# High Efficiency Boilers

*Why?*

*How?*

presented for

**Association of Energy Engineers**

**Feb. 21, 2008**

*If you ask the wrong question, of course, you get the wrong answer. We find in design it's much more important and difficult to ask the right question. Once you do that, the right answer becomes obvious.*

Amory Lovins

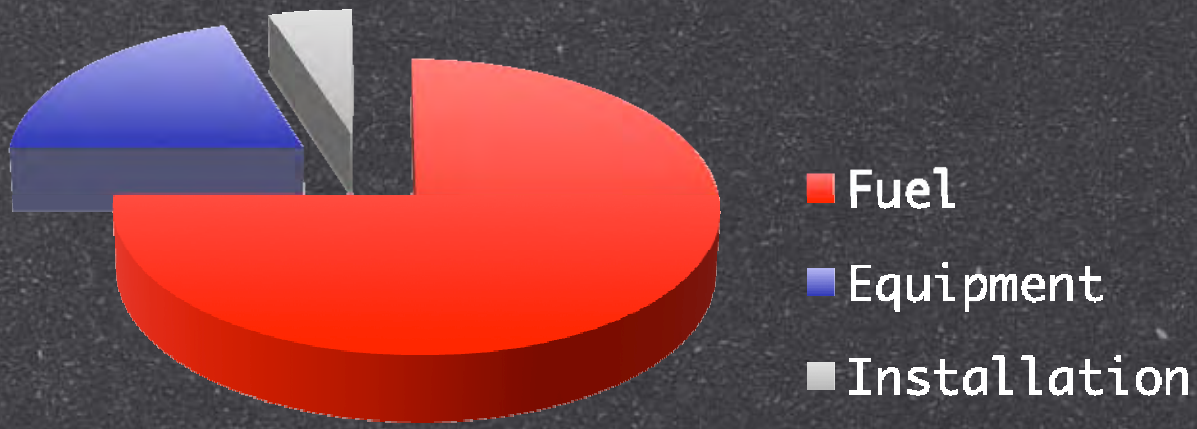
# The Questions

- Why care about efficiency?
- Which efficiency matters?
- How can boilers get higher efficiency?
- What is extra cost ? Is it worth it?
- How to reduce total heating cost?

# Why Care About Boiler Efficiency?

- Buildings use 39% of energy (gas, electric, other) in the U.S.
- Certain efficiency levels may be required
- The major cost of heating is the fuel cost

# Total Heating Costs




- Over a 5 year period, fuel costs are the major cost of a heating plant operation

# Which Efficiency Matters?

- Thermal OR Seasonal
- Peak OR Part Load

# Thermal & Seasonal Efficiencies

- **Thermal Efficiency**
  - One point in time
  - At a given % fire rate
  - At a given Return Water Temperature
- **Seasonal Efficiency**
  - Weighted average of operating efficiencies
  - Takes into consideration the efficiency at part load conditions

