

## Quick Facts

- In the United States, biopower currently accounts for 1.4 percent of total electricity generation, but it provides more electricity than any other renewable source except hydropower, constituting 14 percent of total U.S. renewable electricity generation.<sup>1</sup>
- In 2007, the United States had 12.3 gigawatts of biopower generating capacity, about 1.1 percent of total U.S. capacity, and 15 percent of total global biopower generating capacity.<sup>2,3</sup>
- Under proposed policies to reduce greenhouse gas emissions, biopower is an increasingly important source of renewable electricity, with the projected potential to provide 10 percent of U.S. electricity and 5 percent of global electricity by mid-century.<sup>4,5</sup>

## Background

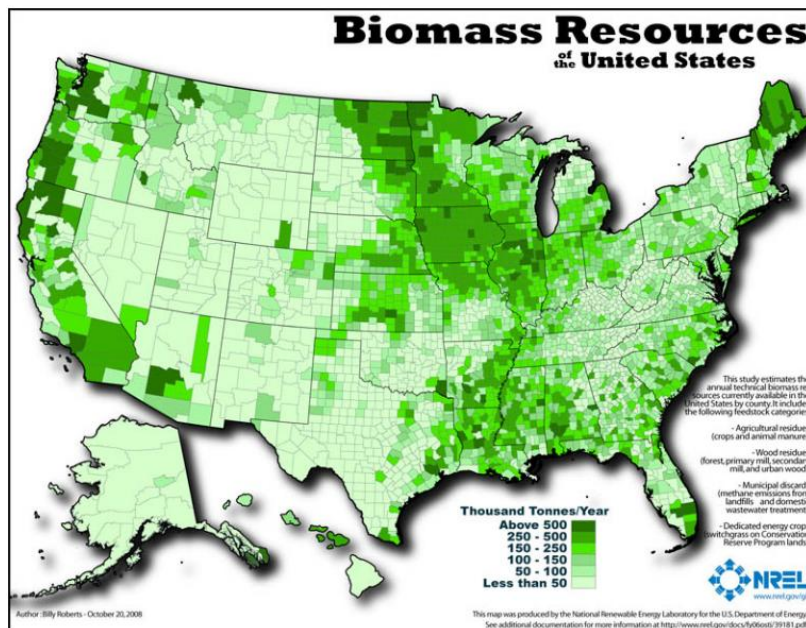
Before fossil fuels like coal and petroleum transformed the world's energy landscape, biomass, especially wood, was a primary source of energy for most of human history.

Biomass still provides one tenth of global primary energy consumption, with two thirds of that attributed to traditional uses of biomass – primarily domestic cooking and heating in the developing world.<sup>6</sup> Biopower, which refers to electricity generation using biogenic fuels, holds significant potential as a major renewable energy source in a low-carbon energy future.<sup>7</sup>

Biomass is available in a substantial yet finite quantity, subject to resource concerns including the availability of suitable land and water, conservation of biodiversity, and protection of water quality. If grown in a sustainable manner, biomass is a carbon-neutral energy source—i.e., the greenhouse gas (GHG) emissions, namely carbon dioxide (CO<sub>2</sub>), released from converting biomass to energy are equivalent to the amount of CO<sub>2</sub> absorbed by the biomass plants during their growing cycles. If coupled with future carbon capture and storage (CCS) technology, a biomass-fueled power plant could even be a net carbon-negative energy source (see [Climate TechBook: CCS](#)).

Although biomass (especially corn and switchgrass) is a familiar source of alternative transport fuels like ethanol and biodiesel (see [Climate TechBook: Biofuels Overview](#)), it is also regularly used to generate electricity and useful heat. Unlike wind and solar power, whose output fluctuates with wind speed and sunlight, biopower operates like traditional fossil fuel technologies insofar as it can generate electricity and heat continuously or according to a schedule.

