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1. The Allure of a Fireplace

We Canadians love our fireplaces. Although their importance as a primary source of heat has dwindled over the past few decades (it is not long ago that virtually everyone depended on wood-burning appliances to survive the Canadian winter), their popularity among consumers has not. In fact, from a marketing perspective, the fireplace has become one of the most important features in the modern Canadian home. It is often difficult to sell a new house without one.

Many of us find the allure of a fireplace irresistible. The beauty of a roaring fire, the cosy or romantic atmosphere it creates, and the sometimes misplaced notion that a fireplace can reduce a home's heating costs and help the environment by using a renewable fuel are all powerful motivators.

However, not all fireplaces are created equal. Recent technological developments have resulted in a new generation of fireplaces that offer remarkably improved operating performance, energy efficiency and safety compared to conventional fireplaces, as well as reduced environmental emissions. Fireplaces that feature this new technology look like conventional fireplaces, produce more attractive flames, and are affordable. The new technology can even be installed in an existing conventional fireplace.

Thanks to these new developments, we can now enjoy all the benefits of a wood fireplace — including substantial heat output—without the worry, risks or problems associated with conventional units, which are simply incompatible with today's new housing or with energy-efficient homes. Improved building practices, along with widespread efforts to reduce air leakage in older dwellings, mean that millions of Canadian homes are too airtight to allow safe and effective use of a conventional wood fireplace.

This booklet will tell you what you need to know about the advantages of the new wood fireplace technology. It also explains the major problems and dangers of conventional fireplaces, and looks to the future in terms of government standards and regulations for fireplaces.

With your safety and well-being at stake, a few minutes reading this booklet will be time well spent.

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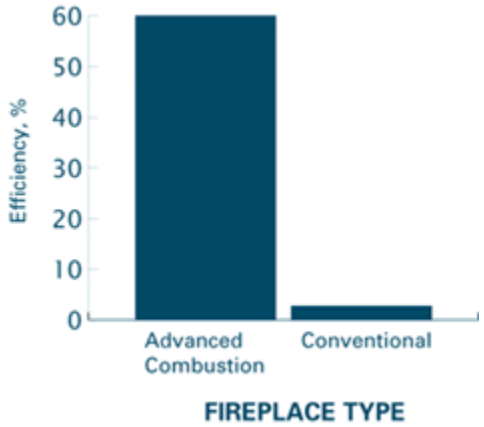
2. Conventional Wood Fireplaces

In a nation that is known for its long, cold winters, it would be difficult to find many people who do not enjoy the warmth and comfort of a wood fire. Unfortunately, with conventional fireplaces, the reality seldom lives up to expectations. Most conventional wood fireplaces are hard to light, smoke, create cold, unpleasant drafts and cause a number of unforeseen problems, some of which can be deadly.

Efficiency — or lack of it!

Conventional wood fireplaces are extremely inefficient, averaging between -10% and +10% energy efficiency (by comparison, the gas and oil furnaces sold today operate at better than 80% efficiency). In the best case scenario, they supply a little heat to the house. Unfortunately, most fireplaces fall into the worst case side of the equation, causing an overall heat loss. Tests have demonstrated that, in most instances, on cold winter days the use of conventional fireplaces will actually result in an increase in fuel consumption for heating.

Figure 1: Efficiency comparison



One of the primary reasons for this inefficiency is that large amounts of heated household air flows through the fireplace and up the chimney when a fire is blazing. A conventional wood fireplace will use up to 10 times the amount of air required by a typical oil or gas furnace. And only a small amount of the air drawn into a fireplace is actually used for combustion; the rest, known as excess or "tramp" air, escapes to the outdoors.

This flow of tramp air has two consequences. First of all, it draws heat that is

generated by the fire up the chimney, rather than transferring it to the house. Second, it results in a high rate of air exchange in the house, which among other things causes the furnace or other primary heat source to work overtime to heat more air. A roaring fireplace can result in all the air in a house being exhausted up the chimney as much as 1.4 times each hour the fireplace is in use. As discussed below, this can disrupt the operation of a new or energy-efficient home, which would typically have an air exchange rate of about 0.3-0.4 air changes per hour, and can lead to potentially catastrophic situations.

