City Waterfront Building Retrofit

City of Toronto

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Disclaimer: This project is supported by the financial contribution of the Independent Electricity System Operator (IESO), through its Conservation Fund. However, the views, opinions and learnings expressed in this report are solely those of The City of Toronto.

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Introduction and Goal

Buildings are the largest source of greenhouse gas (GHG) emissions in Toronto which are generated primarily from burning fossil fuels for heating and domestic hot water use. In 2017, City Council adopted an updated climate change action plan, TransformTO, to lower GHG emissions in all City buildings. Among other recommendations, the plan commits the City to reducing energy consumption in its own buildings by 40% by the year 2040. To achieve the ambitious targets set out in TransformTO, the City adopted a holistic building deep energy retrofit approach that focused on all energy aspects (production, distribution, and consumption) in order to significantly reduce grid dependence and GHG emissions.

The City's Waterfront Building (CWB) located on 627/635 Queens Quay W was a prime candidate for this approach. The building opened in 1996, and many of its systems were approaching end of useful life. Rather than replacing "like for like" equipment, our objective was to demonstrate that existing systems could be replaced with low-carbon solutions with the goal of demonstrating long-term cost savings. The project provided an opportunity to pilot a lake-based hydrothermal heating and cooling system that – when combined with a Building Automation System retrofit and other previously implemented measures such as an LED lighting retrofit and rooftop solar PV coupled with lithium-ion battery storage – would help maximize GHG emission reductions at this building.

In addition, the CWB is a publicly accessible building in an area of the City with high foot traffic. The building serves as a community hub and hosts multiple tenants including: Waterfront Neighborhood Centre, The Waterfront School, City School, and St. Stephens Waterfront Childcare. These elements presented opportunities for knowledge sharing with residents and visitors to Toronto's waterfront, and opportunities for education on energy conservation measures for students.

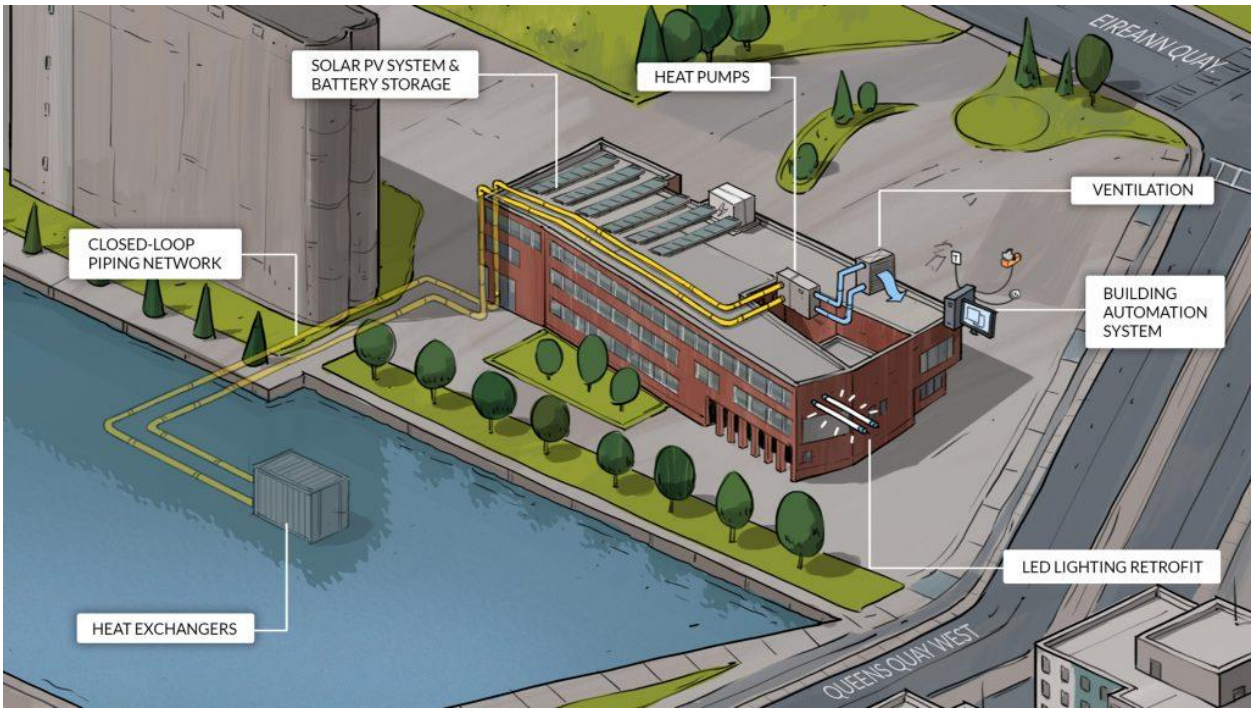
City Waterfront Building at 627/635 Queens Quay W

The key objective of the project was to adopt a holistic building deep energy retrofit approach that would achieve the following targets:

- 100% reduction in on site (GHG) emissions.
- No increase in operational costs. i.e., the project must have a payback.

