Saving Energy in Existing Multifamily Buildings

Duluth Energy Design Conference
February, 2016

Corrie Bastian
Center for Energy and Environment

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Topics

- Who is CEE
- Energy use in multifamily buildings
- Perspective: Understanding the industry
- Retrofit highlights
  - Energy impact
  - Marketability
  - Ensuring success: I, O & M best practices

Who is CEE

The Center for Energy and Environment (CEE) is a nonprofit organization that promotes energy efficiency to strengthen the economy while improving the environment

We conduct research and develop programs so that:

- Businesses operate more efficiently and profitably;
- Government agencies and nonprofits spend less on facilities and functions;
- Utilities achieve their energy-efficiency goals at least-cost; and
- Households save money and improve comfort.

What we do

- Energy Program Design and Delivery
- Engineering Services
- Public Policy
- Lending Center
- Innovation Exchange
  - Research
  - Education and Outreach

CEE multifamily experience

- Facility assessments of over 2,000 buildings in Minnesota
- Completed over 20 research projects

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Current multifamily research projects

- Condensing boiler optimization
- Multifamily ventilation optimization
- Demand Controller recirculation loop controls
- Multifamily aerosol envelope air sealing
- Indoor pool optimization

All funded through the MN Department of Commerce's Conservation Applied Research and Development grant program.

Current multifamily energy efficiency programs

- Energy Star multifamily 3rd party verifier
- One Stop Efficiency Shop lighting program with Xcel Energy
- Multifamily Energy Savings program with MN Energy Resources

Understanding multifamily buildings

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What we know about multifamily buildings

"Multifamily buildings are a tough energy efficiency nut to crack"

Why?

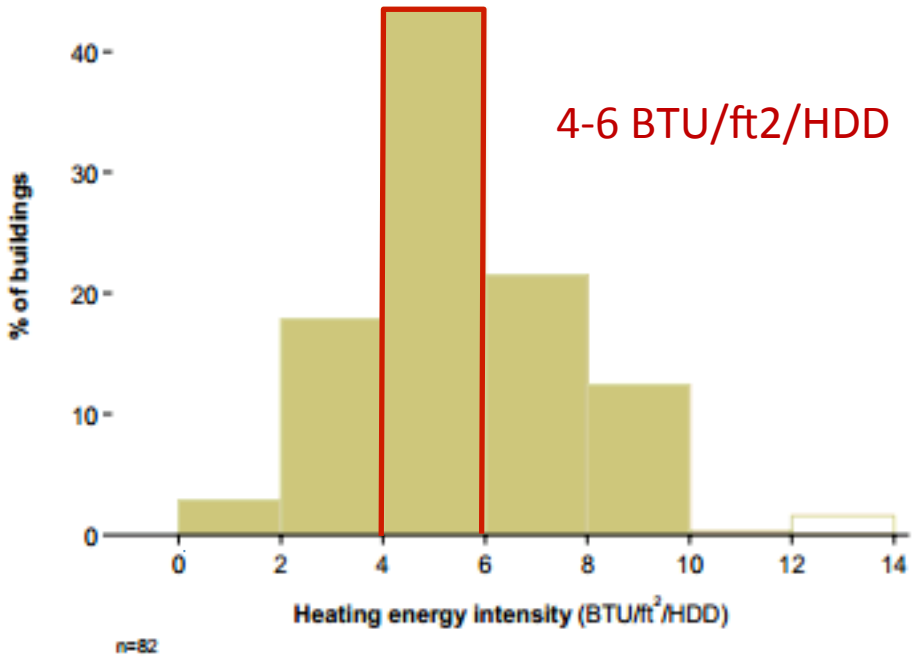
- "Split incentive" / diverging interests between resident and owner
- "Lots of players in the orchestra"
- Perception that technical challenges outweigh financial benefits

Market research on multifamily building owners and managers reveals perceptions of energy efficiency

- “Expensive”
- “Complex maintenance and upkeep”
- “Realized savings are questionable”
- “Improved comfort is a big benefit”
- “Has to be durable”
- “Trustworthy energy efficiency advice is needed”

MN multifamily buildings are relatively "fit" buildings

- Natural gas = common heating fuel (~66%)
- Central hydronic = common heat system (83%)



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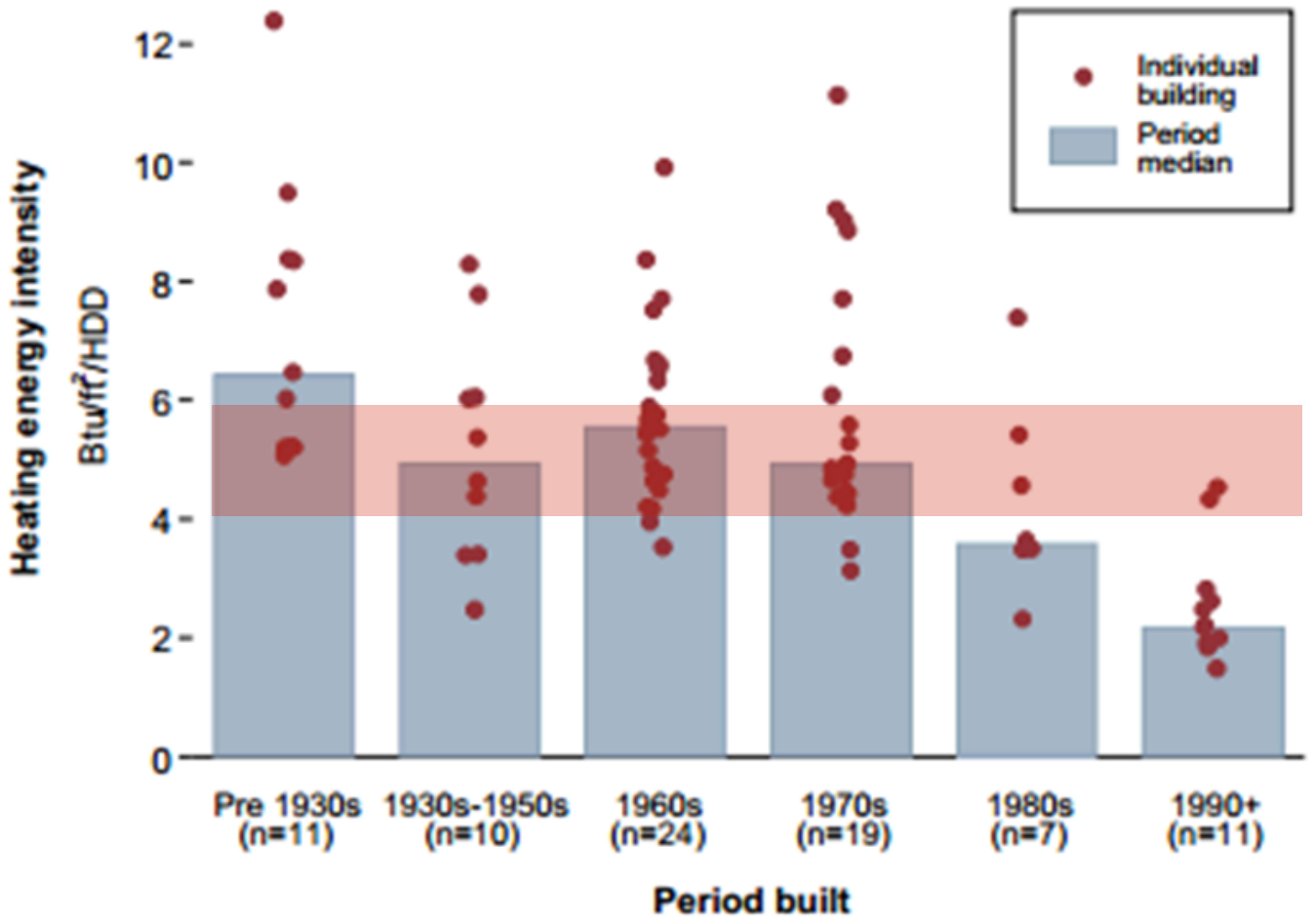
SOURCE: Minnesota Multifamily Rental Characterization Study, Energy Center of Wisconsin and Franklin Energy, 2013; sampled 120 bldgs in MN (78 in Twin Cities, 66 Greater MN)

