Search Energy Solutions, Inc.

Final Report

PowerSentri™ Controls

Technology Demonstration and Validation Project

Prepared for

The New York State Energy Research and Development Authority
Albany, NY

SUMMARY

Introduction

The patented *PowerSentri*™ control concept, is a retrofit product developed to reduce the energy consumption of oil and gas-fired boilers, and refrigeration and air conditioning equipment. The control uses measurements of system temperatures to estimate overall heating or cooling load and in response varies the operating "dead-band" of the primary control with resultant reductions of energy consumption and cycling.

For boiler applications the control can have an added benefit in reducing air pollutant emissions. During startup and shutdown there are elevated levels of emissions associated with incomplete combustion including smoke, CO, and hydrocarbons. Reducing burner cycling rates will reduce the total amount of these emissions.

Objectives

1. To quantify, under realistic field conditions, the impact that the *PowerSentri*™ control has on cycling rates and energy use in boiler, air conditioning, and refrigeration applications.
2. In the case of oil-fired boilers a further objective is to evaluate the impact on air pollutant emissions during typical cyclic operation.

Test Procedures

The work included two key parts: The instrumented field studies of boiler, air conditioning, and refrigeration applications and measurements in the laboratory to allow estimates to be made of the impact of the control on boiler air pollutant emissions.

At field test sites short-term validation analysis can only be performed properly by the elimination and reduction of as many variables as possible, and through the analysis of some of the data on a purely mathematical basis, and some of the data on a statistical basis. After many years of testing by Search Energy Solutions (SES), it was determined that the best way of evaluating these types of controls was to alternate the days that the controls were "in" and "out" of the circuit and to be able to time-stamp and log the required data in such a fashion that it could be segregated into the two different modes of operation (in-circuit and out-of-circuit). Alternating the days that the SES control is "in" and "out" of the circuit has the major advantage of generating base-line data (on out-of-circuit days) without having to depend upon historical data from the site that may or may not be relevant or accurate for the test period. Other advantages are: The minimization of variations due to time-of-day sensitivity, day-of-week sensitivity, degree-day effects, solar effects, etc.

SES installed control equipment at each site to implement the day-on (in-circuit), day-off (out-of circuit) control scheme. Instrumentation was installed to record each compressor or burner "on" and "off" event with a resolution of 0.5 seconds. Total run time of the burner or compressor was used to prepare comparisons of the energy use during day-on and day-off days. For the purpose of this project, this approach required that all burners be of the fixed firing rate or "on/off" type, i.e. not modulating. Local outdoor air temperature measurements were made to allow min times to be compensated for estimated heating and cooling loads.

Space temperatures in the tested buildings were monitored for both heating and air conditioning applications. In refrigeration applications the temperature of the refrigerated space was monitored. In all cases this was done to ensure that the use of the control did not adversely impact the desired end result - comfort or temperature control.

Measurements were also made at the test site of the solar load to enable possible evaluation of the impact of cloud cover on the heating or cooling loads. These were considered for information only and not used in the analysis of energy use reductions only because of the uncertainty associated with correcting for this factor.

In work done at Brookhaven National Laboratory (BNL) - the impact of the control on cycling rates was measured using typical residential heating equipment. An analysis was then done of the impact of the control on air pollutant emissions including CO, NOx, hydrocarbons, and filterable particulates. This analysis was based on prior studies that have been done of steady state and cyclic air pollutants from small oil-fired boilers.

BNL also provided some support and oversight of the field studies, particularly those involving heating boilers. At several sites BNL installed temperature loggers to monitor both boiler cycling patterns and supply and return water temperatures. These measurements were used to confirm SES data on burner start and stop times, cycling patterns and total run times. At one site BNL examined in detail the correlation between daily burner run time and outdoor weather conditions based on local airport data.

Test Sites

Sites were selected to provide a broad range of applications typical of the potential market for the *PowerSentri™* control. These were all commercial sector buildings including schools, libraries, office, hotel, and other applications. Table I below, provides a summary of the field sites and equipment types included in this evaluation.