Figure 1: Biomass Resources in the United States



Source: [National Renewable Energy Laboratory](http://www.nrel.gov) (NREL)

## Description

Woody biomass has been the primary feedstock for electricity and heat generation. Wood used at commercial scale consists mainly of residuals from timber harvesting, sawmilling, and pulp and paper making. Agricultural residue from harvests, mainly wheat straw and corn stover, is another major feedstock group. Future supply may come from “purpose-grown” energy crops such as hybrid poplar or willow trees, but the success of such crops may depend on their effect on food crops, the acceptability of land use conversion, and genetic engineering.<sup>8</sup>

In order for biopower to reach its full potential as a large-scale fuel for electricity and heat generation, dedicated energy crops will be needed.<sup>9</sup> The potential exists today to increase the supply of biomass from existing forests if biomass markets support the costs of recovering it.<sup>10</sup> Currently, however, biomass feedstock supply varies greatly across the United States (see Figure 1).

Electricity and heat from biomass are generated through several methods:

- *Direct-firing*, in which biomass is the only fuel used in a power plant. The feedstock is burned in a boiler to create steam, which is then used to power a steam turbine and produce electricity, similar to a traditional coal power plant. These plants can have efficiencies of up to 40 percent, though the norm is often much lower.<sup>11</sup>

- *Cofiring*, in which biomass is substituted for a portion of the coal used in a coal power plant. In general, a coal plant can be modified to accommodate biomass constituting up to 20 percent of its fuel.<sup>12</sup> The feedstock is blended either initially with coal before combustion in the boiler through a blended delivery system, or in the boiler through a separate feed system, a process that requires more extensive plant retrofitting. Biomass cofiring attains efficiencies of 33 to 37 percent, equivalent to that of the average coal plant.<sup>13</sup>
  - *Repowering* is an option to more substantially modify an existing fossil fuel power plant so that biomass fully substitutes for the fossil fuel for which the plant was originally designed. This is a more expensive option, requiring extensive retrofitting. A power plant is often repowered, versus retrofitted for co-firing, in order to meet environmental regulations and continue operating.
- *Combined heat and power (CHP, or cogeneration)*, in which a fuel is burned to produce both electricity and useful heat. The biomass is combusted to produce steam to power a turbine generator, and the exhaust is then used onsite for another electricity generation cycle or directly for industrial uses, such as heat needed in pulp and paper mills, or for district heating.<sup>14</sup> This combined generation improves on the efficiencies of conventional separate heat and power generation, in which the energy losses are nearly double that of combined heat and power. Combined heat and power plants have efficiencies as high as 75 to 90 percent.<sup>15</sup> Biomass CHP makes up a third of the existing U.S. biopower generating capacity but accounts for an even greater fraction (60 percent) of total biopower generation.<sup>16</sup>
- *Gasification*, in which the feedstock is processed in a hot, oxygen-starved environment to produce a synthesis gas, or syngas, composed mostly of carbon monoxide and hydrogen. This gas then fuels a gas turbine to produce electricity. In a biomass integrated gasification combined cycle plant (BIGCC), the exhaust from the first cycle is run through a steam turbine in a second cycle, similar to a natural gas combined cycle power plant. While still a developing technology, BIGCC plants are expected to have efficiencies of up to 60 percent.<sup>17</sup> Of the biopower technologies, BIGCC is the most promising for integration with CCS.<sup>18</sup>
- *Anaerobic digestion*, in which bacteria are used to decompose organic matter – typically waste – into a methane-rich biogas which is then purified and used for electricity generation (see [Climate TechBook: Anaerobic Digesters](#)). This process does not use traditional biomass feedstocks; rather, it typically captures and utilizes the biogas emitted from the plentiful waste found at landfills (landfill gas) and farms.
- *Municipal Solid Waste*, in which solid, nonhazardous waste is incinerated in waste-to-energy facilities, generating electricity or heat as a byproduct. Concerns for air quality and environmental impacts have brought development of this non-traditional biopower generation to a near halt. Nearly 13 percent of trash in the U.S. was burned for energy in 2007.<sup>19</sup>

### Environmental Benefit/Emission Reduction Potential

The net effect of biopower on GHG emissions depends on, among other factors, the direct and indirect land-use changes associated with biomass fuel production.<sup>20</sup>

Biopower already plays a role in avoiding GHG emissions. According to the National Renewable Energy Laboratory (NREL), if current biopower generation were replaced with traditional coal-fueled electricity generation, the United States would use 22 million more short tons of coal annually and the U.S. electric power sector would emit nearly 8.4 million more metric tons of CO<sub>2</sub>, an increase of about 0.3 percent over 2007 emissions.<sup>21</sup> Coupling biopower plants with CCS technology could produce energy with net zero or even negative GHG emissions and play a role in reducing the concentration of GHGs in the atmosphere.<sup>22</sup>

