Commercial Refrigeration Technologies: Opportunities and Best Practices for Green Design

Conventional Refrigeration Systems

Supermarkets around the world rely on refrigeration technologies to keep produce fresh, milk cold, and ice cream frozen.

In the United States, supermarkets have historically used centralized direct expansion (DX) commercial refrigeration systems. These DX systems typically have a charge of 3,000 to 4,000 pounds of refrigerant and can leak in excess of 20 percent of their refrigerant charge each year. Refrigerant leaks are costly and are detrimental to the environment due to their high global warming impact.

Green DX Systems

While leaked refrigerant can be expensive to replace, centralized DX systems are cost-effective when properly designed, installed, and maintained. Centralized DX systems benefit from lower installation costs when compared with many alternative commercial refrigeration technologies. In addition, centralized DX systems can be more energy efficient than alternative systems.

Thoughtfully designed, installed, and maintained systems—referred to as **'Green DX systems'**—are a proven and reliable technology. In addition to cutting costs, Green DX systems can help supermarkets reduce their impact on the environment (see flip side for tips on designing a Green DX System).

Alternative Refrigeration Systems

In addition to Green DX systems, supermarkets can also adopt alternative refrigeration designs and refrigerants. Examples of alternative refrigeration systems include distributed systems, secondary loop systems, cascade systems, and carbon dioxide (CO_2) systems. While alternative refrigeration systems often benefit from smaller refrigerant charge sizes and lower refrigerant leak rates, they can present other challenges related to upfront costs and technician familiarity, and need to be carefully designed to maintain efficiency.

[1] Estimated impacts are based on generalized assumptions and were calculated using the GreenChill Climate Impact Calculator and the GreenChill Financial Impact Calculator, available online at http://www2.epa.gov/greenchill/reports-guidelines-and-tools.

[2] Estimated impacts are based on emissions of R-404A and were calculated using the Greenhouse Gas Equivalencies Calculator, available online at http://www.epa.gov/cleanenergy/energy-resources/calculator.html.

Benefits of Green and Alternative Designs

Each type of commercial refrigeration technology offers advantages and challenges. With many supermarkets focused only on the challenges, the advantages of green or alternative designs are often overlooked. As exemplified below, systems with smaller refrigerant charge sizes and lower refrigerant leak rates provide notable financial and environmental benefits.

Financial Impact[1]

Refrigerant leaks from a conventional DX system can be up to 1,000 pounds of refrigerant each year. At $4 – $6 per pound, leaked refrigerant translates into a lot of money. For example, to pay the annual replacement cost of leaked refrigerant, a supermarket would have to sell roughly:

- 135,000 gallons of milk, or
- 125,000 pounds of ground beef.

Environmental Impact[2]

The more climate-damaging refrigerants that are commonly used in a supermarket can mean emissions equal to almost 1,800 metric tons of CO_2. This is equivalent to:

- Annual CO_2 emissions from roughly 375 passenger vehicles, or
- Annual CO_2 emissions from the energy use of roughly 160 U.S. homes.

