CASE STUDY

University of Victoria Student Housing and Dining Complex

Net-Zero Energy-Ready Challenge Winners Series | May 2024

ZERO EMISSIONS BUILDING EXCHANGE

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The Net-Zero Energy-Ready Challenge

The Net Zero Energy-Ready (NZER) Challenge is a CleanBC incentive program, launched in 2018, for large buildings. In addition to providing financial support for developments targeting NZER levels of energy efficiency (top step of the BC Energy Step Code or the Passive House standard), the program aims to celebrate, promote and learn from these innovative and exemplary projects.

Out of over 50 applications received, a juried competition resulted in the selection of 11 winning projects that represent the best examples of NZER buildings. These projects received up to $390,000 in incentives to help cover the estimated cost premiums associated with the design and construction of NZER buildings. Some of these projects were constructed for less than the cost of an equivalent building that met the minimum requirements of the BC Building Code.

UBCO Skeena Residence (Credit: Andrew Latreille)

Carrington View Building A (Credit: Skyline Living)

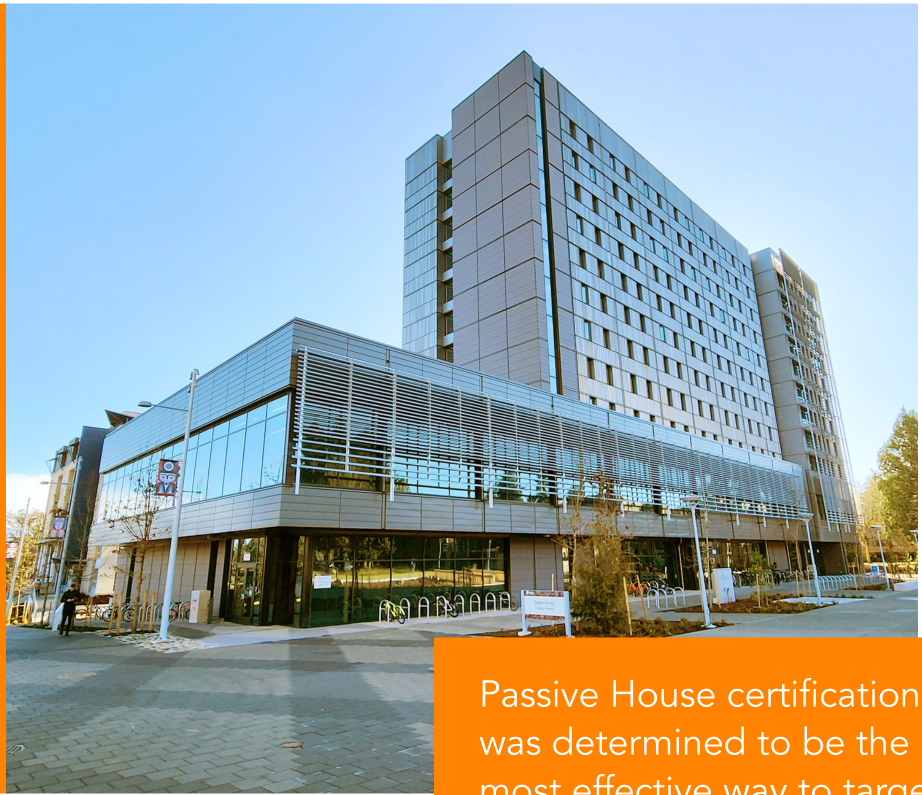
OSO (Credit: Seth Conlin, In Flight Robotics)

Project Overview

Buildings are the biggest source of emissions in large urban centres like Vancouver and Victoria and this is almost entirely due to burning fossil fuels for space heating, hot water heating, cooking and fireplaces. At the University of Victoria, buildings represent an astonishing 97% of the campus's emissions, 92% of which are due to the burning of gas, diesel and heating fuel. The University has committed to reduce its emissions 50% by 2030 and achieve net zero emissions by 2040 (relative to a 2010 baseline). Prior to the completion of the first phase of this project, the University had reduced emissions by 30%. To achieve its 2030 and 2040 targets, the University concluded that all new buildings must be near-zero emissions (all-electric) and the campus's gas-fired district energy system (owned and operated by the University) must be decarbonized.

