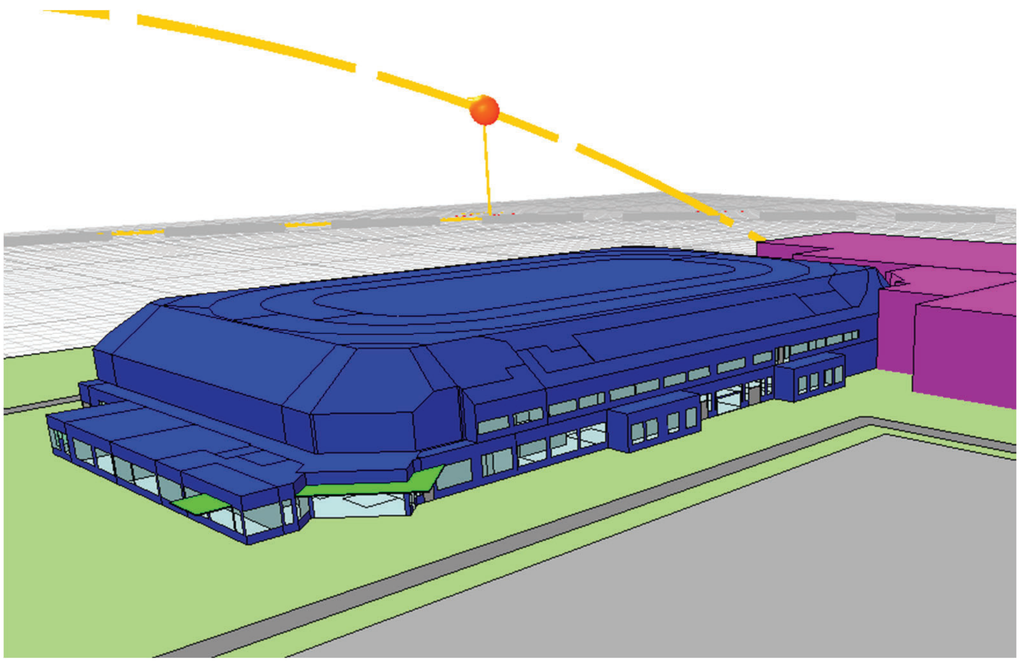
Engineers

# CN Centre

## Building Energy Study – Rev. 2

**12187 Ospika Blvd S  Prince George  BC  V2N 1B2**



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# 1.0 Introduction

FaulknerBrowns Architects (the Client) commissioned Read Jones Christoffersen Ltd. (RJC) to prepare an energy study for the CN Centre. This energy study was conducted to inform and guide the design process towards an optimized renewal of the building envelope and mechanical systems, as well as achieving a lower carbon footprint. The goal of this report is to demonstrate the impact of the enclosure and mechanical systems on the energy consumption of the building to inform the final envelope assemblies and mechanical systems for the upcoming renewal project planned for the building.

## 1.1 Energy Model Calibration

Built in 1995, the CN Centre is a multi-purpose arena with a seating capacity of approximately 6,000. The ice surface is removed during the months of May, June, and July to accommodate non-ice events and maintenance activities.

It is our understanding that several building enclosure energy conservation measures (ECMs) are being considered for this facility as part of the upcoming renewal project. However, it should be noted that building enclosure ECMs may reach a point of diminishing returns; beyond certain insulation thresholds, further increases do not significantly enhance energy savings and may not justify the added capital costs. This study, therefore, also analyzes planned and optional mechanical system upgrades in conjunction with envelope upgrades.

The energy model inputs are based on documents provided by the City of Prince George. These include original drawings, specifications, shop drawings, energy audits, and building condition assessments. The enclosure performance was determined using assembly details and a detailed thermal bridging calculation of the CN Centre performed by RJC Engineers.

