DEEP EMISSIONS RETROFIT OF A 1968 OFFICE TOWER

A JOURNEY THAT STARTS WITH A SOLID CAPITAL PLAN

CASE STUDY

NOVEMBER 2021

zebx

GOLDEN PROPERTIES

Can GHG emissions from older high-rise office buildings be significantly reduced without a deep energy retrofit?

This depends largely on the energy supply. In provinces like BC, Manitoba and Quebec, buildings can draw energy from both natural gas and a low-carbon electrical grid. This provides building owners with two choices, each with distinctly different GHG profiles. In 2010, Golden Properties, the owner and property manager of the building located at 1177 West Hastings Street in downtown Vancouver, decided to significantly reduce the building's GHG emissions by incorporating both energy conservation measures and an electrification strategy into its capital planning. The results so far are impressive.

FROM

16

ENERGY STAR RATING

36.28

GHGI ($kgCO_2e/m^2$)

IN 2011

A 70% REDUCTION!

TO

81*

ENERGY STAR CERTIFIED*

10.76

GHGI ($kgCO_2e/m^2$)

12 MONTHS ENDING JUNE 2021

** An especially impressive result for a building with greatly reduced occupancy due to the pandemic (the Energy Star rating is negatively affected by low occupant density).*

GENESIS OF A GOAL

General Building Details:

Building Address	1177 West Hastings Street, Vancouver, BC
Climate Zone	4
Year of Construction	1968
Occupancy	Lobby, bank and small restaurant at ground level and offices above
Building Height	26 storeys above-grade (including a three-storey podium) and four parkade levels below-grade
Number of Elevators	Four servicing the tower, four servicing the podium, one park-ade shuttle
Gross Floor Area	30,138 m^2 (324,403 ft^2)
Gross Leasable Area	28,487 m^2 (306,634 ft^2)
ESPM® Total Area	30,110 m^2 (324,103 ft^2)

** Value derived from Energy Star® Portfolio Manager® (ESPM)*

THE STARTING LINE (2011)

Building Performance:

PEAK POWER DEMAND	1,710 kW (August)
ENERGY USE INTENSITY	430.55 kWh/m^2
GHG INTENSITY	36.28 $kgCO_2e/m^2$ *

** Calculated using emissions factor from ESPM Greenhouse Gas Inventory and Tracking (10.2 g/kWh for electricity and 181.53 g/kWh for natural gas)*

Original Design Details:

GLAZING	Single-paned, curtain wall above the ground floor
TOWER AND PODIUM* ROOFING	Conventional, two-ply, modified-SBS roofing assembly with 50mm (2") of polyisocyanurate rigid insulation
HEATING SYSTEM	Two 1968 Cleaver-Brooks gas-fired boilers with a combined capacity of 4,103 kW (14 MBtu)
COOLING SYSTEM	Two 1968 Trane centrifugal chillers with a combined capacity of 2,813 kW (800 tons)
VENTILATION SYSTEM	Four air handling units with air-side economizers ducted to provide constant air volume distribution
DOMESTIC HOT WATER	Combined with the space heating plant

