

SUCCESSFUL FIREPLACES IN TIGHT HOUSES



A central location, a tall chimney, and controlled combustion are the keys to a good burn

Builders are beginning to hear more complaints that traditional masonry fireplaces leak smoke and burn too much wood for too little heat output. The fact is, open site-built

by John Gulland

masonry fireplaces have always been filthy, smoky, and inefficient, but these drawbacks were less noticeable in drafty, uninsulated houses. Today's tighter homes, however, are less forgiving, and their occupants are less tolerant.

In addition, many modern fireplaces are used strictly as a design element, and many designers have no training in what makes one work. On top of that, many of the masons and other heating contractors who build fireplaces carry over outdated design traditions that are at the root of performance problems.

It doesn't have to be that way. Building scientists now understand why traditional fireplace designs perform poorly, and masons, manufacturers, and hearth installers have responded with new prod-

ucts and techniques that eliminate past problems.

In this article, I'll discuss the common causes of fireplace problems, and propose solutions for masonry fireplaces and heaters, as well as less expensive, efficient wood-burning metal fireplaces.

Why Fireplaces Fail

When it comes to traditional open masonry fireplaces, masons have perpetuated outdated ideas about the smoke shelf, the mysteries of the smoke chamber, and the need for wide, but shallow-throat dampers.

Today, it is clear that all three of these features work against successful fireplace performance (see Figure 1). The smoke shelf and shallow-throat damper both act as obstacles to straight exhaust flow. And the smoke chamber actually reduces the strength of a chimney's draft by slowing and cooling the fireplace exhaust. The performance of many brick fireplaces can be improved immediately by removing the throat damper and smoke shelf, and installing a chain-operated damper at the top of the chimney. The results are a smooth, straight path for the exhaust and less smoking when a fire burns.

Cold Hearth Syndrome

But the biggest source of trouble is the location of the fireplace. Over the past 50 years of residential design, fireplaces have migrated from the center of the house to a position against the exterior walls, or even into chases that are completely outside the house. This causes cold hearth syndrome, which is the source of most fireplace failures.

The most dramatic effect of a cold hearth is a predictable blast of cold air when the fireplace doors are opened to build a fire. Smoke tends to fill the room when someone tries to light a kindling fire. This is a com-

