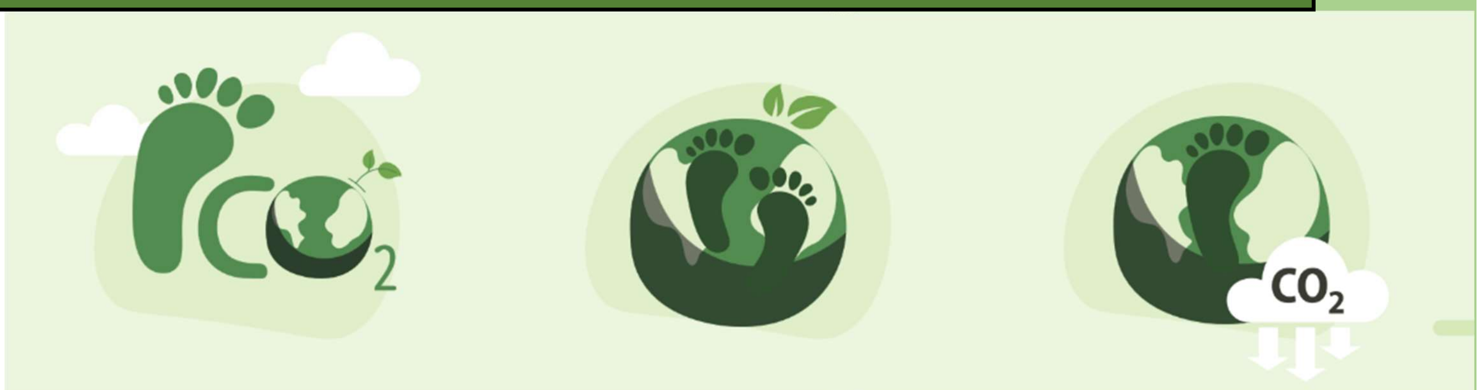
Analysis of Low-Carbon Facility Designs In Health Care Facilities



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August 2025

DISCLAIMER

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This project was conducted under the mentorship of staff conducted under the mentorship of staff at the Provincial Health Services Authority (PHSA) and Fraser Health. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of PHSA, Fraser Health, or the University of British Columbia.

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1 Project Introduction

1.1 Background

Despite its core mission to safeguard and promote health, the health sector is a significant contributor to the climate crisis, the most pressing health challenge of the 21st century. Healthcare facilities, due to their energy-intensive operations and 24/7 service demands, represent a significant share of public sector emissions. Globally, the healthcare sector is responsible for approximately 4.4-5% of GHG emissions [1,2], and in Canada, this figure is estimated at 5-5.2% [3,4].

To support CleanBC's goal of reducing greenhouse gas emissions by 50% by 2030, new healthcare facilities in BC are being designed with low-carbon strategies. Understanding current design components, comparing projected versus actual energy performance, and analyzing sector trends are essential. While innovative technologies are considered, there is often hesitation due to perceived risks. By examining data from energy models across projects, the Energy and Environmental Sustainability team can identify patterns, provide project teams with examples, and help set realistic yet ambitious performance targets through a data-driven tool. This report presents a cross-project analysis of energy model data for acute and long-term care facilities in BC. The findings aim to inform future facility planning, foster knowledge sharing among project teams, and ultimately improve alignment between facility design strategies and provincial climate goals.

1.2 Description and Scope

The project aims to identify low-carbon design trends in BC's Lower Mainland health care facilities by developing an updatable database of energy system components and performance metrics. It will draw from energy model reports and utility data of recent and ongoing projects, covering elements like building envelopes, heat recovery, ventilation, electrification, and renewable energy. The goal is to highlight successful designs, track emerging trends, and identify gaps in current energy model reporting. The project scope is outlined below.

- Identify high-level categories of low-carbon strategies by reviewing energy model reports, plus interviewing 1 or 2 Energy Managers on the Energy and Environmental Sustainability team.
- Gain a high-level understanding of energy loads in healthcare and current best practice design strategies for energy conservation and GHG reduction.
- Review system descriptions in energy model reports and design reports, for 15 – 20 facilities, currently in the design process, and create a comparative spreadsheet identifying low-carbon strategies for each facility.
- Pull energy performance data available in the same energy model reports, and enter it into a spreadsheet.

- Collect and input energy and GHG emissions performance data for 10 existing, newer facilities from the health authorities' utility database, to show trends. Consider whether performance can be correlated to high-level design choices.

2 Available Data

2.1 Facilities currently in planning, design, or construction phase

Energy model (EM) reports for acute care and long-term care (LTC) facilities that are currently in planning, design, or construction phases were provided by the project mentor. These reports are referred to as EM-Business Plan and EM-Design, depending on whether they were created during the business plan phase or the design phase. It is essential to understand the distinction between these two types of documents: EM-Business Plan reports typically include more assumptions and higher-level information necessary for their intended audience to approve the budget. In contrast, EM-Design reports tend to be more detailed and technical. The reports used for data extraction are listed in Table 1. Facility names have been anonymized to maintain confidentiality.

Table 1: Available reports for acute and long-term care facilities

Facility Name	Report Type
Acute-1	Energy Model Report (Design Stage)
Acute-2	Energy Model Report (Design Stage)
Acute-3	Energy Model Report (Design Stage)
Acute-4	Energy Model Report (Design Stage)
Acute-5	Energy Model Report (Design Stage)
Acute-6	Energy Model Report (Design Stage)
Acute-7	Energy Model Report (Design Stage)
Acute-8	Energy and Emission Report (Business Plan)
LTC-1	Energy Model Report (Design Stage)
LTC-2	Energy and Emission Report (Business Plan)
LTC-3	Energy and Emission Report (Business Plan)
LTC-4	Energy and Emission Report (Business Plan)
LTC-5	Energy and Emission Report (Business Plan)
LTC-6	Energy Model Report (Design Stage)
LTC-7	Energy and Emission Report (Business Plan)
LTC-8	Energy and Emission Report (Business Plan)
LTC-9	Energy and Emission Report (Business Plan)
LTC-10	Energy Model Report (Design Stage)

The data in these reports were presented in varying formats, which made it challenging to extract and compare information consistently across facilities. Further details regarding these formatting inconsistencies are discussed in Section 5.

2.2 Existing Facilities

For existing facilities, energy end-use data was extracted from EM- Business Plan and EM-Design reports, and a pre-existing EUI Tool provided by the project mentor. The collected data is from facilities that became operational since 2012. This data includes energy intensities by category for both gas and electricity sources. The predicted EUI values from EM reports were compared against actual energy consumption, allowing for assessment of facility-level performance. This comparison helps to identify which facilities have met, exceeded, or underperformed relative to their original design expectations.

