The Role of Biomass Energy in EPA's Greenhouse Gas Rule

Partnership for Policy Integrity

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This is a working document and subject to change.

Contents

A good news/bad news story about bioenergy and the greenhouse gas rule

The EPA's recently published Existing Source Performance Standards for greenhouse gas emissions (the "greenhouse gas (GHG) rule") relies on four main "building blocks" to reduce carbon dioxide emissions from the power sector. The ultimate goal is that each state should achieve a target emissions rate (expressed as pounds of CO_2 per megawatt-hour of electricity generated) that is in many cases significantly lower than the present emissions rate. One of the building blocks for achieving emissions reductions is increased efficiency at existing coal plants, thereby reducing their emissions of CO_2 per unit energy generated. Another is increased use of "low" or "zero" emissions renewable energy.

Biomass energy – the combustion of wood and other biological materials in power plants – has been promoted extensively at the state level as renewable energy. However, it is well-known that per megawatt-hour (MWh), biomass power plants emit more CO_2 than coal plants, and that co-firing biomass at coal plants increases CO_2 emissions and decreases facility efficiency (see Appendix 2 for more details). Given these facts, it is important to determine how the EPA counts bioenergy emissions under the existing source GHG rule, and what role EPA envisions for biomass power in helping states meet target emissions rates.

The short answer is that, amazingly, despite all the time and energy that EPA and others have devoted to developing a biogenic carbon accounting framework, EPA's assumptions and modeling in support of the GHG rule treat bioenergy as having **zero carbon emissions**, making bioenergy under EPA's framework as effective at "reducing" greenhouse gas emissions as wind power. That's the bad news. The "good" news is, that despite this fundamental flaw, the modeling does not project any significant increase in biomass energy generation in the years leading up to 2030, when the rule is supposed to have achieved a 30% reduction in power sector emissions. However, this fact only bodes well to the extent that EPA modeling can be assumed to be representative of actual development of biomass power, and given the leeway that EPA is providing to the states, it seems likely that EPA modeling could ultimately prove irrelevant.

The following report explores these findings in more depth, and contemplates what they may mean for the integrity of the ESPS rule and the future development of biomass power.

Bioenergy does not directly provide "mitigation" of emissions in the GHG rule

The objective of both the New Source Performance Standards (NSPS) and the Existing Source Performance Standards (ESPS, here also referred to as the "greenhouse gas rule" or "GHG rule") is to reduce CO_2 emissions from the power sector. As coal plants are the largest source of CO_2 emissions in the power sector, the rules naturally focus on reducing emissions at coal plants. The NSPS rule focuses on emissions at new power plants, proposing an emissions standard that essentially prohibits development of coal plants unless they can reduce their emissions through carbon capture and sequestration. The ESPS focuses on the existing fleet and the power sector as a whole, mandating not only improved efficiency and lower emissions at individual coal plants, but also replacing coal-fired generation with lower-emitting natural gas plants,[1] renewable energy, and nuclear power, as well as reducing electricity demand.

Importantly, neither the NSPS nor the ESPS offers biomass co-firing as a means to "reduce" emissions at coal plants. To allow biomass co-firing would be counter to the intent of the rules, since co-firing biomass at a coal plant decreases facility efficiency and increases CO_2 emissions per megawatt-hour. Indeed, an increased facility heat rate (the amount of energy required to produce electrical energy) was recently cited by Georgia Power as one reason to *not* convert its Plant Mitchell from coal to biomass.[2] Likewise, EPA notes in a technical document[3] for the GHG rule that, regarding co-firing,

"*logistics and boiler engineering considerations place limits on the extent of biomass that can be fired. The logistic considerations arise because it is only economic to transport biomass a limited distance from where it is grown given the low energy density of the fuel. In addition, the extent of storage that can be devoted at a power plant to this relatively low density fuel is another limiting factor.* ***Boiler efficiency and other engineering considerations, largely due to the relatively higher moisture content and lower heat content of biomass compared to fossil fuel,*** *also plays a role in limiting the level of co-firing*." (emphasis added)

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[1] As the rule does not take into account methane leakage from natural gas, it is extremely questionable whether increased deployment of natural gas under the rule will produce any climate benefit whatsoever.
[2] Georgia Public Service Commision. Georgia Power Plant Mitchell Unit 3 Biomass Conversion Cancellation: Decision Review Findings. June 5, 2014.
[3] U.S. Environmental Protection Agency. Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model. Page 5-9.

While EPA has not offered biomass co-firing as means of "reducing" greenhouse gas emissions at coal plants, the Agency has stopped short of grappling with the real implications of bioenergy emissions. Although it's been three years since EPA's deferral of regulation of bioenergy CO_2, and nearly two years since the Science Advisory Board (SAB) panel issued its report, EPA has not produced a carbon accounting framework for bioenergy in time to inform the existing source GHG rule. Both the NSPS and the ESPS are the worse for the poor timing, with both rules claiming that EPA is still studying the issue. However, there are hints that EPA understands what a science-based carbon accounting framework would look like. For instance, the September 2013 draft of the NSPS acknowledges,

"In its Advisory, the SAB recommended revisions to the EPA's proposed accounting approach, and also noted that biomass cannot be considered carbon neutral a priori, without an evaluation of the carbon cycle effects related to the use of the type of biomass being considered."

and

"*In general, the overall net atmospheric loading of CO_2 resulting from the use of a biogenic feedstock by a stationary source will ultimately depend on the stationary source process and the type of feedstock used, as well as the conditions under which that feedstock is grown and harvested.*"[4]

These were statements that indicated EPA might be ready to tackle a science-based accounting framework. Months later, however, the ESPS indicates that EPA is still studying the issue:[5]

"*The EPA is in the process of revising the draft framework and considering next steps, taking into account both the comments provided by the SAB and feedback from stakeholders. The EPA's biogenic CO_2 accounting framework is expected to provide important information regarding the scientific basis for assessing these biomass-derived fuels and their net atmospheric contribution of CO_2 related to the growth, harvest and use of these fuels. This information should assist both states and the EPA in assessing the impact of the use of biomass fuels in reaching emission reduction goals in the energy sector under state plans to comply with the requirements in the emission guidelines*."

In fact, as the NSPS rule noted, the report of the Science Advisory Board was unambiguous in its conclusion, that

"Carbon neutrality cannot be assumed for all biomass energy a priori. There are circumstances in which biomass is grown, harvested and combusted in a carbon neutral fashion but carbon neutrality is not an appropriate a priori assumption; it is a conclusion that should be reached only after considering a particular feedstock's production and consumption cycle" [6]

Given the amount of time spent by the SAB in formulating this conclusion, and EPA's recognition (in the text of the NSPS rule) that bioenergy can't automatically be considered carbon neutral, it is thus remarkable that EPA has chosen to treat bioenergy as having zero carbon emissions for purposes of the

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[4] Standards of performance for greenhouse gas emissions from new stationary sources: electric generating units. 40 CFR Part 60, [EPA-HQ-OAR-2013-0495; FRL-9839-4] RIN 2060-AQ91. September 20, 2013.

[5] Environmental Protection Agency. 40 CFR Part 60: Carbon pollution emission guidelines for existing stationary sources: electric generating units; proposed rule. Federal Register Vol. 79 No. 117, June 18 2014, page 34925

[6] United States Environmental Protection Agency. SAB review of EPA's Accounting Framework for Biogenic CO_2 Emissions From Stationary Sources. EPA-SAB-12-011. September 28, 2012. Washington, DC. (http://yosemite.epa.gov/sab/SABPRODUCT.NSF/57B7A4F1987D7F7385257A87007977F6/$File/EPA-SAB-12-011-unsigned.pdf).

ESPS rule. There is no question, however, that this is what the Agency has done in calculating current state-level emissions rates, and future "target" rates, based on fossil fuel emissions alone.[7]

Assuming carbon neutrality invalidates current and future emission rate estimates
By lumping bioenergy with all other renewables, and treating a power plant burning trees as if it "reduces" emissions the same as a wind farm, EPA has ceded important scientific ground, and fundamentally undermined its ability to regulate bioenergy emissions in the future. It also introduces significant errors into the estimate of present day power sector CO_2 emissions and target emissions rates. The state where this is most apparent is Maine, where about 20% of the state's power in 2012 was generated by burning wood and "wood-derived" fuels, meaning liquors and other wastes from pulp and paper-making.

Using Energy Information Administration (EIA) data on 2012 total power sector generation[8] and CO_2 emissions,[9] the difference in emissions rates with counting and not counting biomass emissions in Maine is apparent. When bioenergy emissions are not included in the total, EIA's emission rate for all power generation in the state is 544 lb/MWh. When emissions from bioenergy are included, however, the calculated emissions rate more than doubles, to 1,268 lb/MWh. EPA's calculations of power sector emissions differ from EIA's, and due to the opaque nature of the calculations, it is not easy to determine which electricity generation subsectors EPA includes. Nonetheless, the effect of not counting bioenergy emissions is apparent in EPA's estimate of current power sector emissions: 873 lb CO_2/MWh – and the target rate for 2030: 378 lb CO_2/MWh. EPA's entire modeling scenario – the "current" emissions rate, and the projected emissions rate in 2030 after reductions are achieved – depends on pretending that burning wood and waste materials has zero carbon dioxide emissions.

