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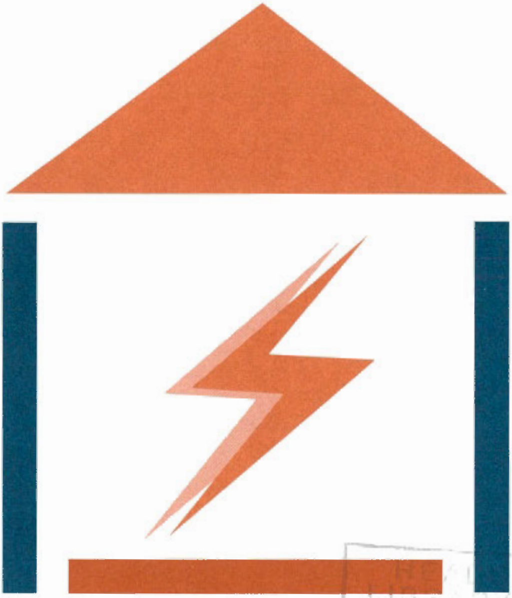
Heating with Electricity

Home Heating and Cooling Series 2

Canada

Heating with Electricity



Home Heating and
Cooling Series

This publication was developed under contract with Ontario Hydro.

Canadian Cataloguing in Publication Data

Main entry under title:

Heating with electricity

Rev. ed.
(Home heating and cooling series)
Issued also in French under title: Le chauffage à l'électricité.
Previously published: Energy, Mines and Resources Canada, c1986.
Co-published by Ontario Hydro.
ISBN 0-662-22824-3
Cat. no. M91-2/19-1995E

1. Electric heating – Handbooks, manuals, etc.
2. Dwellings – Heating and ventilation – Handbooks, manuals, etc.
3. Dwellings – Energy conservation.
I. Canada. Natural Resources Canada
II. Ontario Hydro

TH7610.H52 1995 697.045 C95-940004-2E

To receive additional copies of this free publication, write to:
Energy Publications
c/o Canada Communication Group
Ottawa, Ontario
K1A 0S9

Facsimile: (819) 994-1498

Aussi disponible en français sous le titre : ***Le chauffage à l'électricité.***

Printed in Canada

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INTRODUCTION

If your present home heating system is costing too much to operate, is in poor condition, or if you are planning on buying a new home, you are probably considering what your heating options are. About 60 per cent of the energy required to run the average home is used for space heating. Therefore, one of the most important projects you will undertake as a homeowner, after insulating and air sealing, is choosing, modifying, or changing your heating system. A wise decision about heating can significantly reduce the cost of running your home, and also make your home more comfortable. Your decision will also determine the environmental impact of heating your home. Some very impressive improvements have been made in heating systems in recent years, and there is now a vast range of equipment on the market.

You'll be using your new or improved heating system for a long time, so it is important to do your homework before you make a choice. It's worth taking the time now to ensure that you make the best choice for your situation. You should thoroughly investigate all your options first. However, these days your options can be quite bewildering, partly because of the wide range of equipment that is now available and also because of new rules and regulations about what is and isn't allowed. This booklet has been written to assist you in this process. It will be useful whether you are installing a system in a new home, replacing a system in an existing home or simply considering upgrading your present system.

How to use this booklet

To simplify the process, we have identified four interrelated steps for making your home heating decisions. These are:

Step 1: Draftproofing and insulating

Step 2: Selecting your energy source

Step 3: Selecting or improving your heat distribution system

Step 4: Selecting your heating equipment

The steps and each option will be discussed briefly in chapter one. The remainder of this booklet focuses on the **electricity** heating option. If you decide to use an electric heat pump, more information is available in the booklet:

- ***Heating and Cooling with a Heat Pump***

If you decide to use **oil, gas** or **wood** for heating your home, refer to companion booklets in this series entitled:

- ***Heating with Oil***
- ***Heating with Gas***
- ***A Guide to Residential Wood Heating***

These publications are available from Natural Resources Canada (see page 42), your local gas or electrical utility, or fuel oil supplier.

How you use this booklet is determined in part by where you are in your decision-making process.

- *If a new house is being built for you, you may have ALL the steps and options open to you. (Steps 1 through 4)*
- *If you already own your home but are considering replacing an old heating system, MANY of the steps and options may be available — if you have a variety of fuel/energy choices in your area. (Steps 1 through 4)*
- *If you already have a satisfactory distribution system, either forced-air or hydronic, and are interested only in upgrading it (Step 3) while reducing your heating bill, then your range of options is restricted to possibly insulating and draftproofing (Step 1), switching energy sources (Step 2), and either selecting higher efficiency equipment or possibly upgrading and adding-on to your current furnace or boiler (Step 4).*
- *If you are satisfied with your existing heat source, then you should still look at Steps 1, 3, and 4 in the process.*

Before proceeding any further, you should familiarize yourself with a number of basic concepts that will help you understand your options.

Basic Concepts

Energy Conservation

Energy conservation is a broad term which refers to saving energy. In the context of home heating, energy conservation can be achieved by insulating, caulking and weatherstripping, upgrading your windows, turning down the thermostat or by improving the energy efficiency of your heating system.

Energy Efficiency

Fuel-burning systems (natural gas, oil, propane, wood) lose heat because of incomplete combustion, cold start-up, the heat carried away in the combustion gases, and warm house air that is drawn up the chimney. The extent of these losses determines the efficiency of the furnace or boiler, given as a percentage indicating the amount of original heat that actually warms the house.

Steady-state efficiency measures the maximum efficiency the furnace achieves after it has been running long enough to reach its peak operating temperature. This is an important standardized testing procedure that is also used by a serviceperson when adjusting the furnace, but the figure it gives is not the efficiency the furnace or boiler will achieve in actual use over the course of a heating season. This is much like the differences between the fuel consumption figures published for cars and the actual consumption the car will achieve in day-to-day service.

Seasonal efficiency takes into consideration not only normal operating losses, but also the fact that most furnaces rarely run long enough to reach their steady-state efficiency temperature, particularly during the milder weather at the beginning and end of the heating season. Loss of heated air up the chimney, both when the furnace is running and when it is not, and loss of heat from the furnace itself up the chimney after the furnace has shut down are components of this loss. This figure, known as the **Annual Fuel Utilization Efficiency (AFUE),** is most useful to a homeowner, because it provides a good indication of how much annual heating costs will be reduced by improving existing equipment or replacing it with a higher efficiency unit.

Electric space heating equipment using **resistance heating** is typically 100 per cent efficient because all of the electrical energy used is converted into heat and there are no combustion losses through the chimney.

All types of heating systems come complete with their own jargon. If you are heating with electricity or considering it, the better you understand the terminology of electric heating, the better equipped you'll be to make a good heating system choice. The textbox "Coming to Terms with Electricity" presents some of the basics.

Coming to Terms with Electricity

Here are some common terms you'll come across while exploring the option of heating with electricity.

watt (W) The *watt* is the basic unit of measurement of electric power. The heating capacity of electric heating systems is usually expressed in *kilowatts* (kW). One kW equals 1000 watts.

kilowatt hour (kWh) One kWh is the amount of electric energy supplied by 1 kW of power over a one-hour period. When converted to heat in an electric resistance heating element, one kilowatt hour produces 3.6 megajoules (MJ) or 3412 British Thermal Units (Btu) of heat.

ampere (A) Electric flow is called *current* and is expressed in *amperes*. The short form is A, although *amp* is also used.

volt (V) A *volt* is the basic unit of measurement for voltage or potential difference. *Voltage* causes an electric current to flow.

Putting it all together
A *watt* is the power you get when one *volt* of potential difference pushes one *ampere* of current.

Expressed mathematically
Wattage = Voltage X Amperes (i.e., $W = V \times A$)

Certification and Standards
All electric furnaces, plenum heaters, and electric baseboard heaters sold in Canada must meet strict manufacturing and installation standards for electrical safety. The standards fall under the umbrella of provincial safety codes and the Canadian Standards Association (CSA). Before purchasing your heating equipment, be sure it carries the appropriate certification labels.

Federal or provincial energy efficiency standards are now in place (or under consideration) for space heating equipment. To date, there are no standards that apply to electric resistance heating equipment; only heat pumps are affected. See page 18 for further information on energy efficiency standards.

