FEATURE

Leading Canada by Example:

University of British Columbia invests in greener infrastructure

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The University of British Columbia (UBC), near downtown Vancouver, is fully committed to sustainability and is doing all that it can to lead Canada by example to a greener future. In 1990, UBC was among the first signatories of the Talloires Declaration – a 10-point action plan for incorporating sustainability and environmental literacy at colleges and universities, signed by more than 350 institutions in more than 40 countries. Since then, UBC has been delivering on this agreement – and much more. It has become the first university in Canada to adopt a sustainable development policy (1997), open a campus sustainability office (1998), publish a campuswide sustainability strategy (2006), become designated as a Fair Trade Campus (2011) and receive a gold rating in STARS (2011), the Sustainability Tracking, Assessment & Rating System of the Association for the Advancement of Sustainability in Higher Education. Over the past 15 years, the concept of sustainability has become an embedded part of UBC's culture, influencing research, teaching, projects and overall operations in an effort to make the world a better place.

UBC has implemented many different sustainability initiatives across the campus – from creating compost programs and transit incentives (increasing ridership by 230 percent in six years) to growing organic food for a campus farmer's market and optimizing efficiencies in older buildings.

Most notably, UBC has set its goals to the skies for reducing greenhouse gases, which so far has been another success story. In 2007, UBC became the first Canadian university to achieve the Kyoto Protocol's international targets for greenhouse gas reductions – five years before the Kyoto deadline. It did so by reducing the greenhouse gas emissions of its core academic buildings by more than 6 percent below 1990 levels, despite a 35 percent growth in floor space and a 48 percent increase in student population between 1990 and 2007. After realizing more than CA$18 million ($16.39 million) in energy savings from this initiative, UBC set aggressive milestones for continued environmental improvements.

At the GLOBE 2010 international environmental conference in Vancouver, UBC voluntarily announced its Climate Action Plan targets of reducing annual greenhouse gas emissions from the 2007 milestone an additional

- 33 percent by 2015,
- 67 percent by 2020 and
- 100 percent – achieving net zero emissions – by 2050.

Measures to upgrade the campus district energy system are a key component of UBC's plan to reach these new more ambitious targets.

FROM STEAM TO HOT WATER

Since 1924, UBC's Vancouver campus has been served by a central steam heating system. The central plant currently houses four boilers, ranging in age from 37 to 53 years, with a combined production capacity of 420,000 lb/hr. This system has been supplying more than 130 buildings totaling approximately 1.3 million sq m (14 million sq ft) of space – representing 80 percent of core campus facilities.

But as UBC takes aim at the 2015 emissions reduction target, it has embarked on a major district energy system upgrade that is converting the aging steam-based network to hot water. Under construction since

The University of British Columbia's stunning Vancouver campus is set on the western tip of the Point Grey Peninsula. Here the North Shore Mountains and Burrard Inlet provide a majestic backdrop for the university.

2011 and slated for completion in 2015, the new low-temperature hot water system will provide the platform for achieving the university's long-term energy goals and eliminating fossil fuel use. It is also expected to decrease campus greenhouse gas emissions by 22 percent or more.

A budget of CA$88 million has been dedicated to replacing the steam infrastructure. The project involves the installation of approximately 12 km (7.5 miles) of insulated distribution piping, more than 110 energy transfer stations across campus and a new 60 MW (205 MMBtu/hr) natural gas-powered hot water Campus Energy Centre (CEC). The conversion project is being rolled out in nine phases, and, as of February 2014, was more than halfway complete.

Until the CEC plant is built in 2015, a Temporary Energy Centre (TEC) is converting steam from the existing central plant to provide up to 16 MW (55 MMBtu/hr) of hot water to heat the growing number of buildings as they are converted to the new system. The TEC houses two 8 MW steam-to-hot-water heat exchangers and two distribution pumps, all in a 40-ft storage container.

Supplementing this hot water source is UBC's new Bioenergy Research and Demonstration Facility (BRDF), a CA$27.4 million first-of-its kind biomass combined heat and power system built in 2012. The BRDF gasifies wood waste to create synthetic gas that is used to concurrently produce up to 2 MW of electricity (using Jenbacher engines) and 3 MW (10 MMBtu/hr) of thermal energy – by generating 10,000 lb/hour of steam and converting it to hot water with oversized heat exchangers from a neighboring building. Alternatively, if electricity is not required, it can produce 6 MW (20 MMBtu/hr) of thermal energy by generating 20,000 lb/hour of steam. In addition, the hot water collected from waste heat recovery by a separate heat exchanger is also directed into UBC's district energy system.

