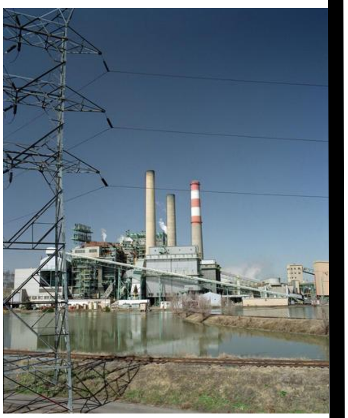

ECONOMIC, ENERGY, AND ENVIRONMENTAL BENEFITS OF BOILER OPTIMIZATION USING THE SEI ACOUSTIC PYROMETER

SUMMARY REPORT

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INTRODUCTION

Boilers account for approximately 6,500 trillion Btu or about 37% of all industrial energy use (excluding electricity) in the United States. Coal and natural gas boilers are also used extensively in power generation, with more than 1500 boilers providing more than 500 million Btu per hour of steam. As fuel prices have increased drastically over the past few years, industrial facilities and utilities are seeking low-cost ways to improve energy management and reduce energy costs. Boilers represent a key energy and cost savings opportunity – an increase in boiler fuel efficiency of a few percent can have a significant impact on a facility's boiler operating costs. The BOILERWATCH® MMP-II Acoustic Pyrometer (AP) System developed by Scientific Environmental Instruments Inc. (SEI) can help boiler operators increase boiler efficiency while helping to extend the life of the boiler.

U.S. BOILER POPULATION

An inventory of industrial and electric power generation (utility) boilers in the U.S. is shown in Table 1; the number of boilers is broken down by boiler size category. The total boiler capacity for each size category is summarized in Table 2 [1] [6].

TABLE 1. U.S. BOILER INVENTORY (NUMBER OF UNITS)

	Industry							Electric Power Generation[b]
MM Btu/hr[a]	Food	Paper	Chemicals	Refining	Metals	Other Mfg	Industry Total	
<10	6,570	820	6,720	260	1,850	7,275	23,495	37
10-50	3,070	1,080	3,370	260	920	3,680	12,380	90
50-100	570	530	950	260	330	930	3,570	203
100-250	330	540	590	200	110	440	2,210	660
250-500	70	490	350	220	120	110	1,360	593
500-1,000								586
1,000-5,000								824
5,000+								210
Total	**10,610**	**3,460**	**11,980**	**1,200**	**3,330**	**12,435**	**43,015**	**3,203**

a Million Btu per hour
b excluding boilers with 0 load hours

TABLE 2. U.S. BOILER INVENTORY (TOTAL BOILER CAPACITY, MM BTU/HR)

	Industry							Electric Power Generation
MM Btu/hr	Food	Paper	Chemicals	Refining	Metals	Other Mfg	Industry Total	
<10	31,070	4,105	28,660	1,255	7,505	29,710	102,305	161
10-50	64,970	24,490	81,690	6,670	19,405	80,585	277,810	2,795
50-100	37,885	36,665	64,970	18,390	22,585	62,630	243,125	15,864
100-250	47,950	81,500	8,640	30,480	17,775	62,790	249,135	110,501
250-500	27,860	229,590	150,915	114,720	45,365	47,760	616,210	212,847
500-1,000								416,669
1,000-5,000								1,868,427
5,000+								2,062,855
Total	**209,735**	**376,350**	**334,875**	**171,515**	**112,635**	**283,475**	**1,488,585**	**4,690,119**

This analysis uses data from an SEI Acoustic Pyrometer system installation in Mexico and the Energetics Incorporated *Technology Energy and Cost Estimation* model to create an energy, cost, and emissions savings profile of a typical industrial boiler in the U.S. power generation industry. As shown in Tables 1–2, boiler capacity can vary widely. To capture a range of operating characteristics, three typical industrial boiler sizes are included in the analysis: 50 MMBtu/hr, 100 MMBtu/hr, and 250 MMBtu/hr. A typical industrial boiler is assumed to operate 330 days per year and consume a 50/50 mix of natural gas and by-product fuel (fuel gas or refinery gas) [1].

We have included a typical 3,000 MMBtu/hr coal-fired power generation boiler in the analysis to show the relative impact between industrial and utility boilers.

SUMMARY OF SEI DATA AND KEY ANALYSIS ASSUMPTIONS

The data in Table 3 was provided by SEI from installation of an AP system on a 5,000 MMBtu/hr (500 MW) power generation boiler in Salamanca, Mexico, firing a combination of fuel oil and natural gas. The November data represents the base case without AP, and the December data represents the optimized case with AP.