The new student residences were the largest capital project in the University's history. They presented the University's Campus Planning and Sustainability team with a golden opportunity to follow through on the University's commitment to climate action. Until this project, the University had targeted LEED Gold for its most recent projects. For this project, the University decided to pursue both LEED Gold (v.4) and Passive House certification. In the absence of the Province's new Zero Carbon Step Code, requiring Passive House certification (Primary Energy Renewable pathway) was determined to be the most effective way to target emissions reductions.

A major challenge to achieving this goal was the very large commercial kitchen in one of the two buildings and the very high concentration of students residing in the two buildings. Ultimately, air source heat pumps were the technology that contributed the most to the emissions reductions.



Passive House certification was determined to be the most effective way to target emissions reductions.

With these two new buildings, the University increased the number of beds on campus while reducing the campus's overall emissions. This is because the climate-friendly, 783-unit complex replaced three older emissions-intensive buildings including two residences comprising 162 units in total. With an increased capacity of 621 beds, the University is also better able to meet its live-on-campus guarantee for first-year students.

Project Specs

Address	Cheko'nien House: 2425 Sinclair Rd Sngequ House: 2429 Sinclair Rd Victoria, BC
Climate Zone	4
Ownership Type	University student residence and dining facility
Residential Units	Cheko'nien: 398 Sngequ: 385
Levels [1]	Cheko'nien: 8 Sngequ: 11
All-Electric Buildings [2]	Yes
Minimum Building Code Requirement	BCBC 2018
Canadian Construction Documents Committee Contract	CCDC 5B
Gross Floor Area	Cheko'nien: 16,236 m^2 (174,763 ft^2) Sngequ: 14,577 m^2 (156,906 ft^2)
PHPP Treated Floor Area	Cheko'nien: 11,473 m^2 (123,494 ft^2) Sngequ: 10,726 m^2 (115,454 ft^2)
Window-to-Wall Area	Cheko'nien: 23% Sngequ: 14%
Form Factor [3]	Cheko'nien: 1.4 Sngequ: 1.2
Construction Start	Cheko'nien: April 2020 Sngequ: February 2021
Construction Completion	Cheko'nien: July 2022 (27 months) Sngequ: July 2023 (29 months)

As-Built Airtightness at 50 Pa (ACH)	Cheko'nien: 0.22 Sngequ: 0.38
Primary Energy Renewable (PER) [4]	Cheko'nien: 325.5 kWh/m2yr Sngequ: 96.2 kWh/m2yr
Final Energy Demand [4]	Cheko'nien: 610 kWh/m2yr Sngequ: 160.7 kWh/m2yr
Annual Heating Demand [4]	Cheko'nien: 10.5 kWh/m2yr Sngequ: 14.1 kWh/m2yr
Annual Cooling Demand [4]	Cheko'nien: 0.1 kWh/m2yr Sngequ: 0.1 kWh/m2yr
Greenhouse Gas Intensity (GHGI) [5]	Cheko'nien: 6.71 kg CO2eq/m2yr [6] Sngequ: 1.77 kg CO2eq/m2yr

1: The buildings do not have a basement or underground parking.

2. The domestic hot water systems of each building are connected to the University's gas-fired district energy system for both supplementary heating and full redundancy (backup). Some gas appliances are installed in the commercial kitchen.

3. The form factor is the ratio of the building envelope area (all areas where heat loss can occur) divided by the gross floor area. Using the treated floor area from PHPP for the calculation results in a higher form factor.