Replacing coal with biomass not only lowers GHG emissions but also reduces sulfur dioxide emissions, which cause acid rain and health problems, because biomass feedstocks have lower sulfur content than coal.<sup>23</sup>

If proposed climate policies are adopted in the United States, biopower could surpass hydropower as the largest source of renewable electricity within roughly a decade and expand to produce a projected 8 percent of total U.S. electricity in 2030.<sup>24</sup>

When coupled with plug-in hybrid electric or electric vehicles (PHEVs or EVs), biopower can complement biofuels and even serve as an alternative to liquid transport fuels derived from biomass. For example, a study comparing the use of biopower to charge PHEVs or EVs and the use of cellulosic ethanol to fuel vehicles with internal combustion engines estimated that the biopower/(PH)EV scenario allows for 81 percent more miles driven and 108 percent more emission reductions per unit of land devoted to growing biomass.<sup>25</sup>

As one indicator of the significant potential role for biopower in global GHG abatement, the International Energy Agency (IEA) estimates that, by 2050, global use of biomass for electricity, heat, and transport fuels could grow by four to five-fold to constitute 20 percent of total primary energy consumption.<sup>26</sup> Under an aggressive global effort to reduce emissions, IEA projects that increased biopower generation could provide 3 percent of global energy-related emission reductions—and 8 percent of emission reductions from the electric power sector—compared to “business as usual” by 2050. IEA estimates that, in this scenario, global biopower generation could increase ten-fold from 2005 to 2050 (compared to a seven-fold increase in the “business-as-usual” scenario).

The GHG emission reduction benefits of biopower should be balanced with its potential negative environmental effects. Dedicated energy crops may increase the use of fertilizer and pesticides, and removing biomass from agricultural and forest ecosystems may have undesirable effects on nutrient cycles. Safeguards for biodiversity may be needed, especially if changes in land use convert natural ecosystems to more intensive use for dedicated energy crops. If growing the biomass fuel supply requires irrigation, biopower can require upwards of 143 times more water than power generation from fossil fuels and renewables. Energy crops will need to match appropriate agricultural conditions and climates to avoid exacerbating water constraints.<sup>27</sup>

## Cost

The cost of biopower plants depends on the location and type of power plant as well as whether the feedstock is available at a competitive price. The economics of biopower favor close proximity to feedstocks because transportation costs can be significant.

Biomass cofiring is one of the most economic uses of biomass for electricity generation.<sup>28</sup> Some estimates place the cost of electricity from biomass cofiring at or below the costs of electricity from traditional natural gas or coal power plants.<sup>29</sup> The cost of retrofitting a power plant for biomass co-firing ranges from \$50 to \$700 per kilowatt of capacity retrofit, depending on the type of boilers.<sup>30</sup> One recent estimate found that the cost of installing scrubbers, the traditional route for coal plants to reduce non-GHG pollution and meet air quality regulations, was actually 40 percent higher than the cost of reducing pollution by repowering to use biomass.<sup>31</sup>

Once fully commercialized, BIGCC is expected to be a major cost-competitive, large-scale biopower technology. Recent estimates from the U.S. Energy Information Administration (EIA) put the levelized cost of electricity from BIGCC in the U.S. at 10.7 cents per kilowatt-hour (kWh) (2007 USD), which is nearly 20 percent more than the expected levelized cost of electricity from a traditional new coal or natural gas power plant.<sup>32</sup> These estimates also put the levelized cost of biopower above that of wind power, but since biopower is not variable like wind power, biopower can still be a preferred choice in many situations.<sup>33</sup>

