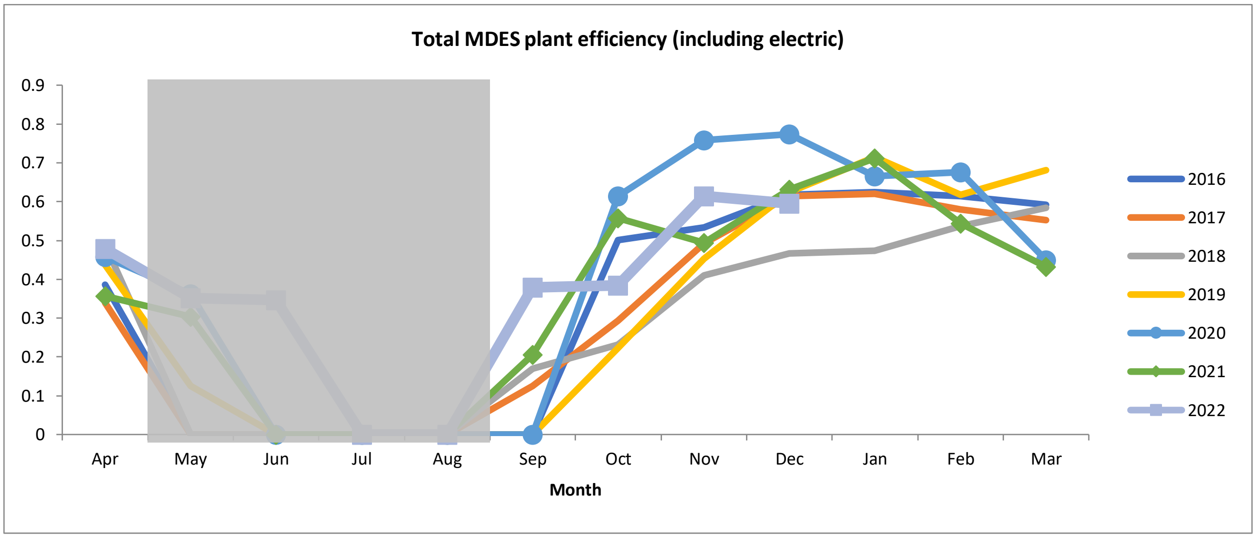

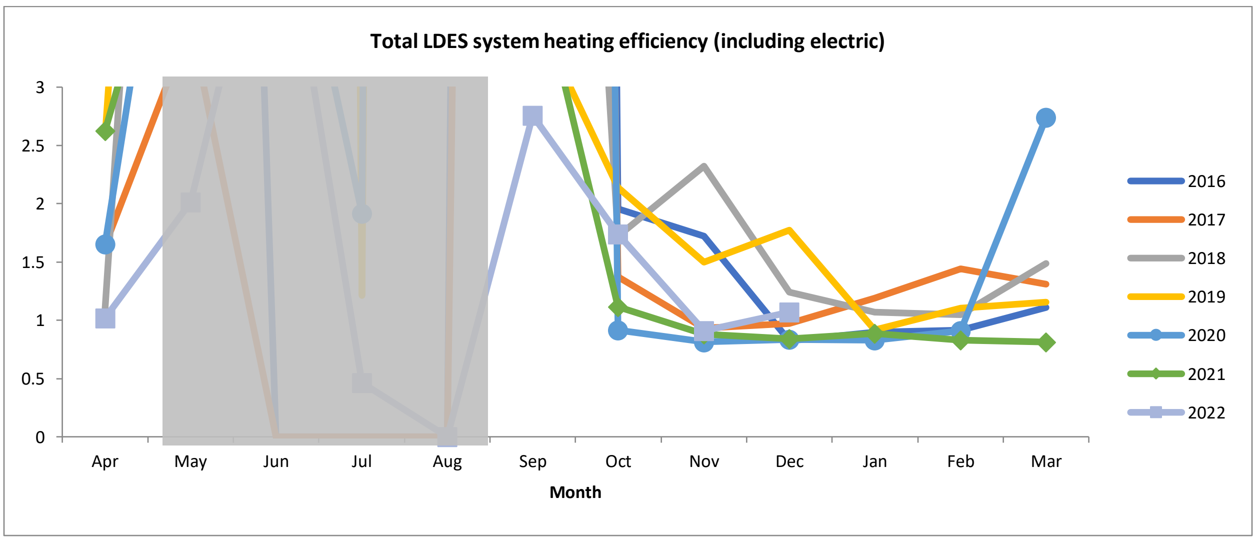

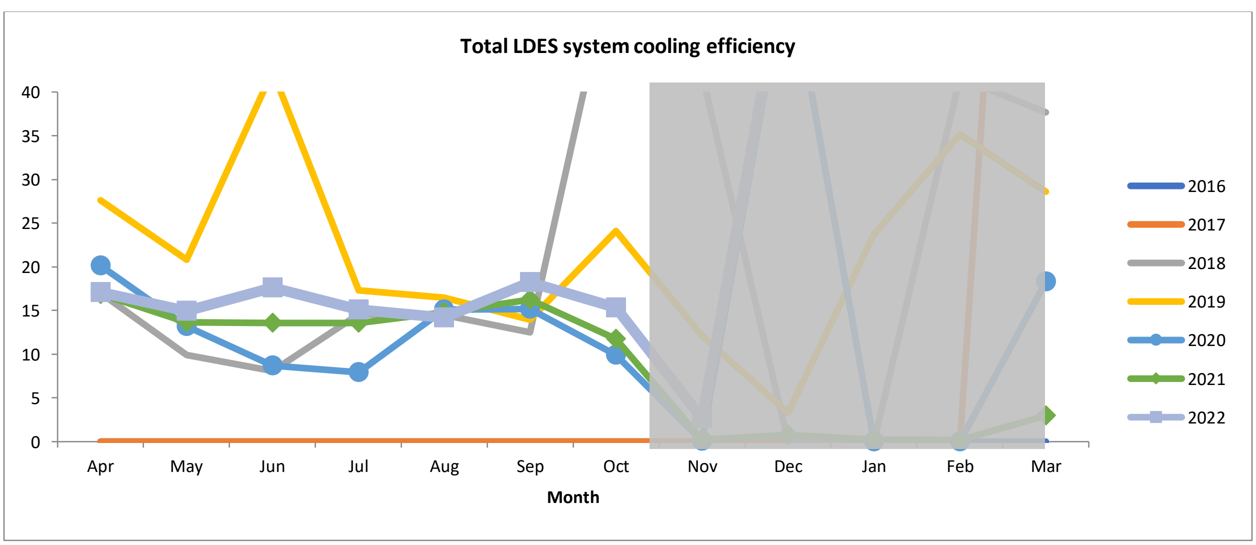

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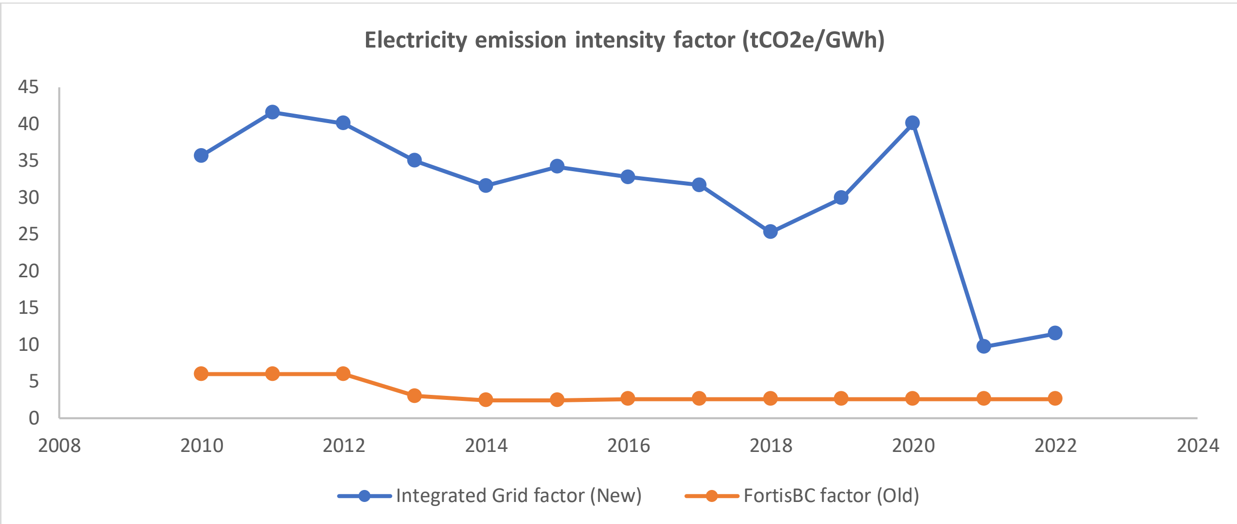
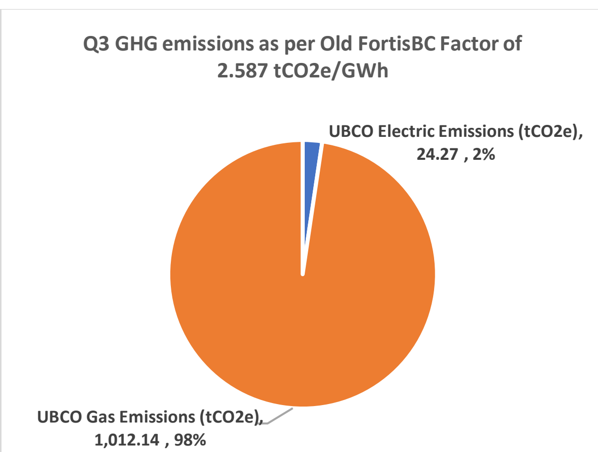
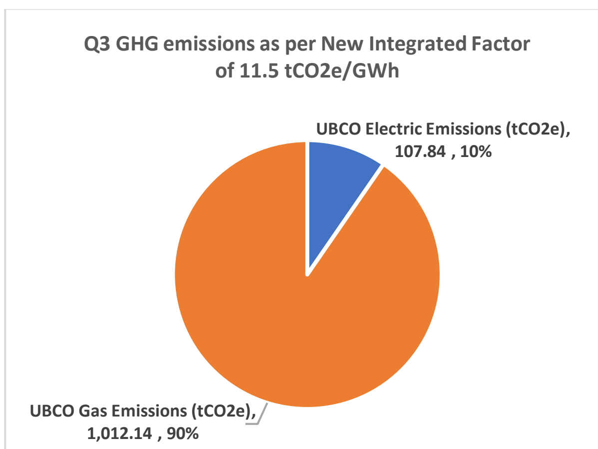
2.13. Electricity emission intensity factors modelling for UBCO

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[3]. The charts below show the increase in GHG emissions when considering new integrated electricity emissions factor.





[3] 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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2.14. 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. 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 used for evaluation and processes can be 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. 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 and strategies will be considered for reduction and standardization of air changes during both occupied and unoccupied hours.

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 was completed in FY22-23 and implementation of the measure is expected to be completed in FY23-24.

3.2. 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

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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 was completed in Q3 2022.

3.3. 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 was kick started in October 2022 and is expected to be completed by Q4 2022.

3.4. 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

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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.

3.5. Install 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.

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.

3.6. IAQ monitoring system for EME building

UBCO Energy Team has engaged an engineering consultant to determine if an IAQ (Aircuity) monitoring system can assist with ventilation shortages in the EME HRV system.

This study is currently underway and is expected to be completed by Q4 2022

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

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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[4]	93%
ADM	95%
CHP	94%
FIP	92%
CCS	95%
DAY	94%
EDL	93%
EME	94%
GEO	56%
GYM	95%
LIB	90%
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%

[4] 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.

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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.

Facilities Management investigated power factor for UCH and took actions to improve power quality to Upper Campus Health which was improved from 54% to 98%. Similar excerise will be carried out for identified 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.

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 currently underway with an expected completion by Q4 2022.

