

Table 9. Comparison of estimated emissions between U.S. cellulosic and corn ethanol facilities and petroleum refineries producing gasoline.

Refinery, Type	Estimated Emissions (lb/1000 gal fuel produced <sup>a</sup> )									
	CO <sub>2</sub>		PM Total	PM <sub>10</sub> <sup>c</sup>	PM <sub>2.5</sub>	SO <sub>x</sub>	NO <sub>x</sub>	CO	VOCs	HAPs
	Biogenic <sup>b</sup>	Fossil Fuel <sup>e</sup>								
Cellulosic ethanol, demonstration <sup>d</sup>	14,592	0	9.2	7.4	1.3	4.5	26	25	42	5.8
Corn ethanol, commercial <sup>e</sup>	7,700	6,100	1.6	1.3	—	1.0	2.6	3.0	3.0	0.55
Petroleum, commercial (gasoline) <sup>f,g</sup>	0.0	2,600	—	0.78	0.45	2.5	3.7	1.4	0.65	<0.01

Notes: <sup>a</sup>Note that for every unit of energy that can be produced from a gallon of ethanol (from corn or cellulosic material), 50% more energy (a factor of 1.5) can be obtained from a gallon of gasoline. <sup>b</sup>Includes CO<sub>2</sub> emissions from energy and nonenergy (i.e., refining process) sources at the facilities. Biogenic sources include feedstock and waste material (e.g., lignin). <sup>c</sup>Includes CO<sub>2</sub> emissions from on-site energy sources that use traditional fossil fuel (e.g., natural gas, coal, etc.). <sup>d</sup>These emissions are the average of the estimates or limits from the permit documentation from the 7CEDF in this paper.<sup>72-80</sup> The CO<sub>2</sub> emissions estimates assume biomass is used as fuel for all energy sources. For PM<sub>10</sub> emissions, limits from the Genera Energy permit were excluded from the cellulosic average (as described above) because of the relatively high cooling tower permitted emission rate that was not reflective of the other cellulosic facilities with PM<sub>10</sub> data. <sup>e</sup>The biogenic CO<sub>2</sub> from corn ethanol refineries is based on a 1:1 (w/w) CO<sub>2</sub>-to-ethanol ratio as derived from fermentation stoichiometry. Corn fuel combustion CO<sub>2</sub> is estimated using California's GREET 1.7 model,<sup>1118</sup> which assumes natural gas as the fuel. <sup>f</sup>Petroleum refinery emission estimates for all pollutants except HAPs are based on U.S. petroleum refinery emission factors for gasoline production using DOE's GREET 1.7 model<sup>1110</sup> and input values appropriate for 2005–2030. The HAP estimates for petroleum refineries were based on total nationwide estimated emissions of air toxics for 153 U.S. petroleum refineries in 2002 that were obtained from data collected as part of a risk and technology review for EPA's NESHAP from petroleum refineries proposed rule.<sup>111</sup> These HAP estimates were also used in the analyses<sup>112</sup> performed for the proposed RFS2.<sup>31</sup> <sup>g</sup>Petroleum refineries are subject to several federal and state environmental regulations that have resulted in the use of numerous environmental controls that include air pollutant control equipment.<sup>113,114</sup> More information on the air pollution rules that apply to petroleum refineries can be found on the EPA website at <http://www.epa.gov/ttn/atw/petrefine/petrefpg.html>.