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Scoping Study:
Reducing Smoke Emissions From Home Heating With Wood

Prepared for
Environment Canada
Air Pollution Prevention Directorate

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TABLE OF CONTENTS

Executive Summary

This study reviews existing sources of data to profile the use of wood burning appliances for residential heating. The profile consists of four elements:

- the extent and patterns of wood energy use;
- the characteristics and capabilities of wood burning appliances and of the industries that manufacture and supply them;
- the features and status of regulatory initiatives to reduce environmental impacts;
- and the constraints and opportunities that could influence efforts to promote more environmentally friendly wood burning appliances and user practices.

Wood is by far the most prevalent renewable energy source in Canada; about one fifth of single family dwellings are heated to some extent with wood. Even those householders who report the use of wood as a supplementary fuel tend to use it to provide a large part of their total heating needs. Despite this surprisingly high usage level, wood heating is declining in Canada. A number of reasons have been cited for the decrease, including the appeal of improved gas hearths, the low cost of natural gas, and negative publicity regarding the environmental appropriateness of wood heating.

Since wood heating regained popularity in the late 1970s in response to high conventional energy prices and worries about security of supply, wood stove technology has been transformed. Better looking and performing stoves and the ability to watch the fire as it burns have added to the desirability of using wood as a fuel for space heating of living areas. Used this way, wood offers good prospects for the displacement of fossil fuel consumption and the reduction of greenhouse gas emissions. In most regions outside large urban centres, it costs less to heat with firewood purchased at market prices than with oil, propane, electric resistance and wood pellets, but it is more costly than using natural gas or a ground source heat pump (depending on electrical power rates).

The U.S. Environmental Protection Agency (EPA) has regulated the emissions from wood stoves and fireplace inserts since 1988 by restricting manufacture and sale to those appliances that are tested and certified as meeting particulate (smoke) emission limits. Wood stoves that are laboratory tested and certified by the EPA emit an approximate average of 5 grams of particulates per hour of operation during in-home field tests. This level of particulate emissions is between one fifth and one tenth of that emitted by conventional wood burning stoves.

Canada has no federal regulation or guideline that is applicable to wood heating. Responding to concerns about air quality, the province of British Columbia adopted a regulation in 1994 that functions in all material respects identically to

the EPA standard; in fact B.C. references both the EPA regulation and the Canadian Standards Association B415.1 standard that is harmonized with the EPA requirements. No other province has adopted a regulation mandating wood stove smoke emission limits, although several have expressed interest in doing so.

The smoke emissions from individual wood burning units are also strongly influenced by the quality of fuel and by the operating techniques employed by users. Creative public information programs could promote the techniques of responsible wood heating and help Canadians who heat with wood to use them effectively.

Advanced wood stoves that meet the EPA and B.C. requirements operate at higher efficiencies than conventional wood stoves, resulting in annual fuel cost savings of between $150 and $350 on firewood purchased at market prices. These substantial annual savings make upgrading to advanced technology an attractive investment. These savings are acknowledged by industry specialists to be a primary motivation in the decision by householders to upgrade from conventional appliances.

Regulatory action by the U.S., and subsequently by B.C. has had a significant effect on the Canadian market; it is estimated that of all current wood stove sales, somewhat more than half are of certified low emission models. The relevant industry, as represented by the Hearth Products Association of Canada (HPAC), supports the adoption of a national regulation similar to that adopted by British Columbia in 1994. Based on recent consultations conducted by the HPAC, there is reason to expect that a majority of provincial ministers of environment would respond positively to a federal regulatory initiative on wood burning appliances. The B.C. experience suggests that the administration and enforcement costs to support such a regulation would be low.

Despite the performance and environmental advantages of advanced wood heating technologies, the older conventional technologies are still far more prevalent in Canadian homes. Obstacles to the uptake of advanced technology wood stoves include the absence of an emission regulation, the higher cost of advanced stoves, resistance to change on the part of purchasers, and a lack of information. These obstacles could be minimized through the mechanism of a Canada-wide emission regulation, combined with effective public information and incentives for wood heat users to upgrade.

A significant reduction in smoke emissions from wood heating is achievable, but will depend on the combined efforts of a number of stakeholders. The federal government has a key role in the establishment of a Canada-wide emission regulation, and in the formation of and support for partnerships aimed at developing and disseminating information in support of the public's environmentally appropriate use of wood as a heating fuel. Likely partners include the hearth industry, other departments or agencies of government at all

levels, financial institutions, the insurance industry and public health organizations. All the identified partners could support and participate in programs such as stove change-outs, clean burn demonstrations, and programs to distribute public information.

The research for this study revealed that there is inadequate information available on how Canadians use wood fuel to heat their homes. More specific information on the attitudes of the users, the types of appliances currently in use, and the way they are used is needed to guide the development of effective public education materials. Research into the performance characteristics of the various appliance types is also needed. These two data sources—user profiles and appliance characteristics— are required to develop projections of environmental impacts and as a base line against which to measure progress in reducing negative impacts.

Résumé

L'étude, qui est fondée sur des sources de données actuelles, vise à brosser un tableau de l'usage d'appareils de chauffage au bois en milieu résidentiel. Elle porte sur quatre éléments :

- l'ampleur de l'utilisation du bois à des fins énergétiques et les habitudes qui s'y rattachent;
- les caractéristiques et les capacités des appareils de chauffage au bois ainsi que des industries qui les fabriquent et les fournissent;
- les particularités et l'état d'avancement des initiatives de réglementation axées sur la réduction des incidences environnementales;
- les contraintes et les possibilités qui pourraient influer sur les efforts de promotion des appareils de chauffage au bois et des méthodes d'utilisation plus respectueux de l'environnement.

Le bois est de loin la source d'énergie renouvelable la plus répandue au Canada; environ le cinquième des logements unifamiliaux sont chauffés au bois dans une certaine mesure. Même les occupants qui se servent du bois comme combustible d'appoint tendent à y recourir pour répondre à une grande partie de leurs besoins en chauffage. Malgré ce taux d'utilisation étonnamment élevé, le chauffage au bois est actuellement en baisse au Canada, et ce, pour diverses raisons : l'attrait des foyers au gaz perfectionnés, le faible coût du gaz naturel, la mauvaise publicité concernant les émissions polluantes produites par la combustion du bois, etc.

Depuis que le chauffage au bois a retrouvé la faveur du public à la fin des années 70 en raison du prix élevé des sources d'énergie classiques et des craintes quant à la sécurité d'approvisionnement, la technologie du chauffage au bois s'est transformée. Plus jolis et plus performants que leurs prédécesseurs, les nouveaux appareils incitent les gens à recourir au bois pour chauffer les aires habitables tout en admirant le feu qui brûle. Utilisé de cette façon, le bois offre de bonnes perspectives pour le remplacement des combustibles fossiles et la réduction des émissions de gaz à effet de serre. Dans la plupart des régions éloignées des grands centres urbains, le chauffage au bois acheté au prix du marché est plus économique que l'usage de sources d'énergie comme le pétrole, le propane, l'électricité ou les granules de bois, mais moins que le gaz naturel ou la thermopompe puisant l'énergie dans le sol (selon les tarifs d'électricité en vigueur). L'Agence de protection de l'environnement (EPA) des États-Unis réglemente depuis 1988 les émissions de poêles et de foyers encastrables au bois. Ainsi, elle autorise uniquement la fabrication et la vente d'appareils vérifiés et homologués qui respectent les seuils d'émissions

particulaires (fumée) fixés. Les poêles à bois testés et homologués par l'EPA émettent en moyenne environ cinq grammes de particules par heure de fonctionnement durant les essais en milieu résidentiel. Ces émissions sont de cinq à 10 fois moins élevées que celles produites par les poêles à bois classiques.
Le gouvernement du Canada ne dispose d'aucun règlement ni d'aucune ligne directrice sur le chauffage au bois. Afin d'apaiser les inquiétudes liées à la qualité de l'air, la province de la Colombie-Britannique a adopté en 1994 un règlement qui fonctionne à tous égards importants de façon identique aux normes de l'EPA. La C.-B. fait d'ailleurs mention de la réglementation de l'EPA et de la norme B415.1 établie par l'Association canadienne de normalisation et harmonisée avec les exigences de l'EPA. Aucune autre province n'impose actuellement de seuils d'émissions pour les poêles à bois, même si plusieurs entendent le faire.

Par ailleurs, la qualité du combustible et les méthodes d'utilisation influent considérablement sur les émissions des appareils de chauffage au bois. La mise en place de programmes d'information créatifs pourrait permettre de promouvoir les techniques de chauffage au bois responsables et d'aider les utilisateurs à les appliquer efficacement.

Les poêles à bois perfectionnés qui sont conformes aux exigences de l'EPA et de la C.-B. affichent un meilleur rendement que les appareils classiques, ce qui se traduit par des économies annuelles de 150 $ à 350 $ en bois de chauffage acheté au prix du marché. Ces économies substantielles rendent attrayant l'investissement dans une technologie de pointe. Elles sont d'ailleurs reconnues par les spécialistes de l'industrie comme une des principales raisons qui incitent les occupants à acquérir un nouveau modèle.

Les mesures de réglementation des États-Unis et de la Colombie-Britannique ont une grande incidence sur le marché canadien. Selon des estimations, de tous les poêles à bois vendus actuellement, un peu plus de la moitié sont des modèles à faible taux d'émission homologués. L'industrie, représentée par la Hearth Products Association of Canada (HPAC), favorise la mise en application d'un règlement national semblable à celui que la C.-B. a adopté en 1994. Selon des consultations menées récemment par la HPAC, il y a raison de croire que la plupart des ministres provinciaux de l'Environnement seraient en faveur d'un projet de règlement fédéral sur les appareils de chauffage au bois. L'expérience de la C.-B. montre que les coûts afférents à l'administration et à l'exécution d'un tel règlement seraient peu élevés.

En dépit du rendement et des avantages environnementaux des nouvelles technologies de chauffage au bois, les anciennes technologies sont encore beaucoup plus répandues dans les foyers canadiens. Parmi les obstacles à l'achat d'appareils de pointe, il y a notamment l'absence de réglementation sur les émissions, le coût élevé des nouveaux modèles, la résistance au

changement du consommateur et le manque d'information. Il serait possible de minimaliser ces obstacles en mettant en place un règlement pancanadien relatif aux émissions, doublé d'un programme d'information et d'incitation efficace visant à encourager les utilisateurs à moderniser leurs appareils de chauffage au bois.

Il est aussi possible de réduire sensiblement les émissions produites par la combustion du bois, mais non sans les efforts concertés de divers intervenants. Le gouvernement fédéral doit jouer un rôle essentiel dans l'élaboration d'une réglementation pancanadienne sur les émissions ainsi que dans la création et la promotion de partenariats visant à sensibiliser le public à l'utilisation écologique du bois de chauffage. Ces partenariats pourraient notamment être conclus avec des fabricants de foyers, des ministères ou organismes de tous les paliers de gouvernement, des institutions financières, l'industrie de l'assurance et des organismes de santé publique. Tous les partenaires confirmés pourraient adhérer et apporter leur soutien à des programmes centrés sur le remplacement des poêles, la démonstration de procédés de combustion propre et l'information du public.

Par ailleurs, l'étude révèle un manque de renseignements adéquats sur les habitudes de consommation du bois de chauffage dans les foyers canadiens. Il faut obtenir de l'information plus précise sur l'attitude des gens, les types d'appareils employés et les méthodes d'utilisation pour guider la conception de produits d'éducation du public qui sont efficaces. Il faut également étudier les caractéristiques de rendement des divers types d'appareils. Les données recueillies permettront ensuite de prévoir les incidences environnementales et de mesurer les progrès en matière de réduction des répercussions défavorables.

1. Introduction

Wood ranks as the fourth most popular home heating fuel in Canada, after gas, electricity and oil. About one in five single family dwellings is heated to some extent with wood. Householders who heat with wood attract little attention from the media or from government, and the companies that supply equipment and fuel are small, widely disbursed and low-profile. As a result, the significant contribution of wood to the residential energy supply mix can be surprising, even to those with some involvement in housing and energy issues.

Wood heating does tend to attract media and government attention when wood smoke causes noticeable impacts on local air quality or when nuisance smoke emissions cause friction between neighbors. The periodic complaints about smoke pollution from wood burning create the image of wood as a sort of delinquent heating fuel, the use of which, some say, should be minimized for environmental reasons. Wood may also be viewed as an old-fashioned, rather crude way to heat houses, and therefore expendable because other heating options are readily available and have no discernible environmental impacts at the point of use. And, in light of publicity campaigns that promote urban tree planting and rural reforestation programs, and that condemn clear-cut logging, the image of people cutting down trees and burning them, even for heat, is no longer a positive one. The identification of wood heating as a problem to be solved, rather than as one of the four key residential energy options, could create a policy dilemma for governments and therefore raises the question: Are there strategic benefits from the continued use of wood as a heating fuel?

Wood is defined as a renewable energy source, along with wind, solar, hydroelectric and geothermal energy. As one of the few renewable energy sources—each of which has regional and/or site-related limitations—wood can at least be seen as a potentially strategic fuel. Canada's reliance on fossil fuels such as oil, gas and coal makes it among the world's highest per capita emitters of carbon dioxide, the principal greenhouse gas. Both energy and forestry scientists agree that, provided harvesting is conducted in a sustainable manner, the combustion of wood for energy uses contributes no net carbon dioxide to the atmosphere when the normal forest regeneration period is considered.

The 1992 United Nations Conference on Environment and Development (UNCED) in Rio was the site of an historic international agreement to stabilize greenhouse gas emissions at 1990 levels by the year 2000. One of the UNCED documents states:

> The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption, and on growing reliance on environmentally sound energy systems, particularly new and renewable sources of energy.[1]

Wood energy could serve as one of the strategic options in the effort to reduce greenhouse gas emissions from fossil fuel combustion. The Canadian government and the public have used wood energy strategically in the past. In the late 1970s, when oil prices rose rapidly and there were widespread concerns about the security of energy supply, hundreds of thousands of Canadian households fell back on wood as a reliable energy source that sheltered them from the uncertainties of the conventional energy market. They were assisted in doing so through the Canada Oil Substitution Program, a component of the National Energy Program. If, in the face of mounting evidence of global warming/climate change and the continued rise in greenhouse gas emissions, government is forced to employ the tax system to create disincentives for the consumption of fossil fuels, the public would undoubtedly turn again to wood as a secure and price-stable energy source. But exchanging greenhouse gas emissions for poor air quality due to more wood smoke emissions would not be a desirable outcome. This raises the question: Under what conditions can wood be used as an environmentally appropriate fuel?

Wood should be viewed as a conditionally renewable energy source in the sense that wood fuel acquired using unsustainable forestry practices is not truly renewable. Sustainable energy production from trees was addressed in a 1993 paper titled, "Residential Wood Heating: the Forest, the Atmosphere and the Public Consciousness", in which criteria for the consideration of wood as an environmentally appropriate fuel were offered:

> An increase in the use of wood as a fuel for residential heating can occur within the framework prescribed by current principles of environmental sustainability. This framework could be generally described by the following points:
>
> - The integrity of the forest, including the trees, the soil and the site, is maintained.
> - Species diversity within the managed forest is maintained or enhanced.
> - The requirement for the use of non-renewable fossil fuels is reduced, resulting in reduced concentration of greenhouse gases in the atmosphere.
> - Air shed pollutants are minimized and those that are released do not produce health impacts on the population.[2]

The first two points in the list above are important and deserve attention, but they are not addressed in this report. The third point, that greenhouse gas emissions be reduced by fossil fuel displacement, suggests that wood should be converted to usable energy at the highest practical efficiency. That, and the fourth point recommending that air pollution be minimized are key aspects of this report and are discussed in the context of the conversion technologies (stoves, etc.), their

performance characteristics and the householders who use them to heat their homes.

This report gives an overview of how wood fuel is used in Canadian homes. Special attention is given to initiatives designed to reduce the environmental impacts and increase the effectiveness of wood burning for home heating. Its function is to provide background information to assist in the analysis of environmental policy options.

