

Air pollution from biomass energy (updated April 2011)

Despite the frequent depiction of biomass as “clean” energy, data from air permit applications and real smokestack tests demonstrate quite clearly that biomass is a heavily polluting technology.

Burning wood and other biological materials for energy emits as much or more pollution than burning fossil fuels, including coal. Emissions are function of the fuel type, combustion temperature, and pollution controls, but in PFPI’s analysis of air pollution permits in 7 states we have found that biomass burners are always more polluting than natural gas and are similar to coal - admittedly better for some pollutants like sulfur and mercury, but the same or worse for particulates and nitrogen oxides. Being similar to coal hardly qualifies as clean, green energy.

Biomass electricity generation facilities are major air polluters, and in many cases will significantly worsen air quality in the communities and regions where they are constructed. Yet in most cases biomass gets a break because it is (inaccurately) considered [renewable and carbon neutral](#).

The We Energies facility in Rothschild, Wisconsin is an example of regulators allowing a heavily polluting biomass facility to proceed precisely because it is classified as renewable and counts toward the state’s renewable energy goals. According to the facility’s air permit, the new biomass burner, located at the Domtar paper mill, will be a [huge air polluter](#). It will almost certainly throw the region into violation of air pollution health standards for particulate matter, which the US EPA considers a lethal form of air pollution that causes ten of thousands of premature deaths across the country each year and increases the incidence of asthma attacks in children; and it will emit 6 times as much carbon per unit of electricity generated as a natural gas burner being constructed on the same site. State regulators could have required cleaner burning fuels at the plant, but declined to do so specifically because the plant is producing “renewable” energy.

Sanctioning and subsidizing major new sources of potentially lethal air pollution is not what anyone had in mind when establishing renewable energy standards. Regulators should take a clear-eyed, fact-based approach to evaluating whether or not these facilities should operate given the significant air pollution that they cause. In our view, biomass burners should not be allowed to operate until they can show that they are dramatically cleaner than all fossil fuel alternatives, if they are to qualify as renewable energy under state policies.

What kind of pollution does a biomass burner emit?

Burning biomass emits large amounts of pollutants, just like burning other solid fuels such as coal. Burning organic material emits particulate matter (PM), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO₂), lead, mercury, and other hazardous air pollutants (HAPs).

Hazardous air pollutants are a group of [187 toxics](#) that [according to EPA](#) “are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects”. EPA has recently released the newest [National Air Toxics Assessment](#), which characterizes emissions and ambient air concentrations of toxics around the country.

The HAPs emitted in the greatest quantities by burning biomass include the organic HAPs styrene, acrolein, and formaldehyde, and the acid gases hydrofluoric acid and hydrochloric acid,. Biomass burners commonly emit ten tons or more of the acid gases and from one to five tons of organics each year. Even “clean wood” – that is, forestry-derived wood, as opposed to construction and demolition debris – emits these chemicals when burned. Burning clean wood also emits non-negligible amounts of heavy metals. Burning “urban wood” – a friendly term for construction and demolition debris (CDD) – significantly increases emissions of arsenic, chromium, copper, lead, and mercury, as well as dioxins/furans and

pentachlorophenol (PCPs). Biomass developers sometimes claim that sorting out the contaminated wood from CDD produces a “clean” and safe fuel stream, but it is virtually impossible (and not cost effective) to remove the contaminated wood using visual inspection and hand sorting. Even one or two percent contaminated wood can lead to significant emissions of metals when this material is burned (see [a letter documenting the inadequacy of CDD sorting for a proposed CDD-burner in Massachusetts](#), and a [letter from the MA Department of Environmental Health](#) expressing concerns about emissions of metals and other air toxics in the environmental justice community of Springfield, MA, where childhood asthma rates and incidence of high blood lead levels are already twice the State average).

How much pollution do biomass-burning facilities emit?

Most biomass plants do not use the most effective pollution controls, and small-scale biomass burners, like those being installed to provide heat to schools around the country, typically only have minimal controls. Utility-scale biomass plants emit tens to hundreds of tons of particulates, nitrogen oxides, carbon monoxide, and and hazardous air pollutants each year.