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

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

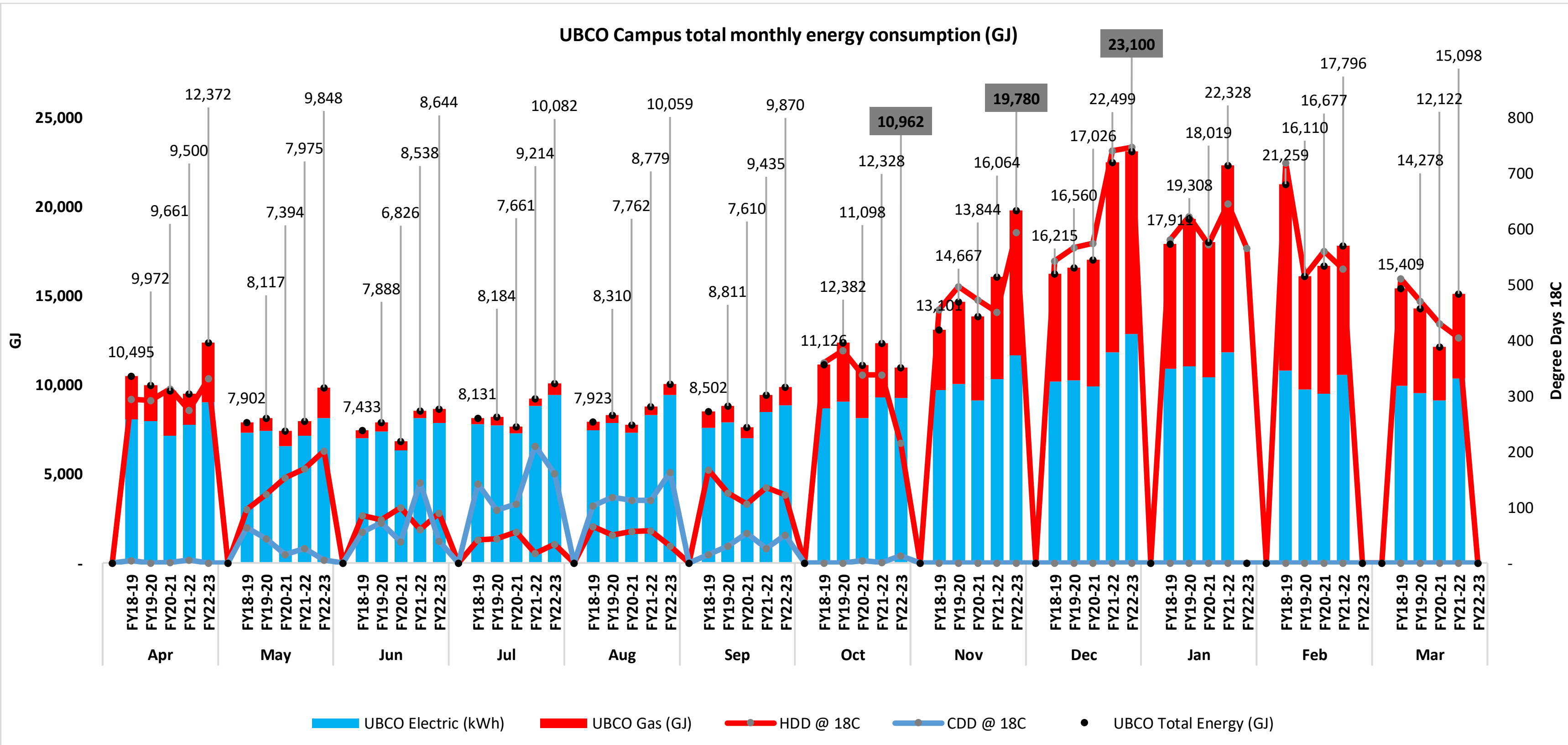
4.4. Childcare (Daycare Extension)

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[5].



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

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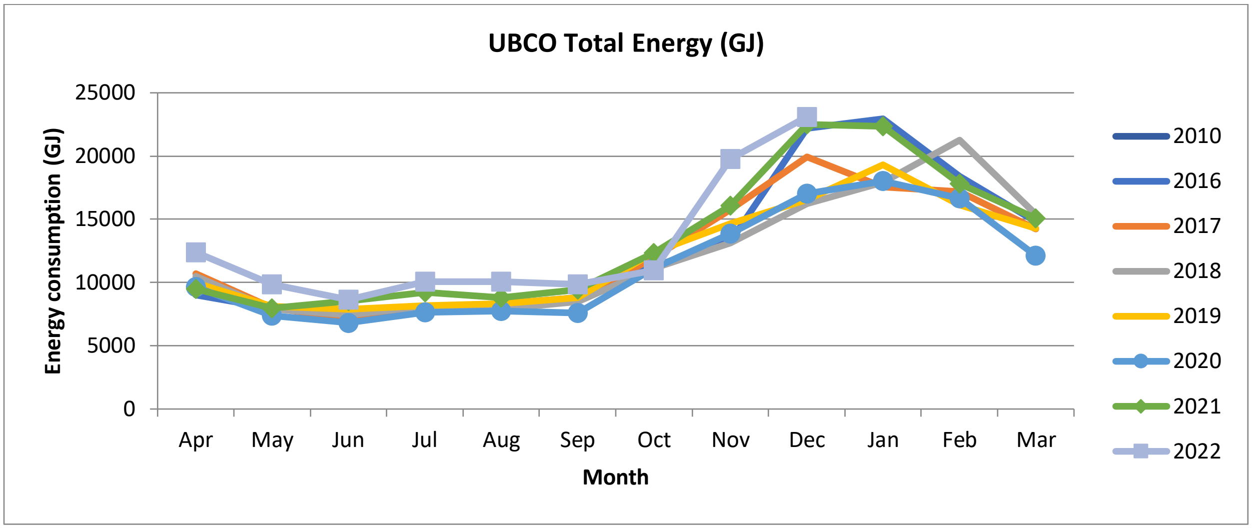

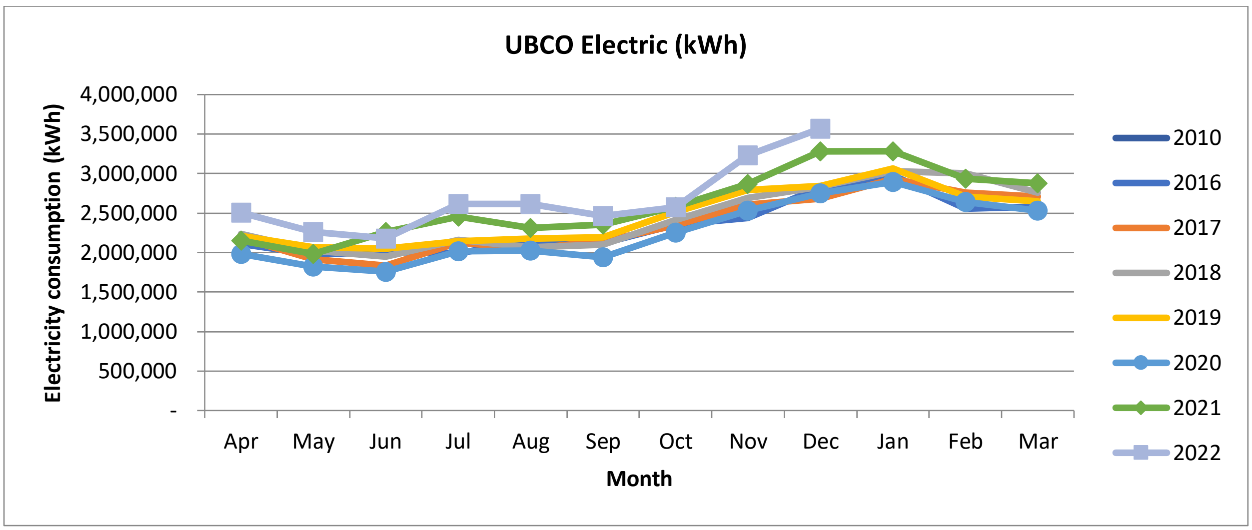

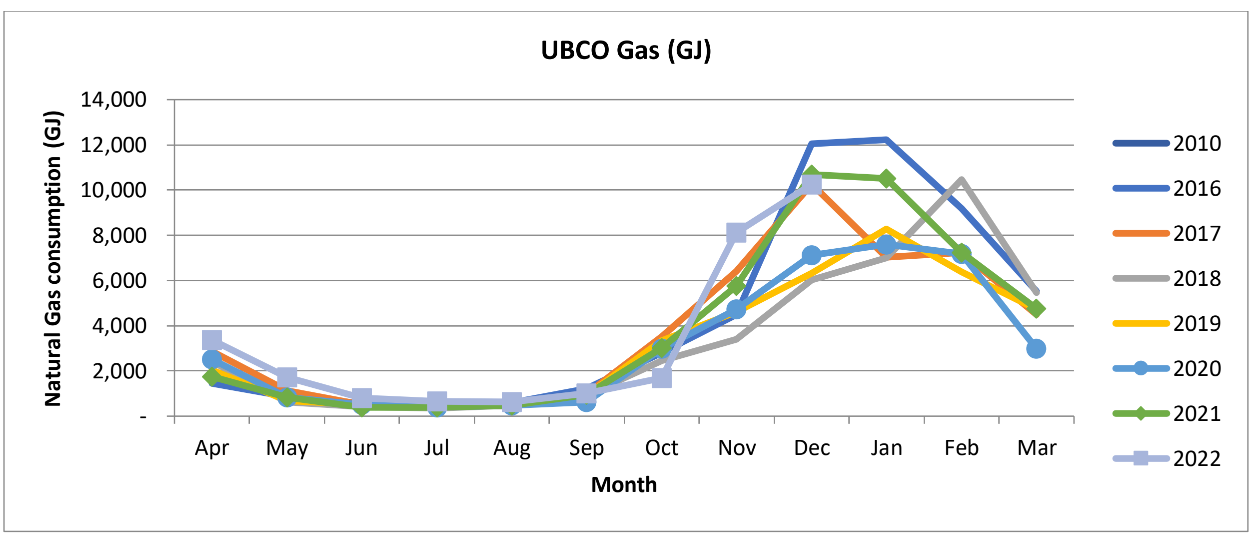

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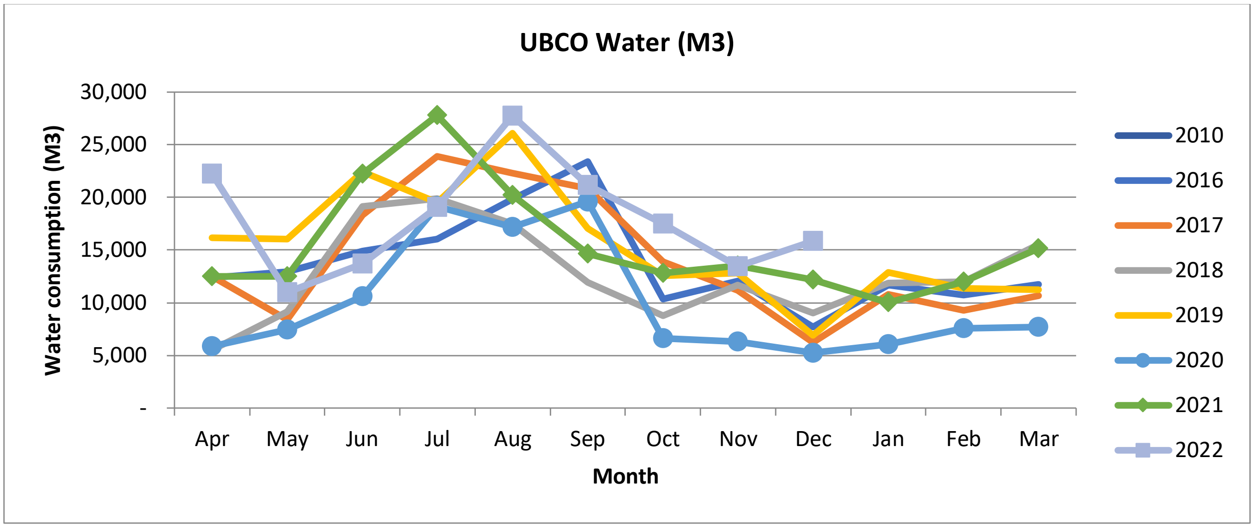

