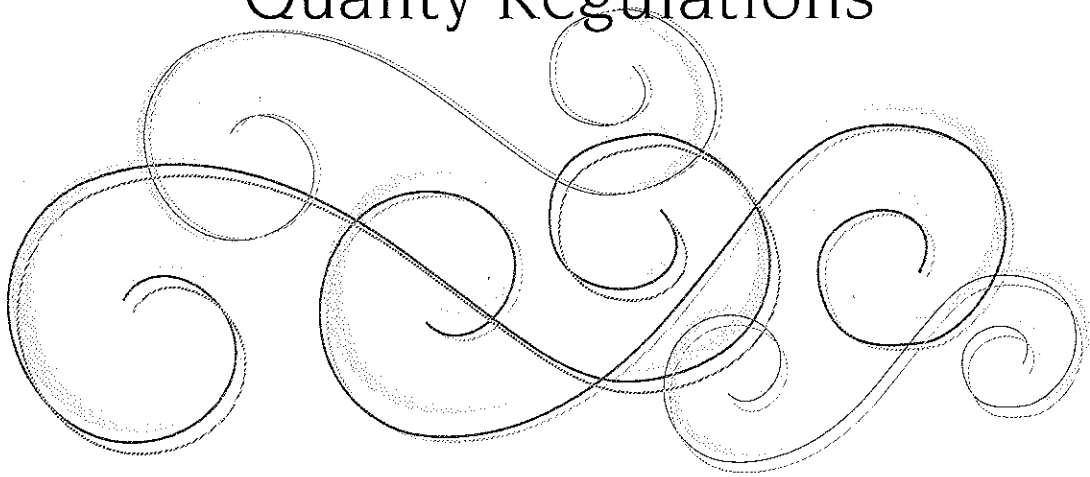
It's Win-Win

New Hearth Product Sales Can Be Part of the Solution for New Air Quality Regulations



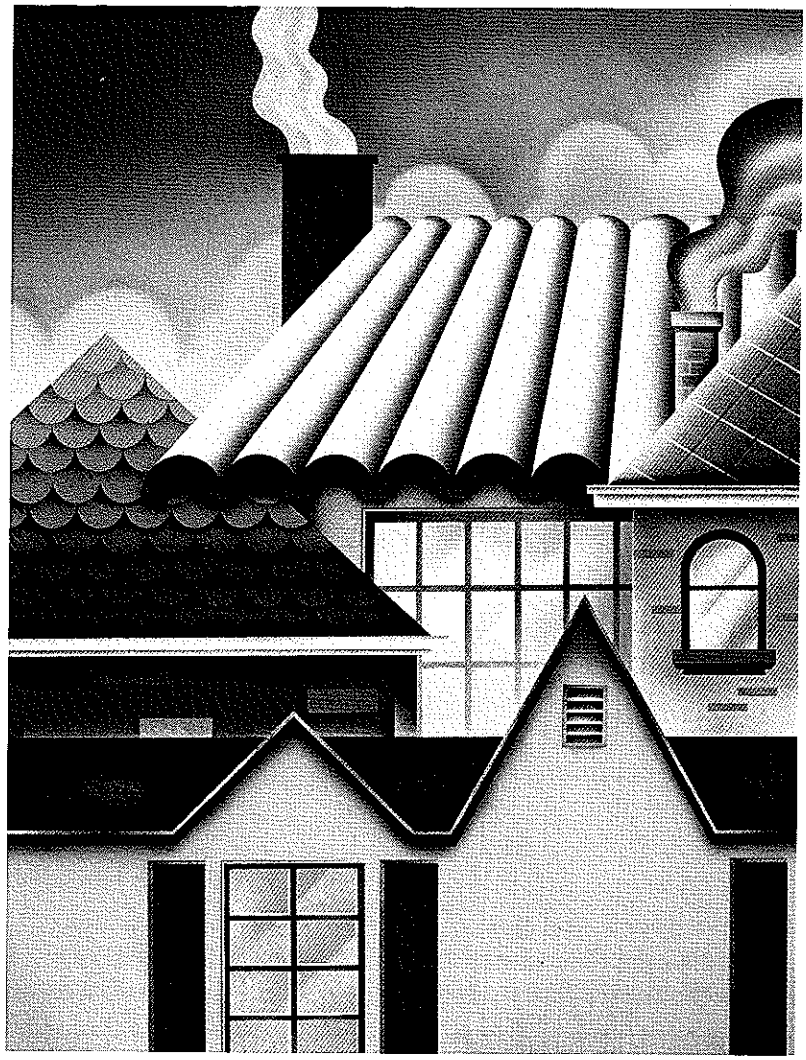
The new National Ambient Air Quality Standard (NAAQS) for fine particulate matter referred to as $PM_{2.5}$ was promulgated last year. A complex time line for monitoring, data review, implementation and compliance has been established by the U.S. Environmental Protection Agency (EPA) that will last over a decade. The number of counties with air quality projected not to meet the new standard is about four times greater than those not meeting the old particulate standard. It is widely recognized that particles emitted from wood heaters and fireplaces are predominately fine particles covered by the new regulation. State and local air quality authorities are gearing up for the new standard now and some are in the process of developing new wood heater and fireplace regulations or are scheduling workshops on how to mitigate the wood smoke problem. How can any of this be a "win-win" for the hearth products industry and the environment?

