There are an unlimited variety of ways to heat and ventilate buildings. The choice of systems is based on a number of factors.

You need an energy source (electricity, natural gas, propane, or fuel oil) and a heat transfer medium (air, water, or steam) that flows through a heat delivery system (pipes and ducts). Typically air or water is used as the heat transfer medium because both are in abundant supply. The heat arrives in the room through grilles and diffusers or convectors, unit heaters, and radiators.

The exception is an infrared or radiant heater which heats objects and people by direct radiation (like the sun) rather than through pipes or ducts.

Heat flow is always from warm to cool. The rate is based on the temperature differences between the hot side and the cool side, as well as the resistance to flow (created by walls, insulation, air films, and other building components).

The basic heating and ventilation system takes the heat from the heat source and distributes it to the places that need it, using fans and ducts for air-based systems or pumps and pipes for water-based systems.

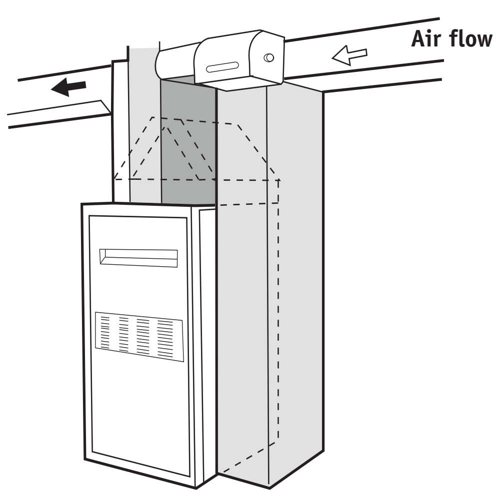
Furnaces

A furnace is a typical inexpensive heating unit. Furnaces are widely available using electricity, natural gas, propane or oil as a fuel source. Furnaces come in various configurations to suit various applications. They are inexpensive to own, operate and maintain.

Furnaces use air to distribute the heat to the rooms they serve. Furnaces rarely have capacities in excess of 200,000 Btu/h (60 kW). The term Btu/h is British thermal unit per hour.

Although furnaces are relatively inexpensive to operate and maintain, they suffer from the drawback that only one thermostat controls many rooms with different heating or cooling requirements. Furnaces are generally installed in mechanical or furnace rooms. Their efficiencies vary depending on type, operation, and the fuel they use.

Figure 5.1 - Typical forced-air furnace



Electric

An electric furnace has an annual fuel utilization efficiency (AFUE) of 100 per cent meaning that essentially 100 per cent of the electrical energy supplied to the furnace is converted to heat in the building.

Natural gas/propane

Standard. A standard natural gas or propane furnace with a standing pilot has an AFUE of 55 to 65 per cent, despite a 75 to 80 per cent combustion efficiency. This means that only 55 to 65 per cent of the energy supplied to the furnace is realized as useable heat in the building. The AFUE is lower than the combustion efficiency because heated building air is constantly flowing out of the chimney through the draft hood on the furnace. The efficiency is lowered further by the standing pilot that generally operates throughout the year (the pilot light can often be shut off if it is not required for the entire year). Standard efficiency units are no longer available on the market.

Mid-Efficiency. A mid efficient natural gas or propane furnace has an AFUE rating of approximately 80 per cent. The efficiency is improved over the standard furnace by replacing the draft hood with an induced draft fan. This eliminates the constant flow of heated building air out through chimney. The furnace also employs electronic ignition, eliminating the standing pilot.

High Efficiency. High efficiency condensing natural gas furnaces are very popular as replacements for old gravity vented furnaces. Choose an Energy Star® qualified high efficiency condensing furnace with a high efficiency variable speed fan motor for both natural gas and electricity savings. The Energy Star units extract at least 92 per cent of the available heat from the burned gas mixture. With a variable speed brushless DC motor, an improvement of 90 per cent can be achieved over a single speed AC fan motor.

Efficiency is further enhanced over a mid-efficient furnace by utilizing a secondary heat exchanger that extracts the latent heat from the water vapour in the flue gases produced during the combustion process. The flue gases are then vented outside and the condensed water vapour is drained to a sewer.

High efficiency furnaces should not be installed in locations where the temperature may drop below the freezing point. There is a condensate trap on the furnace and the water in the trap could freeze. The furnace will not operate if the water in the trap freezes.