Wood Heating Appliance Categories

WOOD STOVE or Space Heater or "Airtight"	A free-standing appliance designed to heat the space in which it is installed and adjacent spaces. Wood stoves, also called woodburning space heaters and colloquially as airtights, are by far the most common wood heating device in Canada, used by almost 90 percent of households that use wood for heating. Advanced low emission, high efficiency wood stoves are readily available on the Canadian market.
FIREPLACE INSERT	An insert is essentially a wood stove that is adapted by the manufacturer for installation within or partly within the hearth area of a masonry or factory-built fireplace. A properly installed insert of good design can deliver heating performance on par with a wood stove
ADVANCED FACTORY-BUILT FIREPLACES	Unlike conventional metal or brick fireplaces that deliver very low heating efficiency, advanced fireplaces perform at about the same efficiency and smoke emissions levels as advanced wood stoves, so they can be used for serious home heating.
PELLET STOVE	Pellet stoves burn a manufactured fuel made of dried, compressed wood "flour", processed from sawdust. An electric motor driven auger moves the fuel from an integral hopper to a small combustion chamber. Pellet stoves operate with low particulate emission levels.
MASONRY HEATER	Evolved from a European tradition, more masonry heaters have been built in Canada in recent years. Although they have specialized operating characteristics, masonry heaters have been shown to produce very low particulate emissions and deliver good performance for serious heating.
CENTRAL HEATING SYSTEMS	Wood-fired central heating systems are available in several forms: add-on furnaces for connection to existing oil or electric furnaces; combination furnaces that burn oil or electricity in addition to wood; and boilers that heat water and use a system of pipes to distribute the heat. Central heating with wood is not as common today as it was 20 years ago.
WOOD COOKING RANGE	A specialized appliance that uses wood fuel to heat a cook-top surface, a bake oven and sometimes, a reservoir for domestic hot water. Cooking ranges are not common in Canada, although a few models are still available for sale in specialty stores.
OUTDOOR BOILER	Gaining popularity recently, particularly in rural Manitoba and Ontario, outdoor boilers are contained in a small shed and use insulated underground piping to deliver heat to the house. They are controversial because they tend to emit high levels of airborne particulate matter.

2. Industry and Market Profile

2.1 Heating Appliances and Decorative Fireplaces

The range in efficiency is wide

Wood can be burned solely for the pleasure of viewing the fire in a fireplace that, with a net efficiency of around zero, is strictly decorative by design. At the other end of the spectrum, wood can be burned in a device boasting a seasonal efficiency of 75 percent and which is easily capable of heating an entire house. The range in heating performance of the wood burning appliances currently in use is extremely wide, so distinguishing between various types according to heating capability and usage patterns is a key part of estimating the use of firewood for either aesthetic or heating purposes and projecting the environmental impacts of this use. A failure to account for these variations would introduce significant distortions in any estimate.

Decorative does not equal inefficient

The task of differentiating decorative from heating appliances is not as simple as labeling all fireplaces as decorative and considering the rest — wood stoves, furnaces, boilers, cooking ranges, and so on — as heating appliances. Such a simple analysis is contradicted by the fact that the most efficient and effective wood heating devices available today are highly decorative fireplaces and wood stoves that look entirely appropriate installed in a well-appointed living room.

Air Control and Heat Exchange Define a Heater

The presence of two physical characteristics tends to separate decorative appliances from heating devices. First, wood heaters have a means to control the flow of combustion air to the fire permitting the user to regulate the rate of burn; and second, they have a means of transferring heat from the exhaust gases to the room. Decorative appliances have neither characteristic. One exception to these criteria is a masonry heater, which does not control combustion air flow, but compensates with a massive heat exchanger that captures the fire's heat for slow release over several hours.

2.2 Woodburning Appliance Manufacturing in Canada

Location of Manufacturers

Statistics Canada tracks wood burning appliance production in its quarterly report, Shipments of Solid Fuel Burning Heating Products (Catalogue 25-002)$_3$. The publication includes a listing of reporting manufacturers. The list for the last quarter 1996 edition shows the following distribution of manufacturers by province:

Nova Scotia	5
New Brunswick	2
Quebec	8
Ontario	16
Manitoba	2
Alberta	1
British Columbia	7
Total	41

See Appendix A for the names and cities of these appliance manufacturers.

Production peaked in the 1980s

The wood burning appliance manufacturing sector grew quickly in the late 1970s and early 1980s in response to strong market demand. Wood stove production peaked in 1984 at 79,000 units and fireplace production peaked in 1987 at 61,000 units, according to the Statistics Canada report on shipments of these products.

A ten year decline

The number of wood burning appliance manufacturers in Canada has been falling gradually since the "boom years" of the mid-1980s. Since then there has been a steady decline in production, most notably of decorative factory-built fireplaces which have been largely replaced in the marketplace by gas fireplaces. In 1996, about 40,000 wood stoves and only about 8,400 factory-built fireplaces were produced, according to Statistics Canada (Figure 1). Fireplace insert sales have gradually declined from a high of 17,000 units to 5,700 in the decade between 1986 and 1996. The production of wood burning central heating appliances like furnaces and boilers has dropped from a high of about 22,000 in 1982 to the 1996 figure of 4,000.

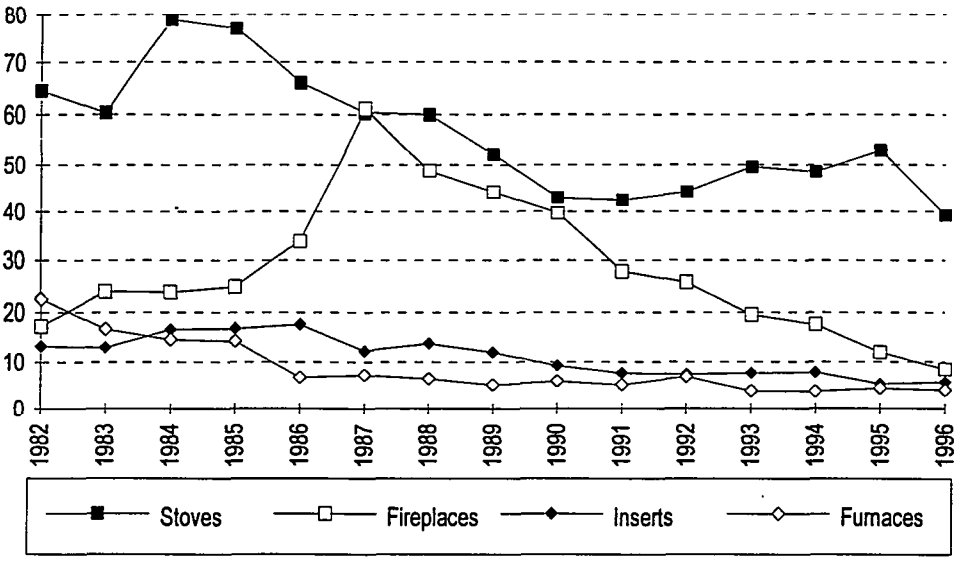
Pellet stove production in 1996

The Statistics Canada quarterly report was updated in 1996 to include the production of pellet burning stoves; it reported that 1,749 pellet stoves were

shipped from Canadian manufacturers plants last year. This figure is included in the total of wood stoves produced in the accompanying graph.

Figure 1. Shipments of Woodburning Appliances from Canadian Manufacturers

1982 - 1996, in thousands of units



Source: Statistics Canada quarterly report, Shipments of Solid Fuel Burning Heating Products (Catalogue 25-002), 1982 through 1996

Exports

According to the Statistics Canada report on appliance shipments, the value of exports of all categories of wood burning appliances in 1996 was $11.7 million on a total production value of $38.7 million, or 30 percent of the output from Canadian manufacturers. The percentage that exports represent of total production appears to be rising; in 1992 exports were 17 percent of the total, in 1993 they represented 21.8 percent, and in 1994 they rose to 24 percent. The dramatic drop in total production in 1996 to 58,000 from 76,000 the year before accounts for the abrupt increase in the percentage of exports; in fact, the value of exports has held steady since 1994.

This significant drop in production of wood burning appliances in 1996 was not reflected in the interviews conducted for this study with wood stove retailers and distributors, most of whom claimed sales in the 1996 year were either stable or up from previous years. It is possible that the drop in shipments for 1996 reflects the selling through of unsold inventory from the previous year, a year in which sales were lower than in 1996, according to some commentators.

Imports

It is apparent that Canada has a balance of trade surplus with the United States in wood heating appliances. Imports represent a relatively small part of the overall market, with U.S. and European products filling niche markets. For example, cast iron stoves of advanced design are probably the most significant product category to be imported and they are widely available in stores across Canada. Imports dominate this product category because there is no Canadian manufacturer of advanced cast iron stoves. There is no reliable source of statistics on the number of imported wood heating appliances, but industry observers interviewed for this project estimate the volume to be in the 5,000 to 15,000 range. Several lines of pellet stoves are also imported from the United States, but the entire pellet stove market is small, estimated to be in the 3,000 to 5,000 range each year.

2.3 Profile of Wood Energy Use in Canada

Statistical sources

The primary source of statistical information on wood heating is the annual Statistics Canada report on Household Facilities and Equipment (Catalogue no. 64-202)[4]. Each year the report provides statistics on the principal fuels and equipment used to heat Canadian homes. One year in five the report expands to include figures for fuel and equipment used for supplementary heating. Fortunately, the report for 1996 presents figures for supplementary heating, and this makes the wood usage profile in this report more useful and current because much of the wood burned in Canada is used to supplement heating provided by other fuels.

Natural Resources Canada (NRCan) conducted a comprehensive survey of energy use patterns in Canadian houses. Its report, titled *1993 Survey of Household Energy Use*[5], provides more details on usage patterns than the standard Statistics Canada annual reports.

Some provincial governments have conducted various types of surveys which may be useful for specific purposes, but the Statistics Canada and NRCan surveys are the most useful because they provide a national overview, and in the case of the annual Statistics Canada survey, provincial figures.

Table 1. shows comparative figures for 1991 and 1996 on the number of households using wood for heating by province, the percentage of single family dwellings heated with wood and the percent change between 1991 and 1996. The usage percentages are compared with the total of single family dwellings (not all dwellings) because 99.7 percent of home heating with wood occurs in houses rather than apartments. The popularity of wood as a home heating fuel varies widely across the regions of Canada.

Table 1. Distribution of Residential Wood Heating in Canada

Comparative figures for 1991 and 1996

	Total Single Family Dwellings		Wood as Principal Fuel # in 000s		% of total		As Supplementary Fuel # in 000s		% of total		% of houses using wood		%
	1991	1996	1991	1996	1991	1996	1991	1996	1991	1996	1991	1996	Change
CA	6701	7872	426	398	6%	5%	956	941	14%	12%	21%	17%	-4%
NF	154	172	41	34	27%	20%	27	23	18%	13%	44%	33%	-11%
PEI	37	44	7	5	19%	11%	11	12	30%	27%	49%	39%	-10%
NS	255	283	40	35	16%	12%	55	56	22%	20%	37%	32%	-5%
NB	206	234	40	42	19%	18%	52	47	25%	20%	45%	38%	-7%
QC	1365	1593	113	140	8%	9%	411	393	30%	25%	38%	34%	-4%
ON	2488	2999	93	81	4%	3%	200	221	8%	7%	12%	10%	-2%
MB	298	335	14	14	5%	4%	24	23	8%	7%	13%	11%	-2%
SK	297	316	10	6	3%	2%	16	15	5%	5%	9%	7%	-2%
AB	710	844	6	-	1%	-	41	28	6%	3%	7%	-	-
BC	892	1053	61	37	7%	4%	119	123	13%	12%	20%	15%	-5%

Source: Statistics Canada Report, Household Facilities and Equipment, Catalogue 64-202, 1991 & 1996

NRCan finds more users than StatsCan

The 1993 NRCan survey produced considerably higher figures than either the 1991 or 1996 Statistics Canada surveys, particularly on the use of wood as the principal heating source. The NRCan survey found 80 percent more households that use wood as a primary heat source than the Statistics Canada figures for 1991, and 97 percent more than the annual survey reported in 1996. The cause of these large differences has not been determined, but the NRCan survey is to be repeated using data to be collected in late 1997. The results may serve to confirm or modify the relative differences between the two surveys. Table 2. below shows a comparison of summary figures from the 1991 and 1996 Household Facilities and Equipment surveys, and the 1993 NRCan survey.

Table 2. Comparative Figures from Three Surveys on Home Heating with Wood

	StatsCan 1991	NRCan 1993	StatsCan 1996
Primary	426	767	389
Supplementary	956	1005	941
Total	1382	1772	1330
% of s.f. dwellings	20	25	17

Source: Statistics Canada Report, Household Facilities and Equipment, Catalogue 64-202, 1991 & 1996; Natural Resources Canada 1993 Survey of Household Energy Use

2.4 Why is Wood Heating in Decline?

A 4% decline in use since 1991

There has been a general decline in the use of wood for both primary and supplementary heating since 1991. Whereas 21 percent of those living in single family dwellings reported the use of wood as the principal or a supplementary heat source in 1991, five years later only 17 percent reported using wood. There was a larger reduction in the use of wood as the principal heating fuel than as a supplementary fuel.

Wood heat retailers report falling sales

Sales of all categories of wood burning equipment declined during 1996, according to a survey of Canadian hearth retailers reported in the March 1997 edition of Hearth and Home Magazine[6]. Although the decline in wood stove sales, which is the largest category, was less than one percent, factory-built fireplace sales dropped 9 percent, cook stove sales fell 7 percent and pellet stove sales were also off 7 percent from the year before. The statistical findings of the Hearth and Home survey may not be fully representative because it is based on a small sample of specialty retailers only.

Speculation on the causes of decline

Although there are no survey results explaining why Canadians are moving away from wood as a heating fuel, most of the hearth professionals interviewed for this study cited three main reasons: more acceptable alternative hearth options, the availability of low cost conventional fuels — mainly piped gas — and an increasingly negative public attitude regarding the environmental implications of heating with wood.

Although gas fireplaces have been available for many years, it has only been in since the late 1980s that the designers of these appliances have succeeded in producing a simulated wood fire that is an aesthetically acceptable alternative to a real wood burning fireplace. Using ceramic or pressed fibre artificial logs, simulated charcoal beds that glow red, and sophisticated burners that produce a realistic yellow flame, gas fireplace makers have achieved a gas fire that is surprisingly similar to a wood fire. The energy efficiency of these gas fireplaces has also improved with the introduction of direct-vent, sealed combustion technology, which also makes installation simple because these units are side-wall vented, needing no chimney. The technical and aesthetic advances in gas technology combine to make a gas fireplace an attractive option, particularly for householders living in urban or suburban areas.

Gas distributors, which are large and well-financed companies, have embraced the gas fireplace as a good way to increase load and monthly billings as well as

appliance sales at their company stores. The marketing of these fireplaces is aggressive, with flyers regularly reaching every household served by the distribution network and offering discounts and attractive payment terms that represent relatively modest increases in the monthly gas bill. These utilities invariably market gas fireplaces against wood burning units by emphasizing the cleanliness, safety and automatic convenience of gas fireplaces. In contrast, the marketing of wood burning appliances is done mostly by small, specialty retail stores that lack the corporate marketing strength of the gas utilities.

During the 1990s the piped gas network has been expanded into areas where wood burning had been popular. Two of many such examples are the Highway 17 corridor in the Ottawa Valley and Victoria Island in B.C. In both cases the novelty of gas fireplaces and the low cost of the fuel has driven strong sales of gas hearths to replace wood burning units.

Provincial lung associations across Canada have established publicity programs that tend to discourage Canadians from heating with wood because of the perceived threat of indoor smoke pollution that can inhibit lung function in small children and can worsen lung problems in older adults. The combined result of aggressive anti-wood marketing by gas distributors and hearth dealers, and cautionary messages from health organizations has been to challenge previously positive public attitudes towards wood burning.