No matter how you are heating your home at the moment, you can probably improve the efficiency of your heating system. Some of the improvements are simple enough to do yourself; others require changes that should only be done by qualified heating contractors (or electricians, in the case of electric systems). All improvements should be effective and pay for themselves within a reasonable period. Also, remember to consider your hot water situation when you are evaluating your heating system. Often the two systems are related and decisions about one can affect the other (See Chapter 5).

1. The Four-step Decision Process for Home Heating

In this chapter, we will describe in more detail each of the four steps in the decision process for home heating.

Step 1. Draftproofing and Insulating

It may be counter-productive to invest in a new or improved heating system, only to allow much of its heat to escape to the outdoors, *due to an inefficient house envelope which needs more insulation or has many air leaks.* To avoid this, you should draftproof (caulk and weatherstrip) and insulate where feasible, **before** having a heating system sized, installed or upgraded.

There are many advantages to draftproofing and insulating. Heating the house will cost considerably less, and you'll be more comfortable because of fewer drafts and warmer surfaces, such as walls. Furthermore, your house will tend to be cooler in the summer. Another benefit to draftproofing and insulating relates to humidity levels. Dry air in a house during the winter is caused by too much outside air getting in. Because cold air cannot hold much moisture, it is very dry. If your house feels too dry, this can be corrected; moisture can be added by means of an accessory such as a humidifier or an evaporator tray, but they need regular maintenance. The best way to increase humidity (and lower heating costs, too) is to reduce air leakage.

Making your house more "airtight" and providing ventilating or exhaust fans gives you control over your ventilation. Instead of overventilating and drying your house, causing drafts and forcing warm, moist air into your wall and attic cavities when it's cold and windy outside, mechanical ventilation in a tight house can be automatically or manually controlled to deliver just the amount of fresh air needed without affecting the house structure. When it's warm and calm outside, even a leaky house may get little fresh air, but a fan can deliver it. A tight house also keeps out noise and outdoor pollution. Many building codes now require mechanical ventilation systems for all new housing. Your serviceperson or builder should be able to provide you with more information about this.

Insulating, caulking and weatherstripping will reduce the amount of heat needed to keep your house comfortable. To ensure that you get a heating system with the right heating capacity, do the draftproofing and insulating **before** you and your contractor determine which heating system and equipment is best. An oversized furnace may cost more, and even an efficient one may unnecessarily waste fuel because it operates in frequent, short cycles. It may also decrease comfort because of the resulting excessive temperature fluctuations.

If you are buying or building a new house, insist on the R-2000 standard or better. R-2000 houses have high levels of insulation, airtight construction, heat-recovery ventilators, heat-saving windows and doors, and other design features, which cut heating requirements by up to 50 per cent compared with conventional construction, and provide enhanced comfort. For more information on R-2000 houses, contact NRCan (see page 42), your local utility or provincial home builders' association.

If your existing home has not been thoroughly reinsulated and draftproofed, this should be done **before** changing the heating system. For more information about draftproofing and insulation, ask NRCan for a copy of *Keeping the Heat In* and for the *Enerfacts* series of factsheets (see page 42). Whether you plan to do it yourself or hire a contractor, these publications explain all the details (including proper insulation levels), and can help make the whole job easier. Remember, putting a new furnace in a leaky house is like installing a big new motor in a car that also needs a new transmission, drive shaft, wheel bearings, and tires.

Step 2. Selecting Your Energy Source

The next step is to select the heating energy source that's right for you. Generally, your options will be oil, natural gas, propane, electricity or wood. You may also choose a combination of these conventional energy sources or even alternative fuels such as solar energy.

Your decision on the most appropriate energy source should be based on a number of considerations, the most important of which are described below.

Energy Availability Considerations

Not all energy sources are available in all areas of Canada. Electricity and heating oil are generally available in most places, but natural gas, which must be delivered by pipeline, is not available in much of the Atlantic region or in many rural and remote areas of other provinces. Propane is available in most parts of Canada and may be used in rural or cottage areas in place of natural gas or fuel oil, although often at a significantly higher operating cost. In many areas, wood is a cost-effective complement to your conventional heating system. Check with your local fuel supplier, gas or electrical utility to see which fuels are available in your area.

Cost Considerations

For most homeowners, the major factor in the home heating decision is cost. This factor will have two major components—the capital cost of the installed heating system and the annual operating cost for energy. Other secondary factors, such as maintenance costs, cleanliness, and noise of operation, supply temperatures, etc., should be considered.

The installed capital cost of a heating system, depending on whether it is new or a retrofit, can include a number of items such as:

- hookup to gas lines or electric power lines
- electric service entrance upgrade for electric heating (a 200-amp service may be required)
- storage tanks for oil or propane
- heating equipment (furnace, boiler, baseboard heaters, heat pump, etc.)
- cost of trenching or drilling for ground-source heat pumps
- chimney or venting (if required)
- ducting system or pipes and radiators
- thermostat and controls
- labour for installation of any of the above items

The capital cost of a heating system can range quite widely: from as low as perhaps $1000 for baseboard heaters in a small house, to as high as $12 000 or more for a ground-source heat pump (also known as an earth-energy system) for a larger home (providing heating, air conditioning, and hot water). Heating contractors or utility representatives can give you an estimate of the installed capital cost of various systems. Always ask for a firm quote before you authorize any work.

The **operating or fuel cost** of a heating system is determined by three major factors:

- *The heating load or heating requirements of the house.* This depends on climate, size and style of house, insulation levels, airtightness, amount of useful solar energy through windows, amount of useful waste heat from lights and appliances, thermostat setting, and other operational factors. Together, these factors determine how much heat must be put into the house by the heating system over the annual heating season. This number, usually expressed as Btu, kWh or MJ per year (see page 5 for a definition of these terms), can be estimated by a competent heating contractor, homebuilder or utility representative.

- *Choice of fuel/energy and its unit price.* Each fuel-type is measured and priced differently. Electricity is priced in cents per kilowatt hour (¢/kWh), oil and propane in cents per litre (¢/L), natural gas in cents per cubic metre (¢/m^3) or dollars per megajoule ($/MJ) or dollars/gigajoule ($/GJ), and wood in dollars per face cord. You must consider the heat content of various energy sources to determine the most cost-effective one for your area. Check with your fuel supplier or utility for the unit prices of energy sources in your area. **Table 1** gives the energy content for the various energy sources in the units in which they are commonly sold.

- *Efficiency of equipment.* The efficiency with which the furnace converts the fuel to useful heat in the home is also an important factor in the heating cost equation. For example, if a furnace has an AFUE of 80 per cent, then 80 per cent of the heat value in the fuel is transferred to the house. The other 20 per cent is lost mostly up the chimney to ensure the safe venting of the products of combustion. Thus, additional fuel must be consumed to account for these losses. Some jurisdictions now regulate the minimum efficiency of furnaces. In the case of electric heating, there are essentially no losses and the efficiency is 100 per cent. Electric heat pumps, on the other hand, have efficiencies over 100 per cent because they use electricity to extract heat from outside air, the ground, or water. Improving the efficiency of the heating equipment reduces fuel use and cost, but with an increased capital cost.

The combination of heating load, fuel choice and equipment efficiency determines the annual cost of heating.

Table 2 shows the formula for calculating annual heating cost and a sample calculation for a moderately sized, single-family home in the Toronto climate region, with an electric resistance forced-air heating system.

TABLE 1

Energy Content of Heat Sources

Heat Source	Energy Content	
	Metric	Imperial
Oil	38.2 MJ/L	140 000 Btu/g(US)
Natural Gas	37.5 MJ/m³	1007 Btu/ft³
Propane	25.3 MJ/L	92 700 Btu/g(US)
Electricity	3.6 MJ/kWh	3413 Btu/kWh
Wood	30 600 MJ/cord	26 000 Btu/cord

Conversion: 1000 MJ = 1 gigajoule (GJ)

TABLE 2

Annual Heating Cost for Electricity

Formula:

$$\text{Annual Heating Cost} = \frac{\text{(electricity cost per unit**)}}{\text{(energy content per unit of electricity) see Table 1}} \times \frac{\text{(annual heating load)*}}{\text{(annual efficiency rating of heating system)***}}$$

Example:

$$\text{Annual Heating Cost of Electricity} = \frac{.075^{**}}{3.6\ \text{MJ/kWh}} \quad \frac{92\,000\ \text{MJ/yr}^{*}}{1.0^{***}} = \$1917/\text{year}$$

Assumptions for this example:

* *The house is a single family home of 154 m³ (approximately 1650 sq. ft.) built between 1960 and 1989 in a Toronto climate zone (3646 Celsius degree days). It has an annual heating load of 92 000 MJ or 92 GJ.*

** *Electricity is priced at 7.5¢/kWh (including GST).*

*** *The efficiency of electric resistance heating is 100%.*

In the end, a homeowner contemplating a new heating system must balance the capital cost against the operating cost and make the best financial decision. Since annual operating costs (and the differences in operating costs with different technologies) are very significant compared to the capital costs, an investment in higher efficiency equipment is often very attractive.

