

### CIBO Estimated Capital Costs For Air Pollution Control Equipment For Liquid-Fired Industrial Boilers and Process Heaters<sup>i</sup>

<b>Pollutant</b>	<b>Particulate Matter (PM)</b>	<b>Hydrogen Chloride (HCl)</b>	<b>Carbon Monoxide (CO)</b>	<b>Dioxin/Mercury (Hg)</b>
<b>Likely Additional Control Required</b>	Fabric Filter (FF)	Scrubber (e.g., spray dryer or wet scrubber)	Catalytic Oxidation (CATOX) or other combustion improvement projects	Carbon Injection (CI)
<b># of Liquid-Fired Boilers and Process Heaters</b>	493 of the 513 liquid-fired units will need a new FF or an upgrade to their current FF or electrostatic precipitator (ESP).	497 of the 513 liquid-fired units need scrubbers or upgrades	469 of the 513 liquid-fired units need CATOX or combustion improvements	495 of the 513 liquid-fired units need CI
<b>Comments/ Assumptions</b>	<ul style="list-style-type: none"> <li>• 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 boilers<sup>ii</sup>.</li> <li>• 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.</li> <li>• If unit had a FF and no emissions information, we assumed no upgrade necessary.</li> <li>• If unit had ESP and no emissions information, we assumed upgrade to ESP was necessary based on EPA baseline emission factors.</li> <li>• FF base capital cost \$7 MM<sup>iii</sup>; FF/ESP base upgrade capital cost \$4 MM.<sup>iv</sup></li> </ul>	<ul style="list-style-type: none"> <li>• If there was information 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.<sup>ii</sup></li> <li>• Scrubber base capital cost \$8 million; scrubber base upgrade capital cost \$4 million.<sup>iv</sup></li> </ul>	<ul style="list-style-type: none"> <li>• 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, 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.</li> <li>• 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).<sup>iv</sup></li> <li>• NOTE: It is uncertain whether a CO catalyst can be applied effectively and efficiently to liquid-fired industrial boilers.</li> </ul>	<ul style="list-style-type: none"> <li>• If there was information in the EPA database that indicated the unit cannot meet the limit, we added carbon injection.</li> <li>• If there was no DF emissions information, we assumed no additional control based on EPA baseline emission factor memo.<sup>ii</sup></li> <li>• If there was no Hg emissions information and no Hg control device, we added CI, based on EPA baseline emission factor memo.<sup>ii</sup></li> <li>• 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.</li> </ul>
<b>Total Capital Cost to Liquid-Fired Units: \$5.9 billion</b>	\$2.1 billion	\$2.4 billion	\$863 million	\$495 million

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<b>Capital Cost Per Unit</b>	<ul style="list-style-type: none"> <li>• Range of Costs Per Unit: \$1.0 to 16.9MM</li> <li>• Average Per Unit Cost: \$4.2MM<sup>v</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Range of Costs Per Unit: \$1.2 to 19.4MM</li> <li>• Average Per Unit Cost: \$4.9MM</li> </ul>	<ul style="list-style-type: none"> <li>• Range of Costs Per Unit: \$435k to 7.3MM</li> <li>• Average Per Unit Cost: \$1.7MM</li> </ul>	<ul style="list-style-type: none"> <li>• \$1 million per unit</li> </ul>

<sup>i</sup> The chart includes data for 513 liquid-fired units >10 MMBtu/hr. The 513 units are derived from 508 units in the liquid MACT subcategory in EPA's Boiler MACT survey database available here: <http://www.epa.gov/ttn/atw/boiler/boilerpg.html#TECH> and 5 units in the forest products industry that are liquid 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.

<sup>ii</sup> 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.

<sup>iii</sup> MM stands for million

<sup>iv</sup> 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  $(100/250)^{0.6}$ ).

<sup>v</sup> 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.