



**MIURA**

# **Boiler Benchmarking: In-Service Efficiency Assessment**

**Kevin Vradenburg**

- **Why benchmark?...**

***You are not managing what you do not measure...***

- **Benchmarking thermal energy systems first and foremost confirms that existing systems are sized appropriately for current load demands**
- **Benchmarking assesses energy performance of existing systems in comparison with the current “state of the shelf” in available technology**
- **Benchmarking allows facilities to better evaluate the carbon intensity of their operations**
- **Benchmarking data can be used to identify opportunities for energy savings & reduced emissions via systems upgrades**
- **Benchmarking data can be used as the basis of capital planning and/or award for energy efficiency rebates / grants**

# Understanding Boiler Efficiency: *In-Service Efficiency*

**Boiler Efficiency**

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**Output Energy**

—————

**Input Energy**



## “Combustion Efficiency” ( $E_c$ )

- The effectiveness of the burner to ignite the fuel
- Per ANSI Z21.13 test protocol

## “Thermal Efficiency” ( $E_t$ )

- The effectiveness of heat transfer from the flame to the water
- Per the Hydronics Institute BTS-2000 test protocol
- Recognized by ASHRAE 90.1 standard

## “Boiler Efficiency”

- Often substituted for combustion or thermal efficiency

## “Fuel-to-Steam Efficiency” (A.K.A. Catalog Efficiency)

- The effectiveness of a boiler operating at maximum capacity and a steady state, with flue losses and radiation losses taken into account.



- A new measure of efficiency is needed...
- “City” vs. “Highway” boiler fuel efficiency is required to better reflect real-life operating conditions

*“Currently...boilers...are rated only in terms of steady-state efficiency at full load, which is not a meaningful indicator of relative energy use or operating costs.”*

Inside ASHRAE – BSE Magazine, June 2005

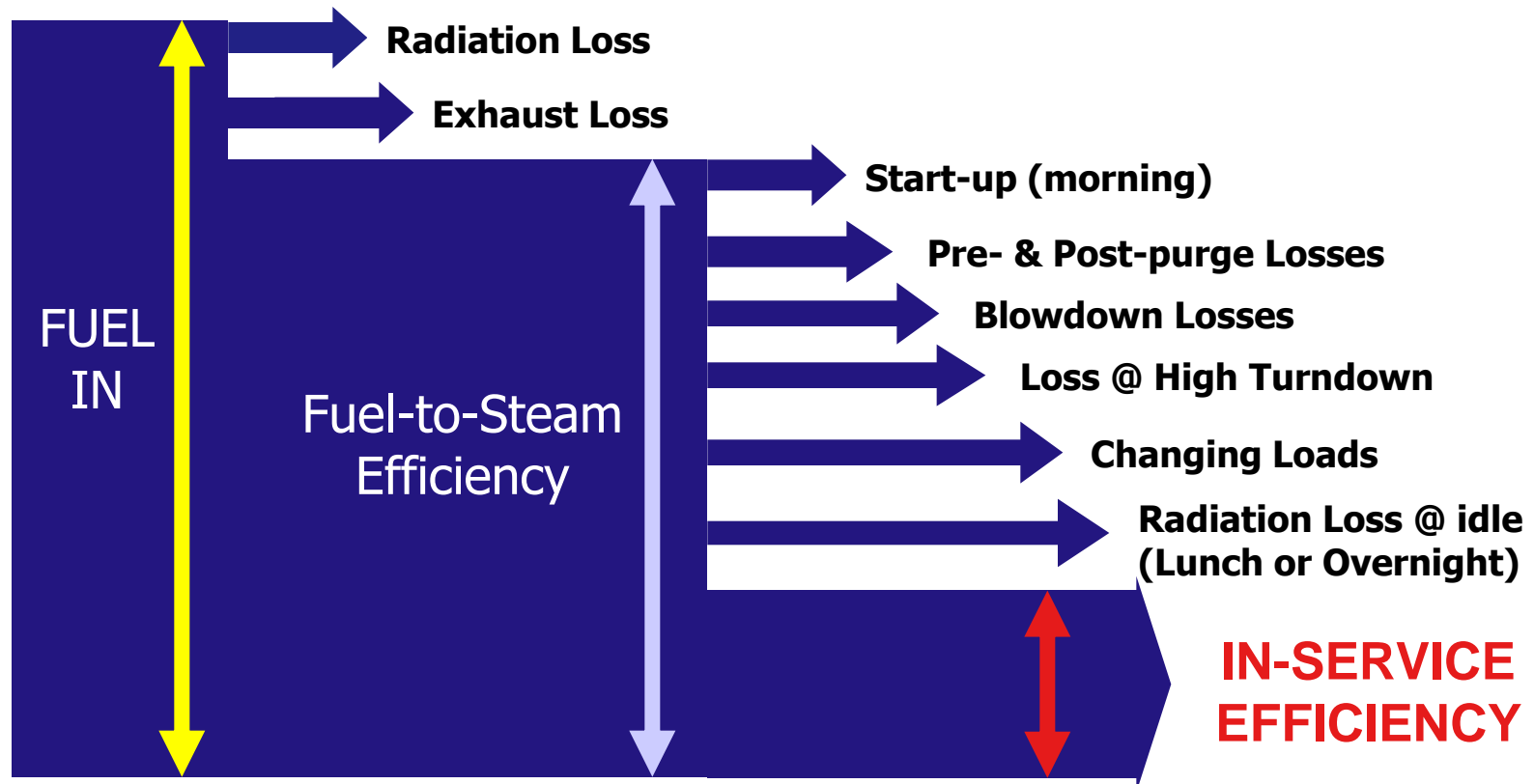
- **ASHRAE scheduled to release new boiler efficiency guideline **Standard 155-P** for public comment September 2010**