ENVIRONMENT

The effects of energy production and consumption play an important role in many of today's key environmental problems. Exploration and extraction for fossil fuels in fragile ecosystems, spills and leaks during transportation, urban smog, acid rain problems, and global climate change—all can adversely affect our environment. Each form of energy has a different impact at different points in the energy cycle. No form of energy is completely harmless, although the environmental impact of some sources of supply, such as passive solar energy heating, are relatively insignificant.

Heating your home affects the environment in different ways, from gases leaving the chimney, to emissions at a coal-fired generating station, to flooding at a remote hydroelectric site. The overall environmental impact is determined by the amount and type of fuel your heating system uses.

We can all be environmentally responsible by *being energy efficient.* Some of the simplest and most effective ways are to improve insulation and tighten the house envelope, install setback thermostats, and improve your heat distribution system.

Selecting the cleanest energy source is also within your power—but this is often a complex assessment that may vary from region to region in Canada. The combustion of natural gas, propane, or fuel oil in your furnace releases various pollutants into the local environment.

While it is easy to blame pollution on combustion products from your fuel-fired heating system, it becomes more complex and debatable when electricity is involved. Electricity is clean at the point of use, but it has environmental impacts at the point of generation. In Alberta, Saskatchewan, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and Ontario, coal or heavy oil is burned to meet electricity demand during the winter. In other provinces—Manitoba, British Columbia, and Quebec — where winter peak demand is met by hydroelectric power, the impact of pollution is much less obvious. It has been argued that certain greenhouse gas emissions, such as methane, can be high in hydro dam projects. Nuclear power produces less conventional pollutants, but has its own set of environmental problems.

In short, there is no easy solution—but by buying the most efficient system with the most appropriate energy source for your area, you can make a major contribution. The simplest approaches are improving insulation and airtightness (while ensuring proper ventilation), installing a high-efficiency heating system, and operating and maintaining the system responsibly.

Policy

A number of provincial governments and electrical utilities are currently moving towards policies, or at least preferences, concerning the choice of energy source for heating homes. This is because they are concerned about the high cost of building new electrical generating capacity and also about the environmental impacts of electricity generated from coal or heavy oil. In provinces such as Ontario and British Columbia, the electrical utilities and provincial governments are discouraging electric-resistance space heating except in certain applications.

Before finally making your energy source choice, you might wish to check with your local gas or electrical utility, fuel oil supplier, heating contractor, and provincial energy ministry for additional guidance.

Step 3. Selecting or Improving Your Heat Distribution System

Most heating systems today are either forced-air systems or hydronic (hot water) systems. These consist of a heating unit (furnace or boiler), a distribution system (ducts and registers or pipes and radiators), and controls (such as thermostats) that regulate the system. Some systems use space heaters and may not have distribution networks.

Forced-Air Systems

The most common type of central heating system used in Canadian homes is, by far, forced warm air. Among its advantages are its ability to provide heat very quickly and the fact that it can also be used to filter and humidify the household air and to provide central air conditioning.

In addition, the furnace fan can be used year-round to provide continuous air circulation to each room, while better balancing the distribution of heat in colder months. But, forced-air heating systems have some disadvantages: the ductwork requires space, and can be expensive to install as a retrofit. Air coming from the heating registers sometimes feels cool (especially with certain heat pumps) even when it is actually much warmer than the room temperature. The effect is much the same as the cooling action of a fan or a summer breeze which some people find uncomfortable. The ductwork that distributes the heat also carries the noise of the furnace to every room, and can circulate dust, as well as cooking and other odours, through the house.

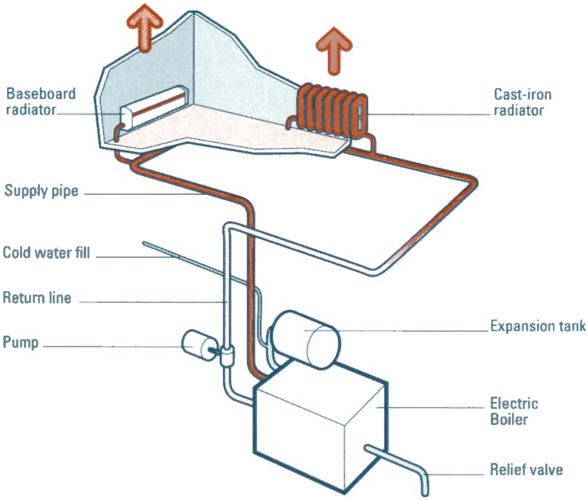
Hydronic Heating Systems

Like a forced-air system, central heating with hot water involves a circulating system that delivers heat to the different rooms and returns the cooled water to the heating source (generally referred to in a hot water or hydronic system as a "boiler") to be reheated.

Hot water heating systems once had large boilers and used large wrought iron pipes and massive cast iron radiators, and many of these are still around in older homes. Now they use smaller copper piping, slim baseboard heaters, and small, more efficient boilers. Recently, CSA-approved plastic piping has become available as an alternative to copper piping for space heat and hot water distribution.

Typical advantages are temperature regulation in each room, ability to provide domestic hot water and smaller dimensions of boilers versus forced air furnaces. Possible disadvantages are higher installed costs and no capability for central air conditioning.

Figure 1: Hydronic heating system



Courtesy of Ontario Ministry of Environment and Energy

Other Types of Systems

Apart from the more popular types of systems noted above, others are also available. These include room heaters, radiant systems, and combination systems.

Room heaters provide heat directly into a room and do not have a distribution system as such. They are available in a range of sizes and fuel types. They provide temperature control in the space where they are located, and their installed cost is usually moderate.

Radiant systems work the way the sun does; they transfer heat directly without the need for a heat transfer medium. The systems can be used for room heating or spot heating, and usually permit temperature control of individual areas. They use electrical heating coils or hot water pipes buried in floors or ceilings, and radiate heat into the room.

Your choice of heat distribution system may be limited by the type of distribution set-up that is already in place. Even though in theory it is possible to change from one type of system to another, it is likely to be an expensive undertaking. Your final choice will probably be based on the answers to one or more of the following questions:

- How much will the system cost compared to other systems?
- Will this type of system suit my lifestyle? Will I be comfortable with it? Do I want to have central air conditioning?
- Is there a contractor available to install the system?
- Is the system compatible with my energy source choice? Amenities such as central air conditioning, humidification and air cleaning require a central forced-air system with ducting, which is not provided by certain electric or non-electric heating options such as baseboard heaters.

Heating with Electricity — What Are Your System Options?

Electricity can be used as the sole heating source or in combination with other sources in a home heating system.

The five basic types of electric heating systems available in Canada are as follows:

- forced-air systems (which can be resistance heating, heat-pump or a combination of the two)
- hot water systems
- room heaters
- radiant systems
- combination systems

Increasingly, homeowners with electric baseboard heating are looking to switch to another fuel or to a heat pump because of the high costs of electric heating. One major constraint is the lack of a distribution system. However, many are finding that air ducts for a central forced-air system, or pipes and radiators for a hydronic system can be installed at a cost which still makes the conversion financially attractive, especially in a bungalow or for the main floor of a two-storey house.

Step 4. Selecting Your Heating Equipment

Once you have selected your fuel type and your heat distribution system, you can begin to consider your alternatives regarding heating equipment and efficiency levels. At some point in your evaluation, you will have to consider whether to upgrade your existing heating equipment or to replace it entirely. A number of things can be done to improve its efficiency and general performance. You also have the choice of several different replacement models with various efficiency ratings and prices.

Here are some details to consider when choosing your equipment:

The Efficiency and Suitability of the Equipment
Chapters two and three of this booklet discuss your options for electric heating equipment in greater detail.

