Case Study

Innovative refrigeration system at the **Loblaws supermarket in Repentigny**, Québec

An opportunity to achieve greater

Eco-Efficiency

Natural Resources Canada
Ressources naturelles Canada

Canada

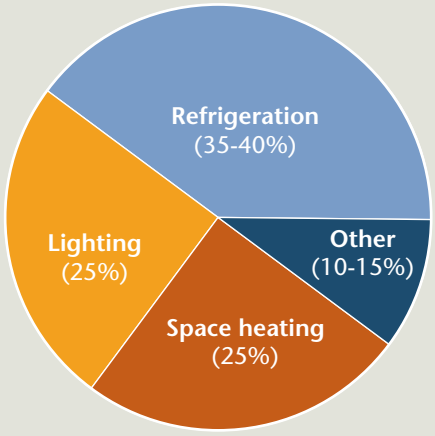
Abstract

In spring 2004, the Loblaws supermarket chain decided to innovate at their new supermarket in Repentigny (QC) by adopting refrigeration technologies and operating practices pioneered and promoted by Natural Resources Canada's CANMET Energy Technology Centre in Varennes (CETC-Varennes). The refrigeration system installed at this Loblaws store has the capacity to reduce overall energy consumption by about 23% compared to a conventional system, mitigate environmental impacts and enhance food product quality along with client comfort. The refrigerated display cases are cooled by secondary fluids, obviating the need for synthetic refrigerant lines, and the heat normally released to the environment is recovered and used to meet the store's space heating and hot water needs. This system is the first of its kind in Canada, and plans are under way to bring it on stream at other, existing Loblaws stores. This project was carried out under the Refrigeration Action Program for Buildings (RAPB), which is managed by CETC-Varennes.

Background

Supermarkets are energy intensive buildings. Approximately 40% of their total energy consumption goes toward operating the refrigeration system that keeps food product cool or frozen. Space heating also accounts for a large share of the energy costs.

Breakdown of energy consumption in a typical supermarket



A supermarket's refrigeration system is generally designed as an autonomous process for producing cold, while the bulk of heat extracted from refrigerated display cases is released to the atmosphere. The quantity of heat involved greatly exceeds the store's energy requirements and could easily meet its heating and hot water needs, even on the coldest winter days. Another operational feature of these refrigeration systems is that they release heat at temperatures around 40°C (105°F), a set point chosen with reference to the climate in the southern United States, but not adjusted to take advantage of the Canadian climate.

The refrigeration systems of most supermarkets use substantial quantities of synthetic refrigerant (roughly 1,000 to 2,000 kg of HCFC or HFC per store), which circulates under pressure from the mechanical room to the refrigerated display cases, through kilometres of piping with hundreds of brazed joints. This is a source of significant leakage, estimated at 10% to 30% a year. The refrigerants are powerful greenhouse gases (GHGs): 1,500 to 3,000 times more damaging relative to an equivalent mass of CO_2.

Loblaw opted to equip its new supermarket in Repentigny with innovative technologies that would reduce energy consumption as well as greenhouse gas emissions while improving food product quality and customer comfort.

Description of the Supermarket

Loblaw is one of the biggest food distributors in Canada with more than 500 supermarkets across the country. The new Repentigny store is a typical Loblaws supermarket with departments that include fruit and vegetables, meats, delicatessen, dairy, beer and wine, bakery, cosmetics, flowers, hardware, electronics and photo shop. The building has a footprint of 10,000 m² (102,000 ft²).

Refrigeration System Characteristics and Energy Efficiency Strategies

The refrigeration system installed at Loblaws is composed of a low temperature system with a nominal capacity of 55 tons of refrigeration (200 kW), and a medium temperature system with a nominal capacity of 110 tons of refrigeration (400 kW). Both systems use HFC-507A as a refrigerant. Key features of the selected system are described below.

Integration of the refrigeration system with the HVAC (heating, ventilation and air conditioning system): The integration of the refrigeration system with the HVAC system is realized by the means of two independent secondary fluid loops in which the heat generated by the medium temperature (MT) and low temperature (LT) refrigeration systems is rejected.