3 Development of Excel Spreadsheets

3.1 Energy Model Metrics Spreadsheet

Data from facilities currently in the planning, design, or construction phase were systematically extracted and organized into an Excel spreadsheet. This spreadsheet captures detailed information across two main categories:

3.1.1 Energy and Emissions Metrics

The spreadsheet includes comprehensive project-level data such as facility name, location, design consultant, report type/status, modeling year, facility type (acute or long-term care), and the simulation software used. Key performance indicators captured include:

- Energy Use Intensity (EUI) and Greenhouse Gas Intensity (GHGI)
- Energy end-use intensities broken down by category: lighting, space heating (gas/electric), space cooling, humidification, pumps, heat rejection, domestic hot water (DHW), elevators, receptacles, the Medical Device Reprocessing Department in a hospital (MDRD), kitchen, refrigeration, and laundry.

For a number of categories, for example, space heating, where the energy source can be gas, electricity, or a combination, the energy consumption metrics are tracked separately. In many EM- Business Plan reports, energy end-use values for individual categories are provided only for the base case, while for the recommended option (which includes multiple energy conservation measures), only the total EUI and GHGI are reported. It was important to have comparisons of designs that included the recommended ECMs. In BC, there is a Treasury Board financial allowance to incorporate ECMs to achieve lower GHG emissions. Therefore, we wanted to include the better performing scenario, as the most likely outcome, in this Study comparison. In order to do that, for these recommended scenarios, end-use values were estimated based on assumptions about the impact of each ECM on specific energy end-use categories. Although these assumptions do not account for overlapping or interactive effects between measures as a full energy model would, the overall trend can still be compared, and the total EUI remains consistent.

Summary statistics such as average and range were calculated for overall EUI and GHGI, categorized by facility type (acute vs. long-term care). Comparative graphs were developed to visualize these trends. Additionally, end-use energy profiles were charted for each facility, enabling performance comparisons within and between the two facility types.

3.1.2 Building Envelope and Mechanical Systems

Key building envelope characteristics documented include:

- Roof and wall R-values
- Glazing U-value and Solar Heat Gain Coefficient (SHGC)
- Window-to-Wall Ratio (WWR) and modeled infiltration rate

Given the influence of the envelope on thermal performance, this data is crucial for understanding building efficiency.

Mechanical system descriptions were also compiled, with a focus on:

- Heating and cooling system types
- Heat recovery systems
- DHW generation methods
- Other systems, including humidification, kitchen equipment, and laundry facilities

Although the descriptions are high-level, together with the end-use metrics, this helps us to link design choices with energy and emissions performance.

3.2 Comparative tool for new facilities

An additional spreadsheet tool has been developed to allow the energy modeller to compare their projected end-use intensities to the collected data from similar facilities. Users can input the energy values of a new facility into a designated sheet. If any value exceeds the average reference value, a pop-up message will alert the user. In addition, a comparative column and graph will automatically be generated in the “Comparison Dashboard” sheet, allowing users to visually assess how each energy end-use category compares with the reference data.

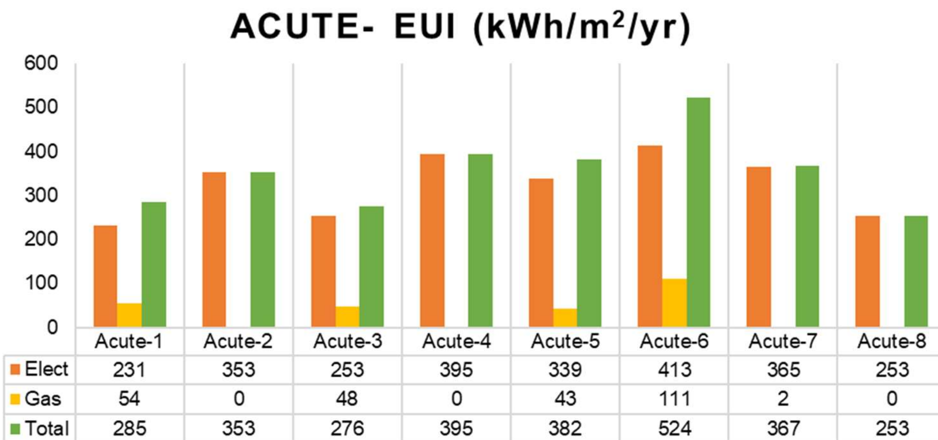
4 Key Findings and Insights

The key observations and conclusions based on the structured Excel datasets are outlined below.

4.1 Energy Use Intensity

The EUI across acute care facilities in BC ranges widely, from 285 to 524 kWh/m²/year. The lowest EUI is observed in Acute-1, while the highest is in Acute-6. This wide variation reflects the complexity and diversity of services within acute facilities and may also be linked to diverse modelling approaches and assumptions. Overall, acute care facilities exhibit higher

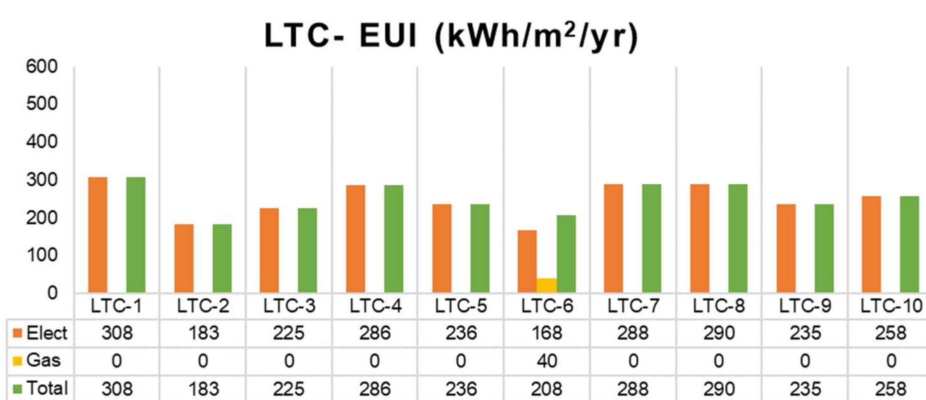
EUI values compared to LTC facilities. Higher EUI values in acute care could be associated with energy-intensive functions such as 24/7 operations, emergency services, diagnostic imaging, and surgical suites, all of which require strict temperature, humidity, and ventilation controls. However, the wide variation in EUI across facilities requires further explanation, particularly among those with similar operating conditions.