The Costs of Purchase, Installation, Operation and Maintenance
Generally, the more efficient heating systems are also more expensive, and this must be kept in mind when considering

changes or new purchases. You will want to make sure that the reduction in energy consumption and enhanced comfort will return the cost of the improvement within a reasonable time.

Servicing and Guarantees

It is also important to know the type of servicing your system requires to keep it operating at peak efficiency, the price of parts, cost of servicing, and details of the guarantees that are provided, such as period covered and whether parts and labour are included. If you are uncertain about a particular model or type, you might ask the seller to give you the names of a few people who have had one installed.

Energy Efficiency Standards

The federal government has implemented energy efficiency standards for heating equipment and other energy-consuming appliances and products. Various provincial governments have introduced energy efficiency standards, and other provinces have stated their intention to follow suit. Generally, these standards establish the minimum acceptable energy efficiency for specific types of heating equipment. Once the standards are in place, low-efficiency models which do not meet the standard will no longer be allowed on the market in that particular jurisdiction.

Availability

Depending on where you live, you may have some difficulty finding the type of furnace, boiler or heat pump you want. This is because the manufacturers' distribution networks may not be fully developed for all models in all parts of Canada. Furthermore, it may be because certain models have become unavailable as a result of government minimum-efficiency standards.

2. Basic Equipment for Electric Heating Systems

In this chapter, the equipment making up different types of electric heating systems will be described.

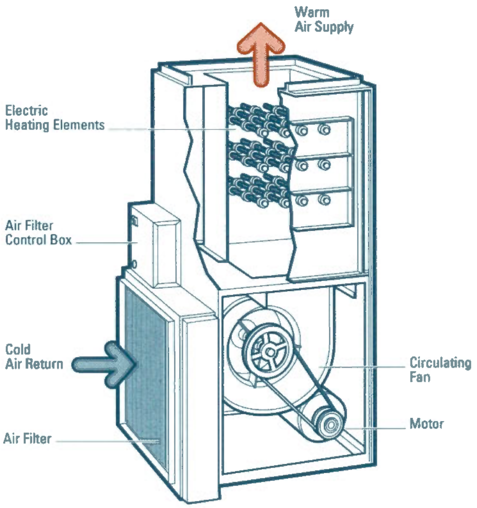
Equipment for Forced-Air Systems

Design and Operation

When an electric furnace delivers heated air blown by a fan through a network of ducts, it is called a forced-air system. Because the fan is literally forcing air through the ductwork to the rooms, this type of system does not depend on natural convection to distribute heated air evenly throughout your house.

The central furnaces for forced-air systems come in a wide range of capacities—generally, from 10 kW to 50 kW. The heating elements, circulation fan, air filter, and control devices are contained in a compact cabinet. The equipment would be quite different if a heat pump was being used.

Figure 2: Central furnace for an electric forced-air system.



If a new electric furnace is replacing another forced-air furnace, the ductwork from the existing system can generally be used in the new system with very few changes. To ensure all ducts are tight, seal the joints with a special duct mastic (sealant). This should eliminate the warm air leaks. High temperature duct tape may work, although it tends to leak or degrade over time. If electricity will be your only energy source, unused chimney flues can be insulated, closed off, and sealed. Closing off the chimney flues can have an effect on drafts and humidity levels in the house, and will reduce heat loss.

To accommodate different types of houses, there are three main furnace designs for use with forced-air systems. The designs are named according to the way air travels from the furnace.

- **Upflow** furnaces are best for basement floor locations.
- **Horizontal flow** furnaces are particularly suited for crawl space installations.
- **Downflow** furnaces are best for installations in mobile homes or on the main floor of houses on concrete slabs.

Electric plenum heaters may be added to forced-air systems to boost capacity or create dual-energy systems. The plenum heater, consisting of one or more heating coils, is inserted into the hot air plenum of the heating system (the plenum is part of the ductwork immediately downstream from the furnace). The furnace fan blows air through these coils on the way to the warm air registers.

NOTE: *Any additions or alterations to an existing furnace involving an electric plenum heater must be done by qualified contractors. The furnace must then be inspected, usually by the local electric utility.*

Maximizing Effectiveness in Forced-air Systems

There are several ways to improve the performance of an existing forced-air heating system. Two of these ways are described below.

Balancing the Heat

Uneven heat distribution is sometimes a problem. This can be caused by the loss of warm air through leaky joints in the heating ducts, ductwork passing through unheated areas, or, most commonly, poorly designed ductwork (i.e., long narrow duct runs). As mentioned previously, sealing all the joints will reduce the heat loss. Ducts passing through an unheated area, such as a crawl space, should be sealed and then wrapped with batt or duct insulation.

Have a serviceperson examine and clean the furnace fan thoroughly, every two or three years. Dirt buildup on the curved blades can reduce the amount of air that is moved, and that will lower furnace efficiency. On a belt-driven fan, the motor should be oiled where possible and the belt tension checked.

The air filter should be cleaned or replaced annually.

Heating Cooler Rooms

Rooms on upper floors or far from the furnace are sometimes difficult to heat because of friction and other resistance to airflow in the ductwork. This problem can sometimes be corrected by slightly modifying the ductwork or by adjusting the balancing dampers in the supply ducts to reduce the airflow to the warmer rooms and increase the airflow to the cooler rooms. Sometimes both of these adjustments are required.

Balancing dampers are usually located in the round supply ducts, close to where they take off from the rectangular main heating duct. They can be identified by the small lever on the outside of the duct. The position of this lever (or sometimes a slot in the end of the damper shaft) indicates the angle of the unseen damper inside the duct.

If there is no such damper at this end of the supply duct, you will have to use the one in the floor register. Start by closing the dampers in the ducts that supply heat to the warmest rooms (even if completely closed, they often will still supply some heat to these rooms). Wait a few days to see what effect this is having on overall heat balance, then make further adjustments as necessary. Such adjustments may reduce the total airflow through the furnace slightly, but this will be balanced to some extent by a slight increase in the temperature of the delivered air.

A large reduction of the airflow could cause an undesirable increase in the temperature of the air inside the furnace plenum (especially if the system includes an air conditioner or heat pump). It would be a good idea to have this temperature rise checked by your furnace service contractor during the next regular maintenance visit.

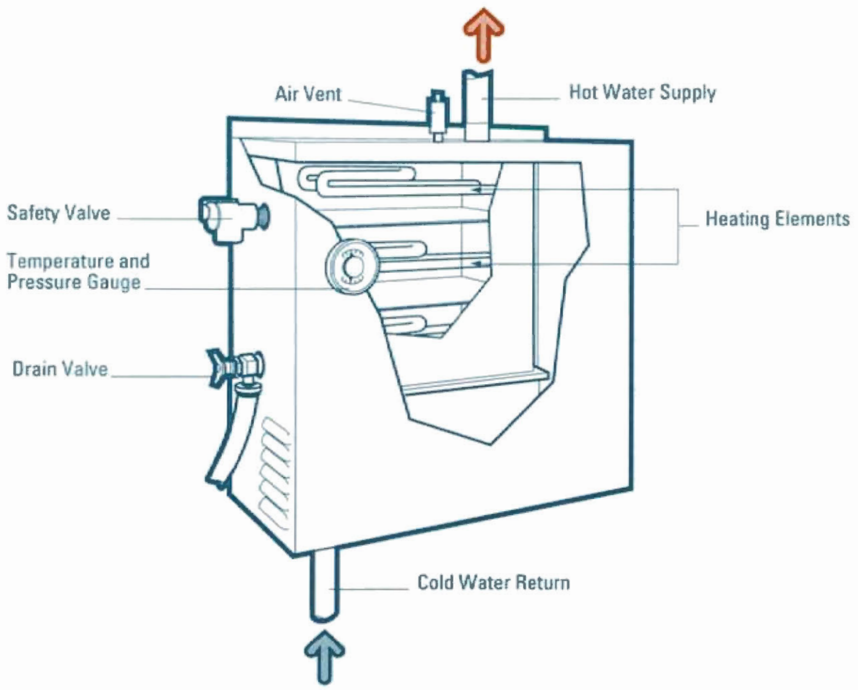
For certain problems that can't be corrected by damper adjustments, there are now drop-in electric fan units on the market which are placed in the floor register to draw air into the room. As a last resort, some of the ductwork can be redone or the circulating fan and motor upgraded.