How Fireplace Design Affects Draft

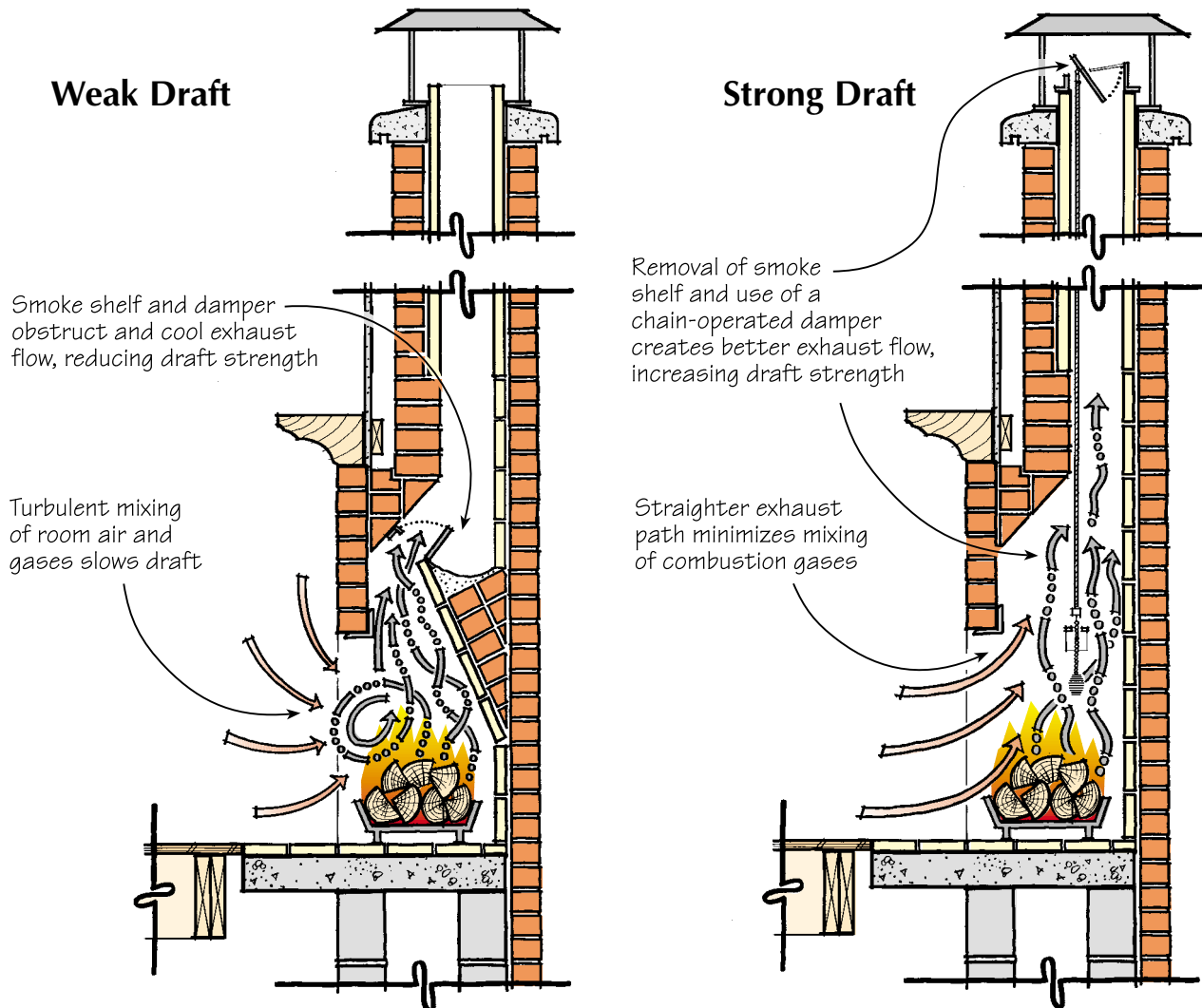


Figure 1. Traditional fireplaces leak smoke into living space and don't produce heat efficiently. The curving smoke chamber, the throat damper, and the smoke shelf all decrease the stability of the chimney draft.

mon, even chronic, characteristic of North American fireplaces.

The syndrome usually has its origin in the decision to place a fireplace outside an exterior wall in a frame or brick chase (Figure 2). The cold outside air sucks warmth from the fireplace and chimney structure, causing the temperature of the air in the flue to drop. When the flue temperature is lower than the house temperature, air begins to flow down the chimney and onto the hearth. This is called a “cold back-draft” and contrary to common belief, it does not happen because cold air is heavy and falls down the chimney. The air is not falling — it is being sucked down by the house.

Just as hot exhaust in a chimney produces a pressure difference called a “draft,” so the relatively warm air in a house produces a pressure difference called “stack effect.” The buoyant warm air rises, producing a slight low pressure zone downstairs and higher pressure upstairs. Since most fireplaces are installed on lower floors, they experience negative pressure due to stack effect when it is cold outside. As soon as the air in the chimney falls below room temperature, the house becomes a better chimney than the chimney itself, and a cold backdraft gets started. The backdraft tends to stabilize because as the chimney becomes full of cold air, it cannot produce any draft to resist the suction of the house.

Tall stack effect. A similar problem is caused by chimneys that fail to extend higher than all of the living space in a house. A chimney that is not tall enough competes with the living space above it to establish the dominant draft (Figure 3, next page). If the upper part of a house envelope leaks enough air through windows, attic access hatches, and wall penetrations, the house will again act as a better chimney than the chimney itself. In these cases, the house is said to have a “taller effective stack” than the chimney. Air will tend to flow down through the chimney, then loop through the house to exit through the attic or upper-story wall leaks. To avoid these problems,

