Heating Ventilation and Air Conditioning (HVAC) Systems

Heating

Energy Saving Opportunities

- Close off unused rooms.
- Set back thermostats at night and when the space is unoccupied. (Setting back thermostats 5ºC at night can save between 7 and 10 percent in annual energy use.)
- Keep air registers and radiators clean and free of obstructions.
- Close doors and windows when the heating is on.
- Switch off exhaust fans at night and on weekends.
- If a new heating system is planned, invest in zone controls.
- Use a set-back thermostat to use less energy for heating and cooling when the space is unoccupied.
- Install insulated doors and energy efficient windows for efficient cooling and heating, and for increased personal comfort.
- Install mechanical ventilation equipment: Mechanical ventilation is usually required to ensure safe, healthy indoor air. Heat recovery ventilators should be considered in cold climates because of energy savings. However,simpler, less expensive exhaust-only ventilation systems are also adequate.
- Ceiling fans can be useful in the winter at a low speed in the clockwise direction to create an updraft. This forces warm air near the ceiling into the cooler spaces below.
- During heating season, keep window treatments (e.g., blinds or curtains) open during times when the sun is shining and closed at night. During cooling season, keep window treatments closed during times when windows are exposed to direct sunlight.
- Plant shade trees and shrubs around your building, particularly on the north-west side.
- Clean air conditioning and heating filters monthly. Forced air heating and cooling systems have filters that trap dirt and dust and must be cleaned or replaced regularly.
- Check heat ducts for leaks. Where accessible, feel ducts for cracks or leaks. Any you find should be sealed tightly using foil-backed tape. Ducts in unheated areas should also be insulated where possible.
- Insulate water heaters and both cold and hot water pipes.
- Replace inefficient boilers.
  - Use modular units to maximize operating loads and reduce casing or flue losses.
  - Decentralize the system into separate heating zones.
  - Downsize the system to avoid overcapacity.
  - Replace inefficient burners.
  - Install automatic flue dampers.
  - Replace pilot lights with electronic ignition.
  - Preheat the air for furnace combustion with waste heat.
  - Recover waste heat from exhaust air, flue natural gas, laundry, kitchen, engine exhaust, condenser, cooling tower.
  - Convert system to radiant heat.
  - Keep the system clean.
  - Slow fans down to reduce air flow, or install variable-speed fans.

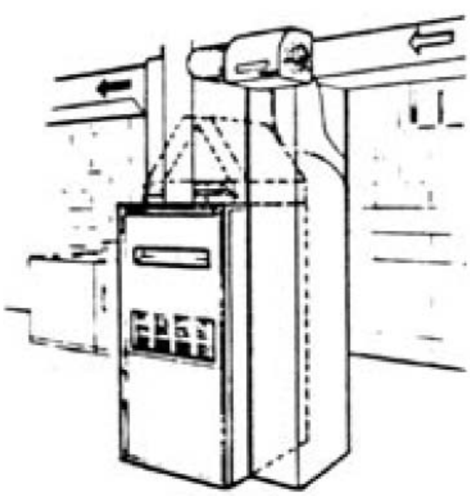
There are many ways to heat buildings. The choice of systems is based on a number of factors. You need an energy source (electricity, natural gas, propane, fuel oil) and a heat transfer medium (air, water, steam) that flows through a heat delivery system (pipes or ducts).

Typically we use air or water as our 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. Heat flow is always from warm to cool. The rate is based on the temperature differences between the hot side and the cool side and the resistance to flow created by walls, insulation, air films, and other building components.

The basic heating 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

The 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). 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.



Typical Furnace

Electric Furnaces

An electric furnace has an annual fuel utilization efficiency (AFUE) of 100 percent. Essentially 100 percent of the electrical energy supplied to the furnace is converted to heat in the building.

General Furnace Maintenance Tips

- Clean or replace furnace filters every three months.
- Clean heating and cooling coils on a regular basis.
- Clean filters and coils will help ensure the furnace operates efficiently by maintaining the optimum air flow and heat transfers.
- Check fan belts for cleanliness and tightness on the pulley.
- Replace belts that are cracked or worn.
- Install a carbon monoxide detector for combustion heating appliances.

Electric heating systems can take many forms: forced air systems, hydronic (hot water) systems, room heaters, radiant systems and combination systems with plenum heaters. Electric heating is often used as individual space heaters as opposed to centralized heating systems with distribution systems. For example, electric baseboard heaters can heat smaller rooms without the need for the ducts or radiators required by forced air models and hydronic systems.

Such electric room heaters may be efficient for smaller rooms that are only heated occasionally since they have individual controls and have low initial costs. However, if it is the only heat source for the entire building, the high price of electricity may motivate a change in heating fuel sources (such as to natural gas). Converting to a new fuel source will require the addition of distribution components (air ducts or pipes and radiators); even so the retrofit often is still cost-effective.