…And yet outliers in (almost) every category



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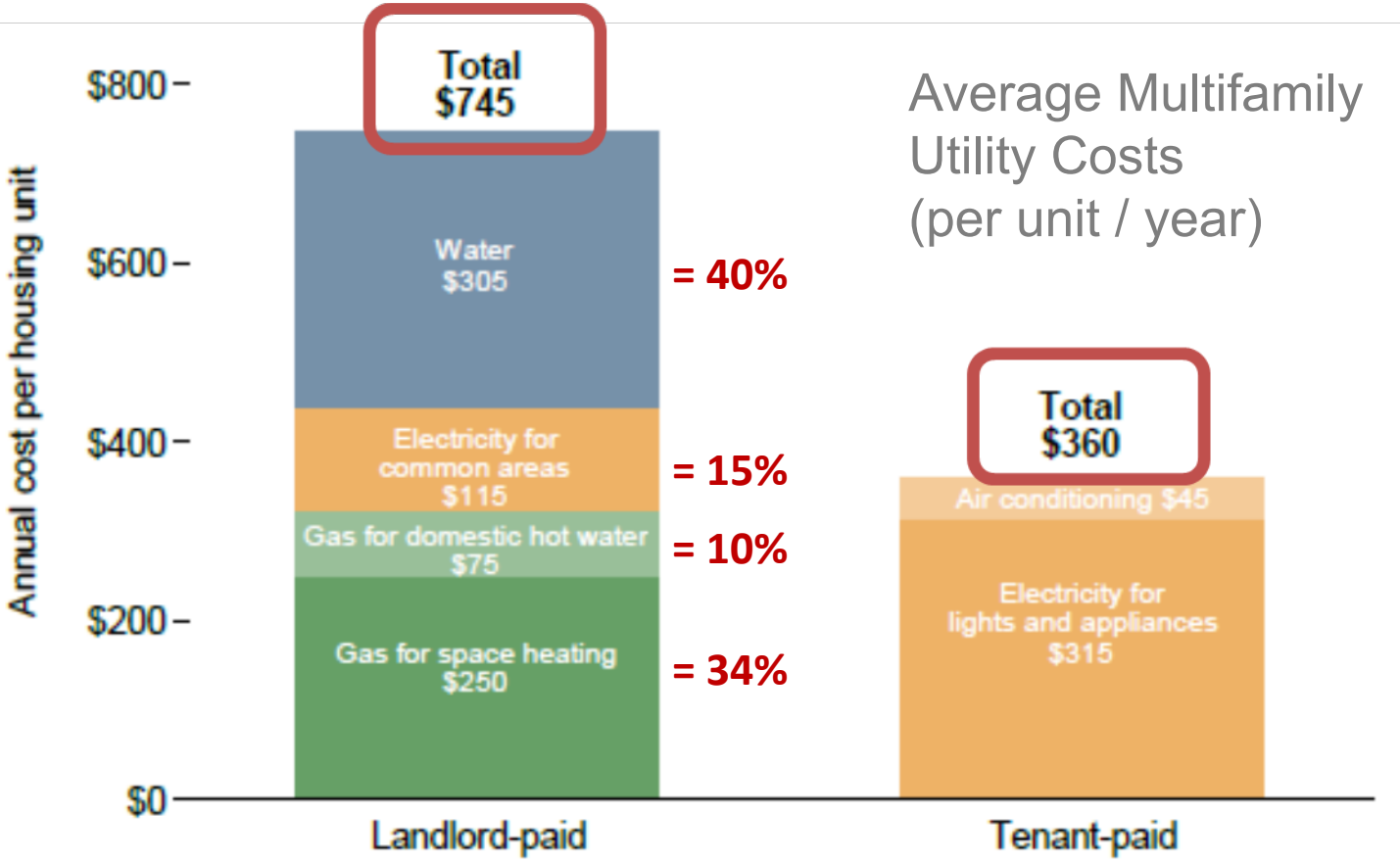
SOURCE: Minnesota Multifamily Rental Characterization Study, Energy Center of Wisconsin and Franklin Energy, 2013; sampled 120 bldgs in MN (78 in Twin Cities, 66 Greater MN)

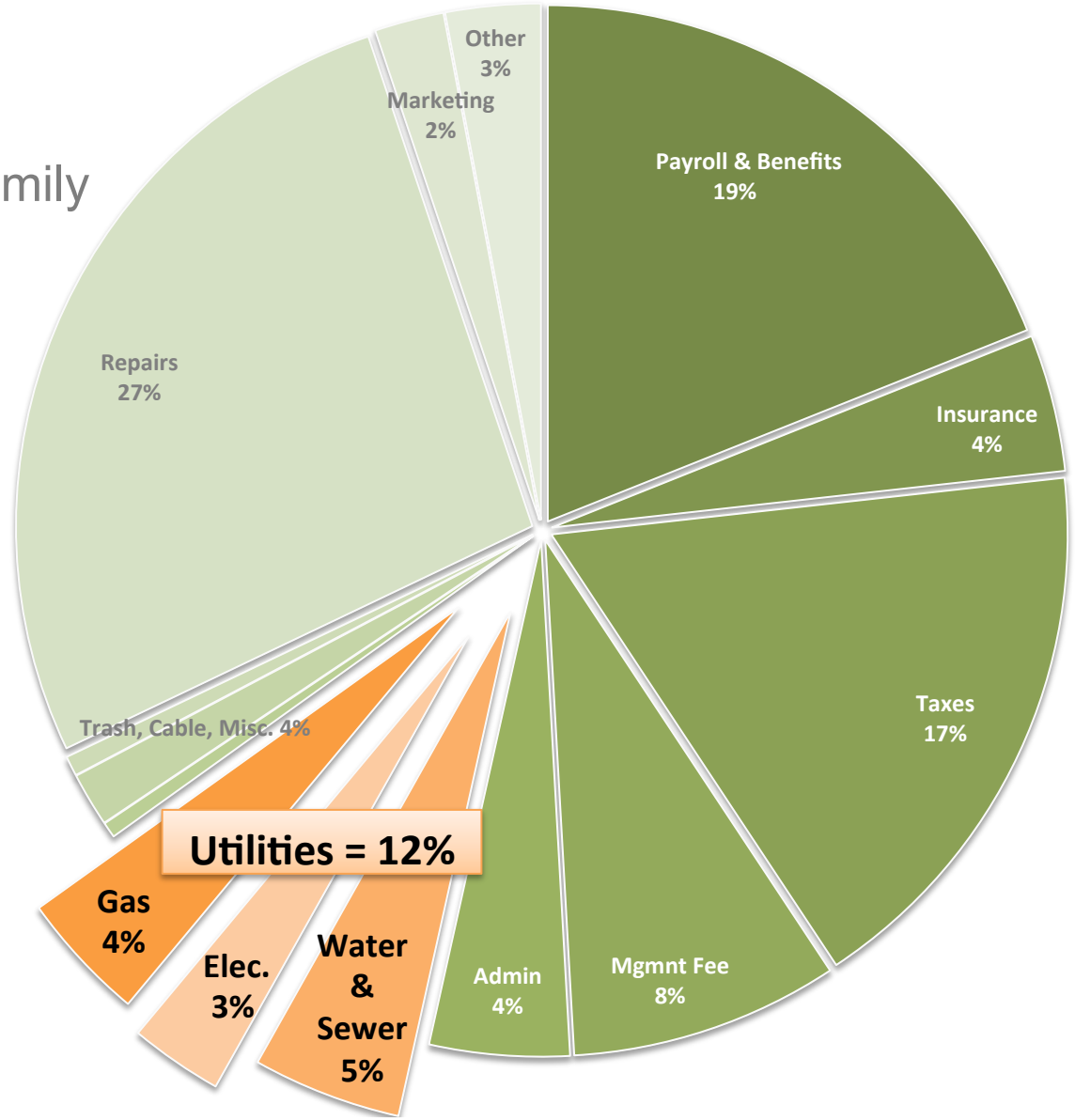
Water and space heating costs dominate



SOURCE: Minnesota Multifamily Rental Characterization Study, Energy Center of Wisconsin and Franklin Energy, 2013; sampled 120 bldgs in MN (78 in Twin Cities, 66 Greater MN)

