PERMANENT
M&V Plan

Boiler Economizer in a Rubber Plant in Bulgaria

Developed within the project Performance Risk Management for Energy Efficiency through Training – PERMANENT – IEE/08/657/SI2.528420

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Dimitar Baev, Eneffect

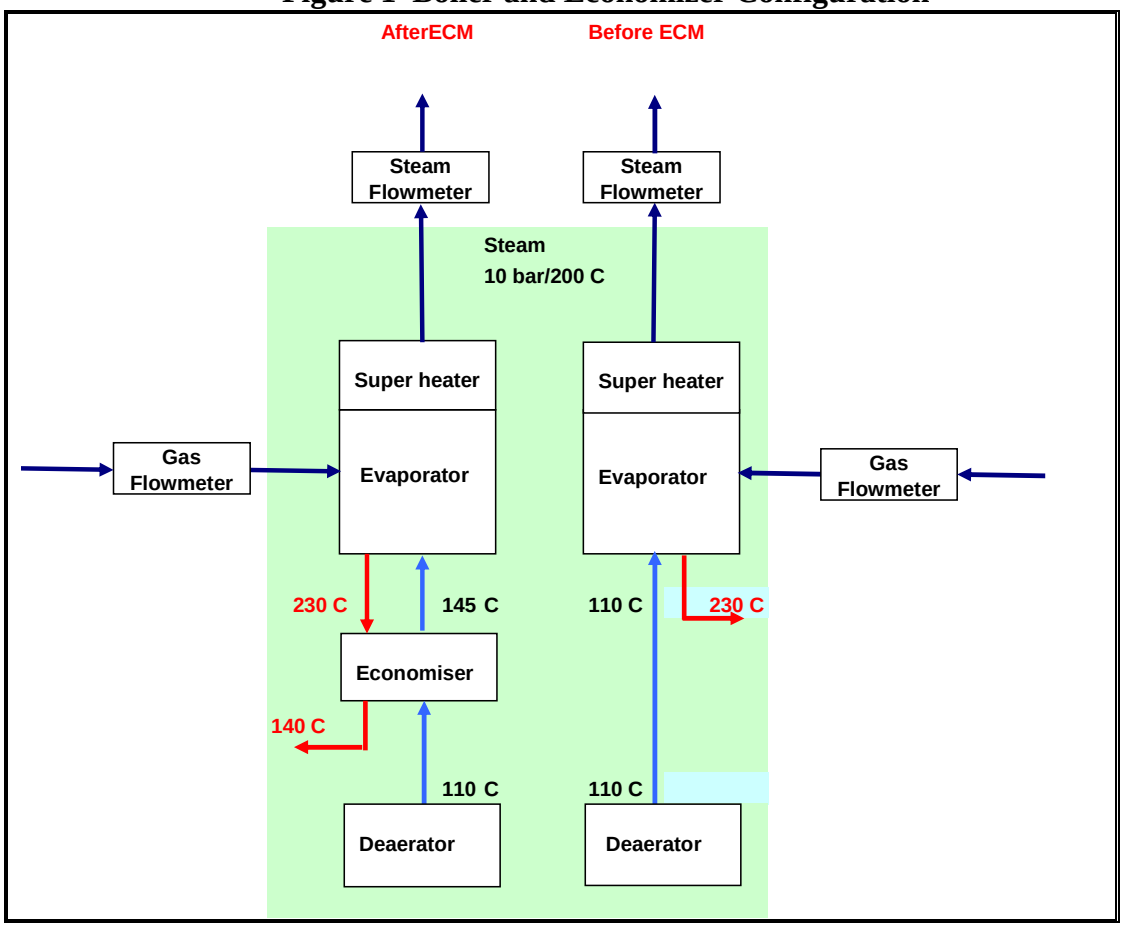
Contents

1. The Energy Conservation Measure

A flue gas economizer was added to a 10 bar steam boiler plant in a Bulgarian rubber manufacturing plant. The steam load on this natural gas fired boiler varies from 17 to 21 tonnes per hour (t/h). The new economizer will preheat boiler feed water from 110°C to 145°C, reducing the specific consumption of fuel per unit of steam produced.

Figure 1 shows the boiler plant configuration before and after this energy conservation measure (ECM).