Although they focus on heating homes, Natural Resources Canada's guide on electric heating options, "Heating with Electricity", may still be useful: oee.rncan.gc.ca/publications/infosource/pub/home/Heating_with_Electricity.cfm

Natural Gas/Propane Furnaces

Standard

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

Mid-Efficiency

A mid efficient natural gas/propane furnace has an annual fuel utilization efficiency (AFUE) rating of approximately 80 percent.

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 the 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. The unit extracts 92 percent of the available heat from the burned gas mixture. Efficiency is further enhanced over a mid-efficient furnace by utilizing a secondary heat exchanger. The secondary heat exchanger extracts the latent heat from the water vapour in the flue gases produced in the combustion process. The latent heat in the water vapour of the flue gases accounts for 10 percent of the energy supplied to the furnace. The flue gases are then vented outside and the condensed water vapour is drained to a sewer.

Venting: As with gas heating appliances, an improvement to efficiency means that consideration must be made to how venting of gases will be exhausted without condensation problems. Old furnaces would exhaust gases at high temperatures through the chimney. However, with improved efficiency flue gases are cooled down and may condense in the chimney leading to deterioration. A liner may be needed to prevent these problems and improve chimney draft.

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.

Although they focus on heating homes, Natural Resources Canada's guide on natural gas furnace options, "Heating with Gas", may still be useful: oee.rncan.gc.ca/publications/infosource/pub/home/Heating_With_Gas.cfm

Oil Furnaces

Older standard oil furnaces have an annual fuel utilization efficiency (AFUE) rating of 60 to 70 percent. This is due to warm air constantly 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 percent.

High efficiency condensing oil furnaces have an AFUE rating of about 86 to 90 percent. They are expensive and not commonly available.

Condensation Problems

Every building needs to balance the ventilation and humidity requirements with the heating demands. Excess moisture may result when more efficient heating systems, draft proofing and insulation are added, since there is less air exchange. The moisture may condense on windows, glass, ceilings and lead to mould growth and/or structural damage. Check the humidifier setting if you have one on your furnace. You may not need a humidifier if the building is airtight. As a final resort, you can consult a contractor about a heat recovery ventilator, which will allow an increase in ventilation and humidity decrease without losing heat energy in the process.

Although they focus on heating homes, Natural Resources Canada's guide on oil furnace options, "Heating with Oil", may still be useful: oee.nrcan.gc.ca/Publications/infosource/Pub/home/heating_with_oil.cfm

Unit Heaters

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

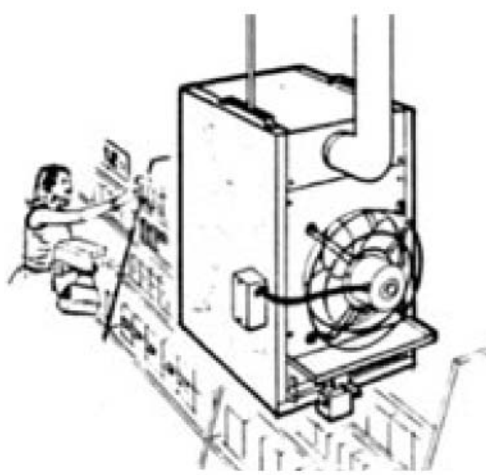
A louvered diffuser on the discharge directs the air around the room. Generally no ductwork is installed on the unit. If ductwork is to be attached, the unit heater must be certified to be installed with ductwork.

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

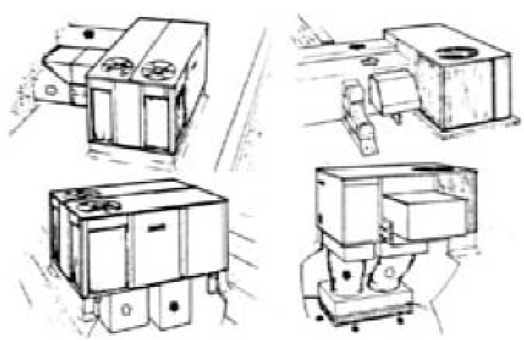
Rooftop Heaters

Rooftop units have a seasonal efficiency rating between 60 to 80 percent. Their 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.

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 they are for furnaces of similar capacity.



Unit Heater



Rooftop Heaters

Heat Pumps (including geothermal)

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 pump systems can be used for space heating and cooling and water heating. 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 2.0 to 3.0. As a result they can produce 2.0 to 3.0 kilowatts of heat energy for every kilowatt of electrical energy supplied to the unit. 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 similar to air conditioning systems.

The outdoor piping system can be either an open system or closed-loop. An open system takes advantage of the heat retained in an underground body of water. The water is drawn up through a well directly to the heat exchanger, where its heat is extracted. The water is discharged back to the underground water body through a separate return or injector well.

Closed-loop systems collect heat from the ground by means of a continuous loop of piping buried underground. An antifreeze solution (or refrigerant in the case of a DX earth energy system) that has been chilled by the heat pump's refrigeration system to several degrees colder than the outside soil, circulates through the piping, absorbing heat from the surrounding soil. For more information about geothermal heat pumps, Manitoba Hydro has a link at www.hydro.mb.ca/earthpower/index.shtml.

