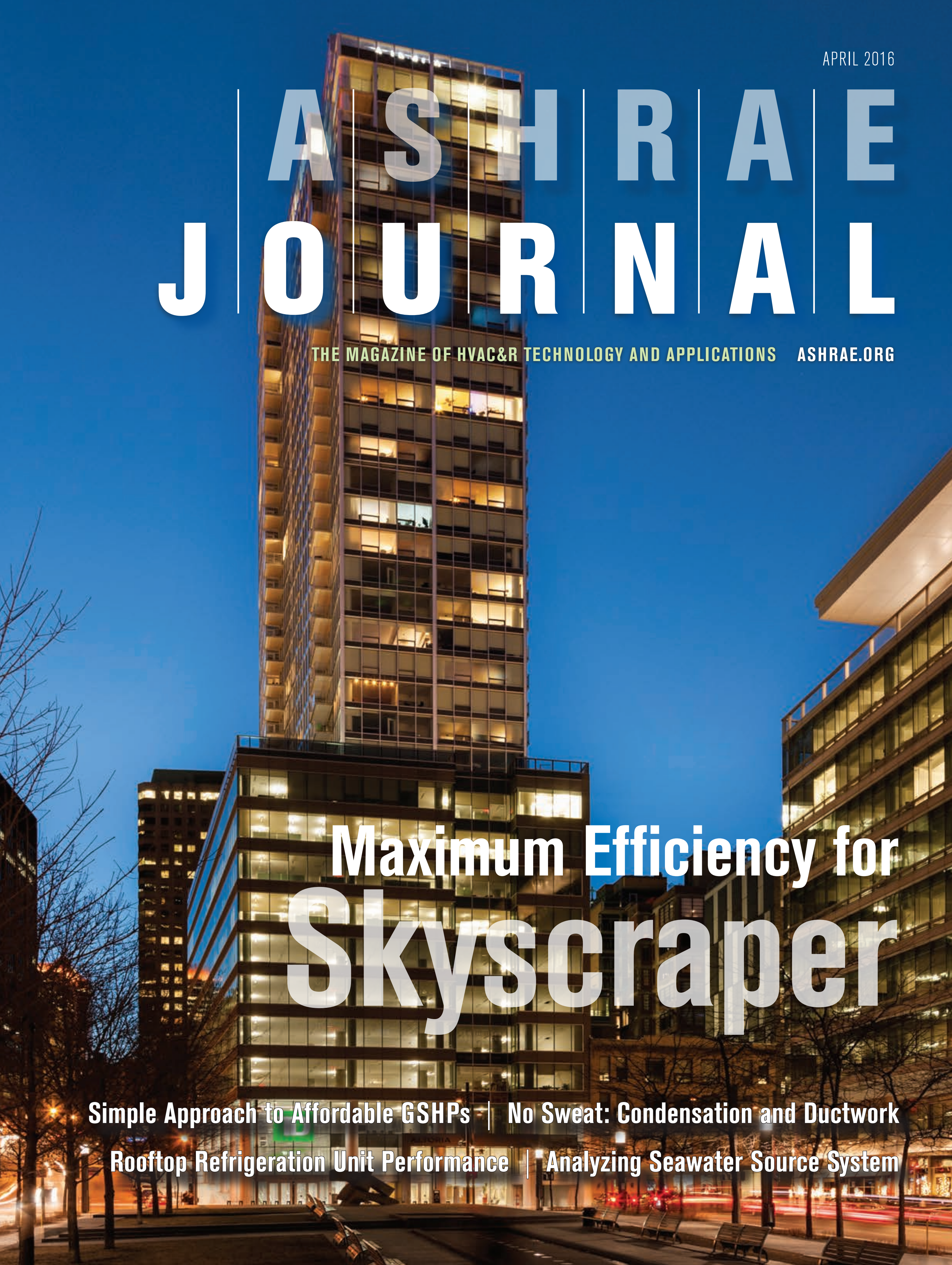

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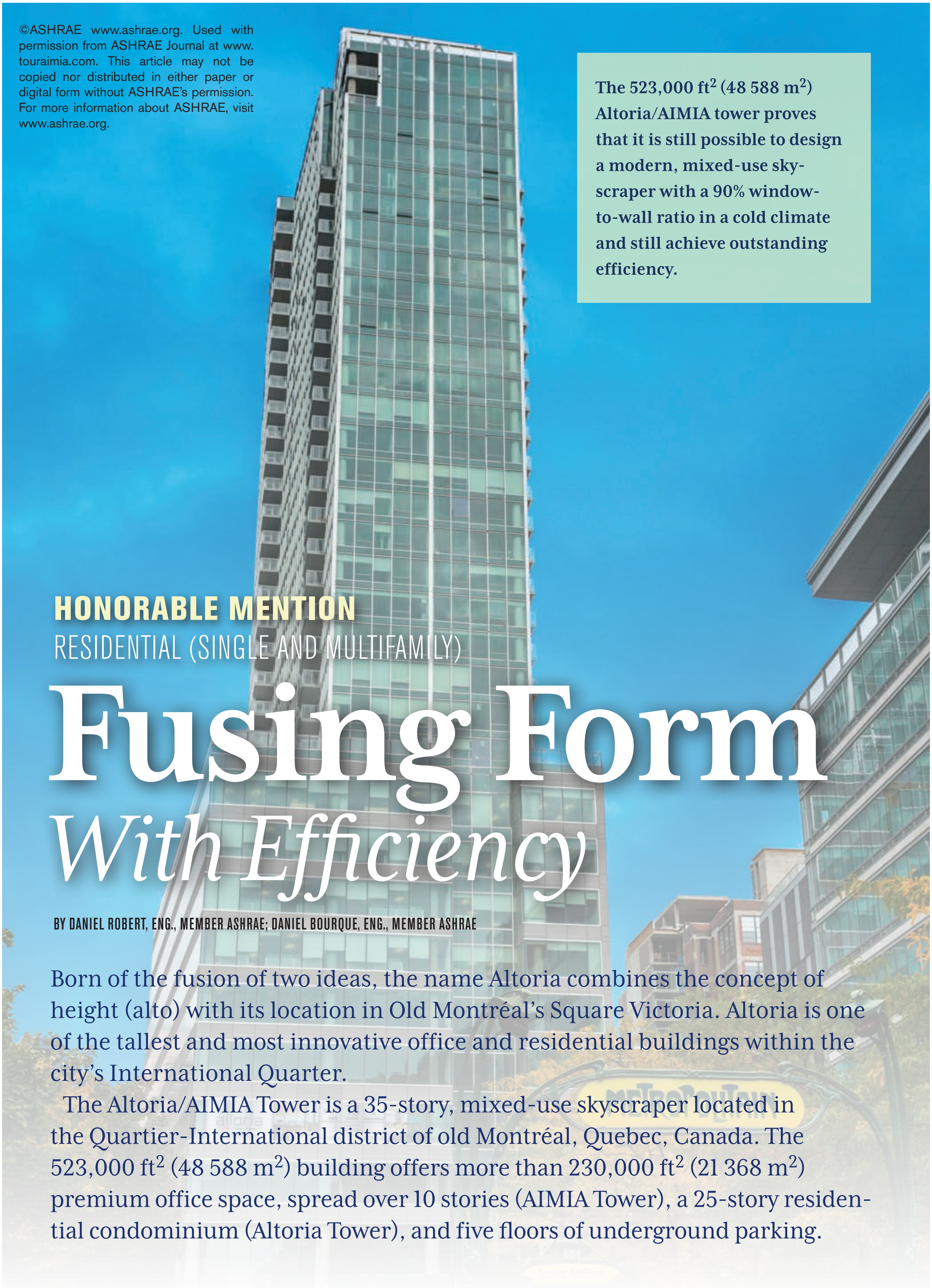
Maximum Efficiency for Skyscraper

Simple Approach to Affordable GSHPs | No Sweat: Condensation and Ductwork

Rooftop Refrigeration Unit Performance | Analyzing Seawater Source System



The 523,000 ft^2 (48 588 m^2) Altoria/AIMIA tower proves that it is still possible to design a modern, mixed-use skyscraper with a 90% window-to-wall ratio in a cold climate and still achieve outstanding efficiency.

