Saving Energy in Existing Multifamily Buildings

Duluth Energy Design Conference
February 21st, 2017

Dan May
Center for Energy and Environment

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In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code/energy** continuing education requirements."

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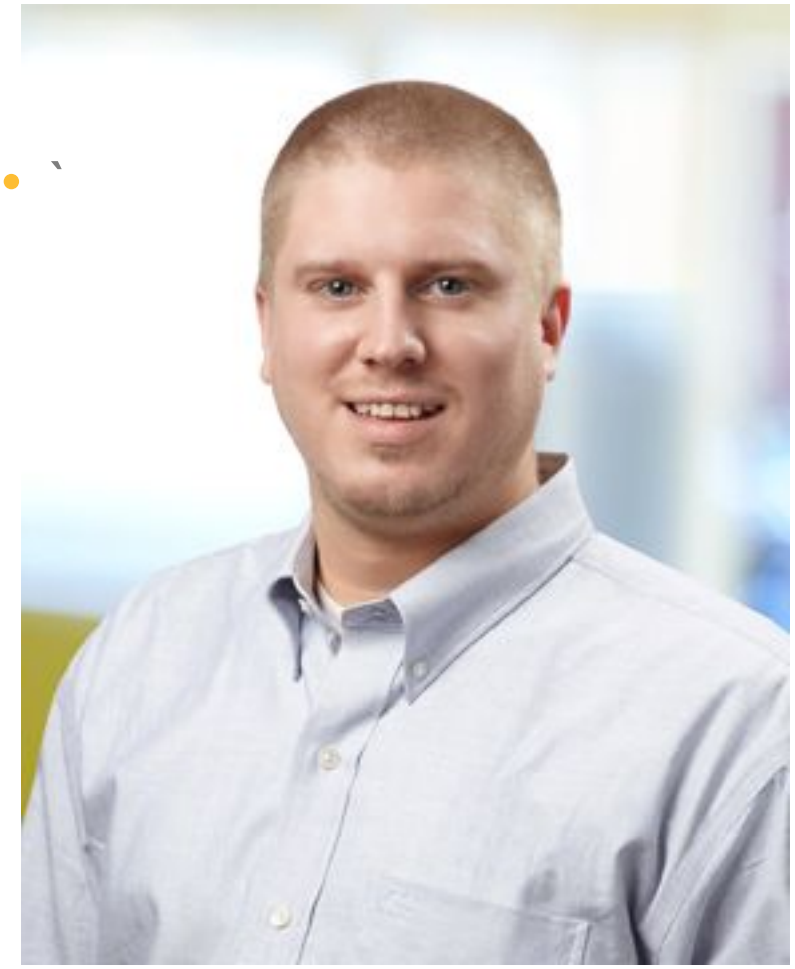
Topics

- Who is CEE
- Energy use and building performance
- Retrofit highlights
  - Energy impact
  - Marketability
  - Ensuring success: I, O & M best practices

About me



Dan May,
Multifamily Project Coordinator

- 8+ years in residential building efficiency & building inspections
- BPI certified Building Analyst
- Coordinator for Multifamily Energy Savings program for MN Energy Resources
- Perform other multifamily energy efficiency projects and research
- B.S. in Residential Building Science Technology, B.A.S. in Construction Management: U of M-Twin Cities

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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.

35 Years of Clean Energy Accomplishments

Program Design and Delivery

- 80,000 Residential Customers
- Supervised and tested 13,300 homes in the Sound Insulation Program
- Completed over 10,500 lighting retrofits resulting in $98M annual savings

Lending Center

- 25,000 loans totaling over $190M
- Close over 800 loans annually
- Average loan amount is $8,000

Engineering Services

- Independent 3rd party investigators
- Investigated over 30M square feet of buildings
- Average building sees a less then 2 year payback

Research

- Nationally recognized
- Research informs all of our programs
- Published over 125 technical papers

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
- Assessment of through-wall condensing furnace/AC packages
- Multifamily aerosol envelope air sealing
- Indoor pool optimization

