DOING IT RIGHT THE FIRST TIME:

ENERGY AND EMISSIONS OUTCOMES OF HEAT PUMP INSTALLATION AT TRIOVEST

HEAT PUMP MODELLING EXERCISE

This modelling exercise examines outcomes resulting from the installation and optimization of heat pumps in two mid-sized office buildings owned by Triovest Realty Advisors Inc.[1] Heat pumps and energy recovery ventilation systems were installed and commissioned for both buildings at the time of construction; what follows is an evaluation of the actual performance of the buildings in 2023 compared to a hypothetical base case scenario with more traditional HVAC systems.

Recognized as the most energy-efficient properties in Triovest's portfolio, both buildings have achieved LEED Gold, BOMA BEST Gold and BOMA's The Outstanding Building of the Year (TOBY) International awards. Their high efficiency is due to advanced systems such as individual zone-based water-source heat pumps, energy recovery ventilation systems and real-time data analytics for building performance optimization.

[1] Triovest is a Canadian real estate firm. See https://www.triovest.com/

	BUILDING 1	BUILDING 2
Size	17,364 m^2 (186,909 ft^2)	26,548 m^2 (285,659 ft^2)
Location	Greater Toronto Area	Greater Toronto Area
Year operational	2015	2018
Floors	5	5
Energy use intensity (EUI)	90 kWh/m^2 (8.7 kWh/ft^2)	90 kWh/m^2 (8.7 kWh/ft^2)
Greenhouse gas intensity (GHGI)	0.7 $kgCO_2/m^2$	0.5 $kgCO_2/m^2$
ENERGY STAR® score[2]	100	99

[2] https://www.energystar.gov/buildings/benchmark/understand-metrics/how-score-calculated

BASE CASE AND PROJECT IDEATION

For this modelling exercise, a base case scenario was developed using RETScreen to evaluate the hypothetical performance of comparable office buildings without heat pumps. This scenario modelled a chiller with a coefficient of performance (COP) of 3.2 and a boiler with an efficiency of 75 percent for both buildings. The energy model was calibrated using actual energy consumption from 2023 for each building.

The following tables provide a breakdown of the two buildings' actual consumption compared to the hypothetical base case consumption for 2023.

2023 CONSUMPTION SUMMARY

BUILDING 1

Scenarios	Electricity (ekWh)	Natural gas (ekWh)	Total (ekWh)
Actual	1,105,440	438,080	1,544,520
Base case	1,939,200	946,465	2,885,665

BUILDING 2

Scenarios	Electricity (ekWh)	Natural gas (ekWh)	Total (ekWh)
Actual	2,036,250	448,430	2,484,680
Base case	2,963,880	1,446,580	4,410,460

Modelling results showed that these buildings would consume 55 percent more energy and emit 60 percent more greenhouse gases compared to the buildings with heat pump systems installed.

2023 CONSUMPTION METRICS

BUILDING 1

Scenarios	EUI (kWh/m^2)	Tonnes of CO_2e	GHGI (tCO_2/m^2)
Actual	90	600	0.035
Base case	170	1,090	0.060

BUILDING 2

Scenarios	EUI (kWh/m^2)	Tonnes of CO_2e	GHGI (tCO_2/m^2)
Actual	95	1,045	0.039
Base case	170	1,660	0.060

ONGOING OPTIMIZATION

Recognizing the potential for further optimization, Triovest Sustainability Solutions (TSS) and on-site property operations teams focused on improving the operation of existing heat pump systems and leveraging advanced analytics for system optimization.

STEP 1: MAKING THE BUSINESS CASE

The original decision to invest in heat pump systems with heat recovery was driven by a compelling business case:

Higher energy savings

- Significant reductions in utility costs due to lower energy consumption.

Reduced emissions

- Alignment with corporate sustainability goals and regulatory requirements.

Enhanced comfort

- Improved occupant satisfaction through better zone-level temperature control.

STEP 2: SELECTING DESIGN, CONTRACTORS AND VENDORS

Design selection

- A detailed assessment was conducted of the existing HVAC configuration, energy recovery ventilation, glycol pumps with variable frequency drives, free cooling and efficient boilers.
  - Building 1 has ClimateMaster horizontal heat pumps of various sizes; Building 2 has Daikin Smart Source horizontal heat pumps of various sizes.
  - The efficiencies of these units, with a heating COP range of 4.8 to 5.8 and cooling EER of 15.1 to 17.8, are significantly greater than the base case scenarios' performance metrics for the hypothetical boiler and chiller.