Approach/Methodology

The closed-loop lake-based hydrothermal system installed as part of this project is one of the first of its kind in Canada. The system operates on 100% electricity and eliminates the need for natural gas, reducing the building's GHG emissions. It significantly improves the efficiency of heating (use of heat pumps instead of gas-fired boilers) and cooling systems (renewable lake energy instead of a cooling tower).



Summary illustration of all retrofit interventions at the City's Waterfront Building. Funds from IESO were used for the lake-based heat exchange system (see labelled as heat exchangers and closed-loop piping network).

Highlights of the closed-loop lake-based hydrothermal system:

- We installed two (2) heat exchangers (HX) in the lake to extract heat from the water in the winter when lake water is warmer than the air and to reject heat from the building into the lake in the summer when the water is colder than the air, allowing for more efficient operation. These heat exchangers are more efficient than air source heat pumps and a regular chiller and cooling tower. Eliminating the need for a cooling tower also saves water. Glycol runs from heat pumps to the lake, but water is used for heating in the building. This required very creative piping and heat exchanger configuration to allow both heating and cooling with minimal equipment. The piping configuration also allows for free cooling where the lake HX can be used without the heat pumps to directly cool the building chilled water loop.
- Use of three (3) heat pumps for resiliency. As the system is sized for peak loads, it can operate with 2 to 3 heat pumps for all but the coldest conditions, resulting in a very resilient system. We retained one of the existing gas-fired boilers as back up, only to be used in emergencies.

- Use of a separate heat pump for domestic hot water (DHW), which operates year-round as a second stage to the larger heating heat pumps.
- We upgraded the building's terminal heating system (radiators and fan coils) to make it compatible with low temperature heating water.

A video showing installation of the heat exchangers in Lake Ontario can be viewed at this link: https://youtu.be/PsBX0tO7eFk.

Cranes hoisting heat exchangers into Lake Ontario

The closed-loop lake-based hydrothermal system was one element in a comprehensive building retrofit that also included earlier installation of LED lighting and rooftop solar PV. The LED lighting measures were completed in 2018 and consisted of upgrades to interior and exterior lighting which reduced electricity consumption, reduced maintenance costs, and improved lighting conditions for facility users. In 2021, a 100kW AC rooftop solar PV array was installed that offsets 12% of the building's electricity usage. The solar PV system is combined with an installed 200kWhr lithium-ion battery. The system is connected to the grid in a net metering configuration which will potentially offset the existing 50kWAC diesel generator. Together, these technologies enhance the building's resiliency by providing energy to the building's critical loads in the case of a grid outage for a minimum of four (4) hours. Energy stored in the battery can also be used to reduce peak electricity demand loads.

Results

The project was successfully completed, and monitoring and evaluation has been underway to assemble the financial and environmental results below. In summary, the projected helped reduce operating costs by 51% and nearly eliminated natural gas use entirely.

Financial Results

The holistic building deep energy retrofit approach to decarbonization bundles measures with relatively short financial paybacks – such as LED lighting – with measures with lengthier payback periods like a lake-based hydrothermal system. It also integrates State of Good Repair (SOGR) budgets and energy program budgets to improve the business case.

The project resulted in a cost savings of 51% due to reduced energy costs, relative to the reference year. See Table 1 for a breakdown of savings throughout the year. The City's Recoverable Debt policy requires that energy projects present a simple payback of under 20 years. Projects that can demonstrate such a payback period can receive City financing which is then repaid from ongoing energy cost reductions or savings.

Table 1 | Project Financial Savings

Time Period	Baseline Period	Post-Retrofit Period	Reduction	% Savings
07/23 – 09/23	$81,493	$27,280	$54,213	67%
10/23 – 12/23	$68,340	$39,116	$29,224	43%
01/24 – 03/24	$90,161	$52,140	$38,021	42%
04/24 – 06/24	$67,557	$32,337	$35,220	52%
Annual Total	**$307,551**	**$150,873**	**$156,873**	**51%**

Environmental Results

The retrofit led to significant reductions in electricity usage, natural gas reliance, total energy usage, GHG emissions, and water usage. Table 2 summarizes these reductions based on quarterly and annual data.