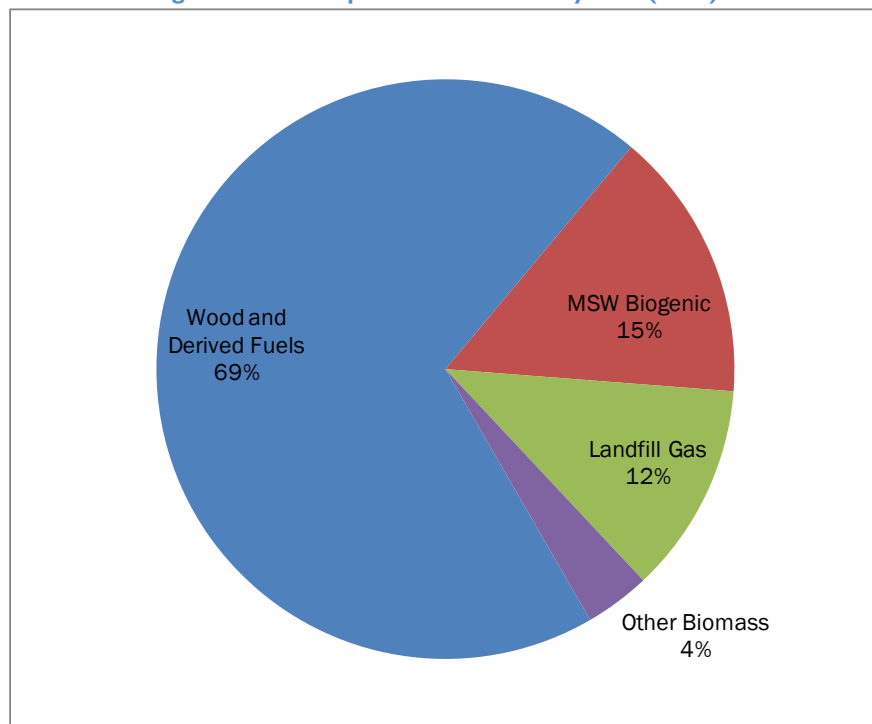
### **Current Status of Biopower**

In 2008, the United States produced a total of 55.9 billion kilowatt-hours of electricity from biomass.<sup>34</sup> Nearly 70 percent of this total used wood and milled residuals, and the remaining 30 percent was from biogenic municipal solid waste, landfill gas, and agricultural and other byproducts (see Figure 2).<sup>35</sup>

In the near term, biomass cofiring is expected to remain the most cost-effective option for expanding biopower for electricity generation.<sup>36</sup> Other biopower technologies have greater potential to meet energy and climate goals in the medium and long term. The most advanced gasification technology is still in an early commercialization stage of development.<sup>37</sup>

Biomass CHP is already widely used in the U.S. pulp and paper industries and accounts for 85 percent of all woody biomass utilization.<sup>38</sup> This technology has been especially extensively deployed in Scandinavia and still holds much potential not only for industrial and commercial purposes but residential heating (district heating) as well.<sup>39</sup>

Figure 2: U.S. Biopower Generation by Fuel (2008)<sup>40</sup>



Notes: MSW biogenic is that portion of municipal solid waste consisting of paper and paper board, wood, food, leather, textiles and yard trimmings. Wood residuals and derived fuels include black liquor and mill byproducts in solid and liquid form. Other biomass includes agriculture byproducts/crops, sludge waste, and other biomass solids, liquids and gases.

### Obstacles to Further Development or Deployment of Biopower

- **Lack of a price on carbon or GHG emission performance standards.** Currently, fossil fuel power plants face no financial consequences for emitting CO<sub>2</sub>. If there were a financial cost associated with GHG emissions, biopower would be more cost competitive with traditional fossil fuel technologies due to its net zero CO<sub>2</sub> emissions.
- **Need for technology research, development, and demonstration (RD&D).** BIGCC technology holds much potential, but the most advanced biomass gasification technology is still in its early commercialization phase. Similarly, the combination of biopower with CCS has not yet been demonstrated.
- **Underutilized feedstock supply.** While biomass electricity is viable using agricultural and forest feedstocks, it is reliant on the annual cycles and practices of these two industries. Analysis shows more biomass is available from existing forests if biomass markets support the costs of recovering it. Dedicated energy crops could also expand the feedstock supply for biopower.
- **Potential land-use impacts.** Converting sensitive ecosystems like wetlands or old-growth forests to grow energy crops can have negative consequences for ecosystem services that they provide, including carbon sequestration. Because there is a finite supply of arable land, increases in agricultural productivity are required in order to allow for large-scale production of energy crops.

Competition between the use of arable land for food production and for biomass feedstock production could have undesired consequences on food prices.<sup>41</sup>

- **Potential water scarcity.** Limited water resources should direct the choice of large-scale energy crops towards the less water-intensive options.

