

**Prevention of Significant Deterioration  
Air Pollution Control Construction Permit Application**

**Appendix D.**

**Case-by-Case Maximum Achievable Control  
Technology (MACT) Analysis for the Biomass-Fired  
Boiler, and Natural Gas-Fired Boiler under Section  
112(g) of the Clean Air Act.**

**50 MW Biomass-Fueled Cogeneration Facility to be Located  
at the Domtar – Rothschild Mill.**

**March, 2010**

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# Executive Summary

Section 112 of the 1990 Clean Air Act Amendments requires the U.S. EPA to develop standards to control emissions from major sources of hazardous air pollutants (HAPs) in source categories on the 112(c) list to levels consistent with the lowest emitting facilities in similar source categories. These National Emissions Standards for Hazardous Air Pollutants (NESHAPs) require the application of the *maximum achievable control technology* (MACT). Section 112(g)(2) of the CAA requires a “case-by-case” MACT determination for new major sources in source categories on the 112(c) list where EPA has not established a NESHAP. Because the U.S. EPA has not established MACT standards for new industrial boilers, We Energies has prepared this case-by-case MACT analysis for the biomass-fueled and natural gas-fueled boilers.

HAPs emitted from biomass-fueled boilers may be classified in four categories: 1) Inorganic, solid phase HAPs, 2) Inorganic, acid gas HAPs including hydrogen chloride (HCl) and hydrogen fluoride (HF), 3) Organic HAPs, and 4) Mercury. The proposed emission standards representing the case-by-case MACT for these HAP categories are summarized in Table ES-1. The limits in Table ES-1 reflect the combustion of biomass fuels and natural gas in an advanced circulating fluidized bed boiler, in combination with a fabric filter baghouse. These control technologies are similar to those used on the best performing similar units reviewed in this analysis.

**TABLE ES-1. Proposed emission standards representing MACT.**

HAP CATEGORY	PROPOSED EMISSION LIMIT
Inorganic, solid phase HAPs	Inorganic, solid phase HAP emissions from the circulating fluidized bed boiler shall be controlled using a fabric filter baghouse as MACT. The proposed PM, PM <sub>10</sub> , and PM <sub>2.5</sub> BACT emission limits represent MACT.
Organic HAPs	Organic HAP emissions from the biomass fuels-fired circulating fluidized bed boiler shall be controlled using good combustion practices as MACT. The proposed CO and VOC BACT emission limits represent MACT.
Hydrogen Chloride (HCl)	Hydrogen chloride (HCl) emissions from the circulating fluidized bed boiler shall be controlled using biomass fuels in combination with a fabric filter baghouse as MACT. Hydrogen chloride (HCl) emissions may not exceed 0.018 lb/mmBtu.
Hydrogen Fluoride (HF)	Hydrogen fluoride (HF) emissions from the circulating fluidized bed boiler shall be controlled using biomass fuels in combination with a fabric filter baghouse as MACT.
Mercury	Mercury emissions from the biomass fuels-fired circulating fluidized bed boiler shall be controlled using biomass fuels in combination with a fabric filter baghouse as MACT. Mercury emissions may not exceed 2.9 pounds per trillion Btu.

## **Inorganic, Solid Phase HAPs.**

Inorganic, solid phase HAPs are controlled by particulate matter (PM) control systems. Based on this case-by-case MACT analysis, We Energies has concluded that the proposed fabric filter baghouse represents the best available control technology (BACT) for PM, PM<sub>10</sub>, and PM<sub>2.5</sub> emissions, and also represents MACT for this HAP category. The best performing similar units employ this technology.

## **Organic HAPs.**

Organic HAPs are emitted from biomass combustion as a result of incomplete combustion. The only technically feasible control method used to control organic HAP emissions from similar circulating fluidized bed boilers is the use of good combustion practices to limit organic HAP formation. Good combustion practices can be monitored using carbon monoxide (CO) as a measure of combustion efficiency, and the U.S. EPA has concluded that the monitoring of CO emissions can be used as a surrogate for the control of organic HAPs. Based on this case-by-case MACT analysis, We Energies has concluded that the proposed BACT CO emission limits also represent the MACT for organic HAPs. The best performing similar units employ this technology.

## **Inorganic, Gas Phase HAPs.**

Inorganic, gas phase HAPs include hydrogen chloride and hydrogen fluoride. These acid gases are formed during combustion from chlorine and fluorine in biomass fuels. These gases are effectively controlled by the highly alkaline ash from biomass combustion in combination with a fabric filter baghouse. Based on this analysis, We Energies has concluded that using low chlorine containing biomass fuels in combination with a fabric filter baghouse represents MACT for HCl emissions. The best performing similar units also employ similar controls. We Energies is also proposing an HCl limit of 0.018 lb/mmBtu.

Based on the available information and permits reviewed, no biomass-fueled boilers were identified with a specific HF emission limit. Based on this case-by-case MACT analysis, We Energies has concluded that using low fluorine containing biomass fuels in combination with a fabric filter baghouse represents MACT for HF emissions. The best performing similar units also employ similar controls.

In the beyond the floor MACT analysis, flue gas desulfurization (FGD) systems, including dry sorbent injection, were evaluated as a potential HCl and HF control technologies. However, the continuous reduction of HCl emissions from biomass combustion by the use of FGD systems and sorbent injection is not demonstrated in practice. Because biomass combustion has high levels of alkali substances in the ash, the additional injection of sorbent may not achieve emission reductions. Even these controls could further reduce HCl emissions, the costs of control would be extremely high, with an average cost effectiveness for the dry sorbent injection system of \$40,000 per ton of HCl controlled. Finally, the use of sorbent injection may adversely impact the reuse of this ash, which would have substantial environmental impacts and additional economic impacts.

## Mercury.

Mercury (Hg) is a trace element in biomass. When biomass is burned, mercury exits the boiler at extremely low concentrations, on the order of parts per *billion*. The proposed fuels for this boiler, including natural gas and biomass fuels, have inherently low mercury concentrations. Based on the available information, the only mercury control used on similar, biomass-fueled boilers is the use of low mercury containing biomass fuels combined with the use of PM control systems. Permitted emission limits for similar biomass-fueled boilers range from 2.27 to 25 pounds per trillion Btu of heat input. Based on the available data, we concluded that the MACT floor for mercury emissions from this biomass-fueled boiler is the use of biomass fuels and a fabric filter baghouse. The resulting MACT floor mercury emission rate is 2.9 lb/trillion Btu of heat input. This emission rate represents a reasonable estimate of the performance of the “best controlled similar unit” under the worst reasonably foreseeable circumstances.

In making a case-by-case MACT determination, the permitting authority is expected to look beyond the MACT floor, to evaluate whether a greater degree of reduction in emissions is achievable, taking into consideration the cost of achieving such emission reductions, and any non-air quality health and environmental impacts and energy requirements. In the beyond the floor mercury MACT analysis, we identified the use of activated carbon injection as a feasible mercury control. While we are not aware of the use of activated carbon injection on any biomass-fueled boiler, based on the current coal-fired utility boiler and municipal waste combustor experience, activated carbon injection is a technically feasible mercury control alternative for this biomass-fueled boiler. However, because the concentration of mercury in biomass is expected to be much lower than in coal or municipal solid waste, the use of activated carbon injection will have limited ability to control mercury. Based on this review and the fact that activated carbon injection has not been demonstrated on similar biomass-fueled boilers, we have concluded that the level of mercury emissions with activated carbon injection will be the same as the level of control when firing low mercury containing biomass fuels and the use of a fabric filter baghouse.

Even if activated carbon injection could reduce mercury emissions, the cost effectiveness of the activated carbon injection system, *based only on the capital investment of the sorbent injection system*, would be at least \$21,000 per pound of mercury controlled. Further, the use of activated carbon injection may also adversely impact the potential reuse of the boiler flyash which could have substantial environmental impacts and additional economic costs. Based on the potential impact to ash disposal, the use of activated carbon injection could have an economic cost of \$85,000 per pound of mercury controlled. This is an extremely high cost, especially since there is no evidence that this level of control could actually be achieved in practice.

Based on this analysis, We Energies has concluded that the case-by-case MACT for the control of mercury emissions from this biomass-fueled boiler is the use of low mercury containing biomass fuels, combined with the use of a fabric filter baghouse. Based on this analysis, We Energies proposes a case-by-case MACT emission limit for mercury emissions from this boiler of 2.9 pounds per trillion Btu of heat input.

## Natural Gas-Fueled Boiler.

The proposed natural gas-fueled boiler is also a potential source of HAP emissions. However, because this is a natural gas-fueled boiler, total potential HAP emissions for this boiler will be less than 2,000 pounds per year. As a result, this boiler will be a minor source of HAP emissions and the Section 112(g) case-by-case MACT requirements are not applicable. 61 Fed. Reg. 68,384, 68,388 (December 27, 1996; sources that take enforceable limits resulting in emissions below the major source threshold do not meet the definition of “construct a major source” under Section 112(g)).

Although We Energies believes Section 112(g) of the CAA is not applicable to this natural gas-fueled boiler, a case-by-case MACT evaluation was performed in the event that Section 112(g) is considered applicable. Table ES-2 is a summary of the proposed case-by-case MACT requirements for the control of HAP emissions from the natural gas-fueled boiler. These emission limits are based on the best performing similar units. To limit mercury emissions from similar sources, the U.S. EPA has restricted the allowable fuels to only natural gas – a low mercury containing fuel. The use of only natural gas will limit potential mercury emissions from this boiler to 0.25 pounds per year.

**TABLE ES-2. Proposed emission limits representing MACT for the natural gas-fueled boiler.**

HAP CATEGORY	PROPOSED EMISSION LIMIT
Inorganic, solid	Proposed PM and PM <sub>10</sub> BACT emission limits represent MACT.
Organic	Proposed CO and VOC BACT emission limits represent MACT.
Inorganic, acid gas	HCl emissions shall be controlled by firing only natural gas. HF emissions shall be controlled by firing only natural gas.
Mercury	Mercury emissions shall be controlled by firing only natural gas.

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- Attachment 1. Potential hazardous air pollutant emissions for the biomass-fired boiler B01 (2 pages).



# Chapter 1. Introduction.

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We Energies' proposed 50 MW Biomass-Fueled Cogeneration Facility will include a new combined heat and power steam generating unit that will use a subcritical pressure, advanced circulating fluidized bed boiler to generate steam to power a nominal 50 MW steam turbine generator<sup>1</sup> and to provide process steam to the Domtar facility. Depending on energy requirements, the boiler will operate at full load for the majority of its operating hours; the unit will also be capable of partial load operation. Associated equipment will include fuel and ash handling systems, cooling towers, one natural gas-fueled package boiler and a diesel feed water pump. Based on the control technology review or BACT analysis and proposed BACT requirements, this boiler will utilize a Selective Non-Catalytic Reduction system (SNCR) for the control of nitrogen oxides (NO<sub>x</sub>), a fabric filter baghouse for the control of particulate matter, and PM<sub>10</sub>, felted fabric media in the baghouse for the control of direct PM<sub>2.5</sub>, the use low sulfur containing fuels including biomass fuels and natural gas for sulfur dioxide (SO<sub>2</sub>) control, and the use low fluorine containing fuels including biomass fuels and natural gas for fluorides (as HF) control.

This document is We Energies' case-by-case maximum achievable control technology (MACT) § 112(g) analysis for this Project.

## 1.1 Application Requirements for a Case-by-Case MACT Determination.

The requirements for a case-by-case MACT analysis are described in 40 CFR § 63.43(e). Under this section, an application for a MACT determination shall specify a control technology selected by the owner or operator that, if properly operated and maintained, will meet the MACT emission limit or standard as determined according to the principles set forth in 40 CFR § 63.43(d).

If the MACT determination concludes that a constructed major source would require additional control technology or a change in control technology, the application for a MACT determination must contain the following information, to the extent needed to determine MACT. Note that much of the required information is included in the air permit application and control technology review(s) for this project. The remaining information is included in this report. As a result, all of the required information is included in either the PSD application or in this analysis.

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<sup>1</sup> Actual net unit capacity will be determined during detailed design. Ambient conditions including air temperature, humidity, and water temperature will vary and impact plant operating capacity. Final design with specific equipment by manufacturer and the integration of this equipment, such as the boiler, turbine, generator, fans and air quality control systems will impact the final combined capabilities, auxiliary power requirements and resulting plant capacity. Daily operating conditions including fuel heat content, fuel moisture content, emissions control operations along with boiler and-or turbine fouling will also have impacts on capacity.

**Application requirements for a Case-by-Case MACT determination as described in 40 CFR § 63.43(e).**

(i) The name and address of the major source;	Application
(ii) A brief description of the major source and identification of any listed source category or categories in which it is included;	Application
(iii) The expected commencement date for the construction;	Application
(iv) The expected completion date for construction;	Application
(v) The anticipated date of start-up;	Application
(vi) The HAP(s) emitted by the source, and the estimated emission rate for each such HAP;	Application and this MACT Analysis
(vii) Any federally enforceable emission limitations applicable to the constructed major source;	Application
(viii) The maximum and expected utilization of the source, and the associated uncontrolled emission rates for that source;	Application
(ix) The controlled emissions for the source in tons/yr at expected and maximum utilization;	Application and this MACT Analysis
(x) A recommended emission limitation for the constructed or reconstructed major source consistent with the principles set forth in paragraph (d) of this section;	This MACT Analysis
(xi) The selected control technology to meet the recommended MACT emission limitation;	This MACT Analysis
(xii) Supporting documentation including identification of alternative control technologies considered by the applicant to meet the emission limitation; and	This MACT Analysis
(xiii) Any other relevant information required pursuant to subpart A.	This MACT Analysis

# Chapter 2. Case-by-Case MACT Analysis Methodology.

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## 2.1 Maximum Achievable Control Technology Definition.

The definition of MACT for new sources is found in section 112(d)(2) and (3) of the Clean Air Act:

(2) STANDARDS AND METHODS.—Emissions standards promulgated under this subsection and applicable to new or existing sources of hazardous air pollutants shall require the maximum degree of reduction in emissions of the hazardous air pollutants subject to this section (including a prohibition on such emissions, where achievable) that the Administrator, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements, determines is achievable for new or existing sources in the category or subcategory to which such emission standard applies, through application of measures, processes, methods, systems or techniques including, but not limited to, measures which—

(A) reduce the volume of, or eliminate emissions of, such pollutants through process changes, substitution of materials or other modifications,

(B) enclose systems or processes to eliminate emissions,

(C) collect, capture or treat such pollutants when released from a process, stack, storage or fugitive emissions point,

(D) are design, equipment, work practice, or operational standards (including requirements for operator training or certification) as provided in subsection (h), or

(E) are a combination of the above.

None of the measures described in subparagraphs (A) through (D) shall, consistent with the provisions of section 114(c), in any way compromise any United States patent or United States trademark right, or any confidential business information, or any trade secret or any other intellectual property right.

(3) NEW AND EXISTING SOURCES.—The maximum degree of reduction in emissions that is deemed achievable for new sources in a category or subcategory shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source, as determined by the Administrator.