2.4 Regional Variations and Patterns

Newfoundland and Prince Edward Island

Since low cost piped gas is not available in the Atlantic provinces, there must be other explanations for the most dramatic percentage reduction in wood use that have occurred there, particularly in Newfoundland and PEI. A retailer who sells mostly propane fireplaces in St. John's gave several reasons for the 11 percent drop in wood use since 1991. He said that wood stoves are messy, unsafe, require too much work and the provincial government has enforced restrictions on firewood cutting on the Avalon Peninsula, which has pushed up the cost of firewood. It is no surprise, therefore, that people shopping for a hearth in St. John's may not receive a positive sales presentation about wood heating.

Despite the reduction in usage in the past five years, Newfoundland still has among the highest provincial concentration with 20 percent reporting wood as their primary heating source and a further 13 percent using wood to supplement other fuels. This total of 33 percent of houses is a dramatic drop from the 44 percent reported in 1991. There was also a significant decline in reported usage on Prince Edward Island, from 49 to 39 percent of houses.

Nova Scotia and New Brunswick

Householders in both Nova Scotia and New Brunswick have been consistent users of wood fuel for heating. The decline in reported usage is more moderate in these two provinces at only 5 percent and 7 percent respectively. Dealers in the Atlantic provinces report the increasing popularity of propane gas fireplaces for their convenience and cleanliness, despite the high cost of the fuel.

Quebec

Quebec has a high frequency of wood burning and, in contrast to the general decline in wood use, there was a significant increase in the number of households reporting wood as the principal heating fuel: from 113,000 households in 1991 to 140,000 in 1996. A reduction in supplementary heating with wood and the increase in the number of households in the province combined to produce an overall reduction in wood usage of 4 percent.

Ontario

Only three percent of those living in Ontario houses report wood as their principal heating fuel and only 7 percent use wood as a supplementary fuel. This is the third lowest provincial frequency of wood fuel usage after Saskatchewan and Alberta. From 1991 to 1996, the number of people using wood as their principal heating fuel fell by 12,000, while there was a 21,000 household increase in the use of wood for supplementary heating.

Prairies

Heating with wood is not popular in the prairies, yet this is the region with the least drop in usage during the five year period under review. The stable usage may indicate that only a core group of householders remain; those whose location and/or income level make wood heating the most practical option.

BC

Between 1991 and 1996 there was a massive reduction from 61,000 to 37,000 in the number of people using wood as their primary heating fuel, possibly a result of negative publicity about wood heating and air pollution. During this five year period, British Columbia established a mandatory emission regulation for woodburning appliances and this action might have sent a signal to the public that wood heating is not desirable. There was a small increase in those using wood as a supplementary fuel since 1991, possibly reflecting a shift in usage within individual households. Wood burning in the lower mainland around Vancouver has declined substantially, but it remains fairly popular in the interior and the northern part of the province. A distributor of wood stoves in B.C. noted that periodically the media picks up wood smoke stories from Washington state where wood smoke emissions regulations are among the most aggressive in the

U.S. Rumours that wood burning will soon be banned circulate on a regular basis, and although no basis in fact exists, the result is to suppress wood stove sales.

The Territories

No usage statistics are available for the northern territories, although it is known that wood remains an important fuel in areas where trees are abundant. A retailer in Whitehorse, Yukon reported that wood burning appliance sales have been flat recently while sales of high efficiency oil-fired heaters has increased.

2.5 Other Characteristics of the Market and the Users

Wood stoves are most common

About 60 percent of principal wood heating appliances are wood stoves, 33 percent are forced air furnaces and 2 percent are boilers. Almost all (98.5 %) householders who use wood as a supplementary fuel do so with a space heating stove. This category would probably include some fireplace inserts, which are essentially wood stoves adapted to fit into masonry fireplaces. Wood is used as a cooking fuel by 51,000 households according to NRCan and by 30,000 according to StatsCan.

Fireplaces

The NRCan Household Energy Use Survey found that 31.2 percent of those living in houses, or 2.2 million households, reported having a woodburning fireplace. While that figure is undoubtedly falling due to gas conversion, when added to those who heat with wood, it reveals that an impressive number of Canadians have owned and operated wood burning devices.

Wood systems are newer than other options

Wood burning appliances used for primary heating tend to be newer than other heating appliances: according to NRCan 1993, 70% of wood appliances for primary use are less than 10 years old; StatsCan finds that 58 percent are less than 10 years old. In contrast, more than 60 percent of all other principal heating systems are more than 10 years old. Wood stoves used for supplementary heating are also relatively new: 62 percent are 10 years old or less. This finding implies that people change their wood stoves with some frequency, although there are no data to suggest why. Part of the reason could be that during the last 10 years in particular there have been significant improvements in aesthetic appeal and performance of wood stoves and, since many of these stoves are in living spaces rather than basements, this may have prompted homeowners to trade up from the "black box" wood stove they bought in the late 1970s or early

1980s. If this analysis were proved correct, it might also suggests that if people knew more about the new technology wood stoves, they might upgrade, not just to reduce smoke emissions, but to take advantage of all the other improvements in the technology, like clear door glass, higher efficiency and more attractive designs.

Wood users like to stay warm

People who heat with wood keep their houses almost one degree warmer during the day than all others: the average daytime temperature for a wood heated house is 21.3°C and the average evening temperature is 21.6°C. The average temperature over night is about the same as for other energy sources at 19.1°C. Source: NRCan 1993.

Supplementary wood use is serious use

Wood heat specialists over the years have speculated about what householders really mean when they indicate the use of wood as a supplementary fuel in the home. Theoretically, supplementary use could mean very occasional use, perhaps only once or twice a month or supplying only 5 to 10 percent of total heating requirements. It has been reported that the term supplementary can be misleading because of the influence of home insurance companies. Many insurers impose a significant surcharge on policy holders claiming wood as a primary heating source. Families that use a wood stove to provide a large majority of heating needs, but have a central heating system for back up heating, may claim the wood stove is only used as a supplementary source to avoid paying higher home insurance premiums. Others may think of their extensive, complex and automatic oil, gas or electric furnace the primary system even though they use a wood stove to supply the majority of home heating.

The NRCan study sheds light on this issue and offers some surprises. It reveals that Canadians who report the use of wood as a supplementary fuel use it to provide a large part of their total heating needs. For example, 60 percent report using their stove more than four hours per day in winter, and a further 15 percent use theirs between one and four hours each day. With 75 percent using their stove every day, this is much more than casual supplementary use. Wood consumption figures confirm this finding. Fully 40 percent of supplementary users report consuming four or more cords per year, a high figure considering that four cords can be enough fuel to heat a small house for an entire winter. A further 29 percent of supplementary users consume between one and three cords of wood per winter. About half report heating the entire house with their wood stove, while a further 35 percent heat only the basement. Electricity is the main energy source being supplemented in Canadian homes (53%) followed by oil (22%).

Not a lot of fuel switching going on

Given the general decline in the use of wood for heating in all regions of Canada, it follows that relatively few people are switching to wood from other fuels. Fuel switching is usually motivated by price variations and, except for an increase in propane prices in the 1996/97 winter, most energy prices have held steady for several years. In fact, specialty retailers suggest that one of the more significant shifts in hearth usage in the past few years is from wood to gas as homeowners remove wood stoves and fireplace inserts and replace them with appliances that burn piped gas or propane.

Upgrading

The purchase of a new wood burning appliance is more likely to be motivated by the need or desire to upgrade an existing unit or to include a wood heater in a new house or renovated space. The retailers interviewed for this study confirmed that fuel switching is not usually a primary reason to purchase, but that upgrading from existing units is a significant component of the market, as are changing houses, building new houses and renovating existing houses.

Aesthetics are important

The motivations behind the purchase of a new wood burning appliance can be more complicated than for other energy sources. For conventional heating equipment like oil and gas furnaces or electric baseboard heaters, the initial equipment cost and the cost of the fuel are the primary factors influencing the purchase. But for wood burning equipment other influences can come into play. Since the majority of wood burning appliances are space heaters located in living areas rather than central furnaces hidden in utility rooms, the look of the appliance is an important consideration at the time of purchase. The development in the mid-1980s of effective "air wash" systems for the glass panels in firebox doors had an important impact on the use and performance of wood burning space heaters. With clear glass for unobstructed fire viewing, the wood heater was no longer a plain box, but became an attractive and desirable part of the living or family room decor.

3. Technology Profile and Regulatory Environment

3.1 Background to Emissions Regulations

Wood stove renaissance 1975 - 1990

The steep rise in oil prices during the 1970s and early 1980s triggered a rebirth of wood as a home heating fuel after decades of decline. Hundreds of wood stove manufacturers sprang up all over North America to meet the public's seemingly insatiable demand for these simple, low-cost appliances, most of which were of welded steel construction. The stove manufacturers of the time boasted of the high efficiency of their products, but this was mostly based on the fact that gasketed loading doors allowed control of combustion air flow and made longer burn cycles possible. The term "airtight", as these stoves were called, was equated with efficiency. Some manufacturers did experiment with baffles, various gas flow patterns and the use of firebrick linings, features designed to improve combustion efficiency.

U.S. emissions regulatory strategies

The full negative effects of residential wood burning became evident when hundreds of households located in mountain valley towns of the Pacific Northwest of the U.S. operated inefficient, smoky stoves during winter days characterized by cold, stable air masses. The combination of mountainous topography, a stagnant air shed, and a high local concentration of inefficient wood burning produced intolerable densities of smoke in several communities. State regulators, and in particular the Oregon Department of Environmental Quality began to research the problem under intense pressure to take action.

Since investigating, charging and prosecuting individual householders for air pollution violations would have been costly — and controversial because of individual rights issues — other strategies to reduce emissions had to be found. Some preliminary research had shown that significant improvements in wood burning technology were possible, so it was decided by the Oregon DEQ to develop a regulation that would mandate the best available pollution control technology. This would be done by requiring all stoves sold in the State to have been laboratory tested and certified as producing smoke emissions during normal operation that were at or below the limits set by the legislation. Although consideration was given to regulating carbon monoxide and other pollutants, eventually it was decided to regulate only particulate emissions, regardless of type.

When Oregon regulators served notice that they would regulate wood smoke emissions, stove manufacturers embarked on concerted efforts to develop clean burning wood stoves. The development of a practical, repeatable test to form the basis of a stove certification program was difficult and controversial because of the complexities of batch-fed, solid fuel combustion and the compromises

inherent in any test and measurement method. Finally, a test was developed and adopted by the State of Oregon which enforced a stove certification program in 1986. With some modifications, the method was subsequently adopted by EPA and enforced nationally in two stages referred to as Phase I in 1988 and Phase II in 1990[7].

In addition to the stove regulation, the state and local authorities developed publicity and incentive programs to encourage householders to upgrade their wood heating equipment. Also, in mountain valley communities with serious wood smoke pollution problems, so-called "No-Burn" days would be announced when stagnant air caused by thermal inversions would trap smoke close to ground level. Under these local ordinances, householders with the new certified wood burning stoves would be permitted to continue using them throughout the no-burn period. This feature of the rules served as an additional incentive to upgrade to the new equipment. Communities such as Comox, B.C. have used similar municipal legislation to reduce wood heating emissions during episodes of poor air quality.

The standardized stove emission test

Briefly, the EPA test protocol calls for precisely-specified dimensional Douglas Fir cribs to be assembled and loaded on a live coal bed that is less than 15 percent of the weight of a full wood load; a 5 minute period is allowed to make adjustments according to the manufacturer's operating instructions, then the combustion air control is set to produce one of four prescribed firing rates: low, medium low, medium high and high. The lowest burn rate is very low; less than one dry kilogram per hour. This cyclical testing is repeated until there is a record of one valid run in each of the four required burn rates. Throughout the testing the exhaust gas is diluted with air according to a prescribed ratio and a sample of this stream is drawn through filters of known weight. The difference in filter weight is used to project total particulate emissions. The test results are expressed in terms of grams per hour of particulate emissions. This form of appliance emission rating permits projections of total air shed impacts to be made.

British Columbia regulation

In 1994 British Columbia adopted a regulation under its Waste Management Act which is functionally identical to the EPA requirements. The motivation for B.C.'s regulatory initiative were serious concerns about air quality in the lower mainland and evidence of air quality problems in some cities in the interior. Of all the regions in Canada, the mountainous topography of B.C. is the closest to that of the U.S. Pacific Northwest where wood heat-related pollution was first identified and regulated. More detail on the B.C. wood stove regulation is provided later in the report.

Wood stoves and inserts are regulated

The EPA regulation was designed to include all wood stoves and fireplace inserts because these were seen to be the main heating appliances and the main source of air pollution because their firing rate can be reduced to a smolder, which releases high concentrations of airborne particulates into the environment.

Through an exemption for appliances with a burn rate over 5.5 kg/h or a fuel/air ratio in excess of 35:1, decorative fireplaces are provided an exemption from the EPA rules. Central heating appliances like furnaces and boilers, as well as cooking ranges are exempt from the regulation on the grounds that they exist in small numbers and regulation would cause excessive hardship for users. As a result of this exemption, there has been virtually no improvement in the combustion technologies used in furnaces and cooking ranges. A few manufacturers have developed low emission/high efficiency fireplaces which they have voluntarily certified to EPA requirements to reach a specific market niche.

Two advanced technologies

Stove makers used one of two main strategies in meeting the new emissions requirements: catalytic technology or advanced, non-catalytic technology. In a catalyst-equipped stove, the exhaust gas is passed through a ceramic honeycomb element coated with platinum or palladium. Proximity to the catalyst has the effect of lowering the ignition temperature of some components of the smoke. Advanced technology stoves—or non-catalytic as they are called in the trade—use firebox insulation, comprehensive baffles and pre-heated combustion air supplied strategically around the firebox, typically through perforated pipes, ducts or chambers, to achieve low emissions. The expected reduction in catalyst performance over extended periods prompted regulators to impose a more stringent particulate emission limit for catalytic appliances: 4.1 g/h compared to 7.5 g/h for advanced stoves. These are the legislated limits for particulate emissions in both the United States and British Columbia.

Questionable durability

Field tests of the certified low emissions stoves built before 1990 revealed problems of premature degradation due to heat stressing of internal components. Some early catalytic stoves had damper and damper frame failures which allowed smoke to bypass the catalyst. There were also fears of premature catalyst degradation. Advanced technology stoves also showed premature degradation during field tests in the late 1980s, although the warping and erosion of baffles had less effect on emissions performance than the failures with catalytic appliances.

Improved durability

The durability of low emission stoves has improved considerably so that today, premature stove degradation is not viewed as a big problem. In most new stoves today, vulnerable parts can be replaced and manufacturers now use more heat-resistant materials such as ceramics and stainless steel. The performance and durability of catalytic stoves has also improved through better design and use of materials. The useful life of a wood stove catalytic element is estimated to be 9,000 to 12,000 hours, or three to five years of use, depending on heating demand, user skill and degree of maintenance provided.

Pellet stoves

Wood pellets are dried wood flour extruded into small glazed cylinders about 6 mm in diameter and random lengths up to about 30 mm. The heat and pressure of the extrusion process reforms the natural lignin in the wood to act as a binding agent; feedstock additives are not normally used by pellet manufacturers. A pellet stove consists of a fuel hopper having a capacity of about 20 kg with an auger at its base that either pushes or drops the pellets into a small perforated bowl through which combustion air flows. Combustion of a small amount of fuel is continuous as new fuel enters the combustion bowl and ash is blown or pushed out by the combustion process. Field testing has shown that properly operating pellet stoves produce low emission levels; usually under 2 g/h. Only a few pellet stoves have been EPA certified. Most manufacturers use the 35:1 air/fuel ratio exemption to avoid the process. The high air/fuel ratio would tend to limit thermal efficiency.

