Think Wood Pellets are Green? Think Again.

Biomass is often described as a clean, renewable fuel and a greener alternative to coal and other fossil fuels for producing electricity. But recent science shows that many forms of biomass—especially from forests—produce higher carbon emissions compared to fossil fuels. In particular, a growing body of peer-reviewed, scientific studies shows that burning wood from whole trees in power plants to produce electricity can increase carbon emissions relative to fossil fuels for many decades—anywhere from 35 to 100 years.[1] This time period is significant: climate policy imperatives require dramatic short-term reductions in greenhouse gases, and these emissions will persist in the atmosphere well past the time when significant reductions are needed.

Unfortunately, the biomass wood pellet industry in the southeastern United States is expanding rapidly. Wood pellet exports from the United States doubled from 1.6 million tons in 2012 to 3.2 million tons in 2013, and they are expected to reach 5.7 million tons in 2015.[2] This growth is driven largely by exports to Europe in response to flawed policy incentives on renewable resources that regard all biomass as carbon neutral.[3]

Although recent science shows that many forms of forest biomass are high-carbon sources of fuel, under the right circumstances, true wood waste could serve as a low-carbon option for producing pellets. For example, sawdust and chips from sawmills that would otherwise quickly decompose and release carbon anyway—can be a low-carbon source.[4] On the other hand, burning whole trees can produce higher carbon emissions than coal, and this elevated CO_2 level with respect to coal can persist in the atmosphere for decades.[5] Therefore, the composition of wood pellets matters greatly: the amount of whole trees used in wood pellets can have a significant impact on the estimated carbon emissions of this fuel source.

NRDC therefore modeled the carbon impacts of burning wood pellets of varying composition in power plants to produce electricity. We used a carbon accounting model developed by the Spatial Informatics Group (SIG) to model scenarios in which pellets sourced from bottomland hardwood forests in Atlantic plain[6] of North Carolina and South Carolina supplied a typical power plant in the United Kingdom[7]. In our analysis, we modeled a range of scenarios in which pellets are made of varying amounts of whole trees, mill waste, and non-merchantable forestry residues (tops and branches from logging operations). Using the model, we estimated the total amount of carbon released over time (cumulative CO_2 emissions) for each scenario and compared those emissions with those from coal and natural gas.

HOW WE MODELED PELLET CARBON EMISSIONS

The SIG model first generates a working forest landscape—including timber harvest and forest regrowth—based on typical forest management in the sourcing ecoregion. The model then estimates the emissions from removing additional forest materials each year for wood pellet production and by burning the pellets to produce electricity. (See the Technical Appendix for information on the SIG model and analytic methods.)

Our modeling assumed that the biomass feedstocks used to produce pellets were typical of the pellet industry.[8] They are:

- **forestry residues**—tops and limbs from forestry operations that are non-merchantable to other markets;
- **whole trees**—merchantable pulpwood, trees from thinning operations, and non-merchantable trees; and
- **mill waste**—by-products of sawmill operations such as sawdust and chips.

(See the Technical Appendix for more information on feedstock definitions.)

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We varied the amounts of each of these three feedstocks, running scenarios in which the proportion of whole trees in the wood pellets ranged from 20 percent to 70 percent.[9] In each of these scenarios, we modeled the emissions resulting from burning the pellets in a typical power plant over a 100-year period. We compared these estimated biomass CO_2 emissions with the CO_2 that would have been emitted by fossil fuels to produce the same amount of electricity.

RESULTS

In the figures below we show the results for three representative scenarios: pellets made of 70 percent, 40 percent, and 20 percent whole trees. The solid black line represents the estimated cumulative carbon emissions per megawatt of power from a power plant burning wood pellets, accounting for the effects of forest regrowth. The dashed lines represent cumulative emissions from fossil fuels per megawatt of power.

For the first several decades of the plant's operations, the burning of pellets creates a pulse of emissions to the atmosphere—namely, increased carbon emissions resulting from combustion. This pulse occurs because wood is less energy-dense than fossil fuels, so burning biomass generally emits more carbon than fossil fuels to produce the same amount of energy.[10] Over time, however, forest regrowth reduces this atmospheric carbon.[11] And after many decades, this regrowth can recapture enough carbon to reduce the cumulative emissions below those of fossil fuels. These results are similar to the "carbon debt" outcomes found in recent biomass studies.[12]

