DEFINING BIOMASS AS A SOURCE OF RENEWABLE ENERGY: THE LIFE-CYCLE CARBON EMISSIONS OF BIOMASS ENERGY AND A SURVEY AND ANALYSIS OF BIOMASS DEFINITIONS IN STATES' RENEWABLE PORTFOLIO STANDARDS, FEDERAL LAW, AND PROPOSED LEGISLATION

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Electricity generated from woody biomass material is generally considered renewable energy and has been considered carbon neutral. However, recent criticism from scientists argues that the greenhouse gas (GHG) emission profile of bioenergy is nuanced and the carbon neutral label is inappropriate. An initial carbon debt is created when a forest is harvested and combusted for bioenergy. Because forests re-grow over a period of years, life cycle analyses show that bioenergy generated from whole trees from forests may not reduce GHG emissions in the short term, as required to combat climate change. State renewable portfolio standards and federal laws and proposed legislation designed to incentivize renewable energy typically define eligible forms of biomass that qualify for these incentives. Most of these definitions are very broad and do not account for GHG emissions from bioenergy. Federal and state laws should incorporate life cycle analyses into definitions of eligible biomass so that these laws incentivize biomass electricity that reduces GHG emissions in the next several decades.

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CHAPTER I

INTRODUCTION

Much debate currently surrounds the issue of the carbon neutrality of energy generated from biomass. Many call the energy generated from biomass "carbon neutral" because the carbon emissions released at biomass electricity generating facilities are from carbon that was captured and removed from the atmosphere during the growth of the biomass.[1] However, in terms of stack emissions, biomass-fired power plants emit more carbon dioxide per kilowatt-hour than coal-fired power plants.[2] Because biomass has generally been considered carbon neutral, greenhouse gas (GHG) emissions from the combustion of biomass have rarely been considered in life cycle assessments (LCA) of biomass energy.[3] Several prominent scientists have recently criticized the practice of considering all bioenergy as carbon neutral regardless of the source of the biomass.[4]

The regulation of biomass energy as renewable energy does not address carbon emissions from biomass energy in a comprehensive manner, if at all. The Environmental Protection Agency's (EPA) decision in 2010 not to exempt biomass energy carbon emissions from regulation in the Prevention of Significant Deterioration and Title V

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[1] *See* Ari Rabl, *How to Account for CO_2 Emissions from Biomass in an LCA*, 12 INT'L J. OF LIFE CYCLE ASSESSMENT 281, 281 (2007).

[2] GREGORY MORRIS, BIOENERGY AND GREENHOUSE GASES 1 (2008).

[3] GIULIANA ZANCHI ET AL., JOANNEUM RESEARCH, THE UPFRONT CARBON DEBT OF BIOENERGY 16 (2010).

[4] *See e.g.*, Timothy Searchinger et al., *Fixing a Critical Climate Accounting Error*, 326 SCIENCE 527 (Oct 23, 2009) [hereinafter Searchinger 2009]; Gregg Marland, *Accounting for Carbon Dioxide Emissions from Bioenergy Systems*, 14 J. OF INDUS. ECOLOGY 866 (2010) [hereinafter Marland 2010]; Eric Johnson, *Goodbye to Carbon Neutral: Getting Biomass Footprints Right*, 29 ENVTL. IMPACT ASSESSMENT REV. 165 (2009).

Greenhouse Gas Tailoring Rule (Tailoring Rule)[5] and the EPA's decision in January 2011 to defer application of this rule to biomass facilities in order to study the issue of carbon emissions from biomass[6] indicate that regulation of biomass energy carbon emissions is unsettled and currently evolving.

Climate scientists argue it is critical that we reduce greenhouse gas (GHG) emissions in the next 20-30 years to avoid irreversible climate change.[7] The National Academy of Sciences, in a report commissioned by the United States Congress, recently stated that there is a "pressing need for substantial action" to reduce GHG emissions and "the nation should reduce [GHG] emissions substantially over the coming decades."[8] Thus, incentive programs designed to encourage the development of renewable energy sources, such as state "renewable portfolio standards,"[9] should incentivize biomass energy that reduces overall carbon emissions in the short to medium term. Life cycle analyses (LCA) that examine the GHG balances for a variety of sources of biomass energy can inform the creation of legal incentive programs that encourage bioenergy from sources that reduce carbon emissions on the time scale required.

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[5] *See* Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 40 C.F.R. § 70.2 (2010) (defining a major source of air pollutants as emitting or having the potential to emit 100 tons per year or more of GHGs); *see also* Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31,514, 31,590 (June 3, 2010) (EPA's response to commenters requesting that EPA exempt emissions from biomass combustion from the Tailoring Rule).

[6] Letter from Lisa Jackson, EPA Administrator, to Sen. Debbie Stabenow 2 (Jan. 11, 2011), *available at www.epa.gov/nsr/ghgdocs/StabenowBiomass.pdf.*

[7] Timothy Searchinger et al., *Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change*, 319 SCIENCE 1238, 1239 (2008) [*hereinafter* Searchinger 2008]; *see also* James Hansen et al., *Target Atmospheric CO_2: Where Should Humanity Aim?* 2 OPEN ATMOSPHERIC SCI. J. 217, 229 (2008).

[8] NATIONAL ACADEMY OF SCIENCES, AMERICA'S CLIMATE CHOICES: REPORT IN BRIEF, 2-3 (2011).

[9] Renewable portfolio standards (RPS) are state laws that require electricity providers to procure a certain percentage of their electricity from renewable energy sources.

This paper focuses on LCAs of GHG emissions from different sources of woody biomass, particularly woody biomass in the Pacific Northwest, and the definitions of eligible woody biomass in state renewable portfolio standards and federal law and proposed legislation. The results of this analysis show that electricity from waste sources of woody biomass and woody energy crops grown in certain conditions are likely to result in reduced GHG emissions within the time period suggested by climate scientists. However, LCAs demonstrate that electricity generated using whole trees does not necessarily reduce GHG emissions within this time period. Most definitions of biomass in state and federal legislation do not address GHG emissions from biomass or limit eligible woody biomass to waste sources, instead generally permitting the use of whole, merchantable trees.

CHAPTER II

ENERGY GENERATION FROM BIOMASS

In 2009, renewable energy accounted for 8% of the United State's energy supply.[10] Biomass energy constituted half of all renewable energy consumed, or 4% of the nation's energy supply.[11] In comparison, hydroelectric power generated 35% of renewable energy; wind, 9%; geothermal, 5%; and solar, 1%.[12] Thus, biomass energy plays a significant role in the supply of renewable energy in the United States.

The term "biomass" encompasses a wide range of materials. Biomass fuels include forestry and agricultural residues, municipal green waste, sewage sludge and biosolids, organic waste by-products and energy crops.[13] Biomass can either be specifically grown for energy as an energy crop, such as willow or poplar trees, or be a waste residue or by-product of other activities.[14]

Biomass waste residues can be primary, secondary, or tertiary residues.[15] Primary residues are by-products of the production of agricultural and forestry crops, which must be gathered from the field to be utilized for energy production.[16] Woody biomass primary residues include unused portions of trees from commercial harvesting operations,

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[10] ENERGY INFO. ADMIN., DEP'T OF ENERGY, RENEWABLE ENERGY CONSUMPTION AND ELECTRICITY PRELIMINARY STATISTICS 2009, http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/rea_prereport.html.

[11] *Id*.

[12] *Id*.

[13] Pascale Champagne, *Biomass*, *in* FUTURE ENERGY: IMPROVED, SUSTAINABLE AND CLEAN OPTIONS FOR OUR PLANET 151-52 (Trevor M. Letcher, ed., 2008).

[14] *Id*. at 155.

[15] *Id*.

[16] *Id*.

unused residue from land clearing operations, and forest thinnings from hazardous fuel reduction operations.[17] Processing of raw organic materials produces secondary residues, which include woody waste material produced at lumber and paper mills.[18] Tertiary residues include waste streams of organic materials after the useful lives of these materials have ended.[19] Woody biomass tertiary residues include wood from demolition of buildings or other discarded wooden materials.

Woody biomass must be harvested, chipped, dried and transported to the processing facility before it can be converted into electricity.[20] Biomass is often air-dried by evaporation by leaving harvested biomass in the forest or at a landing work site nearby.[21] One benefit of drying the biomass in the forest is that leaves and needles fall off and replenish the soil.[22] Also, drier biomass with fewer leaves and needles stores better because it undergoes less decomposition while in storage.[23]

Biomass can be converted to energy via three thermal processes: combustion, gasification and pyrolysis.[24] Combustion, or standard burning, of biomass to provide

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[17] Erin G. Wilkerson & Robert D. Perlack, *Resource Assessment, Economics and Technology for Collection and Harvesting*, *in* RENEWABLE ENERGY FROM FOREST RESOURCES IN THE UNITED STATES 88 (Barry D. Solomon & Valerie A. Luzadis, eds., 2009).

[18] Champagne, *supra* note 13, at 155.

[19] *Id*.

[20] Anton C. Vosloo, *The Future of Methane and Coal to Petrol and Diesel Technologies*, *in* Lechter, *supra* note 12, at 81-83.

[21] *Id*.

[22] *Id*.

[23] *Id*.

[24] Tony Bridgwater, *Bioenergy: Future Prospects for Thermal Processing of Biomass*, *in* FUTURE ELECTRICITY TECHNOLOGIES AND SYSTEMS 121 (Tooraj Jamasb et al., eds., 2006).

heat or electricity is a common practice in commercial settings.[25] Gasification is a more technically involved process that generates fuel gas from biomass.[26] Gasification has been demonstrated on a large scale but is not in wide spread use due to its relative cost compared to fossil fuel based energy.[27] Pyrolysis results in the production of charcoal, liquid fuel or gas vapors depending on the process temperature.[28] Fast, high temperature pyrolysis produces liquid bio-fuel as the main product.[29]

Combustion of biomass is currently the most viable form of generating electricity from biomass. Cogeneration facilities increase the efficiency of biomass combustion. Cogeneration, also called combined heat and power (CHP), is the practice of utilizing both the recovered, low quality heat generated by combustion in addition to the electricity generated.[30] The efficiency of the energy generating system increases as more of this heat is used.[31] Currently, most biomass electricity plants do not utilize this heat unless the plant is co-located with an industry that can use the heat, such as a wood drying operation.[32]

Biomass encompasses a broad category of natural materials, many of which have been use by humans to produce energy for centuries. However, the large-scale use of

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[25] *Id*. at 122.

[26] *Id*.

[27] *Id*. at 132.

[28] *Id*. at 134.

[29] *Id*. at 135 tbl. 5.3.

[30] Barry D. Solomon & Nicholas H. Johnson, *Introduction*, *in* Solomon & Luzadis, *supra* note 16, at 18.

[31] MANOMET CENTER FOR CONSERVATION SCIENCES, MASSACHUSETTS BIOMASS SUSTAINABILITY AND CARBON POLICY STUDY: REPORT TO THE COMMONWEALTH OF MASSACHUSETTS DEPARTMENT OF ENERGY RESOURCES 22 (Thomas Walker, ed., 2010) [hereinafter Manomet].

[32] *Id*.

energy today presents new dilemmas in terms of carbon emissions and the ability of forests and agricultural lands to sustainably produce biomass.

CHAPTER III

GREENHOUSE-GAS IMPLICATIONS OF BIOMASS ELECTRICITY GENERATION

The overall carbon footprint of biomass electricity depends on many things, including the source of the biomass, transportation of the biomass, the method of electricity production, and, in the case of waste sources of biomass, emissions from alternative disposal methods that are avoided by using biomass to produce electricity. In terms of the source of biomass, it is important to distinguish between biomass energy crops, waste sources of biomass and other sources of woody biomass. The various methods of producing electricity from biomass, including the combustion of wood chips in a boiler, pyrolysis of biomass (biochar), and conversion of biomass into liquid fuels, result in different carbon footprints. The timing and rate of carbon emission and absorption by forests can also impact the overall carbon footprint of biomass electricity.

a. Carbon Emissions, Storage, and Absorption in Forests

Forests absorb, store and emit carbon. Forests absorb carbon because trees and other plants absorb carbon dioxide as part of the process of photosynthesis.[33] Forests store the absorbed carbon in the form of live and slowly decomposing woody and plant materials, as well as in the soil.[34] Woody material harvested from forests and preserved as wood (not burned or allowed to decompose) continues to store carbon.[35] The carbon

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[33] *ENCYCLOPEDIA BRITANNICA ONLINE, photosynthesis*, http://www.britannica.com/EBchecked/topic/458172/photosynthesis (last visited May 13, 2011).

[34] Sebastiaan Luyssaert et al., *Old-Growth Forests as Global Carbon Sinks*, 455 NATURE, 213, 213 (2008).

[35] OREGON FOREST RESOURCES INSTITUTE ET AL., FORESTS, CARBON AND CLIMATE CHANGE: A SYNTHESIS OF SCIENCE FINDINGS 127 (2006).

stored in forests is emitted during forest fires,[36] through decomposition of organic materials (i.e. fallen trees, branches, leaves), [37] and when woody material harvested from forests is burned. Based on the rates of absorption and emission of carbon, forests can be carbon sinks, carbon sources, or carbon neutral at a given point in time.

Forests are carbon sinks when they absorb more carbon then they emit and carbon sources when they emit more carbon than they absorb. A review of studies on carbon emissions and absorption found that, on a global scale, forests between 15-800 years old are usually carbon sinks.[38] Much of the analysis here will focus on Pacific Northwest forests because many of these forests are among the most productive and long-lived forests in the world, making these forests potentially a large source of biomass.[39] Overall, forests in the west Cascade region were a carbon source during most of the 1900s due to the conversion of old growth forests to Douglas fir plantations, but these forests became a carbon sink as harvest levels decreased in the 1990s.[40] While forests in western Oregon tend to be carbon sinks, large forest fires, such as the Biscuit Fire in 2002, emit enormous amounts of carbon and can turn a forest sink into a carbon source for a year or more after the fire.[41]

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[36] Garret W. Meigs et al., *Forest Fire Impacts on Carbon Uptake, Storage, and Emission: The Role of Burn Severity in the Eastern Cascades, Oregon*, 12 ECOSYSTEMS 1246, 1247 (2009).

[37] Luyssaert, *supra* note 34, at 213.

[38] *Id*. at 214 fig.1; Tara Hudiburg et al., *Carbon Dynamics of West-Coast Forests*, 19 ECOLOGICAL APPLICATIONS 163, 170 tbl.2 (2009).

[39] *Id*. at 178.

[40] Beverly E. Law et al., *Disturbance and Climate Effects on Carbon Stocks and Fluxes Across Western Oregon USA*, 10 GLOBAL CHANGE BIOLOGY 1429, 1441 (2004).

[41] *Id*. at 1442.

Young forests (less than ten to fifteen years old) are often carbon sources because new forests typically form after the removal or disturbance of a previous forest, resulting in carbon emissions from decaying residue materials that is greater than the carbon absorbed by new growth.[42] Even-aged forests composed of trees of the same age, usually the result of replanting after a harvest, are more likely to become carbon sources when they age than an old-growth forest with trees of mixed age.[43]

A study of forests across the United States and Canada found forests are generally sources of carbon for twenty years after stand replacing harvests and at least ten years after stand replacing fires with local climate playing a significant role in the rate of growth of vegetation and decomposition of organic debris.[44] Insect infestations and thinning operations have the greatest impact on forest carbon flux in the year they occur, with a relatively short recovery period (five to ten years).[45] However, full assessment of the effects of commercial thinning over longer time periods will require more study.[46]

Forests are carbon neutral when they emit and absorb equal amounts of carbon. It has been generally thought that older forests are carbon neutral but newer research shows this is not necessarily the case.[47] Based on an analysis of stand age, total biomass, and the net rate of carbon absorption for forests in Oregon, a recent study found forests in all of the study regions (Coast Range, West Cascades, East Cascades and Klamath

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[42] Luyssaert, *supra* note 34, at 213.

[43] *Id*. at 214; Law, *supra* note 40, at 1430.

[44] B.D. Amiro et al., *Ecosystem Carbon Dioxide Fluxes After Forest Disturbance in Forests of North America*, 115 J. GEOPHYSICAL RES. G00K02, 6-7 (2010).

[45] *Id*. at 9.

[46] *Id*. at 9-10.

[47] *See e.g.,* Hudiburg, *supra* note 38, at 170 tbl.2; Luyssaert, *supra* note 34, at 213.

mountains) continued to absorb more carbon than they released, including forests with a stand age of more than two hundred years old.[48] The authors of this study recommend using a 200-year cutting rotation cycle to maximize carbon stocks in Oregon forests.[49]

Forests in different eco-regions accumulate biomass at different rates and accumulate different maximum amounts of biomass.[50] A study of federal inventory data and additional field measurements found that in the Oregon Coast Range and West Cascade regions, the rate of accumulation of biomass peaks at about eighty years but the total amount of biomass continues to increase in forests over 300 years old in these regions.[51] However, both of these regions have high rates of accumulation to begin with and the decline is only conspicuous in the Coast Range region.[52] The decline is more pronounced in the Coast Range region because these forests are some of the "most productive temperate forests in the world" with aboveground carbon stocks that are similar to tropical forests.[53] In comparison, the rate of accumulation in the Klamath Mountain region is initially half the rate for the Coast Range and peaks when the trees are approximately 110 years old but forests in the Klamath Mountains continue to accumulate biomass for at least 600 years.[54] The maximum amount of live biomass in the Coast Range and Klamath Mountain regions is about three to four times that of the

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[48] Steve Van Tuyl et al., *Variability in Net Primary Production and Carbon Storage in Biomass Across Oregon Forests: An Assessment Integrating Data From Forest Inventories, Intensive Sites, and Remote Sensing*, 209 FOREST ECOLOGY & MGMT. 273, 281 tbl.1 (2005).