MACT is generally a two-step process: establishing the MACT floor (the emission limit achieved in practice by the best-controlled similar source) and then performing a beyond the floor evaluation (whether stricter controls are achievable in light of costs, non-air quality health and environmental impacts and energy requirements). MACT for new sources is defined in 40 CFR § 63.41 as:

*Maximum achievable control technology (MACT) emission limitation for new sources* means the emission limitation which is not less stringent than the emission limitation achieved in practice by the best controlled similar source, and which reflects the maximum degree of reduction in emissions that the permitting authority, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements, determines is achievable by the constructed or reconstructed major source.

The principles of case-by-case MACT have been codified in 40 CFR § 63.43(d):

*(d) Principles of MACT determinations.*

The following general principles shall govern preparation by the owner or operator of each permit application or other application requiring a case-by-case MACT determination concerning construction or reconstruction of a major source, and all subsequent review of and actions taken concerning such an application by the permitting authority:

(1) The MACT emission limitation or MACT requirements recommended by the applicant and approved by the permitting authority shall not be less stringent than the emission control which is achieved in practice by the best controlled similar source, as determined by the permitting authority.

(2) Based upon available information, as defined in this subpart, the MACT emission limitation and control technology (including any requirements under paragraph (d)(3) of this section) recommended by the applicant and approved by the permitting authority shall achieve the maximum degree of reduction in emissions of HAP which can be achieved by utilizing those control technologies that can be identified from the available information, taking into consideration the costs of achieving such emission reduction and any non-air quality health and environmental impacts and energy requirements associated with the emission reduction.

(3) The applicant may recommend a specific design, equipment, work practice, or operational standard, or a combination thereof, and the permitting authority may approve such a standard if the permitting authority specifically determines that it is not feasible to prescribe or enforce an emission limitation under the criteria set forth in section 112(h)(2) of the Act.

(4) If the Administrator has either proposed a relevant emission standard pursuant to section 112(d) or section 112(h) of the Act or adopted a presumptive MACT determination for the source category which includes the constructed or reconstructed major source, then the MACT requirements applied to the constructed or reconstructed major source shall have considered those MACT emission limitations and requirements of the proposed standard or presumptive MACT determination.

The guiding principle for new sources under section 112(d)(3) of the CAA and 40 CFR § 63.43(d)(1) is: “[t]he maximum degree of reduction in emissions that is deemed achievable for new sources in a category or subcategory shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source.” When a standard must be achievable, it must be achievable under most adverse circumstances which can reasonably be expected to recur. Thus, the MACT standard should be set at a

level that is a reasonable estimate the performance of the best controlled similar unit under the worst reasonably foreseeable circumstances.

The guiding principle for new sources under section 112(d)(3) of the CAA and 40 CFR § 63.43(d)(1) is: “[t]he maximum degree of reduction in emissions that is deemed achievable for new sources in a category or subcategory shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source.” While this sentence is relatively straightforward, it can be difficult to follow in practice. The stumbling block for review agencies has often been the phrase, “achieved in practice”. How is “achieved in practice” determined?

The D.C. Circuit Court has ruled that where the law requires a standard be achievable, “it must be achievable under most adverse circumstances which can reasonably be expected to recur.” With respect to implementing section 112(d)(3), the D.C. Court has ruled that EPA is justified in setting the standard at a level that is a reasonable estimate of the performance of the “best controlled similar unit” under the worst reasonably foreseeable circumstances.

Therefore, this case-by-case MACT analysis is based on first identifying the "best performing" similar unit. Then, to account for variability, this MACT analysis includes an objective, engineering analysis to reasonably estimate the performance of the best controlled similar unit under the worst reasonably foreseeable circumstances.

This Project meets the definition of “construct a major source” pursuant to 40 CFR § 63.41(2). It is a new process or production unit that will be constructed at an existing facility and will be a major source of HAP emissions in and of itself. Section 112(g) of the CAA applies to the proposed boilers, but not to the existing Domtar Mill. See 61 Fed. Reg. 68,384, 68,385 and 68,390 (December 27, 1996) (A new process or production unit at an existing major source must itself be inherently emitting- the entire plant site is not the process or production unit) subject to the 112(g) review. See also EPA document dated March 13, 1997, *Questions and Answers on 112(g) Final Rule*, Q9, A9 (when a new major process unit is added to an existing facility, only a new major process unit is subject to review under 112(g), not the entire facility.) Based upon the definition of “construct a major source” within 40 CFR § 63.41 the biomass-fueled CFB boiler should be the exclusive process or production unit subject to Section 112(g), since it is the only process or production unit associated with this Project that would itself be a major source of HAPs.



# Chapter 3. Biomass-Fueled Boiler Case-by-Case MACT Analysis.

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## 3.1 Hazardous Air Pollutant Emissions.

Hazardous air pollutants (HAP) emitted from biomass-fueled boilers may be classified in 4 categories:

<b>CATEGORY</b>	<b>EXAMPLES</b>
1. Inorganic, solid phase HAPs.	Arsenic, Cadmium, Chromium
2. Inorganic, acid gas HAPs.	Hydrochloric acid and Hydrofluoric acid
3. Organic HAPs.	Formaldehyde, 2,3,7,8 TCDD (dioxin)
4. Mercury	

Emission rates are influenced by the chemical characteristics of the fuels, a complex interaction between the various constituents in the fuels, the effectiveness of the combustion process itself, and the emission control technologies employed. Inorganic, solid phase HAPs occur as trace substances in all fuels, including biomass fuels and natural gas. These substances are emitted in solid form, and are effectively controlled by high efficiency particulate matter control systems.

Inorganic, acid gas HAPs include hydrochloric acid and hydrofluoric acid. These acid gases are formed from chlorine and fluorine in the fuels. Hydrochloric acid and hydrofluoric acid are strong acids and are therefore highly reactive. These acid gases are effectively controlled by the highly alkaline ash from biomass combustion in the advanced circulating fluidized bed boiler and in the fabric filter baghouse.

Organic HAPs are emitted from boilers as a result of incomplete combustion. These HAP emissions are best controlled through good combustion practices.

Mercury is a unique pollutant. Biomass fuels contain very small amounts of mercury. Multi-pollutant control systems, including fabric filter baghouse particulate matter control systems are also effective mercury control systems. Mercury specific controls including sorbent injection, oxidation catalysts, and fuel additives are being developed.

Table 1 is a summary of the potential HAP emissions from the biomass-fueled boiler. Detailed HAP emission calculations are included in Attachment 1 to this case-by-case MACT analysis. The HAPs included in this analysis are those HAPs that were identified in U.S. EPA's AP-42, 5th Edition, Wood Residue Combustion, Tables 1.6-3 and 1.6-4 for uncontrolled wood residue combustion, and that are listed as a federal HAP.

**TABLE 1. Summary of HAP Emissions from the biomass-fired boiler by HAP Category.**

Pollutant Category	Potential to Emit	
	tons/yr	% of Total
1 Inorganic, Solid-Phase (20 HAPs)	6.2	8%
2 Inorganic Acid Gases (2 HAPs)	66.6	52%
3 Organic (85 HAPs)	49.4	39%
4 Mercury	0.01	0.008%
<b>TOTAL</b>	<b>122.2</b>	<b>100%</b>

# Chapter 4. Inorganic Solid Phase Hazardous Air Pollutants.

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Inorganic, solid phase HAPs occur as trace substances in the biomass fuels. From Table 2, there are 20 inorganic, solid phase HAPs including antimony, arsenic, beryllium, cadmium, chromium, chromium VI, cobalt, lead, manganese, nickel, and selenium. During combustion, these substances may be volatilized and then re-condense into solid particulate matter as the flue gas cools. These substances are emitted in solid form, and are effectively controlled by modern, high efficiency PM control devices such as the proposed fabric filter baghouse. The Control Technology Review for PM contained in Appendix A of the permit application includes a detailed discussion on PM control from biomass-fueled boilers. These HAPs tend to be enriched on fine PM. Because fabric filter baghouses are more efficient at removing fine PM than other PM control systems, baghouses have higher inorganic, solid phase HAP control efficiencies than other PM, PM<sub>10</sub>, and PM<sub>2.5</sub> control systems.

## 4.1 U.S. EPA Vacated Industrial Boiler MACT Standards.

Pursuant to 40 C.F.R. § 63.43(d), an applicant must consider any proposed § 112(d) MACT standard in a § 112(g) case-by-case MACT determination. Under the vacated National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters, 40 CFR Part 63, Subpart DDDDD, Table 1, particulate matter emissions from new or reconstructed large solid-fuel units are limited to 0.025 lb/mmBtu. This requirement was based on Reference Method 5 or 17, i.e., front half emissions *only*.

## 4.2 MACT Floor Analysis for Inorganic Solid Phase HAPs.

Table 2 is a summary of the required BACT or MACT PM emission limits for new biomass-fueled boilers. Because the boilers in Table 2 are new or modified boilers, these boilers represent the best performing similar units for the control of PM emissions and inorganic, solid-phase HAPs. Based on the information reviewed, the PM emission limits for new biomass-fueled boilers and which have made an initial compliance demonstration range from 0.02 to 0.1 lb/mmBtu, measured as the total filterable and condensable PM. In some cases, the actual emissions are well below these limits. However, MACT for new sources is the maximum degree of reduction that is deemed achievable and shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source. For a standard to be considered achievable, it must be achievable under the most adverse circumstances which can reasonably be expected to occur. Thus, the MACT standard must be set at a level that is a reasonable estimate of the performance of the best controlled similar unit under the worst reasonably foreseeable circumstances.

**TABLE 2. Biomass-fueled boiler particulate matter and PM<sub>10</sub> BACT emission limits.**

Facility	State	Permit Date	Capacity, mmBtu/hr	Primary Fuel	Control System <sup>3</sup>	Limit, lb/mmBtu	
						PM	PM <sub>10</sub>
Yellow Pine Energy Company	GA	May-09	1,529	Wood	FFB	0.01	0.018
South Point Biomass Generation	OH	Apr-06	318	Wood	FFB	0.012	None
Mancelona Renewable	MI	Nov-09	565	Wood	FFB	0.012	0.025
Northern Michigan University	MI	Nov-09	210	Wood	FFB	0.0125	0.025
Nacogdoches Power, LLC	TX	Mar-07	1,374	Wood	FFB	0.015	0.032
Darrington Energy Cogeneration Power Plant	WA	Feb-05	403	Wood / Bark	ESP	None	0.02
Skagit County Lumber Mill	WA	Jan-06	430	Wood / Bark	ESP	None	0.02
Fibrominn Biomass Power Plant	MN	Oct-02	792	Poultry Litter	FFB	0.02	Test <sup>2</sup>
Pub Service of New Hampshire - Schiller Station	NH	Oct-04	720	Wood	FFB	0.025	None
Virginia PWC - Laurention Energy Authority	MN	Aug-05	230	Wood	ESP	0.025	0.025
Hillman Power	MI	Jul-02	300	Wood / TDF	ESP	0.026	None
District Energy St. Paul, Inc.	MN	Nov-01	550	Wood	ESP	0.03	0.03
S.D. Warren Co. - Skowhegan, Me	ME	Nov-01	1,300	Wood	ESP		0.03
Boralex Stratton Energy, LP	ME		672	Wood	ESP		0.03
Wheelabrator Sherman Energy Company	ME	Apr-99	315	Wood	ESP		0.036
Koda Energy	MN	Aug-07	308	Wood / NG	ESP	0.037	0.01
Stoneman Power Plant	WI	Jan-09	340	Wood	ESP	0.06	0.06
Northern Sun	ND	May-06	100	Wood / Hulls	ESP		0.08
Meadwestvaco Kentucky, Inc.	KY	Feb-02	631	Wood	ESP		0.10

**Footnotes**

1. The first limit is for PM or front half emissions; the second limit is for total PM<sub>10</sub> emissions or the combined front and backhalf emissions. Note that many permits only specify the front half emissions.
2. For the Fibrominn biomass-fueled boiler, the permit requires the permittee to conduct performance tests for total condensable PM emissions and propose a limit based on the test results.
3. “FFB” means fabric filter baghouse. “ESP” means electrostatic precipitator.
4. The Schiller Station netted out of PSD review. The limits of 0.025 lb/mmBtu and 0.01 lb/mmBtu on a 24-hour average were established as MACT limits. Compliance is based on Reference Method 5 only.
5. The first limit for the Hillman Power Company is the BACT limit, and is expressed as 7.8 lb/hr. A second limit of 0.1 lb/mmBtu is the MACT limit. The test methods are not specified.
6. For Koda Energy, the first limit is for PM<sub>10</sub> emissions from biomass; the second limit is for natural gas.

In the control technology review, We Energies has proposed the use of a fabric filter baghouse to attain a best available control technology front-half, filterable PM emission limit of 0.015 lb/mmBtu, and a total PM emission limit, including condensable PM, of 0.03 lb/mmBtu. These proposed BACT emission limits are reflected in the limits for the best performing similar units in Table 2. There are many factors that affect the PM emission rates of the best performing units identified in Table 3. While some of the actual performance data indicates that the fabric filter baghouse may achieve lower emission rates during initial performance testing, the MACT limit must be achievable under the most adverse circumstances which can reasonably be expected to occur. Because the solid phase HAPs are controlled in the same manner as PM, the proposed fabric filter baghouse and the PM BACT emission limits also represent the maximum degree of reduction in HAP emissions which can be achieved for this source category. A fabric filter baghouse is the technology used by the lowest emitting sources of inorganic solid phase HAPs. Therefore, we have concluded that the use of PM emissions as a surrogate for emissions of inorganic, solid phase HAP's represents the case-by-case MACT floor for inorganic, solid phase HAPs.

### **4.3 Beyond the Floor Inorganic, Solid Phase HAP MACT Analysis.**

In making a case-by-case MACT determination, the permitting authority is expected to look beyond the MACT floor, to evaluate whether a greater degree of reduction in emissions is achievable, taking into consideration the cost of achieving such emission reductions, and any non-air quality health and environmental impacts and energy requirements. The best control method, based upon information reviewed, used to control inorganic, solid phase HAP emissions from similar biomass fuel-fueled boilers is advanced PM control systems. The most stringent limits achieved in practice result from the use of a fabric filter baghouse. As a result, We Energies has concluded that further control beyond a fabric filter baghouse is not technically feasible.

Note that this case-by-case MACT analysis is based on restricting the biomass fuels used in this boiler to clean biomass fuels. We Energies proposes that the allowable biomass fuels be defined as follows:

*“Biomass fuels”* means a resource that derives energy from wood or plant material or residue, clean solid wood waste and crops grown for use as a resource. Fuel sources may include the following and other qualifying clean sources:

- logging residue
- discarded woody material from primary manufacturing facilities such as paper mills, sawmills, or chip mills
- on-site pulp & paper wastewater treatment plant residue
- leftover woody material from secondary manufacturers such as door, window, cabinet manufacturers
- woody biomass from municipality wood waste, tree services, and construction companies
- clean solid wood waste from discarded wood packaging such as pallets/crating and from construction and demolition activities

- woody biomass plantations, energy crops and agricultural residues

“Biomass fuels” excludes edible portions of food crops, refuse derived fuel, treated wood, municipal solid waste, sewerage sludge, and animal waste.