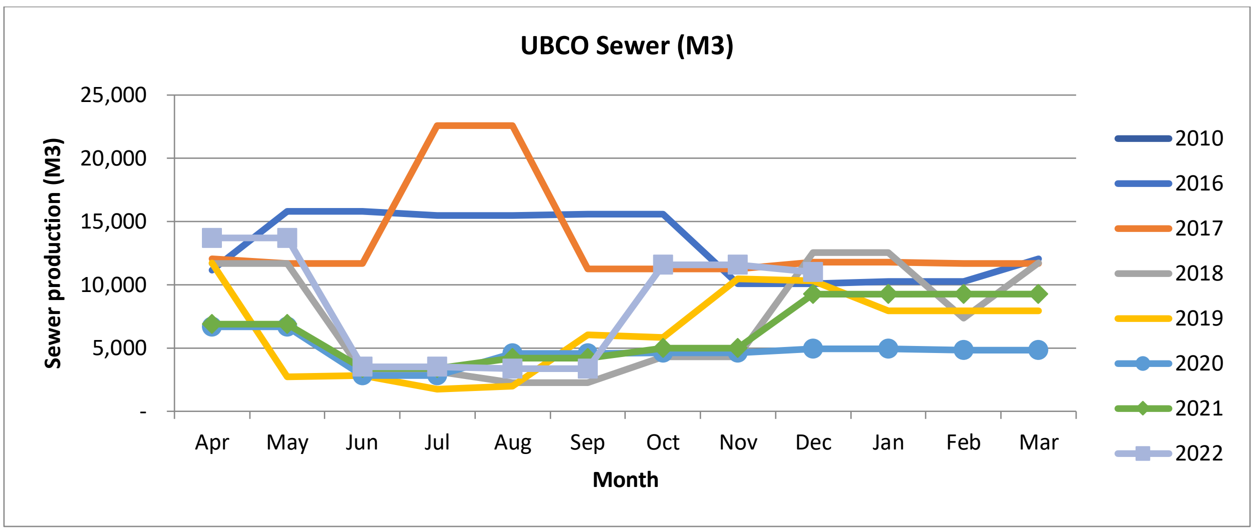

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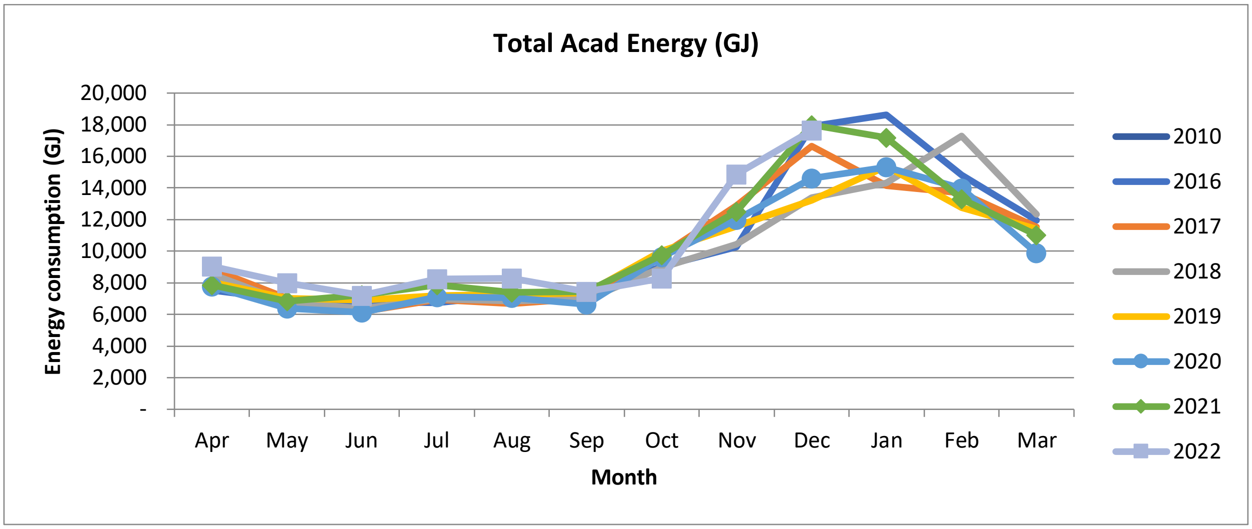

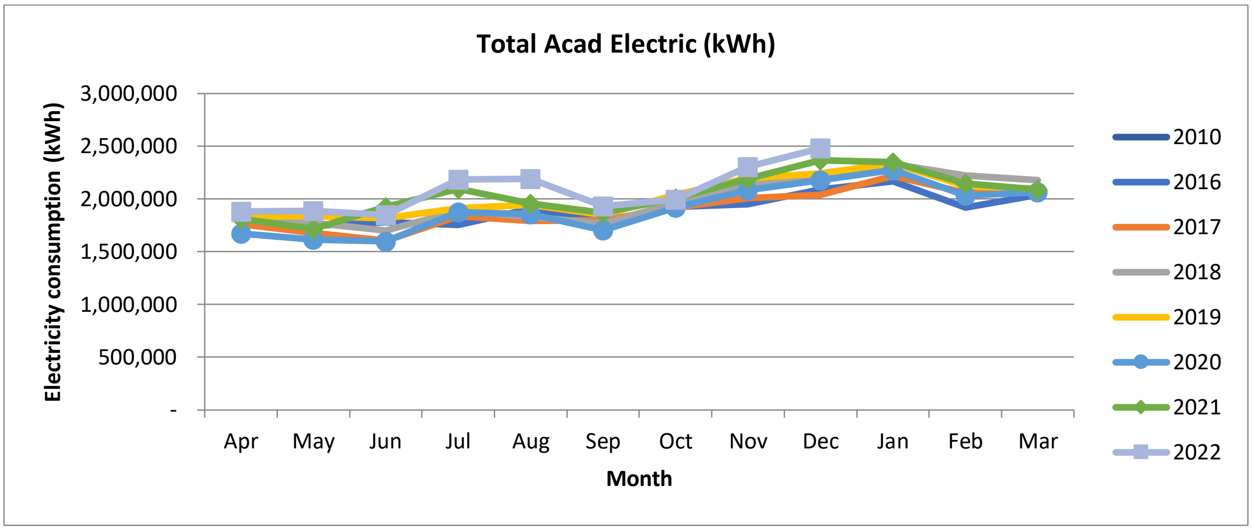

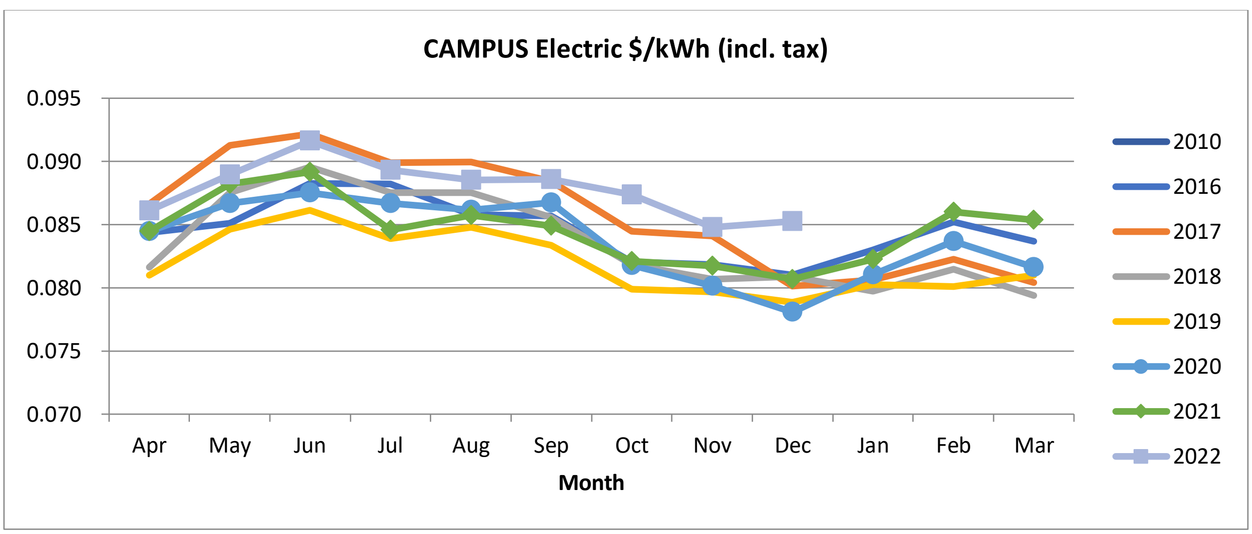

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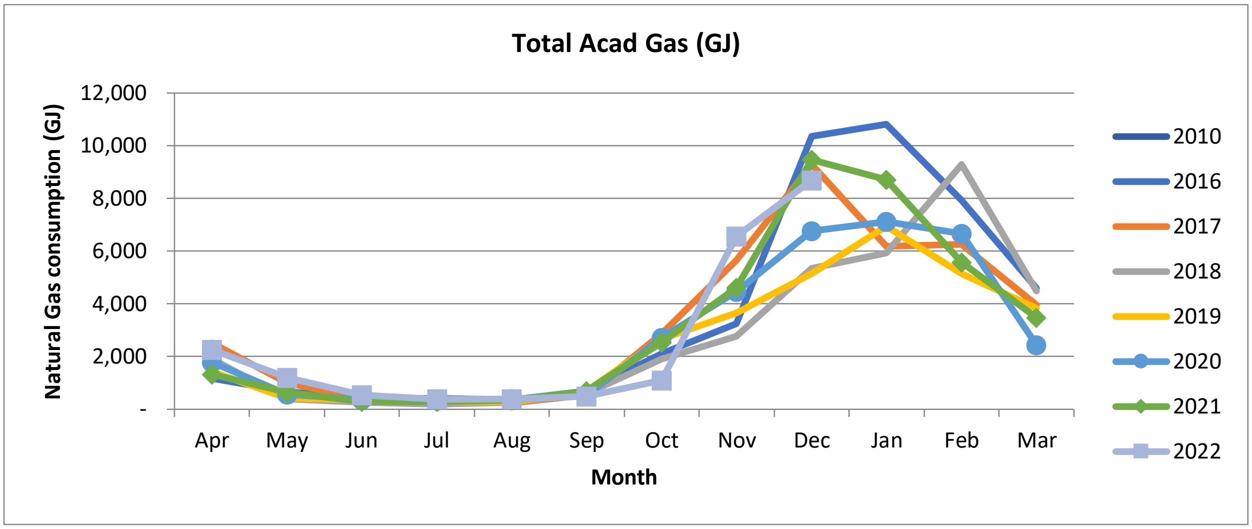

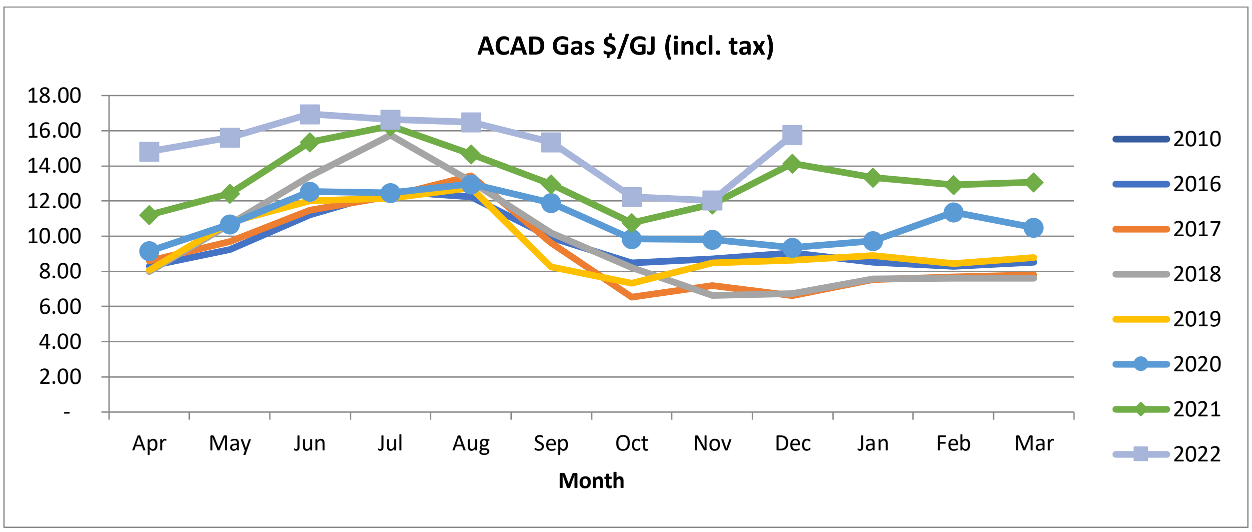

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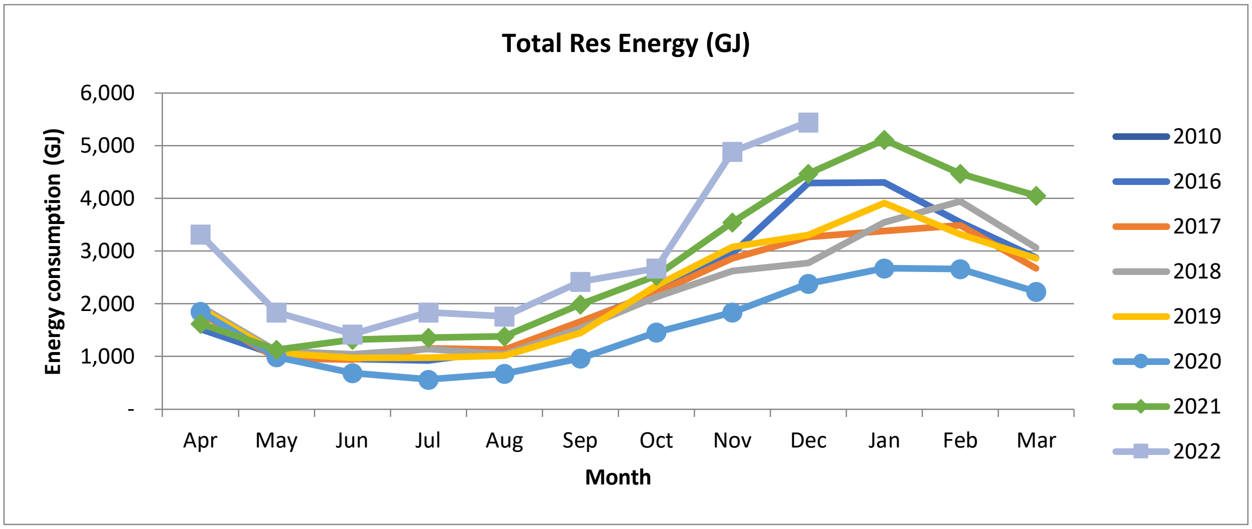