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Table 2 | Project Parameter Reductions

Time Period	Baseline Period	Post-Retrofit Period	Reduction	% Reduction
Project Parameter: Electricity (kWh)				
07/23 – 09/23	411,797	132,489	279,308	68%
10/23 – 12/23	278,321	198,388	79,933	29%
01/24 – 03/24	258,919	265,986	+7,067	+3%
04/24 – 06/24	328,884	157,936	170,948	52%
Annual Total	**1,277,921**	**754,799**	**523,122**	**41%**
Project Parameter: Natural Gas (m3)				
07/23 – 09/23	2,303	14	2,289	99%
10/23 – 12/23	36,556	18	36,538	100%
01/24 – 03/24	98,297	2,062	96,235	98%
04/24 – 06/24	9,607	70	9,537	99%
Annual Total	**146,763**	**2,164**	**144,599**	**99%**
Project Parameter: Total Energy (ekWh)				
07/23 – 09/23	435,658	132,634	303,024	70%
10/23 – 12/23	657,089	198,575	458,514	70%
01/24 – 03/24	1,277,377	287,350	990,027	78%
04/24 – 06/24	428,430	158,662	269,768	63%
Annual Total	**2,798,554**	**777,221**	**2,021,333**	**72%**
Project Parameter: GHG Emissions (Tons of CO2e)				
07/23 – 09/23	36	10	26	72%
10/23 – 12/23	90	15	75	83%
01/24 – 03/24	203	24	179	88%
04/24 – 06/24	43	12	31	72%
Annual Total	**372**	**61**	**311**	**84%**
Project Parameter: Water (m3)				
07/23 – 09/23	1,930	1,048	882	46%
10/23 – 12/23	962	1,025	+63	+7%
01/24 – 03/24	966	1,016	+50	+5%
04/24 – 06/24	1,317	1,185	132	10%
Annual Total	**5,175**	**4,274**	**901**	**17%**

Please note that the indicators above are using before and after building performance figures for the whole "deep retrofit" and are therefore representative of all planned measures i.e., LED lighting retrofit, Building Automation System improvements and energy conservation measures, solar PV and battery storage, and lake-based geo-exchange installation. Of all the listed measures, the lake-based geo-exchange installation will have the highest positive impact on the reduction of natural gas consumption and GHG emissions.

Lessons Learned

One of the key takeaways is to involve and communicate with ALL potential stakeholders (no matter how minimal their role may be) prior to starting the project. For example, we had to wait for approvals from Transport Canada for the installation of the lake-based heat exchanger, but the process could have been expedited if they were engaged from the start.

One of the challenges the project faced was surrounding long procurement times (2 to 3 times longer than normal) due to supply chain issues caused by the pandemic, which created minor issues on site. In the future, we would ask for a guaranteed delivery date for time sensitive supplies or find alternative suppliers that can deliver on time to ensure continued project progress.

In addition, there were complexities around permitting requirements and jurisdiction as the project spanned three separate properties (the waterfront building, the boardwalk, and the lake). These issues were overcome by involving the port authority as well as Transport Canada to determine exact requirements for the in-lake portion of the project.

Conclusion & Next Steps

The City is focused not only on retrofitting municipally owned buildings, but on helping building owners implement energy conservation, fuel switching, and renewable electricity generation measures. Leading by example is an important aspect of the TransformTO Net Zero Strategy. Learnings from this project may be transferrable to other organizations and will inform how we proceed with future projects.

Lake-based hydrothermal could be replicated for many waterfront properties where feasible, for example, there is huge potential in the Portlands area which is currently being redeveloped. LED lighting, building automation systems, and solar plus battery storage are technologies that will be a part of many building retrofits going forward.

Another major reason for implementing projects like this across the City is the added benefit of resilience in a worsening climate. Buildings equipped with solar and battery storage could serve their community as warming centres during winter storms and a place of refuge in the case of prolonged

grid outage. We have begun implementing similar projects at critical service facilities (EMS stations for example) to enhance their ability to perform their duties without interruption in the case of emergency.

Based on the success of the Pilot Project, we plan to continue deploying this holistic deep energy retrofit approach in City buildings with aging infrastructure nearing end of useful life. An important aspect of this pilot is sharing our experience and lessons learned with the public to encourage a shift towards green or clean energy solutions wherever feasible. The City is also promoting lake-based hydrothermal opportunities like this and working to streamline the feasibility and approval process for other lakeside properties, both privately and publicly owned.

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