Sacré-Cœur Hospital, Montreal, with the boiler house located at the rear of the building.

Direct Contact Water Heater

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Located in the northern part of the Montreal island, the "Hôpital du Sacré-Cœur" is one of the major hospitals of Montreal, Quebec. The hospital's site includes more than 600 trees and covers 1,600,000 ft² (150 000 m²).

The main part of the building was built in 1925. The original vocation of the hospital was to provide care for patients affected with tuberculosis, an especially deadly disease in the 1920s. A major addition was completed in 1945 and the hospital began to provide general health care services.

During the first 50 years of its existence, the hospital was managed by a nun's congregation, "Les Sœurs de la Providence." Next to the hospital building, a large complex of 540,000 ft² (50 000 m²) including 750 rooms was built in 1960 to serve as the main residence for the Sisters of Providence.

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In 1970, the hospital became a health care research center associated with the "Université de Montréal." A major renovation provided the hospital with modern critical care and surgery units. Several other modifications were completed following rapid developments in health care such as emergency, radiology, nuclear medicine, scanner, magnetic resonance imaging (MRI), etc. The hospital is an 800,000 ft² (74 000 m²) facility, including 700 beds.

The Heating Plant

The boiler room is a separate building linked to the main building by an underground tunnel. It was built in 1925 and originally included three coal-fired 450 hp (4.4 MW) steam boilers at 125 psig (860 kPa). It also included two piston-type, steam-actuated forced hot water circulators and two piston-type, steam-actuated boiler makeup systems.

In 1960, another underground tunnel linked the boiler room to the new residential building of the Sisters of Providence. It required the addition of two 650 hp (6.4 MW) Grade 6 oil-fired boilers.

The three existing boilers were modified at the same time for heavy (Grade 6) oil combustion. Modifications of all the five boilers were completed in 1976 to add the possibility of natural gas combustion.

The heating plant provides energy for services including heating the hospital building, the nun's residence and the ventilation system's fresh air; producing domestic hot water; and providing energy for the laundry (washing tunnel, calenders, dryers), cooking appliances (kitchen) and sterilization equipment.

About the Author

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Exterior Temperature °C	Temperature of Heating System Supply Water °C	Temperature of Heating System Return Water °C	Temperature of Exhaust Gases °C	Instantaneous Efficiency %
–1	41	37	38	96.7
–10	47	44	45	94.6
–20	56	51	53	92.5
–29	60	53	54	91.0

Table 1: Direct-contact water heater efficiency according to the return temperature of the heating loop.

The Need for Renovation

In the early 1990s, the chief of building services and the managers of the hospital decided to renovate the old boiler house and to lower its operating cost. The objectives for the renovation included: beneficial payback, technical feasibility, reliability of the equipment, low maintenance cost, low supervision cost, flexibility during construction, acceptable construction cost, financing availability, implementation in an existing facility, and lower SO_X and NO_X releases in the environment.

Over the years, many problems were identified with the operation of the heating plant. The problems included: constant supervision of the heating plant; low efficiency of the boilers (very poor at low load); poor flexibility of operation at low load; outdated boilers (no spare parts available); high maintenance cost; the oil heater was required to be on all year; acid (SO_X) droplets and soot deposits on the cars and houses of neighborhood; high cost for boilers and chimney cleaning.

Despite careful installation of all the components for heavy oil or natural gas combustion, the three old boilers were designed to burn coal. It was almost impossible to keep a good efficiency while the load varied continuously throughout the day.

Because of the Province of Quebec's regulation on power plants, constant supervision of the boiler house had to be maintained all day at a rate of one hour for each two hours of operation. In practice, the boiler operator had to be on site 24 hours a day. Constant supervision of a heating plant requires a crew of six boiler operators. The planning of the renovation of the boiler house had to address those two major sources of potential savings on the operation cost.

Design Criteria

The final selection of the equipment was based on the following:

1. Despite a maximum steam requirement of 55,000 lbs/h (16 MW) during the year before the renovation, it was decided to limit the steam production capacity to 12 MW. Building and hot water heating had to be provided partly by other innovative heating apparatus requiring no supervision.

If the total output of all the boilers in simultaneous operation is less than 12 MW, the supervision requirement is one visit of the plant for every 24 hours of operation.

2. The flue gases of a standard boiler generating steam at 125 psig are normally in a range of 450°F (232°C) to 500°F (260°C). A tremendous increase of total plant efficiency could be achieved if the flue gases could be decreased to 100°F (38°C). This could be possible only if low water temperature could be made available at the supply side of the heat exchanger.

3. The heating plant design needed to take advantage of the low temperature of the water makeup for the domestic hot water, the boiler supply and the laundry; the low return temperature from the heating system of the air supplied to the boiler room; and the low temperature on the return of the building heating system (old cast iron radiators).

Energy Efficiency

Figure 1 shows the heating process in the direct-contact water heater. The hospital heating loop is on the right side of the plate type heat exchanger. On the left side is the grey water sprayed over a bank of stainless steel nodules where it is in

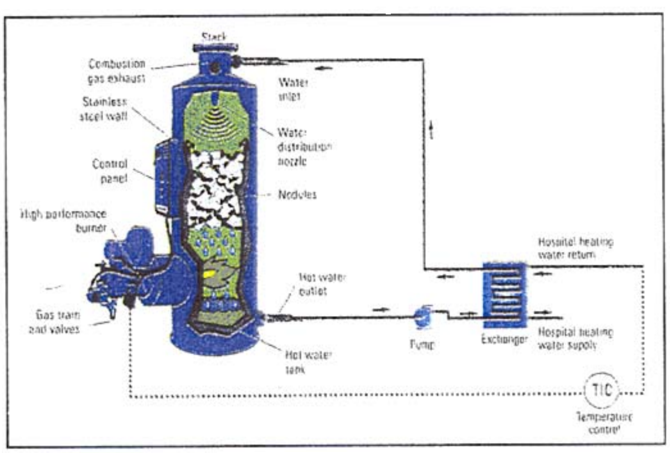

Figure 1: The direct-contact water heater.

