2013 ASHRAE TECHNOLOGY AWARD CASE STUDIES

Whistler Athletes Village, built for the 2010 Winter Olympic Games, has been converted to residential use. A district energy sharing system uses the low-temperature energy from the sewage plant for heating and cooling the buildings.

SECOND PLACE
RESIDENTIAL, NEW

Sewage Plant *Heats Village*

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BUILDING AT A GLANCE

Whistler Athletes Village

Location: Whistler, BC, Canada

Owner: Whistler 2020 Development Corporation

Principal Use: 2010 Olympic Athletes Village

Includes: Service building, residence air-conditioning systems, domestic hot water systems, distribution piping and all controls and metering

Gross Square Footage: 401,505

Conditioned Space Square Footage: 60,085

Substantial Completion/Occupancy: 2010

Occupancy: 100%

National Distinction/Awards: Award of Excellence—Association of Consulting Engineering Companies Canada (ACEC); Energy Action Award—Community Energy Association (CEA)

The Whistler Athletes Village in Whistler, BC, Canada, was originally constructed to house athletes competing at the 2010 Winter Olympic Games. The buildings in Phase 1 have been converted for residential use and have operated for more than two years, during which the connected systems have been monitored on an hourly basis and the results documented.

The primary energy source for heating, cooling and domestic hot water is the district energy sharing system (DESS), which takes low-temperature energy from the existing Whistler Village Sewage Treatment Plant and uses it for heating and cooling the buildings. The DESS is designed with capacity for an eventual community of 400 residential units and their ancillary services.

ABOUT THE AUTHORS
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ABOVE DESS HDPE pipe being thermally welded.

LEFT Newly constructed Athletes' Village prior to residential use.

Treated sewage is pumped from the existing treatment plant to an adjacent mechanical plant room, where it is filtered before passing through a bank of heat exchangers. A two-pipe, reversed return, closed-loop system around the Athlete's Village supplies the energy required for all of the heat pumps in Phase 1 of the project.

Water from the heat exchangers in the mechanical plant room is pumped through high density polyethylene piping, around the distribution loops, providing the energy source for the heat pumps within each of the Village buildings. There are no circulating pumps or control valves between the connected building supply and the return to the DESS. Control is entirely governed by the pressure difference between the supply and return mains.

The heat pumps in each unit were selected to provide 60% of the peak capacity for heating and/or cooling, with electric heating elements installed in each building as backup. The largest pipe at the discharge from in the system mechanical room is 14 in. (356 mm) in diameter. Phase 1 flow from the mechanical room is maintained at 1,600 gpm (101 L/s). Flow rate for the completed system will be 2,400 gpm (152 L/s). Space has been reserved for a future heat exchanger and pump. Two gas-fired standby boilers are located in the mechanical room.

Innovation

The innovative aspects of this project rest completely in the DESS. The system is unique in that it is providing heating, cooling and domestic hot water to a very large development using the energy that is reclaimed from the sewage treatment plant. The first year's operation of the system is producing an energy savings of almost 50% compared to the energy use for comparable buildings. As the system is expanded and the operation is refined, it is expected that this figure will rise to a 60% savings.

Designing the Whistler system was complex because of the variability of the energy source and the residential demands. Further complicating matters was the need for the system to perform in a cold climate. The distribution piping creates a thermal storage that is used by the building heat pumps, functioning in either heating or cooling modes.

The use of a non-freezing compound in the system was not considered necessary because of the temperatures maintained in the DESS. It is estimated that the design life of the system will be at least 50 years, will require a minimum of maintenance, and will be inexpensive to operate, as demonstrated by the first year's operation.

It is projected that the system, when completed, will have provided a 70% reduction in greenhouse gasses, over a comparable district heating system, and up to 3,200 MWh of building energy per year, using the energy that would otherwise be wasted.

Energy Efficiency

Phase 1 of the project has completed two full years of operation and the actual loads that have been experienced have been monitored. The connected buildings are 82% residential and 18% commercial/industrial. The loads that have been used in arriving at the savings are actual and, although there have been some hitches due to startup, control system adjustment and effluent filtering, they compare, favorably, with the original calculated figures.

The savings that were experienced are due, in part, to the energy extracted from the sewage, the use of variable speed drives on all of the

