



steam centre of excellence

Steam Boiler System Optimization



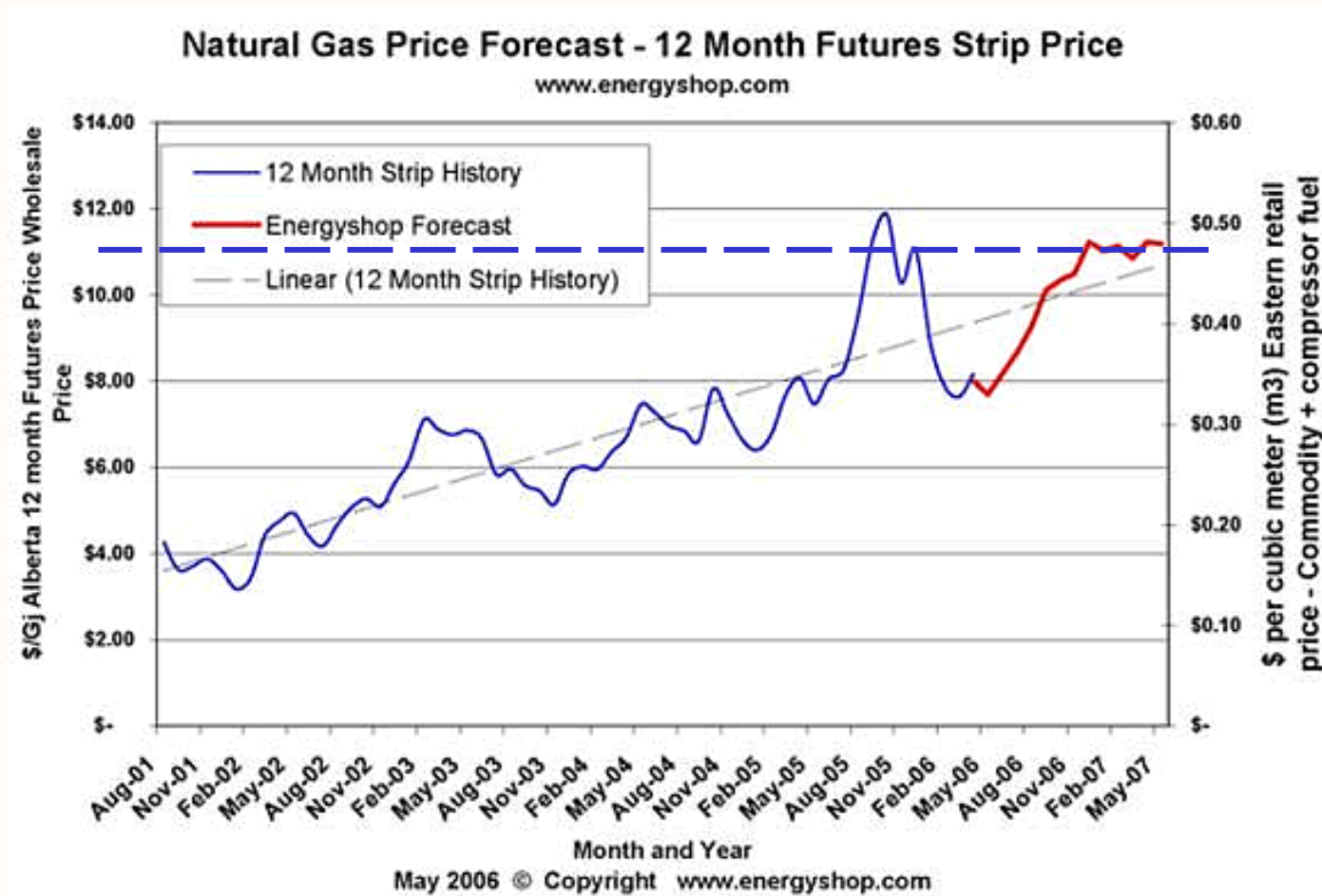
Introduction

- Gas Cost
- Metering Fluids
 - Fuel, Water, Steam
- Steam Costs
- Boiler House
 - Stack Losses
 - Boiler Waterside Surfaces
 - Blowdown

Current Natural Gas Cost

Projected Cost : \$11/ 1MCF(10 Therms/1Gj) ????

1Gj ~ 1 Million BTU's



Improving Boiler Efficiency

Stack Gas Waste Heat Recovery: *Suggested Action*

Boiler Feed Water Heating



- After tune-up determine stack temperature & excess air levels with all heat transfer surfaces clean.
- Determine minimum temperature stack gases can be cooled. (*The lowest for natural gas is 250F*).
- Study the cost effectiveness of installing a feed water economizer or air pre-heater in the boiler.

