THE ADVANCED COMBUSTION WOODBURNING FIREPLACE

An Alternative Efficient Residential Heating System

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INTRODUCTION

Fireplaces have occupied an important place in North American households for more than 400 years. They have acted as a place where the food was cooked, where people gathered around to talk at the end of the day and hopefully, where they could get warm. Even today, builders find it difficult to sell a new house which does not have a fireplace.

However, housing characteristics have changed remarkably, particularly over the last 25 years. Improvements to the building envelope, both in terms of insulation and in terms of air tightness, are reducing the amount of energy actually required for heating new and renovated housing, as well as the amount of air available.

Conventional wood burning fireplaces are incompatible with such housing, due to their gross inefficiencies, large air requirements, significant pollutant emissions, and negative effects on indoor air quality.

New fireplace designs, in the form of **Advanced Combustion Woodburning Fireplaces,** have the potential to convert a most difficult problem into an attractive, marketable solution which is safe, energy-efficient and environmentally benign, while effectively using a renewable energy source. These advanced fireplaces are appropriate and recommended for both new home installations and for retrofit into existing fireplaces.

Conventional Wood Burning Fireplaces

Air Requirements

The measure of air tightness of a house is most often given in terms of air changes per hour (AC/h), with air change being the total volume of air present in the house. 0.3 to 0.5 AC/h are considered necessary to ensure that there is no long term build-up of contaminants in the house. Many new, tight homes require forced ventilation systems to achieve this level. Table I presents a summary of the air requirements of various residential combustion appliances for a typical North American house.

Conventional woodburning fireplaces have massive air requirements, due to high, uncontrolled burning rates and very high excess air levels. Such a fireplace can have air requirements of as much as 680 m^3/h, or about **1.4 air changes per hour (AC/h).** This can cause problems in most housing.

Combustion Spillage

Combustion spillage is the passage of combustion products into the house from a fuel burning appliance. A conventional fireplace can be the source or cause of serious combustion spillage for at least three reasons, as follows:

1. After the fireplace is lit, and before the fireplace chimney gets hot and begins to draw properly, the fireplace can "smoke", with the tell-tale darkened mantle.
2. Once the chimney starts to draw, the house depressurization caused by the fireplace under high burn results in the fireplace "searching" for air. Often the most convenient source is down the chimney of the fossil fuel-fired central furnace or water heater, bringing their combustion products into the house.
3. At the tail end of the burn of the fireplace, the wood has progressed to nearly pure charcoal, with much cooler flue temperatures. Spillage can occur either due to the house being a better chimney than the chimney itself, or due to other appliances such as the furnace taking its combustion air down the fireplace chimney. At this pint, the potential for carbon monoxide (CO) poisoning, usually after everyone is sleepy and is going or has gone to bed, is high, yet has few obvious warning signs.

Air Pollution

Contrary to popular wisdom, conventional fireplaces can be high sources of air pollutants, on the order of 50 g/h, twice the level of conventional "dirty" wood stoves (Figure 1).

Efficiency

In most homes, conventional wood-burning fireplaces have near-zero efficiencies. They supply little if any energy to the house. Field trials have shown that, on cold winter days, use of conventional fireplaces actually resulted in an increase in fossil fuel consumption for heating. The fireplaces actually had a **negative energy efficiency** during this period!

The **inefficiencies of conventional fireplaces** arise for a number of reasons:

1. High excess air for combustion.
2. Large house air requirements
3. Incomplete combustion
4. Minimal heat exchange
5. Inadequate methods of heat transfer to the house
6. Typical location on outside wall

In general, conventional wood burning fireplaces are incompatible with today's better built housing (11).

Advanced Combustion Wood Fireplaces - a Preferred Option

Concern over air pollution resulted in the EPA setting emissions standards for woodstoves in 1990. The effect has been a dramatic improvement in the combustion performance of woodstoves (5,6). Today, advanced combustion woodstoves have clean, efficient combustion.

Some fireplace manufacturers have taken these advanced combustion principles and have produced revolutionary fireplace designs. Suddenly there are real solutions to the conventional fireplace, solutions which are very attractive to homeowners. These new fireplaces can be called **Advanced Combustion Fireplaces.**

Importantly, the flame is exceedingly attractive to watch. There are two simultaneous combustion zones. The first is the conventional flame of a fireplace. The second, rolling to the front immediately above, is an intense turbulent flame which ensures complete combustion. The overall result is a riveting, chaotic, powerful flame, much more interesting than that from a conventional fireplace.

Using minimal excess air and a low burn rate, the **air requirements** of these advanced combustion fireplaces are as low as 0.04 AC/h (Table 1), so there is minimal interaction with the house air, either in releasing indoor pollutants or in causing other combustion appliances to spill. Even so, if desired, they can be connected directly to an outside air source.