You can also check out Natural Resource

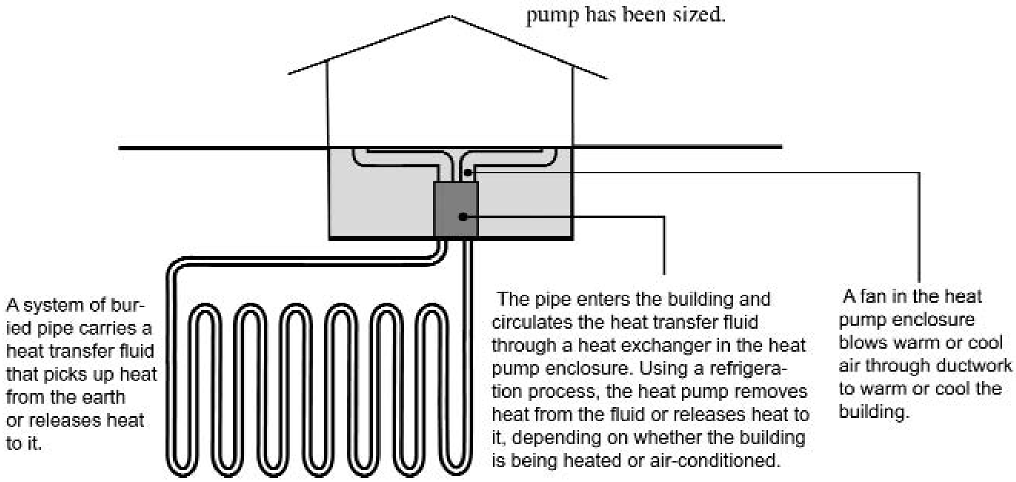
Basics of Heat Pump Operation

A heat pump is a refrigeration unit that moves heat from one place to another, much the same as a kitchen refrigerator moves heat from food inside the fridge to the coils on the back.

Unlike a refrigerator, a heat pump can be reversed, allowing heat to be moved into a facility in winter (heating mode) and out of the facility in summer (cooling mode).

The most popular type of heat pump in Manitoba is a geothermal or ground source heat pump. It moves heat into a facility from the earth (heating season) and into the earth from the facility (cooling season).

In heating mode, on extremely cold winter days, an electric auxiliary heater may be needed to provide additional heat, depending on how the heat pump has been sized.



Canada's guide "Heating and Cooling with a Heat Pump", oee.nrcan.gc.ca/publications/infosource/pub/home/heating-heat-pump/index.cfm

Boiler Systems

A boiler converts fuel energy into a form that is suitable to convey heat energy throughout a facility. The most common forms of heat energy distributed from boilers in religious buildings are low pressure steam and hot water.

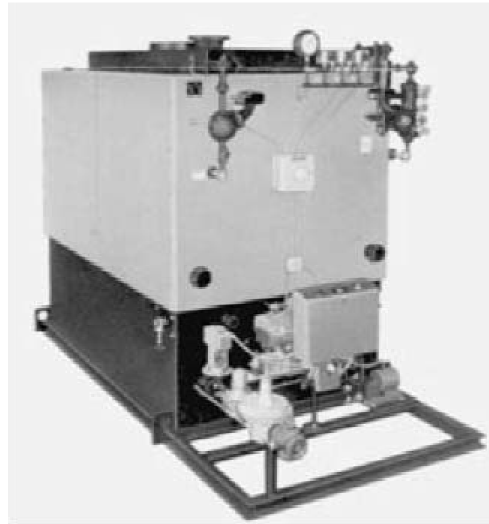
The annual fuel utilization efficiency (AFUE) rating of older natural draft fuel-fired boilers is 45 to 55 percent-slightly lower than the 50 to 65 percent AFUE of a furnace. The difference is because of greater heat loss from the high temperature water stored in the boiler. Newer boilers with electronic ignition and power vents or vent dampers have high AFUE ratings of 78 to 84 percent.

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.

Steam Boiler Systems

A steam heating system uses the vapour phase of water to transport heat from a boiler to the end heating device. Steam is propelled through the supply pipe systems by the pressure generated by the boiler

Steam boiler systems heat water to a boiling point above atmospheric pressure. The greater the pressure the higher the boiling point and the higher the heat content. When the steam gets to the point of use such as a radiator or coil, heat is removed from the steam and the steam condenses. This condensate is normally returned to the boiler to be used as boiler feed water.



