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Project Summary

Preliminary Assessment of Costs and Credits for Hazardous Waste Co-Firing in Industrial Boilers

R. McCormick and L. Weitzman

The full report provides preliminary information on the costs and credits associated with hazardous waste co-firing in industrial boilers. The main objective is to identify and evaluate the costs/credits inherent in current hazardous waste co-firing practices, plus the additional costs that may be incurred as a result of more stringent emissions limitations.

An overview of current hazardous waste/industrial boiler co-firing practices is provided. This overview addresses the type of waste now being disposed of in boilers, the generic designs and capacities of boilers now employing waste co-firing, and the types of air pollution control device (APCD) retrofits that may be required in the advent of air emissions regulations. Parametric cost estimate methods are provided for: (1) waste handling equipment addition, (2) combustion system retrofit, (3) APCD retrofit, (4) incremental O&M costs, and (5) fuel savings and waste disposal credits. The cost estimating approach is designed to account for differences in waste characteristics, boiler design, capacity, and waste/fuel co-firing ratio. Finally, cost/credit calculations are presented for two hypothetical waste co-firing scenarios. These calculations are presented to illustrate how the information provided in this report can be used; no conclusions concerning the economy of waste co-firing are intended.

This Project Summary was developed by EPA's Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The practice of burning hazardous wastes in industrial boilers has become increasingly popular over the past decade. The reasons for this trend are two-fold:

(1) increased prices for conventional fuels, favoring waste substitution or co-firing as a means of reducing fuel expenditures, and

(2) stricter environmental regulations and higher costs for hazardous waste disposal by conventional methods, promoting waste co-firing as a means to eliminate or reduce waste disposal costs.

Two regulatory actions in particular have favored boiler co-firing as a hazardous waste disposal alternative. The first such action was the virtual ban on liquid waste landfilling which promoted thermal destruction (in incinerators, boilers, cement kilns, etc.) as a favored disposal method for hazardous organic liquids. The second regulatory action favoring boiler co-firing was the promulgation of emissions limitations for incinerators burning hazardous wastes. Since 1980, hazardous waste incinerators have been subject to Destruction and Removal Efficiency (DRE) requirements for hazardous organic constituents of the waste, particulate emission limitations, and HCl removal requirements. No such regulations have been imposed on boilers burning hazardous wastes.

In order to assess the need for and impacts of regulations governing hazardous waste co-firing in boilers, the United States Environmental Protection Agency (EPA) is currently conducting a Regulatory Impact Analysis (RIA) study. One of the major elements of this program is an economic assessment of the impacts of boiler performance standards and associated air pollution control requirements. The study addressed in this project summary is intended to provide preliminary cost/credit information for current boiler co-firing practices. As such, it serves as a precursor to the economic impact assessment phase of the RIA.

Objectives and Scope

The underlying objective of the study was to provide a preliminary evaluation of the costs and credits associated with hazardous waste co-firing in industrial boilers. Specific objectives are as follows:

(1) Identify the major waste/boiler co-firing scenarios that need to be addressed for the purposes of the RIA. This is basically an assessment of current and probable future co-firing practices.

(2) Identifying the major costs and credits associated with boiler conversion to waste co-firing, including capital requirements for boiler retrofit, incremental O&M costs, fuel savings credits, and credits for elimination of alternative waste disposal costs.

(3) Develop preliminary cost data for the major and most probable boiler retrofit activities, including possible addition of air pollution control equipment.

(4) Develop a parametric approach to estimate retrofit costs, incremental O&M costs, and credits so that cost/credit tradeoffs can be projected as a function of waste type, waste: fuel co-firing ratio, boiler design and capacity, and potential air pollution control requirements.

Due to the preliminary nature of the study, none of the objectives are addressed in a completely thorough or rigorous manner. The goal is simply to provide a basis for initial decision-making and more detailed future study.