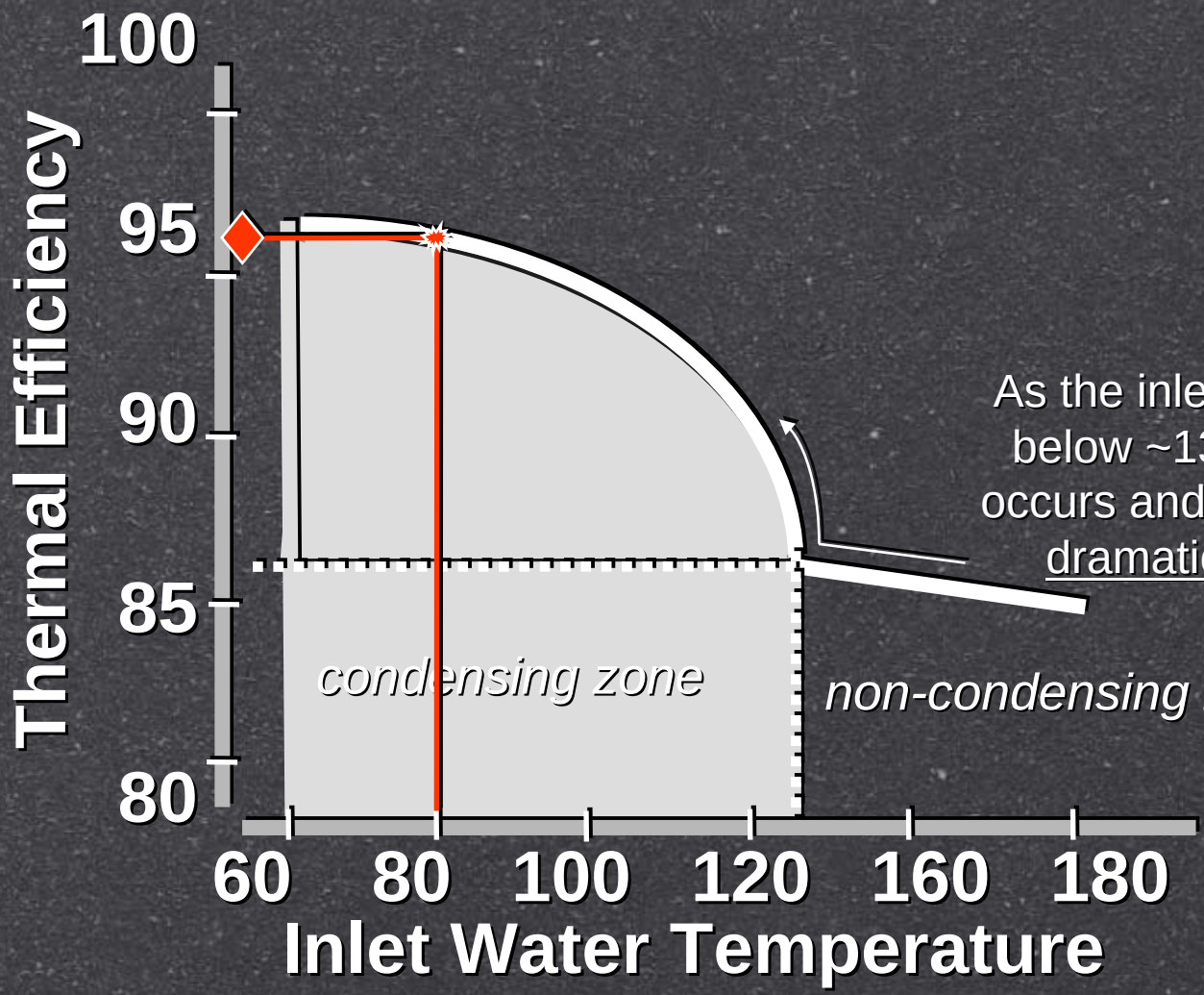
# Part Load Is the Focus

- Most boiler firing is at 25% to 50%
- What is boiler efficiency at part load?

# How Do Condensing Boilers Function to Get Higher Efficiency?

- Condense water vapor from vent gas
- Continuously vary energy input to match load

