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U.S. Experiences in Tackling Energy and Environmental Challenges of Boiler System

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Contents

1. Introduction

In the U.S., energy consumption by steam and process heat combined accounts for over 50% of the total energy use from industrial systems (see Figure 1). The use of boilers, process heaters, and furnaces for generating steam and heat in industrial facilities, commercial settings, and institutions consumes significant amounts of energy and is one of major sources of hazardous air pollutants, which contribute significantly to local pollution and global climate change. To address the energy and environmental challenges caused by boiler systems in the U.S., the country has taken a series of actions to reduce emissions from industrial, commercial and institutional boilers, improve the efficiency of steam systems, replace coal with cleaner energy resources, and promote the wider use of combined heat and power (CHP).

The purpose of this report is to provide a policy framework to understand the U.S. experience in regulating emissions from boilers, process heaters, and furnaces. In addition, this report aims at providing a comprehensive understanding of emission limits, work practice requirements, technical assistance resources, and policies related to these units. Lastly, this report synthesizes key insights based on the U.S. experience as a reference for other countries to consider.

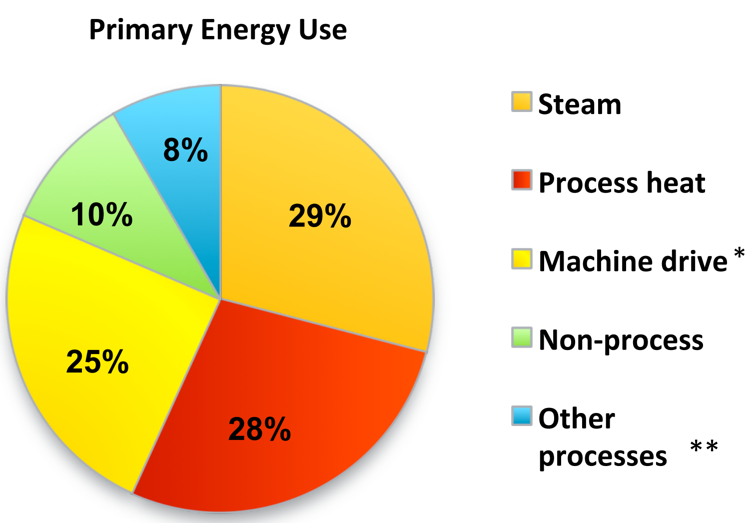

Figure 1 Energy use by industrial systems in the U.S.

** Machine drive refers to a motor driving a compressor, pump, or fan.*

***Other processes include: process heating for controlling chemical reactions (thermo-chemical processes) and establishing favorable physical or mechanical conditions, such as in plastics, food, or textile production*

Source: U.S. DOE, 2010.

To effectively pursue boiler opportunities, the U.S. has taken a holistic approach (see Figure 2). It shows defined targets and goals, provides needed guidance to boiler operators, as well as adopts policy and administrative measures to ensure optimal results. The sections that follow describe each step taken in the U.S.

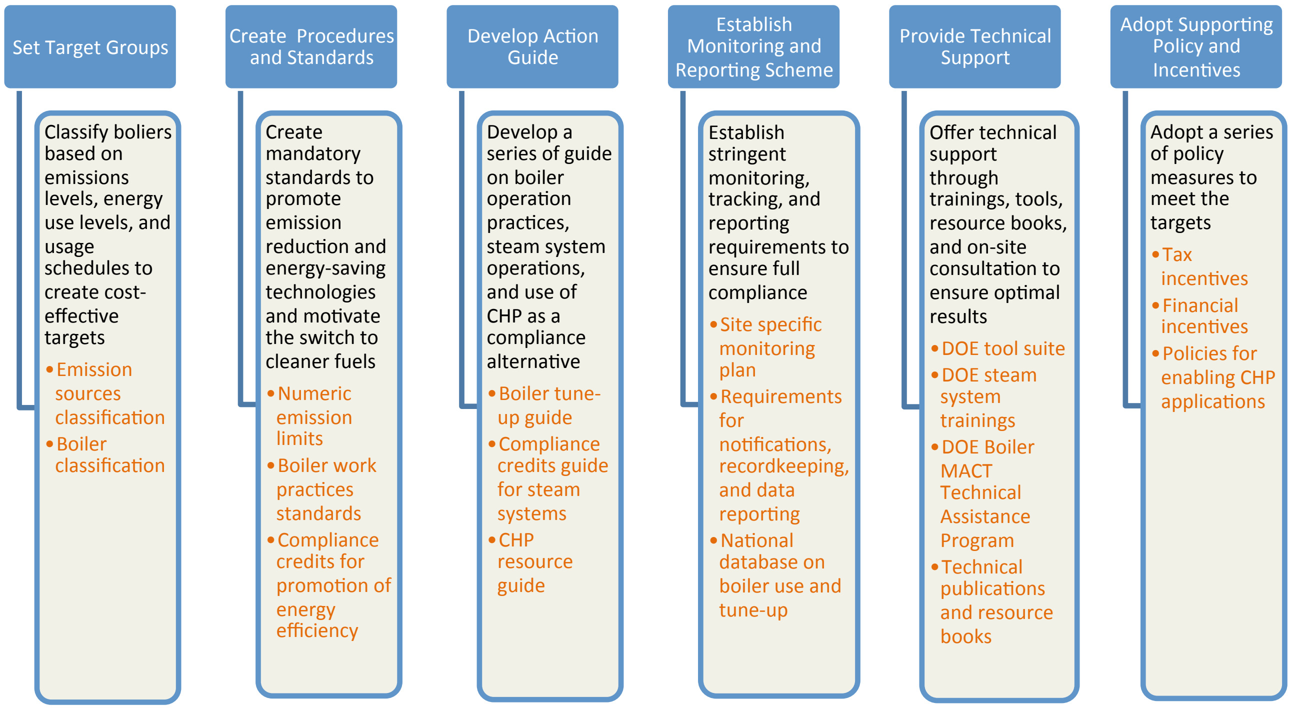

Figure 2 Overall framework of U.S. actions in addressing the boiler challenge

In the United States, the Environmental Protection Agency (EPA) is authorized under the Clean Air Act (CAA) to regulate 187 hazardous air pollutants (HAP). These air pollutants can cause health damages and/or adverse environmental and ecological effects (U.S. EPA, 2013a). The 187 HAP are specified under the Clean Air Act Amendments of 1990, and the list of the pollutants is available on EPA's website (U.S. EPA, 2013b). The Obama Administration has increasingly relied on the EPA's regulatory authority to address GHG emissions from industrial boilers and power plants.

2. Set Target Groups

2.1 Emission Sources Classification

EPA classifies emissions of toxic air pollutants based on the sources of emissions (U.S. EPA, 2013a):

- mobile sources – land, sea, and air transportation
- stationary sources –factories, refineries, power plants, buildings
- indoor sources – such as building materials and other indoor activities (such as cleaning)

Based on emission levels, EPA further classifies emissions into the following categories:

- **Major sources**: Major sources means "any stationary source or group of stationary sources" that emits 10 tons per year or more of any HAP or 25 tons per year or more of any combination of HAP.
- **Area sources**: Area sources means "any stationary source" of HAP that is not a major source, i.e., emit less than 10 tons per year of a particular air pollutant and less than 25 tons per year of aggregated air pollutants. Although emissions from area sources are smaller, collectively a number of area sources can be concerns as well – especially in densely populated areas.

EPA started publishing the listing of "source categories" as early as 1992, and several rounds of revisions and updates have been issued since then.

2.2 Boiler Classification

In the U.S., natural gas is the main fuel for boilers, followed by coal and biomass, respectively (see Figure 3). Industrial, commercial, and institutional boilers are categorized as "major source boilers" or "area source boilers", for the purpose of managing and controlling air pollutant emissions. Major source boilers are mostly located at industrial facilities, such as refineries, chemical plants, and energy-intensive manufacturing facilities. Area source boilers are often located at universities, hospitals, hotels, and commercial buildings (U.S. EPA, 2012).

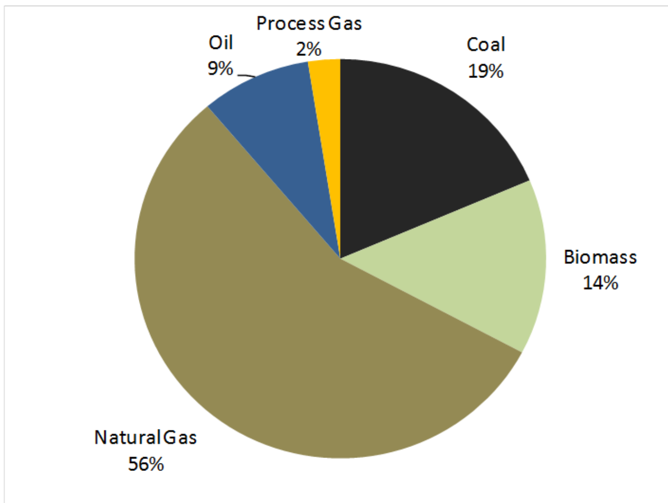

Figure 3 Fuel sources for boilers in the U.S.

Source: U.S. EPA, 2011.

3. Create Procedures and Standards

3.1 Boiler Emission Limits

EPA established HAP emission standards for industrial boilers under the authority of the Section 112 (d) of the CAA, based on maximum achievable control technology (Boiler MACT). The aim is to spur the maximum reduction of hazardous emissions, taking cost and feasibility into account. Under the Clean Air Act Amendments of 1990 Section 112(j), the MACT emission limits for existing sources must be equal to or more stringent than "the average emission limitation achieved by the best performing 12 percent of the existing sources" (U.S. EPA, 2002).

On December 20, 2012, the "National Emission Standards for Hazardous Air Pollutants for **Major** Sources: Industrial, Commercial, and Institutional (ICI) Boilers and Process Heaters" *(emphasis added)* (Federal Register, 2013a), and the "National Emission Standards for Hazardous Air Pollutants for **Area** Sources: Industrial, Commercial, and Institutional Boilers" *(emphasis added)* (Federal Register, 2013b) were finalized following public comments and industry petitions. The reconsideration process allows EPA to address additional technical issues that arise in the public review process, and provides the public the opportunity to review additional measures that were not initially included in the emission limits. With additional information on the real-world performance and operating conditions of affected boilers, EPA adjusted and amended the first proposal of the Boiler MACT. The finalized Boiler MACT were published on January 31, 2013 and February 1, 2013, respectively, for major and area source boilers.

Boiler MACT is established for both major and area source boilers. To achieve the optimal emission reduction results while keeping the implementation cost down, EPA only targets a small share (14%) of the total boilers currently operated in the U.S., which are significant sources of emissions. EPA rules vary by the type of boiler, rather than a rigid, one-fits-all ruling. Among 1.5 million boilers in use in the U.S., merely 2,300 are required to meet the numerical emission limits, accounting for less than 1% of the total boilers in the United States (U.S. EPA, 2012) and about 197,000 (or 13% of the total boilers) need to meet work practice procedures, such as annual tune-ups. The remainder is not subject to the EPA new rule. Figure 4 gives the various categories and number of each category of boilers that are subject to the regulation of ICI Boilers MACT.

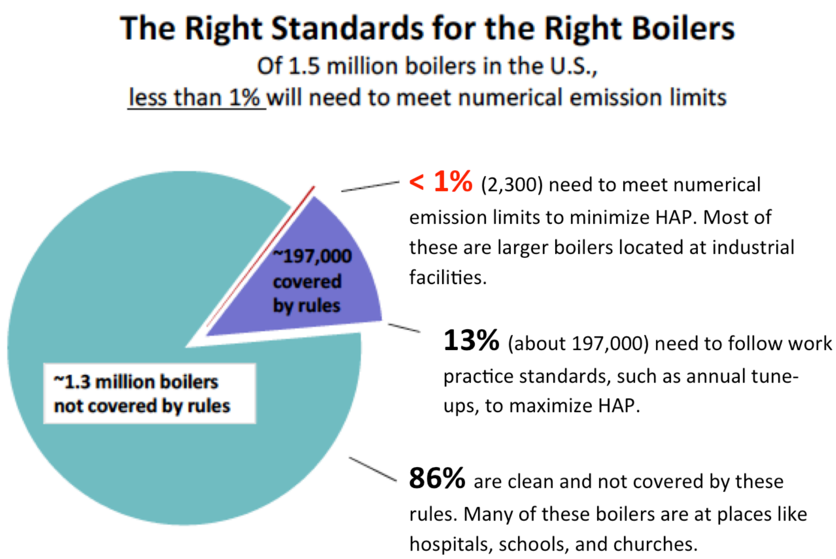

Figure 4 Boilers affected by ICI Boiler MACT

The area source boilers are operated in many types of businesses, such as wood product manufacturing, agriculture, food manufacturing, non-metallic mineral product manufacturing, and are most often found in commercial or public sectors, such as wholesale trade, real estate, education services, civic or professional organizations, public administration, food services and drinking places, heath care and social assistance, and electric power sector.