The facts are clear and compelling - new technology appliances and alternative fuels reduce particulate emissions substantially. Unfortunately, equally clear is the fact that residential wood combustion (RWC) is generally perceived as being environmentally dirty because, frankly, many old technology appliances and practices were. Environmentally the hearth products industry has come a long way since the mid-1980's. Even EPA documents that compile particulate emission factors or that provide guidance on how to achieve compliance with air quality standards do not reflect the current state-of-the-art of RWC. Surveys show that there are about 16.7 million wood stoves and fireplace inserts currently in use for home heating but less than 1.8 million of them can be considered new technology devices. There are approximately another 20 million fireplaces that are used primarily for minor heating and aesthetic purposes. The "win-win" comes into play quite simply in the replacement of old appliances with new technology devices or in the use of alternative fuels in them. This is a rare case where a business opportunity and environmental responsibility can be one in the same.

Editor's Note: *This paper was recently presented to air quality authorities and scientists at a national $PM_{2.5}$ conference cosponsored by the EPA and the Air and Waste Management Association (AWMA), a technical paper is in review for the AWMA journal (the AWMA has 14,000 members worldwide), and two workshop presentations are tentatively scheduled for an association of air quality regulators.*

The Role of Residential Wood Combustion

Forgotten in focused environmental evaluations, such as fine particulate compliance, are economic and other environmental considerations. RWC utilizes a renewable energy source, represents an important part of the nation's space heating budget and the use of fireplaces is a valued household activity for many Americans. In 1993 (the most current year with relevant data), 9 percent of the 96.6 million households nationwide used a wood stove. Also in 1993, 46 percent of the 55.5 million single family detached homes had fireplaces. Currently a fireplace is the third most popular amenity for a single family detached home after a two-car garage and central air conditioning. Almost two-thirds of new single family detached homes have a fireplace, and about 5 percent have two or more fireplaces. Regulators and the public need to be continually reminded that $PM_{2.5}$ reduction solutions based on moratoriums or bans on the installation or use of RWC appliances are not responsible in terms of the national need for the utilization of renewable energy resources, and they are contrary to the lifestyles of most American families. Further, the replacement of home heating based on wood burning with heating options directly or indirectly (in the case of electricity) based on fossil fuel combustion brings other environmental issues not associated with RWC into the picture. These include greenhouse gas emissions, acid precipitation and regional visibility reduction.



Emission Reductions Using New Technology Alternatives

The magnitude of potential $PM_{2.5}$ reductions obtainable by the replacement of old devices and fuels is substantial. The opportunity for reductions is large since there are so many old devices and so few new in use. State-of-the-art of hearth products can easily affect a 70 percent overall reduction in emissions from wood stoves and 50 percent from fireplaces. Nationally, if this reduction were applied to all wood stoves and fireplaces, the reduction in $PM_{2.5}$ would be well over 700 million pounds per year or almost three pounds per every man, woman, and child. Regionally or locally, especially in airsheds where wood smoke is a perceived problem, the relative $PM_{2.5}$ reduction can be much greater.