…And yet they are a small piece of the expense pie

Average MN Multifamily operating expenses



Source: *2013 MN Multi Housing Association Expense survey.* 388 multifamily properties surveyed

i.e. Energy efficiency marketability goes well beyond payback

A good investment…

- Has aggressive energy paybacks
- Lowers O & M costs
- Improves building comfort
- Makes things easier for staff
- Is “tried and true”
- Is easy to implement

Marketable energy efficiency strategies for MN multifamily

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Good opportunities for energy savings – *beyond "the laundry list"*

- Optimizing existing condensing boilers
- Building ventilation modifications
- Demand-based hot water recirculation loop controls
- Aerosol envelope air sealing

Acknowledgements

Projects discussed are supported in part by a grant from the Minnesota Department of Commerce, Division of Energy Resources through a Conservation Applied Research and Development (CARD) program

Optimizing condensing boilers

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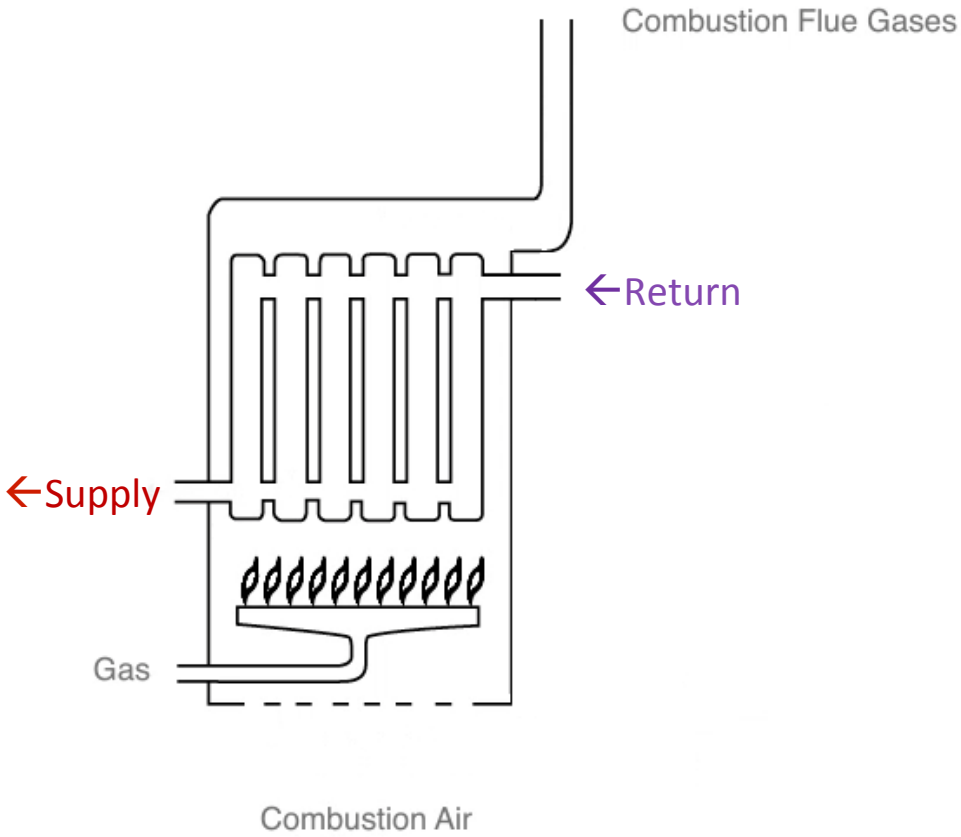
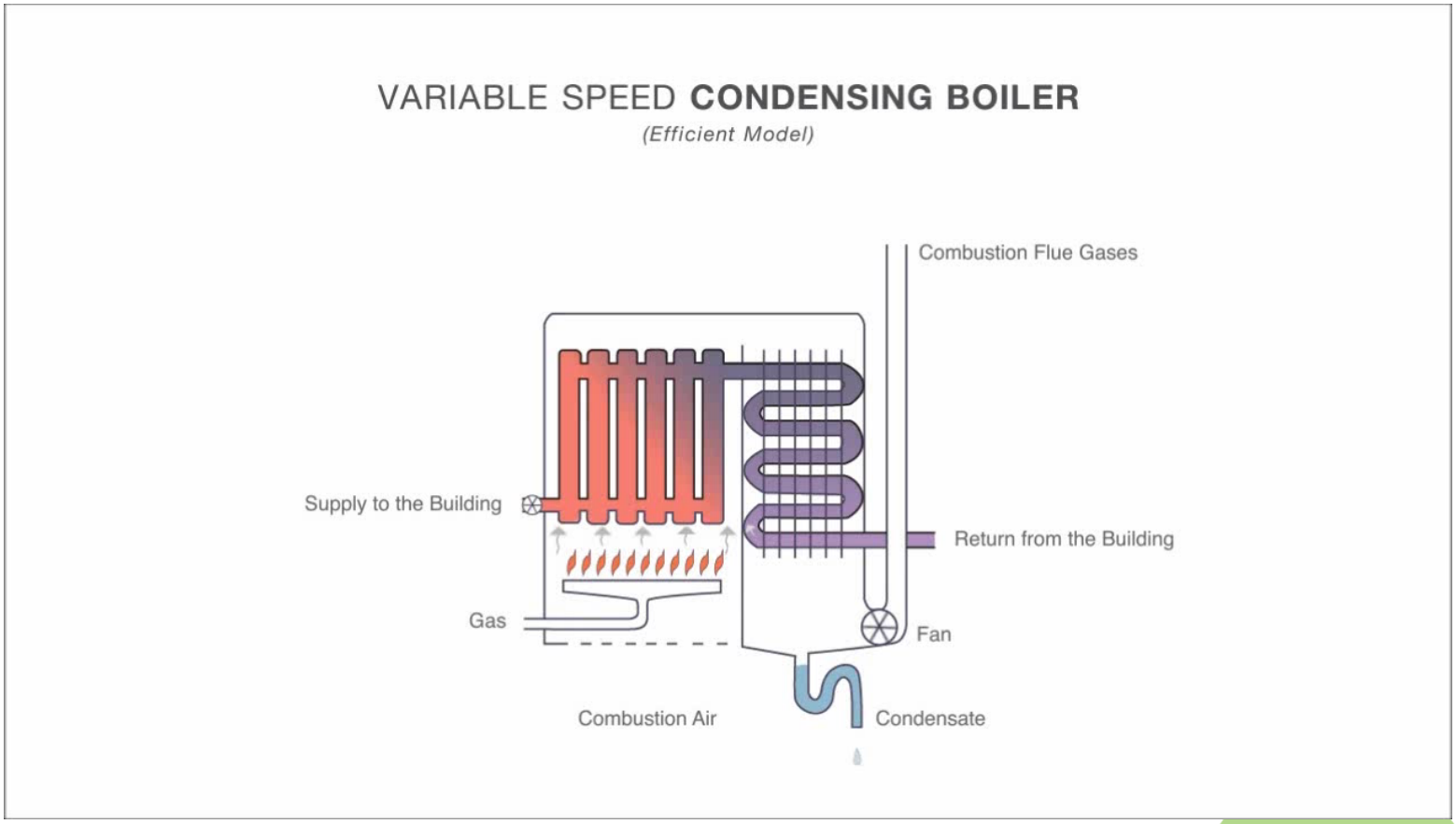
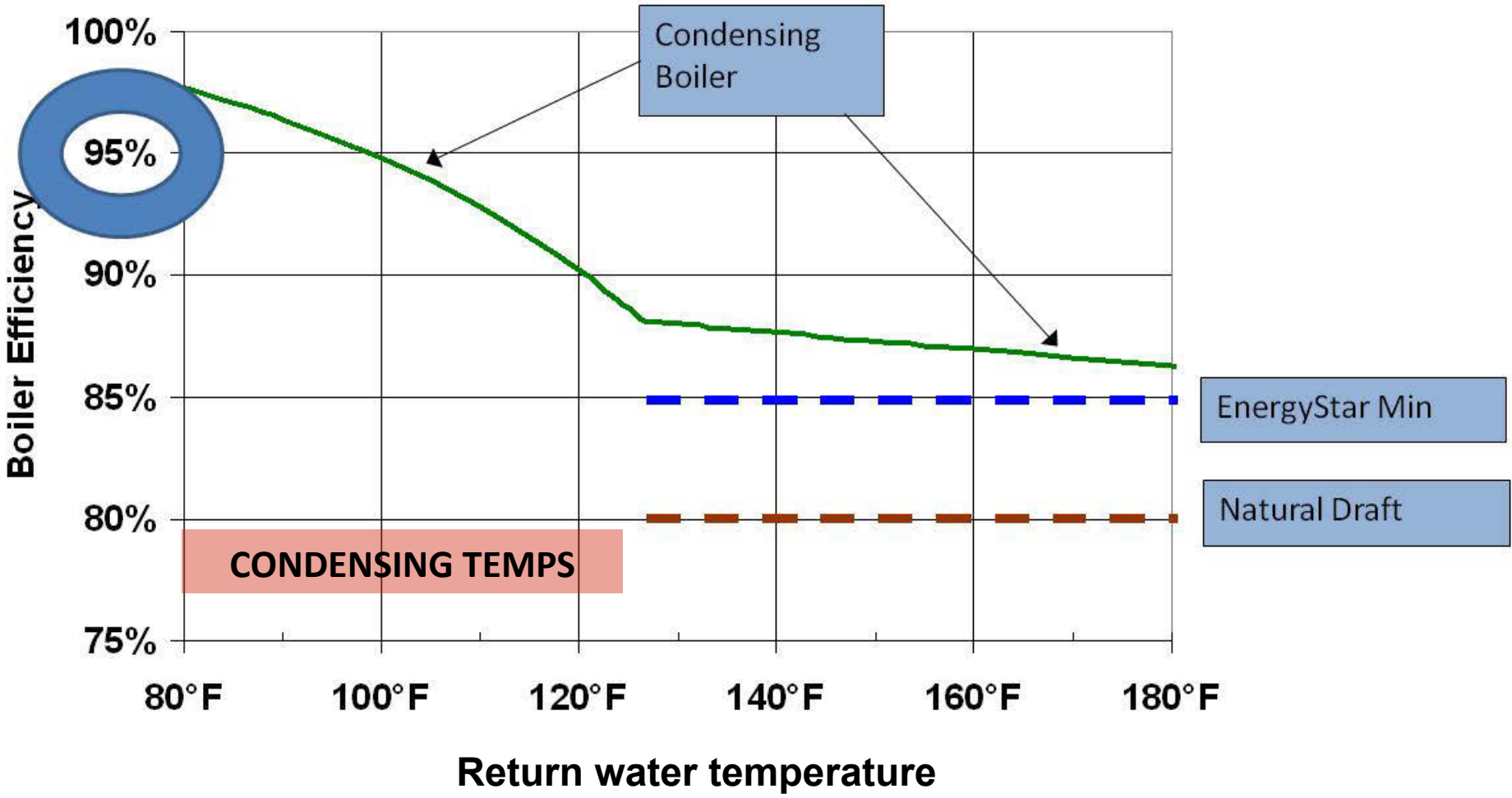
Conventional boiler