EPA estimated that there are a total of 14,136 major source boilers and process heaters to be covered under the new rule, among which about 12% (about 1,700) are required to meet numerical emission limits, while remaining 88% are required to follow the work practice procedure. EPA also estimated that an additional 1,844 new boilers and process heaters will be subject to the new rule over the next three years (Federal Register, 2013a). The following sections, which focus on major source boilers, describe some specific requirements in the EPA MACT rule (see Table 1).

Table 1 Potential regulated industries under the MACT standards

Category	NAICS Code*	Examples of potentially regulated entities
Any industry using a boiler or process heater as defined in the new rule	211	Extractors of crude petroleum and natural gas.
	321	Manufacturers of lumber and wood products.
	322	Pulp and paper mills.
	325	Chemical manufacturers.
	324	Petroleum refineries, and manufacturers of coal products.
	316,326, 339	Manufacturers of rubber and miscellaneous plastic products.
	331	Steel works, blast furnaces.
	332	Electroplating, plating, polishing, anodizing, and coloring.
	336	Manufacturers of motor vehicle parts and accessories.
	221	Electric, gas, and sanitary services.
	622	Health services.
	611	Educational services.

*NAICS: North American Industry Classification System.

** Process heaters refer to units with combustion gases are not directly in contact with process material or gases in the combustion chamber.

Source: Federal Register, 2013a.

The Boiler MACT divides boilers and process heaters into 19 subcategories based on unit types and fuel types, i.e., natural gas and refinery gas units, other gases units, light liquid units, heavy liquid, and units that burn solid fuels (coal and biomass). Requirements set for major source boilers and process heaters are also different, depending on the size of the unit, i.e., smaller than or equal to 5 MMBtu per hour, smaller than 10 MMBtu/hour but larger than 5 MMBtu/hr, and larger than or equal to 10 MMBtu/hour.

Among the 19 subcategories of affected large major source boilers and process heaters (i.e., heat input capacity larger than or equal to 10 MMBtu/hour), the EPA new rule sets numerical emission limits for 16 subcategories. Three subcategories– natural gas or refinery gas units, metal process furnaces, and limited use units –are not subject to emission limits; but are subjected to work practice procedures.

The EPA emission limits for the boilers and process heaters are established for controlling the emissions of five pollutants, including carbon monoxide (CO), hydrogen chloride (HCl), Mercury (Hg), particular matters (PM), and total selected metals (TSM).

3.1.1 Input-based emission limits

EPA has set the emission limits for affected boilers and process heaters based on heat input of fuels. Table 2 displays the numeric emission limits for various types of large major source boilers and process heaters.

Table 2 EPA Emission limits for Boilers and Process Heaters (units with heat input capacity of 10 MMBtu/hr or greater) (input-based)

Subcategory	Filterable PM (or TSM) (lb per MMBtu of heat input)[a]	HCl (lb per MMBtu of heat input)[b]	Mercury (lb per MMBtu of heat input)[a]	CO (ppm @ 3% oxygen)[a]	Alternate CO CEMS Limit (ppm @3% oxygen)[b]
Existing – Coal Stoker	0.040	0.022	5.7E-06	160	340
Existing – Coal Fluidized Bed	0.040	0.022	5.7E-06	130	230
Existing – Coal Fluidized Bed (FB) with FB Heat Exchange	0.040	0.022	5.7E-06	140	150
Existing – Coal-Burning Pulverized Coal	0.040	0.022	5.7E-06	130	320
Existing – Biomass Wet Stoker/Sloped Grate/Other	0.037	0.022	5.7E-06	1,500	720
Existing – Biomass Kiln-Dried Stoker/Sloped Grate/Other	0.32	0.022	5.7E-06	460	ND
Existing – Biomass Fluidized Bed	0.11	0.022	5.7E-06	470	310
Existing – Biomass Suspension Burner	0.051	0.022	5.7E-06	2,400	[c]2,000
Existing – Biomass Dutch Ovens/Pile Burners	0.28	0.022	5.7E-06	770	[c] 520
Existing – Biomass Fuel Cells	0.020	0.022	5.7E-06	1,100	ND
Existing – Biomass Hybrid Suspension Grate	0.44	0.022	5.7E-06	2,800	900
Existing – Heavy Liquid	0.062	0.0011	2.0E-06	130	ND
Existing – Light Liquid	0.0079	0.0011	2.0E-06	130	ND
Existing –Non-Continental Liquid	0.27	0.0011	2.0E-06	130	ND
Existing – Gas 2 (other process gases)	0.0067	0.0017	7.9E-06	130	ND
New – Coal Stoker	0.0011	0.022	8.0E-07	130	340
New – Coal Fluidized Bed	0.0011	0.022	8.0E-07	130	230
New – Coal Fluidized Bed (FB) with FB Heat Exchange	0.0011	0.022	8.0E-07	140	150
New – Coal-Burning Pulverized Coal	0.0011	0.022	8.0E-07	130	320
New – Biomass Wet Stoker/Sloped Grate/Other	0.030	0.022	8.0E-07	620	390
New – Biomass Kiln-Dried Stoker/Sloped Grate/Other	0.030	0.022	8.0E-07	460	ND
New – Biomass Fluidized Bed	0.0098	0.022	8.0E-07	230	310
New – Biomass Suspension Burner	0.030	0.022	8.0E-07	2,400	[c]2,000
New – Biomass Dutch Ovens/Pile Burners	0.0032	0.022	8.0E-07	330	[c] 520
New – Biomass Fuel Cells	0.020	0.022	8.0E-07	910	ND
New – Biomass Hybrid Suspension Grate	0.026	0.022	8.0E-07	1100	900
New – Heavy Liquid	0.013	4.4E-04	4.8E-07	130	ND
New – Light Liquid	0.0011	4.4E-04	4.8E-07	130	ND
New –Non-Continental Liquid	0.023	4.4E-04	4.8E-07	130	ND
New – Gas 2 (other process gases)	0.0067	0.0017	7.9E-06	130	ND

Note: lb/MMBtu heat input basis unless noted; alternative output based limits are not shown in the table above.
CEMS – continuous emissions monitoring system; NA – Not applicable; ND – No data available
[a] 3-run average, unless otherwise noted.

[b] 30-day rolling average, unless otherwise noted.
[c] 10-day rolling average.
Source: Federal Register, http://www.gpo.gov/fdsys/pkg/FR-2013-01-31/pdf/2012-31646.pdf

3.1.2 Output-based emission limits

The EPA Boiler MACT rule has also developed a flexible mechanism for determining emission levels. While the emission limits shown in the Table 2 is based on heat input of the fuels (e.g., in unit of lb/MMBtu for example), EPA has also established alternative emission limits that are based on the output of boilers and process heaters. In the latter option, emissions are measured not by the amount of fuels burned but by the amount of steam, heat, and/or electricity produced. For boilers that generate steam, for example, output-based emission limits are expressed in units of pounds per million Btu of steam output. For boilers that also generate electricity, emission limits are expressed in units of pounds per megawatt-hour. Table 3 is the EPA emission limits based on the output of affected boilers. Adopting output-based emission limits in addition to the input-based provides the flexibility to boilers and process heaters to meet the requirements. Most importantly, output-based emission limits encourage efficiency and pollution prevention. In addition, output-based emission limits allow boilers and process heaters to use energy efficiency as part of their emission control strategy.

Table 3 Output-Based Emission limits for Boilers and Process Heaters
(units with heat input capacity of 10 MMBtu/hr or greater)

Subcategory	Filterable PM (or TSM)	HCl	Mercury	CO (or CEMS)
Existing – Coal Stoker	4.2E-02 lb per MMBtu of steam output or 4.9E-01 lb per MWh of power generation; (or 5.6E-05 lb per MMBtu of steam output or 6.5E-04 lb per MWh)			0.14 lb per MMBtu of steam output or 1.7 lb per MWh; 3-run average
Existing – Coal Fluidized Bed				0.12 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
Existing – Coal Fluidized Bed (FB) with FB Heat Exchange				0.13 lb per MMBtu of steam output or 1.5 lb per MWh; 3-run average
Existing – Coal-Burning Pulverized Coal		0.025 lb MMBtu of steam output or 0.27 lb per MWh	6.4E-06 lb MMBtu of steam output or 7.3E-05 lb per MWh	0.11 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
Existing – Biomass Wet Stoker/Sloped Grate/Other	4.3E-02 lb per MMBtu of steam output or 5.2E-01 lb per MWh; (or 2.8E-04 lb per MMBtu of steam output or 3.4E-04 lb per MWh)			1.4 lb per MMBtu of steam output or 17 lb per MWh; 3-run average
Existing – Biomass Kiln-Dried Stoker/Sloped Grate/Other	3.7E-02 lb per MMBtu of steam output or 4.5 lb per MWh; (or 4.6E-03 lb per MMBtu of steam output or 5.6E-02 lb per MWh)			0.42 lb per MMBtu of steam output or 5.1 lb per MWh
Existing – Biomass Fluidized Bed	1.4E-01 lb per MMBtu of steam output or 1.6 lb per MWh; (or 1.5E-03 lb per			0.46 lb per MMBtu of steam output or 5.2 lb per MWh; 3-

	MMBtu of steam output or 1.7E-02 lb per MWh)			run average
Existing – Biomass Suspension Burner	5.2E-02 lb per MMBtu of steam output or 7.1E-01 lb per MWh; (or 6.6E-03 lb per MMBtu of steam output or 9.1E-02 lb per MWh)			1.9 lb per MMBtu of steam output or 27 lb per MWh; 3-run average
Existing – Biomass Dutch Ovens/Pile Burners	3.9E-01 lb per MMBtu of steam output or 3.9lb per MWh; (or 2.8E-03 lb per MMBtu of steam output or 2.8E-02 lb per MWh)			0.84 lb per MMBtu of steam output or 8.4 lb per MWh; 3-run average
Existing – Biomass Fuel Cells	5.5E-02 lb per MMBtu of steam output or 2.8E-01 lb per MWh; (or 1.6E-02 lb per MMBtu of steam output or 8.1E-02 lb per MWh)			2.4 lb per MMBtu of steam output or 12 lb per MWh
Existing – Biomass Hybrid Suspension Grate	5.5E-01 lb per MMBtu of steam output or 6.2 lb per MWh; (or 5.7E-04 lb per MMBtu of steam output or 6.3E-03 lb per MWh)			2.8 lb per MMBtu of steam output or 31 lb per MWh; 3-run average
Existing – Heavy Liquid	7.5E-02 lb per MMBtu of steam output or 8.6E-01 lb per MWh; (or 2.5E-04 lb per MMBtu of steam output or 2.8E-03 lb per MWh)			0.13 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
Existing – Light Liquid	9.6E-03 lb per MMBtu of steam output or 1.1E-01 lb per MWh; (or 7.5E-05 lb per MMBtu of steam output or 8.6E-04 lb per MWh)	1.4E-03 lb MMBtu of steam output or 1.6E-02 lb per MWh	2.5E-06 lb MMBtu of steam output or 2.8E-05 lb per MWh	0.13 lb per MMBtu of steam output or 1.4 lb per MWh
Existing –Non-Continental Liquid	3.3E-01 lb per MMBtu of steam output or 3.8 lb per MWh; (or 1.1E-03 lb per MMBtu of steam output or 1.2E-02 lb per MWh)			0.13 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
Existing – Gas 2 (other process gases)	1.2E-02 lb per MMBtu of steam output or 7.0E-02 lb per MWh; (or 3.5E-04 lb per MMBtu of steam output or 2.2E-03 lb per MWh)	2.9-03 lb MMBtu of steam output or 1.8E-02 lb per MWh	8.7E-07[a] lb MMBtu of steam output or 1.1E-05[a] lb per MWh	0.16 lb per MMBtu of steam output or 1.0 lb per MWh
New – Coal Stoker	1.1E-03 lb per MMBtu of steam output or 1.4E-02 lb per MWh; (or 2.7E-05 lb per MMBtu of steam output or 2.9E-04 lb per MWh)			0.12 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
New – Coal Fluidized Bed		0.025 lb MMBtu of steam output or 0.28 lb per MWh	8.7E-07[a] lb MMBtu of steam output or 1.1E-05[a] lb per MWh	0.11 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
New – Coal Fluidized Bed (FB) with FB Heat Exchange				0.12 lb per MMBtu of steam output or

