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Biomass energy overview (updated April 2011)

Background: The biomass industry is changing.
The existing fleet of biomass plants in the U.S. is dominated by industrial boilers that generate heat and power by burning sawmill and papermill waste. It's not a large industry, though it's a surprisingly influential one. Now, however, a new fleet of biomass plants are being built. These plants are bigger, are being pushed by developers cashing in "renewable" power subsidies and other financial incentives, and they rely on forest wood for fuel. In most cases, this means they'll burn trees, because the "logging residues" that developers usually claim they'll burn are too scarce to provide the volumes of fuel required. These plants, as well as other demands for "energy wood" that include co-firing biomass at coal plants, wood pellet manufacturing, and wood as feedstock for cellulosic biofuels, will increase air pollution, accelerate forest cutting, and transfer millions of tons of forest carbon directly into the atmosphere right when forest carbon storage is needed most.

What is biomass energy?
There are four basic types of biomass energy technologies:

- Burning or gasifying biomass to produce steam to turn turbines to generate electricity
- Burning biomass to generate heat in thermal systems (when combined with electricity generation this is known as "combined heat and power", CHP)
- Processing biomass feedstocks to produce liquid fuels like corn ethanol or other biofuels
- Collecting gases from landfills or anaerobic digesters to produce energy.

This write-up focuses on combustion of biomass to produce heat and power, recognizing that many of the feedstocks for biofuels are the same materials that are burned for energy generation.

The main types of biomass fuel are forest wood, sawdust and chips from sawmills, "urban wood" (mostly construction and demolition waste), energy crops (such as switchgrass and willow), and crop residues like corn stalks left in the field after harvest. Other "biomass" fuels include chicken litter and the biological portion of municipal waste. With certain exceptions, however, despite the variety of different types of fuel in theory, the current rapid expansion of the biomass energy sector is dependent almost entirely on forest wood.

Utility-scale plants operate at a range of efficiencies, though most new proposals will be about 24% efficient (the very largest plants claim to be around 29% efficient). Some smaller plants are operated for combined heat and power (CHP), which can increase plant efficiency (efficiency is calculated as the ratio of useful btu's recovered to btu's of heat input).

What do "energy wood" proposals mean for forests and air emissions?
There are currently more than 115 new biomass burning electricity generating facilities in various stages of development nationally, and a number of coal plants that plan to co-fire biomass. There are hundreds of proposals nationally for smaller, thermal only burners. There are currently 13 proposals nationally for liquid biofuels plants that will use wood as feedstock, and more than 40 recently built or proposed wood pellet plants. Most of these projects plan to become operational in the next three years,

The average capacity of the biomass burners currently proposed is about 38 MW, but there are more than 30 plants being built in the 50 – 110 MW range, and an as-yet-undocumented number of biomass co-firing proposals for coal plants.

A 50-megawatt plant burns around 2,550 pounds of green wood per minute. Here's a photo of the McNeil biomass plant in Burlington, Vermont, showing the size of the woodpile, and the piles of logs awaiting chipping as fuel.

(Many thanks to Chris Matera of [Massachusetts Forest Watch]() for providing this photo)

McNeil's [own documentation]() states that the plant is fueled with "low-quality trees and logging waste" (so much for claims by biomass developers that they don't use whole trees as fuel) and that the plant burns 76 tons of wood an hour.

The more than 115 "standalone" biomass plants planned to come on line in the next three years will burn around 55 million tons of wood, or the equivalent of about 650,000 clear-cut acres per year by 2014, assuming average forest biomass per acre in the US. An unknown amount of wood will be required for co-firing in coal plants, with estimates for Ohio alone, where the State's Public Utilities Commission has approved over 2,100 MW of biomass power, of about 20 million tons of wood required for fuel annually. Wood demand from new and proposed wood pellet production facilities represents about another 20 million tons a year, and wood demand for liquid biofuels represents another 10 million tons per year, for a combined "clearcut equivalent" of about 1.2 million acres *per year* to meet emerging biomass energy wood demand.