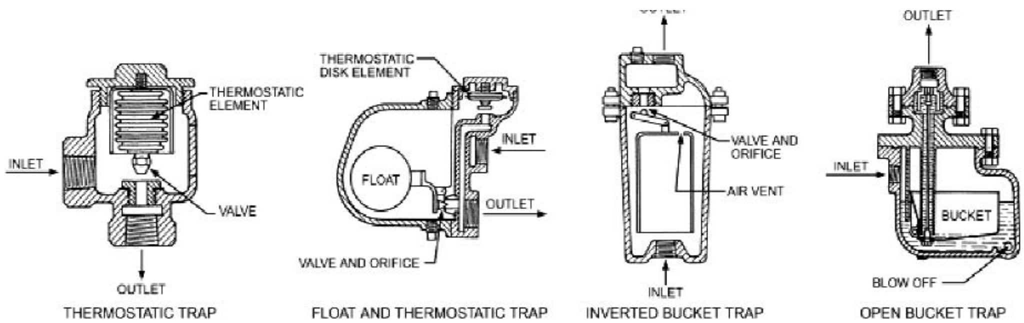
Typical steam boiler system fueled by natural gas. It boils water under pressure to produce high-heat content steam that circulates to heat transfer devices such as radiators or coils where the heat is needed.

Steam traps are installed in the system to discharge condensation to the condensate return lines without discharging steam. A steam system produces a high transfer rate per unit of surface area at the terminal device allowing the use of smaller devices and smaller piping. Less pumping energy is required than for a hot water system but system maintenance is high owing to the number of distribution system components such as steam traps and condensate pumps. Steam systems are more susceptible to condensate loss through steam and condensate leaks.

Steam Traps

Steam traps are installed to keep steam lines and equipment free of condensate, air and other gases. A steam trap is a valve device that discharges condensate and air from a steam line or piece of equipment without discharging steam.

When starting up steam systems, lines and heating equipment are full of air that must be flushed out. During continuous operation a small amount of air and other gases, which enter the system with the boiler feed water, must also be vented.



Steam traps are designed to release water and air from steam lines without releasing steam. Often a key source of inefficiency, they must be cleaned and checked regularly to ensure proper operation.

Some steam traps have built in strainers to provide protection from dirt and scale. Unless removed, this material may cause the trap to jam in an open position, allowing the free flow of steam into the condensate collection system. The condensate discharged from the steam trap normally flows by gravity to an atmospheric pressure return or receiver tank. In some systems the condensate may go to a flash tank first or to drain. The condensate in the return tank is then pumped to the boiler to be used again.

The steam trap has a tight fitting valve attached to a float, inverted bucket, or bellows, that rises when enough condensate drips into the trap and fills it. When the level of condensate in the trap is high enough to operate the float, bucket or bellows, the valve opens and the pressure of the steam in the line that the trap is attached to, pushes the condensate into the condensate return line and then the valve closes sealing the steam line once more. If the valve or float/bellows operator are defective the valve will either not seal properly and steam will constantly leak into the condensate line wasting steam heat and money, or the valve will not open properly and condensate will slowly build up in the line and prevent the steam from heating the building properly, increasing the opportunity for leaks and steam or water hammer.

Steam or Water Hammer

The loud banging sound you hear when the boiler systems starts-up is caused by steam interacting with condensate left in the pipe due to a sag in the pipe or an improperly operating steam trap. When steam meets this little puddle of condensate two things can happen. Either the steam causes the condensate to violently evaporate or the steam could push the condensate forward at speed until it meets a turn in the pipe or other restriction and gives up some of its energy as a loud noise. This noise which sounds like a hammer hitting the pipe is called steam or water hammer.

To reduce hammer ensure the steam lines are sag free, have the proper pitch to allow condensate to flow freely to the condensation return tank and ensure all steam traps are operating properly. Steam or water hammer can cause damage to steam traps and put extra pressure on joints and connectors, causing leaks.

Water Treatment

Water for use in steam or hot water heating systems must be properly treated to avoid the problems inherent with untreated water. The two principle problems that must be overcome are scale and corrosion.

Scale is the deposit left behind by water as it is heated. Scale consists mainly of calcium and magnesium compounds. The presence of these compounds in water constitutes the hardness of the water. A build-up of scale on the inside of a boiler acts as a barrier to heat transfer and can reduce the boiler efficiency by as much as 40 percent.

The second problem that untreated water can cause is corrosion of the tubes in the boiler, as well as steam and water lines and condensate tanks. Corrosion is primarily caused by the presence of oxygen in the water, but the acidity of the water, presence of carbon dioxide and dissolved solids can also increase corrosion.

Best Management Practices for Steam and Condensate Systems

Housekeeping

- Develop a steam trap maintenance program and procedures.
- Check and maintain proper equipment operation.
- Check and correct steam and condensate leaks.
- Train operating personnel.
- Have the condition of the pipes checked regularly by a qualified professional.
- Develop and maintain a chemical treatment program.
- Check control settings.
- Shut down equipment when not required.
- Shut down steam and condensate branch system when not required.
- Install a carbon monoxide detector for combustion heating appliances.

Low Cost Opportunities

- Recover condensate if it presently goes to drain.
- Replace or repair leaking traps.
- Repair, replace or add air vents.
- Insulate uninsulated flanges and fittings.
- Insulate uninsulated piping.
- Repair damaged insulation.
- Remove unused steam and condensate piping.
- Reduce steam pressure where possible.
- Operate equipment in efficient operating range
- Repipe system or relocate equipment to shorten pipe lengths.
- Optimize location of control sensors.