The heat (250 kW or 850 MBtu/hr) rejected by the MT system is recovered by an air coil located in a rooftop unit. The cold fresh supply air and the space return air are mixed at the heat recovery coil. The secondary fluid temperature is varied strategically in order to match the space heating demand. Therefore the MT refrigeration system acts as a heat pump.

The heat (220kW or 750 MBtu/hr) rejected by the LT system is recovered and upgraded by seven water loop heat pump units to meet part of the building's heat requirement. This strategy leads to a lower heat rejection temperature and therefore improves the energy efficiency of the main refrigeration system.

Excess heat in both secondary loops is rejected outside by the means of fluid coolers.

Refrigerant confined to the mechanical room and cold distribution via two secondary loops with environmentally friendly fluids: Potassium formate for low temperatures (around -29°C / -20°F) and propylene glycol for medium temperatures (around -6.5°C / 20°F) are cooled by the refrigerant through a heat exchanger (evaporator). They then circulate through pipes from the mechanical room to the refrigerated display cases at near-atmospheric pressure. This design greatly reduces the quantity of refrigerant required, the possibility of leaks and the energy consumption of the refrigeration system.

Recovery of superheat from the compressors of the low-temperature system: The recovered heat is used to meet domestic hot water needs and to defrost the freezers.

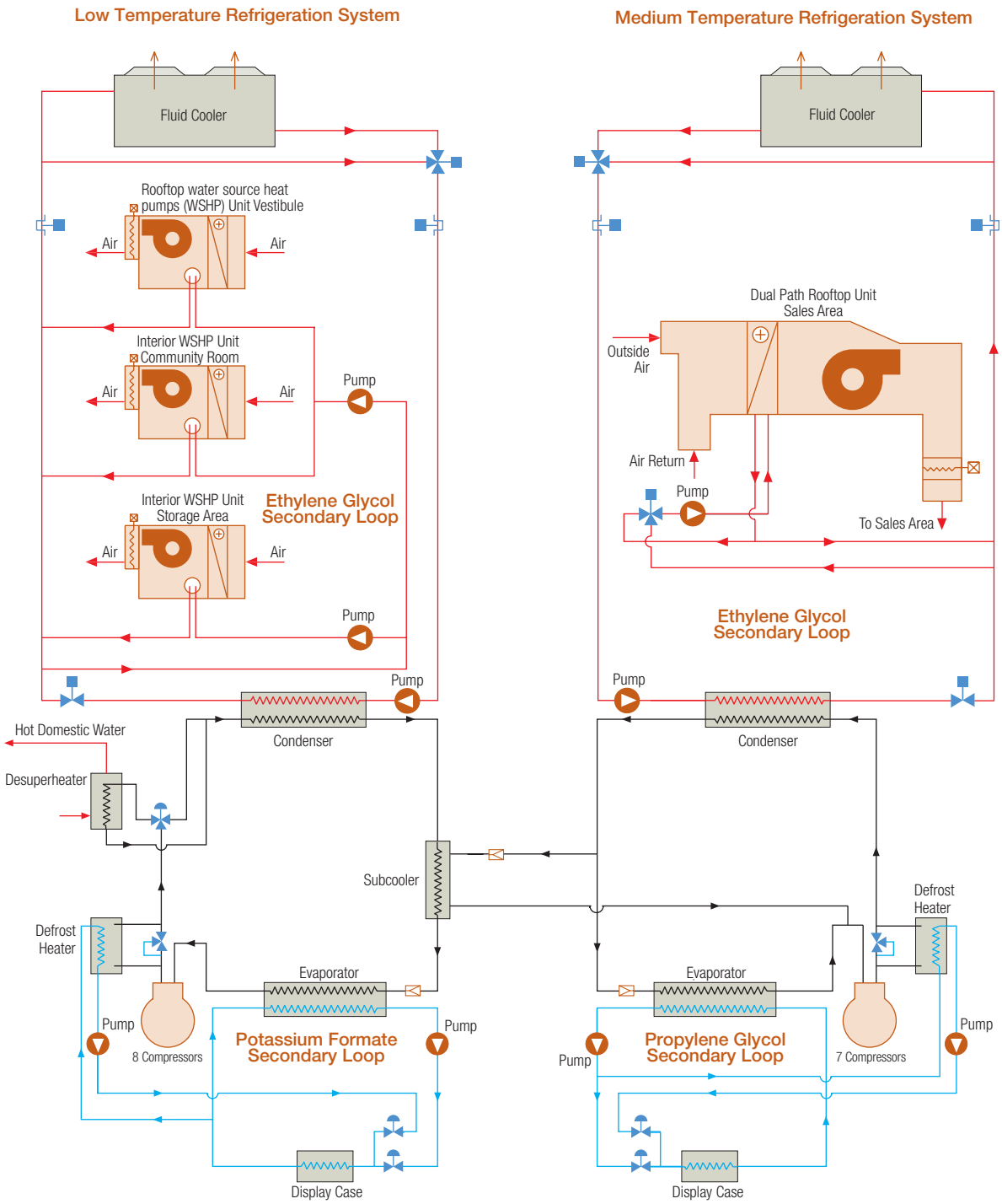
Use of mechanical subcooling for the low-temperature system: Subcooling of the low temperature system liquid refrigerant line by 30°C, corresponding to 15 tons (55 kW) of cooling at design conditions, is performed by the medium temperature system through a plate-type evaporator.

