The False Creek Energy Centre is nestled under the Cambie Street Bridge. Its LED-illuminated exhaust flues extend above street level. Ausenco Sandwell

Tapping into waste heat

Vancouver's False Creek Energy Centre provides an adaptable, renewable, and innovative energy solution

Chris Baber

The False Creek Energy Centre in Vancouver, British Columbia, was responsible for generating the heat and hot water for the Olympic Village at the 2010 Winter Games, as well as for the rest of the new Southeast False Creek community. What's unique is that most of this energy was extracted from the wastewater flowing underneath the neighborhood's streets.

This "green" technology is truly innovative – False Creek is the first utility in North America to capture and use waste heat recovered from untreated urban wastewater.

Tapping in

The False Creek Energy Centre is integrated with a municipal wastewater pumping station and recovers heat from untreated urban wastewater, a renewable energy source. Wastewater that flows into the pump station is diverted to a traveling-screen filter that removes solids before the flow is sent to a heat pump.

Similar to a geothermal application, heat pumps are used to transfer the heat energy from the wastewater to a hot-water distribution system. Heat pumps use a refrigerant evaporation–compression cycle to transfer heat from a low-grade source (wastewater) to a higher-grade source (hot water). After heat is recovered from the wastewater, the wastewater and filtered solids are recombined and pumped to the Iona Island Wastewater Treatment Plant outside of the municipal boundary.

Since the Olympic Games period, this wastewater-heat-recovery process has supplied approximately 70% of the total thermal energy demand of the Southeast False Creek neighborhood, with solar thermal modules and efficient natural gas boilers making up the balance.

Distributing the warmth

The False Creek Energy Centre is part of the Neighbourhood Energy Utility (NEU), which serves the new Southeast False Creek community. NEU's three key components are

- the False Creek Energy Centre that supplies thermal energy in the form of heated water,
- an insulated hot-water distribution pipe system that distributes thermal energy to buildings throughout the Southeast False Creek community, and
- heat exchangers and meters that transfer thermal energy from the distribution pipe system to customer buildings for space heating and domestic hot-water supply.

Energy-transfer stations in each building exchange energy with the circulating hot water, metering the building's energy production and consumption for billing. From the energy-transfer stations, space heat and domestic hot water are delivered to residents by each building's mechanical system. These systems are owned and managed by the property holders and can include radiant floor/ceiling systems, baseboard heaters, and forced-air systems.

Reaping environmental, social, and economic benefits

As Vancouver's first renewable-energy-based district heating system, NEU reduces greenhouse gas emissions by replacing fossil fuels with greener energy sources. In Vancouver, 54% of greenhouse gas emissions come from buildings. A key component of the city's greenhouse gas emission reduction program is renewables-based district energy, which will serve new neighborhood developments like Southeast False Creek and connect to existing natural-gas-heated buildings.

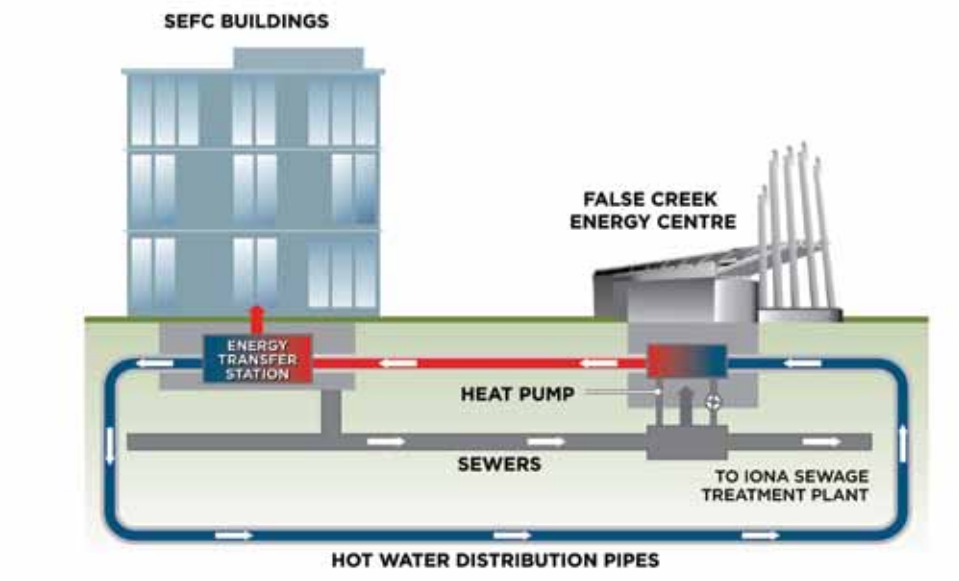
When development in the Southeast False Creek area is completed (about 2020), NEU will provide thermal energy services to more than 560,000 m^2 (6 million ft^2) of buildings and 16,000 residents.

