

CIBO Estimated Capital Costs For Air Pollution Control Equipment For Biomass-Fired Industrial Boilers and Process Heatersⁱ

Pollutant	Particulate Matter (PM)	Hydrogen Chloride (HCl)	Carbon Monoxide (CO)	Dioxin/Mercury (Hg)
Likely Additional Control Required	Fabric Filter (FF)	Scrubber (e.g., spray dryer or wet scrubber)	Catalytic Oxidation (CATOX) or other combustion improvement projects	Carbon Injection (CI)
# of Biomass-Fired Boilers and Process Heaters	352 of the 466 biomass-fired units will need a new FF or an upgrade to their current FF or electrostatic precipitator (ESP).	10 of the 466 biomass-fired units need scrubbers or upgrades	333 of the 466 biomass-fired units need CATOX or combustion improvements	401 of the 466 biomass-fired units need CI (cost of required PM control device included in PM column as necessary)
Comments/ Assumptions	<ul style="list-style-type: none"> • If a unit did not already have a FF or ESP and there was information in the EPA database that indicated the unit cannot meet the limit or there was no emissions information, we assumed a new FF based on EPA baseline emission factors for various control devices for coal fired boilersⁱⁱ. • If the unit already had a FF or ESP and there was information in the EPA database that indicated the unit cannot meet the limit, we assumed an upgrade to the existing FF or ESP. • If unit had a FF and no emissions information, we assumed no upgrade necessary. • If unit had ESP and no emissions information, we assumed upgrade to ESP was necessary based on EPA baseline emission factors. • FF base capital cost \$7 MMⁱⁱⁱ; FF/ESP base upgrade capital cost \$4 MM.^{iv} 	<ul style="list-style-type: none"> • If there was information in the EPA database that indicated the unit cannot meet the limit, we assumed either a scrubber upgrade or new scrubber depending on whether the unit currently had a scrubber. • If there was no emissions information in the EPA database, we assumed the unit would meet the HCl limit without additional control.ⁱⁱ • Scrubber base capital cost \$8 million; scrubber base upgrade capital cost \$4 million.^{iv} 	<ul style="list-style-type: none"> • If there was information in the EPA database that indicated the unit cannot meet the limit or if there was no emissions information in the EPA database and the boiler is not a fluidized bed unit or dry biomass fuel cell, then we assumed that capital would be necessary to either perform combustion/fuel feed improvements or other boiler improvement projects to reduce CO or install a CO catalyst. • Base capital cost of \$3 million was assumed for CO controls (either projects to improve combustion or fuel feed or installation of a CO catalyst).^{iv} • NOTE: It is uncertain whether a CO catalyst can be applied effectively and efficiently to biomass-fired industrial boilers. 	<ul style="list-style-type: none"> • If there was information in the EPA database that indicated the unit cannot meet the limit for either mercury or dioxin, we added carbon injection. • If there was no Hg emissions information in the database, we assumed the unit would meet the mercury limit without additional control.ⁱⁱ • If there was no DF emission information in the database, we assumed that dutch oven and stoker units would need CI, based on EPA baseline emission factor memo.ⁱⁱ • A fixed cost of \$1 million was assumed for installation of a Carbon Injection system for Hg and/or dioxin control, as these systems do not vary much in cost by boiler size.
Total Capital Cost to Biomass-Fired Units: <u>\$2.86 billion</u>	\$1.6 billion	\$92 million	\$792 million	\$401 million

Pollutant	<u>Particulate Matter (PM)</u>	<u>Hydrogen Chloride (HCl)</u>	<u>Carbon Monoxide (CO)</u>	<u>Dioxin/Mercury (Hg)</u>
Capital Cost Per Unit	<ul style="list-style-type: none"> • Range of Costs Per Unit: \$797k to 21.3MM • Average Per Unit Cost: \$4.5MM^v 	<ul style="list-style-type: none"> • Range of Costs Per Unit: \$4.5 to 17.1MM • Average Per Unit Cost: \$9.2MM 	<ul style="list-style-type: none"> • Range of Costs Per Unit: \$435k to 9.1MM • Average Per Unit Cost: \$1.7MM 	<ul style="list-style-type: none"> • \$1 million per unit

ⁱ The chart includes data for 466 biomass-fired units >10 MMBtu/hr. The 466 units are derived from 457 units in the biomass MACT subcategory in EPA's Boiler MACT survey database available here: <http://www.epa.gov/ttn/atw/boiler/boilerpg.html#TECH> and 9 units in the forest products industry that are biomass fired boilers at major sources but were not in EPA's database. Capital cost estimates are not intended to represent a worst case analysis. Rather, they represent typical retrofit costs for the various scenarios based on published reports, industry information on specific project costs, EPA reports or control device fact sheets, or actual BACT or BART analyses submitted to permitting agencies. A primary resource was the document "Evaluation of Air Pollution Control Costs for the Pulp and Paper Industry," prepared by National Economic Research Associates (NERA) in May 2003. Note that costs were not scaled from the date of the reference used to 2011 dollars as the intent was to develop an order of magnitude estimate for each control scenario.

ⁱⁱ Where no emissions data were available in the EPA database for a particular type of unit, EPA's baseline emission factors identified in the memorandum "Revised Development of Baseline Emission Factors for Boilers and Process Heaters at Commercial, Industrial, and Institutional Facilities," January 2011, Appendix D were used to determine if typical emissions from the type of unit (fuel/design/control device) would meet the MACT limits.

ⁱⁱⁱ MM stands for million

^{iv} The base cost assumes a size of 250 MMBtu/hr, the boiler specific cost was calculated using a 0.6 power function and the actual boiler size in MMBtu (e.g., for a 100 MMBtu/hr boiler or process heater, the cost is the base cost times $(100/250)^{0.6}$).

^v Average cost was calculated by adding up the per unit cost for every unit requiring controls to get the total cost for all units and then dividing the total cost by the number of units requiring controls.