Oil

Older standard oil furnaces have an AFUE rating of 60 to 70 per cent. This is due to warm air passing through the heat exchanger. Older heat exchangers offer little resistance to air flow, allowing room air to freely exit the building through the chimney even when the furnace is not operating.

Newer mid-efficiency oil furnaces are equipped with more efficient burners and offer more resistance to air flow when the burner is not firing. The AFUE rating of these furnaces is about 80 to 86 per cent. High efficiency condensing oil furnaces have an AFUE rating of about 86 to 90 per cent. They are expensive and not commonly available.

Infrared radiant heaters

Infrared heaters use a different principle than furnaces, unit heaters, or boilers to warm occupants and rooms. The method is similar to sunshine or camp fires.

Radiant heaters use gas, propane, or electricity to produce a high temperature radiating body. Heat is radiated via infrared rays from the heater to any object visible to the heater. Since these heaters heat objects, not the air, they are sometimes advantageous in an arena application when you want to heat spectators in the viewing stands but do not want to heat the rink itself. They may reduce heating costs since the air does not have to be heated to keep occupants comfortable.

Radiant heaters come in two basic types: high intensity and low intensity.

Low intensity heaters are generally radiant tube heaters. The combustion efficiency of low intensity heaters is about 80 per cent. The infrared efficiency (amount of energy supplied to the heater that is transferred to infrared energy) is as low as 35 per cent.

As a result, 35 per cent of the energy emitted by low intensity heaters is infrared, 45 per cent is convection and 20 per cent is lost out the exhaust (vent).

High intensity infrared heaters have an exposed burner that increases infrared efficiency up to 80 per cent. Since the units are not vented, combustion efficiency is higher than for low intensity heaters. The heaters must be interlocked with an exhaust fan to ensure people are not exposed to harmful levels of carbon monoxide.

High intensity infrared heaters generally require a high ceiling to accommodate the necessary clearances from combustible material.

Figure 5.2 - Radiant tube heater

Unit heaters

Commercial unit heaters are a variation on residential style furnaces and are available in standard and mid-efficiency models. They are popular for heating large rooms with high ceilings.

A louvered diffuser on the discharge directs the air around the room. Generally no ductwork is installed on the unit. If ductwork is to be attached, the unit heater must be certified to be installed with ductwork.

Unit heaters are economical to install and easy to relocate, but have limited applications and do not provide for ventilation. As a result of building code regulations, unit heaters are not allowed in assembly areas, such as meeting rooms or community halls. They are well suited for storage areas, garages, and work shops.

Figure 5.3 - Typical suspended unit heater

Air conditioners

In rinks and arenas, air conditioning is normally restricted to lounge and viewing areas in summer when outdoor temperatures and humidity exceed comfort levels. The air conditioner can be part of a rooftop unit or built into a forced-air furnace system.

Air conditioners are rated in Btu/h. They may also be rated in tons, an old-fashioned term used to describe the cooling effect felt by melting one ton of ice over a 24-hour period. One ton of cooling is equal to 12,000 Btu/h.

The efficiency of an air conditioner is expressed in two ways. One is the EER or Energy Efficiency Ratio, which is expressed as:

$$\textbf{EER} = \frac{\textbf{Btu/h cooling}}{\textbf{watts input}}$$

The EER efficiency ratings are applied to room air conditioners.

The second rating is SEER or Seasonal Energy Efficiency Ratio—essentially the EER averaged out over the entire season. The SEER is expressed as:

$$\text{SEER} = \frac{\text{Total cooling during season, in Btu/h}}{\text{Total energy consumed, in watt-hours}}$$

The SEER efficiency ratings are applied to central air conditioners.

When shopping for a central air conditioner, look for a SEER performance rating above the allowed minimum of 13. An EER rating of at least 10 should be chosen for room air conditioners. Air conditioners above these ratings will ensure energy consumption is not excessive.