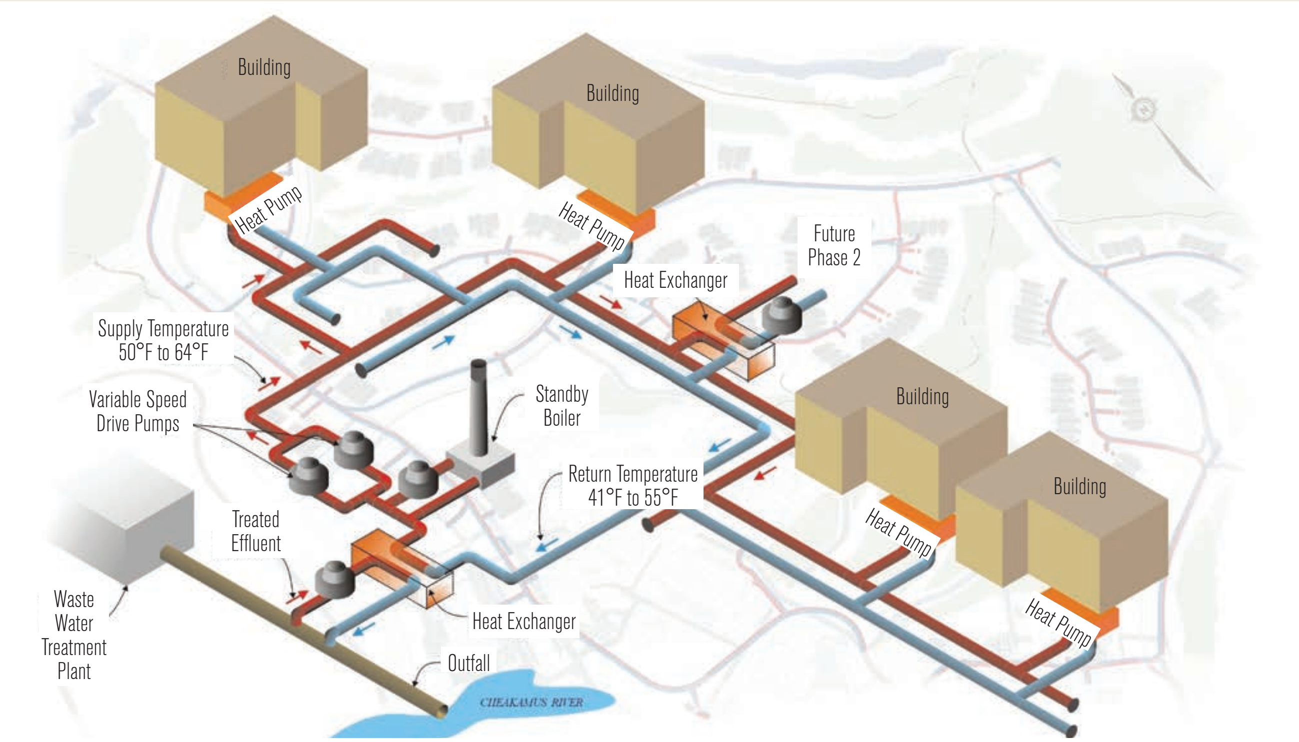

FIGURE 1 Whistler Athletes Village district energy sharing system. Two pipe closed loop can provide both heating and cooling.

pumps and the reclamation of energy from the connected buildings (*Table 1*).

To date, the DESS has shown a 47% reduction in energy compared to traditional natural gas heating systems and a 39% reduction compared to electric systems. The rest of the article discusses the results from the data received from the installed monitoring equipment, the comparison with the initial calculations and the total energy savings.

The site estimate for the completed project was calculated as 16 million Btu/h (4.7 million W). This total site load was estimated by using general energy intensity values per floor area and inserting these figures into the firm's in-house energy software. The daily heating load was initially modeled for the site using 2004 temperature data and assumed balance temperatures.

To estimate the total load for the measured year (August 2010 to August 2011), the initial weather data was replaced with 2010 to 2011 weather data, and the balance temperature was adjusted such that the modeled DESS loads matched the measured DESS loads.

Indoor Air Quality and Thermal Comfort

Indoor air quality and maximum outdoor rate for the housing units and the hostel was determined using ASHRAE Standard 62.1-2004. Controls were set in each building to provide comfort conditions according to ASHRAE Standard 55-2007.

Each of the attached residential units has its own heat pump or heat pumps, taking energy from the DESS and distributing it to the individual spaces. In the summer, when the heat pumps are in their cooling mode, the excess heat in the DESS system is returned to the sewage plant effluent through the heat exchangers.

The domestic water is heated by the energy drawn from the DESS. Domestic water maintained at 130°F (54°C) is heated by the energy drawn from the DESS.

Table 1 Annual loads from August 2010 to August 2011.

ELECTRICITY USED BY ALL ATTACHED HEAT PUMPS	836 MWh	3,852,432 kBtu
ELECTRICITY USED BY ALL CIRCULATING PUMPS	220 MWh	750,640 kBtu
BACKUP ELECTRIC HEAT	605 MWh	2,064,260 kBtu
BACKUP NATURAL GAS HEAT	213 MWh	26,656 kBtu
NATURAL GAS USED BY CENTRAL BOILERS	759 MWh	2,589,708 kBtu
TOTAL	**2,633 MWh**	**8,983,796 kBtu**
DESIGN HEATING LOAD (CALCULATED)	2.65 MWh	9.042 kBtu/h
TOTAL ANNUAL SITE LOAD (CALCULATED)	3,949 MWh	13,473,988 kBtu
TOTAL DESS ENERGY CONSUMED	2,633 MWh	8,983,796 kBtu
Total DESS Efficiency	150%	

Advertisement formerly in this space.