#### **4.4 Proposed Case-by-Case MACT Limit for Inorganic, Solid Phase HAPs.**

Based on this analysis, We Energies has concluded that the proposed BACT PM emission limits and fabric filter baghouse also represent the maximum achievable control technology for solid phase, inorganic HAPs from this boiler. We Energies has also concluded that that the BACT compliance demonstration requirements for PM also demonstrate compliance with the MACT requirements for this boiler, so that no other requirements are necessary for this HAP category. Note that this conclusion is consistent with the MACT determinations made by the Department in the air pollution control construction permit for Weston Unit 4, Permit No. 03-RV-248, condition I.A.12.a.(1), and in the air pollution control construction permit for the Elm Road Generating Station, Permit No. 03-RV-166, condition I.A.12.a.(1).

# Chapter 5. Inorganic, Acid Gas HAPs.

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Inorganic, vapor phase acid gas HAPs include hydrochloric and hydrofluoric acids. They are formed from chlorine and fluorine contained in the biomass fuels. Hydrochloric acid (HCl) and hydrofluoric acid (HF) are strong acids which are water soluble and highly reactive with alkaline components of biomass fuels. As a result, these acids are effectively controlled as a part of the biomass fuel combustion process, and in the fabric filter baghouses. When the fuel fired produces highly alkaline ash as is the case for biomass fuels, most of the chlorine and fluorine is converted as salts, such as sodium chloride, rather than being emitted as the inorganic acid gases.

## 5.1 U.S. EPA Vacated Industrial Boiler MACT Standards.

Pursuant to 40 C.F.R. § 63.43(d), an applicant must consider any proposed § 112(d) MACT standard in a § 112(g) case-by-case MACT determination. Under the vacated National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters, 40 CFR Part 63, Subpart DDDDD, Table 1, HCl emissions from new or reconstructed large solid-fuel units are limited to 0.02 lb/mmBtu. There was no specific MACT limit for HF emissions.

## 5.2 MACT Floor Analysis for Hydrogen Chloride (HCl).

Based on information reviewed and summarized in Table 4, the most stringent HCl emission limit identified for any biomass boiler and which has made an initial compliance demonstration is the limit of 0.02 lb per million Btu heat of input for Public Service of New Hampshire - Schiller Station. This limit apparently reflects the vacated NESHAP limit for new solid fuel-fired boilers in 40 CFR Part 63, Subpart DDDDD, although the limit is stated as a case-by-case MACT limit. Please note, however, that the allowable fuels for the Schiller Station includes wood and coal. The Schiller Station has a circulating fluidized bed (CFB) boiler. The permit requires the use of sorbent (limestone) injection to the CFB boiler for SO<sub>2</sub> and HCl control. However, the use of sorbent injection is not required to demonstrate compliance with the MACT limit. When demonstrating compliance with the MACT limit, the permit states “(The permittee) may demonstrate compliance with applicable emissions rates for HCl, and/or mercury using fuel analysis if the emission rates calculated ... are less than the applicable emission limit”.

The most stringent HCl emission limit in any permit reviewed is 0.006 lb/mmBtu for the Yellow Pine Energy Company, Georgia. The permit for this facility also allows the use of tire derived fuel, and requires the use of a dry sorbent injection system for the control of SO<sub>2</sub> emissions.

**TABLE 3. Biomass-fueled boiler HCl emission limits representing MACT.**

Facility	State	Permit Date	Primary Fuel	Control System <sup>a</sup>	Limit, lb/mmBtu	Operating Facility?
Yellow Pine Energy Company	GA	May-09	Wood / TDF	FFB / SI	0.006	NO
South Point Biomass Generation	OH	Apr-06	Wood	FFB / SI	0.0095	NO
Northern Michigan University	MI	Nov-09	Biomass	FFB	0.01	NO
Nacogdoches Power, LLC	TX	Mar-07	Wood	FFB	0.0213	NO
Fibrominn Biomass Power Plant	MN	Oct-02	Poultry Litter	FFB	0.034 <sup>b</sup>	YES
Pub Service of NH - Schiller	NH	Oct-04	Wood / Coal	FSI / FFB	0.02 <sup>c</sup>	YES
Virginia PWC - Laurention Energy	MN	Aug-05	Wood	ESP	0.02	YES
Darrington Energy Cogeneration	WA	Feb-05	Wood	ESP	No Limit	YES
Hillman Power Company	MI	Jul-02	Wood / TDF	ESP	No Limit	YES
District Energy St. Paul, Inc.	MN	Nov-01	Wood	ESP	No Limit	YES
Koda Energy	MN	Aug-07	Wood / NG	ESP	Syn. Minor	YES
Stoneman Power Plant	WI	Jan-09	Wood	ESP	0.284 <sup>d</sup>	YES

**Footnotes**

- <sup>a</sup> “FFB” means fabric filter baghouse; “ESP” means electrostatic precipitator; “SI” means sorbent injection; “FSI” means “furnace sorbent injection” and refers to limestone injection into the fluidized bed boiler.
- <sup>b</sup> The limit for the Fibrominn Plant is 95% reduction when emissions are greater than 0.034 lb/mmBtu.
- <sup>c</sup> The case-by-case MACT limit for the Public Service of New Hampshire - Schiller Station includes coal combustion. Compliance with this limit may be based on fuel analysis data only.
- <sup>d</sup> The limit for the Stoneman Plant is not a MACT limit, but rather a limit under NR 445, Wis. Adm. Code.

**5.2.1 HCl Fuel Analysis and Emission Data.**

The National Council for Air and Stream Improvement, Inc. (NCASI) evaluated chlorine levels in bark and stemwood in Technical Bulletin No. 0875, *Nationwide Evaluation of Mercury and Chlorine Levels in Bark and Stemwood*, 2004. A four-week sampling program was carried out at 30 pulp and paper and wood products manufacturing facilities across the country. According to this report, the chlorine content of the bark samples ranged from less than 40 to 274 ppm on an oven dry basis, with an average of 90 ppm. The chlorine concentration of stemwood ranged from 50 to 162 ppm, with an average of 70 ppm. Assuming all chlorine is emitted as HCl, the average HCl emission rate was 0.011 and 0.007 lb/mmBtu for bark and stemwood, respectively, with a 95<sup>th</sup> percentile of 0.014 lb/mmBtu.

According to NCASI Technical Bulletin No. 0837, *Emissions of Sulfuric, Hydrochloric, and Hydrofluoric Acids from Combination Bark Boilers*, HCl emissions ranged from 0.016 to 0.058 lb/mmBtu for the coal/bark boilers and from 0.00025 to 0.00045 lb/mmBtu for the oil/bark boilers. Four coal/bark boilers and two residual oil/bark boilers were tested during this study. Two of the four coal/bark boilers were equipped with dry ESPs and two were equipped with venturi scrubbers. One of the two residual oil/bark boilers was equipped with a dry gravel scrubber while the other was equipped with an ESP. The much

lower measured emissions indicate that HCl is being captured in the combustion process and in the PM control systems as salts, rather than being emitted as the acid gas.

Data from the U.S. EPA Report, *Wood Products in the Waste Stream - Characterization and Combustion Emissions*, EPA Report EPA-600/R-96-119a, indicates higher chloride and uncontrolled HCl emissions. The data is summarized in Table 4. This data indicates an average uncontrolled HCl emission rate of 0.084 lb/mmBtu, with a 95<sup>th</sup> percentile of 0.161 lb/mmBtu. The emission factor for HCl emissions from waste wood combustion in the U.S. EPA's AP-42, *Compilation of Air Pollutant Emission Factors*, 5<sup>th</sup> Edition, Wood Residue Combustion, Tables 1.6-3, is 0.0192 lb/mmBtu.

**TABLE 4. Wood fuels analyses data and uncontrolled hydrogen chloride (HCl) emission rate.**

<b>Wood Analyses, dry basis, weight %</b>	<b>Site 1</b>	<b>Site 2</b>	<b>Site 3</b>	<b>Site 4</b>	<b>Site 6</b>	<b>Site 7</b>	<b>Average</b>	<b>90th Percentile</b>
Carbon	50.28	50.55	52.90	45.38	50.11	50.45	49.95	
Hydrogen	5.92	5.95	5.85	5.17	5.87	5.86	5.77	
Nitrogen	0.46	0.53	0.51	0.73	0.52	0.62	0.56	
Sulfur	0.12	0.06	0.08	0.05	0.15	0.10	0.09	
Ash	5.16	7.38	3.87	15.99	5.15	6.40	7.33	
Oxygen	38.07	35.54	36.79	32.69	38.20	36.57	36.31	
Chlorine	0.08	0.03	0.16	0.06	0.03	0.05	0.07	
Heat Content, Btu/lb	8,238	8,599	8,795	7,543	8,353	8,437	8,327	
<b>HCl Combustion Concentration, lb/mmBtu</b>	<b>0.100</b>	<b>0.036</b>	<b>0.187</b>	<b>0.082</b>	<b>0.037</b>	<b>0.061</b>	<b>0.084</b>	<b>0.135</b>

***Footnotes***

Data is from the U.S. EPA Report, *Wood Products in the Waste Stream - - Characterization and Combustion Emissions*, EPA Report EPA-600/R-96-119a.

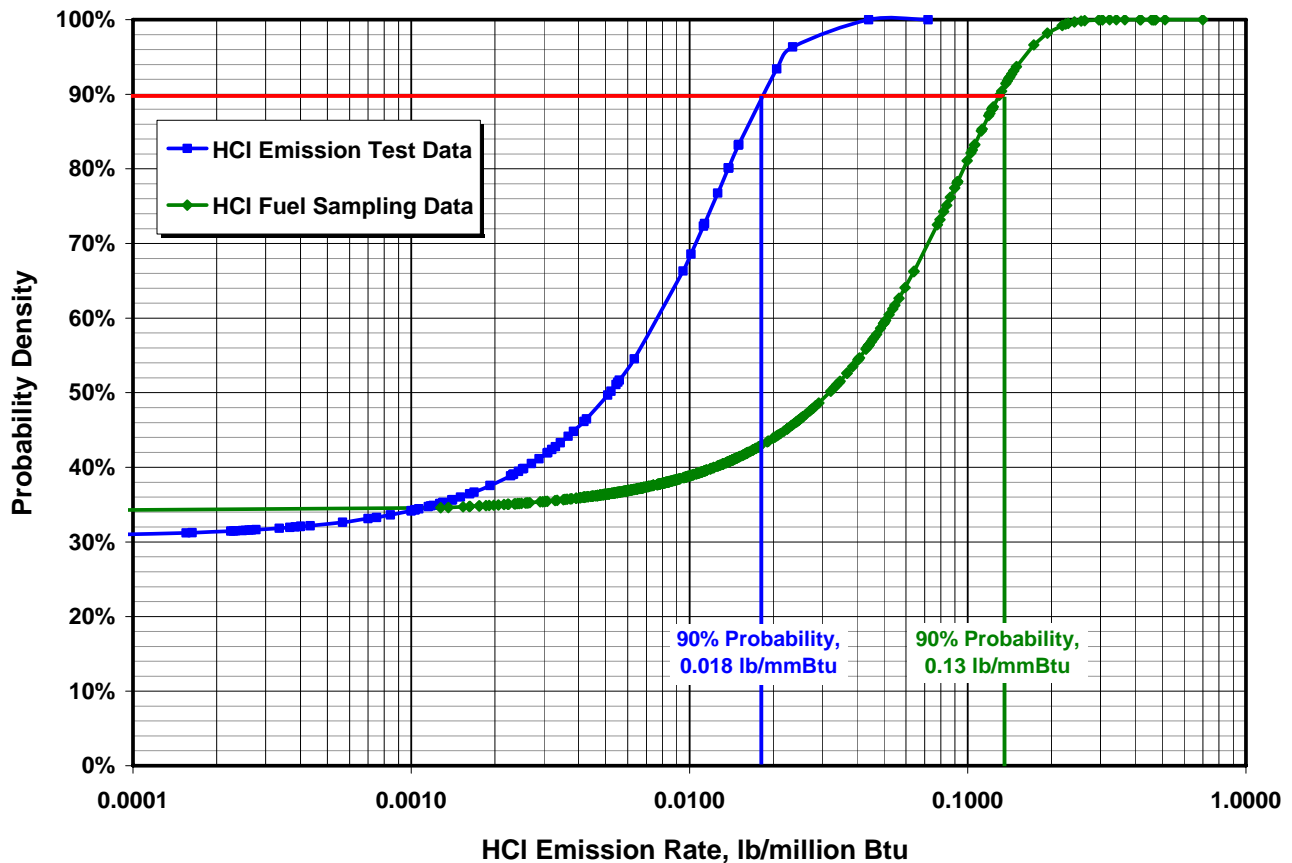
In January, 2010, a preliminary database of emission test data, continuous emission monitoring system (CEMS) data, and fuel analysis data for boilers and process heaters at major sources of HAP was made available at <http://www2.ergweb.com/projects/combustion/combustiontesting.html>. This data includes standardized emission data from both the U.S. EPA's Phase I survey Information Collection Request (ICR No. 2286.01) and the Phase II test plan (ICR No. 2286.03). The database included both fuel sampling and analysis data for HCl, as well as emission test data for HCl from biomass-fueled boilers. The HCl fuel sampling and analysis data included over 500 samples for biomass fuels (with descriptions including wood, bark, plywood, particleboard, hog fuel, paper and paper residues, and biomass). The HCl fuel sampling and analysis data ranged from  $5.5 \times 10^{-7}$  lb/mmBtu to more than 0.5 lb/mmBtu. The database also included HCl emission test data using U.S. EPA Reference Method 26. The HCl emission test data included 78 tests on biomass-fueled boilers, with emission rates ranging from 0.0002 lb/mmBtu to 0.072 lb/mmBtu. Several of the emission test results indicated HCl emissions below the detection limit of the test. This ICR data is plotted in Figure 1 as probability distributions for each data set. The 90% probability distribution for the HCl emission rate, based on fuel sampling and analysis, is 0.13 lb/mmBtu,

while the 90% probability distribution for the HCl emission rate, based on emission testing, is 0.018 lb/mmBtu. This data suggests that the actual HCl emissions are reduced by approximately 85% as compared to the uncontrolled, fuel input or potential combustion concentration for HCl.

This outcome seems logical because of the high levels of calcium and potassium in typical biomass fuels. Ash mineral analysis data from the U.S. EPA Report, *Wood Products in the Waste Stream - Characterization and Combustion Emissions*, EPA Report EPA-600/R-96-119a, Table 7-32 indicates that the evaluated fuels in the report had calcium oxide (CaO) levels of 15.3%. The fuel had an average ash content of 7.8%. From these values, the fuel had a CaO level of 1.19 lb CaO/100 lb dry fuel, or 0.0213 moles of calcium per 100 lb dry fuel. The fuel also had a chlorine content of 0.07%, equal to 0.002 moles of chlorine per 100 lb dry fuel. Therefore, the effective calcium to chlorine ratio in the boiler when firing this typical biomass fuel is more than ten to one (10:1). This high level of reactive CaO would be expected to react with HCl in the flue gas to form calcium chloride.

Based on the available data, we have concluded that the MACT floor for HCl emissions from this biomass-fueled boiler is 0.018 lb/mmBtu. This emission rate represents a reasonable estimate of the performance of the “best controlled similar unit” under the worst reasonably foreseeable circumstances.