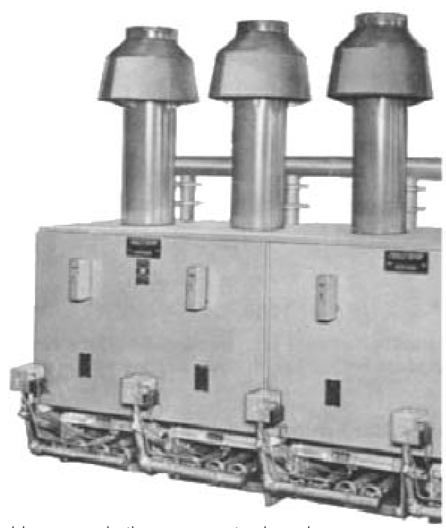
Retrofit Opportunities

- Upgrade insulation on piping to recommended insulation thickness.
- Institute a steam trap replacement program.
- Optimize pipe sizes.
- Recover flash steam.
- Eliminate steam use where possible.
- Stage the depressurization of condensate
- Recover heat from condensate.

Hot Water Boiler Systems

Hot water systems deliver energy from a boiler or heat exchanger to the end use heating device by circulating water through a piping system.

In a typical hot water system hot water is pumped by an electric circulating pump through coils or radiators and heats air that is drawn around the coil by natural convection or by fans. The temperature of the water is determined by the output capacity of the end use heating devices. Most heating systems require a supply temperature of 60ºC (140ºF) to 80ºC (180ºF) although some systems use water as high as 110ºC (230ºF). Water systems range from complex high temperature units



Typical hot water boiler system. Circulates hot water through radiators or other "end-use" devices to areas where heat is needed.

to the more familiar two-pipe units found in many religious buildings.

System efficiency is affected by three factors:
- Boiler or heat exchanger efficiency
- Heat loss from the piping system
- Pumping energy required to maintain the water flow
- Water temperature

Best Management Practices for Boilers

Boiler Operation
- Regularly check water treatment procedures.
- Maintain the total dissolved solids (TDS) of the boiler water suitably low.
- Operate at the lowest steam pressure or hot water temperature that is acceptable to the distribution system requirements.
- Regularly check the efficiency of boilers.
- Regularly monitor and compare performance related data.
- Regularly monitor the boiler excess air.
- Install a carbon monoxide detector for combustion heating appliances.

Boiler Maintenance Routines
These should be done on a regular basis, and never less than once a year. They may be considered to be part of preventive maintenance procedures:
- Keep burners in proper adjustment.
- Check for and repair leaking flanges, valve stems and pump glands.
- Maintain tightness of all air ducting and flue gas breaching.
- Check for "hot spots" on the boiler casing that may indicate deteriorating boiler insulation that should be repaired during the annual shutdown period.
- Keep the fireside surfaces of boiler tubes clean.
- Replace or repair missing or damaged insulation.
- Replace boiler observation or access. doors, and repair any leaking door seals.
- Periodically calibrate measurement equipment and tune the combustion control system.

Boiler Retrofit Opportunities
- Reduce boiler excess air.
- Install new boiler.
- Upgrade burner.
- Lower water temperature with outdoor reset control

Improving the Efficiency of a Heating System

Conventional fossil fuel burning heating equipment is typically in the range of 55 to 65 percent efficient. This is because these units have a pilot light that is always burning (called a standing pilot) and utilizes a natural draft venting system (draft hood). This results in a constant flow of air through the boilers or draft hood and out the venting system (chimney). When the heating system is in standby mode, heat from the exchangers will be extracted by heated room air flowing through the heating equipment and carried outdoors via the venting system. This loss is referred to as stand-by loss.

When a natural draft heating system is firing it removes heated building air to the outdoors via the venting system to maintain a constant pressure at the burners. This air is referred to as dilution air. The stand-by and dilution loss could represent 5 to 30 percent of the natural gas consumption for these units.

A mid efficient natural gas heating system is about 80 percent efficient because it uses an electronic ignition to light the flame instead of a standing pilot, and uses a draft fan that starts only when there is a call for heat to provide the draft instead of the outmoded draft hood.

A high efficiency natural gas heating system is between 90 and 95 percent efficient. These units include electronic ignition, a draft fan and a secondary heat exchanger to condense the moisture in the exiting flue gases removing additional heat.

Electric heating systems (boilers, furnaces, baseboards or plug-in heaters) are considered to be 100 percent efficient. The efficiencies of all these systems do not include the efficiency of delivery or distribution, and can vary depending on maintenance and other factors.

Heat pumps typically have a coefficient of performance (COP) of 2 to 3, which means that for every unit of electricity used to operate the heat pump, 2 to 3 units of heat energy are produced. This is sometimes referred to as an efficiency of 200 to 300 percent.

Converting Your Heating Source — How Much Could You Save as a Percentage of Your Current Total Heating Costs?