[49] *Id*. at 289.

[50] Hudiburg, *supra* note 38, at 168.

[51] *Id*.

[52] *Id*.; *id*. at 172 fig.4.

[53] *Id*. at 175.

[54] *Id*. at 170 tbl.2.

East Cascade and Blue Mountain regions.[55] The differences between regions in the rates of accumulation and maximum biomass make it difficult to generalize about carbon storage potential across all forests.

The same study found that in Oregon and Northern California, the average age of trees is significantly greater on public land than private land.[56] For example, in the Coast Range and West Cascade regions, the average stand age on public lands is approximately twice that on private land (156 versus 83 and 254 versus 105, respectively).[57] This difference in age results in carbon stores that are 30-50% higher on public land in Oregon and Northern California than the private land in the same area.[58] In order to maximize carbon stores, forests should be managed to maximize total biomass accumulation rather than to maximize the rate of accumulation.[59] While carbon storage in Oregon and Northern California forests could be double current levels, the authors of this study found it may be more realistic to "increase rotation ages by 30-50 years or reduce the acreage that is harvested in areas more likely to reach the theoretical [maximum carbon storage] levels (Coast Range, West Cascades, Klamath Mountains)."[60]

This discussion of rates of accumulation of biomass and maximum levels of biomass accumulation suggests forests' abilities to accumulate and store carbon should be recognized and considered in evaluating the desirability of using forest biomass for

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[55] *Id*. at 168.

[56] *Id*.

[57] *Id*. at 165 tbl.1.

[58] *Id*. at 175.

[59] *Id*. at 177.

[60] *Id*. at 178-79.

electricity. Also, the rate of accumulation of biomass in forests is significant in calculating the overall carbon footprint of biomass electricity produced from forest sources of biomass, for example in a Life-Cycle Analysis.

b. <u>Life-Cycle Analysis Methodology and Counting Carbon Emissions and Capture</u>

A Life-Cycle Analysis (LCA) involves the "investigation and evaluation of the environmental impacts of a given product or service," including all steps of the production chain and full life-cycle.[61] LCA is a widely accepted methodology for calculating the GHG emissions balance for bioenergy systems.[62] A GHG balance for a bioenergy system must account for emissions of carbon dioxide, methane, and nitrous oxide,[63] and the absorption by biomass of carbon dioxide from the atmosphere.[64] Also, LCAs for bioenergy projects should be designed to determine the additionality of the project, or the extent to which GHG emission reductions represent additional reductions compared to today's status quo.[65] This concept is particularly relevant when determining whether to assign credits in LCAs for carbon captured during the growth of biomass.

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[61] Francesco Cherubini, *GHG Balances of Bioenergy Systems – Overview of Key Steps in the Production Chain and Methodological Concerns*, 35 RENEWABLE ENERGY 1565, 1566 (2010).

[62] *Id*. at 1565.

[63] *Id*. at 1567. Because these three compounds impact climate change in varying degrees, their impacts are standardized relative to the effect of carbon dioxide, using the unit "CO_2-equivalent" (CO_2-eq). *Id*.

[64] Rabl, *supra* note 1, at 281.

[65] Timothy G. Foley et al., *Extending Rotation Age for Carbon Sequestration: A Cross-Protocol Comparison of North American Forest Offsets*, 259 FOREST ECOLOGY & MGMT. 201, 204 (2009).

i. Counting Carbon Emissions from Biomass Combustion and Carbon Capture from Biomass Growth

Debate exists among policy makers, scientists, environmentalists and the biomass industry as to whether or not carbon emissions from combustion of biomass should be included in the GHG LCA for a bioenergy system. This debate is related to the timing of the capture, release, and re-capture of the carbon emissions. To consider biomass electricity carbon neutral at the time of generation requires either assigning a carbon credit for the carbon captured during the growth of the biomass or assuming that the carbon emissions from combustion of biomass are immediately re-captured by growing plants.[66] Both of these assumptions may be reasonable for energy crops. Assuming immediate recapture could be acceptable for fast growing plants such as energy crops harvested annually or on a relatively short time scale.[67] Also, assigning a carbon credit for the carbon captured during biomass growth is suitable for bioenergy crops planted specifically for the purpose of absorbing carbon for conversion to energy because the carbon captured represents additional carbon absorbed over today's status quo. If we assign a credit for the carbon captured by the biomass as it grew, prior to combustion for energy, then the credits for this captured carbon will cancel out the emissions from combustion resulting in zero net emissions (ignoring any emissions from production, fertilizer, transportation, land use change, or other sources and any changes in soil carbon).

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[66] *See* Zanchi, *supra* note 3, at 16.

[67] *See id*.

However, it does not seem appropriate to assume immediate recapture of carbon or to assign a carbon capture credit in a LCA for non-energy crop forms of biomass, for example, natural forests or forests grown for lumber. Most trees in forests grow slowly making the assumption of immediate or near-immediate recapture inapplicable. Also, it does not make sense to credit the capture of carbon by non-energy-crop biomass in an LCA because the carbon absorbed by this biomass does not represent additional carbon absorption relative to the status quo today. Because we are trying to decrease our net carbon emissions based on today's levels, when doing an LCA of GHG emissions from bioenergy, it does not make sense to credit carbon that does not represent additional carbon captured.

The term "upfront carbon debt" is used to describe the carbon emissions profile of forests harvested for bioenergy. Because there is a delay between the release of carbon during combustion and re-capture of carbon by forest re-growth, an upfront carbon debt exists.[68] This upfront carbon debt takes several decades of forest re-growth to erase, as discussed below in part c, which means biomass energy does not necessarily reduce carbon emissions in the short to medium term (20-50 years).[69] Also, while new trees or other crops can re-capture the amount of carbon dioxide released during combustion for bioenergy,[70] there is no guarantee replanting will occur or that forests will be allowed to grow for a sufficient time to re-capture enough carbon to offset the original release.

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[68] *Id*. at 5.

[69] *Id*.

[70] ROBERT L. EVANS, FUELING OUR FUTURE: AN INTRODUCTION TO SUSTAINABLE ENERGY, 101 (2007); Champagne, *supra* note 13, at 152.

Because of these complications, and those discussed above, many scientists argue that GHG emissions from and captured by biomass should be included in LCAs.[71]

The fact that bioenergy can have a sizable upfront carbon debt is significant because GHG emissions must be reduced in the next 20-30 years to combat climate change.[72] Carbon dioxide molecules from biomass electricity behave identically to carbon dioxide molecules from coal and other fossil fuels in terms impacts on climate change. Therefore, we must determine the real effectiveness of woody biomass to offset GHG emissions in a short-term time frame.[73] LCAs that account for the release and recapture of carbon are a useful tool for performing such an analysis.

ii. Basic Methodology of a Life-Cycle Analysis of Greenhouse Gas Balances for Bioenergy

An LCA of GHG emissions for a bioenergy system requires calculating the total GHG emissions of the bioenergy system and the fossil fuel system the bioenergy system will replace, referred to as the reference energy system.[74] The GHG savings of the bioenergy system relative to the reference system is calculated by subtracting the GHG emissions of the bioenergy system from the GHG emissions of the reference system.[75] A number of different units can be used to express the results of the GHG balance. For energy crops, expressing GHG emissions in terms of kilograms of CO_2-eq per acre allows

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[71] *See e.g.*, Rabl, *supra* note 20, at 281; Johnson, *supra* note 4; Searchinger 2009, *supra* note 4; Marland 2010, *supra* note 4.

[72] Searchinger 2008, *supra* note 7, at 1239; *see also* Hansen, *supra* note 7, at 229.

[73] Zanchi, *supra* note 3, at 5.

[74] Bernhard Schlamadinger et al., *Towards a Standard Methodology for Greenhouse Gas Balances of Bioenergy Systems in Comparison with Fossil Energy Systems*, 13 BIOMASS & BIOENERGY 359, 364 (1997).

[75] Cherubini, *supra* note 61, at 1567.

comparison of the land-use efficiency of a given energy crop.[76] For biomass residue feed stocks, using the units of kilograms of CO_2-eq per kilowatt-hour allows comparison of the emissions across different types of feedstock or type of energy.[77] Using the units of kilograms of CO_2-eq per kilogram of feedstock allows comparison of alternative fates or uses for a given residue.[78] Final outcomes are also sometimes presented on a per year basis.[79]

In order to make a valid comparison between the GHG emissions of a bioenergy system and a fossil fuel reference system, the systems must similarly include emissions from production, distribution and combustion of the fuel.[80] The type of fossil fuel used in the reference system should be specified because oil, natural gas and coal have different GHG emission factors.[81] The GHG savings of a bioenergy system relative to a coal reference system are much larger than when natural gas is used for the reference system.[82]

Whether the biomass is grown as an energy crop or is a residue or by-product of another activity has an impact on the methodology for calculating the GHG emissions of a bioenergy system.[83] Because biomass residues are produced regardless of whether they are utilized for bioenergy, the avoided GHG emissions from the alternative fates of the

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[76] *Id*. at 1568.

[77] *Id*.

[78] *Id*.

[79] *Id*.

[80] *Id*.

[81] *Id*.

[82] *Id*.

[83] *Id*.

residues must be credited in an LCA of GHG emissions for a residue-based bioenergy system.[84] All of the energy and material inputs of the growing and cultivating phases are attributed to the primary product, not the residues.[85] Thus, emissions attributed to energy crops include GHG emissions from the manufacture and use of fertilizer, herbicides, and farm machinery used during the growth and harvest stages.[86] Any GHG emissions from the manufacture and use of machinery to collect or bundle residues after the primary crop has been extracted should be attributed to the residues. GHG emissions from drying, chopping, transportation, and combustion must be accounted for both energy crops and biomass residues.[87]

When bioenergy production involves a change in land use in order to grow the biomass material, GHG gas emissions are created as a result of the land use change and must be included in a complete LCA.[88] For example, if forest or grassland is cleared to grow energy crops, the loss of stored carbon from belowground biomass (roots), soil and the cleared aboveground vegetation must be counted.[89] This type of land use change is called a direct land use change.[90] The cultivation of bioenergy crops can also result in indirect land use change when bioenergy crops are planted on existing agricultural land and other land is brought into cultivation to grow the crops displaced by the energy

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[84] *Id*. at 1570. The term "alternative fates" is synonymous with "prior uses."

[85] *Id*.

[86] *Id*.

[87] *Id*.

[88] Searchinger 2008, *supra* note 7, at 1238.

[89] *See* Joseph Fargione et al., *Land Clearing and the Biofuel Carbon Debt*, 319 SCIENCE 1235, 1236 (2008).

[90] Cherubini, *supra* note 61, at 1571.

crops.[91] The magnitude of the GHG emissions will depend on the original state of the land.[92] These emissions happen relatively quickly but can be amortized over a period of years when included in a LCA.[93] Biomass residues and bioenergy crops grown on unproductive land or abandoned agricultural land do not create land-use change and associated emissions.[94]

Thus, whether biomass electricity results in lower carbon emissions than fossil fuel-based electricity is a complicated matter that depends, in part, on the source of the biomass fuel, whether there is a change in land use, the type of replaced fossil fuel, the rate of re-growth of vegetation and the time frame considered.[95] The outcomes of LCAs of GHG emissions often vary for similar systems because different basic assumptions about a variety of factors, including the type of biomass source, the inclusion or exclusion of various parts of the energy production process, and end-use technologies, often differ.[96] These differences make comparisons between LCA studies difficult.

c. <u>Carbon Emissions and Credits from Different Sources of Woody Biomass</u>

The type of biomass material used as fuel impacts the GHG balance of bioenergy. Woody biomass fuels can be divided into four categories: energy crops, woody waste

[91] *Id*. at 1571. This phenomenon is also referred to as "leakage."

[92] Searchinger 2008, *supra* note 7, at 1239; Zanchi, *supra* note 3, at 29-30 (comparing land use change GHG emissions for different land types).

[93] Alissa Kendall et al., *Accounting for Time-Dependent Effects in Biofuel Life Cycle Greenhouse Gas Emissions Calculations*, 43 ENVTL. SCI. & TECH. 7142 (2009); Searchinger 2008, *supra* note 7, at 1239.

[94] Searchinger 2008, *supra* note 7, at 1240; Fargione, *supra* note 89, at 1236.

[95] Marland 2010, *supra* note 4, at 868; *see also* Zanchi, *supra* note 3, at 5 (Whether biomass energy reduces GHG emissions depends on "the source of wood, the efficiency of conversion, the type of substituted fuel and the mix of final products.")

[96] Cherubini, *supra* note 61, at 1565.

materials, thinnings from overgrown forests resulting from fire suppression, and existing natural forests or forests grown for lumber. Each of these categories of fuel has a different carbon emissions profile.[97]

i. Forest Sources of Biomass and Biomass Residues

Generation of electricity from treetops, limbs and other unmerchantable materials left in the forest after timber harvests results in fewer overall carbon emissions and a shorter carbon recovery time as compared to other sources of woody biomass.[98] This is because biomass waste is typically burned in slash piles or left to decompose, both of which produce carbon emissions. As discussed above, when evaluating the carbon emissions from electricity generated from waste sources of woody biomass, emissions from alternative disposal methods that are avoided by using biomass to produce electricity must be considered. In other words, the emissions produced by the electricity generation must be compared to the would-be emissions from the burning slash piles or decomposing biomass. The first step in this process is to identify the various alternative disposal methods and determine the emissions from these disposal methods.

Waste sources of woody biomass include forestry and agricultural residues, waste from wood products industries, construction debris, and urban tree care and landscaping waste. In the United States, by one measure, approximately 16 percent of the total volume removed during logging is residue consisting of treetops and small branches.[99] Because this material is typically uneconomic to remove, it is often burned on site in

[97] Manomet, *supra* note 31, at 6.

[98] *Id*. at 109; *see also* Zanchi, *supra* note 3, at 32 (assuming annual extractions).

[99] Wilkerson & Perlack, *supra* note 17, at 69.

slash piles to reduce fire danger.[100] The Oregon Forest Practice Administrative Rules allow mechanical processes, fire and "other means" as methods to minimize woody biomass or slash residue from harvesting operations.[101] In Oregon, woody biomass residues generated from forestry activities are generally burned on-site in slash piles or left to decompose.[102]

Waste sources of biomass will produce emissions regardless of the manner of disposal. Combustion of biomass in slash piles or in energy facilities produces carbon dioxide emissions.[103] The combustion of biomass in slash piles also produces carbon monoxide and fine particulate matter ($PM_{2.5}$), but decomposing biomass and using biomass to produce electricity results in little to no production of these pollutants.[104] When biomass decomposes, whether on the forest floor, in a landfill, or in any other location, carbon dioxide and potentially methane are released.[105] Decomposing biomass that is naturally dispersed on the forest floor is not likely to release methane, but methane can form when biomass is put into landfills or is heaped into slash piles and left to decompose.[106]

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[100] *Id*. at 70.

[101] OR. ADMIN. R. 629-615-0000(2) (2010).

[102] CARRIE LEE ET AL., STOCKHOLM ENVIRONMENT INSTITUTE & OLYMPIC REGION CLEAN AIR AGENCY, GREENHOUSE GAS AND AIR POLLUTANT EMISSIONS OF ALTERNATIVES FOR WOODY BIOMASS RESIDUES 20 (2010).

[103] GREGORY MORRIS, NATIONAL RENEWABLE ENERGY LABORATORY, NREL/SR-570-27541, THE VALUE OF THE BENEFITS OF U.S. BIOMASS POWER 7 (1999).

[104] Lee, *supra* note 102, at 33-34 figs.4 & 5.

[105] *Id*. at 48.

[106] *Id*.

Because different basic assumptions about a variety of factors often differ, and because there are very few analyses that compare carbon emissions from the various alternative fates of logging residues,[107] comparisons between LCA studies is difficult. The following sections examine the methodologies and results of several studies of GHG balances of bioenergy generated from woody biomass and woody biomass residues.

A. Study Summary: Manomet

The Commonwealth of Massachusetts Department of Energy Resources commissioned a study by the Manomet Center for Conservation Sciences (Manomet study) that addresses, among other things, the GHG implications of shifting from fossil fuel energy sources to forest biomass sources in Massachusetts.[108] The Manomet study utilizes a "comprehensive lifecycle carbon accounting framework" that addresses emissions from "biomass combustion technology, the fossil fuel technology it replaces, and the biophysical and forest management characteristics of the forests from which the biomass is harvested."[109] This approach allows analysis of the decrease over time in the carbon debt generated from combustion of biomass as the harvested forest re-grows.[110] However, this study does not account for changes in soil carbon, which, if accounted for, would tend to increase the initial carbon debt.[111] The Manomet study does not focus on the use of woody biomass residues as an independent fuel source but rather as part of a

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[107] Lee, *supra* note 102, at 18; *see also* THE HEINZ CENTER & THE PINCHOT INSTITUTE FOR CONSERVATION, FOREST SUSTAINABILITY IN THE DEVELOPMENT OF WOODY BIOENERGY IN THE U.S. 2 (2010).

