U.S. Department of Energy
Energy Efficiency and Renewable Energy

Mechanical Systems - Enhancing Technologies

High Performance Heating Systems

By
Peter Rimassa - AERCO International

Rebuild America
U.S. Dept. of Energy

HEAT YOU CAN BANK ON

Questions???

- Who Like to Save Money???
- Who Believes Simple is Better???
- Who Does Not Like to Save Money???
- Who Believes Complicated is Better???

Chelmsford High School - 33% Saving a Year!

After 25 years the existing cast iron boilers were replaced with a 10 million BTU/hr. high efficiency boiler plant. The boiler plant has a total input in five (5) independent units.

After a complete year of operation, the system reduced fuel consumption 33% based on the owners figures.

Marblehead High School - 30% Saving a Year

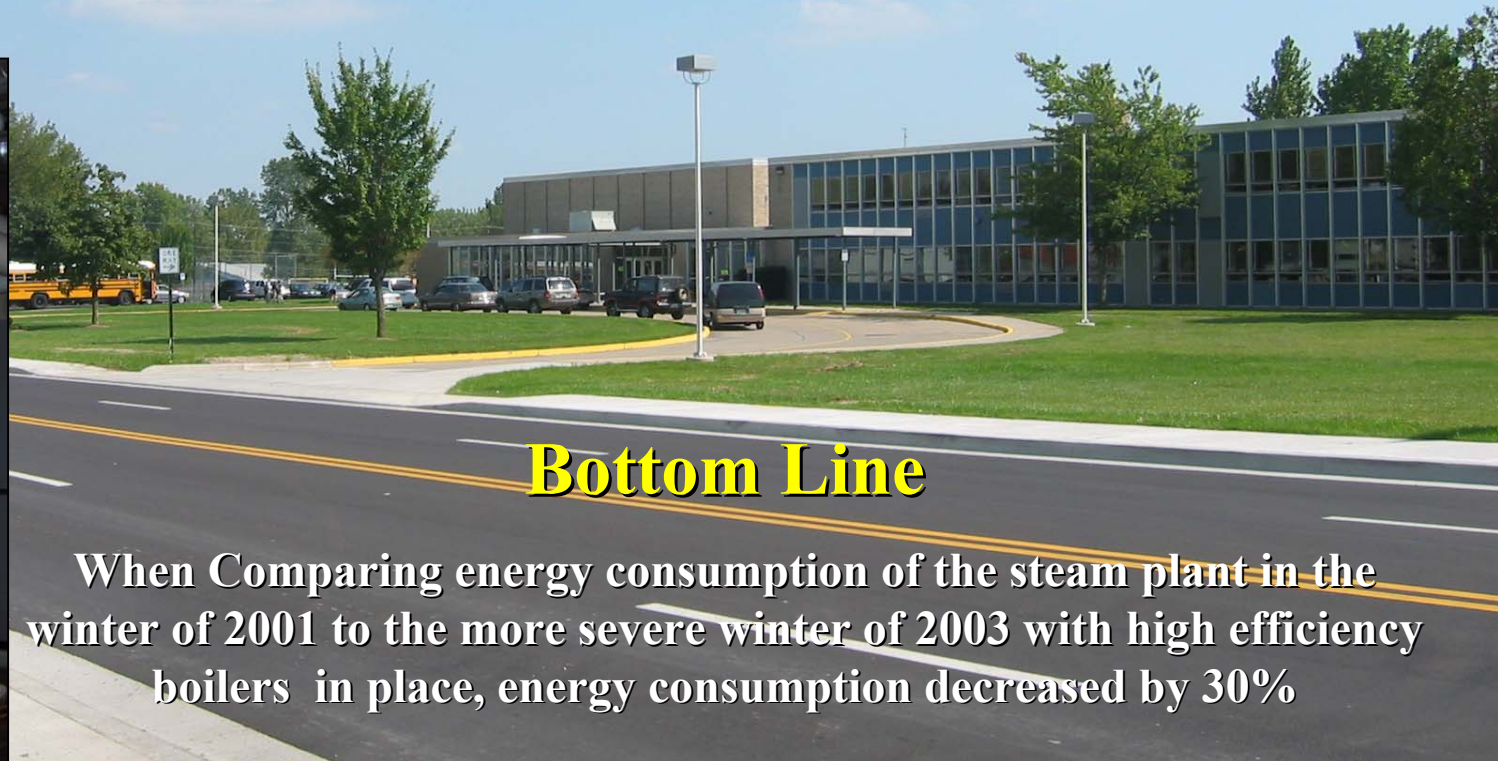
This high school was designed around a 40°F temperature differential to take advantage of the condensing operation of high efficiency boilers.

Burning only and exactly the fuel needed, the high efficiency boiler plant is projected to save 30% or more of the energy used with a conventional heating boiler plant.

Geyer Middle School, IN

Geyer Simplifies their heating system by eliminating two (2) 42 year old large steam boilers and converted the system to hot water and installed high efficiency hot water boilers

30% Savings per year now available for educating kids!!