Emissions The intense secondary combustion zone ensures that the emissions of incomplete combustion products (air pollutants) of the advanced combustion fireplaces are reduced 10-fold from a conventional fireplace.

Efficiency in contrast to the dismal efficiency of a conventional fireplace, the efficiency of advanced combustion fireplaces is very high, and can be greater than that of a conventional gas or oil furnace. They operate at low excess air, have good heat exchange, use ceramic glass in their viewing doors, which allows most of the infra-red heat from the flame to come into the room, and other superior features.

Design Characteristics of an Advanced Combustion Fireplace Along with its advanced combustion design, typical characteristics of this new fireplace has air-tight doors, a hot air-swept, clean, ceramic glass window, good heat exchange, an effective circulating fan to modulate heat supply heat to the house, and an insulated outer casing. A schematic of an advanced combustion fireplace is given in Figure 2 (11).

In order to ensure good performance, an advanced combustion fireplace should meet the emissions criteria of either EPA 1990 or CSA B415. Only advanced combustion fireplaces meeting these criteria may be installed in Canada's R-2000 housing.

These advanced fireplaces are appropriate for new homes and new fireplace installations, as well as for retrofit into existing fireplaces.

Masonry Heaters

A **masonry heater** is another type of fireplace (10) that has the potential for clean burning and good efficiencies. Similar units have been common in Europe for a long time, but until recently have been rarely sold in North America. The small but vigorous North American industry has made significant strides in producing much improved masonry heaters in recent years.

In this type of fireplace, wood is burned at a high rate for a short period. This high burning rate, coupled to good combustion design and reduced excess air, 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 can be extracted and stored in the masonry. The masonry subsequently releases the heat to the house slowly over a long period. To ensure that the heat actually does get into the house, it is good practice to build a masonry heater on an inside wall, where possible.

Just having someone say they have a masonry heater isn't enough, however. Look for test results giving EPA-equivalent performance. Guidelines have been developed to allow good designs of masonry heaters to be properly utilized as a clean, effective heat source in energy efficient housing, such as R2000.

Pellet Fireplaces

Pelletized fuels from wood and other biomass wastes can also be utilized in efficient, clean burning **pellet fireplaces** (4). The ease of handling and automated feed may tend to compensate for the higher capital and fuel costs. While more commonly used as stoves, pellet burning fireplaces are also available. To get a clean burning, efficient unit, get one that has been tested to EPA 1990 or CSA B415 criteria; otherwise high excess air can result in low efficiencies. As well, it will ensure that your unit has the potential to burn cleanly. Just being a pellet stove does not guarantee this. New designs are being developed which will allow the efficient burning of a high ash pellet, opening up large supplies of agricultural waste as a potential home energy source.

Locating an Advanced Design Fireplace for Maximum Benefit

If you are building a new home or wish to install a new fireplace in an exiting home, take some time to plan the installation so that the fireplace can contribute meaningfully to your heating needs.

Locate the fireplace in a part of the house which you wish to be warmest, and where you spend much of your waking hours, usually on the main floor, where the kitchen, living and/or family and dining rooms are located. A basement is not a good location, as it is often difficult to get the heat upstairs, basement walls are usually poorly insulated (if at all) and poor draft can result in problems.

The layout of the house is also important. A relatively open design that focusses on the fireplace which allows heat to flow easily to other areas is desirable.

With the fireplace is usually located in a major living area, with an "open" view to other regions, these advanced design fireplaces can become extremely effective space heating systems (8). If people are increasingly comfortable in the area where they spend the majority of their time, the overall heat demands of the house can be lowered, through a de-facto zoning system. The real seasonal efficiencies of such installations can surpass their laboratory-tested efficiencies.

A large market opportunity exists for advanced combustion fireplaces as a retrofit in as many as 20% of existing North American households - those presently heated with electric baseboards. These homes often have an existing conventional fireplace located as a focal point in a major living area, which is ideal as a means to back out 50-60% of costly electric heat, without the high cost of a distribution system, and being "green" in the process.

Potential for New Generation Integrated Fireplaces

For the foreseeable future, North Americans will continue to demand fireplaces in their homes. However, house heat demands getting lower and lower and, at the same time, fireplace efficiencies are getting higher and are supplying more and more heat to the house. An increasingly difficult problem with energy-efficient fireplaces becomes the following - how to allow the use of the fireplace without causing intense overheating, especially as the outside temperature warms? As well, the low heat demand of new homes makes one ask the question, "Why do I need 3 combustion sources - one for a furnace, one for a water heater and one for a fireplace - when I really even don't need much heat at any one time?"