[108] Manomet, *supra* note 31, at 6.

[109] *Id*.

[110] *See e.g.*, *id*. at 6 fig.1, 105.

[111] *Id*. at 83; s*ee also* MARY S. BOOTH, REVIEW OF THE MANOMET BIOMASS SUSTAINABILITY AND CARBON POLICY STUDY 18-19 (2010).

bioenergy harvest from a forest that includes both whole trees and residues.[112] The authors included whole trees because woody residues are not available in sufficient quantities to supply the proposed expansion of biomass electricity in Massachusetts and would be less cost effective than whole trees.[113]

Multiple harvest scenarios are used to analyze the timing of the recapture of carbon released as a result of electricity generation from woody biomass. The scenarios differ in terms of harvest intensity and whether or not treetops and limbs are utilized. The two main types of scenarios are "business as usual" harvests and biomass harvests.[114] Business as usual (BAU) harvests are based on logging practices in Massachusetts where harvests typically remove only the larger, higher quality trees and total removal is around 20% of the "above-ground live stand carbon" in a forest.[115] No treetops or limbs are removed from the forest as part of a BAU scenario harvest.[116] Biomass harvest scenarios include more intensive removal of trees than a BAU scenario harvest, which generates more treetops and limbs than a BAU scenario, plus the removal and use of 65% of treetops and limbs.[117]

Of the six scenarios analyzed, the rate of carbon recapture by the re-growing forest was fastest for the scenario with "heavy BAU" removals (32% of above ground live stand carbon) and "light biomass" removals (20% of above ground live stand carbon

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[112] *See* Manomet, *supra* note 31, at 109.

[113] *Id*. at 33, 39.

[114] *Id*. at 101.

[115] *Id*. at 107.

[116] *Id*. at 84 exhibit 5-2, 107.

[117] *Id*. at 83, 101 exhibit 6-3.

and 40% of tree tops and limbs removed) with approximately 86% of the carbon recaptured after ninety years.[118] This is because the light biomass harvest contains proportionally a larger amount of logging residues that would otherwise decay and add to the carbon debt.[119] Harvest levels this light would not necessarily produce an adequate supply of biomass materials to support a viable, expanded biomass industry in Massachusetts.[120] In the scenarios where removals approach clear-cut levels, approximately 68% of the carbon is recaptured after ninety years.[121] None of these six scenarios models the use of only treetops and limbs as biomass fuel because these materials are not generated in Massachusetts in sufficient quantities to play a significant role in the biomass industry.[122] However, the authors note that when biomass fuel consists of only treetops and limbs, approximately 68% of the carbon is recaptured after ten years and 97% is recaptured after fifty.[123] The study finds that the use of treetops and limbs makes biomass electric power "look favorable" to natural gas electric but the use of this type of fuel is not included the analysis of avoided emissions discussed below.[124]

However, accounting for avoided emissions from fossil fuels shortens the length of time required to recover the initial carbon debt.[125] For example, for the harvest scenario discussed above (heavy BAU/light biomass), when a typical biomass electric

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[118] *Id*. at 108.

[119] *Id*.

[120] *Id*.

[121] *Id*. (scenarios 3 and 6).

[122] *Id*. at 110.

[123] *Id*. Treetops and limbs left in the forest take about ten years to decay. *Id*. at 93.

[124] *Id*. at 110 exhibit 6-12; *see id*. at 112 (The use of only treetops and limbs as fuel is not included in exhibit 6-13).

[125] *Id*. (compare exhibit 6-13 to exhibit 6-9).

facility replaces a coal electricity facility, the carbon debt is repaid in approximately twelve years and a carbon dividend of 68% is realized in ninety years.[126] However, for all other harvest scenarios considered, when a biomass electricity facility replaces a coal electricity facility, the carbon debt was repaid in approximately twenty-one to thirty two years.[127] In contrast, when a biomass electric facility replaces a gas electric facility, depending on the harvest scenario, forty-five to upwards of ninety years are required to repay the carbon debt.[128] Regardless of the type of fossil fuel, the initial carbon debt of biomass energy is repaid faster when biomass is used to generate heat than when biomass is used to generate electricity.[129]

This study notes several key findings and identifies issues and choices policymakers must address. The key findings include that harvest practices and intensities, the type of energy producing biomass technology, and the type of fossil fuel energy plant being replaced have significant impacts on the magnitude of carbon debts from biomass energy.[130] Because the scenarios considered in this study generally indicate biomass energy results in near-term increases in GHG levels but lower long-term GHG levels, policymakers must weigh the long-term benefits with the short-term drawbacks.[131] The authors also note that this study focused on biomass from natural forests (including both whole trees and residues) in Massachusetts so the results of this

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[126] *Id*. at 112.

[127] *Id*. at 112 exhibit 6-13.

[128] *Id*.

[129] *Id*.

[130] *Id*. at 107, 105, 112.

[131] *Id*. at 113-14.

study should not be applied to other sources of biomass and generalization of results to areas beyond Massachusetts and New England is problematic.[132] Finally, the authors note that if policymakers believe no or low carbon energy sources will be developed in the next couple of decades, it makes less sense to promote the development of biomass energy with high initial carbon debts and longer payback periods.[133]

B. Study Summary: Joanneum Research

Scientists with Joanneum Research were some of the first researchers to study lifecycle analyses of carbon emissions when forests are harvested for bioenergy, beginning in the mid-1990s.[134] Early analyses noted the importance of the timescale of carbon emissions and recapture for forestry-based bioenergy.[135] An early model was based on a generic forest with average growth rates and a sixty year harvest rotation, included the displaced emission from fossil fuels, and assumed 23% of the harvested biomass was left onsite, 55% was used for wood and paper products, and 22% was used for energy production.[136] This model indicated a little over forty years were required to reach zero net carbon emissions.[137] Rates of forest re-growth, the efficiency of conversion of biomass into energy, the type of fossil fuel being replace, and the efficiency of manufacture and use of wood products to displace more energy-intensive

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[132] *Id*. at 113.

[133] *Id*.

[134] *Id*. at 95. *See e.g.*, Bernhard Schlamadinger & Gregg Marland, *Full Fuel Cycle Carbon Balances of Bioenergy and Forestry Options*, 37 ENERGY CONSERVATION & MGMT. 813 (1996).

[135] *Id*. at 818.

[136] *Id*. at 814-15. The growth rate was set as 2 $tC\ ha^{-1}\ yr^{-1}$ for the early life of the forest and then declined with age. *Id*.

[137] *Id*. at 815.

materials were identified as important factors impacting the net carbon balance of forestry-based bioenergy.[138] Scientists at Joanneum Research also noted as early as 1996 that the best use of forests could be simply to let the forests stand and store carbon.[139] More recent research has reaffirmed the importance of these factors and noted the significance of any land use changes resulting from bioenergy projects, such as conversion of natural forest to managed forest or crops.[140]

For woody biomass residues from logging operations in Finland, a recent study from Joanneum Research notes that, if left in the forest to decay, after twenty years approximately 90% of the carbon in the residues will have been released to the atmosphere.[141] By examining studies of woody biomass removal in boreal or temperate forests, this study determined that, when bioenergy from woody biomass residues replaces natural gas, after twenty years, carbon emissions from the bioenergy were 80% of the emissions that would have been emitted by using natural gas and 70% after fifty years.[142] If bioenergy from residues replaces coal, carbon emissions are reduced to 40% of emissions using fossil fuel after twenty years and to 30% after fifty years.[143] This represents a reduced rate of carbon emissions but indicates using woody biomass residues is not carbon neutral.

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[138] *Id*. at 818.

[139] *Id*.

[140] Marland 2010, *supra* note 4, at 868.

[141] Zanchi, *supra* note 3, at 23.

[142] Zanchi, *supra* note 3, at 32. Emissions from transportation and processing (chipping) of the biomass are not included in this model. *Id*. at 18. This should not effect the results greatly because emissions from transportation and processing typically account for a small percentage of overall emissions from production. Lee, *supra* note 102, at 39; Morris, *supra* note 2, at 22.

[143] Zanchi, *supra* note 3, at 32.

C. Study Summary: Stockholm Environment Institute

The Olympic Region Clean Air Agency (ORCAA) commissioned the Stockholm Environment Institute (SEI) to study air pollutant emissions from the alternative fates of logging residues in the Pacific Northwest and develop a Woody Biomass Emissions Calculator.[144] SEI designed the report and calculator to be used by decision makers to compare air pollutant emissions from various alternative fates of logging residues.[145] This study is unique because it focuses on forests, fates of woody residues and types of energy used in the Pacific Northwest. This study concludes that the vast majority of GHG emissions from the use of woody biomass residues to generate electricity result from the use or processing (generally combustion) of the residues rather than the gathering, chipping and transporting of residues.[146] Also, this study concludes that woody biomass residues that displace fossil fuels result in the greatest reductions in net GHG emissions when the most efficient biomass electricity generation methods are used (e.g. industrial boilers).[147]

The approach taken by SEI focuses solely on the "post-harvest to grave" emissions from alternative fates of woody biomass residues rather than a full lifecycle analysis.[148] By design, this approach does not account for emissions from forestland management practices or the effects of carbon sequestration.[149] Thus, this approach does

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[144] *See* Lee, *supra* note 102.

[145] *Id*. at 18.

[146] *Id*. at 39.

[147] *Id*. at 40.

[148] *Id*. at 19.

[149] *Id*.

not assess overall emissions or the impact of different forestland management practices on carbon sequestration over time.[150] Also, this study does not consider the impact of black carbon[151] or aerosol $PM_{2.5}$[152] emissions on climate change.[153]

The method used by SEI to calculate the net carbon emissions from various alternative fates for woody biomass residues can be divided into three main steps. First, calculate the system emissions, the carbon emissions resulting from the "gathering, transporting, processing, and using or disposing of woody biomass residues" are calculated.[154] Second, to calculate the displaced emissions, the carbon emissions are calculated that would have occurred from products that are not used because woody biomass residues are used instead (e.g. electricity generated from hydropower or fossil fuels).[155] Third, subtract the displaced emissions from the system emissions to determine the net carbon emissions.[156] Finally, compare the net emissions for various alternative fates for woody biomass to determine which alternative results in the least amount of carbon emissions.

System emissions are very similar for electricity generated from the combustion of woody biomass residues in integrated gasification and combustion (IGC) systems and

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[150] *Id*.

[151] Black carbon, commonly known as soot, is a particulate matter formed during incomplete combustion of fossil fuels, biofuels, and biomass and has recently been identified as a contributor to global warming.

[152] Aerosol $PM_{2.5}$ is particulate matter 2.5 micron or less in diameter suspended in the surrounding air.

[153] Lee, *supra* note 102, at 22.

[154] *Id*.

[155] *Id*. at 22, 71 fig.29.

[156] *Id*. at 22.

cogenerators (systems that produce both heat and electricity).[157] System emissions for the combustion of woody biomass residues by these processes are less than the system emissions from the combustion of biomass in slash piles but greater than the system emissions from decomposition of biomass that is not heaped into piles.[158] Biochar production is the only method of energy production that results in system emissions that are less than system emissions from decomposition.[159] This reflects the ability of biochar production to both generate electricity and sequester carbon in the leftover charcoal.

Net emissions for electricity generated from the combustion of woody biomass residues are equal to the system emissions minus the displaced emissions. This study assumes the electricity generated from biomass displaces electricity generated from fossil fuels, specifically electricity from a combined-cycle natural gas turbine.[160] The study researchers chose natural gas as the fuel replaced by biomass because new electricity generation would replace marginal electric generation sources (the last sources brought online to provide power during any time period), which in the Pacific Northwest are typically coal or natural gas-fired generating units.[161] Electricity generated (using woody biomass residue) from biochar production, an IGC system or a cogenerator has lower net emissions than woody biomass residue left to decompose.[162] While an IGC system and a cogenerator release the same amount of GHG emissions for a given amount of wood

[157] *Id*. at 33 fig.10.

[158] *Id*.

[159] *Id*.

[160] *Id*. at 71 (for cogenerator); *id*. at 69 (for ICG); *id*. at 56 (for biochar).

[161] *Id*. (citing NORTHWEST POWER AND CONSERVATION COUNCIL, MARGINAL CARBON DIOXIDE PRODUCTION RATES OF THE NORTHWEST POWER SYSTEM 1 (2008).).

[162] Lee, *supra* note 102, at 36 fig.13.

burned, IGC systems are more efficient, producing more electricity per amount of wood, and thus displace more fossil-fuel generated electricity.[163] This results in IGC systems having lower net emissions than cogenerators.[164] However, both IGC systems and cogenerators have lower net emissions than biochar production because biochar production is a relatively inefficient way to produce electricity and displaces less fossil fuel generated electricity than either of the previous methods. Biochar production does still result in lower net emissions than decomposition and biochar may be useful in some situations as a soil amendment.

D. Study Summary: Morris

Gregory Morris is the director of the Green Power Institute, the renewable energy program of the Pacific Institute.[165] In 2008, Robert Cleaves, chairman of the USA Biomass Power Association,[166] released a study conducted by Gregory Morris on behalf of the Pacific Institute: *Bioenergy and Greenhouse Gases*.[167] The model developed by this study was included as an appendix to a State of California study and described as an independent consultant report regarding a landscape carbon model of the use of forest resources for bioenergy in California.[168]

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[163] *See id*. at 33 fig.10; *id*. at 36 fig.13.

[164] *See id*.

[165] Pacific Institute, Green Power Institute, http://www.pacinst.org/topics/global_change/green_power_institute/index.htm (last visited May 12, 2011).

[166] Biomass Power Association, Steering Committee, http://www.usabiomass.org/pages/about_steering.php (last visited May 12, 2011).

[167] Timothy Charles Holmseth, *Pacific Institute Releases Study Results on GHG Emissions*, BIOMASS POWER AND THERMAL, June 2, 2008, http://www.biomassmagazine.com/articles/1693/pacific-institute-releases-study-results-on-ghg-emissions/.

[168] PACIFIC SOUTHWEST RESEARCH STATION, USDA FOREST SERVICE, CEC-500-2009-080, BIOMASS TO ENERGY: FOREST MANAGEMENT FOR WILDFIRE REDUCTION, ENERGY PRODUCTION, AND OTHER BENEFITS 124 (2009).

The study of greenhouse gas implications of biomass energy production by Gregory Morris is based on the California biomass and biogas industries but purports to be applicable to biomass energy production throughout the United States and beyond.[169] The model developed in this study is a "stock-and-flow" model[170] and tracks, over a 100-year period, the atmospheric concentrations of GHG emissions that would result from one year of biomass energy production at 2008 levels in California.[171] Based on practices in California, biomass fuels are assumed to be a mix of wood-processing, in-forest, agricultural, and urban wood residues, landfill gas and animal manures.[172] The alternative fates of these biomass residues would be open burning, forest accumulation, controlled or uncontrolled landfill burial, spreading, composting or combustion in a kiln boiler or as firewood.[173] Decomposition of residues on the forest floor after a timber harvest is not considered as an alternative fate.[174] Emissions of gaseous carbon from biomass in landfills are taken to be more than fifty percent methane.[175]

First, the model inventories the amount of each type of biomass fuel used in California's bioenergy industry over a one-year period and estimates the amount of biomass that would be disposed of via each alternative fate considered.[176] Second, the model calculates the total carbon dioxide and methane emissions that would be released

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[169] Morris, *supra* note 2, at 1.

[170] *Id*. at 18.

[171] *Id*. at 14.

[172] *Id*. at 5.

[173] *Id*. at 17.

[174] *Id*. at 8.

[175] *Id*. at 15.

[176] *Id*. at 18.

from each alternative fate.[177] This analysis includes carbon emissions from fossil fuel used in producing and delivering each type of biomass fuel.[178] Finally, the atmospheric concentrations of carbon dioxide and methane are calculated over a 100-year period based on the natural decay and removal of these gases.[179]

The GHG emissions from electricity generated from fossil fuels that are avoided by using biomass energy (a fifty-fifty mix of coal and natural gas) are calculated and the decay and removal of these gases is included for comparison.[180] The model also includes parameters relating to the alternative fate of forest accumulation (no harvesting or thinning) representing the relationship between increased storage of carbon in the forest, a lower growth rate due to crowding, and an increased risk of wildfire.[181] The impacts of forest-thinning operations on carbon storage and atmospheric levels of carbon are also modeled.[182]

The results of this study are presented in two formats. First, the total atmospheric GHG burden of all California biomass energy production in 2005 and resulting profile for the subsequent one hundred years is presented.[183] The GHG burdens resulting from biomass energy, alternative disposal methods and avoided fossil fuel are compared, as well as the net biogenic carbon (emissions from biomass energy minus avoided emissions

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[177] *Id*.

[178] *Id*. at 22.

[179] *Id*. at 18.

[180] *Id*. at 18, 24.

[181] *Id*. at 18, 20, 24.

[182] *Id*. at 24.