The hostel is somewhat different. The ground floor has been converted into a restaurant while the upper floors are fitted with bunk beds, which are independently rented. Heat pump recovery units reclaim the heat from all of the exhaust air and use this air as ventilation for the rental areas. An air-to-water heat pump on the roof provides hot or chilled water for the ground floor fan coil units.

To get the optimal thermal comfort of 60% thermal radiation and 40% thermal convection (*2007 ASHRAE Handbook—HVAC Applications*), heating is provided by radiant floors. Control setpoints for temperature are always within acceptable ranges that provide thermal comfort according to ASHRAE Standard 55-2004.

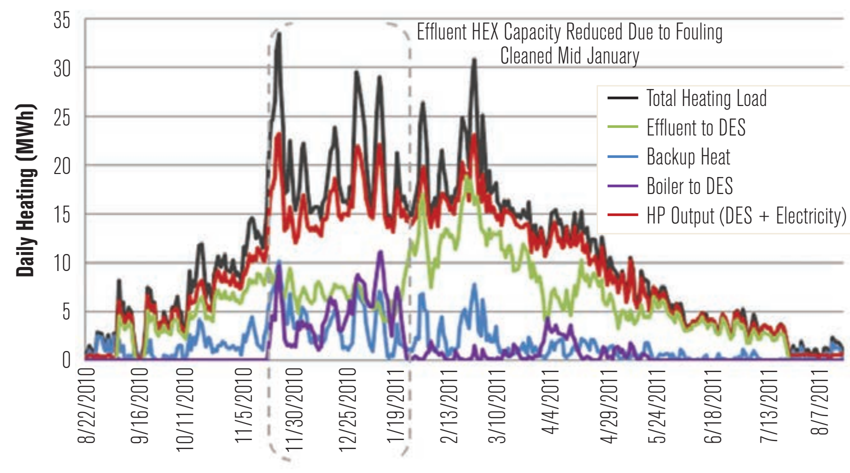

FIGURE 2 Annual heating load.

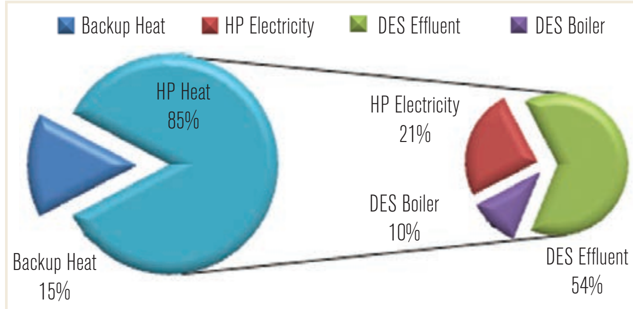

FIGURE 3 Heating load source.

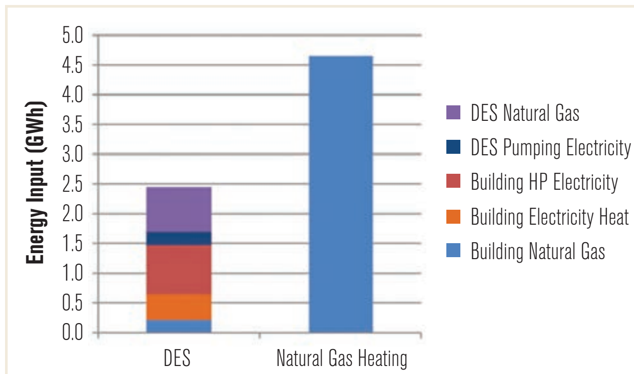

FIGURE 4 District energy vs. natural gas heating.

Operation and Maintenance

The project is controlled by an advanced automation management system that coordinates and optimizes the DESS systems to ensure the maximum of energy saving along with maximum indoor comfort conditions. The control system uses a fully open network protocol (BACnet), communicating with multiple distributed control panels, including third-party manufacturers controls (supplied with the units), for a fully integrated seamless control system. The DDC system is monitored by the wastewater plant operators and independently by an outside consulting firm.

Cost Effectiveness

The capital cost for the completed Village's DESS was estimated at $4 to $5 million. A comparable conventional district heating system was estimated at between $25 and $33 million ($20 to $25 million for insulated steel pipe and $5 to $8 million for the energy center). The DESS uses high density polyethylene, uninsulated piping, operates at ambient temperatures, benefits from energy sharing between buildings in heating and cooling modes, and requires less capital and operating costs.

Environmental Impact

Reduction in greenhouse gases is a key factor in the installation of the DESS. Using polyethylene for all of the underground piping and the possible future use of tertiary effluent for non-toxic water distribution are examples of impact reductions. The greenhouse gas (GHG) emissions associated with space heating, space cooling, and domestic hot water were calculated using electricity and natural gas consumption.

Electricity in British Columbia is assumed to produce 0.022 tons of CO_2 emissions. The GHG emissions for a 50/50 mix of standard distributed natural gas heating and electric heating and cooling were calculated as 497 tons per annum. The DESS, using wastewater heat recovery, reduced the typical emissions by 285 tons, which is a 57% reduction or equivalent to taking approximately 57 cars off the road. ■