



Global Warming Reduction Benefits From the Use of Pellet Fuel for Residential Heating

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Myth #1

Biomass Fuels are Greenhouse Gas Neutral

They are not.

A more accurate statement is:

“Carbon dioxide produced by biomass combustion is not considered a greenhouse gas.”



The U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks

“The combustion of biomass fuels such as wood, charcoal, wood waste, and biomass-based fuels such as ethanol from corn and woody crops generates CO₂. Assuming the biogenic carbon emitted from biomass combustion as CO₂ is offset or exactly balanced by the uptake of the CO₂ by the growth of new biomass, the total amount of bio-derived CO₂ in the atmosphere will not increase over time. This has been officially recognized in that CO₂ emissions from biomass combustion have been estimated separately from fossil fuel-based CO₂ emissions and are not included in the official inventories of CO₂ sources in the U.S. or Canada.”



Reasons for Greenhouse Impacts from Biomass Combustion

1. Methane produced as a product of incomplete wood combustion (PIwC) is a greenhouse gas and it has a *Greenhouse Warming Potential* (GWP) 21 times larger than carbon dioxide.
2. *Energy Return on Energy Investment* (EROEI) is approximately 13:1 for pellet fuels. Most of the energy invested in pellet fuels is the fossil fuels that power the manufacturing, drying, and transportation of pellet fuels.



Myth #2

Greenhouse Gas (GHG) Uptake by Photosynthesizing Plants and Their Release Rates from Biomass Fuel Combustion are Significant

For example, it has been stated:

- By replacing harvested mature trees with more rapidly photosynthesizing juvenile trees removes carbon dioxide more rapidly from the atmosphere thereby producing a global warming benefit.
- Burning biomass rather than using it structurally or land-filling it increases global warming impacts due to fast release rather than slow release through decay.

These factors have only very small impacts on the bio/atmospheric carbon cycle and are even then only realized over a long periods of time compared to introducing fossil fuel carbon (tens of millions of years old) into the modern carbon cycle. (Note: the bio-productivity of the oceans dwarfs the bio-productivity of terrestrial woody plants)



Bottom Line #1

There is a large greenhouse gas benefit realized by using pellet fuel in lieu of fossil fuel for residential heating. This is primarily due to its carbon dioxide being excluded as being counted as a GHG. However, don't forget that the methane produced by PIwC and the CO₂ generated by the energy invested in pellet fuel production are still significant enough to be included.

Net GHG benefit from replacing fossil fuel heating appliances with pellet fuel heating appliances =

- (CO₂ from fossil fuel combustion)
- (CO₂ from invested energy for fossil fuels)
- (CH₄ from incomplete fossil fuel combustion)
- + (CO₂ from invested energy for pellet fuel)
- + (CH₄ from pellet fuel combustion)



Bottom Line # 2

There is an additional GHG benefit realized by using pellet fuel in lieu of natural gas. Since North American natural gas averages about 90% methane, the loss of 1.75% of the amount of natural gas that reaches homes from leaking valves, flanges, pumping stations, etc., results in an additional and significant contribution to GHG emissions.

GHG benefit of replacing natural gas heating appliances with pellet fuel heating appliances =

- (CO₂ from natural gas combustion)
- (CO₂ from invested energy for natural gas recovery and transport)
- (unburned CH₄ from natural gas burners)
- (fugitive CH₄ loss)
- + (CO₂ from invested energy for pellet fuel)
- + (CH₄ from pellet fuel combustion)]



Bottom Line #3

There are differences in GHGs between cordwood and pellets. The magnitude and direction of the net effect of the differences is not known but needs to be resolved. Two difference factors favor pellets one favors cordwood.

EROEI for pellets is about 13:1, EROEI.

For cordwood EROEI is greater but there are no data.

Methane emissions from cordwood are greater than for pellets but there is only limited data.

Pellet stoves are more efficient than cordwood stoves (~75% vs. ~ 65%). Therefore, less biomass is burned in a pellet stove and can be easily quantified.