Particulate Emissions from Wood Burning

Particulate emissions from wood heaters and fireplaces are very variable due to the large number of appliance types, fuels and operating conditions. However,

" The challenge for the hearth products industry is to provide solid credible documentation on the performance of new technology appliances and alternative fuels and to effectively disseminate this information to decision makers in the regulatory community."

as with all things, average values do exist and are needed to be able to show the advantages of new technologies. The average values compiled by the EPA are about 15 grams of particles from every kilogram of wood burned in an uncertified conventional wood stove and about 17 grams of particles from every kilogram of wood burned in a traditional fireplace. While most of the particles emitted from RWC are $PM_{2.5}$, it appears that about 5 percent, 15 percent and 50 percent of particles in the emissions from wood stoves, fireplaces and pellet stoves respectively, are not fine $PM_{2.5}$ particles but are larger than 2.5 microns in diameter. Chemically, about 90 percent of the total particles of all sizes from wood stoves and fireplaces are composed of organic compounds (made up of carbon, hydrogen and oxygen), 10 percent is elemental carbon (also referred to as graphitic carbon or soot) and less than a percent are inorganic salts. Particles composed of organic compounds have a shorter lifetime in the atmosphere than those composed of inorganic compounds (e.g., road and agricultural dusts, coal fly ash, and marine aerosols) due to their loss by vaporization and oxidation.

Comparative Emission Units

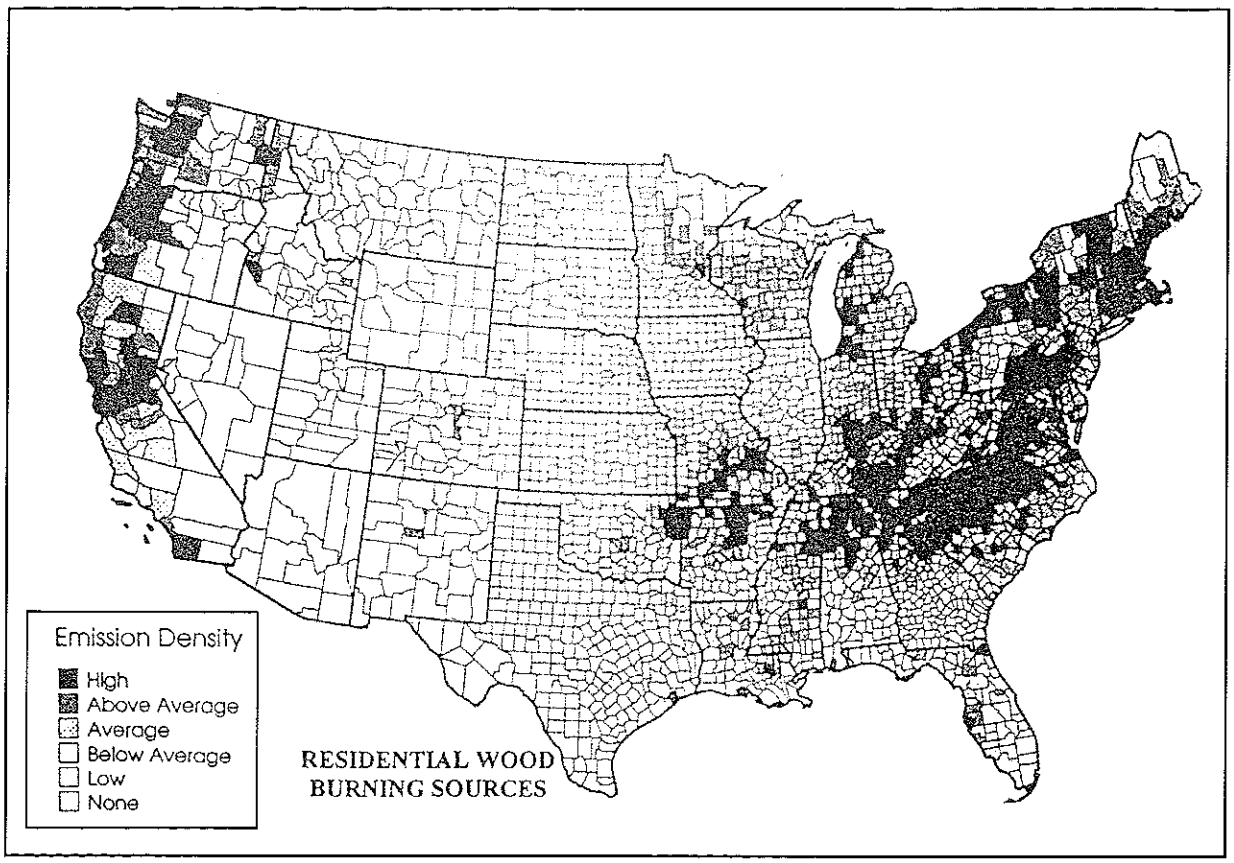
Particulate emissions from RWC have been reported in three ways: (1) emission factors [i.e., mass of emissions per mass of dry fuel burned (g/kg or lb/ton)], (2) emission rates [i.e., mass of emissions per time of appliance operation (g/hr)], and (3) mass of emissions per unit of heat delivered (g/MJ or lb/million Btu). There has been some concern about adding the third relatively unfamiliar way of reporting emissions (the mass of emissions per unit of heat delivered) to the fray. It must be emphasized it is very advantageous for the hearth products industry to use the mass of emissions per unit of heat delivered term for appliances used primarily for heating purposes since new technology appliances are more efficient than the older appliances. Therefore, newer appliances have effectively lower emissions, even if their emission factors (g/kg) are comparable. The mass of emissions per unit of heat output term (g/Mj) reflects this environmental gain.

