Boiler Benchmarking: In-Service Efficiency Assessment

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Benchmarking to Save Energy:

- **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**

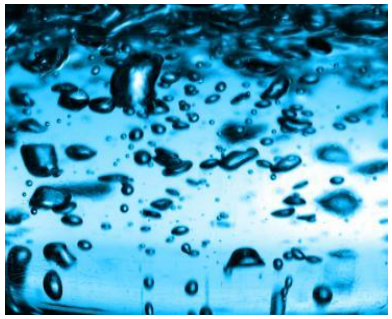
Understanding Boiler Efficiency:
In-Service Efficiency

Boiler Efficiency = $\dfrac{\text{Output Energy}}{\text{Input Energy}}$

Understanding Boiler Efficiency:

"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"

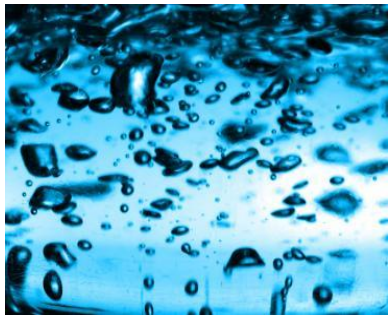
- Often substituted for combustion or thermal efficiency

"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.

Understanding Boiler Efficiency:

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



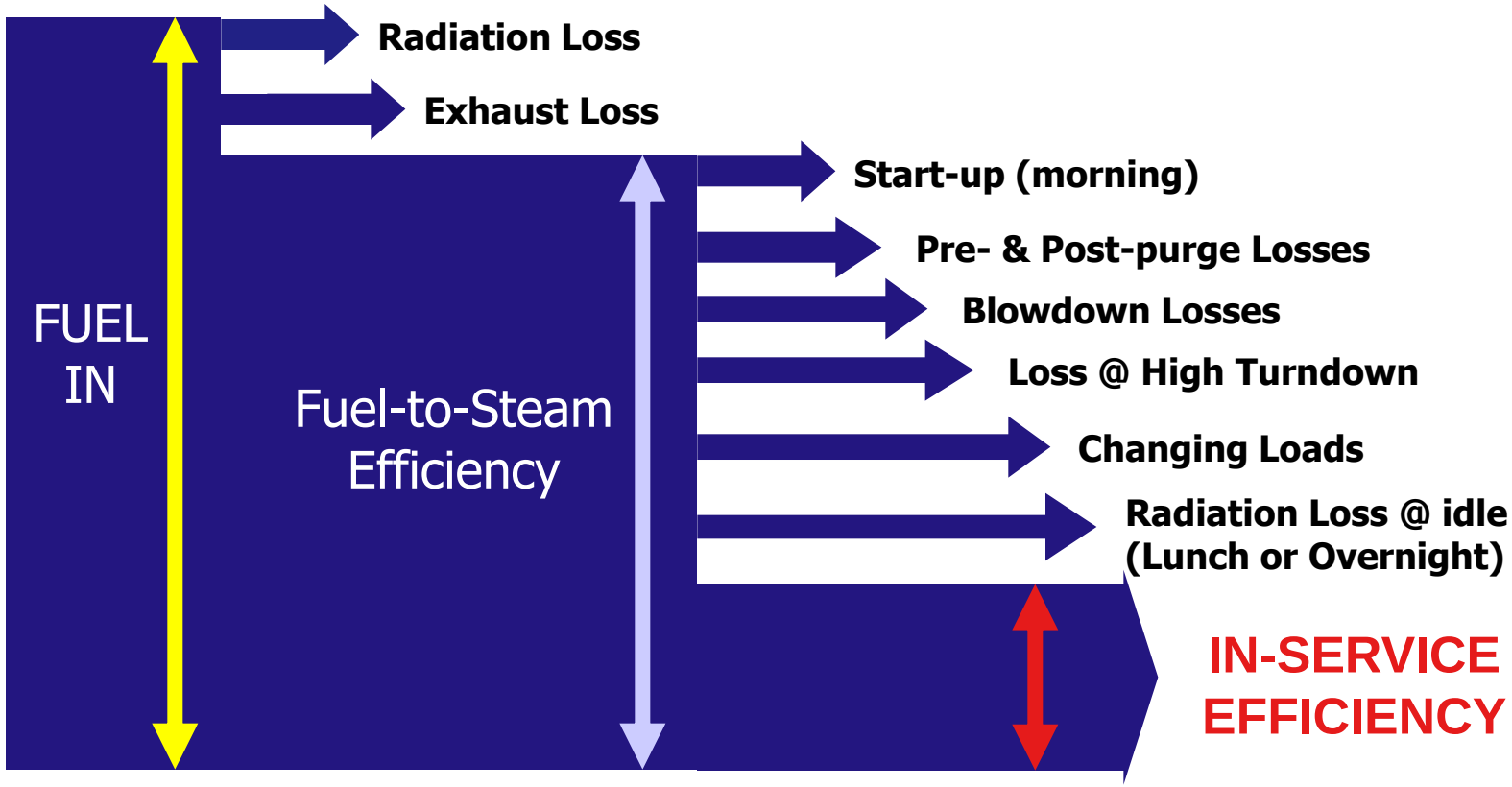
> ***“Currently...boilers...are rated only in terms of steady-state efficiency at full load, which is not a meaningful indicator of relative energy use or operating costs.”***
>
> Inside ASHRAE – BSE Magazine, June 2005