Appliance performance

Now, about fifteen years after the search for improved wood combustion technology began in a concerted way, the performance gains are impressive. To assist in the discussion and analysis of the various wood burning technologies, three simplified categories of appliance have been offered in Table 3. The table presents high, medium and low efficiency ranges, suggests the wood burning technologies that would fit within each range and provides the average particulate and carbon monoxide emissions for the technologies. Since there will always be exceptions to such general categories, the table is not intended to be definitive, but rather a helpful tool for classifying and analyzing the range of available equipment.

Table 3. Summary of Woodburning Appliance Categories and Performance

Efficiency Range	Appliance Category	Average Emissions
HIGH 60% to 80%	• EPA/B415 certified space heaters • EPA/B415 certified fireplace inserts • EPA/B415 certified fireplaces • Pellet stoves • Masonry heaters	• EPA/B415 catalytic: pm* 6.5 g/h**; CO*** 44.7 g/h • EPA/B415 non-cat: pm 5.1 g/h; CO 77.0 g/h • Pellet stoves: pm 1.1 g/h; CO 13.8 g/h • Masonry heaters: pm 3.0 g/h; CO 40 g/h
MEDIUM 30% to 60%	• Space heaters (airtights) • Wood furnaces and boilers • Cooking ranges • Fireplaces with gasketed doors and heat exchanger	• All conventional closed combustion stoves, various studies; pm low of 19.6 g/h; high of 41.4 g/h; CO 165 g/h
LOW DECORATIVE -10% to 30%	• Fireplaces with loose doors and/or no heat exchanger • Free-standing fireplaces • Open fireplaces	• Laboratory tests of open fireplaces: pm 44g/h; CO 267 g/h

Source: References 8 & 9

Notes: * particulate matter; ** grams per hour; *** carbon monoxide

Debating the baseline data

There has been a long-standing debate regarding the emission rate of conventional equipment since this forms the baseline for all subsequent emission reduction efforts. Since all tests of wood burning equipment are costly because of the need for specialized equipment, and since in-situ, real world tests are particularly costly, relatively few have been done. The figures given in Table 3. as the range of particulate emission rates for conventional, medium efficiency appliances (low of 19.6 g/h and a high of 41.4 g/h) and in particular the average of 25 g/h used by the EPA have been highly controversial and are still disputed by industry, which claims the average is closer to the high value of about 40 g/h. These emission figures were the average of continuous samples taken over a period of a week in wood heated houses. Unusually low emission figures can result if the weather during the test period is especially cold, because the resulting higher average fuel firing rate is associated with a cleaner burn and lower emission rate. Distortions in performance can also occur if the user of the system being tested is on "best behaviour" during the week of testing. Finally, the accepted emission rates include only conventional stoves, ignoring cooking ranges, furnaces, boilers and outdoor boilers, which there is reason to believe

may produce higher emissions than space heating stoves. No attempts have been made to test and profile the average emissions rate of a given appliance over the range of conditions experienced in a typical heating season.

The debate about the appropriate base performance figures for conventional equipment highlights a recurring theme in all discussions of wood burning appliance emissions: that very little field research has been done into emission levels, the characterization of emission constituents and the extent to which changes in various parameters affect performance. Little is known, except in general terms, about the affect of, for example, firing rate, fuel moisture content, fuel species, heating system design and so on. A good example of the weakness of data used for projections of wood burning emission impacts is reflected in the response by the U.S. Hearth Products Association (HPA) to EPA's 1996 Polycyclic Organic Matter (POM) Emission Inventory for Residential Wood Combustion (see Appendix E). In HPA's challenge it is noted that in the EPA draft report, the emission factor for all 25 million wood burning devices is based on a total of 14 test runs using only one conventional and one catalytic stove. Given that there is no sizable body of high quality data, any projections of residential wood burning air emission impacts tend to have low confidence levels.

3.2 The Effect of Regulation on the Products and the Market

Trends affecting performance

The rate of development of new wood heating equipment slowed considerably once the main manufacturers completed their lines of low-emission EPA certified products and the market demand for wood burning appliances slowed in the face of increased popularity of gas hearths. Despite these influences that tend to inhibit research investments, there have been some developments.

When the State of Oregon and subsequently the EPA enforced mandatory emission regulations, it was generally believed that non-catalytic advanced appliances could not meet the emission standard with firebox sizes exceeding about 2.5 cu. ft. This was seen as a serious limitation, particularly in the cold climates of most of Canada where the conventional fireboxes in wide use were well in excess of 3 cu. ft. in volume. It gave catalytic appliances an initial edge in the market because they could use large fireboxes and still meet the standard. However, since 1990, several models of advanced technology stoves with fireboxes in excess of 3 cu. ft. have achieved EPA certification. Manufacturers have employed subtle improvements in firebox and air supply design to achieve low emissions from larger fireboxes. This development has made the non-catalytic advanced units more competitive with catalytic models and more suitable in a wider range of applications, particularly whole house heating. Canadian manufacturers are well known for their skill in developing effective advanced non-catalytic technologies and perhaps as a result, non-cats dominate the Canadian market.

Driven by more stringent state emission requirements, most notably in Washington State, which has imposed a maximum particulate rate of 4.5 g/h, stove manufacturers have managed to re-certify updated models of advanced technology units in the 2 to 3 g/h range, far lower than the original performance in the 4 to 7 g/h range. Not only are fireboxes getting bigger, but emission rates are falling as appliance designers further refine the designs that first emerged in the mid-1980s.

Impact of emissions regulations

The regulation of particulate emissions from residential wood burning equipment in the U.S. was a watershed event for the industry. Those appliance manufacturers with sufficient human and financial resources turned those resources to the task of developing a new generation of wood stoves at a time when there was scant evidence that they could succeed in meeting the new emission limits. Those manufacturers without the needed resources to develop the new products left the industry in a rapid process of rationalization.

As the new products reached the market in the late 1980s, stove buyers could, for the first time, compare the various options based on reliable performance figures instead of the exaggerated and unsubstantiated claims that had previously characterized the marketing of wood stoves. With more accurate performance information to work with, stove dealers were better able to advise customers on the most appropriate appliance for their needs.

Evaluation

Evaluating the effectiveness of emission regulations in improving air quality through direct measurements would be a costly and complex process. The impact on local air sheds of replacing conventional wood heating equipment with certified low emission appliances has not been measured reliably. Although one such study was conducted in Crested Butte, Colorado, the finding of a 59 percent reduction in fine particulates had a low confidence level because some homeowners simply took out their wood stoves and did not replace them. Other factors such as temperature and wind conditions during the test period, and the difficulty of distinguishing between the various particulate emission sources also limit the accuracy of before and after studies.

Given the large performance differences between conventional and certified low emission appliances that have been demonstrated in laboratory testing and confirmed in real world in-situ testing, the most practical way to evaluate the benefit of an emission regulation would be to track the uptake of advanced technologies by the public through survey research methods, and project the airshed impacts based on average emission rates for the various appliance categories. No studies of this type for jurisdictions in the U.S. or British Columbia have been found in the literature.

Research being conducted by the Advanced Combustion Technologies laboratory at NRCan for Environment Canada will provide a better profile of the exhaust components of both conventional and certified low emission appliances. The results of this work will permit more accurate projections of organic compound emissions than have been possible to date. As well, survey research being done for Environment Canada will help to characterize the frequency at which advanced technologies exist in Canadian houses, again helping to refine projections of air emission impacts. Both of these research efforts, while they aim to reveal the key indicators of progress in emission reduction, should be considered the preliminary steps in a larger project to fully characterize appliance performance and usage patterns.

Cost versus performance

With the exception of B.C. residents, Canadians interested in buying a wood stove or fireplace insert can choose between a conventional model or one that is certified as clean burning by EPA. There are significant differences in both price and performance between the two. The retailers interviewed for this project reported that the price spread between conventional stoves and EPA certified stoves is between $200 and $500. In the low price range for a small stove that would heat a seasonal cottage or a large room, a conventional unit can cost as little as $400, whereas the lowest price EPA certified model would be around $600, although most would be $900 or more. For larger units capable of heating an entire small home, the conventional model would cost between $600 and $800 and an EPA certified unit would be $1100 and up.

With such a large price spread, one might expect that the low emission units would be hard to sell, but this is apparently not the case. There are two main reasons why EPA certified stoves account for between 85 and 100 percent of sales in specialty retail stores and over half of all sales in most market areas. First, almost all certified stoves include features that buyers want and don't usually find on conventional stoves. These desirable features include glass doors with air wash systems, ash drawers, integral shielding for close installation clearances, decorative plated trim pieces and attractive styling. Each one of these features adds to the selling price, but also adds to the perceived value of the product, making it more attractive. The second reason given for strong sales of low emission stoves is that they have been on the market for almost a decade and the general public is beginning to see their advantages. It is apparently not uncommon for a stove buyer to express the awareness that an EPA stove will ultimately save money because its higher efficiency translates into less wood purchased and burned. The idea of getting more heat for less wood with the new stoves is "on the street" according to dealers. Even though comparative efficiency figures are not consistently published by stove manufacturers, the better performance of a low emission model is immediately apparent to a new user. Retailers made a point of noting that, despite the fact that the stoves are regulated on the basis of particulate emissions, it is the higher efficiency and

lower fuel costs, rather than concerns over air quality, that influence the purchase decision.

The status of conventional equipment

Most of the conventional technology wood heating appliances on the market are models that have been in production for many years, and their designs have not changed substantially since their introduction. Virtually all conventional wood stoves are priced under $1,000. Some particularly inexpensive models degrade rapidly when used for serious heating near the limit of their heat output capability. It is clear that some householders buy and replace these units every few years, reasoning that they are so inexpensive that perhaps five years of use is acceptable.

Ever since the EPA regulated wood stove emissions in 1988, and in particular, when British Columbia established identical smoke limits in 1994, the expectation has existed in the Canadian hearth products industry that in the near future such regulations would be made mandatory across Canada. Interviews with key manufacturers of conventional appliances revealed that there are two distinct strategies to deal with the expected regulation of stove emissions. One strategy is to withdraw from the market when conventional products are no longer permitted; one manufacturer clearly indicated that he would do just that. The second, more common strategy is to shift production to advanced technology units which some manufacturers are already producing. Several manufacturers are already prepared to make this shift whenever an emissions regulation comes into effect in their main market area.

Outdoor boilers: a step backward on emissions?

One significant trend in the conventional technology category is the emergence and surprising popularity of outdoor boilers, particularly in rural Manitoba and Ontario. These units have the size, shape and appearance of a metal-clad garden shed of the type used to store lawn mowers and other equipment. The metal shell encloses an atmospheric boiler fired with wood. Insulated piping is run under ground to the house where the hot water is fed through a radiator in the supply plenum of an existing forced-air furnace or sent directly to hydronic radiators throughout the house, before being returned to the boiler for re-heating. These boilers are usually of simple internal design, although at least one manufacturer offers a catalyst as an optional upgrade. Purchasers are apparently motivated by the idea that the perceived mess of wood heating is kept out of living areas and the fact that the combustion unit is outdoors eliminates the worry of house fire. Outdoor boilers, however, are an expensive option, retailing for between $3,500 and $6,000, plus installation which can drive the total price towards $10,000 in some cases. The units have potential advantages, such as domestic hot water heating and the output to heat two or more small buildings when used as a sort of mini district-heating plant. However,

the units are commonly oversized for the actual load, with the result that their main mode of operation is an off-cycle smolder.

Outdoor boilers are a controversial product because during their on/off operational cycle they frequently emit a large volume of dense smoke. Complaints about smoke from outdoor boilers are widespread, prompting some municipalities in North Western and Eastern Ontario to create bylaws banning the products from their jurisdictions, and in one case, forcing the Ontario Ministry of Transport to issue a warning to an operator because visibility for drivers on an adjacent highway was inadequate for safe travel. While no reliable performance data was found for outdoor boilers, most commentators assume that their delivered efficiencies are low. The problem of contaminated soil has also been reported when a structural or piping failure led to the spillage of a large quantity of antifreeze into a residential yard in Manitoba.

In those areas where outdoor boilers are popular, they tend to be the source of most wood smoke-related complaints. This product category is not included in emission regulations established by the U.S. or B.C. No data has been found to quantify the use of outdoor boilers or their performance characteristics. However, since they have apparently gained a significant market share in some regions and since there is some evidence to suggest that they can produce significant smoke emission problems, further research is warranted. In particular, a study of emissions and efficiency performance would be helpful, as would a survey to determine how many of these units are in use.

Industry supports emission regulations

The hearth industry, including trade associations, manufacturers and retailers, strongly supports the enforcement of mandatory emission regulations for wood stoves. Although there is some altruism and good corporate citizenship involved in their support, most of the reasons have to do with good business practice. Here are some of the stated reasons why the industry supports emission regulations:

- Low emission stoves work better. They produce a more stable fire that is less likely to smolder and they provide a more consistent and reliable overnight burn than conventional models.
- People find EPA certified stoves more satisfying to use because of glass air wash systems and other features. Dealers know that the more satisfied their customers are with their stove, the more likely they will be to encourage their friends to buy.
- Smoke belching from chimneys gives wood heating a bad name. If all stoves were clean burning, dealers would be better able to promote wood as an environmentally responsible way to heat houses.

- Low emission stoves are safer because they produce less combustible deposits in chimneys; fewer chimney fires mean fewer insurance claims and a more positive public profile for wood heating.
- An emission regulation would level the playing field. Retailers report that a customer can leave a specialty retail store after hearing a sales presentation on the advantages of low emission appliances and visit a building supply store that sells uncertified stoves and hear exactly the opposite message, i.e. that EPA certification is a gimmick that makes no difference and that specialty stores just sell fancy, over-priced stoves. Some dealers claim there are also public safety implications to this market dynamic; that is, the specialty store tends to employ staff that have met the professional certification requirements of the Wood Energy Technical Training Program (WETT), and these people pass on safety messages during a sales presentation, whereas this is less likely to occur in a building supply or general merchandiser. An emission regulation would give specialty stores a fairer opportunity to make the sale and have the opportunity to pass on safety information.

3.3 The Positions of Provincial Governments

The most recent review of the policies of provincial governments regarding the adoption of emission regulations for wood burning appliances was in response to a September 24, 1996 letter from the Hearth Products Association of Canada (HPAC) to each provincial minister of energy and environment. The letter (see Appendix B) dealt with the adoption of efficiency requirements for gas-fired hearth products as well as the issue of wood burning emission regulations. The provincial ministers were informed that the industry, through HPAC "would welcome new Canada-wide regulations on wood burning appliances, the same as those currently in place in BC." The responses of the ministers was generally positive, with some ministers clearly voicing support for action on wood stove emissions and noting the importance of common standards across Canada. Other ministers expressed reservations about the enforcement costs of additional regulations, yet indicated support for appliance performance standards to be incorporated into safety test standards. There was a significant range in the apparent familiarity of the ministries with the issue of wood burning emissions; some have a high awareness level and others display little knowledge of the issue. Some relevant excerpts from the Ministers' responses are contained in Appendix C.

3.4 Implications of a Regulation

What enforcement costs?

The concerns expressed by some environment ministries regarding the administrative costs of regulating wood burning emissions would be significantly diminished by feedback from British Columbia on the experience with its 1994 regulation. The Air Resources Branch, the group within the environment Ministry

that took the lead in developing the regulation, has had virtually no administration and enforcement costs since the regulation came into effect on November 1,1994. Although the regulation (B.C. Reg. 302/94, see Appendix D) prescribes fines for non-compliance of up to $200,000, none have been levied so far and no significant instances of non-compliance have been reported. The Ministry attributes the lack of enforcement problems to the industry's general support for the regulation, combined with market-driven willingness of hearth industry companies to report instances of non-compliance that come to their attention. More exploration of the British Columbia experience may be warranted in order to address concerns over enforcement costs.

3.5 The B.C. Emissions Regulation: A Model for Canada?

The expected route through the energy efficiency act

The environmental impacts from the use of household equipment is most commonly regulated indirectly through measures intended to reduce energy consumption. The EnerGuide program created public awareness of appliance efficiency through highly visible labeling of the products' energy efficiency performance. Several provinces, notably B.C. and Ontario, as well as the federal government, have enacted energy efficiency acts which require minimum energy efficiency limits and test protocols to be incorporated in product certification standards. This approach is favoured because, after the consultations and negotiations result in amendments to testing and certification standards, there is no enforcement role required of the government departments that establish the act requiring standardization of minimum efficiencies. Energy efficiency becomes simply another requirement for product certification and acceptability in the market place.