For fireplaces used primarily for aesthetic or minor heating purposes, the emission rate term (g/hr) provides the best comparison. The amount of wood burned and the corresponding emissions are not directly related to heat demand, but are more or less constant for a given appliance. In addition, both of the two alternatives to fireplaces burning cordwood have fixed burn rates associated with them. The manufacturers of wax logs generally recommend one-at-a-time usage with a specified burn duration per log and most decorative gas log systems operate in a simple on/off mode with no burn rate control. The emission rate term (g/hr) allows for the comparison of these two alternatives with cordwood burning in a fireplace for aesthetic or minor heating purposes.

The Technical Details of the Alternatives and the Economics

For the purposes of estimating $PM_{2.5}$ emission reductions, RWC can be broken down into three categories. These are: (1) wood stoves/heaters, (2) fireplaces used as a heat source, and (3) fireplaces used for aesthetic and minor heating purposes. A shopping list of lower emission options for each of these categories has been compiled. Each option has different costs for the homeowner, different $PM_{2.5}$ reduction potentials, and different levels of available documentation to support the $PM_{2.5}$ reductions claimed.

Cost is the bottom line, both for the consumer and for the regulator who needs to assess the viability of an emission reduction plan. The EPA has



recommended that the strategies to attain compliance with the $PM_{2.5}$ standards should limit the cost per ton of pollutant to $10,000. Most of the alternatives discussed here, particularly for conventional wood stoves in colder climates, are well below this cap. Some areas in violation of particulate standards, have been so due to a few very high twenty-four hour periods. In these cases, the use of manufactured fuels represents a low cost option, even though their cost per ton of pollutants reduced is on the higher end of the spectrum among alternatives, because they can be used in existing appliances during short air pollution advisories or episodes.

There are two components to consumer costs. These are: (1) the initial costs which include appliance purchase, installation labor, chimney modifications, gas hookups and other miscellaneous home modifications necessary to accommodate the new appliance, and, (2) the annual cost difference between operating the old appliance with cordwood versus a new appliance and/or using alternative fuel. This cost difference includes the difference in fuel prices, electricity needed for fans and electronic components, catalyst replacement, differences in chimney cleaning costs, etc.

Based on U.S. Department of Energy surveys, it is estimated that nationwide on the average 2.5 cords of wood are burned in each wood stove, 1.5 cords are burned in each fireplace used for heating and about one-half of a cord are burned in fireplaces used for aesthetic and minor heating purposes. To provide a "yardstick" for comparison, typical costs for the national average fuel consumptions and mid-cost appliances were calculated. Clearly, the annual cost differences will vary with climate and the initial costs will vary with the appliance model. Also, as with most things, the higher cost alternatives often have increased convenience or aesthetic qualities associated with them.

1. Wood Stoves/Heaters

There are 8.3 million old conventional uncertified wood burning stoves currently in use. Low emission alternatives to conventional stoves burning cordwood are certified non-catalytic wood stoves, certified catalytic wood stoves,

"Wood stoves have been designed for a lifetime of about 40 years. Without regulatory impetus, the replacement of existing wood stoves will be a slow process."

pellet stoves, masonry heaters, and manufactured densified fuel.