HONORABLE MENTION

RESIDENTIAL (SINGLE AND MULTIFAMILY)

Fusing Form *With Efficiency*

BY DANIEL ROBERT, ENG., MEMBER ASHRAE; DANIEL BOURQUE, ENG., MEMBER ASHRAE

Born of the fusion of two ideas, the name Altoria combines the concept of height (alto) with its location in Old Montréal's Square Victoria. Altoria is one of the tallest and most innovative office and residential buildings within the city's International Quarter.

The Altoria/AIMIA Tower is a 35-story, mixed-use skyscraper located in the Quartier-International district of old Montréal, Quebec, Canada. The 523,000 ft^2 (48 588 m^2) building offers more than 230,000 ft^2 (21 368 m^2) premium office space, spread over 10 stories (AIMIA Tower), a 25-story residential condominium (Altoria Tower), and five floors of underground parking.

Tower Description

The floor-to-ceiling windows and spacious balconies of the condos offer homeowners panoramic views of Old Montréal, the St. Lawrence River,and Mont Royal. Because of this floor-to-ceiling glazing, the design team had to go beyond standard concepts to recover heat in Montréal's cold climate with nearly 8,000 heating degree days (°F).

The design team used a method its firm developed where mechanical costs were discussed upfront for every aspect of the developer's vision while it worked on the design with the associated costs already known. This helped to elminate financial surprises upon completion.

The mechanical concept transfers energy that in most buildings would be wasted, extracts energy from the geothermal wells and then relies on high-efficiency equipment to meet the remaining heating and cooling requirements.

These complex mechanical systems were pulled together easily by the energy management and control system (EMCS). During commissioning and throughout the warranty period, the design team constantly monitors the system's operation and can tweak settings to increase efficiency.

The building sits on top of the city's Metro system, as well as Montréal's underground city, which comprises 20 miles (32 km) of tunnels, and interconnects much of Montréal's downtown core. This complicated the structure, construction and possible size of the geoexchange system.

Project Description

Altoria/AIMIA combines the elegance of a modern glass tower and the energy efficiency of a LEED Gold project.

Most Canadian projects focus on optimizing the heating systems and heat recovery as the heating season is long and energy intensive. On this mixed-use project, the synergies between an exothermic office space and residential spaces operating 24 hours a day were maximized.

Heat recovery is prioritized on heat from toilet, dryer, and general exhausts. The recovered heat is used to heat the following systems:

- Office perimeter zones;
- Residential hydronic thermal loop;
- Preheat domestic hot water;
- Outdoor swimming pool (used from May through October); and/or
- Parking garage.

When additional heat is available, it is stored directly in the ground via a partial geoexchange system comprising 15 vertical closed loop wells of 500 ft (152 m). Only once all the immediate heating needs are met and the geothermal wells have stored what they can, the remaining heat is then rejected from the office hydronic thermal loop via evaporative fluid coolers and from the residential hydronic thermal loop via a heat exchanger coupled with an open cooling tower.

Whenever additional heat is required beyond what the geoexchange system can provide (this usually will occur when the outdoor temperatures drop below 23°F [–5°C]), two condensing boilers and an off-peak electrical boiler add the required heat to the loop.

Connected to this thermal loop are distributed hybrid heat pumps (HHP), which are used to heat and cool the office spaces as well as the condo units. These HHPs use compressors with flooded condensers in cooling mode, but use a direct water heating coil for heating (i.e., no compressor energy to provide heat—just like a conventional fan coil).