Emissions are typically expressed in air permits as pounds of pollution per million btu of heat input (as fuel). The problem with this approach is that it hides differences in efficiency that exist between facilities. Converting these rates so they are expressed in terms of emissions per unit energy delivered to the grid is a more accurate way of evaluating the impact of different technologies and fuels.

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 much larger Pioneer Valley Energy Center (PVEC), a 431 MW gas and diesel plant proposed in Westfield, Massachusetts. The emissions rate for the biomass plant far exceeds that for the gas plant for criteria air pollutants, HAPs, and carbon dioxide. Yet biomass proponents insist on calling biomass a “clean” fuel.

<i>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</i>	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%

Here are some more data on pollution emissions, showing how different the emissions are when the same burner is firing different fuels. The following table is from the air permit application for the Hu Honua facility in Hawaii, an old coal burner that is being retrofitted to burn wood and biodiesel. Pollution emissions from the boiler (here expressed as pounds per million btu) are significantly greater when biomass is used as a fuel:

Boiler Criteria Pollutant Emission Factors

Pollutant	Biomass (controlled) ^a	100% S15 Biodiesel (uncontrolled) ^d
	lb/MMBTU	lb/MMBTU
NO _x	0.15	0.109
CO	0.176	0.055
SO ₂	0.028 ^b	0.002
FPM ₁₀ (filterable)	0.012	0.002
TPM ₁₀ (filterable and condensable)	0.024	0.002
PM _{2.5} ^c	0.024	0.002
VOC	0.028	0.007

^a Biomass emission factors for NO_x, CO, and FPM₁₀ are proposed as Best Available Control Technology (BACT). TPM₁₀ are assumed to be equal to twice the FPM₁₀ emission rate.

^b Average uncontrolled SO₂ emissions expected to be 0.045 lb/MMBtu based on an average sulfur content of 0.01% in the wood but would vary depending on the wood. As needed, 0.028 lb/MMBtu would be achieved through iron or lime injection.

^c Assuming PM_{2.5} is equivalent to TPM₁₀.

^d S15 Biodiesel Emission Factor Basis: PM, NO_x, and CO emission factors for the boiler are from the Minnesota Air Pollution Biofuels Report. VOC based on EPA AP-42, Chapter 1.3. SO₂ based on a sulfur content of 15 ppm in the fuel for S15 biodiesel and 100% conversion of sulfur to SO₂.

Emissions data for school-sized boilers also highlight the difference between biomass and other fuels. The Wyalusing School District in Pennsylvania applied for air permits for a new biomass burner, and a new oil burner. Emissions rates for the biomass burner are higher for PM, NO_x, and CO, but are lower for VOCs and SO₂ (differences in the total tons emitted are to some extent also a function of the different amounts of time the burners are projected to be used.). All rates are in units of lb/mmbtu.

Wyalusing Area School District - emissions from new biomass and oil burners

	PM rate	PM tons	NOx rate	NOx tons	CO rate	CO tons	VOC rate	VOC tons	SO ₂ rate	SO ₂ tons
Oil burner	0.03	0.29	0.12	1.18	0.04	0.39	0.025	0.25	0.21	2.06
Wood burner	0.22	8.68	0.182	7.18	0.163	6.48	0.004	0.16	0.002	0.08

Control of particulate matter

Particulate matter emissions are implicated in a wide range of health impacts, from asthma and heart disease to diabetes. Even when the most sophisticated emissions controls are used, biomass burning produces large amounts of the fine particulate matter that penetrates deeply into the lungs. There are a number of technologies for reducing emissions of filterable particulate matter, but three main technologies are often used with biomass burners. None is truly effective at removing fine particulates.

Cyclone and multicyclone systems rely on centrifugal force to spin particulates out of the flue gas. Cyclonic systems are not effective at removing the fine particulate matter that has the greatest impact on air quality and health, although [according to EPA](#), some high efficiency systems show removal of 60 to 95% for PM₁₀ and 20 to 70% for PM_{2.5}. Cyclone systems are often found as the sole means of PM control at small-scale burners like those installed in schools around the country. Emissions data from the Wyalusing air permit, above, show that a typical school burner may emit around 9 tons of particulate

matter a year. These emissions occur from low stacks and impinge directly on children in playgrounds and as they sit in class.

Electrostatic precipitators (ESPs) use an electric field to remove particles from the flue stream. They can remove up to 99% of fine particles (PM_{2.5}) from the flue gas, although their efficacy in removing ultrafine particles is not well quantified. ESPs are expensive and are not typically installed in building-scale biomass burners.

