Global Warming Reduction Benefits of Manufactured Biowax-Fiber Fireplace Logs
(Summary Report)

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March 27, 2007

Introduction

Climate change and the emissions of greenhouse gases have become some of today's most pressing societal issues. The purpose of this study was to evaluate and compare the greenhouse gas emissions (GHG) from commonly used fireplace fuels. The focus of this analysis was the State of California, as the state government has taken a leading role in the measurement and regulation of greenhouse gas emissions from anthropogenic sources. While the data utilized to support the final calculations of fireplace GHG emission are based on California fireplace usage, the conclusions noted herein are applicable to other states with large metropolitan areas where fireplace usage is common.

In 2004, anthropogenic activities in California were responsible for 492 million metric tons of carbon dioxide (CO_2) equivalent greenhouse gas emissions. Within the United States, California is the second largest emitter of CO_2 after Texas, and only nine nations in the world have greater total GHG emissions than California. The combustion of biomass fuels in lieu of fossil fuels is generally recognized to reduce global warming impacts, and is being strongly advocated by industry and government officials as a significant opportunity to reduce GHG emissions within the state.

Residential fireplaces are in wide use in California and, because of the state's large population, there are more fireplaces than in any other state. Fireplaces can be fueled by four sources of energy: natural gas, liquefied petroleum gas (LPG), cordwood, and wax-fiber firelogs. Historically, wax-fiber firelogs have been composed of both biomass fiber and petroleum wax (i.e., a mixture of biomass and fossil fuels). A new generation of wax-fiber firelogs now available replace the fossil fuel derived petroleum waxes with renewable, natural waxes derived predominantly from plant materials, making an entirely biomass-derived product.

Wax-fiber firelogs have become popular for use in solid fuel fireplaces, with 57 % of solid fuel fireplace users reporting burning wax-fiber firelogs occasionally in 2006, and 22 % using them as their normal fuel. Over 100 million firelogs are sold annually in North America. California is the largest market for firelogs and over 30% of all firelogs produced are consumed within the state.

There are six fireplace hardware/fuel options available for California residents. These are: (1) vented natural gas fireplaces; (2) vented LPG fireplaces; (3) vented natural gas log sets; (4) vented LPG log sets; (5) cordwood burned in solid fuel fireplaces; and, (6) wax-fiber firelogs burned in solid fuel fireplaces. Fireplace inserts designed to convert the open fireplace to a closed combustion heater are not included in this analysis. Once fireplaces have been converted to heaters by the installation of gas, pellet or cordwood inserts, they no longer fill the role of a traditional fireplace.

About 73 % of solid fuel fireplaces and 80 % of gas-fueled fireplaces are used in a given year. Most fireplaces, that are used, are used for aesthetics or for occasional secondary heat; very few are used for primary heat, principally due to their low heating efficiencies. On the average, a fireplace in California, if it is used, is used 38 times per year with duration between 2.5 hrs to 3.5 hrs. (It should be noted that, not surprisingly, the frequency of fireplace usage varies in the different climate zones in California. The usage frequency quoted here is based on data primarily derived from the Central Valley and Bay Area. Fireplace usage will be greater in colder northern and mountainous regions and less in the southern areas of the state.)

Energy per Fireplace Fire Event (FFE)

Because of the different operational characteristics among the six fireplace hardware/fuel options, each fireplace option consumes a different amount of energy for a typical residential fireplace fire.

For example, the energy content of a typical wax-fiber firelog is approximately 14,000 Btu per dry pound as compared to about 8,500 Btu per dry pound for natural cordwood. Further, the average moisture content of wax-fiber firelogs is much less than normal cordwood used in fireplaces. Because of an inherent higher energy content and lower moisture content, firelogs have a higher energy density than normal cordwood. Accordingly, less mass of fuel is required for a comparable fire and consequently for emissions comparisons with cordwood to be meaningful they need to be made on a per fireplace fire-event rather than on a unit mass basis.

Further, unlike utilitarian heaters, fireplaces are used more for aesthetics and for the comfort that radiant heat provides in the proximity of the fire. In many cases, the net overall home heating effectiveness is negative due to drawing large volumes of unheated outside air into the home. For these reasons, appliance efficiencies are not applicable for comparisons between the fireplace/fuel options.

