Improving Energy Efficiency in Warehouses

Warehouses are moving beyond simply providing storage; many now offer high-tech inventory tracking and value-added services such as quality-control testing and repackaging. As warehouses grow more sophisticated, their energy consumption grows, and energy-efficiency measures can be a boon to the bottom line.

Warehouses in the U.S. spend an average of US$0.70 per square foot ($ft^2$) on energy: About half of that cost is for natural gas and half for electricity. Energy costs for some warehouses are more than 10 percent of their total revenue. Heating and lighting are the two largest energy end uses for warehouses, together accounting for 64 percent of total warehouse energy use. That makes those systems the best targets for energy savings (**Figure 1**).

Quick Fixes

Turning things off when you don't need them and keeping equipment in good repair save energy.

Seals. One of the greatest sources of energy losses for heated or refrigerated warehouse spaces is air infiltration through gaps around loading-dock doors during loading and unloading operations. Regularly checking and repairing gaps in seals is a quick energy saver.

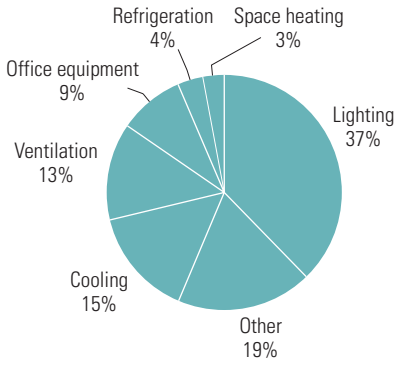
Maintenance. Regular maintenance of heating, ventilation, cooling, and refrigeration systems—including changing filters regularly—is important for good operation and to avoid energy waste.

Delamping. Light fixtures often have more lamps than are required for recommended lighting levels. Remove unnecessary lamps.

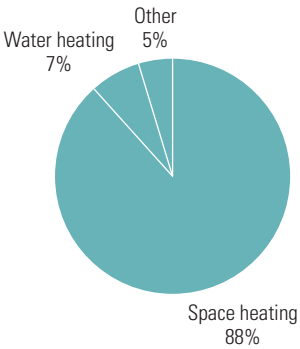
Controlling outside air intake. Not heating outside air during unoccupied periods saves an average of about US$0.50 (C$0.54) per hour for each 1,000 cubic feet per minute (cfm) (28.32 cubic meters per minute) of heated air. Estimates are based on US$12 per million Btu (MMBtu) (C$13.02/MMBtu) of natural gas, a gas-fired heater efficiency of 80 percent, and an average temperature change of 30° Fahrenheit (F) (16.7° Celsius [C]) between the outside air and the temperature of the heated

Figure 1: Warehouse energy consumption by end use in the U.S.
Data from the U.S. Energy Information Administration (EIA) show that about 50 percent of U.S. warehouse energy use is natural gas consumption and 48 percent is electricity consumption. Lighting and cooling account for 37 percent and 15 percent of electricity use, respectively. Space heating accounts for 88 percent of natural gas use. (See U.S. EIA, "CBECS: End-Use Consumption by Principal Building Activity" [1999], www.eia.doe.gov/emeu/cbecs/enduse_consumption/pba.html.)

A. Warehouse electricity usage



B. Warehouse natural gas usage



Source: E SOURCE; data from U.S. EIA

space. Economizer controls can be used to vary the amount of outdoor air used, based on outside air temperature. Or simple scheduling controllers can be set to bring in outside air at specific times (such as during business hours) and can reduce the need for mechanical heating or cooling. In both cases, these controls can reduce energy costs significantly.

Ventilation and temperature settings. Many warehouse areas have rooftop units for heating, ventilation, or cooling. Some are also equipped with exhaust fans. Exhaust fans for warehouse spaces should be shut off when the space is unoccupied. In addition to the outside air controls described earlier, avoiding unnecessary fan use saves an additional US$0.10 (C$0.11) per hour for every 1,000 cfm (28.32 cubic meters per minute). For additional savings, the temperature setpoint should be reduced during the heating season by 10°F (6°C) or more when areas are unoccupied.

Longer-Term Solutions

With investment of money and time, there are many more opportunities for improving energy efficiency in warehouses.