4. Based on the PHPP modelling which incorporates the final airtightness test results. For Cheko'nien House, PHI determined that the maximum PER value was 332.8 kWh/m2yr. For Sngequ House, PHI determined that the maximum PER value was 98.8 kWh/m2yr.

5. Calculated by multiplying the final energy demand by the 2023 emissions factor for electricity listed in the BC Building Code (Section 10.3). The handful of gas-fired appliances in the commercial kitchen are not included in the GHGI.

6. The high energy requirements of the commercial kitchen in this building result in a higher GHGI. Cheko'nien House would meet EL-2 of the new BC Zero Carbon Step Code. Sngequ House would meet EL-4 (top step).

Project Team

Owner	University of Victoria
Project Manager	Colliers Project Leaders
Construction Manager	EllisDon Kinetic Joint Venture
Mechanical Contractor	Strathcona Mechanical
Architect	Perkins+Will Architects
Building Envelope, Energy Modelling and Passive House Consultant	RDH Building Science
Passive House Certifier	Passive House Institute
Kitchen Consultant	Kaizen Foodservice Planning & Design
Structural Engineer	Fast+Epp
Mechanical Engineer	Introba
Electrical Engineer	WSP Engineers

Photo credit: Perkins+Will Architects

Project Highlights

Not a Normal Commercial Kitchen

One of the most unique aspects of this project was the large commercial kitchen in Cheko'nien House. It was designed to provide approximately 9,000 meals a day in a 715-seat, two-level dining hall. The Passive House Institute (PHI), the certifying organization, had never certified a Passive House building with a commercial kitchen this large before. Based on significant input from the project's design team, PHI developed a set of certification criteria, not only for this project, but for all future projects with commercial kitchens targeting Passive House certification (worldwide).

To achieve the certification criteria developed by PHI for this project, the use of gas-fired appliances had to be almost eliminated. Instead, highly energy-efficient induction cooktops were selected for all but a handful of cooking stations. With almost no gas-fired appliances, the energy required to keep the kitchen from overheating is greatly reduced.

A major source of energy consumption in a commercial kitchen is the energy required (exhaust fans and make-up air fans). To reduce energy consumption, variable-speed exhaust fans were installed. Each range hood can automatically adjust the hood's exhaust airflow based on real-time parameters such as temperature, relative humidity (moisture), CO^2 and NO^2. Optimizing the exhaust airflow not only reduces the energy required to operate the fans but it also reduces the energy required to condition the incoming make-up air. The hood's capture efficiency was increased with the installation of side guards and a proprietary air nozzle system.

"The Student Housing and Dining Project exemplifies the University's dedication to energy efficiency and emissions reduction. A key project highlight was the transition of our kitchen equipment to induction cooking within a Passive House building, representing a crucial shift towards a more sustainable student residence community, integrating climate action and operational efficiency."

Mike Wilson, Director of Campus Planning & Sustainability, University of Victoria

Another novel approach taken by the mechanical design team to reduce ventilation-related heating demand was the installation of a customized heat recovery system that transfers heat from the exhaust air streams to the make-up air streams when required. The heat recovery system consists of a hydronic coil in the exhaust fans and make-up air units, piping to interconnect them and pumps to circulate water between them. Should the heat recovery system be insufficient to warm the incoming air, electric duct heaters provide the additional heating.

Some of the other energy conservation measures for the kitchen include the use of heat pumps to generate domestic hot water, grouping appliances with similar ventilation requirements, setting a lower temperature setpoint for the incoming make-up air, and passive hot water heat recovery.

This kitchen is likely to consume four to five times less energy than a conventional commercial kitchen (0.94 kW/meal instead of 4.15 to 4.7 kW/meal).

"The project has accelerated our response to climate change by advancing our strategies for building systems electrification, including our District Energy Plant (DEP). The electrification of our DEP is a critical initiative that reinforces our commitment to climate action and plays a pivotal role in achieving our ambitious emissions reduction targets."