- Certified non-catalytic stoves

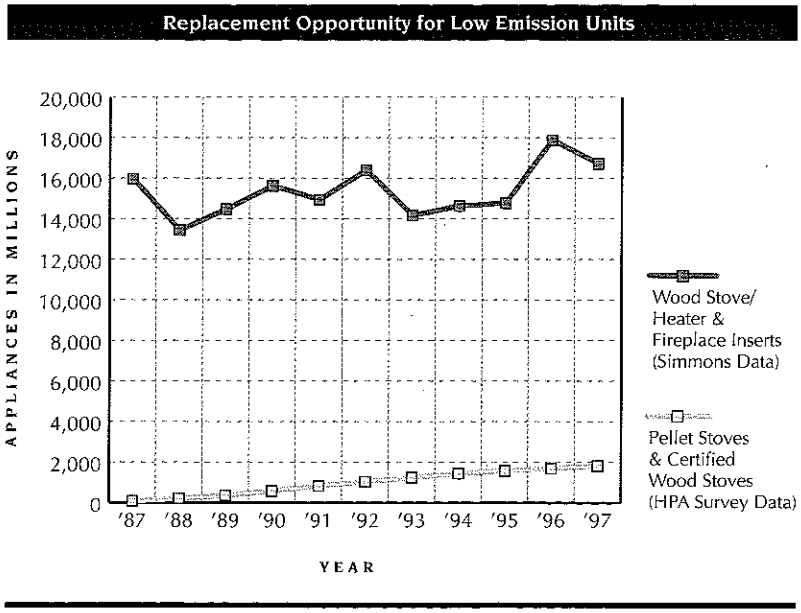
There are only 0.6 million certified non-catalytic wood stoves currently in use. There are 119 models listed as certified by the EPA. Non-catalytic technology achieves the reduction in emissions primarily by using secondary combustion air and heat-retaining refractory materials that promote complete combustion. A substantial fraction of emissions from non-catalytic wood stoves occurs during fire start-up, before efficient combustion is achieved. Certified non-catalytic wood stoves can reduce emissions by 71 percent, compared with conventional stoves. Research funded by the EPA showed that long-term durability can be an issue. However, it is generally believed that the durability of stoves has improved since the models used in the EPA research. Manufacturers' records have shown that durability is not a problem for well-built stoves under normal in-home use. The typical initial cost for a certified non-catalytic wood stove has been estimated at $2075 and the typical annual difference in cost of operation is $67 less than an old conventional cordwood stove, primarily due to increased efficiency.

- Certified catalytic stoves

There are only 0.4 million certified catalytic wood stoves currently in use. There are 83 models listed as certified by the U.S. EPA. As with non-catalytic stoves, emissions are at their highest during start-up when combustion is less efficient and, in the case of catalytic stoves, before the catalyst reaches its operating temperature. Certified catalytic wood stoves with new catalysts can reduce emissions by 74 percent, compared with conventional stoves. The emission control effectiveness of most catalytic stoves in typical residential use decreases with time. However, economic analysis has shown that the routine replacement (once every three to five years) of catalysts adds only modestly to the annualized cost of operating a catalyst wood stove. Furthermore, it should not be forgotten that catalyst technology has advantages. One advantage is large units can be designed to produce low emissions and certified using catalyst technology. Another advantage is that catalysts can control emissions over a wide range of burning conditions in typical size stoves. As with the certified non-catalytic stoves, EPA funded research has shown that long-term durability can be an issue. Also, as with non-catalytic stoves, it is generally felt that durability of catalytic stoves has increased since the models used in the EPA funded research. Durability, except for the expected decrease in catalytic activity, is not an issue for well-built models under typical in-home use. The typical initial cost for a certified catalytic stove is $2425 and its typical annual cost of operation is about $16 less than a conventional stove when all factors are taken into consideration.

- Pellet stoves

There are 0.3 million pellet stoves currently in use. During the 1995-1996 heating season, 654,000 tons of pellets were sold. There are two categories of pellet stoves - certified and exempt. There are five models listed as certified by the EPA. Appliances with a greater than a 35 to one air-to-fuel ratio are exempt from certification. Early models with the high air-to-fuel ratio had lower efficiencies than certified models due to sensible heat loss out the exhaust. This is not the case with newer models, since the high air-to-fuel ratio needs to be demonstrated only at low burn rates to obtain the exemption. At more normal burn rates, the air-to-fuel ratio is much lower. Pellet stoves can reduce particulate emissions by 92 percent, compared with conventional cordwood stoves. Reduction in $PM_{2.5}$ is expected to be even greater than the reduction of total particles since the $PM_{2.5}$ fraction of pellet stove particulate emissions is smaller than for cordwood stoves. The typical initial cost for a pellet stove is $2385 and it typically costs about $145 more annually to operate it than a conventional cordwood stove.