The dominance of bioenergy emissions in Maine, compared to the amount of power produced from burning wood and wood wastes, is illustrated graphically in Figures 1a and 1b.

[7] U.S Environmental Protection Agency. Goal Computation Technical Support Document for the CAA Section 111(d) Emission Guidelines for Existing Power Plants Docket ID No. EPA-HQ-OAR-2013-0602. June, 2014.
[8] Energy Information Administration. Annual Generation. State Historical Tables for 2013, December 2013.
[9] Energy Information Administration. Annual Emissions. State Historical Tables for 2013, December 2013.

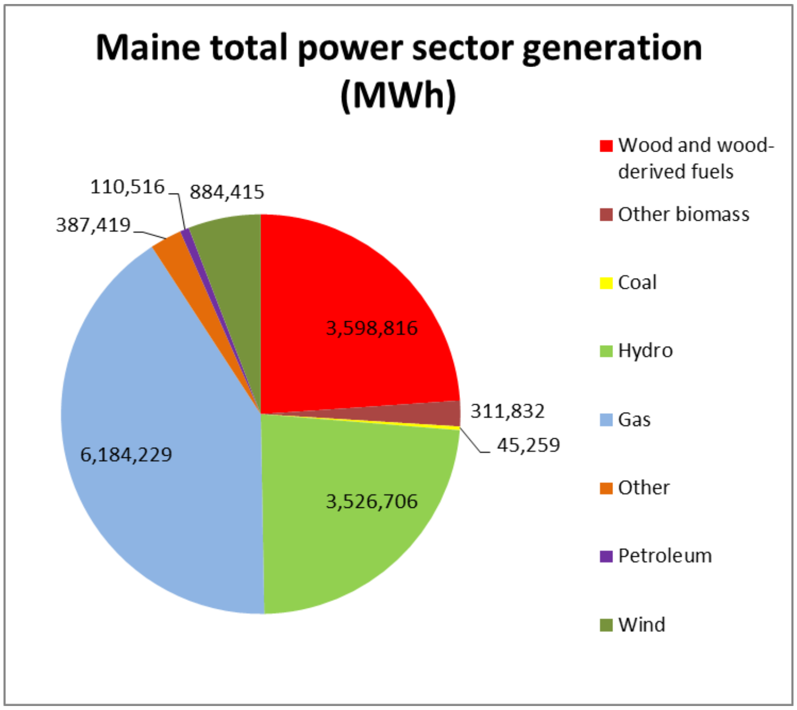

Figure 1a. EIA data on power generation in Maine in 2012. About one quarter of the state's energy comes from wood and other biomass fuels, mostly biogenic municipal waste.

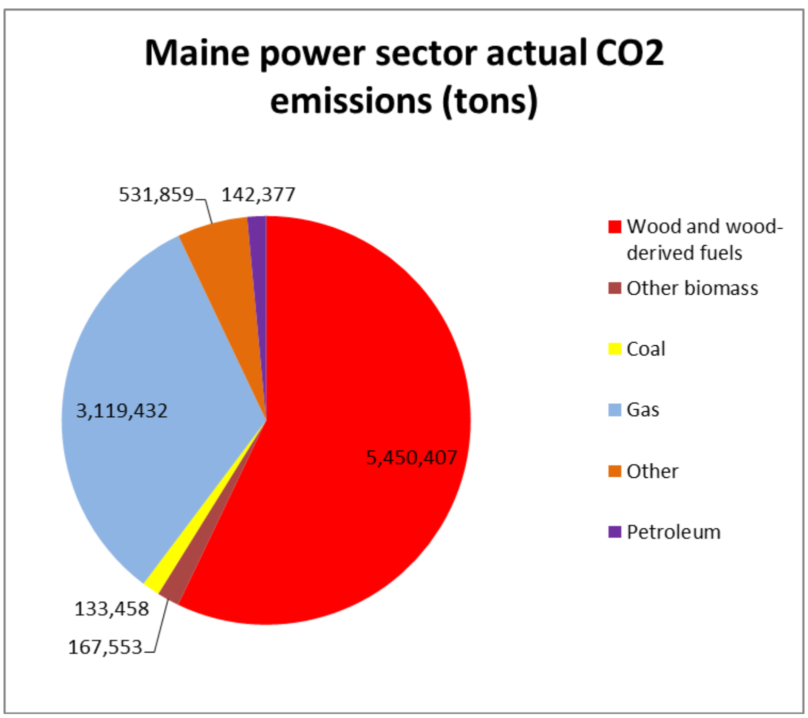

Figure 1b. Almost 60% of Maine's power sector emissions come from burning biomass.[10]

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[10] Emissions from biomass are calculated assuming wood is 45% moisture content and contains 4,730 btu/lb (This is the "higher heating value." See page 201 of Biomass Energy Data Book 4th Edition: http://cta.ornl.gov/bedb/pdf/BEDB4_Full_Doc.pdf)

EPA's assumption that bioenergy has zero carbon emissions introduces errors for other states, as well. The amount by which EPA's estimate of the current power sector emissions rate and the target emissions rate will underestimate actual emissions is affected by the amount of biomass burned and the percent of total power generated by bioenergy. The top ten states for each of these categories differ somewhat, with California leading in the total amount of biomass burned, and Maine leading in terms of the percent of the state's power generated by bioenergy.

State	Biomass power generation (MWh)	State	Biopower as % of total generation
CA	3,797,596	ME	20.4%
GA	3,107,494	NH	5.4%
ME	2,944,950	VT	5.0%
AL	2,768,765	ID	3.0%
LA	2,366,281	MS	2.7%
NC	2,262,087	GA	2.5%
FL	2,057,561	AR	2.4%
SC	1,940,953	LA	2.3%
MI	1,697,524	VA	2.0%
AR	1,589,891	SC	2.0%

Table 1. Top ten states by biomass power generation and percent total power from biomass, 2012

The fact that bioenergy emits so much more CO_2 at the stack than fossil fuels (see Appendix 2) means that even a couple percent biomass energy generation can increase a state's calculated emissions by five or six percent, depending on the CO_2 intensity of the rest of the state's power sector.

EPA's justifications for not counting bioenergy emissions

The treatment of biomass power as having zero emissions in the calculations of the rule introduces a foundational error, baked in to the calculation of the emissions rates for states that burn significant amounts of biomass now. What is EPA thinking? Does the Agency really not understand the implications of simply pretending there is no CO_2 coming out of a power plant stack when the fuel is wood? EPA lost this point in the US Court of Appeals in 2013, when the Court found that there was nothing ambiguous about the word "emit" in the context of Clean Air Act permitting.[11] According to the Court, EPA had no justification for counting bioenergy emissions as zero.

It is difficult to interpret why the EPA would bake in the assumption of carbon neutrality to its projections under the ESPS, but one explanation may be that the model that EPA uses for its projections, the Integrated Planning Model (IPM), is old and out of date and simply continues to treat bioenergy as carbon neutral, even though current science shows otherwise. Another explanation may be that EPA is sticking to its story that all biomass is "waste" that would decompose and emit CO_2 anyway – the argument that the Agency used to justify the original exemption for counting bioenergy CO_2 emissions for purposes of Prevention of Significant Deterioration permitting:

3. Potential for Some Biomass Feedstocks To Have a de minimis Impact on Carbon Levels in the Atmosphere: EPA has sufficient information at this time to conclude that at least some biomass feedstocks that may be utilized to produce energy have a negligible impact on the net carbon cycle, such as residue material (e.g., sawdust from milling

[11] *Center for Biological Diversity v. EPA*, D.C. Cir. No. 11-1101, July 12, 2013

operations) that would have decomposed under natural circumstances in a relatively short period of time (e.g., 10–15 years). Given this negligible impact on the carbon cycle, the gain from regulating emissions from combustion of this feedstock for bioenergy could be considered to be trivial.[12]

Despite an abundance of evidence submitted to EPA that existing and proposed biomass plants do not just burn waste wood and "residues" [13] – and further, modeling that shows that net CO_2 emissions from residues can be significant (the SAB report states that burning "residues" and waste wood can have a significant carbon impact;[14] also, see Appendix 2) – EPA may be sticking to its story that burning waste wood and residues has a minimal carbon impact, and that bioenergy facilities only burn waste wood. The flip side of this is that the Agency does seem to increasingly recognize that net greenhouse gas emissions are greater when trees are harvested for fuel, as demonstrated in the Region 9 EPA response to comments on the recently issued PSD permit for the Sierra Pacific Anderson biomass facility in California. The document, issued in April 2014, claims as does the ESPS that EPA is "still working" on an accounting framework for bioenergy:

"*As previously stated, EPA is not currently prepared to classify any particular biomass feedstocks as a "clean fuel" or "inherently lower emitting" or to engage in a quantitative ranking and comparison of the net atmospheric contribution of such fuels*"[15]

but then goes on to say that fuels will be restricted at the plant to those with lower net emissions impacts (emphasis added):

"*The revision is intended to clarify that SPI will be limited to the following types of biomass fuels: mill residues; untreated wood debris from urban areas (e.g., pallets and crates); agricultural crops and residues; forest residues; and non-merchantable forest biomass.* ***EPA believes*** *that these revisions to Permit Condition X.G. will limit the facility to the types of biomass fuels that are* ***generally considered to have lower net atmospheric contributions when combusted****. In addition, the record reflects that SPI's proposed cogeneration project is not intended to use timber harvested solely for the purpose of biomass combustion. See Second Recirculated Draft EIR, February 2012, at 2.0-20. Nevertheless, in response to the commenter's concerns, EPA's revisions to Permit Condition X.G.* ***are intended to preclude the use of this type of feedstock***."[16]

This decision suggests that at least in Region 9, EPA's thinking on the topic of bioenergy emissions is evolving in the direction laid out by the most current science, which recognizes that burning trees in power plants is dangerously counterproductive if the goal is to reduce energy sector greenhouse gas emissions.

However, it is a real danger that if wood waste is treated as having zero or negligible emissions, then *everything* will be defined as "waste." For instance, Dominion Energy in Virginia is converting three coal-fired power plants to burn wood, with total forest wood consumption around 2 million tons of forest

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[12] "Deferral for CO2 Emissions from Bioenergy and Other Biogenic Sources under the Prevention of Significant Deterioration (PSD) and Title V Programs," 76 Fed. Reg. 15,249 (March 21, 2011)

[13] Forest wood use for biomass fuel is growing so fast, and in so many categories, that the bioenergy tracking service Forisk has recently partitioned energy wood use into categories of "softwood pulpwood,", "hardwood pulpwood," "logging resdues/dirty chips," "urban wood," and "mill residues." Forisk Wood Energy US database, May 6, 2014.

[14] The report states, "*For logging residues and other feedstocks that decay over longer periods, decomposition cannot be assumed to be instantaneous… For residues, consider alternate fates (e.g., some forest residues may be burned if not used for bioenergy) and information about decay. An appropriate analysis using decay functions would yield information on the storage of ecosystem carbon in forest residues*."

[15] U.S. Environmental Protection Agency, Region 9. Responses to Public Comments on the Proposed Prevention of Significant Deterioration Permit Major Modification for Sierra Pacific Industries - Anderson Division. April, 2014. Page 10

[16] Ibid, page 11

wood per year (translating to just over 2 million tons of CO_2 emitted per year). A letter from Dominion to EPA's Science Advisory Board on biogenic carbon states that waste wood "*to us means forest materials including residues (tree tops, non-merchantable sections of stem, branches, and bark), **small trees** and other low value materials*"[17] (emphasis added). Covanta Energy, another operator of wood-fired biomass power plants (as well as municipal waste incinerators) distinguishes residues from whole tree chips but nonetheless treats whole tree chips as waste wood, stating that their Burney Mountain Power facility in California burns "waste" comprised of "forest residue, mill residue and **whole tree chips**."[18] Their website additionally states that they use "**logs from forest thinning**" for fuel.[19] These are just two of many biomass power companies that are burning trees in the guise of "waste" wood.

What is the role for bioenergy under the greenhouse gas rule?

EPA's approach in the GHG rule is to offer states a "menu" of options for reducing greenhouse gas emissions, which in addition to the building blocks of increased efficiency at coal plants and new renewable energy, also includes greater dispatch of natural gas plants and increased demand side efficiency. EPA models and projects potential outcomes of the rule using the Integrated Planning Model (IPM) which is designed to seek optimal, least cost scenarios for power sector development, given initial sets of constraints. EPA used IPM to model a "Base Case," representing development of the power sector if the GHG rule is *not* adopted,[20] and other scenarios representing implementation of the rule with state versus regional goals and goal implementation over differing timeframes.

The scenarios produced by the model depend on the input assumptions. Thus, despite the model's treatment of bioenergy as having zero carbon emissions, the IPM scenarios of biopower buildout with implementation of the greenhouse gas rule actually show very *low* levels of biopower sector development. This is because while EPA includes existing biomass energy facilities, the Agency chose to exclude new biomass energy in the forward-looking modeling for how states would achieve their target emissions rates. A technical document explains:[21]

"1.3. RE Target Generation Methodology by Technology Type
This section describes the methodology employed to produce target generation levels for each state by technology type. The RE technology types that contribute to each state's target generation level are utility-scale solar, onshore wind, conventional geothermal (hydrothermal), hydropower, and select existing biopower capacity types."

However, EPA goes on to indicate that the biomass energy industry shouldn't take this personally (emphasis added) -

"EPA notes that RE target generation levels are used solely to inform each state's goal calculation and are not prescriptive of any RE compliance outcome – either in sum or by technology type. Consequently, whether or not any particular RE technology is considered in this Alternative RE Approach ***does not have any bearing on what***

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[17] Pamela F. Faggert, Dominion Resources Services, Inc. Comments to the Science Advisory Board biogenic carbon emissions panel on its draft advisory report regarding EPA's accounting framework for biogenic CO_2 emissions from stationary sources. March 16, 2012.

[18] Other Renewable Energy Projects, Covanta website, (http://www.covantaenergy.com/what-we-do/our-services/other-renewable-energy.aspx).

[19] http://www.covantaenergy.com/what-we-do/our-services/other-renewable-energy.aspx

[20] http://www.epa.gov/airmarkets/powersectormodeling/cleanpowerplan.html

[21] U.S. Environmental Protection Agency. Alternative Renewable Energy Approach Technical Support Document. Technical Support Document (TSD) for Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units. Docket ID No. EPA-HQ-OAR-2013-0602, June 2014.

types of RE generation a state may consider in developing its state plan for complying with its state goal*"*

A footnote to this section additionally emphasizes,

"*Existing dedicated biomass and landfill gas facilities contribute to RE target generation levels. The analysis in this TSD does not consider biomass renewables in its evaluation of renewable development potential for BSER,* ***but the preamble discusses the possibility of a path for states to consider it in their plans****.*"

Thus, while EPA's own modeling does not plan for development in the bioenergy power sector, the rule leaves the door wide open for states to continue developing biomass power plants.

The IPM modeling projections for bioenergy buildout if the rule is enacted are indeed low, as is to be expected if new development is precluded. Biopower buildout under both the State Option I modeling scenario (under which GHG reduction targets are achieved by 2030) and State Option 2 runs (under which GHG reductions are slightly less aggressive than under Option I by the year 2020[22]), are both *lower* than for the Base Case, under which the GHG rule is not implemented. If it were not for EPA's encouragement of states to continue considering bioenergy, this finding would itself be extraordinary – that EPA has modeled the best path forward for reducing greenhouse gas emissions, and it *doesn't include any new biomass power plants*.

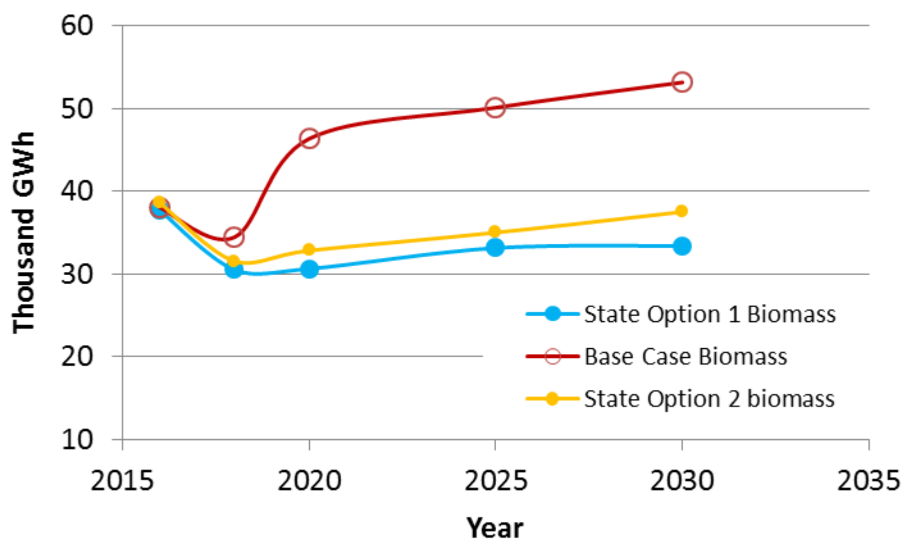

Figure 2. Biopower development under the Base Case (no GHG rule) and two implementation scenarios, as predicted using EPA's IPM model.

