HONORABLE MENTION: COMMERCIAL BUILDINGS, EXISTING

HVAC modifications at the Complexe Desjardins in Montreal resulted in savings of 11.5 million kWh annually. Heat pumps and heat recovery systems were added to three of the four towers.

OFFICE RETROFIT

By **Roland Charneux, P.E.,** Fellow ASHRAE

The managers of Complexe Desjardins (Desjardins Gestion Immobilière) decided in 2004 to make major electromechanical upgrades to improve the overall energy efficiency of the 1970s-era office building complex in Montreal (Climate Zone 6A). The complex consists of three office towers sitting on a base structure that includes a central atrium, retail space and a food court. Below that are four levels of underground parking. In addition, a fourth tower is an independently owned hotel.

Thorough study and analyses led to a solution that consisted of the installation of a 330 ton (1160 kW) heat pump and an innovative system to recover heat from computers, the lighting system and occupants, which would then be used to heat the envelope of the building and the outside air supply. This system also would humidify inexpensively. The design concept was successfully implemented on the North Tower and then applied to the other two office towers (East and South).

The concept can be applied to other large existing buildings with little adaptation.

Systems Before Renovation

Before renovations, the HVAC systems in the 19-story North Tower (21,500 ft² [2000 m²]) had one 100% dedicated outdoor air system (DOAS) (54,000 cfm [25 500 L/s]), supplying air to perimeter

About the Author

Roland Charneux, P.E., is COO at Pageau Morel & Associes in Montreal. He is an ASHRAE-certified Healthcare Facility Design Professional (HFDP).

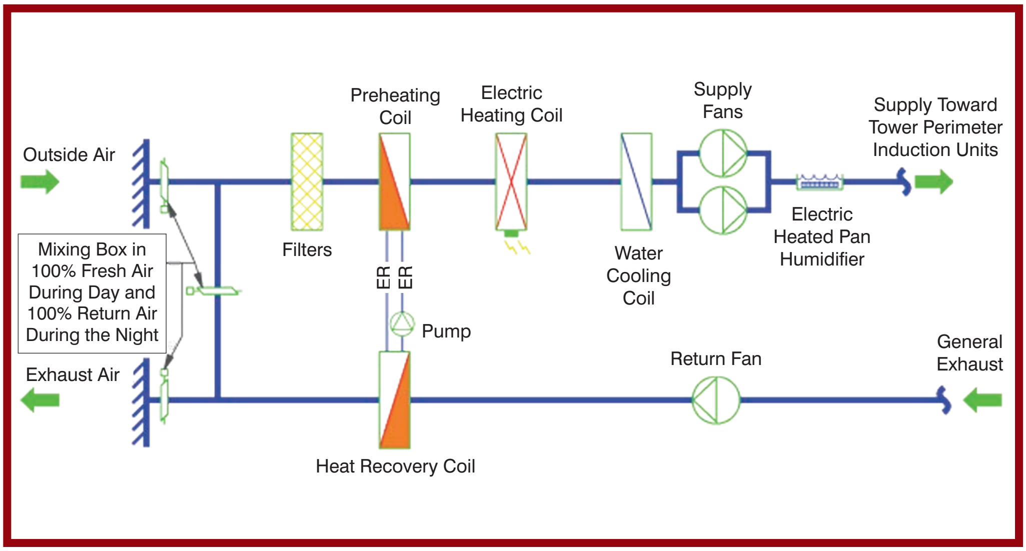

Figure 1: Original dedicated outdoor air system (DOAS) for the North Tower. The system had an electric coil, a chilled water coil, a runaround glycol loop for heat recovery on the exhaust air and an electrically heated hot water humidification pan.

induction units. This system was fitted with an electric coil, a chilled water coil, a runaround glycol loop for heat recovery on the exhaust air and an electrically heated hot water humidification pan (*Figure 1*). The induction terminal units have an electric coil and a chilled water coil to maintain adequate perimeter zone air temperature.

On each floor, an air-conditioning unit draws its return air from close to the perimeter (obtaining its required outside air from there), supplying air conditioning to the floor's internal zones using chilled water coils. Complexe Desjardins is an all-electric building (Quebec's electricity is mostly renewable hydroelectricity) and, as such, the hot water used in the pan humidifiers was heated using an electric heater. Also, chilled water was produced centrally and distributed to the various HVAC rooms throughout the complex.