TABLE 3. ANALYSIS OF SALAMANCA INSTALLATION DATA	
Acoustic Pyrometer (AP) System Costs	
Initial Cost of BOILERWATCH® MMP-II Acoustic Pyrometer System	$89,000
Acoustic Pyrometer (AP) System Installation	$31,500
Salamanca Boiler System	
Boiler Description	Borsig boiler, 20 fuel oil / natural gas burners (front and rear walls)
Steam Flow	210,100 lb/hr
Steam Pressure	2,631 psia
Steam Temperature	1004°F
Salamanca Energy Data	
Boiler Base Case, w/out AP (November 7, 2006 data)	
Average Fuel Oil Input	97,114 lb/hr
Average Natural Gas Input	21,214 lb/hr
Average Steam Output [a]	32,215,295 lb/hr
Boiler Optimized Case, w/ AP (December 4 – 9, 2006 data)	
Average Fuel Oil Input	97,339 lb/hr
Average Natural Gas Input	20,521 lb/hr
Average Steam Output [a]	32,693,390 lb/hr

a It is assumed that this is on a per hour basis. Note that the average steam output values under energy data significantly differ from the steam flow value under boiler system. This was not explained by SEI personnel, but does not affect the analysis calculations.

The energy data in Table 4 were adjusted so that the optimized case energy data (fuel oil and natural gas) were on the same average steam out level as the base case (see Table 4). This provided a consistent basis to calculate actual energy savings.

TABLE 4. ADJUSTED ENERGY DATA	
Energy Data [a]	
Base Case	
Average Energy Input (MMBtu/hr)	2,430
Average Steam Energy Output (MMBtu/hr)[b]	**32,148**
Optimized Case	
Average Energy Input (MMBtu/hr)	2,382
Average Steam Output (MMBtu/hr)	**32,148**

a MMBtu/hr = million Btu per hour
b Conversion assumes 1,000 Btu/lb steam

As the data in Table 4 shows, the use of the AP system resulted in a 2% decrease in fuel consumption. This value, along with the AP system cost data in Table 3 were used as inputs to the Energetics energy and economics estimating model. Note that since the boiler capacity is defined as the fuel input, the boiler efficiencies for the three boiler capacities are not necessary for the analysis. Key financial assumptions, including energy prices for three scenarios (business-as-usual, high, and low) are shown in Table 5. For by-product fuel the price is assumed to be zero.

TABLE 5. KEY FINANCIAL ASSUMPTIONS	
Discount Rate	10%
Inflation Rate per Year	2%
Equipment Lifetime (Years)	10
Natural Gas Prices ($/MMBtu)[a]	
Business-As-Usual	$6.81
High	$8.75
Low	$5.35

a Based on historical (since 2003) and projected U.S. industrial natural gas prices [2,3]. Fuel prices are assumed steady for the 5-year energy projections in the results section.

ANALYSIS RESULTS

The economic, energy, and environmental benefits resulting from implementation of the SEI acoustic pyrometer system on a 50, 100, and 250 MMBtu/hr industrial boiler are shown in Table 6 along with the benefits for a typical 3,000 MMBtu/hr coal fired power generation boiler, similar to the Salamanca installation presented in Table 3.

Energy, cost, and emissions savings are projected out to five years for the four boiler examples in Figures 2, 3, and 4.

TABLE 6. ECONOMIC, ENERGY, AND ENVIRONMENTAL BENEFITS OF BOILERS OPERATING WITH THE SEI ACOUSTIC PYROMETER SYSTEM[a]

	Industry			Electric Power Generation[g]
Boiler Capacity (MMBtu/hr)[b]	50	100	250	3,000
Annual Energy Savings (Billion Btu/year)	7.9	15.8	39.4	236.5
Annual Energy Cost Savings ($/year)				
Business-As-Usual Case	$26,845	$53,690	$134,225	$369,000
High Natural Gas Price Case	$34,493	$68,985	$172,463	
Low Natural Gas Price Case	$21,090	$42,179	$105,449	
Annual Rate of Return (%)[c]				
Business-As-Usual Case	22	44	111	303
High Natural Gas Price Case	28	57	142	
Low Natural Gas Price Case	17	35	87	
Discounted Payback Period (years)				
Business-As-Usual Case	6.9	2.8	1.0	0.36
High Natural Gas Price Case	4.9	2.1	0.8	
Low Natural Gas Price Case	>10[d]	3.8	1.3	
Annual Emissions Reductions[e]				
CO_2 (MTCE/year)[f]	124	248	621	5,990
NO_x (lb/year)	1,838	3,676	9,189	132,167
Particulates (lb/year)	3	7	17	6,296
VOC (lb/year)	50	101	251	676