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

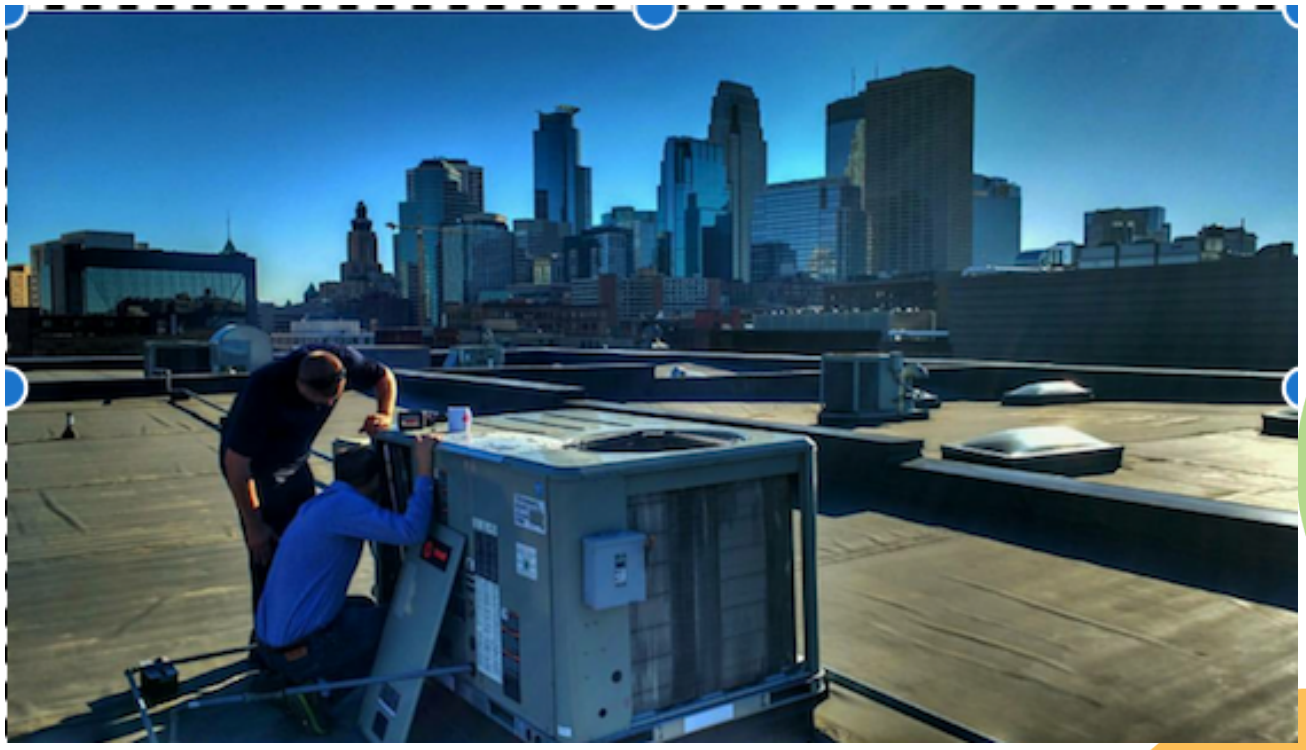
Abstracts and full reports available at **mncee.org**

Innovation Exchange

Current multifamily energy efficiency programs

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

Energy use and building performance



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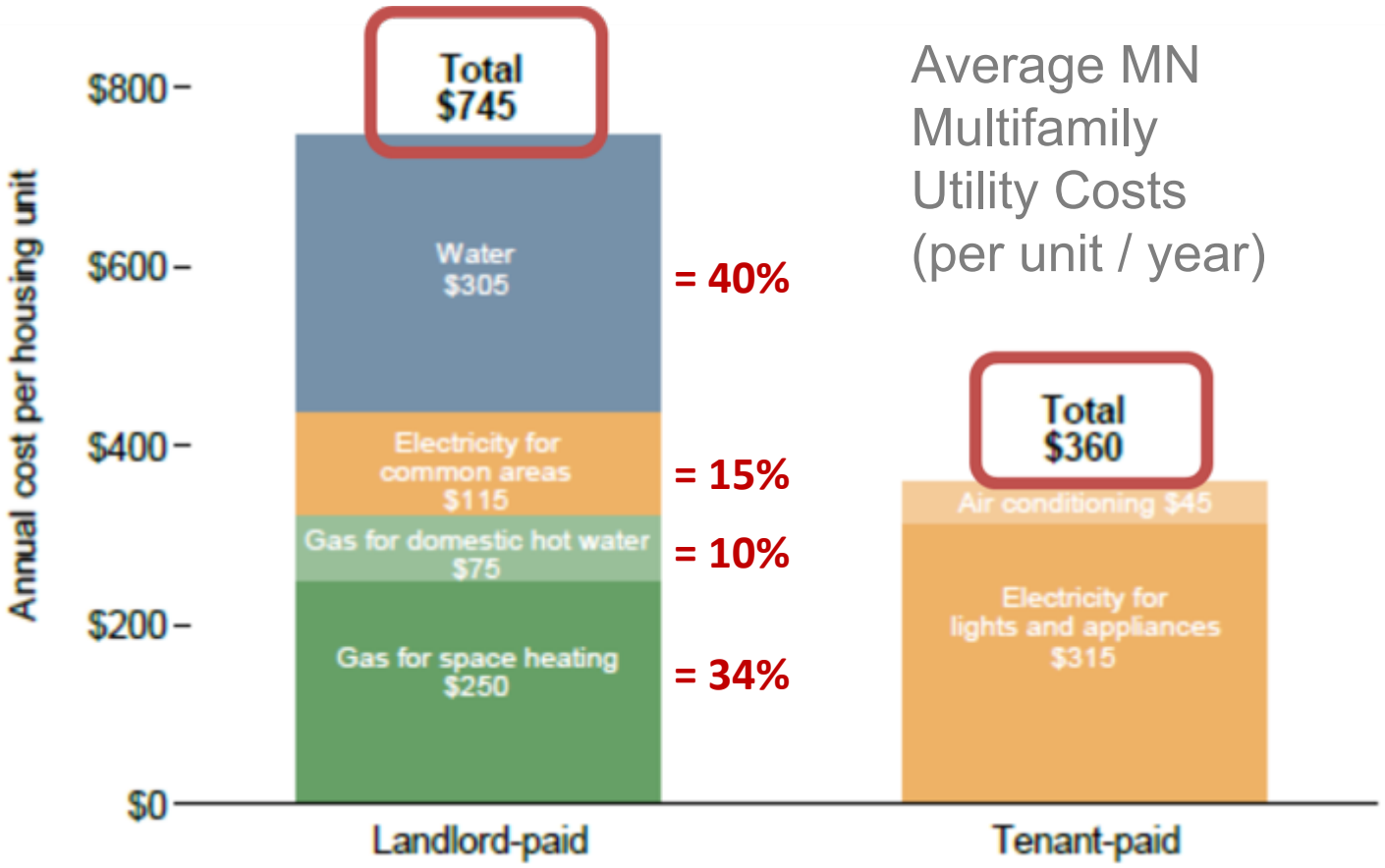
Water and space heating costs dominate