Condensing boiler



Achieving rated efficiency (>90% efficiency)



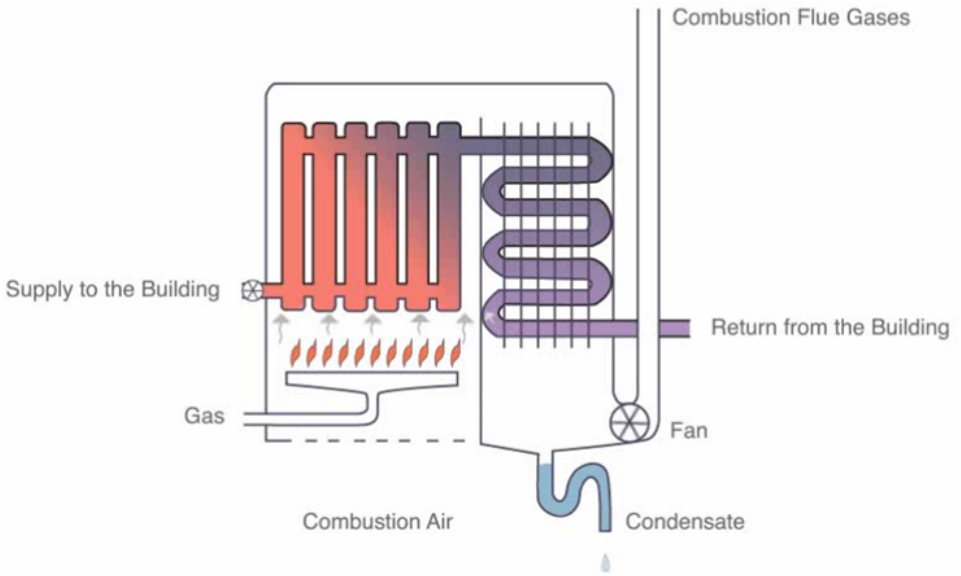
Condensing?

Benefits

- 4-10% of gained efficiency
- Eliminate short-cycling
- Getting what you paid “extra” for

THE KEY: Driving down return water temperature

- Maximize heat transfer at heating elements
- Send lower temp water out to the building
- Make sure boiler output matches demand
- Make sure your piping isn't dumping supply water into return
- Make sure domestic hot water is not integrated with space heating boiler



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How?

- **Considerations for an existing condensing system**
  - Proper excess air levels
  - Adjusting outdoor reset and sequencing/staging controls
  - Reducing maximum output temp
  - VFD pumping for increased heat transfer
- **OR Considerations at time of replacement**
  - Boiler room piping
  - Choosing a boiler with good on board reset and sequencing/ staging controls