Locating the Chimney

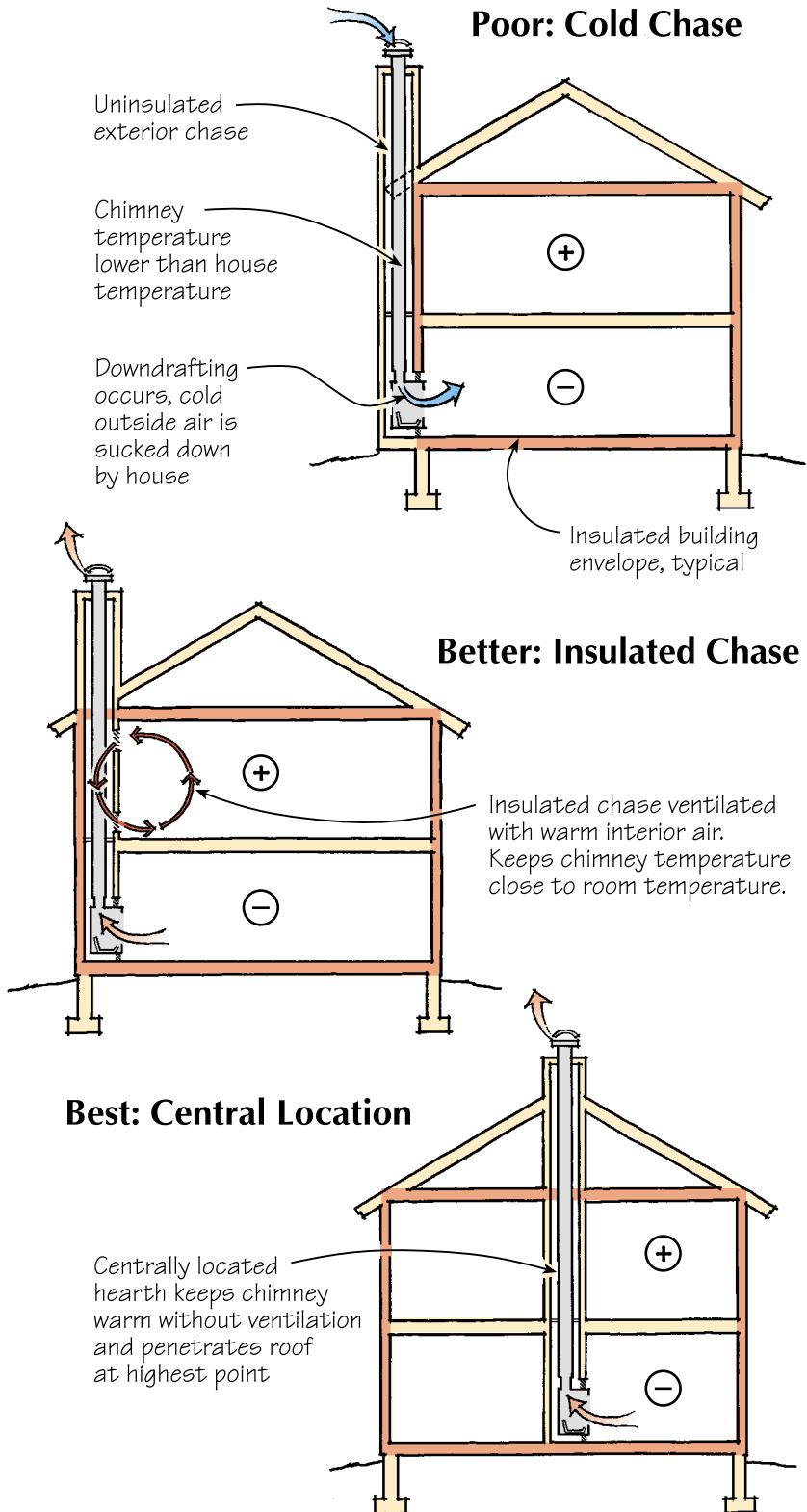


Figure 2. Chimneys built on an outside wall, whether exposed or boxed with an uninsulated chase, are prone to downdrafting (top). One solution is to insulate the walls of the chase and to vent the chase to the interior so warm air can circulate (middle). The best solution is to locate the chimney properly in the first place. The ideal location is in the center of the house (above), because the surrounding air will keep the chimney warm and the chimney will penetrate the roof at its highest point.

chimney tops should always penetrate the highest section of the conditioned living space.

In all cases, the cold hearth syndrome has two necessary ingredients without which it will not occur: a misplaced chimney and a fireplace located low in the house. If we could move the fireplace and its chimney towards the center of a house, the syndrome would vanish. Or we could move the fireplace to the highest floor of the house where the higher pressure caused by rising warmer air would ensure a good draft.