[183] *Id*. at 26.

from the alternative disposal methods).[184] These results show that, after ten years, by using 4.6 million bone dry tons[185] (bdt) of biomass for biomass energy in 2005, biogenic GHG emissions were reduced by approximately four million tons of CO_2 equivalents and an additional approximately 3.5 million tons of CO_2 equivalents from fossil fuels were avoided.[186]

The results are also presented as the GHG burden associated with disposal of a given amount of biomass in a single year via the alternative fates considered by this study.[187] Based on the natural decay and removal of these gases, according to this model, all alternative fates considered, including burning in open slash piles, composting or landfill disposal, create a higher greenhouse gas burden than the use of biomass for electricity.[188] The net effect of thinning overgrown forests and using the residue for bioenergy results in a GHG burden that, one hundred years later, is more than twice the burden of all other methods of disposal or use.[189] However, by comparing the GHG burden of thinned forests with that of overgrown forests, Morris concludes that thinning forests results in a comparatively lower GHG burden.[190] The model indicates that, if over-crowded forests are more prone to devastating wildfire and are assumed to have net-

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[184] *Id*.

[185] A bone dry ton is a unit used to describe the amount of dried biomass that weighs 2000 pounds when dry.

[186] Morris, *supra* note 2, at 27. Total GHG emissions for California were approximately 500 million CO_2-eq so this represents a reduction of approximately 1.5%. *See* CALIFORNIA ENERGY COMMISSION, CEC-600-2006-013-SF, CALIFORNIA GREENHOUSE GAS EMISSIONS AND SINKS: 1990 TO 2004 i (2006).

[187] Morris, *supra* note 2, at 28.

[188] *Id*. at 28 fig.12.

[189] *Id*. at 28, 31.

[190] *Id*. at 32.

zero-growth, these forests are actually carbon sources.[191] Thus, because thinning forests increases growth and reduces wildfire risk, the thinned forests result in a lower GHG burden.[192] Morris finds that increasing the amount of material removed during thinning reduces the GHG burden as opposed to a lighter thinning.[193]

Morris concludes that the use of woody biomass residues for bioenergy results in the lowest GHG burden for all alternative pathways considered. Using biomass residues for electricity instead of following the open burning or composting pathways results in an immediate reduction in GHG emissions. However, it may be that not all of his assumptions are supportable, in particular the assumption of non-growth in the thinning for wildfire risk reduction scenario.[194]

E. Summary of Life-Cycle Analysis Studies

These studies show that, in general, electricity generated from waste sources of woody biomass results in GHG emission reductions in a relatively short timeframe, regardless of the type of fossil fuel system replaced. Using whole trees for electricity production may or may not reduce GHG emissions in the short term because the initial carbon debt is highly dependent on harvest practices and intensities, the type of energy producing biomass technology, and the type of fossil fuel energy plant being replaced have significant impacts on the magnitude of carbon debts from biomass energy.[195]

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[191] *Id*. at 32-33.

[192] *Id*.

[193] *Id*. at 33.

[194] *See* Van Tuyl, *supra* note 48, at 281, and discussion in text.

[195] *See* Manomet, *supra* note 31, at 107, 105, 112.

Biomass electricity produced in Massachusetts using whole trees and waste materials that replaces electricity generated from natural gas will not reduce GHG emissions within the next twenty to thirty years but may reduce GHG emissions relative to coal.[196] This suggests that these types of biomass facilities do not reduce GHG emissions relative to natural gas facilities on the time scale required to combat climate change but may reduce GHG emissions relative to coal facilities. However, this analysis did not account for changes in soil carbon, likely resulting in under-estimates of the initial carbon debt. Unfortunately, these results cannot be directly applied to electricity generated from woody biomass grown in the Pacific Northwest. LCA studies of GHG emissions from electricity generated in the Pacific Northwest from different types of woody biomass, including whole trees and waste only scenarios, that account for changes in soil carbon are needed.

ii. Energy Crops

In contrast to slow growing trees from forests primary devoted to wood production, fast growing trees, such as poplar and willow trees, can be grown as bioenergy crops. It is widely accepted by scientists that carbon sequestered by the growing of energy crops should be subtracted from the overall GHG balance thus cancelling out carbon emissions from combustion.[197] As discussed previously, GHG emissions from construction and use of farm equipment, herbicides and fertilizers, transportation, and land use change (including changes in carbon stored in soils) must

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[196] *See id*. at 112 exhibit 6-13.

[197] *See e.g.*, *id*. at 95; Gregory A. Keoleian & Timothy A. Volk, *Renewable Energy from Willow Biomass Crops: Life Cycle Energy, Environmental and Economic Performance*, 24 CRITICAL REV. IN PLANT SCI. 385, 397 (2005).

still be counted.[198]

The GHG balance for energy crops depends on the condition of the land before conversion to energy crops. When new energy crops are planted on land that was not storing carbon in the form of biomass or soil carbon, there is no decrease in the baseline carbon stores when energy crops are grown and then combusted.[199] However, the baseline carbon stores vary significantly based on the previous state of the land, the type of crop grown and the type of bioenergy produced.[200] For cropland converted to short-rotation forestry (SRF) with a seven-year rotation period, there is little initial decrease in soil carbon and any loss is soon recovered.[201] For permanent grasslands converted to seven-year SRF, a longer time period, 5-10 years, is required to recover the initial carbon loss.[202] When a forest is converted to SRF plantation, 45-170 years are required to offset the initial carbon loss depending on the forest's initial carbon stocks.[203] These changes in land use must be accounted for in the carbon footprint of energy crops.

Willow biomass has been fairly widely studied as a source of short-rotation woody biomass. One study of willow biomass, using a three-year crop rotation, accounted for GHG emissions from diesel fuel use, machinery manufacturing, fertilizer

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198 Keoleian, *supra* note 197, at 394; Zanchi, *supra* note 3, at 29.

199 Zanchi, *supra* note 3, at 29.

200 *Id*.

201 *Id*.

202 *Id*.; Similar analyses of the carbon debt for conversion of grassland to cropland for corn ethanol show a payback period of between two to ninety-three years. Hyungtae Kim et al., *Biofuels, Land Use Change, and Greenhouse Gas Emissions: Some Unexplored Variables*, 43 ENVTL. SCI. & TECH. 961, 965 (2009); Fargione, *supra* note 89, at 1236 fig.1. The conversion of abandoned cropland to corn ethanol production has a shorter payback period of approximately forty-eight years while the conversion of abandoned and marginal cropland to prairie biomass ethanol production incurs very little or no carbon debt. *Id*.

203 Zanchi, *supra* note 3, at 30.

and herbicide manufacturing and transport, nursery operations, and nitrous oxide emissions from fertilizer and decomposing leaf litter.[204] Emissions from land use change were not included.[205] This study found that, for energy produced from the direct firing or gasification of willow biomass, GHG emissions were approximately 40-50 g CO_2-eq/kW-h.[206]

Another study considered the use of poplar chips grown on a short-rotation (four year) to produce heat and electricity.[207] This study accounted for GHG emissions from machinery involved in plantation establishment, harvesting, drying, storage, and transportation.[208] GHG emissions related to the manufacture and use of herbicides were included, but based on growing practices, it was assumed fertilizers were not used.[209] GHG emissions from land use change were not included because sufficient methodologies and data were not available.[210] Based on a combustion facility producing both heat and electricity 4,124 MJ of power are produced using one tonne of poplar chips with 25% water content.[211] GHG emissions are equal to 6.3E-03 kg CO_2-eq/MJ electricity.[212] This is equivalent to 22.68 g CO_2-eq/kW-h and 25.98 kg CO_2-eq/ton of green poplar chips. These results are similar to the results of other studies examined by

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[204] Keoleian, *supra* note 197, at 396.

[205] *See* Keoleian, *supra* note 197.

[206] Keoleian, *supra* note 197, at 402.

[207] Anne Roedl, *Production and Energetic Utilization of Wood from Short Rotation Coppice – A Life Cycle Assessment,* 15 INT'L J. LIFE CYCLE ASSESSMENT 567 (2010).

[208] *Id*. at 570 tbl.1.

[209] *Id*. at 569.

[210] *Id*. at 572.

[211] *Id*. at 573.

[212] *Id*. at 574.

the authors.[213]

Both of these studies show electricity from woody energy crops can have a lower rate of emissions than natural gas, which has life-cycle emissions of about 500 g CO_2-eq/kW-h.[214] This is because the carbon captured by the growing energy crops offsets the emissions from combustion for electricity generation. However, the failure to include land use change emissions makes these analyses somewhat incomplete and less useful.

d. Conclusions Regarding Emissions from Woody Biomass Electricity

Whether biomass electricity results in lower carbon emissions than fossil fuel-based electricity is a complicated matter that depends, in part, on the source of the biomass fuel, whether there is a change in land use, the rate of re-growth of vegetation, the time frame considered, and the method of accounting.[215] Due to the life-cycle differences between energy crops, biomass residues, and forests, these categories of biomass should be treated separately for regulatory purposes. The electricity generated from woody energy crops and woody biomass residues can result in lower GHG emissions than electricity generated from fossil fuels on a short-term time scale. However, electricity generated from whole trees not grown as energy crops generally has a higher GHG balance in the short-term than fossil fuel electricity. Electricity generated from whole trees may result in reductions in GHG emissions relative to coal within a

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[213] *Id*. at 575.

[214] *Id*. at 576; Keoleian, *supra* note 197, at 398; Paulina Jaramillo et al., *Comparative Life-Cycle Air Emissions of Coal, Domestic Natural Gas, LNG, and SNG for Electricity Generation*, 41 ENVTL. SCI. & TECH. 6290, 6293 (2007).

[215] See also Zanchi, *supra* note 3, at 5 (Whether biomass energy reduces GHG emissions depends on "the source of wood, the efficiency of conversion, the type of substituted fuel and the mix of final products.")

couple of decades but will not result in reductions relative to natural gas within that time period. Also, if changes in soil carbon are accounted for, biomass electricity generated using whole trees will not likely result in reductions relative to coal within the next couple of decades.

Policy makers could choose to incentivize electricity generated from whole trees not grown as energy crops if it was decided that short term increases in emissions with reductions in later years were desired. However, because scientists have recommended that we reduce GHG emissions in the next twenty to thirty years to avoid irreversible climate change,[216] incentivizing a form of energy that increases carbon emissions during that period is contraindicated.

Thus, incentives, such as state Renewable Portfolio Standards (RPS),[217] should distinguish between woody energy crops, woody residues, and whole trees from forests. If states permit the use of whole trees not grown as energy crops, facilities should be required to demonstrate, using LCAs, that the use of such fuel will reduce GHG emissions in the next ten to twenty years. The following review finds that nearly all state RPS programs do allow the use of whole trees not grown as energy crops and do not require facilities to demonstrate GHG emissions reductions.

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[216] *See e.g.*, Searchinger 2008, *supra* note 7, at 1239; Hansen, *supra* note 7, at 229; National Academy of Sciences, *supra* note 8, at 2-3.

[217] *See* discussion *infra* p. 39.

CHAPTER IV

LEGAL TREATMENT OF GHG EMISSIONS FROM BIOENERGY IN DEFINITIONS OF BIOMASS IN STATE RENEWABLE PORTFOLIO STANDARDS (RPS)

For the last ten to fifteen years, international bioenergy policies have generally considered burning biomass a "climate friendly" form of energy generation.[218] These policies have been based on the presumption that the CO_2 emissions from burning biomass will be recaptured by growing trees, thus lowering net CO_2 emissions over time.[219] However, researchers in the 1990s began modeling the impacts of burning biomass on greenhouse gas levels.[220] Researchers and some international policy makers now recognize that it is not possible to generalize about the climate benefits of burning biomass.[221] However, the presumption of biomass carbon neutrality remains widespread.[222]

There has been a recent move towards requiring the reporting of CO_2 emissions from combustion of biomass. For example, the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, California's mandatory GHG reporting program, the Western Climate Initiative, and The Climate Registry all require the reporting of CO_2 emissions from biomass combustion from

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218 Manomet, *supra* note 31, at 9.

219 *Id*.

220 *Id*. at 11. (*See e.g.*, Bernhard Schlamadinger & Gregg Marland, *The Role of Forest and Bioenergy Strategies in the Global Carbon Cycle*, 10 BIOMASS & BIOENERGY 275 (1995).

221 Manomet, *supra* note 31, at 11-12 (citing INTERNATIONAL ENERGY AGENCY, BIOENERGY—A SUSTAINABLE AND RELIABLE ENERGY SOURCE (2009) and Searchinger 2009, *supra* note 4).

222 *See* Manomet, *supra* note 31, at 12.

stationary sources.[223] The final USEPA rule, Mandatory Reporting of Greenhouse Gases,[224] does not require electricity generators to count emissions from biomass combustion when determining whether the reporting threshold is met.[225] If a facility exceeds the threshold based on non-biogenic carbon emissions, the facility is required to separately report the biomass emissions.[226]

However, the "Tailoring Rule,"[227] which governs which new stationary sources of GHG emissions will be required to obtain permits under the Clean Air Act, does not provide a blanket exemption for biomass facilities. In EPA's preamble to the rule, EPA responds to comments that biomass facilities should not be required to obtain such permits by noting that treatment of biomass combustion as carbon neutral may be valid but EPA does not take a final position.[228] In July 2010, the EPA issued a call for information about GHG emissions from biomass energy and how these emissions should be treated.[229] On January 12, 2011, the EPA announced its intention to promulgate rules that would defer application of the tailoring rule to biomass facilities in order to "give EPA time to effectuate a detailed examination of the science associated with biogenic CO_2 emissions and to consider the technical issues that the agency must resolve in order to account for biogenic CO_2 emissions in ways that are scientifically sound and also

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[223] *Id*. at 14.

[224] 40 C.F.R. pt. 98, (2010) (effective December 29, 2009).

[225] Manomet, *supra* note 31, at 14.

[226] *Id*.

[227] Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 40 C.F.R. §§ 51, 52, 70, and 71 (2010).

[228] Id. at 421.

[229] Call for Information: Information on Greenhouse Gas Emissions Associated with Bioenergy and Other Biogenic Sources, 75 Fed. Reg. 41,173 (July 15, 2010) (request made by EPA).

manageable in practice."[230] The treatment of GHG emissions from biomass facilities is not settled and is evolving.

a. Definitions of Eligible Biomass in State RPS Programs

Renewable Portfolio Standards (RPS) are energy policies adopted by states to promote renewable energy by requiring retail sellers of electricity to procure a certain amount of electricity from renewable energy resources.[231] As of May 2011, thirty-six states have enacted some form of RPS.[232] While each of these states consider electricity generated from biomass to be a source of renewable energy for purposes of their RPS programs, each state defines eligible sources of biomass differently. The following is a survey and policy analysis of definitions of eligible biomass in state RPS programs with a particular focus on eligible woody biomass. The effectiveness of these definitions to incentivize woody biomass that will reduce GHG emissions will be analyzed and policy recommendations given in a following section of this paper. Briefly, nearly all state's RPS definitions of eligible woody biomass do not address GHG emissions from biomass and allow the use of whole trees not grown as energy crops without requiring facilities demonstrate GHG emissions reductions. Because LCAs of GHG balances for different

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[230] Letter from Lisa Jackson, EPA Administrator to Sen. Debbie Stabenow 2 (Jan. 11, 2011), *available at www.epa.gov/nsr/ghgdocs/StabenowBiomass.pdf.*

[231] NANCY RADER & SCOTT HEMPLING, THE RENEWABLES PORTFOLIO STANDARD: A PRACTICAL GUIDE 1 (2001).

[232] Database of State Incentives for Renewables & Efficiency, Rules, Regulations & Policies for Renewable Energy, http://www.dsireusa.org/summarytables/rrpre.cfm (last visited May 9, 2011). The thirty-seven states are Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Iowa, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Texas, Utah, Vermont, Virginia, Washington, West Virginia, and Wisconsin.

types of woody biomass indicate that the use of whole trees not grown as energy crops is unlikely to create emissions reductions in the next several decades, RPS programs should not consider this type of fuel to be eligible biomass. State RPS programs could include provisions that would allow facilities to use whole trees not grown as energy crops if the facilities could demonstrate, using LCAs, that the use of this fuel results in GHG emission reductions.

Terminology varies from state to state and for purposes of clarity, I will use the following terms. "Renewable portfolio standard" or "RPS" will be used generically to refer to state's energy policies described above. "Eligible biomass" will be used to describe the types of biomass that a state considers to be a source of renewable energy. "Tier I," "Class I" and "Main Tier" are used in RPS programs to describe types of renewable energy that are more strongly incentivized. "Tier II" or "Class II" energy is less strongly incentivized. The terms "Tier" and "Class" will be used as appropriate for each state's statute.

b. <u>Summaries of Individual States' Definitions of Eligible Biomass</u>

States are grouped by whether or not whole trees are considered eligible biomass and whether or not the RPS programs are mandatory or not. Rather than enforceable standards, seven states have RPS goals, which are voluntary and serve simply to generally encourage the use of renewable energy.

i. States with Mandatory RPS Programs that Consider Whole Trees To Be Eligible Biomass

A. Arizona

In Arizona, biomass and biogas electricity generators are considered eligible renewable energy resources under the state's Renewable Energy Standard.[233] Eligible biomass fuel is generally described as "any raw or processed plant-derived organic matter available on a renewable basis."[234] This general description is followed by a list of examples of specific types of eligible materials including "dedicated energy crops and trees; …wood wastes and residues, including landscape waste, right-of-way tree trimmings, or small diameter forest thinnings that are 12" in diameter or less; dead and downed forest products; …forest-related resources, such as harvesting and mill residue, pre-commercial thinnings, slash, and brush."[235] The only woody biomass specified as ineligible is "painted, treated, or pressurized wood, wood contaminated with plastics or metals, …or recyclable post-consumer waste paper."[236] The fuel that may be used in eligible biogas generators is described as gases derived using anaerobic digestion from a list of biomass materials including "wood wastes."[237]

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[233] ARIZ. ADMIN. CODE § R14-2-1802(A) (2010).

