# ENWAVE: DEEP LAKE WATER COOLING

## *Keeping Toronto cool*

*Enwave is the largest provider of district cooling from a renewable resource in North America, with over 30 buildings connected to the system and capacity to serve an estimated 100 buildings. Enwave's Deep Lake Water Cooling system began operation in July 2004 and helps keep downtown Toronto buildings cool year-round while enhancing the supply of potable water with a clean water source, decreasing electrical demand and consumption, increasing employment opportunities, and helping businesses and Toronto residents reduce greenhouse gas emissions and improve outdoor air quality. Enwave DLWC exemplifies the ability of district energy systems not only to extend and improve the operations of critical municipal infrastructure systems, but also to improve community infrastructure resiliency and adaptability. DLWC has attracted international interest and lowered and stabilized the cost of operations for local businesses and residents.*

## Overview

Three intake pipes each reaching 5 km into Lake Ontario bring cold water (4°C) from 83 metres below the surface of the lake to the City of Toronto's water filtration plant. The pipes are made from high-density polyethylene and are held in place on the bottom of Lake Ontario using concrete collars. Close to the shoreline, they are buried in the beach sand to prevent damage from wind and wave action and ships. The pipes are routed to the City's water intake and filtration plant on Toronto Island, and from there to the John Street pumping station.

**High density polyethylene pipes are installed 83 m below the surface of Lake Ontario.**

### Ownership

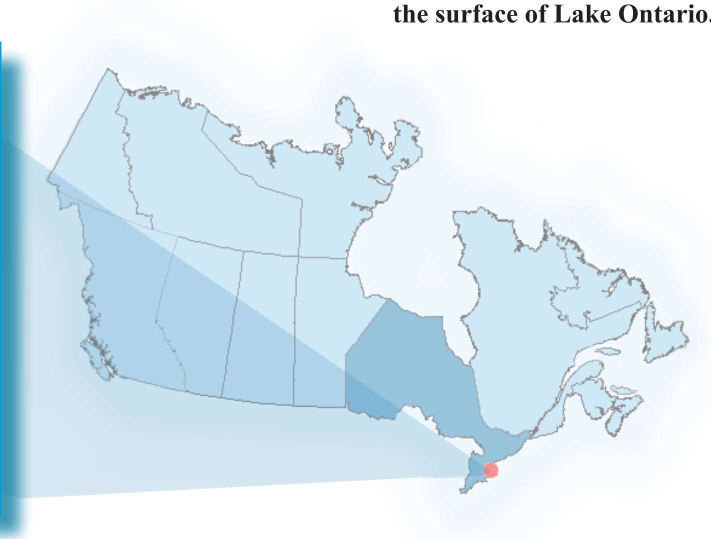
- Public ownership

### Plant capacity

- 11 MW
- 75,000 tons cooling

### Sectors served

- ☑ Residential
- ☑ Commercial
- ☐ Institutional
- ☐ Industrial



The coldness of the lakewater is transferred through 18 pairs of stainless steel heat exchangers (with over 800 sandwiched plates per heat exchanger) to Enwave's closed-loop chilled water supply distribution network. The water enters the system at 4°C. Returning water from the distribution system, which is not more than 13°C, is cooled using the deep chilled water from the lake and then by centrifugal polishing chillers to around 3°C. Once it has passed through the heat exchanger, the water drawn from the lake (which is now not more than 13°C) enters the City's potable water supply system. The system is designed to air-condition nearly 3.2 million m$^2$ of office space, replacing in-building electrically driven chillers. The systems can provide 75,000 tonnes of connected refrigeration demand.

## Context

Interest in deep lake water cooling (DLWC) in Toronto has an extensive history. An initial study was conducted in 1981 by Engineering Interface Ltd. for the Canada Mortgage and Housing Corporation. The report concluded that DLWC was feasible and the idea was nicknamed "freecool" to reflect the savings provided by using a natural resource.

Although the potential for DLWC was presented to the Toronto City Council and the report was updated in the early 1980s by the Ontario Ministry of Energy, no major private investor could be found to finance the project. However, the city needed to improve outdoor air quality, reduce greenhouse gas emissions and reduce electricity demand and the city's reliance on chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) refrigerants to comply with the Montréal Protocol. With the support of the Canadian Urban Institute, detailed environmental and technical studies were carried out and a conference held in the early 1990s to demonstrate the opportunities for DLWC.

### Structure

Enwave Energy Corporation is a registered Ontario Business Corporation, with two shareholders – the City of Toronto and Ontario Municipal Employees Retirement System (OMERS) – which each have a 43% and 57% share of the corporation respectively. Enwave operates the DLWC system; its Board of Directors is appointed by the shareholders.