Equipment for Electric Hydronic Systems

Design and Operation

Electric hot water or hydronic systems deliver heat to living areas through pipes and radiators instead of through the ducts that a forced-air system uses. The central boiler uses electric elements to heat water, which is circulated by a pump through the pipes and then through the radiators or pipes in the floor. Radiators are usually installed along outside walls and under windows.

Figure 3: Central boiler for an electric hydronic system.



The central boiler in an electric hot water heating system is compact. Its heating elements are immersed directly in the water (like an electric kettle). Where space is limited, the boiler can be installed on a basement wall, in a closet, under a kitchen cabinet—it can even be hung from basement ceiling joists.

If you are replacing a boiler in an existing hydronic system with a new electric boiler, you can probably use the existing heat distribution pipes.

The heat distribution pipes in a hot water heating system will freeze as quickly as any other pipe containing water. If the pipes freeze, they will burst and can cause serious damage to the house and its contents. It is important to take a few precautions to prevent the pipes from freezing. Insulating the pipes will help them to retain heat longer, as well as get more heat to the registers. In any case, it is always important to keep the heating system operating at a level that will keep the water from freezing.

Maximizing Effectiveness

As with forced-air furnaces, there are several ways to improve the performance of hydronic heating systems.

Improving Heat Distribution

Old-fashioned gravity systems that circulate the water by natural convection (hot water is lighter than cold water) are less efficient than systems that use pumps. Slow heat circulation causes house temperatures to fluctuate noticeably, and it takes a long time to restore the temperature after a night-time setback. Also, a gravity system cannot circulate hot water to radiators or baseboard heaters in basement living areas, where they would be below the level of the boiler. All of these problems can be overcome by adding a circulating pump, and replacing the open expansion tank in the attic with a sealed and pressurized expansion tank near the boiler.

Balancing the Heat

Balancing the heat delivered to different areas of the house is as important with hydronic heating as it is with a forced-air system. Radiators are often fitted with simple manual valves that can be used to control the amount of water flowing through them. Such valves can be used to vary the heat delivered to different rooms in the same way that balancing dampers are used in a forced warm-air system.

One device that can vary the heat output automatically is a thermostatic valve that can be set to control the temperature in any room. However, this will not work on radiators or baseboard heaters installed on what is called a "series loop" system. In a "series loop", the water must pass through all the heating units on its way back to the boiler. If there is more than one loop in the system, some balancing of the heat output can be achieved by adjusting the valves that control the water flow through each loop. The same type of baseboard radiators are equipped with built-in air dampers which allow heat output to be regulated to some extent.

Automatic Setback Thermostat

The easiest way to save heating dollars is to lower the temperature setting on your thermostat when possible. An automatic setback thermostat will adjust your home's temperature automatically. This thermostat has a mechanical or electronic timer that allows you to preset household temperatures for specific periods of the day and night. As a general rule, you will save two per cent on your heating bill for every 1°C you turn down the thermostat.

The thermostat can be programmed to reduce the temperature an hour before you go to bed and to raise it again before you get up in the morning. You could also have it reduce the temperature during the day when the house is unoccupied, and raise it shortly before you return. For example, you could have the temperature set at 17°C when you are sleeping or not at home, and at 20°C when you are awake.

Experiment with the unit after it is installed, until you find the most comfortable and economical routine for you and your family.

If you have a hot water (hydronic) system, you can also reduce energy usage through zone control. With this system, thermostat-controlled valves on each radiator permit the control of individual room temperatures. A heating contractor can provide more information about zone control and can install all required equipment when the heating system is installed.

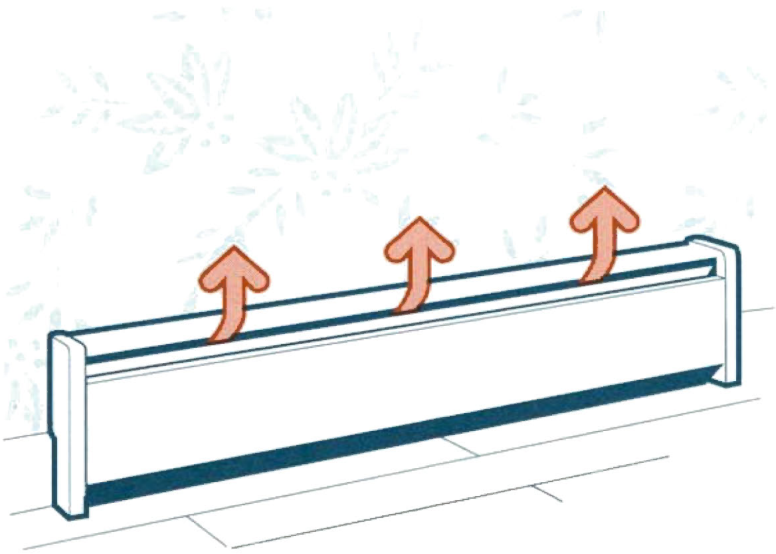
NOTE: *For all-electric heat pump systems, setback thermostats are generally not recommended.*

Electric Room Heating Equipment

Because room heaters are separately installed in each room in your house, they permit individual room temperature control. Thermostat controls are located in the unit itself or mounted on a nearby wall. All room heaters have built-in controls to prevent overheating if airflow is restricted. A wide variety of room heaters are available at moderate cost.

The most common type of room heater is the permanently mounted and wired **baseboard heater.** Ideally, baseboard heaters should be installed, unobstructed, under windows on outside walls. Baseboard heaters rely on the natural convection of heated air to circulate heat. They are available in different lengths, which make them easy to match to the heating requirements of a room.

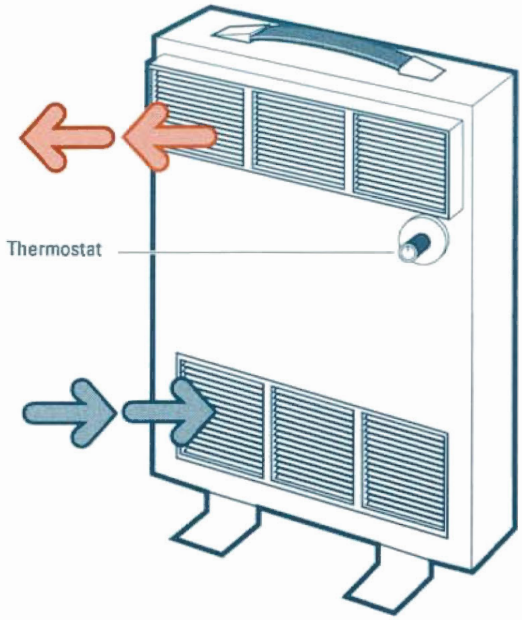
Figure 4: An electric-resistance baseboard heater.



Individual heating units, such as electric baseboard heaters, normally require a dedicated electric circuit for each unit. Easy installation of this wiring is a significant factor in the cost of a retrofit system. In new construction, baseboard heating usually has the lowest first cost, but often has very high operating costs.

If a baseboard retrofit installation is difficult or impossible, other types of room heaters can do the job. Portable convection, radiant and fan-assisted units range from 500- to 1500-watt capacity and are available in many types, shapes, colours, and sizes. Although they are small enough to plug into regular house circuits, make sure that house wiring can handle the additional electric load. These units are most convenient where temporary warmth is needed. Portable units should be considered as supplementary to the existing heating system, and may not be appropriate for wet locations.

Figure 5: A portable electric room heater.



Cabinet model convection heaters can be mounted onto a wall or recessed into it. **Wall insert units** are similar, but are designed only to be recessed into the wall. Both cabinet and wall units are suitable for confined areas such as hallways, entranceways, porches, landings and bathrooms. They can be used as either a primary or supplementary heat source. Some have a small fan to distribute heat more quickly. **Drop-in** or **floor insert units** are designed for use in front of stairways, floor-level windows or sliding glass doors.

Figure 6: A cabinet model convection heater.