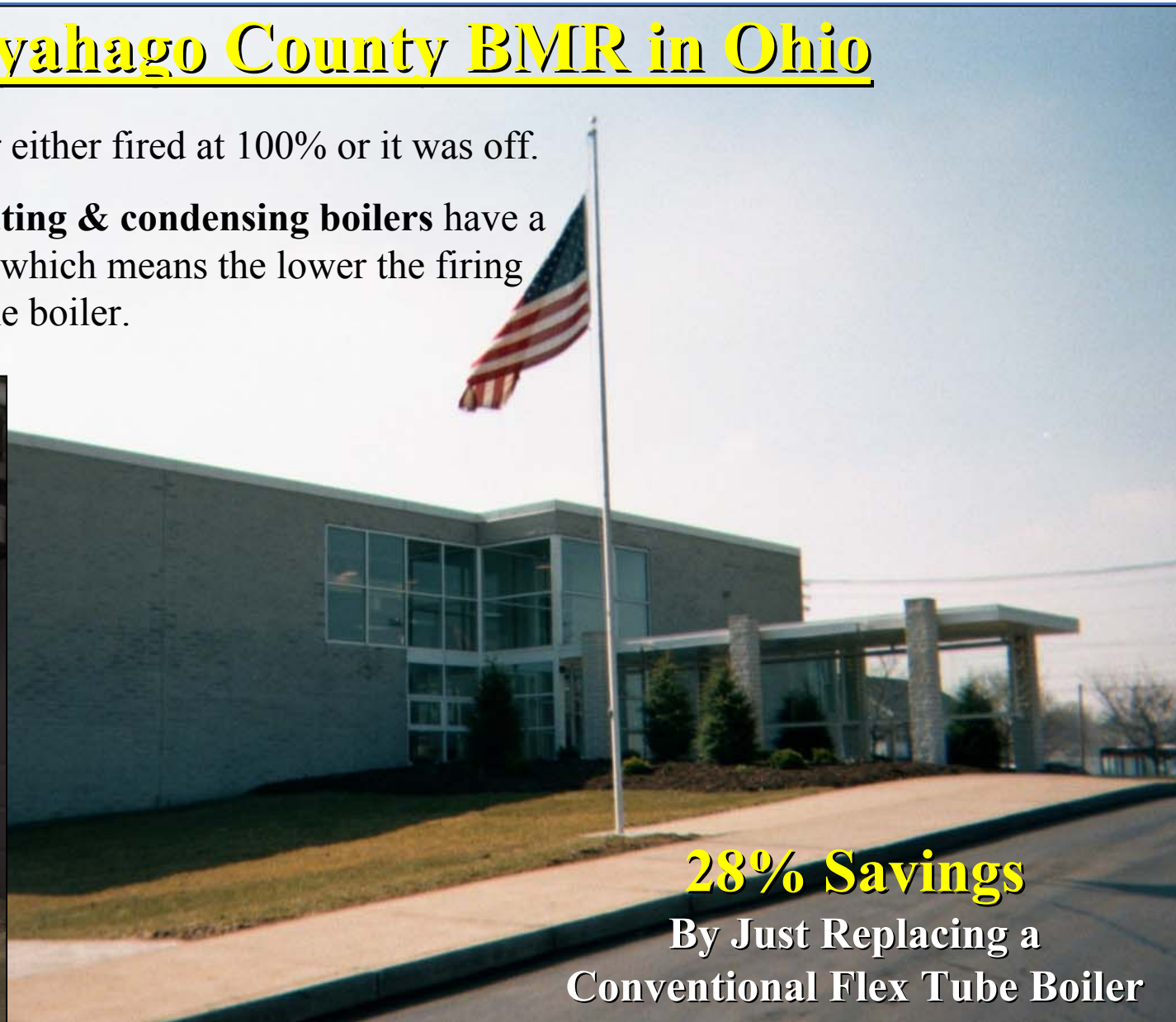
Bottom Line

When Comparing energy consumption of the steam plant in the winter of 2001 to the more severe winter of 2003 with high efficiency boilers in place, energy consumption decreased by 30%

Cuyahago County BMR in Ohio

The Old Flex tube boiler either fired at 100% or it was off.

High efficiency modulating & condensing boilers have a inverse efficiency curve which means the lower the firing rate the more efficient the boiler.



28% Savings

By Just Replacing a Conventional Flex Tube Boiler

Efficiency Definitions

Thermal Efficiency

Test of Useful Output of Boiler Compared to Total Fuel Used

"Output/Input" x 100

Seasonal Efficiency

Boiler Effectiveness Over Entire Heating Season (*Partial Loads*)

Total Seasonal Heating BTU/Total Seasonal Fuel Usage

System Efficiency

Useful Energy Delivered to Rooms Compared to Total Fuel Used

Maximum Fuel Savings

What is Considered a High Efficiency Boiler???

Conventional Efficiency: 80 - 83%

Mid Efficiency: 84 - 88%

High Efficiency: 89% and up (condensing)

Condensing

Captures *"latent heat"* for +90 + % efficiency by installing product with incoming water temperatures significantly below 140°F (warranty coverage)

What defines condensing boilers?