We show these numbers to convey the magnitude of what's proposed; that doesn't mean we assume that forests will be clear-cut for fuel, although Maine, the state with the most biomass plants now, allows clear-cuts of up to 250 acres for biomass. It is important to realize, however, that if forests are *not* clear-cut to provide fuel – for instance, if only half the wood per acre is removed – it will take twice as many acres of forest to supply the needed wood. It is not uncommon for biomass operations to remove half the standing trees, because the large equipment used for industrial scale biomass harvesting can't operate in a tight environment, and also because biomass harvesting is not cost-effective unless it's done intensively. Biomass proponents make many claims that "thinning" forests for biomass "improves" forest health, but such claims should be contrasted with the wreckage left after an industrial biomass harvesting operation has moved through a forest.

What's behind the explosion in biomass energy?
Biomass energy is booming because in theory, biomass energy is renewable and "carbon neutral" and can reduce carbon emissions that accelerate global warming. Because it is considered renewable it is eligible for multiple tax credits, subsidies, and incentives. In practice, however, wood-burning biomass is the biggest carbon polluter of all, per unit of energy generated. It is worse than coal, worse than oil, and worse than natural gas, both because of the low energy to carbon ratio inherent in wood, and also because biomass facilities generally operate at considerably lower efficiencies than fossil fueled facilities. Typical CO_2 emissions at a utility-scale biomass plant are 150% those of a coal-burner, and 300 – 400% those of natural gas facility (click here for a more detailed explanation of carbon accounting for biomass).

Biomass plants that burn "waste" wood that would decompose and emit carbon dioxide even if not used as fuel, are often considered as carbon neutral. Proponents argue that since this material will end up as CO_2 in the atmosphere anyway, why not use it to generate some power in the meantime? However, it is important to remember that burning emits carbon instantaneously, while decomposition takes years and even decades, and in the case of the waste wood left over from logging operations, actually builds soil carbon in the meantime.

While people can argue about whether burning waste is really carbon neutral in a meaningful timeframe, there really shouldn't be any argument about whether it's a good idea to cut trees to burn in power plants. As shown by the Manomet Study, increasing forest harvesting to provide biomass fuel unambiguously and dramatically increases carbon emissions, relative to fossil fuels, both because wood is such a high carbon, low efficiency fuel, and because cutting forests for fuel decreases their ability to take carbon dioxide out of the atmosphere. This combined effect of high stack emissions and degradation of forest carbon uptake capacity contributes to high "net" emissions for biomass power (see more here).

Biomass power threatens forests and will increase CO_2 emissions
The vast majority of the over 115 biomass electricity generating plants under construction or in the permitting process plan on burning wood as fuel. Proponents of biomass typically claim that biomass plants will be powered by branches and treetops left over from commercial logging operations, but these claims don't stand up to scrutiny. To the contrary, in every state we have analyzed, including Washington, Vermont, Massachusetts, Wisconsin and New York, the amount of slash generated by logging operations falls far short of the amount needed to feed the proposed biomass burners. In other states, including Ohio and North Carolina, utilities have been more forthright and simply admitted that biomass electricity generation means cutting and burning trees.

Although the trees burned in these boilers may eventually grow back, it takes many decades, if not a century, to "renew" the forest resource and "neutralize" the substantial and immediate pulse of carbon injected into the atmosphere when they are burned. And in any case, simply re-growing biomass that has been cut and burned doesn't necessarily reduce net energy emissions compared to simply continuing to burn fossil fuels, because using biomass to generate energy emits a lot more carbon than using fossil fuels, while diminishing the ability of forests to sequester carbon for decades (see the section on carbon emissions for a more detailed explanation of why biomass facilities are not renewable or carbon neutral in any meaningful sense of the terms).

Biomass Thermal vs. Electricity Generation

Using biomass for heating is fundamentally more efficient than using it to drive a turbine for electricity generation, meaning that fuel demand per unit useful output is reduced. In general, biomass burners operated for heat, or for combined heat and power, are also significantly smaller than utility-scale electrical generating plants, which demand hundreds of thousands of tons of wood a year. These facts combined mean that thermal biomass and combined heat and power generation represents less of a threat to forests than large-scale electricity generation plants.

But biomass energy for thermal and electrical generation do share many of the same problems as utility-scale power generation.