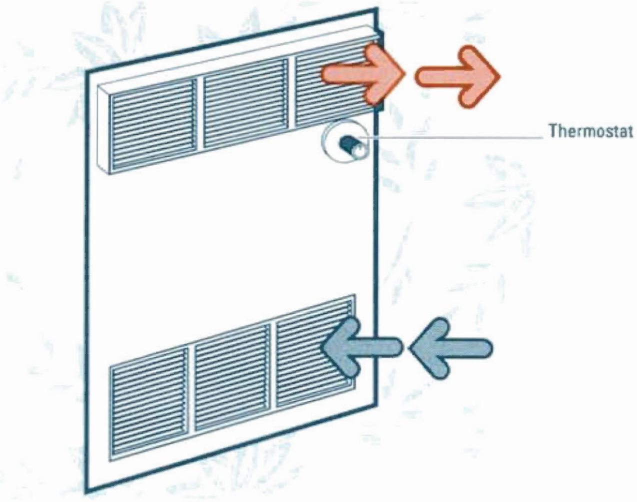
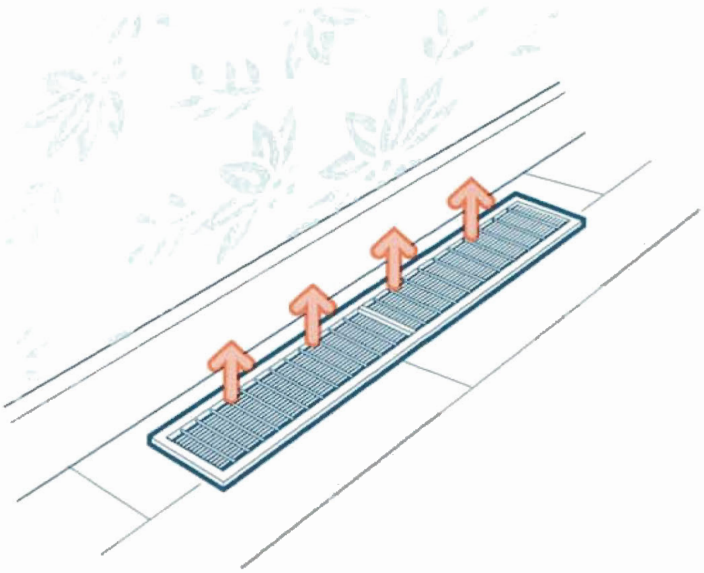


Figure 7: A floor insert unit.



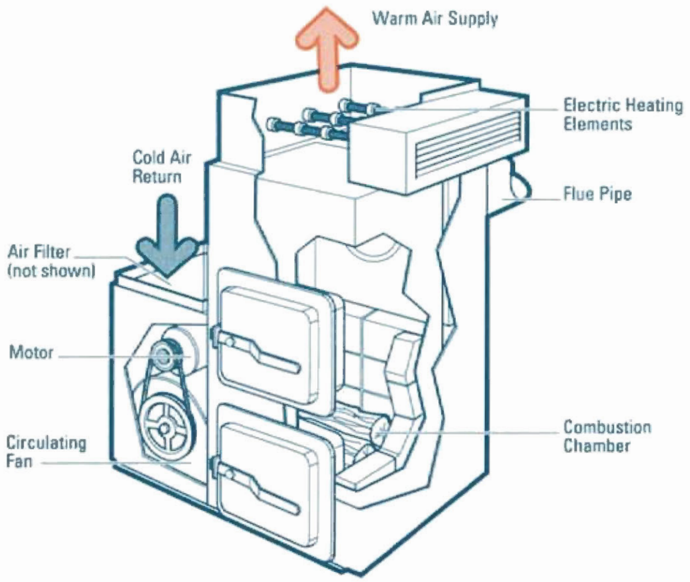
Other types of electric heaters, such as oil-filled rods, quartz heaters and duct heaters are also available. Check with a local distributor, your local utility, or a local contractor for more information about these. Some products are designed as booster heaters for existing forced-air heating systems. The installation of duct heaters requires a qualified contractor.

Equipment for "Combination Systems"

WOOD-ELECTRIC

Wood-electric combination furnaces are common in rural areas. They are similar in design to standard wood furnaces, but contain built-in electric elements. These elements are activated only if the wood furnace cannot meet the heating requirements of the home. Electric baseboard heaters can also be used to supplement a central wood furnace, a wood-oil combination furnace, or a wood stove.

Figure 8: A combination wood-electric furnace.

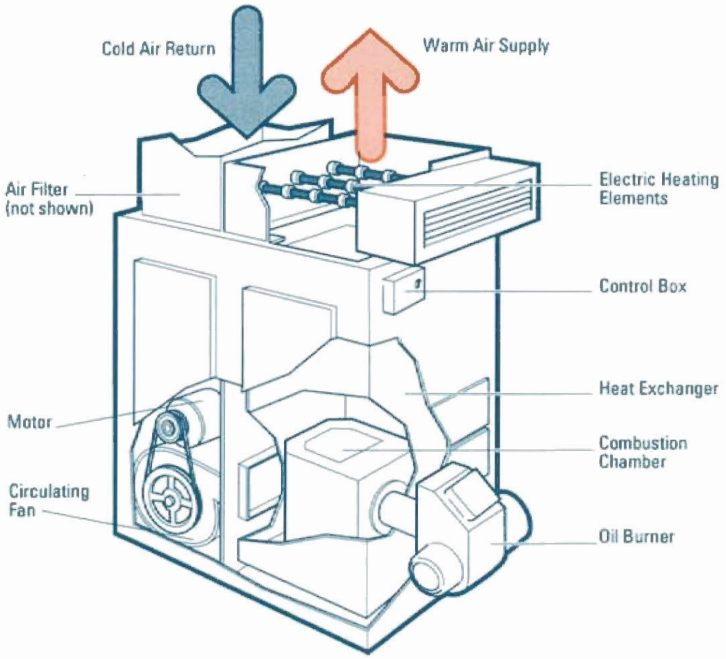


Note: *An electric plenum heater cannot be added to a forced-air wood furnace.*

Oil-Electric

Oil-electric combination systems consist of an oil furnace with factory-installed electric heating elements. The electric elements supply enough heat for some of the heating season, with the oil burner providing heat during the colder periods.

Figure 9: An oil-electric combination furnace.



Another oil-electric combination option is to add an electric plenum heater to an existing forced-air oil heating system. In milder weather, the furnace fan and plenum heater are used to warm the house. During cold weather, higher electricity costs make oil the lower-cost heating source. Dual energy rates exist in the province of Quebec to encourage such usage.

Heat Pumps

Heat pumps produce useful heat by transferring or pumping heat from one place to another. Since it normally takes less energy to transfer heat than to generate it, heat pumps are often very energy efficient.

Although a heat pump is technically similar to a household refrigerator, it can be used for both heating and cooling. In the summer, it removes heat from the air inside the house and transfers it outside much like a conventional air conditioner. In the winter, the heat pump operates in reverse, removing heat from the cold outside air or ground, and transferring it inside the house.

Residential heat pumps are divided into two major groups: air-source ("air-to-air") and ground-source. Each type will be briefly described here. For more information, refer to a companion booklet in this series entitled *Heating and Cooling with a Heat Pump* (see page 42 for ordering information).

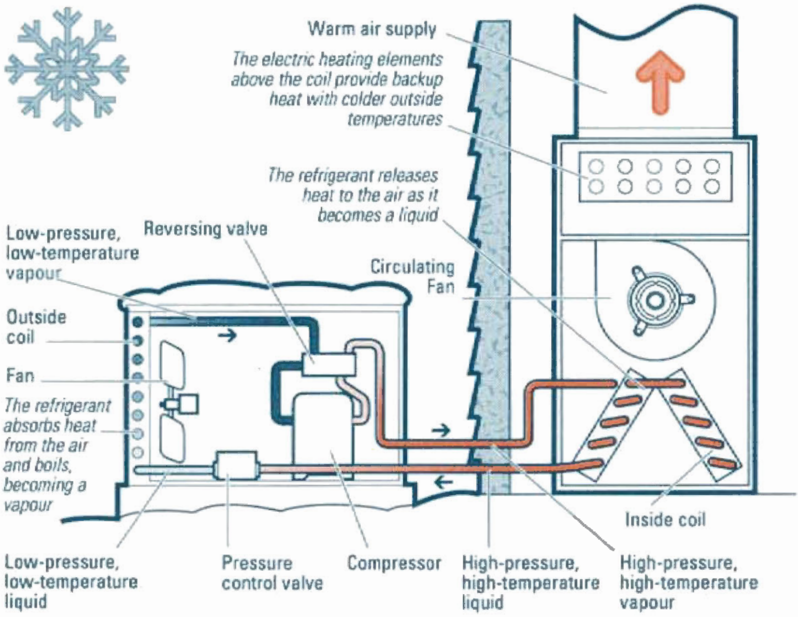
Air-Source Heat Pumps

A typical residential air-source heat pump resembles a residential central air conditioner. In fact, the only difference between a heat pump and an air conditioner is the heat pump's ability to reverse the flow of refrigerant so that the equipment can provide heating in the winter as well as cooling in the summer. Even cold air contains heat. Because heat is absent only at absolute zero (-273°C), heat pumps can operate even during the coldest Canadian winter.