Condensing

The 'regain' of energy that occurs when water vapor found in flue gas changes state (condenses), becoming a liquid.

1 pound of condensate = 970 BTUs

When condensing occurs within the heat exchanger, the additional energy (heat) is transferred to the boiler water.

Why Condensing Occurs

When flue gas drops below its dewpoint ~ **135°F** condensing occurs. Cool water surrounding the heat exchanger "cools" flue gases within.

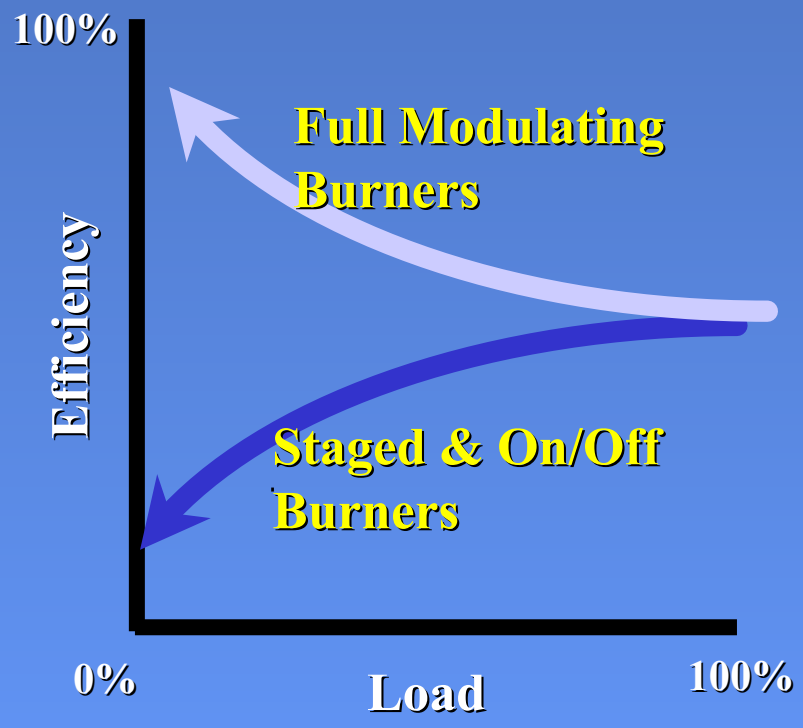
In general, you cannot achieve thermal efficiencies in excess of 87% without some condensing occurring.

Why Modulate the Fuel/Air Input?

- Turndown Increases Efficiency
  Eliminates *Cycling* Losses
  No Energy Waste

- Match Energy Input
  to Actual Heating Load
  No Energy Waste

- Precise Temp Control at All Loads
  Maximize System Efficiency
  & Simplify Building Controls



Thermal Efficiency Rating

BTU/hr = 500 x Delta T x GPM

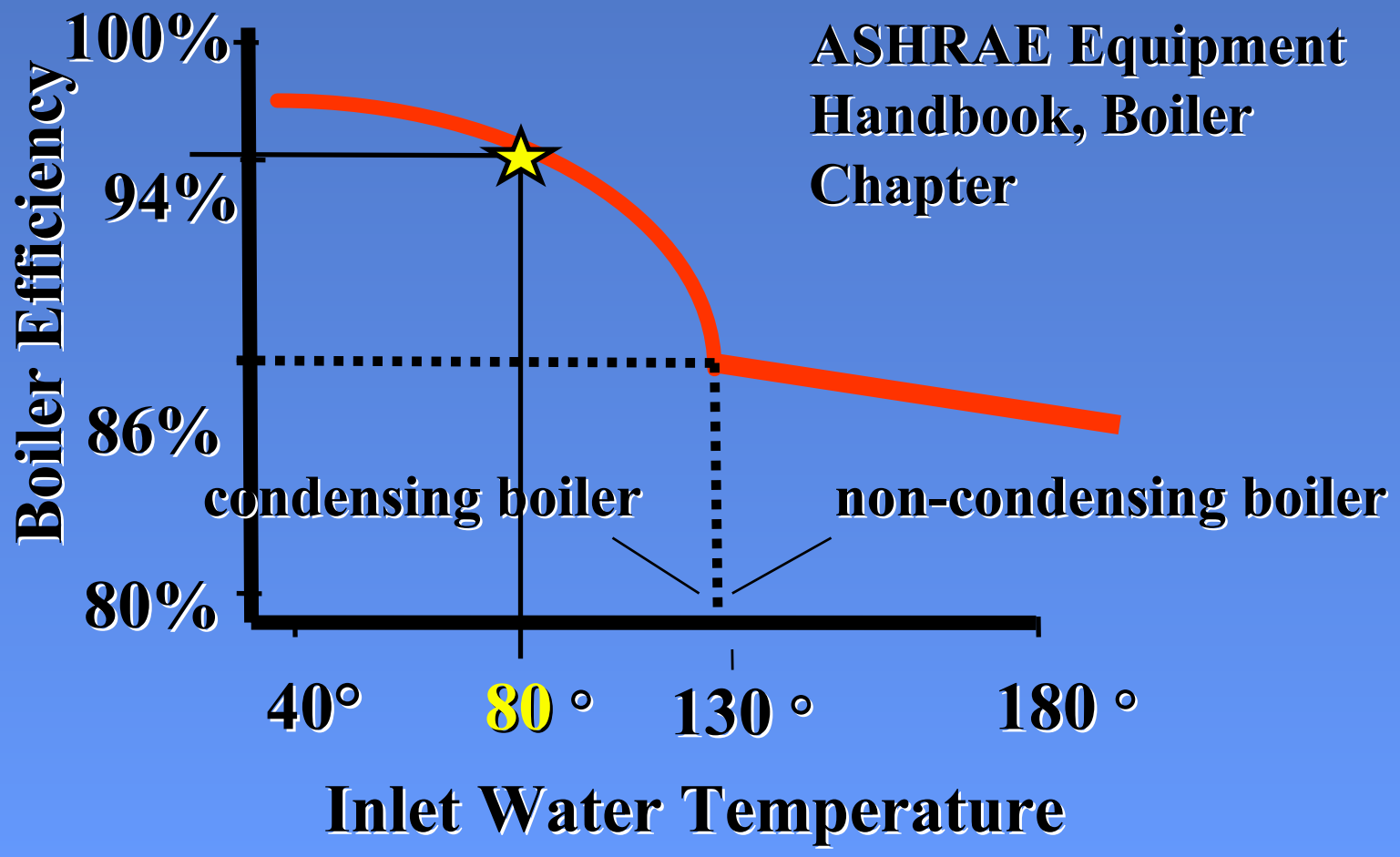
Thermal Efficiency Measurement: **(Energy out/Energy in) x 100**