Unfortunately, moving a problem fireplace is not practical after it's been built, but you can still prevent cold

hearth syndrome by keeping the chimney from falling below room temperature. One way to do this is to trick the fireplace into thinking it is inside. This requires building a sealed, insulated chase that thermally matches the house wall construction. The chase should be vented to the inside so that warm house air circulating in it will keep it at about house temperature.

A better solution is to design out cold hearth syndrome at the planning stage by bringing the fireplace and chimney in from the cold. Ideally the fireplace should be located centrally, in the heart of the home, so that the chimney will penetrate the roof closer to its highest

point. This makes for a tall chimney with a large temperature differential between combustion exhaust and outside air — the two ingredients that make for the most reliable and stable draft. Straight venting systems also work better, so elbows and offsets in the chimney should be avoided.

Makeup Air

While improper design and location is a major cause of poor fireplace performance, tighter house construction and powerful exhaust fans must share some of the blame. By installing vapor barriers and using doors and windows that have sealing gaskets, builders

How Chimney Height & Placement Affect Drafts

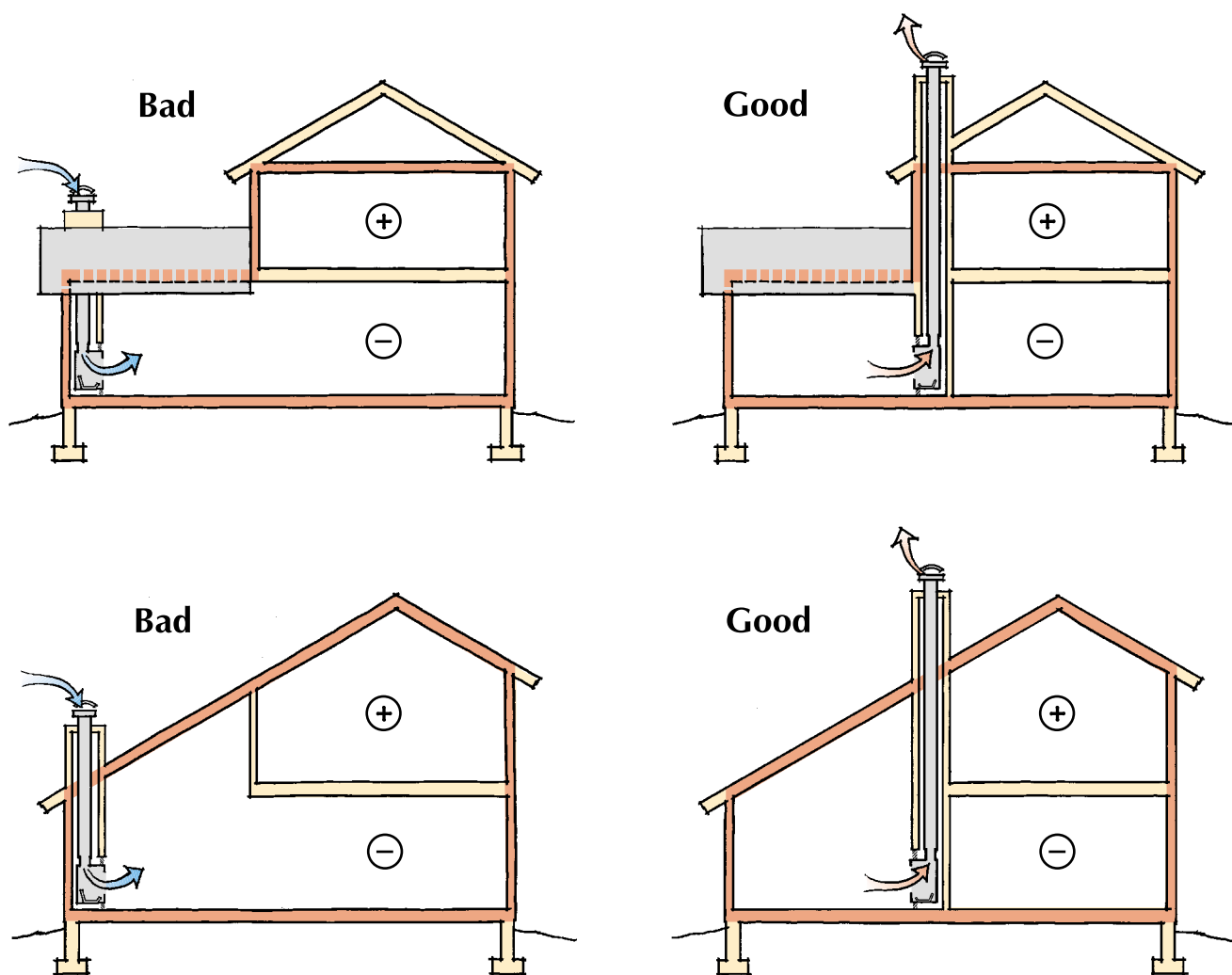


Figure 3. Chimneys built on outside walls are often too short to counter the house's stack effect and are prone to downdrafts. Again, moving the chimney closer to the center of the house ensures a tall chimney with a strong draft.

commonly reduce air leakage by more than 75% compared with the standard construction of 20 years ago. And homes are now commonly equipped with high-volume exhaust fans, such as those in downdraft kitchen ranges, which can move air out of the house at a rate of 600 cubic feet per minute (cfm) or more. Because tightly sealed house walls will not allow this much air back into the house through leakage, these powerful fans create negative pressure that can cause a chimney to backdraft and fill a house with smoke (Figure 4).

One standard fix for smoky fireplaces has been to install a supply of outdoor air in the belief that air starvation is the root cause. While lack of combustion air may be a problem in some cases, supplying outdoor air to the fireplace through a duct is certainly not the cure. Two research studies, one conducted in Canada on a series of factory-built fireplaces and one done in the U.S. on a masonry fireplace, looked into the behavior of outdoor combustion air supplies. In both studies, the fireplaces were installed within chambers that could be depressurized continuously after a fire was lit. As the fires died down to charcoal, technicians monitored car-