Regulation of efficiency is not advised

The regulation of the environmental impacts of wood burning equipment is different. The EPA wood stove regulation was and is unusual because it is the first North American case in which a home appliance was regulated on the basis of its direct impact on the environment, rather than indirectly through minimum efficiency requirements. In the case of woodburning equipment it is not just appropriate, but necessary, to regulate particulate emissions rather than efficiency. This is because the energy efficiency of a wood burning appliance can be boosted simply by increasing heat transfer surface area and limiting combustion air flow to the fire, just as the manufacturers of "airtights" did in the 1970s. The technology required to minimize smoke emissions, particularly at the relatively low burn rates needed for home heating, is far more complex and difficult to perfect. EPA certified stoves do produce much lower particulate emissions at low burn rates than conventional equipment is capable of, and as a byproduct, total efficiency rises because of reduced chemical losses in the form of smoke. Although the EPA does not require average efficiency to be reported

on appliance certification labels, the Oregon Department of Environmental Quality did, and their list of certified wood burning appliances showed that none had an efficiency lower than 60 percent and that the average efficiency was about 70 percent. Therefore, there is no need to regulate wood burning appliance efficiency because acceptable efficiency is a byproduct of low emissions combustion. Also, forcing manufacturers to compete with each other by engineering their products to produce lower and lower flue gas temperatures (which is technically easy to do) is not advisable because the result would be operational problems such as combustion spillage and flue gas condensation in chimneys.

Canadian manufacturers are major exporters

In 1988 when the EPA established its regulation, its influence was felt immediately in Canada. Canada's largest and most successful wood stove manufacturers, whose export sales often exceeded domestic sales, had been busy developing low emission products for several years and had products ready for certification. The companies with the most market influence abruptly stopped producing conventional equipment and this sent a strong message throughout the Canadian market that these companies staked their future on advanced technology products. Canadian specialty retailers enthusiastically embraced the new technologies.

CSA B415.1 mirrors the EPA requirements

When, in the early 1990s, the B.C. government served notice that it would establish a wood smoke regulation, and it was apparent that it would not simply adopt a U.S. government regulation, the Canadian Standards Association technical committee responsible for standard *B415.1 Performance Testing of Solid Fuel Burning Stoves, Inserts and Low-Burn-Rate Factory-Built Fireplaces*[13], rushed to form a consensus. Although the committee had been meeting intermittently since 1984, the prospect of its standard being mandated caused its efforts to become more focused. It soon became clear that the B415 standard could not deviate from the EPA regulation without causing massive disruption to the market. Even though there were (and are) industry complaints about certain details of the EPA methodology, the fact is that it functions with reasonable effectiveness and has become an integral component of the North American hearth industry. The industry members on the B415.1 committee argued forcefully that the standard would have to mirror the EPA requirements precisely or every product would have to be re-tested at great expense, and possibly re-engineered at even greater expense. Eventually, CSA B415 was published in a form such that EPA test results could be deemed to meet its requirements and vice versa. The CSA B415.1 standard was published in 1991, but had no effect until it was referenced in legislation by British Columbia.

The B.C. regulation under the Waste Management Act administered by the Ministry of Environment makes reference to and accepts both CSA B415.1 and the EPA requirements. As a practical outcome of this approach, all emission certification testing is done in the United States by agencies accredited by the EPA. Only those Canadian manufacturers who export wood stoves to the U.S. build low emission products and have them certified because the high costs of product development and certification mean that access to the larger U.S. market is needed to justify the investment. Part of the EPA wood stove regulation stipulates that testing must be conducted by agencies located in the continental U.S. and which are accredited by the EPA. There is no mechanism by which a Canadian manufacturer could have a product tested in Canada to the CSA B415.1 standard and have it accepted by EPA for access to the U.S. market. As a result, there has been virtually no testing and certification done under the CSA B415 requirements.

Among those interviewed for this project, there was strong support for a Canada-wide regulation based on the B.C. approach. Provincial governments foresee enforcement problems if they were to act unilaterally and would expect some people to go to neighboring provinces to buy conventional equipment. On the other hand, a national regulation would be relatively easy to enforce because it would bring Canada's regulations in line with the U.S., its largest trading partner. The harmonization of wood stove emission standards might also make possible a bi-lateral agreement on reciprocal acceptance of low-emission certification between the two countries. A reciprocal agreement of this type would have the effect of lowering testing costs for Canadian manufacturers and encouraging the development of Canadian testing facilities and expertise.

What are B415.2 and B415.3?

As noted, B415.1 addresses space heaters such as stoves, inserts and efficient fireplaces. B415.2 covers central heating systems like furnaces and boilers, and B415.3 is for the testing of site-built and decorative fireplaces, and large factory-built fireplaces. Neither B415.2 or B415.3 are fully developed and ready for use. Activity on the two standards is unlikely in the absence of expressed government interest in calling them up in a regulation.

4. Purchase Motivation

4.1 The Cost of Heating With Wood

The actual amount of money that a given household spends on the winter supply of wood can vary widely. Some people go into the bush to cut the trees and process the firewood themselves. Others buy a large truck load in log lengths which they then cut and split. Still others buy split, seasoned firewood. Each approach has costs, but some people spend more labour for their winter fuel and some spend money. There is also a wide range in the price of processed firewood, depending on whether it is purchased in an urban or rural area. In Table 4. a price of $175 per full cord (4 x 4 x 8 feet) or about $60 per "face cord" (4 x 8 feet x [about]16 inches) has been selected as a common price for split wood in rural areas and small towns. Delivery costs can push the price towards $200 per full cord in some regions. Firewood can be twice this price in urban areas.

Table 4. Sample of Annual Heating Costs Using Various Fuels

Appliance Type	Energy Cost	Fuel Energy Content	Annual Heat Loss	Appliance Efficiency	Annual Cost
EPA certified wood stove	$175.00	30600	10000000	72	$794
Conventional wood stove	$175.00	30600	10000000	60	$953
Central wood furnace	$175.00	30600	10000000	50	$1,144
Pellet stove - higher cost fuel	$240.00	19800	10000000	70	$1,732
Pellet stove - lower cost fuel	$180.00	19800	10000000	70	$1,299
Oil furnace, conventional	$0.39	38.23	10000000	65	$1,553
Oil furnace, high efficiency	$0.39	38.23	10000000	80	$1,275
Electric baseboard or furnace	$0.08	3.6	10000000	95	$2,339
Ground source heat pump	$0.08	3.6	10000000	260	$855
Propane mid-efficiency	$0.42	25.3	10000000	80	$2,075
Natural gas mid-efficiency	$0.21	37.52	10000000	80	$700
Natural gas condensing	$0.21	37.52	10000000	93	$602

Notes:
Source of base values and calculations is the NRCan pamphlet: Comparing Heating Costs[10]
Fire wood price: The figure of $175 is an average price for a cord of split wood in rural areas and small towns. In urban areas the price can be twice this amount.
Price of pellets: Two price scenarios are provided to account for variations in shipping costs and discounts for bulk purchases.
Fuel Energy Content: firewood - megajoules per full cord, pellets - megajouls per ton, fuel oil - megajouls per litre, electricity - megajouls per kilowatt hour, propane - megajouls per litre, natural gas - megajouls per cubic metre.

House Heat Loss: the figure of 10000000 is a factor representing the estimated annual heat loss of a 186/m^2 (2000 sq.ft.) house built since 1985 and located in a climate zone similar to that of Ottawa or Montreal.

At $175 per full cord, firewood is less costly to heat with than oil, propane, electric resistance and pellets, but is more costly than using natural gas or a ground source heat pump.

Note that a household which upgraded to an EPA certified stove at 72 percent efficiency from a conventional stove at 60 percent efficiency would save $159 in fuel costs each year. Compared with a wood furnace operating at 50 percent efficiency, the savings would be $350 each year. These substantial annual savings make upgrading to advanced technology an attractive investment.

4.2 Purchase Incentives

There are strong incentives to burn gas

The most significant heating system purchase incentives are offered to Canadians by gas utilities and, to a lesser extent, fuel oil distributors. Gas distributors have employed aggressive marketing programs offering discounts and attractive payment terms for homeowners who purchase gas fireplaces and other gas-fired appliances. The marketing is sophisticated, highly seductive and, in the case of gas fireplaces, challenges the safety and environmental appropriateness of wood burning fireplaces, so it should not be surprising that people are buying more gas fireplaces and fewer wood burning appliances than in the past. Here are some direct quotes from gas company advertising:

- *"A natural gas flame does not produce dangerous sparks. You don't have to worry about long-burning embers or chimney embers because when the fire is out, it's out."*
- *"A natural gas fireplace burns cleaner than a wood fireplace."*
- *"And they're easy to use: there's no kindling, no sparks, and no smoky rooms."*[11]
- *"In fact, a typical customer is still paying less for natural gas now than in 1984."*[12]

The Canadian public receives these messages in a more convincing form and with greater frequently than messages suggesting that wood is a viable and appropriate energy source. Observers of the wood heating appliance market suggest there is evidence that the public is turning against wood energy based on mixed messages regarding its environmental impacts and a misunderstanding of how wood fuel consumption functions in relation to greenhouse gas emissions.

Green Communities

The Green Communities program, offered in B.C., Ontario and New Brunswick, was largely a public information program that helped people make environmentally sound purchase decisions. Partnerships were established with financial services companies, notably Canada Trust, to provide loans with terms matched to the energy cost savings resulting from purchases. Discussions were held regarding the payment-based-on-savings for the purchase of low emission wood stoves, but the program was discontinued before this initiative reached fruition.

No incentives for wood

No incentive programs for the purchase of low emission wood stoves were found during the research for this project.

4.3 Obstacles to the uptake of advanced technologies

Rural, low income households

It is almost axiomatic to state that low income earners living in rural areas heat with wood. Where incomes are low and there is high unemployment, people are better able to spend time on fuel wood acquisition and preparation than to spend money on processed firewood or another processed fuel. Based on the assumption (and it is an assumption) that low income rural families constitute a significant portion of those who claim wood as their primary heating fuel, does it follow then, that this group is more likely to purchase inexpensive conventional stoves than to spend more on an EPA certified model? While there is no base of statistical information that can answer this question with precision, the views of the wood heat retailers interviewed for this project shed light on the matter.

Obstacle #1: No emissions regulation

Retailers were asked to identify obstacles to the uptake of advanced technologies. Virtually all retailers (outside B.C.) first mentioned the lack of an emission regulation as a key obstacle to the increased adoption of advanced stoves. This answer is not as rhetorical as it may first seem. The dealers point out that currently the shopper receives mixed and confusing messages from various retailers. Mass merchandisers, hardware stores and building supply outlets compete in the marketplace primarily on the basis of lower price and tend not to carry the more expensive wood burning models. Their message to prospective customers tends to be: Why pay more?, which is probably a compelling argument for someone on a limited income. Specialty retailers have a greater challenge in informing their customers of the more complex efficiency and environmental advantages of the more costly certified products. A mandatory emission regulation would have the effect of leveling the informational playing field.

Obstacle #2: Price

Ultimately the purchase decision often comes down to price. While the incremental cost of low emission technology may add only $100 to $200 to the retail price of the product, the additional features, such as ash pan and glass door, that tend to accompany emission certification, increase the price spread to about $500. At the lowest price points, an EPA certified model can be about twice as costly as a conventional unit. This is a significant disincentive to adopt the technology. According to the retailer's responses, the most effective way to influence the purchaser is to point out that fuel cost savings will compensate for the higher purchase price within two or three heating seasons.

Obstacle #3: Tradition

Some of the retailers interviewed for this project mentioned that the customer's age and education or access to information seemed to influence the purchase decision. Older people who have heated with wood for decades may resist adopting the new technologies and may replace a worn out conventional stove with a new one of similar design. Their own experience would seem to reinforce this approach; having heated with wood successfully for many years, why would they need to spend more on advanced technologies? People who have not seen the new appliances operate or have not talked to friends or family members who use and like them, are less likely to spend the additional amount on advanced technology. Also, many people view wood stoves as simple devices and associate them with practicality, economy, and even frugality. The new generation of advanced technology stoves tend to be more decorative than traditional stoves. Large glass panels in doors, modern shapes and bright plated trim may not be the image traditional wood burners feel comfortable with.

Obstacle #4: No access to information

People living in rural and remote areas or small towns far from urban centres may shop for and purchase a new wood stove, yet throughout the process never learn that a new generation of appliances is available. Many rural areas are not served by specialty wood stove and fireplace retailers, the main outlets for EPA certified models, so advertising messages promoting the advantages of the new technologies would not reach households there. Dealers and distributors interviewed for this project mentioned rural Newfoundland as a region where the adoption of advanced technologies has been slow. One Ontario manufacturer noted that a significant proportion of his entire production of conventional stoves goes to the Newfoundland market.

First Nation communities located in rural and remote areas are also examples of this dynamic. In many of these communities, all building materials and durable household goods are shipped in from building supply distributors located several hundred miles away. To a large extent, householders in these communities have only the product offerings from a single company to choose from, so they

may never learn that other options are available. A related problem specific to remote communities is the fact that advanced technology stoves tend to weigh more than conventional models because of their complex internal features. The added weight can be a disincentive to buy them because of the higher shipping costs involved.

5. Prospects for Reduced Emissions

5.1 Some Strategic Options

A gradual reduction is underway

Assuming the estimate by industry commentators that somewhat more than half of total sales are of advanced technology stoves is reasonably accurate, a significant shift in the stove population is already underway. This means that the new technologies are well represented in the market place, that they are proven under Canadian conditions, and that there is a sufficient base of professional knowledge and skill in the industry in most regions to support the public in their use of advanced wood burning technologies.

A national emission regulation

Clearly, the best mechanism by which to lower smoke emissions from residential wood burning appliances is to replace conventional equipment with certified low emission stoves. And the most effective tool available to influence the uptake of the new technologies is a national emission regulation requiring all stoves offered for sale to meet the requirements of CSA B415/EPA standards. Such an approach is recommended because, although provincial governments express some interest in and support for regulating wood stove emissions, there is no evidence that other provinces will take individual action as B.C. did in 1994. The willingness of the hearth industry to support a regulation, and B.C.'s experience with high compliance rates and low enforcement costs make such a regulatory initiative a positive step in all respects. In fact, it is difficult to identify a constituency that would oppose it, aside from those in political circles who oppose any form of regulation on principle. While there is likely a traditionalist segment of the population that would criticize the government for causing the cost of wood stoves to rise, the evidence of higher quality and added value cannot be ignored. Note that some conventional stoves consist of little more than an empty steel box with a door. Given the minimum useful life span of a wood stove of perhaps 10 years, over which time the incremental cost of advanced technologies is spread, the cost impacts do not seem unreasonable. It is also possible that the price of the least expensive advanced technology stove would come down after a regulation were established as manufacturers seek to fill the low cost market niche formerly filled by conventional stoves; that is, plain, unadorned styling and lacking additional features such as ash pan and large glass door panel.

Public education

There is a significant human factor involved in the rate of particulate emissions from a given wood burning appliance. A certified low emission stove could be operated to produce very high emissions if the fuel is too wet, is not split to the

correct size, is not loaded into the stove correctly and if the combustion air control is closed too much. Conversely, a conventional appliance can be operated to produce moderate emissions by a knowledgeable, conscientious person using good fuel. The knowledge and skills required to burn wood effectively are not intuitive; they must be learned and practiced if improvement is to occur. Without input and support, users may never have their misconceptions and improper techniques corrected. Public education initiatives aimed at reducing smoke emissions could be effective by providing support to people who heat with wood, regardless of the appliance they use. A project of this type is being planned in Nova Scotia for the fall of 1997. It is a prototype partnership between the hearth industry, the insurance industry, the regional lung association and at least two agencies of the provincial government.

