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Is Biopower Carbon Neutral?

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Summary

To promote energy diversity and improve energy security, Congress has expressed interest in biopower—electricity generated from biomass. Biopower, a baseload power source, can be produced from a large range of biomass feedstocks nationwide (e.g., urban, agricultural, and forestry wastes and residues). The two most common biopower processes are combustion (e.g., direct-fired or co-fired) and gasification, with the former being the most widely used. Proponents have stated that biopower has the potential to strengthen rural economies, enhance energy security, and minimize the environmental impacts of energy production. Challenges to biopower production include the need for a sufficient feedstock supply, concerns about potential health impacts to nearby communities from the combustion of biomass, and its higher generation costs relative to fossil fuel-based electricity. At present, biopower generally requires tax incentives to be competitive with conventional fossil fuel-fired electric generation.

An energy production activity typically is classified as carbon neutral if it produces no net increase in greenhouse gas (GHG) emissions on a life-cycle basis. The legislative record shows minimal debate about the carbon status of biopower. The argument that biopower is carbon neutral has come under scrutiny in debate on its potential to help meet U.S. energy demands and reduce U.S. GHG emissions. Whether biopower is considered carbon neutral depends on many factors, including the definition of carbon neutrality, feedstock type, technology used, and time frame examined. Carbon flux (emission and sequestration) varies at each phase of the biopower pathway, given site- and operation-specific factors. A life-cycle assessment (LCA) is a common technique to calculate the environmental footprint, including the carbon flux, of a particular biopower pathway. However, past legislation would not have required a standardized LCA for biopower.

The carbon-neutral status of biopower may be of concern to stakeholders, especially if Congress expands support for biopower. Questions such as where the feedstock supply for biopower originates, if it is managed in a sustainable manner, and whether the associated air-quality impacts from biopower generation are tolerable are part of the biopower carbon-neutrality debate. Congress may decide whether the current approach regarding the carbon status of biopower is acceptable or whether additional carbon accounting for biopower is warranted and what impact this accounting might have on renewable energy, agricultural, and environmental legislative goals.

Two recent actions by the executive branch—the U.S. Environmental Protection Agency's (EPA's) Clean Power Plan (CPP), which addresses carbon dioxide (CO_2) emission reductions from existing fossil fuel-fired electric power plants, and EPA's proposed framework to account for biogenic CO_2 emissions from stationary sources—could focus attention on biopower's carbon neutrality. The CPP requires states to devise a plan that allows them to reach a state-specific CO_2 emission reduction goal by 2030, using various options, including renewable energy (e.g., biopower). In the CPP final rule, EPA specifies that "qualified biomass" may be included in a state plan given certain conditions. In November 2014, EPA released its second biogenic accounting framework. The framework addresses some of the EPA Science Advisory Board's recommendations from the first framework, released in 2011, including the finding that "carbon neutrality cannot be assumed for all biomass energy a priori." EPA acknowledges that the framework is an analytical methodology and that some stakeholders may consider it an example of how EPA may treat biogenic emissions in both the CPP and the Prevention of Significant Deterioration program. However, EPA reports that it "has not yet determined how the framework might be applied in any particular regulatory or policy contexts or taken the steps needed for such implementation."

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Introduction

Biomass energy, or bioenergy, may receive more attention from stakeholders as an alternative to fossil fuels because of its potential to minimize the environmental impacts of energy production, provide energy security, and promote economic development. Biomass is organic matter—woody biomass, agricultural biomass, animal wastes, and aquatic biomass—that can be converted to energy (e.g., heat, electricity, or liquid transportation fuels).[1] One form of bioenergy is biopower, electricity generated from biomass (e.g., paper mill residues). As federal and state governments and others dedicate more resources to biopower, these same government agencies, along with environmentalists, biomass feedstock producers, and others, are paying more attention to the biopower carbon-neutrality issue. The carbon-neutral designation typically is assigned to an energy-production activity that essentially produces no net increase in greenhouse gas (GHG) emissions on a life-cycle basis (or one that absorbs the amount of carbon dioxide emitted during the power-production cycle).[2] Where biopower stands among the other renewable energy sources with respect to GHG emissions may affect the level of future legislative support granted to it.

Many views exist about whether biopower is carbon neutral and how its net carbon status is determined. Some biomass feedstock producers and biopower generators, among other stakeholders, contend that biopower is carbon neutral because the carbon released during bioenergy production comes from a feedstock that removed the carbon from the atmosphere as it was growing—biomass. Some environmentalists, among others, argue that biopower is not carbon neutral because the amount of GHG emissions released per unit of energy during simple biopower combustion may be higher for certain biomass fuels than for fossil fuels or because, even if the GHG emissions from certain biomass fuels are lower than those from fossil fuels, they are still not zero. Stakeholders often base their perspectives on differing assumptions, technologies, and time frames.