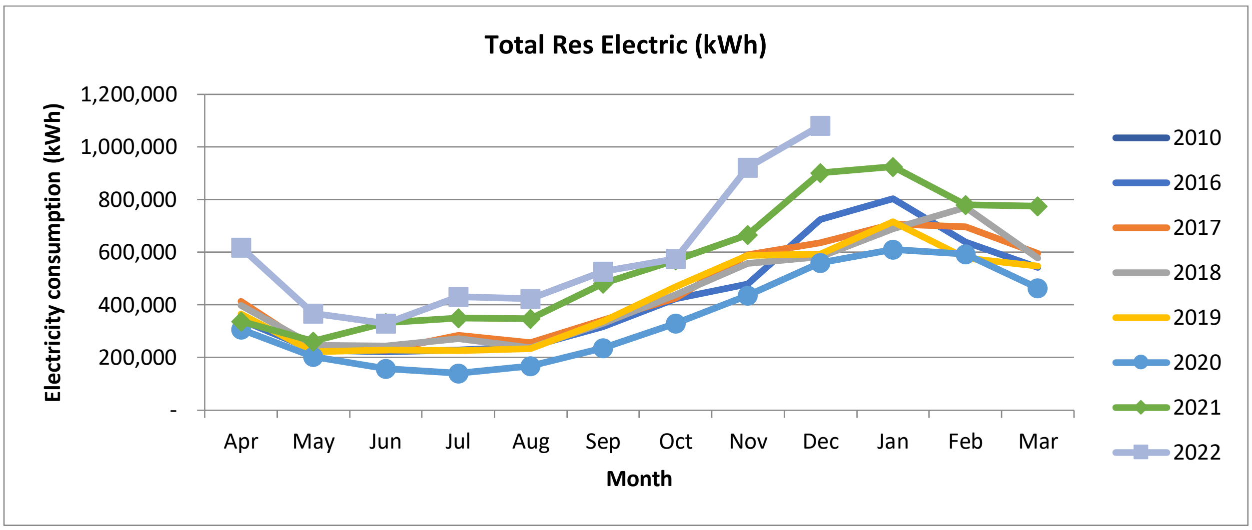

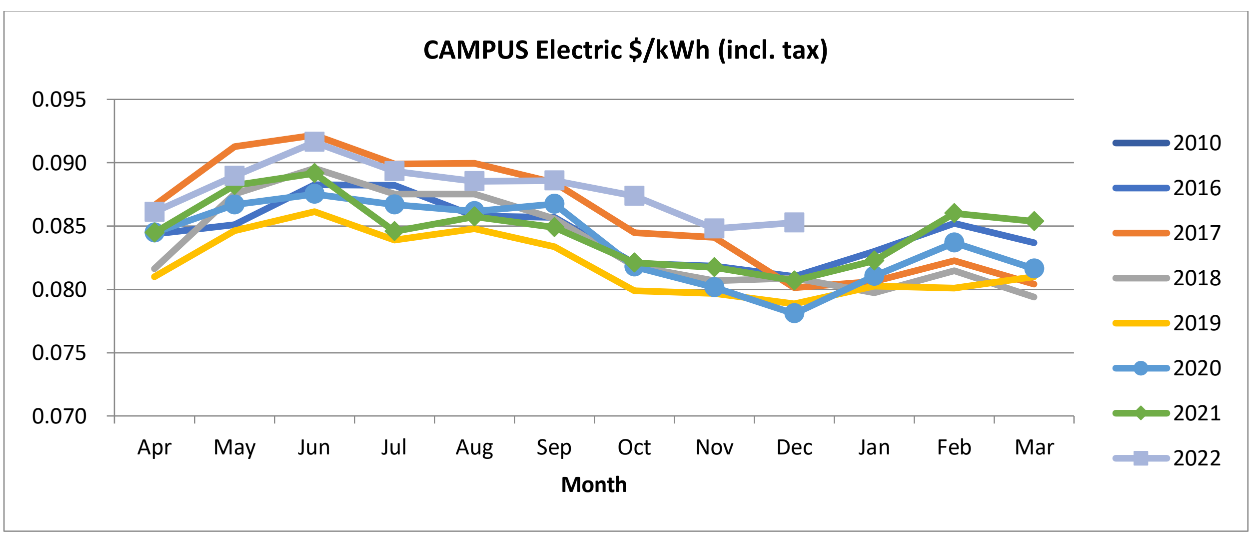

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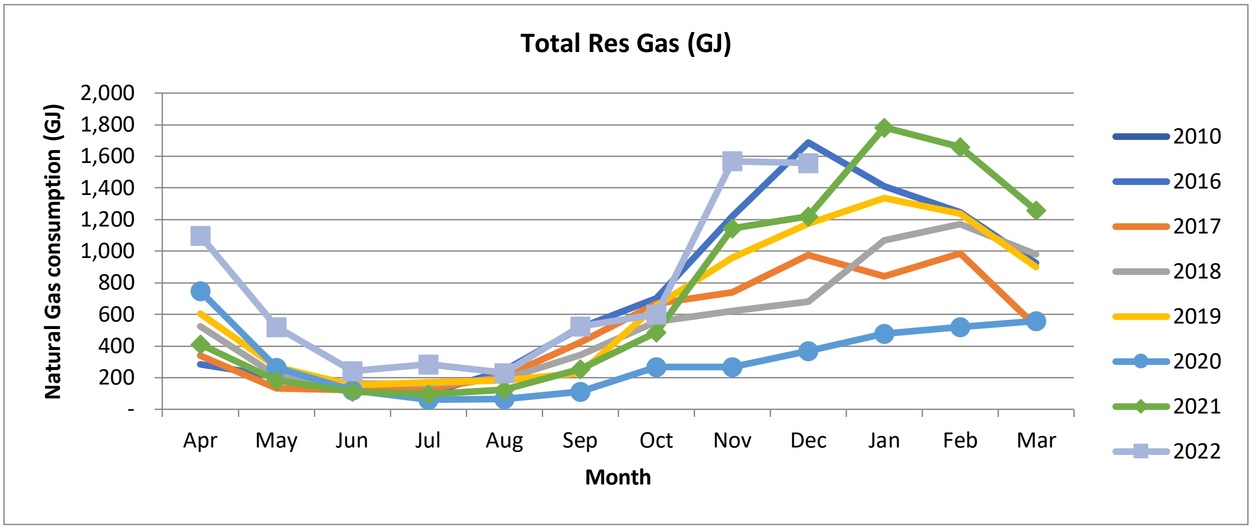

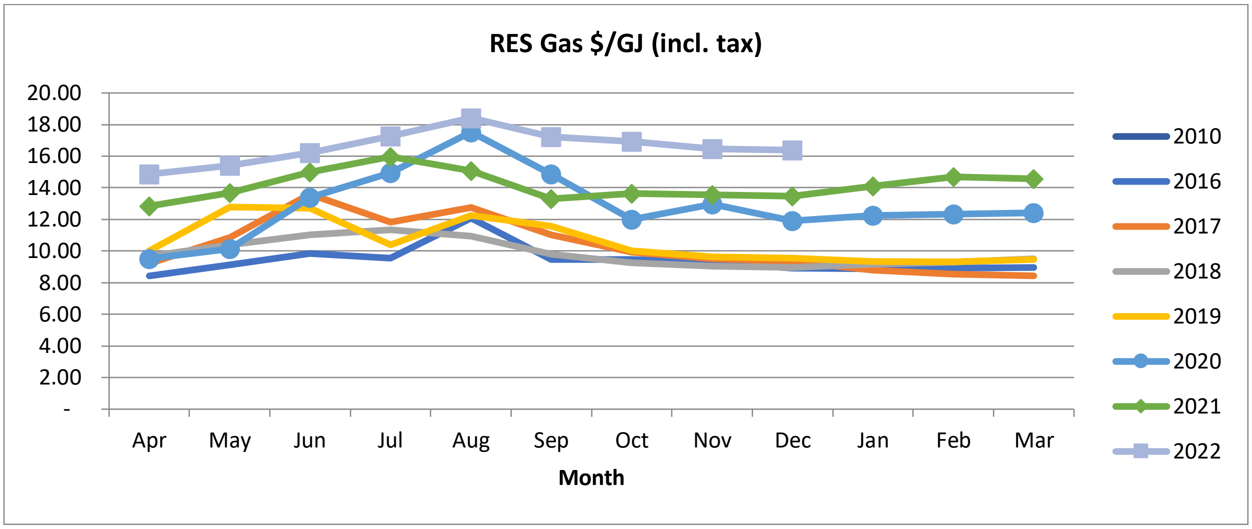

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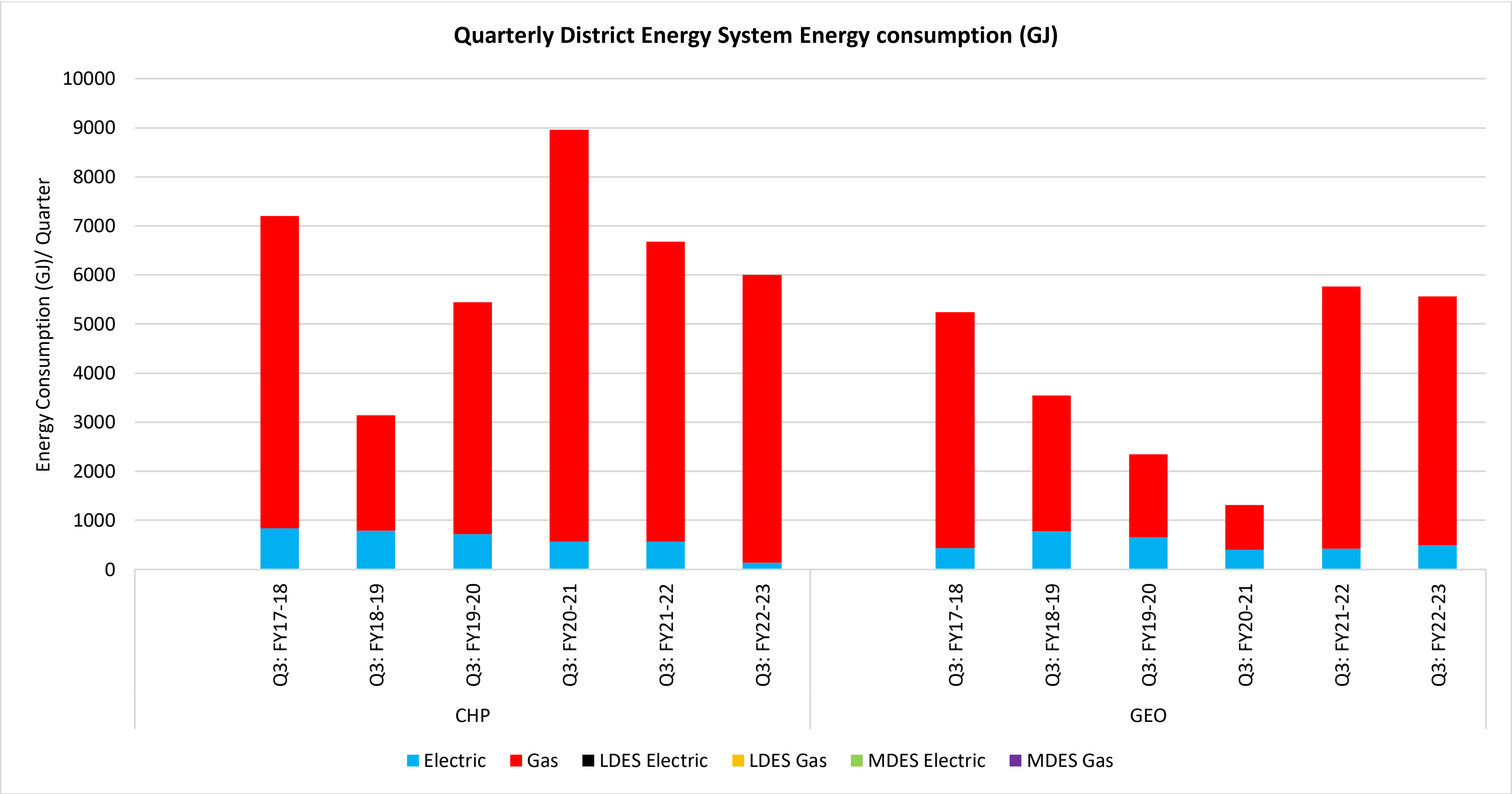