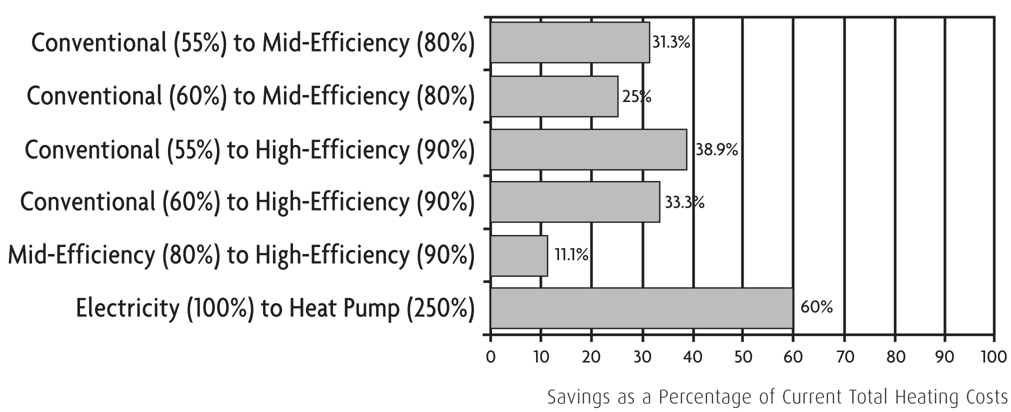
Although a ground source or geothermal heat pump system can reduce the cost of heating an existing electrically heated building by 60 percent, it is difficult to accurately predict dollar savings resulting from the conversion of a natural gas system to a heat pump system as there are many factors such the impact of demand charges, potential rate class changes and the actual cost of electricity (runoff or lowest block rate).

Before replacing any existing building heating system, detailed and itemized load calculations should be performed by a contractor or technologist certified by the Heating, Refrigeration & Air Conditioning Institute of Canada (HRAI) or the Hydraulics Institute. Replacing an aging low efficiency heating system with an energy efficient unit that uses the same fuel can be cost effective, but care must be taken when converting to another fuel particularly an electrical or heat pump system.

Conversion to a Geothermal Heating System

Considerations to be taken before converting to an electrical or heat pump heating system:

1. Is the present electrical service large enough to handle the increased load of an electrical heating system or a heat pump with supplemental heating system?
2. An electrical heating system (either conventional or heat pump) can result in a demand charge that will offset some of the savings — determined by existing electrical consumption, load factor and size of installed equipment.
3. Although a forced air system is easily converted to a heat pump system, heat pumps produce low temperature air of around 38ºC to 43ºC (100ºF to 110ºF) so ducts for hot air distribution system(s) may have to be enlarged to ensure that the same amount of heat is available to each room.
4. Hot water systems also use high temperature hot water of 60ºC to 80ºC (140ºF to 180ºF), which is higher than normally produced by a heat pump system so an engineering study must be conducted to ensure existing pipes and radiators are big enough to carry the higher water flows required to maintain adequate heating capabilities.
5. Because a steam heating system uses very



high heat, replacing a steam heating system with a heat pump will also require replacing all heating radiators, piping and controls. An engineering study is required.

6. To install a closed loop system requires a large area of land, either a lawn or parking lot, where the horizontal pipes can be installed. If only limited amount of land is available more expensive vertical pipes can be used. Efficiency is enhanced when adequate ground water is available. An engineering study is required.
7. It is not recommended to set back the temperature when using a heat pump system because the recovery time is very long and will cause the supplemental heating equipment to operate excessively, reducing savings.
8. Setting back the temperature when using an electrical heating system will cause increased demand charges as all the electrical heaters will come on at the same time to bring the temperature back to normal, increasing the recorded demand.

Building Heating System Replacement Requirements

For projects involving replacement of existing building heating systems, it is recommended that detailed and itemized load calculations be performed by an engineer registered by the provincial Association of Professional Engineers or by a Contractor or Technologist certified by the Heating, Refrigeration & Air Conditioning Institute of Canada (HRAI) or the Hydraulics Institute.

The Design Heating Load Calculations should be determined in accordance with generally accepted engineering standards as described in:

- ASHRAE Handbook and Standards
- HRAI Digest
- Hydronics Institute Manuals

As a minimum, the Summary of Heating Loads (below) should be completed and signed by the registered Engineer or the certified Contractor or Technologist responsible for the calculations and equipment sizing.