a All financial analysis results are before-tax values.
b Analysis assumes that boilers operate 330 days per year at full capacity.
c Does not include the discount rate.
d Payback period is greater than the assumed technology lifetime.
e Emission coefficients from the U.S. Environmental Protection Agency and U.S. Department of Energy [4,5].
f Metric tons carbon equivalent.
g Electric power generation analysis is based on bituminous coal fuel at a business-as-usual price of $37.51 per short ton and an average heating value of 24 MMBtu/ton [7].

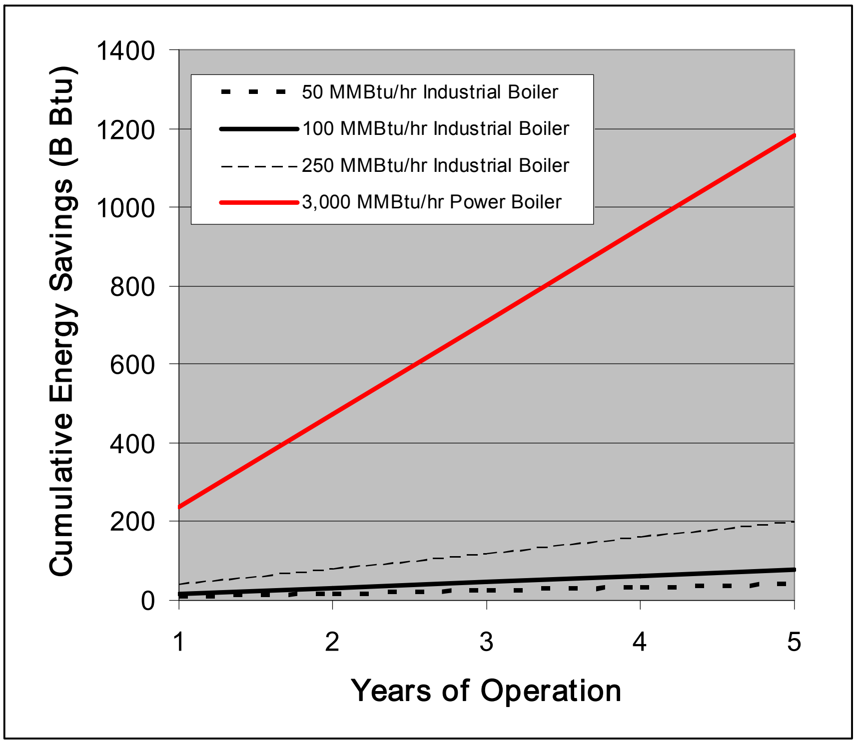

Figure 1. Cumulative Energy Savings
(Billion Btu)