Figure 1 Boiler and Economizer Configuration



The ECM will be commissioned by a representative of the economizer supplier and witnessed by the plant engineer. They will verify:

- installation according to the approved engineering drawings and specifications,
- achievement of the specified increase in boiler feedwater temperature and reduction of the temperature of the stack gases,
- proper updating of the operating manual and maintenance procedures, and

proper training and understanding of the operating and maintenance personnel.

2. M&V Option and Boundary

Because the ECM focused only on the boiler economizer, it was decided to follow IPMVP Vol I 2010 Option B Retrofit Isolation: All Parameter Measurement. The performance of the boiler including its economizer will be measured, isolated from the rest of the rubber plant. The following measurement devices were installed before installation of the economizer:

- gas flow meter for the boiler
- steam flow meter for the boiler

The ECM will have a minor energy effect beyond this measurement boundary because it requires more boiler fan energy. The cost effect of the added electricity for this fan is expected to be less than 1% of the value of the fuel savings, so will be ignored.

3. Baseline Definition

Baseline performance was monitored for the month of November 2009, before the ECM was installed. The boiler hourly gas consumption and steam production were continuously measured and recorded during boiler operating hours. The steam load varied from 17,2 t/h to 20,6 t/h. The number of hours at each load level was counted, and the gas consumption at each level was totaled. The specific gas consumption at each load level was then computed (in GJ/t) as shown in the Appendix, with the data.

The static factors defining boiler energy performance in the baseline were noted:

- boiler insulation level - as provided by the manufacturer
- condensate return fraction: 90%
- burner type with operating and firing control settings are recorded in boiler plant files
- operation was typically 9 hours per weekday during the baseline period

4. Reporting Plan and Calculation

Avoided gas use will be reported for a one month test period after installation of the economizer. The same gas and steam measurements made in the baseline period will continue during the reporting period.

Avoided gas will be reported under the conditions of the reporting period, following IPMVP Equation 1b:

Avoided Gas Use (Savings) =
Adjusted Baseline Gas – Reporting Period Gas
+/- Non-routine Adjustments for changes in static factors

Where:

- Reporting Period Gas - will be determined from the boiler gas meter.

- Adjusted Baseline Gas - will be the specific gas consumption from the Appendix for each steam rate in the reporting period, multiplied by the total amount of steam generated at that rate.

Non-routine baseline adjustments - will be specially engineered if there is a change in any static factors affecting boiler energy use, between the baseline period and the reporting period.

5. Meter Specifications

Gas meter: ITRON, FLUXI 2000/TZ turbine meter, accuracy ± 1%
Steam meter: ABB, type Trio-Wirl VT, accuracy ± 1%

6. Energy Prices

Avoided gas will be valued at the price the plant pays for Bulgargas JCS gas during the reporting period.

7. Monitoring Responsibilities

Gas and steam meter data will be continuously logged and stored by the plant energy manager in Excel tables. All static factors are recorded in the boiler plant operating and maintenance records by boiler plant staff.

Review and analysis of the reporting period data and static factors will be performed by an independent consultant according to this M&V Plan.

8. M&V Budget

The costs of meter rental and the independent consultant will be 2400 BGN (about 2% of the expected annual savings).

9. Quality Assurance Procedures

The plant energy manager will:

- daily check operation of the measurement and data logging equipment,
- store the measured steam and gas data,
- verify that static factors are recorded in plant records,
- determine the current gas prices in the reporting period, and
- review the independent consultant's savings report for accuracy.

10. Appendix

Baseline Boiler Performance Summary
November 2009

Steam load t/h	Number of hours at this load level	Steam Produced (tonnes)	Gas Consumed (1000 nm^3)	Specific consumption of gas (SC) (GJ/t)
A	B	C	D	
		= A * B		= 33.5 * D / C
17.2	5	86.0	7.835	3.052
17.4	9	156.6	14.136	3.024
17.6	7	123.2	11.018	2.996
17.8	6	106.8	9.462	2.968
18.0	15	270.0	23.696	2.940
18.2	7	127.4	11.074	2.912
18.4	10	184.0	15.840	2.884
18.6	8	148.8	12.686	2.856
18.8	9	169.2	14.284	2.828
19.0	12	228.0	19.057	2.800
19.2	10	192.0	15.887	2.772
19.4	6	116.4	9.534	2.744
19.6	8	156.8	12.713	2.716
19.8	11	217.8	17.476	2.688
20.0	21	420.0	33.349	2.660
20.2	14	282.8	22.219	2.632
20.4	18	367.2	28.543	2.604
20.6	7	144.2	11.088	2.576
Total/Mean	**183**	**3497**	**289.90**	**2.777**

Energy Savings Report
Boiler Economizer at Bulgarian Rubber Plant

Reporting Period: January 2010.