	Acute-1	Acute-2	Acute-3	Acute-4	Acute-5	Acute-6	Acute-7	Acute-8
Elect	231	353	253	395	339	413	365	253
Gas	54	0	48	0	43	111	2	0
Total	285	353	276	395	382	524	367	253

Figure 1 Energy End Use Intensity Data for Acute Facilities

In contrast, LTC facilities show a narrower EUI range, from 183 kWh/m²/year (LTC-2) to 308 kWh/m²/year (LTC-1). Most LTC facilities fall within the 225-290 kWh/m²/year range. This relative consistency is likely due to their more predictable operational patterns, lower ventilation requirements, and fewer high-energy medical functions compared to acute hospitals. Additionally, the data for most LTC facilities come from business plans, which tend to reflect energy-efficient design options aimed at minimizing operational carbon footprints. These often assume full electrification strategies, contributing to lower and more stable EUIs.

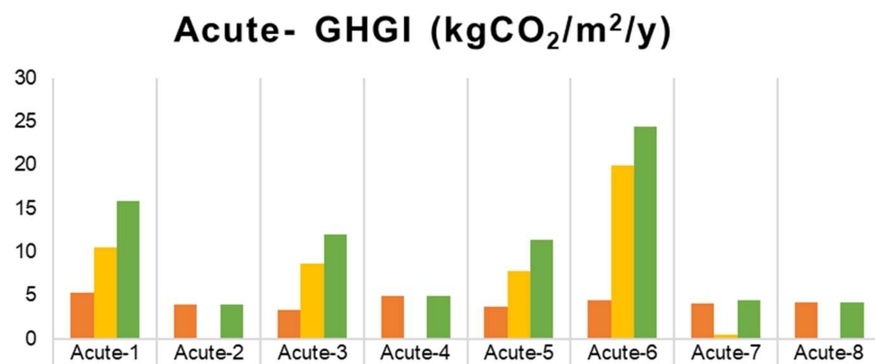


	LTC-1	LTC-2	LTC-3	LTC-4	LTC-5	LTC-6	LTC-7	LTC-8	LTC-9	LTC-10
Elect	308	183	225	286	236	168	288	290	235	258
Gas	0	0	0	0	0	40	0	0	0	0
Total	308	183	225	286	236	208	288	290	235	258

Figure 2 Energy End Use Intensity Data for Acute Facilities

4.2 Greenhouse Gas Emissions Intensity

Greenhouse Gas Emissions Intensity (GHGI) varies significantly across facilities and is heavily influenced by the fuel mix, particularly the presence or absence of natural gas. For acute care facilities, GHGI ranges from 3.9 to 24.3 $kgCO_2/m^2/year$. Acute-6 reports the highest GHG intensity (GHGI) among acute facilities, with a gas EUI of 111 $kWh/m^2/year$ and the highest total EUI in the group. On the other end, Acute-2 has the lowest GHGI (3.9 $kgCO_2/m^2/year$), due to its reliance on electricity only. Interestingly, Acute-3 has a lower overall EUI than Acute-2 but a much higher GHGI (12 $kgCO_2/m^2/year$), again highlighting the significant impact of gas use, even in smaller proportions, on emissions. This reinforces a key trend: facilities with higher gas consumption tend to have much higher GHG emissions, as gas is a carbon-intensive fuel source. This trend is especially pronounced in BC, where the electricity grid is predominantly powered by low-carbon hydropower. In such a context, electrification significantly lowers operational GHG emissions, while even partial gas use can disproportionately raise a facility's GHGI.



	Acute-1	Acute-2	Acute-3	Acute-4	Acute-5	Acute-6	Acute-7	Acute-8
Elect	5.3	3.9	3.3	4.9	3.6	4.4	4.0	4.2
Gas	10.5	0.0	8.6	0.0	7.7	19.9	0.4	0.0
Total	15.8	3.9	12.0	4.9	11.4	24.3	4.5	4.2

Figure 3 Greenhouse Gas Emissions Intensity (GHGI) in Acute Facilities

In LTC facilities, GHGI is generally much lower than in acute facilities, ranging from 2.3 to 11.5 $kgCO_2/m^2/year$. The majority fall between 3.0 and 3.8, reflecting their predominantly electric heating and hot water systems. Higher GHGI values are observed in:

- LTC-2 (7.3)- despite having the lowest EUI of 183, the GHGI is elevated due to the use of a higher emission factor (0.04) in the report, compared to 0.01 in others.
- LTC-4 (11.5)- similarly affected by a higher emission factor (0.04).
- LTC-6 (9.1)- in this case, the emission factor is the same as others (0.01), but the facility uses natural gas for space and/or water heating, which significantly increases emissions even if gas use is limited.

These observations clearly show that in BC’s clean electricity context, the use of natural gas is the most critical factor influencing GHGI, even more than total energy use.

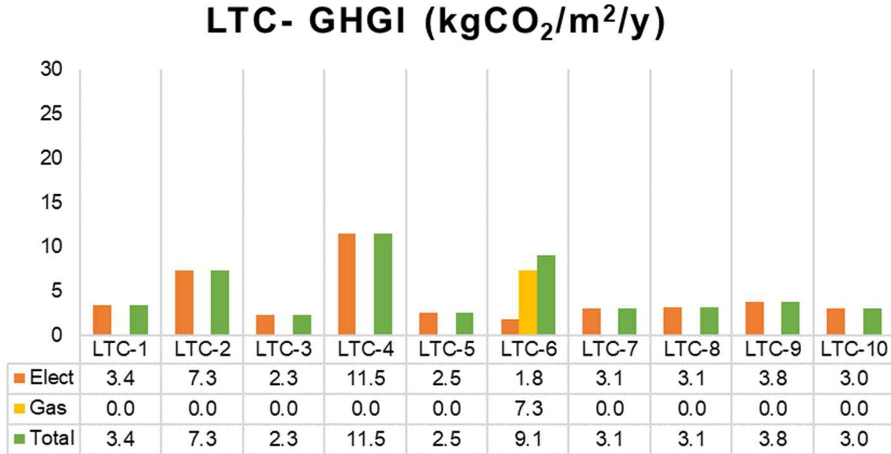


Figure 4 Greenhouse Gas Emissions Intensity (GHGI) in LTC Facilities

4.3 Energy End Use Patterns

The newly designed acute care hospitals and LTC facilities demonstrate distinct energy-use patterns that reflect their different functions and user needs. This comparison (presented as average EUI load distribution in Figures 5 and 6) offers key insights that can inform future policy, design, and retrofit strategies.