**FIGURE 1. Hydrogen chloride (HCl) fuel sampling and analysis and emission test data for biomass combustion from the U.S. EPA’s industrial boiler ICR.**



### 5.3 Beyond the Floor MACT Analysis for Hydrogen Chloride (HCl).

Based upon the information reviewed, the most common method used to control HCl emissions from biomass fueled-boilers is the use of biomass fuels with inherently low chloride concentrations, combined with the use of a fabric filter baghouse or electrostatic precipitator. This combination of controls effectively control these acid gas emissions through the reaction of the acid gas with the alkaline ash. In addition, several facilities are required to use dry sorbent injection systems. However, all of the facilities that were identified with MACT limits may demonstrate compliance with the MACT limit without the requirement to operate sorbent injection systems. Further, of the five facilities identified with MACT limits, 3 facilities are allowed to fire solid fuels including tire derived fuel (TDF), and coal. Therefore, while the use of FGD systems may also control HCl and HF emissions, the use of FGD systems is not necessary to achieve very low HCl and HF emission rates when firing biomass fuels.

The actual control of HCl emissions by the reaction of the flyash with the acid gas is difficult to predict. For coal combustion, the EPRI report, *Emission Factors Handbook: Guidelines for Estimating Trace Substance Emissions from Fossil fuel Steam Electric Plants*, Final Report, April, 2002, indicates that the expected HCl and HF control efficiency for subbituminous coal combustion (which has a highly alkaline ash) of 80% and 50%, respectively. However, the continuous reduction of HCl emissions from biomass combustion by the use of FGD systems including sorbent injection is not well understood or demonstrated in practice. Because biomass combustion already results in high levels of calcium oxide (CaO) and potassium oxide (K<sub>2</sub>O) in the ash, the additional injection of sorbent may not achieve substantial emission reductions.

Even if the use of FGD systems or sorbent injection could further reduce HCl emissions, the costs of control would be extremely high. The lowest cost option, a dry sorbent injection system, would have a total capital cost of \$3.3 million, annual O&M costs of \$860,000, and a total annual cost of \$1.2 million (refer to the control technology review for fluoride emissions). If the sorbent injection system could reduce HCl emissions by 50%, from an emission rate of 0.018 lb/mmBtu and 63.1 tons per year, to 0.009 lb/mmBtu and 31.6 tons per year, the average cost effectiveness for the dry sorbent injection system would be \$38,000 per ton of HCl controlled. This is an extremely high cost which does not represent MACT for the control of HCl emissions.

In addition, the use of sorbent injection may adversely impact the reuse of this ash which would have substantial environmental costs and additional economic impacts. The biomass-fueled boiler is expected to consume approximately 48 tons per hour of bone-dry biomass fuels, or 416,000 tons per year of bone-dry biomass fuels. At a typical ash content of 7%, the combustion of these fuels would produce about 29,100 tons per year of ash. This ash will be derived from biomass fuels, and is anticipated to have value as a soil amendment or fertilizer. However, if sorbent injection were to adversely impact the reuse of this ash, the ash may need to be disposed of in a landfill. Not only would this have environmental consequences, but this could also lead to much higher costs.

## 5.4 Proposed Case-by-Case MACT for Hydrogen Chloride (HCl).

This case-by-case MACT analysis found that the most stringent limit achieved in practice for HCl emissions from any biomass-fueled boiler is 0.02 lb/mmBtu. The most stringent HCl emission limit in any permit reviewed is 0.006 lb/mmBtu for the Yellow Pine Energy Company, Georgia. Data from the U.S. EPA's Information Collection Request for biomass-fired industrial boilers indicates a 90% probability for the HCl emission rate, based on actual emission testing, of 0.018 lb/mmBtu. This is the case-by-case MACT floor for HCl emissions from this boiler.

In the beyond the floor MACT analysis, flue gas desulfurization (FGD) systems, including dry sorbent injection, were evaluated as a potential control technology for HCl emissions from biomass combustion. However, the continuous reduction of HCl emissions from biomass combustion by the use of FGD systems and sorbent injection is not demonstrated in practice. Because biomass combustion already results in high levels of calcium oxide (CaO) and potassium oxide (K<sub>2</sub>O) in the ash, the additional injection of sorbent may not achieve substantial emission reductions. Even if the use of FGD systems or sorbent injection could further reduce HCl emissions, the costs of control would be extremely high, with an average cost effectiveness for the dry sorbent injection system of \$38,000 per ton of HCl controlled. In addition, the use of sorbent injection may adversely impact the reuse of this ash which would have substantial environmental costs and additional economic impacts.

Based on this analysis, We Energies has concluded that the use of biomass fuels in combination with a fabric filter baghouse represents MACT for the control of HCl emissions from this boiler. We Energies proposes the following emission limits as MACT for HCl emissions.

1. Hydrogen chloride (HCl) emissions from the circulating fluidized bed boiler shall be controlled using biomass fuels in combination with a fabric filter baghouse as MACT.
2. Hydrogen chloride (HCl) emissions may not exceed 0.018 lb/mmBtu.
3. Compliance with this emission limit shall be demonstrated using U.S. Reference Methods 26 or 26A, or another method approved in writing by the Department.

## 5.5 MACT Floor Analysis for Hydrogen Fluoride (HF).

Based on the permits and information available, We Energies did not identify any biomass-fueled boiler with a hydrogen fluoride (HF) emission limit. As noted above, the U.S. EPA did not include a specific MACT emission limit or standard under the now vacated National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters, 40 CFR Part 63, Subpart DDDDD.

### 5.5.1 HF Fuel Analysis and Emission Data.

There has been a very limited amount of information available on fluoride levels in biomass fuels. According to NCASI Technical Bulletin No. 0837, *Emissions of Sulfuric, Hydrochloric, and Hydrofluoric Acids from Combination Bark Boilers*, HF emissions ranged from 0.00023 to 0.0011 lb/mmBtu for the coal/bark boilers and from 0.000016 to 0.000074 lb/mmBtu for the oil/bark boilers.

According to the U.S. EPA's MACT database emission factors from the U.S. EPA memorandum from Christy Burlew and Roy Oommen, to Jim Eddinger, U.S. Environmental Protection Agency, OAQPS (C439-01), dated October, 2002, *Development of Average Emission Factors and Baseline Emission Estimates for the Industrial, Commercial, and Institutional Boilers and Process Heaters National Emission Standard for Hazardous Air Pollutants*, the emission factor for HF emissions from wood-fueled boilers is 0.0081 lb/mmBtu.

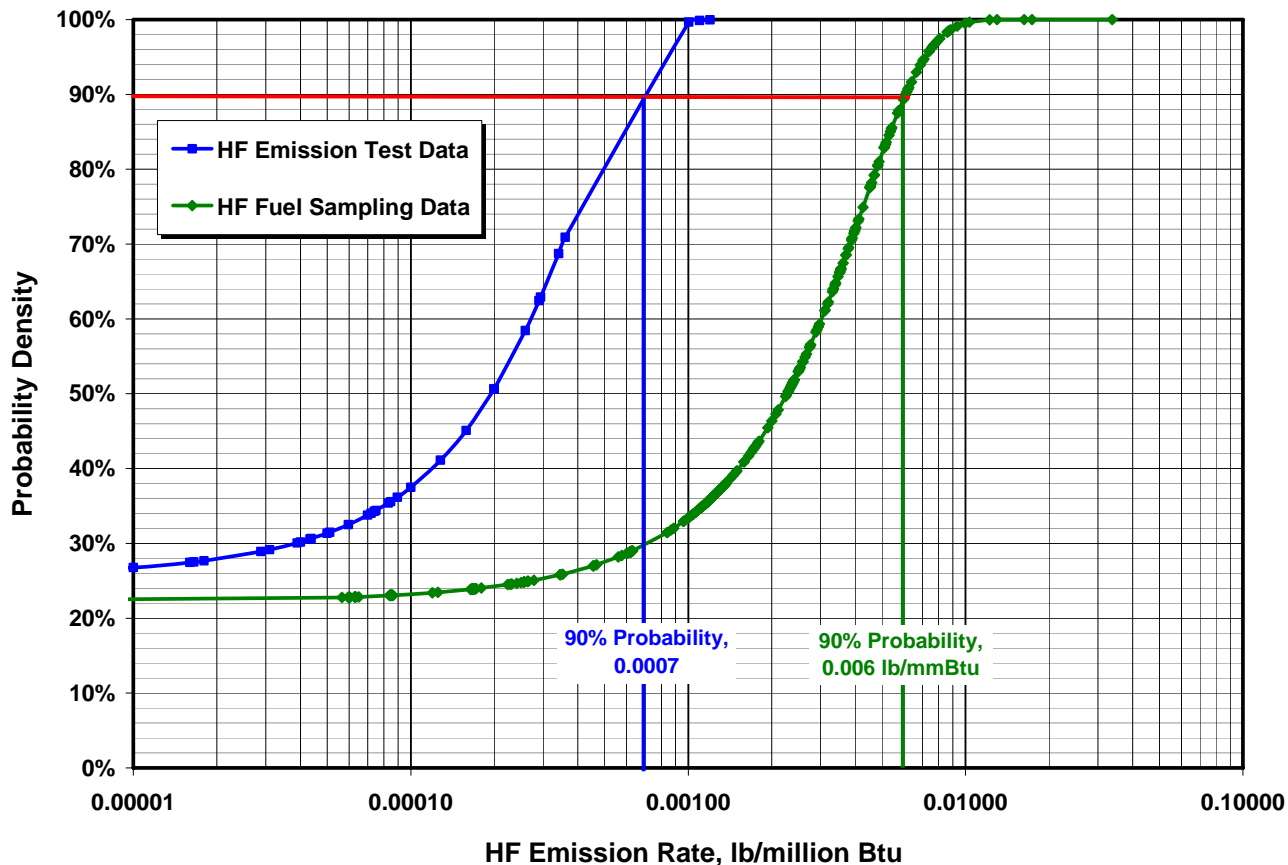
The U.S. EPA's AP-42, *Compilation of Air Pollutant Emission Factors*, 5<sup>th</sup> Edition, Wood Residue Combustion, does not list an emission factor for HF emissions. In Switzerland, the combustion requirements for wood limit HF emissions to 2 mg/m<sup>3</sup>, equal to 0.0011 lb/mmBtu.

In January, 2010, a preliminary database of emission test data, continuous emission monitoring system (CEMS) data, and fuel analysis data for boilers and process heaters at major sources of HAP was made available at <http://www2.ergweb.com/projects/combustion/combustiontesting.html>. This data includes standardized emission data from both the U.S. EPA's Phase I survey Information Collection Request (ICR No. 2286.01) and the Phase II test plan (ICR No. 2286.03). The database included both fuel sampling and analysis data for HF, as well as emission test data for HF from biomass-fueled boilers. The HF fuel sampling and analysis data included over 350 samples for biomass fuels (with descriptions including wood, bark, plywood, particleboard, hog fuel, and biomass). The HF fuel sampling and analysis data ranged from 1.1 x 10<sup>-6</sup> lb/mmBtu to 0.033 lb/mmBtu. The database also included HF emission test data using U.S. EPA Reference Method 26. The HF emission test data included 34 tests on biomass-fueled boilers, with emission rates ranging from 0.000003 lb/mmBtu to 0.0012 lb/mmBtu. Nineteen (19) of the emission test results indicated HF emissions below the detection limit of the test. This ICR data is plotted in Figure 2 as probability distributions for each data set. The 90% probability for the HF emission rate, based on fuel sampling and analysis, is 0.006 lb/mmBtu, while the 90% probability distribution for the HF emission rate, based on emission testing, is 0.0007 lb/mmBtu. This data suggests that the actual HF emissions are reduced by almost 90% as compared to the uncontrolled, fuel input or potential combustion concentration for HF.

As discussed with respect to HCl emissions, this outcome seems logical because of the high levels of calcium and potassium in typical biomass fuels. Typical biomass fuels have a CaO level of 1.19 lb CaO/100 lb dry fuel, or 0.0213 moles of calcium per 100 lb dry fuel. From the TCR fuel sampling database, the biomass fuels have a typical fluorine content of well below 100 mg per kg, or 0.01%. A fluorine content of 0.01% is equal to 0.0005 moles of fluorine per 100 lb dry fuel. Therefore, the effective calcium to fluorine ratio in the boiler when firing this typical biomass fuel is more than forty to one (40:1). This high level of reactive CaO would be expected to react with HF in the flue gas to form calcium fluoride.

Based on the available data, we have concluded that the MACT floor for HF emissions from this biomass-fueled boiler is the use of biomass fuels and a fabric filter baghouse. The resulting emission rate is expected to be less than 0.001 lb/mmBtu. The use of biomass fuels and a fabric filter baghouse represents a reasonable estimate of the performance of the “best controlled similar unit” under the worst reasonably foreseeable circumstances.

**FIGURE 2. Hydrogen fluoride (HF) fuel sampling and analysis and emission test data for biomass combustion from the U.S. EPA’s industrial boiler ICR.**



## 5.6 Beyond the Floor MACT Analysis for Hydrogen Fluoride (HF).

Based upon information reviewed, the most common control method used to control HF emissions from biomass fueled-boilers is the use of biomass fuels with inherently low fluoride concentrations, combined with the use of a fabric filter baghouse or electrostatic precipitator. This combination of controls effectively control these acid gas emissions through the reaction of the acid gas with the alkaline ash. In addition, several facilities are required to use dry sorbent injection systems. However, all of the facilities that were identified with MACT limits may demonstrate compliance with the MACT limit without the requirement to operate the sorbent injection system. Based on the permits and information available, We Energies did not identify any biomass-fueled boiler with a hydrogen fluoride (HF) emission limit.

The actual control of HF emissions by the reaction of the flyash with the acid gas is difficult to predict. For coal combustion, the EPRI report, *Emission Factors Handbook: Guidelines for Estimating Trace Substance Emissions from Fossil fuel Steam Electric Plants*, Final Report, April, 2002, indicates that the expected HF control efficiency for subbituminous coal combustion (which has a highly alkaline ash) of 50%. However, the continuous reduction of HF emissions from biomass combustion by the use of FGD systems including sorbent injection is not demonstrated in practice. Because biomass combustion already results in high levels of calcium oxide (CaO) and potassium oxide (K<sub>2</sub>O) in the ash, the additional injection of sorbent may not achieve substantial emission reductions.

As with the control of HCl emissions, even if the use of FGD systems or sorbent injection could further reduce HF emissions, the costs of control would be extremely high. The lowest cost option, a dry sorbent injection system, would have a total capital cost of \$3.3 million, annual O&M costs of \$860,000, and a total annual cost of \$1.2 million (refer to the control technology review for fluoride emissions). If the sorbent injection system could reduce HF emissions by 50%, from an emission rate of 0.001 lb/mmBtu and 3.5 tons per year, to 0.0005 lb/mmBtu and 1.8 tons per year, the average cost effectiveness for the dry sorbent injection system would be more than \$700,000 per ton of HF controlled. This is an extremely high cost which does not represent MACT for the control of HF emissions.

In addition, the use of sorbent injection may adversely impact the reuse of this ash which would have substantial environmental costs and additional economic impacts. The combustion of biomass fuels would produce about 29,100 tons per year of ash. This ash will be derived from biomass fuels, and is anticipated to have value as a soil amendment or fertilizer. However, if sorbent injection were to adversely impact the reuse of this ash, the ash may need to be disposed of in a landfill. Not only would this have environmental consequences, but this could also lead to much higher costs.

