Second Place: Commercial Buildings, New

The Cartierville YMCA combines heat recovery with geothermal to save $200,000 annually on energy-related costs.

Sustainability at the Y

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The Cartierville YMCA is an 88,000 ft^2 (8180 m^2) building that offers aquatic, sports and recreation facilities. The project was made possible due to an innovative public-community partnership between the Quebec government, the City of Montreal and the YMCA. The owners mandated an energy-efficient HVAC design that would become a focal point of this environment-friendly building. By combining renewable geothermal energy and heat recovery systems, the mechanical engineering team was able to craft a self-financing project designed to reduce energy consumption by 54%, which translates into savings of $200,000 a year on energy-related costs.

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Choosing Efficient Systems

To help designers target the most energy and cost-efficient HVAC systems, energy simulation models were used to evaluate different scenarios. The simulation software simultaneously takes into account weather data, building envelope parameters and complex building HVAC system interactions, which are practically impossible to estimate using traditional calculation methods. Using DOE2.1e simulation software, the mechanical design team was able to accurately analyze peak loads, as well as the building's hourly loads throughout the year, enabling them to pinpoint potential heat recovery capacity.

Due to their elevated hot water consumption (pools, showers, whirlpools, etc.), as well as extra air conditioning and dehumidification needs, recreation facilities tend to have high energy bills. Therefore, designers wanted to focus on potential energy recovery systems before tapping into the grid or even renewable energy. Simulation models helped confirm that heat recovery equipment and geothermal energy constituted the most cost-efficient combination. By providing data on part-load building behavior and available excess heat, building simulations proved essential to the design and sizing of geothermal and heat recovery equipment.

Domestic and pool hot water exchangers and heaters.

Interactive Water Networks

Typically deemed unusable, excess heat is often discarded by conventional HVAC systems by means of air condensers or cooling towers, even in winter. By carefully analyzing the building's heating, cooling and dehumidification loads throughout the year, designers used building simulation models to create a sophisticated multiple water network system that prioritizes heat recovery.

Flexibility between water networks is one of the key elements to fully recovering internal energy before tapping into geothermal or grid equipment to supply the building's varying needs (*Figure 1*). First, a mixed water loop supplies the building's 21 water-to-air heat pump units. Heat pumps were designed to supply the thermal zone, enabling the system to heat or cool according to actual zone needs, therefore avoiding wasteful terminal reheat typical of traditional multizone systems. The mixed water loop directly transfers excess internal heat to the colder areas of the building. A second network consists of a chilled water loop used to dehumidify air in the aquatic center and cool the mechanical room year-round, as well as supply the fresh air cooling coil. An 84 ton (300 kW) recovery chiller rejects excess heat into the heating network (third network). Heat is rejected only when energy can no longer be recycled throughout the building, either by means of the geothermal loop or the two dry coolers on the roof. The third water network, as mentioned, is a heating loop that can preheat and heat fresh incoming air, as well as the building's pools, domestic hot water and heat pump units during winter.

When recovered energy can no longer meet the building's heating demands, the network draws energy from the ground heat exchanger. Two electric hot water boilers provide auxiliary heating during heavy winter periods. Furthermore, the innovative HVAC systems also greatly reduce the amount of energy required for the dehumidification process of return air from the pool area (*Figures 1* and *2*). Since the dehumidification cooling coil is supplied by the recovery chiller, excess heat goes directly into the heating loop (third loop) and is subsequently used to reheat previously cooled air. Another interesting feature is the installation of an enthalpy wheel that recovers sensible and latent heat usually lost in outgoing exhaust air and transferring it to the incoming fresh air with an average efficiency of 75% (*Figure 2*).

By reducing the amount of energy wasted, the flexible water networks and fresh air heat recovery systems not only save energy, they also enable a radical downsizing of related equipment.

When there is a great deal of complex electromechanical equipment, as is the case at the Cartierville YMCA, operation and maintenance activities can quickly become troublesome. To

Building at a Glance

Cartierville YMCA

Location: Montreal

Owner: YMCAs of Quebec

Principal Use: Recreation

Includes: Pools, indoor jogging track, gymnasium, fitness studios, multifunctional rooms, locker rooms, café and daycare