Contractor/vendor selection

- Investing in skilled labour and high-quality components ensures long-term efficiency gains. Contractors were selected through a rigorous process, requiring them to have proven expertise in heat pump systems and building automation.

STEP 3: INSTALLING HVAC EQUIPMENT

Heat pumps

- A total of 394 heat pumps were installed in ceiling-suspended systems across both buildings. Collaboration with experienced vendors ensured seamless integration with building automation controls.

Energy recovery ventilation

- Installed to improve heat recovery from return air, reducing the need to mechanically preheat fresh air entering the buildings.

Building automation system (BAS)

- Installing a BAS with the ability to monitor and control equipment remotely provides many benefits such as improved energy efficiency, better operations, faster resolution of system issues, and improved equipment useful life.

STEP 4: OPTIMIZING HVAC EQUIPMENT

After the buildings were commissioned, an additional data analytics platform (HIVE) was integrated with the BAS to improve efficiency. HIVE's continuous monitoring system enables real-time fault detection and ongoing energy management improvements. The existing heat pump systems have been optimized over the years as follows:

- HVAC schedules have been trimmed and zone temperature setpoints adjusted based on the occupancy and vacant spaces.
- Minimum ventilation rates have been maintained for areas that are not occupied to adhere to ASHRAE standards.
- Heat pump setpoints have been adjusted routinely to prevent neighbouring zones' heat pumps from interfering with one another.
- Overnight setbacks have been put into place to avoid unnecessary cooling and heating.

Challenges with installation and optimization included:

- Coordinating between contractors.
- Calibrating systems in real time.
- Managing occasional compatibility issues with BAS components.

The TSS and on-site property operations teams continue to use the data analytics platform to fine-tune setpoints and schedules for optimal energy performance.

STEP 5: MEASURING RESULTS

The installation and subsequent optimization of heat pumps demonstrated substantial benefits.

Energy reduction

- Both buildings operate with a combined energy use intensity (EUI) of 90 kWh/m^2, a 55 percent improvement over the assumed base case buildings with boiler and chiller HVAC systems. As expected, most of the energy reduction was observed in natural gas consumption, as the building uses electric heat pumps for its main source of heating (compared to the boiler from the base case scenario). On average, a 61 percent reduction was observed for natural gas consumption and a 37 percent reduction for electrical consumption. The ongoing optimization activities initiated in 2018 are resulting in an average annual energy reduction of 4 to 5 percent.

GHG reduction

- The buildings achieved a 60 percent reduction in GHG emissions compared to baseline scenarios. Annual emissions are an average of 825 tonnes of equivalent carbon dioxide (CO_2e) for both buildings compared to the base case scenario of 1,375 tonnes of CO_2e.
- Use of the optimized heat pump systems, compared to the traditional chiller and boiler-based systems, saved 555 tonnes of CO_2e from entering the atmosphere.