## 5.7 Proposed Case-by-Case MACT for Hydrogen Fluoride (HF).

Based on the permits and information available, We Energies did not identify any biomass-fueled boiler with a hydrogen fluoride (HF) emission limit. Based on the available data, we have concluded that the MACT floor for HF emissions from this biomass-fueled boiler is the use of biomass fuels and a fabric filter baghouse. The resulting emission rate is expected to be less than 0.001 lb/mmBtu.

In the beyond the floor MACT analysis, flue gas desulfurization (FGD) systems, including dry sorbent injection, were evaluated as a potential control technology for HF emissions from biomass combustion. However, the continuous reduction of HF emissions from biomass combustion by the use of FGD systems and sorbent injection is not demonstrated in practice. Because biomass combustion already results in high levels of calcium oxide (CaO) and potassium oxide (K<sub>2</sub>O) in the ash, the additional injection of sorbent may not achieve substantial emission reductions. Even if the use of FGD systems or sorbent injection could further reduce HF emissions, the costs of control would be extremely high, with an average cost effectiveness for the dry sorbent injection system of more than \$700,000 per ton of HF controlled. In addition, the use of sorbent injection may adversely impact the reuse of this ash which would have substantial environmental costs and additional economic impacts.

Based on this analysis, We Energies has concluded that the use of biomass fuels in combination with a fabric filter baghouse represents MACT for the control of HF emissions from this boiler. The principles of case-by-case MACT in 40 CFR § 63.43(d)(3) states:

*(d) Principles of MACT determinations.*

(3) The applicant may recommend a specific design, equipment, work practice, or operational standard, or a combination thereof, and the permitting authority may approve such a standard if the permitting authority specifically determines that it is not feasible to prescribe or enforce an emission limitation under the criteria set forth in section 112(h)(2) of the Act.

Because HF emissions from biomass combustion are very small, it is not feasible to prescribe or enforce an emission limitation for HF emissions. Therefore, We Energies proposes the following emission limits as MACT for HF emissions.

1. Hydrogen fluoride (HF) emissions from the circulating fluidized bed boiler shall be controlled using biomass fuels and natural gas in combination with a fabric filter baghouse as MACT.

# Chapter 6. Organic HAPs.

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Organic HAPs are emitted from biomass combustion as a result of incomplete combustion. A detailed discussion of control options for other products of incomplete combustion including carbon monoxide (CO) and volatile organic compound (VOC) emissions is included in the control technology review. Potential organic HAPs resulting from biomass combustion include a wide range of organic compounds, including polycyclic aromatic compounds, dioxins, furans, and formaldehyde. These HAPs may be considered as a subset of the general class of organic compounds referred to VOC. As a result, minimizing VOC (and CO) emissions will also minimize organic HAP emissions.

The use of CO or VOC emissions as a surrogate for the control of organic HAP emissions is consistent with the U.S. EPA's practice when establishing MACT standards for combustion source categories emitting organic HAP's. For example, in the preamble for the "*National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters.*" 69 Fed. Reg. 55218, September 13, 2004, the U.S. EPA stated: "Because CO is a good indicator of incomplete combustion, there is a direct correlation between CO emissions and the formation of organic HAP emissions. Monitoring equipment for CO is readily available, which is not the case for organic HAP. Also, it is significantly easier and less expensive to measure and monitor CO emissions than to measure and monitor emissions of each individual organic HAP. Therefore, using CO as a surrogate for organic HAP is a reasonable approach because minimizing CO emissions will result in minimizing organic HAP emissions."

## 6.1 U.S. EPA Vacated Industrial Boiler MACT Standards.

Pursuant to 40 C.F.R. § 63.43(d), an applicant must consider any proposed § 112(d) MACT standard in a § 112(g) case-by-case MACT determination. Under the vacated National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters, 40 CFR Part 63, Subpart DDDDD, Table 1, CO emissions from new or reconstructed large solid-fuel units larger than 100 mmBtu/hr are limited to 400 ppm by volume on a dry basis corrected to 7% oxygen, on a 30-day rolling average. This emission rate is equal to 0.44 lb/mmBtu. In the control technology review for this biomass boiler, We Energies has proposed a CO BACT emission limit of 0.20 lb/mmBtu on a 30-day rolling average basis.

## 6.2 MACT Floor Analysis for Organic HAPs.

Table 5 is a summary of new biomass-fueled boilers which have commenced initial operation, the allowable fuels, and the CO emission limit which represents BACT. Because these are new units, or existing units with new controls, these units represent the best performing similar units for the control of

CO emissions and organic HAPs. Note that from Table 5, of the top 6 ranked facilities, i.e., the Public Service of NH - Schiller Station, South Point Biomass Generation, Yellow Pine Energy Company, Nacogdoches Power, LLC, Mancelona Renewable, and Northern Michigan University, only the South Point Biomass boiler is a stoker boiler. The other boilers are fluidized bed boilers. Based on the information reviewed, the CO emission limits for new biomass-fueled boilers and which have made an initial compliance demonstration range from 0.10 to 0.63 lb/mmBtu. We Energies has proposed a best available control technology CO emission limit of 0.20 lb/mmBtu, achieved through good combustion practices. Because the organic HAPs are controlled in the same manner as CO emissions, the proposed use of good combustion practices and the CO BACT emission limit represents the maximum degree of reduction in organic HAP emissions which can be achieved by utilizing this control technology for any biomass-fueled boiler. This analysis indicates that the use of CO emissions as a surrogate for emissions of organic HAP's represents the case-by-case MACT floor for organic HAP emissions from this boiler.

**TABLE 5. Carbon monoxide (CO) BACT emission limits for biomass fuel-fueled boilers.**

Facility	State	Permit Date	Capacity, mmBtu/hr	Primary Fuel	Limit, lb/mmBtu
Pub. Service of NH - Schiller Station	NH	Oct-04	720	Wood	0.10
South Point Biomass Generation	OH	Apr-06	318	Wood	0.10
Yellow Pine Energy Company	GA	May-09	1,529	Wood	0.15
Nacogdoches Power, LLC	TX	Mar-07	1,374	Wood	0.15
Mancelona Renewable	MI	Nov-09	565	Wood/Biomass	0.17
Northern Michigan University	MI	Nov-09	210	Wood/Biomass	0.17
Fibrominn Biomass Power	MN	Oct-02	792	Poultry Litter	0.24
Virginia PWC - Laurention Energy	MN	Aug-05	230	Wood	0.30
District Energy St. Paul, Inc.	MN	Nov-01	550	Wood	0.30
Sierra Pacific Aberdeen facility	WA	Oct-02	310	Waste Wood	0.35
S.D. Warren Company	ME	Nov-01	1,300	Wood	0.40
Stoneman Power Plant	WI	Jan-09	340	Wood	0.40
Koda Energy	MN	Aug-07	308	Wood / Nat. Gas	0.43
Martinsville Thermal LLC	VA	Sep-03	120	Wood	0.44
Wheelabrator Sherman Energy	ME	Apr-99	315	Wood	0.45
Northern Sun	ND	May-06	100	Wood / Hulls	0.63
Skagit County Lumber Mill	WA	Jan-06	430	Wood	0.93
Sierra Pacific Industries	CA	Dec-02	245	Wood	1.15

### **6.3 Beyond the Floor Organic HAP MACT Analysis.**

The only control methods, based upon available information, actually used to control organic HAP emissions from biomass-fueled boilers is good combustion practices. One facility, the South Point Biomass Generation Facility in Ohio, is also required to use an oxidation catalyst for the control of CO emissions. However, this facility has not yet commenced operation. There are significant technical questions regarding the ability of oxidation catalysts to control organic HAP emissions from biomass-fueled boilers. Because of the serious technical questions regarding the use of oxidation catalysts on circulating fluidized bed biomass-fueled boilers, We Energies has concluded that further control beyond the use of good combustion practices is not technically feasible.

### **6.4 Proposed Case-by-Case MACT Limit for Organic HAPs.**

Based on this analysis, We Energies has concluded that the proposed BACT CO emission limits and use of good combustion practices also represent the maximum achievable control technology for organic HAPs from this biomass-fueled boiler, so that no other requirements are necessary for this HAP category. Note that this conclusion is consistent with the case-by-case MACT determinations for organic HAP emissions made by the Department in the air pollution control construction permit for Weston Unit 4, Permit No. 03-RV-248, condition I.A.12.a.(3), and in the air pollution control construction permit for the Elm Road Generating Station, Permit No. 03-RV-166, condition I.A.12.a.(3).



# Chapter 7. Mercury.

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Mercury is a trace element in biomass fuels. Mercury is an unusual metal because it boils at a very low temperature of 675 °F. When fuel is burned, the high combustion temperatures vaporize mercury to form elemental mercury ( $Hg^0$ ). This gaseous form of mercury may then react with other substances in the flue gas to form oxidized mercury ( $Hg^{+2}$ ). Some mercury may be adsorbed onto particulate matter, called particle bound mercury ( $Hg_p$ ). The total mercury in the flue gas ( $Hg_T$ ) is the sum of  $Hg_p$ ,  $Hg^{+2}$ , and  $Hg^0$ . Mercury is present at varying concentrations in biomass. When biomass is burned, mercury exits the boiler at extremely low concentrations, on the order of parts per *billion*.

## 7.1 U.S. EPA Vacated Industrial Boiler MACT Standards.

Pursuant to 40 C.F.R. § 63.43(d), an applicant must consider any proposed § 112(d) MACT standard in a § 112(g) case-by-case MACT determination. Under the vacated National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters, 40 CFR Part 63, Subpart DDDDD, Table 1, mercury emissions from new or reconstructed large solid-fuel units are limited to 0.000003 lb/mmBtu, or 3.0 pounds per trillion Btu of heat input.

## 7.2 State of Wisconsin Mercury Rule

Under NR 446.03(2)(a), Wis. Adm. Code, new sources with allowable mercury emissions of 10 pounds per year or more must control mercury emissions to a level which is the best available control technology. However, under s. NR 446.03(2)(b), Wis. Adm. Code, units that are subject to an emission limit required for mercury under sections 111 or 112 of the Clean Air Act are exempt from this requirement. Because this § 112(g) MACT determination will result in a mercury emission limit required under CAA § 112, this unit is exempt from the requirements of NR 446, Wis. Adm. Code.

## 7.3 MACT Floor Analysis for Mercury.

Table 6 is a summary of new biomass-fueled boilers which have commenced initial operation, and the mercury emission limit which represents MACT. Because these are new units, or existing units with new controls, these units represent the best performing similar units for the control of mercury emissions. Based on the information reviewed, the mercury emission limits for new biomass-fueled boilers and which have made an initial compliance demonstration is 3.0 pounds per trillion Btu of heat input. Other emission limits range from 9.0 to 25.0 lb/TBtu. All of the permits with a MACT limit required initial compliance demonstration by stack testing. No sources were required to install mercury specific controls.

**TABLE 6. Biomass-fueled boiler mercury emission limits representing MACT.**

Facility	State	Permit Date	Primary Fuel	Control System <sup>a</sup>	Limit, lb/TBtu <sup>b</sup>	Operating Facility?
Northern Michigan University	MI	Nov-09	Wood	FFB	2.27	NO
Pub Service of NH - Schiller	NH	Oct-04	Wood / Coal	FFB	3.0	YES
Virginia PWC - Laurention Energy	MN	Aug-05	Wood	ESP	3.0	YES
South Point Biomass Generation	OH	Apr-06	Wood	FFB	9.0	NO
Yellow Pine Energy Company	GA	May-09	Wood	FFB	25.0	NO
Nacogdoches Power, LLC	TX	Mar-07	Wood	FFB	No Limit	0.17
Mancelona Renewable	MI	Nov-09	565	FFB	No Limit	
Fibrominn Biomass Power Plant	MN	Oct-02	Poultry Litter	FFB	No Limit	YES
Darrington Energy Cogeneration	WA	Feb-05	Wood	ESP	No Limit	YES
Hillman Power Company	MI	Jul-02	Wood / TDF	ESP	No Limit	YES
District Energy St. Paul, Inc.	MN	Nov-01	Wood	ESP	No Limit	YES
S.D. Warren Co. - Skowhegan, Me	ME	Nov-01	Wood	ESP	No Limit	YES
Koda Energy	MN	Aug-07	Wood / NG	ESP	Syn Minor	YES
Stoneman Power Plant	WI	Jan-09	Wood	ESP	No Limit	YES

**Footnotes**

<sup>a</sup> “FFB” means fabric filter baghouse. “ESP” means electrostatic precipitator.

<sup>b</sup> “TBtu” means trillion Btu or 10<sup>12</sup> Btu.

**7.3.1 Mercury Concentrations in Biomass.**

The National Council for Air and Stream Improvement, Inc. (NCASI) evaluated mercury levels in bark and stemwood in Technical Bulletin No. 0875, *Nationwide Evaluation of Mercury and Chlorine Levels in Bark and Stemwood*, 2004. A four-week bark and stemwood sampling program was carried out at 30 pulp and paper and wood products manufacturing facilities across the country. According to this report, the mercury content of the bark samples ranged from less than 1.0 to 37.4 parts per billion (ppb) on an oven dry basis, with an average of 12.5 ppb. For stemwood, the mercury concentration ranged from 1.0 to 10.4 ppb, with an average of 2.7 ppb. Assuming all mercury in the fuel would be emitted, the average uncontrolled mercury emission rate was 1.42 pounds per trillion Btu (lb/TBtu) and 0.28 lb/TBtu for bark and stemwood, respectively. The 90<sup>th</sup> percentile value was 2.0 lb/TBtu. Note that a mercury emission rate of 1.42 lb/TBtu is equal to a mercury flue gas concentration of 0.2 parts per billion or 2.4 micrograms per dry standard cubic meter (ug/dscm).