bon monoxide readings in the chamber to see when exhaust began to spill from the fireplaces. Tests were done with and without combustion air supplied from outside the depressurized chamber. No consistent difference in spillage timing or amount could be found whether or not outdoor air was supplied.

The reason is simple: Air flows to zones of lower pressure. If a room is depressurized to the point where its low pressure overwhelms the chimney draft, smoke will flow into the room. Obviously, ducting makeup air to the fireplace doesn't work. In fact, building code authorities are currently removing mandatory outdoor air requirements for fireplaces that were added only a few years ago, just before research debunked the idea.

Where a notorious air-guzzling downdraft kitchen range causes excessive depressurization, many homeowners will simply not use their range exhaust when the fireplace is burning. But a better solution is to install a kitchen makeup air system that is interlocked to the range exhaust switch. This kind of makeup air system would force air into the house to compensate for the kitchen range exhaust flow. This would prevent depressuriza-

tion, and solve the smoky fireplace problem.

Controlled Combustion

The design of the fireplace itself plays a big role in the level of satisfaction it provides. The internal features that produce efficient, smokeless combustion tend to be the same as those that produce reliable chimney venting and trouble-free operation. To help guide fireplace design, here is a simple rule of thumb that neatly summarizes a lot of expensive research: The more air a fireplace demands for normal operation, the more fussy and spillage-susceptible it will be.

Open fireplaces are the worst because they consume huge amounts of air — much more than is needed for combustion — which cools the system, thereby reducing draft. If your clients insist on a traditional fireplace, make sure they also agree to equip it with tightly sealed doors. The more you control the combustion in the firebox, the higher the temperatures of the exhaust and the stronger the draft.

If your client doesn't want glass doors or much heat, direct them to a gas hearth. Do the same if the architect's plans call for a hearth in an outside chase situated at the low eaves of