Summary of Heating Loads

	Item	Heat Loss in Btu/hr
1.	Walls (above grade)	____________
2.	Walls (below grade)	____________
3.	Floor Slab (Edge(s) or Grade STET if applicable)	____________
4.	Floor Slab Remainder (if applicable)	____________
5.	Roof/Attic	____________
6.	Windows	____________
7.	Doors	____________
8.	Other (please specify)	____________
9.	Infiltration (air leakage)(Indicate equivalent air change rate used) __________ AC/hour	____________
10.	Mechanical Ventilation (outdoor air) (Indicate design flow rate in cubic feet per minute) ________ cfm	____________
11.	Contingency (Safety Margin) Required for quicker recovery from temperature setback (shall not exceed 25 percent of items 1-10 above)	____________
	Total Design Heat Load	____________
12.	Heating Plant Selection: ________ X ________ = (No. of units; Output Btu/h per unit)	____________ Total Heating Output

Recommended Specifications for Replacement Boilers and Furnaces

1. Natural Gas Boilers

1.1 **Residential size boilers** with input ratings of less than 300,000 Btu/h
- Shall meet Canadian Gas Association Standard CGA 4.9
- Minimum efficiency of 82.5 per cent AFUE (Annual Fuel Utilization Efficiency) in accordance with Gas Appliance Manufacturers Association (GAMA) Certified Efficiency Ratings
- Electronic Ignition (No standing pilot)
- Electro-mechanical vent damper

  OR Power Burner
  OR Induced Draft Fan
  OR Power Vent

1.2 **Commercial size boilers** with input ratings of greater than 300,000 Btu/h
- Minimum combustion efficiency of 80 per cent as per ANSI/ASME PTC 4.1, UL 795
- Electronic Ignition (no standing pilot)
- Electro-mechanical vent damper

  OR Power Burner
  OR Induced Draft Fan
  OR Power Vent

2. Hot Water Boiler System Controls

2.1 An indoor/outdoor (outdoor reset) control shall automatically adjust the supply water temperature of the system in relation to outdoor air temperature.

3. Gas Furnaces

3.1 CSA approved high efficiency condensing natural gas furnaces only.

3.2 Minimum efficiency of 90 percent AFUE in accordance with the latest version of the GAMA Certified Efficiency Ratings.

4. Thermostatic Controls

4.1 The supply of heating energy to each heating zone shall be individually controlled by thermostat controls responding directly to temperature within each zone.

Passive Solar Heating

Especially if you are planning new construction, it makes sense to take full advantage of the sun's energy with a few tips:

1. Building Orientation: Use a compass to locate true North and South and place the building's long axis perpendicular to it. Plant deciduous trees to block the summer sun. Plant evergreens on the North and East sides to provide a windbreak; rock outcroppings, hills and neighbouring buildings can also fill this role. Take future buildings in the surroundings into account for shade.
2. Insulate (see the "insulation" section): this is important to ensure any heat gains in the winter are not lost from the building.
3. Window design: Try to catch low winter sun while avoiding the high summer sun by using vertically oriented glass. Choose the best windows to reduce nighttime energy loss. The most efficient type is triple-glazed glass with krypton gas fill.

Catch the summer rays:

Place the majority of glazing on the South side of the building. Do not over glaze this side either to prevent excess heat. Low-emissivity glass is effective to avoid solar gains, however, if you'd like your windows to act as solar collectors on a particular wall then these would not be the best choice. Have window units that can open to prevailing wind side as well as on the opposite side of the building to allow air to cross-flow at night. Limit glazing on the North, Northeast and Northwest sides.

To prevent the summer sun from heating the building, provide sun shade over the East, West and South-facing windows as necessary. Summer screen blinds could work. A solar mass such as cement/tile flooring or walls in dark colours in occupied space can absorb heat to moderate temperatures. In the evening, when the temperature drops, the stored energy will radiate back into the room.

Active Solar Air Heating

A product you could install on your walls to further increase your solar heat gain and reduce the heating system load is called the Solarwall® by Conserval Engineering Limited. This cladding material can be applied to the South, East and West walls to pre-heat air that is allowed in through small perforations on the surface. The air is heated on sunny days by 17-28 degrees Celsius. The air rises behind the cladding and is drawn into the building by the ventilation system. The product works in winter as snow reflects the majority of the sun's radiation into the Solarwall. On cloudy days, diffused light can provide 25% of available solar radiation.

Solarwall® can keep walls cooler in the summer as it shades the interior wall. Unheated air is allowed in through dampers that are electrically or manually-controlled. Solarwall® can also be mounted on the roof, this will pay off especially if you are replacing a roof as the incremental cost is negligible.

Consolair unit is a similar product: it is a retrofit product that attaches to the South-facing exterior wall or roof and acts like a thin greenhouse layer. A thermostat controls a room ventilation fan bringing in the preheated air or it is drawn in by a building ventilation system. The unit can produce 2900 kWh of energy based on 2200 hours of sunlight. At a hydro rate of 10 cents/kWh, the savings would be $300 per year.

Solar Water Heating

If your building consumes a certain amount of hot water, this might be a good idea. A solar hot water heater is designed to capture the sun's energy and use it to heat the water you normally use. You will be assured enough hot water even on cloudy days with a small solar-heated water storage tank. You will need room for this inside the building alongside your existing water heater, as well as the heat transfer unit that is connected to the solar collectors (usually on the roof). A dealer will be able to help you to choose among the variety of designs. There are two basic types: a year-round and a seasonal water heater. Since most religious buildings are used year-round, this will be the best option to ensure it can operate in all climate conditions. To determine the size for a solar water heater you will need to know the number of occupants in the building and their water use.