# First Steps – Benchmarking Performance

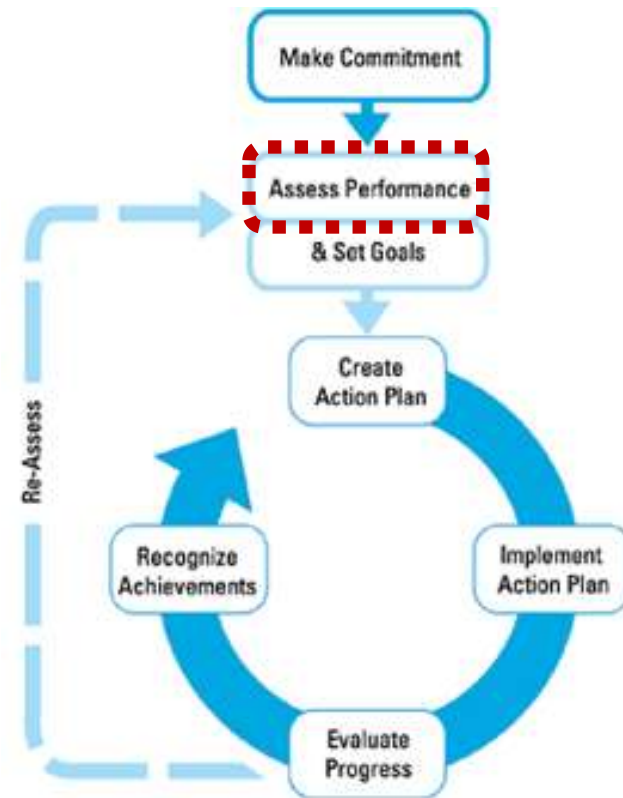
## *Tracking Energy Losses*

- Evaluate Existing Boiler In-Service Efficiency



# Benchmarking to Save Energy: *In-Service Efficiency (ISE) Study*

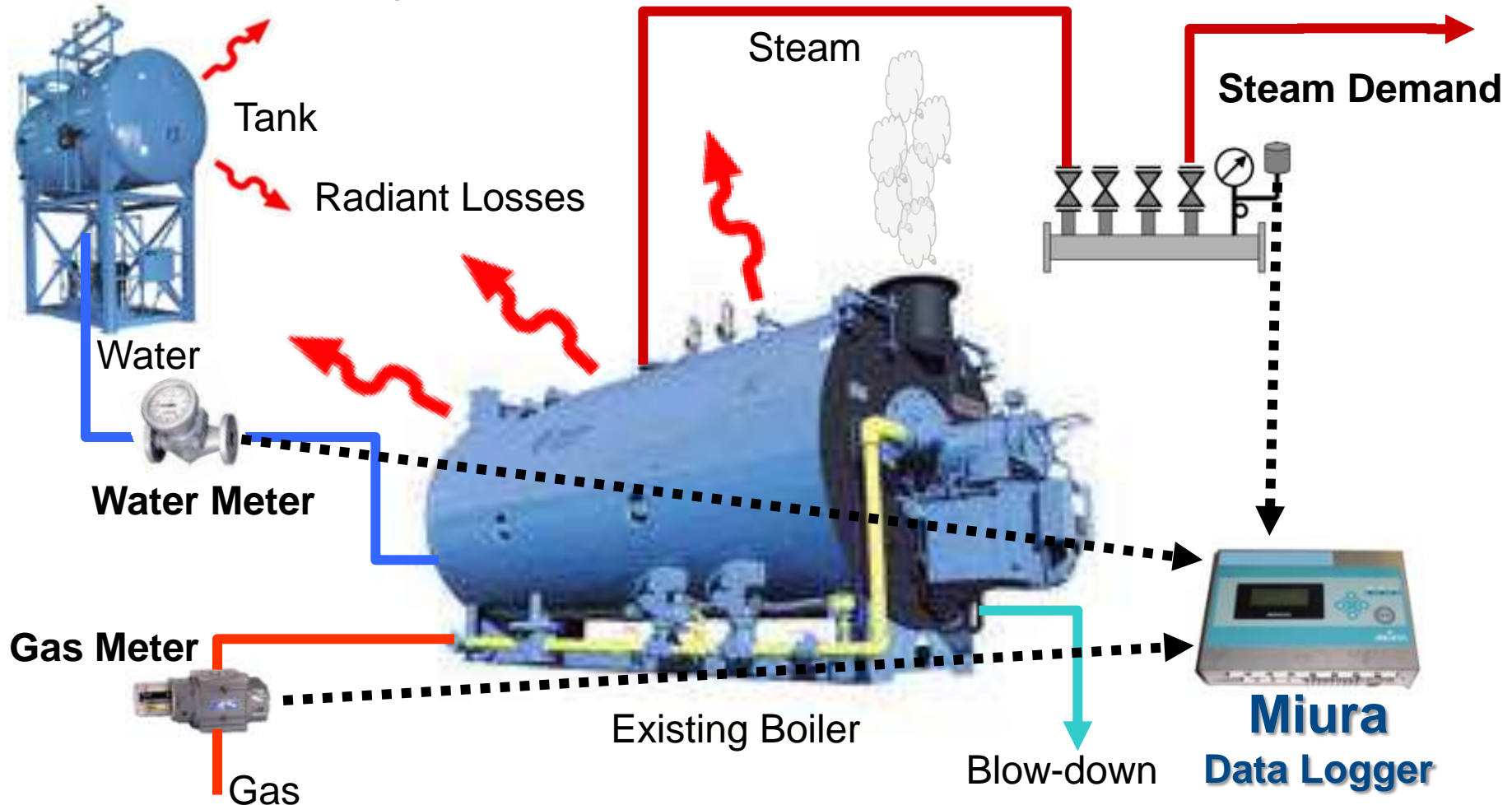
- Meter existing equipment & collect data on current consumption, including:
  - Gas & water consumption rates
  - Gas pressure at the meter
  - Gas temperature at the meter
  - Feed-water temperature
  - Steam pressure
  - Blow-down rate
- Review utilities statements for historical data
- Size loads and determine load “profile” (i.e., high-low load swings) over test period
- Determine **In-Service Efficiency** to “benchmark” existing energy performance
- Compare benchmark data vs. Miura system efficiency to estimate savings & reduced environmental impact



Courtesy of ENERGY STAR  
Program Guide

# In-Service Efficiency Analysis: *Benchmarking Tools*

- Miura's **Data Logger** records metered usage to benchmark existing efficiency:



# Understanding Boiler Efficiency: *In-Service Efficiency*

## ▪ Calculating In-Service Efficiency:

$$\frac{\text{F.W. usage} \times (1 - \text{B.D. rate}) \times (\text{T.H. in steam} - (\text{F.W. Temp.} - 32))}{\text{Gas BTU} \times 35.357 \times \frac{(14.69 + \text{Gauge gas pressure})}{(459.4 + \text{Gas Temperature})} \times \text{Gas usage}}$$