Energy utility data specific to the CN Centre is not available, as utility billing is aggregated for the entire exhibition grounds. This includes the Kin Centre, Agriplex, Gymnastics, Rodeo Grounds, & Ice Oval. As such, a detailed calibration of the energy model was not feasible. However, a simplified calibration was performed using a combination of the available utility data and information from a heat recovery study conducted by Polar Engineering in 2023. The model has been calibrated to align with the following values from that study, as summarized in Table 1:

| TABLE 1: CALIBRATION TARGETS[1] | | |
|---|---|---|
| **End-use** | **Thermal Demand (GJ/yr)** | **Natural Gas (GJ/yr)** |
| Space Heating | 5,834 | |
| Domestic Hot Water (DHW) | 1,660 | |
| Snow melt | 416 | |
| Zamboni | 260 | |
| Total | 8,170 | 11,000 |

1. Targets extracted from the heat recovery study conducted by Polar Engineering in 2023

Natural gas consumption at the CN Centre is estimated to represent approximately 52% of the total energy use across the exhibition grounds. Based on this, it was assumed that the CN Centre accounts for a similar proportion of the total electricity consumption, which was used to establish an approximate electricity calibration target. The energy model of the existing facility was developed and calibrated using IES VE 2024 software to align with the findings of the 2023 energy audit conducted by Polar Engineering.

The results of the calibrated baseline energy model—representing the existing conditions of the CN Centre—are presented in Table 2. A summary of the key energy model inputs is provided in Table 3.

| TABLE 2: BASELINE ENERGY MODEL PERFORMANCE | | | | |
|---|---|---|---|---|
| **Building** | **Utility** | **Consumption [MWh]** | **Energy Use Intensity[1] [kWh/m$^2$]** | **Annual Greenhouse Gas (GHG) [$tCO_2e$]** |
| CN Centre | Electricity | 2,468 | 179 | 27 |
| | Natural Gas | 3,146 | 228 | 582 |
| | Total | 5,614 | 407 | 609 |

1. Based on a modelled floor area of 13,791 [m$^2$]

| TABLE 3: ENERGY MODEL INPUT SUMMARY (EXISTING BUILDING) | | | |
|---|---|---|---|
| <u>Project Details</u><br>**Building Address:**<br>**City (AHJ):**<br>**Energy Targets:** | <br>12187 Ospika Blvd S, Prince George, BC V2N 1B2<br>City of Prince George<br>Cost-effective enclosure upgrades | | |
| **Building Enclosure (IP)** | **Mechanical** | **Operating Conditions** | **Internal Loads & Schedules** |
| **Roofs (combined):**<br>R-10.5 effective<br><br>**Exterior Walls (combined):**<br>*<u>R-4.2 overall effective after thermal bridging</u>*<br><br>**Glazing (combined):**<br>Double glazed; aluminum U-0.57; SHGC: 0.65<br><br>**Opaque Doors (combined):**<br>R-2.3 effective<br><br>**Underground Wall/Footings:**<br>R-7.5 vertical insulation extending 5'<br><br>**Arena Slab:**<br>Uninsulated (except beneath ice)<br><br>**Infiltration:**<br>1.3 L/s/m² façade at operating pressure (2.0 L/s/m² normalized envelope air leakage at 75 Pa) | **Ventilation:**<br>40,000 cfm total<br>No energy recovery<br><br>**Heating/Cooling:**<br>Mixed-air constant volume air-handling units with hydronic heating/cooling<br><br>**Fan Power:** Adjusted for calibration<br><br>**Heating Boiler & Service Water Heater:**<br>Non-condensing, 74% seasonal efficiency<br><br>**Water-Cooled Chiller:**<br>Rated COP: 5.5<br><br>**Ammonia Ice Plant:**<br>Cooling COP: 3.5 (air-cooled)<br>(August – April)<br><br>**Pumps:**<br>Heating: 19 W/gpm<br>Cooling: 21 W/gpm | **Operating Hours:**<br>5 am – 12 am, 7-days/week<br><br>**Rink Ice Setpoint:**<br>-5°C<br><br>**Heating Setpoints:**<br>Audience/Storage/ Mechanical: 10°C<br>Corridors/Stair/ Washroom: 15°C<br>Office/Lounge/ Lobby/Locker/Laundry/ Multipurpose/Kitchen: 22°C with 18°C nighttime setback<br>Atrium: 0°C<br><br>**Cooling Setpoints:**<br>Stairway/Mechanical/ Washroom: None<br>All other: 24°C, off at night | **Lighting Power Densities (LPDs), Equipment Power Densities, Occupancy & Schedules:**<br>Per NECB 2011 by space type<br><br>**Service Hot Water Demand (including zamboni & snow melt):**<br>74 kW thermal<br><br>**Ice plant load (August – September):**<br>151 kW thermal<br>(43 kW electric)<br><br>**Exterior Lighting:** 2 kW<br>**Elevator:** 3 kW |

## 2.0 Breakdown of Building Heat Loss

Energy modeling results indicate that the majority of heat loss in this facility occurs through ventilation exhaust (as there is no heat recovery), which accounts for approximately 51% of total heat loss. The remaining 49% is due to heat loss through the building enclosure and infiltration (air leakage). Figure 1 below illustrates the sources of heat loss in the baseline model. A breakdown of the baseline model energy consumption is provided in Appendix A.



