HVAC RETROFIT MODELLING EXERCISE

EXPLORING SAVINGS FOR PUBLIC SECTOR FACILITIES

The following modelling exercise describes a heating, ventilation and air conditioning (HVAC) retrofit for a public sector facility in the Greater Toronto Area. The municipality wanted to explore potential savings for retrofitting the existing HVAC equipment, which was at the end of its useful life.

LIBRARY + THEATRE BUILDING

Size	42,176 square feet
Location	Greater Toronto Area
Floors	Three (including one basement)
Zone, year built	Zone 1 – Library, 1970 Zone 2 – Theatre foyer, 1995 Zone 3 – Theatre, 1995

EXISTING MECHANICAL SYSTEMS

System	Description (Zones 1 and 2)	Description (Zone 3)
Heating	Hydronic natural gas-fired boiler system and air handling units (AHUs).	AHU with natural gas-fired burner.
Heating efficiency	Seasonal efficiency of 70%.	Seasonal efficiency of 75%.
Cooling	Air-cooled chiller.	Direct expansion (DX) system in the AHU.
Cooling efficiency	Seasonal coefficient of performance (COP) of 2.5.	Seasonal COP of 2.5.
Ventilation	Respective AHUs provide fresh air for all zones equal to 15% average.	
Controls	Existing building automation system controls HVAC systems.	
Domestic hot water	Electric water heaters.	

PROPOSED RETROFIT

System	Description (Zones 1 and 2)	Description (Zone 3)
Heating	Air source (air to water) heat pump system.	Air source (air to air) heat pump system.
Heating efficiency	Heating Seasonal Performance Factor (HSPF) of 8.5. Heat recovery efficiency of 75%.	HSFP of 8.5. Heat recovery efficiency of 75%.
Cooling	High-efficiency magnetic bearing chiller.	Air source heat pump.
Cooling efficiency	Seasonal COP of 4.	Seasonal COP of 4.
Ventilation	New heat recovery ventilators (HRVs).	
Distribution	Hydronic pumps to be replaced with premium efficiency models. Supply and return fans to be replaced with premium efficiency models and equipped with variable frequency drives (VFDs).	
Controls	N/A (no retrofit proposed).	
Domestic hot water	N/A (no retrofit proposed).	

MODELLED RESULTS

The results presented below are taken from a preliminary analysis of the proposed HVAC system retrofit using Natural Resource Canada's RETScreen Expert software. The model accounts only for energy associated with existing and proposed HVAC systems. The model is based on assumptions about the building enclosure following a review of available documentation and a facility walkthrough. Other electricity loads, such as lighting and plug loads, are not included in the analysis. The model also assumes that the heat pump system would provide 100 percent of the annual heating demand.

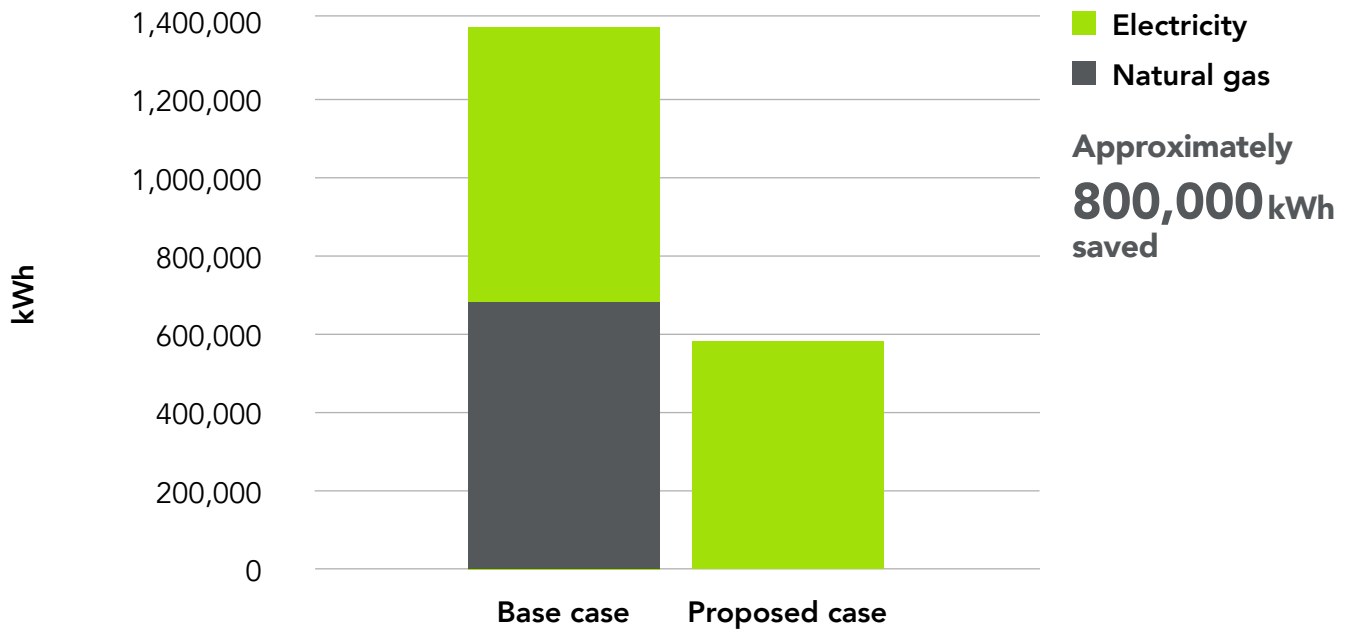## MODELLED FUEL CONSUMPTION AND COST OUTPUT SUMMARY