Huge volumes of tramp air are a reflection of the poor overall design of most conventional fireplaces. The problem is that most fireplaces found in today's homes are designed for viewing, not for producing useable heat. Conventional fireplaces generally do a poor job of collecting heat from the flame and flue gases and transferring it to the house; in other words, they offer poor heat exchange. The little heat that most conventional fireplaces can extract often goes into the fireplace wall, from where much of it is conducted directly outside, rather than into the house. Some homeowners have fans in their fireplaces to assist with the distribution of heat to the room. Unfortunately, these fans are often inefficient and may even use more energy than they transfer to the home. Others are so noisy that they are turned off.

Another design problem is that conventional fireplaces have a large leakage area (the chimney opening), which allows heated house air to be lost or cold air to enter the home, even when the fireplace is not in use. Although one might think that the damper alleviates this problem, in reality, its impact is questionable. Tight-fitting glass doors can help reduce "off-cycle" loss of heated indoor air; however, when the fire is burning, these doors may actually result in increased air demands due to a more intense combustion and higher burning rate. Moreover, most fireplace doors use tempered glass (to withstand the heat), which does not transmit most of the infrared radiation from the fire to the room.

Environmental issues

Many homeowners use their conventional fireplaces because they think this is less environmentally harmful than heating with oil, gas or electricity. Not so! Wood combustion in these fireplaces results in high levels of emissions, contributing to air pollution problems outside the home, as well as to indoor air quality problems.

Again, there are a number of reasons for this. First, the design of a conventional fireplace does not promote complete combustion of the wood. As the fire burns, complex and volatile combustion products are being boiled or distilled out of the wood. These products, in the form of smoke, often enter the chimney before they can be ignited and burned. Some may condense in the chimney, forming creosote, which in turn can cause chimney fires. However, most escape to the outdoors where they are a significant cause of air pollution. The incomplete combustion products can even spill into the home, causing serious indoor air

quality problems.

Wood burning and the environment

Advanced combustion fireplaces are one of a number of technologies that can dramatically reduce the amount of smoke and other pollutants, including greenhouse gases, which are produced by the burning of wood (for other options, see section entitled **Other Efficient Wood-Burning Appliances**).

When their atmospheric concentration increases, the greenhouse gases, mainly carbon dioxide, cause the average global temperature to rise, with potentially disastrous results. The burning of carbon-based fuels is a main cause of increased levels of atmospheric carbon dioxide.

Wood, however, differs from fossil fuels such as oil and gas because it is a renewable fuel. As a tree grows, it absorbs carbon dioxide from the air and stores it in the wood as carbon. This carbon makes up about half of the weight of wood. When wood is burned, carbon dioxide is released again to the atmosphere. The same amount of carbon dioxide would be released if the tree died and was left to rot. Our forests can be a perpetual source of fuel, provided they are cared for and managed properly.

Indoor air quality problems

Conventional fireplaces can contaminate indoor air at both the beginning and end of the burn cycle. When a fire is first lit, the chimney is not usually warm enough to properly draw the combustion products to the outdoors. As a result, much of the smoke and gases spill back into the home. Furthermore, during this high-burn period, the fireplace may become starved for air and "search" for a source within the house. Often, the most convenient source is the chimney of the central furnace or gas water heater. In extreme cases, the fireplace's overwhelming need for air can actually reverse the flow of air down through the furnace or water heater chimney, drawing the combustion products from the furnace or water heater back into the home. At the end of the burn cycle, a conventional wood

fireplace can be a major source of carbon monoxide (CO). As a fire burns down and the wood reaches a charcoal state, it emits significant amounts of CO, an odourless, toxic gas. The dying fire also means that the chimney is cooling and will be less likely to draw the CO to the outdoors. The house may become a better "chimney" than the chimney itself (see box below). Under certain circumstances, the gases may also be pulled back into the home as the furnace or water heater go "searching" for air — and find it by using the fireplace chimney! In either case, there is a potential for CO poisoning of the occupants, which can, and does cause deaths in Canada every year.

The house as a chimney

An operating chimney is an enclosed column of warm air or gases surrounded by colder outside air. The warm air or gas in the chimney is more buoyant than the dense, cold outside air, so it rises, producing a draft in the system.

In the winter, your house is also an enclosed column of warm, buoyant air that creates its own form of draft. In effect, the warm air pushes upward, creating higher air pressure at the top of the house. At the same time, the pressure in the basement is lower than the pressure outside.