				1.5 lb per MWh; 3-run average
New – Coal-Burning Pulverized Coal				0.11 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
New – Biomass Wet Stoker/Sloped Grate/Other	3.5E-02 lb per MMBtu of steam output or 4.2E-01 lb per MWh; (or 2.7E-05 lb per MMBtu of steam output or 3.7E-04 lb per MWh)			0.58 lb per MMBtu of steam output or 6.8 lb per MWh; 3-run average
New – Biomass Kiln-Dried Stoker/Sloped Grate/Other	3.5E-02 lb per MMBtu of steam output or 4.2E-01 lb per MWh; (or 4.2E-03 lb per MMBtu of steam output or 5.6E-02 lb per MWh)			0.42 lb per MMBtu of steam output or 5.1 lb per MWh
New – Biomass Fluidized Bed	1.2E-02 lb per MMBtu of steam output or 0.14 lb per MWh; (or 1.1E-04 [a] lb per MMBtu of steam output or 1.2E-03[a] lb per MWh)			0.22 lb per MMBtu of steam output or 2.6 lb per MWh; 3-run average
New – Biomass Suspension Burner	3.1E-02 lb per MMBtu of steam output or 4.2E-01 lb per MWh; (or 6.6E-03 lb per MMBtu of steam output or 9.1E-02 lb per MWh)			1.9 lb per MMBtu of steam output or 27 lb per MWh; 3-run average
New – Biomass Dutch Ovens/Pile Burners	4.3E-03 lb per MMBtu of steam output or 4.5E-02 lb per MWh; (or 5.2E-05 lb per MMBtu of steam output or 5.5E-04 lb per MWh)			0.35 lb per MMBtu of steam output or 3.6 lb per MWh; 3-run average
New – Biomass Fuel Cells	3.0E-02 lb per MMBtu of steam output or 2.8E-01 lb per MWh; (or 5.1E-05 lb per MMBtu of steam output or 4.1E-04 lb per MWh)			1.1 lb per MMBtu of steam output or 10 lb per MWh
New – Biomass Hybrid Suspension Grate	3.3E-02 lb per MMBtu of steam output or 3.7E-01 lb per MWh; (or 5.5E-04 lb per MMBtu of steam output or 6.2E-03 lb per MWh)			1.4 lb per MMBtu of steam output or 12 lb per MWh; 3-run average
New – Heavy Liquid	1.5E-02 lb per MMBtu of steam output or 1.8E-01 lb per MWh; (or 8.2E-05 lb per MMBtu of steam output or 1.1E-03 lb per MWh)	4.8E-04 lb MMBtu of steam output or 6.1E-03 lb per MWh	5.3E-07[a] lb MMBtu of steam output or 6.7E-06 [a] lb per MWh	0.13 lb per MMBtu of steam output or 1.4 lb per MWh; 3-run average
New – Light Liquid	1.2E-03[a] lb per MMBtu of steam output or 1.6E-02 [a] lb per MWh; (or 3.2E-05 lb per MMBtu of steam output or 4.0E-04 lb per MWh)			0.13 lb per MMBtu of steam output or 1.4 lb per MWh
New –Non-Continental Liquid	2.5E-02 lb per MMBtu of			0.13 lb per MMBtu

	steam output or 3.2E-01 lb per MWh; (or 9.4E-04 lb per MMBtu of steam output or 1.2E-02 lb per MWh)			of steam output or 1.4 lb per MWh; 3-run average
New – Gas 2 (other process gases)	1.2E-02 lb per MMBtu of steam output or 7.0E-02 lb per MWh; (or 3.5E-04 lb per MMBtu of steam output or 2.2E-03 lb per MWh)	2.9-03 lb MMBtu of steam output or 1.8E-02 lb per MWh	1.4E-05 lb MMBtu of steam output or 8.3E-05 lb per MWh	0.16 lb per MMBtu of steam output or 1.0 lb per MWh

[a] If conducting stack tests to demonstrate compliance and your performance tests for this pollutant for at least 2 consecutive years show that your emissions are at or below this limit, you can skip testing, if all of the other provisions of performance testing are met. For all other pollutants that do not contain a footnote "a", your performance tests for this pollutant for at least 2 consecutive years must show that your emissions are at or below 75 percent of this limit in order to qualify for skip testing.
Source: Federal Register, 2013a.

3.2 Boiler Work Practice Procedures

Section 112 (h) of the Clean Air Act allows the EPA to establish standardized work practice procedures to replace numerical emission limits when it is not practical to prescribe or enforce the numerical standards. Work practice procedures mandate periodic boiler tune-ups and reports to EPA at a frequency based on the fuel type and size of the boiler.

Facilities with large major source boilers (heat input capacities larger than or equal to 10 MMBtu/hr) are also required to carry out one-time energy assessments on related energy using systems. For special units that are not subject to the numerical emission limits, i.e., natural gas, refinery gas, and limited use boilers, periodical tune-ups are required.

Some units are required for a tune-up every five years while some others need to conduct a tune-up every two years. For boilers larger than or equal to 10 MMBtu/hr, tune-up has to be carried out annually. The detailed requirements for work practices procedures are shown in Table 4.

Table 4 Work Practice Standards in EPA Boiler MACT (for Major Source Boilers)

Major Source Boilers	Work Practice Standards Requirements
1. A new or existing boiler or process heater with a continuous oxygen trim system that maintains an optimum air to fuel ratio, or a heat input capacity of less than or equal to 5 million Btu per hour in any of the following subcategories: unit designed to burn gas 1; unit designed to burn gas 2 (other); or unit designed to burn light liquid, or a limited use boiler or process heater.	Conduct a tune-up every 5 years as specified under the Boiler MACT rule
2. A new or existing boiler or process heater without a continuous oxygen trim system and with heat input capacity of less than 10 million Btu per hour in the unit designed to burn heavy liquid or unit designed to burn solid fuel subcategories; or a new or existing boiler or process heater with heat	Conduct a tune-up of the boiler or process heater biennially as specified

input capacity of less than 10 million Btu per hour, but greater than 5 million Btu per hour, in any of the following subcategories: unit designed to burn gas 1; unit designed to burn gas 2 (other); or unit designed to burn light liquid.	
3. A new or existing boiler or process heater without a continuous oxygen trim system and with heat input capacity of 10 million Btu per hour or greater.	Conduct a tune-up of the boiler or process heater annually as specified. Units in either the Gas 1 or Metal Process Furnace subcategories will conduct this tune-up as a work practice for all regulated emissions under this subpart. Units in all other subcategories will conduct this tune-up as a work practice for dioxins/furans.
4. An existing boiler or process heater located at a major source facility, not including limited use units.	Must have a one-time energy assessment performed by a qualified energy assessor. An energy assessment completed on or after January 1, 2008, that meets or is amended to meet the energy assessment requirements in this table, satisfies the energy assessment requirement. A facility that operates under an energy management program compatible with ISO 50001 that includes the affected units also satisfies the energy assessment requirement. The energy assessment must include the following with extent of the evaluation for items a. to e. appropriate for the on-site technical hours listed in the MACT rule. a. A visual inspection of the boiler or process heater system. b. An evaluation of operating characteristics of the boiler or process heater systems, specifications of energy using systems, operating and maintenance procedures, and unusual operating constraints. c. An inventory of major energy use systems consuming energy from affected boilers and process heaters and which are under the control of the boiler/process heater owner/operator. d. A review of available architectural and engineering plans, facility operation and maintenance procedures and logs, and fuel usage. e. A review of the facility's energy management practices and provision of recommendations for improvements consistent with the definition of energy management practices, if identified. f. A list of cost-effective energy conservation measures that are within the facility's control. g. A list of the energy savings potential of the energy conservation measures identified. h. A comprehensive report detailing the ways to improve efficiency, the cost of specific improvements, benefits, and the time frame for recouping those investments.
5. An existing or new boiler or process heater subject to emission limits during startup.	Must operate all CMS during startup. For startup of a boiler or process heater, you must use one or a combination of the following clean fuels: natural gas,

	synthetic natural gas, propane, distillate oil, syngas, ultra-low sulfur diesel, fuel oilsoaked rags, kerosene, hydrogen, paper, cardboard, refinery gas, and liquefied petroleum gas. If you start firing coal/solid fossil fuel, biomass/bio-based solids, heavy liquid fuel, or gas 2 (other) gases, you must vent emissions to the main stack(s) and engage all of the applicable control devices except limestone injection in fluidized bed combustion (FBC) boilers, dry scrubber, fabric filter, selective non-catalytic reduction (SNCR), and selective catalytic reduction (SCR). You must start your limestone injection in FBC boilers, dry scrubber, fabric filter, SNCR, and SCR systems as expeditiously as possible. Startup ends when steam or heat is supplied for any purpose. Must comply with all applicable emission limits at all times except for startup or shutdown periods that need to conform to this work practice. Must collect monitoring data during periods of startup as specified. Must keep records during periods of startup. Must provide reports concerning activities and periods of startup, as specified.
6. An existing or new boiler or process heater subject to emission limits during shutdown.	Must operate all CMS during shutdown. While firing coal/solid fossil fuel, biomass/bio-based solids, heavy liquid fuel, or gas 2 (other) gases during shutdown, you must vent emissions to the main stack(s) and operate all applicable control devices, except limestone injection in FBC boilers, dry scrubber, fabric filter, SNCR, and SCR. Must comply with all applicable emissions limits at all times except for startup or shutdown periods that need to conform to this work practice. Must collect monitoring data during periods of shutdown as specified. Must keep records during periods of shutdown. Must provide reports concerning activities and periods of shutdown, as specified.

Source: Federal Register, 2013a.

Area source boilers are also subject to periodic boiler tune-up (see Table 5).

Table 5 Work Practice Standards for Area Source Boilers

Area Source Boilers	**Work Practice Standards Requirements**
Natural gas/refinery gas units (Gas 1)	N/A
Limited use units (≤10% average annual operating capacity factor)	Tune-up every 5 years. Existing units must complete an initial tune-up.
Seasonal boilers (biomass or oil-fired boilers that have at least 7 consecutive months of shutdown each 12 month period)	Tune-up every 5 years. Existing units must complete an initial tune-up.

Units with an oxygen trim system that maintains an optimum air-fuel ratio (for all fuels, all sizes, both new and existing boilers)	Tune-up every 5 years.
Existing Sources	
≤5 MMBtu/hr	Oil-fired: Tune-up every 5 years; Coal-fired: Tune-up every 2 years; Units with continuous oxygen trim systems: Tune-up every 5 years; Initial tune-up required.
>5 MMBtu/hr and < 10 MMBtu/hr	Oil-fired (not including limited use units, seasonal units, or units that use an oxygen trim system): Tune-up every 2 years; Coal-fired: Tune-up every 2 years; Units with continuous oxygen trim systems: Tune-up every 5 years; Initial tune-up required.
≥ 10 MMBtu/hr	Coal, biomass, or oil-fired: 1) meet emission limits: coal-fired – Hg, and CO; biomass, oil-fired – no emission limits 2) tune-up every 2 years (units with continuous oxygen trim systems: tune-up every 5 years) – serves as work practice standard for dioxin/furan emissions 3) one-time energy assessment
New Sources	
≤5 MMBtu/hr	Oil-fired: Tune-up every 5 years; Coal-fired: Tune-up every 2 years; Units with continuous oxygen trim systems: Tune-up every 5 years.
>5 MMBtu/hr and < 10 MMBtu/hr	Oil-fired (not including limited use units, seasonal units, or units that use an oxygen trim system): Tune-up every 2 years; Coal-fired: Tune-up every 2 years; Units with continuous oxygen trim systems: Tune-up every 5 years.
≥ 10 MMBtu/hr	Emission limits: 1) coal--fired – Hg, PM, and CO; 2) biomass, oil-fired – PM (new oil-fired boilers that combust only low-sulfur oil are not subject to the PM emission limit) 3) Co CEMS can be used in place of meeting the CO emissions limit Tune-up every 2 years (units with continuous oxygen trim systems: tune-up every 5 years)

Source: EPA, 2013b. ICF International, 2013a.