Main Energy-Efficiency Components

Geoexchange

Given the small footprint of the building, it was never a goal to make the geoexchange system the primary source of heating and cooling, but rather to be a system that would run at 100% capacity as often as possible in order to maximize its efficiency and use. A bank of water-to-water heat pumps (WWHPs) are used to extract heat from the 15 wells in heating season. However, the WWHPs are

BUILDING AT A GLANCE

Altoria/AIMIA Tower

Offices and Residential Condominiums

Location: Montréal

Owner/Developer: Kevric Real Estate Corporation

Principal Use: Residential/commercial

Includes: Offices and residential condos

Employees/Occupants: Approximately 1,500

Gross Square Footage: 523,000

Substantial Completion/Occupancy: June 1, 2014

Occupancy: AIMIA 70%, Altoria 95%

National Distinctions/Awards: AIMIA – LEED Canada CS Gold; Altoria – anticipating LEED Canada NC Silver

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bypassed in heat rejection mode, with the thermal fluid going directly into the wells (*Figure 1*).

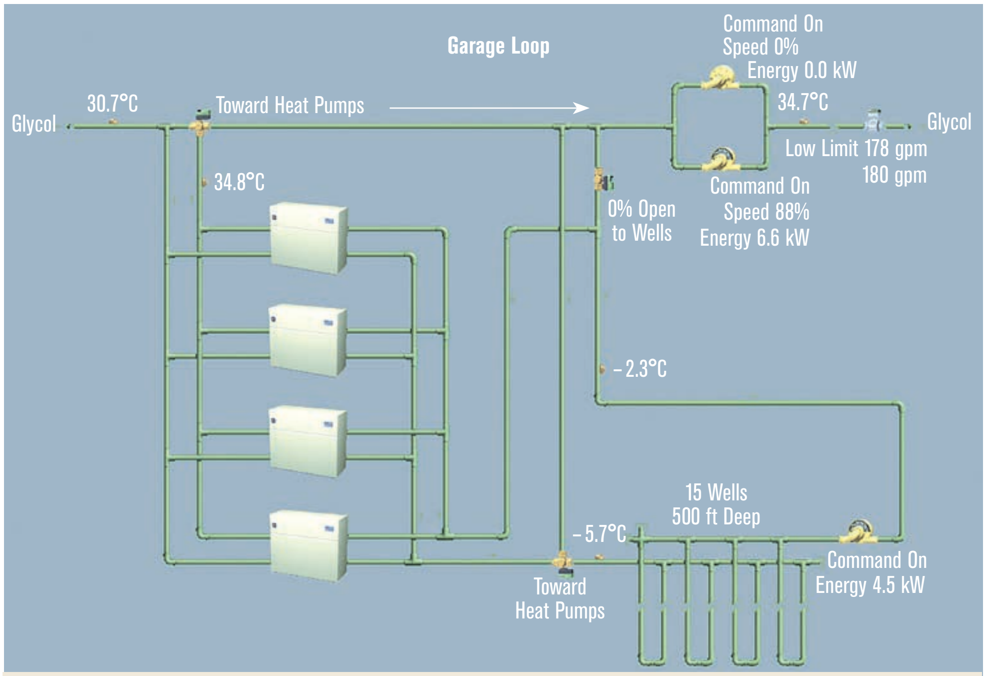

FIGURE 1 Geoexchange system.

Extensive VFD Use

Nearly all ventilation systems and most of the pumps are designed to be variable volume with variable frequency drives.

Demand Ventilation in Garage

The garage ventilation systems are operated to maintain low carbon monoxide (CO) levels in the parking and are designed to be variable volume to avoid over venting the garage in CO purge mode. In practice, we are able to maintain negative pressure in the garage and negligible CO levels with optimal fan operation, which is aligned with our overall energy saving strategy.