At night, the dedicated outdoor air systems operate as a 100% recirculation system to provide perimeter heating. Also, another 100% DOAS supplies outside air to the commercial retail spaces (23,000 cfm [10 850 L/s]). This system was identical to the previous system, though smaller in size. Finally, two recirculating, dual-duct systems (77,500 cfm and 58,000 cfm [36 600 L/s and 27 400 L/s]) supply conditioned air to spaces located within the lower levels of the tower (180,000 ft² [16 750 m²] of office spaces and storage areas). Those systems had a dual supply fan, an electric coil in the hot duct and a chilled water coil in the cold duct (*Figure 2*).

Building at a Glance

Name: Complexe Desjardins

Location: Montreal

Owner: Desjardins Gestion Immobilière

Principal Use: Office

Includes: Retail, Storage

Employees/Occupants: 10,000

Substantial Completion: 2008

Implemented Modifications

Traditionally, in a northern climate such as Montreal, inexpensive air conditioning for internal spaces comes from airside economizer cycles. However, heating for the perimeter zones and heating and humidification of the outside air are still needed. Consequently, the airside economizer is basically wasting a lot of warm energy that could be reused if harnessed correctly. In this existing building retrofit, the cooling loads described in the previous section had to be harnessed to contribute to building heating and humidification loads using decentralized chillers acting as a heat pump and adiabatic humidifiers.

In the North Tower, a 330 ton (1160 kW) heat recovery water source heat pump on the chilled water network was installed. It uses return chilled water to produce hot water used to heat and humidify outside air and to satisfy a part of the building envelope heating load. The hot water pan humidifiers were replaced with one-pass adiabatic humidifiers, using warm air to evaporate the water and producing humidification, while preconditioning the return air for sensible cooling purposes.

The installation of a 330 ton (1160 kW) chiller (to act as a "heat pump") in the main ventilation mechanical room reduced required pipe lengths and installation costs (*Figure 3*). This chiller cools chilled water returning from the recirculation air-conditioning units located on each tower floor, using it as a heat source and precooling the chilled water returning to the chiller plant (reducing its load). Condenser water (with glycol antifreeze) is supplied to the 100% dedicated outdoor air systems 4-01 and 2-31, as described later. Since the cooling load is present 24/7 in many parts of the complex, the heat recovery chiller is continuously providing heating capacity. The heat pump chiller load is controlled by the condenser heat needs.

In the DOAS, a hot glycol coil had been installed before the electrical coil (which now serves as a second-stage heating), while adiabatic humidifiers replaced the hot water pan humidifiers (*Figure 4*). Similar modifications were made to the dual-duct systems serving the lower levels, except that the adiabatic humidifiers have been located before one of the return fans to reduce its size and costs (*Figure 5*). Also, during the humidification months, the exhaust air damper is completely closed, and air is exhausted from the spaces using other ducts, rebalancing the exhaust network. Also, a complete reconditioning of the affected HVAC systems was carried out.

Combined together, those modifications allow heating and humidification of the towers using almost exclusively recovered energy from the indoor office spaces.

Innovation

Recovering the internal loads is not new. However, the originality of the solution lies in the innovative layout of the electromechanical equipment. First, decentralized heat recovery chillers were installed to minimize first costs and reduce the central plant chiller load. Consequently, there is no additional electrical energy demand on the building for the heat recovery systems. Second, installing the adiabatic humidifier in the return airstream of the dual-duct systems gives the hu-