3.3 Operating Limits

Each boiler that is required to meet the numerical emission limits must have operating limits. The operating limits are set based on the type of pollutants and the type of operating parameters used. For example, if the boiler is required to meet the emission limit of carbon monoxide, and the operating limits are measured based on oxygen, a unit-specific limit for minimum oxygen level must be established, by using data from the oxygen analyzer system. The oxygen data must be collected every 15 minutes during the performance test period. If the boiler is required to meet emission limits of PM, TSM, or mercury, and the operating limits are based on electrostatic precipitator parameters, a site-specific minimum total secondary electric power input must be established, by using data from the voltage and secondary amperage monitoring during the PM or mercury performance test. The measurements must be collected every 15 minutes.

4. Ensure Compliance

4.1 Compliance of the Boiler MACT Rule

Existing and new boilers must comply with numeric emission limits, work practice procedures, and operating limits at all times when in operation. To demonstrate compliance with all applicable emission limits, owners or operators must use one of the following methods: performance stack testing, fuel analysis, or continuous monitoring systems (CMS)[1].

The performance stack testing demonstrates the boiler's compliance by using EPA-specified methods in Boiler MACT. Boiler owners or operators are also required to conduct fuel analysis, except for boilers that only burn one type of fuel or use natural gas or refinery gas. For boilers that are required to meet total selected metals (TSM) limits, Boiler MACT also requires facilities to conduct initial and annual stack tests to determine compliance with the TSM emission limits.

To ensure continuous compliance, the owners who operate boilers that burn solid fossil fuels or heavy liquids with heat input capacities of 250 MMBtu/hr or greater need to install, certify, maintain, and operate a continuous parameter monitoring system (CPMS), or a continuous emission monitoring system (CEMS) for particular matter (PM). For demonstrating continuous compliance of hydrogen chloride (HCl) emission limit, the EPA Boiler MACT rule also uses SO_2 emissions as an alternate operating limit.

4.1.1 Compliance period

To allow boiler operators to have a reasonable time frame to meet the Boiler MACT rule, EPA has offered a compliance period of up to 3 years. Boilers that began operations since June 4, 2010 are defined as existing boilers. These boilers must comply with the EPA new rule within 3 years from Boiler MACT was issued (i.e., by January 31, 2016). New boilers are required to comply with the rule on January 31, 2013 or immediately upon startup. For new boilers that began construction (or reconstruction) between June 4, 2010 and January 31, 2013, the compliance date will be January 31, 2016. Boiler owners or operators can apply for extensions on a case-by-case basis and the maximum time of extension is one year. If the owners or operators still fail to meet the requirements after the extension, they will be subject to enforcement actions under Section 113 of the CCA, including facing the civil penalty of not more than $25,000 *per day* for each violation of the CCA.

4.1.2 Costs of compliance and monitoring

EPA estimated the incremental cost of complying with Boiler MACT (see Table 6) in comparison to the 2011 Boiler MACT rule. The results show a national cost impact of $4.7 billion in capital expenditures and $1.5 billion per year in total annual costs, considering fuel savings. Both capital costs and annual costs include costs for control devices, work practices, testing, and monitoring. Specifically, the costs of

[1] Continuous monitoring systems include a continuous emission monitoring system (CEMS), continuous opacity monitoring system (COMS), or particular matter continuous parameter monitoring system (PM CPMS).

amended requirements and emission limits resulted a cost impact of $1 billion in capital expenditures and $0.31 billion per year in total annual costs (Federal Register, 2013a). Compliance with the Boiler MACT emission limits will be costly for coal and oil units. The annualized testing and monitoring cost for coal units is estimated to be $46 million per year. This would be a strong incentive for boiler owners or operators to consider switching to cleaner fuels.

Table 6 Total Capital Costs and Annual Costs of Affected Boiler Units

Source	Subcategory	Estimated/ projected number of affected units	Capital costs (10^6 $)	Testing and monitoring annualized costs (10^6 $/yr)	Annualized cost (10^6 $/yr) (considering fuel savings)
Existing Units	Coal units	621	2,554	46	904
	Biomass units	502	405	29	109
	Heavy Liquid units	319	761	5.4	221
	Light Liquid units	615	712	4.2	166
	Non-Continental Liquid units	21	62	0.8	17
	Gas 1 (NG/RG) units	11,929	77	0.9	(295)
	Gas 2 (other) units	129	138	2.3	58
Energy Assessment	ALL	1,700 (Facilities).	N/A	N/A	28
New Units	Coal units	0	0	0	0
	Biomass units	82	381	5.6	[a] 99
	Liquid units	0	0	0	0
	Gas 1 (NG/RG) units	1,762	11	0	[a] 5.1
	Gas 2 (other) units	0	0	0	0

[a] Total annualized costs for new units do not account for fuel savings since no fuel savings are estimated in the first year for new units.

Source: Federal Register, 2013a.

4.2 Promoting Energy Efficiency through Compliance Credits

To provide boiler owners with the flexibility for compliance while at the same time promoting greater energy efficiency, EPA has created energy efficiency credits for existing boilers as an alternative way to comply with the numerical emission limits. The compliance credits will be base on output-based emissions limits, rather than heat input-based limits. The efficiency credits allow a “system approach” to credit the efficiency improvement realized on the whole energy system. Credits can also come from pollution prevention projects that lead to a reduced emissions or consumption of fuels in boilers.

Under the Boiler MACT rule, efficiency credits must come from energy conservation measures that were implemented after January 1, 2008. In addition, shut-down of boilers cannot be used to obtain efficiency credits, unless the shut-down of boilers is permanent, and is a part of the energy saving measures identified in the required energy assessments (Federal Register, 2013a).

To acquire and use the credits for compliance of emission limits under the Boilers MACT, an emission benchmark must be established, and an Implementation Plan must be developed. After the credits are calculated, the boiler owners or operators must apply for the efficiency credits according to the procedures set forth under the Boiler MACT. The efficiency credits are designed to encourage existing units to adopt energy efficiency measures and cannot be used on new or reconstructed boilers. Detailed guidance on emission credits can be found on EPA’s website (Paper et al., 2012).

The benchmark shall be established using at least one year's data, and it should be before the implementation of the identified energy-saving measures. The calculation of the efficiency credits uses the following equation:

$$ECredits = \left(\sum_{i=1}^{n} EIS_{iactual} \right) \div EI_{baseline}$$

Where,

ECredits = Energy input savings for all energy conservation measures implemented for an affected boiler, expressed as a decimal fraction of the baseline energy input;
$EIS_{iactual}$ = Energy input savings for each energy conservation measure *i;*
$EI_{baseline}$ = Energy input baseline for the affected boiler;
n = number of energy conservation measures.

The required Implementation Plan needs to include necessary contents such as information on all boilers that are taking compliance credits, descriptions of the implemented energy conservation measures, energy savings generated from each measure, and explanation of the criteria used to determine the savings.

After the efficiency credits are calculated, the adjusted emissions level should be determined by using the following equation. Boiler owners or operators can apply the earned credits and use the adjusted emission level to satisfy the emission limits specified in the Boiler MACT.

$$E_{adj} = E_m \times (1 - ECredits)$$

where:

E adj = Emission level adjusted by applying the efficiency credits earned, lb per million Btu steam output (or lb per MWh power) for the affected boiler;
Em = Actual emissions measured, in lb per million Btu steam output (or lb per MWh) for the affected boiler, during the performance test. This measurement should be made after completion of the boiler tune-up so that any efficiency improvements as result of tune-up will be included.

5. Develop Action Guides

5.1 Boiler Tune-Up Guide

As a core part of the work practices procedures in the Boiler MACT, owner or operators of both major source and area source boilers are required to conduct annual, biennial, or 5-year basis boiler tune-ups, depending on fuel sources, equipment, and boiler size. The EPA has issued a *Boiler Tune-up Guide* to appropriately direct boiler owners and operators carrying out required boiler tune-up activities (U.S. EPA, 2013c). The tune-up activity is the act of reestablishing the air-fuel mixture for the operating range of the boiler. Oxygen and unburned fuel (carbon monoxide is generally the indicative measurement) are balanced to provide safe and efficient combustion. Carbon monoxide (CO) concentrations are also measured to ensure proper burner operation. A primary goal of a boiler tune-up is to improve boiler efficiency with respect to combustion operations.

The boiler tune-up guide consists of two major parts. The first describes the basic activities and minimum requirements associated with a boiler tune-up while the second part provides additional guidance on what if manufacturer's specifications are not available as well as what tools or methods can be used to measure oxygen and CO. In addition, the EPA's tune-up guide provides necessary sources if a boiler owner or operator needs more detailed information on performing a boiler tune-up (U.S. EPA, 2013c).

The guide on the basic activities and minimum requirements related to the boiler tune-up is a set of check lists intended to be a time ordered tool to aid in planning and conducting boiler tune-ups. The checklist covers activities ranging from preparation of the tune-up and as-found observation to conducting the tune-up and creating proper documentation. Table 7 shows the checklist for each of these activities.

Table 7 Check lists of basic activities for a boiler tune-up

Preparation	**As-found observation**	**Tune-up**	**Documentation**
	Identification of the as-found conditions centers on measurement of the operating parameters of the combustion process that will be modified during the tune-up process. The primary measurements required under the Boiler MACT Rule are flue gas oxygen content and flue gas carbon monoxide content at the high-fire or typical operation load.	The tune-up activity is the act of ensuring the burners are properly mixing the air and fuel and of reestablishing the most appropriate amount of excess air throughout the operating range of the boiler.	
a) Clearly identify the target equipment along with the intent and goals of the tune-up. b) Assemble boiler drawings and data	a) Examine the combustion control components (i.e., the system controlling the air-to-fuel ratio) and ensure it is functioning properly. b) Examine the burner internal	Tune-up each operating position of the combustion control system (from high-fire through low-fire). **NOTE: The EPA rule only requires that the tune-up be**	a) As-found conditions. b) Post tune-up conditions. c) Modifications and repairs completed. d) Recommended

sheets. c) Assemble burner drawings and data sheets. d) Assemble combustion control information. e) Identify environmental regulations and limitations. Typically nitrogen oxides (NOx) and combustible material (often identified as CO) are specifically addressed in the emission limits. f) Identify steam production control strategy that will be used during the tune-up. g) Identify in-situ instrumentation and verify calibration. h) Identify measurement locations and verify access. The most common flue gas measurement location is immediately downstream of the steam generation section of a water-tube type boiler. For a fire-tube type boiler the flue gas sample is most	components and identify any defects, if applicable. c) Examine the general boiler conditions and identify any defects. d) Measure and record the following for each operating position of the combustion control system. • Observe flame pattern, flame dimensions, and burner condition. • Flue gas oxygen content. • Flue gas carbon monoxide (CO) content. • Flue gas emissions content (NOx, if appropriate). Additional flue gas component analysis is required when the environmental permit specifies limits on emission components. A common regulated emission component is nitrogen oxides (NOx). • Emissions control settings. Flue Gas	**conducted at high-fire or the typical operating load.** a) Establish steady operation for the target operating point. b) Adjust combustion control position relationship to achieve desired combustion characteristics. • Flue gas oxygen content - target will generally be the manufacturer's specifications. • CO content - target will generally be the manufacturer's specifications. • NOx content, if applicable – target will generally be the limit specified in the environmental permit. Adjustments for emissions control are generally completed after combustion adjustments are established. c) Measure and record the following for each operating position	investigations and modifications. e) Identified shortcomings of the equipment.

commonly taken as the exhaust gases exit the boiler proper. i) Establish tune-up timeframe.	Recirculation flow settings (if applicable). • Final flue gas temperature. e) Document any modifications completed at this point.	of the combustion control system. **NOTE: Only the high-fire or typical operating load need to be recorded to comply with the EPA rule.** • Observe flame pattern, flame dimensions, and burner condition. • Flue gas oxygen content. • Flue gas CO content. • Flue gas emissions content (NOx and others). • Final flue gas temperature. d) Document any modifications completed at each point.	

Source: U.S. EPA, 2013c.

Under the situation of lacking manufacturer's specifications, EPA's boiler tune-up guide also provides general information of the typical control limits for boilers. The appropriate range within which to manage excess oxygen depends on the fuel type and the method of monitoring and controlling flue gas oxygen content. Table 8 shows the *expected* operating range for boilers. The numerical values in the table represent the amount of oxygen (O_2) in the flue gas as it exits the combustion zone. This is the actual field measurement for most boilers and it is the common control parameter. The oxygen concentrations noted in the table include both "wet basis" measurements and "dry basis" measurement. The EPA boiler MACT rule allows measurements on either a dry or wet basis as long as it is the same before and after the adjustments are made. In the tune-up guide, EPA emphasized that flue gas oxygen content targets may be influenced by environmental controls, such as nitrogen oxides (NOx) control. When a boiler is equipped with NOx control the minimum oxygen concentrations are sometimes higher than if the boiler was equipped with a standard burner without NOx control.

