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Optimize Thermal Energy Management with Modular *On-Demand* Boilers

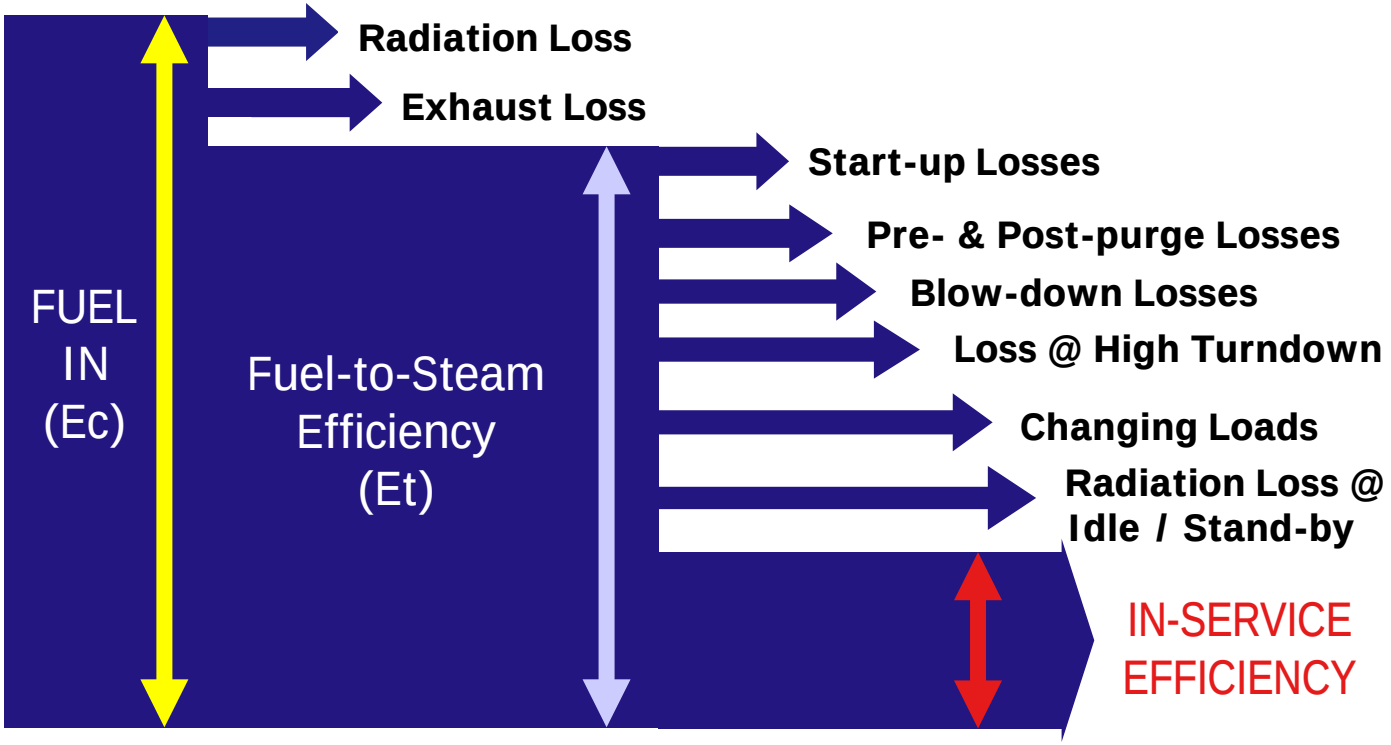
Jason Smith, LEED A.P.

Boiler Efficiency Metrics

- Thermal Energy Optimization "Drivers":
  - Aged / obsolete boiler inventory
  - Thermal energy management constrained by aged / obsolete boiler design limitations
  - Insufficient detail in current boiler efficiency metrics
  - Unequal focus on energy production vs. efficiency
  - Boiler performance–tolerance dynamic is upside-down
  - Boilers = "front line" of carbon footprint reduction
  - Boilers = significant opportunity for neutral / "negative" cost carbon abatement strategy via improved energy efficiency

In-Service Efficiency

- Boiler *Operating* Efficiency:
  - Understanding operating efficiency = accounting for energy losses
  - Assess all contributing losses during typical boiler operating cycle



