DEC
engineering sustainability

DEC VANCOUVER
309-713 COLUMBIA STREET,
NEW WESTMINSTER, B.C. CANADA V3M 1B2
TEL. 604 525-3341
ENGINEERINGSUSTAINABILITY.COM

DEC VICTORIA
211-957 LANGFORD PARKWAY
VICTORIA, B.C. CANADA V9B 0A5
TEL. 250 381-9622

Whistler Athletes' Village District Energy Sharing System

Introduction and System Overview

The Whistler Athletes Village is located in the Resort Municipality of Whistler, British Columbia, and was originally constructed to house the athletes competing at the 2010 Olympic Games. The buildings in Phase 1 have, now, been converted for Residential usage and have been in operation for over a year, during which time 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 the heating and cooling the project. The system is designed for an eventual community of 400 residential units and their ancillary services. Treated sewage is pumped from the Treatment Plant to an adjacent Mechanical Plant Room where it is filtered before passing though a bank of heat exchangers. If there is insufficient heat to maintain the set water temperature, boilers are activated in sequence to maintain DESS output temperature. Two-pipe, closed loop system around the Athlete's Village, provides the energy required by all of the connected Heat Pumps in the project. The clean water is pumped through high density polyethylene piping, to the Heat Pumps within each of the Village buildings, transferring the low intensity energy from the DESS, into the higher energy required for heating and cooling. The heat pumps in each of the units are selected for 60% of the peak capacity using either natural gas or electricity. Back-up electric heaters are installed in each building. The completed installation was designed to provide a 50% reduction in overall energy consumption and a 70% reduction in greenhouse gas emissions, when compared to conventional heating systems. The following pages show the results from the data received from the monitoring equipment, the comparison with the initial calculations and the total energy savings. Total Site Estimate for the completed project was calculated as being 16,000,000 BTU/Hr. This Total Site Load was estimated, using General Energy Intensity Values per Floor Area and inserting these figures into the firm's in-house software. Sheet #1 of these calculations is attached as an Addendum to this report for your information.

Energy Efficiency

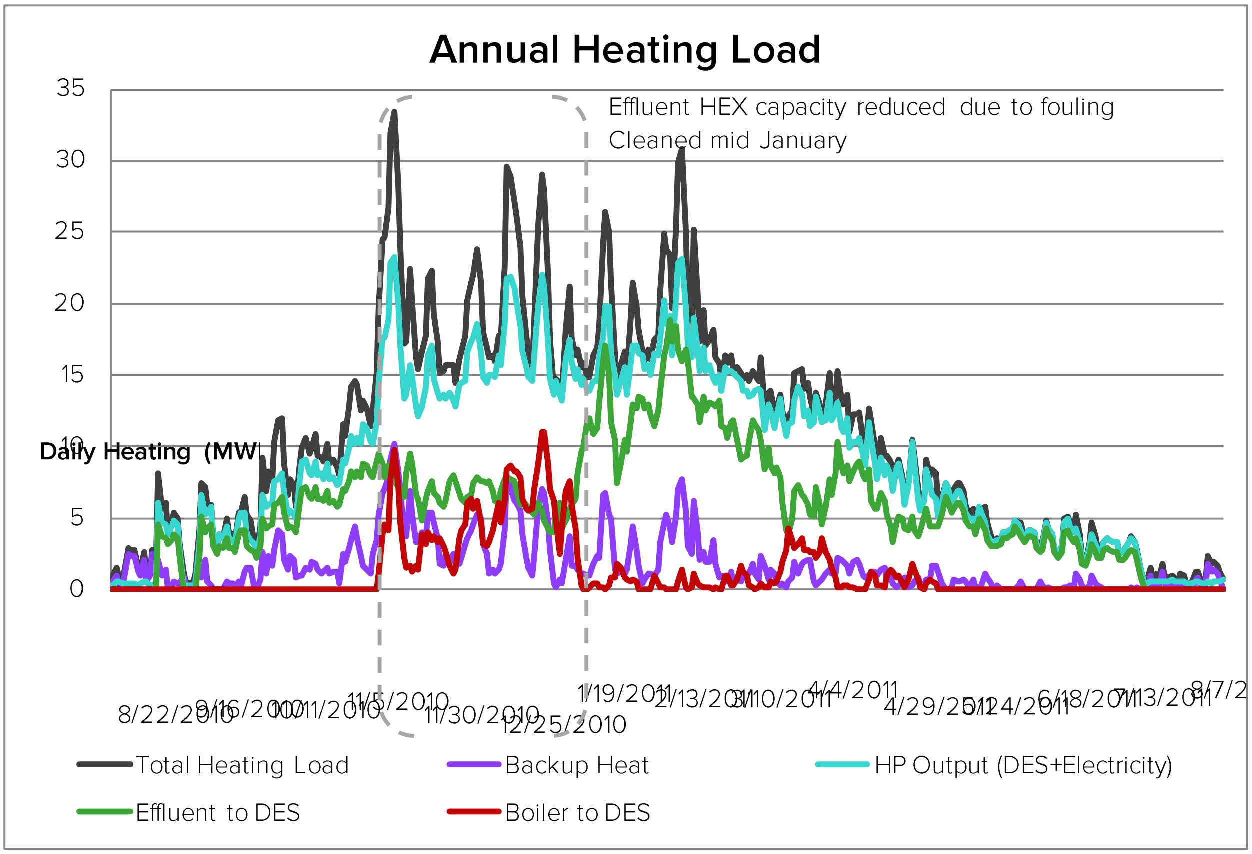
The project has completed one full year of operation and the actual loads that have been experienced have been monitored. The projected buildings are 82% Residential and 18% Commercial/Industrial with the existing Commercial Building being the Hostel The loads that have been used in arriving at the savings are actual and, although there have been some hitches due to start-up, control system adjustment and effluent filtering, they compare, favorably, with thr 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 pumps and the reclaim of energy from the connected buildings. Measurements cover the period from August 2010 to August 2011.

