Why CO_2 from Wood Fuels Is Carbon Neutral in Combustion

The first serious flaw in research that shows that carbon emissions for wood combustion add to the stock of atmospheric carbon is the timing of their carbon cycle assumptions. The second serious flaw is the accounting for contemporaneous carbon dioxide (CO_2) emissions from the combustion of wood. This article discusses both.

by William Strauss

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The discussion about carbon emissions and the impact of using biomass for fuel on atmospheric carbon dioxide levels requires a conclusion about the effects of CO_2 on climate. To frame the foundation of our discussion, let's begin with two points.

First, most of the developed world has moved past the debate on whether or not geologic carbon released from the combustion of fossil fuels is driving climate change. There is uncertainty over how quickly and forcefully changes in atmospheric CO_2 levels will drive climate change, but there is nearly unanimous consent that dramatic changes are occurring now and will occur in the future.

Second, the United States is part of a major growth industry in the production and export of industrial grade wood pellets to Europe and eastern Asia. Even if U.S. environmental and energy policy does not acknowledge and price the external costs of adding to the atmospheric and oceanic carbon stocks, U.S. business is investing heavily in a sector that does depend on carbon policies in Europe and elsewhere.

In Europe, industrial wood pellets are co-fired with coal in large power plants to lower the total CO_2 output per megawatt-hour of generated electricity. As of May 2012, the United States was producing 3.2 million tons per year of wood pellets for export.[1] That production level is expected to double by the end of 2014 and is forecast to reach at least 18 million tons per year by 2017.[2]

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It is ironic that the United States, which has no policy on CO2 emissions, is the global leader in the production of low-carbon fuel for power generation in Europe.

Putting a price on carbon, either with subsidies such as Britain's renewable obligation certificates (ROCs) or with penalties such as Sweden's carbon tax, is an internalization of the cost of the environmental harm that is caused by adding to the stock of carbon in the ecosphere.

The policies of co-firing wood pellets with coal (or in some locations, firing 100% pellets) is also an affirmation of the carbon benefits of combusting a renewable woody biomass-based fuel.

The net carbon emissions from burning wood-based fuels is the subject of some debate. But as this article will demonstrate, the thesis that wood combustion is worse than coal is wrong for many reasons.

Sustainable Sources

The overarching necessary condition for reaping carbon benefits from wood-based fuels is that the wood must be from sustainable sources. "Renewable" energy is not renewable unless it renews! The European buyers of pellets for power production absolutely require a chain of custody that leads back to forests that are certified as sustainable. If there is any validity to a model that has carbon cycling from atmosphere into trees and back into the atmosphere, the stock of trees must remain constant or growing. Depleting the forests for energy is not renewable. A shrinking forest is a net carbon source.

Fortunately, the U.S. forest products industry has a long history of managing forests for sustained yield. In some states, the majority of the managed forests are certified sustainable by either Forest Stewardship Council (FSC) or the Sustainable Forestry Institute (SFI).

A serious flaw in research that shows that carbon emissions for wood combustion add to the stock of atmospheric carbon is the timing of their carbon-cycle assumptions. Many models begin the story at the moment the wood is harvested.[3] Without fossil fuel combustion, and assuming a stable forest stock, the carbon in the trees is part of a net stock of non-geologic carbon on the planet. In other words, no new carbon from combustion is released when a tree is harvested, refined, and used as fuel.[4] What is released used to be in the atmosphere before the new growth captured it.

All of the studies that show that wood-to-energy adds to the carbon stock of the atmosphere assume a carbon debt is created that has to be repaid by new growth over 30 to 80 years (or more is some studies).

Figure 1 shows the correct frame of reference for a forest that is sustainably managed. The figure shows the carbon-cycle for one harvest. In this model, the forest grows at a rate of one ton per acre per year.[5] The model forest is 100,000 acres,[6] which means that each year there is 100,000 tons of new growth. The figure assumes that this year's 100,000 tons harvest started growing 30 years ago in 1984. Note that the net carbon stock of the atmosphere is reduced over those 30 years as the new growth absorbs carbon. This is shown by the downward sloping green line.