### Policy Options to Help Promote Biopower

Government support could significantly encourage biomass-fueled electricity and other low-carbon energy technologies. Much of the existing biopower capacity is a result of synergies between industrial waste disposal and energy needs. With appropriate climate and energy policies, biopower could be a primary renewable resource in a portfolio of low-carbon energy technologies.

- **Price on carbon emissions and sinks.** A price on carbon, such as that which would exist under a GHG cap-and-trade program (see [Climate Change 101: Cap and Trade](#)), would discourage traditional fossil-fuel use and spur investments in a range of clean energy technologies, including biopower. A carbon pricing policy could also acknowledge the value of carbon sinks that absorb emissions, both natural sinks like forests and human-engineered sinks like CCS.
- **Government funding for RD&D.** Government funding or financial incentives for RD&D can advance biopower technology (e.g., BIGCC and biopower coupled with CCS). Research focused on improving agricultural productivity could expand the supply of food and energy crops that can be produced from a given quantity of land. Additional scientific research could also improve the understanding of the net GHG impacts of large-scale biomass production.
- **Production tax credit.** The American Recovery and Reinvestment Act of 2009 extended the federal production tax credit (PTC) to generators for not only biomass electricity but also other renewable electricity generation through 2013. This incentive makes investments in biopower more cost-competitive with traditional fossil fuel.
- **Renewable portfolio standard (RPS).** Currently 30 states and the District of Columbia have renewable portfolio standards (RPSs), all of which include at least some form of biopower as a qualified renewable energy source.<sup>42</sup> An RPS requires that a certain amount or percentage of a utility's power plant capacity or electricity sales come from renewable sources by a given date. Congress is considering proposals for a national RPS.
- **Sustainability guidelines for biomass.** Policies and guidelines that determine the net GHG abatement of biomass feedstocks and feedstock production methods can ensure that biopower delivers a maximum net GHG reduction benefit. In addition, policies to address concerns such as biodiversity threats and competition for water from dedicated energy crops can balance GHG emission reductions and other environmental concerns.

### Related Business Environmental Leadership Council (BELC) Company Activities

- [AEP](#)
- [DTE](#)
- [Duke Energy](#)
- [Johnson Controls, Inc.](#)
- [Lockheed Martin](#)
- [Ontario Power Generation](#)
- [PG&E](#)
- [SC Johnson](#)
- [Weyerhaeuser](#)

### Related Pew Center Resources

[\*Agriculture's Role in Greenhouse Gas Mitigation, 2006\*](#)

[\*Climate Change 101: Technology, 2009.\*](#)

[Map: State Renewable Portfolio Standards](#)

[\*A Performance Standards Approach to Reducing CO2 Emissions from Electric Power Plants, 2009.\*](#)

[\*Race to the Top: The Expanding Role of U.S. State Renewable Portfolio Standards, 2006\*](#)

[\*The U.S. Electric Power Sector and Climate Change Mitigation, 2005.\*](#)

### Further Reading / Additional Resources

[Intergovernmental Panel on Climate Change \(IPCC\)](#)

- Fourth Assessment Report (2007).
- Technical Paper on Climate Change and Water (2008).

International Energy Agency (IEA)

- [Bioenergy Website](#)
- [Bioenergy: A Sustainable and Reliable Energy Source](#) (2009)
- [Cogeneration and District Energy](#) (2009).

- [Combined Heat and Power: Evaluating the Benefits of Greater Global Investment](#) (2008).
- [Energy Technology Essentials: Biomass for Power Generation and CHP](#) (2007).

Pacific Northwest National Laboratory (PNNL) Global Technology Strategy Project (GTSP), [Biotechnology and Biomass: A Core Element of a Global Energy Technology Strategy to Address Climate Change](#) (2007).

REN21, [Renewables Global Status Report 2009](#).

U.S. Environmental Protection Agency

- [Biomass Combined Heat and Power Catalog of Technologies](#) (2007).

U.S. Department of Energy

- [Biomass Energy Data Book](#) (2006).
- [Power Technologies Energy Data Book](#) (2006).

<sup>1</sup> Energy Information Administration (EIA), Electric Power Monthly with data for April 2009, (15 October 2009).

<sup>2</sup> EIA, Electric Power Annual with data for 2007, (21 January 2009).