Co-Firing Scenarios Evaluated

The range of hazardous waste co-firing scenarios addressed in the study is necessarily limited in terms of waste type, boiler design characteristics, capacity, and waste: fuel co-firing ratios. The evaluation is limited to those scenarios that best represent current practice and probable future practice.

Waste Characteristics

As a starting point, the evaluation is limited to hazardous organic liquid waste co-firing. This limitation is imposed because organic liquids are the prime candidates for boiler co-firing. Second, the economic evaluation is based on on-site generation of the organic liquid wastes being co-fired. The third major assumption is that the majority of wastes co-fired in industrial boilers possesses desirable fuel properties. Heating values are assumed to be greater than or equal to 8,000-10,000 Btu/lb, such that the waste will support combustion. Water, ash, and halogen contents are also assumed to be reasonably low. Finally, reasonable mid-range waste: primary fuel co-firing ratios are considered. The range is 10-50% waste with primary fuel, with the percentage based on gross heat input.

Boiler Designs and Capacities

The basic boiler designs considered in the study are those characteristic of the industrial size range (up to 250,000 lb/hr steam) originally designed to burn natural gas, distillate oil, residual oil, or a combination of these fuels. The three most common design types, addressed in the study, are as follows:

1. Scotch firetube, N-pass design, packaged boilers for natural gas, distillate oil firing. Single burner design, with no economizer for air heater. Typical capacities are 10,000 to 30,000 lb/hr steam, up to 50,000 lb/hr steam. Saturated steam up to 150 psig.
2. Watertube design for natural gas, distillate oil, gas/distillate, or gas/distillate/residual oil firing (with oil preheat equipment). Single or multiple burner design. Steam capacities of 20,000 to 100,000 lb/hr saturated at 125 to 250 psig design rating. Economizers not atypical at more than 50,000 lb/hr steam, but air heaters rare.
3. Watertube design with multiple burners for gas/oil firing. Steam capacities of 100,000 to 250,000 lb/hr and up, with turbogenerator steam pressures and superheat in the larger size ranges. Economizers typical, and possibly air heaters.

These boiler designs are most common (and compatible) for liquid waste co-firing, although a limited number of coal-fired boilers are also being used to co-fire hazardous liquids. Both stoker and pulverized coal-fired boiler conversion for waste co-firing are addressed to a minor extent.

Findings

Capital Requirements For Boiler System Retrofit

As indicated in the preceding section, one of the baseline assumptions of this study is that boilers co-firing hazardous wastes are originally designed to burn one or more conventional fossil fuels—natural gas, or oil. Therefore, an initial capital investment is required to retrofit a boiler for waste co-firing. This capital investment can be divided into three components:

(1) *addition of waste storage and* feeding equipment,

(2) boiler modification to accommodate the waste fuel, and

(3) air pollution control device addition for particulate/HCl removal, if required by regulation.

The direct capital cost requirements for boiler retrofit were broken out as follows:

- Waste handling equipment
  Tanks (installed)
  Pumps (installed)
  Piping (installed)
  Filters (installed)
- Burner system modification
  Equipment
  Installation
- APCD additions
  Equipment
  Installation

Engineering designs and cost data are provided on waste storage tanks and transfer lines, as well as boiler nozzles, complete burner assemblies, and burner assembly plus blower and controls. Design specifications and cost for electrostatic precipitators, baghouses, and venturi scrubbers/acid gas adsorber systems are also given. To determine design characteristics of air pollution control devices (APCD) it was assumed that the boilers would have to meet standards for particulate and hydrogen chloride emissions that were comparable to those hazardous waste incinerators.

Cost multipliers are provided for estimating the following indirect cost: engineering and supervision, construction and field expense, construction fee, start-up, and contingency.

Incremental O&M Cost

Incremental O&M costs for boiler operation are likely whenever waste, rather than fuel, is burned. These incremental costs can include increased consumption of electric power and water, higher costs for maintenance and residue disposal; add-on costs for scrubbing chemicals, liquid nitrogen, and waste analysis, plus capital recovery charges. The full report identifies how boiler retrofit affects each of these cost components and provides typical units costs for estimating incremental cost increases.