** Podium roof is a green roof (with native plants)*

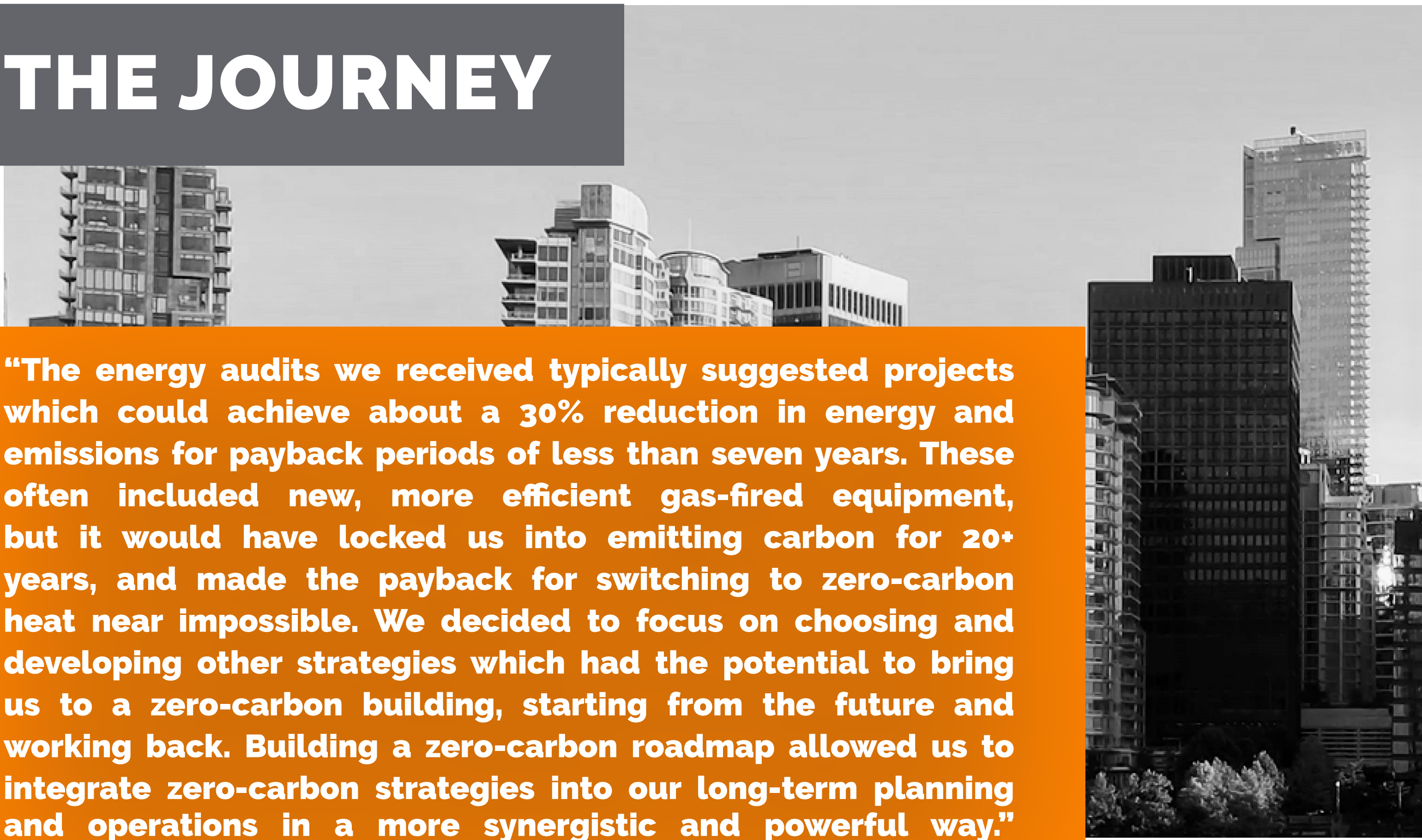
Golden Properties, established in 1975, is the owner and manager of a small office portfolio totalling approximately 46,452 m^2 (500,000 ft^2) of gross leasable area. This private, family-owned company has a passion for sustainability and green initiatives.

In 2010, it was 42 years old. The owner was fully aware of the fact that many of the systems in the building were nearing the end of their service life. The likelihood of costly maintenance and unplanned replacement was becoming higher with every passing year. Instead of simply establishing a capital plan based on like-for-like replacement, Golden Properties decided to set a higher goal for themselves.

In 2011, they engaged a local engineering firm to provide an energy audit of the building. Once completed, it was decided to integrate some of the energy conservation measures (ECM) that were included in the energy audit into the property's capital plan. This decision was not only motivated by relatively low (less than ten years) simple payback periods for some of the projects (as estimated by the owner), but also the owner's ambition to reduce the building's carbon footprint and its associated impact on climate change. The timing for some of the projects was based on some BC Hydro incentives as well as financing opportunities.

To make matters more challenging, the capital plan was based on undertaking projects while the building was fully occupied. This implied that the timing for certain projects had to be meticulously planned to avoid any inconvenience to tenants. This included strategies such as working after-hours or on weekends, taking advantage of tenant turnover and having interim systems in operation to ensure continuity of services.