[234] *Id*. at § R14-2-1802(A)(2).

[235] *Id*.

[236] *Id*.

[237] *Id*. at § R14-2-1802(A)(1).

B. California

The California Renewables Portfolio Standard statute does not place any limits on the types of biomass materials that may be used to produce eligible electricity.[238] However, a biomass energy facility is only considered an eligible "in-state renewable electricity generation facility" under the state RPS if the facility reports to the commission administering the RPS "the types and quantities of biomass fuels used."[239] The commission submits annual reports to the Legislature regarding "the types and quantities of biomass fuels used by facilities receiving funds" under the RPS and "their impacts on improving air quality."[240]

The California Energy Commission has the authority to adopt guidelines to administer funding programs under the RPS.[241] Under the Renewable Energy Program Guidelines issued by the California Energy Commission, electricity from a biomass facility is eligible under the RPS if the biomass fuel falls under the definition of biomass in the Overall Program Guidebook.[242] This guidebook broadly defines eligible biomass as "any organic material not derived from fossil fuels" and specifically includes "construction wood wastes, landscape and right-of-way tree trimmings, mill residues that result from milling lumber, …and wood and wood waste from timbering operations."[243]

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[238] *See* CAL. PUB. RES. CODE § 25742(d) (2010).

[239] *Id*. at § 25742(d)(1).

[240] *Id*. at § 25748(a)(4).

[241] *Id*. at § 25747(a).

[242] CALIFORNIA ENERGY COMMISSION, CEC-300-2007-006-ED3-CMF, RENEWABLES PORTFOLIO STANDARD ELIGIBILITY 11 (3rd ed. 2008).

[243] CALIFORNIA ENERGY COMMISSION, CEC-300-2007-003-ED2-CMF, OVERALL PROGRAM GUIDEBOOK 16-17 (2nd ed. 2008).

Landscape and right-of-way tree trimmings are further defined to include tree removal for the purpose of establishing or maintaining right-of-ways for "the provision of public utilities," "fuel hazard reduction" and "the public's recreational use."[244]

C. Colorado

Under Colorado's Renewable Energy Standard, biomass electricity is eligible for the RPS.[245] The statute generally describes eligible biomass as "[n]ontoxic plant matter" consisting of "urban wood waste, mill residue, slash, or brush."[246] Colorado regulations further explain the definitions of slash and brush to mean "products and materials derived from forest restoration and management, including, but not limited to, harvesting residues, precommercial thinnings, and materials removed as part of a federally recognized timber sale or removed to reduce hazardous fuels, to reduce or contain disease or insect infestation, or to restore ecosystem health."[247]

D. Connecticut

The definition of eligible biomass in Connecticut's Renewables Portfolio Standard focuses on emissions. Eligible "renewable energy" includes electricity produced from "low emission advanced biomass conversion technologies" and other fuels derived from agricultural produce that the state determines "provide net reductions in greenhouse gas emissions and fossil fuel consumption."[248] Biomass facilities are only eligible for "Class I" status if the emissions of nitrogen oxides are below a certain amount

[244] *Id.*

[245] COLO. REV. STAT. § 40-2-124(1)(a) (2009).

[246] COLO. REV. STAT. § 40-2-124(1)(a)(I) (2009).

[247] 4 COLO. CODE REGS. § 723-3-3652(b) (2010).

[248] CONN. GEN. STAT. § 16-245n(a) (2010).

and sustainable biomass fuel is used or the facility is an older and smaller facility that uses sustainable biomass fuel.[249] Sustainable biomass is generally defined as "biomass that is cultivated and harvested in a sustainable manner."[250] More specifically, sustainable biomass does not include construction and demolition waste, finished biomass products from lumber or paper mills, or biomass from old growth timber stands, although there are some exceptions to these limitations for older facilities.[251] Biomass facilities qualify for "Class II" status if nitrogen oxide emissions are below a certain level, regardless of the type of biomass fuel used.[252]

E. Delaware

The Delaware Department of Natural Resources and Environmental Control (DNREC) is responsible for determining the types of eligible biomass that may be used in combustion facilities under the state's Renewables Portfolio Standard.[253] DNREC has promulgated regulations specific to electricity generated from the combustion of biomass.[254] These regulations require energy crops and agricultural residues used as fuel in combustion facilities to meet the standards of the United States Department of Agriculture's National Organic Program or follow a list of management practices that minimize herbicide and pesticide use and promote soil and water conservation.[255] In order to be eligible under Delaware's RPS, woody biomass combusted to produce

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[249] *Id*. at § 16-1(a)(26)(A).

[250] *Id*. at § 16-1(a)(45).

[251] *Id*.

[252] *Id*. at § 16-1(a)(27).

[253] DEL. CODE tit. 26, § 352(6)(h) (2010).

[254] 7-100-106 DEL. CODE REGS. § 1.0 *et seq*. (2010).

[255] *Id*. at § 5.2.

electricity must be grown and harvested under a conservation and management plan that, among other things, addresses the protection of soil and water resources, incorporates sustainable rates of harvest, limits the use of pesticides and herbicides, avoids forest conversion to plantations or non-forest land uses, and excludes material from trees more than 150 years old.[256] There are no limits on the types of organic materials that can be used to produce biogas via anaerobic digestion.[257]

F. Hawaii

Under Hawaii's Renewable Portfolio Standard, electricity generated from biomass is eligible with no restrictions on the type of fuel or process used.[258] Biomass crops, agricultural and animal residues and wastes, municipal solid waste and other solid waste are specifically considered eligible.[259] Timber or other forestry products are not mentioned.

G. Iowa

Iowa was the first state to create a renewable portfolio standard program when it passed the Alternative Energy Production Law in 1983. While the term biomass is not used, types of eligible biomass specifically mentioned include "refuse-derived fuel" and "agricultural crops or residues."[260] Wood-burning facilities are considered eligible

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[256] *Id*. at § 5.3.

[257] DEL. CODE tit. 26, § 352(6)(f) (2010).

[258] HAW. REV. STAT. § 269-91 (definition of "renewable energy" subpart (7)) (2010).

[259] *Id*.

[260] IOWA CODE § 476.42(1)(a) (2010).

sources of renewable energy.[261] Eligible woody biomass fuels are not defined or discussed so presumably all forms of woody biomass may be considered eligible.[262]

H. Kansas

Under Kansas's Renewables Portfolio Standard, only certain types of biomass are considered eligible sources of energy. Energy crops, cellulosic agricultural residues, plant residues, and "clean, untreated wood products such as pallets" are the only types of biomass specifically mentioned as eligible.[263] Other sources of energy can be eligible under the RPS if certified as renewable by the commission administering the statute.[264]

I. Maine

The Maine Renewables Portfolio Standard defines eligible renewable energy sources to include biomass facilities fueled by wood or wood waste and biogas from the anaerobic digestion of agricultural products, by-products or wastes.[265] In regulations promulgated in 2007, Class I and Class II renewable energy resources are both defined to include "biomass generators," but specific types of biomass are not mentioned.[266]

J. Maryland

Eligible or "qualifying" biomass is a Tier I energy source[267] and is defined in detail in Maryland's Renewable Energy Portfolio Standard.[268] Qualifying biomass is

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[261] *See id.*

[262] *See id*.

[263] KAN. STAT. § 66-1257(f) (2010).

[264] *Id*. at § 66-1257(f)(11).

[265] ME. REV. STAT. tit. 35, § 3210(B-3)(1)(f), (C)(2)(g) (2010).

[266] *See* 65-407-311 ME. CODE R. §§ 3(B)(1)(g), 4(B)(1)(b)(vii) (2010).

[267] MD. CODE, PUB. UTIL. COS. § 7-701(l)(3) (2010).

[268] *Id*. at § 7-701(h).

generally defined as "nonhazardous, organic material" available on a "renewable or recurring basis."[269] Sources of woody biomass that are explicitly permitted include mill residue, precommercial soft wood thinning, slash, brush and yard waste,[270] pallets,[271] silvicultural sources[272] and energy crops.[273] Qualifying biomass does not include sawdust and wood shavings,[274] "unsegregated solid waste or postconsumer wastepaper" or "invasive exotic plant species."[275] Old growth timber is also specifically excluded from qualifying biomass.[276] The RPS includes a detailed definition of "old growth timber" that specifies that old growth timber is timber from a forest "at least 5 acres in size with a preponderance of old trees, of which the oldest exceed at least half the projected maximum attainable age for the species."[277] To be an old growth forests the forest must also exhibit several additional characteristics described in the statute.[278]

K. Michigan

In Michigan, biomass is an eligible source of renewable energy under the state's Renewable Energy Standard.[279] Biomass is generally defined as "any organic matter that is not derived from fossil fuels" that "replenishes over a human, not a geological, time

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[269] *Id*. at § 7-701(h)(1).

[270] *Id*. at § 7-701(h)(1)(i)(1).

[271] *Id*. at § 7-701(h)(1)(i)(2).

[272] *Id*. at § 7-701(h)(1)(i)(3).

[273] *Id*. at § 7-701(h)(1)(ii).

[274] *Id*. at § 7-701(h)(1)(i)(1)(A).

[275] *Id*. at § 7-701(h)(3).

[276] *Id*. at § 7-701(h)(1)(i)(1).

[277] *Id*. at § 7-701(e)(1).

[278] *Id*. at § 7-701(e)(2).

[279] MICH. COMP. LAWS § 460.1011(i)(i) (2010).

frame."[280] Types of woody biomass specifically allowed include trees and wood from sustainably managed forests or procurement systems, precommercial wood thinning waste, brush, yard waste, and wood wastes and residues from the processing of wood products or paper.[281] However, eligible biomass is not limited to only these types of biomass and there are no types of biomass specifically excluded.[282]

M. Minnesota

Biomass is considered an eligible renewable energy source in Minnesota's Renewables Portfolio Standard.[283] However, the description of eligible biomass is unusual because it does not mention any types of woody biomass.[284] Instead, biomass is described as including "without limitation" landfill gas, anaerobic digester systems, wastewater sludge that is not incinerated, and mixed municipal solid waste.[285]

N. Missouri

The definition of "renewable energy resource" under Missouri's Renewable Energy Standard (RES) is basically identical to Kansas's RPS.[286] The term "biomass" is not used but instead a list is given of individual types of biomass that are eligible renewable energy resources.[287] Dedicated energy crops, agricultural and plant residues, and clean, untreated wood "such as pallets" are specifically listed as eligible fuel

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[280] *Id*. at § 460.1003(f).

[281] *Id*.

[282] *See id*. ("including, but not limited to, all of the following" types of biomass).

[283] MINN. STAT. § 216B.1691(1)(a)(5) (2010).

[284] *See id*.

[285] *Id*.

[286] *Compare* MO. REV. STAT. § 393.1025(5) (2010) and KAN. STAT. § 66-1257(f) (2010).

[287] MO. REV. STAT. § 393.1025(5) (2010).

sources.[288] Additionally, pyrolysis, a method for converting biomass to energy, is listed as an eligible source of energy if waste material is used as the fuel.[289] Finally, the department administering the RES may certify other sources as qualifying as renewable energy.[290] In regulations adopted August 16, 2010, the Missouri Public Service Commission defined renewable energy resources to using the same definition used in the RES statute, and thus did not change the types of eligible biomass.[291]

N. Montana

Under Montana's Renewable Resource Standard, "low-emission, nontoxic biomass" is an eligible source of renewable energy if specific types of fuel are used.[292] Eligible types of woody biomass are limited to dedicated energy crops and solid organic fuels from "wood, forest, or field residues."[293] Wood treated with chemical preservatives is specifically mentioned as ineligible.[294]

O. Nevada

The definition of eligible biomass under Nevada's Energy Portfolio Standard is very broad and contains no limits other than that the material be "organic matter … available on a renewable basis."[295] Specific types of eligible biomass are listed as

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[288] *Id*.

[289] *Id*.

[290] *Id*.

[291] MO. CODE REGS. tit. 4 § 240-20.100(1)(K) (2010).

[292] MONT. CODE ANN. § 69-3-2003(10)(g) (2010).

[293] *Id*.

[294] *Id*.

[295] NEV. REV. STAT. § 704.007 (2010).

including, "without limitation," wood and wood wastes.[296] Regulations promulgated by the Nevada Public Utilities Commission adopt the statutory definition of biomass[297] and further state that biomass includes "without limitation" "[a]ny product made from agricultural crops or residues, including, without limitation, cooking oils."[298]

P. New Hampshire

New Hampshire's Electric Renewable Portfolio Standard has a relatively well-developed statutory scheme related to biomass. "Eligible biomass technologies" are considered a Class I source of renewable energy.[299] Eligible biomass technologies are those that use certain types of biomass fuel and meet emissions limits for nitrogen oxide and particulates.[300] Eligible biomass fuels include "clean and untreated wood such as brush, stumps, lumber ends and trimmings, wood pallets, bark, wood chips or pellets, shavings, sawdust and slash" and energy crops, but no construction or demolition debris.[301] Regulations simply adopt the statutory definition of eligible biomass fuels.[302] The RPS statute also includes provisions for how to verify and report emissions from biomass sources.[303] Regulations describe the process for becoming a certified biomass facility after demonstrating sufficient emission levels.[304]

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[296] *Id*. at § 704.007(2).

[297] NEV. ADMIN. CODE § 704.8835(1) (2010).

[298] *Id*. at § 704.8835(2)(b).

[299] N.H. REV. STAT. § 362-F:4(I) (2010).

[300] *Id*. at § 362-F:2(VIII)(a).

[301] *Id*. at § 362-F:2(II).

[302] N.H. CODE ADMIN. R. PUC 2502.04 (2010).

[303] N.H. REV. STAT. § 362-F:12 (2010).

[304] N.H. CODE ADMIN. R. PUC 2502.04 (2010).

Q. New Mexico

New Mexico's Renewables Portfolio Standard considers biomass resources to be a source of renewable energy.[305] Types of woody biomass that are specifically considered eligible include "small diameter timber, salt cedar and other *phreatophyte*[306] or woody vegetation removed from river basins or watersheds in New Mexico."[307] Salt cedar is a major invasive species in the southwestern United States.[308] Regulations simply duplicate the statute's definition of eligible biomass resources.[309]

R. New York

Electricity generated from biomass is eligible under New York's Renewable Portfolio Standard as Main Tier energy if it is generated via direct combustion, in a combined heat and power facility or in a co-firing plant.[310] The eligible types of biomass are listed by category and described in detail.[311] The categories that include woody biomass are agricultural residue, harvested wood, mill residue wood, pallet waste, refuse derived fuel, site conversion waste wood, silvicultural waste wood, energy crops and

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[305] N.M. STAT. § 62-16-3(E)(2)(d) (2010).

[306] A *phreatophyte* is a type of deep-rooted plant that relies on groundwater for moisture. Salt cedar is a type of *phreatophyte*. *ENCYCLOPEDIA BRITANNICA ONLINE*, *North American Desert*, http://www.britannica.com/EBchecked/topic/418771/North-American-Desert (last visited May 13, 2011).

[307] *Id*.

[308] PLANT CONSERVATION ALLIANCE, NATIONAL PARKS SERVICE, FACT SHEET: SALTCEDAR 1 (2005), *available at* http://www.nps.gov/plants/alien/fact/tama1.htm.

[309] N.M. CODE R. § 17.9.572.7(D) (2010).

[310] NEW YORK PUBLIC SERVICE COMMISSION, Case 03-E-0188, ORDER APPROVING IMPLEMENTATION PLAN, ADOPTING CLARIFICATIONS, AND MODIFYING ENVIRONMENTAL DISCLOSURE PROGRAM, amended app. B at 1 (April 14, 2005) [hereinafter New York Order]. Additional guidance regarding the use of biomass energy to comply with New York's RPS can be found in the *New York State Renewable Portfolio Standard: Biomass Guidebook*. ANTARES GROUP, INC., NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY, NEW YORK STATE RENEWABLE PORTFOLIO STANDARD: BIOMASS GUIDEBOOK (modified August 21, 2009 Pub. Serv. Comm'n Order).

[311] New York Order, *supra* note 310, at amended app. B at 4.

urban wood and related waste.[312]

New York's harvested wood category includes wood harvested commercially.[313] Biomass facility owners must comply with a Forest Management Plan that promotes forest ecosystem health and the conversation of biological diversity and productive forest capacity.[314] Suppliers of biomass fuel must comply with Forest Management Plans of biomass facilities and their own harvest plans, and professional foresters must monitor harvests.[315] The same requirements apply to the category of silvicultural waste wood.[316] The mill residue wood category includes all clean wood waste from sawmills, millworks and the secondary wood products industries.[317] The categories of pallet waste, refuse derived fuel, and urban wood and related waste must be composed of clean wood.[318] Site conversion waste wood includes wood harvested during the clearing of forestland for development purposes.[319]

S. North Carolina

Biomass is considered a renewable energy resource under North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard.[320] The specific types of woody biomass mentioned in the statute are broad categories of materials and include

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312 *Id*.