Excess air can dictate boiler efficiency

Measured as % Oxygen in flue gas

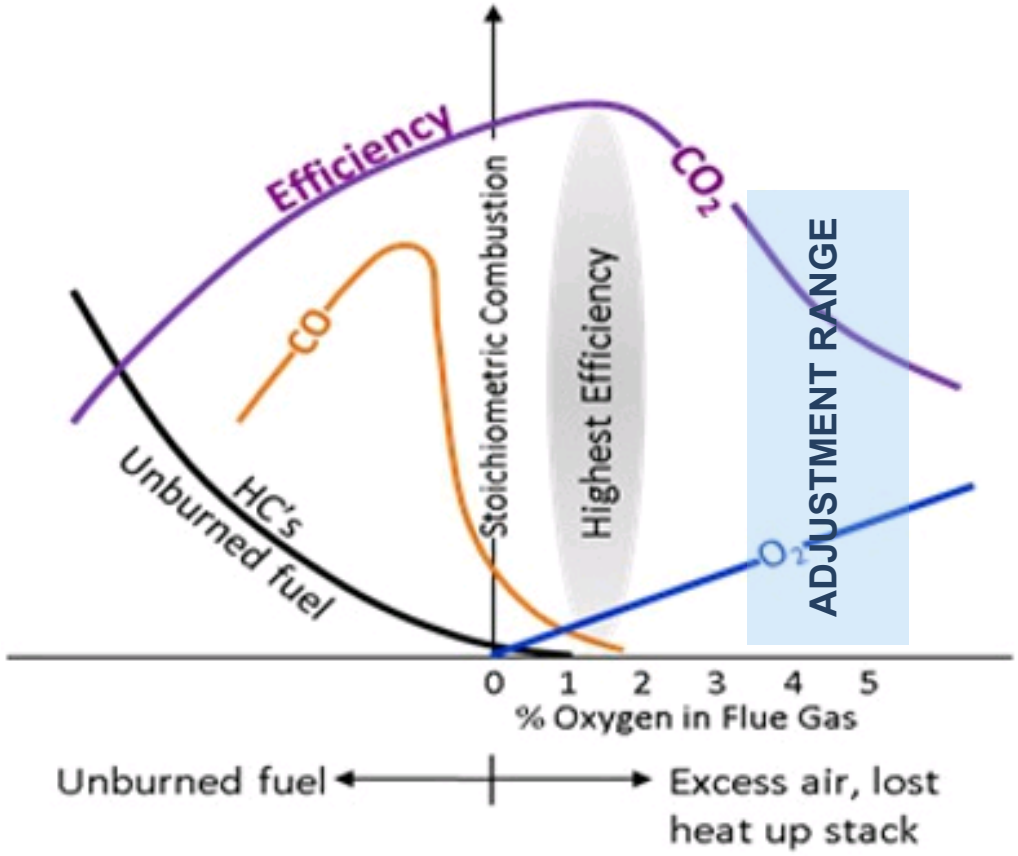
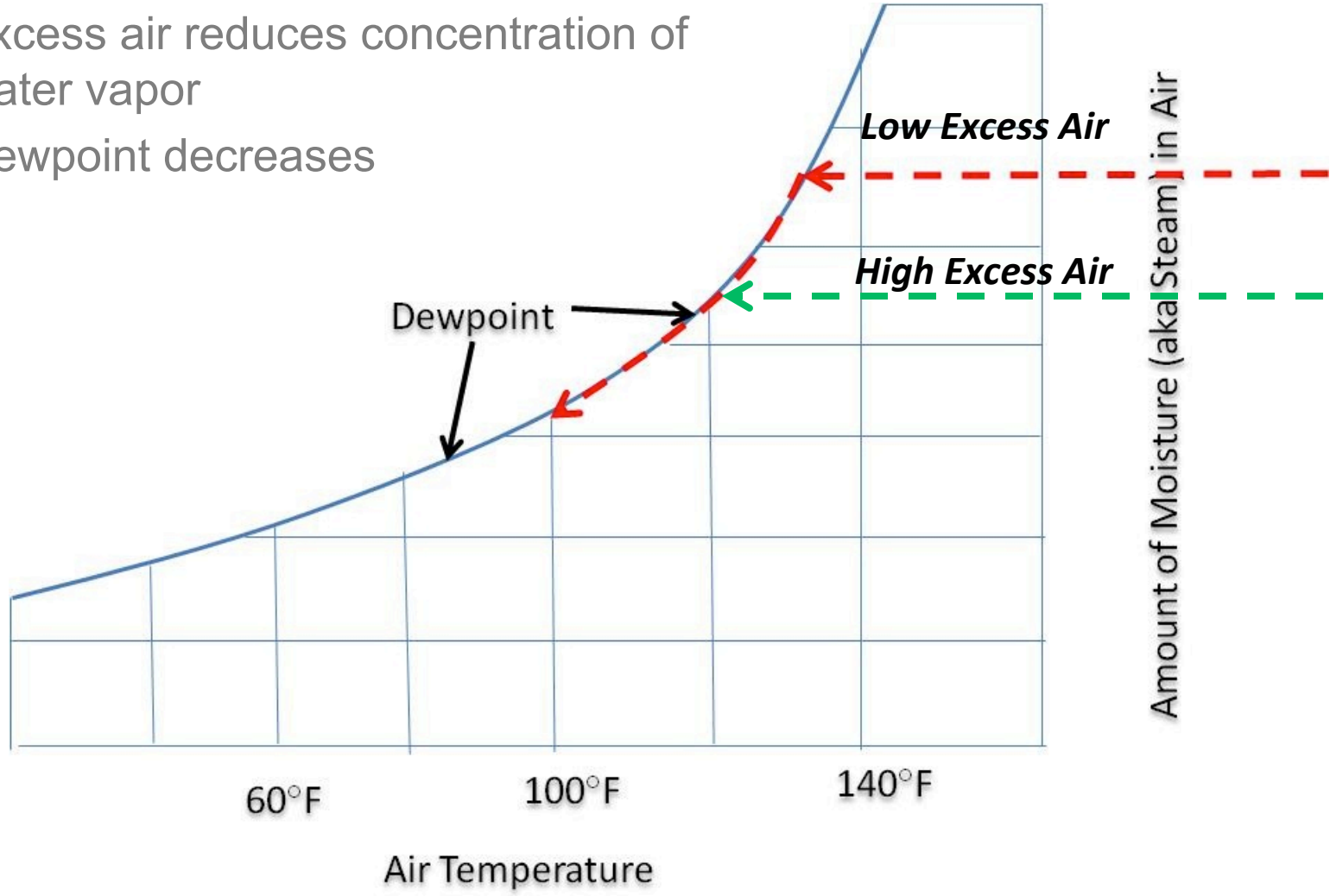


Image source: industrialheating.com

Condensing boiler sensitivity to excess air

- Controlling excess air very important
  - Excess air reduces concentration of water vapor
  - Dewpoint decreases



Oxygen levels in flue gas

Table 4: Recommended Combustion Levels

	Natural Gas All Models	Propane Solo 60/175/250	Propane Solo 399
O2 Min.	2.30%	2.70%	3.70%
O2 Max.	5.30%	4.70%	5.20%
CO2 Min.	8.80%	10.70%	10.00%
CO2 Max.	10.50%	12.00%	11.00%
CO Max.	100 ppm	100 ppm	100 ppm

Boiler 2

testo310
V5.2 42813307/1

Company_____
Address_____
Phone_____

11/20/2014 12:57:52 pm

Fuel Natural gas
CO2max 11.7%

4.3%	O2
99ppm	CO
155.8°F	Fluegas Temp
88.5%	Eff
Oppm	Ambient CO
65.1°F	Ambient Temp
--.-inH2O	Draft
23.6%	Excess air
--.-inH2O	Pressure
H-9.24%	CO2 Low-9.35
126ppm	Undiluted CO

Smoke no. - - -
Smoke no.Ø -
HCT ____°F
For questions call-_____

Boiler 1

testo310
V5.2 42813307/1

Company_____
Address_____
Phone_____

11/20/2014 12:28:07 pm

Fuel Natural gas
CO2max 11.7%

4.4%	O2
92ppm	CO
134.2°F	Fluegas Temp
89.0%	Eff
Oppm	Ambient CO
65.1°F	Ambient Temp
--.-inH2O	Draft
23.6%	Excess air
--.-inH2O	Pressure
H-9.24%	CO2 Low 9.41
115ppm	Undiluted CO

Smoke no. - - -
Smoke no.Ø -
HCT ____°F
For questions call-_____

Heating elements: You're stuck with them

- It isn't cost effective to add more
- Dirty or blocked radiation affects heat transfer