# Inlet Water Temp Effect on Boiler Efficiency

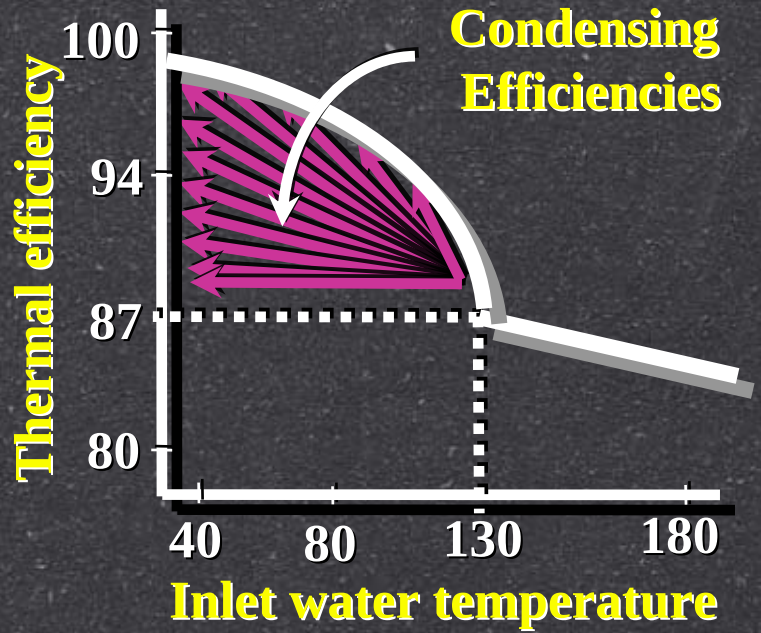


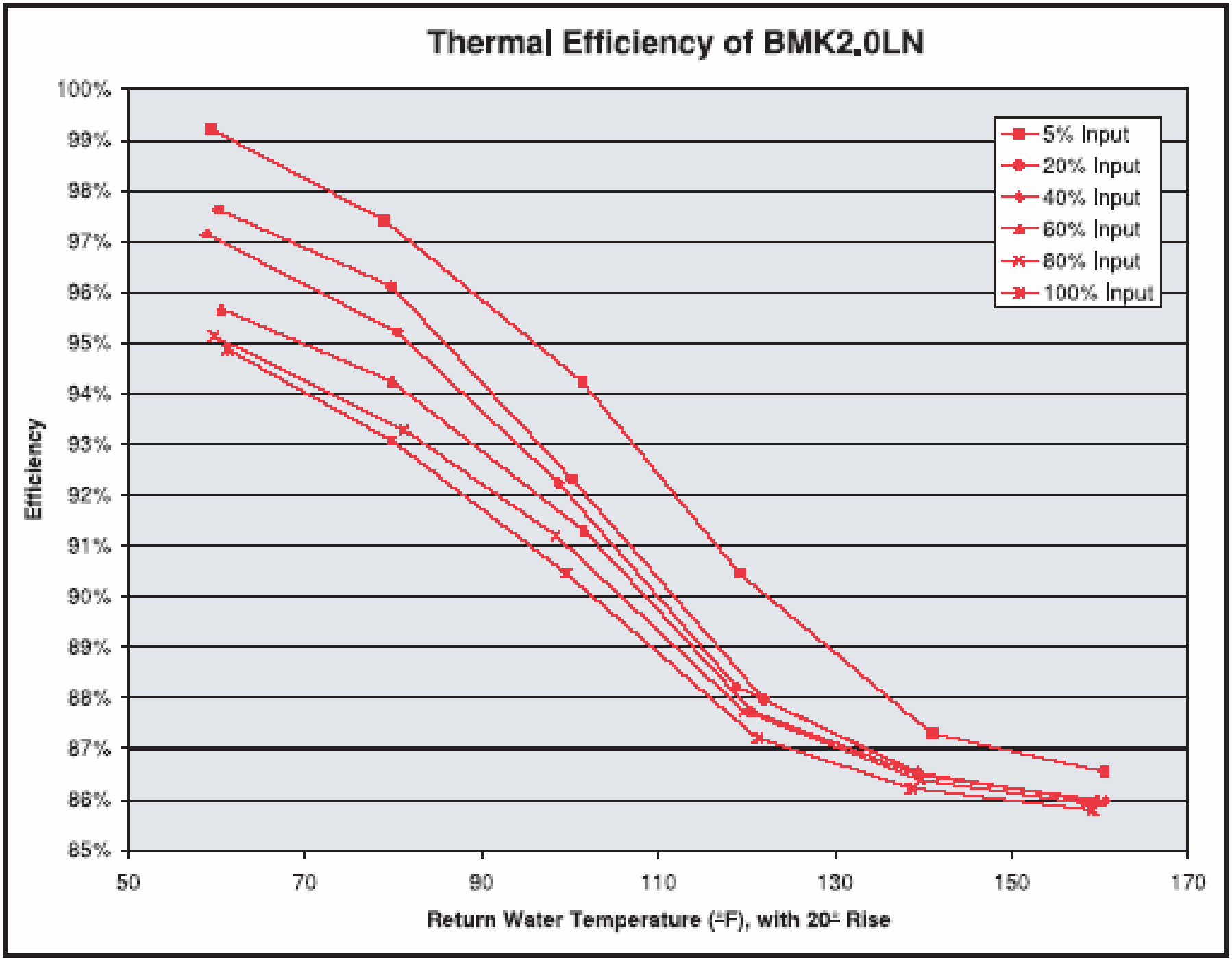

As the inlet water temp. falls below ~130 F, condensing occurs and boiler efficiency is dramatically increased.