Outdoor Air (OA) Energy Recovery

The main OA systems for the office and condo towers use aluminum mass regenerative technology to preheat and precool the fresh air with the toilet and general exhaust as the energy sources. This technology offers up to 89% nominal heat recovery efficiency (sensible and latent).

Dryer exhaust for the condo tower uses fan wall technology for low turndown ratio and increased efficiency; this fan wall system is coupled to a WWHP to recuperate energy from hot and humid air back to the condo's hydronic thermal loop when required (*Figure 2*).

Independent Loops

Three low-temperature hydronic thermal water loops connected to each other and serving distinct areas are designed to transfer heat among them:

- **Offices' hydronic thermal water loop**. On every floor, each façade has its own hybrid heat pump (HHP), and the core has two cooling-only HHPs; all HHPs are variable airflow with a VFD and multistage compressor. Excess heat is first rejected to the geothermal wells and then rejected from the loop via evaporative fluid coolers. At very low outdoor temperatures, two condensing boilers add heat to the loop.
- **Condos' hydronic thermal water loop.** Every condo has at least one HHP to meet heating and cooling requirements. All HHPs are connected to the condos' water loop. Excess heat is rejected from the loop via a heat exchanger coupled to an open cooling tower. At very low outdoor temperatures, a condensing boiler adds heat to the loop.
- **Garage loop.** It connects directly to the office loop, and services the heating fan coils, OA heating systems, as well as connects to the geoexchange system.

Energy Monitoring

The project included an extensive measurement and verification (M&V) plan to track the energy used by the various entities in this mixed-use building. Where feasible, the team also monitors the energy consumption of the pumps and fans via the EMCS to see where the electrical power is used by the HVAC system (*Figure 3*).

Indoor Air Quality

The Altoria/AIMIA tower was designed to meet ASHRAE Standard 62.1-2010 and ASHRAE Standard 55-2010 requirements.

Outdoor air that is brought to the office building is controlled and metered via the EMCS. All outdoor air systems serving occupied spaces are equipped with