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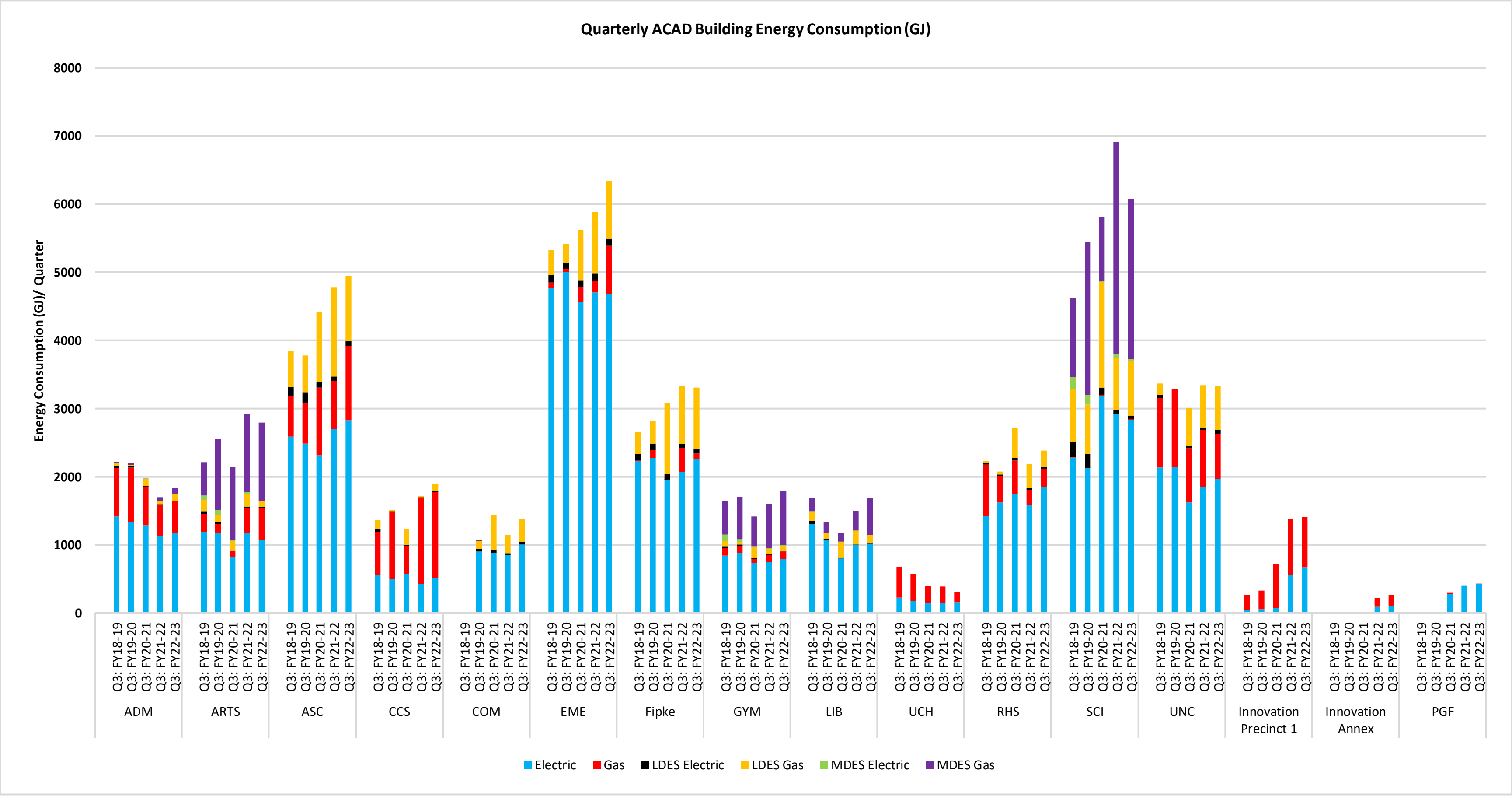

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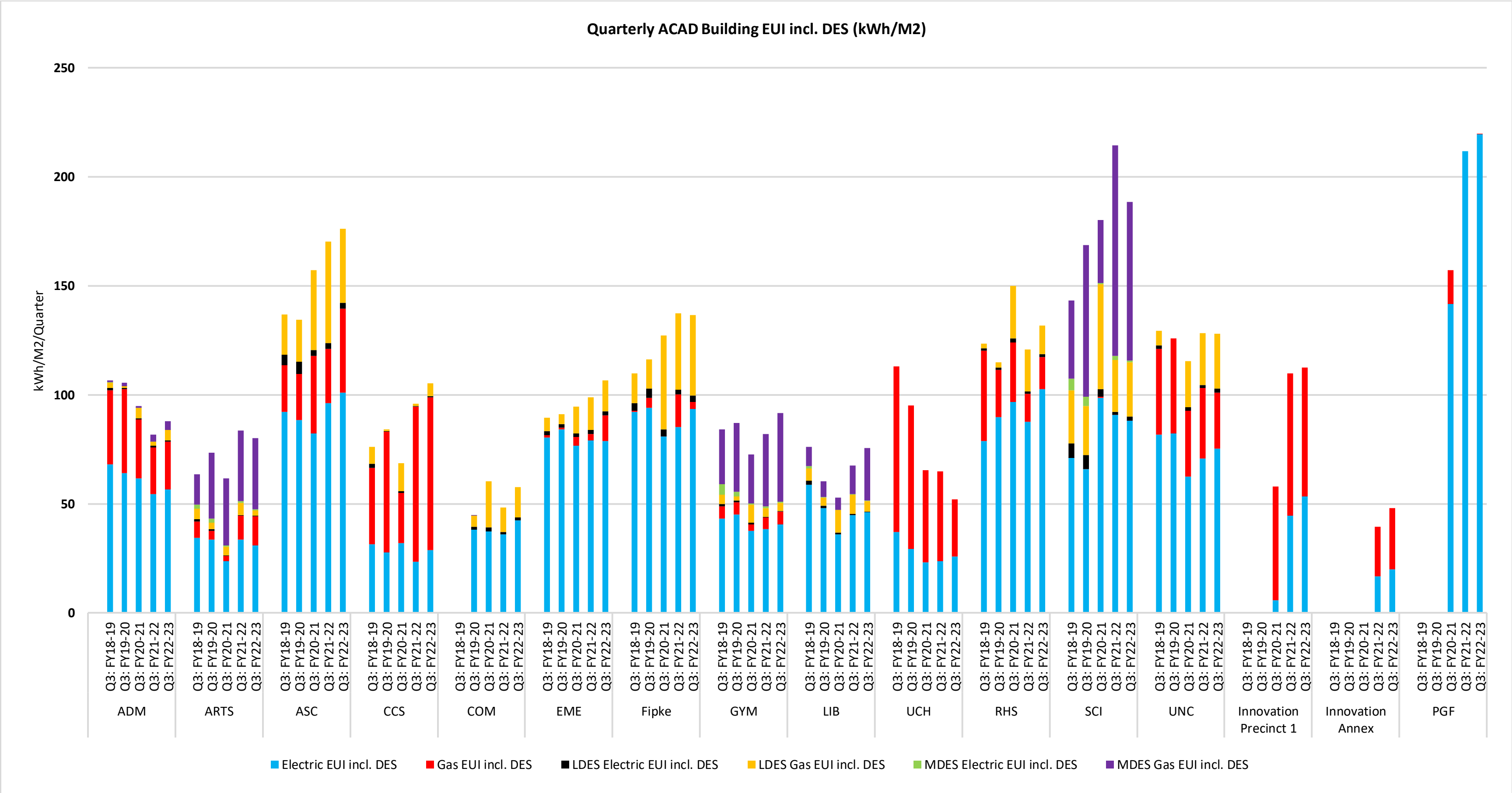

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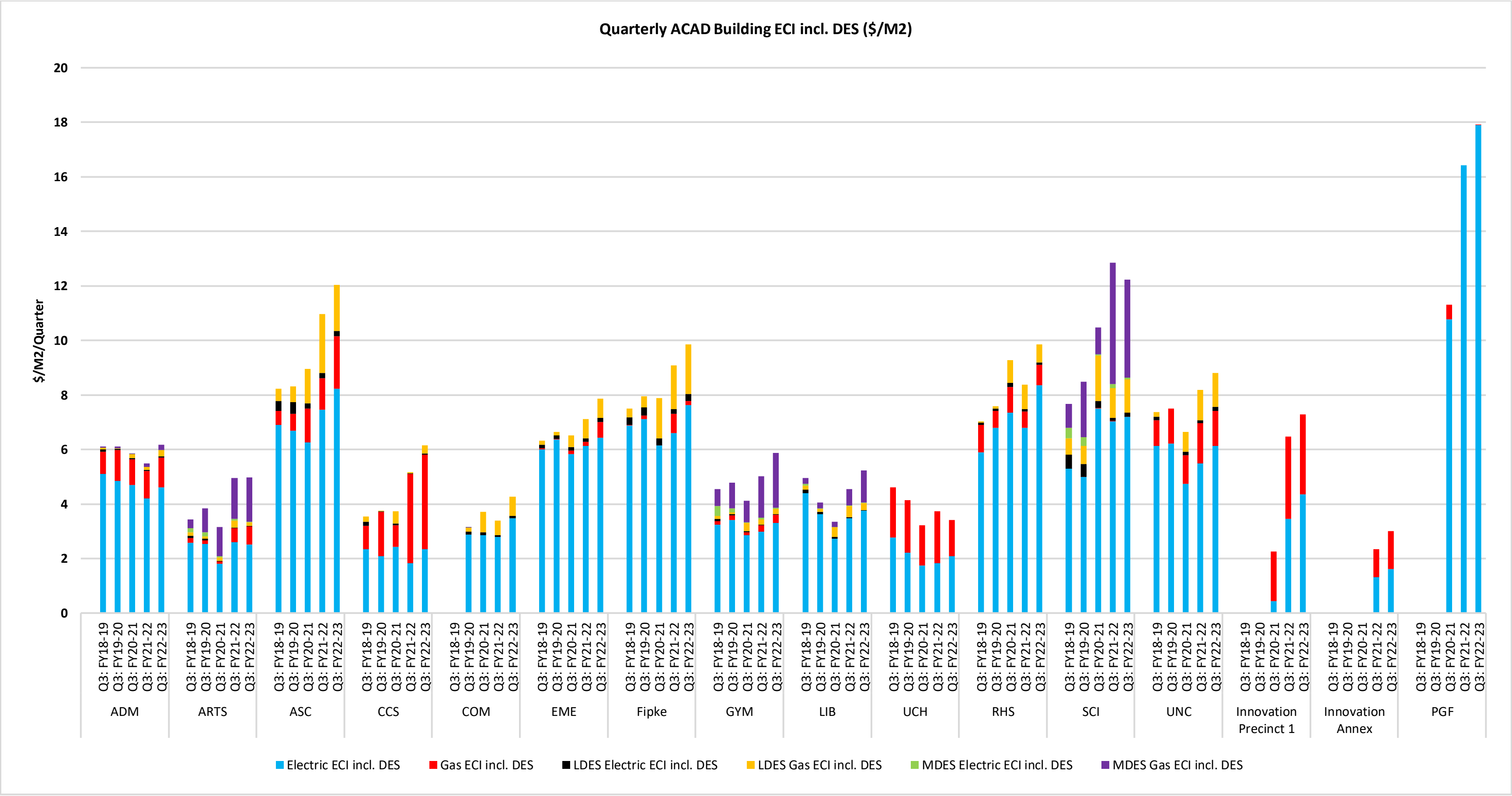

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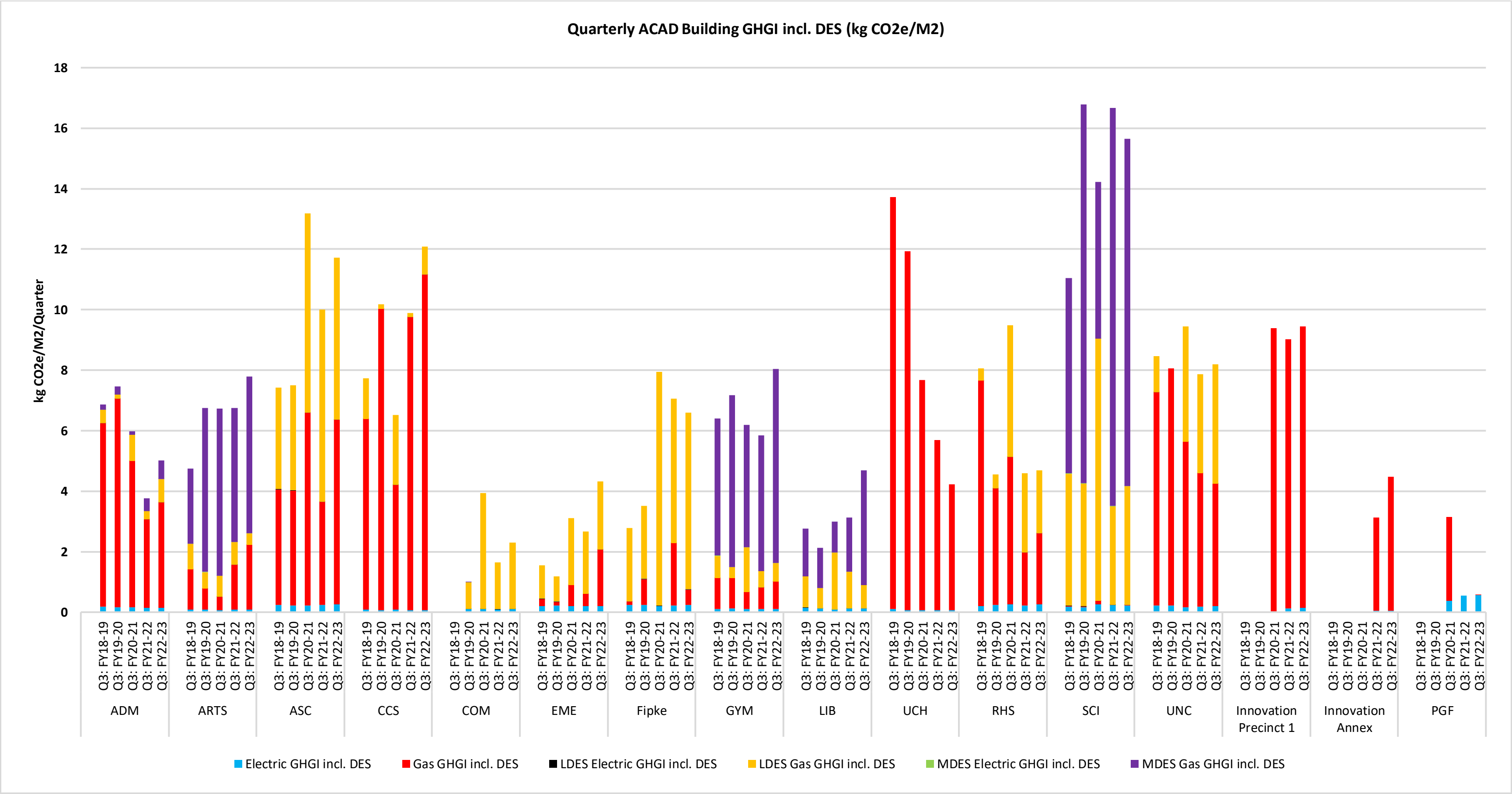