Whatever the size of the biomass burner, if it is fueled by increased forest harvesting, its net carbon emissions will be greater than a comparably sized fossil fueled facility, requiring years to multiple decades for forest regrowth to erase the carbon debt created by removing trees. The 2009 Searchinger et al paper "Fixing a critical climate accounting error" provides a concise description of why increasing forest harvesting for fuel increases carbon emissions. The Manomet Study provided the research and modeling that showed why this is true on the ground, demonstrating that fueling even small, efficient biomass burners with whole trees increases net carbon emissions over using fossil fuels for two to three decades.

And fuel demands for even small facilities can be a challenge to meet. In 2004, Middlebury College in Vermont conducted a wood fuel sustainability study that concluded that their proposed (now built) 2 MW combined-heat-and-power gasification plant would require 40,000 acres of forest to provide fuel, once current sawtimber and firewood demands on the forest were taken into account. Scaled up, such a proposal would require one million acres of land to supply a 50 MW plant. Middlebury College has since initiated a pilot willow-growing project, to provide fuel when the local chip supply tightens, although early results from a test-firing of the willow fuel indicate that fuel moisture is a significant problem. The Middlebury plant uses about 20,000 tons of fuel a year, compared to the 650,000 tons per year that a 50 MW facility requires.

Some biomass burners are fueled by wood pellets, which burn more cleanly and efficiently than the raw green wood typically burned at utility-scale biomass plants. This is because wood pellets are generally made of the white, debarked trunkwood of larger trees, which has been dried to produce optimum combustion. Given the inputs required to create pellet fuels, the process of pellet production itself is extremely wasteful and polluting, requiring about two and a half tons of trees to produce one ton of finished pellets and emitting large amounts of particulate matter and other pollutants. Pellet production, primarily for thermal biomass, is a looming threat to forests and climate as demand for pellets grows steadily, particularly in European markets.

And biomass energy facilities of all scales can be significant air polluters. In particular, pollution from small thermal systems can be problematic due to their low smokestack heights, minimal emissions controls, and close proximity to sensitive populations such as school children. Large facilities typically have more sophisticated pollution control equipment, but the sheer amount of wood burned means that these plants typically emit tens to hundreds of tons of hazardous air pollutants, particulate matter, nitrogen oxides, sulfur dioxide, and carbon monoxide (see the section on air pollution for more details).

Air pollution emissions from biomass

Burning wood emits large amounts of air pollution, and existing biomass plants in the US are generally quite old and lacking modern emissions controls. EPA recently fined two plants in California's Central Valley for failing to install emissions controls and otherwise flaunting responsible practice.

While new biomass burners are somewhat cleaner than existing plants, it is surprising to most people that wood, supposedly a "clean" fuel, has an emissions profile very similar to that of coal. (See the air pollution section for more detail). EPA recently acknowledged this by setting a single “solid fuels” emission standard for coal and biomass for the pollutants regulated under the “boiler rule”, which is the part of the Clean Air Act that regulates emissions of hazardous air pollutants. Allowable emissions of particulate matter, hydrochloric acid, and mercury are the same for biomass and coal under the boiler rule, and allowable emissions of carbon monoxide (which EPA treats as a proxy for organic HAPs like formaldehyde and benzene) and dioxins/furans are considerably higher for biomass than coal.

Emissions of pollutants from burning any fuel are a function of the emissions inherent to combustion, and the efficacy of emissions controls. The largest biomass plants are small in comparison to an average coal plant, and it is generally not cost-effective for biomass plants to install the most effective control technologies. Consequently, claims that biomass is “cleaner burning” than coal are not justified, with the exception that sulfur emissions from coal are almost always higher than from biomass (though sulfur dioxide emissions from biomass plants burning sulfur rich fuels will overlap with emissions at the lower end of coal plants burning low-sulfur coal; this would be the case with the sulfur emissions limit set for the We Energies/Domtar biomass plant in Wisconsin; see our comments)

To give an idea of how much pollution a biomass plant can produce, here are emissions numbers from the air permit and application documents for the proposed 100 MW Gainesville Renewable Energy Center (GREC) in Florida, contrasted with air permit numbers from the Pioneer Valley Energy Center (PVEC), a 431 MW gas and diesel plant proposed in Westfield, Massachusetts.