In 2013, the BRDF supplied the campus with 14 percent of its average annual heating requirements through hot water – up to 11 percent in the winter and up to 26 percent in the summer. Once the hot water district energy system is completed, the BRDF will be able to supply more than 20 percent of the average annual demand, including the majority of the summer demand. Improvements are still being made on the BRDF, and it is expected to be able to provide up to 8.5 MW (29 MMBtu/hr) of thermal energy by midyear 2014 and still generate 2 MW of electricity (6 percent of the UBC academic core electrical consumption). It is projected to cut UBC gas consumption by 12 percent and reduce annual emissions by 9 percent or more.

ONCE COMPLETED, UBC'S DISTRICT ENERGY SYSTEM WILL BE ONE OF THE LARGEST STEAM-TO-HOT-WATER CONVERSION PROJECTS IN NORTH AMERICA.

Once completed, UBC's district energy system will be one of the largest steam-to-hot water conversion projects in North America – providing space heating and domestic hot water to more than 130 buildings covering more than 800,000 sq m (8.6 million sq ft) of floor space, delivered through the new distribution network from the new Campus Energy Centre. When the new plant

Installation of 16-inch preinsulated hot water distribution piping, University of British Columbia

is up and running, the BRDF will continue to act as the base energy source throughout the year for hot water production for the UBC district energy system, while the CEC will adjust its heating supply to match the varying seasonal demands on campus. The existing central steam plant is scheduled to be demolished in 2016, and the TEC will be available for sale to third parties who have already expressed interest.

Besides lowering emissions by 22 percent, converting from steam to hot water is estimated to save the university up to CA$5.5 million in annual operational and energy costs. These cost savings will be driven by energizing hot water at a lower annual average supply temperature of around 80 degrees C (176 F) using variable-speed pumps, compared to steam at an annual average supply temperature of 190 C (374 F) – thus burning less natural gas to heat the supply. Further savings will be realized by replacing the aging distribution network, thereby eliminating leaks throughout the underground network and the high costs of maintaining a high-pressure steam system. Other project elements, such as carbon tax credits from using renewable natural gas, will contribute to cost savings as well, although to a lesser extent.

In addition to installing the new hot water system and BRDF, UBC 's energy improvements include measures to optimize academic building energy performance. This is expected to lower emissions by 10 percent through the replacement of pumps, chillers and other mechanical equipment, as well as through recommissioning automated building management systems such as heating, ventilation, cooling and lighting.

PIPING SYSTEM DESIGN

To implement such a massive infrastructure project and achieve its ambitious targets, UBC awarded the design of the hot water distribution piping system to British Columbia-based Kerr Wood Leidal Associates Ltd. The design team used a demand-based approach to optimize the distribution network by minimizing pipe sizes and total pipe length, while increasing the ratio of the total distance of the main header loop compared to the branches.

Special design considerations were also given to the existing underground conditions, which include a complicated network of buried utilities. With close communication and the support of UBC Utilities and its geographic information system utility maps, the team performed test excavations during the design stage to confirm the location of any critical conflicts with existing utilities. Based on the results of the test excavations and existing as-built drawings, a shallow piping design was implemented where required, along with the necessary provisions for piping protection. Additionally, expansion loops were installed in strategic locations, providing flexibility to overcome conflicts with the existing utilities.

Following UBC's mandate to reduce its greenhouse gas emissions by 33 percent by 2015, the design incorporated existing infrastructure and utilized waste heat recovered from the BRDF cogeneration plant in the district energy system. The system was further optimized by locating the new CEC next to the Life Sciences Centre, source of one of the largest energy demands on campus. Cascading the district piping system at Life Sciences using a three-pipe system allowed for a relatively lower design temperature and additional energy savings.

CONSTRUCTION CHALLENGES

UBC's decision to implement the district energy system in nine phases provided an opportunity to adapt the design so that completed phases could be energized and commissioned before the new CEC is finished in 2015. This was achieved through the addition of the TEC, which utilizes the existing central steam plant to heat the hot water district energy system as each new phase is completed across campus. UBC is able to realize significant energy and cost savings by expediting connection to the hot water distribution piping system and decommissioning sections of the existing inefficient steam distribution network before overall project completion.

Although phasing the construction has allowed for earlier cost and energy savings, it has also presented some challenges. To secure the total funding for the project, construction across the north campus of UBC was divided into nine phases, and the project team was required to demonstrate that the first four phases of underground piping and energy transfer station installations could be delivered on time, within budget and produce the expected performance and sustainability results.

As this process was repeated three times before full funding became available, the selection of an experienced and dependable contractor was of paramount importance for project viability. British Columbia-based Division 15 Mechanical Ltd. was procured for the majority of the construction to date. With a tight budget for a project of this size and scope, Division 15's construction team used creative strategies to ensure that each phase would be completed within the construction time frames. The team mobilized multiple construction crews and implemented concurrent construction activities in selected locations to ensure minimum disruption to the university.

To further optimize construction and reduce the project cost, synergies between other concurrent landscape and construction projects were identified and achieved through careful scheduling of activities. The strong on-site presence of the construction management team and weekly site coordination meetings involving different project teams minimized conflicts and duplication of activities and enhanced shared tasks like common trenching and restoration.