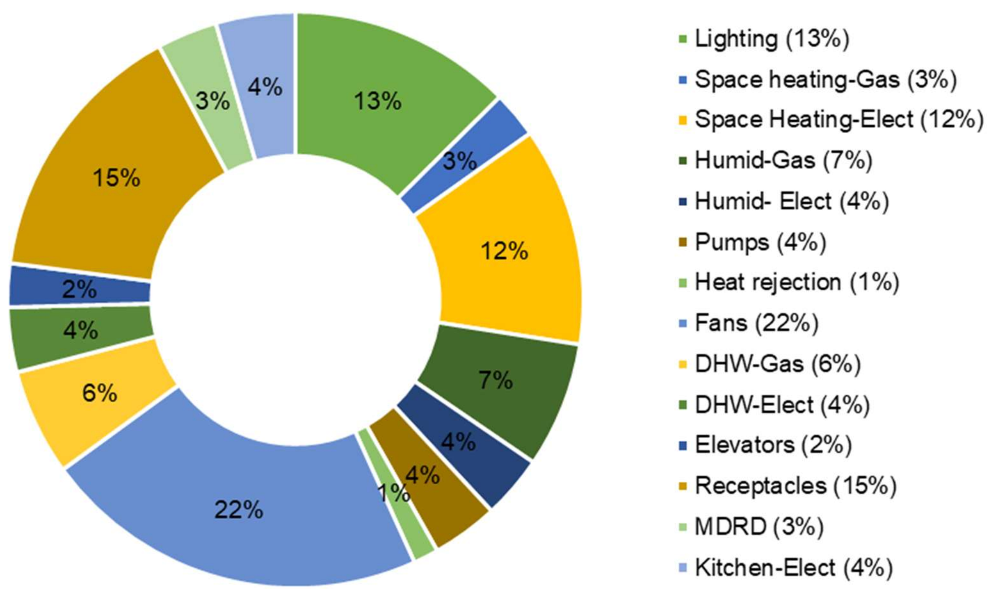


Figure 5 Average Energy End Use Distribution in Acute Facilities

One of the most prominent similarities between the two facility types is the high energy share dedicated to fan systems. In both acute care and LTC facilities, fans account for roughly one-fifth of the total energy use, based on extracted energy model data. This significant share highlights the critical role of ventilation in healthcare buildings, where maintaining a healthy indoor environment is essential for patient safety and comfort. Given this substantial energy demand, any future efficiency or electrification strategies must give high priority to how air is moved and managed, ensuring that ventilation systems are both energy-efficient and capable of meeting strict indoor air quality requirements. From an energy conservation perspective, this end use represents a significant opportunity for improvement, and energy modellers should give careful consideration to fan systems when identifying and evaluating energy conservation measures. Space heating in acute facilities accounts for 14.9% (Elec + Gas) of overall EUI, while 16.5% is all electric in LTC facilities.

Lighting is another area where patterns diverge. LTC homes dedicate a larger share of their energy (16.7%) to lighting compared to acute care (12.6%). This reflects the residential nature of LTC, where lights remain on for extended periods in resident rooms and communal areas, supporting comfort and safety for elderly populations. Similarly, receptacle loads (essentially all plug-in devices) make up 15.1% of energy use in acute care but only 6.1% in LTC. The higher load in hospitals is linked to medical and monitoring equipment, and IT data rooms that operate continuously.

Other building services, such as domestic hot water, kitchens, and laundry, also reflect functional differences. Hospitals use more hot water overall (9.6% of total energy) and often still rely on gas-fired systems, while LTC homes use less (5.4%), with fully electric systems. Kitchens in LTC consume a larger energy share (16.3%) than those in acute care (4.5%). Similarly, laundry, which is more visible in LTC settings, reflects the day-to-day residential care activities that define long-term living environments.

From a policy perspective, this comparison reinforces the importance of tailoring energy and carbon strategies to the unique needs of each building type. For acute care, the focus should be on reducing ventilation and plug loads without compromising patient safety or care quality; potentially through better zoning, demand-controlled ventilation, and energy-efficient medical devices. For LTC, electrification is already well underway at the business plan level; however, in final designs, some facilities have reverted to some reliance on gas due to cost-cutting directives. The other facets may involve enhancing controls, improving lighting efficiency, and rethinking kitchen and laundry system design for energy savings and resident comfort.

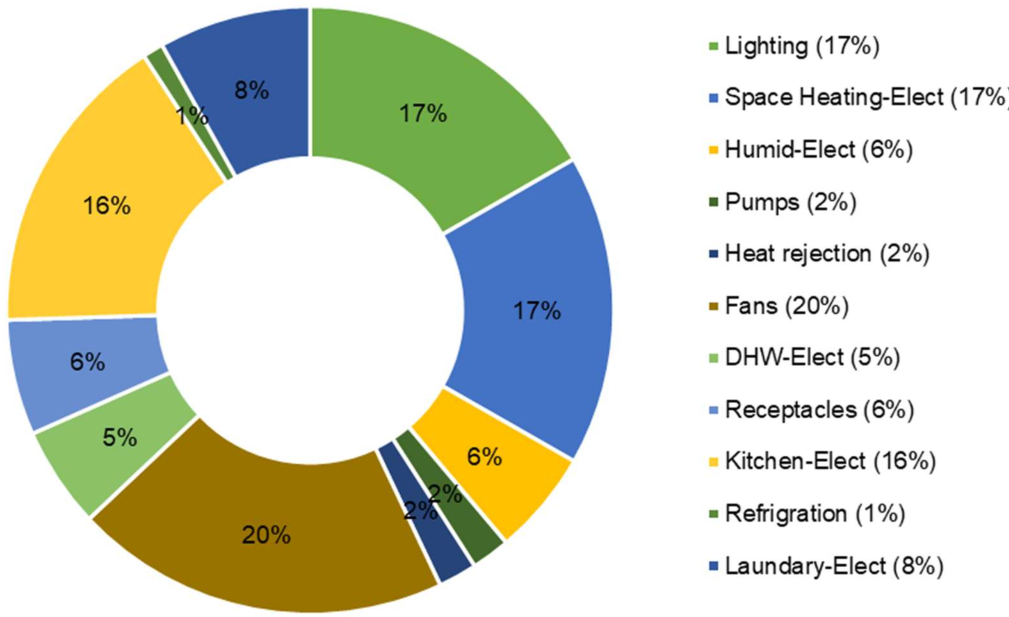


Figure 6 Average Energy End Use Distribution in Acute Facilities

4.4 Category-wise EUI Comparison in Acute and LTC Facilities

Figures 7 and 8 show category-wise plots of EUIs for all acute and LTC facilities, respectively. Several challenges were encountered during data extraction, including the lack of consistency in how end-uses are defined, dependence on load assumptions and default values during the business plan phase, invisible design factors, and interactions between design features and actual load profiles. Despite these challenges, some conclusions can be drawn from the available data, which can help identify ways to improve accuracy and facilitate more meaningful comparisons for benchmarking and promoting best practices.