In 2013, when this year's 100,000-ton harvest is combusted as fuel, the previously sequestered carbon is released. The cycle is repeated in 2045. But the carbon does not have to wait until 2045 to be removed from the atmosphere. The new 100,000 tons that grows in 2013 captures all of the carbon released, as long as the net stock of wood on the 100,000 acres of forest is not diminished. In contrast, if the same amount of energy is released from coal in 2013 and 2045, the net stock of atmospheric carbon is permanently increased. This is shown by the black line in Figure 1.

The model used to generate Figure 1 uses the carbon emission assumptions that are in the Manomet study.[3] And that leads to our second critique.

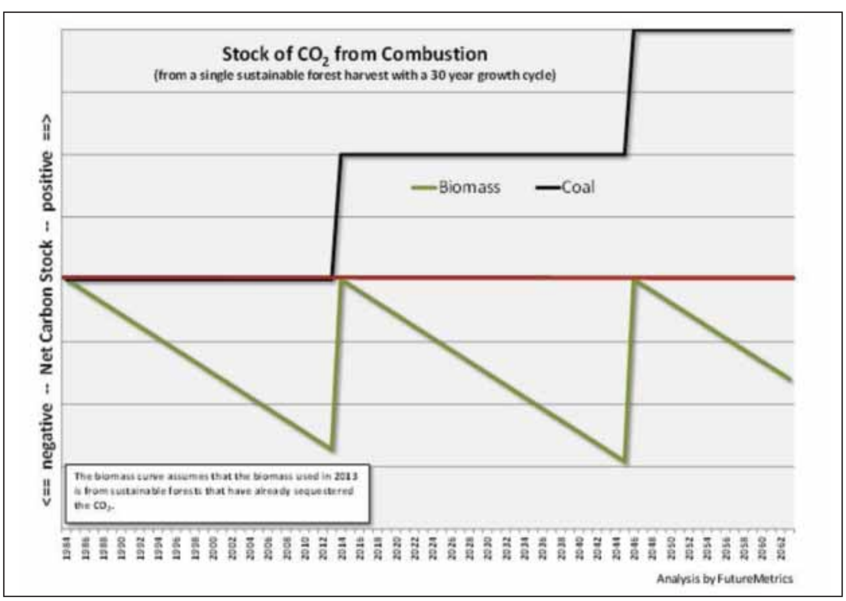

Figure 1. The carbon-cycle for one harvest of a forest that is sustainably managed.

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CO_2 Emissions

The Manomet study assumes that the combustion of wood releases 34.6% more CO_2 than the combustion of coal.[7] We all know that coal started its life a long time ago as biomass. And, it turns out, on a dry basis, coal and wood yield very similar results in terms of the CO_2 produced (in terms of kilograms of CO_2 per unit of potential energy).

The results of our analysis shows that wood is generally about the same or perhaps a bit lower in CO_2 emissions on a dry basis (zero moisture content). Of course, most wood does not have zero moisture content (MC).

It is the water in fuel that causes its CO_2 emissions to increase over the dry weight basis. The scientific terminology for the process that drives this phenomenon is known as "the enthalpy of vaporization". In simple terms, it takes energy to evaporate the water in the wood or coal and convert it to vapor (steam). All of that energy is then sent out the chimney and into the atmosphere in water vapor. Thus, to get a million BTUs of useful energy from the fuel, a larger mass of wood is necessary to compensate for the losses from vaporizing all that water. More wood per unit of energy means more CO_2 per unit of energy.

Figure 2 shows the CO_2 production for wood from 0% to 50% MC. The Manomet study used 45% (page 103 of that study). The figure also shows CO_2 from several grades of coal. At 45% MC, the combustion of wood yields approximately 9% more CO_2 per unit of useful energy than an average of the coal grades' outputs.[8] While still more than coal, this is significantly less than the 34.6% difference that drives the Manomet model. Wood at MC below 20% has the same or less CO_2 emission per unit of useful energy as most grades of coal.