<sup>3</sup> REN21, [Renewables Global Status Report 2009](#), Table R4.

<sup>4</sup> Environmental Protection Agency (EPA), [Analysis of H.R. 2454 in the 111th Congress, the American Clean Energy and Security Act of 2009](#), 2009, ADAGE model results, Scenario 2.

<sup>5</sup> International Energy Agency (IEA), *Energy Technology Perspectives 2008: Scenarios and Strategies to 2050 (ETP2008)*, 2008, BLUE Map Scenario, see Table 2.5.

<sup>6</sup> IEA, *Energy Technology Perspectives 2008*, p. 308.

<sup>7</sup> IEA, *Energy Technology Perspectives 2008*, p. 307

<sup>8</sup> JA Edmonds, MA Wise, JJ Dooley, SH Kim, SJ Smith, PJ Runci, LE Clarke, EL Malone, & GM Stokes, *Biotechnology and Biomass: A Core Element of a Global Energy Technology Strategy to Address Climate Change*, (College Park, MD: Global Energy Technology Strategy Program, May 2007), p. 10.

<sup>9</sup> Edmonds et al, *Biotechnology and Biomass*, p. 7.

<sup>10</sup> Robert D. Perlack, Lynn L. Wright, Anthony F. Turhollow, and Robin L. Graham, *Biomass As Feedstock For A Bioenergy And Bioproducts Industry: The Technical Feasibility Of A Billion-Ton Annual Supply*, Environmental Sciences Division, Oak Ridge National Laboratory, April 2005.

<sup>11</sup> Wright et al, *Biomass Energy Data Book*, p. 63; Dan Richter, "Wood Energy in America," EESI briefing on 2 June 2009.

<sup>12</sup> Kevin Comer, "Background and Policy Issues for Biomass Co-firing and Repowering," EESI briefing on 21 August 2008.

<sup>13</sup> Lynn Wright, Bob Boundy, Bob Perlack, Stacy Davis, Bo Saulsbury, *Biomass Energy Data Book: Edition 1*, (Oak Ridge, TN: Department of Energy (DOE), Energy Efficiency and Renewable Energy, Sept 2006), p. 63.

<sup>14</sup> District heating refers to a network for distributing hot water or steam through insulated pipes to serve commercial, residential, institutional, or industrial demand for space heating and process heat.

<sup>15</sup> Low estimate from IEA, *Combined Heat and Power: Evaluating the benefits of greater global investment*, (Paris: IEA), p. 10; high estimate from IEA, *Energy Technology Perspectives 2008*, p. 328.

<sup>16</sup> Paul J. Lemar (Resource Dynamics Corporation, "CHP and Biopower: Market Drivers and Outlook," (Washington, D.C.: EPA CHP Partnership Partners Meeting, 6 June 2008), slides 5, 7; EPA, *Biomass Combined Heat and Power Catalog of Technologies*, p. 1.