Indeed, bioenergy development under the model is essentially flat. Data from the Energy Information Administration (EIA) reveal that the whole bioenergy industry generated about 37.8 thousand gigawatt-hours (GWh) of electricity in 2012.[23] Under the IPM scenarios for State Option I and State Option 2,

[22] Environmental Protection Agency. 40 CFR Part 60: Carbon pollution emission guidelines for existing stationary sources: electric generating units; proposed rule. Federal Register Vol. 79 No. 117, June 18 2014, page 34931

[23] Energy Information Administration. Annual Generation. State Historical Tables for 2013, December 2013.

bioenergy generation in 2030 decreases to 33 and 37 thousand GWh, respectively, while the Base Case generation is 53 thousand GWh.[24]

EPA's projections of biomass buildout, even under the Base Case, are also low relative to projections from the Energy Information Administration's modeling. The EIA uses the National Energy Modeling System (NEMS) to develop its Annual Energy Outlook (AEO). Each year, the AEO "reference case" modeling shows actual energy sector development for the preceding two years, then forecasts future development, with forecasts varying widely year to year. Comparing the EPA's IPM projections for the GHG rule (which start in 2016) to EIA's AEO forecasts, it can be seen that the EPA's Base Case projection tracks EIA's 2012 reference case scenario until about 2025, but shows lower capacity thereafter. The State Option 1 scenario is lower after about 2018 than all of EIA's recent AEO projections.

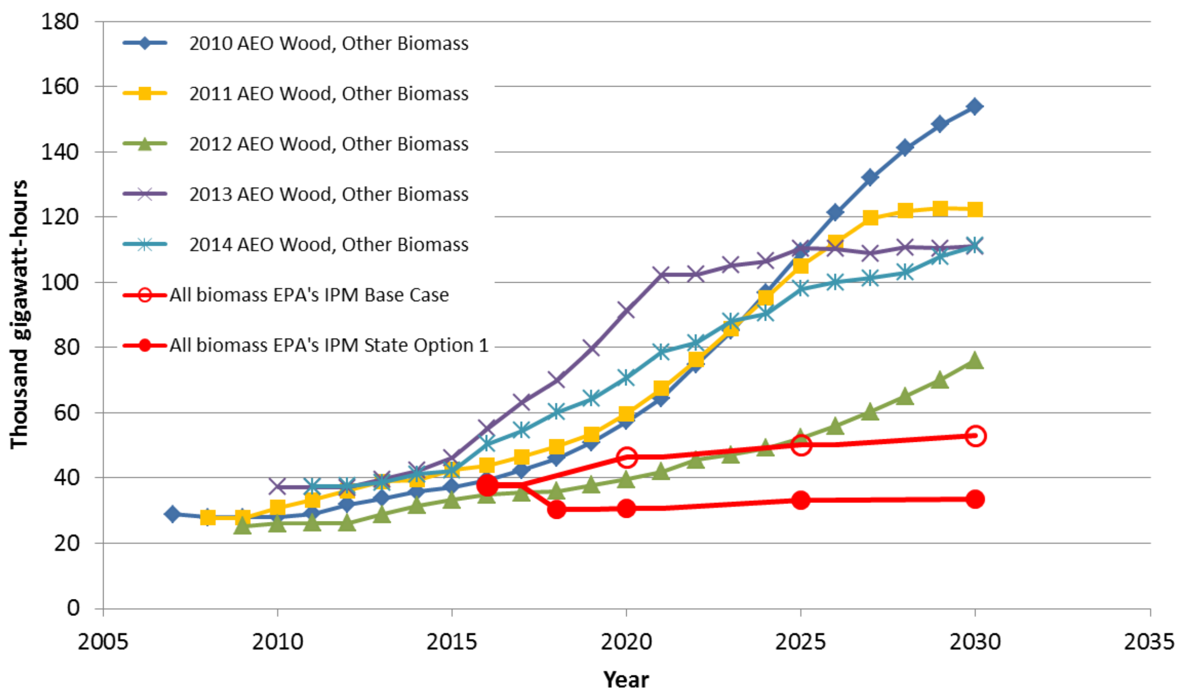

Figure 3. EPA's predictions for bioenergy development contrasted with EIA's predictions.

Why has EPA not included new bioenergy capacity in its GHG rule modeling?

The reasons for EPA's decision to not include new bioenergy capacity in its IPM model runs are somewhat opaque. One reason may be that compared to other forms of renewable energy, the capacity of bioenergy is extremely limited, and it is unrealistic to expect that new biomass energy facilities fueled by the "residues" that are supposedly available could provide any substantial amount of power.[25] EPA based their initial estimates of renewable energy capacity on a "renewable energy potential" study by the National

[24] These numbers are obtained by summing the "biomass" and "biomass co-firing" values on the "summary" tab of the "ssr" spreadsheets provided by EPA for each scenario. These are available for download at http://www.epa.gov/airmarkets/powersectormodeling/cleanpowerplan.html

[25] The amount of residues that are actually available to fuel biomass power plants is certainly limited; however, if biomass power plants harvest forest wood for fuel, then limits on fuel availability would be removed. However, this would be a disaster for forests and the carbon sequestration capacity that they provide.

Renewable Energy Laboratory (NREL).[26] The following table, taken from that report, shows the technical potential for different forms of renewable energy, with technical potential meaning that almost all constraints are removed – for instance, under this analysis, a given area of land is considered "available" for all uses simultaneously.

Table ES-1. Total Estimated U.S. Technical Potential Generation and Capacity by Technology

Technology	Generation Potential (TWh)[a]	Capacity Potential (GW)[a]
Urban utility-scale PV	2,200	1,200
Rural utility-scale PV	280,600	153,000
Rooftop PV	800	664
Concentrating solar power	116,100	38,000
Onshore wind power	32,700	11,000
Offshore wind power	17,000	4,200
Biopower[b]	500	62
Hydrothermal power systems	300	38
Enhanced geothermal systems	31,300	4,000
Hydropower	300	60

[a] Non-excluded land was assumed to be available to support development of more than one technology.
[b] All biomass feedstock resources considered were assumed to be available for biopower use; competing uses, such as biofuels production, were not considered.

Table 2. NREL's technical analysis for renewable energy capacity in the United States.

The estimate for biopower capacity is notably low, compared to other technologies, and even so, it's probably a significant overestimate, because not only does NREL's estimate include all forms of biopower (including methane collection from human and animal waste) but it considers that *all* biomass is available to generate combustion-biopower, rather than being collected for use as ethanol feedstock. Even with these assumptions, biopower is considered to have only 1.5% the generation potential of onshore wind (500 TWh versus 32,700 TWh).

Further, the NREL technical potential estimates are unrealistic for yet another reason – they are based on an NREL study by Milbrandt, of biomass availability in the United States.[27] The Milbrandt study assessed potential biomass "availability" in each state, examining the categories of crop residues, forestry residues, "urban" wood, and mill residues. Crop residues make up the bulk of the biomass considered to be potentially available for biomass power generation in the Milbrandt study, outweighing forestry residues[28] by a factor of 2.8 and urban wood by a factor of 5.1. This is why, in NREL's assessment of technical

[26] Lopez, A. et al. U.S. renewable energy technical potentials: a GIS-based analysis. National Renewable Energy Laboratory Technical Report NREL/TP-6A20-51946. July, 2012.
[27] Milbrandt, A. A geographic perspective on the current biomass resource availability in the United States. National Renewable Energy Laboratory, Technical Report NREL/TP-560-39181. December, 2005.
[28] The category of "forest residues" in the Milbrandt report unequivocally includes whole tree harvesting. It includes "*logging residues and other removals. Logging residues are the unused portions of trees cut, or killed by logging, and left in the woods. Other removals are considered trees cut or otherwise killed by cultural operations (e.g. pre-commercial thinning, weeding, etc.) or land clearings and forest uses that are not directly associated with round wood product harvests*." (Milbrandt, 2005, page 18).

potential for biomass power generation, the states of Ilinois, Indiana, Iowa, Missouri, Nebraska, and Ohio – not exactly known for their forestry resources – provide a combined total of 16 GW of the potential overall biopower capacity of 62 GW (26%).[29]

The problem with all this supposedly available crop-based biomass and the biopower capacity it potentially supports is that very few biomass plants or coal plants can actually burn crop residues for fuel, as is shown by the fact that almost every one of the biomass power plants being proposed around the country plans to burn wood as fuel.[30] Crop residues are dirty and contain relatively high amounts of potassium and other elements that foul emissions controls. Collection, processing, and storage of these materials is expensive, a fact that EPA acknowledges in its IPM modeling by attaching not only a $12/dry ton surcharge on all types of biomass for transport, but also a $20/ton surcharge for storage of crop residue-derived biomass fuels, since they can only be collected at certain times of the year and must be stored in quantity until they are needed.[31]

In addition to biomass fuel costs, which are perpetual (in contrast to the "fuels" of wind and solar energy, which are perpetually free) biomass power plants are expensive to build and require substantial and ongoing infrastructure investments. EPA's IPM documentation document contains the following table,[32] which shows the costs of building new infrastructure. Bioenergy is substantially more expensive than onshore wind, per kilowatt-year, including both the initial infrastructure investment and ongoing "fixed" costs (the annual expense of maintaining a unit) and "variable" costs (expenses associated with operating units, including for pollution controls).

