THE TREATMENT OF BIOMASS FUELS IN CARBON EMISSIONS TRADING SYSTEMS

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Cover photo: The main house at Airlie Center, the location of the Greenhouse Gas Emissions Trading Braintrust meetings. Photograph reproduced with the permission of Airlie Foundation.

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The Airlie Carbon Trading Papers

The Airlie Carbon Trading Papers are intended to help lay the intellectual foundation for a US greenhouse gas emissions trading system, which is a leading policy option for realizing cost-effective reductions of greenhouse gas emissions. The papers are the product of a unique research, analysis and dialogue process directed by the Center for Clean Air Policy. Since November 1996, the Center has convened regular meetings of its “Greenhouse Gas Emissions Trading Braintrust”, a group of high-level representatives of industry, environmental organizations, state and federal government agencies and academe. The opinions expressed in these papers are those of the Center, though our views are informed by the extensive dialogue with Braintrust participants.

Braintrust members and Center staff conduct research and analysis of key design and implementation questions, then bring their findings and proposals to the group for discussion. The purpose of this process is to investigate alternative design options in detail rather than to arrive at consensus on a preferred option.

At the outset, the Braintrust identified a number of priority issues, including: definition of the instrument that would be traded, determination of who would be required to hold allowances, methods for allocating allowances, and the elements of the trading system compliance infrastructure. Braintrust members agreed to start with a focus on energy-related carbon dioxide emissions. Secondary issues identified by the Braintrust include the integration of additional greenhouse gases into the system, the incorporation of emissions reductions from forestry and land use activities and foreign countries, and the mitigation of any adverse impacts of carbon regulation on US industry.

Why the “Airlie” Carbon Trading Papers? The Airlie Center serves as the backdrop for the Braintrust’s meetings. Situated outside the Washington, DC beltway in Warrenton, Virginia, Airlie provides an informal, congenial atmosphere that allows participants to leave their affiliations “at the door” and to build strong working relationships. These factors have been critical to the success of the Braintrust process.

About the Center for Clean Air Policy

Since its inception in 1985, the Center for Clean Air Policy has developed a strong record of designing and promoting market-based solutions to environmental problems. The Center’s dialogue on acid rain in the 1980s identified many of the elements of the SO2 control program that were adopted by the Bush Administration and eventually codified in the Clean Air Act Amendments of 1990. Since 1990, the Center has been active on the issue of global climate change. Center staff have participated in the Framework Convention on Climate Change negotiations and in domestic efforts to address greenhouse gases, analyzing and advocating market-based climate policies such as emissions trading and joint implementation. The Center brokered the world’s first energy sector joint implementation project. The Center is also active in the areas of air quality regulation, electricity industry restructuring, and transportation and land use.
The Treatment of Biomass Fuels in Carbon Emissions Trading Systems

I. Introduction

The use of biomass fuels presents the opportunity to reduce net greenhouse gas (GHG) emissions, because net emissions from biomass are less than those of fossil fuels. In fact, biomass may be a carbon-neutral fuel because emissions from combustion may be completely offset by carbon captured in growing biomass.\(^1\) Not all biomass fuels produce zero carbon emissions, however; biomass obtained at the cost of net deforestation produces net positive carbon emissions. The challenge in integrating biomass into an emissions trading program is to ensure that only biomass fuel that provides carbon benefits is exempted from allowances and that other biomass fuel is not.

This paper presents an approach for including biomass fuels in a carbon emissions trading program. Under this method, plantations that produce carbon-neutral biomass would be certified as having done so. An upstream trading system (where emission allowances are required of fuel producers) would mean that the plantations would not be required to hold allowances for the certified biomass they sell, while in a downstream system (in which emission allowances are required of fuel users), purchasers of certified biomass would not need to surrender allowances for biomass-related emissions. In either case, under a GHG emissions trading system biomass fuel would gain a price advantage over fossil fuels, which would require allowances due to their carbon emissions.

The paper also argues that a relatively simple approach to biomass fuels should be adopted in the early years, focusing only on the net carbon impacts of closed-loop biomass that is used for power generation or as a feedstock for ethanol production. This approach could be refined later to capture other greenhouse gases such as nitrous oxide (N\(_2\)O), and to cover more complex fuel cycles like that of wood waste.