The debate concerning biopower's designation as carbon neutral may intensify, given possible congressional and Administration decisions. Congress may consider legislation involving biopower (e.g., under renewable energy and clean energy assistance and energy efficiency). Additionally, biopower production may receive increased attention due to executive branch actions, such as the U.S. Environmental Protection Agency's (EPA's) Clean Power Plan[3] and EPA's proposed framework to account for emissions of biogenic carbon dioxide (CO_2) from stationary sources.

This report discusses some factors taken into account when considering whether biopower is carbon neutral. It does not discuss carbon accounting for other bioenergy pathways.[4]

[1] For more information on biomass, see CRS Report R40529, *Biomass: Comparison of Definitions in Legislation*, by Kelsi Bracmort.

[2] The life cycle of a bioenergy pathway includes all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through distribution, delivery, and use of the finished fuel by the ultimate consumer. The mass values for all greenhouse gases (GHGs) are adjusted to account for their relative global warming potential.

[3] For more information, see CRS Report R44145, *EPA's Clean Power Plan: Highlights of the Final Rule*, by Jonathan L. Ramseur and James E. McCarthy.

[4] Congress addressed carbon accounting for another major bioenergy pathway—liquid transportation biofuels—with a life-cycle emission analysis (a requirement within the Renewable Fuel Standard). For more information, see CRS Report R40460, *Calculation of Lifecycle Greenhouse Gas Emissions for the Renewable Fuel Standard (RFS)*, by Brent D. Yacobucci and Kelsi Bracmort.

Biomass Carbon Cycle

The carbon cycle encompasses the many pathways through which carbon is exchanged between the atmosphere and the land and water.[5] Human activities (also called *anthropogenic activities*) contribute to the carbon cycle by emitting CO_2. The human contribution of CO_2 to the carbon cycle is relatively small compared to other contributions, but CO_2 released to the atmosphere from human activities is taken up by soils, vegetation, and the ocean at a slower rate than the rate at which human activities are emitting CO_2. If the excess carbon is not stored in land and ocean sinks, the atmospheric concentration of CO_2 increases, potentially impacting the Earth's climate.

One significant anthropogenic source of CO_2 is energy production. The net effect of an energy activity on the carbon cycle can be classified in one of three ways. A *carbon-positive* activity releases CO_2 into the atmosphere. A *carbon-negative* activity removes more CO_2 from the atmosphere than it emits. A *carbon-neutral* activity is one in which the CO_2 release and absorption are essentially in balance. No commonly accepted definition for a carbon-neutral activity exists in the biopower arena. Those involved with bioenergy have put forth multiple assertions about carbon neutrality, including the following:[6]

- Biomass energy is carbon neutral because biomass is naturally carbon neutral. The premise is that if biomass is carbon neutral, then any product resulting from its use is also carbon neutral.
- Biomass energy is carbon neutral if growing the biomass removes as much CO_2 as is emitted into the atmosphere from its combustion.
- Biomass energy is carbon neutral only if the net life-cycle emissions are zero.[7] Emissions include the emissions from the cultivation, harvest, and transportation of the biomass, as well as from its combustion.
- Biomass energy is carbon neutral if it achieves lower net increases in atmospheric GHGs when compared to alternative energy activities.

Each assertion raises issues. For instance, declaring that biomass energy is carbon neutral because biomass is naturally carbon neutral does not account for GHG emissions released due to management of crops grown for energy production (e.g., fertilizer). In addition, there may need to be additional plantings of certain biomass feedstocks to remove the CO_2 emitted from biomass cultivated for energy production.

The carbon cycles for a bioenergy system and a fossil fuel system differ in at least two ways: the carbon source (finite versus renewable) and the atmospheric carbon concentration (potentially stable versus additional; see **Figure 1**). Three main factors contribute to the amount of carbon emitted from biopower generation: feedstock production (cultivation and harvest), feedstock transport, and the biopower technology type. However, as noted by many sources, feedstock production also absorbs carbon during growth.

[5] Carbon is an elemental building block of molecules that make up all organisms on Earth. Carbon cycling is the process by which living things absorb carbon from the atmosphere, carbonate rocks and ocean deposits, dead organic matter in the soil, or food and return it to the atmosphere or soil by respiration, combustion, or decay.

[6] R. Miner, "Biomass Carbon Neutrality in the Context of Forest-based Fuels and Products," U.S. Department of Agriculture (USDA) Bioelectricty and GHG Workshop, Washington, DC, November 15, 2010. Some of the definitions are not mutually exclusive.

[7] A life-cycle assessment (LCA) accounts for the GHG emissions from bioenergy production. The LCA is further discussed in "Greenhouse Gas Emission Accounting for Biopower Production," below.