ASHRAE Equipment Handbook, Boiler Chapter

# Why a Condensing Design?

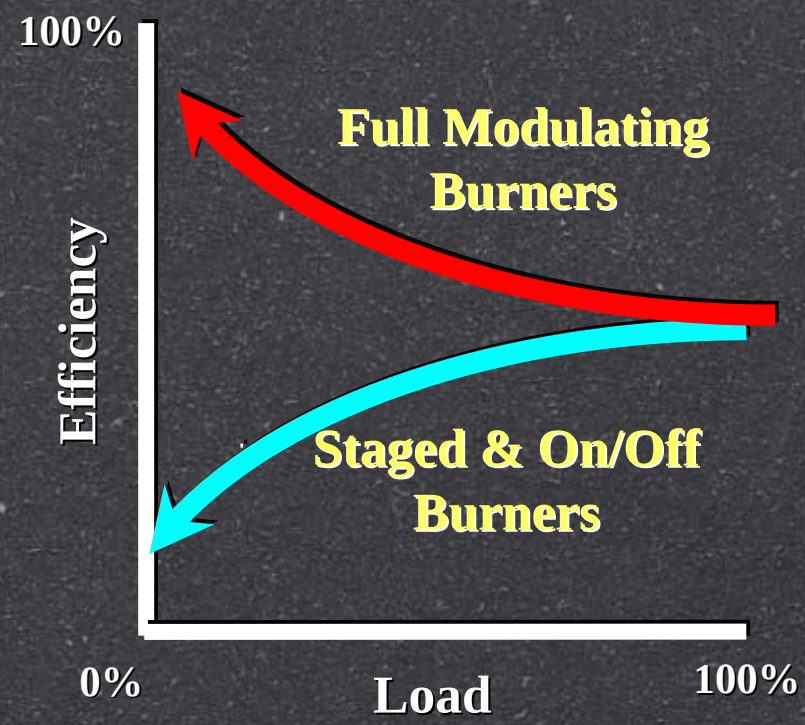
- Thermal Efficiencies in Excess of 90%
- System Flexible: Any Water Temperature
- Eliminate Thermal Shock 'Worries'
- Eliminate Primary/Secondary Pumping and 2, 3 or 4-way Control Valves



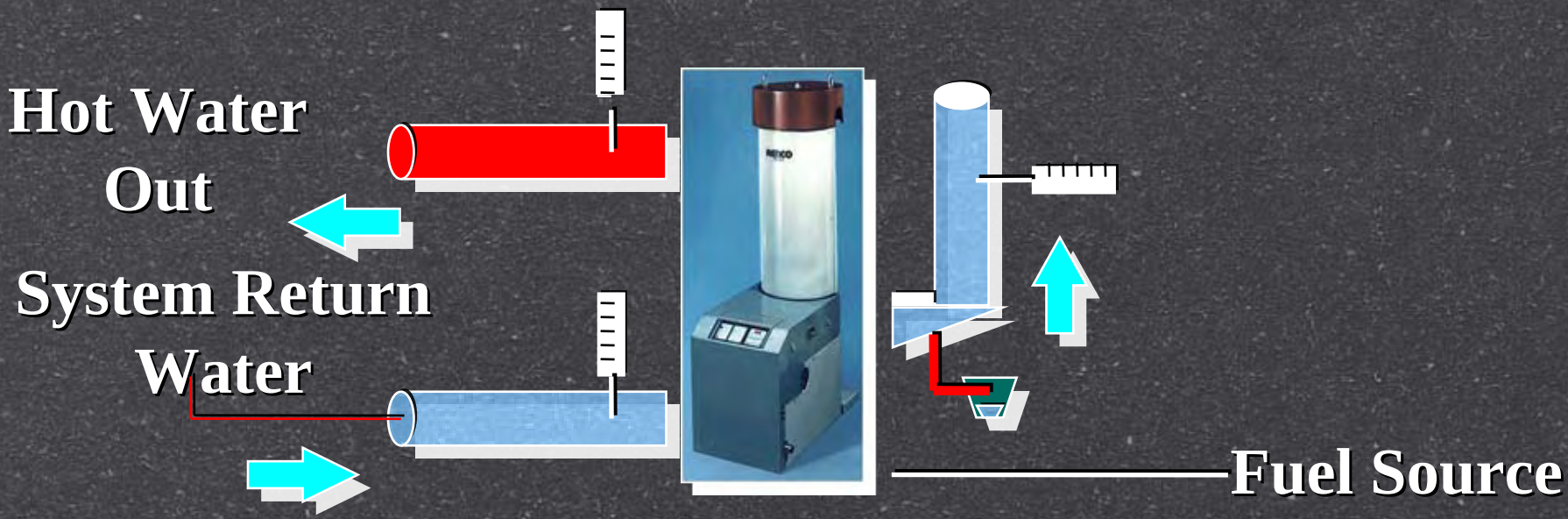

Thermal Efficiency of BMK2.0LN
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
89%
88%
87%
86%
85%
Efficiency
5% Input
20% Input
40% Input
60% Input
80% Input
100% Input
50
70
90
110
130
150
170
Return Water Temperature (°F), with 20° Rise

# Why Modulate the Fuel/Air Input?

- Eliminate Cycling Losses
  *No Energy Waste*
- Accurately Match Energy Input to Heating Load
  *No Energy Waste*
- Precise Temperature Control at All Heating Loads
  *Maximize System Efficiency & Simplify Building Controls*



# ANSI Z21.13 Thermal Efficiency Rating
# Fact or Fiction?




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

but...