Table 4-16 Performance and Unit Cost Assumptions for Potential (New) Renewable and Non-Conventional Technology Capacity in EPA Base Case v.5.13

	Biomass-Bubbling Fluidized Bed (BFB)	Geothermal	Landfill Gas			Fuel Cells	Solar Photovoltaic	Solar Thermal	Onshore Wind	Offshore Wind
			LGHI	LGLo	LGVLo					
Size (MW)	50	50	50			10	150	100	100	400
First Run Year Available	2018	2018	2016			2016	2016	2016	2016	2018
Lead Time (Years)	4	4	3			3	2	3	3	4
Availability	83%	87%	90%			87%	90%	90%	95%	95%
Generation Capability	Economic Dispatch	Economic Dispatch	Economic Dispatch			Economic Dispatch	Generation Profile	Generation Profile	Generation Profile	Generation Profile
	Vintage #1 (2016-2054)					**Vintage #1 (2016)**				
Heat Rate (Btu/kWh)	13,500	30,000	13,648	13,648	13,648	9,246	9,756	9,756	9,756	9,756
Capital (2011$/kW)	4,041	1,187 - 15,752	8,408	10,594	16,312	7,117	3,364	4,690	2,258	6,298
Fixed O&M (2011$/kW/yr)	103.79	50 - 541	381.74	381.74	381.74	357.47	21.37	66.09	38.86	72.71
Variable O&M (2011$/MWh)	5.17	0.00	8.51	8.51	8.51	0.0	0.0	0.0	0.0	0.0

Table 3. EPA's IPM model assumptions for the costs of building new renewable energy infrastructure.

Combined, fuel costs, infrastructure costs, and maintenance costs can quickly drive bioenergy costs to an uneconomic level where the IPM model is likely to "choose" lower cost renewable energy options over bioenergy.

[29] Lopez, A. et al. U.S. renewable energy technical potentials: a GIS-based analysis. National Renewable Energy Laboratory Technical Report NREL/TP-6A20-51946. July, 2012. Data from Table 8, page 16.

[30] Forisk Wood Energy US database, May 6, 2014.

[31] U.S. Environmental Protection Agency. Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model. Page 11-2.

[32] Ibid, page 4-32.

Could the rule increase forest harvesting for biomass energy?
How significant is it that EPA has not included new biopower capacity in its modeling for states? Does it portend that the Agency has turned the corner on bioenergy, and recognizes that the majority of new biomass power plants now being proposed burn wood – not sawdust, not mill residues (as these are already allocated), and not fast-rotation energy crops like switchgrass – but forest wood, derived from forest trees – trees that are our only significant terrestrial carbon sink? Is it simply a reflection of how uneconomic bioenergy is compared to other forms of renewable energy, or compared to natural gas? Or does it mean that EPA is simply punting on the bioenergy question, and leaving it up to the states, because the issue has become too political and controversial?

For now, the answer is not clear, but it unfortunately does appear to contain some element of a "punt" by EPA on bioenergy. As demonstrated above, EPA has left the door open for states to propose bioenergy as a means to increase renewable energy capacity, and is soliciting comment on deployment of bioenergy at the state level:

"*Beyond the types of state plan measures already discussed in this section of the preamble, the agency has identified a number of other measures that could also lead to CO_2 emission reductions from EGUs. These include, for example, electricity transmission and distribution efficiency improvements, retrofitting affected EGUs with partial CCS,* ***the use of biomass-derived fuels at affected EGUs,*** *and use of new NGCC units. Although the emission reduction methods discussed in this section are not proposed to be part of BSER, the agency anticipates that some states may be interested using these approaches in their state plans.* ***The agency solicits comment on whether these measures are appropriate to include in a state plan to achieve CO_2 emission reductions from affected EGUs***." [33] (emphasis added)

Given that the EPA itself is supposed to be coming up with a framework for carbon accounting, and given that EPA solicited, and received, abundant comments on greenhouse gas emissions from bioenergy when it issued the biogenic C deferral, to say nothing of the extensive input during the US Court of Appeals case on the deferral and the expert input provided by the Science Advisory Board, for EPA to be soliciting *additional* comment on whether burning biomass can "reduce" greenhouse gas emissions seems like stalling tactics. The Agency should have more than enough information now to produce a science-based carbon accounting framework.

Further, the lack of enforceable language in the GHG rule suggests that even if EPA does develop a carbon accounting framework for bioenergy, it is likely to be weak and unenforceable. The ESPS indicates it's likely that the states will be wagging the dog on the bioenergy rules:

"*Because of the positive attributes of certain biomass-derived fuels, the EPA also recognizes that biomass-derived fuels can play an important role in CO_2 emission reduction strategies. We anticipate that states likely will consider biomass-derived fuels in energy production as a way to mitigate the CO_2 emissions attributed to the energy sector and include them as part of their plans to meet the emission reduction requirements of this rule and we think it is important to define a clear path for states to do so.*" [34]

If EPA came out with a strong and decisive carbon accounting framework that acknowledget the true emissions from burning biomass, states that were serious about reducing emissions would eliminate large-scale bioenergy from their list of options, as Massachusetts has done and as Vermont is starting to do.[35]

[33] Environmental Protection Agency. 40 CFR Part 60: Carbon pollution emission guidelines for existing stationary sources: electric generating units; proposed rule. Federal Register Vol. 79 No. 117, June 18 2014, page 34923
[34] Ibid, page 34924
[35] See http://www.pfpi.net/vermont-biomass-power-plant-denied-approval-on-basis-of-greenhouse-gas-emissions

However, there is no indication in the rule that EPA has any means, or intent, of providing real leadership or enforcing a carbon accounting framework at the state level. Indeed, the language around deployment of the carbon accounting framework is notably weak:

"*The EPA **expects** that the framework, when finalized, will be a resource that **could** help inform states in the development of their CAA section 111(d) plans*."[36] (emphasis added)

Unfortunately, some of the states that are now experiencing the highest bioenergy development are also those states that are targeted by the rule to show the greatest reductions in power sector emissions rates. Ranked in descending order of the percent reduction required, Washington, South Carolina, Oregon, New Hampshire, and Georgia are all states that have shown a predilection for building large, low-efficiency, high fuel consumption wood-burning power plants (see Appendix 1 for full list of states, EPA's current emission rate estimates, and target emission rates). These states, and the bioenergy developers therein, will no doubt pressure EPA to allow bioenergy as a means of "mitigating" power sector carbon emissions. Given EPA's weak performance in standing up to this kind of pressure so far, prospects dim for both forests in these states, and for the ability of the GHG rule to accomplish real emissions reductions.

Carbon offsets, bioenergy, and beyond the fenceline mitigation

Certain to become an issue of contention in the proposed greenhouse gas rule is the extensive use of "beyond the fenceline" mitigation measures for reducing greenhouse gas emissions, as EPA has recognized in its request for comments.[37] While the NSPS rule treats an individual power plant as the entity of concern, setting a fixed emissions standard that applies at the facility, the ESPS seeks a "best system of emission reduction" (BSER) for entities where the boundaries are less clear. Does increased use of low- or zero-emissions renewable energy (EPA's terms) somewhere in a state constitute a "reduction" in greenhouse gas emissions from that state's coal-fired plants? Can increased demand-side efficiency likewise constitute a reduction? These questions will no doubt be extensively argued and likely litigated as well.

Meanwhile, it is important to recognize that most claims for bioenergy as having "low" or "zero" carbon emissions *also* rely on "beyond the fenceline" mitigation. Biomass can't play a role in reducing greenhouse gas emissions at the time it is burned, because essentially all biomass fuels emit more CO_2 per unit energy generated than all fossil fuels. Thus, any claim that bioenergy emits "less" CO_2 than fossil fuels relies on calculation of net CO_2 emissions over time. Lifecycle GHG accounting can show lower net emissions for biomass than for fossil fuels, based on either the idea that fuels are waste that would decompose and inevitably emit CO_2 anyway, or that fuels are sourced from forests or crops that can regow and sequester an equivalent amount of CO_2 as emitted by burning the material as fuel. However, as neither process is instantaneous, no biomass energy can be instantaneously carbon neutral.

