REVIEW OF "THE NEAR-TERM MARKET AND GREENHOUSE GAS IMPLICATIONS OF FOREST BIOMASS UTILIZATION IN THE SOUTHEASTERN UNITED STATES"

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CONTENTS

INTRODUCTION

The Duke Bioenergy Study assesses the amount of biomass energy that could be generated by maximizing co-firing woody biomass at coal plants in ten Southeastern states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia, with an aggregate average rate of 10.1% coal plant capacity being fueled by biomass.

The study seeks to determine the effect of "moderate policy drivers" on renewables deployment, in this case the mandate to reduce greenhouse gas (GHG) emissions from coal plants by using sources of wood fuel that the study considers to have no net emissions. The relative ease of co-firing biomass in coal plants relative to building direct-fired plants is seen as a possible early policy response.

The study concludes that biomass co-firing at coal plants can realistically reduce carbon emissions. However, this conclusion relies modeling that makes a number of assumptions. This document highlights those assumptions, and the consequences for the study's conclusions if these assumptions are not met.

How the study was conducted

The study examines the wood use and carbon emissions consequences of using wood to generate about 10% of the power at all coal plants in the ten-state region. The study first examines a regional scenario, which aggregates demand at the regional level and treats all biomass as equivalently available for all plants, stating, "no restrictions are placed on the relationship between the location of the facility and the location of the biomass." The second scenario restricts biomass sourcing to counties within 50 miles of each coal plant.

The study calculates net emissions from burning biomass and concludes a carbon benefit from biomass when emissions are lower than from coal. The model uses a five-year time step in the Subregional Timber Supply Model (SRTS) to calculate net emissions as forest sequestration minus emissions under two scenarios, one in which 25% of logging residues are utilized, and one in which 50% are utilized. The SRTS model utilizes Forest Service Forest Inventory and Analysis data on forest parameters and growth, integrating this with information on economic drivers for planting and harvesting to provide projections of changes in forest resources. Net carbon emissions are calculated as forest carbon sequestration, minus carbon removed as fuel under the two harvesting scenarios.

The study considers four main kinds of biomass fuel to be available: wood from logging residues of ongoing pulpwood harvesting, which is considered to entail no emissions since this material would otherwise be left or burned in slash piles, resulting in a net emission of carbon; displaced pulpwood harvesting, also considered to entail no emissions, since this wood was being cut in any case; increased harvesting of pulpwood, which is considered to represent a net carbon emission since an increase in cutting over baseline rates occurs; and residues from this increased cutting, which are presumably treated as representing a carbon emission, though the study is not explicit on this point. The justifications behind what sources of fuel are considered as causing a net carbon emission are discussed later in this document.

Assumptions behind the co-firing model

The ultimate metric for assessing whether biomass co-firing is beneficial is the degree to which it reduces carbon emissions, relative to emissions from coal only. Since wood inherently emits more carbon per unit of energy produced, even when burned at the same efficiency as coal, wood will only be considered to reduce carbon emissions if sources of "carbon free" wood can be burned (waste wood is often considered to be carbon free, since burning it for energy is considered to emit no more emissions than if it were left to decompose), or if forest growth rates are sufficiently high in a biomass utilization scenario that carbon is quickly resequestered (in the co-firing model, carbon sequestration rates are accelerated by the model assuming that future forest planting is stimulated by increased wood demand).

For the Southeastern co-firing scenarios, the reductions in carbon emissions from burning wood, relative to emissions from coal, are relatively small for the aggregated analysis where all woody fuels are considered equally available to every coal plant. For the regional analyses where coal plants are limited to using fuel from within a 50 mile radius, the Highland Rim analysis shows that emissions would actually be significantly *higher* with biomass co-firing than without, and for several of the other regions, the benefits in terms of carbon savings are so small as to be negligible (Figure 1). With such slim margins, it is important to check whether the assumptions behind the model give confidence that the results are robust.