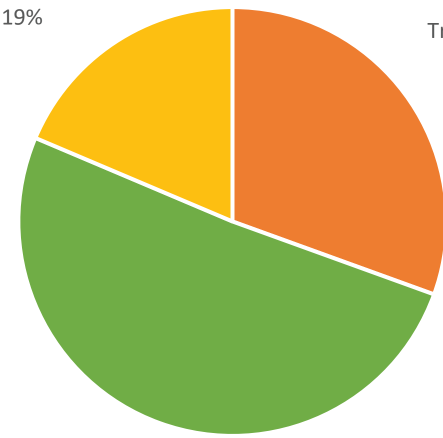



**Figure 1 – Building Heat Loss Contribution**

## 3.0 Energy Performance: Comparing 4 Envelope Scenarios

The energy performance of the building has been studied under the following 4 scenarios, with the results summarized in Table 4. In order to isolate the impact of the potential envelope upgrades, the following four scenarios were evaluated with the same mechanical system (existing).

**TABLE 4: SUMMARY OF ECM SCENARIOS & ANNUAL PERFORMANCE**

| Scenario | Infiltration (L/s/m² @ 75 Pa) | External Door | External Wall | External Window | Roof | Electricity (MWh) | Natural Gas (MWh) | Carbon Emission (tonnes) | Energy Cost Savings |
|---|---|---|---|---|---|---|---|---|---|
| Baseline Model | 2.0 | Existing | Existing | Existing | Existing | 2,468 | 3,146 | 609 | $- |
| Improved Performance | 1.2 | Door A | Wall A | Window A | Roof A | 2,189 | 2,833 | 548 | $32,244 |
| Enhanced Performance | 1.2 | Door B | Wall B | Window B | Roof B | 2,156 | 2,791 | 540 | $36,207 |
| High Performance | 1.2 | Door B | Wall C | Window B | Roof C | 2,150 | 2,780 | 538 | $37,059 |

In our energy study, the following enclosure ECMs were evaluated across various scenarios, including the existing condition for each component.

**Roof Upgrade:**

- Existing:
  Sloped standing seam roof: 4" batt insulation, R-9.3 effective

- Roof A:
  Sloped standing seam roof: 4" Polyiso insulation, R-19.4 effective

- Roof B:
  Sloped standing seam roof: 5.5" Polyiso insulation with Polyiso coverboard, R-30.0 effective

- Roof C:
  Sloped standing seam roof: 8.0" Polyiso insulation with Polyiso coverboard, R-42.3 effective

**Exterior Wall Upgrade:**

- Existing (R-4.2 overall effective)
  Metal cladding + steel stud w/ R-19 batt: no exterior insulation, R-10.6 effective
  Brick veneer + CMU: 1.5" XPS, R-9.3 effective
  Brick veneer + concrete: no exterior insulation, R-1.6 effective

- Wall A (R-16.2 overall effective):
  Metal cladding + steel stud: 7.5" mineral wool, R-39.1 effective
  Brick veneer + CMU: 4" mineral wool, R-18.4 effective
  Brick veneer + concrete: 6.5" mineral wool, R-27.1 effective

- Wall B (R-18.8 overall effective):
  Metal cladding + steel stud: 9" mineral wool, R-44.1 effective
  Brick veneer + CMU: 5.5" mineral wool, R-23.7 effective
  Brick veneer + concrete: 8" mineral wool, R-32.1 effective

- Wall C (R-20.9 overall effective):
  Metal cladding + steel stud: 10.5" mineral wool, R-48.9 effective
  Brick Veneer + CMU: 7" mineral wool, R-28.9 effective
  Brick Veneer + concrete: 9.5" mineral wool, R-36.4 effective