Rooftop heaters

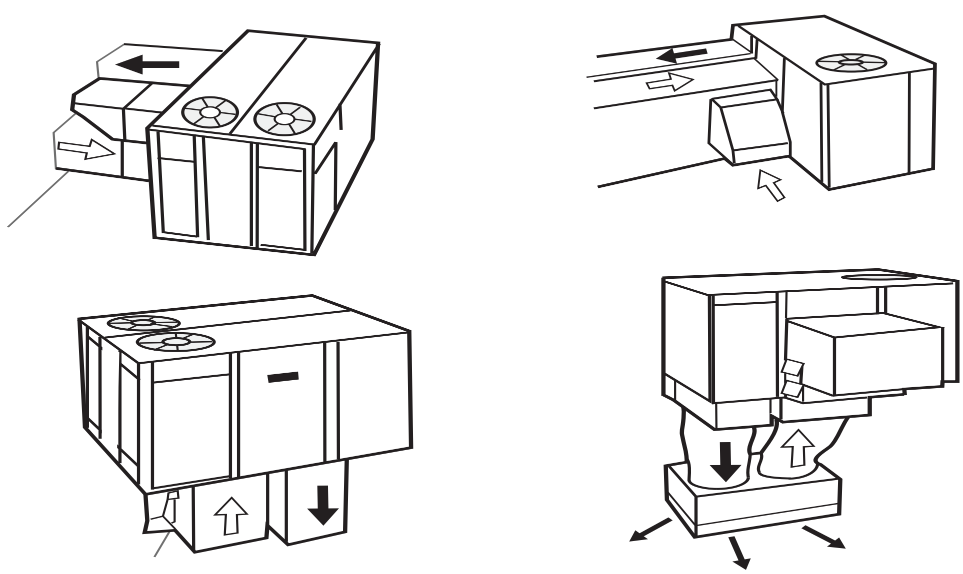
Rooftop units will have a seasonal efficiency rating between 60 to 75 per cent. The rating depends on the type of pilot, burner, unit location, cabinet insulation, and hours of operation.

As the name suggests, rooftop units put the equipment on the roof, freeing up valuable floor space. Rooftop equipment for general space heating is usually supplied with an air conditioning system, including ventilation.

Rooftop heaters with economizers use cool outside air instead of mechanical cooling to provide free cooling. When compared to furnaces with cooling coils, rooftop heaters use less electricity to cool your rooms.

Rooftop heaters distribute air through ductwork, normally above the ceiling. They cost more than a furnace but provide cooling and ventilation in a single packaged unit. Installation costs are lower or the same as installation costs of furnaces of similar capacity.

Figure 5.4 - Rooftop heaters



Heat pumps

A heat pump uses refrigerant circuits to move or pump heat from one location to another rather than using an electric heating element or burning fossil fuels.

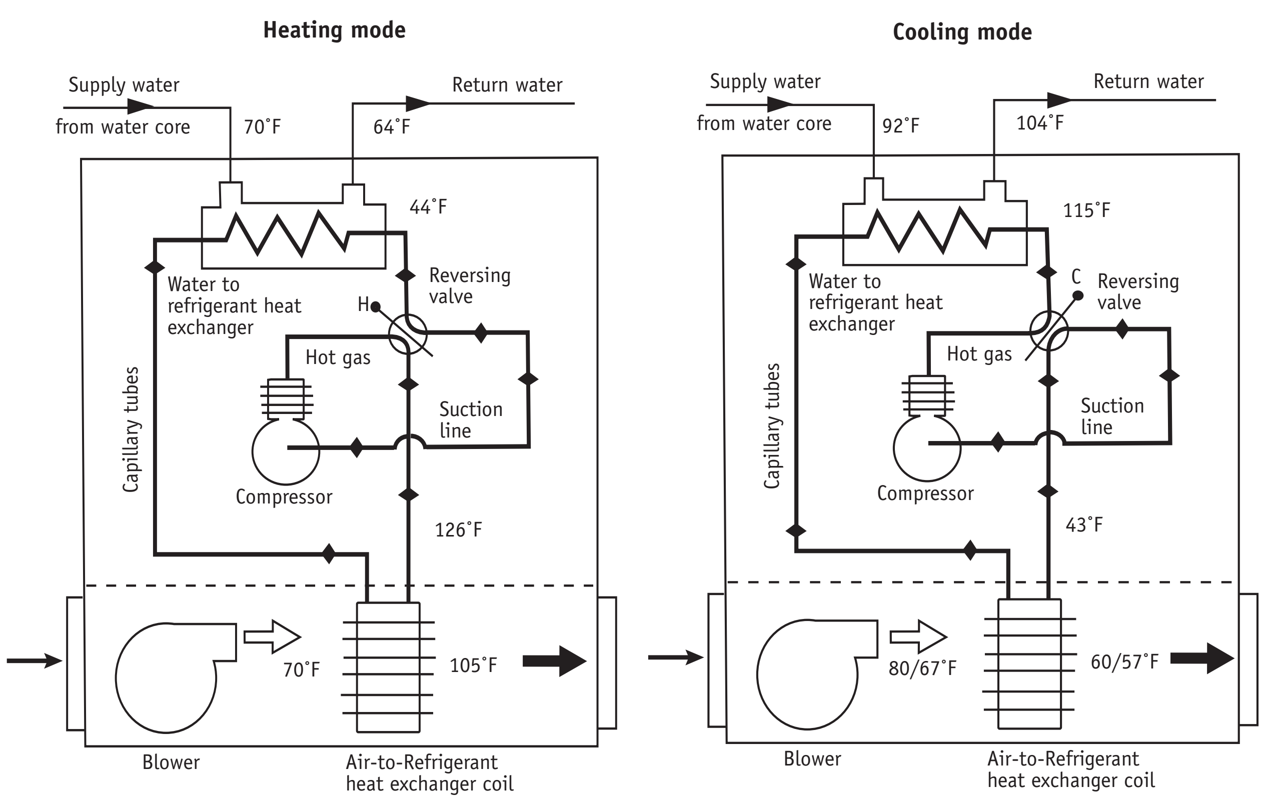
Heat pumps can heat or cool depending on the requirement of the space they serve. Depending on whether the pump is in heating or cooling mode, an internal four-way reversing valve redirects refrigerant flow and reverses the function of the evaporator and condenser coils (a coil that absorbs heat in one case rejects heat in the reversed position).