To provide a basis for comparison, the concept of a Fireplace Fire Event (FFE) was developed. Simply put, the FFE is the single typical fireplace fire that ranges between 2.5 hrs and 3.5 hrs in duration and that provides the consumer with the fireplace experience. The amount of energy consumed to provide that experience varies with the fireplace/fuel option based on the particular physical / chemical characteristics and burn rates of the various fuel options. (Table ES-1)

Table ES-1
Energy per Fireplace Fire Event (FFE)

Fireplace/Fuel Type	Btu/FFE	Fuel Unit/FFE
Vented NG Fireplace	76,800	74.8 ft^3
Vented LPG Fireplace	76,800	0.84 gal.
Vented NG Log Set	155,950	151.8 ft^3
Vented LPG Log Set	155,950	1.70 gal.
Wax-Fiber Firelog in Solid Fuel Fireplace	79,760	6 lbs.
Cordwood in Solid Fuel Fireplace	219,390	26.9 dry lbs

NG = Natural Gas

Fuel Cost Comparison

Economic implications are components of any GHG mitigation strategy. Each of the six-fireplace/fuel options has different fuel and hardware costs associated with them. The difference in fuel costs to provide a typical fireplace fire, or a fireplace fire event (FFE), varies with fuel type due to characteristically different amounts of energy required for the different fireplace/fuel scenarios and the different unit prices for the different fuels. The cost for a typical fire in California for each of the fireplace/fuel scenarios is shown in Table ES-2.

Table ES-2
Fuel Cost Comparison

Fireplace/Fuel Type	Btu/FFE[1]	Fuel Unit/FFE[1]	Cost of Fuel per Fire[2]
Vented NG Fireplace	76,800	74.8 ft^3	$ 0.89
Vented LPG Fireplace	76,800	0.84 gal.	$1.66
Vented NG Log Set	155,950	151.8 ft^3	$1.81
Vented LPG Log Set	155,950	1.70 gal.	$3.36
Wax-Fiber Firelog in Solid Fuel Fireplace	79,760	6 lbs.	$2.99
Cordwood in Solid Fuel Fireplace	219,390	26.9 dry lbs (bulk)	$2.47[3]
		0.75 ft^3 (bundle)	$3.99[4]

NG = Natural Gas
[1]FFE = Fireplace Fire Event
[2]LPG fuel cost (197.2 cents per gallon) used in estimate is for the West census region, 2006.
Natural gas fuel cost ($11.92/$10^3$ ft^3) used in estimate is for California, 2006, neither costs include taxes.
[3]Bulk cordwood data used in calculation are $283/cord and 3081 lbs/cord.
[4]A bundle of cordwood as purchased at a retail store is usually 0.75 cubic feet, costs $3.99 and is designed to fulfill the fuel requirements of a single FFE.

An existing solid fuel fireplace can be used with cordwood or wax-fiber firelogs or it can be converted to gas (natural gas or LPG) with a log set. Usually the conversion to gas also requires that the gas piping system inside the home be modified or extended. The average cost for installation of a gas log set is $1,209. If the cost of gas log conversion is amortized on a per fire basis over the normal useful lifetime (12.7 years) of a log set, the cost per fire for gas logs sets increases by $2.50 for a total cost of $4.31 per fire for natural gas and $5.86 per fire for LPG.

Fireplace Greenhouse Gas Emissions Comparison

Greenhouse gases emitted from fireplaces include water, carbon dioxide, methane, nitrogen oxides, carbon monoxide, and a variety of non-methane volatile organic compounds. Fine particles are also emitted from fireplaces.

As with the complete combustion of any organic material, carbon dioxide and water are the end products of complete combustion in fireplaces. The combustion efficiency of fireplaces, regardless of the fuel type, is generally over 90 %. Consequently, the carbon dioxide emission levels can be estimated from the carbon content of the fuel and the fuel burn rate. The fraction of carbon that is not completely combusted is primarily in the form of creosote and soot accumulated on chimney surfaces or as char in combustion residue (bottom ash) with a smaller fraction lost as products of incomplete combustion (PIC) in air emissions.

There are four major components of greenhouse gas emissions from fireplaces: (1) Carbon dioxide directly emitted from fuel combustion in the fireplace; (2) Secondary CO_2 emitted from energy used in the extraction, harvesting, manufacturing, handling, processing, transporting, etc. of the fuel prior to it being burned in the fireplace; (3) Methane directly emitted as a product of incomplete combustion when the fuel is burned in the fireplace; and, (4) Fugitive CH_4 emissions from the natural gas system prior to the natural gas reaching the fireplace. Air emissions of particles and other gases play only a very minor role in terms of climate impact as compared to these four major components.