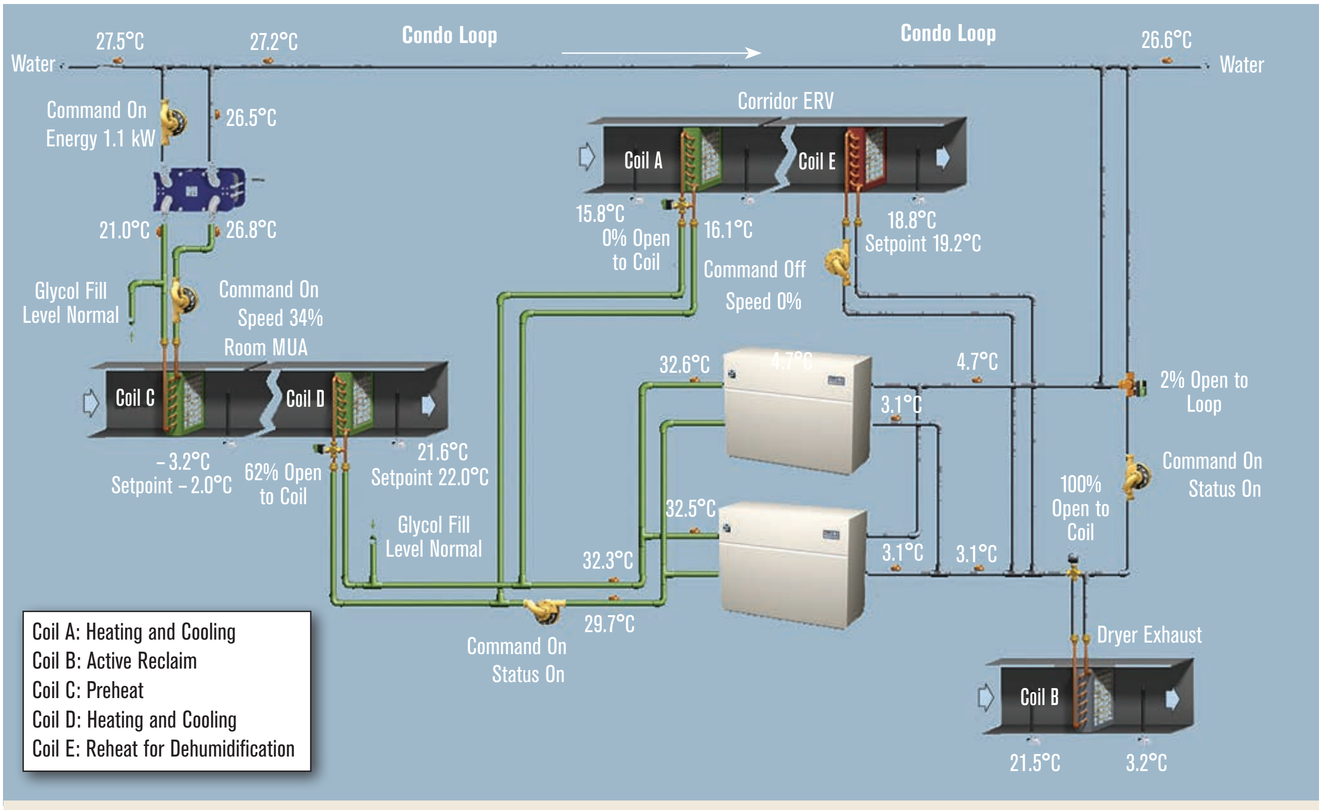

FIGURE 2 Condo outdoor air heat recovery.

MERV 13 filters. In addition, a demand-controlled ventilation strategy was implemented to allow the optimization of outdoor air treatment in the office tower using CO_2 sensors (in the high occupancy areas and in the return of the HHPs) and variable frequency drives on the dedicated outdoor air systems.

As has become industry standard for a LEED project, all materials, adhesives, sealants, paints, coatings and flooring systems used during construction were low-emitting.

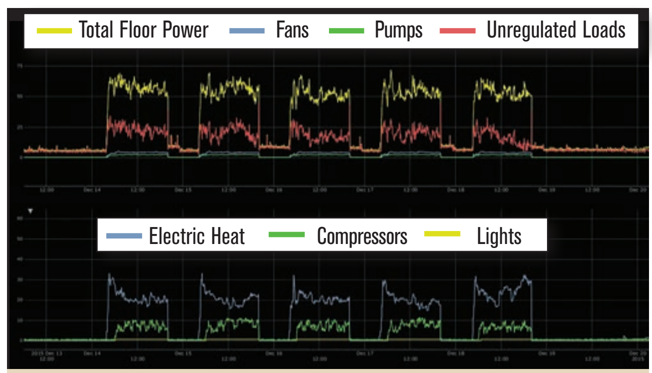

FIGURE 3 Electrical breakdown.

Innovation

The integrated design approach adopted in this project fostered innovation at different aspects of the building construction. The most prominent HVAC innovations in this project are:

- The optimization of the HVAC infrastructure by using nonconventional water temperature differentials and mono-pipe risers to optimize pumping power and piping network's first cost (which resulted in a measured average of 0.6 gpm/ton for over 8,000 hr/yr);
- When the office loop is in heat rejection mode, all heat is made available to residential tower loop, as well as the outdoor pool heater, domestic hot water (DHW) preheat systems and the parking garage loop.
- Maximizing the use of recovered heat and heat extracted from geothermal wells, then using the excess heat among the three hydronic thermal water loops;
- The extensive monitoring and metering of recovered heat and energy transferred between different hydronic thermal water loops for tenants and billing accordingly; and
- The heating by hybrid heat pumps (HHP) that transfer heat to zones via a hot water coil instead of the conventional water source heat pumps (WSHP) that transfer heat by using the compressors.