Figures 1 and 2 together show the modeled emissions when the proportion of whole trees in pellets ranges from 40 percent to 70 percent. The modeling shows that it will take approximately 55 years for forest regrowth to recapture enough carbon from the atmosphere to reduce the plant's cumulative emissions below those of coal. At levels greater than 40 percent, pellets emit more carbon than coal for most of this period. In addition, as the percentage of whole trees increases above 70 percent (not shown in the figures), the level of carbon emissions continues to increase.[13]

When whole trees make up 20 percent of the wood in pellets, emissions are slightly higher than natural gas and slightly lower than coal for a period of approximately 55 years, as shown in Figure 3. Even when whole trees make up as little as 12 percent of pellets, our modeling showed that burning pellets still produces emissions comparable to natural gas trend line for approximately 50 years. (See Technical Appendix for information on additional scenarios.)

Figure 1: Cumulative emmissions ($MgCO_2e/MW$)

Pellets made of 70 percent whole trees

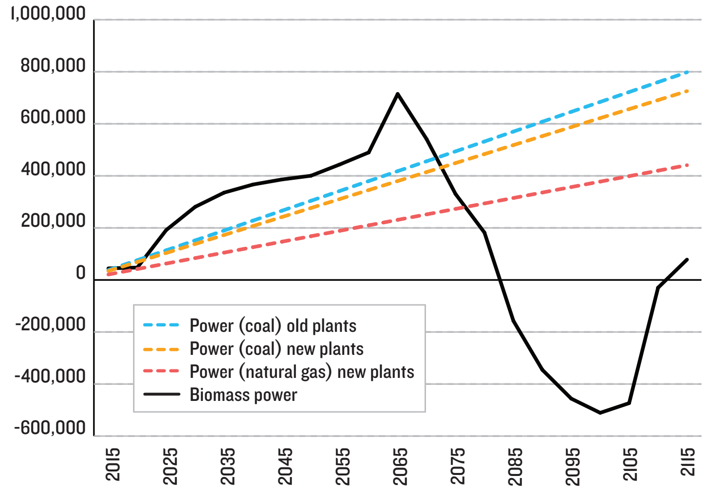


Figure 2: Cumulative emmissions ($MgCO_2e/MW$)

Pellets made of 40 percent whole trees

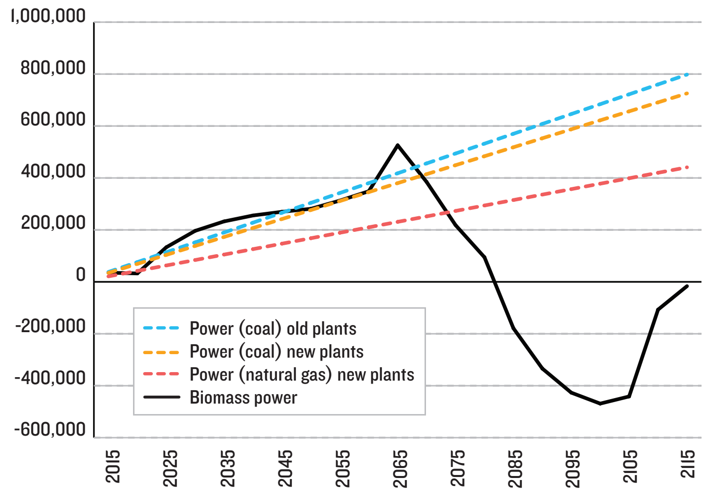
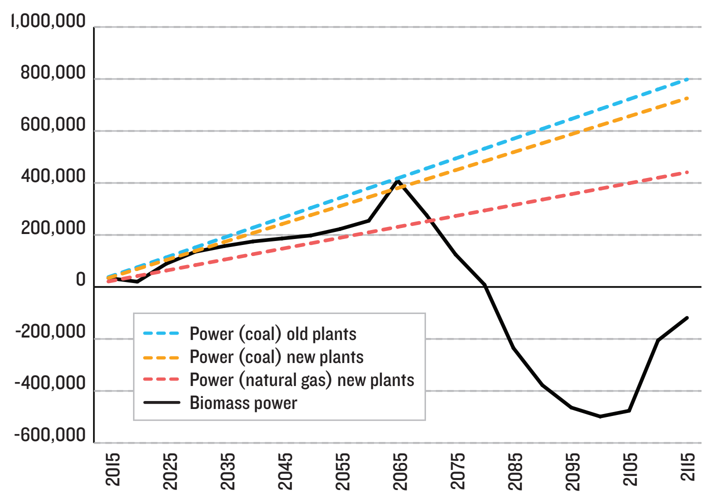