Table 8 Typical control limits for boilers

Typical Flue Gas Oxygen Content Control Parameters								
Fuel	Automatic Control Flue Gas O_2 Content				Positioning Control Flue Gas O_2 Content			
	Minimum		Maximum		Minimum		Maximum	
	Wetl Gas Sample [%]	Dry Gas Sample [%]	Wetl Gas Sample [%]	Dry Gas Sample [%]	Wet Gas Sample [%]	Dry Gas Sample [%]	Wet Gas Sample [%]	Dry Gas Sample [%]
Natural Gas	1.5	1.8	3.0	3.6	3.0	3.6	7.0	8.0
No. 2 Fuel Oil	2.0	2.2	3.0	3.3	3.0	3.3	7.0	7.6
No. 6 Fuel Oil	2.5	2.8	3.5	3.8	3.5	3.8	8.0	8.5
Pulverized Coal	2.5	2.7	4.0	4.3	4.0	4.3	7.0	7.4
Stoker Coal	3.5	3.7	5.0	5.3	5.0	5.3	8.0	8.4
Stoker Biomass-Wet	4.0	5.2	8.0	9.7	5.0	6.4	8.0	9.7
Stoker Biomass-Dry	4.0	4.4	8.0	8.6	5.0	5.5	8.0	8.6

Source: U.S. EPA, 2013c.

5.2 Guide of Applying Compliance Credits

To help boiler owners and operators to use consistent methodology for calculating the compliance credits that boiler owners and operators can apply to offset emissions with energy efficiency improvement, a guide on calculating efficiency credits was developed by the Oak Ridge National Laboratory (Paper et al., 2012). The guide provides detailed information on how to calculate and document efficiency credits generated from energy conservation measures for boilers that are covered by the Boiler MACT.

Key components of a boiler system include the following functional areas: 1) the boiler itself, 2) the condensate recovery system, 3) the distribution system, and 4) the end uses of the steam, as illustrated in Figure 5. The guide on compliance credits covers the boilers functions area from 2) through 4), and does not include the boiler itself. For the boiler itself, the EPA's Boiler Tune-Up Guide provides comprehensive information.

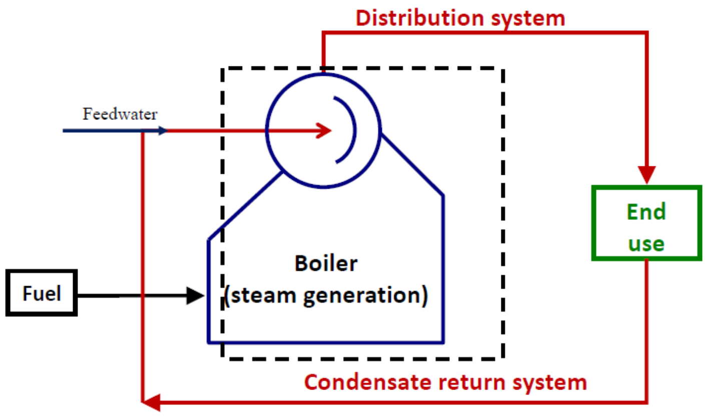

Figure 5 Illustration of a boiler system

The guide on compliance credits suggests that for simple steam systems, especially for those do not have cogeneration applications, methods based on thermodynamics and fundamental laws of conservation of mass and energy should be used. For complicated steam systems, the guide suggests using a "system approach" and a rigorous model, such as the U.S. DOE's Steam System Assessment Tool (SSAT), to understand the interactions and impacts of any change on the whole system.

The guide describes energy efficiency improvement and emission reduction opportunities that are commonly found in the steam systems beyond the boilers. These measures can be aggregated into the following seven categories:

- Recovery energy produced from the boiler
- Optimize boiler blowdown
- Improve insulation on the steam distribution system
- Implement a steam leak detection management program
- Implement a steam trap management program
- Reduce end-use steam requirements
- Improve condensate recovery

For each energy conservation measure listed, the guide provides a description of the measure, its required field measurement, and methods of quantifying its fuel and cost saving potentials. In addition, the guide also discusses possible exceptions to realize the projected energy savings and describes typical energy savings and payback time from implementing the measure.

5.3 CHP Resource Guide

To help the adoption of combined heat and power (CHP) as a technical and economical compliance strategy for boiler owners or operators, the Department of Energy has supported development of a resource guide on CHP (Midwest CHP Application Center and Avalon Consulting Inc., 2005; NASEO, 2013). The CHP resource guide is a comprehensive guide of providing a ready reference for the basic principles of CHP and the "Rules–of–Thumb" that apply when considering the application of CHP. It is intended to provide "packets" of information to serve as a refresher or provide reference to specific information to assist in performing a first level screening or assessment of the suitability of CHP in a particular facility. The CHP Resource Guide provides information on key CHP technologies including engines and turbines, generators, inverters, technologies for heat recovery and grid interconnection, and thermally-activated machines. It also describes how to assess the CHP potential and suitability to a particular facility, how these technologies are employed in actual applications, and what tools can be used to assist the assessment of the application.

5.4 Other Implementation Guides

In addition to the above guides, EPA has also published a series of supporting documents including fact sheets, questions and answers (Q&A), and specific guides for small entity or individual technicians. It is worthy to note that many of these documents focus primarily on area source boilers and target small entities that normally do not have an access to relevant skills and resources. Below is a list of these supporting documents that is developed in the U.S. to support the implementation of the Boiler MACT rules (U.S. EPA, 2013d).

- Overview MACT Rule Summary Fact Sheet
- Overview MACT Rule Technical Fact Sheet
- Fact Sheet - Area Source Boilers
- Fact Sheet - Major Source Boilers
- Summary of Area Source Boiler Requirements Brochure
- Boiler MACT: Questions and Answers
- Area Source Boiler: Questions and Answers
- Tune-up Guidance and Example Recordkeeping Form - area sources
- Tune-up Guide for Owners and Operators - area sources
- Area Source Boilers: Small Entity Compliance Guide
- Major Source Boilers and Process Heaters: Small Entity Compliance Guide
- Tune-up Guide for Technicians - area sources

6. Monitoring and Reporting for Ensuring Compliance

6.1 Site Specific Monitoring Plan

Boiler owners and operators are required to meet the requirements of emission limits, work practice procedures, and operating limits. Facilities must demonstrate their compliance with emission limits via applying performance stack testing, fuel analysis, or continuous monitoring systems (CMS). If plants utilize stack testing for demonstrating compliance, a site-specific monitoring plan must be developed for using any CMS (such as continuous emission monitoring systems, or continuous opacity monitoring system, or continuous parameter monitoring system, or particulate matter continuous parameter monitoring systems).

The site-specific monitoring plan must include elements of boiler design, data collection, and quality assurance and control. Boiler owners or operators need to submit the site-specific monitoring plan at least 60 days before initial performance evaluation of CMS.

6.2 Requirements for Notifications, Recordkeeping, and Data Reporting

Boiler owners or operators must demonstrate continuous compliance according to the specified methods with each emission limit, operating limit, and work practice procedures specified in the EPA Boiler MACT rule. To demonstrate continuous compliance, boiler owners or operators are required to monitor and collect data according to the Boiler MACT rule and the site-specific monitoring plan. Except for monitor malfunctions, associated repairs, and required quality assurance or control activities (including, as applicable, calibration checks and required zero and span adjustments), boiler owners or operators must monitor continuously (or collect data at all required intervals) at all times that the affected source is operating. Boiler owners or operators must report each instance in which they did not meet each emission limit and operating limit. These instances are deviations from the emission limits specified by the EPA boiler MACT rule and these deviations must be reported according to the MACT requirements.

Following the date on which the initial performance test is completed or is required to be completed, whichever date comes first, boiler owners or operators must not operate above any of the applicable maximum operating limits or below any of the applicable minimum operating limits at all times except during periods of boiler startup, shutdown and malfunction. Operating limits do not apply during performance tests. Operation above the established maximum or below the established minimum operating limits constitutes a deviation of established operating limits.

Boiler owners and operators need to submit notifications to EPA under several circumstances, which include notifications of boiler start-up dates if the operation start date of an affected boiler was prior to January 13, 2013, the intention of conducting a performance test if required, notifications of compliance status if it is required to conduct an initial compliance demonstration, notifications on fuel switching (switching to non natural gas, refinery gas), and notifications on using or stop using solid wastes.

The notification of compliance status must include details of the boilers, subcategories of the boilers, designed heat input capacity, summary of performance tests results, calculations conducted to demonstrate initial compliance, and identifications of planned methods for compliance (through emissions averaging and/or efficiency credits).

To provide boiler owners or operators with clear instruction on notifying their compliance, the EPA has developed a series of example notification forms. Below is a list of example on standardized notification form for compliance on different activities:

- Notification of Compliance for Emission Limits
- Notification of Compliance for Tune-Ups
- Notification of Compliance for Energy Assessments

The EPA Boiler MACT also puts forward requirements on recordkeeping. For example, for area sources boilers, required type of records includes (U.S. EPA, 2013e):

- Types and amount of fuel used monthly for boilers with emission limits
- Documentation that startups and shutdowns were done according to manufacturer's recommended procedures for boilers subject to emission limits
- All required notifications and reports, with supporting documentation
- Demonstration of compliance with emission limits, operating limits, tune-ups, and the energy assessment, as applicable
- Malfunction occurrences, duration, and actions taken
- Days of operation per year for seasonal boilers
- Copy of the federally enforceable permit and records of fuel use for limited-use boilers

A preferred form developed by EPA to instruct boiler owners or operators on what on-site record should be maintained for documenting the tune-up is shown in the appendix section.

For data reporting, the boiler owners or operators need to submit compliance reports that must contain information on the performance related to meeting the emission limits or work practice standards, i.e., the deviation from the limits. The compliance reports must be submitted within 60 days after the completion of each performance test. EPA has created a set of online database and reporting systems for reporting, tracking and documenting the compliance. The boiler owners or operators are required to submit the compliance reports to the EPA's WebFIRE database, by using the agency's Compliance and Emissions Data Reporting Interface (CEDRI), which could be accessed through EPA's Center Data Exchange (CDX) (U.S. EPA, 2014a). Facilities that conducted performance evaluation test using continuous emission monitoring systems also need to submit relative accuracy test audit (RATA) data to CEDRI. Separate from the submission of the compliance reports, boiler owners or operators are also required to submit performance test data by using the EPA's Electronic Reporting Tool (ERT) (U.S. EPA, 2014b). For confidential business information (CBI) that is claimed by the boiler owners or operators, a complete ERT file together with the claimed confidential business information must be mailed to EPA via electronic storage media (e.g., compact disks, or flash drives) with CBI labels on them.

If fraudulent statements are found in the submitted documents, EPA or EPA regional offices can take legal actions under Section 113 of the Clean Air Act (CAA). In appropriate cases, submitting false information can be considered as violation of the United States Constitution (18 U.S.C. § 1001), and thus would face criminal charges of imprisonment of up to 5 years.

6.3 National Database on Boiler Use and Tune-Up

EPA has created a national database for existing industrial and commercial boilers (U.S. EPA, 2013d). The database includes over 150,000 industrial and commercial boilers, and together they consume about 40% of all energy consumed in respective sectors. In the process of developing the Boiler MACT, EPA conducted surveys on boiler emissions, and collected survey data in the database.

7. Provide Technical Support

7.1 DOE Boiler MACT Technical Assistance Program

To help boiler owners or operators meet the requirements of the Boilers MACT, the U.S. Department of Energy (DOE) has launched the Boiler MACT Technical Assistance Program. First piloted in Ohio since March 2012, the program has now been expanded to different regions. Through site visits and provision of information, the program provides technical assistance in supporting boiler owners and operators using clean energy as boiler MACT compliance strategies. The program was also developed in accordance with the Federal Executive Order issued in August 2012 to accelerate the investment in industrial energy efficiency and greater use of combined heat and power (CHP).

The program is implemented by DOE's eight regional Clean Energy Application Centers, which provide site-specific technical and cost information to the major source boilers that burn coal or oil. Through onsite visits, experts from these Application Centers meet with the facilities, discuss strategies for compliance, and provide information on potential funding and financing opportunities. Qualified Specialists that passed the DOE training and examination of the Steam System Assessment Tool (SSAT) and the Process Heating Assessment and Survey Tool (PHAST) play an effective role in assisting facilities in complying Boiler MACT.