But…

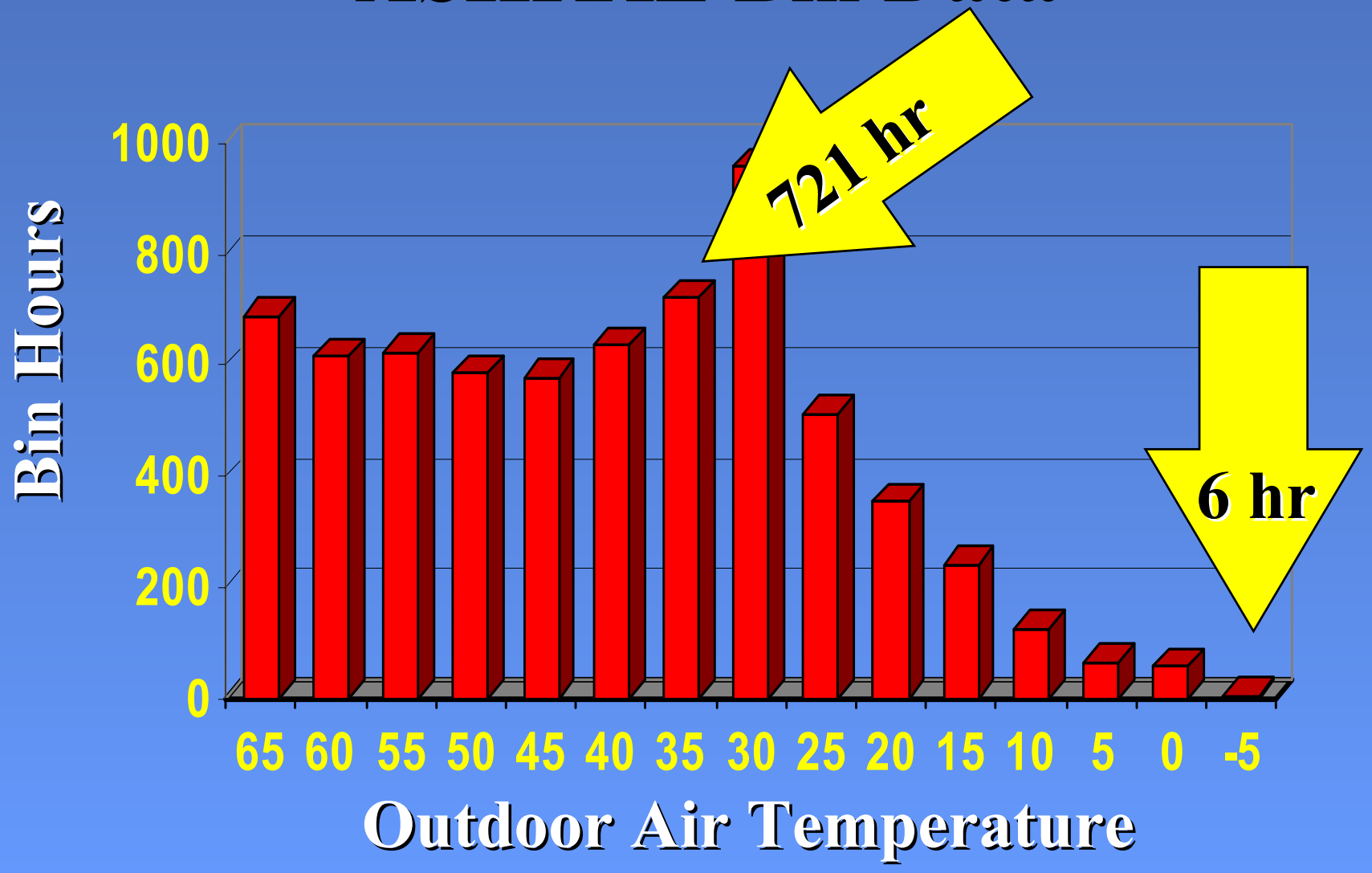
Test Conditions Require: **80°F inlet water temperature**
180°F outlet water temperature
100% Firing Rate (full capacity)
30-minute test period after "full soak"

This is NOT representative of typical heating applications!