Data from the U.S. EPA Report, *Wood Products in the Waste Stream - - Characterization and Combustion Emissions*, EPA Report EPA-600/R-96-119a, indicate much higher biomass fuel mercury

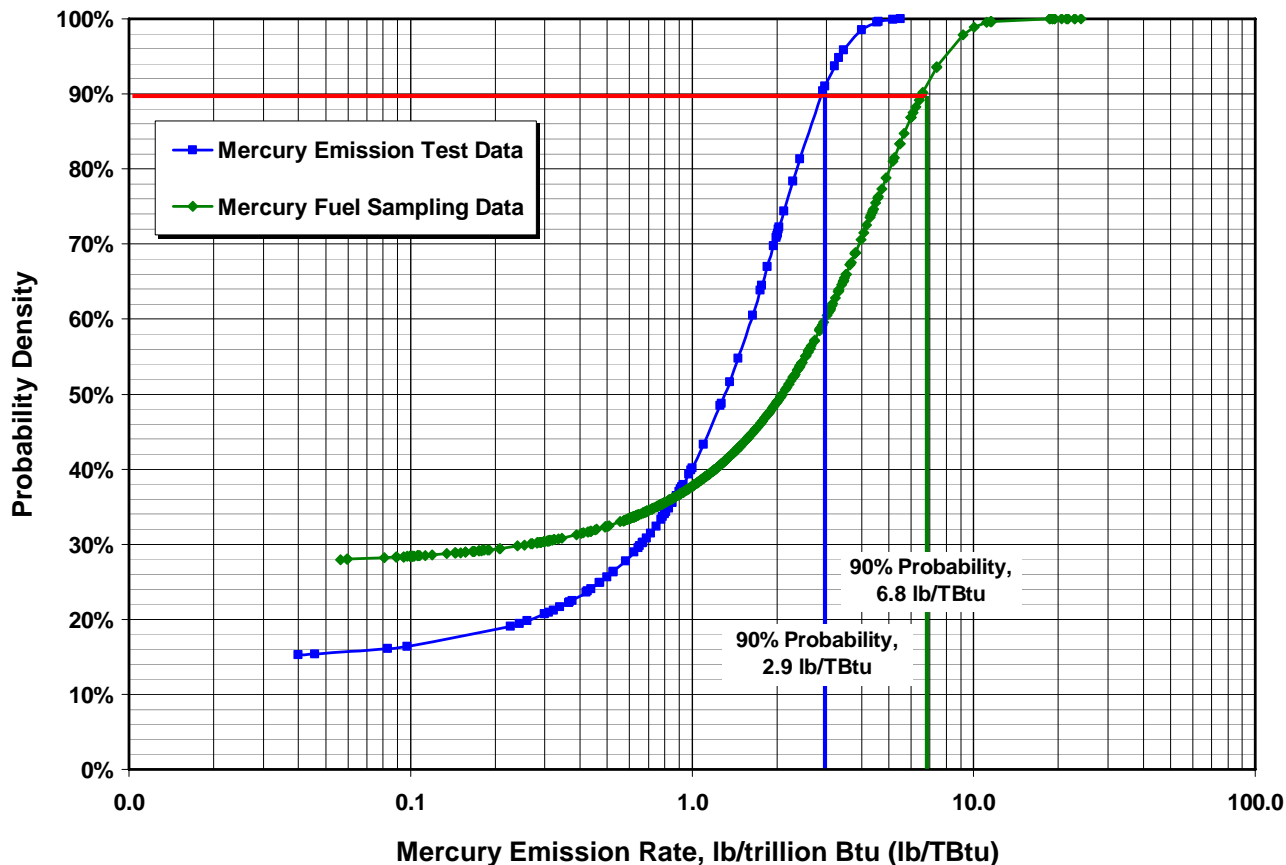
concentrations. According to Tables 7-32 and 7-33 of this report, wood fuel analyses from 6 processors and 41 total samples indicates an average wood fuel heat content of 8,260 Btu/pound, and an average mercury concentration of 0.10 parts per million, equal to an uncontrolled mercury emission rate of 12.0 lb/TBtu. In Table 8-3 of this same EPA report, the measured mercury emission rate from biomass-fueled spreader stokers (15 points total) had an average of 0.33 ug/dscm, a median of 0.48 ug/dscm, and a maximum of 1.01 ug/dscm. In Table 8-5 of this EPA report, the measured mercury emission rate from biomass-fueled fluidized bed boilers (3 points total) had an average of 0.26 ug/dscm, and a maximum of 0.27 ug/dscm. An emission rate of 1.0 ug/dscm is equal to an emission rate of approximately 0.6 pounds per trillion Btu.

The emission factor for mercury emissions from waste wood combustion in the U.S. EPA's AP-42, *Compilation of Air Pollutant Emission Factors*, 5<sup>th</sup> Edition, Wood Residue Combustion, Tables 1.6-4, is 3.5 lb/TBtu, and is given an A rating. This emission factor is also in the U.S. EPA's FIRE database.

In January, 2010, a preliminary database of emission test data, continuous emission monitoring system (CEMS) data, and fuel analysis data for boilers and process heaters at major sources of HAP was made available at <http://www2.ergweb.com/projects/combustion/combustiontesting.html>. This data includes standardized emission data from both the U.S. EPA's Phase I survey Information Collection Request (ICR No. 2286.01) and the Phase II test plan (ICR No. 2286.03). The database included both fuel sampling and analysis data for mercury, as well as emission test data for mercury from biomass-fueled boilers. The mercury fuel sampling and analysis data included over 500 samples for biomass fuels (with descriptions including wood, bark, plywood, particleboard, hog fuel, and biomass). The mercury fuel sampling and analysis data ranged from 0.06 lb/trillion Btu to 60 lb/trillion Btu. The database also included mercury emission test data. The mercury emission test data included 77 tests on biomass-fueled boilers, with emission rates ranging from 0.03 lb/trillion Btu to 5.5 lb/trillion Btu. Eighteen (18) of the emission test results indicated mercury emissions below the detection limit of the test. This ICR data is plotted in Figure 3 as probability distributions for each data set. The 90% probability for the mercury emission rate, based on fuel sampling and analysis, is 6.8 lb/trillion Btu. The 90% probability distribution for the mercury emission rate, based on emission testing, is 2.9 lb/trillion Btu. This data suggests that the actual mercury emissions are reduced by almost 60% as compared to the uncontrolled, fuel input or potential combustion concentration for mercury.

Based on the available data, we have concluded that the MACT floor for mercury emissions from this biomass-fueled boiler is the use of biomass fuels, natural gas, and a fabric filter baghouse. Biomass fuels generally have very low mercury levels, with typical mercury in fuel levels of 0.3 to 3.0 pounds per trillion Btu of heat input. The resulting emission rate is expected to be 2.9 lb/trillion Btu of heat input, equal to 5 micrograms per dry standard cubic meter of exhaust gas. This emission rate represents a reasonable estimate of the performance of the "best controlled similar unit" under the worst reasonably foreseeable circumstances.

**FIGURE 3. Mercury (Hg) fuel sampling and analysis and emission test data for biomass combustion from the U.S. EPA’s industrial boiler ICR.**



## 7.4 Beyond-the-Floor Analysis for Mercury.

In making a case-by-case MACT determination, the permitting authority is expected to look beyond the MACT floor, to evaluate whether a greater degree of reduction in emissions is achievable, taking into consideration the cost of achieving such emission reductions, and any non-air quality health and environmental impacts and energy requirements. The following represents a beyond the floor MACT analysis for mercury emissions from this biomass-fueled boiler.

### 7.4.1 Potential Mercury Control Technologies.

As discussed above, biomass fuels generally have very low mercury levels, with typical mercury in fuel levels of 0.3 to 3.0 pounds per trillion Btu of heat input. Therefore, mercury emissions from biomass-fueled boilers are effectively controlled by the use of these low mercury containing biomass fuels combined with the co-benefits of the particulate matter control systems. Although we are not aware of any biomass-fueled boiler using post combustion mercury control systems, mercury emissions from municipal waste combustors and coal-fueled electric utility steam generating units may also be controlled

through mercury-specific control technologies. Based upon available information, mercury specific controls include activated carbon injection (ACI), mercury oxidation catalysts, and other controls, including halogen injection into the boiler. Development of halogenated powdered activated carbon (PAC) sorbents, including brominated PAC, is also underway to improve mercury control performance. Both the mercury oxidation catalysts and activated carbon injection systems may be installed upstream of the particulate matter control system to enhance mercury capture and control.

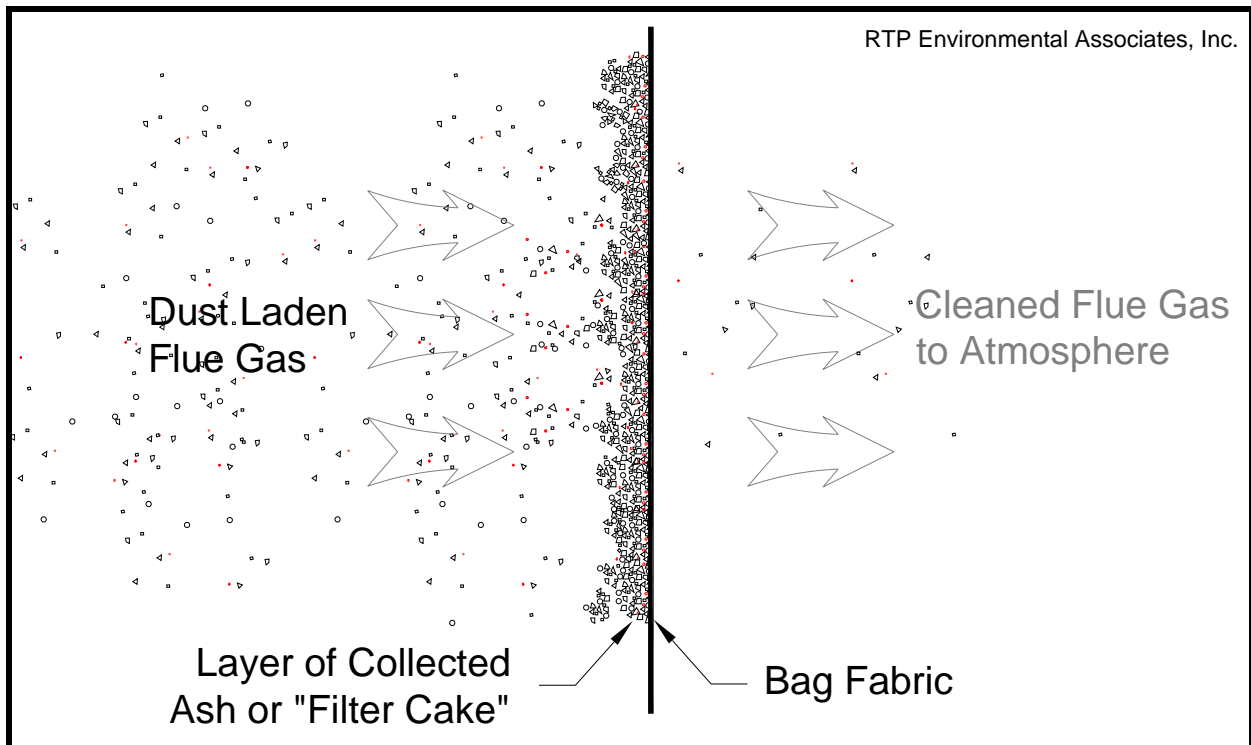
## **7.4.2 Technically Feasible Mercury Control Technologies.**

### **7.4.2.1 PM Control Systems and Mercury Control.**

Based on a review of the available information, there is little information on the level of control which may be expected from the PM control systems for biomass-fueled boilers. However, there is available information for mercury control for coal combustion. According to the U.S. EPA report “*Control of Mercury Emissions from Coal-Fired Electric Utility Boilers*” published in February, 2004, and “*Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update*”, published February, 2005, emission tests indicated that mercury control efficiencies for coal-fired electric generating units equipped with only fabric filter baghouse PM controls averaged 72% and 90% for subbituminous and bituminous coal combustion, respectively. By comparison, coal-fired electric generating units equipped with only electrostatic precipitator PM controls averaged 3% and 36% for subbituminous and bituminous coal combustion, respectively.

The improved mercury control efficiency for coal-fired boilers using fabric filter baghouses as compared to those using electrostatic precipitators is probably due to the increased contact that the flue gas experiences with fly ash and unburned carbon on the filter cake of the fabric filter. Figure 4 is a depiction of the flue gas flow through the fabric filter bag. The filter cake acts like a fixed-bed reactor, contributing to greater mercury oxidation and adsorption. Mercury capture is also related to the levels of halogens in the fuel. Higher levels of especially chlorine and bromine in fuels appears to enhance mercury oxidation and improve mercury control in PM control systems.

**FIGURE 4. Depiction of the flue gas flow through the fabric filter baghouse filter cake showing the mechanism for particulate collection and mercury control.**



#### 7.4.2.2 Sorbent Injection.

Mercury emissions from coal-fired boilers and municipal waste combustors may be controlled through the injection of mercury sorbents into the flue gas. The most common mercury sorbent system is activated carbon injection (ACI). ACI involves the injection of powdered activated carbon (PAC) into the flue gas upstream of a PM control system. The sorbent may be injected into the flue gas upstream of the primary PM control system, or it may be injected downstream of the primary PM control system and upstream of a separate PM control system, usually a pulse jet baghouse, to collect the mercury sorbent separately from the fly ash. In this latter arrangement, a system called a Compact Hybrid Particle Collector (COHPAC™) may be used. When a COHPAC is combined with sorbent injection, it is called Toxic Emission Control (TOXECON™).

From 2001 to 2003, the Department of Energy's National Energy Technology Lab, the Electric Power Research Institute (EPRI) and a group of utility companies conducted field test projects with test periods of five to ten days to evaluate ACI. The results of these tests are summarized in Table 7.

Several factors affect the mercury control performance of ACI, including the uncontrolled mercury emission rate or concentration, the sorbent injection rate, the flue gas temperature, and the sorbent characteristics. Other factors also affect mercury removal, including fabric filter baghouse and bag design, and baghouse operation. For ACI, the sorbent injection rate is typically expressed in pounds of

sorbent used for each million actual cubic feet of flue gas, or lb/mmACF. For a 50 MW boiler, a sorbent injection rate of 1.0 lb/mmACF will correspond to approximately 12 pounds per hour. Flue gas temperature is also critical to ACI performance. At temperatures above 350 °F, the mercury capture of PAC drops off rapidly. At Salem Harbor, increasing the ESP inlet temperature from 300 to 350°F reduced mercury removal from approximately 90% to approximately 10% to 20%.

**TABLE 7. Short term activated carbon injection field test projects. Data from “Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update”, Table 5.**

Unit	Fuel	PM Control System	Mercury Capture, %	
			Baseline	With ACI
PG&E Brayton Point	Bituminous Coal	Two CS-ESPs in series	90.8%	94.5%
PG&E Salem Harbor	Bituminous Coal	CS-ESP	90.0%	94.0%
WEPCO - Pleasant Prairie	Subbituminous Coal	CS-ESP	5%	65%
Alabama Power - Gaston	Bituminous Coal	HS-ESP + COHPAC™	0	25 – 90%
Univ. of Illinois - Abbott	Bituminous Coal	CS-ESP	0	73%

Finally, the sorbent characteristics can have a significant impact on mercury control performance in coal-fired boiler applications. From the above table, the mercury removal performance of plain powdered activated carbon is variable, and can be low on low chlorine (or total halogen) containing fuels such as subbituminous coal. Adequate halogens in the flue gas appears to improve mercury capture by activated carbon injection. This finding has led to the development of *halogenated* PAC sorbents. Halogenated PACs using bromine or iodine, such as brominated (B-PAC), offer several potential benefits, including the potential for lower PAC injection rates and better performance. Longer term, full scale tests on coal-fired units indicate mercury removal efficiencies of 70% to 95% at sorbent injection rates ranging from 0.5 to 6.4 pounds per million cubic feet of flue gas<sup>2</sup>.