The diagram shows the units for each variable in the equation:

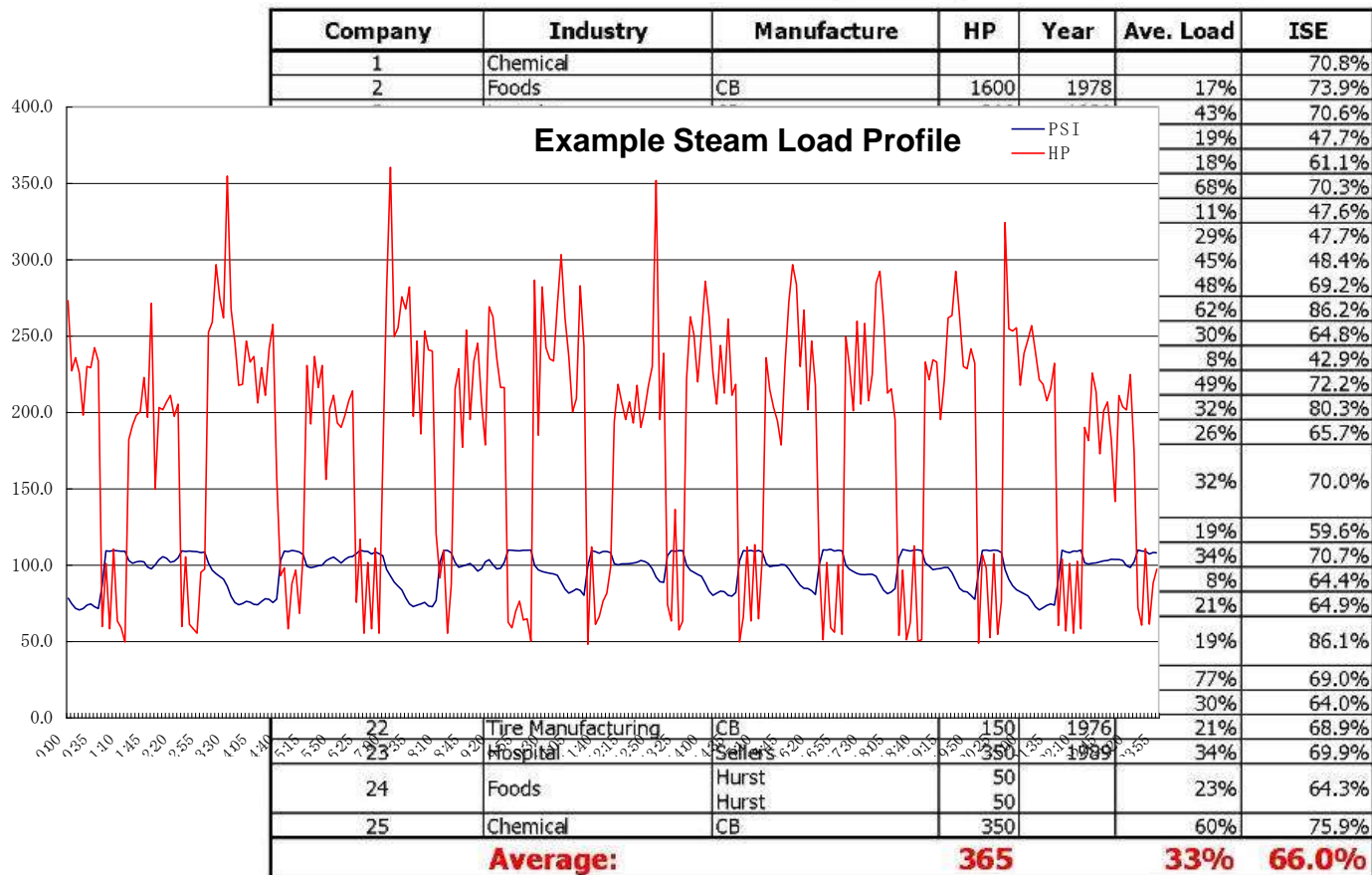
- F.W. usage**: LB (pounds)
- B.D. rate**: % (percent)
- T.H. in steam**: BTU/LB (British Thermal Units per pound)
- F.W. Temp.**: °F (degrees Fahrenheit)
- Gas BTU**: BTU/SCF (British Thermal Units per standard cubic foot)
- Gauge gas pressure**: PSI (pounds per square inch)
- Gas Temperature**: °F (degrees Fahrenheit)
- Gas usage**: CF (cubic feet)