- <sup>17</sup> Wright et al, *Biomass Energy Data Book*, p. 63; Krister Ståhl, Lars Waldheim, Michael Morris, Ulf Johnsson, and Lennart Gårdmark, "Biomass IGCC at Värnamo, Sweden – Past and Future," The Global Climate and Energy Project Energy Workshop (Stanford, CA: Global Climate and Energy Project, 27 April 2004). It must be noted, however, that the only BIGCC demonstration plant in the world operated at half of the 60% potential efficiency.
- <sup>18</sup> Steven J. Smith, Antoinette Brenkart, and Jae Edmonds, [Biomass With Carbon Dioxide Capture and Storage In a Carbon Constrained World](#), presented at 8th International Conference on Greenhouse Gas Control Technologies (Pacific Northwest National Laboratory and the University of Maryland, 2006).
- <sup>19</sup> EPA, *Municipal Solid Waste in the United States: 2007 Facts and Figures*, (Washington, D.C.: EPA, Office of Solid Waste, Nov 2008), p. 15.
- <sup>20</sup> Searching, Timothy et al., "Fixing a Critical Climate Accounting Error," *Science*, 23 October 2009.
- <sup>21</sup> Coal displacement calculation from J. Aabakken, *Power Technologies Energy Data Book: Fourth Edition*, 12.3 Coal Displacement Calculation (Golden, CO: NREL, August 2006); avoided emissions from 12.1 Renewable Energy Impact Calculations.
- <sup>22</sup> Pamela L. Spath and Margaret K. Mann, *Biomass Power and Conventional Fossil Systems with and without CO2 sequestration – Comparing the Energy Balance, Greenhouse gas Emissions and Economics*, (Golden, CO: National Renewable Energy Laboratory, January 2004).
- <sup>23</sup> M.K. Mann & P.L. Spath, "A life cycle assessment of biomass cofiring in a coal-fired power plant," *Clean Products and Processes*, 3 (2) (August 2001), p. 81-91.
- <sup>24</sup> EIA, [Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009](#), basic policy case, (4 August 2009).
- <sup>25</sup> J.E. Campbell, D.B. Lobell, and C.B. Field, "Greater Transportation Energy and GHG Offsets from Bioelectricity Than Ethanol," *Science* (324) 22 May 2009, pp. 1055-1057.
- <sup>26</sup> IEA, *Energy Technology Perspectives 2008*, BLUE Map Scenario, p. 309-10.
- <sup>27</sup> Intergovernmental Panel on Climate Change, *Technical Paper on Climate Change and Water*, Technical Paper VI (June 2008), p. 119; P. W. Gerbens-Leenes, A. Y. Hoekstra, Th. van der Meer, "The water footprint of energy from biomass: A quantitative assessment and consequences of an increasing share of bio-energy in energy supply," *Ecological Economics* vol. 68 (2009), pp. 1052-60.
- <sup>28</sup> Mann & Spath, "A life cycle assessment of biomass cofiring in a coal-fired power plant," p. 85.
- <sup>29</sup> Tracy Beer (Manager, Duke Energy Regulated Renewable Energy and Carbon Strategy), [presentation to Carolinas Speakers Bureau](#), (30 April 2009).
- <sup>30</sup> Low estimate from NREL, "Biomass Cofiring: A Renewable Alternative for Utilities," Biopower FactSheet, June 2000; high estimate from Forest Products Laboratory, "Wood Biomass for Energy," (Madison, WI: U.S. Department of Agriculture, April 2004).
- <sup>31</sup> Anna Austin, "[Ohio Edison opts for 100 percent biomass power](#)," *Biomass Magazine* (August 2009); Susanne Calabrese, "Ohio Edison agrees to repower coal plant with biomass, reducing carbon emissions," (9 Sept 2009).
- <sup>32</sup> National Academies of Science, *Electricity from Renewable Resources: Status, Prospects, and Impediments*, forthcoming 2009.
- <sup>33</sup> National Academies of Science, *Electricity from Renewable Resources: Status, Prospects, and Impediments*, forthcoming 2009.
- <sup>34</sup> EIA, "Electricity Net Generation From Renewable Energy by Energy Use Sector and Energy Source, 2004 – 2008," from *Renewable Energy Consumption and Electricity Preliminary Statistics, 2008*, released July 2009.
- <sup>35</sup> EIA, "Electricity Net Generation From Renewable Energy by Energy Use Sector and Energy Source, 2004 – 2008."
- <sup>36</sup> IEA, *Energy Technology Essentials*.
- <sup>37</sup> Bauen et al., *Bioenergy*, p. 6.
- <sup>38</sup> Wright et al., *Biomass Energy Data Book*, p. 1-2.
- <sup>39</sup> Amanda Chiu, "One Twelfth of Global Electricity Comes from Combined Heat and Power Systems," in Vital Signs Online, (Washington, D.C.: Worldwatch Institute, October 2008).

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<sup>40</sup> EIA, “Electricity Net Generation From Renewable Energy by Energy Use Sector and Energy Source, 2004 – 2008,” from *Renewable Energy Consumption and Electricity Preliminary Statistics, 2008*, released July 2009.

<sup>41</sup> Food and Agriculture Organization, *The State of Food and Agriculture 2008: Biofuels: Prospects, Risks, and Opportunities*, (Rome: Food and Agriculture Organization, 2008), p. 8; Donald Mitchell, *A Note on Rising Food Prices*, World Bank Policy Research Working Paper No. 4682 (Washington, D.C.: World Bank, Development Prospects Group, July 2008).

<sup>42</sup> DOE & North Carolina State University, [Database of State Incentives for Renewables & Efficiency](#).