The former Municipality of Metropolitan Toronto worked with the Toronto District Heating Corporation (TDHC) (an agency created by Provincial legislation and predecessor to Enwave) to explore the possibility of placing district cooling systems in the City of Toronto railway lands as an alternative to cooling towers.

The City remained interested in the potential to harness the energy from the lake and an environmental assessment was completed in 1998. Financial support for advanced engineering work was provided by the Department of Natrual Resources Canada in the form of a grant of $1 million half repayable) and additional private equity from shareholders for a total feasibility and engineering design cost of $3.5 million. The Federation of Canadian Municipalities provided a capital works loan from the Green Municipal Fund of $10 million at market rates which has subsequently been fully repaid by Enwave.

The first customers for DLWC were the Air Canada Centre and the Metro Toronto Convention Centre. The first office complexes were the Oxford Buildings at One University Avenue and the Royal Bank Plaza which came on line in July 2004 The successes of the first users of DLWC contributed to attracting additional customers and have enabled Enwave to become the largest provider of district cooling from a renewable resource in North America, with nearly 50 customers signed and 30 buildings connected to the system.

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## Benefits

### General

- Provides air-conditioning to residential, commercial, retail, institutional, and government buildings, and major sports facilities.
- Price-competitive service is sustainable, clean, and renewable.
- Extends municipal infrastructure and reduces strain on electricity infrastructure, including the transmission grid.
- Provides residents of Toronto with an improved source of water supply that is cleaner and cooler.

### Environmental

- Reduces electricity usage by 90 percent compared to a conventional cooling system.
- Frees up more than 61 MW of electricity for Ontario's and Toronto's electrical grids.
- 79,000 tonnes of carbon dioxide are removed from the air annually (based on the displacement of coal and at full system build out) - equivalent to taking 15,800 cars off the road.
- Over 1880 litres per second of lake water cooling demand avoided due to reduction in electricity generation
- Removes 145 tonnes of nitrogen oxide and 318 tonnes of sulphur dioxide from the atmosphere relative to the use of coal-fired electricity.
- Reduces the need for cooling towers, thus relieving valuable commercial office space for other uses and saving some 714 million litres of fresh potable drinking water.
- Buildings that covert to use DLWC can decom mission older electrically driven refrigeration systems that contain CFCs and HCFCs.

### Economic

- Use of a renewable energy source reduces the potential for rate increases and is free of influence from volatile energy markets
- Estimated to generate 1,000 person-years of local labour in construction.
- Lower energy costs for customers.

## Timeline

**1997** Environmental assessment commences for DLWC; Toronto District Heating Corporation begins financial restructuring.

**1998** Environmental assessment completed for DLWC.

**1999** Toronto District Housing Corpora tion becomes Enwave (private corporation co-owned by the City of Toronto and the Borealis Penco Fund, now the Ontario Municipal Employees Retirement System).

**2000** Phase II of emerging studies for DLWC begins.

**2002** Construction starts.

**2003** Intakes placed out in the lake; additional equipment including switch gear, control systems, heat transfers, and pumps constructed.

**2004** Enwave begins supplying customers with DLWC.

**2007** Growing customer base with nearly 50 buildings signed on and 30 connected (estimated system capacity – 100 office buildings).

## Performance

The system uses 85 million kilowatt-hours per year less than conventional cooling systems or roughly the amount of power required to supply 6800 homes a year. The reduction in water consumption from cooling towers is 700 million litres per year less than conventional systems. The estimated reduction in greenhouse gas emissions (carbon dioxide) is 79000 tonnes a year, or the equivalent of 15800 cars. This estimate is based on displacing coal-fired electricity.

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## Lessons learned

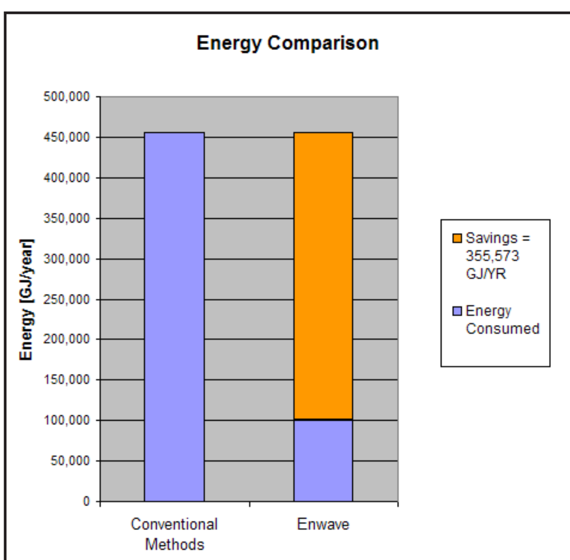
**Taking a life-cycle cost approach to a customer's needs can help make the business case for district energy**. Enwave needed to dispel misconceptions about district energy, project viability, and costs for converting from in-building cooling systems in order to get customers to sign up. Enwave addressed its customers' concerns directly by presenting a sound business case that offered a detailed financial costing over the entire life of the project. A key message conveyed to potential customers was that the project offered long-term price stability (insulated from price hikes for electricity or gas) and reduced maintenance costs. Making this business case meant developing a rapport with customers, from the building manager to the senior decision-maker.