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

First Steps – Benchmarking Performance

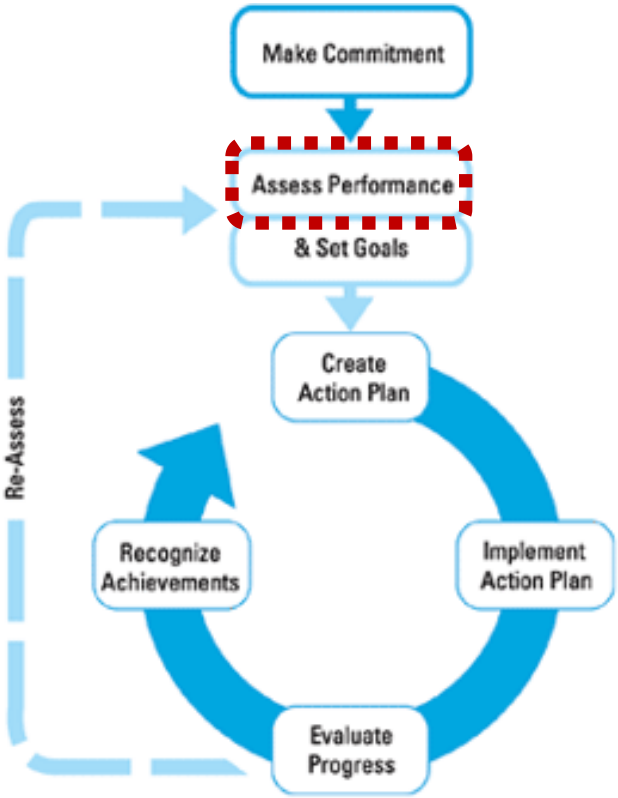
Tracking Energy Losses

- **Evaluate Existing Boiler In-Service Efficiency**



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

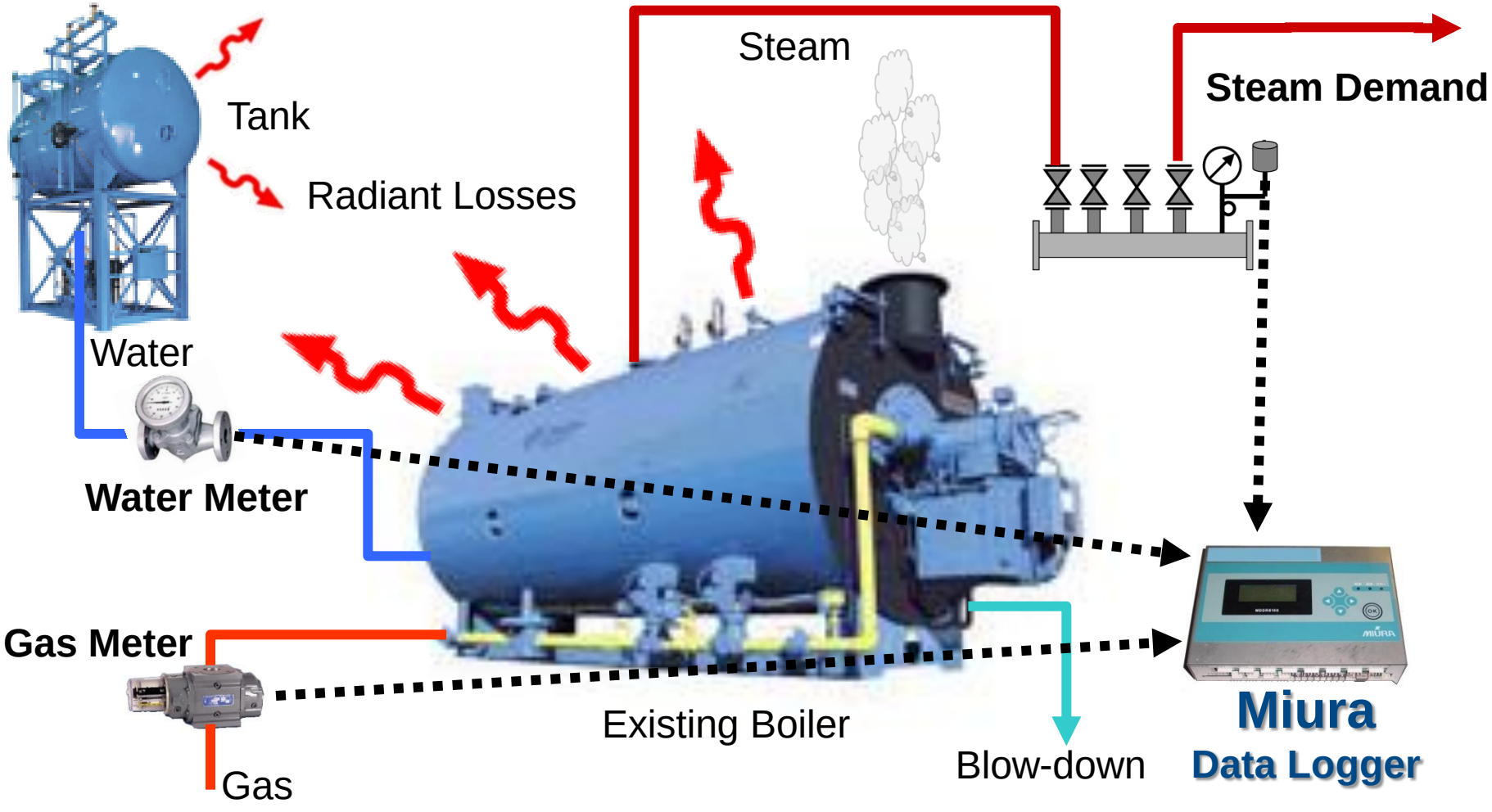
- **Meter existing equipment & collect data on current consumption, including:**
  - Gas & water consumption rates
  - Gas pressure at the meter
  - Gas temperature at the meter
  - Feed-water temperature
  - Steam pressure
  - Blow-down rate
- **Review utilities statements for historical data**
- **Size 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