**Window Upgrade:**

- Existing:
  Windows: Aluminum frame thermally broken storefront, double glazed (U0.54, SHGC 0.67)
  Glazed swing doors: Aluminum frame, single glazed (U1.08, SHGC 0.42)

- Window A:
  Windows: Aluminum frame thermally broken curtain wall, double glazed (U0.33, SHGC 0.34)
  Glazed swing doors: Aluminum frame thermally broken, double glazed (U0.54, SHGC 0.20)

- Window B:
  Windows: Aluminum frame thermally broken curtain wall, triple glazed (U0.19, SHGC 0.27)
  Glazed swing doors: Aluminum frame thermally broken, triple glazed (U0.46, SHGC 0.18)

**Door Upgrade:**

- Existing:
  Opaque swing doors: steel door (R-2.0)
  Overhead sectional doors: 1" polystyrene (R-2.3)

- Door A:
  Opaque swing doors: Thermally broken insulated door (R-2.7)
  Overhead sectional doors: 2" polystyrene (R-3.2)

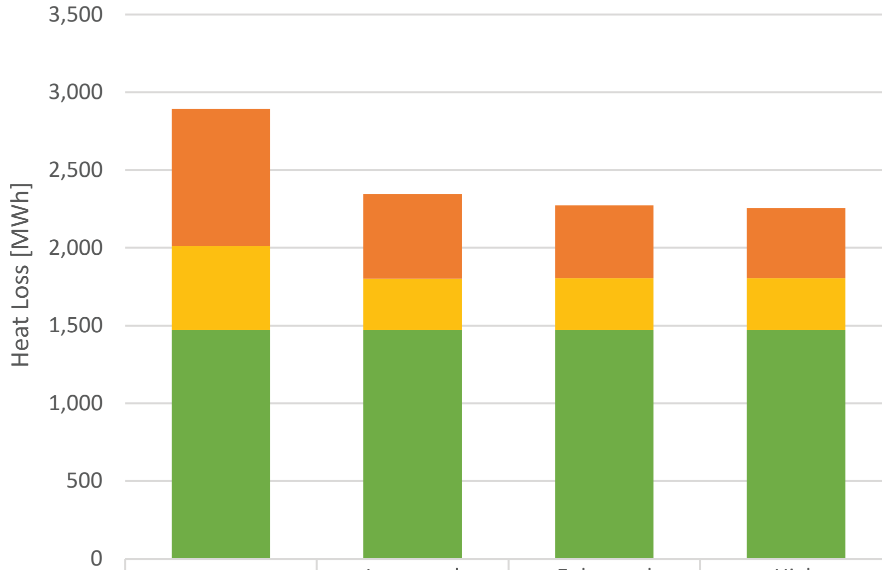
- Door B:
  Opaque swing doors: Fiberglass (R-4.9)
  Overhead sectional doors: 3" insulated, thermally broken (R-5.7)

Electricity and Natural gas rates were determined using actual bills for the period from 2022 to 2025, based on monthly usage and all charges (the Carbon Tax has been removed from the natural gas price). Prices and emission factors for each energy source are presented in Table 5.

**TABLE 5: FUEL PRICES & EMISSION FACTORS**

| Fuel Type | Price ($/kWh) | Price ($/GJ) | Emission Factor (kgCO2e/MWh) |
|---|---|---|---|
| **Electricity** | $ 0.0838 | -- | 11 |
| **Natural Gas** | $ 0.0284 | $ 7.89 | 185 |

## 3.1 Impact of the Building Enclosure on Heat Loss




| | Baseline | Improved Performance | Enhanced Performance | High Performance |
|---|---|---|---|---|
| Transmission Heat Loss | 883.53 | 543.91 | 469.13 | 450.93 |
| Infiltration Loss | 539.02 | 331.25 | 332.75 | 333.28 |
| Ventilation Loss | 1471.26 | 1471.26 | 1471.26 | 1471.26 |

| | | | | |
|---|---|---|---|---|
| Enclosure Costs ($) | N/A | $2,976,719 | $3,581,920 | $3,930,069 |

**Figure 2 – Building Heat Loss in Different Scenarios**

As shown in Figure 2, heat transmission through the building envelope accounts for approximately 30% of the existing building's heat loss. A significant portion of the building's heat loss—approximately 51%—is attributed to ventilation air heating. This demand is primarily driven by the design, control strategy, and efficiency of the mechanical ventilation systems, rather than the performance of the building enclosure. As such, enclosure upgrades alone will have limited impact on reducing this component of the heating load.