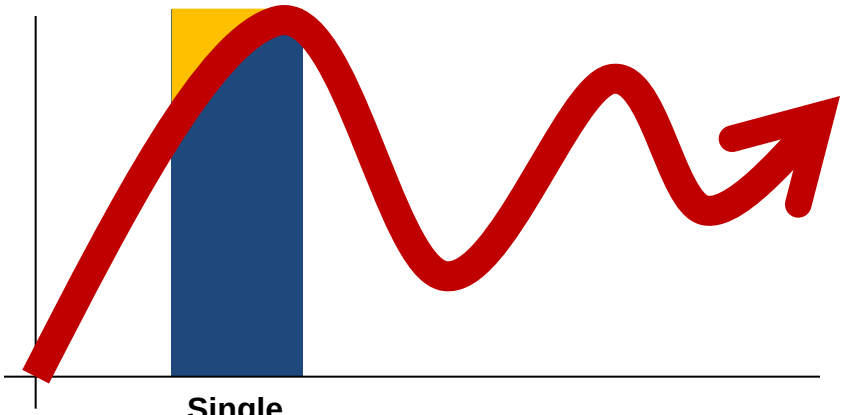
Boiler Efficiency Metrics

- ASHRAE 155-P:
  - Covers steam & hot water boilers (individual, multiple & modular) ≥ 300,000 Btu/hr capacity
  - Expands scope of efficiency calculation beyond E_t
  - Captures Annual Seasonal Efficiency by accounting for all boiler operating states, including:
    - Off & isolated
    - Off with through-flow from active boilers
    - Operating at steady-state high fire
    - Modulating
    - Operating at steady-state low fire
    - Cycling
    - Idling

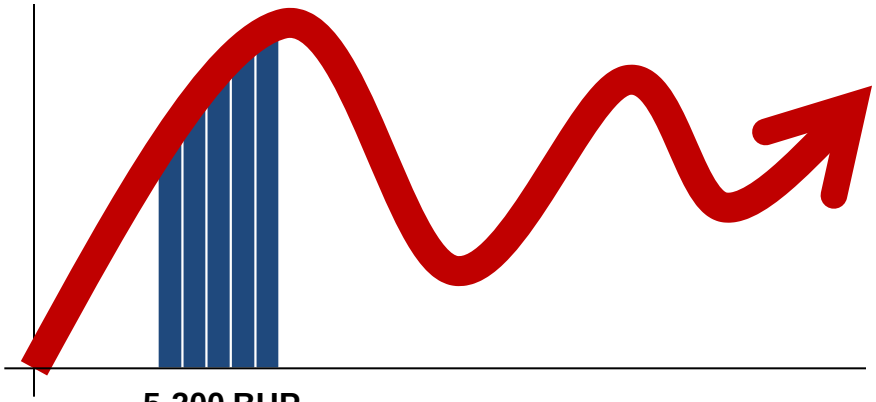
Increasing ASE

Managing Load Variability

- Conventional approach:
  - Over-commitment of capacity results in over-shooting demand with significant energy losses at load swings
- Modular approach:
  - Sub-dividing output & sequentially staging multiple modular boilers enhances energy management via precise load matching



Single
1000 BHP Boiler



5-200 BHP
Modular Boilers

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Modularity

- Modular boiler array:
  - Modulation of output to meet load demand occurs at the scale of the boiler rather than simply the burner for enhanced performance