Employees/Occupants: Up to 2,500 per day

Occupancy: Variable

Gross Square Footage: 88,000

Substantial Completion/Occupancy: April 2010

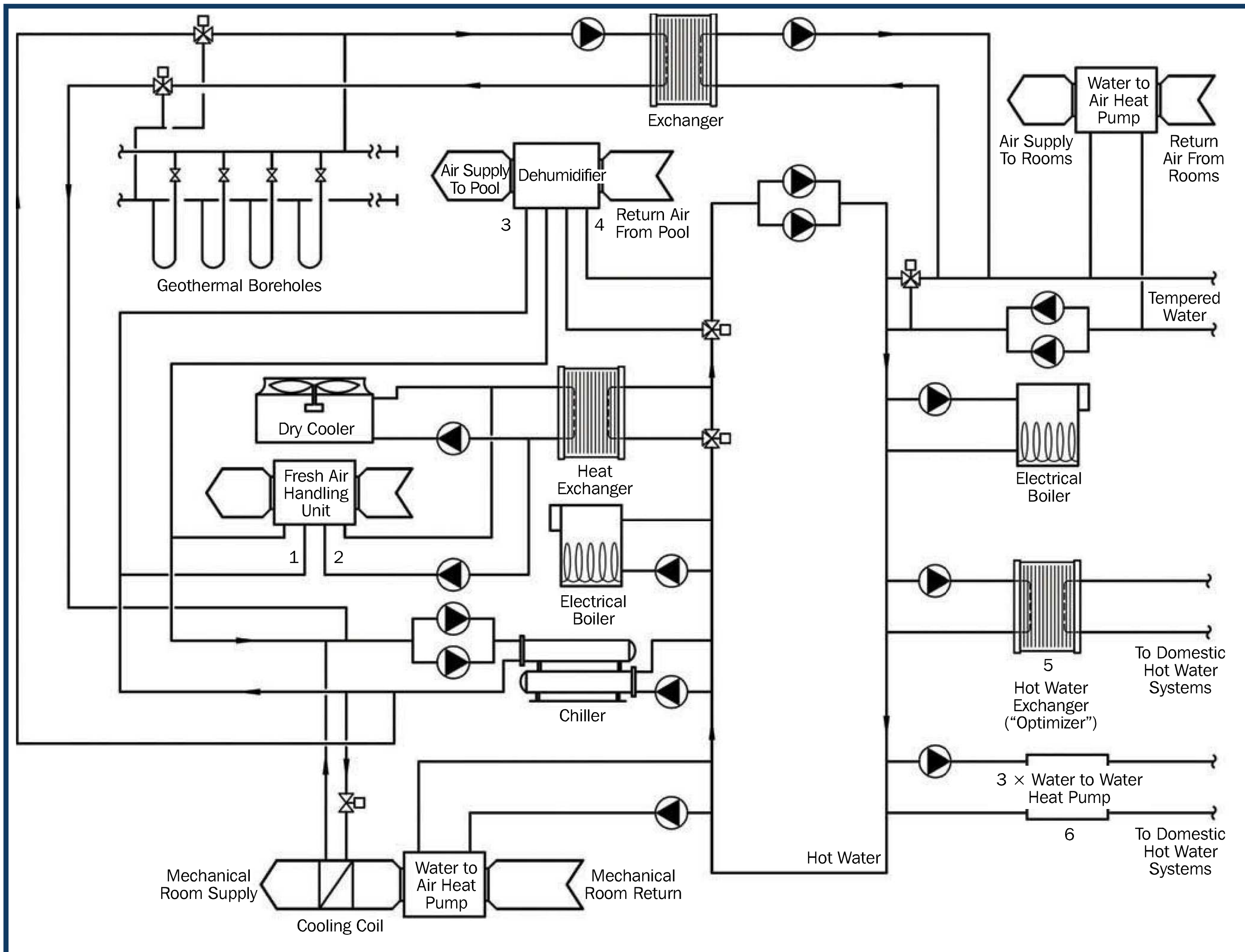

Figure 1: Water networks.

ease equipment operation and maintenance, the building is equipped with automatic controls that monitor and regulate HVAC system components such as heat pumps, chillers, fans, boilers and other related equipment. Also, centralized controls detect system malfunctions and failures quicker and simplify maintenance scheduling.

Grappling With Hot Water Consumption

As mentioned previously, recreation facilities tend to have high energy bills, due in part to their elevated hot water consumption (pools and showers). To maximize energy efficiency, the mechanical engineering team designed effective HVAC systems that can recover energy to meet both spatial heating and hot water requirements for:

- The semi-Olympic pool, 82 ft (25 m) kept at 85°F (29°C);
- The children's wading pool kept at 87°F (30.5°C);
- The whirlpool kept at 101°F (38°C); and
- Domestic hot water (showers in five locker rooms) supplied at 140°F (60°C).

To recover as much energy as possible, multiple systems preheat incoming cold municipal water to supply the different hot water needs. First, incoming municipal cold water is preheated via three water-to-water heat exchangers (optimizers) plugged into the heating loop, which enables the primary hot water system to take advantage of geothermal and recovery energy. At this point domestic water is already hot enough to supply the semi-Olympic pool.

Next, three water-to-water heat pumps, with a total capacity of 30 tons (105 kW), supply extra heat via three additional water-to-water heat exchangers, bringing domestic hot water up to 127°F (53°C). The final step in the heating process is carried out by two electric hot water heaters bringing domestic hot water up to 140°F (60°C). The heating loop (including heat recovery and geothermal energy), combined with the domestic hot water heat pumps, supply 88% of the building's hot water demands.

Reducing Installation Costs, Boosting Efficiency

Unfortunately, excavation and materials for geothermal ground exchangers are costly. Also, due to the region's extreme weather conditions, the average heating or cooling part load for a building in Quebec is generally under 50% of its

peak load. Therefore, heat pump efficiency is considerably reduced when sized to meet the building's overall needs.