Mike Wilson, Director of Campus Planning & Sustainability, University of Victoria

A High-Carbon District Energy System

In 2019, prior to the start of construction, the University had upgraded its district energy system (DES) with three new, high-efficiency, gas-fired boilers. The DES is connected to 32 buildings across campus. During the early design stages of the project, it became evident that the Primary Energy Renewable (PER) pathway would be the best way to achieve the University's emissions-reduction goals. However, this, along with the very high domestic hot water (DHW) demand, precluded the use of the University's carbon-intensive DES. As a result, it was determined that on-site, electric heat pumps would be used for both space heating and DHW. If the buildings were to have used the DES as the source for DHW or space heating, it would have been extremely difficult to achieve Passive House certification because the PER value is negatively impacted by a non-renewable fuel source. In addition, given the very high demand for DHW in the buildings, connecting to a gas-fired DES, even with its high-efficiency gas-fired boilers, would have resulted in an increase in the University's emissions. The University was aiming for the opposite. Nonetheless, the University chose to connect the two buildings to the DES as a source of both supplemental and full back-up DHW heating.

Preparing for a 2050 Climate

The 2018 BC Building Code (BCBC) required that HVAC designs be based on historical weather data to determine the heating capacity of the mechanical systems and did not require cooling for residential buildings. Because the original intent was to build a student residence without cooling, Introba encouraged the University to analyze the overheating risk of the design by using energy modelling and future climate data, something Introba had been doing on its Passive House residential projects since 2019.

The rest of the University's student housing does not have cooling and on occasion in the summers, overheating occurs in the residences. During the design process, the province was also experiencing above-average summer heat and some forest fires. This brought thermal comfort in a future climate to the forefront of design conversations and the decision was made to assess the overheating risk and, if present, assess different cooling strategies to address it.

> **Based on the expected service life of the mechanical equipment, the project team targeted thermal comfort for 2050.**

For the assessment, 2050 and 2080 regional climate projections were provided by the Pacific Climate Impacts Consortium (a regional climate service centre at the University). Four cooling strategies were considered using the two climate projections: passive cooling, dedicated mechanical cooling, integrated cooling (integrated with the ventilation system) operating at a minimum ventilation rate and integrated cooling operating at double the minimum ventilation rates. After extensive analysis, it was determined that all four approaches would provide sufficient cooling for the current climate, only two approaches would provide sufficient cooling for 2050 and only dedicated mechanical cooling would provide sufficient cooling for 2080. The analysis was based on the 2013 CIBSE TM52 (The limits of thermal comfort: avoiding overheating) standard. Based on the expected service life of the mechanical equipment, the project team targeted thermal comfort for 2050. The two strategies on the table were integrated cooling with a 200% ventilation rate and dedicated mechanical cooling. To reduce costs, the University decided to proceed with an integrated HVAC system that can double the ventilation rate as required to maintain thermal comfort throughout the summer. In terms of duct sizing and equipment capacity, targeting thermal comfort in 2050 resulted in larger ducts and higher-capacity heat pumps to temper the ventilation air.

	Thermal Comfort (Line 1– CIBSE compliance) (Line 2 – PHPP results)			**Cost**
	Current Climate	2050	2080	
Passive Cooling	✓	X	X	$
	0%	1%	7%	
Hybrid Cooling (Minimum Ventilation)	✓	✓	X	$$
	0%	1%	7%	
Hybrid Cooling (200% Ventilation)	✓	✓	X	$$
	0%	1%	5%	
Mechanical Cooling	✓	✓	✓	$$$
	0%	0%	0%	

Technical Details

Structure

The structures of both buildings primarily consist of cast-in-place columns, walls and suspended slabs that are supported by a combination of raft slabs, ranging from 1 to 1.8 m thick, and pad footings. The structural specifications allowed between 30% and 50% supplementary cementitious materials (SCM) in the concrete mixes, depending on the structural component. Post-tensioned concrete transfer beams were constructed over the two large multi-purpose rooms in Sngequ House to allow for greater column spacing. The slabs-on-grade are installed on structural aggregate which was placed over the pad footings and raft slabs. Cheko'nien House includes a two-storey, mass-timber podium that wraps around a portion of the concrete structure. It is constructed of cross-laminated timber (CLT) panels, as well as glue-laminated beams and columns from Kalesnikoff, located in BC's Southern Interior. The CLT panels are covered in a concrete topping and exposed from below.