Variable condensation pressure (floating head pressure): The integrated HVAC-R system is managed so as to take advantage of the Canadian climate by modulating temperature or condensation pressure in keeping with the building's heating requirements and the outdoor temperature.

Other measures:

- Installation of a control system to optimize overall system operation.
- Installation of variable speed pumps on the cold secondary loops.

Integrated HVAC-R System



Benefits

The integrated refrigeration system installed at Loblaws provides the following benefits compared to a conventional design:

- Reduction in energy used for building space heating
- Reduction in synthetic refrigerant charge
- Decrease in refrigeration energy consumption
- Decrease in greenhouse gas (GHG) emissions
- Easier operation and maintenance
- More stable food temperatures resulting in quality and shelf life improvements
- Greater in-store comfort for customers

		Equivalent supermarket without heat reclaim	Loblaw supermarket in Repentigny	Reduction
Energy Consumption				
Refrigeration	(kWh-eq./yr)	2,800,000	2,500,000	11%
Space heating	(kWh-eq./yr)	1,800,000	232,000	87%
Total	(kWh-eq./yr)	8,300,000	6,400,000	23%
Synthetic Refrigerant (HFC-507A)				
Charge	(kg)	2,500	725	71%
Leaks	(kg)	625	36	94%
GHG Emissions				
Emissions HVAC&R	(t-eq.CO_2/year)	3,000	730	76%
Total emissions	(t-eq.CO_2/year)	4,600	2,400	48%

Technical partners

CIMA, Engineering consultant

Hill-Phoenix, Manufacturer of refrigeration equipment and refrigerated display cases

Hussmann, Manufacturer of refrigerated display cases

Keeprite, Manufacturer of fluid coolers

Consolidated Energy Solutions, Inc., Manufacturer of HVAC systems

Micro Thermo Technologies, Instrumentation and control

Hydro-Québec, Data acquisition and performance analysis

CETC-Varennes, Design support and performance analysis

Financial partners

Natural Resources Canada
- TEAM (Technology Early Action Measure) Program
- OEE (Office of Energy Efficiency)
- CETC-Varennes

AEE (Agence de l'efficacité énergétique du Québec)

Hydro-Québec

RAPB

The Refrigeration Action Program for Buildings (RAPB) fosters the use of innovative refrigeration practices in order to reduce the greenhouse gas emissions that result from the efficient use of energy and the reduction of refrigerant leaks in supermarkets, ice and curling rinks.

A french version is also available

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