II. The Biomass Fuel Cycle

Closed Loop Biomass for Power Generation

Net Carbon Emissions

Although biomass-derived fuel may be carbon-neutral in the sense described above, to understand the full emissions impacts of biomass fuels, a life cycle analysis (LCA) is

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\(^1\) Biomass produces no carbon only in the sense that combustion emissions are offsets by sequestered carbon, but it is unlikely to be carbon-neutral from a full life-cycle accounting (LCA) perspective. LCA is discussed further below. Biomass fuel cycles in which emissions from combustion are offset by replanting is known as “closed loop” biomass.
needed. Figure 1 illustrates the fuel cycle of biomass-powered electricity generation. The figure focuses on carbon dioxide (CO$_2$) emission impacts only. The numbers in Figure 1 are taken from a recent LCA of an integrated gasification electricity plant fueled by biomass from hybrid poplar plantations. The 914 g/kWh shown near the left side of the figure represents the CO$_2$ absorbed by the growing biomass, which nearly offsets the 917 g CO$_2$/kWh emitted upon combustion. Most of the emissions occur as the fuel is combusted at the power plant. The schematic thus illustrates how biomass fuel cycles may be essentially a closed loop, or carbon-neutral.

Figure 1 also shows that the production of biomass results in CO$_2$ emissions other than those from combustion. These include emissions from fuel use at the plantation as well as emissions associated with the transport of biomass from the plantation to the power plant. From an LCA perspective, the net emissions of CO$_2$ equal about five percent of total carbon throughput.

The analysis in Figure 1 does not include the pool of carbon in the plantation soil. While significant amounts of carbon are stored in soils, most of this is immobile. When a plantation is established, there may be some initial soil carbon losses, but the early years of biomass growth at the plantation will result in some carbon sequestration in the soils. There is some suggestion in the literature that poplar and switchgrass, two of the leading energy crops, will transfer carbon to the soil in the first years of operation. Eventually, perhaps over several decades, the soil carbon will return to dynamic equilibrium with the rest of the environment, and no further net transfers of carbon to or from the soil will take place. The increased carbon sequestration in the early years of the plantation could more
than offset the net emissions from the rest of the fuel cycle for a number of years after the establishment of biomass plantations. However, the amount of soil carbon fluxes of this kind will be highly site-specific. Generally, soil carbon fluxes will be insignificant compared to the fluctuations in standing biomass.

Figure 1 also does not include the carbon emission impacts of establishing plantations when there is a change from one land cover to another. Establishing a plantation introduces a new carbon cycle. The net carbon impact of this change could be measured by comparing a baseline of the net carbon emissions for the previous land use with the new carbon cycle. Many biomass plantations would be established on land that otherwise would have been uncultivated, thus the carbon emissions associated with the land use conversion would be small relative to the carbon embodied in the new biomass.

Other Gases
Table 1 shows the breakdown of emissions in closed loop biomass electricity by greenhouse gas. Carbon dioxide accounts for 87 percent of the greenhouse gas impact of biomass electricity, while nitrous oxide from fertilizer inputs to the plantation contributes 12 percent of total life cycle greenhouse gas emissions.

<table>
<thead>
<tr>
<th>Greenhouse Gas</th>
<th>Emissions in g CO$_2$-equivalent/kWh (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Carbon Dioxide Emissions</td>
<td>49.80 (87%)</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>6.98 (12%)</td>
</tr>
<tr>
<td>Methane</td>
<td>0.21 (&lt;1%)</td>
</tr>
<tr>
<td><strong>Total Net Emissions</strong></td>
<td><strong>56.99 (100%)</strong></td>
</tr>
</tbody>
</table>


In addition to the fuel cycle for biomass-powered electricity generation depicted in Figure 1, several other biomass fuel cycles also could contribute to greenhouse gas mitigation strategies. Co-firing biomass with coal in existing coal plants represents a promising option in the near term. Here, biomass is mixed with the coal that is burned in an existing coal plant. Existing coal-fired plants can be co-fired with up to 15 percent biomass with only minor modifications to the coal plant. This level of co-firing is more cost-effective than other levels.

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2 The figures in Table 1 are given in terms of equivalent radiative forcing. Radiative forcing refers to the ability of a gas to trap heat in the atmosphere. Grams per kWh of methane and nitrous oxide were multiplied by their respective 100-year radiative forcing indices to produce the numbers in Table 1 in equivalent grams of CO$_2$ per kWh.

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_The Treatment of Biomass Fuels in Carbon Emissions Trading Systems_
Biomass can also be transformed to liquid fuels for transportation applications. Dedicated crops or municipal solid waste both can be used to produce ethanol and other liquid fuels, and processes also exist for making diesel fuel from genetically engineered algae. These are still in early stages of development, however.

Waste products, such as urban wood wastes also may be part of a biomass fuel cycle, as illustrated in Figure 2. While the combustion of these wastes may be distant from the original biomass growth, in principle this biomass fuel cycle is also closed loop.

III. Biomass Fuels in Emissions Trading Programs

Proper accounting for the carbon impacts of biomass fuels under emissions trading will depend in part on the design of the trading system. If the system covers all greenhouse gases, then accounting for the emissions impacts of biomass would require tracking nitrous oxide and methane emissions as well as carbon dioxide. For the sake of simplicity, it has been assumed here that the greenhouse gas emissions trading system would cover only carbon dioxide. Thus, in seeking a way to integrate biomass fuels into a trading system, this paper focuses on accounting for the carbon dioxide impacts of biomass fuels.