* Assuming electricity emission factor of 2.587 tCO_2e/GWh (old FortisBC grid factor)

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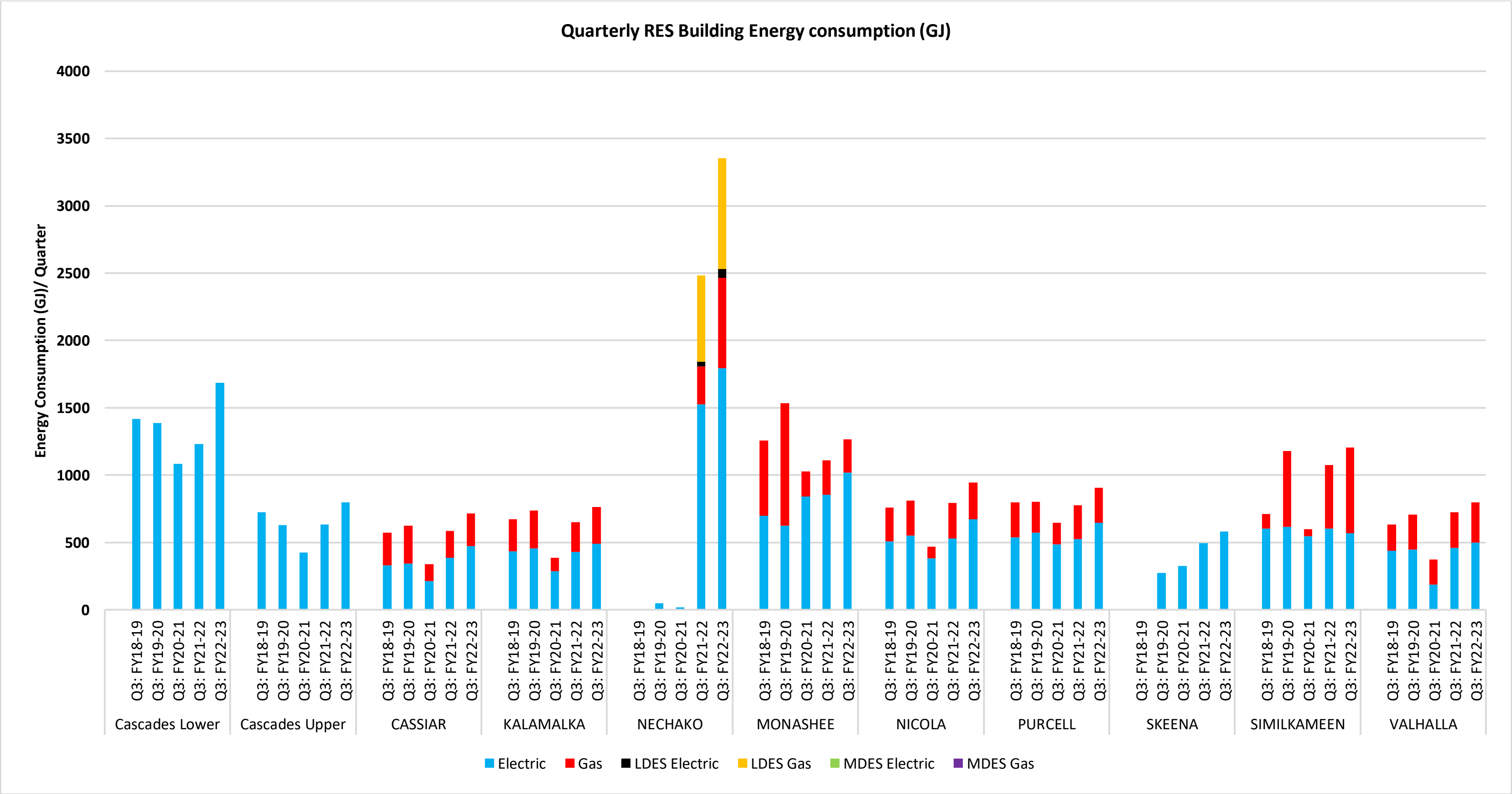

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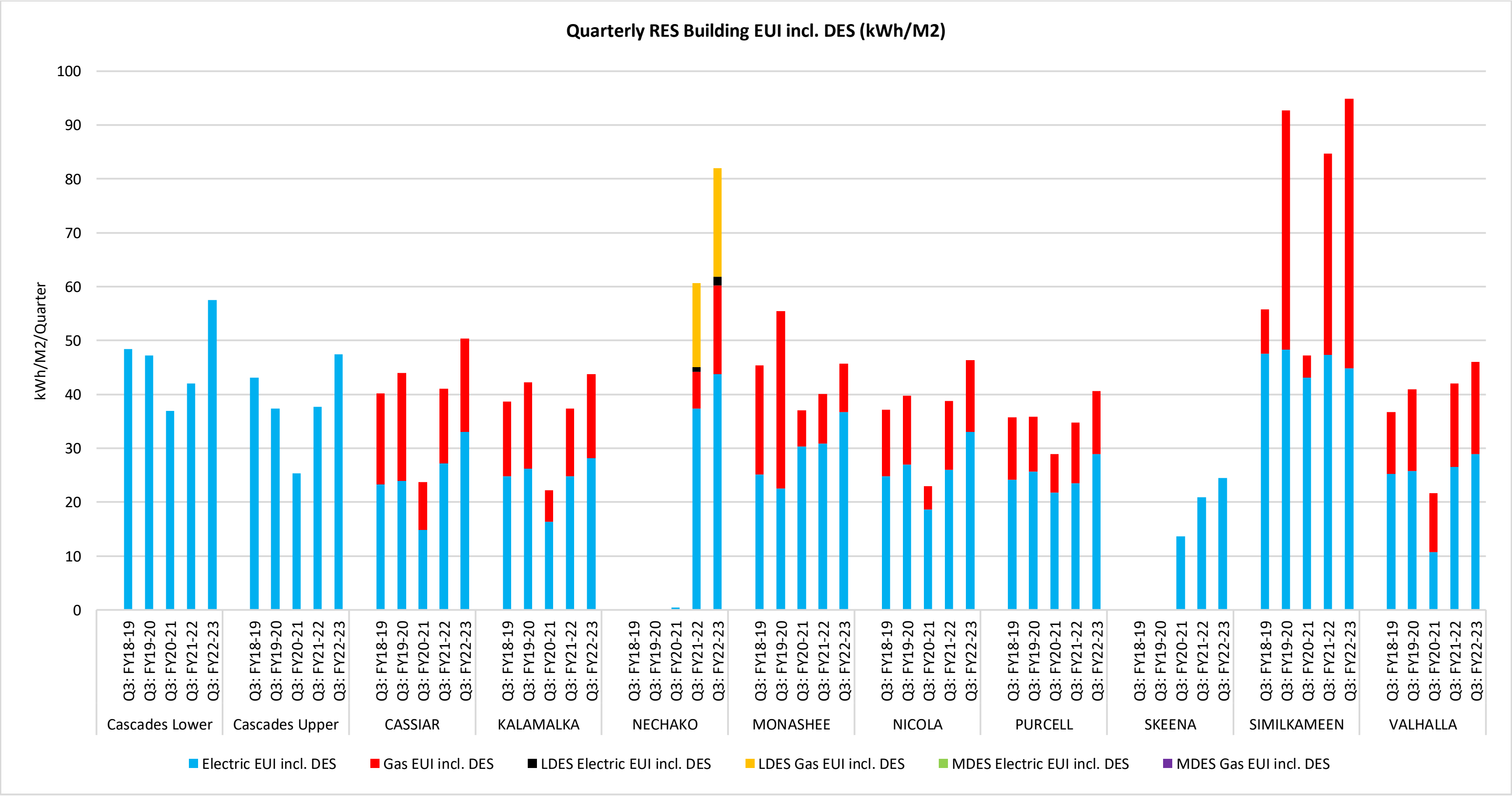

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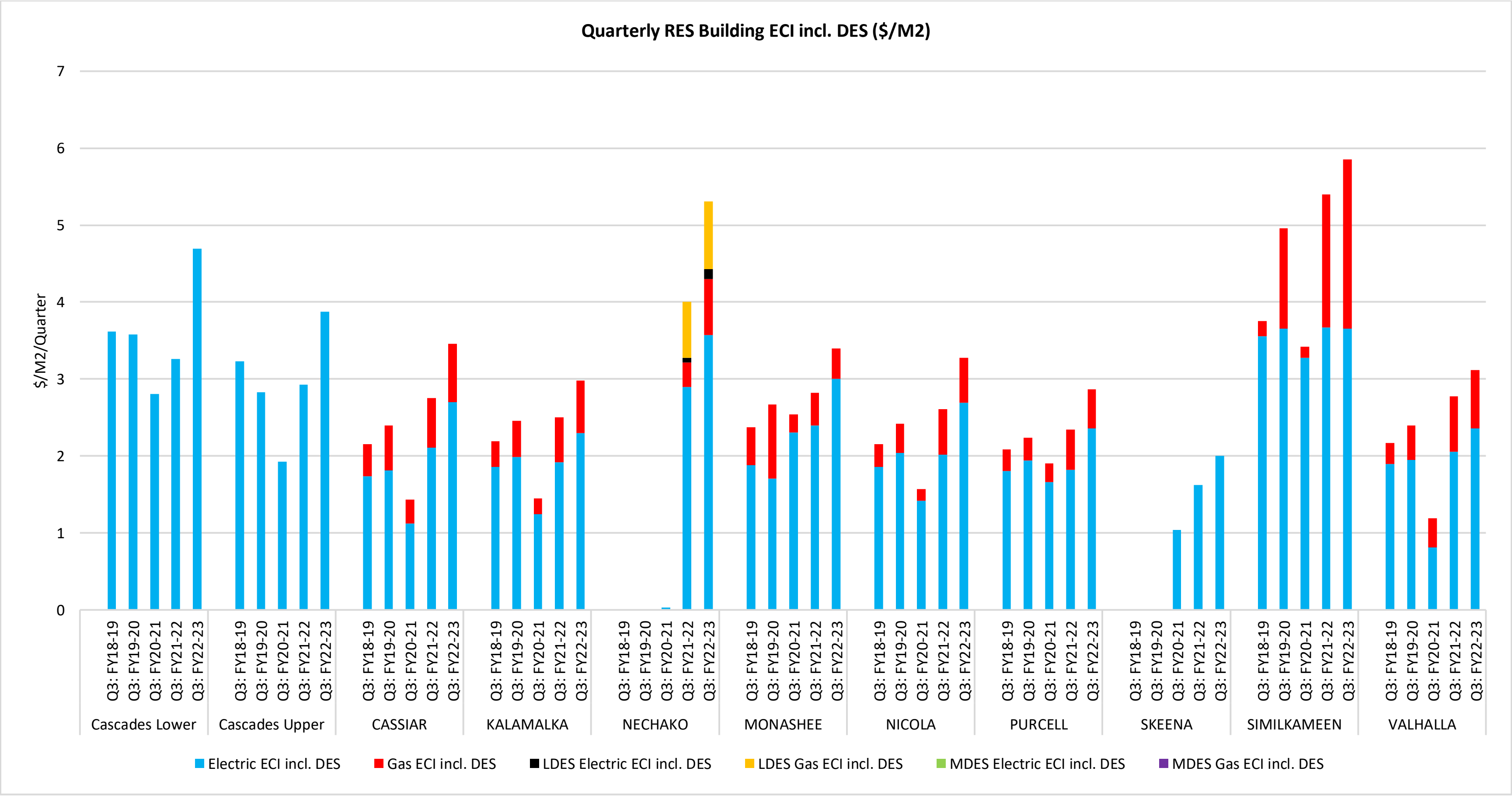