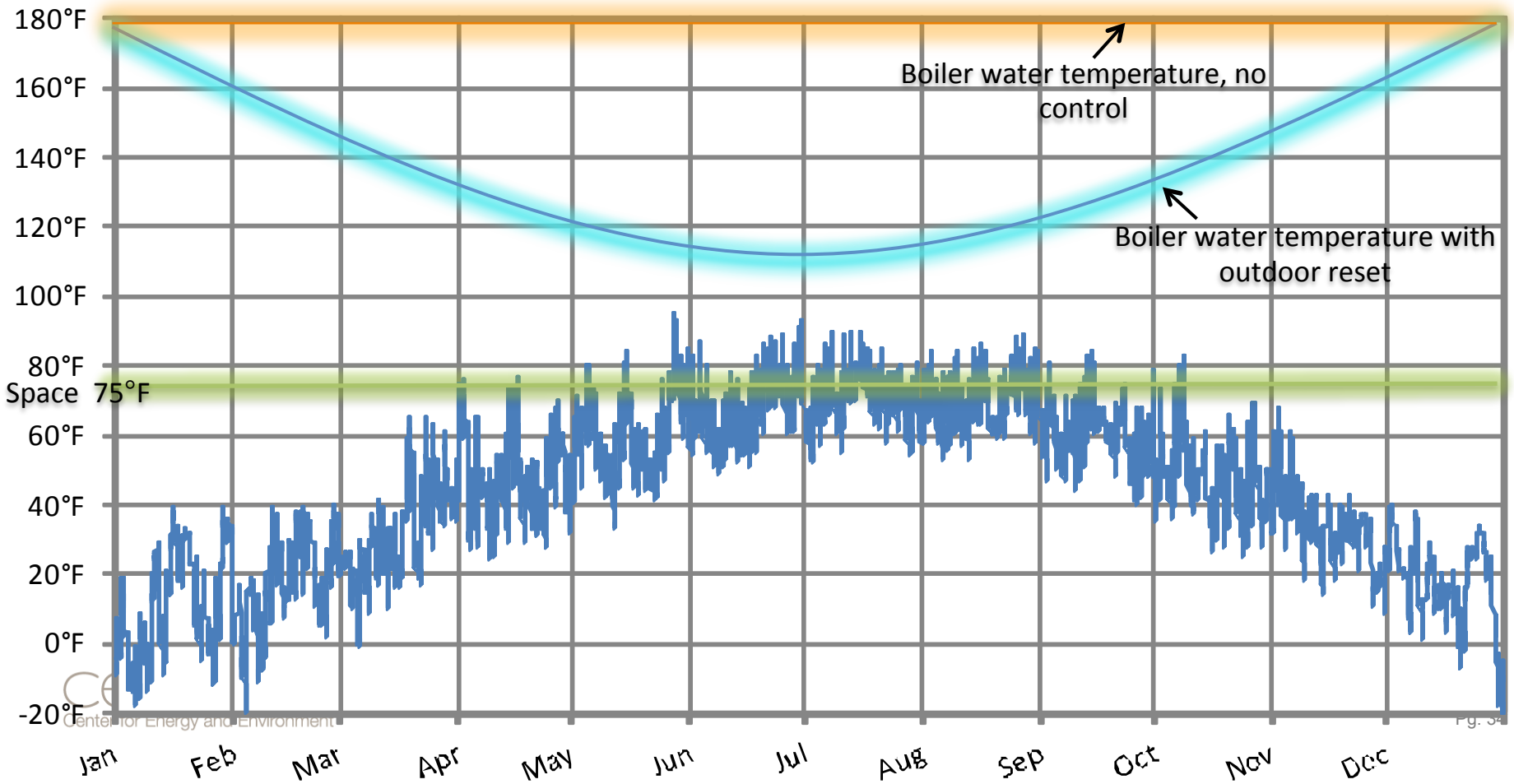
Control boilers for lowest possible output

- Optimized outdoor reset
- Finding the lowest max output temp for the building
- Sequencing and staging for optimal efficiency

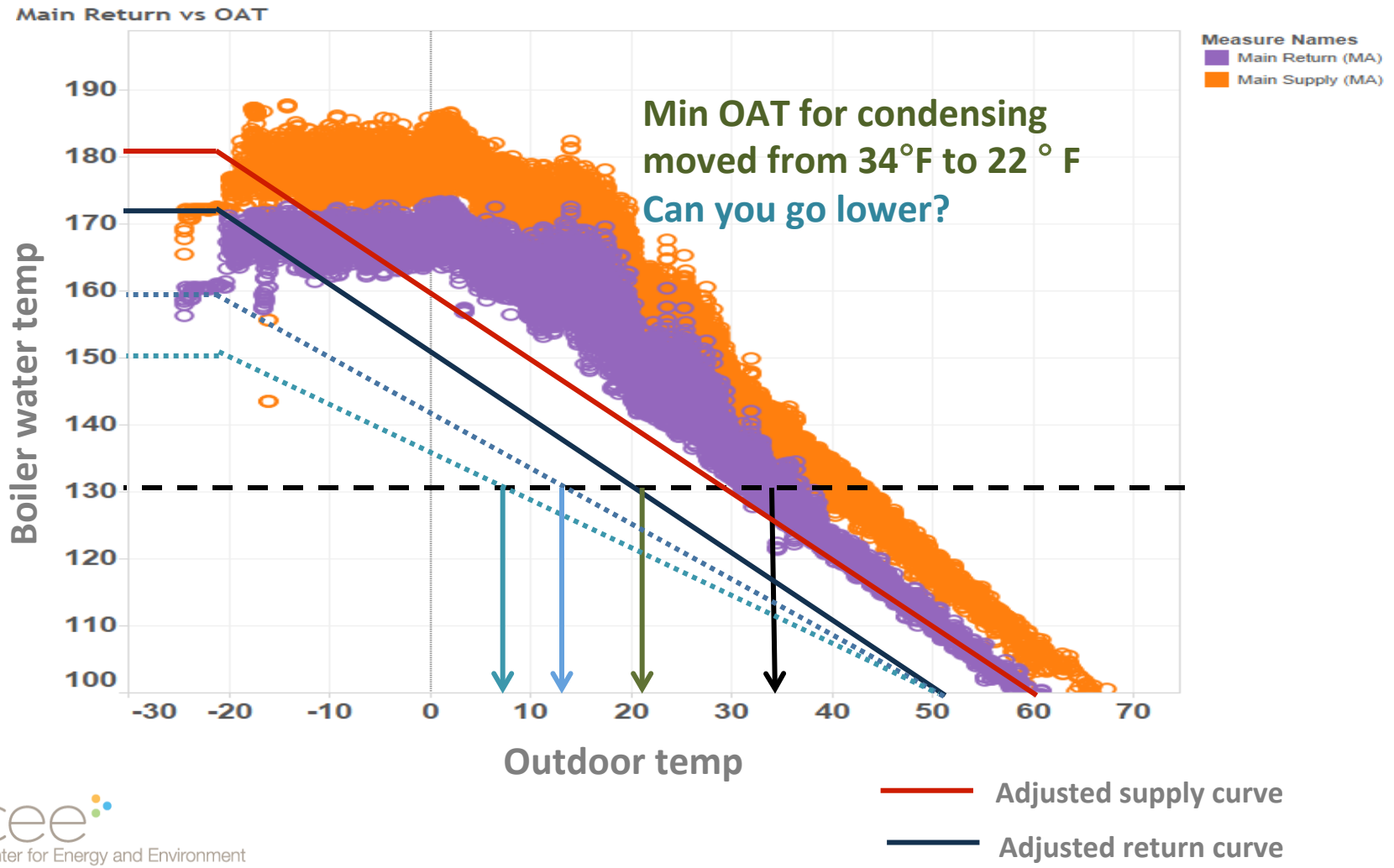
Control the boiler so it doesn't exceed demand

Outdoor reset lowers boiler water temperature

As outdoor temps get warmer, the building heating load gets smaller and the boiler water temperature can be lowered.