Under some circumstances, the house can become a more effective chimney than the chimney itself—especially if the chimney is located on an outside wall. Rather than using the chimney to release household air and combustion gases to the outdoors, air will be drawn back into the home through the chimney. This reverse flow of air can result in the spillage of combustion gases from a fireplace or other combustion appliance, into the home.

As a basic safety precaution, the installation of a carbon monoxide detector close to the fireplace would be a wise decision. In fact, CO detectors are recommended for all homes that have combustion appliances. These devices will continually monitor the air for CO and sound a loud alarm when high levels are detected — just as your smoke detector will signal the possible existence of a fire. If your CO detector goes off, everyone in the house should seek medical treatment,

particularly if you are experiencing headaches, lethargy and nausea. It is also critical that you determine the source and cause of the high CO levels and have the situation remedied by a professional.

What to do?

Until recently, there were no simple solutions that could make a conventional wood fireplace work truly efficiently, safely and with low pollutant emissions. Most remedial actions address only minor or isolated aspects of the problem. At best, measures such as providing an outside air supply or installing glass doors or heat exchangers will increase efficiency to the 10 to 20% level. They can also lead to their own set of problems. For example, depending on outdoor conditions, conventional fireplaces can sometimes attempt to use a large outside-air supply duct as if it were a chimney, which can cause a fire.

One partial solution is to burn artificial fire logs, which can minimize air demand and reduce pollutant emissions and the chances of combustion gases being spilled into the house. On the down side, artificial logs burn longer, but at a lower heat rate and can be costly.

By far the best solution is to convert your existing conventional fireplace into an efficient, clean-burning advanced combustion unit. As described in the following section of this booklet, these new wood fireplaces operate safely, efficiently, produce a minimal amount of emissions and can reduce energy bills.

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3. Advanced Combustion Wood Fireplaces

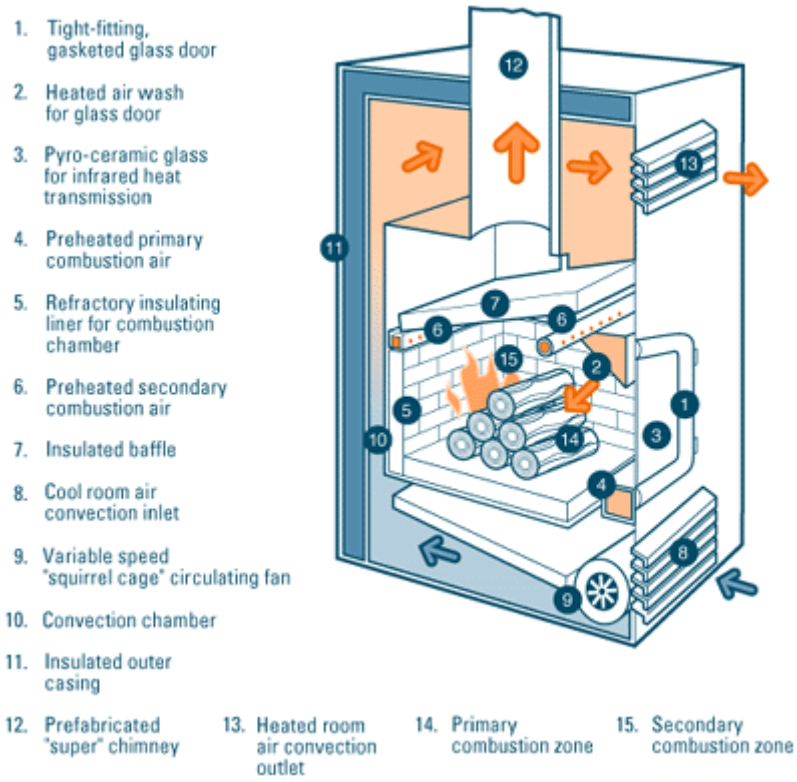
Advanced combustion technology was developed as part of a major effort to reduce emissions from wood stoves in order to meet environmental regulations in both Canada and the United States. The principal design elements of the wood stove technology are now being incorporated into new fireplaces, producing an attractive, safe, efficient and cost-effective alternative to conventional fireplaces. This new technology is also available in a form which can be installed into an existing fireplace, converting it into an excellent performer.