Avoided gas use in January 2010 was 634 GJ. The avoided cost in that period was 11500 BGN.

Observed Data

The data recorded for boiler steam operations during January 2010 are shown in Table 1 below.

January 2010 date	Time of the day									
	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
	Steam load (t/h)									
4	17,2	17,4	17,8	18,6	19,6	19,8	19,0	19,2	18,0	
5	17,4	17,4	17,6	18,4	19,4	20,0	20,2	18,8	18,0	
6	17,2	17,2	18,8	20,0	20,2	20,2	20,0	19,4	18,2	
7	17,2	17,4	19,0	20,2	20,4	20,4	20,2	19,2	18,2	
8	17,2	17,2	17,4	19,4	20,2	20,2	20,0	19,2	18,0	
11	17,4	17,6	18,8	19,0	20,4	20,4	20,2	19,6	18,4	
12	17,8	18,0	19,2	20,0	20,0	20,0	19,8	19,6	18,4	
13	17,6	18,2	18,8	19,8	20,0	20,2	20,4	19,0	18,0	
14	18,0	19,2	19,2	20,0	20,4	20,6	19,4	19,2	18,6	
15	17,8	19,0	19,0	20,2	20,4	20,4	20,0	19,0	18,0	
18	18,0	18,0	18,8	19,8	20,2	20,0	20,0	19,6	18,4	
19	17,4	17,4	17,6	18,6	19,8	20,0	20,4	19,8	18,2	
20	18,2	18,4	19,0	20,6	20,4	20,4	20,2	19,0	18,0	
21	18,0	18,0	19,0	20,2	20,0	20,0	20,0	19,6	18,4	
22	17,6	18,0	18,8	19,6	20,0	20,4	19,4	19,2	18,6	18,0
25	18,2	18,4	19,0	19,8	20,4	20,2	20,0	19,8	18,8	18,4
26	18,0	18,6	19,6	20,6	20,6	20,4	19,8	19,2	17,8	17,6
27	17,4	17,8	18,0	19,0	20,0	20,0	20,0	19,2	17,8	17,6
28	18,2	18,8	19,4	20,0	20,4	20,4	20,4	19,8	18,8	18,6
29	18,4	18,6	19,6	20,6	20,6	20,6	20,4	19,8	18,6	18,4

Table 1 - Boiler Steam Load January 2010

The total gas consumed by the boiler during this period was 9236 GJ.

The boiler plant static factors were unchanged.

Calculations

The load data of Table 1 was reviewed to count the number of hours at each steam load range, as shown in Table 2, below.

Steam Load (t/h)	Number of hours at this load level	Baseline Specific Consumption of Gas (GJ/t)	Adjusted baseline gas (GJ)
A	B	C	
		M&V Plan Appendix	= A * B * C
17.2	6	3.052	315
17.4	9	3.024	474
17.6	7	2.996	369
17.8	6	2.968	317
18.0	16	2.940	847
18.2	7	2.912	371
18.4	10	2.884	531
18.6	8	2.856	425
18.8	9	2.828	478
19.0	12	2.800	638
19.2	10	2.772	532
19.4	6	2.744	319
19.6	8	2.716	426
19.8	11	2.688	585
20.0	22	2.660	1170
20.2	14	2.632	744
20.4	18	2.604	956
20.6	7	2.576	371
Total	**186**		**9870**

Table 2 - Adjusted Baseline Gas Calculation

The Adjusted Baseline Gas use shown above was determined by multiplying together, for each load range (from 17,2 to 20,6 t/h):

- the baseline specific consumption of gas, taken from the Appendix of the M&V Plan, and
- the amount of steam generated at that steam rate (= steam load t/h * number of hours).

The total Adjusted Baseline Gas for the reporting period was computed to be 9870 GJ.

Using the equation of the M&V Plan:

Avoided Gas = 9870 - 9236 = 634 GJ

Non-routine baseline adjustments were not required because static factors were unchanged.

At the 18,21 BGN/GJ gas price of January 2010, the avoided cost is 634 * 18.21 = 11.545 BGN.

Savings are reported at the beginning of this report using only three significant digits, to match the least number of significant digits used in the calculation, found in the steam load range values used to determine steam volumes.