Ground source heat pumps have coefficient of performance (COP) ratings between 3.1 and 4.9. As a result they can produce 3.1 – 4.9 kilowatts of heat energy for every kilowatt of electrical energy supplied to the unit. Check current federal government regulations for minimum efficiency ratings for heat pumps.

Heat pump systems can be used for space heating and cooling, as well as for water heating. Special care must be taken in the piping of the system to avoid fouling of the heat exchanger inside the unit. Several new designs use an integrated heating and cooling system for rinks and arenas, incorporating heat pumps with regular ice plant equipment to meet the space heating, water heating, and air conditioning demands of the complex.

For arenas, these systems have a higher first cost (installed price) and lower operating costs than conventional systems. Maintenance costs may be slightly higher than conventional heating systems but are similar to air conditioning systems.

Figure 5.5 - Heat pump operation



Hot water/steam systems

Central boilers can heat a building. The AFUE rating of older, natural draft fuel-fired boilers is 45 to 55 per cent—slightly lower than the 55 to 65 per cent AFUE of a furnace. The difference is because of greater heat loss from the high temperature water stored in the boiler. Newer condensing boilers with electronic ignition and power vents or vent dampers have high AFUE ratings of 90 to 96 per cent. Boilers can employ baseboard radiators, convection radiators, and coils in air handlers to transfer heat to the building via convection. Heat can also be transferred by radiation through hot water tubing installed in a concrete slab. A combination of all of these techniques can also be used.

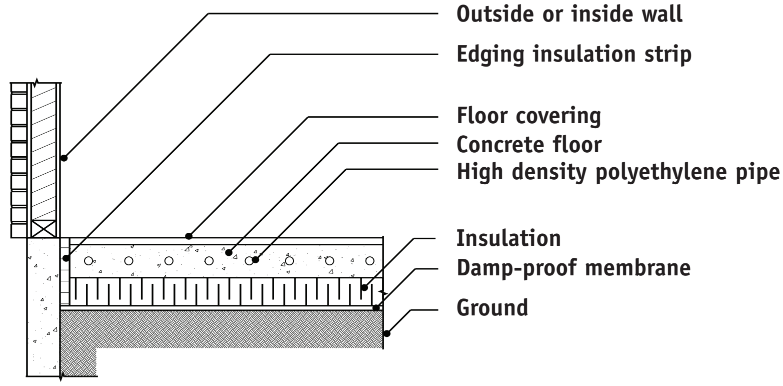
In buildings with large concrete slabs and relatively low heat loss, radiant slab heating systems can be considered an alternative to other heating systems. Pipes embedded in the slab circulate hot water or use electric resistance heat to warm the concrete. The mass of the slab holds the heat in the floor for long periods and maintains the heat at floor level where it is needed. This is especially important in rooms with high ceilings where stratification can keep much of the heat high in the room and cause cool drafts at the floor.

Slab heating systems are well suited to heating lobbies and entranceways, viewing areas, and dressing rooms. A separate ventilation system may also be required to provide air flow. Extreme care must be taken in the installation and long term maintenance of in-slab heating systems to ensure good operation. Improper care may lead to leaks and costly repairs since a large area of floor may need to be torn up to find one small leak. It is important to install R-10 to R-15 insulation under the heated slab to reduce the amount of heat lost to the ground.