Fuel type		Base case		Proposed case		Projected annual savings	
Fuel type	Rate[1]	Consumption	Cost	Consumption	Cost	Saved	Cost savings
Natural gas	$0.40	64,397 m^3	$25,759	0 m^3	$0	64,397 m^3	$25,759
Electricity	$0.15	704,115 kWh	$105,617	590,287 kWh	$88,543	113,828 kWh	$17,074
Total			$131,376		$88,543		$42,833

The next page presents the fuel consumption and cost summaries in a bar chart format.
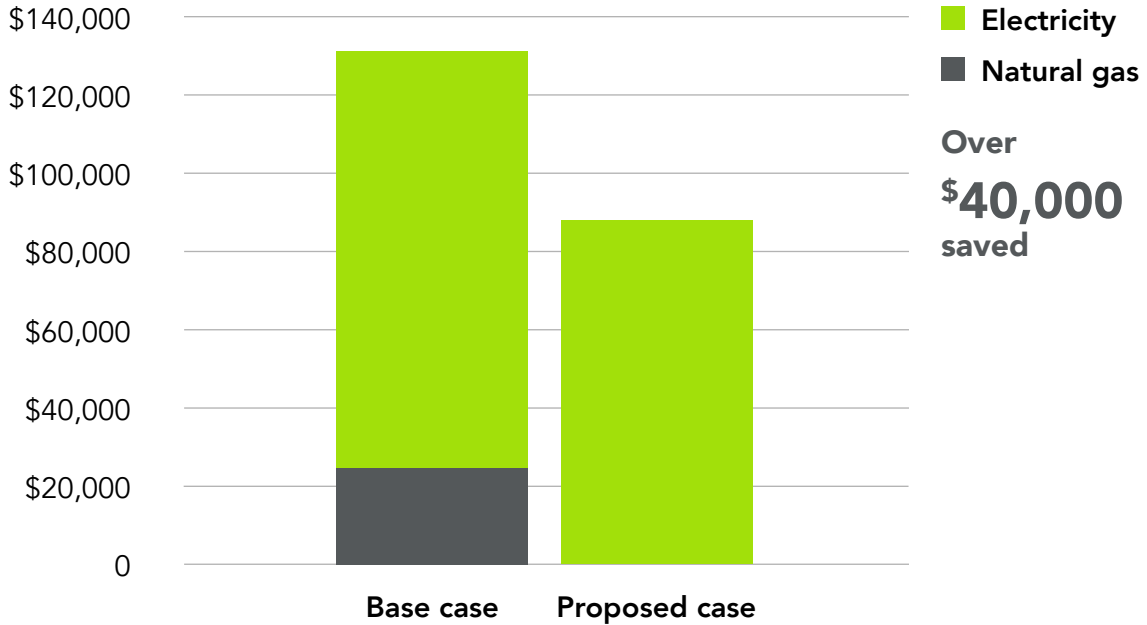
[1] The fuel rate (price per unit fuel) is an overall blended rate which includes all associated fees and excludes HST.

MODELLED FUEL CONSUMPTION AND COST OUTPUT SUMMARY

FUEL CONSUMPTION SUMMARY²

- Electricity
- Natural gas

Approximately
800,000 kWh
saved

kWh axis: 0 · 200,000 · 400,000 · 600,000 · 800,000 · 1,000,000 · 1,200,000 · 1,400,000

Base case · Proposed case

COST SUMMARY

- Electricity
- Natural gas

Over
$40,000
saved

Cost axis: 0 · $20,000 · $40,000 · $60,000 · $80,000 · $100,000 · $120,000 · $140,000

Base case · Proposed case

² A conversion factor of 10.628 kWh per m³ of natural gas is used.