In fact, both arguments for eventual carbon neutrality of biomass energy are essentially **carbon offset schemes**, in that they assume that a process occurring in some other place, and at some future time, compensates for CO_2 emissions from burning biomass (see Appendix 2 for modeling of typical time periods required for bioenergy CO_2 emissions to be offset). Can the GHG rule accommodate a scenario whereby it is acceptable to increase powerplant or grid-wide emissions by substituting biomass for fossil fuels, based on the idea that emissions will eventually be offset? Does EPA have the jurisdiction under the GHG rule to discriminate between stack emissions at the present time – which for every biomass fuel are greater than

[36] Ibid, page 34927

[37] Environmental Protection Agency. 40 CFR Part 60: Carbon pollution emission guidelines for existing stationary sources: electric generating units; proposed rule. Federal Register Vol. 79 No. 117, June 18 2014, page 34888

emissions from coal, per megawatt-hour – and "net" emissions in the future, which are calculated assuming that emissions are offset?

In a narrower context, but also pertaining to Clean Air Act implementation, the US Court of Appeals has already weighed in on the question of whether offsetting of bioenergy greenhouse gas emissions constitutes a reduction. Much of the court's reasoning for ruling against EPA's deferral of biogenic CO_2 regulation turned on the plain meaning of the word "emit," and the fact that the Clean Air Act regulates stack emissions of power plants and other stationary sources. However, a concurrent opinion issued with the main ruling also explained that the Clean Air Act *forecloses* any "offsetting" approach – i.e., taking off-site carbon sequestration into account as a compensating factor that can mitigate a power plant's emissions – because "The statute does not allow EPA to exempt those sources' emissions of a covered air pollutant just because the effects of those sources' emissions on the atmosphere might be offset in some other way."[38]

The EPA may have already internalized this lesson with regard to the ability of states to use actual carbon offsets as a means of mitigating power sector emissions under the GHG rule, whereby, for instance, a forest and its carbon sequestration capacity is preserved to compensate for a fossil fuel plant's CO_2 emissions. The ESPS rule is initially somewhat ambiguous as to whether the GHG rule allows offsets, but, an assessment included in a technical support document seems to clearly prohibit use of offsets for mitigation:

*"For emission budget trading programs that regulate EGUs and include offsets, which we define here as emissions reductions from sources not regulated by the trading program, **emissions reductions from offsets would not be counted** when evaluating CO_2 emission performance of affected EGUs, because those reductions would not come from those affected EGUs"*[39]

The prohibition on use of offsets may provide some insight for the parallel issue of bioenergy emissions offsetting. If EPA does not intend to allow actual offsets under the rule, then it is hard to see how biomass emissions that rely on offsite regrowth of fuels can be allowable, especially when most power plant operators do not own or otherwise control the forest lands where future carbon sequestration is ostensibly to occur.

The situation with regard to "waste" materials that would decompose anyway may be more ambiguous. The offsetting of emissions from burning true wastes simply relies on time, and the assumption that decomposition would be emitting greenhouse gases anyway if the material were not burned for fuel. In this case, as decomposition can take years to decades, and net emissions from biomass burning will almost always exceed "anyway" emissions from decomposition (see Appendix 2), the question is simply whether the ESPS rule can count hypothetical reductions in emissions that will occur at some future time as a real reductions in current emissions.

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[38] *Center for Biological Diversity v. EPA*, D.C. Cir. No. 11-1101, July 12, 2013; Concurrence page 3.

[39] U.S. EPA. Projecting EGU CO_2 Emission Performance in State Plans. Technical Support Document (TSD) for Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units. Docket ID No. EPA-HQ-OAR-2013-0602, June 2014. Page 37.

Appendix 1: EPA's current and target emissions rates for states ranked by emission reduction required under the GHG rule[40]

	current fossil rate	fossil + nukes + RE	block 1	block 1&2	1&2&3	1&2&3&4	% reduction
Washington	1,379	756	728	444	298	215	72%
Arizona	1,551	1,453	1,394	843	814	702	52%
South Carolina	1,791	1,587	1,506	1,342	866	772	51%
Oregon	1,081	717	701	565	452	372	48%
New Hampshire	1,119	905	887	710	532	486	46%
Georgia	1,598	1,500	1,433	1,216	926	834	44%
Arkansas	1,722	1,634	1,554	1,058	996	910	44%
New York	1,096	978	970	828	652	549	44%
New Jersey	1,035	928	916	811	616	531	43%
Minnesota	2,013	1,470	1,389	999	1,042	873	41%
North Carolina	1,772	1,647	1,560	1,248	1,125	992	40%
Louisiana	1,533	1,455	1,404	1,043	978	883	39%
Tennessee	2,015	1,903	1,797	1,698	1,322	1,163	39%
Texas	1,420	1,284	1,235	979	861	791	38%
Florida	1,238	1,199	1,169	882	812	740	38%
Virginia	1,438	1,302	1,258	1,047	894	810	38%
Massachusetts	1,001	925	915	819	661	576	38%
Mississippi	1,140	1,093	1,071	809	752	692	37%
Maryland	2,029	1,870	1,772	1,722	1,394	1,187	37%
Oklahoma	1,562	1,387	1,334	1,053	964	895	35%
Colorado	1,959	1,714	1,621	1,334	1,222	1,108	35%
South Dakota	2,256	1,135	1,067	732	900	741	35%
Nevada	1,091	988	970	799	720	647	35%
Wisconsin	1,988	1,827	1,728	1,487	1,379	1,203	34%
New Mexico	1,798	1,586	1,513	1,277	1,163	1,048	34%
Illinois	2,189	1,894	1,784	1,614	1,476	1,271	33%
Idaho	858	339	339	339	291	228	33%
Delaware	1,255	1,234	1,211	996	892	841	32%
Michigan	1,814	1,690	1,603	1,408	1,339	1,161	31%
Pennsylvania	1,627	1,531	1,458	1,393	1,157	1,052	31%
Connecticut	844	765	764	733	643	540	29%
Ohio	1,897	1,850	1,751	1,673	1,512	1,338	28%
Utah	1,874	1,813	1,713	1,508	1,454	1,322	27%
Alabama	1,518	1,444	1,385	1,264	1,139	1,059	27%
Nebraska	2,162	2,009	1,889	1,803	1,652	1,479	26%
Alaska	1,368	1,351	1,340	1,237	1,191	1,003	26%
California	900	698	697	662	615	537	23%
Kansas	2,320	1,940	1,828	1,828	1,658	1,499	23%
Missouri	2,010	1,963	1,849	1,742	1,711	1,544	21%
Montana	2,439	2,246	2,114	2,114	1,936	1,771	21%
Indiana	1,991	1,924	1,817	1,772	1,707	1,531	20%
West Virginia	2,056	2,019	1,898	1,898	1,687	1,620	20%
Wyoming	2,331	2,115	1,988	1,957	1,771	1,714	19%
Kentucky	2,166	2,158	2,028	1,978	1,947	1,763	18%
Iowa	2,197	1,552	1,461	1,304	1,472	1,301	16%
Hawaii	1,783	1,540	1,512	1,512	1,485	1,306	15%
Rhode Island	918	907	907	907	867	782	14%
Maine	873	437	437	425	451	378	14%
North Dakota	2,368	1,994	1,875	1,875	1,865	1,783	11%

[40] U.S Environmental Protection Agency. Goal Computation Technical Support Document for the CAA Section 111(d) Emission Guidelines for Existing Power Plants Docket ID No. EPA-HQ-OAR-2013-0602. June, 2014.

Appendix 2: Technical information on CO_2 from biomass energy

Carbon dioxide emissions from power plants

All fuels produce CO_2 when burned. The general assumption is that all carbon in the fuel is converted to CO_2, though in fact, some small fraction is emitted as carbon monoxide (CO) and other carbon-containing compounds such as volatile organics.

CO_2 emissions from power plants are typically expressed in units of pounds of CO_2 per megawatt-hour of electricity produced (lb CO_2/MWh).

How much CO_2 does burning wood emit?

Biomass power plants may burn a variety of fuels, including energy crops, crop residues, wood, and "wood-derived fuels," the residuals from pulp and papermaking.[41] However, the overwhelming majority of new biomass power plants now being proposed burn wood. The rest of this factsheet assumes that wood is the main fuel burned for biomass.

Green wood when it is harvested can be more than 50% water by weight. A typical industry assumption is that wood is 45% water by weight. Of the 55% "bone dry" mass that is left after subtracting water weight, around 50% is carbon.[42] The conversion factor for carbon to CO_2 during combustion is the molecular weight of CO_2 (44) divided by the molecular weight of carbon (12).

The full conversion equation thus reveals that burning one ton of "green" wood at 45% moisture content emits just over one ton of CO_2:

1 ton green wood * 0.55 ton bone dry wood/ton green wood * 0.5 ton carbon/ton bone dry wood *44 tons CO_2÷12 tons carbon = 1.008 tons CO_2

How much CO_2 does a biomass power plant emit?

To compare the amount of CO_2 emitted by biomass power plants versus a same-sized coal or gas plant, the CO_2 emissions need to be expressed using a common currency, rather than in terms of the pounds or tons of fuel burned.