Additionally, with all these control technologies, we are talking about removal of filterable particulate matter, which is just one component of total particulate matter. The other component is known as “condensable” particulate matter, and it consists of the fine and ultra-fine particles derived from sulfur, nitrogen, and VOC emissions that condense in the atmosphere after the flue gas has left the stack. Because the actual formation of condensable particulate matter depends both on emissions and atmospheric chemistry, it is not well characterized, therefore most air permitting agencies make some assumption about the ratio of condensable to filterable particulate matter when they are writing a permit for the amount of total particulate matter (filterable plus condensable) emitted by a facility. Such assumptions may or may not be well-justified.

Fabric filters or baghouses are generally considered the most effective means of emissions control for filterable particulates. They can show control efficiencies upwards of 99%. They are installed at some mid-sized facilities and many utility-scale facilities.

The amount of particulate matter emitted from a biomass burner is highly sensitive to small differences in control efficiency. The following table shows how much filterable PM₁₀ is emitted in four different scenarios. Note that the first scenario combusts a much smaller amount of wood than the other three – this is meant to represent the operation, for instance, of a biomass burner at a mill that is generating power and heat for its own operation. Despite the relatively small amount of wood burned, the average control efficiency of 80% for the multiclone system means that PM emissions are quite high.

The three other scenarios (2-4) show a larger amount of wood, such as would be burned at a utility-scale biomass plant supplying power to the grid, and three different levels of control efficiency. Even a few tenths of a percent of control efficiency make a large difference to the total tons of PM emitted. This is also relevant to control of heavy metals, which are generally assumed to be emitted as a component of particulate matter, with the exception of mercury, which is emitted as a vapor.

Control of filterable particulate matter

Scenario	Control technology	control efficiency	uncontrolled		tons PM (uncontrolled)	PM rate (lb/mmbtu)	tons PM emitted
			PM10 (lb/mmbtu)	tons wood			
1	Multiclone	80.0%	6.5	26,000	799	1.3	160
2	ESP	99.0%	6.5	400,000	12,298	0.065	123
3	Baghouse	99.5%	6.5	400,000	12,298	0.0325	61
4	Baghouse	99.9%	6.5	400,000	12,298	0.0065	12

Emissions from small-scale biomass burning compared to wood stove emissions

Biomass proponents will sometimes claim that biomass burners “emit less pollution than a woodstove”. For well controlled facilities, per unit wood burned, this is true, because baghouses and other pollution control equipment reduce the amount of pollution emitted. However, the sheer amount of material burned

in a utility-scale facility or even at a medium-sized sawmill means that pollution emissions massively exceed those from a residential wood-burner. And the emissions are no less harmful. The size distribution of the particulate matter that escapes control by a baghouse or ESP is shifted toward the smallest size fractions – and in the case of particulates (not to mention all the other pollutants) what you can't see can definitely can hurt you.

But what about a school-sized facility, compared to a woodstove? Estimates of the amount of particulate matter emitted by a residential woodstove vary by a factor of ten or more, but assuming an average PM emission rate of 30 grams per hour (a value between old woodstoves and EPA-certified woodstoves), and assuming 6 months of stove operation at 18 hours per day, the average woodstove emits about 214 lb of particulate matter over the heating season. Assuming 6 months of operation for a school sized boiler of about 4 mmbtu, such a facility might emit around 1.9 tons of particulate matter. This would then be about the equivalent of PM emissions from about 18 residential woodstoves.

How do emissions from biomass plants compare with coal plants?

Different plants have different emissions rates depending the fuel burned, control equipment installed, and how well the facility is operated. The EPA "[BACT Clearinghouse](#)" (BACT means "Best Available Control Technology") contains permitted emission rates for fossil fuel and biomass plants around the country. While the database is not comprehensive, and does not necessarily show the best controlled plants, it provides a representative sample of some of the lower emitting plants around the country. The following table shows a range of emission rates for existing coal plants and biomass plants from the BACT Clearinghouse, as well as the Ryegate biomass plant in Vermont, a recently re-permitted existing plant, and rates from a variety of permits for proposed biomass plants around the country.