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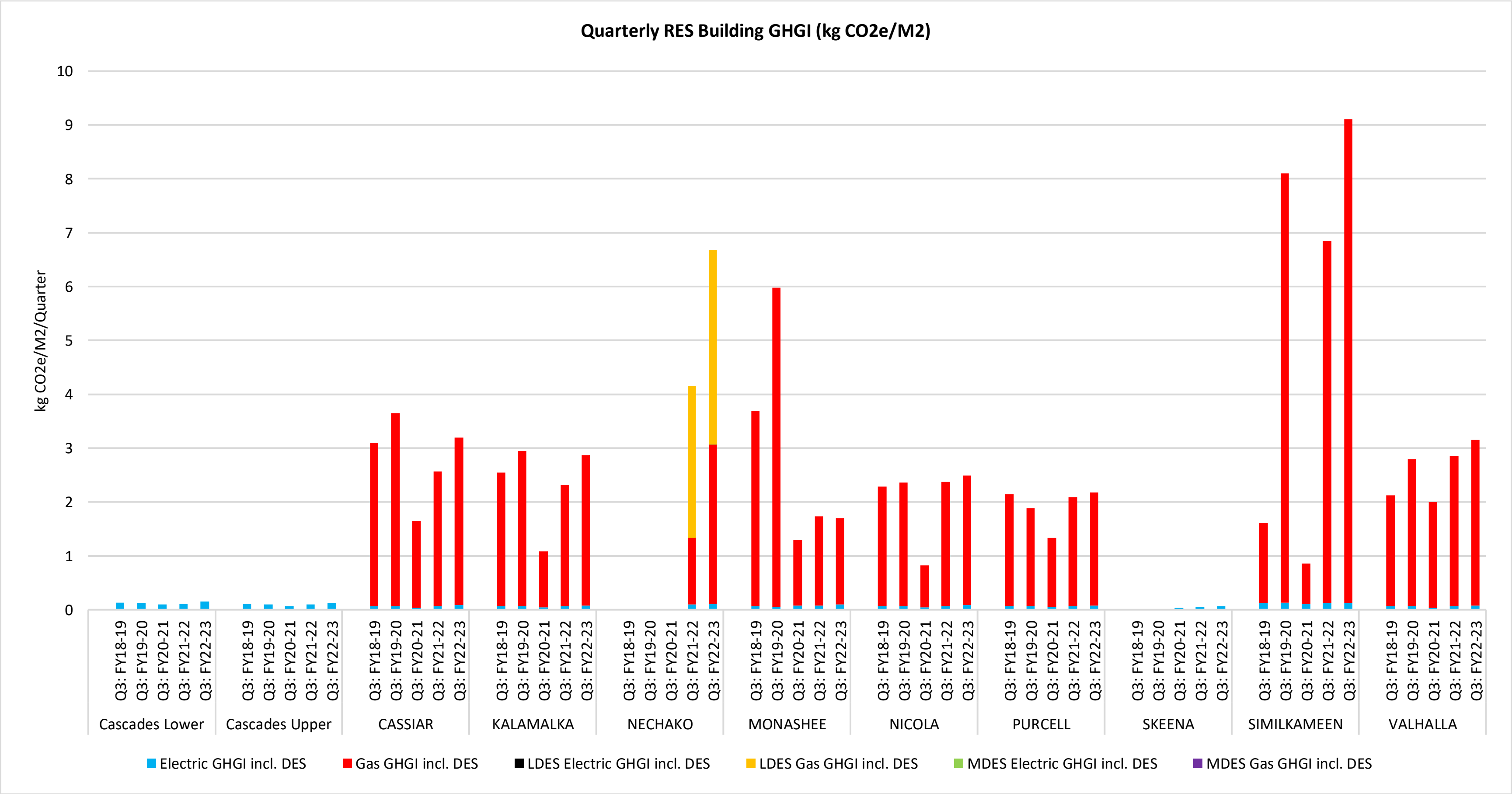

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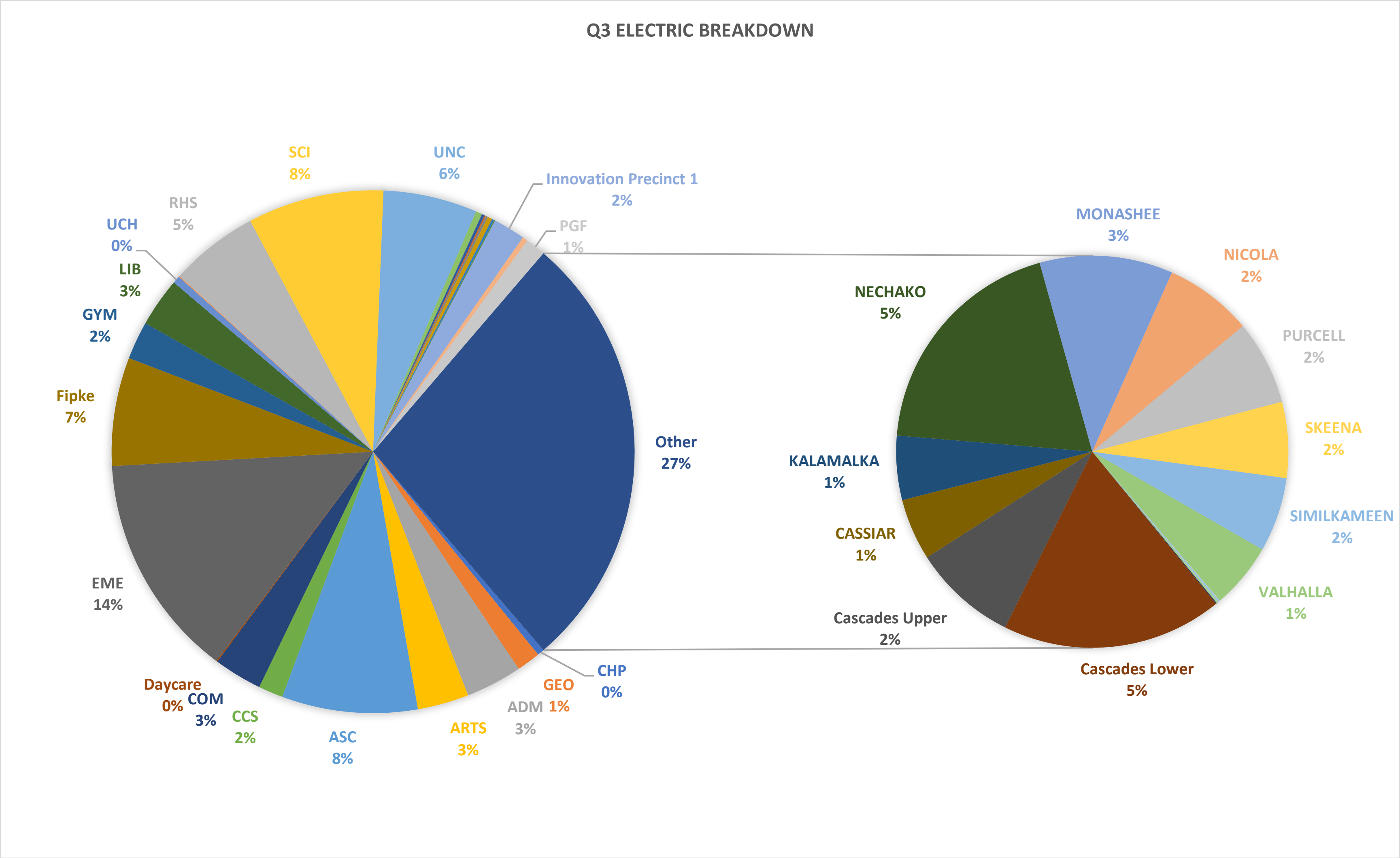

Note: Building electricity and gas consumption values shown are for consumption within the building. Indirect gas consumption via MDES & LDES is not included.

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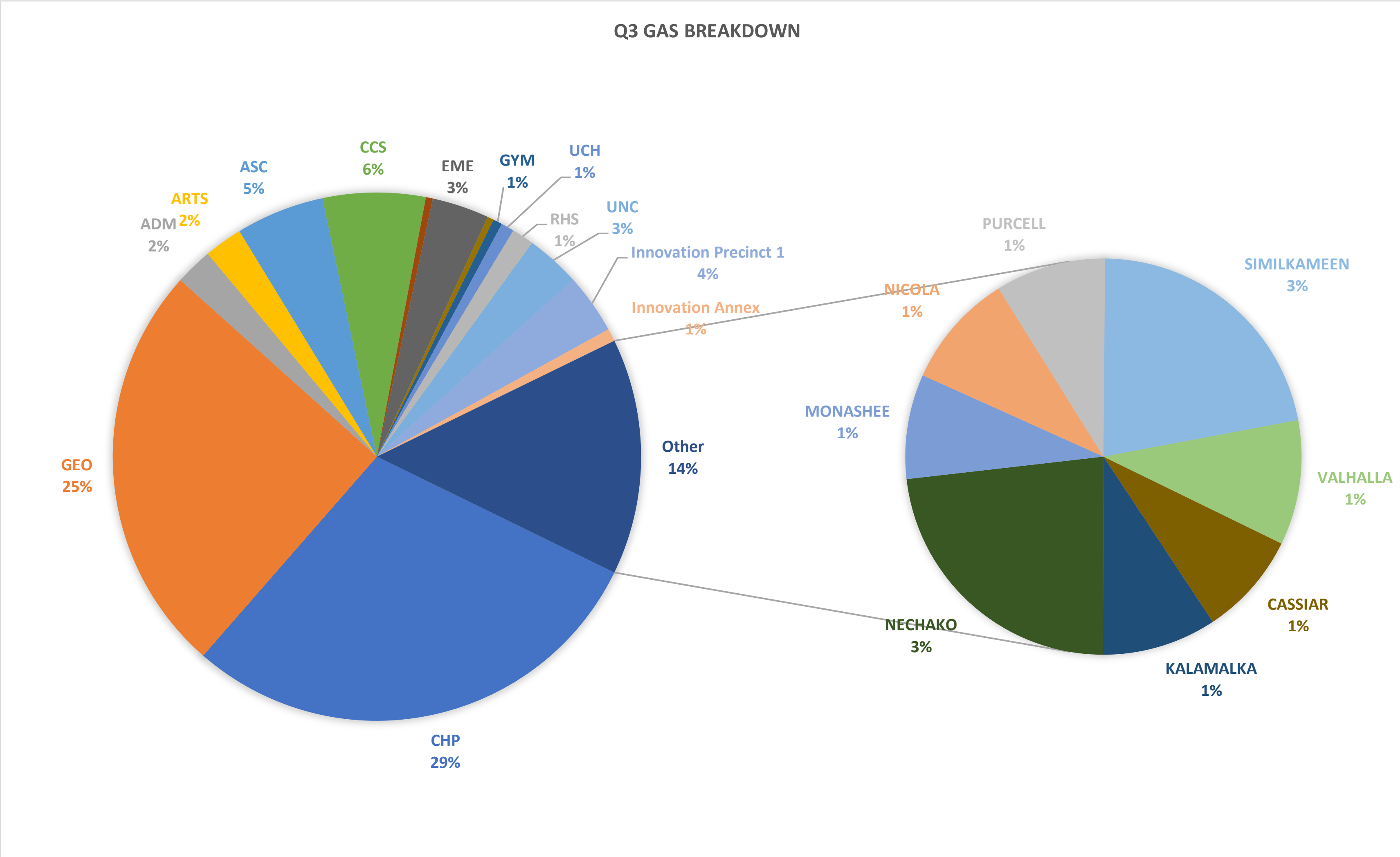

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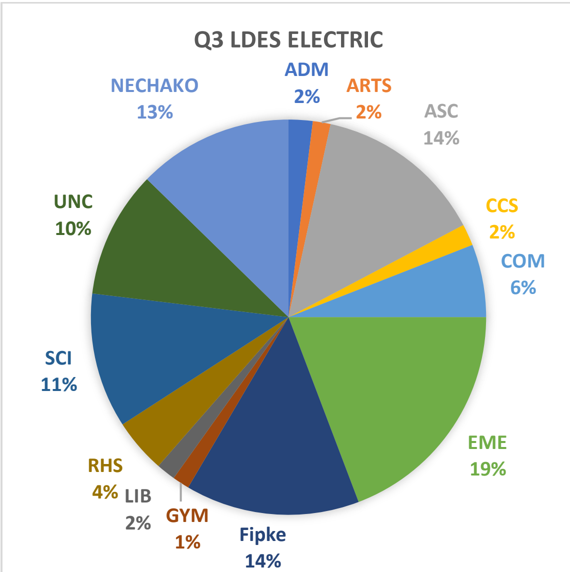