4.4.1 Acute Care Facilities

Lighting EUIs across the acute facilities mostly vary between 36 and 51 kWh/m²/year. However, Acute-8 stands out with a significantly higher lighting EUI of 75 kWh/m²/year, which may be attributed to the fact that this figure comes from a business plan rather than an EM report. Most facilities incorporate efficient lighting controls such as daylight and occupancy sensors. However, the values remain higher than the best practice targets outlined by Greening Health Care, which range from 18 to 25 kWh/m²/year based on performance data from Ontario hospitals [5].

Electric space heating is the dominant approach across the facilities, with gas being used only in limited capacities. Notably, Acute-5 shows a higher gas heating EUI of 36 kWh/m²/year. In terms of electric heating, Acute-8 demonstrates a very low EUI of 4 kWh/m²/year. In contrast, Acute-5 and Acute-6 report much higher values, 101 and 120 kWh/m²/year, respectively. All facilities, including Acute-5, use heat recovery chillers (HRCs) as a primary heat source, while Acute-6 uses heat recovery from a water-source heat pump

(WSHP). However, the reasons behind these elevated electric heating EUIs are not explicitly documented in the available reports.

Cooling energy use varies considerably across facilities. Acute-1 and Acute-7 report very low cooling EUIs of 4 and 8 kWh/m²/year, respectively, while Acute-2 and Acute-6 are on the higher end with 61 and 65 kWh/m^2/y. The reasons for elevated values for Acute-2 and Acute-6 are not mentioned in the EM reports; however, they may be justified given their specific functions. Acute-2 serves as a cancer care facility, and Acute-6 is an emergency services building, both of which may demand higher cooling loads for equipment and patient comfort. Not all reports include data for humidification. Where reported, gas-based humidification EUIs range from 2 to 27 kWh/m²/year, while electric or adiabatic systems show higher values ranging between 24 and 47. These variations may stem from differences in control strategies, equipment type, and required indoor environmental conditions/set points.

Pump EUIs are relatively consistent across most facilities, falling in the range of 12 to 20 kWh/m²/year. Acute-5, however, has an unusually low pump EUI of just 3. For DHW, facilities utilize a mix of electric, gas, and hybrid systems. Acute-2 and Acute-4, which rely fully on electric systems, report low DHW EUIs of 11 and 8, respectively. On the other hand, Acute-8 reports a very high DHW EUI of 48 kWh/m²/year, again possibly due to it being based on business plan data. Acute-6 shows the highest DHW EUI at 106, using steam heat exchangers as the primary source and steam boilers as a top-up. In comparison, Acute-5 achieves a much lower DHW EUI of 5 by using a hot water loop as the primary source and steam coils only for supplemental heating.

Receptacle loads are consistently high across all facilities, ranging from 20 to 90 kWh/m²/year, reflecting the extensive use of medical and office equipment. However, possible reasons for such wide variations are not explicitly mentioned in the respective reports. Only Acute-1 provides reported data for kitchen EUI, while this end use is omitted in the reports of other facilities. Elevator EUIs range between 2 and 22, while Medical Device Reprocessing Department (MDRD) loads vary from 3 to 20.

Fan energy use shows the widest variability, ranging from 15 to 134 kWh/m²/year. The values appear much higher than Greening healthcare best practice targets (35 to 51 kWh/m2/y [5]). Acute-8 has the lowest fan EUI at 15, which again may reflect the more optimistic assumptions found in business planning documents rather than operational modeling. The high fan EUI in some acute care facilities (up to 134 kWh/m²/year) may reflect extensive ventilation demands, particularly in areas with high air change requirements. Additionally, system design factors like the use of 100% outdoor air, long duct runs, high static pressure from filtration, and the lack of variable-speed controls may contribute to increased fan energy consumption. However, specific causes are not identified in the reviewed reports.