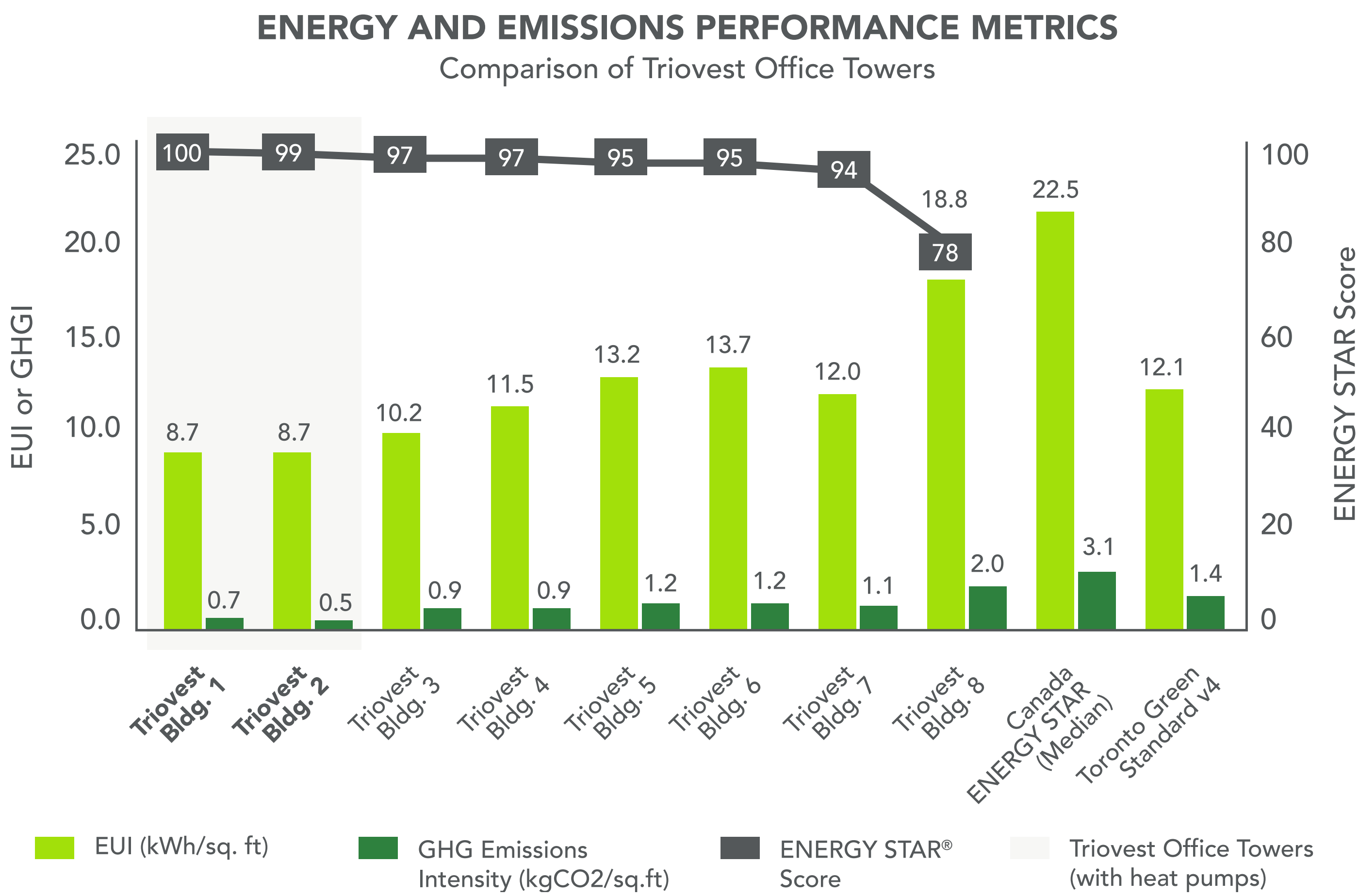
Cost savings

- Utility bills were significantly reduced, enhancing operational profitability and reducing carbon costs. The reduced carbon emissions also avoided $35,845 in carbon costs for fuels that would have been purchased for a less efficient boiler-chiller combination. Carbon pricing on fuels began in 2019 and these savings accumulated between 2019 and 2024.

Intangible benefits

- Enhanced zone-level control leads to consistent temperatures and better indoor air quality, improving comfort year round. Occupants and maintenance staff also benefit from increased operational reliability and reduced downtime due to the system's predictive maintenance capabilities. Finally, Triovest benefits from positive recognition from stakeholders for their commitment to sustainability leadership.

STEP 5: MEASURING RESULTS



This graph compares the Energy Use Intensity (EUI) and Greenhouse Gas Intensity (GHGI) of the two Triovest office buildings with heat pumps to six other buildings in Triovest's portfolio. The graph also includes the ENERGY STAR median values for all benchmarked office buildings in Canada, and the Toronto Green Standard target for newly constructed commercial buildings.

CONCLUSION

The success of the Triovest buildings 1 and 2 illustrates the transformative impact of "doing it right the first time" through intelligent design, optimized operations and advanced analytics. The project not only delivered significant energy and emissions reductions but also set a benchmark for sustainable building practices. With a combined EUI of 90 kWh/m^2 and GHG reductions of 60 percent, these buildings highlight the potential of heat pumps and integrated systems in achieving a low-carbon future.

Special thanks to Zaheer Khalfan and the TSS team for their important contributions to this significant achievement.

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