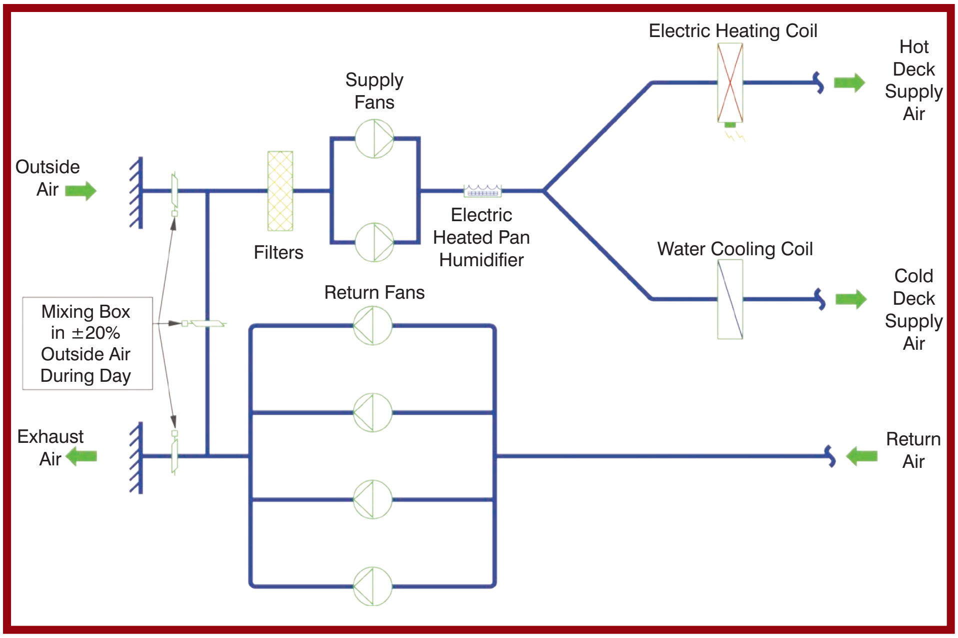

Figure 2: Original dual-duct systems.

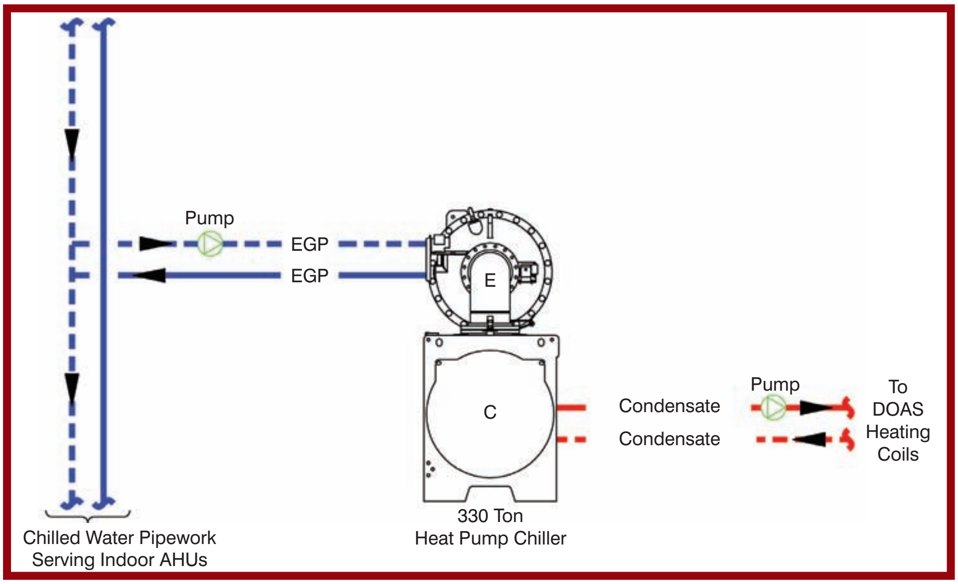

Figure 3: Connections of the new heat recovering heat pump chillers (typical).

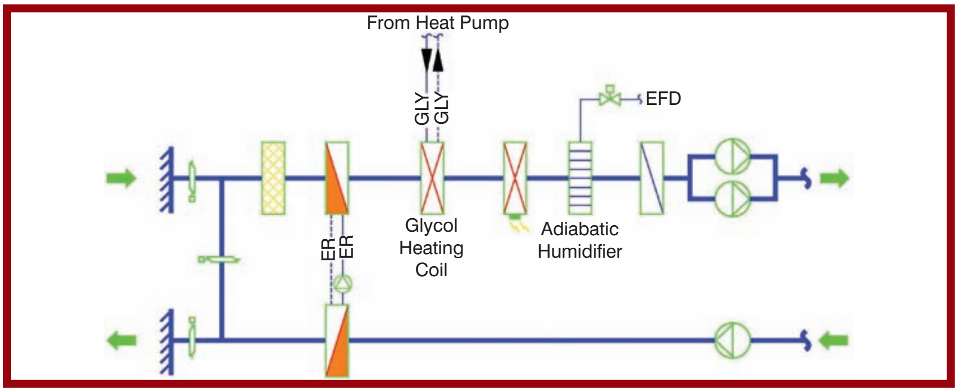

Figure 4: Modified dedicated outdoor air systems.

midifier a higher air temperature to operate with, downsizing the equipment and further reducing first costs.