The break-down is as follows. (Loads are measured is in Megawatt Hours and kBtu/sq.ft./yr):

Electricity used by all attached Heat Pumps	836 MWh	3,852,432 KBtu
Electricity used by all Circulating Pumps	220 MWh	750, 640 KBtu
Back-up Electric Heat	605 MWh	2,064,260 KBtu
Back-up Natural Gas Heat	213 MWh	726,656 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 MW	9,042 KBtu
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%	

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. By improving the central boiler efficiency and maintaining the effluent heat exchange performance through automatic filter cleaning, the total reduction in energy compared to traditional systems is expected to reach 60%. The tweaking of the boiler systems is already improving the efficiency of the DESS. Boiler efficiency will certainly improve as Phase 2 construction is connected into the system.

Figure 1 – Annual Daily Heating Load and Energy from Sources.



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 2010-2011 weather data, and the balance temperature was adjusted such that the modeled DESS loads matched the measured DESS loads.

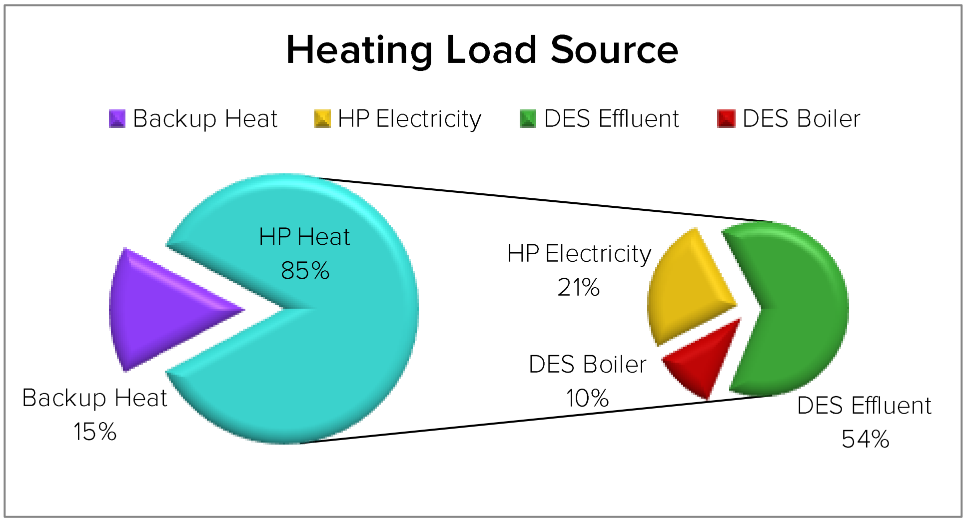
The above plot shows the daily heating load, and the heating output of the building backup heat (electric for residential and natural gas for commercial) and the building heat pumps. The energy supplied to the heat pumps by the effluent heat exchangers and the natural gas boilers is also shown. The effluent and boiler energy output to the district energy system was measured throughout the year. The backup heat and heat pump electricity usage has been estimated from the heat pump manufacturer's specified COP.

From November 2010 to January 2011, the capacity of the heat exchangers was reduced due to fouling. The heat exchangers were cleaned in January 2011, which significantly improved the performance. The improved filtering, described in the introduction, will provide a further improvement in future years.