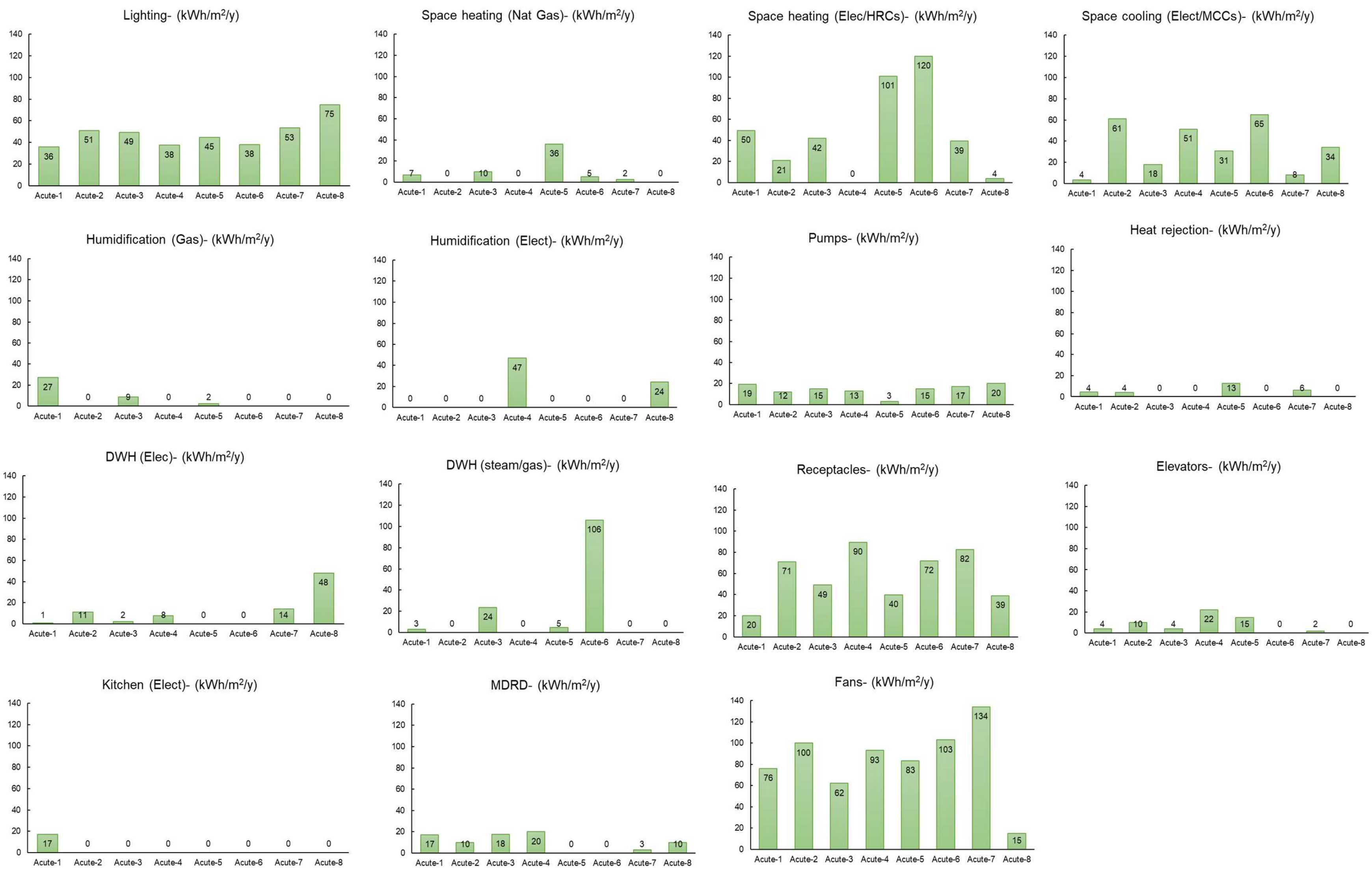


Figure 7 Energy end-use for various loads in Acute care facilities

4.4.2 Long-term care facilities

The energy performance of LTC facilities shows that the most prominent contributors to overall EUI are fans, lighting, space heating, kitchens, and receptacles. Most of the available data for these facilities comes from business plans, which can sometimes include assumptions rather than detailed modeling, so values should be interpreted accordingly.

Lighting varies from 28 to 59 kWh/m²/year across facilities, while lighting data for LTC-4 was not available. All LTC facilities use electric heating systems, except for LTC-6, which uses a condensing boiler as the primary heating source and a VRF heat pump system as a secondary source. Interestingly, LTC-6 reports the lowest electric heating EUI (13 kWh/m²/year), while LTC-10 shows the highest (62 kWh/m²/year). This wide variation may be due to differences in envelope efficiency, occupant load, or heating system performance, but the reports don't provide enough detail to confirm.

Cooling loads are modest, as expected for BC's relatively mild climate. Cooling EUIs range from 5 to 28 kWh/m²/year, reflecting standard seasonal demand. Many reports do not provide data for humidification. Where available, EUIs range from 3 (LTC-3) to 48 (LTC-1) kWh/m²/year. The unusually high value for LTC-1 is attributed in the report to combined fan and humidification loads. However, this is confusing since fan loads are also listed separately and included in the total EUI. Pump loads are relatively low and consistent, with EUIs ranging from 1 to 15 kWh/m²/year, indicating efficient water circulation systems and likely limited pumping demand beyond DHW and HVAC loops.

Fan energy use shows significant variation, ranging from 28 kWh/m²/year (LTC-2) to a notably high 121 kWh/m²/year (LTC-1). The report for LTC-1 attributes the high value to fans running continuously, whereas in acute facilities, fans cycle on and off during unoccupied hours. However, this explanation appears inconsistent when comparing similar occupancy profiles in other LTC facilities. System design, lack of variable-speed controls, or inaccurate assumptions in the business plan may be contributing to this anomaly.

Most LTC facilities rely on electric systems for DHW production, with heat pumps commonly used. EUIs range from 8 to 23 kWh/m²/year for these electric systems. LTC-6 is an exception, using steam heat exchangers as the primary DHW source, with a DHW EUI of 28. Only two facilities reported elevator energy use, with EUIs ranging from 7 to 15 kWh/m²/year, which aligns with expectations for mid-rise residential-type buildings with regular elevator usage. Plug loads are relatively high, ranging from 11 to 42 kWh/m²/year, likely reflecting continuous use of medical, personal care, and office equipment throughout the facilities.

Kitchens and laundry services are central to LTC operations. All reviewed EM- Business Plans indicate that both services are electric in the recommended (enhanced) options. Kitchen EUIs show a wide range, from 17 to 77 kWh/m²/year, which may reflect variations in kitchen size, meal service frequency, equipment efficiency, or reporting accuracy. Unfortunately, no clear justification is provided in the reports for high or low values. Laundry

EUIs are relatively more consistent, between 17 and 27 kWh/m²/year, aligning with routine resident care needs. Refrigeration loads are reported only for LTC-1 at 3 kWh/m²/year, likely underestimated or included elsewhere in other end-use categories, such as plug loads.

4.5 Commonly Employed Energy Conservation Measures

Energy Conservation Measures (ECMs) are proposed strategies or technologies aimed at reducing energy use and greenhouse gas (GHG) emissions. These measures are presented as options for consideration and may not necessarily be incorporated into the final design. There is a strong incentive to adopt ECMs that significantly lower GHG emissions, as meeting a 50% reduction relative to a Gold baseline can qualify for the Ministry of Health allowance of a 3% increase in the construction budget. As a result, many business plans present ECMs as options for consideration to achieve energy and GHG reductions. Similarly, certain EM-Design reports highlight ECMs that have been adopted as part of the building design. The following is a summary of ECMs employed in EM- Business Plans and EM-Design reports;

1. Heat Recovery

- Active heat recovery using heat recovery chillers (HRCs), heat pump, compressor-based, etc.
- Passive heat recovery using run-around loops, heat wheels, thermal labyrinth, etc.
- Use of thermal gradient header to improve the active/passive heat recovery
- Other strategies to switch or combine active and passive, depending on when it is appropriate

2. Efficient HVAC Systems

- Central air handling units (AHUs) with VAV or CAV systems and hydronic reheat
- High-efficiency chillers (air-source, water-cooled, and 4-pipe systems)
- Displacement ventilation and mixed-mode systems
- Dedicated systems for critical spaces (e.g., comms/electrical rooms)
- Adiabatic humidification systems

3. Electrification and Decarbonization

- Electrification of steam generation, DHW, space heating, kitchens, and laundry
- High-temperature CO_2 and dedicated heat pumps for DHW
- All-electric building designs using electric boilers and heat pumps

4. Envelope and Lighting Efficiency

- High-performance building envelopes (increased roof/wall insulation, high R-values, improved glazing, external shading, enhanced air tightness)
- Glazing upgrades, including low-e and electrochromic windows
- Lighting power density (LPD) reduction, LED lighting, daylight, and occupancy sensors

5. Controls and System Optimization

- Use of Variable Frequency Drives (VFDs) for pumps and fans
- Occupancy- and schedule-based controls
- Whole-building and system-level metering to support performance-based commissioning
- Renewable and Low-Carbon Energy Sources

It is important to note that the list of ECMs presented above is a high-level summary from various reports and includes strategies that may appear contrasting. Certain ECMs are better suited to specific conditions and may not be universally applicable. For example, Constant Air Volume (CAV) systems with hydronic reheat are implemented in some facilities, while others adopt Variable Air Volume (VAV) systems. VAV systems tend to be more energy-efficient and better suited to varying load conditions, whereas CAV systems are simpler and may be favored in areas with strict ventilation requirements. In practice, many facilities use a combination of Constant Air Volume (CAV) and Variable Air Volume (VAV) systems: CAV serves central corridors, while VAV serves patient rooms where cooling and heating demands are more variable and influenced by factors such as solar gains and room location.