Installation of concrete formwork (Photo credit: Perkins+Will Architects)

Airtightness

Passive House projects require a minimum airtightness of 0.6 ACH (at 50 Pa). During the design development stage, the project team decided to aim for a higher level of airtightness to relax the energy performance requirements for the rest of the building envelope components. Ultimately, the aim was to reduce the overall cost of the project by focusing on the most cost-effective strategy to improve the energy performance of the buildings. To achieve the more stringent airtightness of 0.4 ACH, very careful attention was given to air barrier delineation, continuity and detailing during both the design and construction phases. Zonal airtightness tests (using temporary interior walls) were performed soon after the installation of the curtain walls glazing and windows began on the first building to be constructed. This was done to ensure that both the curtain wall and windows, as well as the air barrier tie-in to the surrounding exterior walls were not compromising the overall airtightness target.

> **In addition, full mid-construction airtightness tests (using diagnostic tools like smoke machines and infrared cameras) were conducted on both buildings to identify deficiencies in the air barrier.**

Soprema® Sopraseal Stick AVB PRO (and Stick VP in some locations) was adhered to the 16 mm (5/8") thick CGC SECUROCK® glass-mat exterior sheathing. The Soprema® base sheet membrane acts as the air barrier for the roofing assembly. A liquid-applied membrane was used for wall penetrations. These rigorous quality control measures by the entire project team allowed the buildings to greatly exceed the airtightness target.

Insulation

The typical above-grade, exterior walls were designed to achieve an effective, clear-field thermal resistance ranging from RSI 4.4 to 5.1 m^2 K/W (R-25 to 29). To accomplish this, 200 mm (8") of ROCKWOOL Cavityrock® stone wool insulation board was installed over the sheathing. The insulation is supported by a stainless-steel cladding support system (by LKMe) and insulation hangers (pins). Cavity insulation was installed in some locations only for sound attenuation and is not accounted for in the energy modelling. The typical below-grade concrete walls were designed to achieve an effective, clear-field thermal resistance of RSI 7 m^2·K/W (R-40). They are insulated with 200 mm of SOPRA-XPS extruded polystyrene (XPS) panels. The insulated slabs-on-grade were designed to achieve an effective, clear-field thermal resistance of RSI 1.8 m^2 K/W (R-10) with 50 mm (2") XPS insulation installed below them. The roofs were designed to achieve an effective, clear-field thermal resistance of RSI 11.6 (over concrete) and 13 (over CLT) m^2·K/W (R-66 and R-74, respectively). This was achieved by using a Soprema roofing assembly with a bottom layer of sloped polyisocyanurate insulation, a 250 mm (10") layer of polyisocyanurate insulation and a top layer of 65 mm (2 ½") stone wool insulation. The sloped insulation package, ranging in thickness from 12 mm (½") to 191 mm (7½"), is included in the energy modelling.

Insulation (Photo credit: Perkins+Will Architects)

Fenestration

Cascadia Windows & Doors provided Passive House-certified fixed windows and high-performance operable windows. Both types of windows are from their fibreglass-framed, triple-glazed Universal Series™. The insulating glass units (IGU) for the windows are argon-filled and have two low-emissivity (low-E) coatings and a solar heat gain coefficient (SHGC) of 0.33 (centre of glass). A low SHGC reduces the cooling load in the summer months. The average overall effective U-value of the windows ranged from 0.7 to 0.77 W/m^2K (ISO 10077). The detailing of the window installation was the result of an extensive and collaborative process between the design and construction teams that focused on delivering thermal performance while ensuring constructability. The detailing was assessed through energy modelling and a full-scale mock-up before proceeding with the window installation.