5.2 How the Stakeholders Can Contribute

The importance of partnerships

Wood is unique among the main home energy sources in that its fuel supply sector, aside from wood pellet manufacturers, is all but invisible and is not involved in the trade associations or in discussions of policy. For all the other energy sources, the fuel supplier has regular contact with the householder, if only in the form of a monthly bill. This regular contact creates opportunities to pass on various messages, such as helpful seasonal tips commonly included in electrical utility mailings. More importantly, the fuel supply sector for electricity and fossil fuels is where the financial strength of the industry lies. In the case of residential wood energy, the largest companies in the industry are the stove manufacturers, only a few of which employ more than 100 people. The rest of the industry is made up of product distributors, wood stove and fireplace retailers, and chimney sweeps, all small companies employing two to twenty people.

As a result, the industry does not have the resources to communicate with the Canadian public in the conventional ways that the oil, gas and electrical industries do. The formation of partnerships with allied industries and with agencies of government is perhaps the only way the industry has of communicating non-commercial messages to the public.

Those Canadian families who heat their homes with wood receive very little support for their efforts. It is rare for any media, print or electronic, to mention wood heating in either a positive or negative context. These homeowners are not acknowledged for their use of a renewable energy source, nor are they encouraged to improve their use of wood by using techniques that reduce smoke and increase efficiency. A public information initiative could help Canadians who heat with wood to understand the techniques of responsible wood heating and take pride in their ability to use them effectively.

What can the Federal Government do to reduce emissions?

With its national mandate, the federal government has a key role in the reduction of residential wood burning emissions. The Minister of Environment could consult with provincial counterparts with a view to reaching a consensus on a plan to institute a national emissions regulation. If a consensus is achieved—and there is some reason to believe this is possible—the Ministry could then proceed with a regulatory initiative. This single step, which experience in B.C. suggests is low in administrative overhead, yet highly productive, could set the stage for some useful partnerships designed to educate the public about advanced technologies and the importance of responsible wood heating practice.

If a national emissions regulation is not seen as a viable initiative, the federal government could support the adoption by individual provinces of standards on emission limits. This approach is less desirable because it is likely that some provinces, notably in the Prairie region, would not participate and this would lead to a patchwork of requirements across the country. The wood energy industry has specifically expressed the importance of regulatory harmony across all Canadian markets. The federal government could assist the process by developing a guideline as a model for use by the provinces.

Other federal departments and related agencies have much to contribute to an emissions reduction strategy based on a multi-stakeholder model. Natural Resources Canada could provide technical, policy and communications support. Health Canada might also contribute technical and communications support based on its specialized perspective. Canada Mortgage and Housing Corporation has an influence, through research, publications and programs, on heating system selection and use in Canada, and these may be influenced by and have an influence on a national emissions reduction program.

What can provincial governments do to reduce emissions?

Initially, provincial governments could support an emission reduction strategy by endorsing a federal initiative to establish a regulation requiring emission testing and certification. Should a federal regulation be established, each province could increase its impact by publicizing its support for the use of low emission appliances. Including effective messages about wood heating along with their other housing-related public information materials would be just one way the provinces could influence current and prospective users of wood fuel. To have valuable input, governments do not need to get involved in quasi-commercial messages like advice to upgrade to an advanced technology appliance — this can be left to private sector partners. Governments, however, are in the best position to offer general messages designed to help the public use wood fuel responsibly. For example, governments can help people to understand that a thick blue-gray plume of smoke from a chimney is highly visible evidence of environmental irresponsibility. If governments and their partners seeded the

formation of a social consensus that visible wood smoke is bad and evidence of a lack of wood burning skill, while offering tips on avoiding smoky fires, a gradual improvement in wood heating practice could result.

If it is determined that a federal emissions regulation would not be established, provincial governments should be encouraged to adopt such regulations within their jurisdictions. A federal guideline would be of significant assistance to such initiatives.

What can the hearth industry do to reduce emissions?

The hearth industry in Canada has an excellent record of effective collaboration with government in support of the public's use of wood fuel. When, in the late 1970s, it became apparent that the rapid increase in the use of wood was leading to an unacceptable increase in house fires, the industry worked enthusiastically along side regulatory agencies to put in place an installation code and the array of safety test standards that now form the basis of the wood heat safety components of building codes. In the mid-1980s, when it was recognized that the industry had a key role in providing the public with accurate and reliable advice and services, the industry partnered with the federal and provincial governments to develop the Wood Energy Technical Training (WETT) program. When provincial governments decided that they would not regulate the wood energy trade directly as has been done with other home heating fuels, the industry agreed that it would establish a system of self-regulation by issuing certificates of qualification based on WETT training. Today, the WETT program is a highly successful and respected component of the wood heat safety regulatory system that is endorsed by all provincial governments. The wood heat industry is experienced in establishing and maintaining effective partnerships and has had considerable success with such ventures.

One example of an industry-driven mechanism to reduce emissions that has been used successfully in the U.S. and B.C. is a program referred to as a stove change-out. It is an information and incentive program designed to help householders to upgrade their conventional wood burning equipment. Participation by manufacturers, distributors and retailers combine to create financial incentives (discounts) on the price of advanced technology appliances. The discount can be contingent upon the householder turning in their conventional appliance for destruction. This mechanism creates an excellent media opportunity in which a huge pile of "old smokers" heads off to the crusher, presumably to be recycled into new, low emission stoves. The participation of government in change-out programs is critical in endorsing, not the commercial aspects of the program, but the environmental advantages that accrue from upgrading.

What Can Financial Institutions Do to Assist?

Financial institutions could be effective partners in a change-out program by providing specialized loan programs based on projected fuel cost savings. The estimated annual savings of between $150 and $350 per year through the use of advanced technologies could be seen as an offset to the cost of such loans. This approach would give substantial meaning to the concept of resource conservation through technology upgrade. The participation of government with the hearth industry in promoting such a program among financial institutions would be of significant assistance in creating credibility and a sense of shared interest.

Other Possible Partners

The insurance industry has long been a partner of the hearth industry in helping the public to heat their homes with wood more safely. Insurance companies play a key role by having contact with the householder whenever there is the potential for a change in risk, such as the installation of a new wood stove. This contact is a good opportunity to remind people of the importance of a good chimney and proper installation to ensure that their new advanced technology appliance will function safely and to its potential. As part of a change-out program, participating insurance companies could offer preferred rates to policy holders who use advanced stoves and have had their installations inspected.

Provincial and regional lung associations have been active in promoting better indoor and outdoor air quality. An initiative planned for the Fall of 1997 in Nova Scotia and New Brunswick is expected to include the hearth industry, insurance industry, provincial governments and the lung association as partners to educate the public on clean burning techniques. If successful, this model could be replicated in other regions.

6. Conclusions

6.1 Wood is by far the most commonly used renewable energy source by Canadian householders. About one fifth of single family dwellings are heated to some extent with wood. Even those Canadians who report the use of wood as a supplementary fuel tend to use it to provide a large part of their total heating needs.

6.2 The aesthetics of the stove and the fire are more important to people now than in the past. The more attractive stoves and the ability to watch the fire as it burns has added to the desirability of using wood as a fuel for space heating of living areas. Used this way, wood offers good prospects for the displacement of fossil fuel use.

6.3 In most regions outside large urban centres, it costs less to heat with firewood purchased at market prices than with oil, propane, electric resistance and pellets, but it is more costly than using natural gas or a ground source heat pump (depending on electrical power rates).

6.4 Wood stoves certified as low emission by the U.S. Environmental Protection Agency operate at an approximate average of 5 grams per hour which is between one fifth and one tenth of that emitted by conventional wood stoves.

6.5 The smoke emissions from individual wood burning units is strongly influenced by the quality of fuel used and the operating techniques employed by users. Public information programs could help Canadians who heat with wood to understand the techniques of responsible wood heating and take pride in their ability to use them effectively.

6.6 Certified low-emission wood burning appliances operate at higher efficiencies than conventional equipment, resulting in annual fuel cost savings of between $150 and $350. These substantial annual savings make upgrading to advanced technology an attractive investment. These savings are acknowledged to be a primary motivation in the decision by householders to upgrade their older appliances.

6.7 Regulatory action by the U.S., and subsequently by B.C. has had a significant effect on the Canadian market; it is estimated that of all current wood stove sales, somewhat more than half are of EPA certified low emission models.

6.8 The relevant industry, as represented by the Hearth Products Association of Canada, supports the adoption of a national regulatory initiative similar to that adopted by British Columbia in 1994, which is in all functional respects the same as the EPA requirements.

6.9 There is reason to expect that a majority of provincial Ministers of Environment would respond positively to a federal regulatory initiative.

6.10 The B.C. experience suggests that the administration and enforcement costs to support the regulation would be low.

6.11 Obstacles to the uptake of advanced technology wood stoves include the absence of an emission regulation, the higher cost of advanced stoves, resistance to change on the part of purchasers, and a lack of information.

6.12 The obstacles mentioned above can be minimized through the mechanism of a Canada-wide emission regulation, combined with effective public information and incentives for wood heat users to upgrade.

6.13 There is inadequate information available on how Canadians use wood fuel to heat their homes. More specific information on the attitudes of the users, the types of appliances currently in use, and the way they are used is needed to guide the development of effective public education materials. Research into the performance characteristics of the various appliance types is also needed. These two data sources—user profiles and appliance characteristics— are required to develop projections of environmental impacts and as a base line against which to measure progress in reducing negative impacts.

7. Recommendations

7.1 The federal Ministry of Environment should investigate the strategy of adopting an emission regulation using the B.C. experience as a model. An alternative to this preferred approach would be the development of a federal guideline which interested provinces could use as a model for regulations within their jurisdictions.

7.2 Environment Canada should support research designed to more accurately characterize the emissions from the full range of wood burning equipment so that projections of air shed impacts can be made with more precision and so that progress in emissions abatement can be more accurately assessed.

7.3 Environment Canada should support survey research designed to better characterize the various patterns of wood heat usage, the results of which would permit more accurate projections of environmental impacts. This research data would also provide insights into how Canadians view wood heating and use wood as a home heating fuel which can be used in the development of effective public information materials.

7.4 Environment Canada should consider supporting research into the full life-cycle cost of wood burning equipment as a component of the complete analysis of wood as a residential energy source.

7.5 Environment Canada should help in the formation of and support for partnerships aimed at developing and disseminating information in support of the public's environmentally appropriate use of wood as a heating fuel. Likely partners include the hearth industry, other departments or agencies of government at all levels, financial institutions, the insurance industry and health organizations.

7.6 All the identified partners should support and participate in programs such as stove change-outs, clean burn demonstrations, and programs to distribute public information.

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9. Jaasma, D. R., McCrillis, R. C.; Comparability Between Various Field and Laboratory Wood stove Emission Measurement Methods; delivered to the annual meeting of the Air and Waste Management Association, 1991
10. Comparing Heating Costs, Natural Resources Canada Catalogue No.:M91-2/43-1996E, 1996
11. Light My Fire, brochure, Consumers Gas Company Store, September 1996
12. Customer newsletter explaining a fuel price increase, Consumers Gas, February 1997
13. CAN/CSA B415.1-92 Performance Testing of Solid-Fuel-Burning Stoves, Inserts and Low-Burn-Rate Factory-Built Fireplaces, Canadian Standards Association, 1992

Appendices

Appendix A List of Reporting Firms, Shipments of Solid Fuel Burning Heating Products, December 1996, Statistics Canada Catalogue 25-002

Name Nom	Plant Location Localisation de l'usine
Nova Scotia - Nouvell Écosse	
Acadian Woodstoves Inc. (2)	Saltspring
Kerr Controls Limited (9)	Truro
Lunenberg Foundry & Engineering Ltd. (1,2,3,4,6,7,10,A)	Lunenberg
Newmac Manufacturing Inc. (7,8,10,A)	Debert
Parrsboro Metal Fabricators Ltd. (7,8,9)	Parrsboro
New Brunswick - Nouveau-Brunswick	
Entreprise Fawcett (Div. of 3135772 CDA Inc.) (1,2,3,7,8)	Sackville
NY Thermal Corp. (9)	Sussex
Québec	
Cheminées Sécurité International Ltée (1,5)	Laval
Drolet Poêles & Foyers Inc. (1,2,5)	Québec
J.A. Roby Inc. (2)	Charlesbourg
Les Foyers Don-Bar (1996) Ltd. (1,2,5)	Lévis
P.S.G. Distribution Inc. (1,2,7,8,10,B)	La Guadeloupe
Produits D'Acier Nordic 1989 (26457747 Qué. Inc.) (1,4,5,6)	Rivière des Prairies
Thermo 2000 Inc. (1,7,9)	Richmond
Les Poêles et Foyers Beausoleil Enr.	St-Gabriel de Brandon
Ontario	
Anvil Fireside Accessories Ltd. (4)	Mississauga
Cascade/Triumph Manufacturing (1992) Ltd. (1,2,6)	Ajax
City Metal Manufacturing Inc. (1)	Downsview
Decaro Manufacturing Ltd. (1,6)	weston
Olsen Manufacturing Co. Inc.	Wallaceburg
Heartland Appliances Inc. (3)	Kitchener
Heritage Energy Systems (1,6)	Collingwood
Ka-Heat kachelopen Ltd. (2)	Cobourg
Old Time Stove Co. Inc. (2,6)	Kitchener
Security Chemineys Int'l Ltd. (5)	Whitby
Polaris Fireplaces Inc. (1,2)	Oakville
Quality Railings Ltd. (1)	Weston
Selkirk Metalbestos (5)	Brockville
Wolf Steel Ltd. (2,5,6)	Barrie
Haugh's Products Inc.	Brampton
Harthex Inc.	Guelph

List of Reporting Firms, 1996

Liste de firmes répondantes, 1996

Name Nom	Plant Location Localisation de l'usine
Manitoba	
Falcon Machinery (1965) Ltd. (2,7,8,10,B)	St-Boniface
Kingsman Industries (Div. of R-co. Inc.) (2,5)	Winnipeg
Alberta	
Kirks Sheet Metal Products	Three Hills
British Columbia - Colombie-Britannique	
Fire Hearth Mfg. Ltd. (5)	Burnaby
Northern Fireplace Ltd. (4,5,6)	Summerland
Osburn Manufacturing Inc. (2,6)	Victoria
Pacific energy Woodstoves (1986) Ltd. (2,6,8)	Duncan
Regency Industries (2,5,6)	Delta
RSF Energy Ltd. (2,5,8)	Smithers
Valley Comfort Systems Inc. (1,2,8)	Penticton

The numbers shown after the firm name relate to the items listed on pages 1 and 2 and indicate the type of operations carried on by the firm.

Les chiffres figurant après le nom des firmes correspondent aux articles énumérées aux pages 1 et 2 et identifient le genre d'activité opérée par la firme.

This survey measures, on a quarterly basis, the shipments of selected solid fuel burning heating products. The target population is all known major manufacturers of these products. The frame for this commodity survey is based mainly on the Annual Survey of Manufactures (ASM). Since the ASM lags behind this commodity survey, there is some risk of undercoverage. However, this should be minimal as market information is used to update this commodity survey's frame on a regular basis. The last break in these series occurred in 1988 with the introduction of the harmonized system (HS) coding system. Based on the 1994 ASM (Fabricated Metal Products Industries, Catalogue 41-251-XPB) the reporting firms in this survey account for approximately 95% of the total value of shipments of these products. For the twelve month period in 1996, the degree of estimation for non-response was 3.8%. On a quarterly basis, late responses are imputed using a variety of methods, the most common being a trend analysis.