Figure 3: Cumulative emmissions ($MgCO_2e/MW$)

Pellets made of 20 percent whole trees



CONCLUSIONS

In sum, our modeling shows that wood pellets made of whole trees from bottomland hardwoods in the Atlantic plain of the U.S. Southeast—even in relatively small proportions—will emit carbon pollution comparable to or in excess of fossil fuels for approximately five decades. This 5-decade time period is significant: climate policy imperatives require dramatic short-term reductions in greenhouse gas emissions, and emissions from these pellets will persist in the atmosphere well past the time when significant reductions are needed. Moreover, several studies have concluded that logging residuals alone may be unable to meet bioenergy demands in the region we modeled, and that pulpwood trees may need to be used to meet the increasing demand.[14]

These results have significant implications for the wood pellet industry and its expansion. Pellet manufacturer Enviva LP and British utility Drax Power are at the head of this industry. Drax operates the United Kingdom's largest coal-fired power plant and is converting half of its six generating units to run solely on wood pellets.[15] Enviva is the largest producer and exporter of wood pellets in the United States and a primary biomass supplier to Drax. The company owns and operates five production plants in the Southeastern U.S. that have a combined wood pellet production capacity of approximately 1.7 million metric tons per year.[16]

Enviva has claimed that its wood pellets are a clean source of fuel for electricity production and that they do not increase carbon emissions.[17] Yet the company has not publicly disclosed the composition of its wood pellets. If Enviva's pellets were comprised of whole trees from the modeled Southeast bottomland hardwoods—even in relatively small proportions—they would emit carbon pollution comparable to fossil fuels for decades. The company has the responsibility to come clean with the public, investors, and regulators by disclosing the makeup of its fuel, and to take steps to ensure that its pellets do not increase carbon emissions.

Enviva facility in Ahoskie, NC.

As the calls to curb carbon pollution grow louder, power companies face increased pressure to find cleaner sources of energy. Many have turned to woody biomass for fuel, much of which comes from forests. The wood is chipped or turned into pellets—small, compressed cylinders of woody material. These pellets are burned in power plants just like coal. Most suppliers are operating under the false assumption that, since trees can grow back and resequester carbon, then they are a carbon-neutral fuel when burned. However, mounting scientific evidence shows that it could take many decades for forest regrowth to offset stack emissions from power plants.

TECHNICAL APPENDIX: HOW THE SPATIAL INFORMATICS GROUP'S (SIG) CALCULATOR WORKS

This analysis is based on a Greenhouse Gas Calculator developed for NRDC by the Spatial Informatics Group (SIG). The Spatial Informatics Group's (SIG) Greenhouse Gas Calculator estimates the carbon emissions from woody biomass energy sourced from forests in the southeastern United States. The user first specifies a power-generating facility type, plant efficiency, mix of feedstock types, sourcing ecoregion, and forest type to generate a *biomass power scenario*. For this analysis, NRDC set parameters consistent with wood pellets sourced from a mix of mill waste, forestry residues, and whole tree boles from bottomland hardwoods in the Atlantic Coastal Flatwoods ecoregion.

The calculator models the greenhouse gas emissions and sequestration over time in the chosen region under the specified scenario. The calculator then compares these against a *business-as-usual* scenario—namely, the emissions and sequestration that would occur in the absence of the specified biomass sourcing and combustion. The difference between the two trajectories represents the net cumulative greenhouse gas emissions on a carbon equivalent per-output-energy (per-MWh) basis attributable to the user-specified facility's sourcing and power generation operations.

The calculator relies entirely on data and results from the study *Biomass Supply and Carbon Accounting for Southeastern Forests* (Colnes et al.) to generate both the biomass power scenarios and business-as-usual scenarios.[18] These researchers assumed: (1) typical and customary silvicultural systems implemented in each ecoregion and forest type, and (2) typical markets and end uses for the varying size classes of wood products harvested (pulpwood 4–10 inches in diameter at breast height [dbh] and sawlogs greater than 10 inches dbh). Materials less than 4 inches in diameter were considered non-merchantable and left to decay in forests in the *business-as-usual* scenario.[19]

Silvicultural scenarios were modeled by Colnes et al. using 2010 U.S. Forest Service Forest Inventory and Analysis (FIA) data for each ecoregion. The U.S. Forest Service Forest Vegetation Simulator Southern Variant was used to account for changes in on-site forest carbon pools. The forest carbon accounting included above- and belowground live trees, standing deadwood, belowground deadwood, and down deadwood. Carbon stored in wood products in use and in landfill pools was simulated separately in the SIG Calculator.