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Operation and Maintenance

Since all HVAC equipment is centralized with the EMCS, the building's operation is fully automatic with no intervention required other than regular maintenance.

Several key trends were programmed during commissioning to follow up on system performance and to measure the heat recovery and transfer. These trends were analyzed on a monthly basis during the first year of operation and allowed several parameters and setpoints to be optimized.

A comprehensive M&V plan is used to monitor energy consumption at every mechanical system and meter the energy transfer between the offices and residential towers and the offices and the parking garages. The owners are using the EMCS for tenants' energy billing.

The project achieved LEED CS EA Cr5 (measurement and verification) and LEED NC EA Cr5.2 (tenant submetering).

Energy and Economic Benefits

This high-rise building is designed to exceed Canada's Model National Energy Code for Buildings (MNECB) by 30% for the office tower and by 38% for the residential tower, despite a nearly 90% window to wall ratio.

On top of energy cost savings, the selected concept and decentralized HVAC equipment required less room than traditional centralized systems, creating more floor space and higher ceilings, eliminating rooftop chillers, and reducing structural requirements. *Table 1* lists the energy and cost savings of the project with respect to the MNECB.

TABLE 1 Projected financial highlights.

		SUMMARY OF ENERGY & COST PERFORMANCE					
		PROPOSED BUILDING		REFERENCE BUILDING		SAVINGS	
		Energy (MJ)	Cost ($)	Energy (MJ)	Cost ($)	Energy (%)	Cost (%)
OFFICE TOWER	Electricity	10 075 679	241,283	12,518,028	292,796	20	18
	Natural Gas	1 286 852	14,947	6 948 282	73,211	81	80
	Total	11 362 531	256,230	19 466 310	366,007	42	30
CONDO TOWER	Electricity	7 274 928	141,491	11 087 478	223,902	34	37
	Natural Gas	2 077 722	24,188	3 238 072	42,159	36	43
	Total	9 352 650	165,679	14 325 550	266,061	35	38

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The Office Tower's real energy consumption and spending during the first year of operation was 60.3 kBtu/ft^2 (684.8 MJ/m^2) and CAN$1.22/ft^2 (CAN$13.13/m^2) (June 2014 to May 2015). This rough data taken from the utility bills does not include weather normalization and occupancy rates or miscellaneous additional loads that may not be modeled in the energy simulation. That year, Montréal experienced the coldest winter in 150 years; Operating cost are expected to decrease in the second year of operation as the office portion becomes fully occupied. Then, heat generated by human and business activities can be harvested and transferred to those systems providing heating whenever it is required.

Altoria Tower's real energy consumption and spending in the first year is not relevant because of the low occupancy rate, although 80% of condos are sold.

Environmental Impact

Due to the efficiency of the mechanical systems installed, the overall project has avoided the emission of more than 343 tons of CO_2 into the atmosphere per year, the equivalent of planting 8,780 trees or removing 73 medium cars from the road. This avoided emissions are associated with the gas energy savings. However, the electrical energy savings, 48% of the total energy savings, has no direct avoided emissions in Quebec since electricity is mostly produced by hydro-electrical plants.

If we consider the Canadian average emissions factor (0.22 kg CO_2/kWh), the electrical energy savings of the project avoids the emissions of an additional 382 tons of CO_2, the equivalent of planting an additional 9,800 trees or removing an additional 81 medium cars from the road.

In addition to avoided GHG emissions, the project consumes 38% less potable water (for irrigation and sewage conveyance) than it would have consumed if the building was not designed to meet CaGBC LEED NC – WE Cr1 & CaGBC LEED NC – WE Cr2.

Conclusion

The Altoria/AIMIA tower proves it is possible to design a mixed-use skyscraper with a 90% window-to-wall ratio in a cold climate and still achieve outstanding efficiency. ■

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