THE JOURNEY



"The energy audits we received typically suggested projects which could achieve about a 30% reduction in energy and emissions for payback periods of less than seven years. These often included new, more efficient gas-fired equipment, but it would have locked us into emitting carbon for 20+ years, and made the payback for switching to zero-carbon heat near impossible. We decided to focus on choosing and developing other strategies which had the potential to bring us to a zero-carbon building, starting from the future and working back. Building a zero-carbon roadmap allowed us to integrate zero-carbon strategies into our long-term planning and operations in a more synergistic and powerful way."

- ALEX LAU, VICE PRESIDENT, GOLDEN PROPERTIES LTD.

2010

JUN — GOAL ESTABLISHED

The building owner established a goal to eliminate GHG emissions from the building.

2011

FEB — ENERGY AUDIT

A mechanical engineering consulting firm provided an energy audit. The audit recommended a number of energy conservation measures including:

- Building automation system (BAS) upgrades
- Replacement of the single-pane curtain wall with a double-pane curtain wall
- Heating and cooling plant upgrades
- HVAC system upgrade
- Lighting system upgrade

MAR — WASHROOM LIGHT SWITCHES REPLACED

An electrical contractor replaced the light switches in the washrooms with motion-sensing switches. The decision to proceed with this project was based on a low payback period.

2012

JAN

ELEVATOR MODERNIZATION BEGINS

Although not included in the 2011 energy audit, the Operations Team decided to take advantage of BC Hydro's special incentive program for elevator controls and regenerative drives. This project was the first project in BC to be accepted into the program. The regenerative drive generates energy during the elevator's descent and deliver it to the building's electrical loads. The elevator modernization included renewal of the cab interiors and replacement of all the original elevator equipment for all nine elevators. The incremental cost increase for regenerative drives and the annual cost savings resulting from the associated reduction in energy consumption translated into a simple payback period of approximately seven years.

Regenerative drives

The elevator modernization project achieved an energy savings of approximately 65%

JAN

WASHROOM RELAMPING BEGINS

The incandescent bulbs in the pot lights were replaced with LED bulbs.

2013

MAR

ROLLER BLIND INSTALLATION BEGINS

Although not included in the 2011 energy audit, the Operations Team investigated the use of window film as a strategy to reduce the solar heat gain through the glazing. Because the simple payback period was too high for the window film, the Operations Team chose to install manual roller blinds instead. The work is still ongoing because the installation of the roller blinds is undertaken during tenant turnover.

AUG

ELECTRICAL SUBMETERS INSTALLED

Although not recommended in the 2011 energy audit, the Operations Team began the installation of eight electrical submeters to monitor energy consumption in greater detail. These submeters allowed the owner to measure energy consumed by systems and components such as the chillers, cooling tower, fans, lighting, plug loads, as well energy consumed by specific tenants.

NOV

ENERGY AUDIT

Another mechanical engineering consulting firm was engaged to provide a new energy audit. This second audit recommended a number of energy conservation measures including:

- BAS upgrades
- Heating and cooling plant upgrades
- Lighting system upgrade
- Installation of variable speed drives for the fan and pump motors
- HVAC system upgrade

2014

APR

ELECTRIC VEHICLE CHARGING STATIONS INSTALLED

Two Level 2 EV charging stations were installed.