To establish the *business-as-usual* scenario, Colnes et al. modeled a landscape including woodsheds around 17 existing biomass facilities in the region as of 2010. Each woodshed was specified by a 50 mile-radius around each known existing biomass facility. The researchers first prescribed default silvicultural practices across the entire landscape over time (except for 19 percent of the acreage, which was put off-limits due to operational constraints and protected status). Within the woodsheds, they prescribed more intensive silviculture to produce additional biomass material to meet the existing facility's demand—typically an extra thinning cycle and removal of boles smaller than 4 inches dbh (hereinafter "biomass harvest").[20] This mix of default silviculture and biomass harvest across the 17-facility landscape constitutes the *business-as-usual* scenario.

Colnes et al. then modeled additional timber harvesting above the *business-as-usual* associated with new demand in additional 50-mile-radius woodsheds, which had the more intensive "biomass harvest" prescriptions described above. The modeling in Colnes et al. meets this increased demand first with residues and non-merchantable boles, then with pulp sized boles and tree tops. The difference between emissions from new demand and emissions from the *business-as-usual* scenario produces net emissions factors on a per-output-energy (per-MWh) basis.

The SIG Calculator builds on Colnes et al.'s results in two main ways. First, it allows the user to simulate the sourcing location and feedstock type by disaggregating emission factors associated with a single ecoregion and forest type inside the Colnes et al. study area. Second, it scales the net, per-MWh emission factors by the size of the power-generating facility specified in a *biomass power scenario*. For the purposes of this analysis, NRDC assumed that the new demand was generated in the Atlantic Coastal Flatwoods (Forest Service Ecoregion 232) of North Carolina.

Besides the analysis of forest growth, the SIG Calculator folds in greenhouse gas emissions from feedstock processing, transportation, and energy conversion at the power plant. It does not include greenhouse gas emissions from plant construction or plantation management. SIG added parameters regarding the additional emissions of transporting the biomass fuel from the U.S. Southeast to the United Kingdom, along with analogous mining and transportation emissions for the displaced coal.

The SIG Calculator estimated emissions from harvesting equipment using a factor of 0.015 ton of CO_2 per bone dry ton (BDT) of harvested material. Truck transportation emissions were estimated using a factor of 0.000134 ton of CO_2 per BDT-mile, which assumed 12.5 tons per truck, 6 miles per gallon, and 22.2 lbs. CO_2 per gallon of diesel fuel (see sources cited in Colnes et al., pg. 84).

The SIG Calculator assumes that mill residues are carbon neutral—meaning neither biogenic nor fossil fuel (e.g., transport and processing-related) carbon emissions are associated with their use.

The SIG Calculator further assumes that logging residues constitute 32 percent of harvest volume for bottomland hardwoods in the Atlantic Coastal Flatwoods. In order to generate representative ratios of logging residues versus roundwood for fuelsheds in the Atlantic Coastal Flatwoods (Forest Service Ecoregion 232) of North Carolina, we retrieved reported volumes of logging residue and roundwood by weight for six counties in the ecoregion from the Timber Products Output Database.[21] In 2009, the most recent year for which reports were available, logging residues constituted an average of 32 percent of the harvest volume in hardwoods by weight.

Endnotes

1 Colnes, A., et al., *Biomass Supply and Carbon Accounting for Southeastern Forests*, The Biomass Energy Resource Center, Forest Guild, and Spatial Informatics Group, February 2012, www.biomasscenter.org/images/stories/SE_Carbon_Study_FINAL_2-6-12.pdf. Harmon, M., *Impacts of Thinning on Carbon Stores in the PNW: A Plot Level Analysis*, Oregon State University, May 2011. Mitchell, S., M. Harmon, and K. O'Connell, "Carbon Debt and Carbon Sequestration Parity in Forest Bioenergy Production," *GCB Bioenergy* 4, no. 6 (November 2012): 818-827. Repo, A., et al., "Sustainability of Forest Bioenergy in Europe: Land-use-related Carbon Dioxide Emissions of Forest Harvest Residues," *GCB Bioenergy*, published online March 2014. Stephenson, A. L., and D. MacKay, *Life Cycle Impacts of Biomass Electricity in 2020: Scenarios for Assessing the Greenhouse Gas Impacts and Energy Input Requirements of Using North American Woody Biomass for Electricity Generation in the UK*, U.K. Department of Energy and Climate Change, July 2014, www.gov.uk/government/uploads/system/uploads/attachment_data/file/349024/BEAC_Report_290814.pdf. Ter-Mikaelian, M., et al., "Carbon Debt Repayment or Carbon Sequestration Parity? Lessons from a Forest Bioenergy Case Study in Ontario, Canada," *GCB Bioenergy*, published online May 2014. Walker, T., et al., *Biomass Sustainability and Carbon Policy Study*, Manomet Center for Conservation Sciences, June 2010, www.mass.gov/eea/docs/doer/renewables/biomass/manomet-biomass-report-full-hirez.pdf.