# Boiler In-Service Efficiency: Tracking Results



- Benchmarked energy efficiency of 25 boilers via ISE data:
- **Average In-Service Efficiency = 66% at 33% average load factor**

Results from ISE Studies - **Competitor's Boilers** (updated 2007-07-30)



# Energy Efficiency – R.O.I.:

## *Life-cycle Impact*

### ▪ Typical 600 BHP Installation:

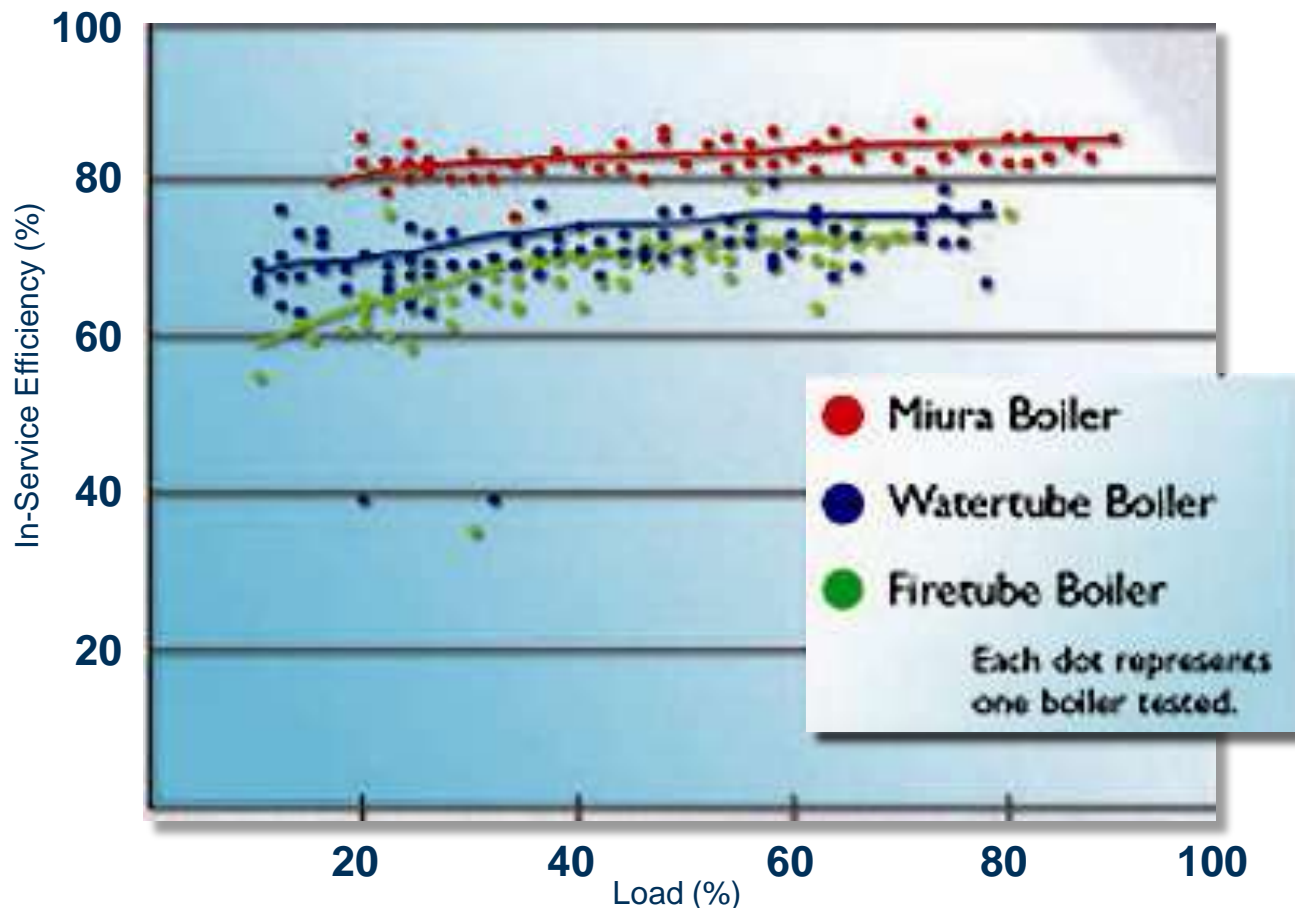
- Average Load: 400 BHP
- Operation: 16 hrs/day, 5 days/wk, 50 wks/year
- Fuel Usage: 629,712 therms/yr
- Annual Fuel Cost: @ \$1.00/therm = **\$629,712 / yr**
- Initial Boiler Cost: w/ installation = \$275,000
- Annual Fuel Savings @ 20% = **\$125,942 / yr**
- Annual Reduction in CO<sub>2</sub> Emissions: **630 metric tons CO<sub>2</sub> / yr**
- Projected Life-cycle Fuel Savings = **+\$3.5 million (over 20 yrs)**
- Projected Life-cycle CO<sub>2</sub> Reduction = **17,500 mtCO<sub>2</sub> (over 20 yrs)**
- Estimated Annual Savings in Cost of Carbon = **+\$12,000 / yr**