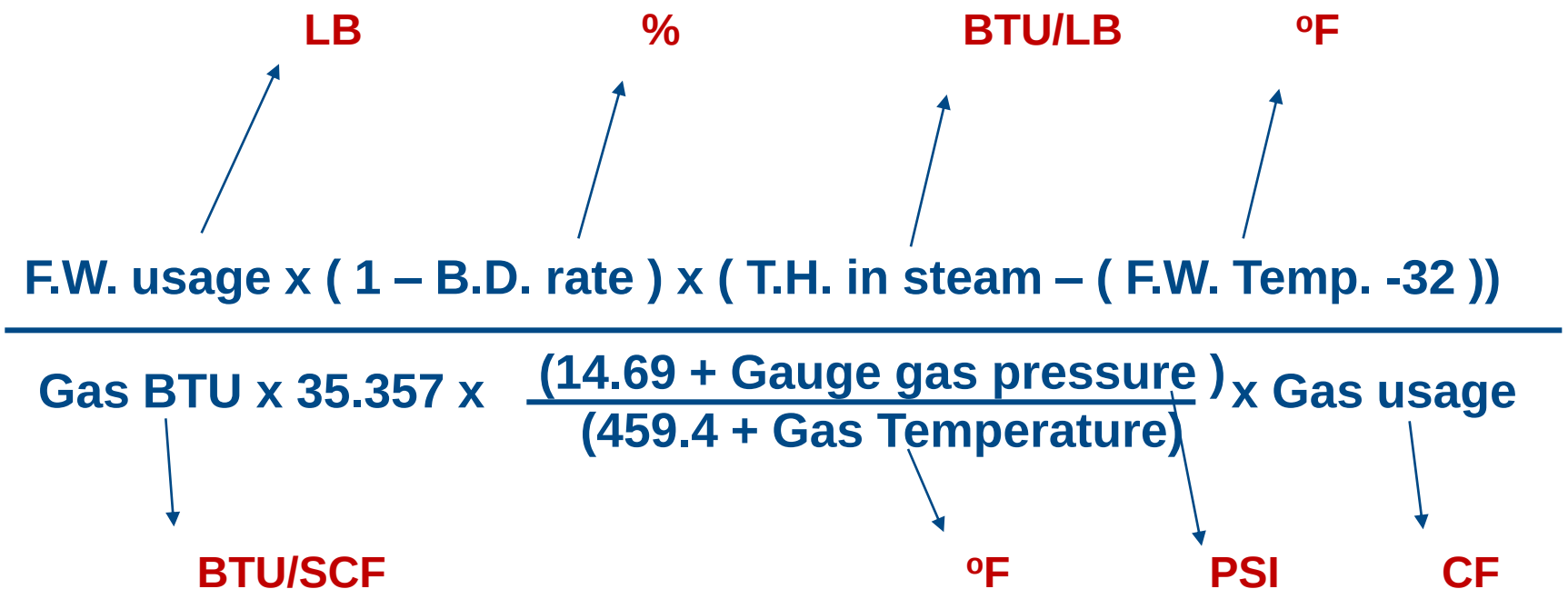
In-Service Efficiency Analysis:
Benchmarking Tools

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



Understanding Boiler Efficiency:
In-Service Efficiency

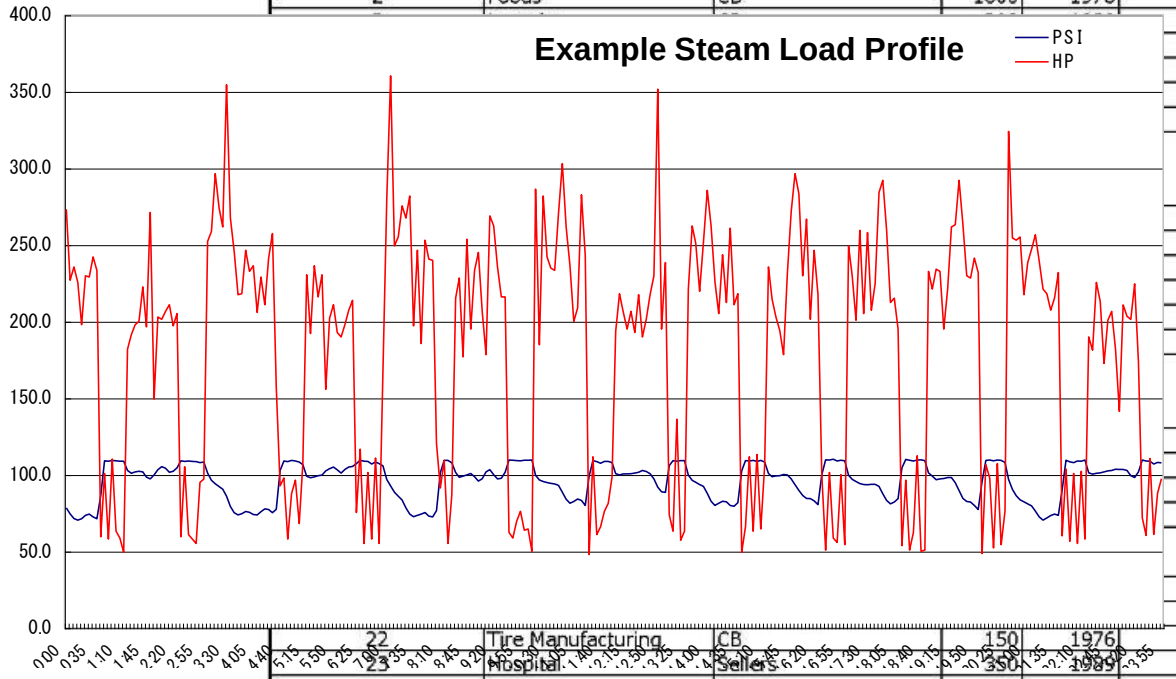
- **Calculating In-Service Efficiency:**