Optimizing outdoor reset

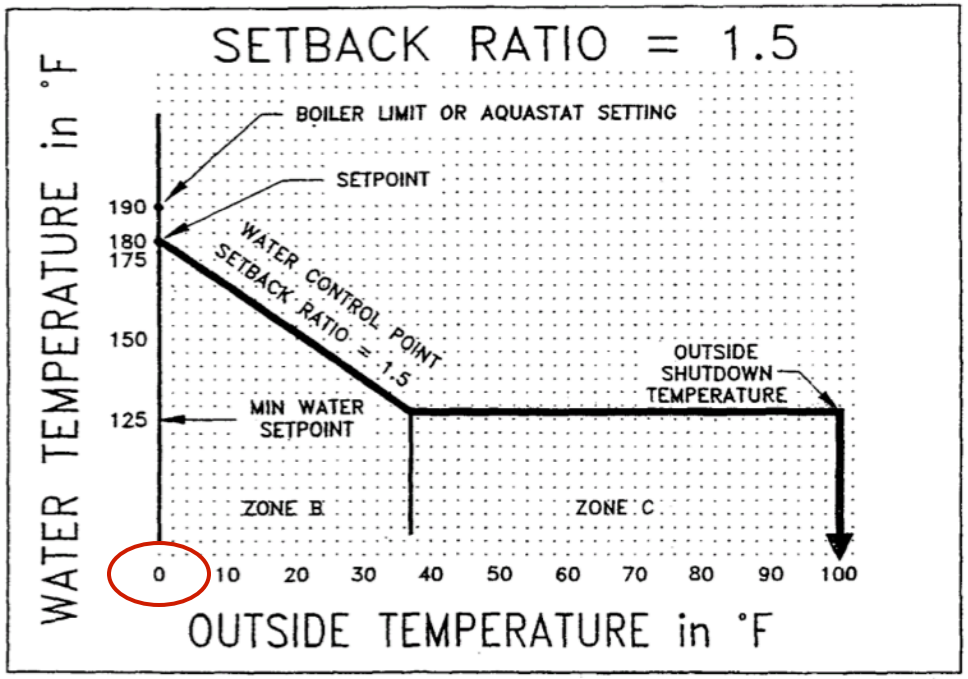


Outdoor reset adjustment

14 unit building:
9.5% space heating savings (no cost)
Reduced building over-heating

At replacement: Identify boiler control limitations

- This boiler control's non-adjustable minimum outside temp of 0°F is not ideal for MN



Boiler sequence and firing stage controls: matching output to load for best efficiency

Lower output firing stages have increased thermal efficiency

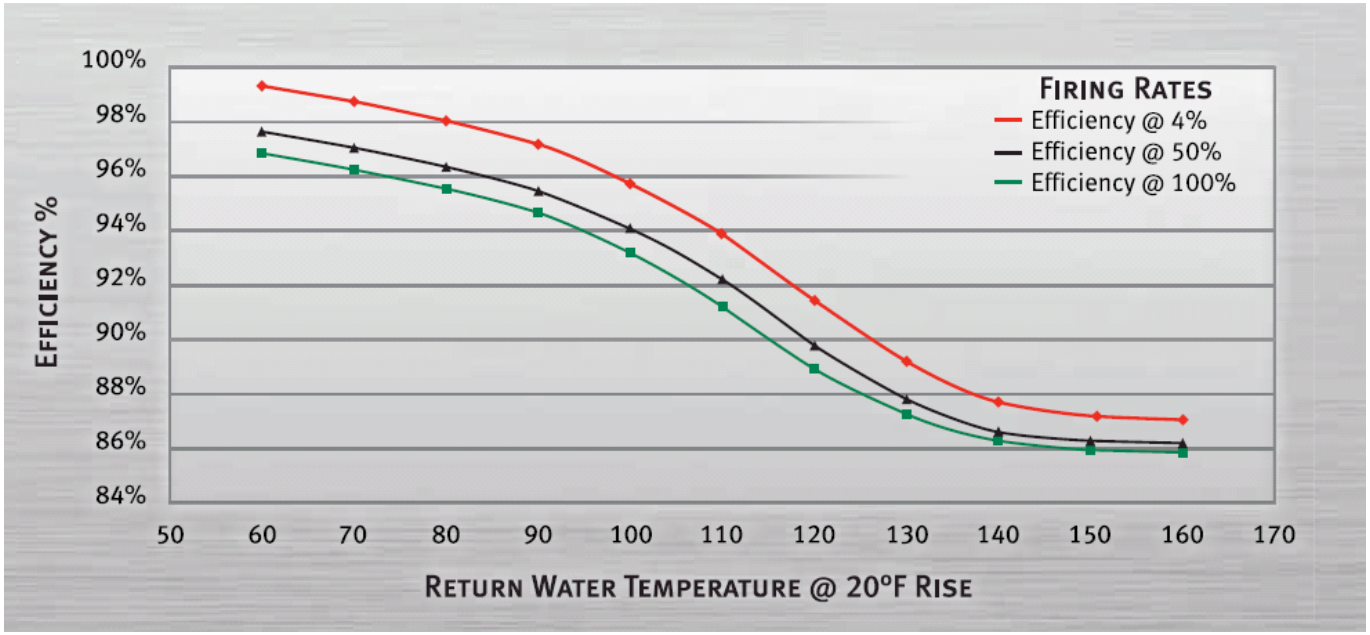


Image source: Lochinvar.com

Lochinvar Knight boiler cascade strategies:

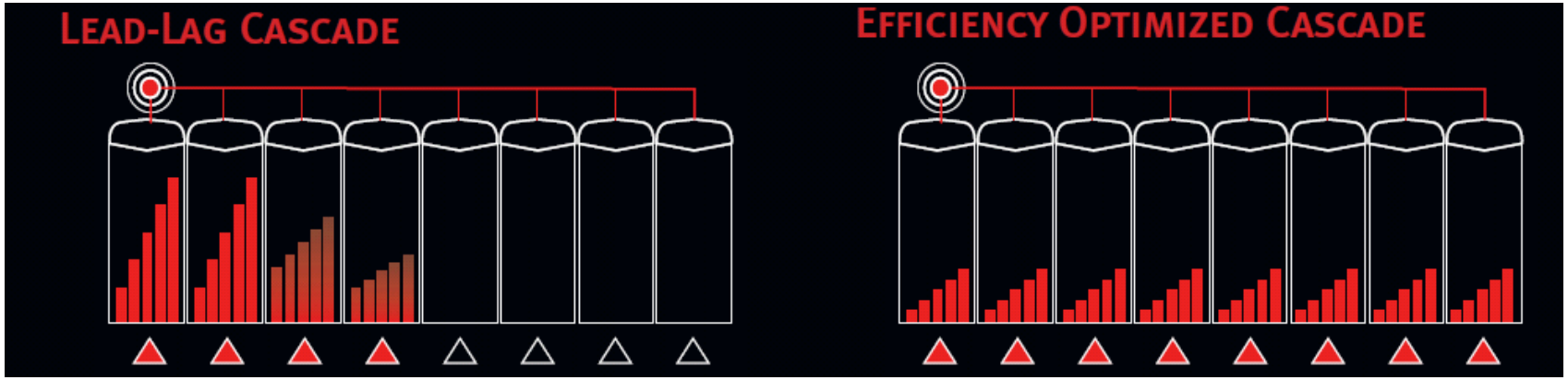


Image source: lochinvar.com

Sequencing boilers: mixed efficiency

41 unit building:
11% space heating savings
3 year payback
Reduced short-cycling

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Sequencing/staging: All firing on at once because they can't talk to each other