When properly installed, slab heating systems have shown energy savings. It is possible to lower space temperature and lower ceiling temperatures while maintaining occupant comfort, due to the warm floor and occupant zones. Tubing can also be installed in spectative seating, if it is a poured concrete slab. This technique further increases overall system efficiency since only the occupants are heated and the seating areas can be zoned. It is therefore possible to heat only certain sections of the seating area when the entire arena is not used.

The installation cost of this system is much higher than it is for a furnace or rooftop systems, especially when the cost of the air circulation system is added to the cost of the slab heat and boiler system. In-floor heating systems can be problematic in some parts of Saskatchewan where soil heaving is common. An option may be to apply rigid insulation to the footings (or grade beam) and extend that insulation about 3 feet below the footings at a 45° angle below horizontal to about 3 feet out from the building. Rigid insulation on the outside of a building must be enclosed to protect it from the sun and from rodents.

Figure 5.6 - In-slab heating system



Ventilation

Ventilation of buildings, whether natural or mechanical, is critical for the health and safety of occupants.

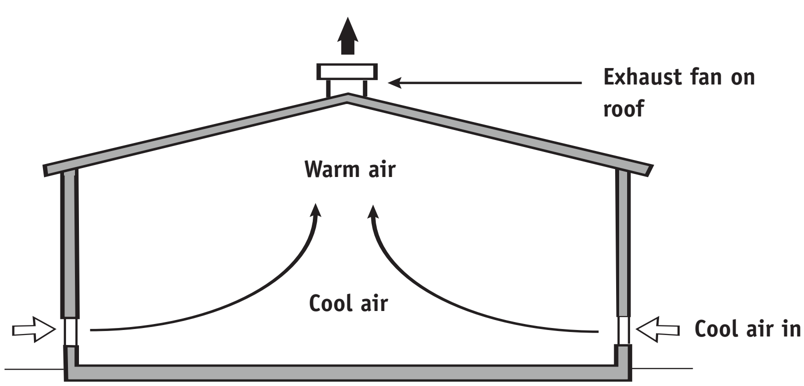
Natural ventilation

When an occupied room gets too hot we like to open a window for some fresh air. This is an example of natural ventilation for thermal comfort. Outside air comes into the room through the window and cools off that area. It is intentional and we are controlling it. In warm weather, we save energy by reducing heat gain through the walls and by not operating cooling equipment. In cold weather, opening a window will increase the load on your heating system and cost money.

In rinks it is very common to ventilate the arena in winter to freeze the ice when a refrigeration plant is not in place.

Natural ventilation of a rink or arena in winter saves energy by reducing the run time of the refrigeration equipment in artificial ice facilities. This is also covered in the following section.

Figure 5.7 - Natural ventilation in a rink



Health Issues

To ensure the safety of occupants, ventilation is required. The American Society of Heating, Refrigerating and Air Conditioning Engineers [ASHRAE] has established a table of suggested ventilation rates. The rate of ventilation is a function of activity, the number of people in the room and the odours associated with the activity. For example, the lounge in a curling rink can have a lot of people in a small space. Ventilation is required to dilute the odours and bring in clean fresh air for the occupants.

Arenas need ventilation. There are a number of cases where the carbon dioxide and carbon monoxide produced by the ice cleaning equipment was not removed properly and the vapours made members of hockey teams ill. Ventilation dilutes and removes those vapours and provides a healthy atmosphere for users.

Increased levels of activity accelerate the rate at which occupants are affected by these air pollutants. Essentially, these pollutants deprive users of the oxygen necessary for activities such as skating, curling, and dancing.

Occupational Health and Safety standards have set acceptable maximum levels for carbon monoxide at 50 parts per million (ppm). Exposure above these levels may produce symptoms including cherry red lips and finger nails, reddening of the skin, headaches, giddiness, shortness of breath, faintness, or collapse.

Maximum acceptable levels for carbon dioxide are recommended at 1,000 ppm. Exposure above these levels for extended periods may produce carbon dioxide narcosis. Symptoms include fatigue, headaches, stupor, and loss of sensation.

If you observe people in the rink or arena with the symptoms listed above, immediately move them outside into fresh air and administer oxygen if available. Keep victims warm and contact a doctor or transport victims to a hospital.