As most people will still want some sort of fireplace, this presents an opportunity for a new integrated fireplace (9). Such an appliance will require new intelligent designs and controls, combining some if not all of the house space and water heating (and perhaps even ventilating) requirements in one piece of equipment - a **new generation, advanced combustion, integrated fireplace**, using a renewable energy source. However, even if we can develop such an appliance, it will not be enough to leave it at that point. Careful integration with the house design and layout will be required, following the "**house as a system**" approach.

Conclusions

1. **Conventional wood burning fireplaces** are extremely inefficient, are sources and/or causes of serious indoor air quality problems, and can result in life-threatening situations. They are **incompatible with today's housing**.

2. Advanced combustion wood burning fireplaces meeting performance levels of ERP1990 or CSAB415 have low pollutant emissions. **Only these wood burning fireplaces should be installed in new or renovated housing**. These designs, as inserts, are also most suitable for retrofit into existing fireplaces. Such equipment, if properly located, can have seasonal efficiencies greater than conventional gas or oil furnaces, while making effective use of a renewable energy source.

3. **Well-designed and properly installed masonry heaters** and **pellet fireplaces** present other potentially clean burning, efficient alternatives.

4. For the advanced combustion wood fireplaces to reach their energy potential, they should be **properly installed in a major living area**, with heat access to other parts of the house.

5. Deceasing heat loads with new housing technology are creating the potential for a **new generation of integrated fireplace**, which can incorparate the needs for space and water heating, aesthetics, flame viewing, and even ventilation with one unique, efficient energy generator, allowing biomass to make a major contribution in the North American residential energy sector.

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Table I. **Air Demands for Residential Combustion Appliances.**

APPLIANCE	AIR REQUIREMENTS		EFFICIENCY
	m^3/h	AC/h	%
Conventional Wood Fireplace	**680**	**1.4**	0-15
Advanced Wood Stove	17	.03	55-75
Advanced Combustion Wood Fireplace	**23**	**.04**	45-75
Conventional Gas or Oil Furnace	200	.40	60

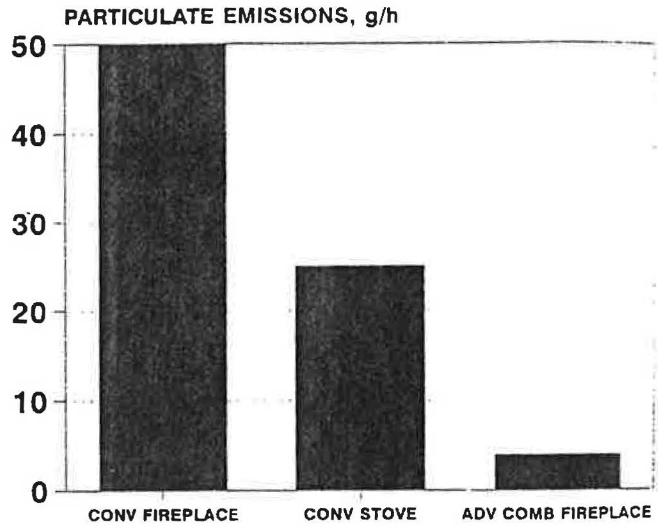

Figure 1.
Comparison of Pollutant Emissions from
Conventional and Advanced Combustion Fireplaces

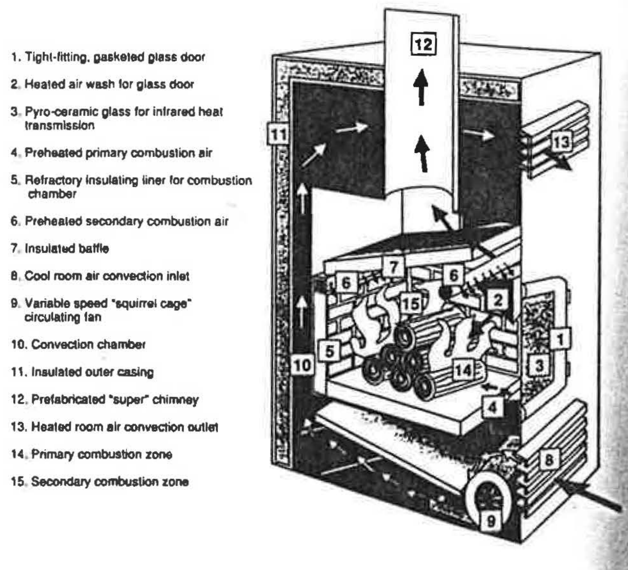

Figure 2.
Schematic showing Characteristics
of Advanced Design Fireplace (11)