The 100 MW Gainesville Renewable Energy biomass plant will emit dramatically more pollution than a 431 MW gas/diesel plant in Massachusetts, both as total tons, and as lb per MWh	GREC: 100 MW biomass: tons per year	GREC biomass lb/MWh	PVEC: 431 MW nat gas/diesel: tons per year	PVEC: nat gas/diesel lb/ MWh	GREC rate as % PVEC rate
Nitrogen oxides	416.4	0.95	91.9	0.05	1953%
Carbon monoxide	713.8	1.63	59	0.03	5214%
Particulate matter	249.8	0.57	49.1	0.03	2193%
Sulfur dioxide	243.9	0.56	16.7	0.01	6295%
Volatile organic compounds	77.3	0.18	23.8	0.01	1400%
Hazardous air pollutants	24.7	0.06	5.1	0.003	2087%
Carbon dioxide	1,232,225	2,813	1,432,825	759	371%

Greenhouse gas emissions from biomass burning

Burning one ton of green wood emits a little more than one ton of CO_2 (assuming wood has 45% moisture content, an industry standard). Carbon dioxide from new standalone facilities will be about 55 million tons per year, or 78 million tons if preliminary estimates of co-firing are included. Emissions from the standalone biomass facilities are about 50 percent worse than coal per megawatt of energy produced and three to four times (400%) the emissions from natural gas, although emissions from a biomass boiler will be 612% those from a new natural gas boiler at the We Energies/Domtar plant in Wisconsin (click here for our letter on that project). For perspective, 78 million tons of carbon dioxide emissions projected to be emitted annually by recent and proposed biomass burning is about the same amount of fossil-fuel CO_2 emissions from the combined electric power sectors in AK (4.7 m tons), ME (5.2 m tons), NH (6.1 m tons), CT (8.9 m tons), HI (9.5 m tons), OR (10.4 m tons), WA (14.9 m tons), and NJ. (17.7 m tons) in 2009.

Current regulation

In January 2010, the EPA proposed to give all biomass burning facilities a three-year exemption from CO_2 monitoring and emissions controls under the so-called “tailoring rule” of the Clean Air Act (the formal proposal was issued in March 2011). The agency is now embarking on a review to determine how to account for carbon emissions from biomass electricity generation. The outcome of this review will greatly influence the industry's long-term viability, but the three-year suspension of permitting means that plants will rush to be built and thus be grandfathered and exempt from carbon accounting if and when EPA reinstitutes it.

Notably, the state of Massachusetts completed a similar multi-stakeholder review in about 7 months. The state-commissioned "Manomet" study concluded that in New England forests, it would take 40 years of re-growth to draw the carbon pollution from biomass electricity generation down to parity with burning coal for those same four decades. True carbon neutrality, meaning that all the carbon released when trees are burned has been recaptured, would take many more decades still. A review of the Manomet study suggests that due to a number of assumptions made in the report, actual time to achieve parity with fossil fuel emissions may be even longer than was concluded.

Concurrently, EPA's new boiler rule sets emission limits on particulate matter, carbon monoxide, hydrochloric acid, dioxins, and mercury, for commercial and industrial boilers that emit more than 25 tons of specified hazardous air pollutants per year. For those that claim emit less, much weaker standards apply (see the section on air pollution for more details). Particulate matter and carbon monoxide are also regulated as critieria air pollutants, along with nitrogen dioxide (NO_2), sulfur dioxide (SO_2), volatile organic carbons (VOCs) and lead. Biomass plants basically go through the same permitting procedures as other facilities with regard to meeting emissions thresholds, etc; however, the Clean Air Act and other environmental legislation contain certain loopholes for biomass power facilities.

Biomass: Coal's Secret Weapon

In several states, particularly Ohio, coal-burning power plants are blending wood with coal to meet state renewable energy mandates. Burning wood with coal actually increases carbon emissions and can require significant amounts of wood given the relative enormity of most coal plants. The 2,100 MW of biomass power approved by the Ohio Public Utilities Commission would require about 20 million tons of wood fuel a year (see the website of the Buckeye Forest Council for more information on biomass in Ohio). But because biomass is considered carbon neutral and renewable, burning forest wood in coal-fired power plants qualifies for renewable energy credits and helps utilities attain renewable energy goals.