Design features

In these new designs, the secret of success is the use of a sophisticated secondary combustion process that ensures more complete combustion of the wood, thereby increasing the fireplace's operating efficiency and reducing the amount of incomplete combustion products that escape the firebox.

Advanced combustion fireplaces use two separate paths of combustion air, both of which are preheated. One source of air is fed directly to the burning wood, while the second is aimed immediately above the main fire to capture and ignite the incomplete combustion products that would otherwise be released into the chimney. The result is two simultaneous combustion zones and flame patterns — a visual effect that is entrancing.

Figure 2: Advanced combustion fireplace



Advanced combustion fireplaces have truly airtight, gasketed doors, a special ceramic (pyro- or neo-) glass window that allows most of the infrared heat from the flame to be transmitted to the room, and a hot air "sweeping" of the window to allow clear viewing. Because these fireplaces are often installed with their back against an exterior wall, they should also have some type of insulated outer casing that prevents unwanted heat loss from escaping.

What makes them better performers?

Aside from their superior performance, these advanced combustion units differ from conventional fireplaces in that they have better heat exchange properties. Room air is drawn in through a grille under the firebox, from where as quirrel cage fan sends it through a heat exchanger and back into the room through grilles at the top of the fireplace. With some units, the heat can also be ducted to adjacent rooms or into the basement, where an auxiliary fan can send it through ducts to other parts of the house.

As a result of their enhanced combustion features, the air requirements for these new fireplaces are low. Advanced combustion fireplaces require as little as 7 L/s (14 cfm) of air from the house in order to operate properly. This small amount of air is about one tenth of the ventilation required for a typical house. Such an air requirement for advanced combustion fireplaces is about the same as that required by high-efficiency gas or oil furnaces.

However, even with this low air-exchange rate, it is a good idea to supply

the fireplaces with direct outside air for combustion (this is mandatory in some provinces).

Advanced combustion fireplaces have little or no interaction with the house air, so the chances of combustion products spilling into the home are minimal. In addition, they greatly enhance the safety and effectiveness of supplying outdoor air directly to the fireplace. The maze that is used to preheat this air before it is released to the firebox is so complex that it is difficult for the combustion gases to use this route as an exhaust.

Energy efficiency

Advanced combustion fireplaces can offer high levels of energy efficiency — approximately 50 to 70%, and even higher when they are installed in a major living area with an open view to other parts of the house (this allows the homeowner to lower the average temperature in the house). In such an installation, these fireplaces can reduce overall energy demand and heating bills in a home. In particular, dramatic cost savings and enhanced comfort are possible for many homes currently heated by electric baseboards.

Table 1

Typical Heating System Efficiencies and Energy Savings

Energy Source	Technology	Seasonal Efficiency (AFUE) %	Energy Savings % of Base**
Wood	Central furnace	45-55	
	Conventional stove (properly located)	55-70	
	"High-tech" stove (properly located)	70-80	
	Advanced combustion fireplace	50-70	
Oil	Cast-iron head burner (old furnace)	60	Base
	Flame-retention head replacement burner	70-78	14-23
	High-static replacement burner	74-82	19-27
	New standard furnace	78-86	23-30
	Mid-efficiency furnace	83-89	28-33
	Condensing furnace	85-95	29-37
	Integrated space/tap water	83-89	28-33 space

	mid-efficiency		40-44 water
Natural Gas	Conventional	60	Base
	Vent damper with non-continuous pilot light	62-67	3-10
	Mid-efficiency	78-84	23-28
	High-efficiency condensing furnace	89-96	33-38
	Integrated space/tap water condensing	89-96	33-38 space 44-48 water
Electricity	Electric baseboards	100	
	Electric furnace or boiler	100	
	Air-source heat pump	1.7 COP*	
	Earth-energy system (ground-source heat pump)	2.6 COP*	
Propane	Conventional	62	Base
	Vent damper with non-continuous pilot light	64-69	3-10
	Mid-efficiency	79-85	21-27
	Condensing	87-94	29-34

** COP = Coefficient of Performance, a measure of the heat delivered by a heat pump over the heating season per unit of electricity consumed.*