Home Heating in the United States

| Fuel | Main Heating Fuel (2005 housing units, X 1000) | Secondary Heating Fuel (2005 housing units, X 1000) | Millions of Btu per Household (2001) |
|----------------------------------|--|--|---|
| Electricity* | 40,648 | 12,582 | 108.7 (36.4)** |
| Piped Gas | 61,850 | 7194 (combined piped and bottled gas) | 72.4 |
| Bottled Gas | 7551 | | 40.2 |
| Fuel Oil | 10,260 | 829 | 81.7 |
| Kerosene or Other Liquid Fuel | 713 | 791 | 16.1 |
| Coal or coke | 114 | 104 | - |
| Wood | 1768 | 9361 | 25.9 |
| Solar Energy | 16 | 27 | - |
| Total | 123,257 | 27,345 | 92.2*** |

*72% of electricity is generated by fossil fuels, transmission line losses are 12%, and coal-fired power plants (ie, good ones) are 33% efficient

**108.7 is primary, 36.4 is site

***excludes primary electricity and wood



Global Warming Benefit Scenario

61,850,000 households use natural gas as main heating fuel (AHS, 2005)

72.4 million Btu natural gas/household (EIA, 2001)

Assume 0.1% of these households change 50% of their heating needs to pellet fuel

$(0.001) \times (0.5) \times (61,850,000 \text{ households}) \times (72.4 \text{ million Btu/household}) = 2.2 \text{ trillion Btu}$

GHG from the combustion of 2.2 trillion Btu of natural gas =

$$\begin{aligned} & (133,000 \text{ tons CO}_2\text{-eq. from CO}_2 \text{ emitted upon combustion}) \\ & + (20,880 \text{ tons CO}_2\text{-eq. emitted from invested energy}) \\ & + (61 \text{ tons CO}_2\text{-eq. from methane directly emitted upon combustion}) \\ & + (14,900 \text{ tons CO}_2\text{-eq. from fugitive methane loss}) \\ & = \mathbf{168,761 \text{ tons CO}_2\text{-eq.}} \end{aligned}$$

GHG from the combustion of 2.2 trillion Btu of pellet fuel =

$$\begin{aligned} & (15,600 \text{ tons CO}_2\text{-eq. from CO}_2 \text{ emitted from invested energy}) \\ & + (19,500 \text{ tons CO}_2\text{-eq. from methane directly emitted upon combustion}) \\ & = \mathbf{35,100 \text{ tons CO}_2\text{-eq.}} \end{aligned}$$

Net GHG benefit from pellet fuel = $168,761 - 35,100 = \mathbf{133,661 \text{ tons CO}_2\text{-eq.}}$



Bonus Topic: Pellet Fuel vs Corrosion

The Players

| | |
|----------|---|
| Ash | Potassium, sodium, and other salts (namely, sulfates and chlorides) |
| Sulfur | Organic sulfur, sulfate sulfur and pyritic sulfur |
| Chlorine | Chlorides and organic chlorine |
| Nitrogen | Amino acids (protein, seed germ) |



Common Sources of Corrosive Agents

- Demolition wood (high chloride and sulfate)
- Bark (high nitrogen and potassium)
- Coal dust (high sulfur and salts)
- Chlorinated plastics (PVC)
- Sea salt (logs transported in marine environment)
- Treated wood (preservatives, resins, pesticides, glues, paints, etc.)
- Agricultural byproducts (straw, stubble, stover, nut husks, etc.) have high potassium and chloride
- Seeds (high nitrogen)
- Log yard debris (plain dirt)



Chemistry

- Potassium salts, namely, potassium chloride (KCl) and potassium sulfate (K_2SO_4) are volatile, i.e., they reach the stack rather than remaining in the ash, have low melting points, ie, they facilitate clinker formation, and they are a major component of plant tissue as reflected in the need for potassium fertilizer
- Organic sulfur and pyritic sulfur (common in coal) form corrosive sulfate salts and sulfuric acid
- Organic chlorine forms corrosive hydrochloric acid and chloride salts
- The decomposition/combustion of amino acids produces corrosive nitric acid and ammonium salts



Typical Corrosive Content of Pellet Materials

| Material | Ash (%) | Nitrogen (%) | Sulfur (ppm) | Chlorine (ppm) | Potassium (ppm) | Sodium (ppm) |
|----------|--------------------|--------------------|--------------------------------------|----------------------------|-----------------|-----------------------------|
| Wood | 0.51 | 0.22 | 278 | 48 | 493 | 17 |
| Bark | 4.85 | 0.34 | 403 | 221 | 1750 | 23 |
| Straw | 5.40 | 0.54 | 766 | 1150 | 7940 | 60 |
| | PFI standard 1% | Sunflower 1.38% | low sulfur coal <10,000 ppm | PFI standard 300 ppm | | sea salt, 306,000 ppm |



Hardwood vs Softwood

Hardwood 1.0% to 1.3 % ash

Softwood 0.4% to 0.8% ash

Counter-intuitively, softwood pellets have more heat (Btu) per pound when made to the same size and density than hardwood pellets due to a typically higher resin (17,400 Btu/lb) and lignin content as compared to hardwood



Summary

For most pellet materials potassium salts (KCl and K_2SO_4) and the nitrogen content are most important in terms of corrosion