313 *Id*.

314 *Id*.

315 *Id*.

316 *Id*.

317 *Id*.

318 *Id*.

319 *Id*.

320 N.C. GEN. STAT. § 62-133.8(a)(8) (2010).

wood waste, energy crops and combustible residues.[321] Biomass facilities are required to use Best Available Control Technology (BACT) to reduce air emissions.[322] The North Carolina Utilities Commission decided in October 2010 that whole trees constitute eligible biomass under the state RPS.[323] The Commission found that the statutory language "biomass resource, including" followed by a list of types of biomass was a list of examples of eligible biomass rather than an exhaustive or exclusive list.[324] The decision is being appealed to the North Carolina Court of Appeals.[325]

T. Ohio

Ohio's Alternative Energy Resource Standard considers biomass energy as an eligible form of renewable energy.[326] Specifically, energy derived from bark, wood chips, and sawdust as non-treated by-products of the pulping and wood manufacturing processes are considered eligible, but eligible biomass is not limited to this list of materials.[327] Regulations further explain that "biomass energy" is a very broad term that includes, but is not limited to, energy crops and their residues, wood and paper manufacturing waste, forestry waste, and other vegetation waste.[328]

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[321] *Id*.

[322] *Id*. at § 62-133.8(g).

[323] Order Accepting Registration of Renewable Energy Facility at 5, In the Matter of Application of Duke Energy Carolinas, L.L.C., For Registration of Buck Steam Station, Unites 5 and 6, as New Renewable Energy Facilities, No. E-7, Sub. 939, 940 (N.C. Util. Comm'n. Oct. 11, 2010).

[324] *Id*. at 4.

[325] Notice of Appeal, In the Matter of Application of Duke Energy Carolinas, L.L.C., For Registration of Buck Steam Station, Unites 5 and 6, as New Renewable Energy Facilities, No. E-7, Sub. 939, 940 (N.C. Util. Comm'n. Nov. 10, 2010).

[326] OHIO REV. CODE ANN. § 4928.01(A)(35) (2010).

[327] *Id*.

[328] OHIO ADMIN. CODE 4901:1-40-01(E) (2010).

U. Oregon

Electricity generated from biomass is considered a form of renewable energy under Oregon's Renewable Portfolio Standard.[329] Electricity from biomass is considered eligible renewable electricity if it is not generated by burning wood treated with chemical preservatives or municipal solid waste.[330] However, as an emergency measure to preserve "the public peace, health and safety," Oregon's legislature passed legislation allowing municipal solid waste to be considered qualifying biomass from March 4 – December 31, 2010.[331] Types of woody biomass that are eligible include, but are not limited to, "[f]orest or rangeland woody debris from harvesting or thinning conducted to improve forest or rangeland ecological health and to reduce uncharacteristic stand replacing wildfire risk" and "[w]ood material from hardwood timber" grown for the paper manufacturing industry and other woody energy crops.[332]

V. Rhode Island

Electricity produced using eligible biomass fuel is considered a renewable energy resource under Rhode Island's Renewable Energy Standard.[333] Eligible biomass fuel includes various forms of woody biomass, specifically "brush, stumps, lumber ends and trimmings, wood pallets, bark, wood chips, shavings, slash and other clean wood that is not mixed with other solid wastes" and energy crops.[334] Regulations further clarify that

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[329] OR. REV. STAT. § 469A.025(2) (2009).

[330] *Id*. §§ (2)-(3).

[331] *See* Act of March 4, 2010, ch. 17, § 3, 2010 Or. Laws; Act of March 18, 2010, ch. 71, §§ 2-3, 2010 Or. Laws.

[332] OR. REV. STAT. §§ 469A.025(2)(c)-(e) (2009).

[333] R.I. GEN. LAWS § 39-26-5(a)(6) (2010).

[334] *Id*. at § 39-26-2(7).

eligible biomass fuel includes "yard trimmings, site clearing waste, [and] wood packaging."[335] Certification is required for energy to be considered eligible renewable energy and biomass facilities must have an approved biomass fuel source plan to receive certification.[336] The biomass fuel source plan is designed to demonstrate that the biomass fuel used is eligible biomass fuel.[337]

W. Texas

Biomass and biomass-based waste products are considered sources of renewable energy under Texas's Renewable Generation Requirement.[338] Renewable energy is generally described as "an energy source that is naturally regenerated over a short time" and derived directly or indirectly from the sun, moving water or "other natural movements and mechanisms of the environment."[339] Biomass is not defined in any more detail in the statute or regulations.[340]

X. Utah

Utah's Energy Resource Procurement Act created a program like a renewable portfolio standard, except that an electrical utility is not required to purchase renewable energy if it believes doing so is not cost effective.[341] For this reason, Utah's program is more like a renewable portfolio goal than a standard. Utah's definition of eligible woody biomass uses wording similar to Oregon's. In Utah, eligible woody biomass includes

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335 90-060-015 R.I. CODE R. § 3.7 (2010).

336 *Id*. at § 6.1(i).

337 *See id*. at § 6.9.

338 TEX. UTIL. CODE § 39.904(d) (2010).

339 *Id*.

340 *See* TEX. P.U.C. SUBST. R. 25.173(c)(17) (2010).

341 UTAH CODE § 54-17-502(7) (2010).

"forest or rangeland woody debris from harvesting or thinning conducted to improve forest or rangeland ecological health and to reduce wildfire risk," organic and agricultural waste, and dedicated energy crops, but excludes wood treated with chemical preservatives.[342]

Y. Washington

Washington's Renewable Energy Standard considers most biomass fuels to be eligible sources of renewable energy.[343] Eligible biomass is broadly defined to include "solid organic fuels from wood, forest, or field residues, or dedicated energy crops."[344] However, certain types of biomass that are not eligible include chemically treated wood, black liquor from paper production, wood from old growth forests and municipal solid waste.[345] Regulations simply repeat this definition of eligible biomass.[346]

Z. Wisconsin

Wisconsin's Renewable Portfolio Standard includes biomass as a source of renewable energy.[347] Eligible biomass is defined as including fuel derived from "wood or plant material or residue, biological waste, [or] crops grown for use as a resource."[348] There are no types of woody biomass that are specifically excluded.

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[342] *Id*. at § 54-17-601(11)(a)(iv).

[343] WASH. REV. CODE § 19-285-030(18)(i) (2010).

[344] *Id*.

[345] *Id*.

[346] *See* WASH. ADMIN. CODE § 194-37-040(25) (2010); WASH. ADMIN. CODE § 480-109-007(18) (2010).

[347] Wis. Stat. § 196.378(1)(h)(1)(g) (2010).

[348] *Id*. at § 196.378(1)(ar).

ii. States with Voluntary RPS Programs that Consider Whole Trees To Be Eligible Biomass

A. North Dakota

Under North Dakota's Renewable and Recycled Energy Objective, biomass qualifies as an eligible source of renewable energy.[349] There are no restrictions on the types of woody biomass that are eligible because agricultural crops, wastes and residues (which would include energy crops) and wood, wood wastes and residues are all listed as eligible sources of biomass.[350] As an objective, North Dakota's RPS is voluntary and there are no sanctions for failure to meet the objective.[351]

B. Oklahoma

Oklahoma's Renewable Energy Goal, passed in May 2010, permits the use of biomass as an eligible renewable energy resource.[352] Types of woody biomass specifically mentioned include the broad categories of agricultural crops and their residues, wood and degradable organic wastes.[353] As a goal, this standard is not enforceable.

C. South Dakota

South Dakota's Renewable, Recycled and Conserved Energy Objective allows the use of biomass as an eligible renewable energy source.[354] Types of woody biomass that

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[349] N.D. CENT. CODE § 49-02-25(4) (2010).

[350] *Id*.

[351] *Id*. at § 49-02-28.

[352] OKLA. STAT. tit. 17, § 801.4(D)(7) (2011).

[353] *Id*.

[354] S.D. CODIFIED LAWS § 49-34A-94(5) (2010).

are specifically mentioned as eligible include "wood and wood wastes and residues" and agricultural crops which presumably includes all energy crops.[355] South Dakota's RPS is voluntary and there are no sanctions for failure to meet the objective.[356]

D. Vermont

Vermont does not have a binding renewable portfolio standard but instead has a voluntary program, the Sustainably Priced Energy Enterprise Development (SPEED) program. The SPEED program identifies certain amounts of renewable energy that utilities are to provide, but if utilities do not meet these levels, the SPEED program will be replaced by a binding RPS program.[357] Biomass is considered a source of renewable energy but is not defined in any detail.[358] However, there is a requirement that wood biomass resources have a design system efficiency of at least fifty percent in order to receive the statutory price for electricity generated by the facility.[359]

E. Virginia

Biomass is considered a source of renewable energy under Virginia's Voluntary Renewable Energy Portfolio Goal.[360] Virginia limits the total amount of certain types of woody biomass that can be used towards meeting its RPS goal unless these types of wood were used as fuel prior to 2007.[361] These types of woody biomass whose use is limited

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[355] *Id*.

[356] *Id*. at § 49-34A-101.

[357] VT. STAT. ANN. tit. 30 § 8005(d)(1) (2010).

[358] 30-000-054 VT. CODE R. § 4.304(B)(1) (2010).

[359] VT. STAT. ANN. tit. 30 § 8005(j) (2010).

[360] VA. CODE ANN. § 56-585.2(A) (2010) (referring to the definition of renewable energy found in VA. CODE ANN. § 56-576 (2010).).

[361] *Id*. at § 56-585.2(F).

include "green wood chips, bark, sawdust, a tree or any portion of a tree which is used or can be used for lumber and pulp manufacturing by facilities located in Virginia."[362] One effect of this limitation is to prevent the RPS goal from incentivizing the combustion of wood to generate energy when the wood could be used for other purposes. No limits are placed on the use of certain other types of "sustainable biomass and biomass based waste to energy resources."[363] These other types of woody biomass whose use is not limited include "mill residue, except wood chips, sawdust and bark; pre-commercial soft wood thinning; slash; logging and construction debris; brush; yard waste; shipping crates; dunnage; non-merchantable waste paper; landscape or right-of-way tree trimmings; [and] agricultural and vineyard materials."[364]

F. West Virginia

Under West Virginia's Alternative and Renewable Energy Portfolio Standard, it is possible for an electric utility to meet the RPS requirements by purchasing only "alternative" energy, which includes coal and natural gas-based energy, and no "renewable" energy.[365] Biomass energy is considered a renewable energy source and is broadly defined as "nonhazardous organic material" available on a recurring basis.[366] Pulp mill sludge is the only biomass material specifically mentioned but nothing in the statute suggests other biomass materials are not eligible.[367]

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[362] *Id*.

[363] *Id*. The definition of "biomass, sustainable or otherwise" is to be construed liberally. *Id*. at § 56-576 (definition of "renewable energy").

[364] *Id*. at § 56-585.2(F).

[365] *See* W. VA. CODE § 24-2F-5 (2010).

[366] *Id*. at § 24-2F-3(13)(F).

[367] *Id*.

iii. States with Mandatory RPS Programs that Do Not Consider Whole Trees To Be Eligible Biomass

A. Illinois

In Illinois, "crops and untreated and unadulterated organic waste biomass" and "tree waste" are considered eligible biomass under the state's Renewable Portfolio Standard.[368] In 2009, the Illinois legislature modified the definition of "renewable energy resources." Where "trees and tree trimmings" had originally been considered renewable energy resources, only "tree waste" is now considered a renewable energy resource.[369] The RPS specifically excludes energy generated by the incineration of certain types of biomass, including "landscape waste other than tree waste" and woody biomass materials other than "untreated and unadulterated waste wood."[370]

B. Massachusetts

Massachusetts' Renewable Portfolio Standard considers "low emission advanced biomass power conversion technologies" to be eligible sources of renewable energy.[371] Older biomass facilities retrofitted with advanced conversion technologies may be eligible if approved by the Department of Energy Resources.[372] Biomass fuels that are specifically permitted include "wood, by-products or waste from agricultural crops, food

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[368] 20 ILL. COMP. STAT. 3855/1-10 (definition of "renewable energy resources") (2010).

[369] *See* S.B. 2150, 96th Gen. Assem., Reg. Sess. (Ill. 2009), available at http://www.ilga.gov/legislation/publicacts/96/096-0159.htm.

[370] 20 ILL. COMP. STAT. 3855/1-10 (definition of "renewable energy resources") (2010).

[371] MASS. GEN. LAWS ch. 25A, § 11F(b)(8) (2010).

[372] *Id*. at § 11F(b)(last sentence).

or animals, energy crops, biogas [and] liquid biofuel."[373] State regulations further define "eligible biomass fuel" to include clean wood waste such as brush, stumps, lumber ends and trimmings, wood chips, shavings, and slash; energy crops; by-products or waste from animals or agricultural crops; and biogas.[374] Draft regulations proposed in September 2010 and revised in May 2011 limit eligible woody biomass fuel to forest derived residues, forest salvage, non-forest derived residues, and energy crops, limit the proportion of a timber harvest that can be considered eligible biomass fuel, and define "low emission" biomass energy.[375] As part of receiving certification as a low emission biomass facility, the facility must demonstrate that a lifecycle analysis of greenhouse gas emissions shows, using a twenty-year life cycle, at least a fifty percent reduction of greenhouse gas emissions per unit of energy as compared to a natural gas facility using the "most efficient commercially available technology."[376] The proposed regulations have received negative feedback from the forest products industry.[377]

C. New Jersey

Biomass fuel that is cultivated and harvested in a sustainable manner is considered a Class I renewable energy under New Jersey's Renewables Portfolio Standard.[378] Regulations further explain that the definition of eligible biomass includes,

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[373] *Id*. at § 11F(b)(8).

[374] 225 MASS. CODE REGS. 14.02 (definition of Eligible Biomass Fuel) (2010).

[375] Proposed revision to 225 MASS. CODE REGS. 14.02 (adding definition of Eligible Biomass Woody Fuel) (May 2011); proposed revision to 225 MASS. CODE REGS. 14.05(1)(a)(7)(f) and 14.05(1)(a)(8) (May 2011).

[376] *Id*. at 14.05(1)(a)(7)(f)(iii).

[377] *See e.g.*, DAVID TENNY, NATIONAL ALLIANCE OF FOREST OWNERS, Re: Draft Proposed Regulation: Renewable Portfolio Standard – Biomass Policy Regulatory Process (October 21, 2010).

[378] N.J. REV. STAT. § 48:3-51 (2009) (definition of "Class I renewable energy").

among other materials, dedicated energy crops and trees, wood and wood residues, and other waste materials, but does not include old-growth timber.[379] The regulations further define eligible wood and wood residues to mean wood from the thinning of trees or from the forest floor,[380] ground or shredded scrap wood that does not contain any metal,[381] and wood waste from lumberyards or paper mills, excluding black liquor.[382] Certain types of woody biomass are not eligible for Class I status include treated, painted or chemically coated wood, wood waste from demolition or construction, old-growth timber, and "wood harvested from a standing forest" unless the forest is a bioenergy plantation.[383] The regulations also require biomass facilities to receive approval of both the type of biomass fuel used and the facilities' pollution control methods before being certified as sources of Class I renewable energy.[384]

D. Pennsylvania

Under Pennsylvania's Alternative Energy Portfolio Standard, biomass energy is considered a source of renewable energy.[385] Certain types of biomass qualify as Tier I energy sources, including dedicated energy crops;[386] crops grown on land protected by the Federal Conservation Reserve Program provided that such crop production is not in

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[379] N.J. ADMIN. CODE § 14:8-2.2 (2010) (definition of "biomass").

[380] *Id*. at § 14:8-2.5(d)(2).

[381] *Id*. at § 14:8-2.5(d)(4)(i).

[382] *Id*. at § 14:8-2.5(d)(4)(ii).

[383] *Id*. at § 14:8-2.5(l)(1), (5-7).

[384] *Id*. at § 14:8-2.5(d)-(f).

[385] 73 PA. STAT. ANN. § 1648.2 (2010) (definition of Alternative Energy Sources subpart (7)).

[386] *Id*. at § 1648.2 (definition of Alternative Energy Sources subpart (7)(i)).

conflict with the purposes for which the land was set aside;[387] and solid cellulosic waste materials such as pallets, landscape or right-of-way tree trimmings, and agricultural residues from orchards, vineyards, grains and other crops.[388] By-products of the pulping and wood manufacturing processes, such as bark and wood chips, were originally considered Tier II energy sources.[389] However, electricity generated from these materials within the state of Pennsylvania is now considered a Tier I energy source while electricity generated from these materials out of state is considered Tier II.[390]

c. **Analysis of Definitions of Eligible Biomass in RPS Programs**

Different states consider a wide variety of biomass materials to be eligible forms of renewable energy. While states consider different biomass materials to be eligible, in terms of the formatting of the statutory language, most states include a list of eligible materials as part of the definition of biomass. One challenge in comparing these definitions is that the statutory language is not always clear as to whether the list of biomass materials is an exhaustive list or a non-exclusive list of examples.

This challenge is especially relevant to the question of whether whole trees that are not waste material, part of a thinning operation, or grown as an energy crop are considered eligible biomass. The vast majority of states' RPS programs either explicitly permit the use of "wood" (which includes whole trees) or are ambiguous. A few states clearly do not allow whole trees to be considered as eligible biomass. Illinois removed

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[387] *Id*.