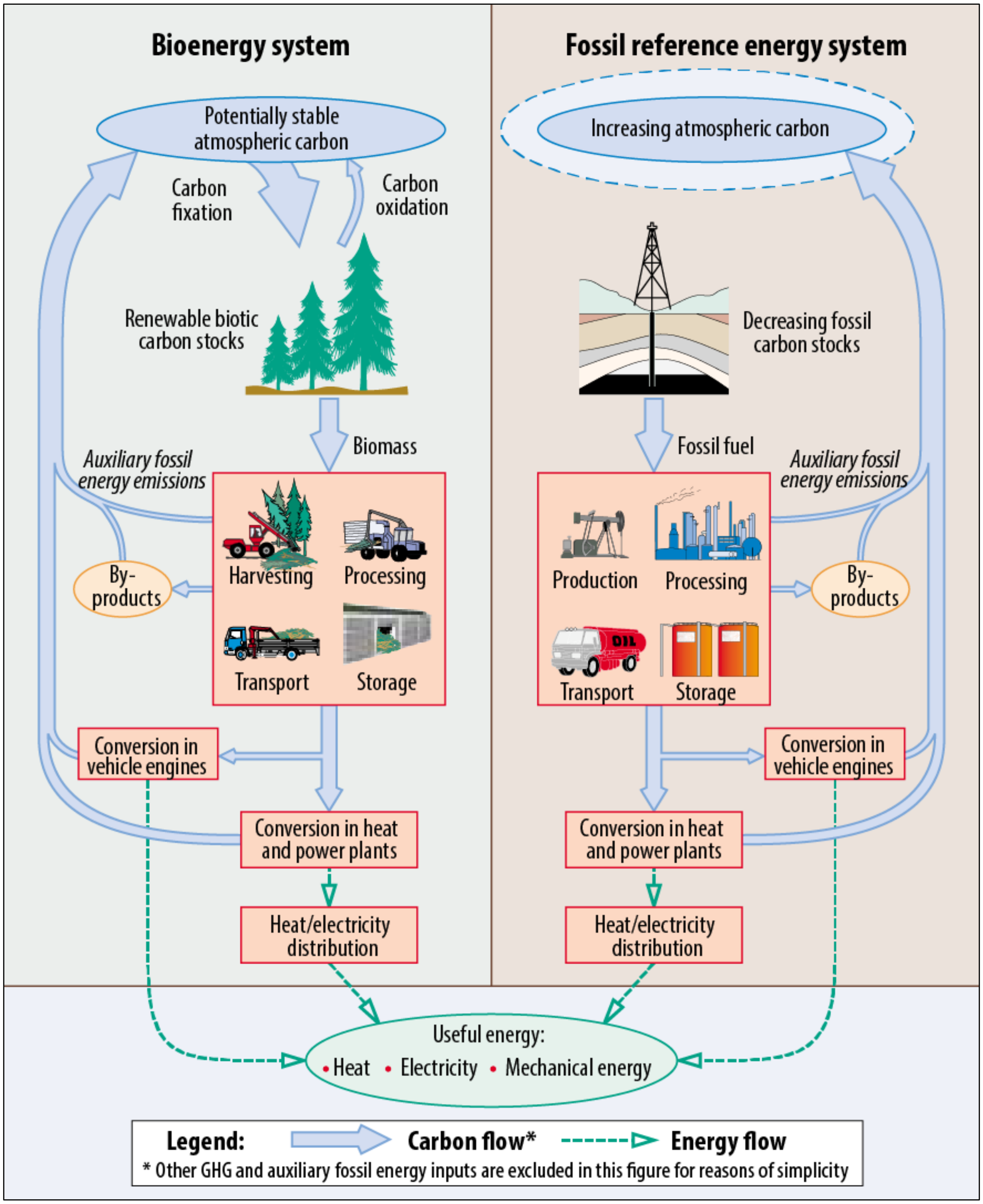
Greenhouse Gas Emission Accounting for Biopower Production

Whether and how to conduct GHG emission accounting for biopower are issues that have been under consideration for the last few years. GHG emission accounting can be used to compare the environmental footprint of a biopower operation with that of a conventional fossil fuel operation (e.g., electricity from coal or natural gas).[8] A life-cycle assessment (LCA) is one method to calculate the environmental footprint. The LCA is an analytic method for identifying, evaluating, and comparing the environmental impacts of emissions and the resource depletion associated with a specific process.[9] An LCA generally uses observed data and assumptions to model what GHGs are being released at each phase of the process. Ideally, an LCA would encompass economic and social factors for a more comprehensive assessment (e.g., job growth, poverty). However, most LCAs focus exclusively on emissions and fossil fuel consumption. An LCA can be one element used in assessing a preferred energy approach, along with cost and performance data. In some cases, even if LCA results favor a particular approach, an LCA alone might not be the deciding factor when choosing an energy process; financial objectives, policy goals, and other factors may influence which approach is selected.

[8] For the purposes of this report, greenhouse gas emission accounting refers to methods used to compute the GHGs emitted from one or more stages of biopower production. Further carbon flux, or GHG flux, refers to the total greenhouse gas emitted or sequestered at particular stages of the biopower production process.

[9] National Renewable Energy Laboratory, *Energy Analysis*, October 2010, at http://www.nrel.gov/analysis/tech_bio_analysis.html. For more information on life-cycle assessments, see U.S. Environmental Protection Agency (EPA), *Life Cycle Assessment: Principles and Practice*, EPA/600/R-06/060, Cincinnati, OH, May 2006.