An 11 °F rise in the feed water temperature entering the boiler brings the efficiency up 1%

OR

A 40F change in exhaust temperature will improve boiler efficiency by 1%

Stack Gas Waste Heat Recovery

Recoverable Heat from Boiler Flue Gas

Boiler thermal Output MMBtu/hr
Recoverable Heat MMBtu/hr

Initial Stack Temp F	10	25	50
400	0.65	1.3	2.6
500	1.15	2.3	4.6
600	1.65	3.3	6.5

Based on 15% excess air and a final stack temperature of 250F

Boiler generates 10,000 lb/hr @ 150 psig

Make-up + condensate return temp = 117F

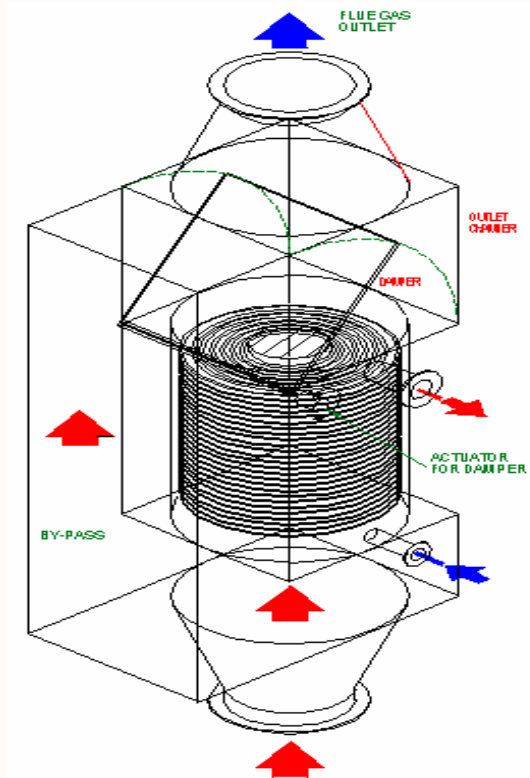
Stack temperature = 500F

Hours of operation = 8,400 /yr

Gas Cost = \$11.00 per MCF

Annual Savings = 1.15mmBTU's/hr x \$11.00/mmBTU's/hr x 8,400 hr/yr

Annual Savings > \$106,000/yr



A 11.5%+ fuel savings

Flue Gas Analysis

Flue Gas Temperature Less
Combustion Air Temperature
Combustion Efficiency for Natural Gas



% Air Excess	O2	200	300	400	500	600
9.5	2.0	85.4	83.1	80.8	78.4	76.0
15	3.0	85.2	82.8	80.4	77.9	75.4
28.1	5.0	84.7	82.1	79.5	76.7	74
44.9	7.0	84.1	81.2	78.2	75.2	72.1
81.6	10.0	82.8	79.3	75.6	71.9	68.2

Example

300 HP BOILER

Before Tune up:

300 HP Output = 10,045,000 Btu/hr
Hours of Operation = 8000 hrs

Steam Pressure = 150 psig

Excess air 44.9%

Flue Gas Temp less air temp = 400 F

Boiler Combustion Efficiency = 78.2%

After Tune Up:

Excess Air = 15 %

Flue gas temp less air temp = 300F

Boiler Combustion Efficiency = 82.8 %

Cost savings @ \$11.00/MMBtu > \$ 67,000

On well designed natural gas fired system, an excess air of 10-15% is attainable.

**Boiler overall efficiency can be improved by 1% for each 15%
reduction in excess air.**

Energy Loss due to Scale Deposits

Scale Thickness in Inches	Normal	Scale Type High Iron	Iron plus silica
1/64	1.00	1.6	3.5
1/32	2.00	3.1	7
3/64	3.00	4.7	-
1/16	3.9	6.2	-

Fuel Loss % of Total Use

Normal Scale: low pressure applications

High Iron & Iron Plus Silica: high pressure application

Example:

- Boiler uses 450,000 MMBtu of fuel while operating 8000 hrs
- 45,000 lbs/hr of 150 psig steam
- Scale thickness = 1/32"
- Normal composition = 2% Fuel Losses
- Gas cost = \$11.00 / MCF
- Annual operating cost increase = \$81,000

$$\begin{aligned} \text{Annual Operating Cost Increase} &= 450,000 \text{ mmBTU's/yr} \\ &\times \$11.00 \text{ mmBTU's} \times 0.02 = \$81,000.00 \end{aligned}$$