The data show that emission rates for NOx at some coal plants are lower than at many biomass plants. If the typical difference in plant efficiency were taken into account and the rates expressed on a per MWh basis, instead of a heat input basis, the difference would be even greater. Similarly, there is a high degree of overlap for CO and PM emission rates between coal plants and biomass plants. Sulfur dioxide (SO₂, or SOx) is the pollutant where emission rates are clearly higher for coal than biomass. The BACT Clearinghouse does not include data on VOC emissions.

boilers > 250 mmbtu/hr, emissions as lb/mmbtu of heat input

	Existing coal	Existing biomass	Ryegate biomass	Proposed biomass
NOx	0.07 (several)	0.065, 0.1 - 0.15	0.15	0.06 - 0.15
CO	0.1, 0.13, 0.135	0.1, 0.19, 0.24, 0.3	0.3	0.0365 - 0.176
PM10 fil	0.01, 0.012	0.02, 0.025, 0.03	0.017	0.008 - 0.015
SOx	0.1, 0.14, 0.245	0.02	0.019	0.012 - 0.042

Some coal plants achieve lower emissions rates than are allowed in their permits. For instance, the Mount Tom coal plant in Holyoke, MA, has turned in stack test data that indicate the plant's SO₂ emission rate is 0.066 lb/mmbtu, lower than any rate reported in the BACT clearinghouse database. The data also indicate a total PM₁₀ emission rate of 0.0059 lb/mmbtu, meaning that yearly emissions of PM10 from this 147 MW facility are around 39 tons per year if the facility operates continuously. In contrast, the 35 MW Palmer Renewable Energy biomass plant to be built in nearby Springfield, MA, will have a total PM10 emission rate of 0.019 lb/mmbtu and will emit 42.4 tons of PM₁₀ per year.

Does co-firing biomass reduce emissions?

Co-firing biomass is sometimes seen as a way to reduce emissions at coal plants, particularly of sulfur dioxide, because wood generally has a lower sulfur content than coal (an exception is construction and

demolition debris, which can have relatively high sulfur content probably due in some part to contamination by gypsum wallboard waste).

While replacing a significant amount of coal with wood would reduce sulfur emissions, the effect on other pollutants is not straightforward. Test-firing data from the Killen coal plant in Ohio, which proposes to co-fire 5% wood by heat content (amounting to over 8% by mass) shows that adding even this small amount of wood to the fuel stream produces dramatic increases in emissions of carbon monoxide and hazardous air pollutants.

The following data are from the Killen plant’s technical support document for the air permit application to co-fire biomass. Metals emissions show some small increases and decreases with addition of biomass, and there are small percentage decreases in emissions of hydrochloric acid and hydrofluoric acid, but the key thing to notice is that replacing 5% of the boiler’s heat input with biomass produces no improvement in criteria pollutant emissions with the exception of a small decrease in lead emissions. It does, however produce large percentage increases in carbon monoxide, volatile organic compounds (VOCs), and certain organic hazardous air pollutants (HAPs).

“PTE” means “potential to emit”, which standardizes emissions by assuming the boiler operates at full capacity 365 days of the year. All emissions are expressed as tons per year (“tpy”).

Boiler #2 (B001)	PTE - Coal only	PTE - Coal/biofuel
Pollutant	tpy	tpy
Particulate (total filterable)/PE	2,596	2,596
PM ₁₀ (filterable)	1,843	1,843
PM _{2.5} (direct)	1,324	1,324
SO ₂	31,158	31,158
NO _x	18,175	18,175
CO	2,596	3,895
VOC	70.1	88.3
Lead	0.45	0.43
Sulfuric acid (H ₂ SO ₄)	38.9	38.9

	PTE - Coal only	PTE - Coal/biofuel
Pollutant	tpy	tpy
POM (reported as PAH)	0.02	→ 0.20
Acetaldehyde	0.66	→ 1.71
Benzene	1.51	→ 6.89
Formaldehyde	0.28	→ 5.98
Toluene	0.28	→ 1.46

The Killen plant will co-fire about 180,000 tons of wood per year, or the equivalent of the wood that could be produced by clearcutting about 2,050 acres of Ohio’s forests per year (we use U.S. Forest Service [data](#) to estimate standing biomass). Increasing the amount of wood co-fired to a level that would actually decrease sulfur emissions would require significantly increasing forest harvesting, and would meanwhile have unacceptably large effects on emissions of other pollutants. Co-firing biomass should not be allowed as a way for coal plants to avoid installing modern pollution control equipment, which is vastly more effective at reducing sulfur emissions than changes in fuel.