However, both efficiency and capacity decrease with lower outside temperatures.

"Mini-split" heat pumps, which have a small air-handler mounted on an inside wall to supply heating and cooling to a single room, have recently become available. These systems do about the same job as a window air conditioner, but are much quieter and have high efficiencies. However, they can be expensive to buy.

Figure 10: An air-source heat pump during the heating cycle.



Because the output of air-source heat pumps declines with decreasing outdoor temperature, the house's heating load increases. Thus, air-source heat pumps are normally equipped with supplementary or auxiliary heating equipment, such as electric plenum heaters, or oil or gas-fired furnaces that can "top up" or replace the heat output of the heat pump in order to meet the heat load of the house at colder temperatures.

The actual performance of heat pump systems is indicated by its seasonal coefficient of performance (COP). The seasonal COP is the amount of heat delivered, divided by the amount of electricity consumed by the heat pump and its backup heater over the whole heating season. While the "nominal" COP of a heat pump system might be 3.0, the actual seasonal COP more typically averages 1.8 in southern Ontario and lower in colder regions. The actual seasonal COP is dependent on local climate with higher values in milder climates where the backup heating system does less of the season's heating.

Ground-Source Heat Pumps (Earth-Energy Systems)

Ground-source heat pumps are different from air-source heat pumps in that the medium from which the heat is extracted is the ground or underground water, instead of air. For this reason, ground-source heat pumps have come to be known as earth-energy systems (EESs).

Since the temperature of the ground or ground water is much higher than the ambient air temperature in the winter and is fairly constant, the seasonal COPs of these heat pumps are much higher (2.5 to 3.5) than the COPs of air-source heat pumps (1.8). Unlike the air source-heat pump, the output does not fall with colder outside temperatures. Thus, in colder climates, earth-energy systems are more effective.

The New Technologies

In recent years, the heating industry has concentrated more on oil and natural gas heating systems than electric ones. Nevertheless, there have been some developments in electric heating, in addition to ground-source heat pumps.

Electric Thermal Storage

Electric thermal storage (ETS) heating was developed in Europe in the 1940s, and was introduced to the U.S. market in the 1980s. This type of space-heating system is capable of providing all of a home's heating requirements by storing heat produced during the night, when many utilities offer lower time-of-use or off-peak rates. Most of the ETS systems now available can provide 24 hours of on-peak heat from as little as eight hours of off-peak charge.

There are four basic ETS space-heating systems available for homes: central storage, room storage, slab storage and warm room concept. They all operate on the same basic principle. A central electric storage furnace consists of a storage medium (usually called the core) and controls, which sense when a charge is required for the off-peak period. Elements within the storage core heat ceramic bricks, crushed rock or water to a predetermined temperature level to provide the heating requirements for the entire on-peak period. Room storage units are smaller versions of central ETS furnaces, and supply the heating for individual rooms. They come in a variety of sizes from 2 to 7.2 kilowatts. Larger rooms in the home may require more than one storage heater.

These systems can offer savings of up to 30 per cent on heating costs, if there are significant off-peak (night) electricity rates.

Condensation Problems

Electrically heated homes may experience problems of high humidity because they lack a chimney, and therefore have lower rates of air exchange which rid the house of moisture.

Heavy condensation on the inside of windows, damp ceilings and mould growth are indicators of too much moisture. If this is not corrected, serious structural damage can eventually occur. Indoor condensation problems can be solved. Because most of the humidity indoors comes from regular household activities (such as showering and cooking), your first step should be to reduce the amount of moisture from these sources. You can do this by using lids on pots when cooking, keeping showers short, and ensuring that your dryer vents to the outside, etc. You should consider installing exhaust fans in the bathroom and kitchen, and using a dehumidifier in the house. Dehumidifiers can be freestanding or attached to a central forced-air furnace. As a last resort, you should speak with a contractor about installing a heat recovery ventilator (HRV) that will increase ventilation and decrease humidity without wasting energy.

Improved Thermostats and Fans

More sophisticated electronic and self-tuning thermostats are also being developed. These are very sensitive and help reduce the temperature "swing" from an average of 1.5—4°C to 0.5—1°C. They ensure that the central furnace or electric baseboard heater "kicks in" and shuts off as close to the required temperatures as possible. Energy savings from these advanced mechanisms can vary from zero to perhaps ten per cent of seasonal energy consumption for certain systems.

More efficient furnace fans and motors for forced-air systems have been developed and are widely available. They will improve the overall efficiency of your system.

3. Accommodating the Electrical Load

If you are planning to heat with electricity, it may be necessary for you to upgrade or adjust your home's electric service in order to cope with the additional load. Two basic approaches are described in this chapter.

Electrical Service Panels

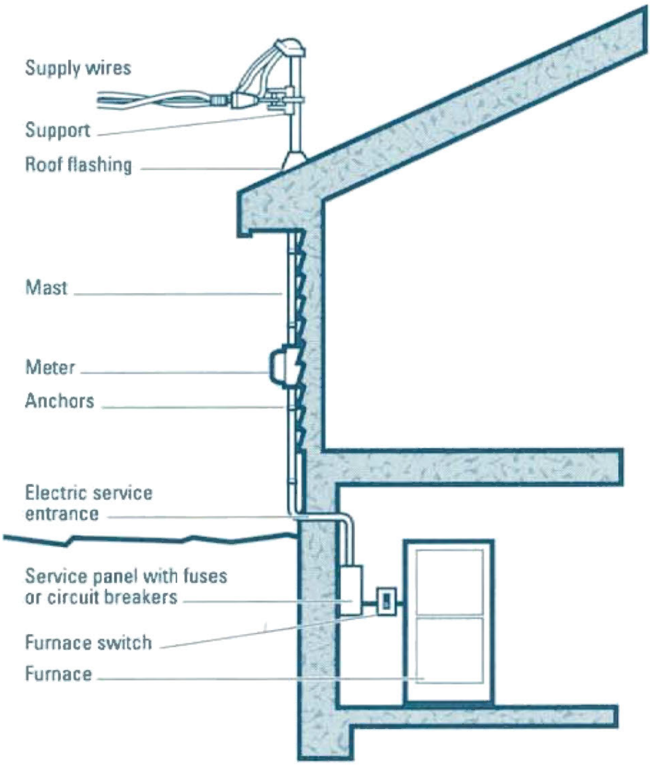
If you're not heating with electricity at present, your home probably has a 60A or 100A electrical service. If you decide to change to electric heat you may have to upgrade your home's electric service to 200A or more.

Upgrading an electrical service involves replacement of:

- the electrical service panel (fuse box or breaker panel)
- the three heavy wires that supply electricity to your home and their housing
- the meter base and receptacle

If you are building a new house, consider installing a 200A service no matter what type of heating system you are considering; this could avoid costly service upgrading in the future. Your utility can assess consumption of electricity and future needs, and normally has the final authority in determining a home's service capacity.

Figure 11: Typical electric service installation



A central electric furnace will require its own switch, sized in accordance with the furnace output and usually mounted beside the main service panel.

Your local electrical utility should be consulted before any work begins. Either you or your electrical contractor must obtain a permit from the appropriate authority before any alteration to electric wiring is undertaken. Some utilities also provide precise information on cost and installation. The installation should be inspected upon completion.

Load Management Devices

Equipment is now available to manage the extra load placed on a standard (100A) electric service when an electric heating system is added to a household. These load management devices can be applied to any electric heating system but are used primarily with electric plenum heaters added on to an oil system. Sensors on the wires supplying electricity to the house monitor the amount of electricity used. Electricity passing through these wires sets off a low-level electric current in the sensor. As house demand rises and falls, this current will fluctuate accordingly.