• Masonry heaters

Masonry heaters are exempt from U.S. EPA certification and, in fact, the certification procedure is not applicable to their design or intended mode of operation. The state of Colorado does, however, have an emission limitation applicable to masonry heaters. Masonry heaters are more costly than cordwood or pellet stoves and for that reason, many fewer of them are in place. Because of their aesthetic appeal, many of them are the centerpieces of homes and are often installed in more expensive houses. They achieve their low emissions by burning a large mass of cordwood in a short time period. The high burn rate enhances complete high-temperature combustion and commensurate low emissions. The short-duration, high-burn heats a large masonry mass that radiates heat to the living space well after the fire is out. To enhance transfer of the heat to the masonry material, the exhaust gas is routed through a "folded" pathway through the appliance. Masonry heaters can reduce emissions by 85 percent, compared with conventional stoves. The typical initial cost for a masonry heater is $10,500 and it typically cost about $109 less per year to operate it than a conventional cordwood stove due primarily to increased efficiency and the need for less frequent chimney cleaning. The initial cost of a masonry heater is added to the basis of home value and usually is recovered on the sale of the home.

• Densified fuel

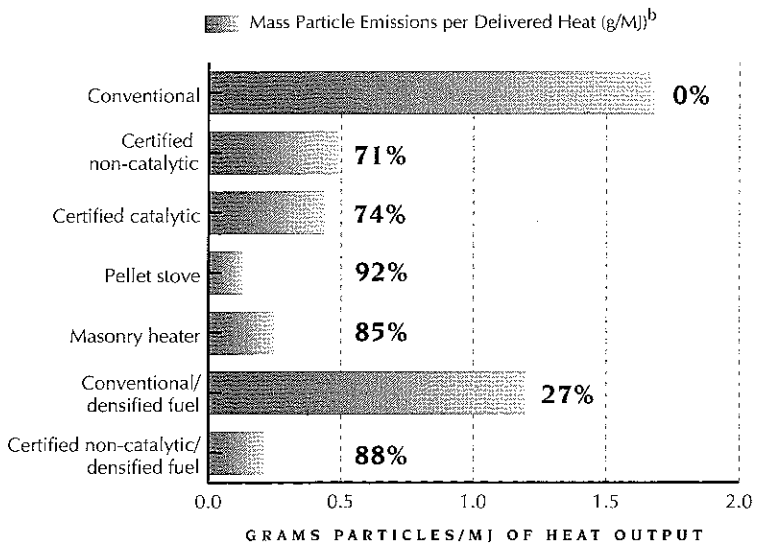
Manufactured densified fuel is commonly used in cordwood stoves due to its convenience and good burning characteristics. Its use is most prevalent in the Western U.S. It is typically composed of compressed sawdust, and it is significantly denser and drier than cordwood. The dense, clean, low moisture fuel produces lower emissions than cordwood when burned in conventional stoves. Densified fuel burned in conventional stoves can reduce emissions by 27 percent. Not surprisingly, when densified fuel is burned in certified stoves, further reductions in emissions can be achieved. It should be noted that quality densified fuel has been made from a variety of waste biomass materials besides sawdust. These have included straw, rice hulls, waste paper, cardboard, nut shells, and palm boughs. The emissions from these products vary, but are generally lower than from cordwood. There is, of course, no initial cost associated with using densified fuel in a conventional cordwood stove. The annual cost difference using densified fuel versus cordwood is $291 more.

2. Fireplaces Used as a Heat Source

There are 27 million fireplaces currently in homes. There are two structural types of fireplaces - manufactured metal fireplaces (referred to as zero-clearance fireplaces) and masonry fireplaces. Zero-clearance fireplaces are designed to last 40 years or more. Masonry fireplaces can last indefinitely. Consequently, the 27 million fireplaces currently in homes will be available for use well into the future.