Biomass and the Clean Air Act

Large-scale biomass burners are subject to Clean Air Act regulation and permitting like other emitters, with one crucial difference. The Clean Air Act requires “Prevention of Significant Deterioration” (PSD) review for air quality when a new “major source” facility is built or when an existing facility undergoes major modification in an area that is either classed as in attainment, or unclassifiable, with regard to the National Ambient Air Quality Standards (NAAQS). PSD review [requires](#) installation of the Best Available Control Technology (BACT, a standard that takes into consideration the cost of air pollution controls, and allows rejection of some controls as too expensive), air quality analysis, an additional impacts analysis, and public involvement. However, while the threshold for triggering PSD review for a fossil-fueled boiler 250 mmbtu/hr or greater is emission of 100 tons of a criteria pollutant, the threshold for triggering PSD review for a biomass burning facility is 250 tons. This means that a facility burning biomass can emit two and a half times the amount of pollution that a fossil-fueled facility emits before it is subjected to a similar level of scrutiny and emissions control.

Biomass, Hazardous Air Pollutants, and EPA’s “boiler rule”

To reduce the amount of hazardous air pollutants emitted by commercial and industrial boilers, EPA sets limits for certain pollutants under the “boiler rule”, which is part of the Clean Air Act. The boiler rule is especially significant for biomass burners because although the boiler rule regulates fossil-fueled boilers only up to 25 MW in size, it regulates all biomass boilers, no matter how large.

The boiler rule sets the maximum allowable emission limits for just five pollutants, although there are 187 different HAPs recognized by EPA. Setting emissions limits for each one would be difficult, so instead, EPA regulates the majority of pollutants by dividing them into classes and using proxies to estimate how well their emissions are controlled. Under the boiler rule, particulate matter (PM) serves as a proxy for metallic HAPs like arsenic and lead, and carbon monoxide (CO) is regulated as a proxy for organic HAPs like formaldehyde and acrolein. The boiler rule regulates dioxins/furans, mercury, and hydrochloric acid (HCl) directly, with HCl also acting as a proxy for other acid gases (like hydrogen fluoride).

To control emissions of these pollutants, EPA sets maximum emissions rates for different kinds of boilers and different fuels. These emission rates are based on the “best performing” (lowest emitting) units that already exist. To set emissions rates for existing boilers, EPA essentially averages the best performing 12% of boilers, using their emission rates as the standard that all existing units are supposed to achieve. For new as-yet-unbuilt boilers, EPA expects those to achieve the same emission rate as the single best performer (lowest emitter) that already exists. These standards are referred to as Maximum Achievable Control Technology (MACT), and are set for coal, biomass, gas, and other liquid fuels boilers.

EPA further identifies two categories of emission sources under the boiler rule – “major” and “area” sources. A major source is one which emits 25 tons or more of total HAPs, and 10 tons or more of any single HAP (for biomass, the HAP usually emitted in the greatest quantities is hydrochloric acid, or HCl). An “area” source is one which emits HAPs below these thresholds.

Since the emission rules for major sources are considerably more stringent than for area sources, there is a great incentive for facilities to characterize themselves as area sources. Below is a summary of the allowable emission rates for major and area sources. Emission rates for biomass under the major source rule are the same as for coal, except for emission rates of carbon monoxide and dioxins/furans, which are generally higher than for coal.

“Boiler rule” emission rates for major sources.