MAY

BAS UPGRADE BEGINS

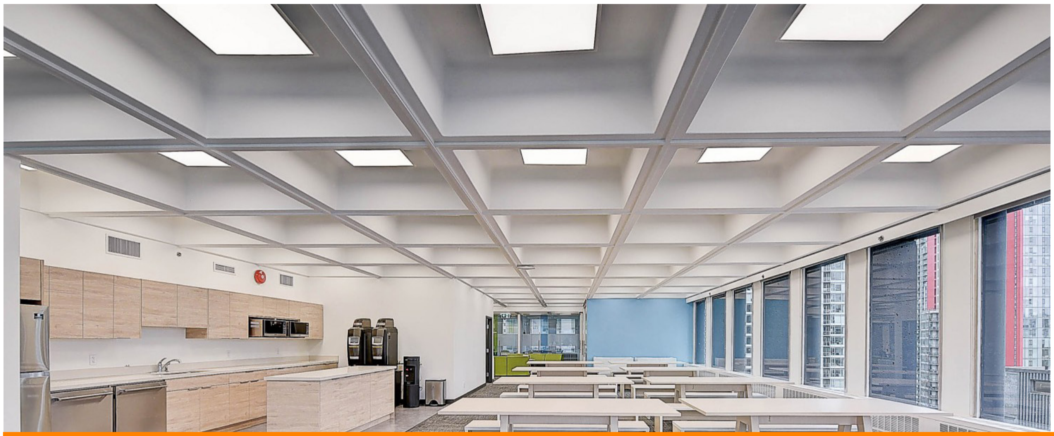
An upgrade to the pneumatic BAS began. The upgrade included installing new digital unit controllers and connecting them, along with the existing pneumatic field devices, to a new digital field panel to provide standalone control of the HVAC equipment. The new BAS also collects data from meters installed throughout the building to monitor and control building operations.

2015

JUN

OFFICE LIGHTING SYSTEM UPGRADE BEGINS

After considerable research and evaluation, replacement of the lighting systems began. The decision to proceed was not strictly based on payback period. Instead, it was part of an over-arching lighting upgrade plan to improve tenant satisfaction and operational flexibility. The upgrade included replacement of the T8 light fixtures with custom, high-CRI LED fixtures and installation of numerous sensors to monitor occupancy, daylight, humidity and temperature. The fixtures and sensors are connected to new, wireless, smart lighting controls which allows the Operations Team to control individual fixtures and assign them to any switch using a mobile app.



The energy consumed by the lighting systems dropped by approximately 70% and resulted in a payback period of less than seven years (for the incremental cost increase of a customized lighting system).

JUN

CHILLER PLANT REPLACEMENT BEGINS

The Operations Team determined that the two chillers, which dated from original construction, should be replaced to avoid end-of-service-life reliability issues. The business-as-usual approach would have been to replace the chillers with more modern, high-efficiency versions of the same chillers. Instead, because the team had a decarbonization roadmap that identified that a heat-recovery chiller (HRC) could provide heat to the building, the team selected a heat recovery chiller for one of the replacement chillers. This was the first step in a plan to redesign the heating system so that it could run on 60°C (140°F) hot water rather than just the 82°C (180°F) hot water from the gas-fired boilers. The decision was made to move forward with a new setup that would incorporate a 1,583 kW (450 ton), variable-flow, centrifugal chiller, sized to handle the majority of the cooling load and a second 528 kW (150 ton), helical rotary heat recovery chiller. After Trane and the Operations Team evaluated past operational data for the chillers, it was determined that the combined capacity of the new chillers could be reduced by 703 kW (200 tons) - a 25% reduction in capacity. - and still provide more than enough cooling for the hottest days of the summer. To maintain cooling during the project, one chiller was replaced at a time, beginning with installation of the larger chiller*.

** More details on the design and installation of the chiller plants is available in the case study by Trane®*

In the first year of operation, energy consumption by the new, smaller cooling plant was approximately 900,000 kWh less than the year before - a 73% reduction!

Installation of the chiller plant

Centrifugal chiller

AUG

ENERGY AUDIT

Another mechanical engineering consulting firm was engaged to provide an energy audit. This third audit recommended a number of energy conservation measures including:

- Replacement of the single-paned curtain wall with a triple-paned curtain wall
- Conversion of the dual-duct HVAC system from constant volume to variable volume
- Upgrades to LED lighting and new lighting controls
- Replacement of the heating plant with heat pumps (and electric boiler back-up)
- Generation of domestic hot water using heat recovered from other mechanical systems
- Installation of a roof-mounted photo voltaic array

OCT

COOLING TOWER REPLACEMENT BEGINS

As part of the replacement of the cooling plant, the forced draft cooling tower on the roof was replaced with a new, high-efficiency, single-cell, induced draft cooling tower capable of providing up to 1,695 kW (482 tons) of cooling. The cooling tower includes a variable-speed-drive for the fan. To avoid inconveniencing the tenants, the project took place when cooling was not required.