Carbon monoxide safety

Carbon monoxide (CO) is a colourless, odourless gas that is released when natural gas, gasoline, diesel, propane, kerosene, heating oil, or wood burns without enough oxygen. Dangerous accumulations of CO can result from a faulty appliance, clogged chimney, inadequate venting, or a buildup of engine exhaust. To reduce the amount of toxic gases produced while the arena is in use, follow these guidelines:

1. Make sure the arena is well ventilated by fans, doors, and louvered vents. Turn on the exhaust fan. Open doors and louvered vents before, during, and after the time when the ice-resurfacing machine is operating. To increase air flow through the arena, make sure the fresh air intakes are at the opposite end of the building from the exhaust outlet. Ceiling fans may help reduce the level of exhaust gases at ice level, so run them continuously.

2. Install three-way catalytic converters on ice resurfacers, which reduce levels of hydrocarbons, CO and NO_2. Consider buying electric or battery-operated resurfacers, which reduce, and in some cases eliminate, concerns about air quality.

3. Warm up resurfacing machines outside or in a well-ventilated and specifically designed room; or attach a hose to the exhaust pipe to draw the toxic gases outside. Most vehicles must be warmed up for at least five minutes for catalytic converters to work properly.

4. Extend the exhaust pipe of the ice-resurfacing machine upwards so it is at least one foot higher than the top of the rink safety barrier. This will reduce the build-up of CO and NO_2 at ice level.

5. Service the ice resurfacer regularly, according to the manufacturer's recommended schedule. Tune up at least after every 100 hours of use. Analyze the gas content of the engine exhaust to make sure the engine is properly tuned. Ensure catalytic converters are working properly.

6. Connect louvered vents electrically to exhaust fans so they operate at the same time. Exhaust fans can be set to turn on automatically to make sure they are used properly. Timers can be installed to control the operation of infrared heaters.

7. Open rink barriers while resurfacing the ice. This allows greater air flow across the resurfaced area, again reducing gas build-up. Make sure spectators and players stay clear of gate openings during resurfacing.

8. Install carbon monoxide detectors near the ice surface, and test them regularly. Consider testing the arena air regularly for CO and NO_2 to ensure gas levels are acceptable.

9. Levels should not exceed 25 ppm for CO and 0.25 ppm for NO_2. Test results exceeding these levels should trigger an immediate response to rectify the cause, as outlined in points 1 to 7 above. Arenas should strive to keep their exhaust gas levels as low as possible. Levels exceeding 125 ppm for CO and 2.5 ppm for NO_2 require occupants to leave the building immediately.

10. Any illness among skaters, regardless of the gas levels, should trigger immediate ventilation of the arena, a stop to all skating activities and a full investigation that involves the local Medical Health Officer.

11. Make the arena a smoke-free environment. Provincial regulations require your rink or arena to be smoke free. Cigarette smoke contains CO.

Mechanical ventilation

Use mechanical ventilation to remove vapours, heat, smoke and other air-borne contaminants. This produces positive, measurable air movement in spaces to improve indoor air quality and/or provide the desired room temperatures.

Rooftop exhaust fans are installed on arenas and rinks to help freeze ice in suitable weather conditions as well as to remove smoke, heat, and possibly dust during indoor rodeos or dances held in the rink.

Lounges, lobbies, and kitchens use fans to remove smoke and odours.

Ventilation costs can be significant. Operating a 3 hp exhaust fan for 2,000 hours (25 per cent of the time over one heating season) would cost roughly $500 a year at 2006 rates.

Heat recovery ventilators (HRVs)

An HRV is an air-to-air heat recovery unit that removes heat from warm stale air being exhausted from a building and uses it to heat incoming cold fresh air. The recovery of heat saves energy by reducing the load on the heating system. See more on heat recovery in Section 9 and Appendix vi.

Heat reclaim

Up to 50 per cent savings in domestic hot water heating costs can be realized by installing heat reclaim on refrigeration equipment. Pre-heating of the water is relatively easy and produces water up to 90°F (32 C). The water heater only needs to boost the water to 140°F (60 C).

For a detailed discussion of financing and cost/benefit analysis, please see Section 3.

Heating ventilation energy efficiency

Energy is defined as power multiplied by time. To reduce energy you must reduce the power or reduce the time you are using the power.

Reducing a heating thermostat setpoint maintains the same power requirement for that heating unit but reduces its run time. Similarly, shutting off motors reduces run time but does not change the motor power. Both actions take the same approach to conserving energy.