Installation of the sunshades (Photo credit: Perkins+Will Architects)

The curtain walls on the first and second levels of both buildings have operable windows at the top of the curtain walls that are controlled by the building automation system (BAS). The curtain walls consists of Wicona's Passive House-certified, thermally-broken WICLINE 90SG (operable) and WICTEC 50HI (fixed) curtain wall framing made of low-carbon aluminum. The triple-glazed IGUs are argon or krypton-filled (depending on the building), have a SHGC ranging from 0.257 to 0.535 and have two low-E coatings. The average overall effective U-value of the curtain walls ranges between 0.68 to 1.44 $W/(m^2K)$ for the portions with only fixed glazing and 0.88 to 1.06 $W/(m^2K)$ for the portions with operable glazing.

Shading

Fixed external horizontal and vertical sunshades were installed over or adjacent to many of the windows and curtain walls on the south and east elevations of both buildings, typically at larger glazed openings and where students congregate (dining hall, student lounges, etc.). Some of the glazed openings on the ground floor of both buildings benefit from second floor overhangs.

Internal, floor-to-ceiling, motorized blinds were installed on the curtain walls at the podium level of both buildings to control solar heat gain. The motorized blinds are controlled by the BAS to either maximize it in the heating season or minimize solar heat gain in the cooling season. The windows for the student bedrooms are inset so the surrounding wall can provide some shading.

Thermal Bridging

Thermal bridging was significantly reduced through an extensive collaborative process with the entire design and construction team. Every attempt was made to minimize the number of penetrations through the walls and roofs. The aluminum-framed fenestration is all thermally broken. Rooftop equipment supports, maintenance-access anchors, sunshade supports and a variety of other components are mounted to the roofs and exterior walls with structural thermal breaks such as plywood and Fabreeka-TIM® structural thermal pads. The cladding supports are made of stainless steel – a material with only 6% the thermal conductivity of aluminum. Instead of using aluminum for the wall flashing, a Soprema self-adhering air/vapour barrier sheet membrane was used, in part because of its lower thermal conductivity. The perimeter and foundation columns and walls are better insulated than for conventional projects to reduce thermal bridging through the slab-on-grade insulation layer. Parapets were detailed to allow the wall insulation to connect back to the roof insulation as a continuous layer.

The design team captured their efforts to minimize or eliminate thermal bridging in a thermal bridging tracker – an exhaustive list of all thermal bridges on both buildings. This information was translated back into the architectural drawings, where each junction and detail included its thermal performance (linear and point transmittances).

Swegon Gold RX Heat Recovery Ventilator (Photo credit: Introba)

Ventilation

To conform to the Passive House standard, the two buildings are ventilated with 23 heat recovery ventilators (HRV). The ventilation systems are zoned by elevation for the student residences and by the type of space for the remaining areas (excluding the commercial kitchen). Cheko'nien House includes eight semi-centralized systems and Sngequ House includes 15. Each system includes a Swegon Gold RX HRV ranging from size 05 to size 50 and from a sensible heat recovery efficiency of 83.5% to 89%. Most HRVs are located on the roofs of the two buildings. Ventilation air is supplied to each suite and exhausted out from the washrooms, electrical and communications closets, study rooms and student lounges on each floor. Smoke/fire dampers were installed in the return ducting at fire-rated shafts. No fire dampers were required for the supply ducts serving the suites because they are small enough to meet the exception rule in the building code.