Subcategory	Particulate Matter	Hydrogen Chloride	Mercury (Hg)	Carbon Monoxide (ppm @3%oxygen)	Dioxin/ Furan (TEQ) (ng/dscm)
Existing –CoalStoker	0.039	0.035	4.6E-06	270	0.003
Existing -Coal Fluidized Bed	0.039	0.035	4.6E-06	82	0.002
Existing –Pulverized Coal	0.039	0.035	4.6E-06	160	0.004
Existing –Biomass Stoker/other	0.039	0.035	4.6E-06	490	0.005
Existing -Biomass Fluidized Bed	0.039	0.035	4.6E-06	430	0.02
Existing –Biomass Dutch Oven/Suspension Burner	0.039	0.035	4.6E-06	470	0.2
Existing –Biomass Fuel Cells	0.039	0.035	4.6E-06	690	4
Existing –Biomass Suspension/Grate	0.039	0.035	4.6E-06	3,500	0.2
Existing –Liquid	0.0075	0.00033	3.5E-06	10	4
Existing – Gas2 (OtherProcess Gases)	0.043	0.0017	1.3E-05	9	0.08
Existing –non-continental liquid	0.0075	0.0003	7.8E-07	160	4
New –Coal Stoker	0.0011	0.0022	3.5E-06	6	0.003
New - Coal Fluidized Bed	0.0011	0.0022	3.5E-06	18	0.002
New – Pulverized Coal	0.0011	0.0022	3.5E-06	12	0.003
New – Biomass Stoker	0.0011	0.0022	3.5E-06	160	0.005
New - Biomass Fluidized Bed	0.0011	0.0022	3.5E-06	260	0.02
New – Biomass Dutch Oven/Suspension Burner	0.0011	0.0022	3.5E-06	470	0.2
New – Biomass Fuel Cells	0.0011	0.0022	3.5E-06	470	0.003
New - Biomass Suspension/Grate	0.0011	0.0022	3.5E-06	1,500	0.2
New – Liquid	0.0013	0.0031	2.1E-07	3	0.002
New – Gas 2 (Other ProcessGases)	0.0067	0.0017	7.9E-06	3	0.08
New – non-continental liquid	0.0013	0.0032	7.8E-07	51	0.002

“Boiler rule” emission rates for “area” sources.

Subcategory	Heat Input (mmbtu/hr)	Pollutants	Emission limit
Coal			
Existing coal-fired boiler	>= 10	Mercury	0.0000048 lb/mmbtu
Existing coal-fired boiler	>= 10	Carbon monoxide	400 ppm by vol @3% O2
New coal-fired boiler	>= 30	Particulate matter	0.03 lb/mmbtu
New coal-fired boiler	>= 30	Mercury	0.0000048 lb/mmbtu
New coal-fired boiler	>= 30	Carbon monoxide	400 ppm by vol @3% O2
New coal-fired boiler	>= 10 and < 30	Particulate matter	0.42 lb/mmbtu
New coal-fired boiler	>= 10 and < 30	Mercury	0.0000048 lb/mmbtu
New coal-fired boiler	>= 10 and < 30	Carbon monoxide	400 ppm by vol @3% O2
Biomass			
New biomass-fired boiler	>= 30	Particulate matter	0.03 lb/mmbtu
New biomass-fired boiler	>=10 and < 30	Particulate matter	0.07 lb/mmbtu
Oil			
New oil-fired burner	>= 30	Mercury	0.03 lb/mmbtu
New oil-fired burner	>= 10 and < 30	Carbon monoxide	0.03 lb/mmbtu

From the heat input levels set in the area source rule, one can see that EPA had in mind regulating relatively small boilers. A 10 mmbtu/hr boiler is representative of the size being installed in some school districts, capable of heating more than one building. A 30 mmbtu boiler is the size used by a small sawmill. However, many of the extremely large boilers being built currently are classified as “area” sources. For instance, the Gainesville Renewable Energy Center, a 116 MW (gross; 100 MW net) biomass burner with a 1,359 mmbtu boiler, is considered to be an “area” source, because the project claims it will emit less than 25 tons of hazardous air pollutants (the exact value in the permit is 24.7 tons of HAPs). This massive project, which will burn well over a million tons of wood a year, will therefore not be held to the stricter standards of the “major” source boiler rule.

An important thing to notice about the area source rule is that while EPA set limits for mercury and carbon monoxide for existing and new coal boilers, to which it adds the regulation of PM for new coal boilers, new biomass boilers are only required to meet PM standards, and there are no standards at all for existing biomass boilers.

Information on air pollutants

Nitrogen dioxide (NO₂)

Nitrogen dioxide (NO₂) is the indicator species for the NO_x group of gases, which includes nitrous acid and nitric acid. It primarily forms when fuels are burned at high temperatures. These acidic gases directly impact respiratory health, and also contribute to formation of ozone and condensable particulate matter. Nationwide, the majority of NO₂ is from the transportation sector, but utilities and other sources of combustion [account for about 34% of total emissions](#).