- **Operations costs quickly dwarf initial boiler investment**
- **Energy efficiency = economic + environmental benefits**

# Understanding Boiler Efficiency: *In-Service Efficiency*

- **In-Service Efficiency by Boiler Type:**
- **Miura's modular systems provide increased energy efficiency at around 85% consistently from low to high load factors**



# Steam Cost Calculator: TCO (Total Cost of Operation) Analysis

- Fuel Cost
- Water Cost
- Sewer Cost
- Electricity Costs
- Chemical Costs
- Service Contract
- O&M Costs
- Future CO<sub>2</sub> Costs
- Projected Lifecycle Costs

Customer's name	Example 1		
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Usage		Reference	
Boiler HP	400	HP	200
Number of boilers	2	boilers	3
Average load	25	%	30
Operation time	12	hours/day	24
	300	days/year	300

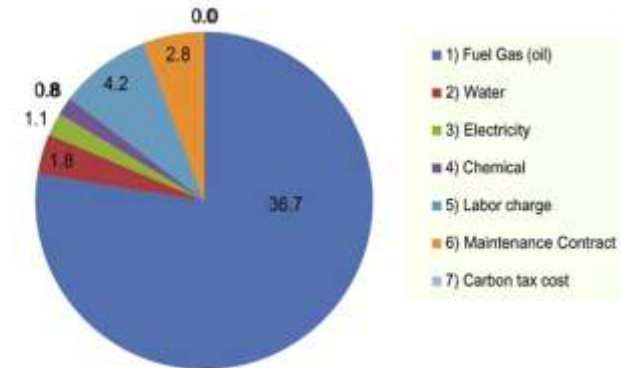
Price for customer		Reference	
Water (supply + sewer)	5.8	\$/gal	7.8
Fuel gas (oil)	0.8	\$/therm	0.9
Electricity	7	C/KWH	6
Chemical	0.80	\$/100HP	1.00
Labor charge	2,500	\$/month	2,000
Maintenance contract	10,000	\$/boiler	6,000
Carbon tax	0	\$/ton-CO2	12

System information		Reference	
Steam pressure	130	PSI	120
Steam enthalpy	1193.5	btu/lb	1192.4
Blow down ratio	5	%	10
Feed water temp	190	F	190
In service Efficiency	73	%	75
Condensation return	30	%	50

Steam Price per 100 HP	
1) Fuel Gas (oil)	36.7 = (\$/therm) x (3,348,000) / (100,000) / (ISE)
2) Water	1.8 = (\$/gal) x (City water usage)
3) Electricity	1.1 = (C/KWH) x 15 / 100
4) Chemical	0.8
5) Labor charge	4.2 = (\$/month) / (HP * average load * hours/m)
6) Maintenance Contract	2.8 = (\$/year) / (HP * average load * hours/year)
7) Carbon tax cost	0.0 = (\$/tonCO2) * (3,348,000) / (ISE) / 100,000 / 200
<b>Total*</b>	<b>47.3</b>