For instance, if the amount of electricity used in a house is heavy—say when the water heater, stove and dryer are all in operation at the same time—the device restricts the amount of current allowed to reach the heating elements of the heating system. This prevents an overloaded demand on the house's electricity supply. (In a system using a plenum heater, the load monitor compensates for an increased household demand for electricity by temporarily switching off one or more of the plenum heater's elements.) Then, as appliances are turned off, the sensor responds by allowing more electricity to flow to the heating system (or by switching the plenum heater's elements back on) up to the full capacity required. Except for water heaters and dryers, nearly all of the electricity used by household electric appliances ends up as heat—which compensates somewhat for a slightly lower output by the heating system.

Load monitors may eliminate the need for upgrading to a 200A service. In some provinces, however, electrical utilities may find these devices unacceptable. Be sure to check with your electrical utility if you're considering using this kind of equipment.

4. The Mechanics of Buying, Installing and Maintaining a System

Buying Electrical Space-Heating Equipment

You can't shop for a heating system the way you shop for a camera or a pair of shoes. There are no furnace stores where the different makes and models can be examined, compared, and priced. To get first-hand information on the different makes and models available, you will have to contact a number of heating firms. Ask them for the manufacturers' illustrated sales literature on the equipment they sell and install. You should also contact the local distributor, electrical utility or contractor for assistance and information. Your local utility can provide information on the cost of purchasing or renting, installing your system, and the estimated seasonal heating costs associated with the type of equipment you plan to use.

If you have decided on a particular type of equipment, check the literature carefully to see if it describes the features you are looking for. Look, too, for the efficiency rating.

Having an Electric Space-Heating System Installed

If you decide to use an electric heating system, you will have to hire a licensed electrician to install it. The first step is to ask local electrical or heating contractors for estimates. Estimates should include the following items:

- The total cost for **all** necessary work.
- An itemized listing of all work included in the bid, such as removal of existing heating equipment and alteration or replacement of the main service panel and service entrance; the customer portion of alterations to service wires above or below grade to the transformer pole and transformer pole replacement (sometimes the responsibility of the customer in rural areas).

- A rough diagram showing the layout of any new wiring and the location of heating equipment.
- A statement that clearly defines who is responsible for:
  - all necessary permits and payment of related fees
  - on-site inspections by the utility
  - alterations to the transformer or related outside equipment that has to be done by the utility
  - all related costs such as subcontracts with tradespeople.
- A statement that includes when electric service will be interrupted and for how long, how much of the existing equipment will be used, and when the job will be completed.
- A schedule and method of payment.

Consider additional upgrading or improvements to house wiring while this work is being done. The provision of split receptacles to kitchen counter areas, an electric stove receptacle, outside lighting, and draftproofing of receptacles in outside walls may be possible and relatively economical, while the work on the heating system is being completed.

You should get several estimates on the work to be done. When you are comparing these estimates, cost will be an important factor, but there are other considerations. Some contractors may be more cooperative and, consequently, better at explaining what has to be done. Others may use higher quality components or may schedule the work to your convenience.

Ask contractors for the names of homeowners for whom they have done similar work. The Better Business Bureau will know if the contractor is a member and whether any recent complaints have been filed. Your Chamber of Commerce or Board of Trade may also be able to help. Don't hesitate to ask for a clear explanation of any aspect of the work before, during or after installation of your heating system.

In most provinces, if wiring has been upgraded, a service panel replaced, heating equipment added, or load management devices installed, the work must be inspected by the utility, municipality, or province. The contractor should have these inspections done before the circuits are energized or wiring is hidden behind walls.

Maintaining Your System

In general, electric resistance heating systems require relatively little maintenance and they tend to last for a long time without requiring replacement.

Maintenance by contractors is usually limited to the replacement of broken electric heating elements in central electric furnaces or baseboard heaters. Owners can improve the performance of their heating systems by vacuuming the elements on any baseboard heaters and by replacing filters in electric forced-air furnaces.

Care of the Distribution System

If you have a forced-air system, remove obstructions from ducts, warm air registers, and cold air returns so that air can move freely around the system. Seal all joints in the ducting, and consider insulating all exposed warm air ducts.

If you have a hydronic system, there are a few things you can do to maintain your system:

- insulate hot water pipes
- once or twice a year, bleed air bubbles out of radiators so they can fill with water
- vacuum the radiators
- check to see that the level of water in the expansion tank is below flood level
- oil the circulating pump (according to the manufacturer's instructions)
- allow air to flow freely around radiators

If you are planning to be away from your home for an extended period, arrange to have a neighbour check your house every day to ensure that the heating system is operating. If the system fails, a heating contractor must be notified immediately.

Billing

Billing for electric heating is handled by your local electrical utility, and appears as part of your total household electric bill. Rather than having higher bills in the winter months, you can often arrange for equal billings from your electric utility.

5. Electric Water Heaters

After the space-heating system, domestic water heaters consume the second-largest amount of energy in most Canadian houses. Depending on the house type and on the number and lifestyles of the inhabitants, hot water consumption may account for more than 20 per cent of total annual energy consumption in the home. Many Canadian homes have electric water heaters to supply hot water for household use.

An electric water heater usually consists of a tank, thermostats, two electric resistance elements (which are submerged inside the tank), and inlet and outlet pipes for cold and hot water respectively. Internal thermostats regulate the temperature of the water. Tanks are typically insulated on the exterior with mineral wool insulation and lined on the inside with a thin epoxy or ceramic glass layer. When hot water is needed, the elements are activated, which then heat the water until it reaches the correct temperature. Essentially, electric hot water heaters are large closed electric kettles. Water temperature is generally maintained at between 49°C (120°F) and 60°C (140°F).

The submerged electric resistance heating elements found in water heaters are very efficient, providing about 99 per cent of the available heat to the surrounding water. Even so, older water heating systems lose considerable heat as a result of standby and distribution losses.

Certain modifications can help to save energy and dollars with water heaters. An economical way to reduce these costs is to wrap an insulating blanket around the storage tank. These are easy to install and very cost-effective. However, it is extremely important not to insulate over any controls or wiring. Follow the manufacturer's instructions.

External thermostats allow the homeowner to lower the temperature of the water according to need, and also permit the heater to be switched off when not in use.

Thermal traps are "low tech" devices that can be fitted to the tanks, and reduce energy consumption by reducing convection in the attached water pipes. "Bottom boards" can be placed beneath the water heater to reduce conductive heat loss to the floor.

Consider installing one of the new, higher efficiency electric water heaters to maximize your energy savings. These reduce heat loss by using more insulation around the tank and hot water distribution pipes.

Hot water can also be provided by a *heat pump electric water heater*. This is often a ground-source heat pump with an additional condenser or heat exchanger. For further information, refer to our booklet, *Heating and Cooling with a Heat Pump*.

Note that electric water heaters are covered by existing and proposed efficiency standards in various parts of Canada. These guidelines will help you choose the most efficient system for your needs.

6. Need More Information?

Free Home Energy Publications

Natural Resources Canada (NRCan) has many publications that can help you understand home heating systems, home energy use, transportation efficiency, and what you can do to reduce your energy costs while increasing your comfort.

Want to Draftproof and Reduce your Energy Use?

Keeping the Heat In is a guide to all aspects of home insulation and draftproofing. Whether you plan to do it yourself or hire a contractor, this 100-page book can help make it easier.

Enerfacts are informative, easy-to-read fact sheets that look at specific aspects of draftproofing and reducing energy consumption. They can help you sort out the materials and procedures involved in determining where your house loses energy and what to do about it.

How About Home Heating Systems?

If you are interested in a particular energy source, you may find NRCan's booklets on heating with gas, oil, heat pumps, wood, or solar hot-water heating helpful.

...and Consumer's Guides?

The *Consumer's Guides* can help you choose energy-efficient items such as office equipment, household appliances, lighting products, windows and doors, a resale home, or an R-2000 home.

...AND ENERGUIDE DIRECTORIES?

The EnerGuide Program is designed to help you choose energy-efficient products that use the least amount of energy. The EnerGuide label, which is affixed to household appliances and room air conditioners, helps you choose the most energy-efficient models. Directories are published each year that list the EnerGuide ratings of major electrical household appliances and room air conditioners.

... AND TRANSPORTATION EFFICIENCY?

The *Car Economy Calculator* helps you determine your vehicle's fuel consumption. The annual *Fuel Consumption Guide* lists the fuel consumption ratings of most new vehicles sold in Canada. Information is also available on fuel alternatives to gasoline and diesel (i.e., propane, natural gas, ethanol and methanol).

To receive any of the free publications listed above, please write to the following address:

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