Heating & Cooling

For highly energy-efficient buildings, the heating and cooling system can be integrated with the ventilation system. This often results in capital cost savings. A Mitsubishi City Multi heat pump is connected to the variable refrigerant flow (VRF) heating and cooling coils of each Swegon HRV to temper the ventilation air being supplied to all areas of the buildings. The heat pumps range in capacity from 15 to 85 kW (approximately 4 to 24 tons). An occupant-controlled 200 W electric baseboard heater is installed in each suite for back-up or supplemental heating. It is interconnected to a window sensor so that if the window is open, the heater is disabled.

Mitsubishi City Multi air source heat pump (Photo credit: Introba)

For the common areas on the first two levels of each building, a dedicated variable refrigerant flow (VRF) heating and cooling system supplements the heating and cooling provided by the ventilation air. The VRF systems include fan coil units in the ceiling plenums (ducted to supply and return grilles) and Mitsubishi heat pumps. VRF systems allow for simultaneous heating and cooling of different zones.

Two strategies were adopted for mixed-mode cooling of the dining hall and multi-purpose spaces in Cheko'nien House and the offices on the west elevation of Sngequ House. In these locations, the operable windows at the top of the curtain wall are motorized and controlled by the building automation system (BAS). When the BAS determines that cooling is required for a specific zone and the outdoor temperature is sufficiently lower than the indoor temperature, it opens the windows in the zone to cool the space (with cross ventilation and stack ventilation) before the mechanical cooling is activated.

Energy modelling showed that maximizing the use of outdoor air for cooling should reduce the annual cooling energy load by approximately 80%.

Should the air quality deteriorate because of forest fire smoke, the BAS closes the windows and the HVAC system maintains the spaces at a comfortable temperature while providing fresh, filtered outdoor air.

The second strategy employs the bypass mode of the Swegon HRVs to avoid transferring the heat energy in the exhaust air to the supply air. To reduce the likelihood of overheating on very hot days, the ventilation airflow can be increased (up to 200%) for more cooling capacity.

Domestic Hot Water

The two buildings are expected to require a staggering 28,000 L/day of domestic hot water (DHW). To fulfill this daily requirement with as little energy consumption as possible, heat pumps and drain water heat recovery were installed. Based on a limited variety of DHW heat pumps available during the early design stages, Colmac CxV-5 air-source heat pumps were selected to generate DHW for the complex. 15 DHW heat pumps are located on the roof of the six-storey portion of Cheko'nien House and ten are located in the three-storey external mechanical enclosure attached to Sngequ House. The podium levels of each building have separate DHW systems from the residential levels above.

These cold-climate air-source heat pumps can produce 60°C water at -12°C (outdoor air) and 49°C water at – 20°C. The coefficient of performance of these heat pumps varies from 1.9 at -9°C (outdoor air) to 4.2 at 24°C. The PVI® DHW storage tanks are insulated with 152 mm (6") fibreglass insulation which translates to an insulative resistance value of RSI 4.6 m^2K/W (R-26). This is double the typical thickness for storage tanks. The tanks are constructed using a highly durable stainless steel alloy that provides the tanks with a very long service life. DHW distribution piping is insulated with 50 mm (2") thick insulation. The DHW circulation pumps are programmed to operate intermittently, remaining off most of the time.

To reduce the energy required for DHW, passive drain water heat recovery is used for the showers in the residences. The domestic cold water supply piping wraps around the drain piping to preheat the cold water.

The University's district energy system (DES) is used to provide supplementary and if necessary, full back-up heating for the DHW systems. Two plate heat exchangers interconnect the DES to the DHW system in each building. When the temperature in the storage tanks drops below a specific setpoint, the building automation system activates pumps that circulate hot water between the heat exchangers and the storage tanks.

Colmac air source heat pumps for domestic hot water (Photo credit: Perkins+Will Architects)

Energy Metering

Both buildings include metering systems that measure water consumption, district energy consumption and electrical consumption. The electrical metering system allows for detailed analysis of various building systems such as the domestic hot water heat pumps, the heat pumps used for space heating and cooling and the HRVs. Individual meters are also installed for tenanted areas of the buildings where the tenants pay for their own energy use.

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