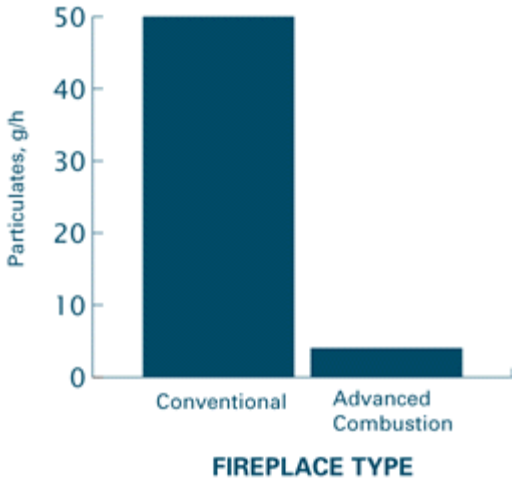
*** Base represents the energy consumed by a standard furnace.*

Environmental benefits

The environmental benefits of the new technology are also impressive. The use of two combustion zones reduces emissions of incomplete combustion products by ten fold compared to a conventional fireplace. The new technology thus enables the environmentally friendly use of a renewable energy source. The low levels of incomplete combustion products and creosote also virtually eliminate the potential for chimney fires.

An added benefit of these units is that in case of an electrical power failure, they can still operate as emergency heat sources for the house. Even though the electrical circulating fan on the fireplace will not operate, the heat from the fire will radiate into the house along with natural convection from the fireplace, supplying a significant amount of heat to the house.

Figure 3: Pollutant emissions for different wood-burning fireplaces



What to look for?

Advanced combustion fireplaces will usually cost between $1500 and $2500, with installation.

If you are purchasing a new home and want a fireplace added, take the opportunity to choose an advanced combustion unit. If you already own a home with a conventional fireplace, consider a retrofit with the new technology to ensure comfort, energy efficiency and safety.

If retrofitting, look for an advanced combustion unit that is especially designed to be inserted into an existing fireplace. You will likely have to put a liner in your existing chimney to make it compatible with the new technology. Use an approved stainless steel chimney liner to ensure a good draft and prevent condensation of combustion products.

A new installation should use one of the high-temperature chimneys designed specifically for wood-burning appliances. These metal chimneys are designed to withstand continuous gas temperatures of 650° C, which is higher compared to chimneys intended for other fuels. This chimney type has a thicker wall, more insulation and a higher grade inner liner than other chimneys.

It is worth noting that only these types of advanced combustion fireplaces may be installed in Canada's super energy-efficient R-2000 Homes, since the low emissions level is generally a sign of high operating efficiency and low air requirements suitable for operation in airtight houses.

What does the future hold?

The design and manufacture of energy-efficient wood-burning appliances, including fireplaces, is an ongoing process. Work is continuing to create integrated wood heating systems that are energy-efficient, environmentally

friendly and safe to operate in today's homes. As well, the federal government plans to develop seasonal efficiency standards for wood fireplaces. Over time, the introduction of regulations and standards for fireplaces could make the use of advanced combustion fireplaces mandatory.

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4. Other Efficient Wood-Burning Appliances

Aside from advanced combustion units, two other types of potentially efficient wood fireplaces are also sold in Canada. They are as follows:

Pellet fireplaces

Pellet fireplaces are similar in concept to advanced combustion fireplaces but use fuel pellets (made from wood and other biomass wastes) rather than cordwood. The ease of fuel handling and automated feeding can make up for the significantly higher cost of pelletized fuel. Many pellet systems can burn even cleaner than advanced combustion units because of the nature of their combustion system. Although they are usually more expensive than advanced combustion fireplaces, some units can be sidewall-vented in certain installations, avoiding the cost of a chimney.

Buy only a pellet fireplace that has been tested to and meets the United States EPA 1990, 40 CFR Part 60 or CSA B415.1-M92 standard.

To ensure that you are purchasing an advanced combustion wood-burning fireplace, buy a new unit that meets the emissions criteria of either the United States Environmental Protection Agency's (EPA) wood-burning appliance standard (1990, 40 CFR Part 60), or the Canadian Standards Association's standard CSA B415.1-M92 (Performance Testing of Stoves, Inserts and Low to Medium Burn Rate Factory Built Fireplaces).

Masonry heaters

Masonry heaters can also be clean burning, and some can achieve good efficiency levels. Although they are common in Europe and have been for some time, until recently such heaters were rarely sold in North America. However, in the past few years, the small but vigorous North American industry has made significant strides in producing much improved masonry heaters.