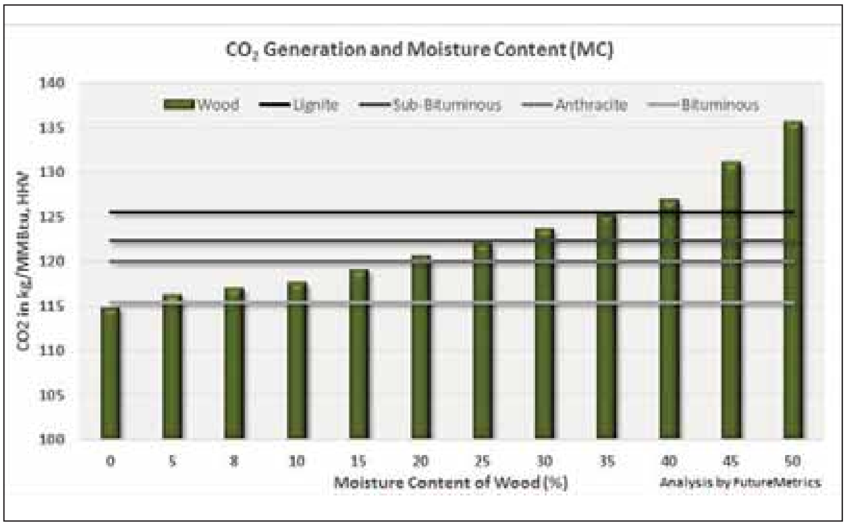

Figure 2. The CO_2 production for wood and several grades of coal from 0% to 50% moisture content.

Summary

Creating new coal to recycle the carbon released from coal combustion takes eons. As we have clearly shown above, with sustainable forest management, the recycling of carbon from wood combustion is contemporary and continuous. Therefore, the net stock of CO_2 in the atmosphere from the combustion of wood is not increased.

This conclusion underpins the policies that are both mitigating CO_2 emissions and benefiting the U.S. export market. Over the next three or four years, around $3 billion will be invested in the United States for 15 million tons per year of new pellet manufacturing capacity. Annual revenues from the export of U.S. pellets are expected to be more than $2.9 billion in 2017.

All of that investment is for the export of low carbon fuels to nations that have codified the carbon benefits of sustainably sourced wood pellet fuel. It is ironic that the United States, which has no policy on CO_2 emissions, is the global leader in the production of low-carbon fuel for power generation in Europe. **em**

End Notes and Sources

1. Harris, Jr., T.G.; Baldwin, S.; Smith, J.; Simmons, R. Southern Timber Market Trends. Presented to the Forest Landowners Association at the Wood Pellet Update, Sawgrass, FL, May 30, 2012.
2. Walker, S. North American Wood Pellet Markets. Presented to the Pellet Fuels Institute at the 2012 PFI Annual Conference, Mashantucket, CT, July 29-31, 2012.
3. *For example:* Manomet Center for Conservation Sciences (2010) "Massachusetts biomass sustainability and carbon policy study: report to the commonwealth of Massachusetts Department of energy resources. *And*: Holtsmark, B. The outcome is in the assumptions: analyzing the effects on atmospheric CO_2 levels of increased use of bioenergy from forest biomass; *Gcb Bioenergy* **2012**, *9* (29), 512929-05; DOI: 10.1111/gcbb.12015.
4. The harvest, refinement, and transport of wood-base fuels does require fossil fuel (e.g., diesel for trucking, heavy oil for shipping, and electricity from coal or gas for pelletizing). A life cycle analysis of pellets has a component of carbon emission from those activities. Fossil fuels also incur extraction, transportation, and refining carbon debts.
5. Northern forests grow a slightly above that rate. Southern forests grow at a significantly higher rate.
6. The United States and Canada have more than 480 million acres of certified sustainable forestland. See Wood Products Council (2012) "Sustainable Forestry in North America."
7. Based on data in the table in appendix 2-A on page 129 of the Manomet study.
8. This assumes that both the coal plant and the biomass power plant have the same boiler efficiency. This may not be true for older stoker biomass power plants, but is true for modern fluidized-bed systems.

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