Similarly, some designs incorporate displacement or mixed-mode ventilation, which can offer improved indoor air quality and thermal efficiency. In contrast, other facilities rely on traditional centralized Air Handling Units (AHUs) due to the complexity and control requirements of alternative strategies, particularly in hospital environments where air change rates and pressure control are critical. Displacement ventilation remains a relatively new approach and has not been widely adopted.

In terms of envelope design, operational preferences like maintenance, availability, etc., play an important role in selecting the measures for building envelopes. Certain projects proposed electrochromic (dynamic) glazing for automated solar control, while others proposed external shading devices. Although both approaches aim to reduce solar heat gain and improve occupant comfort, electrochromic glazing involves higher costs and advanced integration. In contrast, shading devices offer a more passive, cost-effective solution.

Overall, this list provides a useful overview of the ECMs commonly preferred by energy modelers across various hospital projects in BC.

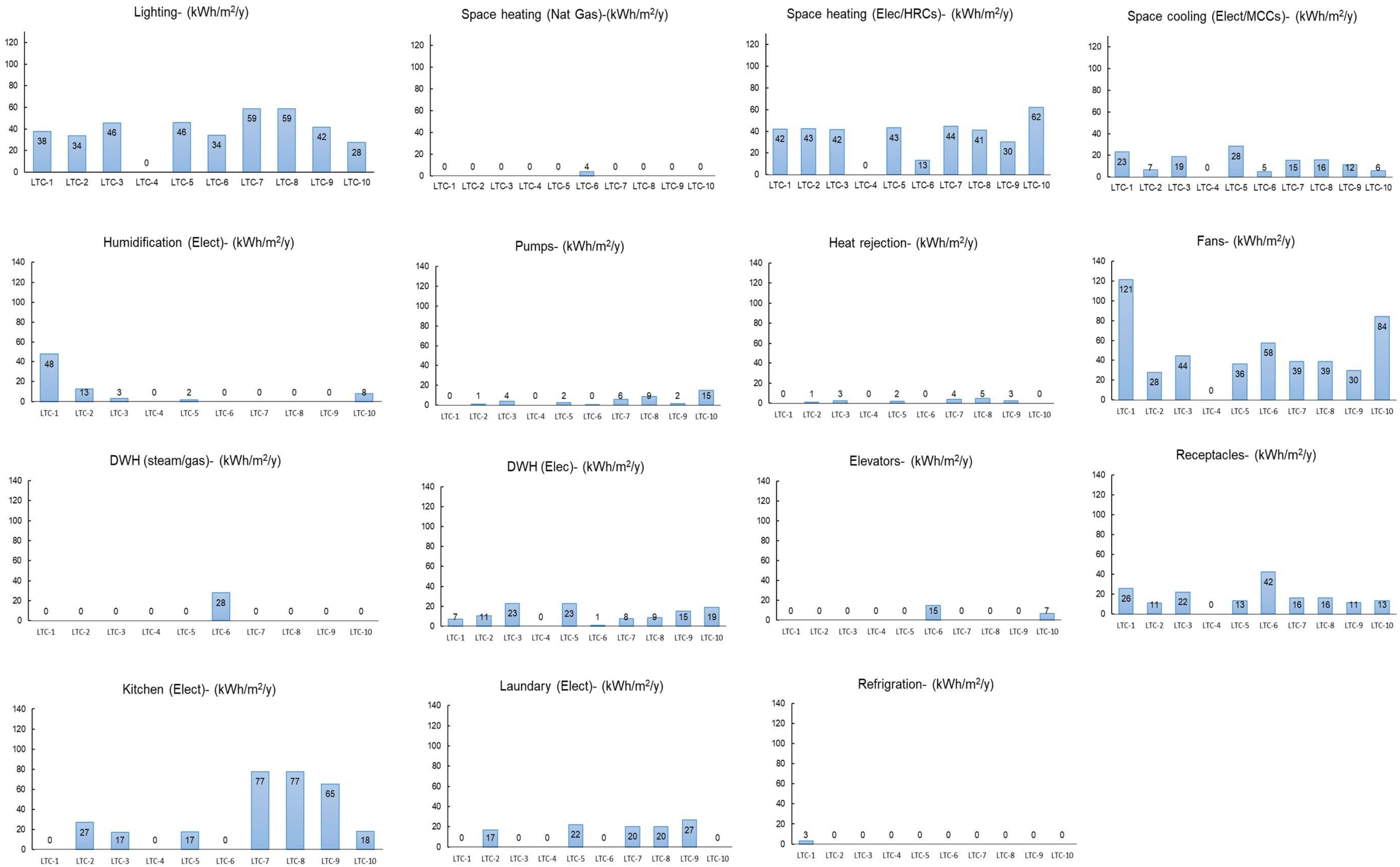


Figure 8 Energy end-use for various loads in long-term care facilities

4.6 Comparison of Modelled and Actual Energy Performance in Existing Hospitals

Table 2 presents a comparison between the proposed (modelled) and actual energy use intensity (EUI) data for existing health care facilities in BC. While modelled (predicted) EUI data is available for 18 facilities, actual measured energy data exists for only 8 of these. Furthermore, detailed end-use category data (e.g., lighting, heating, cooling) is not available for the existing hospitals. Consequently, the comparison is limited to total EUI values rather than a breakdown by end-use.

Significant discrepancies are evident between the modelled and actual energy performance, with actual EUIs in most facilities exceeding design-stage predictions by a wide margin (ranging from 57% to 223%). A key factor contributing to this increase appears to be higher natural gas consumption compared to modelled values. It suggests that actual energy use aligns more closely with base case designs rather than the recommended designs incorporating multiple energy conservation measures. Notably, only Facility D and Facility K show reasonable alignment, with actual total EUI differing from modelled values by just +0.4% and -2.4%, respectively.

These deviations could stem from multiple factors.

- Modelling assumptions during design may not fully capture real operational behaviors, including occupancy patterns, equipment loads, or control strategies.
- Execution and construction quality can also diverge from design intent, leading to inefficiencies. At commissioning time, only functional testing and training are provided to facilities, not the energy implications of design and sequences of operation.
- Moreover, operational practices, such as poor maintenance of HVAC systems, override of automated controls as they are not well understood, or suboptimal scheduling, can significantly increase energy consumption.
- Additionally, data quality issues, including metering inaccuracies or exclusion of certain energy uses, may affect the reported values.