[388] *Id*. at § 1648.2 (definition of Alternative Energy Sources subpart (7)(ii)).

[389] *Id*. at § 1648.2 (definition of Tier II Alternative Energy Source subpart (6)).

[390] 66 PA. CONS. STAT. § 2814(b) (2009).

the word “trees” from its definition of “renewable energy resources” and replaced it with “tree waste” indicating a clear intent not to include whole trees as eligible biomass.[391] The Massachusetts’ statute lists “wood” as an example of eligible biomass[392] but regulations limit eligible woody biomass fuel to clean wood waste.[393] New Jersey regulations prohibit the use of “wood harvested from a standing forest” to generate Class I energy unless the forest is a bioenergy plantation.[394] Pennsylvania’s RPS statute contains an exhaustive list that does not include whole trees but instead only includes waste materials and energy crops.[395] Two other states allow whole trees in limited circumstances only. Colorado allows “materials removed as part of a federally recognized timber sale” to be considered eligible biomass.[396] Virginia limits the overall volume of “tree[s] or any portion of a tree which…can be used for lumber and pulp manufacturing…in Virginia” that can be used for generating RPS eligible electricity.[397] These six states at least limit, and some prohibit, the use of whole trees as eligible biomass, but this is a clear minority of the thirty-eight states with RPS programs.

Some states require that eligible woody biomass be grown according to forest management plans. Delaware requires detailed conservation and management plans for

[391] *See* S.B. 2150, 96th Gen. Assem., Reg. Sess. (Ill. 2009), *available at* http://www.ilga.gov/legislation/publicacts/96/096-0159.htm.

[392] MASS. GEN. LAWS ch. 25A, § 11F(b)(8) (2010).

[393] 225 MASS. CODE REGS. 14.02 (definition of Eligible Biomass Fuel) (2010).

[394] N.J. ADMIN. CODE § 14:8-2.5(l)(7) (2010).

[395] 73 PA. STAT. ANN. § 1648.2 (2010) (definition of Alternative Energy Sources subpart (7)); 66 PA. CONS. STAT. § 2814(b) (2009).

[396] 4 COLO. CODE REGS. § 723-3-3652(b) (2010).

[397] VA. CODE ANN. § 56-585.2(F) (2010).

the growth and harvest of eligible woody biomass.[398] New York requires detailed forest management plans and harvest plans for commercially harvested wood.[399] Michigan's RPS statute mentions trees and wood from sustainably managed forests or procurement systems[400] but does not discuss what constitutes a sustainably managed forest. Similar to the issue of the eligibility of whole trees, the number of states that require forest management plans is a small minority.

Several states exclude old growth trees from eligible woody biomass. Connecticut excludes biomass from old growth timber stands from Class I renewable energy sources, although there may be some exceptions for older facilities.[401] Delaware excludes from eligible biomass material from trees more than 150 years old.[402] Maryland excludes old growth timber from eligible biomass, and the RPS contains a detailed description of what constitutes old growth.[403] New Jersey does not consider old growth timber to be a source of eligible biomass.[404] Washington excludes wood from old growth forests from eligible biomass.[405]

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[398] 7-100-106 DEL. CODE REGS. § 5.3 (2010).

[399] New York Order, *supra* note 310, at amended app. B at 4.

[400] MICH. COMP. LAWS § 460.1003(f) (2010).

[401] CONN. GEN. STAT. § 16-1(45) (2010).

[402] 7-100-106 DEL. CODE REGS. § 5.3 (2010).

[403] MD. CODE, PUB. UTIL. COS. § 7-701(e)(2) (2010).

[404] N.J. ADMIN. CODE § 14:8-2.2 (2010) (definition of "biomass").

[405] WASH. REV. CODE § 19-285-030(18)(i) (2010).

There is no single, widely accepted definition of what constitutes old growth forest, nor any uniform measurement methodology for applying existing definitions.[406] However, despite this lack of uniformity in assessment methods, it is clear that old growth forests do not compromise a significant portion of forestland in the eastern United States.[407] Four out of the five states that exclude old growth timber from eligible biomass are in the Northeast United States where less than one percent of forestland is old growth forest.[408] The Southeast and Great Lakes areas have even lower percentages of old growth forest but no states in these regions explicitly prohibit the use of old growth timber under their RPS programs.[409] However, while Illinois, a state in the Great Lakes region, does not prohibit old growth per se, because the use of whole trees is not permitted, old growth trees would not be considered eligible biomass under the state's RPS.[410] Of all regions in the United States, the Pacific Northwest has the largest percentage of old growth forests, ranging from six to twenty-one percent, depending on the definition of old growth.[411] Washington is the only state in the Pacific Northwest that prohibits the use of old growth under its RPS, and no states in this region prohibit the use of whole trees. There are many factors that impact a state's decision to exclude old growth timber from eligible biomass under RPS programs. The management of old

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[406] NATIONAL COMMISSION ON SCIENCE FOR SUSTAINABLE FORESTRY, BEYOND OLD GROWTH: OLDER FORESTS IN A CHANGING WORLD, A SYNTHESIS OF FINDINGS FROM FIVE REGIONAL WORKSHOPS 12 (2008) [hereinafter Beyond Old Growth].

[407] *Id*.

[408] *Id*.

[409] *Id*.

[410] *See* S.B. 2150, 96th Gen. Assem., Reg. Sess. (Ill. 2009), *available at* http://www.ilga.gov/legislation/publicacts/96/096-0159.htm.

[411] Beyond Old Growth, *supra* note 406, at 13.

growth forests is a complicated issue, invoking politics, economics and emotions, that has many aspects that extend outside the realm of renewable energy.

Several states' RPS programs address nitrogen oxide, particulate and/or greenhouse gas emissions from biomass facilities. Connecticut considers low emission advanced biomass conversion technologies to be an eligible source of renewable energy if nitrogen oxide emissions from these sources meet certain limits.[412] Massachusetts uses nearly the same term - low emission advanced biomass power conversion technologies, but does not address nitrogen oxide emissions.[413] However, Massachusetts has proposed restrictions on greenhouse gases from woody biomass electricity.[414] Montana describes eligible biomass as "low-emission" but does not elaborate on the meaning of "low-emission."[415] New Hampshire requires that eligible biomass technologies meet nitrogen oxide and particulate standards.[416] Biomass facilities in New Jersey must receive approval of their pollution control methods.[417] North Carolina requires biomass facilities use best available control technology.[418] All of the states listed above, except Massachusetts, addresses emissions from biomass facilities as a local air quality problem, focusing on nitrogen oxides (precursors of acid rain and ground level ozone), particulates, and general pollution control. In contrast, Massachusetts' proposed regulations focus on limiting greenhouse gas emissions from biomass facilities, thus addressing global climate

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[412] CONN. GEN. STAT. § 16-245n(a) (2010); *Id*. at § 16-1(a)(26)(A).

[413] MASS. GEN. LAWS ch. 25A, § 11F(b)(8) (2010).

[414] Proposed revision to 225 MASS. CODE REGS. 14.05(1)(a)(7)(f)(iii) (May 2011).

[415] *See* MONT. CODE ANN. § 69-3-2003(10)(g) (2010).

[416] N.H. REV. STAT. § 362-F:2 (VIII)(a) (2010).

[417] N.J. ADMIN. CODE § 14:8-2.5(d)-(f) (2010).

[418] N.C. GEN. STAT. § 62-133.8(g) (2010).

change rather than local air quality.[419] Clearly, both local air quality and global climate change are important issues. Ideally, RPS programs that are designed to assist states in transitioning to non-fossil fuel based energy systems should address both issues.

[419] *See* proposed revision to 225 MASS. CODE REGS. 14.05(1)(a)(7)(f)(iii) (May 2011).

CHAPTER V

LEGAL TREATMENT OF GHG EMISSIONS FROM BIOENERGY IN DEFINITIONS OF BIOMASS IN FEDERAL LAW AND PROPOSED FEDERAL LEGISLATION

Biomass was first defined in federal law in the Energy Security Act of 1980.[420] Biomass was defined as "any organic matter which is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants."[421] Nearly twenty years later, a Presidential Executive Order issued in 1999 defined biomass as "any organic matter that is available on a renewable or recurring basis (excluding old-growth timber), including dedicated energy crops and trees, agricultural food and feed crop residues, aquatic plants, wood and wood residues, animal wastes, and other waste materials."[422] Old-growth timber means "timber of a forest from the late successional stage of forest development. The forest contains live and dead trees of various sizes, species, composition, and age class structure."[423] These two definitions of biomass were likely used as early model definitions because they are similar, and in some cases identical, to many definitions of eligible biomass in state RPS programs.[424]

Federal legislation enacted in the last several years is notable for the lack of a uniform definition of biomass. Indeed, sometimes a single bill may have multiple

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[420] *See* Energy Security Act of 1980, Pub. L. No. 96-294, 94 Stat. 611 (1980).

[421] *Id*. § 203(2)(A), 94 Stat. 683 (codified at 42 U.S.C. § 8802(2)(A) (2011)).

[422] Exec. Order No. 13,134, 64 Fed. Reg. 44,639, 44,641 (August 16, 1999) (titled Developing and Promoting Biobased Products and Bioenergy).

[423] *Id*.

[424] *See e.g.*, NEV. REV. STAT. § 704.007 (2010) (uses same language as Energy Security Act of 1980); N.J. ADMIN. CODE § 14:8-2.2 (2010) (explicitly adopts definition of biomass from Executive Order 13,134, *supra* note 422).

definitions of biomass.[425] To some extent, having multiple definitions of biomass is a result of different laws focusing on different issues. For example, in the Energy Policy Act of 2005 (EPAct of 2005) in the section related to the Renewable Energy Security Provision, biomass is broadly defined to include "wood and wood wastes and residues."[426] In contrast, the section in the EPAct of 2005 related to the "Grants to Improve Commercial Value of Forest Biomass for Electric Energy, Useful Heat, Transportation Fuels and Other Commercial Purposes Program," biomass is limited to waste byproducts and defined as "nonmerchantable materials or precommercial thinnings that are byproducts of preventive treatments, such as trees, wood, brush, thinnings, chips, and slash, that are removed – (A) to reduce hazardous fuels; (B) to reduce or contain disease or insect infestation; or (C) to restore forest health."[427] The biomass industry has lobbied for a unified biomass definition.[428]

Several issues related to the definition of woody biomass are not treated uniformly in federal law and proposed legislation. First, there is disagreement over whether woody biomass materials from federal lands should be considered eligible sources of biomass, and if so, what types of woody biomass materials are eligible. Second, federal law is split regarding whether eligible biomass from private forestland

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[425] *See e.g.*, Energy Policy Act of 2005, Pub. L. No. 109-58 § 203(b)(1), 119 Stat. 652 (codified at 42 U.S.C. § 15,852(b)(1) (2011)); Pub. L. No. 109-58 § 206(a)(6)(B), 119 Stat. 655 (codified at 42 U.S.C. § 6865(c)(6)(B) (2011)); Pub. L. No. 109-58 § 210(a)(1), 119 Stat. 658 (codified at 42 U.S.C. § 15,855(a)(1) (2011)); Pub. L. No. 109-58 § 932(a)(1), 119 Stat. 870 (codified at 42 U.S.C. § 16,232(a)(1) (2011)); Pub. L. No. 109-58 § 1307 § 48B(c)(4), 119 Stat. 1004 (codified at 26 U.S.C. § 48B(c)(4) (2011)); Pub. L. No. 109-58 § 1512(r)(4)(B), 119 Stat. 1089 (codified as amended at 42 U.S.C. § 7545(o)(1)(I) (2011)).

[426] Pub. L. No. 109-58 § 206(a)(6)(B).

[427] Pub. L. No. 109-58 § 210(a)(1).

[428] *See* Michael Brower, *American Council on Renewable Energy Leading Biomass Definition Effort*, ENERGY PULSE (Dec. 23, 2010) http://www.energypulse.net/centers/article/article_display.cfm?a_id=2372.

should be restricted to residue and waste materials or instead include merchantable whole trees. Third, only a few definitions of biomass address the issue of land use change resulting from the conversation of forested or agricultural land into land for growing energy crops. These issues are significant because, while none of these definitions specifically address GHG emissions, these issues are all related to the overall GHG emissions of biomass electricity.

a. <u>Treatment of Woody Biomass from Federal Lands</u>

Federal law and recently proposed legislation are split regarding whether eligible biomass includes woody biomass materials from federal lands, and if so, what types of materials are eligible. None of the definitions of eligible biomass in the Energy Policy Act of 2005 addressed biomass from federal lands but the definitions are broadly stated so that biomass from federal lands would be eligible.[429] For example, the Federal Purchase Requirement for Renewable Energy passed as part of the Energy Policy Act of 2005 does not specifically address biomass from federal land but allows the use of "any lignin waste material…derived from…any of the following forest-related resources: mill residues, precommercial thinnings, slash, and brush, or nonmerchantable material."[430] Based on this broad definition, waste materials from logging or thinning operations on federal land would be considered eligible.

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[429] *See* Pub. L. No. 109-58 § 203(b)(1); § 206(a)(6)(B); § 210(a)(1); § 932(a)(1); § 1307 § 48(c)(4); § 1512(r)(4)(B).

[430] Pub. L. No. 109-58 § 203(b)(1)(A), 119 Stat. 652 (codified at 42 U.S.C. § 15,852(b)(1)(A) (2011)).

In 2007, there was a shift towards limiting, or in some cases completely excluding, biomass from federal lands. The Energy Independence and Security Act of 2007[431] contained two definitions of biomass. The definition of eligible biomass for the Renewable Fuel Standard excludes biomass from federal lands in any form.[432] The identical definitions of eligible biomass in the Express Loans for Renewable Energy and Energy Efficiency program and the Small Business Energy Efficiency Program do not specifically address biomass from federal land but this material would be eligible under the broad language of the definition.[433] Changes to the tax code in 2007 do not specifically address biomass materials from federal land.[434] The most recently enacted federal legislation defining renewable biomass, the Food, Conservation, and Energy Act of 2008 (FCEA), contained a single definition that permitted biomass from federal lands but only biomass that was the "byproduct of preventive treatments" that "would not otherwise be used for higher-value products."[435] FCEA also provided funding for development of biomass projects with priority given to projects using "low-value forest biomass" for energy production.[436]

[431] Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492 (codified in scattered sections of U.S.C.).

[432] Energy Independence and Security Act of 2007, Pub. L. No. 110-140 § 201(l)(I), 121 Stat. 1520-21 (codified at 42 U.S.C. § 7545(o)(1)(I) (2011)).

[433] *See* Pub. L. No. 110-140 § 1201(aa)(BB)-(CC), 121 Stat. 1764 (codified at 15 U.S.C. § 636(31)(a)(31)(F)(i)(I) (2011)); Pub. L. No. 110-140, § 1203(e)(z)(4)(A)(i)(II)-(III), 121 Stat. 1771-72 (codified at 15 U.S.C. § 638(z)(4)(A)(i)(II)-(III) (2011)).

[434] *See* 26 U.S.C. § 45(c)(2)-(3)(2011) (closed and open loop biomass); *id*. § 45K(c)(3); *id*. § 48b(c)(4).

[435] Food, Conservation, and Energy Act of 2008, Pub. L. No. 110-246 § 9001(12)(A), 122 Stat. 2066 (codified at 7 U.S.C. § 8101(12)(A) (2011)).

[436] Pub. L. No. 110-246 § 9012(c)(1), 122 Stat. 2095 (codified at 7 U.S.C. § 8112(c)(1) (2011)).

Four pieces of federal legislation proposed between 2009 and 2010 include definitions of biomass. These definitions treat biomass from federal lands in one of two ways. Three bills, the American Clean Energy and Security Act (ACESA) of 2009,[437] the Clean Energy Jobs and American Power Act (CEJAPA),[438] and the discussion draft of the American Power Act (AmPA),[439] have essentially identical definitions of eligible biomass from federal lands. This definition allows the use of "[m]aterials…from National Forest System land and public lands…that are removed as part of a federally recognized timber sale" but does not allow any biomass from federal land in various conservation programs or trees harvested from old-growth or late-successional stands.[440] This definition is broad in scope and not limited to waste or residue materials.

The American Clean Energy Leadership Act (ACELA) of 2009[441] treats biomass from federal lands differently. This definition limits eligible biomass from federal lands to slash, "byproducts of ecological restoration, disease or insect infestation control, or hazardous fuels reduction treatments," and material not useable for sawtimber because of

[437] American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. § 101(a) § 610(a)(15)(A) (2009) (sponsored by Representatives Waxman and Markey). This bill passed the House but not the Senate.

[438] Clean Energy Jobs and American Power Act, S. 1733, 111th Cong. § 102 § 700(46)(I) (2010) (sponsored by Senators Kerry, Boxer, and Kirk).

[439] American Power Act discussion draft, § 2002(a)(44)(A) (released May 12, 2010), available at http://kerry.senate.gov/work/issues/issue/?id=7f6b4d4a-da4a-409e-a5e7-15567cc9e95c (sponsored by Senators Kerry and Lieberman).

[440] *See e.g.*, H.R. 2454 § 101(a) § 610(a)(15)(A). These conservation lands include the National Wilderness Preservation System, Wilderness Study Areas, Inventoried Roadless Areas, National Landscape Conservation System, National Monuments, National Conservation Areas, Designated Primitive Areas, or Wild and Scenic Rivers corridors, or trees in old growth and late-successional stands. *Id*.