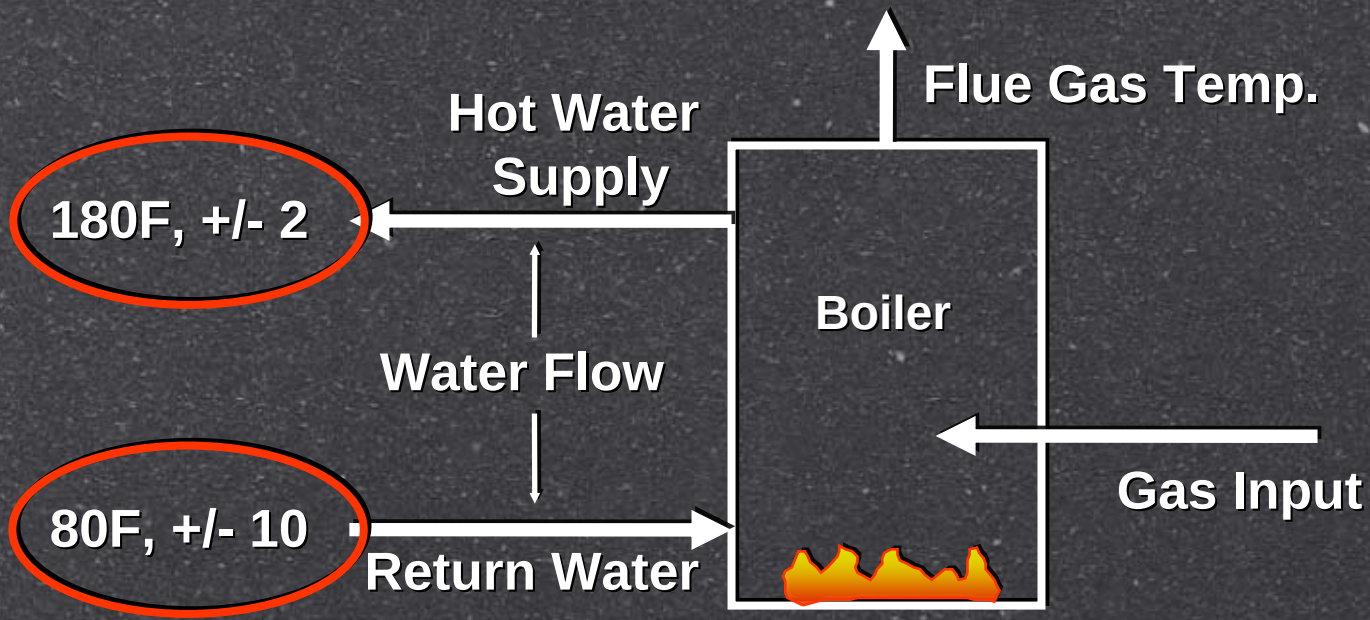
80F inlet water 180F outlet water

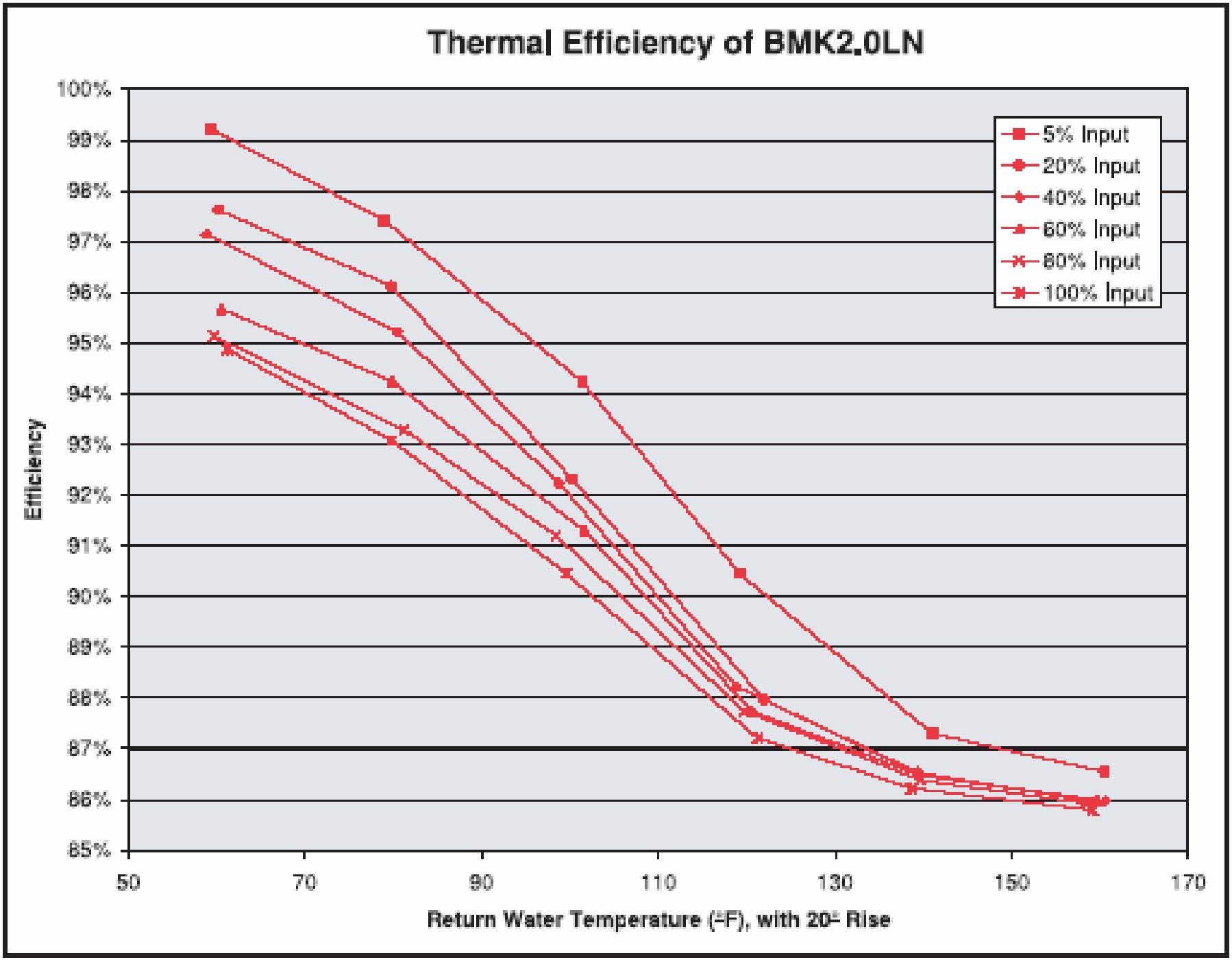
***Is this representative of real heating applications?***

# ANSI Z21.13-2000: Thermal Efficiency Test
# BTS -2000: Combustion Efficiency Test