Figure 2 also illustrates the potential energy savings from infiltration improvements. Our calibrated energy model reveals that the air leakage rate of the existing facility is approximately 2.0 l/s/m² @ 75Pa. Based on RJC's experience, achieving an air leakage rate of 1.2 l/s/m² @ 75Pa for existing buildings is feasible using self-adhered membranes and effective building enclosure details.

# 4.0 Energy Performance: Combining Mechanical & Envelope Upgrades

In addition to envelope upgrades, it is understood that major mechanical upgrades are also being planned. To better understand the impact on energy savings of the combination of mechanical and envelope upgrades, RJC has modelled additional scenarios. A detailed heat recovery study was performed in 2023 by Polar Engineering, including mechanical ECM recommendations. That study recommends water-side heat recovery (from the ammonia ice plant and HVAC chiller) and an upgrade to a condensing boiler. Additional measures to reduce ventilation heat loss by means of a heat recovery ventilation system has also been investigated.

Regardless of which mechanical upgrades are selected, the building will benefit from enclosure upgrades to reduce annual and peak heating demand. When sizing new mechanical equipment, the planned enclosure upgrades should be considered, as it may allow the use of smaller equipment.

The **"Planned Mechanical"** scenario includes upgrade measures identified by the City of Prince George as being planned in the near future. These upgrades have important interactions and have therefore been combined. They include ECM 2, 4, 5b, and 7 from the 2023 Polar Engineering heat recovery study, and are as follows:

- Space heating boilers: Replace existing boilers with condensing boilers (Polar ECM 5b)
- Heat recovery chiller: Recover waste heat from the ammonia ice plant and HVAC chiller via a common condenser water loop; integrate condenser water loop with heating water loop with a water-to-water heat pump to boost temperature from 30°C to 80°C; Replace cooling towers and rooftop condenser with adiabatic fluid coolers (Polar ECM 2 & 4)
- Heat recovery for DHW: Integrate the DHW into the heat recovery network from ECM 2 & 4 (Polar ECM 7)

The **"Proposed"** scenario includes the "Planned Mechanical Upgrades" and the "Improved Performance Envelope" from Section 3.

The **"Proposed + HRV"** includes an additional optional measure to reduce ventilation heat loss by adding a heat recovery wheel (60% sensible effectiveness) to the three main air-handling units (either by retrofit or replacement).

Table 6, Figure 3, and Figure 4 illustrate the performance of each scenario.

**TABLE 6: ANNUAL PERFORMANCE SUMMARY OF ADDITIONAL SCENARIOS**

| Scenario | Electricity [MWh] | Natural Gas [MWh] | Carbon Emission [tonnes] | Energy Cost [$] | Energy Cost Savings [$] |
|---|---|---|---|---|---|
| **Baseline Model** | 2,468 | 3,146 | 609 | 296,243 | $- |
| **Planned Mechanical** | 2,436 | 1,688 | 339 | 252,193 | $44,050 |
| **Proposed[1]** | 2,159 | 1,444 | 291 | 221,997 | $74,246 |
| **Proposed[1] + HRV** | 2,153 | 753 | 163 | 201,886 | $94,357 |