Burning biomass is also being eyed as the primary means for coal fired-power plants to "reduce" carbon emissions under future federal climate legislation. There is no existing technology that can reduce CO_2 pollution from coal burning power plants. Carbon capture and sequestration is decades away from commercial viability, if it ever is perfected. Burning trees, however, is viable today, and as long as it is wrongly considered carbon neutral it will remain the carbon emission reduction strategy of choice for coal-fired power plants.

Subsidies and incentives for biomass power

Biomass power benefits handsomely from its classification as renewable energy, which makes it eligible for a raft of federal, state, and ratepayer subsidies and tax breaks. Five are especially important.

Renewable Energy Credits - Burning biomass generates Renewable Energy Credits (RECs) under current carbon accounting rules and renewable energy definitions. The definition of biomass as renewable and carbon neutral is integral to the eligibility of biomass facilities to receive Renewable Energy Credits (RECs). Every megawatt-hour of electricity generated at a biomass plant is accompanied by a REC, which can then be sold to power providers who are obligated to purchase a certain amount of energy from renewable sources. The REC's can be sold separately from the power itself, which is fed into the grid and becomes indistinguishable from power generated from conventional sources. RECs thus essentially serve as a demonstration that a certain amount of power has been generated from renewable sources. The value of RECs fluctuates significantly, but at current prices, a 50 MW biomass plant may generate from $5 million to $10 million a year.

Energy Production Tax Credit - Biomass energy is eligible for a 1.1 cent per kilowatt hour energy production tax credit for five years, a rate that reduces the tax burden of a typical 50 MW plant by about $4.4 million per year.

Investment Tax Credit or Section 1603 Treasury Grants - Instead of taking the production tax credit, biomass developers can choose an investment tax credit (ITC) created under the 2009 American Reinvestment and Recovery Act (ARRA) as amended. The ITC, reimburses 30 percent of plant development costs if the plant begins construction by the end of 2011. Many proposed plants are eager to begin construction to qualify within the eligibility window for this program, which yields a $30 million to $75 million payout for a typical utility-scale biomass plant.

Exemption from Carbon Allowances - Biomass burners do not have to purchase carbon allowances under regional carbon cap and trade schemes such as the northeast's Regional Greenhouse Gas Initiative. A typical 50 MW biomass power plant would avoid payments of $58 million over the five year period starting in 2012, a savings that would increase to $110 million for the 2021 – 2025. This exemption is particularly disturbing because biomass burners are actually bigger carbon polluters than coal.

BCAP Fuel Subsidies - Biomass suppliers are also eligible for the Biomass Crop Assistance Program, administered by the U.S. Department of Agriculture, that provides matching payment for up to $45 per dry ton (about $25 per green ton) of fuel. The program has been extremely popular, and cost taxpayers $243 million in 2009/2010 – money that paid for sawdust, bark, and woodchips to be burned in facilities that emit about the same air pollution as coal, and dramatically more CO_2 than coal.

The States

In the absence of a federal renewable energy mandate states have stepped into the void with renewable energy (portfolio) standards and greenhouse gas reduction initiatives that set goals and provide incentives for the development of renewable energy (see a list of state and federal programs here). Swept ahead by a flood of state and federal tax breaks and financial incentives, and shielded by the inaccurate definition of biomass energy as carbon neutral and renewable, these goals have produced a nationwide onslaught of proposals to build wood-burning biomass power plants; more than 115 today and climbing.

Biomass battles are brewing in more than a dozen states, from Washington to Massachusetts, Wisconsin, Ohio, Florida, Georgia, Vermont, New Hampshire, North Carolina, Hawaii, Michigan and Maine. Advocates and market conditions have combined to shelve proposed plants in some of these states, but new proposals far outweigh the relatively few withdrawals.

Massachusetts stands out as the one state that has conducted a transparent, independent review of the science on the renewability and carbon neutrality of tree-burning biomass. The resulting Manomet study recommended much tighter criteria for renewable energy credits that would severely limit the eligibility of low-efficiency wood-burning biomass power plants for renewable energy credits.