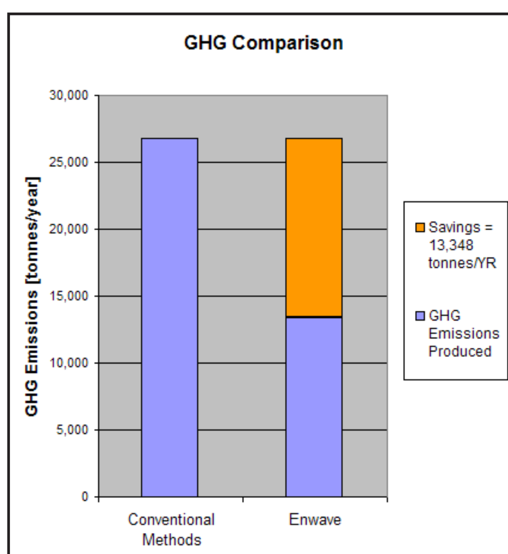
**Limited technical understanding of new products can result in risk aversion by regulatory authorities, customers, and decision makers and add costs to the operation of a plant.**

## Information at a glance

Building types served: Commercial, residential, retail, university, government and sports facilities
Building area served: 3.2 million $m^2$
Location: Toronto, Ontario
Completed: 2004
Operator: Enwave Energy Corporation
Total Demand: 75,000 tons refrigeration
Technology: Cold-energy transfer loop relies on a natural cool energy source, which is extracted using uses stainless steel heat exchangers; additional cooling capacity to increase distribution system capacity provided by 2 x 4700-tonne steam driven centrifugal chillers
Total System Demand: 75,000 TR (260 MW) of refrigeration
Fuel type: Deep lake water and natural gas for steam driven chillers
Distribution system: Over 10.6 km of steel and high density polyethylene pipes
**Total cost of project:** $238 million

## Energy / Greenhouse Gas Savings:



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Part of the challenge of getting the DLWC project implemented was convincing provincial regulators that the extraction of a natural resource - water - which would normally be subject to a fee for industrial use, should be exempt from fees. Enwave successfully demonstrated that the merits of the project offered the province sufficient financial and environmental savings to warrant an exemption. In addition, Enwave pointed out that other water plants in Ontario are not subject to a significant fee for water taking. For Enwave, the business case to move forward hinged significantly on not being levied a fee for water extraction since no more water is taken from Lake Ontario than before Deep Lake Water Cooling came into operation. In other words Enwave uses the cold from the water, not the water itself.

**Overlooking details can have a cumulative impact on the project.** Enwave experienced some technical challenges in minimizing the risk in the design and deployment of the project. They learnt that attention must be paid to details by tending to small problems before they have a chance to escalate. For example Enwave carried out a gridded temperature monitoring program and found that the literature does not represent the actually temperature regime in the lake. As a result the intakes were lengthened from 2.7 km to 5.0 km in length to go beyond the shoreline effects that were picked up in the monitoring program

**Patience is a virtue when it comes to signing up customers.** For Enwave, garnering the necessary support to move forward with DLWC required a decade of continuous effort. The same level of patience is also needed when developing a customer base to secure initial financing capital and to advance the project. For many customers, agreeing to long-term contracts (some nearly 20 years) is a daunting prospect, despite the many environmental and financial benefits. Remaining focused on the competitive hallmarks of district energy, such as energy and maintenance costs savings and worry-free operations, can help persuade customers to sign up. Also the realization that a chiller purchase is really a 25 year commitment since chillers last on average almost that long according to ASHRAE.

**Successful project timing starts with a long-range scan of the market place for both potential customers and access to required labour.** Across Canada, large-scale infrastructure projects are creating local shortages for experienced labour, particularly pipefitters, welders, and project managers. At the same time, the cost of product materials is also increasing. As oil prices have gone up, so have costs for fossil fuels and associated products such as steel for piping. Careful consideration should be given to the expected start date of a project and associated increases in material costs, as well as and access to skilled labour, not only for construction, but also for the operation and maintenance of a plant.

## Future

Enwave anticipates increasing the undiversified DLWC system load from the current 75,000 tons of refrigeration to 100,000 tons to meet growing customer demand.

### For more info, contact:

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