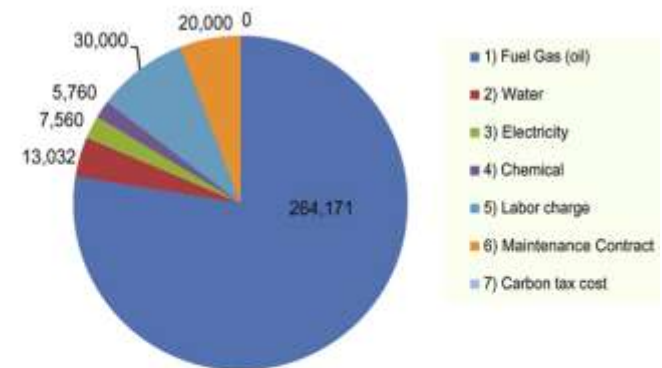
Total price for a year	
1) Fuel Gas (oil)	264,171 = (\$/100HP) x (100HP * boilers * average load * hour)
2) Water	13,032 = (\$/100HP) x (100HP * boilers * average load * hour)
3) Electricity	7,560 = (\$/100HP) x (100HP * boilers * average load * hour)
4) Chemical	5,760 = (\$/100HP) x (100HP * boilers * average load * hour)
5) Labor charge	30,000 = (\$/100HP) x (100HP * boilers * average load * hour)
6) Maintenance Contract	20,000 = (\$/100HP) x (100HP * boilers * average load * hour)
7) Carbon tax cost	0 = (\$/100HP) x (100HP * boilers * average load * hour)
<b>Total*</b>	<b>340,523</b>

Steam price per 100HP



TOTAL \$ 47.3

total price for a year



TOTAL \$ 340,523

# Energy Efficiency Incentives: Natural Gas Rebate Programs

- Utilize ISE Study data to satisfy incentives EE performance metrics
- Growing list of state & utilities sponsored rebate programs...



- Refer to [www.dsireusa.org](http://www.dsireusa.org)

# Example Gas Rebate Program: *Think Smart -Think Green*

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national**grid**

- Program website: [www.thinksmarthinkgreen.com](http://www.thinksmarthinkgreen.com)
- Program includes utility customers in the states of Massachusetts, New Hampshire, New York & Rhode Island
- Natural gas rebates available for qualifying applicants in the following categories:
  - Natural gas heating
  - Natural gas hot water
  - Prescriptive controls
  - Insulation
  - Gas-fired commercial kitchen equipment
  - Energy efficiency engineering studies
  - Economic redevelopment projects
  - **Custom projects**

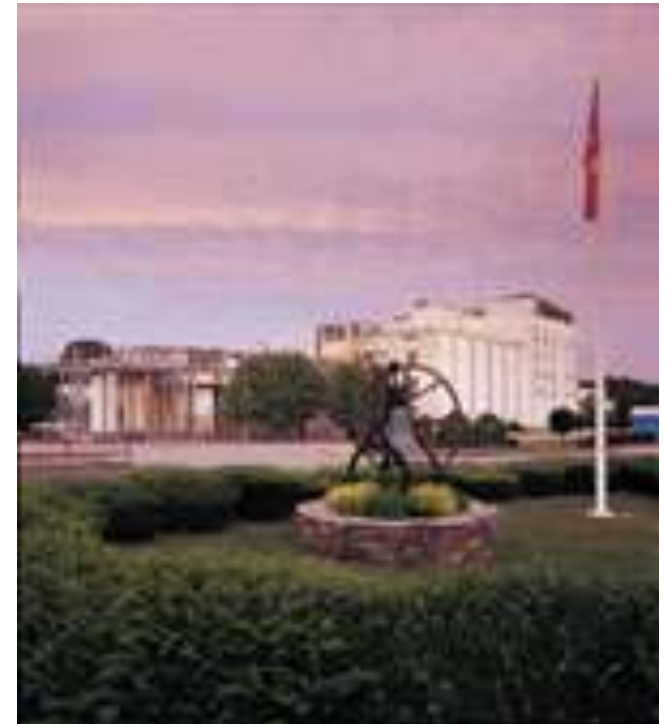
# Case Studies:

## *Rhodes Technologies (Rhode Island)*

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**nationalgrid**

- **Boiler Installation – (2) 200 BHP & (4) 50 BHP units**
- **Placed into service – 2008**
- **Participation in National Grid's *Think Smart Think Green* rebate program:**  
**\$100,000 energy efficiency rebate paid back to customer via cost sharing through gas rebate program**





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**Questions:**