NEU has economies of scale and flexible infrastructure that can adapt to using a wide variety of renewable "waste energy" options that would otherwise not be available to an individual building-heating system. Through its high system efficiencies and by using wastewater-heat recovery to supply approximately 70% of the annual energy demand, NEU eliminates more than 65% of the carbon emissions associated with the heating and hot-water use of buildings.

Melding function with form

Prior to development of the False Creek Energy Centre in Vancouver, British Columbia, neighbors expressed concerns regarding the effect of an industrial facility in their neighborhood. To ensure good integration with the existing community, the False Creek Energy Centre makes use of innovative architectural design to showcase its unique function. Ausenco Sandwell (Vancouver) was the design engineer for the facility.

Its fingerlike exhaust flutes integrate eye-catching public artwork that responds to the energy consumption of the neighborhood it serves: LED lights change color from blue in times of low energy demand to red at times of high demand. The project was recipient of a 2010 Lieutenant Governor's Award in Architecture, the highest honor bestowed in the province of British Columbia.



The False Creek Energy Centre extracts the heat from wastewater flowing beneath the streets of Vancouver, British Columbia, to provide heat for the Southeast False Creek (SEFC) community. To date, this renewable energy source has been able to supply about 70% of the area's total thermal energy demand.

In addition, the Leadership in Energy and Environmental Design (LEED™) buildings connected to NEU further minimize energy demand and greenhouse gas emissions using high-quality building envelope design and hot-water radiant heating systems.

Through NEU's use of renewable energy sources and flexibility to adapt to future energy technologies, it is anticipated that NEU customers will enjoy rate stability that outperforms conventional options. Also, NEU supports the use of radiant hot-water heating systems in buildings that provide customers with a higher level of comfort with lower energy use, compared to conventional space-heating options. In addition, NEU eliminates heat-production equipment from Southeast False Creek buildings, creating more space for green roofs and reducing maintenance for building owners.

NEU is a self-funded utility that will provide return on investment to Vancouver's taxpayers while providing competitive rates to customers. NEU helps building developers meet the energy efficiency and green building requirements for Southeast False Creek more cost-effectively, compared to the use of distributed stand-alone green energy options.

Choosing the source

Prior to NEU's development, Vancouver investigated various

The exhaust stacks of the False Creek Energy Centre blend into the skyline of Vancouver, British Columbia. The energy center, owned and operated by the Neighbourhood Energy Utility, is the first utility in North America to capture and use waste heat recovered from untreated urban wastewater.
Ausenco Sandwell

heat sources for the Southeast False Creek neighborhood, including geothermal, solar, biomass (wood waste), natural gas cogeneration, and wastewater-heat recovery.

For this site, geothermal was determined to be cost-prohibitive due to the high capital cost associated with installing a well field of adequate capacity for the neighborhood. Solar thermal was determined to be incapable of supplying adequate energy for the Vancouver climate (cloudy and wet in heating months). Natural gas cogeneration was proven cost-prohibitive due to the low cost of electricity in British Columbia, and it did not sufficiently reduce greenhouse gas emissions.

Biomass and wastewater-heat recovery were demonstrated to potentially deliver the economic and environmental performance required to deliver energy at a cost competitive with traditional gas and electric heating sources.

While further technology investigations were ongoing, Vancouver began public consultation for the two heat-source options. With only 3 years in the schedule from concept to completion, the timeline was very tight to ensure that the project would be complete for the Olympics – so both options were presented to residents.

The biomass option generated a number of negative public perceptions that would have required at least an additional 6 to 12 months of community engagement to resolve. The wastewater-heat-recovery option had a number of technical risks (see below), but those were addressed concurrently with the public outreach.

Given Vancouver's increased comfort that the sewage-heat-recovery risks could be managed and that there was insufficient schedule time to pursue biomass, the city went with the wastewater-heat-recovery option.

Building a reliable system

One of the first challenges with creating North America's first wastewater-powered heat-recovery systems was finding the right heat pump. The False Creek Energy Centre needed a unit that could supply hot water at temperatures up to 80°C and was capable of accommodating wastewater flows through its evaporator heat exchanger. Additionally, the heat-pump system had to be able to accommodate periods of low energy demand through the summer months. Heat pumps typically are limited to turndown of 50%.

Prior to developing NEU, only one heat-pump supplier worldwide had a product proven for such applications, and that supplier does not serve the North American market. In addition, Vancouver needed to limit its development and operations risks as much as possible with this new technology.