Figure 1. Bioenergy CO_2 Balance vs. Fossil Fuel CO_2 Balance

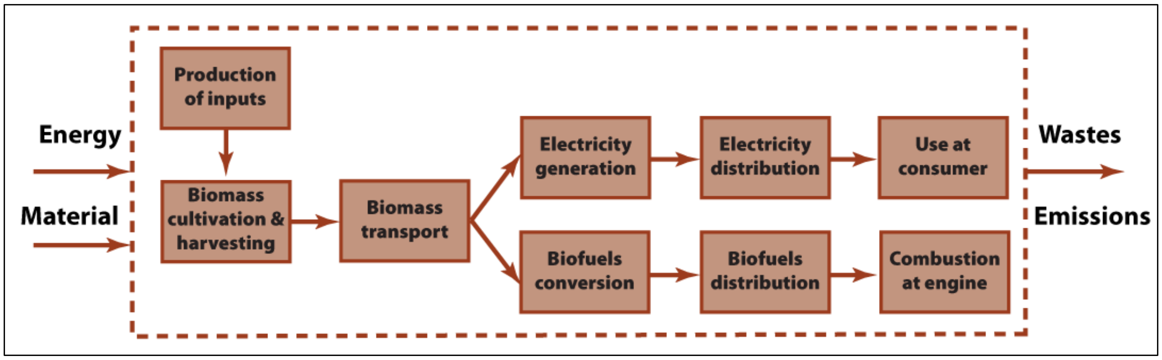


Source: International Energy Agency (IEA), IEA Bioenergy Task 38, *Greenhouse Gas Balances of Bioenergy and Bioenergy Systems*, 2002. Adapted by the Congressional Research Service (CRS).

Notes: The magnitude of the carbon flows, as indicated by the width of the arrows, is a significant part of the debate over the carbon neutrality of bioenergy.

GHG accounting with an LCA can be performed at each phase of the biopower pathway: biomass cultivation and harvest, biomass transport, electricity generation, electricity transmission and distribution, and electricity end use (**Figure 2**). The first three phases of the biopower pathway (cultivation and harvest, transport, and electricity generation) are where the bulk of GHG emissions occur. GHG flux during the first three phases is site and operation specific and depends on many factors, including the biomass type, management strategies, and biopower generation technology.

Figure 2. Biopower and Biofuel Pathways



Source: Q. Zhang, K.R. Goldstein, and J.R. Mihelcic, "A Review of Life Cycle Assessment Renewable Energy Derived from Forest Resources," in *Renewable Energy from Forest Resources in the United States*, ed. B. D. Solomon, C. A. Luzadis (New York: Routledge, 2009). Adapted by CRS.

Published LCAs for biopower are limited and, as noted above, may not be applicable to specific cases.[10] The LCAs performed often are tailored to one feedstock and one biopower technology type, and LCA results vary depending on assumptions such as the time frame of the assessment.[11] The LCA time frame can be long (e.g., "cradle to grave") or relatively short (e.g., "cradle to gate").[12] Different LCA time frames can lead to radically different, even contradictory, results. The majority of biopower LCAs were completed for two biopower technology types: combustion and gasification. Both technologies have strengths and weaknesses.[13] The technology to co-fire (or combust) biomass with coal is available at commercial scale and is in use today. Gasification technology is in the development and demonstration phase.[14]

Although biopower LCAs are scarce compared to liquid transportation biofuel LCAs, certain trends appear in existing assessments. For instance, the National Renewable Energy Laboratory (NREL) reviewed and analyzed 57 biopower LCAs. The NREL review shows that biopower reduces GHG emissions when compared with fossil-based generation of electricity.[15] Elsewhere, some members of the academic community reviewed more than 25 LCAs. They determined that

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[10] Most LCAs for bioenergy have focused on GHG emissions from biomass used for liquid transportation fuels and its impact on climate.

[11] For more information on biopower LCAs, see Electric Power Research Institute, *Literature Review and Sensitivity Analysis of Biopower Life-Cycle Assessments and Greenhouse Gas Emission*, January 2013.

[12] A cradle-to-grave time frame generally includes all phases from feedstock production to energy end use. A cradle-to-gate time frame generally includes a fraction of the complete biopower pathway and may include feedstock production, feedstock cultivation, feedstock transport, and electricity generation.

[13] D. Peterson and S. Haase, *Market Assessment of Biomass Gasification and Combustion Technology for Small- and Medium-Scale Applications*, U.S. Department of Energy National Renewable Energy Laboratory (NREL), NREL/TP-7A2-46190, July 2009, at http://www.nrel.gov/docs/fy09osti/46190.pdf.

[14] Some gasification plants are starting to come on-line. For example, the PHG Energy waste-to-energy gasification plant in Tennessee began operating in 2013 and can process up to 12 tons of waste per day.