Certification

To properly account for the carbon impacts of biomass fuels, the emissions trading system would need to distinguish biomass fuels that are carbon-neutral from those that are not. Biomass fuels that have no carbon impacts should not need allowances. Ensuring that this is the case could be accomplished through a program of certification of biomass plantation carbon impacts. As biomass crops mature and become ready for the market, an independent third party could certify that the carbon to be emitted upon the combustion of biomass is offset by new carbon being sequestered in growing stock.

The certification program would function in the same way regardless of the incidence of regulation in the trading system. In an upstream trading system, where allowances would be held by fuel producers, certified plantation owners would not need to hold allowances for the biomass fuels they produced, while in a downstream system energy users would not need to surrender allowances for emissions from the combustion of certified biomass. Biomass would thus become more competitive with fossil fuels, because fossil fuel producers would need allowances for the carbon embodied in their fuels.

Although we have used biomass electric power as an example, the certification program would function in essentially the same way for other biomass fuels, such as ethanol. The upstream and downstream arrangements described in the previous paragraph would also apply to these fuel cycles. Ethanol used in the transportation sector might be difficult to cover in a downstream system because of the enormous number of end users, but this difficulty would arise when trying to regulate use of any transportation fuel downstream and is not unique to biofuel.

The carbon emissions from plantation operations such as transportation of biomass fuel from the plantation to the power plant fall outside the certification process, but would be covered in a trading system. In an upstream system, these emissions would be covered by the allowances held by fuel producers for the fossil fuels they sell. In a downstream system, the plantation owners would need to hold allowances for the fossil fuels they use. Thus, the emissions associated with plantation management would be fully accounted for in a trading system.

There has been discussion of the use of emissions baselines in evaluating the carbon impacts of establishing biomass feedstock plantations. Comparing the carbon flows from the preceding land use with that of the plantation would result in the calculation of the emission impacts of the land use change. Most plantations would be established on lands that are uncultivated, making it unlikely that the emissions associated with the land use conversion would be significant enough to prevent certification. Thus quantifying emissions baselines for plantations probably need not be required for certification of zero-carbon biomass.

A related issue is that the increasing use of biomass fuels may create incentives for replacing existing forests or other lands with recreational or ecological values with
plantations. The certification program could be designed to protect certain lands by qualitatively excluding plantations which replace such land uses. At present, it is unlikely that landowners would replace forests with biomass plantations because the economics do not justify doing so.

Other Fuel Cycles

The proper treatment of biomass fuel cycles other than biomass plantations presents challenging questions. It is not immediately obvious, for example, how to certify biomass that is made into wood products such as paper or furniture which eventually might become power plant fuel. The proper accounting for the carbon emissions of the waste products that end up in landfills also does not fit neatly into a trading program.

IV. Program Development

The complications discussed above suggest a phased approach for implementing a biomass certification program, which could run as follows:

- Phase 1: The first phase would entail the establishment of procedures to measure and certify the carbon absorbed by biomass being raised to be an energy feedstock and for the production of liquid fuels. This phase might also include monitoring of nitrous oxide emissions from fertilizer applications to develop a procedure for covering these emissions.

- Phase 2: In the second phase, refinements could be made to address more difficult accounting issues. These refinements could include the development of procedures for certifying biomass wastes; the expansion of certification to account for nitrous oxide and methane, and perhaps the development of a system to account for both the carbon emission impacts of plantation establishment and net soil carbon impacts. These last steps could provide information that would be useful in the establishment of a national program to bring carbon sequestration projects into the greenhouse gas emissions trading system.

This phased approach would allow program administrators to gain experience with biomass technologies as they were becoming established and commercialized, and then later refine the carbon accounting system as biomass technologies began to penetrate the market and issues such as emissions from fertilizer began to be significant.
V. Conclusion

Recognizing that biomass fuels may play a significant role in greenhouse gas mitigation under emissions trading, this paper has presented a system for integrating biomass into a carbon emission trading system. The foundation of the proposed phased program would be the certification of the carbon impacts of biomass crops used as energy resources. Biomass plantations that produced fuel for power generation or feedstocks for ethanol production would be exempt from needing carbon allowances, provided that they were certified as being carbon-neutral. Special procedures to appropriately integrate liquid fuels such as ethanol would need to be developed. Certification could be expanded later in the program to cover other greenhouse gases such as nitrous oxide, and other biomass fuels such as wood wastes. By enabling the exemption of certified carbon-neutral biomass fuels from carbon allowances, a program of biomass certification would ensure that the emissions benefits of biomass were recognized in fuel markets.