To find a solution, the NEU project team lobbied worldwide heat-pump suppliers to make them aware of the new opportunity in Vancouver and its potential for replication elsewhere. The result was three separate suppliers expressing interest in developing the purpose-built heat-pump system.

Vancouver negotiated a supply contract with a North American

This heat-pump system transfers thermal energy from wastewater to the Neighborhood Energy Utility's thermal distribution system. Kieran McConnell, City of Vancouver, British Columbia

vendor. The contract included performance requirements for the heat pump and associated penalties. In addition, a maintenance contract was negotiated with this vendor to provide all maintenance services required for 10 years. For a flat fee, the vendor ensures that the heat-pump system is performing.

Overcoming operational challenges

The city also faced concerns about how to ensure the maintenance and reliability of the system when using a heat source as variable as wastewater.

Heat-exchanger fouling. Wastewater contains solid particles that could clog heat-exchanger systems and fats, oils, and grease that could coat pipes and lead to biofilm growth – all of which can prevent efficient heat exchange.

NEU used several means to overcome these operational hurdles. To prevent clogging, a 2-mm traveling screen was installed to remove solid particles before the water passes through the heat exchanger. To eliminate worries about buildup and biofilm on the pipes, NEU chose a shell-and-tube heat exchanger, which can be adapted to include an automated-brush cleaning system. A four-way valve also was added to enable periodically reversing the wastewater's flow direction.

Now, after 9 months of operation, the traveling screen and four-way valve are proving effective in keeping heat-exchanger surfaces clean.

Variable flows. Early in the preliminary design process, it was observed that wastewater flows in the Southeast False Creek catchment were insufficient to supply the needed 2.7 MW of thermal energy. In particular, nighttime flows were very low.

The city implemented some design solutions to remedy this. First, the wastewater-heat-recovery facility was connected to a force main serving downtown Vancouver. Then, automated control valves were added to provide additional flow to make up the shortfall flowing into the pump station. Operations were adjusted at the pump station that feeds the supplemental force main to ensure that wastewater flows continuously, versus intermittently as it was doing before. With these changes, the system receives adequate flows to operate throughout the night, and wastewater availability is not a limiting factor.

Solids buildup in wet wells. Because solids are removed from the flow during heat recovery, sewer utility operators had concerns about solids building up in the wet well and increasing maintenance requirements. The solution was a self-cleaning, trench-type wet well design. Solids collected by the traveling screen are deposited in the center of trench flow downstream of the heat exchanger. Also, the station's pumps periodically ramp up to high speed to create turbulent flow conditions, which clean all solids and grit from the wet well areas, eliminating periodic maintenance cleanings.

So far, these measures have been successful. The self-cleaning wet well design is performing well, and no wet well cleanings have been needed.

By using a heat pump at the False Creek Energy Centre to extract heat from wastewater and delivering it to nearby buildings, the Neighborhood Energy Utility estimates that it can supply about 80% of the neighborhood's annual thermal energy. Kieran McConnell, City of Vancouver, British Columbia

Similar to a geothermal application, heat pumps at the False Creek Energy Centre are used to transfer the heat energy from the wastewater to a hot-water distribution system. In Vancouver, British Columbia, wastewater-heat recovery outperforms geothermal, as the average temperature of wastewater is about 20°C (68°F), which is much warmer than the ground temperature. Kieran McConnell, City of Vancouver, British Columbia

Exceeding expectations

The time and effort spent to ensure that the system works properly has paid off. Today, the heat-pump system provides a higher level of energy output than initially planned – 3.5 MW versus the planned 2.7 MW. This has been achieved through a conservative heat-pump design and optimization of output temperatures.

Thus, it is anticipated that the NEU project will exceed its target of supplying 70% of the annual energy from wastewater-heat recovery. The current estimate is that heat recovery will supply approximately 80% of the neighborhood's annual energy, improving environmental and economic performance of the system.

Building on NEU's success, Vancouver is committed to expanding renewable energy systems across the city. This city's overall district energy strategy includes new renewables-based district energy systems to serve new developments and areas of high natural gas usage, rezoning requirements for new developments in high-density areas to ensure that all new buildings are compatible with district energy and will connect to a system when it is available, and conversion of existing legacy steam-heat systems to renewable bioenergy sources.

To complement the district energy strategy, the city's green building program ensures that new buildings minimize energy consumption and provides incentives to encourage demand-reduction retrofits of existing buildings.

Chris Baber *has served as project manager for development of the Neighbourhood Energy Utility on behalf of the City of Vancouver since 2006.*