Cette enquête mesure, sur une base trimestrielle, les livraisons de certains produits de chauffage à combustible solide. La population cible est formée de tous les fabricants connus de ces produits. La base de sondage de cette enquête sur les produits est principalement tirée de l'enquête annuelle sur les manufactures (EAM). Compte tenu du retard de l'EAM sur cette enquête, il y a risque de sous-dénombrement. Cependant, ceci devrait être minime en raison des renseignements ayant trait au marché qu'on utilise afin de mettre à jour sur une base régulière la base de sondage de cette enquête sur les produits. La dernière solution de continuité de ces séries est survenue en 1988 et est attribuable à l'introduction du système de codage du Système harmonisé (SH). D'après l'EAM de 1994 (Industries de la fabrication des produits métalliques, n° 41-251-XPB au catalogue), les entreprises déclarantes qui participent à cette enquête représentent environ 95% de la valeur totale des livraisons de ces produits. Pour la période de douze mois en 1996, le degré d'estimation de la non-réponse est de 3.8%. Sur une base trimestrielle les réponses en retard sont imputées à partir de diverses méthodes, la plus courante étant

Appendix B Hearth Products Association of Canada letter to provincial and federal ministers of environment, September 24, 1996

September 24,1996

Dear Minister,

The Hearth Products Association of Canada (HPAC) and it's members fully support your efforts to improve energy efficiency and reduce the environmental impacts of Canadians in their daily activities. Of special interest to our members is "CGA Standard P.4.1 1996 Draft 'A' Testing Method for Measuring Annual Fireplace Efficiency" (for gas and propane fireplaces). The hearth industry recognizes the value of this standard and has actively participated in it's development. As you are aware business can function only in an environment where the rules are well understood by all involved.

Therefore on behalf of our members we request the following:

- **Implementation dates** - to provide our manufacturing members the time required to complete the necessary testing of their products (not to mention the preparation and printing of new promotional materials necessitated by this "Canada only" standard) our members would like to know your intentions regarding the implementation of CGA P.4.1 as soon as possible. Please keep in mind the current version is a "draft" only and will likely undergo some revisions.

- **"Raising of the bar"** - if, as it has been suggested by some officials, it is their intention to require more stringent efficiency at some point in the future, we request these intentions be clearly stated at this time. The existing draft standard contains recommendation for minimum efficiency levels and, if referenced, would provide uniformity across the country.

- **Standardized requirements** - to minimize potential confusion in the marketplace we request all jurisdictions adopt consistent requirements for gas hearth appliances, ideally following a similar timetable for implementation. We request this item be placed on the agenda of your upcoming meetings of Energy / Environment Ministers.

Ours is a young association with over 450 members and affiliate members from coast to coast, representing all aspects of the hearth business (manufacturing, distribution, sales, installation and service). Our members are a quiet Canadian success story, creating hundreds, if not thousands of manufacturing jobs across the country. Our products are sold in all parts of Canada as well as exported around the world. It would be a very real irony indeed if Canadian made products were in any way excluded from their home market situation that recently occurred for many companies in the implementation of the revised requirements for the "Clean Choice Program on Vancouver Island, BC.

While the topic of efficiencies and emissions are before us let us go beyond gas products for a moment to advise that the hearth industry would also welcome further dialogue on **wood burning appliances**. Since many of the existing wood burning appliances in use in Canada predate the advent of clean burning technologies, we would welcome strategies designed to update this equipment. The industry has made great strides in the development and manufacture of energy efficient, clean burning appliances that benefit the environment as well as improve appliance efficiency and provide greater consumer safety. HPAC would welcome new Canadian regulations on wood burning appliances the same as those currently in place in BC.

In closing, the hearth industry welcomes every opportunity to explore these issues further. Thank you in advance for your response, as a mailing to our membership is planned for the near future This letter is signed on behalf of all HPAC members.

Yours truly,

Malcolm Fisher
HPAC President

Appendix C Excerpts from responses of Ministers of Environment to the HPAC letter.

Newfoundland

The environmental impact of wood burning appliances have been very much on our minds over the years. In fact, the Department was a joint sponsor in the development of the Canadian Standards Association Code CAN/CSA-B415.1, Performance Testing of Solid Fuel Burning Stoves, Inserts and Low-Burn-Rate Factory-Built Fireplaces, *in 1992. We are interested as a Department in working with your Association, as well as other provinces and interested parties in developing Canada wide standards for the benefit of the environment, and considering the industries' need for common standards across the country.*

Hon. Kevin Aylward, Minister of Environment and Labour

Nova Scotia

It is encouraging to hear of your Association's strong support for regulations on wood-burning appliances, similar to those in place in British Columbia. My department is presently cooperating with the Nova Scotia Department of the Environment and the Atlantic Wood Energy Technicians Association (AWETA) on wood-burning issues, including appliance regulation for efficiency and/or emissions. No decisions have yet been made on regulating wood-burning appliances in Nova Scotia.

Hon. Eleanor Norrie, Minister of Energy

New Brunswick

Although the HPAC file does not contain a response from the New Brunswick government, it has previously expressed interest in a wood emission regulation and an interview with an official with the environment ministry revealed a positive attitude regarding the adoption of a Canada-wide regulation.

Ontario

The Minister's response did not address the issue of wood burning emissions. However, an interview with ministry staff confirmed that consideration of a regulation similar to that adopted by B.C. is ongoing.

Manitoba

Complaints about air quality and potential impacts to human health arising with exposure to smoke from the burning of wood and some other solid fuels continue to be brought to the attention of the Department. Although

such concerns are occasional, regrettably, some of these problems are difficult to resolve. Even though the scope of the issue has not been fully quantified, a smoke management strategy might be examined by the Department. In the development of any strategy, interested and potentially affected stakeholders would be given the opportunity to participate in the process. We will note the interest of your organization and advise you should this endeavour proceed.

Hon. J. Glen Cummings, Minister of Environment

Alberta

Alberta has developed our environmental approach to energy efficiency standards through the Clean Air strategic Alliance (CASA). CASA, a partnership of municipal, provincial and federal governments, industry and local environmental groups, develops strategies to deal with current and emerging air quality issues. CASA encourages incorporation of energy efficiency requirements in national manufacturing standards.

Hon. Ty Lund, Minister of Environmental Protection

With respect to the issue of wood burning appliances, solid fuel fired heating appliance standards adopted in Alberta apply to new installations only. The suggestion that existing wood burning appliances be updated with energy efficient, clean burning appliances is best achieved over time through promotion and installation of the more efficient products. This will result in a gradual reduction in harmful emissions without the costs associated with administering additional regulations.

Hon. Murry Smith, Minister of Labour, Alberta

The HPAC letter was also sent to the Minister of Natural Resources Canada, the Hon. Anne McLellan, who responded in part:

In your letter you mention that your association would welcome Canada-wide regulations on wood burning appliances that are similar to those currently in place in British Columbia. I understand that these performance requirements are based on emissions. Our Energy Efficiency Act provides the authority to regulate energy consumption. In Canada, there is no work under way on a consensus-based test protocol. We would, however, be interested in hearing your views concerning the requirements for such a test protocol and subsequent regulation.

Appendix D B.C. Reg. 302/94, Solid Fuel Burning Domestic Appliance Regulation under the Waste Management Act, British Columbia Ministry of Environment

Appendix E Response by the U.S. Hearth Products Association (HPA) to EPA's 1996 Polycyclic Organic Matter (POM) Emission Inventory for Residential Wood Combustion

B.C. Reg. 302/94
O.C. 1066/94

Deposited August 26, 1994

Waste Management Act

SOLID FUEL BURNING DOMESTIC APPLIANCE REGULATION

Contents

Definitions

1. In this regulation:

"air-fuel ratio" means the ratio of the mass of dry combustion air introduced into a firebox to the mass of dry fuel consumed in the firebox, determined in accordance with the Canadian standard or the US standard;

"appliance" means a solid fuel burning device, such as a stove, pellet stove, fireplace insert or factory built fireplace, that

(a) has an air-fuel ratio of less than 35 to 1,

(b) has a minimum burn rate of less than 5 kg/h, and

(c) is used to convert the energy in fuel to useful heat

but does not include a cookstove, a central heating system, a masonry heater or a site-built fireplace;

"burn rate" means the weight of the dry fuel charge, exclusive of the weight of any moisture, divided by the burn cycle time;

"Canadian standard" means the Performance Testing of Solid-Fuel-Burning Stoves, Inserts, and Low-Burn-Rate Factory-Built Fireplaces CAN/CSA-B415.1 standard published by the Canadian Standards Association as amended from time to time;

"cookstove" means an appliance that is

(a) designed primarily to cook food, rather than to dissipate heat directly to a room, and

(b) equipped with an integral enclosed oven with a volume greater than 0.028 m^3;

"cordwood" means conventional firewood;

"**fireplace insert**" means a device that is intended for insertion into a fireplace cavity;

"**pelletized fuel**" means processed fuel consisting of uniform, discrete pellets of compressed, dried biomass material;

"**solid fuel**" includes biomass fuels such as cordwood, chips, sawdust, peat logs, pelletized fuel, and kernel corn but does not include coal;

"**US standard**" means the New Source Performance Standards, Title 40, Part 60, Sub-part AAA of the Code of Federal Regulations (USA) (7-1-92 Edition), published by the United States Environmental Protection Agency.

Emission limits and labeling requirements

2. (1) A person who carries on business in British Columbia as an appliance manufacturer, wholesaler or retailer must not sell for use or for resale an appliance manufactured on or after November 1, 1994 unless the person

(a) ascertains, on the basis of testing carried out in accordance with section 3, that the appliance conforms to either

(i) the particulate emission requirements of the Canadian standard, as determined by the test methods and procedures in that standard, or

(ii) the particulate matter emission limits set out in the US Standard, as determined by the test methods and procedures in that standard, and

(b) ensures that, at the time of the sale, the appliance bears a permanently affixed label that

(i) is readily visible or accessible,

(ii) conforms to the labeling requirements under the Canadian standard or the US standard, as the case may be,

(iii) indicates that the appliance conforms to the particulate emission requirements of the Canadian standard or to the particulate matter emission limits of the US standard, as the case may be, and

(iv) is accurate in all material respects.

(2) Subsection (1) does not apply to a sale of an appliance by a person who has reasonable grounds to believe that the person acquiring the appliance does so solely for the purpose of use outside British Columbia or of resale outside British Columbia.

Testing

3. (1) A person who carries on business in British Columbia as an appliance manufacturer, wholesaler or retailer must ensure that testing of representative samples of the appliances in each model line that are

(a) manufactured on or after November 1, 1994, and

(b) intended for use or sale in British Columbia

is carried out in accordance with subsections (2) and (3).

(2) The testing required by subsection (1) must be carried out

(a) under the Canadian standard by an organization or body accredited by the Standards Council of Canada to test in accordance with that standard, or

(b) under the US standard by an organization or body accredited by the United States Environmental Protection Agency to test in accordance with that standard.

(3) The testing required by subsection (1) must be

(a) carried out as necessary to ascertain whether or not the appliances that are represented by the tested samples conform, as and when sold, to the Canadian standard or to the US standard, as the case may be, and

(b) repeated as necessary to demonstrate that each appliance sold for use or sale in British Columbia conforms at the time of its sale to the Canadian standard or the US standard, as the case may be.

(4) The testing required by subsection (1) must be carried out, and repeated as necessary from time to time, to demonstrate that each appliance sold for use or sale in British Columbia conforms at the time of its sale to the Canadian standard or to the US standard, as the case may be.

Records – keeping, certification and inspection

4. Each person who is an appliance manufacturer, wholesaler or retailer and is required under section 3 to ensure that the testing described in that section is carried out

(a) must, as soon as practical

(i) after each testing, in the case of a person who requested the testing, or

(ii) after purchasing the appliances, in the case of a person who purchases the appliances for resale from another manufacturer, retailer or wholesaler,

obtain from the accredited organization or body that carried out the testing or from the person from whom the appliances were purchased a record of the test results in a form certified on behalf of the accredited organization or body by a responsible person who is able to verify the test results,

(b) must keep the record of the test results at the person's place of business for at least 2 years after obtaining the record of the test results,

(c) if requested to do so by an officer, must produce the record of the test results for inspection during normal business hours, and

(d) if requested to do so by an officer, must provide a written report, in the form the officer requires, as to the information or any part of the information contained in the record of the test results.

Pelletized fuel specification

5. (1) A person who carries on business in British Columbia as a manufacturer, wholesaler or retailer of residential pelletized fuel must not sell for use or for resale any residential pelletized fuel manufactured on or after November 1, 1994 unless the fuel conforms to the specifications set out in the Schedule.

(2) Subsection (1) does not apply to a sale of residential pelletized fuel by a person who has reasonable grounds to believe that the person acquiring the fuel does so solely for the purpose of use outside British Columbia or of resale outside British Columbia.

Offence and penalty

6. (1) A person who contravenes sections 2 (1) or 3 (1) commits an offence and, on conviction, is liable to a fine not exceeding $200 000.

(2) A person who contravenes section 4 or 5 (1) commits an offence and, on conviction, is liable to a fine not exceeding $100 000.

SCHEDULE

(Section 5)

RESIDENTIAL PELLET FUEL SPECIFICATION

Characteristics	Specification
Bulk Density	Not less than 640 kg/m^3
Dimensions	Diameter 6 to 8 mm
Fines	Not more than 0.5% by weight must pass 3 mm screen
Inorganic Ash	Less than 1%
Length	None longer than 4 cm
Sodium	Not more than 300 ppm

[Provisions of the *Waste Management Act* relevant to the enactment of this regulation: section 24.4, 24.5, 35]

Review of the Polycyclic Organic Matter Emission Inventory for Residential Wood Combustion

U.S. Environmental Protection Agency Draft Report:

Emissions Inventory of Section 112(c)(6) Pollutants:
Polycyclic Organic Matter (POM), 2,3,7,8
- Tetrachlorodibenzo-p-dioxin (TCDD)/2,3,7,8
-Tetrachlorodibenzofuran (TCDF),
Polychlorinated Biphenyl Compounds (PCBs),
Hexachlorobenzene, Mercury, and Alkylated Lead

September 1996

reviewed by:
James E. Houck
and
Paul E. Tiegs
Omni Environmental Services, Inc.
5465 S.W. Western Ave.
Beaverton, Oregon 97075
(503) 643-3788

reviewed for:

Hearth Products Association
1601 North Kent Street, Suite 1001
Arlington, VA 22209

November 25, 1996

Introduction

The Hearth Products Association (HPA) has contracted AGI Technologies as an independent consultant to review the U.S. Environmental Protection Agency's (EPA) Section (112)(c)(6) emission inventory draft report. The review focused on emissions of polycyclic organic matter (POM) attributed to residential wood combustion (RWC). Based on the review it is concluded that:
1) The parameters (7-PAH, 16-PAH and EOM) used to assess POM emissions are not acceptable surrogates for total POM,
2) The number of actual measurements on which emission factors are based are grossly inadequate to provide values representative of the entire population of RWC devices in use,
3) The quality of the relatively few actual measurements of emissions factors are low, and the method used to calculate overall RWC emission factors from them is flawed, and,
4) An erroneously large national level activity value for RWC was used to calculate total national emissions.
A discussion of each of these four points follows.

7-PAH, 16-PAH and EOM as Surrogates for Total POM

The Clean Air Act Amendments (CAAA) of 1990 requires the identification of sources responsible for a least 90% of POM (and six other pollutants). In order to meet this requirement, the stated intent of EPA's draft report is to present results of a national emission inventory of POM (along with the six other pollutants). This was not done. Instead, national emission inventories for seven specific polycyclic aromatic hydrocarbons (7- PAH), sixteen specific polycyclic aromatic hydrocarbons (16-PAH), and extractable organic material (EOM) were presented in lieu of an emission inventory for total POM. None of these three parameters are good surrogates for total POM.

Polycyclic aromatic hydrocarbons (PAH) as a group is a subset of polycyclic organic material (POM), furthermore, the seven and 16 specific polycyclic aromatic hydrocarbon compounds (7-PAH and 16-PAH) comprise a very small subset of the total number of PAH. The emission factors for 7-PAH and 16-PAH listed in the EPA draft report are taken from the EPA "Locating and Estimating Air Emission" (L & E) series (reference 1), which in turn takes the values from EPA's AP-42 compilations (reference 2) and two other older reports (references 3 and 4). The EPA draft report states, "The complex mixture of POM consists of literally thousands of organic compounds." The L & E document states, "Theoretically, millions of POM could be formed."