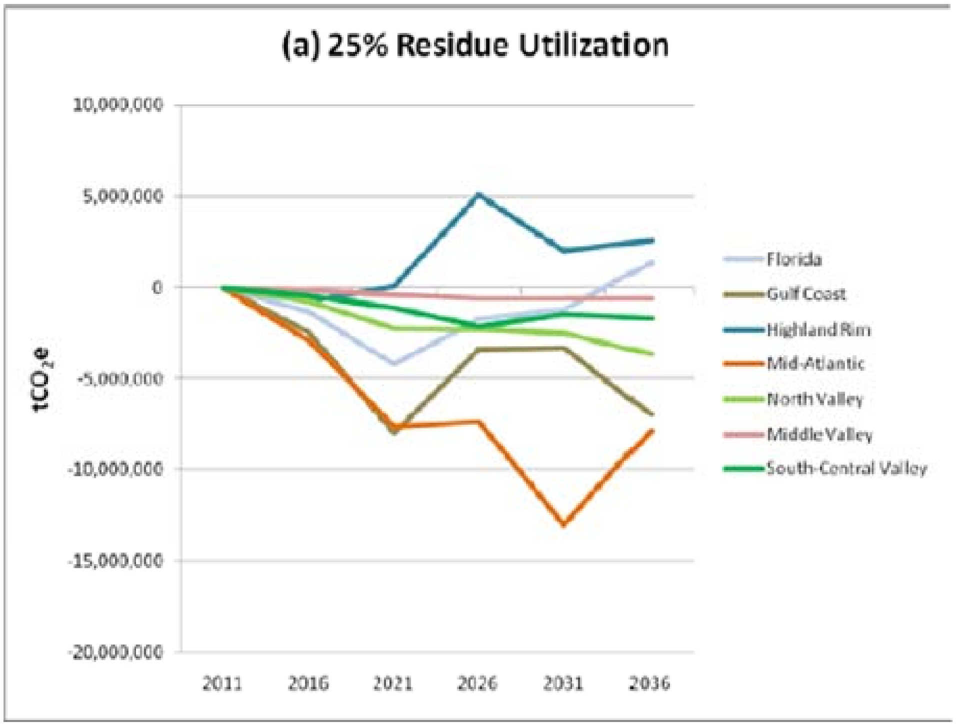

Figure 1. In this graph, modeled net greenhouse gas emissions are tracked through time for each region. Positive values indicate that biomass co-firing is emitting more carbon than the baseline scenario without co-firing; negative values indicate a decrease.

BTU CONTENT OF WOOD IS OVERSTATED

It is necessary to know the Btu content of wood to estimate how much is required to generate a certain number of Btus as electrical power. For the main analysis, the study initially calculates the amount of wood required to meet co-firing demand by assuming that dry biomass contains 9,000 Btu/lb and that wood moisture content is 50%.

$$Gross\ Coal\ Heat\ Input\ (MMBTU) * \frac{1{,}000{,}000\ BTU}{1\ MMBTU} * \frac{1\ dr.lb.biomass}{9{,}000\ BTU} * \frac{2\ gr.lb.biomass}{1\ dr.lb.biomass} * \frac{1\ gr.ton}{2{,}000\ gr.lb.}$$

However, this approach not only assumes a relatively high Btu content for dry wood (the average of the value range provided, of 7,600- 9,600, is actually 8,600) but as the higher heating value, also does not take into account the energy cost of driving off water in the wood. Since for conventional boiler operation the energy of evaporation is not recoverable, it is appropriate to use the lower heating value of wood to determine the available Btus.

Acknowledging that 9,000 Btus is a relatively high estimate for wood energy content, the study later assesses how reducing wood energy content by 15% to account for wood processing and drying would increase their estimates of wood demand, and therefore carbon emissions, which in turn erodes the calculated benefit of co-firing.

According to the ORNL Biomass Energy Data Book,[1] the lower heating value of wood at 50% moisture content is indeed about 85% of the higher heating value, thus the estimate of a 15% penalty is a more realistic estimate than the earlier estimate, and the second set of graphs showing net GHG flux though time (green line) results should be seen as more legitimate than the results reported which do not take into account the energy cost of evaporating moisture in the wood.

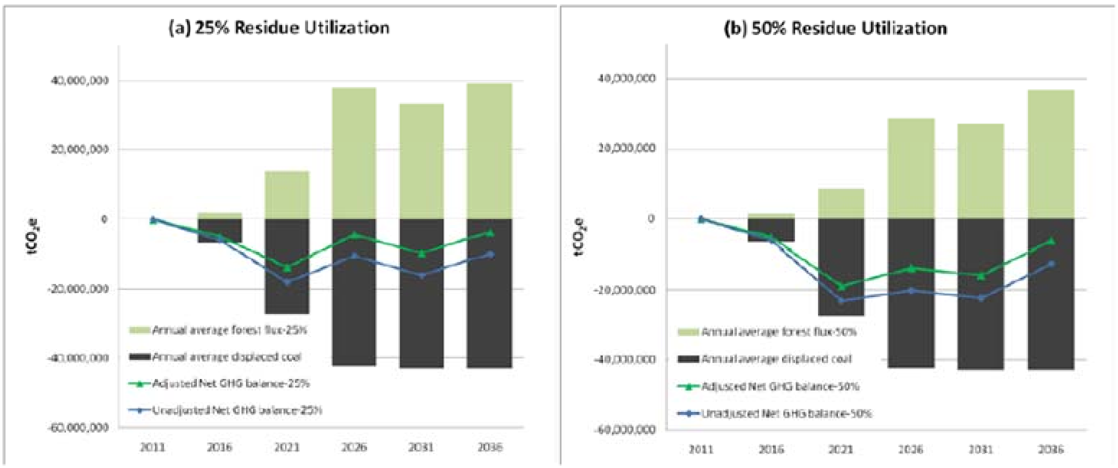

Figure 16. Region-wide net flux of GHG emissions resulting from co-firing in the Southeast, assuming (a) 25% and (b) 50% residue utilization. Negative values indicate net emission reductions relative to baseline scenario coal combustion; positive values indicate net increases. Adjusted GHG balance includes a 15% biomass processing energy requirement applied to an estimated demand of 59,188,213 green tons, while the unadjusted balance does not.