As of January 2010, EPA set a new 1-hour standard for NO₂ of 100 ppb in ambient air, and retained the annual average pollution standard of 53 ppb.

Ozone

A principle component of smog, ground level ozone is formed when nitrogen oxides (NOx), volatile organic compounds (VOCs), carbon monoxide (CO), and methane react, energized by UV light. The main sources of NOx and VOCs are industrial facilities, electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents. As a highly reactive oxidant gas, ozone aggravates the airways, causing respiratory distress and exacerbating asthma. It also damages vegetation and is increasingly recognized as a threat to forest health.

EPA has [proposed revising](#) its eight-hour standard for ozone from 0.075 ppm to 0.06 – 0.07 ppm, acknowledging that the ozone standards set in 2008 were not as protective as recommended by EPA's panel of science advisors, the Clean Air Scientific Advisory Committee (CASAC). EPA has also proposed a new "[seasonal secondary standard](#)" for ozone exposure that represents cumulative exposure during peak ozone season.

Sulfur dioxide (SO₂)

Sulfur dioxide (SO₂) exposure causes breathing difficulty for people with asthma, and is also implicated in regional haze and acid rain formation. A recent EPA [risk assessment](#) for SO₂ concludes that definite health risks to asthmatics occur at concentrations significantly lower than the current 24-hour health standard for SO₂. The document further notes that "over 20 million people in the U.S. have asthma, and therefore, exposure to SO₂ likely represents a significant health issue." The main sources of SO₂ are fossil fuel combustion at power plants and industrial facilities. Along with its direct effects, SO₂ also contributes to the formation of fine particulate matter. EPA concluded that a new SO₂ standard with a 1-hour averaging time would be more protective. As of June 2, 2010, EPA strengthened the NAAQS for SO₂ by adding a 1-hour standard set at 75 ppb.

Particulate matter (PM)

Fine particle emissions arise from both direct ash emissions from combustion at energy plants, but [also](#) form from emissions of sulfur dioxide, nitrogen oxides, ammonia, and volatile organic compounds. Particulate air pollution has long been known to be associated with increased cardiopulmonary symptoms, asthma attacks, days lost from work due to respiratory disease, emergency room visits, hospitalization rates, and mortality. Two size classes are recognized in regulatory schemes: PM₁₀ and PM_{2.5}, with the numeric value referring to the particle size in microns (a micron is one millionth of a meter). There is no current health standard for PM₁₀; EPA's 24-hour and annual exposure standards for PM_{2.5} are 35 micrograms per cubic meter (µg/m³) and 15 µg/m³. EPA's [most recent risk assessment](#) for PM acknowledges that the current standards are insufficiently protective and indicates that the agency will be lowering the National Ambient Air Quality Standards (NAAQS) for PM_{2.5} once more.

The classes of particulate matter classed as "black carbon" are implicated in a [recent study](#) as having up to 60% of the climate warming effect of CO₂, by both creating "brown clouds" and darkening and thus increasing the heat absorption of snow and ice in polar regions. Controlling soot emissions and thus lessening albedo effects may thus be [an even faster way](#) to mitigate sea ice melting than controlling greenhouse gas emissions. A [recent UN report](#) found that controlling black carbon emissions and ozone could dramatically reduce global warming and improve human health.

Lead

Lead exposure primarily occurs from paint that has not been remediated. Lead exposure in children is linked to a variety of developmental and neurological problems. A [recent study](#) concluded that

"long-term trends in population exposure to gasoline lead were found to be remarkably consistent with subsequent changes in violent crime and unwed pregnancy. Long-term trends in paint and gasoline lead exposure are also strongly associated with subsequent trends in murder rates going back to 1900. The findings on violent crime and unwed pregnancy are consistent with published data describing the relationship between IQ and social behavior. The findings with respect to violent crime are also consistent with studies indicating that children with higher bone lead tend to display more aggressive and delinquent

behavior. This analysis demonstrates that widespread exposure to lead is likely to have profound implications for a wide array of socially undesirable outcomes.”

EPA recently dropped the NAAQS for lead from 1.5 µg/m³ to 0.15 µg/m³.