In this type of fireplace, wood is burned at a high rate but for a shorter period. Coupled with good combustion design and reduced excess air, this high burning rate can yield low emissions and higher efficiencies. The hot flue gas leaves the combustion chamber and passes through massive masonry (often with a reverse flow path), where much of the heat from the gas is extracted and stored. Ideally, the masonry subsequently releases the heat to the house slowly over a longer

period. To ensure that this happens, it is preferable to build this type of a fireplace on an inside wall.

Guidelines have been developed that will allow a well-designed masonry heater to be properly used as a clean, effective heat source in energy-efficient housing, such as the R-2000 Home.

Free-standing wood stoves

Although not technically a fireplace, free-standing advanced combustion wood stoves with ceramic glass doors are another clean and efficient wood-burning option. These units have an attractive flame, can be effective space heaters for a single room or a large house, and are even more efficient than advanced combustion fireplaces (to find out how to learn more about this and other wood-burning options, see the section on "For More Information on page 20 of this booklet").

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5. Placing a Fireplace for Maximum Benefit

If you are building a new home with a wood-burning fireplace or installing a completely new fireplace in an existing home, take some time to plan the installation so that the fireplace can contribute meaningfully to your heating needs.

The first rule of thumb is to place the fireplace in the part of the house you want to be the warmest and where you spend most of your time. This is usually on the main floor, where kitchen, dining and living rooms are located. The basement is not usually a good location for a wood fireplace, especially if you want the fireplace to provide heat to other parts of the home. Generally, this only results in the basement being overheated in an effort to keep the main floor comfortable, which wastes fuel. As well, basement installations require a longer chimney, which can result in a poor draft and the spilling of combustion products into the home. Unfinished basements, with poorly insulated walls and floor, are particularly bad locations because too much of the heat is absorbed by the walls and lost directly to the outside. Unless you plan to spend a lot of time in your basement, place the fireplace on the main floor.

The layout of your house will also affect the fireplace's ability to provide heat to other rooms. If you are building a new home, consider a layout that focuses on the fireplace. An open design, where there are few walls to separate rooms on the main floor, allows heat to flow from the fireplace to other rooms. An accessible stairwell will allow the heat to get upstairs as well. A properly located and well-designed fireplace can displace up to 60 per cent of conventional heating requirements while providing a safe and appealing atmosphere, while not consuming an inordinate amount of wood.

If possible, place the fireplace on an inside wall. This will eliminate direct heat loss from the fireplace through an outside wall. It will also make it easier to locate the chimney inside the house. By surrounding the chimney with warm, rather than cold air, you ensure a better draft and reduce the chances of the house becoming a better chimney than the chimney itself. Even if the fireplace is to be placed on an outside wall, you should endeavour to install the chimney within the main structure of the home.

Some fireplaces are approved to be connected to a certain amount of ductwork, which can help move heat to more remote areas of the home. This may be another option worth considering when you are designing a new home. As well, ceiling fans are often a good way to move the heat from a fireplace.

6. Using a Fireplace Efficiently and Safely

An advanced combustion fireplace can be a beautiful, inviting and environmentally friendly source of energy in your home. However, you are an essential part of the formula for success. Follow these basic guidelines to maximize your fireplace's performance and ensure its safe operation:

- Have the fireplace installed by a qualified serviceperson and make sure you have a proper chimney for your unit. In most areas, a special installation permit is required before you begin, as well as an inspection once the work is completed;
- Carefully read the manufacturer's instructions before operating the fireplace for the first time;
- Check the manufacturer's instructions before adding or modifying a mantle or surroundings (minimum clearances are required);
- When the fireplace is operating, turn down your home's main thermostat whenever possible;
- Keep the viewing glass clean to maximize radiant heating (ask your fireplace dealer to recommend a good cleaner); and
- Clean and check your fireplace (including latches and gaskets) and chimney on a regular basis.

7. Need More Information?

Fireplaces are only one of a number of wood-heating options for the home. The Natural Resources Canada publication, *A Guide to Residential Wood Heating*, describes other technologies and systems and provides detailed information on such matters as wood appliance installation, operation and maintenance, chimneys, buying and storing wood, etc.

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

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