FIGURE 2.

Considering the assumptions about wood energy content made in the study, the study's conclusion that about 532 MMBtu of wood, or about 59 million green tons, are required to co-fire at an average rate of 10.1% is not supported. The study acknowledges that taking the 15% moisture penalty into consideration would require 68 million tons to meet fuel needs, but with an average heat content of 8,600 Btu/lb of bone dry wood instead of 9,000 Btu/lb as the study assumes, the lower heating value of wood at 50% moisture content is 3,775 and it would require 70.46 million tons of wood to produce the Btus required.

However, the initial Btu content of bone dry wood and the difference between the higher and lower heating values is only the beginning of the additional energy costs for using wood. Any energy expended in processing beyond the direct costs of drying the wood – for instance, pulverizing wood chips and extruding this material as wood pellets – would be additional to the 15% moisture penalty. Many coal plants are not able to utilize biomass unless it has been processed beyond the green wood chip stage. For instance, a primer on co-firing biomass produced by the Federal Energy Management Program warns that biomass burned in pulverized coal plants with suspension firing must be reduced to a maximum particle size of 0.25 inches at moisture levels of less than 25% for proper operation.[2] Coal plants that prefer to use only "clean-burning" pellets or chips derived from interior trunk wood

[1] Wright, L., et al. 2009. Biomass Energy Data Book: Edition 2. ORNL/TM-2009/098/ Oak Ridge National Laboratory, Oak Ridge, TN.

[2] Department of Energy, Federal Energy Management Program. 2006. Biomass cofiring in coal-fired boilers. DOE/EE-0288.

and excluding bark and low-diameter material will require more trees to be harvested to generate a given amount of fuel, since less of each tree is utilized than when whole tree chips are used. It is thus likely that the energy costs of processing biomass for co-firing are higher than the study has estimated, and that the net carbon emissions are higher.

Boiler derating is not taken into account

While the study acknowledges that losses in overall coal plant efficiency with biomass co-firing can occur, they do not factor this into their analysis. Overall losses of 2% in plant efficiency for a plant burning 10% biomass[3] means that the plant must burn more coal to maintain the same energy output, which further erodes the apparent reduction in GHG achieved by co-firing biomass.

Emissions from fossil fuel use during harvest and transport are not included

Lifecycle emissions may represent a relatively small fraction of total emissions, but can represent a significant use of fossil fuel. A full comparison of the baseline and co-firing scenarios would also take into consideration of lifecycle emissions of coal mining, processing, and transportation. Without this analysis, the small reductions in carbon emissions consequent upon co-firing are further called into question.

Forest residues are assumed to be available and easily utilized

While noting that a reviewer objected that residues might not be as available as the study assumes, due simply to the lack of equipment and infrastructure for collecting these materials, the model nonetheless relies heavily on the availability of residues, stating "We assume that utilization of residuals would increase over time and peak at a 50% utilization rate in 2020". However, there is little evidence to suggest that coal plants can even use residues in substantial amounts. Logging residues have high bark to wood ratio, and are green and can be dirty, factors that lead to greater particulate and NOx emissions. As air quality standards continue to tighten and coal plants are expected to reduce emissions, residues will be even less attractive as a source of wood for co-firing. Plants already prefer white, interior trunk wood chips or pellets made with high quality wood. This trend will likely increase. To the extent that the study overestimates residue availability, it underestimates the amount of new forest harvesting that would have to occur to provide biomass fuel.

Displacement of pulpwood by biomass is assumed to be a viable policy option

A significant source of biomass fuel in the co-firing model is acquired by displacing pulpwood harvesting and increasing harvest rates in pulpwood stands. Under the aggregated regional model scenario where 25% of residues are used as biomass fuel, about 37 million green tons of biomass, or about 65% of the total demand, comes from displacing pulpwood harvesting or increasing harvest rates in pulpwood stands (Figure 5a). For the 50% residue utilization scenario, the amount of displaced or new pulpwood harvesting appears to be about 27 million tons, or 47% of the total wood demand.