7.2 DOE Tool Suite

DOE has developed a range of energy assessment tools for steam system to identify system-wide energy-saving opportunities, quantify energy-saving and cost-saving potentials, and disseminate best practices (U.S. DOE, 2014a). The tools are developed to analyze key components of the entire steam system and evaluate both supply and demand sides of the system, including boiler operations along with steam production, distribution, end use, and steam recovery. Below sections introduce various DOE tools related to the boiler and steam system.

7.2.1 Boiler Tune-up Tool

It is a calculator developed to provide estimates of the current and potential combustion and boiler efficiency. The tool also estimates energy savings associated with tuning boilers to 4% exhaust oxygen level and cleaning the boiler water side heat exchange surfaces to increase efficiency.

Basic input data include: 1) boiler data: maximum and minimum firing rate, inlet and purge air temperature, air humidity ratio, and purge cycle. Default values are provided for several inputs, if exact values are not available; 2) steam parameter: steam system pressure range and steam system volume; 3) fuel type and unit cost; 4) installation costs. The Boiler Tune-Up tool is available in stand-alone version (in excel format), and can be downloaded from DOE's website (U.S. DOE, 2014b).

7.2.2 Steam System Assessment Tool (SSAT)

The Steam System Assessment Tool (SSAT) can be used to assess a combined heat and power (CHP) system, and simulates up to a three-pressure-header steam system. It compares the current steam system with a modified steam system. The modified system is a modification of the current steam system, such as adding or removing a boiler or turbine. By comparing the current steam system to the modified system, the tool allows the users to see the energy and cost impacts of the changes made to the system, prior to actually implementing the measures. Figure 6 shows a modeled steam system, with three-pressure header. In this example, the tool shows the energy impacts of adding another steam turbine to the current steam system, which has one condensing steam turbine and one steam turbine.

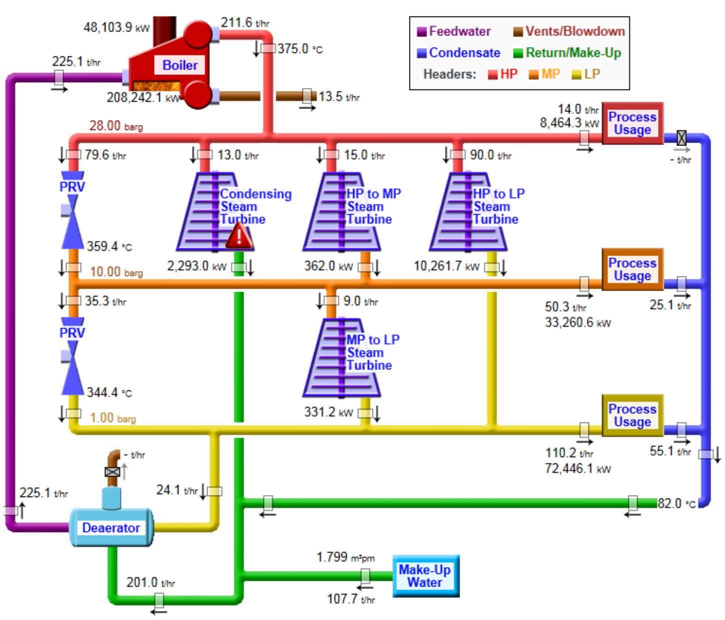

Figure 6 Example of a modeled 3-pressure header steam system

The SSAT Tool allows the users to input measured parameters, such as pressure, temperature, and flow to quantify the energy content of a change, with reasonable accuracy, rather than relying on inaccurate estimates. The tool includes sophisticated algorithms to solve several equations simultaneously, to get to the converged solutions.

Figure 7 illustrates the structure and details of the SSAT. The tool uses a system approach in "what-if scenario", and evaluates potential cost and energy savings if one component of the steam system (boiler steam production, or adding another turbine to the system) is adjusted. Based on input data, the SSAT quantifies the impacts of each system component and adjustments, and estimates potential fuel, electricity, water, and emission savings.

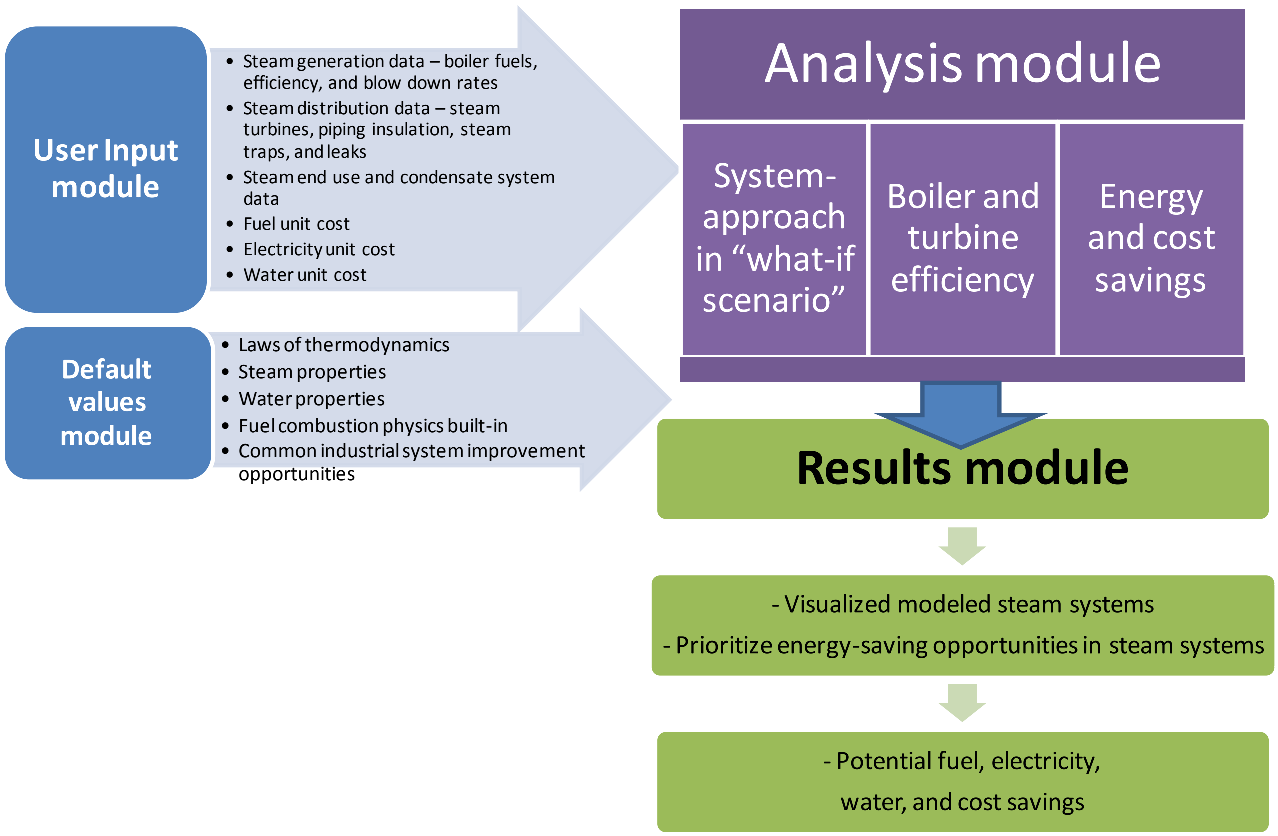

Figure 7 Flow Chart and Structure of the Steam System Assessment Tool

This tool also includes two steam property calculators and seven steam equipment calculators. The tool is available in both English and Chinese, and online version of the tool is available at DOE's website (U.S. DOE, 2014c).

7.2.3 Steam System Scoping Tool

The Steam System Scoping Tool provides systematic approach to conduct initial self-assessment of the steam systems. It profiles and grades operations and management of the assessment steam system. In addition, it benchmarks the assessment steam system operations against best practices.

7.2.4 Steam System Calculators and Modeler

To optimize performance, the impacts of potential adjustments need to be understood individually and collectively. The Steam System Calculator allows the users to input the metrics of their systems, generate a list of detailed system specific steam properties, and test a variety of adjustments on individual equipment.

The accompanying Steam System Modeler allows the users to create up to a 3-pressure-header basic model of their current steam systems. A second model can then be created by adjusting a series of characteristics simulating technical or input changes. This allows the users to see how each component and adjustment impacts the others and what changes may be most beneficial to increase the overall efficiency and stability of the system. An interactive diagram is provided for each model and includes comprehensive steam properties and operational details for clarity and ease of use (U.S. DOE, 2014c).

7.2.5 Steam Generation Equipment Scorecard

The Steam Generation Equipment Scorecard can help users identify areas for energy-efficiency improvement in steam generation equipment, including in areas of steam trap maintenance, water treatment program, system insulation, steam leaks, and heat recovery equipment.

7.2.6 3E Plus Insulation

The 3E Plus Insulation tool calculates the most economical thickness of industrial insulation for steam pipes. It makes calculations using built-in thermal performance relationships of generic insulation materials or supply conductivity data for other materials.

All the tools mentioned above are developed by DOE energy experts, and have been used widely in multiple DOE energy assessment programs, such as large plants assessments and the assessments conducted in small-and-medium plants by the university-based Industrial Assessment Centers (IACs). The DOE tools are open to public, free of charge, and can be downloaded online at the AMO Energy Resources Center.

7.3 Steam System Trainings

The Advanced Manufacturing Office of the U.S. Department of Energy (U.S. DOE) provides comprehensive trainings on energy efficiency targeting both end-users and professionals. All upcoming training events, sessions, and webinars that help facilities improve the efficiency of compressed air, motor, fan, pump, steam, and process heating systems are listed on the DOE's web-site, which are sorted by date, location, and event.

There are three types of training provided by trained experts on boilers and steam systems. Table 9 lists these trainings. The Steam Tool Suite Training, which is a two-hour online training, covers the three main DOE Tools related to boiler efficiency improvement and steam system assessments. The Steam End User Training is a one-day training, which introduces boilers efficiency, steam system and assessment methods to the trainees.

The Qualified Steam Tool Specialists Training is a two and a half day workshop that covers boilers and steam system fundamentals, as well as the steam tool suite. It is a combination of on-site data collection, on-site energy assessment demonstration, and hands-on practices of the tools using real on-site examples. The workshops focus developing models of the assessed steam systems, and evaluating energy and cost saving potentials. The Qualified Steam Tool Specialists Training also includes examinations, and the trainees who meet certain professional qualification requirements and passed the examinations would become the DOE Qualified Specialists of the Steam Tool. DOE maintains a list of Qualified Specialists, which is accessible on DOE's website.

Table 9 Types of Training on Boilers and Steam System

	Steam Tool Suite Training	**Steam End User Training**	**Qualified Steam Tool Specialists Training**
Time duration	2-hour	1-day	2.5 days
Covered content	Steam System Scoping Tool, Steam System Assessment Tool, and 3E Plus	Introduction to steam system analysis and assessment	• Steam system fundamentals and steam tool suite • On-site data collection and energy assessment demonstration • Hands on practices of the steam system tools using on-site example • Develops models of the steam systems and evaluates energy-saving potentials
Onsite practices	No	Yes	Yes
Online teaching available	Yes	Yes	No
List of Trainees available	No	No	Yes: http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/ssat_qualifiedspecialists.pdf

7.4 Technical Publications and Resource Books

To help facilities improving boiler energy efficiency and steam system efficiency, DOE has developed a series of relevant technical publications and resource books (U.S. DOE, 2014a). Below is a list of related technical resource books introduced by DOE, which are open to public and can be downloaded from the DOE's website (U.S. DOE, 2014a).

- Improving Steam System Performance: A Sourcebook for Industry
- Steam Generation, Distribution, Energy Use, and Recovery
- Achieve Steam System Excellence: Industrial Technologies Program Best Practices Steam Overview
- Steam System Opportunity Assessment for the Pulp and Paper, Chemical Manufacturing, and Petroleum Refining Industries
- Guide to Combined Heat and Power Systems for Boiler Owners and Operators
- Guide to Low-Emission Boiler and Combustion Equipment Selection
- Steam System Survey Guide
- Review of Orifice Plate Steam Traps
- Best Practices Steam Technical Brief: Steam Pressure Reduction-Opportunities and Issues
- Best Practices Steam Technical Brief: How to Calculate the True Cost of Steam
- Best Practices Steam Technical Brief: Industrial Heat Pumps for Steam and Fuel Savings
- Best Practices Steam Technical Brief: Industrial Steam System Heat-Transfer Solutions

- Best Practices Steam Technical Brief: Industrial Steam System Process-Control Schemes
- Steam Systems Energy Efficiency Handbook

The Steam System Sourcebook discusses key components of the steam system, such as boilers, turbines, and condensers, explains steam system basics, and provides common performance improvement opportunities that are seen in the U.S. industry. The Steam Survey Guide provides technical information for steam system operators and plant energy managers on the major energy-efficiency improvement opportunities presented in a typical steam system.