Combustion Air vs. Makeup Air

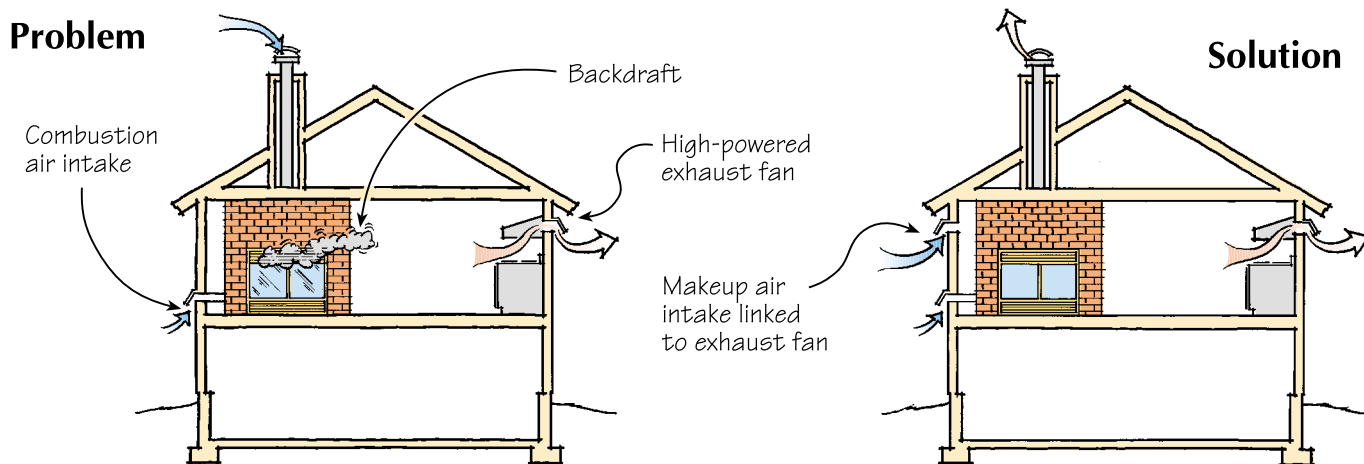


Figure 4. In tight houses, depressurization from cooktop vents, dryer vents, and other exhaust fans can cause fireplaces to backdraft and spill smoke into the room. Instead of ducting combustion air to the fireplace, which does nothing to change room pressure, add a makeup air system linked to the exhaust fans.



Figure 5. The Delta prefabricated metal fireplace is one example of an EPA-certified controlled-combustion fireplace (International Chimney Co., 400 J.F. Kennedy, St. Jerome, Quebec, Canada J7Y 4B7; www.icc-rsf.com; 450/565-6336).



Figure 6. Masonry heaters, with their enormous thermal mass, are designed to burn very hot, then store and slowly release heat. Although more expensive than prefabricated metal fireplaces, they provide a reliable high-performance wood-burning hearth.

a cathedral roof. If the clients cannot be convinced to relocate the fireplace more centrally, you will both probably be happier with a direct-vent gas fireplace.

Several other alternatives to traditional masonry fireplaces are also available. Metal stoves and fireplaces that meet Environmental Protection Agency (EPA) rules for low smoke emis-

sions are the most resistant to leaking smoke into the house because they create a reliable draft (Figure 5). These appliances are equipped with internal baffles, firebox insulation, and strategically placed combustion air inlets, which produce a stable, clean-burning fire, even at low heat output settings.

Don't sacrifice performance for lower cost, however. Some cheap

units are made out of lighter, thinner materials, and are often connected to lightweight air-cooled chimneys with flue diameters that are too small relative to the fireplace opening. All of these cost-saving elements hurt performance.

For customers who insist on a real brick or stone fireplace, a masonry heater is a good option (Figure 6). Masonry heaters use rapid combustion and heat stored in their massive structure to achieve high efficiency and excellent resistance to spillage.

Both types of appliances solve the smoky fireplace problem because they get hot and stay hot until the fire fades to a coal bed and goes out. Both types also produce net efficiencies of more than 60%, a welcome feature during a winter electrical power failure. In addition, high-quality prefabricated metal fireplaces are much less expensive than traditional masonry fireplaces — often less than half the cost, depending on the facade and mantel design (Figure 7).

Trained Installers

In the last 20 years, building science research has clearly shown how fireplaces behave in houses. These insights are now being promoted through professional training programs. When planning a traditional masonry fireplace or metal heater, or even a wood stove, use suppliers, installers, or masons who understand the pitfalls of outdated ideas and impractical designs. Fireplace suppliers and installers who are graduates of the Hearth Education Foundation courses (www.hearthed.com; 716/343-6524) have a better handle on the issues that concern builders than those who are untrained. If a masonry fireplace is required, use only qualified heater masons who are certified under the Masonry Heater Association professional training program (mha-net.clever.net; 802/728-5896). 

Figure 7. Metal fireplaces don't have to look metallic. The masonry surround for this metal fireplace gives a traditional look along with predictable performance, at a savings over a site-built masonry fireplace.



John Gulland is a hearth consultant based in Ontario, Canada. He is author of The Fireplace in the House as a System.