1. Includes the "Improved Performance" envelope upgrade package.

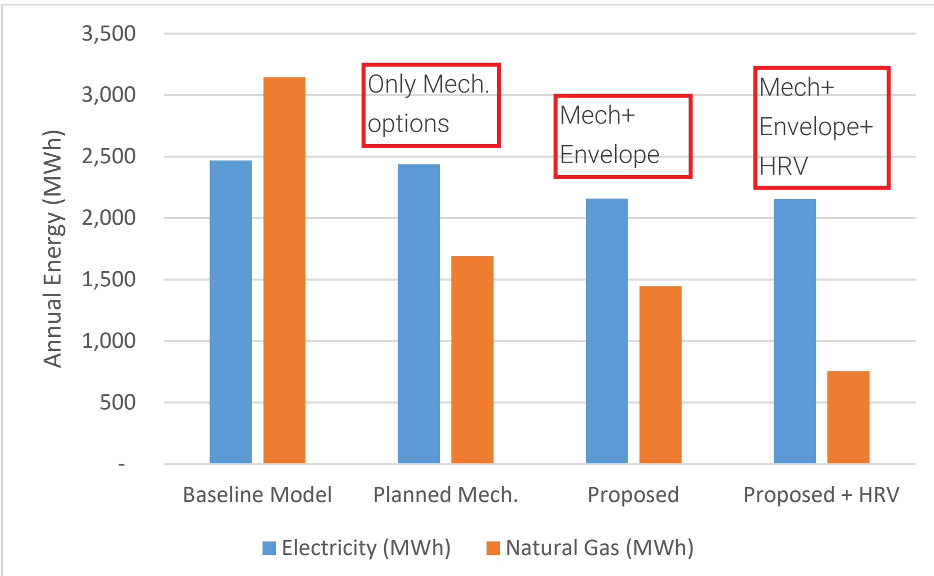



**Figure 3 – Building Energy Consumption by Fuel Type in Different Scenarios**

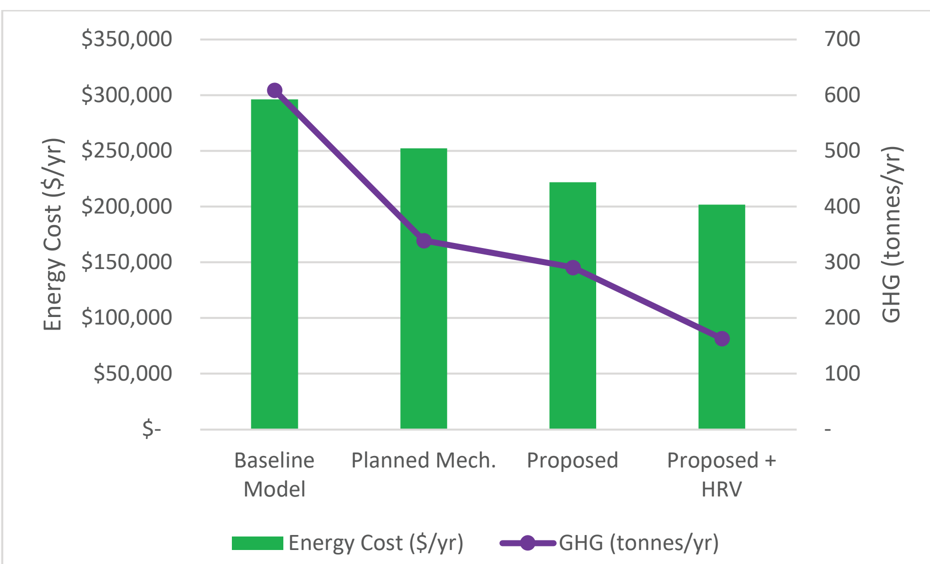



**Figure 3 – Building Energy Cost & Greenhouse Gas in Different Scenarios**

# 5.0 Financial Analysis of Envelope Upgrades

A complete enclosure asset renewal is planned for the CN Centre independent of energy requirements. As such, a capital cost estimate has been assigned to a "Like-for-like" upgrade based on RJC's opinion of probable cost (OPC), representing an enclosure asset renewal with equivalent performance to the existing building. The simple payback period of each envelope upgrade scenario has been calculated against the Like-for-like renewal. The Opinions of Probable Costs are presented by RJC to provide an expectation as to the magnitude of costs required to complete the explored envelope ECMs. The opinions provided are based on conceptual repair methods, recently obtained broad unit rates, and past experience with similar projects. A detailed estimate of costs has not been provided, as it would require the preparation of plans, details, specifications and schedules to achieve a quantified summary of estimated costs in 2025 dollars.

Detailed descriptions of upgraded assemblies can be found in Section 3.

TABLE 7: SUMMARY OF ENVELOPE SCENARIO CAPITAL COSTS[1] AND FINANCIAL PERFORMANCE

| Scenario | External Door | External Wall | External Window | Roof | Total Capital Cost | Capital Cost Premium | Energy Cost Savings ($/year) | Simple Payback (years) |
|---|---|---|---|---|---|---|---|---|
| Baseline (Like-for-like) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | $- | $- | -- |
| Improved Performance | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) |
| Enhanced Performance | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 a |
| High Performance | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b) | ss. 13 and 17(1)(b | ss. 13 a |

1. Capital costs represent Class D – Opinion of Probable Cost estimates

# 6.0 Conclusion and Remarks

Based on the findings of this energy study, along with the associated capital cost estimates, an enclosure asset renewal for the CN Centre aligned with the "Improved Performance" scenario provides the shortest payback period of all the envelope upgrade packages analyzed, while improving the building's energy efficiency and overall thermal performance. By combining the "Improved Performance" envelope upgrade with the planned mechanical upgrades, the proposed design results in annual savings of $74,000 in energy costs and 318 tonnes of carbon dioxide (Table 6).