Following the successful operation in the North Tower, the modifications were implemented in the East and South Towers.

Annual energy savings have been calculated by measuring the chilled water flow rates and temperature differentials produced by the heat pump chillers (data logged every 15 minutes). This thermal energy directly equals energy saved from the use of the electrical coils and pan humidifiers. Energy consumed by the heat pump chillers has been considered to be equal to the energy saved by the central chiller plant, and is excluded from the calculations. *Figures 6a* and *6b* illustrate some of those measurements. *Table 1* gives the annual calculated totals.

Improved Overall Efficiency

Part of the project investment resulted in the major overhaul of the existing HVAC systems, replacing old equipment with modern motorized dampers, cooling and heating recovery coils or reconditioning the fan motors, fans and housing.

The heated pan humidifiers required substantial maintenance each year with associated required downtime. The replacement of those humidifiers by adiabatic ones has helped reduce maintenance costs and downtime, ensuring better system operation. Furthermore, with many newer components added to the existing HVAC systems, the life expectancy of the equipment has been increased. Also, the newer equipment has been chosen for easier maintenance and longevity, which translates into productivity gains for the owner and operation personnel.

For the three towers combined, the work performed required an

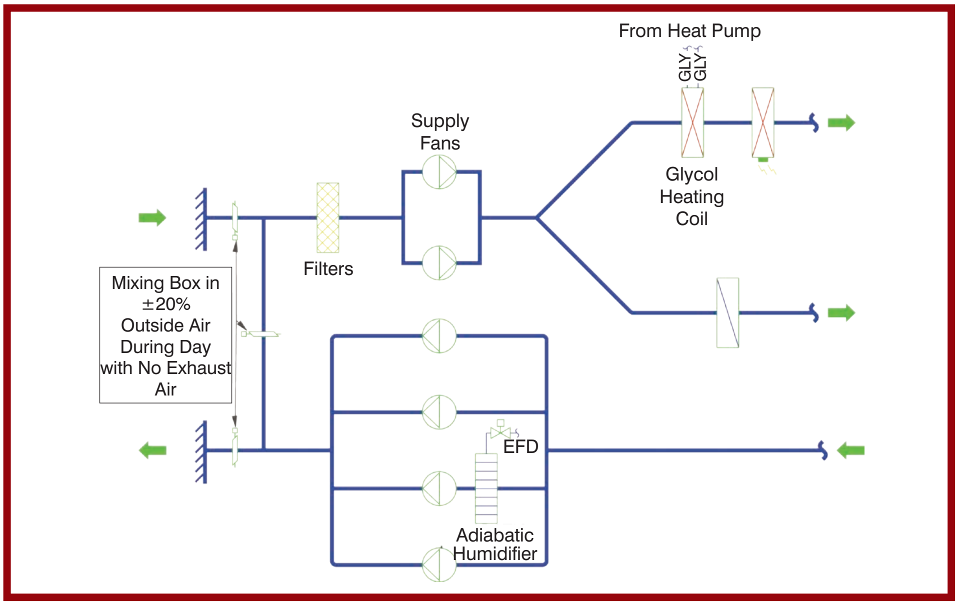

Figure 5: Modified dual-duct single fan systems.

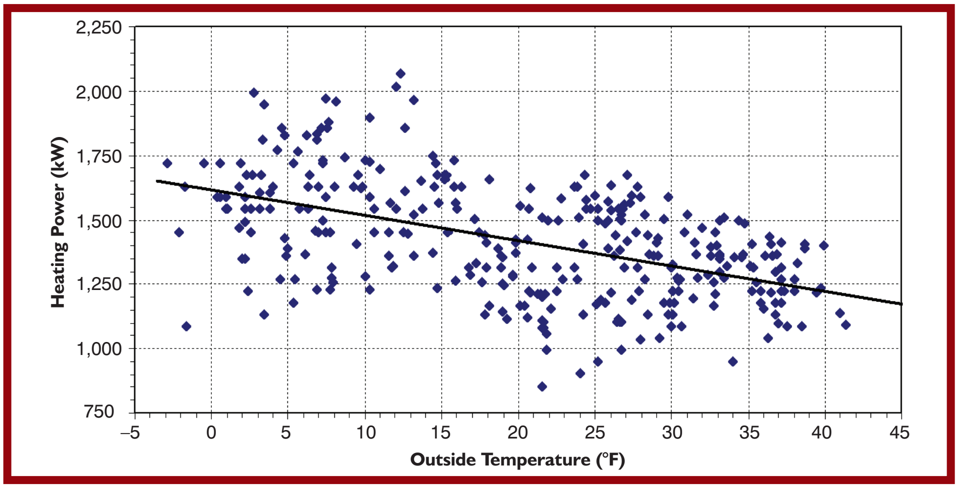

Figure 6a: Day measurements, South Tower heat pump chiller, December 2008.