A key factor in the comparison of GHG emissions from the various fireplaces fuel options is that CO_2 directly emitted upon combustion of biomass is not included in greenhouse gas inventories. This is consistent with guidelines for preparation of greenhouse gas inventories recognized by the Intergovernmental Panel on Climate Change (IPCC)[1], and the United States Environmental Protection Agency (EPA). In fact, in the 2006 U.S. GHG emission inventory report, EPA states, "The combustion of biomass fuels such as wood, charcoal, wood waste, and biomass-based fuels such as ethanol from corn and woody crops generates CO_2. However, in the long run the CO_2 emitted from biomass consumption does not increase atmospheric CO_2 concentrations, assuming the biogenic carbon emitted is offset by the uptake of CO_2 resulting from the growth of new biomass. As a result, CO_2 emissions from biomass combustion have been estimated separately from fossil fuel-based emissions and are not included in the U.S. totals."[2] Consequently, the emissions of biomass fuels are often classified as "carbon neutral", and the carbon dioxide directly emitted from combustion of biomass fuels has been excluded from this analysis.

However, the secondary CO_2 associated with preparing biomass fuels and the CH_4 directly emitted from biomass fuel upon combustion in the fireplace are considered to be contributors to GHG inventories and have been accounted for in the analysis. The contribution of each of the four components and the biomass credit are well understood, can be documented and are upon review of the supporting data intuitively reasonable.

The significant finding (noted in Table ES-3) is that the biowax-fiber firelogs burned in a solid fuel fireplace produce the lowest GHG emission levels among all the fireplace fuel options.

[1] Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme (UNEP), Organization for Economic Co-Operation and Development (OECD), and International Energy Agency (IEA), 1997, Revised 1996 Guidelines for National Greenhouse Gas Inventories

[2] U.S. Environmental Protection Agency, 2006, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004, Washington, DC, http://www.epa.gov/globalwarming/publications/emissions

Table ES-3
Fireplaces in California and Their Greenhouse Gas Emissions

Fireplace/Fuel Type	Number of Fireplaces in Use in California[1]	GHG Emission per Fireplace per Fire (lbs. CO_2-Eq./FFE[2])
Vented Gas Fireplaces		
Natural Gas	1.7 million	11.7
LPG	0.2 million	12.6
Vented Gas Log Sets		
Natural Gas	1.0 million	24.0
LPG	0.06 million	25.7
Solid Fuel Fireplaces	2.7 million[3]	
Cordwood		5.5
Traditional Petroleum Wax-Fiber Firelogs		17.5
New Biowax-fiber Firelogs		4.3

[1]73% of solid fuel fireplaces and 80% of gas-fueled fireplace are used, only the number used are shown in the table.
[2]FFE = Fireplace Fire Event
[3]22% of solid fuel fireplaces users normally use wax-fiber firelogs, more use them less frequently.

Conclusions

New formulation biowax-fiber firelogs are a cost effective method for reducing the greenhouse gas emissions from residential fireplaces. Biowax-fiber firelogs reduce GHG emissions by more than 63 % and 82 % as compared to either natural gas or LPG burned in dedicated vented gas fireplaces or vented gas firelogs installed in open-hearth fireplaces, respectively. Biowax-fiber firelogs also emit 22% fewer green house gases than equivalent cordwood fires. Additionally, numerous studies have shown firelogs produce significantly less particles, carbon monoxide and other hazardous air pollutants than cordwood.

Biowax-fiber firelogs offer an environmentally sound option for residential fireplaces.
Further, increased use of biowax-fiber firelogs as a fireplace fuel conserves natural resources by utilizing byproduct materials and extends the supply of limited fossil fuel resources such as natural gas for utilization for other higher value end uses.

This summary report is an abridged synopsis of a detailed study which draws it conclusions from a rigorous analysis of over 100 publicly available reference documents relating to the usage, physical and chemical properties and emission characteristics of fireplace fuels. A full copy of the entire report, references and appendices are available by request from the author, sponsor of the study, or via the Internet at;
http://www.omni-test.com/publications/GlobalReductionBiowaxFiberLogs.pdf