32 unit building:
6% space heating savings
5 year payback
Reduced short-cycling

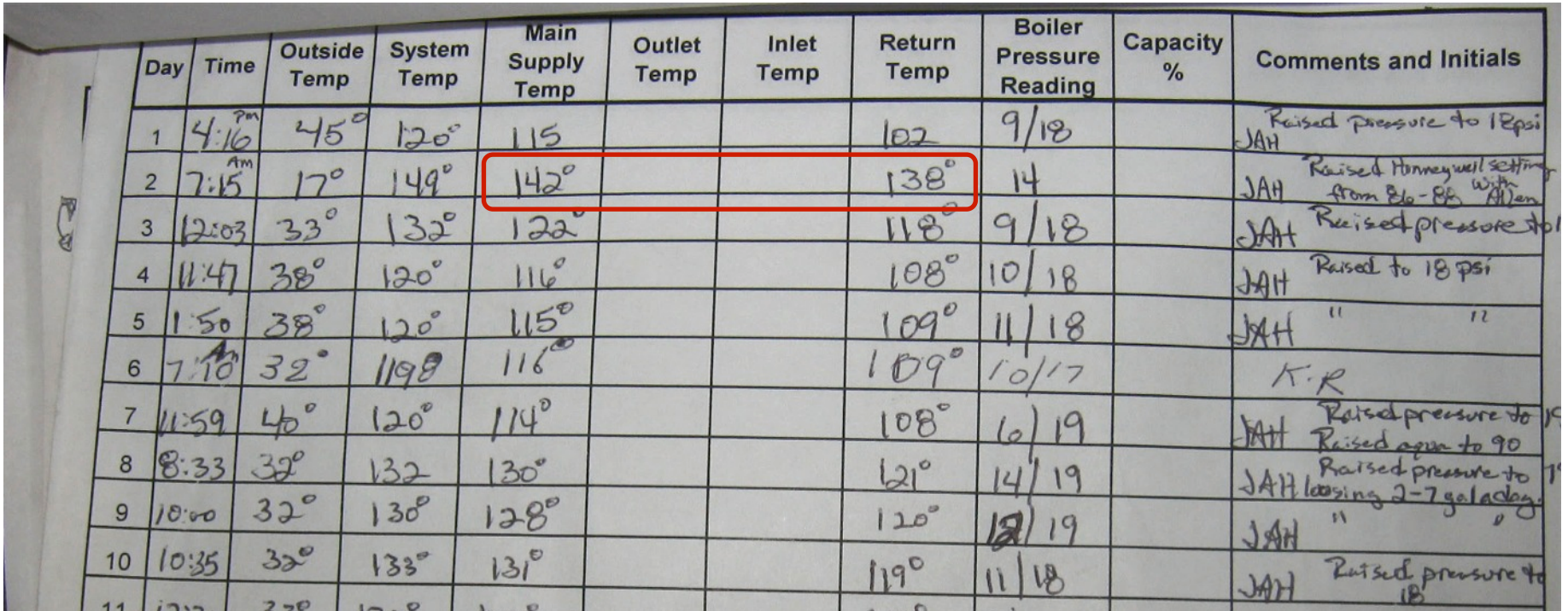
Variable speed pumps (VFDs, VSDs)

- Reduce the pump flow during part-load (when zones close)
  - Allows for lowered return water temperature—more potential boiler condensing conditions
  - Electricity savings

Little difference between boiler supply and return temperatures indicates potential for improvement

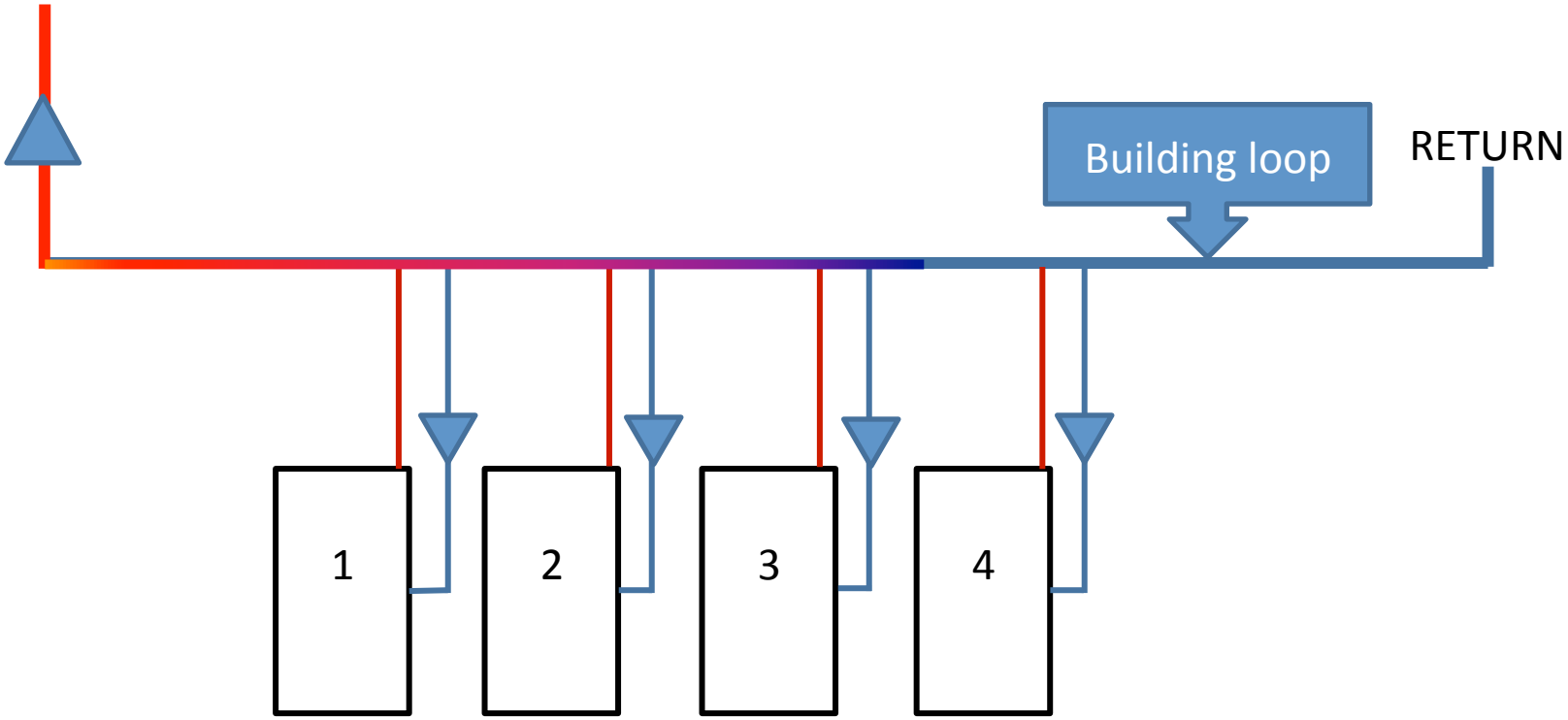
1- Adjust reset temps as low as possible

2- VFD pump control optimizes heat transfer as zones open and close



Day	Time	Outside Temp	System Temp	Main Supply Temp	Outlet Temp	Inlet Temp	Return Temp	Boiler Pressure Reading	Capacity %	Comments and Initials
1	4:16 Pm	45°	120°	115			102	9/18		Raised pressure to 18psi JAH
2	7:15 Am	17°	149°	142°			138°	14		JAH Raised Honeywell setting from 86-88 with Allen
3	12:03	33°	132°	122°			118°	9/18		JAH Raised pressure to
4	11:47	38°	120°	116°			108°	10/18		JAH Raised to 18 psi
5	1:50	38°	120°	115°			109°	11/18		JAH " "
6	7:10	32°	1198	116°			109°	10/17		K.R
7	11:59	40°	120°	114°			108°	6/19		JAH Raised pressure to
8	8:33	32°	132	130°			121°	14/19		Raised aqua to 90
9	10:00	32°	130°	128°			120°	12/19		JAH Raised pressure to loosing 2-7 gal a day
10	10:35	32°	133°	131°			119°	11/18		JAH " "
11										JAH Raised pressure to 18

Boiler room piping: address at replacement



Not ideal: Adjacent boilers warm return water

Better piping