A large number of fireplaces are used as significant supplemental heat sources. Fireplace inserts are designed for increased efficiency, and based on national surveys there are 7.1 million fireplaces with inserts in them. (The term insert as used here is not what most in the hearth products industry might think of as an insert. The term was used in a

Particulate Emission Reduction from New Technology Appliances & Fuels



survey question. An affirmative response to the question probably encompassed having a variety of older fireplace designs and accessories, such as double shell convection designs, convection tubes, blowers, etc. Some of the respondents also may have confused a zero-clearance fireplace unit with the term "insert.") Some fireplaces are even used as primary heat sources. In 1993, 0.4 million households used wood burning fireplaces as their main source of heat. Fireplaces utilizing older technology can reach efficiency levels in the 40 percent range. Older technologies that increase efficiencies and effectively reduce emissions by requiring less wood to provide the same heat include double shell convection designs, convection tubes, the use of blowers to transfer heat, glass doors, and masonry fireplaces with shaped fire chambers. The open radiant fireplace, with an efficiency value of 7 percent was used for comparison with new alternatives since it is the simplest and most common fundamental unit.

- **Certified cordwood and pellet inserts**

Certified non-catalytic, certified catalytic and pellet inserts can be used in existing zero-clearance and masonry fireplaces. They are essentially stoves modified to fit into a fireplace. If properly installed, their performance is similar to that of their stove counterparts, albeit their efficiencies are slightly poorer since convection and radiation of heat is more restricted by their location in the fireplace cavity and they are often located along an outer wall. There are an estimated 0.5 million certified cordwood inserts and 0.2 million pellet inserts in use. The EPA lists four catalytic and six non-catalytic insert models as certified. The emission reductions they provide over the use of a simple open radiant fireplace range from 94 to 98 percent. The typical initial costs are $1850, $2200 and $2400 for non-catalytic, catalytic and pellet inserts. The annual difference in costs from burning cordwood in an open radiant fireplace are $11 less, $52 more and $53 more, respectively.

- **Gas units**

Three types of gas units have the "fireplace-look." They are gas fireplace inserts, decorative gas fireplaces, and gas fireplace heaters. All have negligible $PM_{2.5}$ emissions, compared with cordwood fireplaces. Therefore, particulate reductions are near 100 percent. They can utilize either natural gas or liquefied petroleum gas (LPG). The "downside" of the nearly 100 percent $PM_{2.5}$ reduction is that both natural gas and LPG are, of course, fossil fuels, not renewable biomass fuels. Gas fireplace inserts like certified cordwood and pellet inserts can be put into existing fireplaces. Decorative gas fireplaces and gas fireplace heaters are designed for new construction. Gas fireplace heaters are more sophisticated than decorative gas fireplaces, as they are designed more for efficiency whereas decorative gas fireplaces are designed more for flame presentation. The typical initial cost of a gas insert is $2300. The annual difference in costs from burning cordwood in an open radiant fireplace are $139 less for natural gas and $102 less for LPG.

- **Fireplace-like wood stoves**

Wood stoves can be designed to have the appearance of fireplaces, to be "zero-clearance" units, and capable of being installed at the time of construction. The emission reductions they can offer over simple open radiant fireplaces are on the order of 95 percent.

TABLE ONE

Low Emission, New Technology Alternatives to Conventional Uncertified Stoves Burning Cordwood

Stove/Product	%Emissions Reduction Potential	Total Initial Cost*	Annual Costs Compared to Conventional Stoves Using Cordwood
Certified Non-Catalytic Stoves	71%	$2075	$67 Less
Certified Catalytic Stoves	74%	$2425	$16 Less
Pellet Stoves	92%	$2385	$145 More
Masonry Heaters	85%	$10,500	$109 Less
Manufactured Densified Fuel	27%	$0	$291 More

*Includes unit, installation and chimney work costs

TABLE TWO

Lower Emission Alternatives Compared to Existing Zero-Clearance and Masonry Open Radiant Fireplaces Used as Supplemental or Primary Heat Sources

Product	%Emissions Reduction Potential	Total Initial Cost*	Annual Costs Compared to Conventional Fireplaces Using Cordwood
Certified Non-Catalytic Cordwood Insert	94% -98%	$1850	$11 Less
Catalytic Cordwood Insert	94% -98%	$2200	$52 More
Pellet Inserts	94 -98%	$2400	$53 More
Gas Insert Natural Gas	100%	$2300	$139 Less
Gas Insert LPG	100%	$2300	$102 Less