Adding insulation, reducing infiltration, and installing triple glazed windows are all examples of building envelope energy efficiency that reduce the energy requirement of the heating system. If, at the same time, some heaters are disconnected, or a smaller furnace is installed, the power draw will be reduced. Here are some additional examples of energy efficiency improvements:

Programmable Thermostats. Program the thermostat to set back the temperature during unoccupied hours. A seven-day programmable thermostat will allow you to control multiple temperature set points for each individual day of the week. Set back the thermostat on heating equipment to as low a temperature as is practical in most rooms. Normally 65°F (18 C) is cool enough to save 5 to 7 per cent of the heating energy but still allow for a quick warm-up before occupancy.

Spectator areas should be set back to 35°F (2 C) or cooler, except for games.

Be careful when setting back electric heating systems. Operating setback thermostats may increase your electrical demand if they control electric heaters and multiple units that all come on at the same time during warm-up.

Time Clocks. Time clocks can be used to automatically setback thermostats, shut off ventilation or exhaust systems, and other electrical loads when they are not required.

Equipment Efficiency. When replacing equipment, install high efficiency versions.

The equipment itself consumes a lot of power. Firing efficiencies of boilers, furnaces, and unit heaters have a direct effect on the total energy bill.

If a furnace is 80 per cent efficient, then 80 per cent of the energy to it is used to heat the building and 20 per cent of the energy is wasted. With high-efficiency condensing furnaces, there are no standing pilots or chimney heat losses. A 92 per cent efficient furnace puts 92 per cent of its input energy into the building and wastes only 8 per cent.

Electric heaters are nearly 100 per cent efficient; all heat ends up inside the building. However, current natural gas heating costs for commercial facilities are one-quarter to one-third cheaper than electricity when using the electricity balance rate of $0.05139/kWh.

Ventilation. Shut down ventilation systems when they are not required.

Ventilation is required when a building is occupied. Heating outside air to room temperature can consume a lot of energy. By reducing ventilation rates during periods of low occupancy, or shutting off ventilation during unoccupied hours, power requirements and the time required for heating are both reduced. The overall effect is lower energy consumption.

Ventilation systems are generally set up to bring in a minimum amount of fresh air. That outside air must be heated up to room temperature. If no one is in the area, the heat is wasted. Shut off your ventilation systems during unoccupied hours. You can often accomplish this by installing a switch, spring wound timer, or time clock to your ventilation controls.

Exercise caution when working with gasoline-powered equipment in a building. Ventilate the building long after the work is completed to make sure that all products of combustion are exhausted or diluted. Contact the authority having jurisdiction to confirm appropriate ventilation rates and duration.

Air Traps. Control the flow of natural ventilation in all areas.

In natural ice arenas, ice is sometimes created by bringing in sub-freezing outside air and exhausting warmer inside air. But at some point, you may need to start heating the arena to provide a uniform climate for occupants. This is particularly true in curling rinks where the air temperature is maintained at 35°F (2 C), while the outdoor air temperature can be -22°F (-30 C).

Air traps installed on air intakes allow good air flow into the space when you need it. The rest of the time they trap cold air and reduce uncontrolled infiltration.

Because cold air is denser than warmer room air, the cold air does not rise up the inside leg of the trap (see Figure 5.8) but remains trapped inside the duct. When the exhaust fans start, the air is easily drawn through the ductwork.

The same net effect can be created by equipping inlets with motorized dampers that physically shut off the opening. An air trap costs about $300 installed (see Figure 5.8). A motorized damper of similar total capacity would cost about $1,200 (see Figure 5.9).

Figure 5.8 - Typical air trap

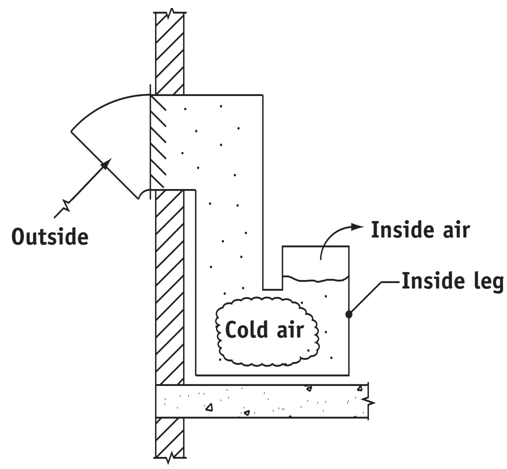
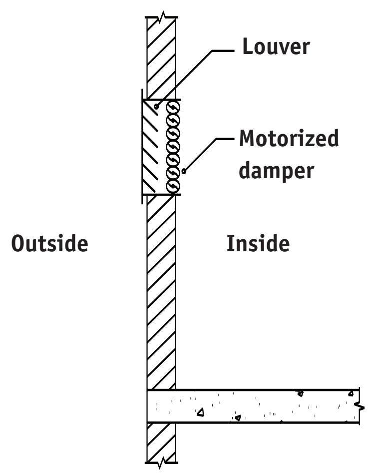