**300,000 Btu/h to 12,500,000 Btu/h**
**Test Boiler at Full Capacity**

***Thermal Efficiency = (Energy Out / Energy In) x 100***

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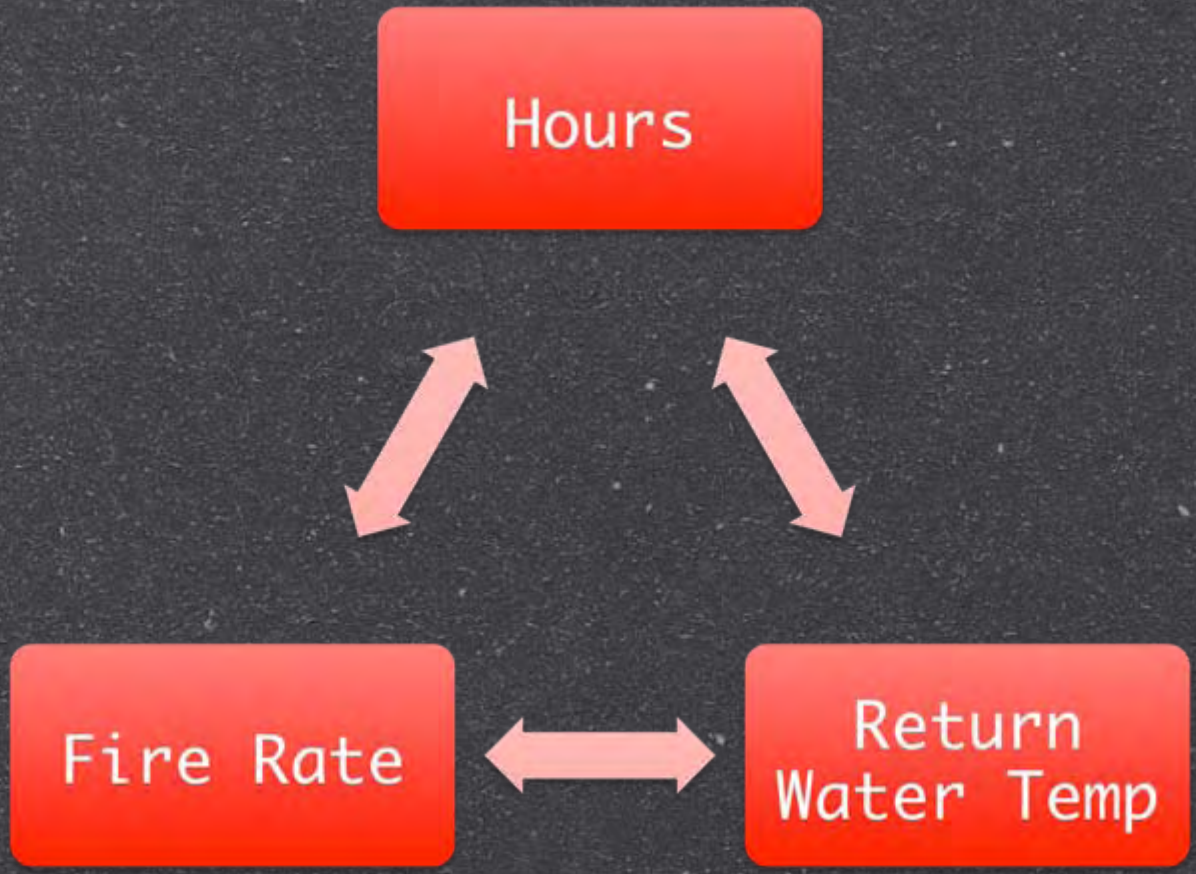
Return Water Temperature (°F), with 20° Rise