Table 1. Field Sites Included in Project

Site		Application Type		
Name	Location	Boiler	Air Cond.	Refrigeration
Beech Street School	Islip, N.Y.	X		
Estee Lauder	Melville, N.Y.	X[1]	X	X
Freeport Electric	Freeport, N.Y.	X		
Lynbrook Library	Lynbrook, N.Y.		X	
Marriott Hotel	Tarrytown, N.Y.	X	X	
Rohm and Hass	Freeport, N.Y.		X	
Quinnipiac Club	New Haven, Ct.	X		
Krinos Foods	Long Island City, N.Y.			X

1 Results from this location are not verifiable due to heating system and data logging equipment problems.

Results

For all of the sites tested an analysis of energy savings was completed using the standard format for presentation used by SES. Results are provided in Table 2, below and indicate energy savings, based on run time reductions, in the 10-20 % range.

Results of the BNL analysis of the run time / degree day correlation at one specific site, the Beech Street School are shown below in Figure 1 for cycling rate and Figure 2 for burner run time. This shows that the control is most effective under cold weather conditions, where the load is higher and this could be expected. Under mild conditions the burner will cycle only periodically when a heat call does occur.

Table 2. Energy Savings Summary with Return On Investment (ROI)

Test Site	Application	System Size (input)	Raw Savings	Degree Day Adjusted Savings	Estimated Project Cost[7]	R01[1]
Beech Street	Hydronic Heating	9.6 mmbtu	11.73%	12.6%	$7800	2.0[2]
Estee Lauder	Air Conditioning	60 Ton	11.46%	10.6%	$1150	3.3 [4]
Estee Lauder	Refrigeration	15 HP	12.06%	12.06	$550	6.8 [4]
Estee Lauder[8]	Hydronic Heating	1.2 mmbtu	10.71 %[8]	13.7%[8]	$4500	7.4[3]
Freeport Electric	Steam Heating	2.9 mmbtu	9.64%	10.08%	$4900	7.0[2]
Lynbrook Library (AC-1)	Air Conditioning	25 Ton	9.90%	11.53%	$1150	5.8 [4]
Lynbrook Library (AC-2)	Air Conditioning	25 Ton	11.78%	13.37%	$1150	7.9 [4]
Marriott Hotel	Dom. Hot-Water	2.4/1.2 mmbtu	8.28%	8.28%	$7800	9.7[3,5]
Marriott Hotel	Air Conditioning	50 Ton	10.30%	19.02%	$2000	1.2[4,6]
Marriott Hotel	Air Conditioning	10 Ton	10.44%	19.15%	$1150	19.4 [4]
Rohm and Hass	Air Conditioning	7.5 Ton	12.05%	12.84%	$575	4.2 [4]
Quinnipiac Club	Steam Heating	3.5 mmbtu	11.04%	14.68%	$9400	8.0 [2,3]
Krinos Foods	Refrigeration	10 HP	10.27%	10.27%	$550	11.7 [4]

1 Operational Months (Approximate)
2 Assume 1 gallon #2 Oil = $2.00
3 Assume I Therm Natural Gas = $1.45
4 Assume 1 KWH = $0.15 (including all charges), Power Factor = 0.9
5 ROI calculation based on 1.2MMBTU input
6 ROI was calculated based on RAW savings and individual compressor run-times because of the different compressor sizes within the unit. Actual calculated savings for the test period was $1,713.
7 Assumes *PowerSentri*™ Controls installed on all units, even though some Boilers or Air Conditioners are only used as Standby systems. Project cost could be reduced by not installing controls on Standby systems.
8 Results from this location are not verifiable due to heating system and data logging equipment problems.