EPA United States Environmental Protection Agency

October 2014
430-F-14-040

Overview of System Components and Best Practices for Green Design

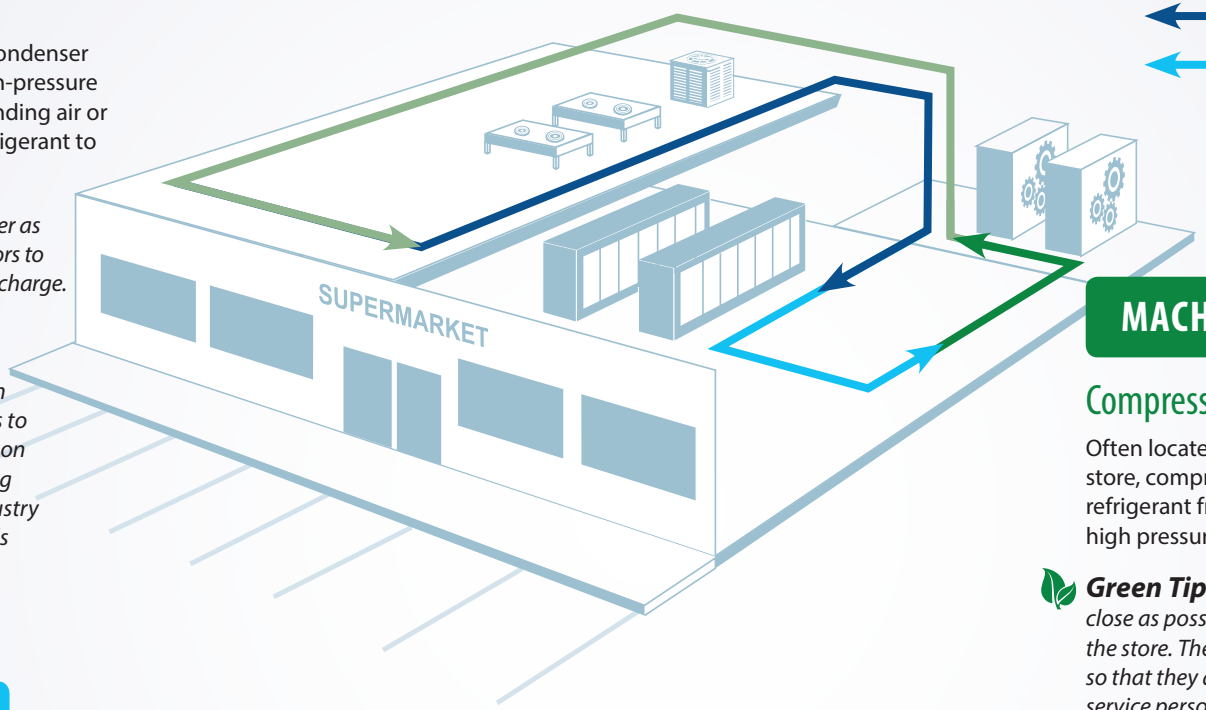
ROOFTOP

Condenser

Typically located outside, the condenser transfers the heat from the high-pressure vapor refrigerant to the surrounding air or a water supply, causing the refrigerant to convert back into a liquid.

Green Tip: *Install the condenser as close as possible to the compressors to minimize the system's refrigerant charge.*

Green Tip: *To reduce your system's refrigerant charge, use split condenser piping along with automated switching techniques to enable the condenser to operate on only one of the two circuits during cold weather months. Apply industry accepted techniques and controls to permit pump out of stranded refrigerant from the inactive condenser circuit.*



Low Pressure Vapor Refrigerant
High Pressure Vapor Refrigerant
High Pressure Liquid Refrigerant
Low Pressure Liquid Refrigerant

MACHINE ROOM

Compressors

Often located in a machine room at the back of a store, compressors pump the low pressure vapor refrigerant from the evaporators and compress it to a high pressure and temperature.

Green Tip: *Compressor racks should be positioned as close as possible to the display cases and walk-ins within the store. They should also be positioned in such a way so that they are easily accessible by maintenance and service personnel.*

Receiver

The refrigerant charge required of a system varies seasonally. To accommodate this variation, additional liquid refrigerant charge is stored in a vessel, known as the receiver, located downstream of the condenser.

Green Tip: *Oversized receivers can lead to overcharged systems. To minimize the charge, carefully select the vessel size to appropriately accommodate your system. Additionally, if possible, use a vertical receiver, which requires less charge than a horizontal receiver.*

SALES FLOOR

Display Cases

Located throughout the sales area, display cases are used to store refrigerated and frozen products.

Expansion Valve

The expansion valve, located inside the display cases, controls the flow of the refrigerant to the evaporator.

Evaporators

Located inside the display cases, evaporators are used to remove heat from the conditioned space within the display cases. Inside an evaporator, liquid refrigerant boils, or evaporates, absorbing heat as it changes to a vapor.

Green Tip: *A variety of practices can be used to reduce the energy consumption of display cases, including the use of LED lights, electronically commutated motors (ECMs), and no-heat glass doors. Reducing the energy load of cases reduces the required refrigerant load, which in turn reduces the amount of refrigerant charge required of the system.*

Piping

Piping is used to transfer the refrigerant from the machine room to the cases located throughout the store. Piping also connects the compressor rack to the condenser via the discharge and condensate line.

Green Tip: *Alternative piping designs, such as suction and liquid loop piping, can be used to reduce the linear feet of piping required by your system as well as the number of fittings. This in turn reduces both the charge size and leak potential of the system.*