Carbon monoxide (CO)

Carbon monoxide is a product of incomplete combustion that when inhaled, interferes with oxygen absorption in the blood. Emissions of CO from biomass boilers generally increase with fuel moisture; “good combustion practices” are frequently cited as the best control for CO emissions. Carbon monoxide can accumulate in closed spaces and could be a problem in the vicinity of improperly ventilated combustion sources. Carbon monoxide is treated under EPA’s “[boiler rule](#)” as a proxy for certain organic toxics that are assumed to increase as CO emissions increase.

Hazardous Air Pollutants (HAPs)

Hazardous air pollutants (HAPs) is the group name for 187 compounds which are known to have highly harmful health or environmental effects. The list includes metals like chromium, lead, and mercury, as well as compounds like dioxins (products of combustion that are widely considered to be among the most toxic chemicals known), benzene (a constituent of gasoline) and formaldehyde. EPA has classified two HAPs as human carcinogens (arsenic and the hexavalent form of chromium, CrVI) and four as probable human carcinogens (cadmium, lead, dioxins/furans, and nickel). All of these HAPs, as well as others, can be emitted in significant amounts by biomass energy facilities that burn “urban wood” as fuel, which contains lead-painted wood, wood treated with copper chromium arsenate, and non-wood materials that exacerbate dioxin/furan formation. Monitoring for these pollutants is rare, but emission levels can be high in the vicinity of specific emitters.

Arsenic

Considered a human carcinogen by EPA, arsenic is highly toxic, and is a principle component of copper-chromium-arsenate (CCA) mixture that was used for pressure-treating lumber. Facilities that proposed to burn waste wood generally rely on visual sorting techniques to remove arsenic-containing pressure-treated wood from the CDD that it burns. However, such detection can be difficult, as noted by the Massachusetts Department of Environmental Protection [website](#), which states

“You can usually recognize pressure treated wood by its greenish tint, especially on the cut end, and staple-sized slits that line the wood. However, the greenish tint fades with time, and not all pressure treated wood has the slits”.

Hexavalent chromium

Chromium is also a constituent of pressure-treated wood, and is toxic, particularly in the hexavalent form (CR VI). EPA’s [website](#) states: “The respiratory tract is the major target organ for chromium (VI) toxicity, for acute (short-term) and chronic (long-term) inhalation exposures. Shortness of breath, coughing, and wheezing were reported from a case of acute exposure to chromium (VI), while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposure. Human studies have clearly established that inhaled chromium (VI) is a human carcinogen, resulting in an increased risk of lung cancer. Animal studies have shown hexavalent chromium to cause lung tumors via inhalation exposure.” EPA’s [conversion constant](#) for the proportion of total chromium from biomass burning that is emitted in the hexavalent form is 56%.

Mercury

Mercury is a significant and dangerous contaminant that damages neurological development and other organ functions. It accumulates up food chains, presenting the greatest threat to humans and fish-eating birds like loons. Mercury is transported in the atmosphere but a significant amount from a point source can be deposited nearby, contaminating soils and water bodies. Biomass burning can emit surprisingly high amounts of mercury; for instance, the 21.5 MW Hu Honua facility planned in Hawaii [would emit](#) about 10 lb of mercury per year. This emissions rate is about 0.053 lb/kWh, more than 21 times the

0.0025 lb/kWh [emissions rate](#) at the Mount Tom coal plant in Holyoke, Massachusetts. To be sure, the rate at the coal plant is this low because the facility has installed expensive emissions control equipment – equipment that biomass developers refuse to install because it is not “cost effective”.

Dioxins/Furans

Dioxins/furans are “persistent, bioaccumulative, and toxic” (PBT) compounds that are created as by-products of chemical manufacturing, and also from combustion. Dioxin/furans are known to affect hormone levels and functions, as well as affecting fetal development, the immune system, and reproduction. They are toxic at levels that already exist in the environment. EPA [states](#): “Because dioxins are widely distributed throughout the environment in low concentrations, are persistent and bioaccumulated, most people have detectable levels of dioxins in their tissues. These levels, in the low parts per trillion, have accumulated over a lifetime and will persist for years, even if no additional exposure were to occur. This background exposure is likely to result in an increased risk of cancer and is uncomfortably close to levels that can cause subtle adverse non-cancer effects in animals and humans.”