Inlet Water Temp Effect on Boiler Efficiency



ASHRAE Bin Data



Assume Full Plant Capacity on Coldest Day

2000 MBH load at -5° F

2000MBH x 6 hrs. = 12,000,000 BTUs

That's 120 therms @ $0.50/therm = ***$60***

Assume Partial Loads on Other Days

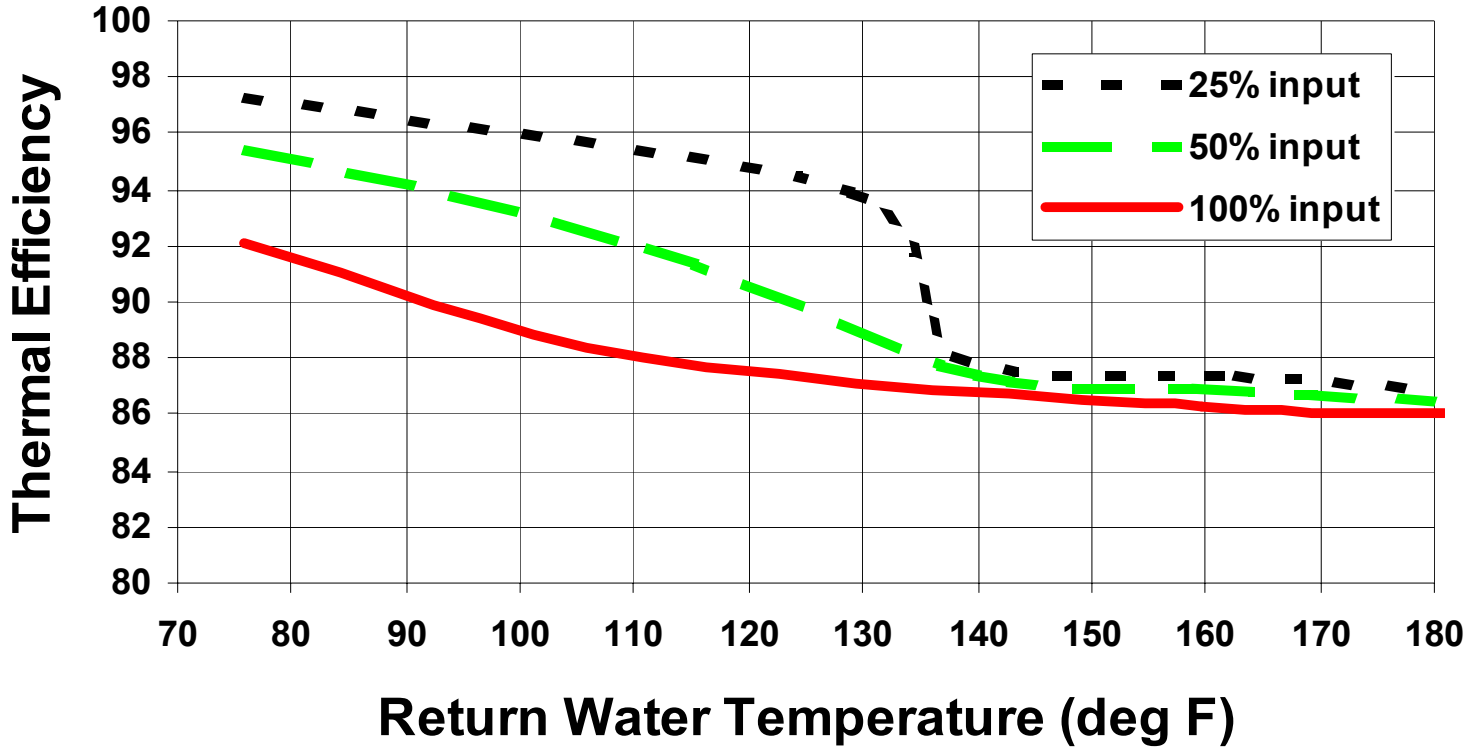
800 MBH load at 30° F

800MBH x 721 hrs. = 576,800,000 BTUs

That's 5768 therms @ $0.50/therm = ***$2884***

When should the boiler operate most efficiently?