Despite data limitations, the observed discrepancies highlight a concerning trend that warrants further investigation. The following are a few recommendations in this regard:

- Undertake a comprehensive analysis to better understand performance gaps.
- Review energy model inputs and assumptions to assess their accuracy and relevance.
- Compare modelled results with as-built and as-operated conditions to identify discrepancies.
- Implement a performance-based commissioning process, repeated quarterly during the first one to two years of operation, to identify issues and make necessary adjustments to achieve predicted performance.
- Conduct site-level audits to detect and address operational inefficiencies.

- Establish a structured feedback process where actual building performance data is regularly compared with the original energy model results.
- Use the findings to refine modelling assumptions and inform future project designs, ensuring more accurate performance predictions and better delivery outcomes.

Table 2 Modelled and Actual Energy Use in Existing Hospitals

Facility	Type	Modelled (Proposed) EUI Data kWh/m2/y			Actual EUI Data kWh/m2/y			Difference
		Elect	Gas	Total	Elect	Gas	Total	
Facility-A	Acute	90.2	87.1	**177.2**	138.0	188.0	**326.0**	↑ **84.0%**
Facility-B		126.8	60.6	**187.4**				
Facility-C	LTC	204.0	45.0	**249.0**	258.0	258.0	**516.0**	↑ **107.2%**
Facility-D	Acute	153.1	68.1	**221.2**	148.0	74.0	**222.0**	↑ **0.4%**
Facility-E	LTC	138.8	163.6	**302.4**				
Facility-F	Acute	196.6	107.3	**303.9**				
Facility-G	Acute	284.3	62.2	**346.5**				
Facility-H	Research Centre	188.0	21.1	**209.2**				
Facility-I	Research Centre	171.6	54.2	**225.8**	192.0	212.0	**404.0**	↑ **78.9%**
Facility-J	Acute	104.4	0.0	**104.4**	251	86	**337.0**	↑ **222.9%**
Facility-K	Acute	252.6	92.6	**345.2**	251	86	**337.0**	↓ **2.4%**
Facility-L	Acute	209.2	56.9	**266.2**				
Facility-M	Acute	205.0	53.0	**258.0**	297	110	**407.0**	↑ **57.8%**
Facility-N	Acute	228.4	25.9	**254.3**	226.73	346.72	**573.5**	↑ **125.5%**
Facility-O	Acute	338.7	43.1	**381.8**				
Facility-P	LTC			**282**				
Facility-Q	Acute	239.9	33.3	**273.2**				
Facility-R	Acute	348.0	176.0	**524.0**				

5 Recommendations for Reporting Consistency in Energy Model Reports

Based on the review of reports and the data extraction exercise, a few recommendations are proposed to improve the consistency and usability of energy model reports. These reports are prepared by different consultants, each following their reporting format. This lack of standardization makes it challenging to extract and compare similar data across projects. For example, the level of detail provided for energy model inputs varies significantly, and some reports do not provide key information such as modelled/conditioned area, emission factors used, etc. This is a low-effort improvement that can provide disproportionally high value by ensuring consistency across reports, improving comparability, and strengthening the reliability of benchmarking exercises.

The reporting of the effects of energy conservation measures (ECMs) on energy end-use categories and overall EUI is also inconsistent. Most reports, particularly business plans, simply describe the proposed measures and report the total EUI without detailing the impact on individual end-use categories. Often, energy end-use values by category are only provided for the base case, while the recommended scenario with multiple ECMs reports only the total EUI and GHGI. Although some reports offer detailed comparisons, many omit a few end-use categories; for instance, kitchens and laundry in LTC care facilities, elevators, and MDRDs in acute care hospitals are missing in some reports. Additionally, categories are inconsistently grouped; for example, some reports combine fan and humidification loads, receptacles and process load, and pumps and heat rejection loads, while others separate them. This inconsistency further complicates data extraction and cross-comparison. It is proposed that all reports provide the EUI values for the following load categories individually:

- Space Heating (Gas)
- Space Heating (Electric)
- Space Cooling (including heat rejection, process cooling)
- Heat Recovery Chiller (both heating, cooling, and process cooling)
- DHW top-up (Gas)
- DHW top-up (Electric)
- Humidification (Gas)
- Humidification (Electric)
- MDRD steam (Gas or electric)
- Fans
- Pumps
- Lighting
- Elevators
- Plug Loads (not including elevators)
- Kitchen (Gas)
- Kitchen (Electric)
- Laundry (only if all laundry is in-house, not just LTC personal laundry)

A key concern is the wide variation in reported EUIs for similar types of hospitals. While such variation may reflect underlying differences, the reports rarely discuss the reasons behind unusually high or low EUIs within categories. It is crucial that future reports include details on energy model inputs and clear explanations and contextual analysis for these variations to provide meaningful insights. Overall, standardizing reporting formats and improving transparency around assumptions and results will greatly enhance the value of energy model reports for decision-makers and stakeholders.

Another key limitation observed in current energy model (EM) reports for healthcare facilities is the lack of background information related to occupancy, departmental scheduling, and operational intensity. While EM results typically present EUI on a per-area basis (kWh/m²/year), which is a standard metric unit, many energy loads, such as plug loads, lighting, ventilation, and kitchen equipment, are directly influenced by how the facility is used, not just by its physical size. Another area of concern is the assumptions used for DHW, elevator, and receptacle loads. These assumptions can significantly influence the final EUI, and the methodology should be updated to better reflect typical hospital load profiles. This absence of operational context makes it challenging to interpret and compare EUI values across facilities with differing levels of service, patient volumes, or utilization patterns, even when floor areas are similar.

5.1 Recommendations for EM reports

To address this gap and support more meaningful energy performance evaluations, the following are a few recommendations:

- Energy model submissions should document key occupancy-related parameters, such as the number of beds, clinical hours, expected staff and patient throughput, and space-use schedules.
- When available, models should reflect and report load assumptions at the departmental level (e.g., operating rooms, imaging suites, kitchens) tied to occupancy or usage data.
- Model inputs related to internal loads should be based on empirical data or validated benchmarks where possible, and cited.
- Design teams and modelers should collaborate with hospital departments during the modelling stage to define realistic operating conditions, schedules, and anticipated service intensity.
- Occupancy-informed load profiles can improve the alignment between modelled performance and post-occupancy outcomes, supporting both validation and commissioning processes.
- Consistent end-use categories should be applied across all EM reports to enable meaningful comparison and benchmarking.
- The gap between modelled and actual use should be addressed through post-occupancy performance verification, commissioning, and ongoing operational optimization.
- Emission factors should be standardized and consistently reported across all projects.
- End-use breakdowns should explicitly include recommended ECMs to support future decision-making and tracking.
- Reporting outputs should follow a consistent format, with minimum required fields clearly defined.

Including this contextual information and reporting consistency will significantly enhance the transparency, interpretability, and usefulness of EM results, especially when used for benchmarking, target setting, or performance verification.

6 References

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