[15] The analysis did not consider land use change. NREL, *Biopower Greenhouse Gas Emissions in the LCA Literature*, October 5, 2011, at http://lcacenter.org/lcaxi/final/446.pdf.

biopower is in the top tier of bioenergy pathways that avoid the most GHG emissions and replace the largest amounts of fossil energy.[16] Approximately 15 of the LCAs reviewed included electricity as an end product, of which at least 10 had an LCA time frame of when the feedstock was extracted to when the biopower was produced (e.g., cradle to gate).

There is an ongoing discussion about the foundation and underlying assumptions of LCAs, GHG modeling, and other methodologies used to evaluate the carbon impact of bioenergy.[17] Some members of the academic community assert that the methodologies do not sufficiently address land use (e.g., land available to satisfy energy, food, and feed needs) and incorrectly account for biomass (e.g., double counting biomass). They contend that some biofuel systems and fossil fuel systems may not be compared easily using some of the methodologies that exist, among other concerns.[18] Others maintain that some of these issues have been addressed, specifically that land-use concerns stem from multiple factors, not just bioenergy, that increased productivity (e.g., rising crop yields) must be considered when discussing global food and feed requirements, and that crops used for bioenergy have the ability to naturally re-sequester carbon under certain circumstances.[19]

Recent Developments Affecting Biopower Assessment

Certain actions have kept the biomass carbon-neutrality issue a concern for the bioenergy and environmental communities, among others. Most notable are EPA's standards for greenhouse gas emissions from existing fossil-fueled power plants (e.g., the Clean Power Plan), EPA's 2014 framework for assessing biogenic CO_2 emissions from stationary sources, and EPA's permitting requirements under the Clean Air Act (CAA).[20]

[16] Q. Zhang, K. R. Goldstein, and J. R. Mihelcic, "A Review of Life Cycle Assessment Renewable Energy Derived from Forest Resources," in *Renewable Energy from Forest Resources in the United States*, ed. Barry D. Solomon, Calerie A. Luzadis (New York: Routledge, 2009). Information regarding the feedstocks, conversion processes, end products, system boundaries, allocation methods, and impact metrics for each LCA is available in Table 8.1.

[17] Although the discussion has primarily centered on biomass used for liquid transportation fuels, these same concerns are applicable to biomass used for any type of energy production, including biopower.

[18] John De Cicco, "The liquid carbon challenge: evolving views on transportation fuels and climate," *WIREs Energy and Environment*, vol. 4 (2015), pp. 98-114; World Resources Institute, *Avoiding Bioenergy Competition for Food Crops and Land*, January 2015.

[19] Renewable Fuels Association, "Debunking Searchinger's Doomsday Theories ... Again," press release, January 29, 2015; Global Renewable Fuels Alliance, "World Resources Institute Wrong About Biofuels Impact on Land Use and the Environment," press release, January 30, 2015.

[20] Members in both chambers of Congress have submitted letters to the EPA Administrator and the Secretaries of Agriculture and Energy expressing their support for the carbon neutrality of forest biomass (Senator Susan Collins, "U.S. Senators Collins (R-ME) and Merkley (D-OR) Urge EPA, DOE, and USDA to Recognize Clear Benefits of Forest Bioenergy in Federal Policy," press release, July 1, 2015; U.S. Representative Reid Ribble, "Ribble to EPA: Don't Punish Sustainable Forestry," press release, August 3, 2015.). Further, many scientists continue to contribute to the discussion by submitting letters to Members of Congress and EPA. In 2014, more than 90 scientists submitted a letter to EPA urging the agency to base its regulations for stationary sources of biogenic emissions (e.g., biopower plants) on sound science "by putting in place a system that links emitter behavior directly to what's happening on the landscape and rigorously assesses the incremental carbon emissions impacts of bioenergy production." Cary Institute of Ecosystem Studies, "Scientists nationwide call on EPA to create scientifically strong pollution standards for biomass energy," press release, June 19, 2014.

The Clean Power Plan

In June 2013, President Obama issued a Climate Action Plan. As part of the plan, EPA was directed to propose standards for "carbon pollution" (i.e., CO_2, the principal GHG) from existing power plants by June 2014 and to finalize the standards by June 2015.[21] In August 2015, the EPA released the final rule for CO_2 emission reductions from existing fossil fuel-fired electric power plants.[22] This rule, commonly referred to as the Clean Power Plan (CPP), requires states to reach a state-specific CO_2 emission-reduction goal (measured in pounds of CO_2 emissions per megawatt-hour of electricity generation) by 2030.[23] States are to develop a plan—using guidance from EPA—that can incorporate renewable energy, including biopower, among other things.[24] EPA reports that "qualified biomass"—biomass feedstock that has been demonstrated to be a method to control increases of CO_2 levels in the atmosphere—may be included in a state's plan. However, there remains uncertainty about which forms of biomass EPA will deem acceptable. Further, there are various stipulations associated with the use of biomass to generate electricity for the CPP. Thus, it is not clear what role biopower will play in the implementation of the CPP.

Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources

EPA released two draft frameworks—the first in 2011 and the second in 2014—that establish a process to evaluate and account for GHGs associated with the use of biomass to produce energy at stationary sources (e.g., biopower).[25] The frameworks indicate how EPA may treat bioenergy for the programs and regulations within its domain. In addition to seeking public comment about the framework, EPA entrusted its Science Advisory Board (SAB) with conducting an independent review of each framework.

The 2014 framework addresses some of the SAB recommendations and stakeholder comments from the 2011 framework. The framework focuses on carbon flux corresponding to three stages of bioenergy production: (1) feedstock growth and harvest; (2) processing, transport, storage, and use of a biogenic feedstock at the stationary source; and (3) the possible alternative fate of biogenic feedstock materials if not used for bioenergy. In preparing the 2014 framework, EPA reports that it considered information that "supports the finding that use of waste-derived feedstocks and certain forest-derived industrial byproducts are likely to have minimal or no net atmospheric contributions of biogenic CO_2 emissions, or even reduce such impacts, when compared with an alternate fate of disposal."[26] EPA acknowledges that the 2014 framework is an analytical methodology and that some stakeholders may consider the framework a precursor to

[21] Executive Office of the President, *The President's Climate Action Plan*, June 2013. The President's Climate Action Plan reiterates the Obama Administration's focus on reducing carbon pollution from power plants, which has included and is likely to continue to involve biopower, among other renewable electricity-generation sources.

[22] EPA, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," Final Rule, prepublication version, August 3, 2015.

[23] For more information on the proposed rule, see CRS Report R44145, *EPA's Clean Power Plan: Highlights of the Final Rule*, by Jonathan L. Ramseur and James E. McCarthy.

[24] For more information, see CRS In Focus IF10280, *The Clean Power Plan (CPP): The Treatment of Biomass*, by Kelsi Bracmort.

[25] EPA, *Accounting Framework for Biogenic CO_2 Emissions from Stationary Sources*, September 2011; EPA, *Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources*, November 2014.

[26] Letter from EPA, Addressing Biogenic Carbon Dioxide Emissions from Stationary Sources, to Air Division Directors, November 19, 2014.

how EPA treats biogenic emissions for both the standards for GHG emissions from existing fossil-fueled power plants and the Prevention of Significant Deterioration program (see "Prevention of Significant Deterioration/New Source Review Program and Title V Greenhouse Gas Permitting Requirements," below).[27] However, EPA reports that it "has not yet determined how the framework might be applied in any particular regulatory or policy contexts or taken the steps needed for such implementation."[28] EPA has requested that the SAB peer review the 2014 framework.[29]

For the 2011 framework, EPA charged the SAB with reviewing and commenting on (1) EPA's characterization of the science and technical issues relevant to accounting for biogenic CO_2 emissions from stationary sources; (2) EPA's framework, overall approach, and methodological choices for accounting for these emissions; and (3) options for improving upon the framework for accounting for biogenic CO_2 emissions, among other issues.[30] The SAB conducted the independent review of the agency's 2011 biogenic accounting framework and released its findings in September 2012. These findings included that "carbon neutrality cannot be assumed for all biomass energy a priori."[31] The SAB acknowledged the "daunting task" of assessing the GHG implications of bioenergy and the "narrow regulatory boundaries" within EPA's purview that limit the consideration of GHG flux at various points along the bioenergy pathway. The SAB identified multiple factors (e.g., time scale, spatial scale, leakage) that require further assessment by EPA and provided recommendations to revise the biogenic accounting framework. The SAB "found that quantification of most components of the framework has uncertainties, technical difficulties, data deficiencies and implementation challenges." The SAB recommended an alternative biogenic accounting framework based on feedstock category, region, land management, and prior land use.

Prevention of Significant Deterioration/New Source Review Program and Title V Greenhouse Gas Permitting Requirements

The CAA's Prevention of Significant Deterioration (PSD)/New Source Review program requires a "new major stationary source or the major modification of any existing stationary source" to undergo preconstruction review and permitting, including the installation of Best Available Control Technology (BACT) to limit emissions.[32] Title V of the act requires all new and existing facilities that have the potential to emit a GHG pollutant in amounts of 100 tons per year or more to obtain permits.[33] In July 2011, EPA decided to defer for a period of three years the application

[27] For instance, more than 75 scientists submitted a letter to the EPA Administrator expressing concerns about EPA's proposed treatment of emissions from biomass used to produce energy. Cary Institute of Ecosystem Studies, February 9, 2015.

[28] EPA, *Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources*, November 2014.

[29] EPA reports that the specific elements of the 2014 framework that it wants the SAB to review are forthcoming. Letter from EPA, Request for Review of Additional Scientific Product, to Science Advisory Board Staff Office, November 19, 2014.

[30] The agency's charge for the SAB, review documents (including the accounting framework), and meeting materials are available at http://yosemite.epa.gov/sab/sabproduct.nsf/0/2f9b572c712ac52e8525783100704886!OpenDocument&TableRow=2.2#2.