For the individual models conducted for each of the seven regions, the results are in some cases more extreme. Except in the case of Florida, the boundaries of the regions do not coincide exactly with state boundaries, making it difficult to use Forest Inventory and Analysis data, which is presented by state, to assess what proportion of the total harvest might be displaced by biomass harvesting under the regional scenarios. For Florida, pulpwood harvests in Florida averaged about 9.4 million green tons per year between 1997 and 2008.[4] At 25% residuals use,

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[3] Department of Energy, Federal Energy Management Program. 2006. Biomass cofiring in coal-fired boilers. DOE/EE-0288.

[4] Johnson, T.G. et al. 2007. Southern Pulpwood Production, 2008. Resource Bulletin SRS-165. United States Forest Service Southern Research Station, Asheville, N.C.

the model estimates that about 5 million tons of pulpwood displacement and increased harvesting would occur to meet the need for biomass fuel, amounting to more than half of the total pulpwood harvest over these years.

Of the seven regions, only two (the Middle Valley and South-Central Valley) appear to be able to meet at least 50% of their biomass need by using residuals, even under the scenario where 50% of residuals are used for fuel. In the other five regions, displacement and increased harvesting of pulpwood sources provides the majority of fuel. The study does not provide any substantive analysis of whether this is either economically or socially desirable.

Displacement of existing industry does not have consequences for GHG emissions

In the model, wood that is redirected from pulpwood to be used as biomass fuel is considered to have no carbon emissions. However, to the extent that using this wood as fuel displaces demand and causes leakage, this wood cannot be considered "carbon free" fuel. The study does acknowledge that leakage of harvesting pushed to other areas by biomass fuel demand may be "significant":

> "We also do not account for any direct changes in net emissions caused by displacement of current industrial users of forest resources. Finally, we note that reduction in forest carbon stock or displacement of industrial production may have GHG implications outside of the study area, and therefore be subject to additional "leakage" deductions; these effects may be significant but are not quantified here."

The study validates this concern by citing a study which found out-of-region harvesting increased when harvesting was restricted under a forest set-aside program, but nonetheless do not estimate what the effects would be on their own model results if leakage effects were taken into account.

Existing and future demands on forest resources are not acknowledged

The Duke report assumes that wood demand for co-firing is the only bioenergy demand placed on forest resources, stating "We also assume that no additional dedicated biomass capacity is added, though evidence suggests that interest in dedicated biomass facilities in the Southeast is increasing."

In fact, there are more than 44 direct-fired biomass plants and co-firing projects at coal plants either proposed or underway in the ten-state region covered by the study. The combined capacity of these proposed projects is over 2,360 MW, and the combined wood demand is over 28 million green tons per year. At least 21 new wood pellet plants are underway or proposed, with a combined wood demand of over 13 million green tons per year, and biofuels proposals that will use wood as feedstock will require over 1.3 million tons per year.[5] Out-of-region wood demand is also growing. Currently, at least one pellet plant in the region, Green Circle Energy of Florida, ships pellets exclusively to Europe; wood demand at this one plant is about 1.3 million green tons a year. Other states are looking to the Southeast to provide woody fuels, as well. The Public Utilities Commission of Ohio just approved re-firing the 312 MW Burger coal plant with 80% biomass. First Energy, the utility that owns the plant, has stated[6] that wood from the South can be one source of fuel for the plant, which will require about 2.5 million tons of wood a year. Assuming that only a portion of this new wood demand is realized, the estimates of wood availability used in the co-firing study cannot be considered valid.

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[5] RISI Wood Biomass Database, June, 2010. Boston, MA. Data on capacity of proposed co-firing proposals from original research.

[6] Lasky, Charles. "Advantages in biomass". Editorial, Akron Beacon Journal, Aug. 18, 2010. http://www.ohio.com/editorial/commentary/100959879.html

CONCLUSIONS

Given the assumptions that are made in the Southeastern co-firing study – the most important being that displacement of pulpwood harvesting does not increase GHG emissions – the study's estimated net carbon balance for biomass co-firing cannot be considered valid. The study essentially states that pulpwood displaced by biomass produces no net greenhouse gas emissions, although there is no reason to assume this would be the case, since the pulpwood industry is quite unlikely to diminish commensurate with increasing need for biomass fuel. Far from serving as a demonstration of a responsible renewable energy solution, the ultimate conclusion of the study – that even with a massive increase in residues collection, displacement of pulpwood harvesting, and an increase in overall harvesting levels, only 5.3% of conventional power generation capacity can be replaced by co-firing biomass – can actually be seen as a cautionary example of the enormous costs borne to achieve a small benefit. In this case the "benefit" is the elimination of a small and uncertain portion of GHG emissions from coal, but given the other assumptions in the study, which underestimates the actual amount of wood required to replace around 10% of coal-fired power, it is likely that real emissions would be considerably higher than the study concludes.