MODELLED ENERGY SAVINGS SUMMARY

	Heating	Cooling	Electricity	Total
Base case	709,965 kWh	111,310 kWh	567,238 kWh	1,388,512 kWh
Proposed case	108,472 kWh	60,949 kWh	420,866 kWh	590,287 kWh
Fuel saved	601,492 kWh	50,361 kWh	146,372 kWh	798,225 kWh
Percentage fuel saved	84.7%	45.2%	25.8%	57.5%

MODELLED BENCHMARKING SUMMARY

	Heating	Cooling	Electricity	Total
	kWh/ft²	kWh/ft²	kWh/ft²	kWh/ft²
NRCan benchmark[3]	–	–	–	23.5
Base case	16.8	2.6	13.4	32.9
Proposed case	2.6	1.4	10.0	14.0
Fuel saved	14.3	1.2	3.5	18.9

[3] Survey of Commercial and Institutional Energy Use (SCIEU) – Buildings 2019 – Library or archives (Year of Construction 1970 to 1979) from Natural Resources Canada – Office of Energy Efficiency.

MODELLED GREENHOUSE GAS (GHG) EMISSION REDUCTION ANALYSIS

EMISSION ANALYSIS

Base case electricity system

Country – region	Fuel type	GHG emission factor[4] (excl. T&D) tCO$_2$/MWh	T&D losses %	GHG emission factor tCO$_2$/MWh
Canada – Ontario	Electricity	0.030	7.0	0.032

Annual GHG emissions	Tonnes of carbon dioxide equivalent (tCO$_2$)	
Base case	146	
Proposed case	19	
Gross annual GHG emission reduction	**Tonnes of carbon dioxide equivalent (tCO$_2$)**	**Percentage in savings**
	127	86.9
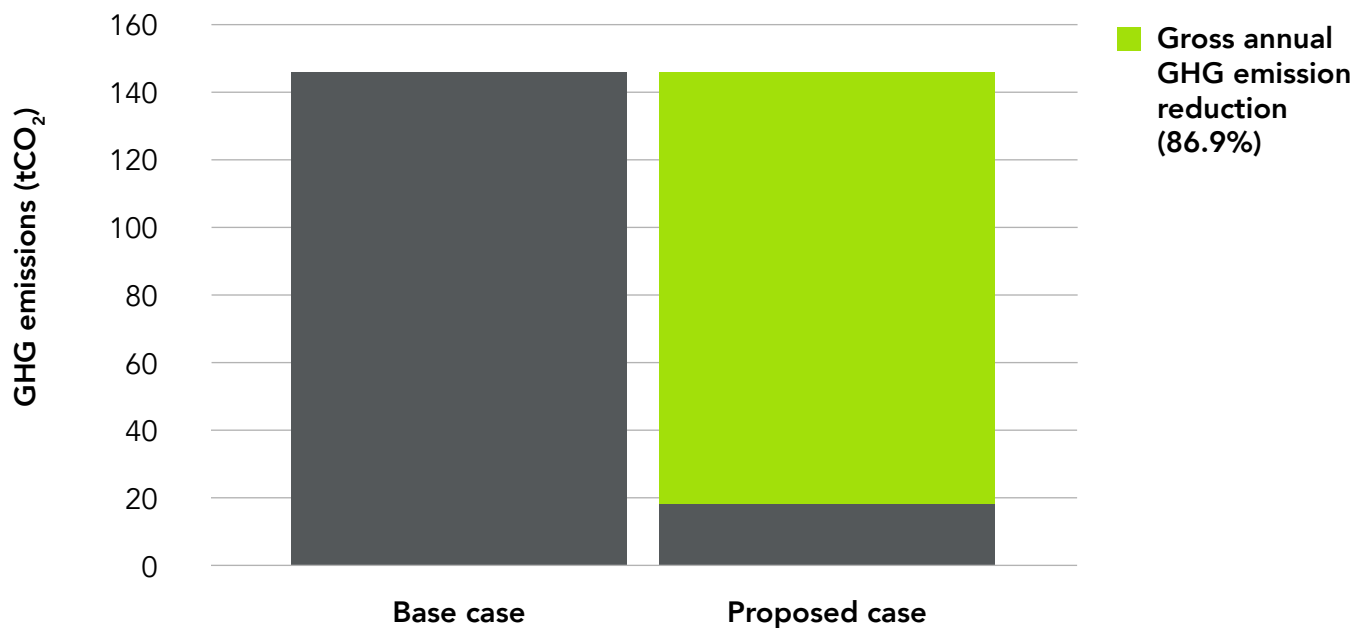
[4] Emission Factors and Reference Values Version 2.0, Environment and Climate Change Canada, May 2024