In addition to the technical publications and resource books, DOE has also created tip sheets, which are normally two-page documents of providing energy-saving tips to improve boilers or the steam system energy efficiency. DOE has also collected information from both large energy assessments and small-and-medium energy assessments conducted in various sectors that use boilers and steam systems, such as petrochemical industry, pulp and paper industry, and metals industry. The collected information is employed to develop case studies and best practices. The ASME (American Society of Mechanical Engineers) Steam System Assessment Standard and guidance documents are developed to set technical requirements for conducting and reporting of a steam system energy assessment.

8. Adopt Supporting Policy and Incentives

8.1 Overview of CHP Development in the U.S.

To accelerate the adoption of energy efficiency, the U.S. has offered incentives at the national, state, and local levels. Many of these incentives are applicable to efficiency improvement in the boiler/steam systems, which would help boilers in compliance with the EPA MACT rules. In addition, the U.S. has stepped up its effort in increasing the applications of combined heat and power (CHP) to reach the target of 40 GW of CHP capacities by 2020 in order to accelerate the transformation to a cleaner and more efficient production of heat and electricity.

In recent years, the U.S. has increased its CHP installed capacity to 82 GW, with 87 percent installed in manufacturing plants around the country (U.S. DOE, 2013; ICF International, 2012b). In 2011, the average capacity factor for generators at industrial CHP plants was 57%. Over 65% of CHP capacity currently operating in the United States is fueled with natural gas, which has relatively low prices resulting from increased shale gas production (U.S. EIA, 2012). The U.S. has set up a goal of installing an additional 40 GW of CHP by 2020, an increase of about 50 percent more than the current levels of U.S. CHP capacity. CHP has tremendous economic, energy, and environmental benefits. Figure 8 illustrates CO_2 emission levels from different applications of coal vs. natural gas with and without CHP applications.

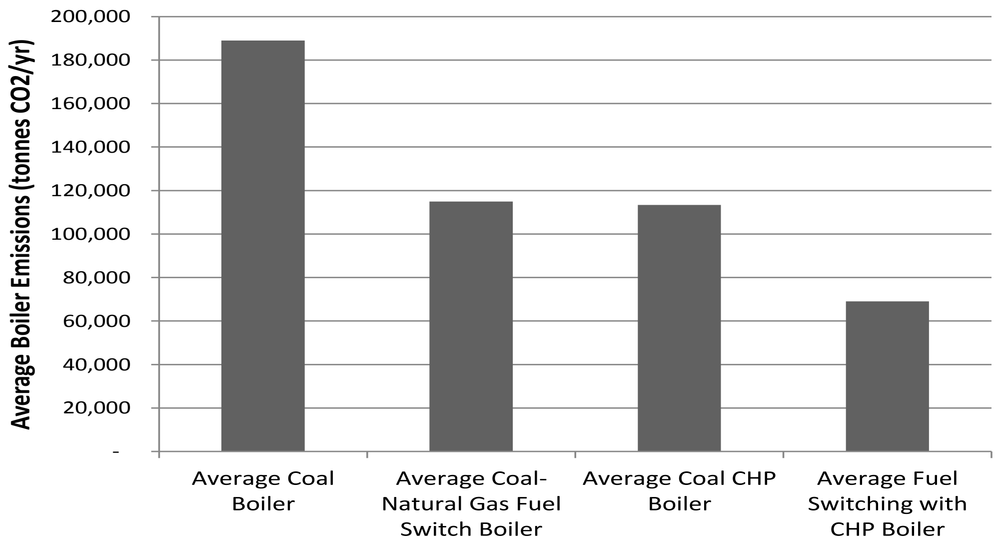

Figure 8 CO_2 emissions from coal vs. natural gas with and without CHP applications

In the U.S., the two most common CHP system configurations are (see Figure 9 and Figure 10):

- Gas turbine or engine with heat recovery unit
- Steam boiler with steam turbine

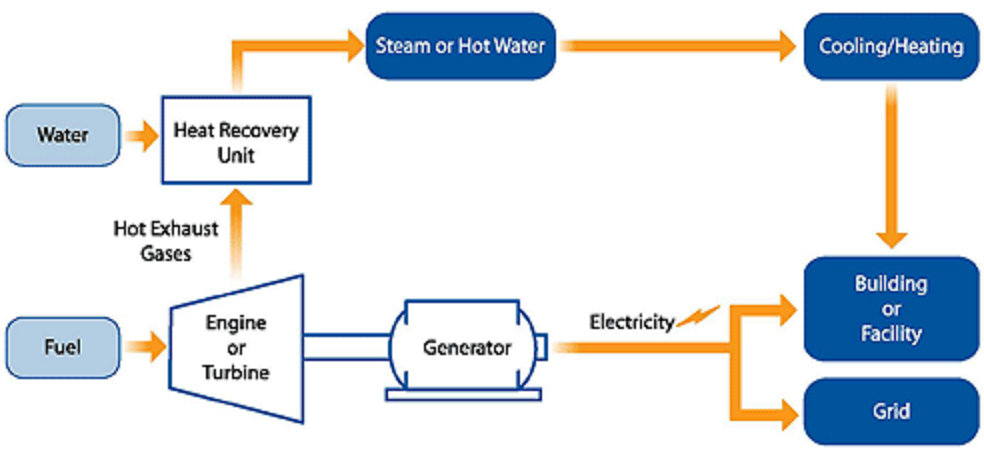

Figure 9 Gas turbine or engine with heat recovery unit

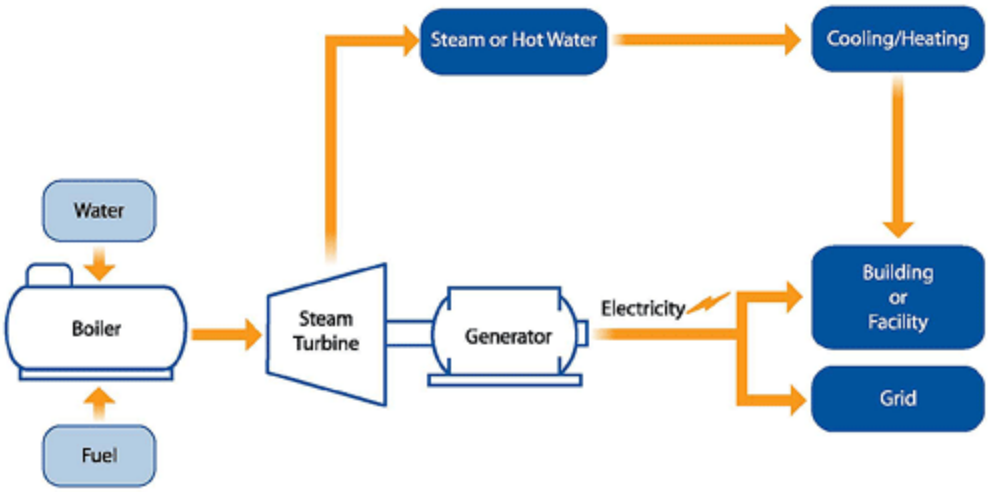

Figure 10 Steam boiler with steam turbine

In the U.S., the Federal and state governments have taken many efforts to promote deployment of CHP. These efforts include:

- CHP is incorporated in state portfolio standards: 40 states and the District of Columbia have some form of state portfolio standards, of which 23 specifically call out CHP and/or Waste to Heat and Power (WHP)
- Many states set a requirement for consideration of CHP in utility integrated resource planning and power procurement plan
- More than 40 states and the District of Columbia have developed interconnection standards of defining how CHP can be connected to the grid
- State like California has initiated feed-in-tariff for CHP systems less than 20 MW that include multi-tiered rates (higher rates for greater efficiency of CHP)
- In some states (e.g., NY, DC), standby rates no longer discourage CHP
- CHP qualify for many federal and state tax benefits and rebates

8.2 Laws and Regulations to Promote CHP

The adoption of CHP systems in the United States grew rapidly after the passage of the Public Utilities Regulatory Policies Act (PURPA) in 1978, as a response to the oil crises and rising energy costs. PURPA encourages the deployment of distributed solutions including CHP units. To ease the connection of these units with the grids, the law requires utility companies to interconnect these units as “qualified facilities” (QFs), charge QFs for reasonable standby and back-up charges, and to purchase excess electricity from QFs at the utilities’ avoided costs. Utilities’ avoided costs would be equivalent to the cost of the utility generating power itself. PURPA along with tax credits (introduced below) had a significant impact on CHP development.

Recent laws such as the 2005 Energy Policy Act, the 2007 Energy Independence and Security Act, the Energy Improvement and Extension Act of 2008, and the American Recovery and Reinvestment Act of 2009 have all increased the federal support on research and development, demonstration, policy, and incentives related to the development of CHP, waste heat recovery, and distributed energy.

8.3 Portfolio Standards

As discussed above, some states in the United States have moved away from input-based emission standards, and begin to adopt the output-based emission standards. Output-based regulations take both power and thermal output of CHP into account, and recognize the high efficiency of environmental benefits of CHP systems. Output-based performance standard has been adopted in about 20 states of the United States, and some of which have also included a thermal credit for CHP.

In addition, a growing number of states have recognized CHP as part of their Renewable Portfolio Standards (RPS) or Energy Efficiency Resource Standards (EERS). These standards either requires that a specific portion of the electricity supply must come from renewable energy or requires that that a percentage reduction in energy sales is achieved from energy efficiency measures. CHP technologies have been recognized as one important option to meet these targets. As of today, 27 states have incorporated CHP into their RPS or EERS.

8.4 CHP Incentives

The most widely used financial incentives for CHP in the United States are tax incentives, mainly in the form of investment tax credits and production tax credits.

A production tax credit is a performance-based credit based on electricity generation. Qualified CHP systems can receive tax credits on per kWh of electricity produced. A form of the production tax credit is "feed-in tariff". Normally, feed-in tariff covers renewable electricity generation technologies, such as wind and solar PV, and very often efficient CHP systems are included. Feed-in tariff guarantees CHP facilities a set price from the utility for all of the electricity they generate and provide to the grid. Typically, feed-in tariff agreements are long term, in the range of 15-20 years. Different from the incentives enacted under PURPA, where utilities were required to pay CHP facilities at the avoided cost of utility's power generation, feed-in tariff typically provides a higher rate than the avoided costs to CHP facilities. For example, California plans to add 6,500 MW of new CHP capacity by 2030 as an important measure to reach its greenhouse gas emissions reduction goals. Feed-in tariff is initiated for CHP systems under 20 MW and with excess power. To be eligible for the feed-in tariff, the CHP systems "must be sized to thermal load and operate at greater than 62% efficiency (lower heating value)." The rate of feed-in tariff is linked to natural gas prices adjusted by the time of day and season (U.S. DOE, 2012).

The investment tax credits aim at reducing the financial risks of a capital-intensive project faced by CHP investors. Tax credits for investing in CHP were created under the Energy Tax Act of 1978 and the Crude Oil Windfall Profits Tax Act of 1980. Waste-heat boilers and related equipment could apply for a 10% tax credit under the Energy Tax Act. This 10% tax credit was further expanded to other CHP equipment under the Crude Oil Windfall Profits Tax Act. Under the Energy Improvement and Extension Act of 2008, the 10% of investment tax credit was reacted at the federal level and through 2016. Eligible CHP systems are the units up to 50 MW and the tax incentive is applicable to the first 15 MW. System efficiency must be at a level of 60% or higher (lower heating value). At the state level, similar programs have also been implemented. For example, a rebate incentive for CHP systems is provided in Massachusetts under the State's Green Communities Act. Eligible CHP systems could receive a rebate of $750/kW up to 50% of total installed costs. The rebate is determined on a case-by-case basis, including considering CHP's participation in the overall energy efficiency portfolio, cost-benefit of the project, CHP's contribution to energy efficiency, project risks, and customer investment threshold (U.S. DOE, 2012).

The *Database of State Incentives for Renewables & Efficiency* (DSIRE, 2014) is developed to document, and track the state-level progress on CHP and other programs. It provides a "go-to" resource for end-users to understand the regulations, permitting requirements, and incentives that affect CHP development.