[31] EPA, *SAB Review of EPA's Accounting Framework for Biogenic CO2 Emissions from Stationary Sources*, EPA-SAB-12-011, September 28, 2012.

[32] 42 USC 7475.

[33] 42 USC 7661. For more information on the Prevention of Significant Deterioration and Title V permits, see CRS Report R41212, *EPA Regulation of Greenhouse Gases: Congressional Responses and Options*.

of PSD and Title V permitting requirements for CO_2 emissions from bioenergy and other biogenic stationary sources.[34] EPA proposed using the three-year time period to conduct a detailed examination of the science associated with biogenic CO_2 emissions from stationary sources to determine how to treat emissions from biomass-fired and biogenic sources (i.e., charging its SAB with reviewing EPA's approach to the assessment of CO_2 emissions from biogenic sources). In 2013, a District of Columbia Circuit court decision vacated the deferral rule because the rule "cannot be justified under any of the administrative law doctrines [de minimis, one-step-at-a-time, administrative necessity, and absurd results] relied on by EPA."[35] The court issued its mandate on August 10, 2015.

Best Available Control Technologies

EPA noted in the PSD and Title V Permitting Guidance for Greenhouse Gases that it may consider certain types of biomass a *best available control technology* (BACT)[36] after taking into account environmental, energy, and economic considerations and state and federal policies that promote biomass for energy-independence and environmental reasons.[37] EPA provided specific guidance on how to consider the unique GHG attributes of biomass as fuel in the BACT selection process.[38] PSD permits require that facilities apply the BACT, but individual states, with EPA guidance, determine BACT on a case-by-case basis.

Considerations for the Regulation of Biogenic CO_2 Emissions

There are some key points to consider about the regulation of biogenic CO_2 sources. First, EPA is in the process of comprehensively assessing the GHG classification for biogenic CO_2 sources (which it is doing with the release of the second framework for assessing biogenic CO_2 emissions). Stakeholders likely will contest in the courts any decision the agency makes regarding these sources, although there is little to no precedent for the courts to follow. Second, EPA, thus far, has received no guidance from the courts (or the SAB) about how to exempt biogenic CO_2 sources from PSD requirements. The court stopped current practices without offering alternatives. Third, the legal and regulatory struggles over biogenic CO_2 sources reflect a larger issue: Congress's bioenergy policy typically has not included carbon accounting for bioenergy, with an exception for the Renewable Fuel Standard.[39] Thus, it is not clear if Congress would treat

[34] EPA, "Deferral for CO_2 Emissions From Bioenergy and Other Biogenic Sources Under the Prevention of Significant Deterioration (PSD) and Title V Programs: Final Rule," 76 *Federal Register* 43490, July 20, 2011. Biogenic includes facilities that emit CO_2 from sources originating via biological processes, such as landfills.

[35] Center for Biological Diversity v. Environmental Protection Agency, 722 F. 3d 401, 412 (DC Cir. 2013).

[36] A Best Available Control Technology (BACT) is a pollution control standard mandated by the Clean Air Act in PSD areas.

[37] EPA, *PSD and Title V Permitting Guidance for Greenhouse Gases*, EPA-457/B-11-001, March 2011. The Supreme Court's 2014 decision for the *Utility Air Regulatory Group v. EPA*, 134 S. Ct. 2427 (2014) case exempted biogenic CO_2 sources along with all other CO_2 sources, unless the source is covered by the PSD program due to its emissions of non-GHG emissions, otherwise known as *anyway sources*. The court decision significantly reduces the number of facilities applying for such permits and, thus, possibly in need of a BACT.

[38] EPA, *Guidance for Determining Best Available Control Technology for Reducing Carbon Dioxide Emissions from Bioenergy Production,* Washington, DC, March 2011, at http://www.epa.gov/NSR/ghgdocs/bioenergyguidance.pdf.

[39] Congress's approach thus far has tended at times to focus singularly on a particular bioenergy source (e.g., ethanol) or a biomass feedstock (e.g., cellulosic), as opposed to an end result that is desired from a policy standpoint (e.g., the most efficient use of biomass for energy production with the least environmental effects).

biopower differently from other types of power generated from conventional energy and renewable energy sources. If EPA is to carry out the bioenergy legal requirements in a timely fashion, it may need better and more explicit direction from Congress. Such direction might include providing EPA with a predetermined amount of time—free of legal intrusions—to resolve issues with stakeholder and public input.