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)



Company	Industry	Manufacture	HP	Year	Ave. Load	ISE
1	Chemical					70.8%
2	Foods	CB	1600	1978	17%	73.9%
					43%	70.6%
					19%	47.7%
					18%	61.1%
					68%	70.3%
					11%	47.6%
					29%	47.7%
					45%	48.4%
					48%	69.2%
					62%	86.2%
					30%	64.8%
					8%	42.9%
					49%	72.2%
					32%	80.3%
					26%	65.7%
					32%	70.0%
					19%	59.6%
					34%	70.7%
					8%	64.4%
					21%	64.9%
					19%	86.1%
					77%	69.0%
					30%	64.0%
22	Tire Manufacturing	CB	150	1976	21%	68.9%
23	Hospital	Seller	350	1989	34%	69.9%
24	Foods	Hurst Hurst	50 50		23%	64.3%
25	Chemical	CB	350		60%	75.9%
	Average:		**365**		**33%**	**66.0%**

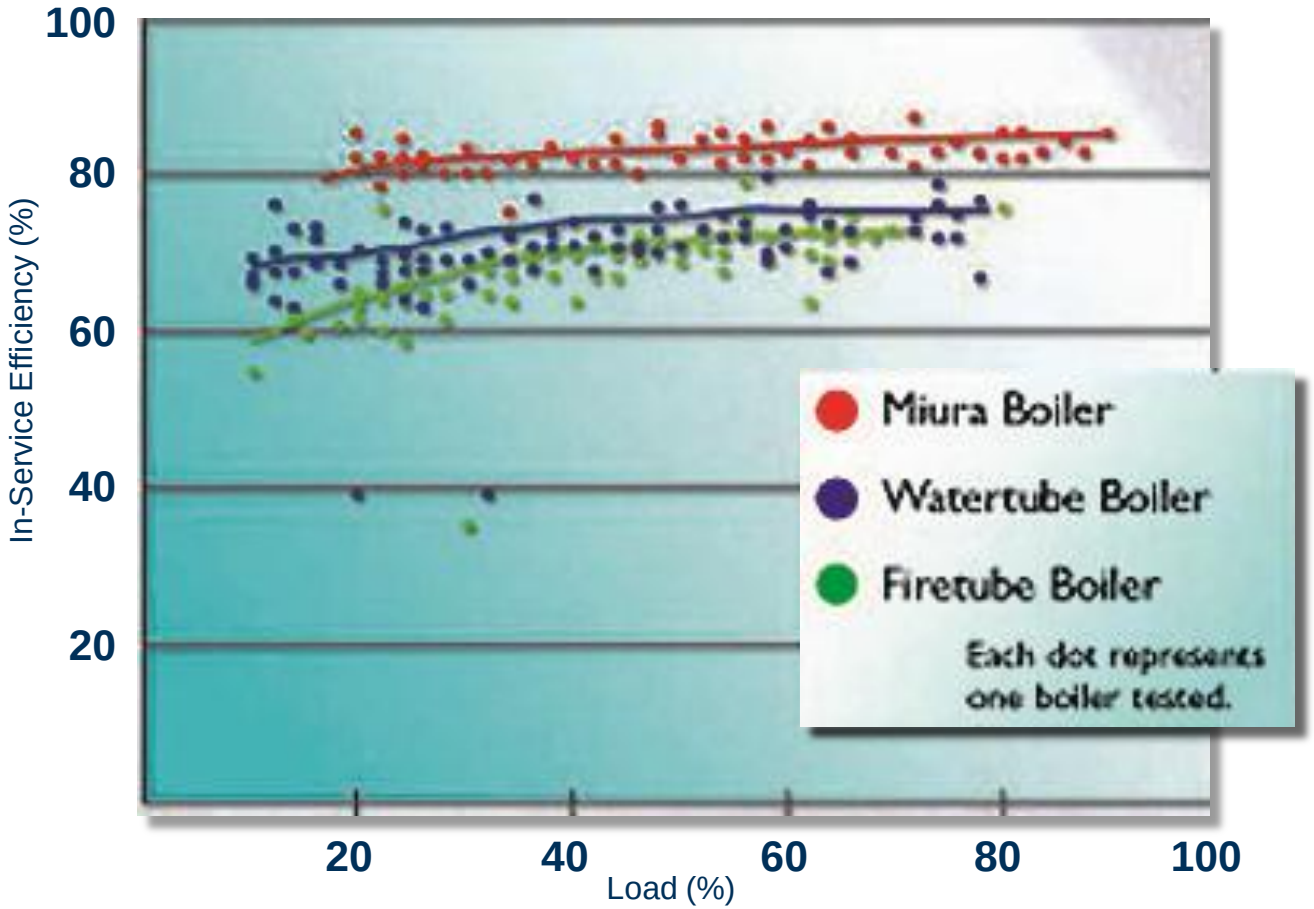
Energy Efficiency – R.O.I.:
Life-cycle Impact