Blowdown Heat Recovery Savings

Flash Steam Recovery

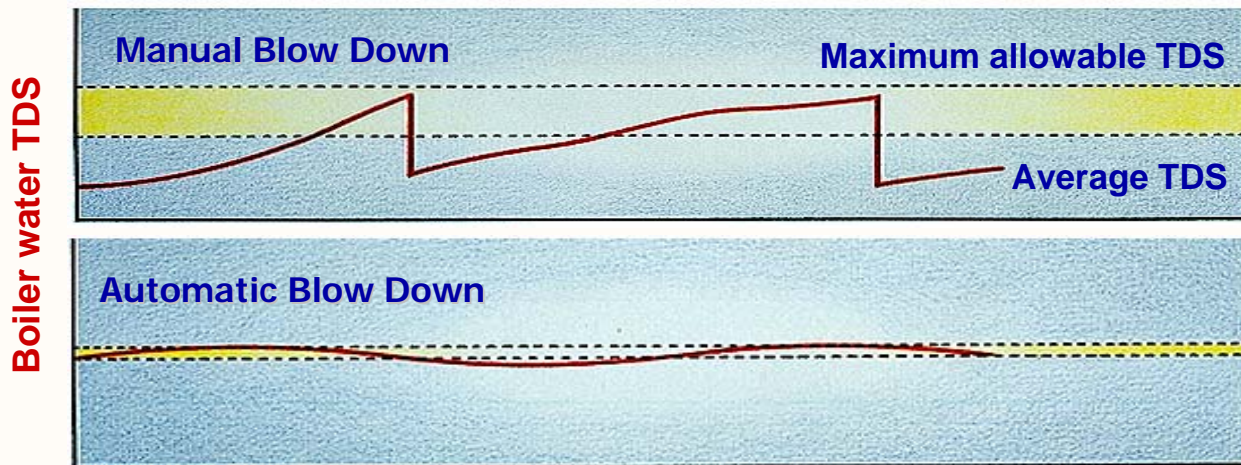


**Potential Savings :
1-10%**

Sensible Heat Recovery

High Pressure Blow Down

Controlling TDS Levels



- Poor control causes waste boiler water through excessive blowdown
- Controlled TDS levels minimize carryover and foaming (caused by high TDS level).
- Lack of control can cause dissolved solids concentration to rise above scaling level.
(One mm of scale build-up increases fuel consumption by 2%.)
- High TDS is corrosive to boiler metal.

Managing Boiler Water Treatment

Recommended Maximum Limits for Boiler Water
American Boiler Manufacturers Association

Boiler Pressure (psig)	Total Solids (ppm)	Alkalinity (ppm)	Suspended Solids (ppm)	Silica (ppm)
0-300	3500	700	300	125
301-450	3000	600	250	90
451-600	2500	500	150	50
601-750	2000	400	100	35
901-1000	1500	300	60	20

Blowdown Heat Recovery Payback Analysis

1 Design Criteria

1.1	Boiler Capacity design	100,000
1.2	Boiler Capacity normal flow	50,000
1.3	Boiler Operating Pressure	150
1.4	Flash Steam Pressure	7
1.5	Boiler TDS	3,200
1.6	Feedwater TDS	200
1.7	Annual Hours Of Operation	8,000
1.8	Gas Cost	\$0.48

\$/Cu/meter

2 Continuous Blowdown Calculation

2.1	% Continuous Boiler Blowdown =	$\frac{\text{TDS Feedwater}}{\text{Boiler TDS} - \text{Feedwater TDS}} =$	6.7%
2.2	Actual Boiler Blowdown =	% Continuous Boiler Blowdown x Boiler Capacity =	3,333

3 Flash Steam Heat Recovery Savings

3.1	Enthalpy of Blowdown @	150 psig	338.6
3.2	Enthalpy of Blowdown @	7 psig	200
3.3	% of Flash Steam Recovered =		14.48%
3.4	Quantity of Flash Steam Recovered =	(Refer to 2.2 x 3.3)	482.8
3.5	Quantity of Flash Steam Recovered =		57.8

4 Sensible Heat Recovery Savings

Assuming temperature of blowdown after the Heat Exchanger is 82F

4.1	Quantity of blowdown to be drained =	total blowdown - flash steam recovery	2850.6
4.2	Enthalpy of Blowdown after heat exchanger =		50
4.4	Total Heat Recovered from continuous blowdown (initial energy - energy drained)		986,137.9

Blowdown Heat Recovery Payback Analysis

5	<u>Pay Back Calculation</u>					
5.1	Value of 1000 gallon of condensate					\$15.00
5.2	Value of Condensate from Flash Steam @ ___ gph (Refer to 3.5)					\$0.87
5.3	Equivalent Gas Cost For Heat Recovered (Refer to 4.4 & 1.9)					\$16.91
5.4	Total Savings					\$17.77
5.5	Total Savings					142,180
5.6	Heat Recovery Equipment					
5.7	Heat Recovery Equipment Cost					\$5,000.00
5.8	Approximate Installation Cost					\$5,000.00
5.9	Total Cost					\$10,000.00

PAY BACK PERIOD IN MONTHS === 0.9

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 - Blowdown
- Distribution & Utilization
 - Steam Distribution Losses
 - Pressure Reduction
 - Internal steam leaks
 - Losses due to leaking steam traps
- Condensate Costs
- Condensate Return Losses
 - Condensate return losses
 - Case Example 2



Questions:????