Incremental O&M costs for waste co-firing in boilers are provided for each of the following categories: power, water, caustic, liquid nitrogen, ash disposal, semivariable costs, operating labor, maintenance, waste analysis, fixed costs, capital recovery, and taxes and insurance.

Credits

Finally, the study provides a methodology for estimating the credits associated with co-firing hazardous wastes. This includes the obvious fuel savings, plus elimination of certain on-site and/or contractor costs for disposal of the waste. These credits fall into two categories: reduced fuel requirements (due to substitution of waste for fuel), and elimination of waste disposal costs.

Cost/Credit Summary

Based on total capital investment, annual O&M costs and annual credits the net annual credit or cost of co-firing with hazardous waste in boilers can be determined. Using the annual waste throughput, an annual unit credit (or cost) can be determined in dollars per pound of waste fired.

Example Cases

The full report presents cost/credit evaluations for two hypothetical co-firing scenarios. These evaluations are intended to demonstrate how the information presented earlier in this report can be used to assess the economics of hazardous waste co-firing for specific situations. Although the results indicate that co-firing is profitable in both cases, no generalization concerning co-firing economics is intended.

Case A

The subject of this evaluation is a large chemical intermediates plant located in the midwestern U.S. Among the many wastes and byproducts generated in this plant is a 2,000 lb/hr, 14 million lb/yr methacrylate bottoms stream with a higher heating value of 12,000 Btu/lb. This waste is currently disposed at a nearby commercial incineration facility at a cost of 4 cents/lb. Other than its 1% ash content, however, this waste is a prime candidate for co-firing in the plant boiler facility.

This case study addresses the incremental costs and credits associated with the switch from off-site disposal to on-site boiler co-firing. Tables 1 and 2 present the pertinent technical and cost information in summary form; the following subsections discuss the methods and assumptions used to develop this information, including the final cost/credit projections.

From this hypothetical case, waste co-firing is an attractive alternative to off-site waste disposal. The fuel savings alone provide a net credit of nearly $700,000/yr. Including waste disposal cost elimination, the annual savings is $1.2 million. This yields a payback period of less than 1 year for the initial $1 million investment.

Table 1. *Case A—Boiler Design and Operating Characteristics*

Parameter	Baseline fuel firing	Waste co-firing
Basic design	Watertube, balanced draft, with economizer	same
Burner system	4 single register gas/oil	same
APCD system	None	ESP (insulated)
Waste storage	None	1-5000 gal tank
Steam pressure, psig	250 sat	250 sat
Steam capacity, 10^3lb/hr	100.0	99.4
Ave. steam load, 10^3lb/hr	80.0	80.0
Heat output, 10^6Btu/hr	81.1	81.1
Mass feed rate, lb/hr		
Fuel	5,096	3,836
Waste	0	2,000
Total	5,096	5,836
Volumetric feed rate, gph		
Fuel	637	480
Waste	0	263
Heat input, 10^6Btu/hr		
Fuel	94.3	71.0
Waste	0	24.0
Total	94.3	95.0
Heat input, with waste, %	0	25.3
Boiler efficiency, %	86.0	85.4
Excess air, %		
Fuel	10	10
Waste	—	25
Total air flow, 10^3lb/hr	77.8	80.5
Combustion gas temp., °F[a]	350	350
Combustion gas flow, 10^3lb/hr	84.0	87.4
10^3 acfm[a]	28.5	29.8
10^3 dscfm	16.2	16.8
Particulate loading, gr/dscf		
ESP inlet	—	0.14
ESP outlet[b]	—	0.03
Required removal efficiency, %	—	78.4
Annual on-stream time, hrs/yr	7000	7000

[a]Economizer outlet temperature.
[b]Applicable particulate standard.