MIURA

- **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_2 Emissions: **630 metric tons CO_2 / yr**
  - Projected Life-cycle Fuel Savings = **+$3.5 million (over 20 yrs)**
  - Projected Life-cycle CO_2 Reduction = **17,500 mtCO_2 (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_2 Costs
- Projected Lifecycle Costs

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

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

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

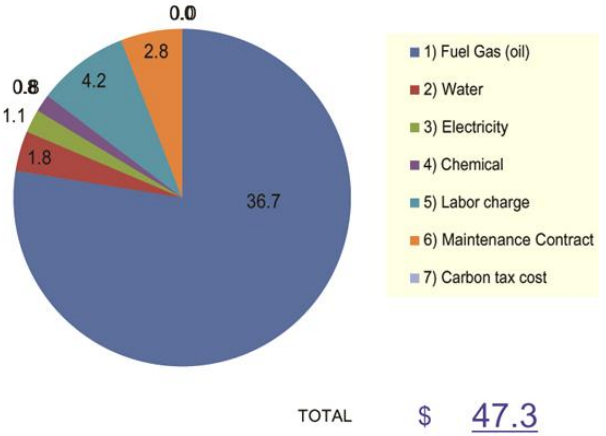
Steam Price per 100 HP

1) Fuel Gas (oil)	36.7	=($/therm)x(3,348,000)/100,000/(ISE)
2) Water	1.8	=($/kgal)x(City water usage)
3) Electricity	1.1	=(C/KWH)x15/100
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)/100000/200
Total=	47.3	

Total price for a year

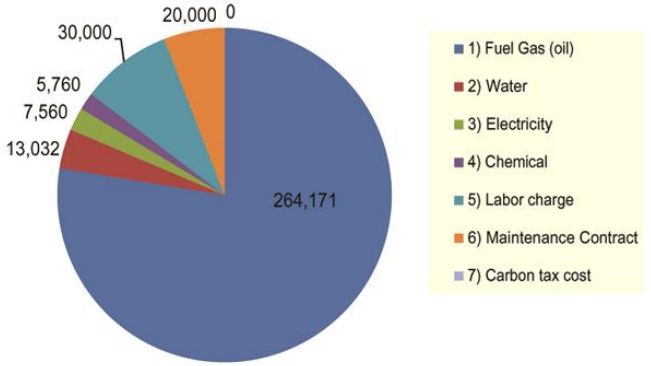
1) Fuel Gas (oil)	264,171	=($/100HP)/(100HP*boilers*average load*hour
2) Water	13,032	=($/100HP)/(100HP*boilers*average load*hour
3) Electricity	7,560	=($/100HP)/(100HP*boilers*average load*hour
4) Chemical	5,760	=($/100HP)/(100HP*boilers*average load*hour
5) Labor charge	30,000	=($/100HP)/(100HP*boilers*average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

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**

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

- **Program website: www.thinksmartthinkgreen.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)

- **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

Questions:

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