It is widely recognized that the concentration of specific chemical compounds that make up the POM fraction of emissions from various air pollutant source categories (e.g., vehicular exhaust versus RWC) vary widely. This can be seen in reviewing the relative concentration of the PAH compounds for different source categories tabulated in the L & E document. In fact, the documented variability of specific PAH species from source category to source category has been suggested as a tool to apportion the relative contribution of different pollutant source categories to measured ambient concentrations (references 5 and 6). For example, in reference 5, it was concluded that the relative proportion of specific PAH species vary over several orders of magnitude from different source types.

The facts that: 1) Seven and 16 specific compounds are being used as indicators of total POM levels which are made up of thousands to millions of different compounds, and, 2) The relative fraction of total POM made up of specific compounds vary widely from source category to source category, demonstrate that the percentage contribution by source for 7-PAH and 16-PAH (shown in Figures 3-1 and 3-2 in the EPA draft report) are not representative of the percentage contribution by source for POM. In light of these concerns selecting a different set of 7 (or 16) PAH as "surrogates" for total POM may have resulted in a different list of significant source categories. It certainly could have resulted in different estimates of the magnitude of total POM emissions from candidate source categories, and, therefore, a different ranking of the relative importance of particular source categories.

The use of EOM as a surrogate for POM is inappropriate. Much of the organic material collected by emission sampling equipment will contribute to the EOM value. Emissions from a source could have a high EOM value without any POM present at all. EOM is simply a measure (an inexact measure) of organic compounds with a low vapor pressure and that can be put into solution with solvent. For this reason, RWC shows a high EOM value as compared to many other source categories. Numerous measurements of the organic carbon,elemental carbon and inorganic content of RWC emissions have shown that more than 80% of particulate emissions (which includes the condensable fraction) are made up of organic compounds (references 6-8). For RWC the overwhelming majority of these compounds are oxygenated aliphatic and monoaromatic compounds, not POM. (references 9-11). As with 7-PAH and 16-PAH, the relative percentages shown for EOM by source category in the EPA draft report (Figure 3-3) are not representative of the relative percentages of POM. Moreover, in the case of RWC, the EOM value is high simply because RWC emissions are very high in non-POM organic compounds that will show up as EOM.

RWC Data Base Size

There were 22.9 million households in the United States which used wood for heat in 1990 (reference 12). Some of these households have more than one wood burning device. The 22.9 million household value is based on a survey that assigned it a 10.1% relative standard error (RSE). Based on the facts that some homes have more than one wood burning device (e.g., both a fireplace and a woodstove) and that the survey value has a 10.1% RSE, a reasonable estimate of the total number of wood burning devices in the United States in 1990 would be 25 million. A supplement report to the Household Energy Consumption Survey (reference 13) reported 8.4 million households burned more than one cord of wood per year and 14.5 million households burned less than one cord of wood per year. Most frequently homes which burn more than one cord of wood would primarily be using a woodstove and those burning less than one cord of wood would be using a fireplace. If wood furnaces are grouped with woodstoves and one takes into account that about 7% of the households that use wood as a primary source of heat use a fireplace (references 13 and 14), and that some homes may have more than one wood burning device, a reasonable esstimate of the total number of woodstoves and fireplaces in the United States in 1990 would be nine million and 16 million, respectively. Based on wood use data (references 12-14) it can be estimated that about 21% of the total cordwood burned in the United States was burned in fireplaces and 79% in woodstoves. These estimates compare favorably with the estimates provided in Appendix A of the EPA draft report (28% for fireplaces and 72% for woodstoves). It also should be noted, as will be discussed later, that the HPA believes that no more than about 5% of the woodstoves in use in 1990 were new technology catalytic/non-catalytic stoves.

The EOM emission factor for all wood burning devices listed in the EPA draft report is based on only 14 tests (reference 11). In Appendix A of the EPA draft report it erroneously states that the EOM emission factor is based on tests with 12 conventional woodstoves and two catalytic woodstoves. This is not correct. One conventional woodstove (a Scott brand stove) was used and tested under 12 operating conditions and one catalytic woodstove (an Earth brand stove) was used and tested under two operating conditions (see reference 15 for test conditions). This error is understandable as reference 11 did not cite the primary report (reference 15) which described the tests. The 7-PAH and 16-PAH emission factors for conventional woodstoves listed in the EPA draft report are taken by AP-42 from the same study (reference 15), while the emission factor for high technology catalytic/non-catalytic woodstoves were based on six additional studies referenced in AP-42. According to the L & E document, "There are fewer PAH emissions test data for fireplaces as compared to woodstoves." Of the two references cited in the L & E document for fireplace tests, the tests listed in one of the references (reference 4) are described in detail in reference 9. The tests are comprised of sampling a single fireplace two times for PAH (two wood types). The second fireplace reference cited in the L & E document (reference 3) is a 1980 literature review of work conducted in the 1970's. The method used to develop the emission factors are not documented in the review but they appear to be a non-statistical "blend" of fireplace test results from three studies including the one fireplace study reported in references 4 and 9.

In summary, the data base for emission factors is not adequate. The EOM emission factor for all 25 million wood burning devices is based on one conventional and one catalytic stove. The 7-PAH and 16-PAH emission factors for the eight to nine million conventional woodstoves, which are responsible for the overwhelming majority of wood consumption and POM emissions, are based on one woodstove. The 7-PAH and 16-PAH emission factors for the 16 million fireplaces are based on no more than several fireplaces tested in the 1970's. (Documentation on tests on only one fireplace have been definitively identified.) There appear to be a few more tests available for high technology catalytic/non-catalytic woodstoves; however, since they represented a relatively small fraction of the total woodstoves in use in 1990 and their emission

factors are smaller than conventional stoves, a detailed accounting of the origins of the 7-PAH and 16-PAH emission factors was not conducted in this review.

Basing emission factors on a limited number of tests is a more serious problem for RWC than most other sources of POM because of the very high variability that can be expected for POM emissions from RWC. It has been well documented that combustion conditions such as temperature, available oxygen, and residence time will influence the production of POM (reference 16). There are many hundreds of types or models of wood burning devices in use, many dozens of tree species are commonly used for wood fuel, draft characteristics vary from home to home (chimney conditions), household altitude is variable, there are variations in fuel wood seasoning and storage practices (wood moisture), and there are wide variations in home owner operation of a wood burning device (burn rate, burn duration, damper setting, kindling approach, etc.). Each of these parameters have significant impacts on combustion conditions and will impact POM emissions. Beyond the variability in woodstove emissions which is due primarily to the differences in combustion conditions and has been well documented for other air pollutants such as particles and carbon monoxide, the variability in the chemical makeup of wood is an additional source of variability for POM as specific POM compounds will be formed by the rearrangement and combining of compounds contained in the wood fuel. Wood is composed of lignin, cellulose, hemicelluloses, and resins. The ratios of these major chemical groups vary from tree species to tree species, particularly in wood from deciduous versus coniferous trees. Resin content, for example, may be particularly important as resins are composed of polyaromatic structures.

To provide insight into the variability of POM emissions associated with RWC, the reader is referred to reference 15 which provides the basis for the EOM emission factor for all 25 million wood burning appliances and the 7-PAH and 16-PAH emission factors for somewhere between eight and nine million conventional woodstoves. Emissions from a single conventional woodstove (a Scott brand stove) and a single catalytic woodstove (an Earth brand stove) were measured. There were twelve tests performed on the conventional woodstove. Two replicate runs were performed each on low and high burn rates using pine fuel at both high and low altitude, and two replicate runs were performed on low and high burn rates using oak fuel at low altitude (six sets of conditions with two replicate runs each). The mean EOM, 7-PAH and 16-PAH emission factors for conventional stoves from these tests are 23.4 lbs/ton, 0.051 lbs/ton and 0.69 lbs/ton, respectively. (The values tabulated in the EPA draft report are a little lower because the data from the two catalytic stove tests were included in the mean values presented there.) The standard deviation around the EOM, 7-PAH and 16-PAH means are 19.5 lbs/ton, 0.052 lbs/ton and 0.42 lbs/ton, respectively. These standard deviations represent 83%, 102% and 61% of the means for the EOM, 7-PAH and 16-PAH values, respectively. It must be emphasized that these values are for a single stove tested 12 times with two fuels, two altitudes, and two burn rates and that one half of the test were replicate tests. The magnitude of the variation in POM emissions among the very large number of parameters encountered among the real-world use of RWC devices must be very large. Statistically using one conventional stove and several fireplaces to represent millions of devices is fundamentally in error.

Quality of Emission Factors

All emission factors listed in the L & E document which is the source of the 7-PAH and 16-PAH emission factors used in the EPA draft report have an emission factor rating of E except for the one fireplace data set which was derived from a 1980 literature review article. The emission factor rating for that data set is U5. An E rating is the lowest and is described as "poor", the U rating is defined as unrated or unratable. The U5 subcategory is further defined as having a "lack of supporting documentation."

The EOM emission factor developed from the 12 tests on a single conventional stove and on two tests on a catalytic stove were obtained by using a non-reference, non-standard sampling protocol. (One author of this review was also the co-author of the study on which the EOM emission factor is based reference 15.) An aliquot of solvent extracts from filters, extracts from XAD-2 resin and probe rinses underwent gravimetric and chromatographic analyses. The EOM value is the sum of the gravimetric and chromatographic determinations on each of the three solutions. It is the authors opinion that the propagated uncertainty of the technique and subsequent addition of six values produced a precision of no better than 30%. Also the gravimetric sample was lost for one run reducing the EOM data set to 13.

Beyond the accuracy and precision of the fundamental measurements, the HPA is concerned about how the emission factors for the various wood burning devices were weighted to produce overall emission factors that were subsequently multiplied by the total national wood use to obtain total RWC values for the national emission inventory tabulation. For example, the L & E document from which the EPA draft report took the weighted 7-PAH and 16-PAH emission factors has tabulations for conventional woodstoves (Table 4.1-1), non- catalytic woodstoves (Table 4.1-2), catalytic woodstoves (Table 4.1-3), pellet stoves (Table 4.1-4), and fireplaces (Table 4.1-5). The emission factors of 0.035 lbs/ton for 7-PAH and 0.517 lbs/ton for 16-PAH for residential wood combustion are listed in appendices A and B of the L & E document and in appendix B and in Table 3-1 of the EPA draft report without any explanation of the calculations used to derive them. Apparently, a weighing factor was used to account for the relative usage of the various devices. In addition, the PAH data for fireplaces shown in Table 4.1-5 of the L & E document are missing a number of the 7-PAH and 16-PAH compounds. There is no explanation on how this lack of data was treated in calculating the weighted emission factors. The Household Energy Consumption and Expenditures survey results (reference 12) also show that 3.5 million cords were burned in other wood burning devices (primarily wood furnaces). No weighing or emission factors have been presented for them.

The development of the EOM emission factor for residential wood combustion is addressed in section A.24 of appendix A of the EPA draft report. In that section it is stated, "Statistical data from a 1990 annual survey of residential homeowner use conducted by the EIA were used to develop the weighing factors to apply to the available emission factor data to represent the split between woodstove and fireplace use. The average nationwide percentage of wood consumption is 28 percent for fireplaces and 72 percent for woodstoves. Consumption for woodstoves can be further divided into approximately 70 percent conventional woodstoves (no control devices) and 30 percent catalytic/non-catalytic woodstoves."

There are two key issues that need to be addressed in regards to these statements. First, the data in the referenced EIA report do not provide a direct mechanism to calculate the relative wood usage between fireplaces and woodstoves. As discussed earlier, the 28% to 72% split for wood use between fireplaces appears reasonable. However, it is not a rigorous quantitative number that can be used to calculate weighted emission factors. (It is unclear whether this split was used to calculate weighted 7-PAH and 16-PAH emission factors as discussed in the preceding paragraph.) The second issue is that the estimate of 30% wood use in catalytic/non-catalytic woodstoves in 1990 is too high. Under federal regulations conventional woodstoves could be manufactured up to July 1, 1988 and sold up to July 1, 1990. While many manufacturers started manufacturing and selling Phase I (and Phase II) certified catalytic and non-catalytic woodstoves prior to these cutoff dates, 30% wood use in them during 1990 is not a reasonable estimate based on the turnover rate of woodstoves. It is likely that less than 5% of the woodstoves in use in 1990 would have been catalytic/non- catalytic stoves. Wood use attributed to them as compared to conventional woodstoves, would be more or less at the same percentage, since they are on one hand, more efficient but on the other hand, one might argue more serious wood burners would purchase them. The low estimate is confirmed by the results of a survey conducted by the Oregon Department of Environmental Quality in

Portland, Oregon for 1993 (reference 17). The results showed that 35% of the homes with woodstoves and stove-like inserts had certified devices in 1993. Certified devices in this case included both Oregon and EPA certified devices. The state of Oregon did not allow conventional stoves to be sold retail after July 1, 1986. (Oregon certification was, by in large, the model on which EPA certification was subsequently based). Consequently, in Portland, Oregon, homeowners took six and one-half years to replace 35% of their woodstoves with certified stoves. Again, nationwide (except for Oregon) conventional woodstoves could be sold up to July 1, 1990 and, of course, the base year for the EPA draft report is 1990.

It is further stated in section A.24 of Appendix A that, "Table A-16 lists the emission factors for each pollutant that were used in the inventory. The EOM factor is a weighted emission factor which represents conventional and catalytic/non-catalytic woodstove use. The EOM emissions factor was developed from test results for 14 woodstoves; 12 of these were conventional stoves and the other 2 were catalytic designs. The EOM emission factor represents an average of these test results weighted based on the percentage of conventional and catalytic/non-catalytic woodstove use described above."

There are three points that need to be addressed regarding these statements. First, as previously discussed, the EOM emission factor was developed from 12 tests on a single conventional woodstove and on two tests with a single catalytic woodstove which will effect the weighing calculation. Secondly, also as previously discussed, a 30% catalytic/non-catalytic number is too high for 1990, and, third, the EOM emission factor (18.66 lbs/ton) listed in Table A-16 of Appendix A was multiplied by 45.6 million tons (rounded off and reported as 46 million tons in Appendix A) to produce a total emission value for RWC of 425,448 tons/yr (Table 3-2 and Figure 3-3 of the EPA draft report). No weighing was performed for the 28% of wood purported by the EPA draft report to be used by fireplaces.

National Level Activity Value

The total cordwood usage value of 45.6 million dry tons for 1994 was reported in appendix B of the L & E document and in appendices A and B of the EPA draft report (rounded off and reported as 46 million in appendix A). This value was multiplied by the 7-PAH, 16-PAH and EOM emission factors to obtain the total RWC values for 1990 of 800 tons/yr, 11,800 tons/yr and 425,448 tons/yr, respectively.

According to the Household Energy Consumption and Expenditure survey (references 12 and 13), 29.1 million cords of wood were burned in 1990 (actually December 1989 through November 1990). The Energy Information Administration uses a conversion factor of 1.163 tons per dry cord (reference 14) which is consistent with the mean cord weight of 1.212 tons per dry cord determined for 36 tree species (standard deviation around the mean of 0.386 tons) commonly used as fuel (reference 18). The 29.1 million cords of wood burned in 1990 multiplied by the conversion factor of 1.163 tons per dry cord yields 33.8 million tons of wood burned in 1990, a significantly lower value than the value (45.6 million tons) used by the EPA. Additional confusion regarding the correct national level of activity value appears to be associated with the facts that both appendices A and B of the EPA draft report and appendix B of the L & E document cite a document that does not contain the national activity level (reference 19 here), and the Energy Information Administration states that the wood energy consumption originally reported for 1990 as 786 trillion BTU was subsequently revised to 581 trillion BTU (see Table 1, page 16 of reference 14). The number of tons of wood corresponding to 786 and 581 trillion BTU are 45.6 and 33.8 million, respectively.

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