While we are not aware of the use of activated carbon injection on any biomass-fueled boiler, based on the current coal-fired utility boiler and municipal waste combustor experience, activated carbon injection is a technically feasible mercury control alternative for biomass-fueled boilers. However, several factors may severely limit the ability of ACI to actually reduce mercury emissions from biomass-fueled boilers. The concentration of mercury in biomass is much lower than in coal, municipal solid waste, or refuse derived fuel, which means the concentration of mercury in the flue gas will also be much lower. The kinetics of the chemical reaction in which activated carbon removes mercury from the flue gas limits the ability to control mercury, and limits the ultimate controlled mercury emission rates which may be achieved in practice. As the mercury concentration in the flue gas decreases, more carbon is needed to

<sup>2</sup> Longer term, full scale test data is from “Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update”, Table 7, and “Accumulated Power-Plant Mercury-Removal Experience with Brominated PAC Injection”, S. Nelson Jr., R. Landreth, Q. Zhou, and J. Miller, Sorbent Technologies Corporation. Presented at the Combined Power Plant Air Pollutant Control Mega Symposium Washington, DC, Aug. 30 – Sept. 2, 2004.

remove the diminishing amounts of mercury. For example, the uncontrolled mercury concentrations at municipal waste combustors have historically been at 100 µg/dscm and higher (60 lb/trillion Btu); uncontrolled mercury at coal fired boilers are at 5 to 20 µg/dscm (3 – 12 lb/trillion Btu). Activated carbon is injected at MWCs at a ratio of about 100 parts of carbon to 1 part mercury to achieve 85% removal. Due to the lower concentrations and the potential for differing mercury species from biomass combustion, far more activated carbon would be required on a molar basis to achieve similar mercury removal efficiencies– perhaps as much as 10 times more. This can result in control costs which increase exponentially, or it may simply mean that ACI would have little effect in reducing mercury emission rates.

#### **7.4.2.3 Mercury-Specific Catalysts.**

Mercury specific catalysts have been investigated primarily as a method for enhancing mercury capture by wet FGD systems in coal-fired electric generating units. These catalysts are intended to oxidize elemental mercury to Hg<sup>+2</sup> which is soluble in water. Research is underway to evaluate catalysts or injection of oxidizing chemicals upstream of wet FGD systems. These approaches are undergoing full-scale evaluation. However, the sulfur dioxide control technology review for this biomass-fueled boiler concluded that a wet FGD system is not an economically feasible control technology and does not represent BACT for this boiler. Therefore, mercury specific oxidation systems are not technically feasible for this boiler.

#### **7.4.2.4 Addition of Mercury Oxidizing Chemicals.**

As noted in the U.S. EPA report “*Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update*”, the addition of chlorine or bromine to the fuel or flue gas is another approach being tested for enhancing the capture of mercury in PM and SO<sub>2</sub> control systems. However, we are not aware of the demonstration of the use of the addition of oxidizing chemicals on any biomass-fueled boiler. Because no data or experience is available for biomass-fueled boilers, the addition of oxidizing chemicals is not a demonstrated, technically feasible mercury control option.

### 7.4.3 Rank of the Technically Feasible Control Technologies.

Based upon available information, the only mercury control used on similar, biomass-fueled boilers is the use of low mercury containing biomass fuels combined with the use of PM control systems. We are not aware of the use of mercury specific controls on any biomass-fueled boilers. Based upon research, testing, and experience at coal-fired power plants and municipal waste combustors, mercury emissions may also be controlled through mercury-specific control technologies including activated carbon injection (ACI), mercury oxidation catalysts, and the addition of mercury oxidizing chemicals in the boiler. Based on this analysis, mercury oxidation catalysts and mercury oxidizing chemicals are not technically feasible control alternatives.

#### 7.4.3.1 PM Control Systems and Mercury Control.

Based upon the mercury MACT floor analysis, biomass fuels generally have very low mercury levels, The use of low mercury containing biomass fuels combined with the use of a fabric filter baghouse is expected to control mercury emissions to 2.9 lb/trillion Btu of heat input.

#### 7.4.3.2 Activated Carbon Injection.

As noted above, we are not aware of the use of activated carbon injection on any biomass-fueled boiler. Because the concentration of mercury in biomass is expected to be much lower than in coal, municipal solid waste, or refuse derived fuel, the reaction kinetics of the chemical reaction in which activated carbon removes mercury from the flue gas will limit the ability of ACI to control mercury. This can result in control costs which increase exponentially, or it simply may mean that ACI would have little effect in reducing mercury emission rates.

Based on this review and the fact that activated carbon injection has not been demonstrated on similar biomass-fueled boilers, We Energies has concluded that the level of mercury emissions with activated carbon injection will be the same as the level of control when firing low mercury containing biomass fuels and the use of a fabric filter baghouse. This ranking is summarized in Table 8.

**TABLE 8. Ranking of the technically feasible mercury control technologies.**

<b>Control System</b>	<b>Expected Emission Rate, lb/TBtu</b>
Biomass-Fueled Boiler with Fabric Filter Baghouse	2.9
Biomass-Fueled Boiler with Fabric Filter Baghouse and Activated Carbon Injection	2.9

#### **7.4.4 Evaluate the Most Effective Controls.**

From Table 8, we have concluded that based on the available information, the level of mercury emissions with activated carbon injection will be the same as the level of control when firing low mercury containing biomass fuels and the use of a fabric filter baghouse. Even if we could conclude otherwise, the use of activated carbon injection does not represent the case-by-case MACT for this boiler.

From a cost perspective, the use of an activated carbon injection system would have a capital cost of \$40 – \$60 per kW of installed capacity, or \$2.0 to \$3.0 million for this biomass-fueled boiler<sup>3</sup>. Based on a 15 year project life and an interest rate of 7%, this capital investment would have an annual capital cost of more than \$200,000 per year. Even if this control system could reduce mercury emissions by 50%, from 20.3 pounds per year, to 10.2 pounds per year, the cost effectiveness of the activated carbon injection system, based only on the capital investment, would be at least \$20,500 per pound of mercury controlled. This is an extremely high cost, especially since there is no evidence that this level of control could actually be achieved.

The use of activated carbon injection may also adversely impact the potential reuse of the boiler flyash which could have substantial environmental impacts and additional economic costs. The biomass-fueled boiler is expected to produce about 29,200 tons per year of ash. This ash will be derived from biomass fuels, and is anticipated to have value as a soil amendment or fertilizer. However, if sorbent injection were to adversely impact the reuse of this ash, the ash may need to be disposed of in a landfill. If the avoided landfill cost is \$30 per ton of ash, the potential disposal of the ash could increase operating costs by \$876,000 per year. This increased cost would be in addition to the sorbent injection capital cost. Based on the potential impact to ash disposal, the use of activated carbon injection could have an economic cost of \$86,000 per pound of mercury controlled.

#### **7.4.5 Beyond the Floor MACT Mercury Conclusion.**

Based upon available information, the only mercury control used on similar, biomass-fueled boilers is the use of low mercury containing biomass fuels combined with the use of PM control systems. We are not aware of the use of mercury specific controls on any biomass-fueled boilers. While we are not aware of the use of activated carbon injection on any biomass-fueled boiler, based on the current coal-fired utility boiler and municipal waste combustor experience, activated carbon injection is a technically feasible mercury control alternative for biomass-fueled boilers. However, because the concentration of mercury in biomass is expected to be much lower than in coal, municipal solid waste, or refuse derived fuel, the reaction kinetics of the chemical reaction in which activated carbon removes mercury from the flue gas will limit the ability of ACI to control mercury. This can result in control costs which increase exponentially, or it simply may mean that ACI would have little effect in reducing mercury emission rates. Based on this review and the fact that activated carbon injection has not been demonstrated on

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<sup>3</sup> The installed cost for PAC injection is from the U.S. EPA Report, *Performance and Cost of Mercury and Multipollutant Emission Control Technology Applications on Electric Utility Boilers*, EPA-600/R-03/110 October 2003, page 83, Figure

similar biomass-fueled boilers, we have concluded that the level of mercury emissions with activated carbon injection will be the same as the level of control when firing low mercury containing biomass fuels and the use of a fabric filter baghouse.

Even if activated carbon injection could reduce mercury emissions by 50%, the cost effectiveness of the activated carbon injection system, based only on the capital investment, would be at least \$20,500 per pound of mercury controlled. Further, the use of activated carbon injection may also adversely impact the potential reuse of the boiler flyash which could have substantial environmental impacts and additional economic costs. Based on the potential impact to ash disposal, the use of activated carbon injection could have an economic cost of \$86,000 per pound of mercury controlled. This is an extremely high cost, especially since there is no evidence that this level of control could actually be achieved.

Based on this analysis, we have concluded that the case-by-case MACT for the control of mercury emissions from this biomass-fueled boiler is the use of low mercury containing biomass fuels, combined with the use of a fabric filter baghouse.

## **7.5 Proposed Case-by-Case MACT Limit for Mercury.**

Based on this analysis, We Energies has concluded that the use of biomass fuels and natural gas in combination with a fabric filter baghouse represents MACT for the control of mercury emissions from this boiler. We Energies proposes the following emission limits as MACT for mercury emissions.

1. Mercury (Hg) emissions from the circulating fluidized bed boiler shall be controlled using biomass fuels in combination with a fabric filter baghouse as MACT.
2. Mercury (Hg) emissions may not exceed 2.9 pounds per trillion Btu of heat input..
3. Compliance with this emission limit shall be demonstrated using U.S. Reference Method 29, or another method approved in writing by the Department.



# Chapter 8. Natural Gas-Fueled Boiler Case-by-Case MACT Analysis.

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A new natural gas-fueled package boiler will be placed in service as part of this project. This package boiler will also be a source of hazardous air pollutants. The package boiler will have a maximum heat input capacity of 350 mmBtu/hr. Because the operation of this boiler is normally only required when the main CFB boiler is offline, the operation of this boiler is expected to be infrequent.

## 8.1 Hazardous Air Pollutant Emissions.

As with the biomass-fueled boiler, hazardous air pollutants (HAP) emitted from natural gas-fueled boilers may be classified in 4 broad categories, including inorganic, solid phase HAPs, inorganic, acid gas HAPs, organic HAPs, and mercury. However, potential HAP emissions are much smaller than for the biomass-fueled boiler. The potential HAP emissions are summarized in Table 9. Note that total potential HAP emissions for this boiler is only 1,844 pounds per year (0.92 tons per year). The HAPs included in the analysis are those HAPs that were identified in U.S. EPA's AP-42, 5<sup>th</sup> Edition, Natural Gas Combustion, Tables 1.4-3 and 1.4-4.

## 8.2 U.S. EPA Vacated Industrial Boiler MACT Standards.

This natural gas-fueled package boiler is generally encompassed within a source category of the Industrial Boiler MACT (NESHAP Subpart DDDDD – Industrial, Commercial, and Institutional Boilers and Process Heaters), which was promulgated on September 13, 2004. Based on the design heat input rating and proposed capacity factor, this boiler would have been considered a new or reconstructed large gaseous fuel-fired boiler under this MACT. This subcategory included the following limits:

Carbon Monoxide..... 400 ppm by volume on a dry basis corrected to 3% O<sub>2</sub>  
(30-day rolling average for units 100 MMBtu/hr or greater)

On June 8, 2007, the United States Court of Appeals for the District of Columbia Circuit (DC Circuit) vacated the Boiler MACT in its entirety.

**TABLE 9. Potential hazardous air pollutant emissions for the natural gas-fueled package boiler.**

Pollutant	CAS No.	Emission Factor		Heat Input mmBtu/hr	Potential to Emit	
		lb/10 <sup>6</sup> scf	lb/mmBtu		lb/hr	ton/yr
2-Methylnaphthalene	91-57-6	2.40E-05	2.40E-08	175	0.000004	0.00001
3-Methylchloranthrene	56-49-5	1.80E-06	1.80E-09	175	0.000000	0.00000
7,12 Dimethylbenz(a)anthracene		1.60E-05	1.60E-08	175	0.000003	0.00001
Acenaphthene	83-32-9	1.80E-06	1.80E-09	175	0.000000	0.00000
Acenaphthylene	203-96-8	1.80E-06	1.80E-09	175	0.000000	0.00000
Anthracene	120-12-7	2.40E-06	2.40E-09	175	0.000000	0.00000
Benz(a)anthracene	56-55-3	1.80E-06	1.80E-09	175	0.000000	0.00000
Benzene	71-43-2	2.10E-03	2.10E-06	175	0.000368	0.00114
Benzo(a)pyrene	50-32-8	1.20E-06	1.20E-09	175	0.000000	0.00000
Benzo(b)fluoranthene	205-99-2	1.80E-06	1.80E-09	175	0.000000	0.00000
Benzo(g,h,i)perylene	191-24-2	1.20E-06	1.20E-09	175	0.000000	0.00000
Benzo(k)fluoranthene	205-82-3	1.80E-06	1.80E-09	175	0.000000	0.00000
Chrysene	218-01-9	1.80E-06	1.80E-09	175	0.000000	0.00000
Dibenzo(a,h)anthracene	53-70-3	1.20E-06	1.20E-09	175	0.000000	0.00000
Dichlorobenzene	25321-22-6	1.20E-03	1.20E-06	175	0.000210	0.00065
Fluoranthene	206-44-0	3.00E-06	3.00E-09	175	0.000001	0.00000
Fluorene	86-73-7	2.80E-06	2.80E-09	175	0.000000	0.00000
Formaldehyde	50-00-0	7.50E-02	7.50E-05	175	0.013125	0.04069
Hexane	110-54-3	1.80E+00	1.80E-03	175	0.315000	0.97650
Indeno(1,2,3-cd)pyrene	193-39-5	1.80E-06	1.80E-09	175	0.000000	0.00000
Naphthalene	91-20-3	6.10E-04	6.10E-07	175	0.000107	0.00033
Phenanathrene	85-01-8	1.70E-05	1.70E-08	175	0.000003	0.00001
Pyrene	129-00-0	5.00E-06	5.00E-09	175	0.000001	0.00000
Toluene	108-88-3	3.40E-03	3.40E-06	175	0.000595	0.00184
Hydrogen chloride			1.24E-05	175	0.002170	0.00673
Arsenic	7440-38-2	2.00E-04	2.00E-07	175	0.000035	0.00011
Barium	7440-39-3	4.40E-03	4.40E-06	175	0.000770	0.00239
Beryllium	7440-41-7	1.20E-05	1.20E-08	175	0.000002	0.00001
Cadmium	7440-43-9	1.10E-03	1.10E-06	175	0.000193	0.00060
Chromium	7440-47-3	1.40E-03	1.40E-06	175	0.000245	0.00076
Cobalt	7440-48-4	8.40E-05	8.40E-08	175	0.000015	0.00005
Copper	7440-50-8	8.50E-04	8.50E-07	175	0.000149	0.00046
Manganese	7439-96-5	3.80E-04	3.80E-07	175	0.000067	0.00021
Mercury	7439-97-6	2.60E-04	2.60E-07	175	0.000046	0.00014
Molybdenum	7439-98-7	1.10E-03	1.10E-06	175	0.000193	0.00060
Nickel	7440-02-0	2.10E-03	2.10E-06	175	0.000368	0.00114
Selenium	7782-49-2	2.40E-05	2.40E-08	175	0.000004	0.00001
Vanadium	7440-62-2	2.30E-03	2.30E-06	175	0.000403	0.00125
<b>TOTAL, All HAPs, pounds per year</b>						<b>1.04</b>

**Footnotes**

The emission factors are for natural gas combustion in the U.S. EPA's AP-42, *Compilation of Air Pollutant Emission Factors*, 5<sup>th</sup> Edition, Natural Gas Combustion, Tables 1.4-3 and 1.4-4

### **8.3 Inorganic Solid Phase HAPs.**

Inorganic, solid phase HAP emissions occur from natural gas combustion as trace substances in the fuel. From Table 9, inorganic, solid phase HAPs include arsenic, beryllium, cadmium, chromium, copper, lead, manganese, nickel, selenium, and vanadium. These substances are emitted in solid form. The amount of ash, and the amount of these trace inorganic substances in natural gas are extremely small. The Control Technology Review for PM and PM<sub>10</sub> for this boiler includes a detailed discussion on PM control for this boiler. We Energies has proposed a particulate matter and PM<sub>10</sub> emission limit for the auxiliary boiler of 0.0075 pounds per million Btu of heat input, averaged over any 3-hour period. This limit is more stringent than the now vacated applicable PM/PM<sub>10</sub> of 0.03 lb/mmBtu for new, large liquid fuel boilers and limited use liquid fuel boilers of 0.03 lb/mmBtu. There are no PM standards for natural gas-fueled boilers. Based on this analysis, the use of PM<sub>10</sub> emissions as a surrogate for emissions of inorganic HAP's represents the case-by-case MACT floor for inorganic, solid phase HAP emissions from the natural gas-fueled boiler.