The envelope upgrades modelled include an estimated 40% reduction in infiltration and the associated heat loss. To ensure that significant infiltration improvements are achieved, it is recommended that the building undergo airtightness testing before and after renovation. Airtightness testing, also known as a blower door test, is a method used to measure the air leakage through a building's envelope. It involves using a fan to pressurize or depressurize the building while measuring the rate at which air escapes or enters. This helps identify areas of unwanted air infiltration, such as gaps or cracks in walls, windows, and doors. Having an airtight building is a great way to reduce energy consumption without driving up the costs of added insulation or specialized equipment. The best way to make sure the project will be at the targeted levels of airtightness at the end of the project is to set the project up for success through the design stage and quantify it with formal testing during construction.

These improvements will not only contribute to operational cost savings but also support broader sustainability objectives and climate action goals by extending the life of the building envelope and reducing its environmental impact.

# 7.0 Limits of Liability

The intent of this report is to identify the energy saving associated with building enclosure renewal and provide recommendations and OPCs to assist with capital planning based on the analysis performed in this report.

OPCs provided by RJC may be based on incomplete or preliminary information and may also be based on factors over which RJC has no control. RJC does not guarantee the accuracy of these cost estimates and shall have no liability where cost estimates are exceeded or are less.

RJC prepared this report for the use of the Client. The material in it reflects RJC's judgement in light of information available at the time of preparation. Any use that a third party makes of this report (including relying on this report for any decisions) is the responsibility of such third parties. RJC accepts no responsibility for damages, if any suffered by any third party as a result of decisions made or actions based on this report.

This report has been prepared in accordance with generally accepted engineering practices. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our scope of work and included in this report, Services performed and outlined in this report were based on visual observations of accessible areas of the building and the previous reports and drawings provided. As such, RJC cannot accept responsibility should the conditions inferred to exist not be so.

# 8.0 Closing

Should you have any further questions or comments, or if we can be of further assistance, please contact this office.

Yours truly,

READ JONES CHRISTOFFERSEN LTD.
**EGBC Permit to Practice No. 1002503**

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**Appendix A – Baseline Energy Model Results**

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# Appendix A

## Baseline Energy Model Results

Figure 2 below illustrates the monthly energy consumed by end-use, and Figure 3 below is an annual summary by end-use and energy type, measured as Energy Use Intensity (EUI). Note that the refrigeration load represents the ammonia ice plant (operates August 1st – May 1st), and service hot water includes DHW, Zamboni, and snow melt.