2 Wood Resources International LLC, "Global Timber and Wood Products Market Update," news brief, October 11, 2012.

3 2009 Renewable Energy Directive, which sets an overall EU target of a 20 percent share of renewable energy by 2020. ec.europa.eu/clima/policies/package/index_en.htm.

4 Stephenson, A. L., and D. MacKay, *Life Cycle Impacts of Biomass Electricity*.

5 Pingoud, K., T. Ekholm, and I. Savolainen, "Global Warming Potential Factors and Warming Payback Time as Climate Indicators of Forest Biomass Use," *Mitigation and Adaptation Strategies for Global Change* 17, no. 4 (January 2012): 369-386. Schulze, E. D., et al., "Large-scale Bioenergy from Additional Harvest of Forest Biomass Is Neither Sustainable Nor Greenhouse Gas Neutral," *GCB Bioenergy* 4, no. 6 (November 2012): 611-616. Walker, T., et al., *Biomass Sustainability*.

6 The sourcing region is the Atlantic Coastal Flatwoods (Forest Service Ecoregion 232)

7 We assumed a capacity factor of 85 percent.

8 Suz-Anne Kinney, "Dispelling the Whole Tree Myth: How a Harvested Tree Is Used," Forest2Market (F2M), December 20, 2013, www.forest2market.com/blog/dispelling-the-whole-tree-myth-how-a-harvested-tree-is-used. The author states: "While whole trees are certainly being harvested, any whole tree that ends up in the wood yard of a pellet facility is either defective in some way (unmerchantable), a pulpwood-sized tree that took 10–15 years to grow or the upper section of a larger tree…. It is impossible to tell which of the latter two categories any single pulpwood-sized log falls into."

9 For each scenario, we held the amount of mill waste constant at 20 percent.

10 Walker, T., et al., *Biomass Sustainability*.

11 In the model, this sequestration also includes avoided decay (decay that would have otherwise occurred).

12 Ter-Mikaelian, et al., "Carbon Debt Repayment." Colnes, A., et al., Biomass Supply and Carbon Accounting . Walker, T., et al., Biomass Sustainability.

13 This is the case all the way to 100 percent whole trees— not illustrated in figures.

14 http://naldc.nal.usda.gov/download/46157/PDF, https://nicholasinstitute.duke.edu/sites/default/files/publications/forest-biomass-supply-in-the-southeastern-united-states-implications-for-industrial-roundwood-and-bioenergy-production-paper.pdf.

15 Livermore, M., "The Contradictions of Biomass," Scientific Alliance, March 10, 2014, www.cambridgenetwork.co.uk/news/the-contradictions-of-biomass.

16 http://247wallst.com/energy-business/2015/04/29/enviva-ipo-generating-heat-and-light.

17 Enviva LP, *Inherent Sustainability & Carbon Benefits of the US Wood Pellet Industry*, white paper, 2012, www.envivabiomass.com/wp-content/uploads/inherent-sustainability-carbon-benefits-20121005.pdf.

18 Colnes, A., et al., *Biomass Supply and Carbon Accounting for Southeastern Forests*, Southern Environmental Law Center, 2012, www.biomasscenter.org/images/stories/SE_Carbon_Study_FINAL_2-6-12.pdf.

19 Materials less than 4 inches in diameter were collected in certain biomass power scenarios only.

20 The "biomass harvest" generates additional timber harvest volume in the forms of (1) non-merchantable tops and limbs, (2) non-merchantable boles less than 4 inches dbh, and (3) pulpwood boles 4–10 inches dbh.

21 U.S. Department of Agriculture Forest Service, Southern Research Station, Timber Product Output (TPO) Reports, Table C10: "Volume of timber removals by State/County, species group, removals class and source," srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php, accessed November 24, 2014. The model partitions logging residues from new harvest to logging residues from existing harvest at a ratio of approximately 4:1.