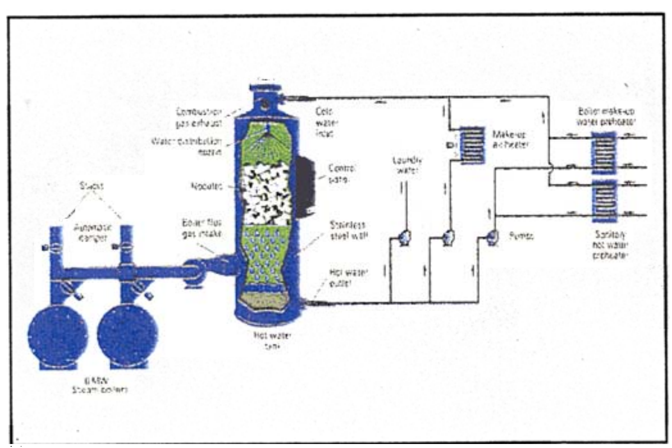

Figure 2: The direct-contact condensing stack economizer.

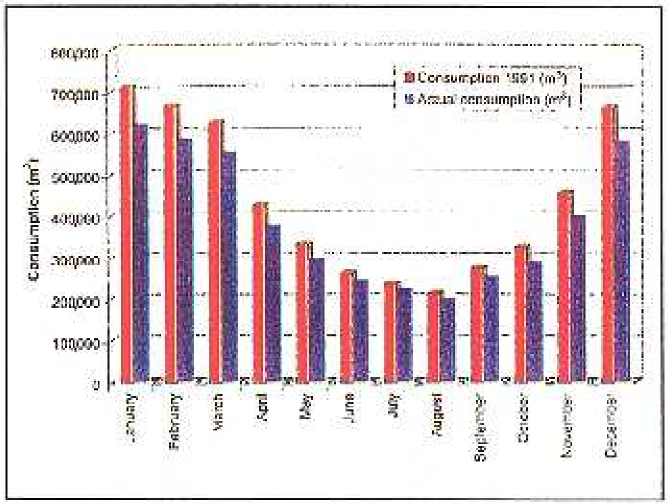

Figure 3: Annual natural gas consumption.

direct contact with the combustion gases. *Table 1* gives the information on the efficiency of the unit according to the return temperature of the heating loop.

Figure 2 shows the heat recovery process in the direct-contact condensing stack economizer. The hot gases (450°F or 232°C) of the two 6 MW standard boilers are introduced in the lower part of the stack economizer by a new induced draft fan. The water to be heated is sprayed at the top of the economizer over the bank of nodules where it is in direct contact with the hot flue gases. To take into account the variable load of the hot water usage at the laundry, heated hot water is accumulated in a reservoir (6,000 gallons or 22 700 L) located at the bottom of the stack economizer. The temperature of the flue gases exhausted from the economizer is normally 10°F (5.6°C) higher than the temperature of the water sprayed over the bank of stainless steel nodules.

When the laundry uses a large amount of hot water, the water makeup of the unit is at its lowest temperature and the exhausted gases could be as low as 50°F (10°C). The temperature of the water sprayed in the economizer is the main factor for the energy efficiency performance of the unit.

The annual natural gas consumption was reduced by 21,200,000 ft³ (600 000 m³) (see *Figure 3*). This lower energy usage generates an annual cost saving of $170,000 (Canadian).

The complete renovation of the heating plant at Sacré-Cœur Hospital generates saving on the energy consumption as well as on the supervision of the operation of the plant. The total cost for the renovation was $1,340,000. The annual savings are:

Supervision:	$ 88,000
Energy:	$170,000
Maintenance:	$ 40,000
Annual saving:	$298,000

The simple payback period is 4.5 years.

[illegible] Standard Steam Boilers; One [illegible] Condensing Stack Economizer	
Flow of Flue Gases	21,000 cfm (9900 L/s)
Inside Water Tank	6,000 gallons (22 700 L)
One Pump for the Laundry	100 gpm (6.3 L/s)
One Pump for the Domestic Hot Water Preheating	130 gpm (8.2 L/s)
One Pump for Makeup Water of the Boilers	70 gpm (4.4 L/s)
One Pump for Air Makeup	100 gpm (6.3 L/s)
One Plate Type Heat Exchanger for Preheating DHW	6,437 MBH (1,885 kW)
One Plate Type Heat Exchanger for Makeup Water	3,470 MBH (1,015 kW)
One Air Makeup System (Heating Coil)	2,500 cfm (1180 L/s) 1,800 MBH (530 kW)
One Direct-Contact Water Heater	20,000 MBH (5,860 kW)
One Pump	1,800 gpm (114 L/s)
Combustion Gas Temperature	149°F (65°C)
One Plate Type Heat Exchanger	20,000 MBH (5,860 kW)
One Induced Draft Fan	21,000 cfm (9900 L/s) 1.5 in. wg (375 Pa) 15 hp (11.9 kW) 450°F (235°C) flue gas temperature

Table 2: All design objectives were met with the installation of this equipment.

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