The Canadian Solar Industries Association (www.cansia.ca) and the Solar Energy Society of Canada, Inc. (www.solarenergysociety.ca) both have databases of dealers across Canada. Natural Resources Canada also has publications and software that can be downloaded to help you determine whether a solar water heater would be a sound investment: www.retscreen.gc.ca.

Before installing a solar water heater, you might want to consider a system that recovers the heat from waste water. Since a lot of heat goes down the drain with grey water, a device called the Power Pipe™ has been developed to capture the heat and transfer it to incoming potable cold water. A spiral pipe containing the incoming cold water supply is wrapped around the vertical drain pipe. The potable water is thus pre-warmed prior to being sent to the hot water heater or plumbing fixtures.

Air Conditioning

Most religious buildings do not have air conditioning. Those that do have it often restrict it to the sanctuary and office areas in summer when outdoor temperatures and humidity exceed comfort levels. It can be part of a rooftop unit or built into a forced-air furnace system. Window units can also provide comfort to a small area such as an office or small meeting room.

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 one ton of ice melting in a 24-hour period. One ton of cooling is 12,000 Btu/h.

The efficiency of an air conditioner is expressed in two ways. One is the EER or Energy Efficiency Ratio, expressed as: EER = Btu/h cooling divided by watts input. The second is SEER or Seasonal Energy Efficiency Ratio-essentially the EER averaged out over the entire season. The SEER is expressed as: SEER =Total cooling during season, in Btu's divided by total energy consumed, in watt-hours. In shopping for an air conditioner, look for a unit with a SEER of at least 13, or an EER of at least 10.

Large assemblies of people can generate large quantities of heat at a rate of about 130 watts/person. Very large and expensive air conditioning systems would be required to meet such peak loads. For this reason, many assembly halls may have undersized air conditioning systems.

Current EnerGuide Room Air Conditioner directories and general information on air conditioning are available at Natural Resources Canada's Office of Energy Efficiency web site: oee.rcan.gc.ca/publications/infosource/home/index.cfm?act=category&category=04&Text=N&PrintView=N

Ventilation

Energy Saving Opportunities

- Make sure that HVAC ducts are well sealed.
- Reduce air stratification.
- Convert to variable air volume (with variable speed fans and dampers).
- Insulate pipe and ductwork.
- Install automatic dampers.
- Consider zoning modifications to ensure heating/cooling only in currently used areas.
- Reduce outside air percentage. Use ASHRAE guidelines of 20 cfm per person.
- Shut off /reduce heat to lobbies, stairwells, hallways.
- Bring cooler outside air in for free cooling (open windows, or use heat exchanger).
- Eliminate simultaneous heating and cooling.
- Ensure exhaust fans are turned off when supply fans are turned off.
- Reduce hours of operation during unoccupied time.

Whether natural or mechanical, ventilation of buildings is required for the health and comfort of occupants.

Natural Ventilation

When an occupied room gets too hot we like to open a window to allow in 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's intentional and we are controlling it. In warm weather we are saving energy by reducing heat gain through the walls and avoiding running cooling equipment. In cold weather, opening a window will increase the load on your heating system and cost money.

Mechanical Ventilation

A central mechanical ventilation system, also called a Heat Recovery Ventilation or HRV system, provides a conditioned air supply through a ducted distribution system to control the interior environment of a building. A system may supply 100 percent outdoor air with all return air exhausted or it may operate with a portion of the return air recirculated through the system. They also exchange heat which in turn reduces the heating / cooling costs. HRVs can also filter incoming fresh air. HRVs can be useful for extremely airtight building to ensure adequate indoor air quality and even distribution of fresh air throughout the building.

Another type of HRV is the Energy Recovery Ventilator that will exchange moisture as well as heat. This will help maintain comfortable humidity levels and by reducing moisture in the summer, an ERV can reduce the energy load of an air conditioner.

For more information on HRV's, see Natural Resources Canada's web site: oee.nrcan.gc.ca/residential/personal/new-homes/r-2000/standard/how-hrv-works.cfm?attr=4

Exhaust ventilation fans are useful for eliminating moisture in certain areas. ENERGY STAR qualified ventilating fans use, on average, 65 percent less energy than standard models.

For more information, see Natural Resource Canada's web site: oee.nrcan.gc.ca/energystar/english/consumers/heating.cfm?attr=4#ventilating

Ceiling fans can be useful for circulating warm air in the winter when set in the clockwise direction at a low speed. There is contention, however, about whether ceiling fans are at all effective in cooling sanctuaries in the summer. Some religious buildings have experienced no improvement in summer with ceiling fans. For information on this, see: www.interfaithenergy.com/article2.htm

For information on ENERGY STAR ceiling fans, see Natural Resource Canada's web site at: oee.nrcan.gc.ca/energystar/english/consumers/heating.cfm?attr=4#ceiling