Taking these two factors into consideration, designers chose to evaluate a cheaper auxiliary heating system (electric boilers) to supply extra heat during periods characterized by intense cold. Energy simulation models helped pin down the percentage of the maximum capacity that should be ensured by the geothermal system. This optimal combination of systems made it possible to reduce the size of the geothermal exchanger to 30% of the design's peak load, consequently keeping excavation and material costs to a minimum.

A blend of water and propylene glycol flows through a set of twelve 450 ft (137 m) deep boreholes, which are connected to the building's water network. Furthermore, by downsizing the heat pump by 70% under the building's peak load, designers ensured that the equipment would work more hours at full capacity, therefore maximizing HVAC performance.

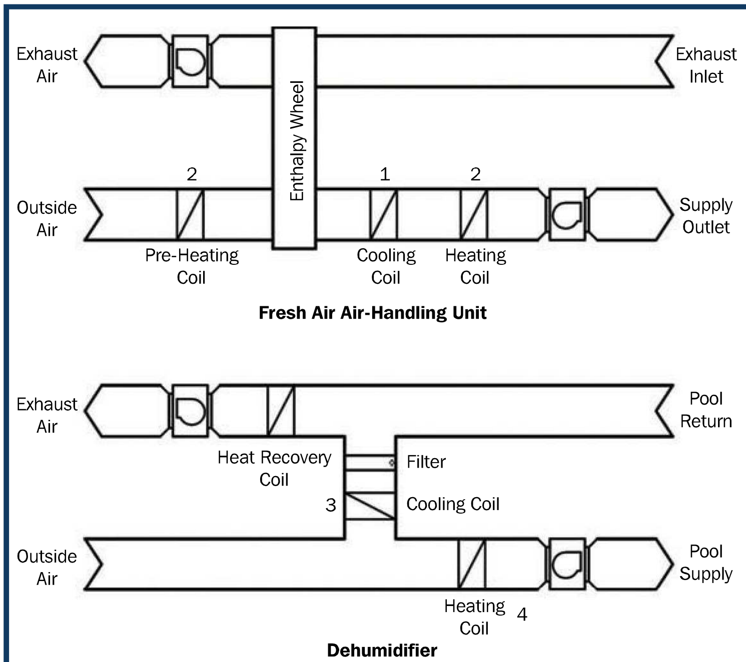

Figure 2: Ventilation.

System Stability

When designing ground loops, it is important to calculate the ground's accumulated heating and cooling loads throughout the whole year, not just peak loads. Unbalanced yearly loads can have damaging long-term effects on the geothermal system's thermal response. One of the ground loop design's goals is to control the rise or drop in temperature over the life cycle of the system. To ensure ground temperature stability, designers built detailed software models of the geothermal closed loop. The analysis provided in-depth data that helped designers map out the appropriate number, depth and configuration of the geothermal boreholes to help guarantee system sustainability.

Reducing Energy Costs and Environmental Impact

The energy-efficient HVAC systems are designed to generate approximate annual financial savings of $200,000 when compared to an equivalent building with standard systems in the Canadian Model National Energy Code for Buildings (MNECB). Although the key energy-saving components, such as geothermal boreholes, were costlier than standard equipment, which resulted in additional initial expenses of around $500,000, these costs were largely offset by a $486,000 incentive grant from Hydro-Québec (the province's electrical provider) to reward energy-efficient design innovation. This substantial incentive reduced an already respectable payback period of 2.5 years to nearly zero.

Simulations established that with a sophisticated design that combines energy recovery with renewable ground energy, this high performance building would use less than half (46%) of the grid energy than a standard construction would use, saving roughly 2.25 million kWh a year, consequently reducing greenhouse gas emissions by 1,200 tons/year. Also, by choosing all-electric systems, the project fully benefits from the province's hydroelectric power (Hydro-Québec), which is a clean energy source.

However, measured energy bills showed higher energy consumptions than predicted, because initial energy simulations did not include all process loads, which are abundant in a community center with aquatic facilities. When taking into account processes such as backwashing, fresh water replacement and spa temperatures, the energy variations between a simulation model and actual energy consumption are less than 6%.

To help further reduce the building's ecological footprint, the architectural design maximizes natural lighting and also includes a white roof. By improving solar reflectivity, white roofs lower roof temperatures during extreme summer conditions, subsequently reducing cooling needs and urban heat islands.

A water management system also helps protect resources by rationing the building's water use. Low-flow water fixtures for showers, low-flush toilets, motion-activated sink faucets, as well as outdoor vegetation that requires little, if any, additional water, help reduce water consumption. The building's landscape design focuses on open urban spaces, with a playground, terrace, and rest areas that provide recreational, leisure and social gathering spaces in green surroundings. By choosing a location that is highly accessible via public transit and integrating 100 bicycle parking spaces, the building encourages the use of sustainable transport.

The Cartierville YMCA's use of renewable energy infrastructure in a neighborhood community center helps illustrate how accessible these technologies have become. By harmonizing sustainable development with economic feasibility, the new Cartierville YMCA is a truly 21st-century expression of the organization's philanthropic values and mission. ■