In the first year of operation, the new cooling tower used 53% less energy and 47% less water

2016

OCT

PARKADE LIGHTING REPLACEMENT BEGINS

To reduce the energy consumed by the parkade lighting, the T8 linear fluorescent fixtures were replaced with LED fixtures. The number of fixtures were reduced from 193 to 84, while maintaining a similar lighting power density. The simple payback period for this project was estimated to be less than two years.

OCT

DOMESTIC WATER BOOSTER PUMPS REPLACED

Based on the age, efficiency and capacity of the existing, constant-speed booster pumps, the Operations Team decided to replace the two pumps with two new, energy-efficient, variable-speed pumps and a new control panel. Since 2012, the plumbing fixtures were gradually being replaced with low-flow fixtures with automatic valves. This allowed for a reduction in the booster pump capacity as well. The payback period was estimated to be less than six years.

2019

NOV

ELECTRIFICATION OF DHW PLANT BEGINS

To decarbonize the domestic hot water (DHW) plant, the DHW piping had to be decoupled from the two, original, gas-fired Cleaver Brooks boilers which generated hot water for both the DHW and space heating systems. Once decoupled, the piping was connected to three 450 L (119 US gallon) electric water heaters which were installed in the sixth floor mechanical room where the boilers are also located. The electrification project was part of a full domestic water repiping project.

2020

JAN

REPLACEMENT OF THE AHU FANS BEGINS

Based on their estimated remaining service life, the four large supply and return fans in the air handling units (AHU) were replaced with four fan arrays (also known as fan walls) comprising between four and nine smaller, variable speed fans. Included in this project was the replacement of the hot water heating coils, dampers and controls. A reduction of approximately 30% in energy consumption was achieved by more efficient fan motors and because the fan array can reduce airflow to match a low heating, cooling or ventilation demand. The fan arrays were also chosen because they provide a high degree of redundancy.