[441] American Clean Energy Leadership Act of 2009, S. 1462, 111th Cong. § 133(1)(b)(1)(K) (2009) (from the Senate Committee on Energy and Natural Resources, reported by Senator Bingaman).

size or quality.[442] Biomass from designated conservation areas on federal land, National Monuments and trees from old growth and late-successional forest stands are not eligible.[443]

These two definitions in proposed legislation have some similarities but, overall, represent very different approaches to the eligibility of biomass from federal lands. Both definitions exclude biomass material harvested from federal conservation areas and trees from old growth and late-successional forest stands. However, the ACELA limits biomass from federal land to waste materials while the CEJAPA, ACESA, and AmPA bills do not. By limiting eligible biomass from federal lands to residues, byproducts and material unusable as sawtimber, the ACELA makes a far smaller volume of biomass from federal land eligible than the approach taken in the three other bills mentioned above.

The Oregon Eastside Forests Restoration, Old Growth Protection, and Jobs Act of 2011 has been proposed, in part, to "conserve and restore the eastside National Forests" in Oregon.[444] This legislation proposes to "use the value of merchantable sawlogs and biomass to offset the cost of improving forest health."[445] While this proposed legislation does not explicitly define biomass, it does refer to biomass as consisting of "slash, brush, and any tree that does not exceed the minimum size standards for sawtimber."[446] The distinction between merchantable sawlogs and biomass is most likely due to economic considerations rather than concern regarding life cycle GHG emissions. However, in this

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[442] *Id*.

[443] *Id*. at § 133(1)(b)(3)(B)(i)-(ii).

[444] Oregon Eastside Forests Restoration, Old Growth Protection, and Jobs Act of 2011, S. 220, 112th Cong. § 2(1) (2011) (sponsored by Senators Wyden and Merkley).

[445] *Id*. at § 4(b)(2)(H).

[446] *Id*. at § 7(a)(2)(A)(vi)(I).

situation, economic considerations have the effect of limiting biomass from federal lands to waste materials.

Overall, current federal law contains both definitions that treat biomass from federal land differently than biomass from private land and definitions that make no distinction.[447] All recently proposed federal legislation specifically addresses biomass from federal lands, considers waste materials from federal land to be eligible biomass, and does not allow biomass from conservation areas, old growth or late-successional stands.[448] However, this proposed legislation is split regarding whether merchantable whole trees from federal lands should be eligible; ACESA of 2009, CEJAPA, and AmPA allow whole trees from federal land but ACELA of 2009 does not.[449]

b. <u>Biomass from Private Forestland: Waste Materials Only or Merchantable Whole Trees?</u>

Another debated aspect of the definition of eligible biomass is whether to restrict biomass from private forestland to residue and waste materials or to include merchantable whole trees as eligible. The definitions of eligible biomass in the Energy Policy Act of 2005 (EPAct) are split with four definitions limiting eligible biomass to waste or byproduct materials and two definitions considering merchantable whole trees as

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[447] *See e.g.*, Energy Independence and Security Act of 2007, Pub. L. No. 110-140 § 201(l)(I), 121 Stat. 1520-21 (codified at 42 U.S.C. § 7545(o)(1)(I) (2011)) (Renewable Fuel Standard specifically excludes biomass materials from federal lands); Pub. L. No. 110-140 § 1201(aa)(BB)-(CC), 121 Stat. 1764 (codified at 15 U.S.C. § 636(a)(31)(F)(i)(I) 2011) (Express Loans for Renewable Energy and Energy Efficiency has broad language that does not specifically address biomass from federal lands).

[448] H.R. 2454 § 101(a) § 610(a)(15)(A); S. 1733 § 102 § 700(46)(I); American Power Act discussion draft, § 2002(a)(44)(A); S. 1462 § 133(1)(b)(1)(K).

[449] *See supra* note 448.

eligible.[450] For example, the Grants to Improve the Commercial Value of Forest Biomass for Electric Energy, Useful Heat, Transportation Fuels, and Other Commercial Purposes program defines biomass as "nonmerchantable materials or precommercial thinnings that are byproducts of preventive treatments."[451] In contrast, the Renewable Energy Security program defines biomass as "any organic matter that is available on a renewable or recurring basis, including…wood and wood wastes and residues."[452] None of the biomass definitions in the EPAct distinguish between biomass from federal land and private land so biomass material from private and public land is treated in the same manner.

The Energy Independence and Security Act (EISA) of 2007 includes both definitions that restrict woody biomass to waste materials and definitions that allow merchantable whole trees. The Renewable Fuel Standard limits eligible biomass to "slash and pre-commercial thinnings…from non-federal forestlands" and "planted trees…from actively managed tree plantations."[453] While privately owned timber lands are sometimes referred to as tree plantations, the meaning of that term here most likely refers to trees grown as energy crops because the statute separately refers to privately

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[450] Definitions that limit eligible biomass from private forestland to waste materials include Pub. L. No. 109-58 § 203(b)(1), 119 Stat. 652 (Federal Government Purchase Requirement for Renewable Energy); Pub. L. No. 109-58 § 210(a)(1), 119 Stat. 658 (Grants to Improve the Commercial Value of Forest Biomass for Electric Energy, Useful Heat, Transportation Fuels and Other Commercial Purposes Program); Pub. L. No. 109-58 § 932(a)(1)(C), 119 Stat. 870 (Bioenergy Program for research and development of bioenergy); Pub. L. No. 109-58 § 1307 § 48B(c)(4)(iii), 119 Stat. 1004 (Credit for Investment in Clean Coal Facilities). Definitions that do not limit eligible biomass from private forestland to waste materials include Pub. L. No. 109-58 § 206(a)(6)(B), 119 Stat. 655 (Renewable Energy Security); Pub. L. No. 109-58 § 1512(r)(4)(B), 119 Stat. 1089 (Conversion Assistance for Cellulosic Biomass, Waste-Derived Ethanol, Approved Renewable Fuels Grants Program).

[451] Pub. L. No. 109-58, § 210(a)(1), 119 Stat. 658.

[452] Pub. L. No. 109-58, § 206(a)(6)(B), 119 Stat. 655.

[453] Pub. L. No. 110-140 § 201(1)(I)(ii), (iv), 121 Stat. 1520-21.

owned forestland.[454] Thus, waste materials are the only type of woody biomass from private forestlands that is considered eligible. The broad language in the identical definitions of eligible biomass for the Express Loans for Renewable Energy and Energy Efficiency program and the Small Business Energy Efficiency Program does not distinguish between biomass from private and federal lands.[455] The language is somewhat ambiguous but likely does not limit eligible woody biomass to waste materials.[456]

The Electricity Produced from Certain Renewable Resources section of the tax code divides biomass into "closed-loop biomass" and "open-loop biomass."[457] Close-loop biomass includes any organic material planted exclusively for the purpose of producing electricity,[458] in other words, energy crops. Open-loop biomass includes only waste materials including "mill and harvesting residues, precommercial thinnings, slash, and brush."[459] The Qualifying Gasification Project Credit limits eligible biomass to waste materials including "byproduct[s] of wood or paper mill operations" and "products of forestry maintenance."[460] None of these three definitions include merchantable whole trees. However, the Tax Credit for Producing Fuel from a Nonconventional Source

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[454] *Id.* at § 201(1)(I)(iv) (referring to non-federal forestlands).

[455] *See id*. § 1201(aa)(BB)-(CC), 121 Stat. 1764; *id*. § 1203(e)(z)(4)(A)(i)(II)-(III), 121 Stat. 1771-72.

[456] *See id*. § 1201(aa)(BB)-(CC), 121 Stat. 1764; *id*. § 1203(e)(z)(4)(A)(i)(II)-(III), 121 Stat. 1771-72 (defining biomass as "any organic material that is available on a renewable or recurring basis, including…trees grown for energy production…[and] wood waste and wood residues").

[457] 26 U.S.C. § 45(c)(2)-(3)(2011) (closed and open loop biomass). The Renewable Electricity, Refined Coal, and Indian Coal Production Credit (IRS Form 8835) is associated with this definition of biomass.

[458] 26 U.S.C. § 45(c)(2).

[459] 26 U.S.C. § 45(c)(3).

[460] 26 U.S.C. § 48b(c)(4).

broadly defines biomass to include any organic material other than oil, natural gas, and coal so merchantable whole trees are eligible under this definition.[461]

The Food, Conservation, and Energy Act of 2008 allows "any organic matter" available on a renewable basis from non-Federal land to qualify as eligible biomass.[462] In contrast, this same act restricts biomass from federal lands to waste materials with no higher-value use.[463]

All recently proposed legislation that defines biomass permits the use of merchantable whole trees from private land for biomass energy. The American Clean Energy and Security Act of 2009[464] and the discussion draft of the American Power Act[465] contain identical definitions of eligible biomass. This definition of biomass allows "[a]ny organic matter that is available on a renewable…basis from non-Federal land…including…plants and trees."[466] This definition contains no other restrictions regarding the eligibility of biomass from private lands.[467]

Other recently proposed legislation considers merchantable whole trees from private land to be eligible biomass but restricts or does not include biomass from private conservation forestland. The American Clean Energy Leadership Act of 2009 defines eligible biomass to include trees harvested from "naturally regenerated forest land; forest

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[461] 26 U.S.C. § 45k(c)(3).

[462] Pub. L. No. 110-246 § 9001(12)(B), 122 Stat. 2066.

[463] Pub. L. No. 110-246 § 9001(12)(A), 122 Stat. 2066.

[464] H.R. 2454 § 101(a) § 610(a)(15)(B).

[465] American Power Act discussion draft § 2002(a)(44)(B).

[466] H.R. 2454 § 101(a) § 610(a)(15)(B)(i)(III); American Power Act discussion draft § 2002(a)(44)(B)(i)(III).

[467] *See id*.

land that was planted for the purpose of restoring land to a naturally regenerated forest," conservation forest land if harvesting methods maintain or contribute to the restoration of the land, and "planted forest land" planted prior to the enactment of the proposed bill.[468] The two categories of naturally regenerated forestland and planted forestland encompass all private forests. Thus, biomass from private conservation forestland harvested in an unsustainable manner is the only type of excluded biomass from private land.

The Clean Energy Jobs and American Power Act (CEJAPA) defines eligible biomass to include whole trees harvested from "naturally regenerated forests or other non-plantation forests" on private land provided the land "is not high conservation priority land."[469] Unlike the ACELA, in the CEJAPA there is no exception to the exclusion of biomass from high conservation priority land if appropriate, sustainable harvesting methods are used.[470]

Overall, existing federal legislation is split between allowing merchantable whole trees from private forestlands and restricting biomass from private forestlands to waste materials. However, all recently proposed federal legislation defines eligible biomass to include merchantable whole trees from private forestlands suggesting a trend in this direction.

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[468] S. 1462 § 133(1)(b)(1)(I).

[469] S. 1733 § 102 § 700(46)(H).

[470] *See id*.

c. **Energy Crops and Land Use Change**

All definitions of biomass in existing and proposed legislation permit the use of woody energy crops. A few definitions of biomass in federal legislation address the issue of land use change, specifically, the conversation of forested or agricultural land into land for growing energy crops. The conversion of forested land to tree plantations results in lower levels of carbon storage and an initial carbon debt that takes decades to pay back.[471] The conversion of agricultural land to land for energy crops can increase food prices and result in the clearing of other land to create new agricultural land.[472]

The Renewable Fuel Standard, as enacted in the Energy Independence and Security Act of 2007, restricts eligible woody energy crops to "actively managed tree plantations on non-federal land cleared at any time prior to enactment of this sentence…."[473] The proposed American Clean Energy Leadership Act of 2009 and proposed Clean Energy Jobs and American Power Act similarly restrict eligible woody energy crops so as to not incentivize land use change.[474]

Overall, the issue of potential land use change caused by expanded production of energy crops has not been widely addressed in definitions of eligible biomass in federal law and proposed legislation. However, there may be a trend in this direction because half of the recently proposed legislation addresses land use change from energy crops.

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[471] L.B. Guo & R. M. Gifford, *Soil Carbon Stocks and Land Use Change: A Meta Analysis*, 8 GLOBAL CHANGE BIOLOGY 345, 347 fig.1 (2002) (indicating decreased levels of carbon in land converted from forest to tree plantation); Zanchi, *supra* note 3, at 30 (noting a 45-170 year payback period for the carbon debt incurred from converting forestland to tree plantations).

[472] *See generally* Rosamond L. Naylor et al., *The Ripple Effect: Biofuels, Food Security, and the Environment*, 49 ENVIRONMENT 30 (2007).

[473] Pub. L. No. 110-140, § 201(1)(I)(ii), 121 Stat. 1520-21.

[474] S. 1462 § 133(1)(b)(1)(I)(ii)-(1)(b)(1)(J); S. 1733 § 102 § 700(46)(H)(i).

d. **Summary of Federal Definitions of Biomass**

Federal law and proposed legislation does not uniformly address several issues related to the definition of woody biomass. While existing and proposed legislation differs as to whether merchantable whole trees from federal lands should be considered eligible sources of biomass, proposed legislation consistently addresses biomass from federal lands separately from materials from private lands, permits the use of woody waste materials from federal lands, and does not allow materials from federal conservation areas, or old-growth or late-successional stands. Current federal law is split regarding whether merchantable whole trees from private forestland are considered eligible biomass, but all proposed legislation considers this type of biomass eligible suggesting a trend towards allowing whole trees. Existing and proposed legislation does not generally address land use change resulting from the conversation of forested or agricultural land into land for growing energy crops, but this issue is gaining greater recognition in recently proposed legislation.

Many federal laws and most definitions of biomass in state RPS programs contain few limits on the types of eligible biomass. In general, these "first-generation" definitions are similar to the definitions of biomass found in the Energy Security Act of 1980[475] and in the Presidential Executive Order issued in 1999.[476] However, some states, such as Illinois, New Jersey, and Pennsylvania, have written or revised their RPS definitions of eligible biomass to exclude whole trees. Some federal laws, such as the Federal Purchase Requirement for Renewable Energy passed as part of the Energy Policy

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[475] Pub. L. No. 96-294, 94 Stat. 611 (1980).

[476] Exec. Order No. 13,134, 64 Fed. Reg. 44,639, 44,641 § 7(a) (August 16, 1999).

Act of 2005,[477] also exclude whole trees. In contrast, all recently proposed federal legislation considers whole trees from private forests to be eligible biomass. However, all recently proposed federal legislation contains definitions of biomass that are generally more detailed and developed than the "first generation" definitions mentioned above.

Unlike a few state RPS programs,[478] no federal law or proposed legislation requires an LCA of GHG emissions or certification regarding the source of the biomass. Despite the lack of these requirements, several issues related to the overall GHG emissions of biomass electricity are addressed in federal legislation because these issues are also related to economic, ecological and social values. Life cycle analyses of GHG emissions from biomass electricity generated using whole trees demonstrate that, at least in some cases, this electricity does not reduce GHG emissions on the time scale required to combat climate change. However, some federal laws and proposed legislation treats whole trees as eligible biomass without analyzing whether, in fact, GHG emission reductions are realized from this fuel type.

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[477] Pub. L. No. 109-58, § 203(b)(1)(A), 119 Stat. 652.

[478] *E.g.*, 7-100-106 DEL. CODE REGS. § 5.3 (2010); New York Order, *supra* note 310, at amended app.B at 4.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Definitions of eligible biomass in state RPS programs and federal laws and proposed legislation vary in content and complexity. The majority of states have broad RPS definitions of eligible biomass with few restrictions on the type of fuel, management and harvest practices, and emissions. As biomass has generally been considered "carbon neutral" in the past, it is not surprising that all RPS programs, except for Massachusetts' proposed regulations,[479] and all federal laws and proposed legislation do not consider greenhouse gas emissions from woody biomass.[480]

However, as the general understanding of the lifecycle of carbon emissions from biomass energy becomes more nuanced, the label "carbon neutral" does not describe some types of biomass when a twenty to thirty year time frame is considered. With this more nuanced understanding of carbon emissions from biomass energy, it now makes sense to reconsider RPS program and federal definitions of eligible biomass and the role of biomass carbon emissions in these definitions. It seems likely, based on LCAs of carbon emissions, and the need to reduce carbon emissions in the short to medium length time frame, that the chipping of old growth trees and slow-growing whole trees that could be used for other purposes should not be considered eligible biomass for laws incentivizing biomass energy.

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[479] *See* proposed revision to 225 MASS. CODE REGS. 14.05(1)(a)(7)(f)(iii) (May 2011).

[480] Connecticut's RPS requires that "alternative fuels, used for electricity generation…derived from agricultural produce, food waste or waste vegetable oil…provide net reductions in greenhouse gas emissions and fossil fuel consumption" in order to be eligible renewable energy. CONN. GEN. STAT. § 16-245n(a) (2010). However, woody biomass is not one of the sources of biomass subject to this restriction.

Now that we have a greater understanding of GHG emissions through LCAs that account for the carbon debt created by harvesting trees and payback over time, narrower definitions of eligible biomass are called for if biomass electricity is to successfully play a role in reducing GHG emissions. Federal laws and state RPS programs should incorporate life cycle analyses of GHG emissions in order to more effectively incentivize biomass fuels that reduce GHG emissions.

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