Full and Part Load Efficiencies



How The Industry Modulates It's Firing Rate

Examples:

Linkages from a Motorized gas Valve to a Damper on the Exhaust

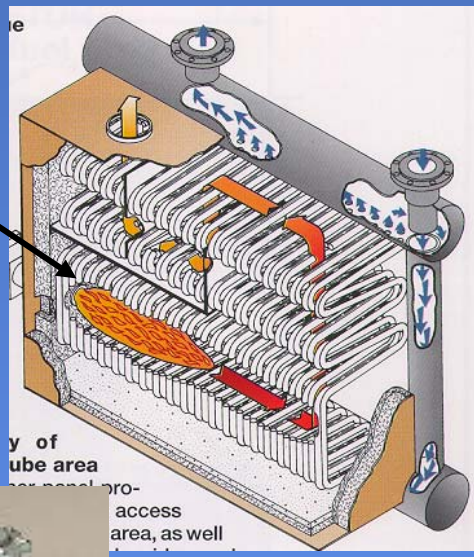
or

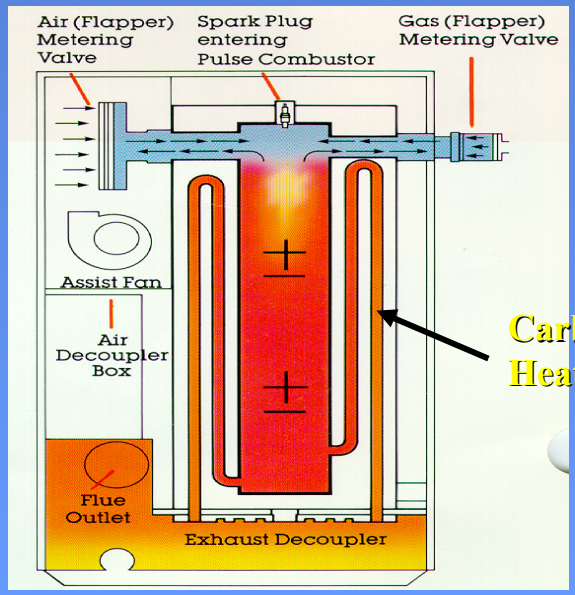
Single Shafted Motorized Air/Fuel Valve

Material of Construction

Stainless Steel
Heat Exchanger

Carbon Steel Water
Tube Heat Exchanger



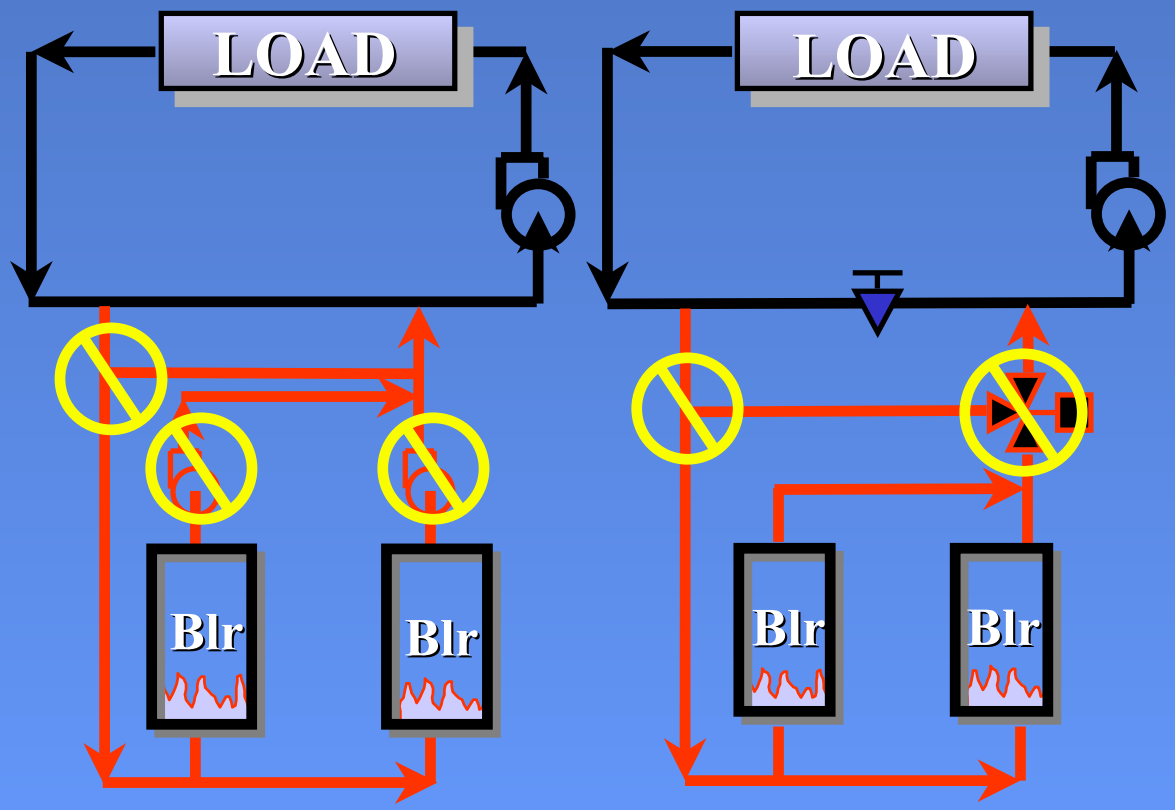


Carbon/Stainless Steel
Heat Exchanger

Copper-Fin Water
Tube Heat Exchanger

Conventional Boiler Piping

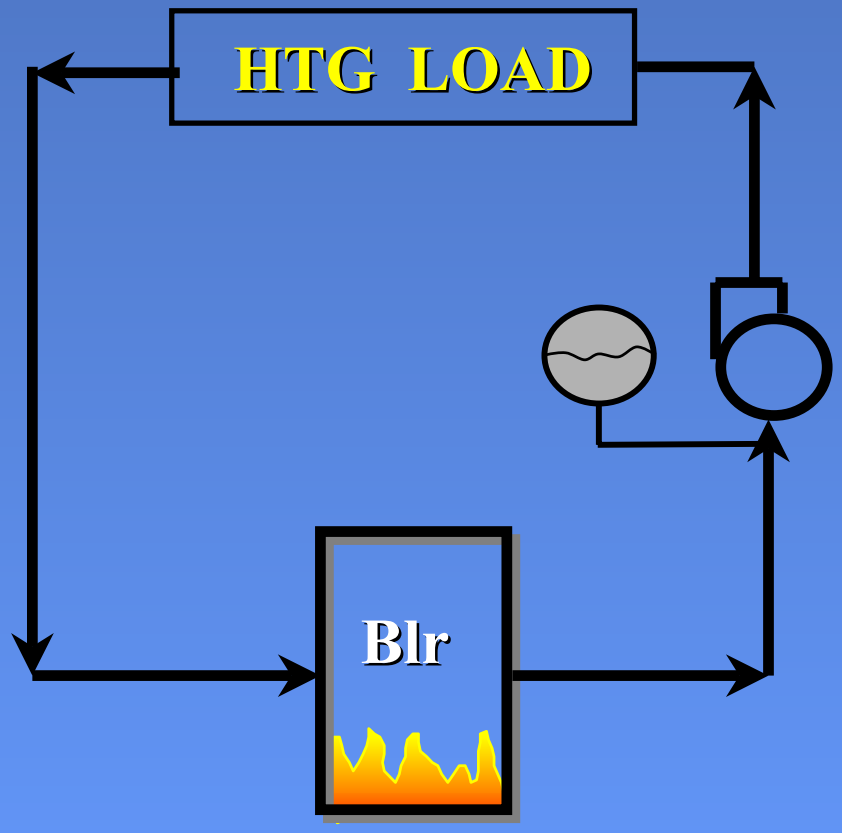
Primary/Secondary Pumping or Control Valve



Protect boiler:

- condensing
- thermal shock