#### **8.3.1 Beyond the Floor Inorganic Solid Phase HAP MACT Analysis.**

The best control method, based upon available information, used to control inorganic, solid phase HAP emissions from natural gas-fueled industrial boilers is limiting fuels to gaseous fuels. As a result, We Energies has concluded that further control beyond the use of natural gas is not technically feasible.

#### **8.3.2 Proposed Case-by-Case MACT for Inorganic, Solid Phase HAPs.**

Based on this analysis, We Energies has concluded that the use of natural gas and the proposed BACT PM<sub>10</sub> emission limit represent the maximum achievable control technology for solid phase, inorganic HAPs from the natural gas-fueled package boiler. We Energies proposes that the BACT compliance demonstration requirements for PM<sub>10</sub> will also demonstrate compliance with the MACT requirements for this unit, so that no other requirements are necessary for this HAP category.

### **8.4 Inorganic Acid Gas HAPs.**

Inorganic, vapor phase HAPs including hydrochloric and hydrofluoric acids are formed from chlorine and fluorine in the fuel. From the memo from Christy Burlew and Roy Oommen, Eastern Research Group to Jim Eddinger, U.S. EPA, OAQPS, October, 2002, *Development of Average Emission Factors and Baseline Emission Estimates for the Industrial, Commercial, and Institutional Boilers and Process Heaters National Emission Standard for Hazardous Air Pollutants*, Appendix A, the HCl emission factor for natural gas combustion is  $1.24 \times 10^{-5}$  lb/mmBtu. This emission rate is about 1 percent of the (now vacated) HCl MACT limit for new, large liquid fuel boilers of 0.0009 lb/mmBtu. Potential HCl emissions are only 16.3 pounds (0.008 tons) per year.

#### **8.4.1 Beyond the Floor HCl MACT Analysis.**

The only known control method, based upon available information, used to control acid gas emissions from natural gas-fueled boilers is the use of natural gas as a fuel. Based on the information reviewed, flue gas desulfurization systems have never been used on natural gas or distillate fuel oil-fired boilers. Even if FGD was used, there is no data or information to suggest that HCl emissions could be reduced below the expected emission rate of 0.0000124 lb/MMBtu. Therefore, We Energies has concluded that the further control beyond the use of natural gas is not technically feasible.

#### **8.4.2 Proposed Case-by-Case MACT HCl Emission Limit.**

This package boiler will fire only natural gas. Restricting the fuels used in these boilers to only natural gas represents MACT for HCl emissions. Therefore, We Energies proposes restricting fuels used in this boiler to only natural gas as the case-by-case MACT limit for HCl emissions.

#### **8.4.3 Hydrogen Fluoride**

Hydrogen fluoride emissions from natural gas combustion are expected to be extremely small. We Energies was not able to identify actual fluoride emissions data for distillate fuel oil or natural gas combustion.

#### **8.4.4 Beyond the Floor HF MACT Analysis.**

As with HCl emissions, the only known control method used to control acid gas emissions from natural gas-fueled boilers is the use of natural gas as the fuel. We Energies has concluded that the further control beyond the use of natural gas is not technically feasible.

#### **8.4.5 Proposed Case-by-Case MACT HF Emission Limit.**

This package boiler will fire only natural gas. Restricting the fuels used in this boiler to only natural gas represents MACT for HF emissions. Therefore, We Energies proposes restricting fuels used in this boiler to only natural gas as the case-by-case MACT limit for HF emissions.

### **8.5 Organic HAPs.**

Organic HAPs are emitted from natural gas combustion as a result of incomplete combustion. A detailed discussion of control options for CO and volatile organic compound (VOC) emissions is included in the control technology review. According to the U.S. EPA's AP-42, potential organic HAPs resulting from natural gas combustion include 24 organic compounds, including polycyclic aromatic compounds, formaldehyde, hexane, and toluene. Hexane actually accounts for approximately 94% of all HAP emissions from natural gas combustion. These organic HAPs may be considered as a subset of the general class of organic compounds referred to VOC. As a result, minimizing VOC emissions will also minimize organic HAP emissions.

The use of CO or VOC emissions as a surrogate for the control of organic HAP emissions is consistent with the U.S. EPA's practice when establishing MACT standards for combustion source categories

emitting organic HAP's. For example, in the preamble for the "*National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters.*" 69 Fed. Reg. 55218, September 13, 2004, the U.S. EPA stated: "Because CO is a good indicator of incomplete combustion, there is a direct correlation between CO emissions and the formation of organic HAP emissions. Monitoring equipment for CO is readily available, which is not the case for organic HAP. Also, it is significantly easier and less expensive to measure and monitor CO emissions than to measure and monitor emissions of each individual organic HAP. Therefore, using CO as a surrogate for organic HAP is a reasonable approach because minimizing CO emissions will result in minimizing organic HAP emissions."

For this natural gas-fueled package boiler, We Energies has proposed a best available control technology CO emission limit of 0.0375 lb/mmBtu, and a VOC emission limit of 0.005 lb/MMBtu, achieved through good combustion practices. Because the organic HAPs are controlled in the same manner as CO and VOC emissions, the proposed use of good combustion practices and the CO (or VOC) BACT emission limit represents the maximum degree of reduction in HAP emissions which can be achieved by utilizing this control technology for a natural gas-fueled boiler. This analysis indicates that the use of CO or VOC emissions as a surrogate for emissions of organic HAP's represents the case-by-case MACT floor for organic HAP emissions from this boiler.

### **8.5.1 Beyond the Floor Organic HAP MACT Analysis.**

The only known control method, based upon available information, to control organic HAP emissions from natural gas-fueled boilers is good combustion practices. Based on the information available to We Energies, no post combustion controls have been required as MACT for similar boilers. While no other controls have been required for similar boilers, other potential VOC control systems include oxidation catalysts and thermal oxidation.

#### **8.5.1.1 Oxidation Catalysts.**

While oxidation catalysts are feasible for reducing CO emissions from natural gas-fueled boilers, there is limited data available on the potential to reduce HAP emissions using oxidation catalysts in natural gas-fueled boilers. The low excess oxygen levels and low temperatures of the flue gas make oxidation catalysts less effective than in combustion turbine applications which have high gas temperatures and 3 – 5 times higher excess oxygen levels.

#### **8.5.1.2 Thermal Oxidation**

Based on the information reviewed, thermal oxidation has never been required or used on a natural gas-fueled boiler, and its ability to reduce HAP emissions is questionable. Thermal oxidation would involve injecting additional air into the flue gas and heating the mixture to approximately 1,500 °F to oxidize organic HAPs to carbon dioxide. However, since the combustion of the reheat fuel would also result in HAP emissions in the same manner as the combustion of the primary fuel creates organic HAPs, there is no evidence that thermal oxidation would result in any reduction in HAP emissions. Since thermal oxidation has never been demonstrated on an Gas-fired boiler, and because there is no evidence that it

could reduce HAP emissions, thermal oxidation is not technically feasible for the control of HAP emissions from this package boiler.

Based on this review, We Energies has concluded that further control beyond the use of good combustion practices is not technically feasible.

### **8.5.2 Proposed Case-by-Case MACT Limit for Organic HAPs.**

Based on this analysis, We Energies has concluded that the proposed BACT CO emission limits and use of good combustion practices also represent MACT for organic HAPs from the natural gas-fueled package boiler, so that no other requirements are necessary for this HAP category.

## **8.6 Mercury**

Mercury emissions from natural gas combustion are also expected to be very small. From the U.S. EPA document AP-42, *Compilation of Air Pollutant Emission Factors*, 5th Edition, Table 1.4-4, mercury emissions from natural gas combustion are expected to be 0.26 pounds per trillion Btu. This appears to be a conservative (high) emission factor which results in potential mercury emissions of 0.34 pounds per year.

Our review of the U.S. EPA's RACT/BACT /LAER Clearinghouse to determine the best performing similar units did not show any similar natural gas-fueled boilers with specific mercury emission limits. To limit mercury emissions from similar sources, regulatory agencies have restricted the allowable fuels to only natural gas and distillate fuel oil – low mercury containing fuels. Therefore, the use of only natural gas represents the MACT floor for mercury.

### **8.6.1 Beyond the Floor Mercury MACT Analysis.**

The only known control method, based upon available information, used to control mercury emissions from natural gas-fueled boilers is the use of these low mercury containing fuels. We Energies has concluded that the further control beyond the use of natural gas as a fuel is not technically feasible.

### **8.6.2 Proposed Case-by-Case MACT Mercury Emission Limit.**

This package boiler will fire only natural gas. Restricting the fuels used in this boiler to only natural gas represents MACT for mercury emissions. Therefore, We Energies proposes restricting fuels used in this boiler to only natural gas as the case-by-case MACT limit for mercury emissions from this package boiler.

# Attachment 1.

**TABLE 1. Potential hazardous air pollutant emissions for the biomass-fired boiler B01 (2 pages).**

HAP Category	Hazardous Air Pollutant	Emission Factor	Heat Input Capacity	Potential to Emit	
		lb/mmBtu	mmBtu/hr	lb/hr	ton/yr
Inorganic, Solid Phase	Antimony	7.9E-06	800	0.006	0.028
	Arsenic	2.2E-05	800	0.018	0.077
	Beryllium	1.1E-06	800	0.001	0.004
	Cadmium	4.1E-06	800	0.003	0.014
	Chromium, total	2.1E-05	800	0.017	0.074
	Chromium, hexavalent	3.5E-06	800	0.003	0.012
	Cobalt	6.5E-06	800	0.005	0.023
	Lead	4.8E-05	800	0.038	0.168
	Manganese	1.6E-03	800	1.280	5.606
	Nickel	3.3E-05	800	0.026	0.116
	Phosphorus	2.7E-05	800	0.022	0.095
	Selenium	2.8E-06	800	0.002	0.010
	Inorganic Acid Gases	Hydrogen chloride	0.018	800	14.4
Hydrogen fluoride		0.001	800	0.8	3.5
Organic	Acetaldehyde	8.3E-04	800	0.664	2.908
	Acetophenone	3.2E-09	800	0.0000	0.000
	Acrolein	7.5E-05	800	0.0601	0.263
	Benzene	4.2E-03	800	3.360	14.717
	Benzo(a)anthracene	6.5E-08	800	0.000052	0.000
	Benzo(a)pyrene	2.6E-06	800	0.002080	0.009
	Benzo(b)fluoranthene	1.0E-07	800	0.000080	0.000
	Benzo(e)pyrene	2.6E-09	800	0.000002	0.000
	Benzo(g,h,i)perylene	9.3E-08	800	0.000074	0.000
	Benzo(j,k)fluoranthene	1.6E-07	800	0.000128	0.001
	Benzo(k)fluoranthene	3.6E-08	800	0.000029	0.000
	bis(2-Ethylhexyl)phthalate	4.7E-08	800	0.000038	0.000
	Bromomethane (Methyl bromide)	1.5E-05	800	0.012	0.053
	2-Butanone (MEK)	5.4E-06	800	0.004	0.019
	Carbon tetrachloride	4.5E-05	800	0.036	0.158
	Chlorine	7.9E-04	800	0.632	2.768
	Chlorobenzene	3.3E-05	800	0.026	0.116
	Chloroform	2.8E-05	800	0.022	0.098
	Chloromethane (Methyl chloride)	2.3E-05	800	0.018	0.081
	Dibenzo(a,h)anthracene	9.1E-09	800	0.000	0.000
	1,2-Dibromoethene	5.5E-05	800	0.044	0.193

**TABLE 1. Potential hazardous air pollutant emissions for the biomass-fired boiler B01 (2 pages).**

HAP Category	Hazardous Air Pollutant	Emission Factor	Heat Input Capacity	Potential to Emit	
		lb/mmBtu	mmBtu/hr	lb/hr	ton/yr
Organic	Dichlorobiphenyl (PCB)	7.4E-10	800		
	Heptachlorobiphenyl (PCB)	6.6E-11	800		
	Hexachlorobiphenyl (PCB)	5.5E-10	800		
	Monochlorobiphenyl (PCB)	2.2E-10	800		
	Pentachlorobiphenyl (PCB)	1.2E-09	800		
	Tetrachlorobiphenyl (PCB)	2.5E-09	800		
	Trichlorobiphenyl (PCB)	2.6E-09	800		
	Total Polychlorinated biphenyls (PCB)	7.9E-09	800	0.000006	0.000
	Total Equiv. 2,3,7,8 TCDD (Dioxins)	3.0e-9	800	0.000002	0.00001
	1,2-Dichloroethane (EDC)	2.9E-05	800	0.023	0.102
	Dichloromethane	2.9E-04	800	0.232	1.016
	1,2-Dichloropropane	3.3E-05	800	0.026	0.116
	2,4-Dinitrophenol	1.8E-07	800	0.000	0.001
	Ethyl benzene	3.1E-05	800	0.025	0.109
	Formaldehyde	4.4E-03	800	3.520	15.418
	Indeno(1,2,3,c,d)pyrene	8.7E-08	800	0.00006960	0.000
	2-Methylnaphthalene	1.6E-07	800	0.00012800	0.001
	Naphthalene	9.7E-05	800	0.078	0.340
	4-Nitrophenol	1.1E-07	800	0.0000880	0.000
	Pentachlorophenol (PCP)	5.1E-08	800	0.0000408	0.000
	Phenol	5.1E-05	800	0.041	0.179
	Propanal (Propionaldehyde)	3.2E-06	800	0.003	0.011
	Propionaldehyde	6.1E-05	800	0.049	0.214
	Styrene	1.9E-03	800	1.520	6.658
	Tetrachloroethene (Perchloroethylene)	3.8E-05	800	0.030	0.133
	Toluene	9.2E-04	800	0.736	3.224
	1,1,1-Trichloroethane	3.1E-05	800	0.025	0.109
	Trichloroethene	3.0E-05	800	0.024	0.105
	Trichlorofluoromethane (CFC-11)	4.1E-05	800	0.033	0.144
	2,4,6-Trichlorophenol	2.2E-08	800	0.000	0.000
	Vinyl Chloride	1.8E-05	800	0.014	0.063
	o-Xylene	2.5E-05	800	0.020	0.088
	Mercury	2.9E-06	800	0.002	0.010
<b>TOTAL</b>				<b>122.2</b>	

**Footnotes**

1. The emission factors are for waste wood combustion in the U.S. EPA's AP-42, *Compilation of Air Pollutant Emission Factors*, 5<sup>th</sup> Edition, Wood Residue Combustion, Tables 1.6-3 and 1.6-4.