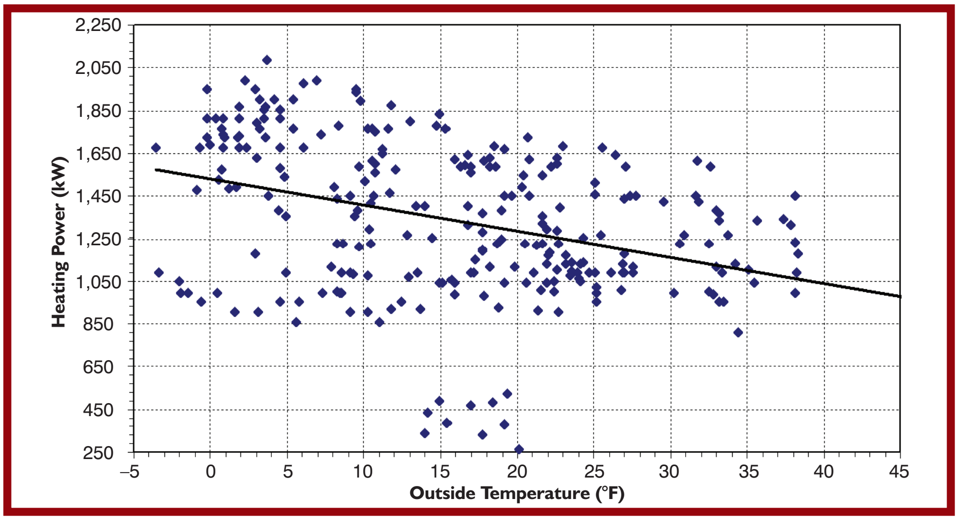

Figure 6b: Night measurements, South Tower heat pump chiller, December 2008.

Towers	Stories	Day (kWh)	Night (kWh)	Total (kWh)	Savings ($0.461/kWh)	Demand Reduction (kW)
North	19	1,146,200	952,000	2,098,200	CA$96,727	700
East	24	2,272,500	2,230,400	4,503,000	CA$207,588	1,700
South	32	2,332,500	2,576,000	4,908,500	CA$226,282	1,750
	Total	5,751,200	5,749,400	11,509,700	CA$530,596	4,150

Table 1: Annual energy savings (calculated from chilled water measurements) are more than CA$500,000.

investment of 3,390,000 Canadian dollars. This translates into a simple payback of 6.4 years (when excluding O&M benefits). Energy-efficiency grants amounted to CA$1,144,000, for a simple payback of 4.2 years.

Additional energy-efficiency measures have been implemented such as new high-efficiency chillers, new direct digital controls and variable frequency drives on pumps. The total energy consumption of the site was reduced from 138,000 MWh in 2005 to 116,500 MWh in 2009, which is more than a 15% reduction.

Environmental Impact

Outside air supply meets or exceeds the minimum quantity requested by ASHRAE Standard 62.1.

The modifications generate annual energy savings of more than 11,500,000 kWh. Since Quebec's electricity is mostly from hydro sources, the emission factor for the province is only 44 lb (20 kg) of CO_2 per MWh. As such, the avoided CO_2 emissions from the electric energy savings are 230 metric tons/year. However, when compared with an efficient combined-cycle gas-fired thermal plant with an emission factor of 992 lb (450 kg) of CO_2 per MWh, the avoided CO_2 emissions become 5,175 metric tons/year. Another comparison can be made assuming gas-fired boilers used for heating (emission factors of 118.9 lb per 1,000 ft^3 [1.9 kg per m^3]). The CO_2 emission savings would be 2,112 metric tons/year.

This solution can contribute greatly to substantial reductions in CO_2 emissions in large existing buildings. Also, the installed heat pump uses R-134a, an HFC. Additionally, less water makeup and chemical treatment of the water is necessary.

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