Fan array

This project is expected to result in a savings of approximately $90,000/year

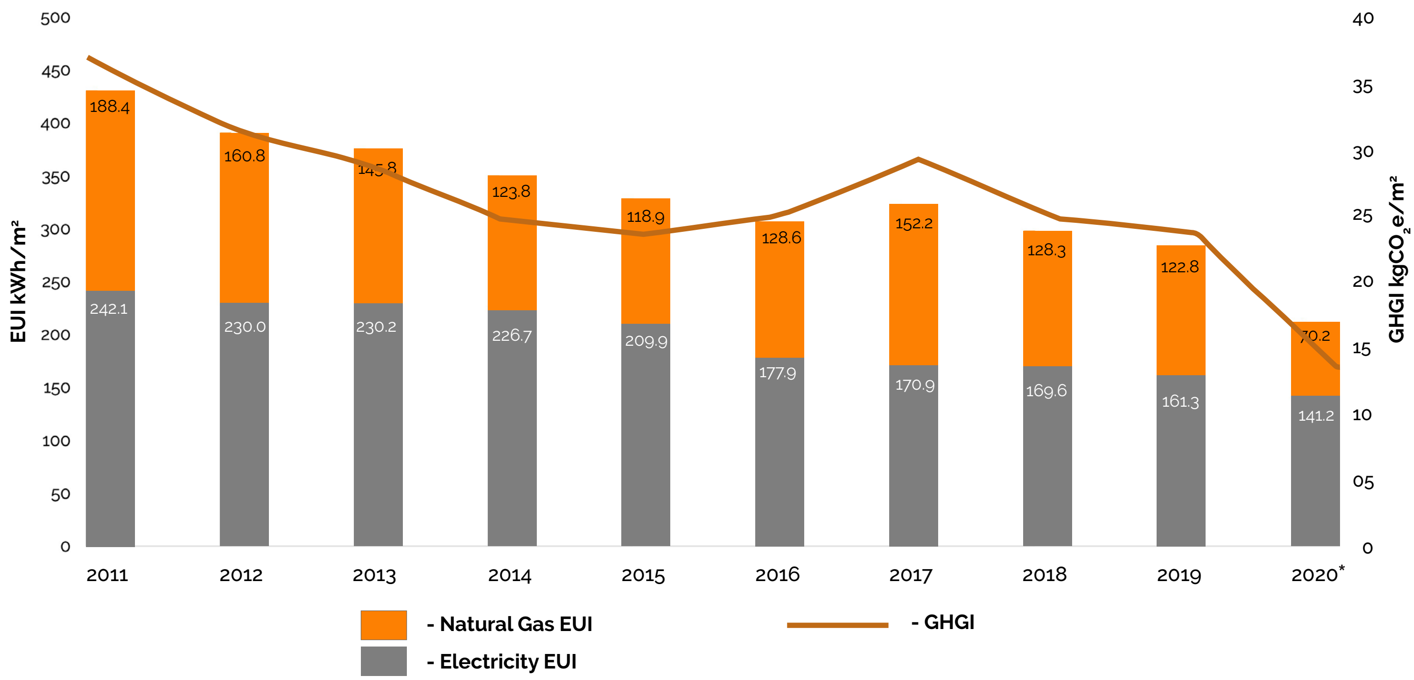
APR

HEAT RECOVERY CHILLER BEGINS HEATING

With the installation of new, low-temperature heating coils in the AHUs and modifications to the routing of the hydronic piping, the HRC could supply 60°C (140°F) water to the heating coils of the AHUs, the perimeter induction units and even the gas-fired boilers. This allowed the building to be exclusively heated with the HRC during the shoulder seasons and heated by both the HRC and gas-fired boilers during the colder months of the year.