Is Biopower Carbon Neutral? It Depends

Carbon neutrality for biopower is calculated most accurately based on the carbon flux (i.e., GHG emission or sequestration) of several parameters over a specified time period. These parameters include at least the following: (1) the feedstock type; (2) the management and procurement of the energy source (in the case of biomass, how the feedstock is managed and harvested); (3) the feedstock transportation method; (4) the energy generation technology; and (5) the time frame to replenish the feedstock. Carbon flux attributed to the management and procurement of biomass feedstock deviates according to the type or mixture of feedstock used. For instance, agricultural biomass entails a different nutrient management plan than woody biomass. GHG emissions may be higher for agricultural biomass due to fertilizer treatments (e.g., emissions from the GHG nitrous oxide from biofuel-dedicated crops).[40] Carbon flux also will vary given how the biomass feedstock is harvested. For example, removal of woody biomass (e.g., thinnings) in large quantities may reduce carbon, and some methane, emissions on a CO_2-equivalent basis that would have been released if the woody biomass remained in the forest to decompose. Biomass-feedstock transport emits differing amounts of GHGs depending on how far one transports the feedstock and on fossil fuel usage.[41] The carbon flux of the biopower generation technology will depend on the type of technology and any emission capture or sequestration.[42] In addition, the time frame (e.g., 40 years, 100 years) assigned for biomass feedstock replenishment will determine CO_2 sequestration rates to balance out the GHGs emitted during biomass combustion, particularly for woody biomass, as growth periods (rotation ages for the trees) are often measured in decades.[43]

It could be argued that only an LCA for each biopower operation can accurately determine whether biopower generation is carbon neutral. Such an LCA would measure carbon flux for each phase of the biopower pathway and incorporate biomass feedstock replenishment. A standard approach to performing a biopower LCA could ensure uniformity in GHG accounting across the biopower sector. However, multiple LCAs can be expensive and time-consuming to complete.

Biopower's carbon neutrality is a contentious aspect of the bioenergy debate. One reason the topic is so controversial is concern about unsustainable harvests of biomass feedstocks. Some environmentalists, among others, contend that if biopower proceeds with no carbon balance restrictions, it could lead to, for example, large amounts of woody biomass removal for energy

[40] When agricultural waste is the biomass used for biopower production, some GHG emissions may be attributed to crop cultivation whereby the crop is used for other feed, fiber, and fuel purposes.

[41] Some stakeholders make the case that feedstock transportation could involve the use of fuels (e.g., ethanol) other than fossil fuels (e.g., diesel or gasoline).

[42] No commercial carbon capture and sequestration (CCS) projects currently operate in the United States. Therefore, CCS is not likely to impact carbon flux at the biopower generation stage in the near term.

[43] For more information on carbon sequestration in trees, see James E. Smith, Linda S. Heath, and Kenneth E. Skog, Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States, U.S. Forest Service, GTR-NE-343, April 2006.

production. Another reason for controversy is concern about the air quality of areas surrounding biopower plants, especially if particulate matter and select compounds from a plant exceed certain limits. These two concerns—sustainability and air quality—can be, and in some cases already are, addressed through other avenues (e.g., sustainability requirements, air-quality regulations) at the federal and state levels.

Legislative Implications

Congress may be prompted to further analyze the carbon status of biopower with congressional oversight or review due to recent and forthcoming developments (e.g., EPA's decisions regarding "qualified biomass" for the CPP and the framework to account for emissions of biogenic CO_2 from stationary sources). Biopower can be produced using multiple biomass feedstocks and technologies. Each feedstock and technology has its own environmental footprint. The time frame to analyze carbon neutrality is relevant because such an analysis would incorporate feedstock replenishment, and thus CO_2 removal rates, and consider technology developments.

Congress could decide to use existing legislative authorities to address carbon accounting for biopower. Federal environmental regulatory controls exist for the three chief environmental concerns associated with a biopower plant—air quality, use of public land, and water discharges. GHG emissions may be accounted for with federal regulations regarding air quality. In addition, a biopower plant also has to meet state regulatory standards, which in some cases may be stricter than the federal regulatory controls.

To the extent carbon neutrality continues to be a legislative concern, Congress could examine whether the current carbon-neutral assumption for biopower is adequate. Congress may consider if additional carbon accounting for biopower is warranted and what impact this accounting might have on renewable energy, agricultural, and environmental legislative goals. A key contributor to this discussion may be whether decisions concerning biopower made by the executive branch contradict legislative goals set by Congress. A full carbon accounting for biopower could result in slowing the achievement of multiple renewable energy, agricultural, and environmental goals. Alternatively, the carbon-neutrality debate for biopower may lead to requests for carbon accounting of some or all energy ventures—renewable and conventional. Lastly, an ill-defined carbon accounting assessment for biopower may limit public and private investment, feedstock production, and more. Scientists, investors, biomass producers, and others may hesitate to expend time and money on expanding biopower efforts if they are not certain about the future contribution of biopower to U.S. energy and environmental goals.

If Congress chooses to address energy security and GHG emission increases, some stakeholders have argued that these goals could be met through the creation of a national renewable electricity standard (RES) or a clean electricity standard (CES). The mandate of a potential national RES or CES may require substantial quantities of baseload power, which some policymakers and others see as being achieved by using biopower. If biopower is a part of an RES or CES, the carbon-neutrality designation of biopower may need to be considered in response to environmental and sustainability concerns.

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