The fact that UBC operates in many ways like a small, isolated city – providing its own electricity, heat, public transit, security, emergency response, hospital, hotels and more – presented some significant construction challenges. In response, the construction team had to develop and implement detailed traffic management plans. Such plans had to accommodate the campus's ongoing construction activities; uninterrupted regular delivery service to laboratories, restaurants and the local hospital; limited single-path fire access constraints; transit bus services through parts of the campus; and the potential for 66,000 staff, faculty and students to be moving by foot or by car every hour when classes change.

Despite the countless planning efforts, the above complexities in combination with the large project magnitude and busy network of underground utilities meant that unexpected challenges were unavoidable. This dictated the need for a seamless collaboration between the owner and design and construction teams to ensure swift and proper responses to the challenges, especially the unexpected site conditions and conflicts with existing underground utilities.

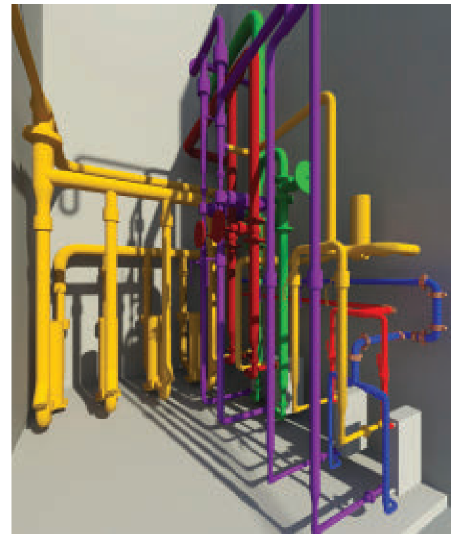
SEAMLESS COLLABORATION BETWEEN THE OWNER AND DESIGN AND CONSTRUCTION TEAMS WAS DICTATED TO ENSURE PROPER RESOLUTION OF UNEXPECTED CHALLENGES.

To meet UBC's aggressive schedule and ensure that the university fulfills its 2015 emissions reduction commitment, Division 15 Mechanical's construction team incorporated laser scanning in mechanical rooms of existing operational buildings, mapping their current conditions and installations. This innovative approach allowed the use of building information modeling to create 3D virtual models of the new hot water energy transfer stations (fig. 1), which in turn facilitated faster off-site prefabrication, minimized conflicts and reduced change orders. Prefabricated pieces were then assembled more quickly on-site, minimizing disruptions to the students and regular university operations.

QUALITY CONTROL AND COMMISSIONING

Regardless of the project size, complexity, schedule and budgetary challenges, compromising the quality of the installation was never an option for UBC. Therefore, quality control was of paramount importance for the construction team, as the primary side of the new hot water energy system was designed not only to comply with the British Columbia Safety Authority's code requirements but also to exceed

Figure 1. Detailed 3D Model of a Hot Water Energy Transfer Station, University of British Columbia.



Source: Division 15 Mechanical Ltd.

ASME B31.1 Standards of Pressure Piping. This dictated the implementation of a rigorous quality control plan, performance of 100 percent radiographic examinations (x-rays) of all underground welds, maintenance of detailed weld maps and logs, and ongoing leak detection testing of the preinsulated piping.

Additionally, converting from steam to hot water provided the perfect opportunity for UBC to investigate each building's mechanical system more thoroughly. Through the development of detailed commissioning plans, the project teams were not only able to properly commission the newly installed hot water energy transfer stations but also to make the necessary changes to improve the efficiency of existing older mechanical systems. In many cases, the commissioning process has identified older existing steam processing equipment, from dishwashers to humidifiers to kilns, which can be converted to hot water or removed completely. The added bonus of this ongoing optimization will be a further reduction in UBC's operational costs and greenhouse gas emissions, which will give UBC a head start toward its next goal of a 67 percent reduction by 2020.

The future looks busy at UBC, as it should at more and more universities across the globe. As the university has demonstrated, millions of dollars of operational cost savings are available annually by reducing building loads and improving mechanical systems. District energy can play a major role in a shift toward operating more sustainably and cost-effectively, and it is possible to implement in phases as budgets allow. Universities and cities alike are encouraged to seize the opportunity to implement these technologies and embark on a path to a more sustainable future.

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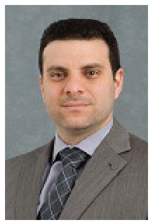

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***Dinos Hadjiloizou, LEED AP**, is an experienced project director, heading the district energy department at Division 15 Mechanical Ltd., a construction firm providing design-build, design-assist and construction services for mechanical and district energy systems throughout British Columbia. With a track record of successfully completing multimillion-dollar projects, Hadjiloizou leads the implementation of many district energy systems, including the one at the UBC. He holds Master of Mechanical Engineering and Master of Business Administration degrees. He can be contacted at DinosH@div15mechanical.com.*