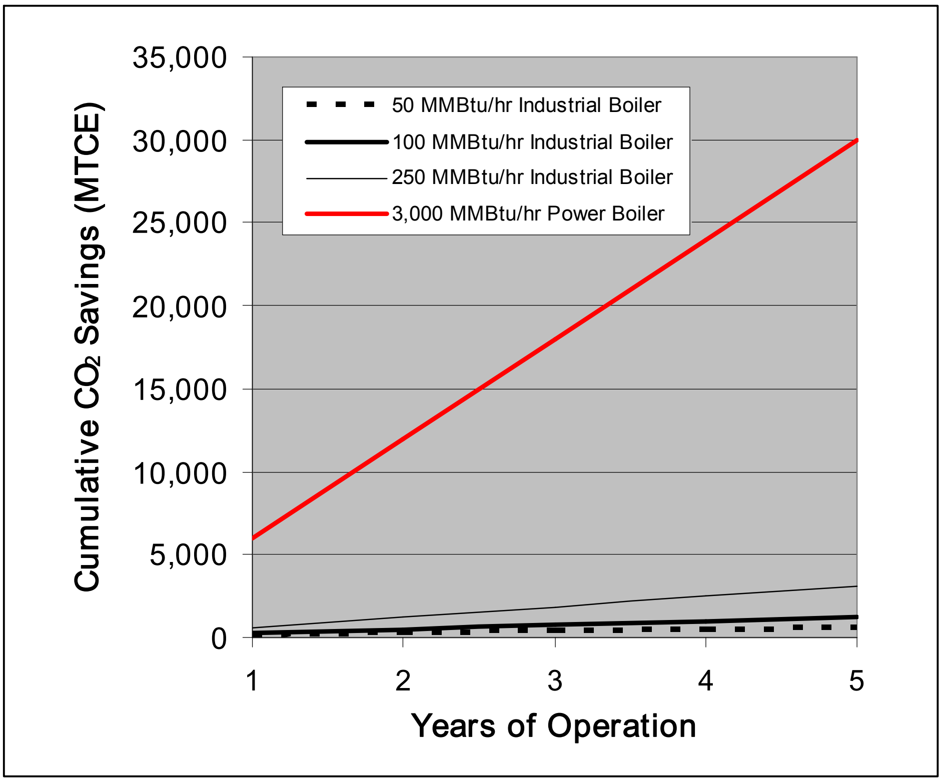

Figure 2. Cumulative Carbon Dioxide Reduction
(Metric Tonnes Carbon Equivalent Btu)

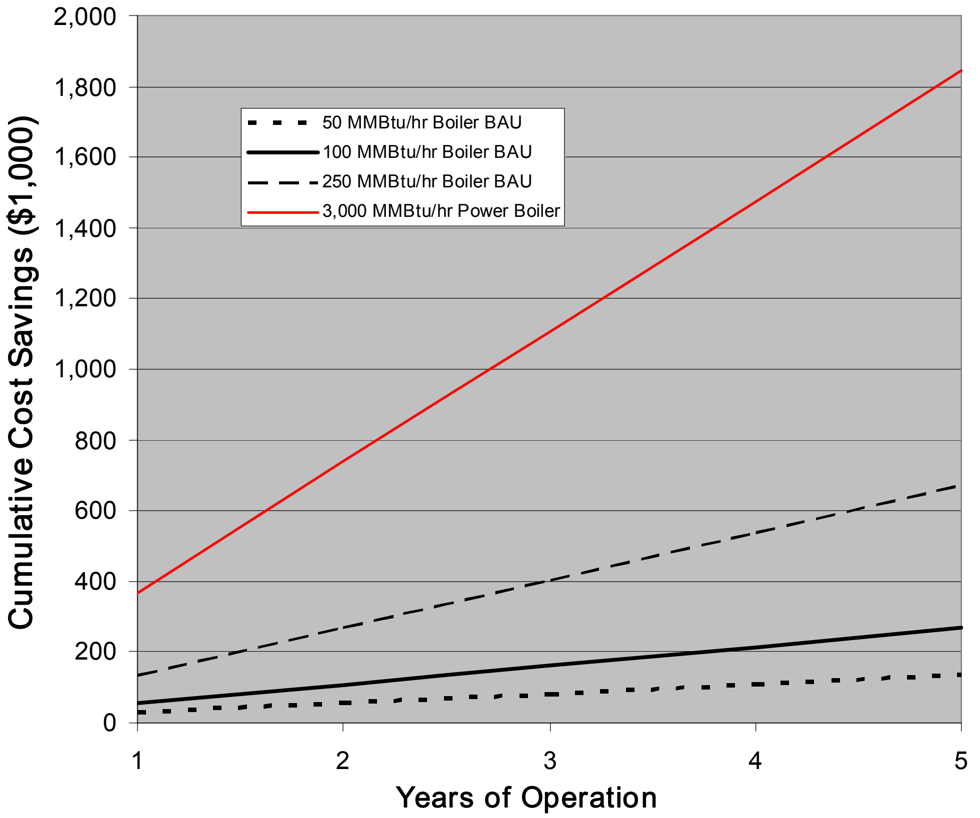

Figure 3. Cumulative Cost Savings for Four Boiler Scenarios
(business as usual fuel prices)

CONCLUSIONS

Paybacks based on energy cost savings are very attractive for boilers using the AP system. Key conclusions:

- Paybacks are most attractive for larger boiler sizes (≥100 MMBtu/hour steam output). An AP system application in a 250 MMBtu/hr boiler can be expected to achieve $134,000 in energy cost savings per year. A mid-size 100 MMBtu/hr boiler can be expected to achieve over $54,000 per year in energy cost savings (business-as-usual natural gas prices).

- Smaller boiler systems (50 MM Btu/hour or less) may not find the AP system economically attractive, except in very high natural gas price scenarios

- By applying the same energy and economics model to a large power generation boiler with AP system installed, the potential energy cost savings are shown to be as high as $369,000 per year for the 3,000 MMBtu/hr coal fired boiler example.

- Emissions of NO_x are reduced along with use of natural gas; the system also reduces emissions of carbon dioxide, a primary greenhouse gas.

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