# Seasonal Efficiency Depends On




ANSI Z21.13 Ignores All Three

# Efficiency Comparison

| | High Efficiency | Mid-Efficiency |
|---|---|---|
| • Thermal, 100% Fire | 86% | 77% (“84%”) |
| • Thermal, 25% Fire | 97% | 70% |
| • Seasonal | ~92% | ~72% |
| • Fuel Savings (72:92) | 21.7% | |

# Installation Results

- **Cuyahoga County BMR/DD -Maple Heights, Ohio**

- **28% Reduction in Fuel Usage**

# How Much Extra Does a Condensing Boiler Cost?

## Is It Worth It?

- Boiler - About 20%
- Offset - 10% reduction in auxiliary costs
- Payback - 1 to 3 years
- NOT a budget breaker

# Budget Breaker?

- If designer does not change his old design approach, equipment may cost 15-20% more
  - payback is usually one to three heating seasons

**However:**

- Use of 40F delta T can reduce piping size and pump cost
- Sidewall or headered venting can save install $$
- Sealed combustion can save louver cost

**Answer - NOT a budget breaker**

# Is It Worth Doing?

- **Spreadsheet comparisons**
  - Usage factor - estimated
  - Unpublished seasonal efficiency - estimated
  - Handout available

# How Can You Reduce Total Heating Cost?

- Make good design choices
- Guide the design team
- Avoid certain pitfalls
- Manage the project AFTER installation
- LEED