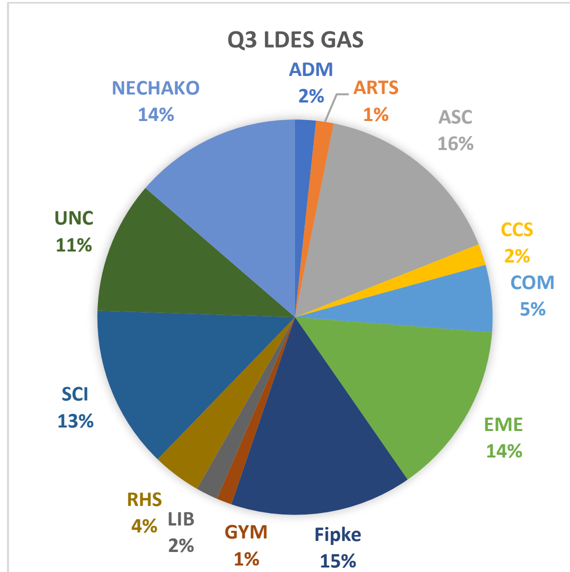

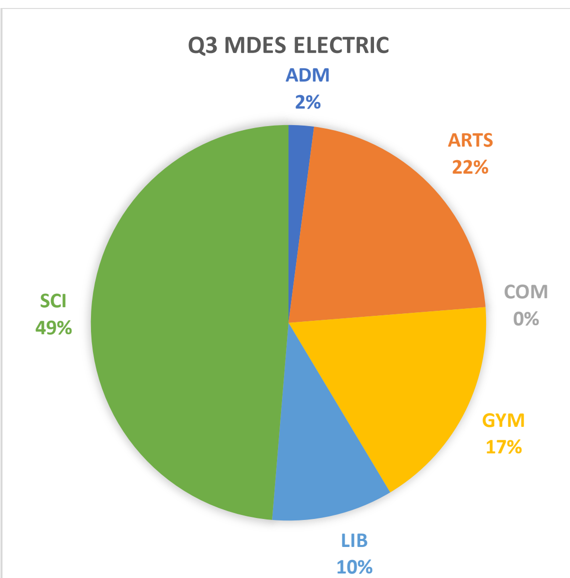

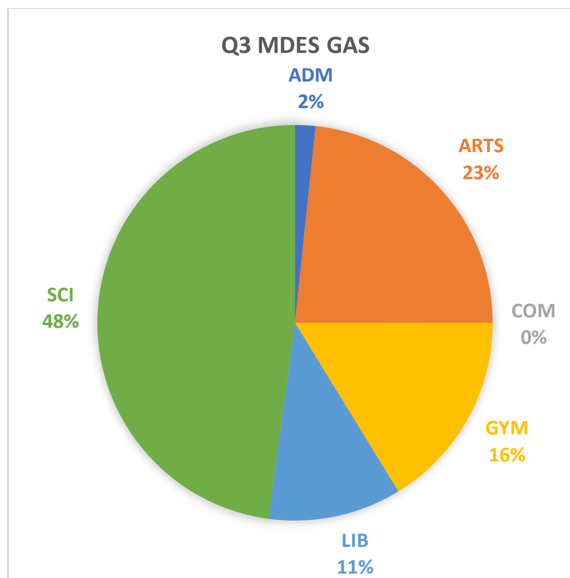

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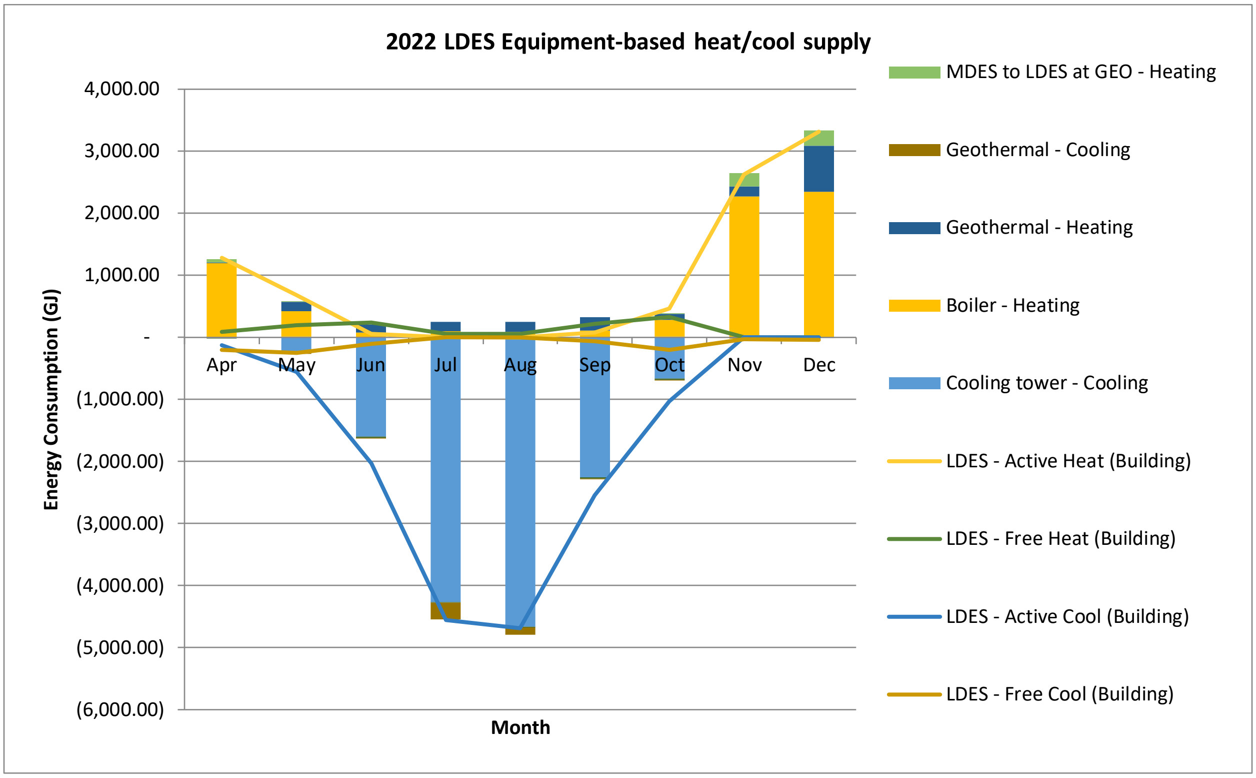

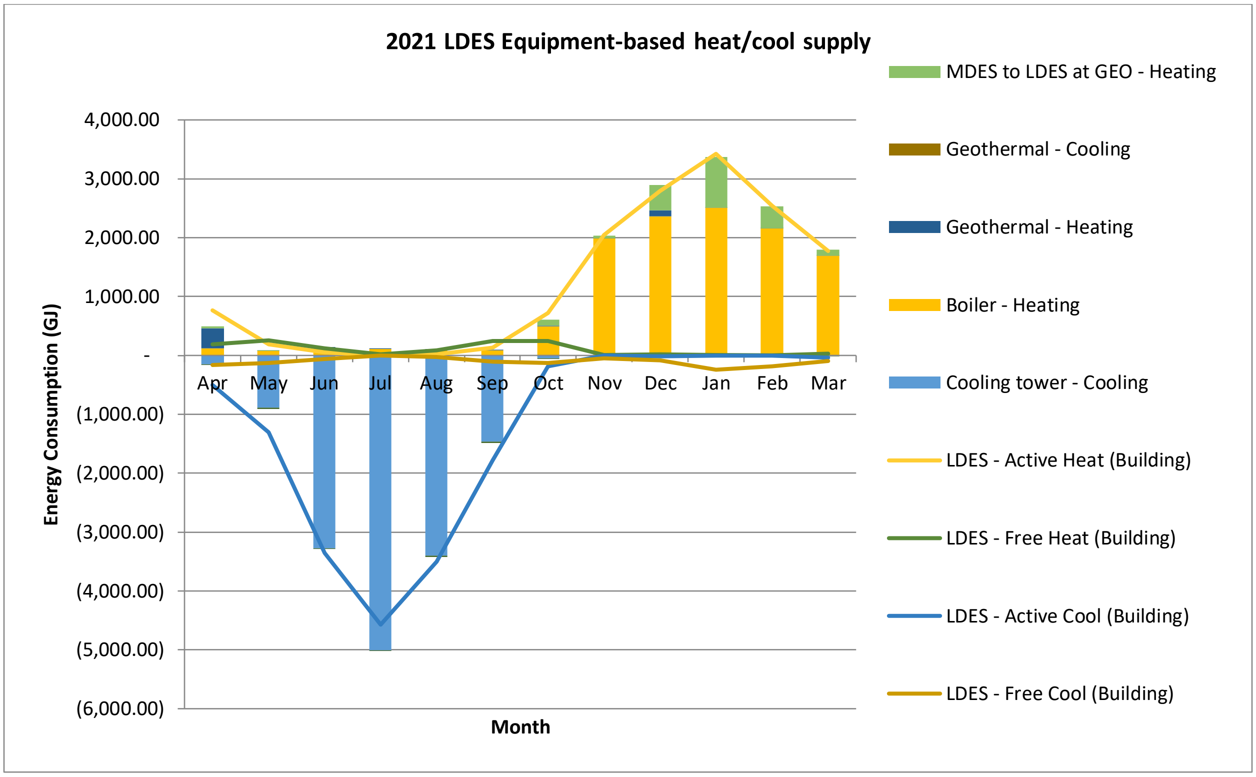

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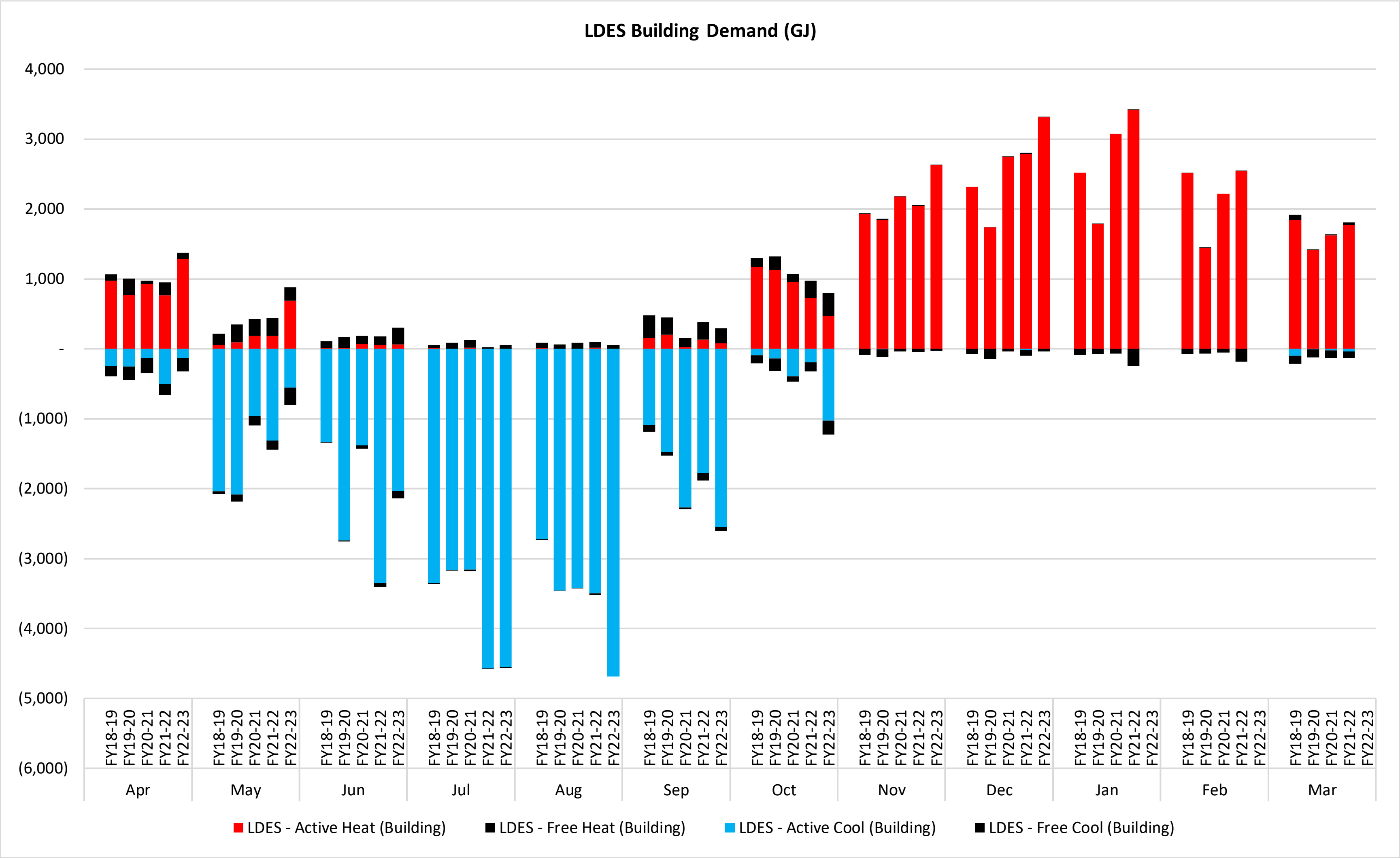

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