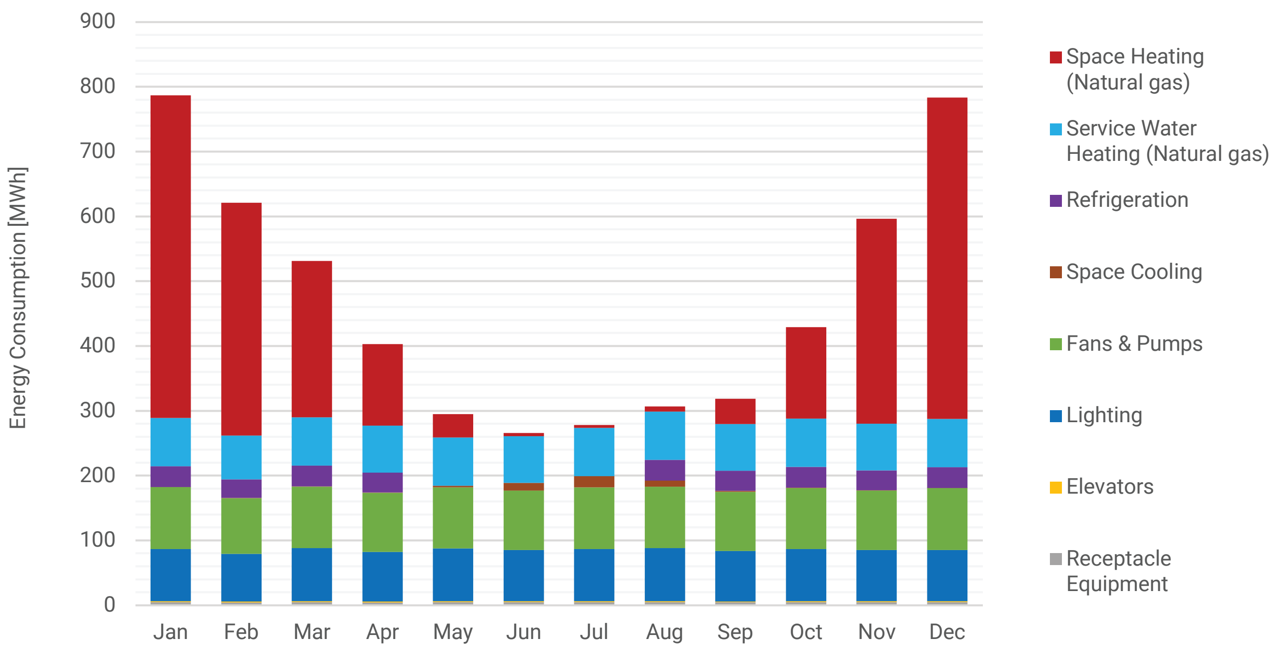


**Figure 2 – Monthly Consumption by end-use**

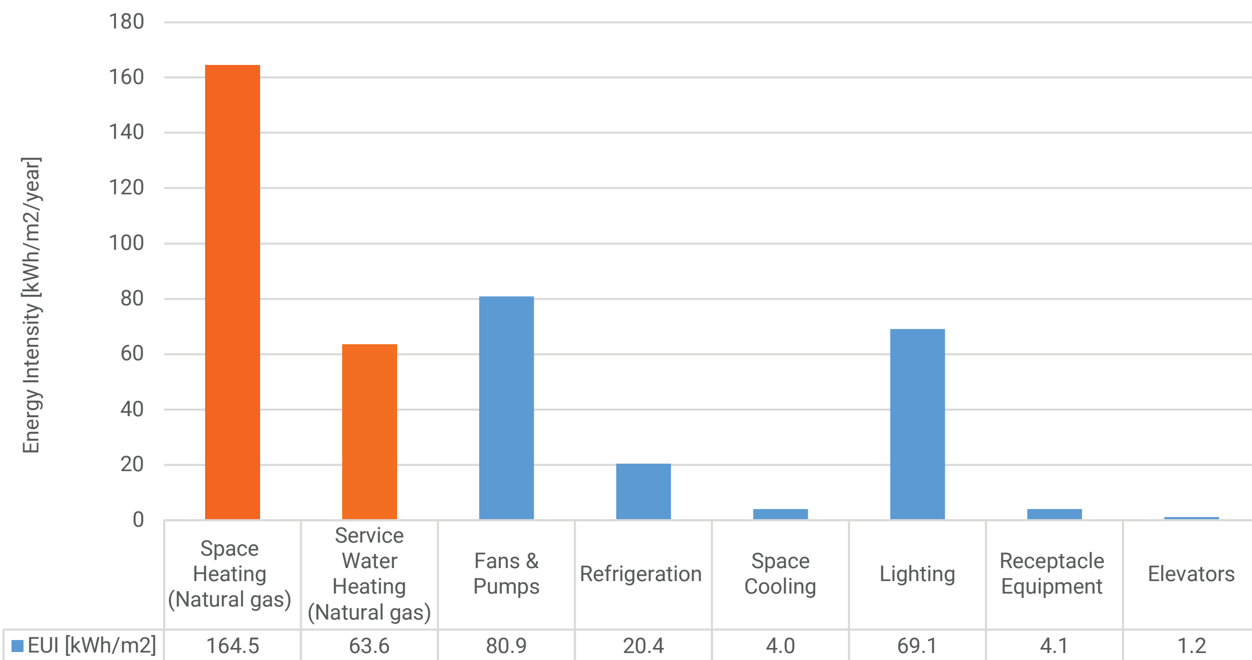


**Figure 3 – Annual EUI by end-use/fuel type**