200HP TDR=1:3 Step-Fire

200HP TDR=1:3 Step-Fire

200HP TDR=1:3 Step-Fire

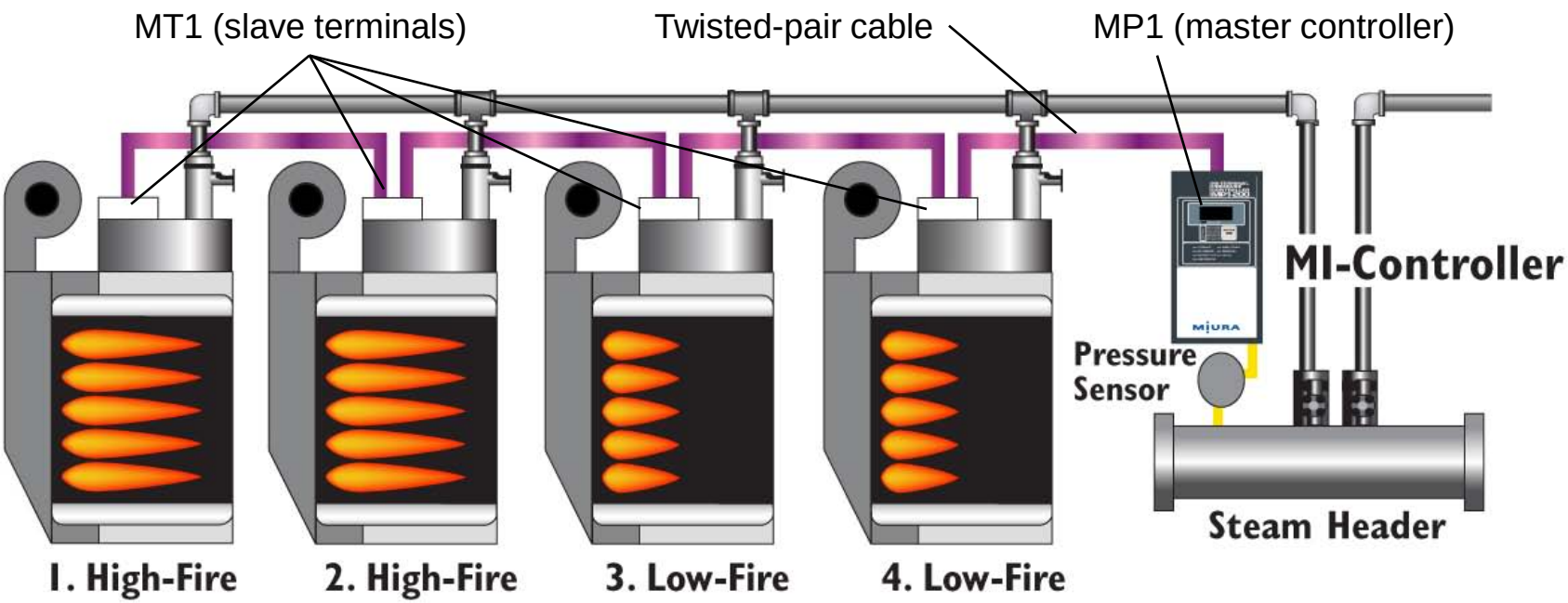
200HP TDR=1:3 Step-Fire

200HP TDR=1:3 Step-Fire

1000 BHP boiler system
TDR=1:15
(15 steps of modulation)

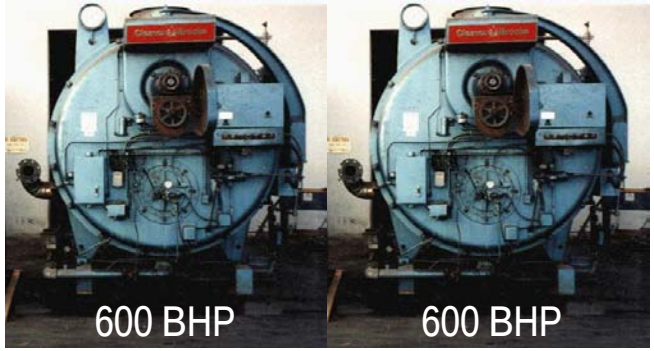
Modularity

- Modular boiler array:
  - Multiple modular boilers make-up large capacity, high turn-down boiler system with enhanced load management

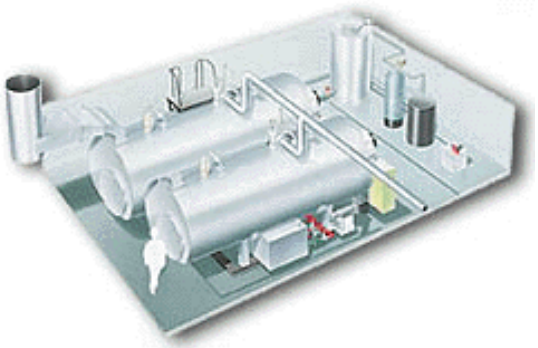


Integrated Back-up (N+1)

- Conventional Approach:



Primary N+1

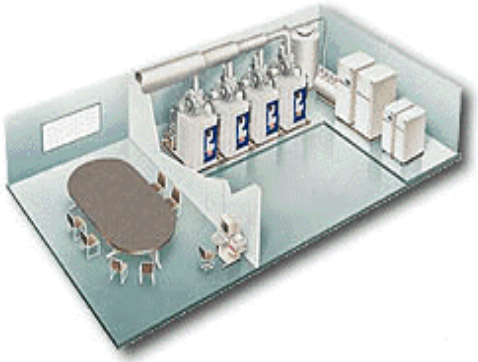


Total Capacity = 1,200 BHP

- Modular Approach:

200 BHP 200 BHP 200 BHP 200 BHP

Primary N+1



Total Capacity = 800 BHP

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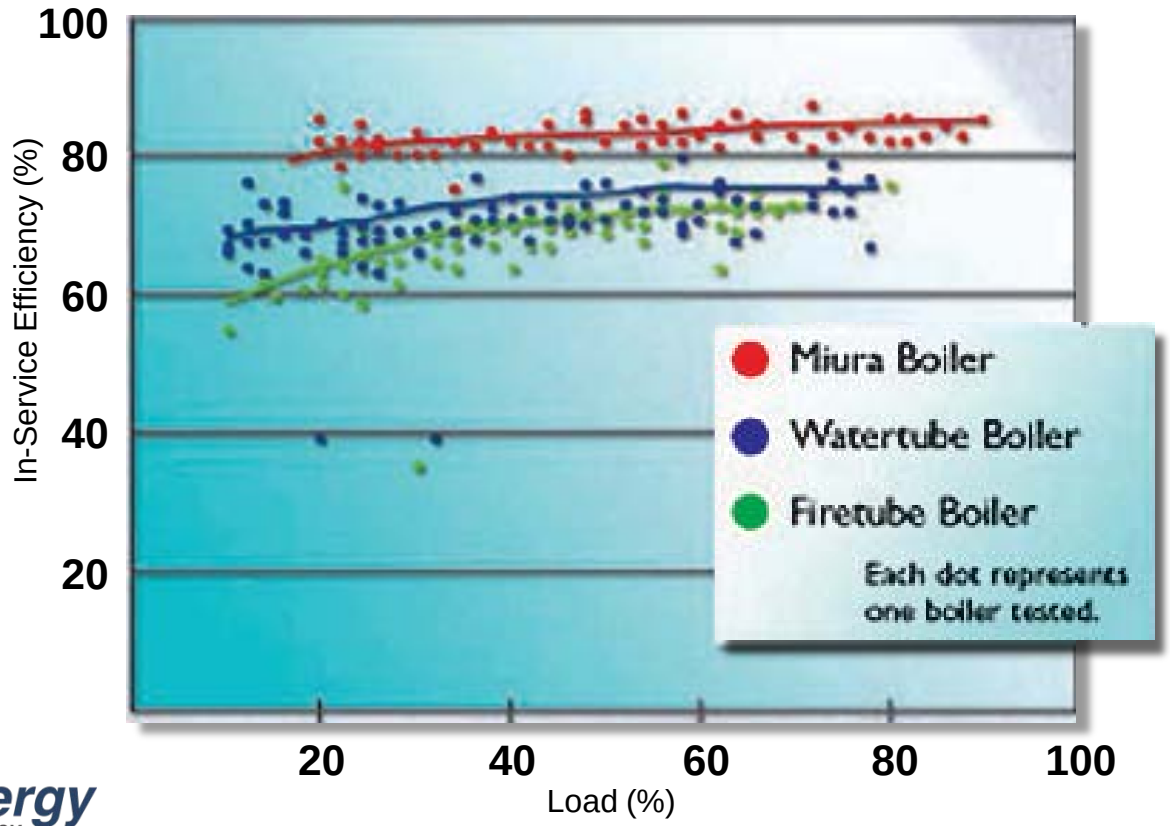
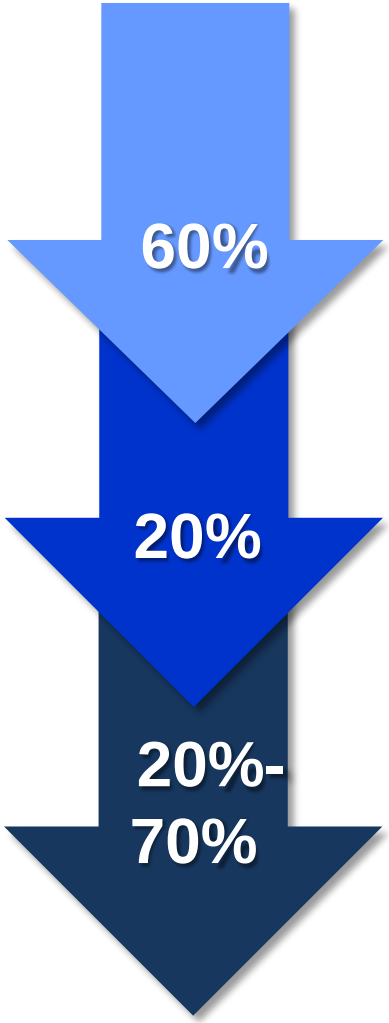
System Performance

- Plotting Performance:
  - Modular, *on-demand* boilers show overall better system efficiency with consistent performance independent of load requirements



Reduced Boiler "Footprint"

- Physical Footprint:
  - Reduced space requirements
  - Reduced energy plant construction costs
  - Reduced boiler "hardware"
- Energy Footprint:
  - Reduced energy consumption / wasted energy
  - Reduced explosive energy
  - Reduced embodied energy
- Environmental Footprint
  - Reduced consumption of natural resources
  - Reduced NOx emissions
  - Reduced carbon footprint



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Case Study

- University of Arkansas:
  - Upgrade: Replaced (3) 600 BHP Firetube Boilers with (6) 300 BHP Modular On-Demand Boilers
  - "Peaking" Plant (Summer Load)
  - Placed into Service: 2008
  - Reported Energy Savings: ~ $280,000 / yr
  - Reported Reduced CO_2 Emissions: ~ 1.2 Million Lbs CO_2 / yr

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Questions / Contact:

Jason Smith, LEED A.P.

(770) 916-1695 Office

(678) 939-7630 Cell

jason.smith@miuraboiler.com

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