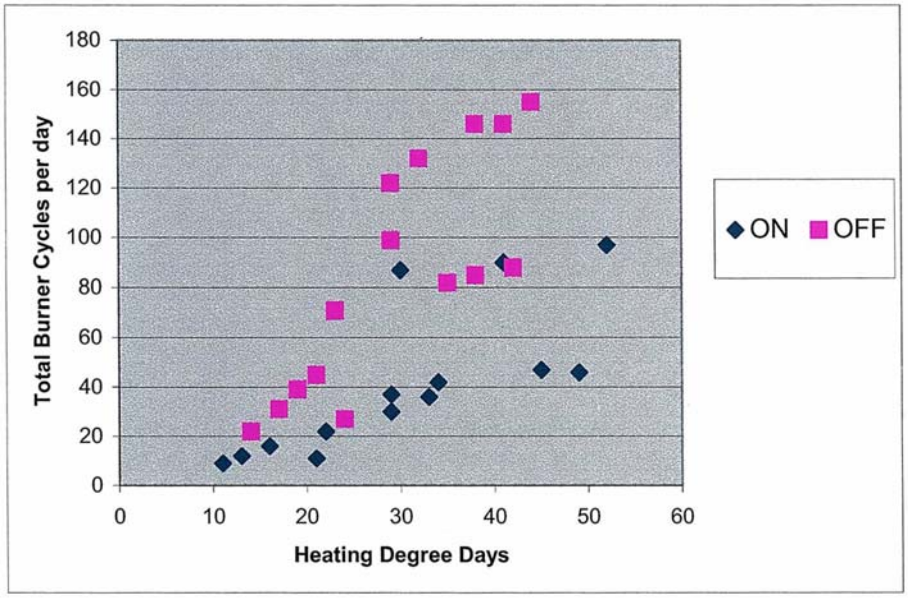

Figure 1. Impact of the control on burner cycling rates at the Beech Street School

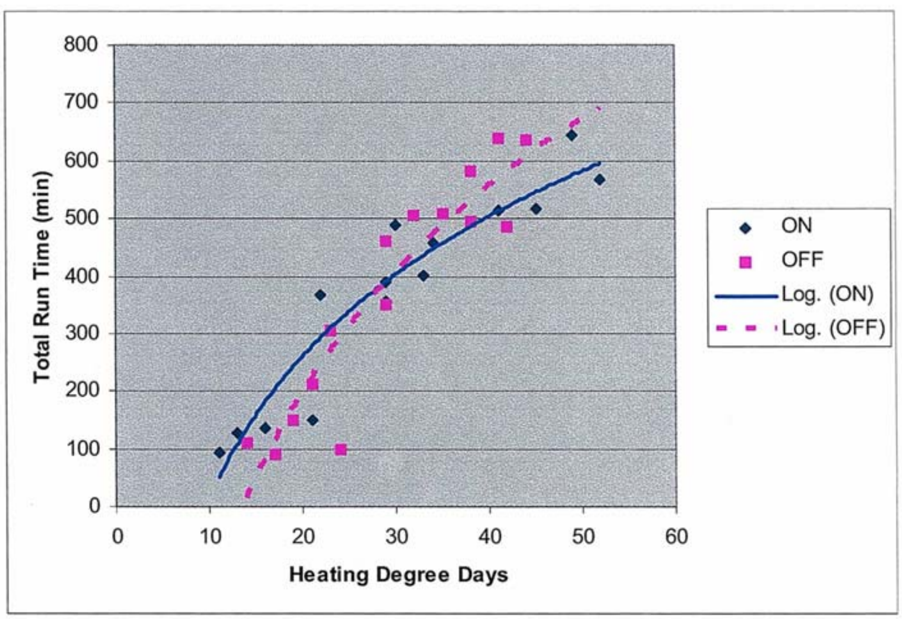

Figure 2. **Correlation between total burner run time (both boilers combined) and heating degree days for the West Islip Beech Street School**

Results of the BNL analysis of emissions impact showed that pollutants related to incomplete combustion (CO, HC, and filterable particulates are decreased with lower cycling rates. Emissions of NOx, however, are increased as the burner operates longer in a fully hot condition. Results of one analysis, done for a simulated year, are shown in Table 3, below.

Table 3. Results of estimates of annual impact on number of cycles and emissions.

		Cycles per hour		Reduction due to control	
Parameter	units	3.2	1.2	total amount	%
cycles	total/year	15162	5686	9476	62.5
Particulates'	gms/year	117.7	70.1	47.6	40.4
HC	gms/year	28.7	19.7	9	31.4
CO	gms/year	2568	1355	1213	47.2
NO_x	gms/year	7079	7785	-706	-10

1. Particulates in this table are measured using a heated filter in accordance with the EPA-5 method.

Pollution Reduction Conclusion

Extrapolating from the above data, it appears that by outfitting 1 million homes with an annual fuel consumption of 1000 gallons of # 2 heating oil would reduce the amount of filterable particulates and hydro-carbons going into the atmosphere by between 1000 - 2000 Tons.