Figure 5.9 - Typical motorized damper



A Look at Maintenance Costs. It is best to install mechanical systems that are easy to maintain and operate. Neglected systems operate poorly and waste energy. It is very important to maintain mechanical equipment to ensure long trouble-free equipment life, optimum performance, and minimum energy costs.

Furnaces, water heaters and electric heaters all provide simple, reliable heat and are easy to maintain. Nearly every community has qualified people to operate this type of equipment.

Air conditioning equipment is somewhat more complex, but refrigeration mechanics are normally available within a reasonable distance of your community.

Installing highly sophisticated equipment and systems may reduce certain energy costs, but they may cost more to maintain. Specialists are normally required to provide maintenance for these systems, at a cost greater than the cost of a local volunteer.

Basic concepts of energy management

If You Don't Need It, Shut It Off. The most common and well understood energy management concept is: if you don't need it, turn it off. This applies to fans, exhaust systems, and ventilation systems.

Identify functions in your building that have limited use; for example, toilet exhaust fans in public washrooms. If the public areas are closed, shut down the washroom exhaust fans.

Domestic hot water

Domestic hot water systems can consume 15 per cent of the total energy for the average arena. Hot water needs are well defined and seldom flexible.

Water for flooding should be at least 130°F (54 C). Some ice-makers prefer temperatures of 150°F (65 C), but for energy savings, set the water temperature as low as possible while still maintaining good ice quality.

Water for showers and lavatories is mixed to 104°F (40 C). However, do not reduce hot water tank temperatures to below 130°F (54 C). A risk of bacterial growth, such as legionella, could occur with cooler temperatures. Water for kitchens may need to be 180°F (82 C) to meet health standards. These standards are based on recommended practice and health codes. Management of energy for domestic water heating falls into two basic categories; management of the source of heat and management of the stored heat.

Our choices for a heat source are:

- Gas-fired
- Electric
- Heat reclaim

Most facilities choose gas-fired heating or electric heat. The relative merits of each choice are explained earlier in this section. Heat reclaim consumes the least energy but is offset by increased capital cost.

We can look at a number of ways to manage heated water. Once the water is hot, the idea is to keep it hot until it is needed. Add insulation to storage tanks and pipes to hold the heat in the water and reduce stand-by loss. Keep storage tanks at the lowest possible temperature that will still provide adequate water volume and temperature for all applications. Do not store hot water below 130°F (54 C) or you will run the risk of promoting biological and bacteriological activities in the water.

Store hot water for flooding near the ice resurfacing equipment room and shower water near the dressing rooms. A lot of heat can be lost in distribution piping. Examine the relative costs of each option carefully. Fill the ice resurfacing equipment just before use to keep the water as warm as possible.

Another technique to avoid stand-by losses is to install an instantaneous gas-fired water heater, which requires energy only when there is a demand for hot water. Since these units do not have a high storage capacity, stand-by losses are further reduced.

Demand limiting

If you have chosen electrical heating for your domestic hot water heating or space heating system, your energy management strategy should include demand limiting.

Explanations of demand are included in Section 1 and in Section 6. Demand limiting will save a lot of money by not allowing the heating systems to operate while the rink compressor is operating at full load.

In summary, the use of natural ventilation to freeze ice is very common and very practical. It saves on compressor run time and in the off season can be used to remove heat. Ventilation is critical in all areas of a facility, particularly in high occupancy areas like seating, dining rooms, and lounges.

Energy efficiency measures should include reviews of operating times and power levels of equipment being used. Time clocks, night set back controls, and equipment efficiencies all help reduce energy consumption.

Energy management involves the analysis and selection of operating schedules, efficient use of fuel, and informed choices on equipment and type of energy.

Rinks, arenas, and recreational facilities in general are often referred to as complexes. There is good reason for this. The facilities and the operating of the facilities is complex. The operation of one system affects the operation of another system, and the net effect can be difficult to fully analyze or predict. Operators must understand the often contradictory requirements of cost and comfort to satisfy the needs of the facility and the people who use it.