Blow is a comprehensive list of tax and other financial incentives offered at both the Federal or State levels and applicable to the boiler owners or operators who carry out energy efficiency improvement projects.

Federal

- Production tax credit
- Business Energy Investment Tax Credit (ITC)
- Modified Accelerated Cost-Recovery System
- Energy Efficient Commercial Building Tax Deduction
- Renewable Electricity Production Tax Credit

State/Local/Utility

- Revolving loan
- Low-interest loan
- Energy efficiency rebate
- Energy equipment property tax exemption
- Real Property tax exemption
- Personal property tax exemption
- Corporate EE tax credits
- Sale tax exemption
- PACE and on-bill financing
- Refundable payroll tax credit

9. Insights for China

China is making significant new efforts to improve the energy efficiency of its industrial boilers. The government seeks to mitigate the adverse impacts (e.g. significant amount of global greenhouse gas emissions and air pollution) of the country's extensive use of coal-burning industrial boilers, which account for 26% of China's total coal consumption. Several agencies are developing action plans on boilers through promoting more efficient technologies and pollution-reduction solutions. This section provides some insights for China drawing from the U.S. experiences in addressing the boiler challenge.

9.1 Taking a holistic approach

To effectively address the boiler challenge, China could take a holistic approach by taking systematic actions from setting up standards, limits, and procedures, to creating action guides, establishing compliance assurance, developing supporting tools and technical resources, providing professional trainings, as well as developing promotional policy.

9.2 Developing a system to ensure performance

To ensure achieving expected results, China is in need for developing an effective system that monitors and verifies the compliance. The U.S. experiences in setting up a comprehensive system of measuring the boiler performance and verifying the compliance through planning, record-keeping, and reporting could be helpful for China.

9.3 Capturing system-wide opportunities

When improving the performance of the boiler itself is important, finding greater energy efficiency opportunities in the whole system (including the boiler, the steam system, and the use of the heat/steam) is more valuable. U.S. has good practices in taking a system-wide approach by focusing on the entire system rather than merely on the boiler. The whole-system approach requires a shift from only assessing the boiler performance to an approach of evaluating the overall performance of the system as a whole. This would also require a shift from input-based approach to output-based approach.

9.4 Avoiding lock-in with coal

The U.S. encourages the strategic use of cleaner natural gas by making coal and liquid fuels expensive in complying with stringent emission limits. For China, reducing the reliance on coal-consuming boilers and increasing the adoption of boilers using alternative fuels (like natural gas or solar) would help China find long-term solution to its environmental and climate challenge. Since China's energy system relies heavily on coal, however, the country's effort in its boiler challenge has so far focused primarily on improving the coal use of boilers. Placing the country's strategic focus – in R&D, market development, and technology deployment –on coal could create an infrastructure that lock-in with coal for a long-time and weaken China's ability to develop and deploy alternative technologies.

9.5 Using boiler initiative as a trigger to drive wider use of CHP

Combined heat and power (CHP) is an effective application of more efficient use of energy. U.S. experiences in taking advantage of the boiler MACT to strategically expanding CHP through technical support and policy promotion could be helpful for China to think of how to taking the boiler work as a trigger to drive wider use of CHP. There is a need in China for removing policy, regulatory, technical, and market barriers in order for CHP to be used more widely.

9.6 Creating effective target group for cost-effective results

To achieve significant emission reduction while keeping the implementation cost down, the U.S. is very selective, targeting only small share (14%) of boilers that pose significant threats to the climate. China's boiler action plans, however, call for taking actions on all of the country's coal-fired industrial boilers. Making the target group so big will increase the implementation cost while bringing a great challenge in monitoring and verifying the performance of a massive number of covered boilers. To help it achieve an optimal result (i.e., biggest impacts with minimum cost), China could create effective target groups of boilers, focusing on selected types and sizes.

9.7 Developing flexible mechanisms to ensure compliance

In addressing its boiler challenge, the U.S. has adopted flexible mechanisms that factor in different needs and conditions of the boiler owners or operators. These flexible mechanisms include adopting different types of standards tailored to different types of boilers, using compliance credits to offset emissions with energy efficiency improvement, creating customized requirements on tune-up schedule and activities, allowing enough time for complying with new rules, and so on. China could learn from the U.S. experiences to avoid one-fit-all solutions and create maximal flexibility by using various options that meet different needs and conditions of the boiler operators.

9.8 Tackling the challenge from both technical and management perspectives

The U.S. boiler MACT rules focus on both technical improvement and enhanced management and operation optimization. China could create greater energy-saving opportunities by both enhancing technical performance of industrial boilers and related systems and improving the management practices of operating industrial boiler systems. Information support and trainings should not be limited only to technicians but also facility managers and system operators.

9.9 Developing action guides to direct implementation

The U.S. has developed a series of action guides and compliance instruction to facilitate implementation of Boiler MACT rules. These guides are particularly beneficial for small entities and operators of area source boilers that have less experience in dealing with energy efficiency improvement. These guides are important as they will provide boiler operators with clear instructions on what to do and how to act. China could learn from this experience and develop proper action guides to make good instruction for boiler operators.

9.10 Providing effective technical and information support

U.S. experiences in providing technical support in form of tools, trainings, resource books, and best practices have shown great effectiveness in assist facilities to meet MACT mandates and to improve their boiler energy use. China could consider of developing proper technical assistance programs to make tools and information available for the operators of boiler systems.

10. Acknowledgment

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Appendix

EXAMPLE Tune-up Record and Compliance Certification

National Emission Standards for Hazardous Air Pollutants for Area Sources:
Industrial, Commercial, and Institutional Boilers
40 CFR Part 63 Subpart JJJJJJ

This form shows examples of what on site records should be maintained to document your tune-up. Your regulated boiler may require additional detail, depending on your boiler design. This list is not all-inclusive, because it is not modeled after a particular system, but instead gives only general information that is applicable to most systems.

What is the purpose of this form?

You may use this form to meet the requirements for completing and documenting a tune-up under the National Emission Standards for Hazardous Air Pollutants for Area Sources: Industrial, Commercial, and Institutional Boilers. However, you may also record the information in another form or format.

SECTION I: INSTRUCTIONS

Check the applicable box below:

☐ My boiler is subject to a tune-up requirement.

STOP If you did not check the box above, do not use this example record. See http://www.epa.gov/ttn/atw/boiler/boilerpg.html for additional implementation tools.

When is this form due** (§63.11225(b))**?

Existing Sources: For each tune-up conducted, Sections I-V of this form are records that you should keep to demonstrate compliance with this rule. The first tune-up should be completed by March 21, 2014. Subsequent biennial or 5-year tune-ups, as applicable, should be completed no later than 25 months or 61 months, respectively, after the previous tune-up.

The first Compliance Certification Report (Section VI of this form) must be prepared by March 1, 2015. Later certifications must be prepared by March 1 of the year following the calendar year during which a biennial or 5-year tune-up is completed.

New Sources: For each tune-up conducted, Sections I-V of this form are records that you should keep to demonstrate compliance with this rule. The first biennial or 5-year tune-up, as applicable, must be no later than 25 months or 61 months, respectively, after the initial startup of the boiler. Subsequent biennial or 5-year tune-ups, as applicable, should be completed no later than 25 months or 61 months, respectively, after the previous tune-up.

The first Compliance Certification Report (Section VI of this form) must be prepared by March 1 of the year following the calendar year during which the first biennial or 5-year tune-up is completed. Later certifications must be prepared by March 1 of the year following the calendar year during which a biennial or 5-year tune-up is completed.

Where do I send this form** (§63.11225(b))**?

This certification does ***not*** need to be submitted, but it must be maintained on site as a record and may be requested by the delegated authority.

SECTION II: RECORD OF GENERAL BOILER INFORMATION

Date:____

Reporting Period:____________________________________

Boiler Operator:_____________________________________

Boiler Emission Unit ID[a]:_______________________________

Tune-Up Conducted By:________________________________
Please Print

[a] Use the boiler emission unit ID consistent with the ID provided in the Initial Notification Report.

SECTION III: RECORD OF TUNE-UP PROCEDURES (§63.11225(c)(2) and (§63.11223(b)(6))

Check the applicable box when the procedure is completed. If the procedure does not apply to you, indicate 'not applicable' or 'NA' in the comments column.

<table>
<tr><th colspan="2">Requirement</th><th colspan="3">Description</th><th>Inspector Comments/ Corrective Actions Taken</th></tr>
<tr><td>☐</td><td>Inspect the burner[b]</td><td colspan="3">Clean or replace any components of the burner, as necessary</td><td></td></tr>
<tr><td>☐</td><td>Inspect the flame pattern</td><td colspan="3">Adjust the burner as necessary to optimize the flame pattern. The adjustment should be consistent with the manufacturer's specifications, if available.</td><td></td></tr>
<tr><td>☐</td><td>Inspect air-to-fuel ratio control system[b]</td><td colspan="3">Ensure system is calibrated and functioning properly, if such a system is installed on the boiler</td><td></td></tr>
<tr><td>☐</td><td>Optimize emissions of carbon monoxide (CO)</td><td colspan="3">Optimize emissions consistent with the manufacturer's specifications, if available, and with any nitrogen oxide requirement to which the boiler is subject.</td><td></td></tr>
<tr><td rowspan="4">☐</td><td rowspan="4">Measure CO and O_2 levels in exhaust, before and after tune-up[c]</td><td>Parameter</td><td>Before</td><td>After</td><td rowspan="4"></td></tr>
<tr><td>Basis (wet or dry)</td><td colspan="2"></td></tr>
<tr><td>CO (ppmv)</td><td></td><td></td></tr>
<tr><td>O_2 (% by volume)</td><td></td><td></td></tr>
</table>

[b] You may delay the inspection until the next scheduled unit shutdown, but you must inspect each burner at least once every 36 months if subject to biennial tune-ups, and at least once every 72 months if subject to 5-year tune-ups.
[c] Measurements may be made on either a dry or wet basis, as long as it is the same basis before and after the tune-up adjustments are made. CO concentration measurements must be made in units of parts per million by volume (ppmv). Oxygen (O_2) concentration measurements must be made as percent by volume.

SECTION IV: RECORD OF MANUFACTURER SPECIFICATIONS (§63.11225(c)(2))

If your boiler has manufacturer specifications for adjusting the flame patterns or optimizing total emissions of carbon monoxide, maintain a copy of these specifications in your records.

SECTION V: RECORD OF FUEL TYPE AND AMOUNT USED OVER THE 12 MONTHS PRIOR TO THE TUNE-UP, BUT ONLY IF THE BOILER WAS PHYSICALLY AND LEGALLY CAPABLE OF USING MORE THAN ONE TYPE OF FUEL DURING THAT PERIOD (§63.11223(b)(6)(iii))

Fuel Type[d]	Amount of fuel used or delivered for the 12 months preceding the tune-up[e]							Units of measure[f]
	Delivery Date Or Period of Consumption							

[Add rows to the table for additional fuels, as necessary.]

If you have more than one boiler that must conduct a tune-up, please repeat Sections II, III, IV, and V for each boiler. Otherwise, proceed to Section VI below.

[d] Report all fuels used in each of the units subject to the standard (e.g., bituminous coal, #6 fuel oil, #2 fuel oil, natural gas, bark, lumber, etc.). See the definition of fuel type in §63.11237.

[e] EPA recognizes that not all facilities have fuel metering capabilities. Records of fuel delivery- instead of fuel consumption- will also meet the rule requirements. Affected sources have discretion on the periods of fuel records maintained on-site. The records may be annual, monthly, or periodic, depending on fuel delivery frequencies.

[f] e.g., Gallons, tons, standard cubic feet (scf), etc.

SECTION VI: FACILITY INFORMATION AND CERTIFICATION (§63.11225(b)(1) and (2))[g]

Facility Name:____

Facility Street Address:______________________________________

________________________________ ____________ _________
City State Zip

☐ I certify that my facility has complied with the requirements in §63.11223 to conduct a biennial or 5-year tune-up, as applicable, of each boiler.

By my signature, I am certifying that my facility has complied with all relevant standards and other requirements of 40 CFR part 63 subpart JJJJJJ and certifying the truth, accuracy and completeness of this document.

____________________________________ ______________________________
Name of Responsible Official (please print) Title

____________________________________ ______________________________
Phone Number Email Address

____ _________________
Signature of Responsible Official Date

[g] This certification does ***not*** need to be submitted, but it must be maintained on site as a record and may be requested by the delegated authority.