The two back-up hot water boilers are of the High Efficiency Condensing type rated at 879 KW each, fired with Natural Gas.

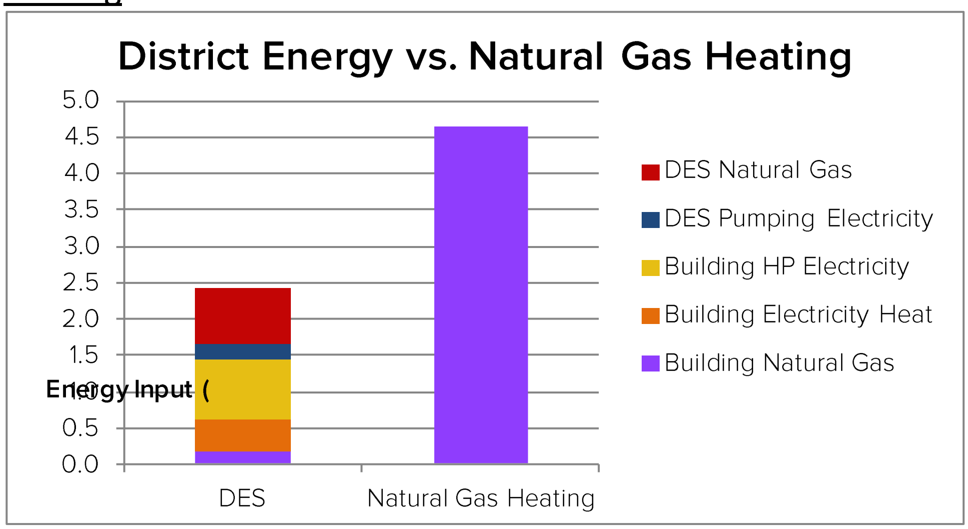
Domestic water in all of the attached buildings is heated by the building heat pumps drawing energy from the DESS,

Figure 2 – Breakdown of Heating Sources



The above figure illustrates the heating energy provided from each source. The chart indicates the percentage of building heating from backup sources (i.e. electric for residential, natural gas for commercial) and the heat pumps.

Figure 3 – Comparison of Energy Input between DESS and Traditional Natural Gas Heating



This figure compares the total energy consumed by the Whistler Athletes' Village District Energy System with a standard distributed natural gas heating system of the same size. The natural gas heating assumes that the building's boilers operate at 85% efficiency. The DESS energy consumption is separated into the various sources of electricity and natural gas. Energy from effluent is not shown as it is considered as 'free' energy.

The one DESS central boiler in use, operated with an overall efficiency of 49%, due to the short cycling during run times. For much of the winter, the amount of additional heat that was required to supplement the effluent heat exchange, was less than the turn down ratio of this boiler. This problem will disappear in the future when Phase 2 goes ahead. In the meantime the energy wastage is minimal.

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 according to ASHRAE Standard 55-2007 . Each of the attached residential units has its own Heat Pump or Heat Pumps, taking its 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. The domestic water is also heated by the energy drawn from the DESS.

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. A water to air 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 (ASHRAE HVAC Application 2007), heating is provided by Radiant Floors. Control set points for temperature are always within acceptable ranges that provide the thermal comfort according to the ASHRAE 55-2004 calculation method

Innovation

The Innovation aspects of this project rests completely in the District Energy Sharing System (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. As previously pointed out, the first years operation of the system is producing an energy saving of almost 50% compared to the energy usage for comparable building. As the system is expanded and the operation is refined, it is expected that this figure will rise to a 60% saving. When the Wastewater Plant is upgraded to Tertiary Treatment, the DESS will be able to distribute the clean effluent to the development, for toilet flushing and irrigation, one more savings feature.

Operation and Maintenance

The project is controlled by a technology advanced ESC Automation Management System that co-ordinates and optimizes the DESS Systems to ensure the maximum of energy saving along with maximum indoor comfort conditions. The control system utilizes 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 control system is monitored by the Wastewater Plant Operators and independently by an outside consulting firm. The foregoing figures and graph have been produced from data received from these sources.

Cost Effectiveness

The Capital Cost for the completed Village's DESS was estimated at $4-5 Million. A comparable conventional district heating system was estimated at between $25 and $33 Million ($20-$25 Million for insulated steel pipe and ($5 to $8 Million for the Energy Center). The DESS uses high density polyethylene, un-insulated piping, operates at ambient temperatures, benefits from energy sharing between buildings in heating and cooling modes, requires less capital and operating costs and has the opportunity to distribute reclaimed water. The DESS has an estimated design life of at least 50 years.