Table 2. *Case A—Overall Cost/Credit Summary*

Item	Cost/credit
Total capital investment	$1,000,000
Annual O&M costs	$ 258,000
Annual credits	
Fuel savings	$ 937,000
Waste disposal elimination	$ 560,000
Total credit	$1,497,000
Net credit	$1,239,000
Annual waste throughput	14,000,000 lb
Unit credit	$0.0885/lb

Case B

The subject of this evaluation is a small chemical processing plant, also located in the Midwest. This plant generates approximately 500 lb/hr (65-70 gph) of liquid waste, primarily methanol and dirty solvents, along with a larger quantity of solid waste. Both the liquid and solid wastes are currently disposed off-site at an average cost of 5 cents/lb. However, the liquid waste is a reasonably good candidate for boiler co-firing, despite the fact that it contains some chlorine and ash. Tables 3 and 4 summarize the technical information, retrofit costs, annual O&M costs, and credits associated with co-firing this waste is an on-site boiler for process steam generation, as an alternative to off-site disposal.

In this hypothetical scenario, waste co-firing is an attractive alternative to off-site disposal assuming that no significant boiler maintenance problems are encountered. The net annual credit is nearly $200,000, providing a payback period of 14 months for the initial $230,000 investment.

However, the payback based on fuel savings alone is marginal; less than $20,000/yr or 8.3% return on investment. This might not justify the initial capital investment if the waste was initially being burned in an on-site incinerator, rather than disposal off-site.

Table 3. *Case B—Boiler Design and Operating Characteristics*

Parameter	Baseline fuel firing	Waste co-firing
Basic design	Firetube, forced draft	same
Burner system	1 gas only	1 gas/liquid fuel
APCD system	None	Wet scrubber
Waste storage	None	1-5000 gal tank
Steam pressure, psig	125 sat	125 sat
Steam capacity, 10^3lb/hr	10.0	9.9
Ave. steam load, 10^3lb/hr	9.0	9.0
Heat output, 10^6Btu/hr	9.04	9.04
Mass feed rate, lb/hr		
Fuel	547	325
Waste	0	500
Total	547	825
Volumetric feed rate		
Fuel, 10^3scfh	11.9	7.07
Waste, gph	0	66.7
Heat input, 10^6Btu/hr		
Fuel	11.9	7.07
Waste	0	5.0
Total	11.9	12.07
Heat input, with waste, %	0	41.4
Boiler efficiency, %	75.8	74.9
Excess air, %		
Fuel	5	5
Waste	—	20
Total air flow, 10^3lb/hr	9.03	9.48
Combustion gas temp., °F		
Boiler exit	550	550
APCD exit	—	155 (sat)
Combustion gas flow, 10^3lb/hr		
Boiler exit	9.70	10.4
APCD exit	—	11.5
Combustion gas flow, 10^3acfm		
Boiler exit	4.33	4.62
APCD exit	—	3.27
Combustion gas flow, 10^3dscfm	1.80	1.92
Particulate loading, gr/dscf		
Boiler exit	—	0.15
APCD exit[a]	—	0.03
Required removal efficiency, %	—	80.0
HCl removal efficiency, %	—	99.0
Annual on-stream time, hrs/yr	7000	7000

[a]Applicable standard.

Table 4. *Case B—Overall Cost/Credit Summary*

Item	Cost/credit
Total capital investment	$ 230,000
Annual O&M costs[a]	$ 146,000
Annual credits	
Fuel savings	$ 165,000
Waste disposal elimination	$ 175,000
Total credit	$ 340,000
Net credit	$ 194,000
Annual waste throughput	3,500,000 lb
Unit credit	$0.0554/lb

[a]Does not include maintenance costs, if any, arising from boiler tube fouling or HCl corrosion.

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R. McCormick and L. Weitzman are with Acurex Corporation, Mountain View, CA 94039.
***Benjamin L. Blaney** is the EPA Project Officer (see below).*
The complete report, entitled "Preliminary Assessment of Costs and Credits for Hazardous Waste Co-Firing in Industrial Boilers," (Order No. PB 85-172 575/AS; Cost: $10.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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