*Includes unit, installation and chimney work costs

TABLE THREE

Lower Emission Alternatives Compared to Cordwood Used for Aesthetic and Minor Heating Purposes

Stove/Product	%Emissions Reduction Potential	Total Initial Cost*	Annual Costs Compared to Cordwood
Manufactured Wax Logs	68%	0	$166 More
Decorative Gas Logs Natural Gas	100%	$650	$15 Less
Decorative Gas Logs LPG	100%	$650	$47 More

*Includes unit, installation and chimney work costs

3. Fireplaces Used for Aesthetic and Minor Heating Purposes

During the 1994-1995 heating season, 17 percent of fireplace owners reported burning wood once or twice a season, 13 percent reported burning wood once or twice a month, and 18 percent reported burning once or twice a week. The sum of these three categories corresponds to about 13 million fireplaces. While these statistics do not provide an exact number of fireplaces used for aesthetic and minor heating purposes, they do illustrate its magnitude. The typical emission rate of a simple open radiant fireplace is about 60 g/hr. The emission rates from open radiant fireplaces were used to compare the emission reductions possible with manufactured wax logs and decorative gas logs.

- **Manufactured wax logs**

Manufactured wax logs are widely used in fireplaces nationwide. One hundred million manufactured logs are burned each year. Manufactured logs were burned some of the time in 30 percent of the fireplaces and exclusively in 12 percent of the fireplaces during the 1994-1995 heating season. They are composed of approximately 60 percent wax and 40 percent sawdust. Paraffin or microcrystalline waxes are used. The heat content of wax logs is much higher than that of wood, and their moisture content is much lower. They are exclusively for fireplaces (not wood stoves), they require no kindling, and are designed for one-at-a-time use. The emissions rate from fireplaces burning the firelogs in the prescribed manner is 19 g/hr which represents a $PM_{2.5}$ reduction of 68 percent as compared to cordwood. There is, of course, no initial cost associated with using wax logs in fireplaces. The annual difference in cost of using wax logs versus cordwood in a fireplace for aesthetic or minor heating purposes is $166 more.

- **Decorative gas logs**

The use of decorative gas logs has become popular. During the 1994-1995 heating season, 17 percent of fireplaces used gas as fuel mostly for decorative gas logs. Decorative gas logs are designed to be used in masonry or zero-clearance fireplaces. Gas log sets consist of a valve and burner assembly, a grate, and imitation logs made of cast refractory or cement. Their functions are primarily for aesthetics with flame appearance being the primary design criterion. Decorative gas logs have negligible $PM_{2.5}$ emissions, compared with cordwood fireplaces. Therefore, particulate reductions are near 100 percent, compared with fireplaces burning cordwood. As with gas fireplaces and inserts, either natural gas or LPG can be used with decorative gas logs. The initial cost for decorative gas logs is about $650 which assumes that the house is already "plumbed" for gas. The annual difference in cost of using natural gas is $15 less and of using LPG is $47 more than the cost of using cordwood in a fireplace for aesthetic or minor heating purposes.

New generation fireplaces

There have been some general improvements in the design of fireplaces that minimize the under-fire air supply and maximize combustion conditions with the introduction of secondary air. Therefore, some new fireplaces may have emission rates lower than the typical 60 g/hr value. However, little data are available on the performance of the new generation of fireplaces.

The Issues, the Challenge and the Course of Action

The reduction of $PM_{2.5}$ levels will be a daunting task for many air quality authorities. It will be fraught with politics, special interest groups, public pressure, economic evaluations and technical issues. A "cookbook" of residential wood combustion $PM_{2.5}$ reduction strategies that will still allow for the use of wood heaters, fireplaces and related appliances and fuels will be taken very seriously.

OMNI Environmental Services working for the Hearth Products Association has initiated the development of $PM_{2.5}$ reduction options applicable for hearth products and has started the technology transfer/education process. These efforts represent just the start.

Constructive criticisms, comments, ideas and data from HPA members are all welcomed and needed for the upcoming challenge.

Dr. James E. Houck is vice president of Omni Environmental Services, Inc. He has over 26 years of air quality experience, has published and presented more than 100 papers on air quality topics, and has provided air quality support for industrial, utility and public sector clients.