

Environmental and Sustainable Technology Evaluations (ESTE): Verification of Fuel Characteristics and Emissions from Biomass-fired Boilers

Impact Statement

The co-firing of biomass in coal-fired boilers may reduce the emissions of criteria pollutants and greenhouse gases while also reducing the use of finite fossil fuel resources. This verification measured the reductions of these emissions from biomass co-fired boilers in the 100 to 1000 million Btu per hour (MMBtu/h) size range. Impacts on ash quality were also measured.

Background

With increasing concern about climate change and fossil fuel energy supplies, there continues to be an interest in biomass as a renewable and sustainable energy source. Many studies have been conducted on the efficacy and environmental impacts of biomass co-firing on large, coal-fired utility boilers, but data have not been available for biomass co-firing in industrial size boilers. EPA's Office of Air Quality Planning and Standards is interested in biomass co-firing in industrial-commercial-institutional (ICI) boilers in the 100 to 1000 MMBtu/h range. The reason for this emphasis is to provide support for development of a new Area-Source MACT standard. There is also interest in developing a guidance memo relating to PM_{2.5} emissions reductions.

In 2006, ETV initiated a study to verify biomass co-firing in coal-fired boilers. EPA contracted with Southern Research Institute (SRI) to develop the protocol and perform the testing needed to verify these technologies.

Objectives

This project evaluated performance and emission reductions for larger ICI boilers as a result of biomass co-firing. The primary objectives were to:

- Evaluate changes in boiler emissions due to biomass co-firing
- Evaluate boiler efficiency with biomass co-firing
- Determine if the value of ash for beneficial uses is reduced due to added carbon and metals content
- Evaluate sustainability indicators including sourcing of biomass and disposal of ash.

Results

Two ESTE biomass co-firing verifications were completed in 2008: [Minnesota Power's Rapids Energy Center Boiler 5 \(MP-5\)](#) which currently co-fires bark with coal, and the [University of Iowa Main Power Plant's Boiler 10 \(UI-10\)](#) which co-fires wood derived pelletized fuel with coal. As noted above, impacts on boiler efficiency and emissions were measured during both tests and varied depending on the technology and application, as shown in the table on the following page.

ETV Program

The [ETV Program](#) operates as a public-private partnership mainly through cooperative agreements between EPA and private nonprofit testing and evaluation organizations. These ETV verification organizations work with EPA technology experts to create efficient and quality-assured testing procedures that verify the performance of innovative technologies. ETV operates six centers which cover a broad range of environmental technology categories.

Vendors and others in the private sector, as well as federal, state and local government agencies, cost-share with EPA to complete priority ETV protocols and verifications. In 2005, a new element of ETV was initiated, Environmental and Sustainable Technology Evaluations (ESTE), in which the most important technology categories for meeting EPA needs are verified through contracts with verification organizations. EPA has developed an ESTE project to verify biomass co-firing in coal-fired boilers. See <http://www.epa.gov/etv/este.html> for more information.

Table 1. Verified Biomass-fired Boilers

Performance Measure		Minnesota Power's Rapids Energy Center Boiler 5 (MP-5) Wood Waste Co-firing with Coal			Iowa Main Power Plant's Boiler 10 (UI-10) Renewafuel Pelletized Wood Fuel		
		Baseline ¹ Averages	Co-fire ² Averages	% Difference ³	Baseline ¹ Average	Co-fire ⁴ Average	% Difference ³
Boiler Efficiency	Heat Input (MMBtu/hr)	299	363	21.8%	265	273	3.00%
	Heat Output (MMBtu/hr)	223	223	0.00%	225.2	230	2.10%
	Efficiency, %	74.5 ± 0.3	61.3 ± 0.7	-17.7%	84.9 ± 0.4	84.1 ± 0.7	-0.90%
PM ⁵ Emissions	Total PM	0.0317 ± 0.005	0.0060 ± 0.003	-81.2%	0.061 ± 0.03	0.044 ± 0.003	-28.1%
	Filterable PM	0.0045 ± 0.0004	0.0037 ± 0.002	-17.1%	0.031 ± 0.008	0.024 ± 0.0018	-22.8%
	Condensable PM	0.0249 ± 0.0013	0.0034 ± 0.0015	-86.5%	0.030 ± 0.02	0.020 ± 0.0012	-33.9%
Gaseous ⁵ Pollutants	SO ₂	0.474 ± 0.02	0.0013 ± 0.0001	-99.7%	2.47 ± 0.14	2.16 ± 0.08	-12.4%
	CO ₂	160 ± 7	131 ± 4	-18.3	205 ± 2	207 ± 0.3	0.82%
	NO _x	0.527 ± 0.01	0.194 ± 0.007	-63.2%	0.460 ± 0.02	0.506 ± 0.018	10.2%
	CO	0.230 ± 0.02	0.555 ± 0.2	142%	0.088 ± 0.010	0.083 ± 0.05	-5.02%

¹ Baseline fuel = 100% coal; ² Co-fire fuel = 8% Coal; 92% woody biomass; ³ Statistically significant changes are bolded; ⁴ Co-fire fuel = 85.1% coal; 14.9% wood; ⁵ lb/MMBtu output

Carbon dioxide (CO₂) emissions associated with sourcing and transportation of biomass and ash disposal under baseline (no biomass co-firing) and test case (with biomass co-firing) conditions were also assessed and the following annual CO₂ emission reductions were estimated:

- **Wood Waste Co-firing with Coal:** 107,000 tons per year, based on a typical heat generating rate of 220 MMBtu/hr, an availability and utilization rate of 75% for Boiler 5, and an estimated CO₂ emission offset of 90% or 148 lb/MMBtu output during co-firing.
- **Renewafuels Pelletized Wood Fuel:** 11,000 to 13,000 tons per year, based on a typical heat generating rate of 160 to 190 MMBtu/hr, an availability and utilization rate of 80% for Boiler 10, and an estimated CO₂ offset of 10% or 20.7 lb/MMBtu output during co-firing.

Metals content in the fly ash were measured and determined to be well below the TCLP metals criteria (40 CFR 261.24) under baseline and co-fired runs during both verifications. Carbon content and ash loss on ignition were also measured and the results indicated that none of the fly ash produced under baseline or co-fired runs during the verifications met the Class F Requirements (C 618-05) for use in concrete. Thus, biomass co-firing did not impact the quality of the fly ash with regard to fly ash TCLP metals and Class F requirements were unchanged. For more information, including additional test results, visit <http://www.epa.gov/etv/este.html>.

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