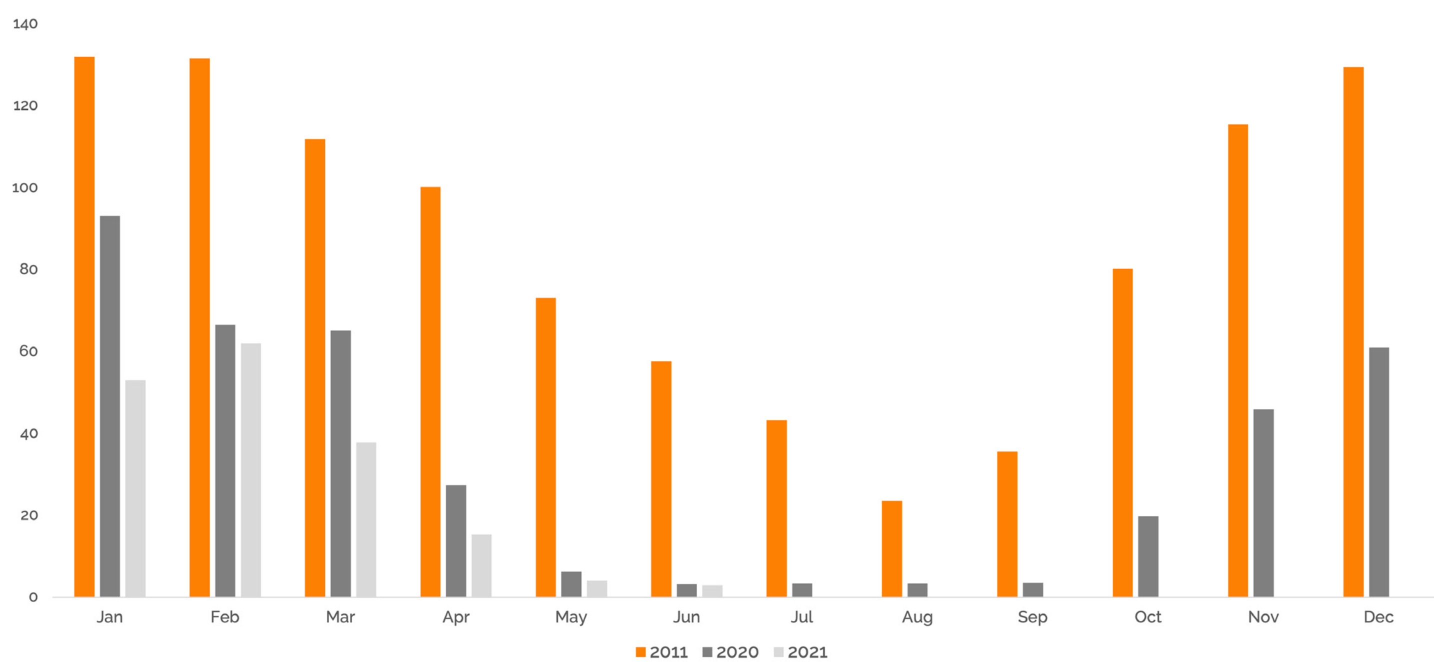
THE RESULTS

Energy Use Intensity and Greenhouse Gas Intensity

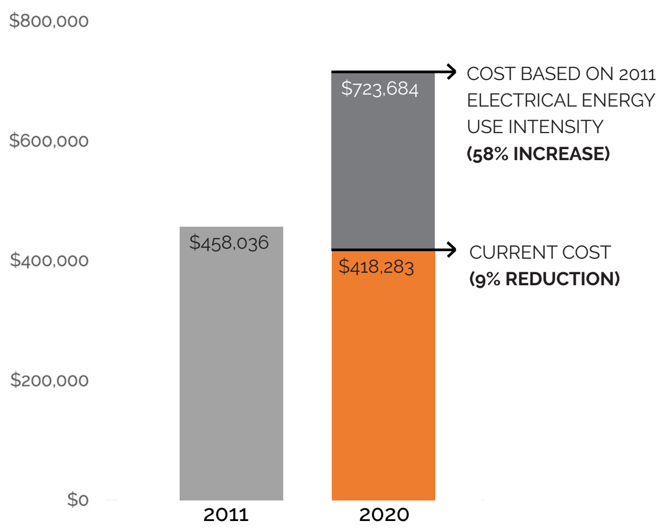


* *The difference between 2019 and 2020 is due not only to the heat recovery chiller, but also the lower occupancy (pandemic) and some operational adjustments to the mechanical systems. As tenants return to the building, there will be more heat to recover by the heat-recovery chillers and the gas consumed by the boilers is expected to decrease.*

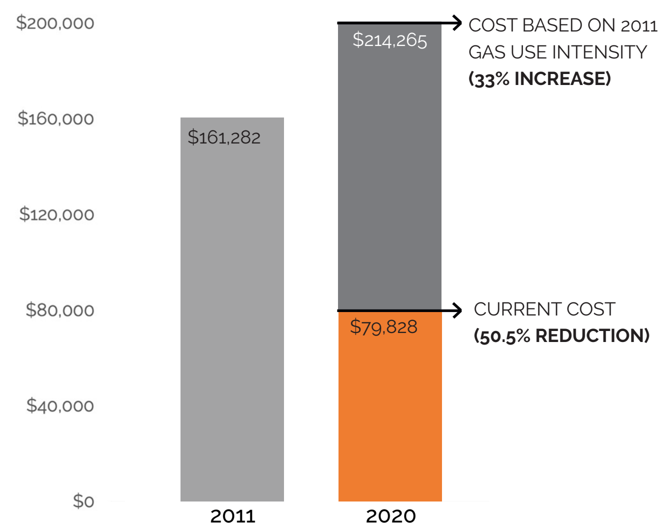
Comparison of the monthly GHGI between 2011, 2020 and 2021



Energy Cost for Electricity



Energy Cost for Natural Gas



12 MONTHS ENDING JUNE 2021

Building Performance:

PEAK POWER DEMAND	1,170 kW (reduced by 31.5%)
ENERGY USE INTENSITY	189.95 kWh/m² (reduced by 56%)
GHG INTENSITY	10.76 $kgCO_2e/m^2$ (reduced by 70%)

ROAD AHEAD

Golden's ten-year journey resulted in some very impressive results and 2021 shows the promise of even lower operational emissions. Given the extent of the GHG reductions achieved, the Operations Team has applied for Canada Green Building Council's (CaGBC) Zero Carbon Building (Performance) certification. The CaGBC certification allows for carbon offsets, but Golden is committed to continuing their pursuit of GHG reductions to minimize the reliance on carbon offsets.

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