Environmental Impact

Reduction in Greenhouse Gases is a key factor in the installation of the DESS. The provision of polyethylene for all of the underground piping and the future the use of tertiary effluent for non toxic water distribution are examples of the reductions.

Water Efficient Domestic and Landscaping

As noted previously, the existing Primary Treatment Plant is set up for the addition of Tertiary Treatment. When this occurs, non-potable water will be pumped around the project for use for toilet flushing and irrigation. It is estimated that this would give a 20% reduction in the domestic water supply cost.

Optimum Energy Performance

The previous calculations show that the savings attributable to the DESS are 47% for Natural Gas and 39% for electric heating when compared to comparable buildings. These are as borne out in this first year of operation. The expectation is that these figures will be increased in future years, particularly when the Tertiary Treatment comes on line.

Commissioning

Commissioning was carried out by a third party Commissioning Agent. This Agent was involved from the beginning of the project.

Minimum IAQ Performance

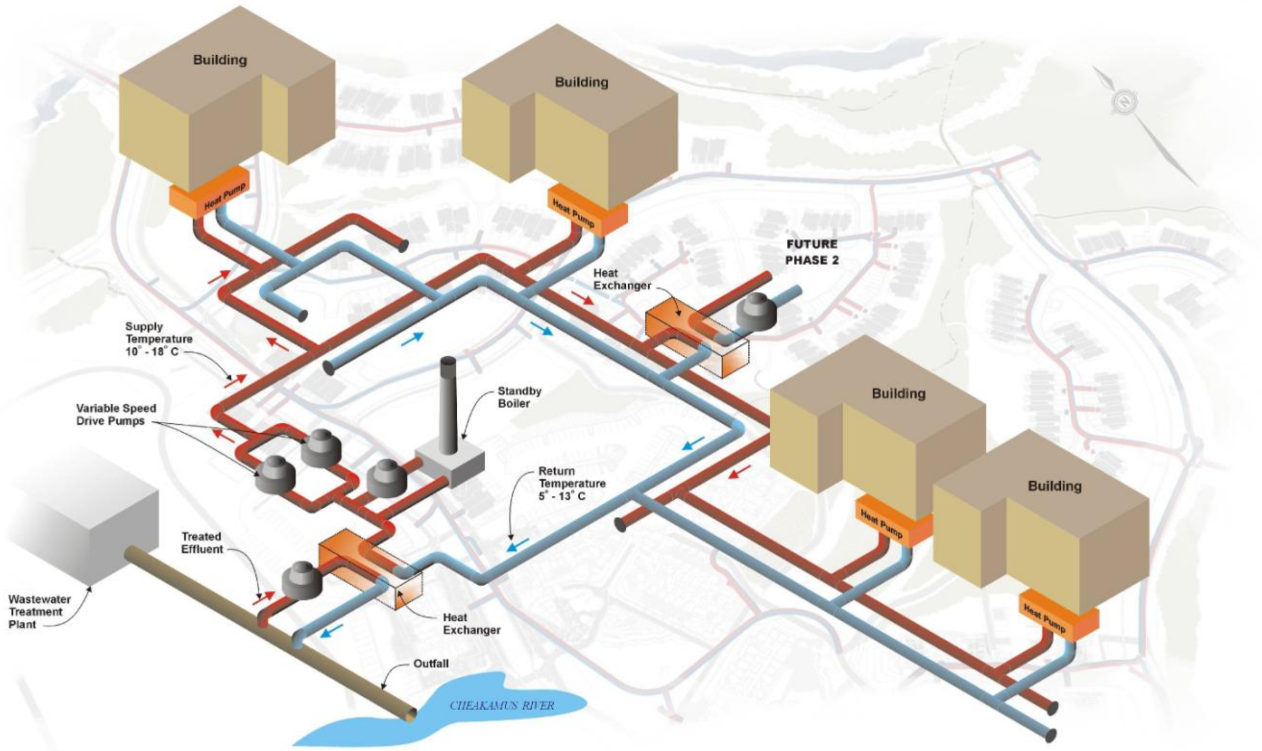
The requirements of Ashrae 62-200 have been met, documented, and are being monitored.

Measurement and Verification

The Developer has implemented a plan to monitor the performance of the DESS on a continuing basis. The output is available to all parties. As indicated in the foregoing, these measurements were used in our foregoing calculations and graphs.

Thermal Comfort

The operating staff has been trained in the operation of the plant and the connected systems and is available for any maintenance or repairs in the attached buildings. The calculations indicate that the DESS will attain a 70% reduction in Greenhouse Gas emissions.



Whistler Athletes' Village District Energy-Sharing System Schematic

Two-pipe closed loop can provide both heating and cooling.