- reduce standby losses

High Performance Heating System



Eliminates:

- Primary/Secondary Pumping & Controls
- 2, 3 or 4 - Way Valves

- Maximize System Efficiency (at any water temperature)
- Maximize Boiler Efficiency
- Reduced Installation Cost

Maximizing Heating System Efficiencies

- **Increase Temperature Differential from 20°F to 40°F (or more)**

  Result: Smaller pipe size

  Lower pump horse power (cost and consumption)

  Improved /operation of valves & terminal units means better control over room temperatures

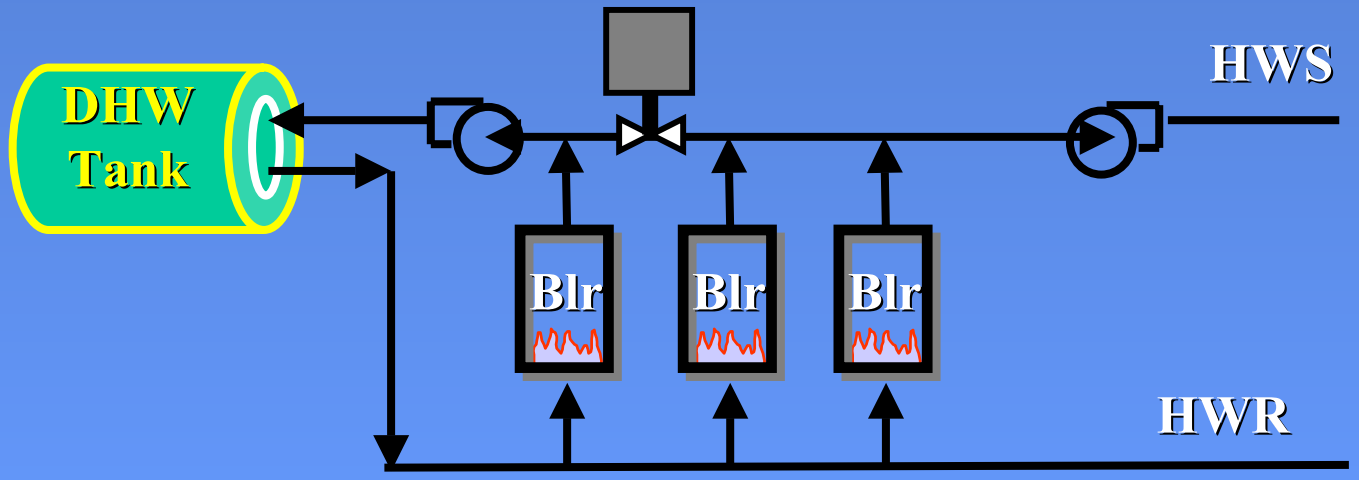
  Lower return water temps to condensing boiler means higher boiler efficiency