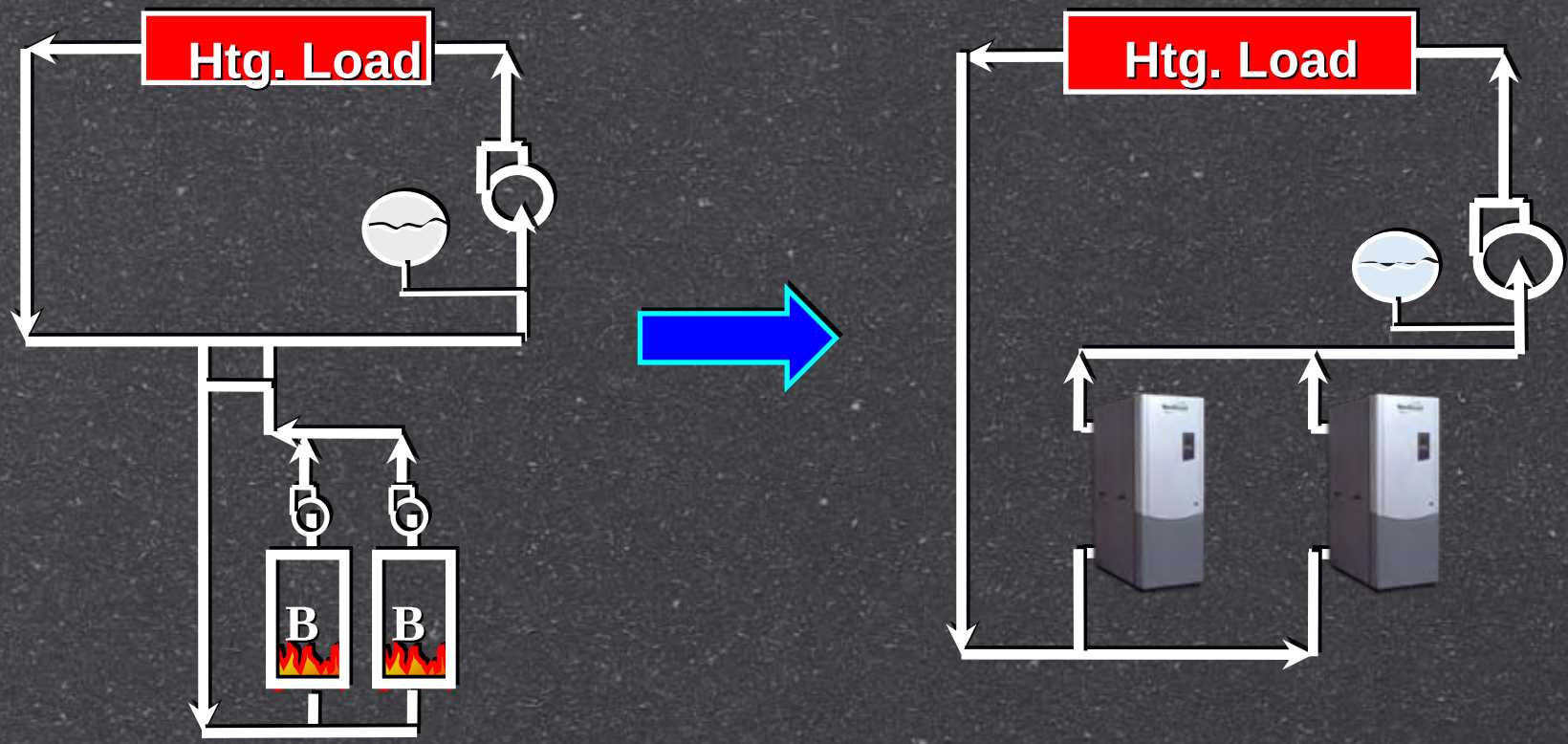
# Make good design choices

- Boiler should **modulate**, like an accelerator on a car
- **Reset schedule**
  - Header temperature should be 140-160F  with OAT of 0F
  - Header temperature should be 100F with OAT of 60F
- **Delta T** should be 30F to 40F
  - Save pumping and piping costs
  - Added cost in terminal size is modest

# Make simplifying design choices

- Omit mechanical draft systems
- Omit pre-heating combustion air
- Omit automatic isolation valves
- Omit unit circulators

# Save Costs -No Unit Circulators



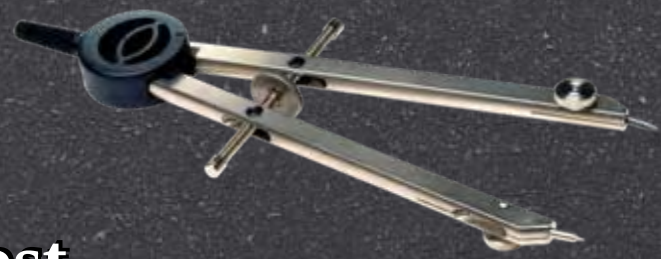

**Reduce/Eliminate Material and Labor:**
**Primary-Secondary Pump, Piping, Elect., Controls, Maintenance AND Improve System Reliability**

# Guide the Design Team

- Forget the old design guidelines
- Meditate on the pie chart and ASHRAE diagram
- Make the treasurer happy
  – focus on seasonal efficiency
- Reflect on the expected life of a boiler - 30 years?

# Guide the Design Team

- At each design review
  - ask how seasonal heating efficiency can be higher
- ***Boiler cost***
  - Does not equal system cost
  - Does not equal total heating system cost over time



# Avoid certain pitfalls

- Gas pressure
- Venting
- Controls coordination
- Space

# Manage the project AFTER installation

- System operator training by design engineers
- Training assistance from equipment suppliers
- ***Measure performance - gas usage***
  - Compare to a standard
  - Compare to design
- ***Schedule maintenance***
  - Build cost into the budget

# LEED

- How to get points with condensing boilers
- Real-time efficiency monitoring
- ***LEED is required by a number of agencies***
  - GSA
  - OSFC
  - More mentioned in January 2008 NEO ASHRAE talk

# What do these buildings have in common?


TRINITY
LUTHERAN
CHURCH


NO
PARKING
BUS
STOP


JUDITH A RESNIK
COMMUNITY
LEARNING CENTER


STOP
10
AEROSPACE INSTITUTE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# For More Information

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