The CO_2 per megawatt-hour produced at any power plant is a function of two main factors:

- The amount of CO_2 emitted by the fuel when it is burned, relative to its energy content, or "heat content" in million Btu (lb CO_2/MMBtu)
- Facility efficiency (MMBtu output of useful energy divided by MMBtu of fuel input). The lower the efficiency of the facility, the more fuel that has to be burned to produce a given amount of "useful" energy.

[41] These wastes are high in moisture content and therefore low in energy, but they are an important fuel for the industries where they are generated, and use of them as fuel solves the industry's disposal problems.

[42] The assumption of 50% carbon content is an oversimplification, as species vary in carbon content (http://www.sciencedirect.com/science/article/pii/S0961953403000333; also http://is.muni.cz/el/1423/podzim2013/MEB423/um/Wood_Combustion_Lesson_02.pdf) but it is a representative average that is widely used. See for instance http://www.epa.gov/burnwise/workshop2011/WoodCombustion-Curkeet.pdf

Coal heat content ranges from 10,000 to over 12,000 Btu per pound,[43] depending on its composition.

Biomass heat content depends on moisture content and composition. "Bone dry" wood with zero moisture has an average heat content of about 8,600 Btu per pound.[44] Green wood "as delivered" at a typical moisture content of 45% has a heat content[45] of about 4,730 Btu/lb.

Expressing CO_2 emission relative to the heating value of a fuel (in MMBtu) provides a "common currency" that takes moisture content and fuel mass out of the equation when comparing fuels. Although a ton of coal contains a great deal more inherent energy than a ton of wood, biomass and coal emit similar amounts of CO_2 per MMBtu of energy in the fuel.[46] If biomass facilities were as efficient as coal plants, then same-sized facilities would emit similar amounts ofCO_2. However, a biomass plant is actually much less efficient than a coal plant,[47] in great part because it takes energy to evaporate moisture in biomass before "useful energy" can be produced from fuel combustion.[48]

The following table summarizes this information for natural gas, coal, and biomass facilities.

Table 1: CO_2 emissions at the stack for biomass, coal, and natural gas electricity generation[49]

Technology	Fuel CO_2 emissions (lb/MMBtu heat input)	Facility efficiency	MMBtu required to produce one MWh	Lb CO_2 emitted per MWh
Gas combined cycle	117.1	45%	7.54	883
Gas steam turbine	117.1	33%	10.40	1,218
Coal steam turbine	206	34%	10.15	2,086
Biomass steam turbine	213	24%	14.22	3,029

Table 1. Per megawatt-hour, CO_2 stack emissions at the biomass plant are about 145% those of coal plant,[50] and 250% - 340% those of a gas plant (depending on whether it is a single cycle plant, or employs a combustion turbine).

Effect of biomass co-firing on coal plant CO_2 emissions

Just as a biomass plant emits more CO_2 per MWh than a coal plant, co-firing biomass in a coal plant decreases overall facility efficiency[51] and increases CO_2 stack emissions. The more biomass that is co-fired,

[43] Values converted from EIA data which is given in units of million btu per short ton: http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb1205
[44] Biomass Energy Data Book 4th Edition, page 205: http://cta.ornl.gov/bedb/pdf/BEDB4_Full_Doc.pdf
[45] This is the "higher heating value." See page 201 of Biomass Energy Data Book 4th Edition: http://cta.ornl.gov/bedb/pdf/BEDB4_Full_Doc.pdf
[46] Both emit a great deal more CO_2 per unit energy in the fuel than natural gas.
[47] Typical assumed peak efficiency for biomass electricity plants is around 24%. However, many facilities have considerably lower efficiencies of 19% – 20%. In general, the smaller a plant is, the less efficient it tends to be.
[48] Biomass Energy Data Book 4th Edition, page 205: http://cta.ornl.gov/bedb/pdf/BEDB4_Full_Doc.pdf
[49] Sources for table: Average heat content of coal: http://www.eia.gov/coal/production/quarterly/co2_article/co2.html
Heat content of biomass: Biomass Energy Data Book 4th Edition, page 204: http://cta.ornl.gov/bedb/pdf/BEDB4_Full_Doc.pdf
CO_2 emissions for natural gas: http://www.eia.gov/environment/emissions/co2_vol_mass.cfm
[50] The 33% efficiency value used as representative of coal plant efficiency is the average efficiency of the existing US fleet of coal plants. The newest coal plants are more efficient.

the further the facility's efficiency will move down the scale from the value for a 100% coal-fired plant (~33% on average in the US) towards the value for a 100% biomass-fired plant (~24%). Typical co-firing rates of ~10% biomass have been observed to degrade coal plant efficiency by 1% - 2%.

Treatment of biomass power as "carbon neutral"

Despite the fact that biomass power plants emit more CO_2 than fossil fueled plants per megawatt-hour, biomass power has been treated as carbon neutral based on two main arguments:

- The first is that mostly waste materials - such as lumber mill shavings, paper mill waste, and "forestry residues," the tops and limbs left over after saw-timber harvesting - are used as fuel. Because such materials would inevitably decompose and emit CO_2, it is argued that burning them as fuel does not emit more CO_2 than would occur in any case. The problem with this argument is that while burning emits CO_2 instantaneously, wood decomposition takes years to decades.

- The second argument for bioenergy being carbon neutral states that when whole trees are used as fuel, carbon emissions are "offset" as standing and/or new trees grow and take up an equivalent amount of CO_2 as was released by burning. The problem with this argument is that burning biomass emits carbon instantly, while regrowth takes decades, and in addition, harvesting forests for fuel compromises their ability to serve as an ongoing carbon sink for fossil fuel emissions.

These arguments are addressed in more detail below.

The "Biomass is carbon neutral because it would decompose anyway" argument

Assuming biomass combustion emissions to be zero because the CO_2 would have been emitted "anyway" from decomposition ignores the fact, highly relevant to calculating the impact of CO_2 emissions on atmospheric CO_2 levels and climate warming, that burning biomass emits CO_2 instantly, while letting it decompose emits it slowly. Figures 1 and 2 show results from a model[52] of CO_2 emissions from alternate fates of biomass – either being burned at a 50 MW biopower plant, or left to decompose. The model assumes a moderate decomposition rate representative of Northeastern forests, and reveals that over time, emissions from burning will always exceed those from decomposition (Figure1). For instance, after ten years of operation, a 50 MW facility would have emitted about 6.3 million tons of CO_2, whereas if those fuels had been left unburned, CO_2 emissions would have been about 2.3 million tons, a difference of 4 million tons (represented by the black arrow).

[51] See Electric Power Research Institute report on co-firing at http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001004319

[52] The model assumes:
Green wood is 45% water by weight
Bone dry wood is 50% carbon
% wood left at year x = $e^{-0.09*(year\text{-}x - 0.05)}$
Wood decomposed at year x = (1 - % wood left at year x)
Facility efficiencies: Coal: 33%; Biomass: 24%; Natural Gas: 45%

Figure 1: Comparison of CO_2 emissions from biomass combustion versus biomass decomposition over time.

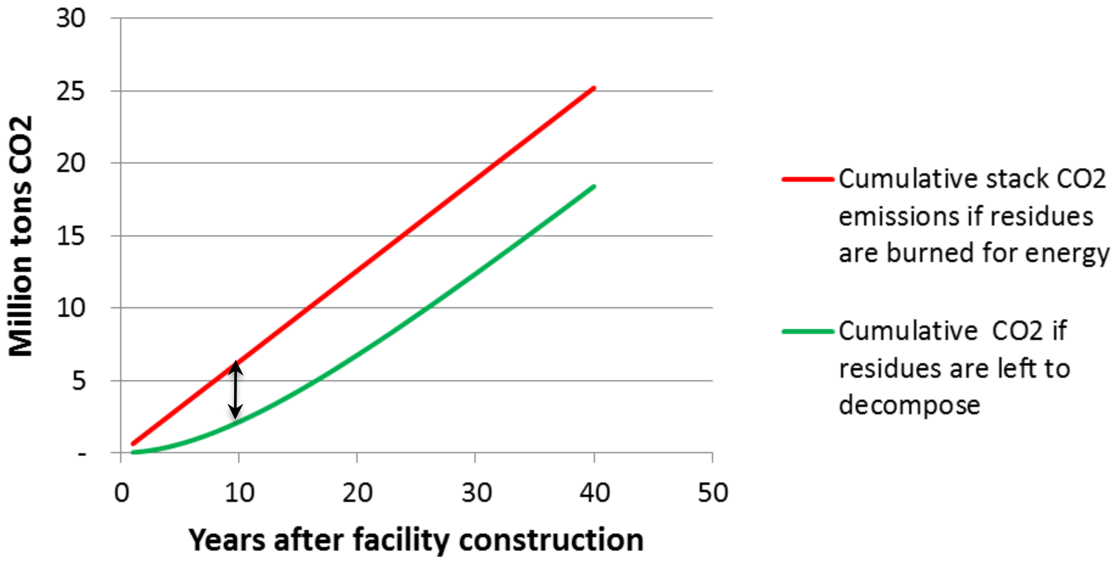

Figure 1. After ten years of facility operation, burning residues will have emitted about four million tons more CO_2 than under the scenario where they are allowed to decompose.