- **Variable Speed Pumps**

  Result: Energy Efficient, Better room temperature control

Space Heating and Domestic Hot Water:
DHW Tank w/ Coil

- 2 Boilers Dedicated to Space Heating
- 1 Boiler Switches between DHW and Space Heating
- Back up for DHW Boiler



Water Loop Heat Pump - Supplemental Heat Requirements

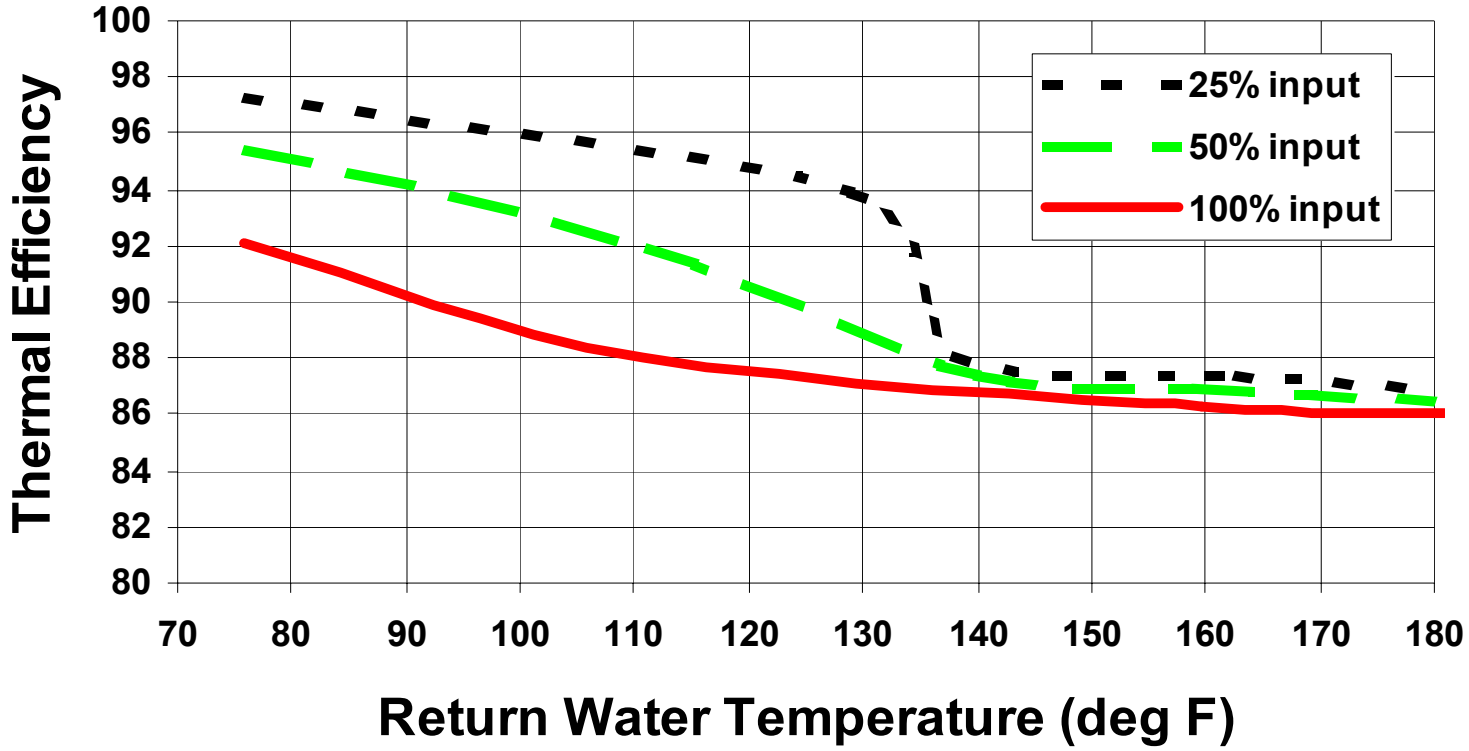
Ideally, amount of energy discharged (cooling mode) by some heat pumps is equal to amount of energy absorbed (heating mode) by balance of heat pumps - no supplemental heat required.

Heat required when loop temp drops below ~60F

Boiler brings loop temperature to ~70-75F

Note: Boilers must accommodate cool circulating water temps!

Full and Part Load Efficiencies



How Can I Achieve 90%+ Average Seasonal Efficiency?

- Boiler must condense water vapor in flue gas under operating conditions
- Must reduce cycling losses by modulating boiler input at partial load conditions
- Must design the system to take advantage of boiler and controls technology

More Questions for the Industry?

- Does the boiler modulate? How much? How?
- Is the boiler a condensing boiler?
- What is the boiler constructed of?
- How diverse is the boiler's venting capabilities?
- Can I take advantage of the boiler capabilities in my overall heating system?

Thank You For Attending This

Program