Big ceiling fans. If the space is air conditioned, ceiling fans save energy by improving air circulation, allowing the temperature setting to be lowered by as much as 4.5°F (2.5°C). If the space is not air conditioned, using large ceiling fans can improve employee comfort, morale, and productivity. Several case studies have shown that the air circulation is better and energy efficiency is greater with large ceiling fans compared to smaller, higher-velocity fans. (One large, slow-moving fan can do the same job as several smaller, high-speed fans.) Large ceiling fans also reduce heating costs in winter by recirculating the higher-temperature air that tends to stagnate near the ceilings of warehouses.

Radiant heating. In many warehouse applications, especially in loading areas, it is costly and inefficient to maintain temperatures of 60° to 70°F (16° to 21°C) to keep staff comfortable. In these situations, reflector-focused gas or electric radiant heaters (also known as beam radiant heaters) can be mounted above the areas that require heat, keeping employees comfortable with the ambient interior air temperature as low as 40° to 50°F (4° to 10°C). This reduction in overall indoor air temperature can dramatically reduce heat loss and energy consumption, sometimes by as much as one-half. The radiant heaters should be controlled by timers or occupancy sensors to minimize their operation when areas are unoccupied.

Reducing air infiltration. Refrigerated areas within warehouses lose a lot of energy when doors open to allow forklifts to come and go. Retrofit solutions include insulated cold-storage doors that open and close quickly (yet safely) and better seals around loading-dock doors.

Fluorescent lighting. Fluorescent lighting is now the best choice for most warehouse applications. For aisles, conventional fluorescent fixtures (T8s or high-efficiency T8s and ballasts) work best at heights of less than 20 feet (6 meters), and combining them with occupancy sensors or timers can save a lot of energy. For aisles requiring greater clearance, and for many high-ceilinged bay areas, high-intensity discharge lighting or high-intensity fluorescent lights are typically used. High-intensity fluorescents have recently been recognized to be at least as effective and usually more energy efficient than metal halide or high-pressure sodium lights.

Metal halide lighting. However, metal halide lamps maintain adequate light levels over the full range of temperatures and, with electronic ballasts, operate more efficiently at extreme temperatures than does fluorescent lighting. In addition, metal halide technology has advanced so that it may be the best lighting choice in some new unconditioned warehouse spaces. Ceramic metal halides with electronic ballasts are an efficient way to provide very good color rendering, which can be important in some warehouse areas—for

example, where the staff uses color to help identify the proper items to pick up.

Occupancy sensors. Occupancy sensors turn off lights when no one is around. New line-voltage occupancy sensors have reduced the installed costs from approximately US$150 to $50 (C$163 to $54) per sensor, making it cost-effective to install one sensor per fixture in low-occupancy spaces and resulting in huge potential energy savings. Occupancy sensors are best used with fluorescent lighting rather than with metal halides because fluorescents have virtually instant restrike capabilities. Metal halides require a several-minute delay between the moment when the light is turned off and the moment when it can be turned on again. However, it is possible to install ballasts with metal halides that dim the lights to about 50 percent power, based on the signal from an occupancy sensor. This option provides about half the potential savings compared to the option of pairing occupancy sensors with fluorescents.

Many of these lighting technologies were brought together in a state-of-the-art 234,000-ft^2 (71,323-square-meter) office product distribution facility built in Vaughn, Ontario. The always-operating facility includes lighting sensors, T8 OCTRON® lamps, and electronic ballasts tied into a computer-controlled energy management system, all of which are expected to result in energy savings of 14,500 kilowatts per month over a standard facility.

Obtaining Assistance

How do you know if any of these suggested fixes are worthwhile for your warehouse? Audits help building managers identify and prioritize cost-effective improvements. Some utilities provide on-site audits for free, and consulting and energy service companies conduct audits for a modest fee. Web-based tools can also help guide your energy-saving plans. For example, the Energy Star program's Portfolio Manager tool can be used to assess and track energy use in warehouses: www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager.

Options for Refrigerated Warehouses

The annual energy intensity of refrigerated warehouses in the United States is about 101,000 Btu per square foot, which is 2.8 times the intensity of nonrefrigerated warehouses. There are several specific equipment upgrades that improve energy efficiency in cold-storage warehouses:

- Moderately oversized evaporative condensers with variable-frequency drives
- Efficient motors for compressors
- Controllers to slow evaporator fans when full-speed operation is unnecessary
- Properly sized evaporator coils with variable-frequency-drive-controlled fans
- Defrost controllers that initiate defrost cycles based on ice buildup in freezers
- Proper insulation of coolers and freezers