Figure 2 shows that same four million tons as the "net" or "additional" CO_2 that is emitted by burning biomass rather than letting it decompose, and shows that this is approximately equal to the CO_2 that would be emitted by a 50 MW coal plant over ten years of facility operation. Thereafter, in this example, a biomass plant may begin to show lower net emissions than a coal plant – provided that the fuel is truly "waste wood that would have decomposed anyway," and not trees harvested for bioenergy, which but for being harvested would have continued to grow and sequester carbon (discussed below).

Figure 2 shows that for this example, net emissions from the biomass plant fueled exclusively by waste wood exceed those from a same-sized natural gas plant for more than 30 years.

Figure 2: Net emissions from bioenergy exceed fossil fuel emissions even when burning waste wood

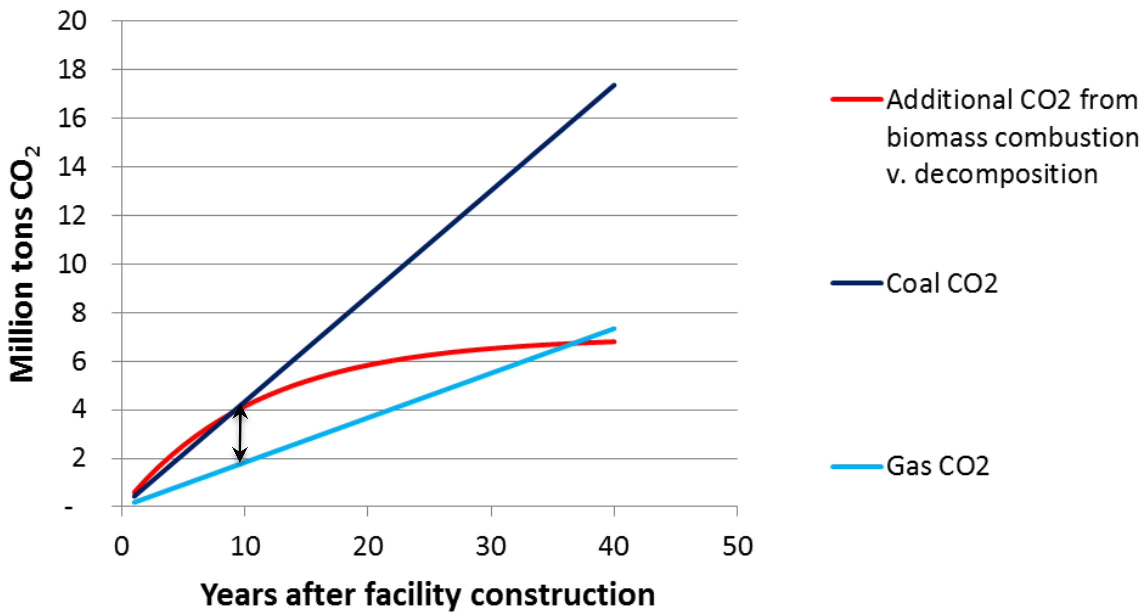

Figure 2. Even after subtracting "anyway" emissions from decomposition, net CO_2 emissions from a biomass plant exceed those from a coal plant for about ten years, and exceed those from a gas plant for more than 30 years.

These results mean that instead of reducing emissions from power generation, biomass power plants burning waste wood "that would decompose anyway" actually increase emissions for at least a decade, even compared to inefficient coal plants.

The "Biomass is carbon neutral because forests take up CO_2" argument

Forests (along with beneficial agricultural activities) are the only carbon sink reported in EPA's inventory of greenhouse gas emissions and sinks, and are estimated to sequester about 13.5% of US CO_2 emissions per year.[53] Forestry activities that cut trees and disturb soils are recognized as sources of CO_2. Critically, forests take up CO_2 emitted by all sectors, including the fossil fueled electricity generation sector.

Net carbon emissions from burning wood as fuel can theoretically be offset by trees re-growing and taking up an equivalent amount of CO_2 as was released by burning. However, numerous scientific studies[54] demonstrate that carbon emissions of biomass power plants are not offset by new forest growth for decades, and that meanwhile, forest carbon uptake is decreased by the very harvesting required to fuel biomass power plants.

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[53] U.S. EPA 40 CFT Parts 60, 70, 71 et al. Standards of Performance for Greenhouse Gas Emissions From New Stationary Sources: Electric Generating Units; Proposed Rule (page 1441)

[54] See for example Searchinger, T., et al. 2009. Fixing a critical climate accounting error. Science 326: 527-528 ; Colnes, A., et al. 2012. Biomass supply and carbon accounting for Southeastern Forests. Biomass Energy Resource Center, Montpelier, VT; Mitchell, S., et al. 2012. Carbon debt and carbon sequestration parity in forest bioenergy production. GCB Bioenergy (2012) doi:10.1111/j.1757-1707.2012.01173.x; McKechnie, J. et al. 2011. Forest bioenergy or forest carbon? Assessing trade-offs in greenhouse gas mitigation with wood-based fuels. Environmental Science and Technology, 45: 789-795.

Because biomass power plants emit more CO_2 per megawatt-hour than fossil-fueled plants, the atmosphere "sees" more power sector CO_2 under a biomass power scenario (that harvests forests and replaces them with seedlings) than it does under a fossil fuel power scenario (where middle-aged and mature forests are allowed to continue growing and sequestering carbon).

Figure 3 is a generalized schematic showing that it takes time for net uptake of CO_2 from new forest growth to bend the net emissions curve for biomass downward. Because biomass plants emit more CO2 than fossil fueled plants per megawatt-hour, until that point when the bioenergy curve crosses the emissions line for fossil fuels, the atmosphere is seeing more CO_2 from a biomass plant than from an equivalently sized fossil fueled plant. For biomass facilities that are harvesting new whole trees as fuel, forest modeling demonstrates that it takes 35 to more than 90 years for new forest growth to offset the extra CO_2 emissions from burning biomass rather than fossil fuels, with shorter offsetting times for biomass-coal comparisons, and longer times for biomass-natural gas comparisons. [55]

Figure 3: Net bioenergy emissions significantly exceed fossil fuel emissions for decades when carbon-sequestering trees are harvested for fuel

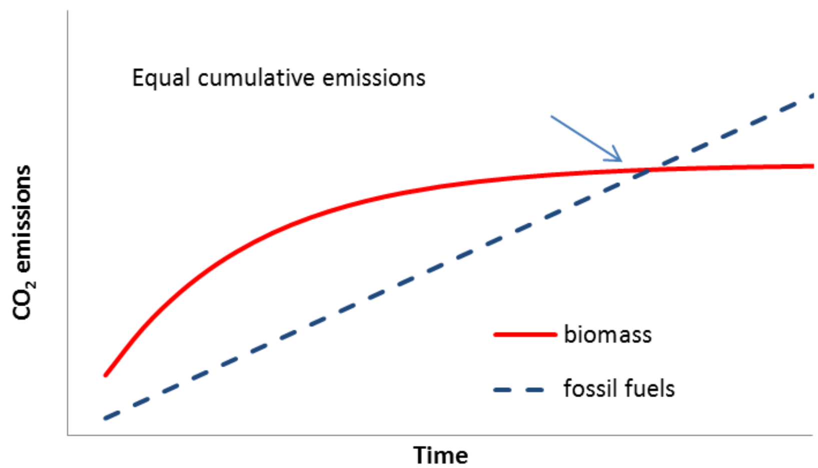

Figure 3. Generalized schematic of CO_2 emissions from a biomass power plant v. a fossil fuel plant.[56] Net emissions for the biomass plant assume that trees are allowed to fully regrow before the next harvest, a condition necessary for emissions from biomass burning to be neutralized.

[55] Walker, T., et al. 2012. Carbon accounting for woody biomass from Massachusetts (USA) managed forests: a framework for determining the temporal impacts of wood biomass energy on atmospheric greenhouse gas levels. Journal of Sustainable Forestry, 32:1-2, 130 – 158; 2010; Searchinger, T., et al. 2009. Fixing a critical climate accounting error. Science 326: 527-528; Colnes, A., et al. 2012. Biomass supply and carbon accounting for Southeastern Forests. Biomass Energy Resource Center, Montpelier, VT; Mitchell, S., et al. 2012. Carbon debt and carbon sequestration parity in forest bioenergy production. GCB Bioenergy (2012) doi:10.1111/j.1757-1707.2012.01173.x.

[56] Figure after Walker, T., et al. 2012. Carbon accounting for woody biomass from Massachusetts (USA) managed forests: a framework for determining the temporal impacts of wood biomass energy on atmospheric greenhouse gas levels. Journal of Sustainable Forestry, 32:1-2, 130 – 158.