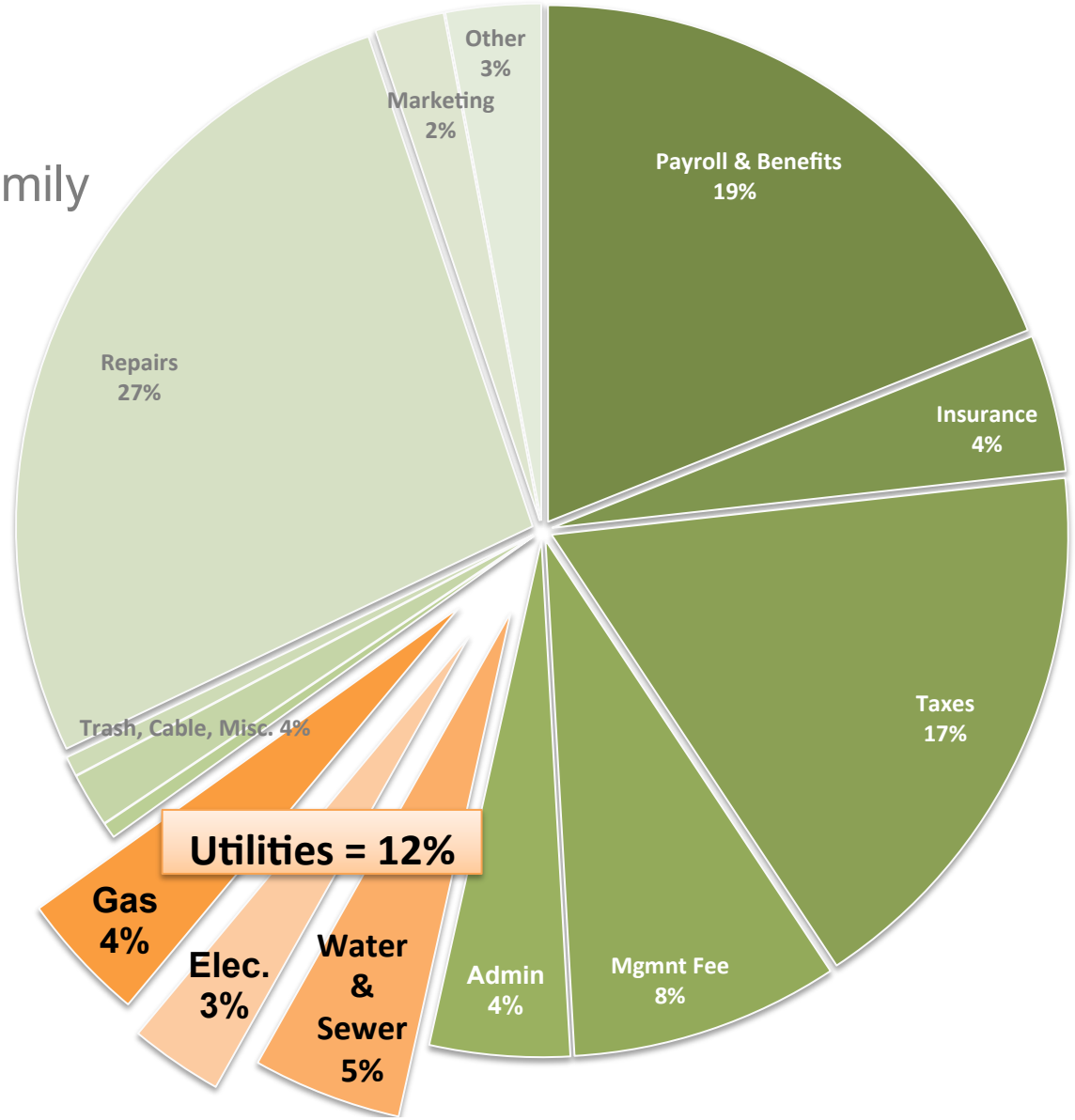


Average MN Multifamily Utility Costs (per unit / year)

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

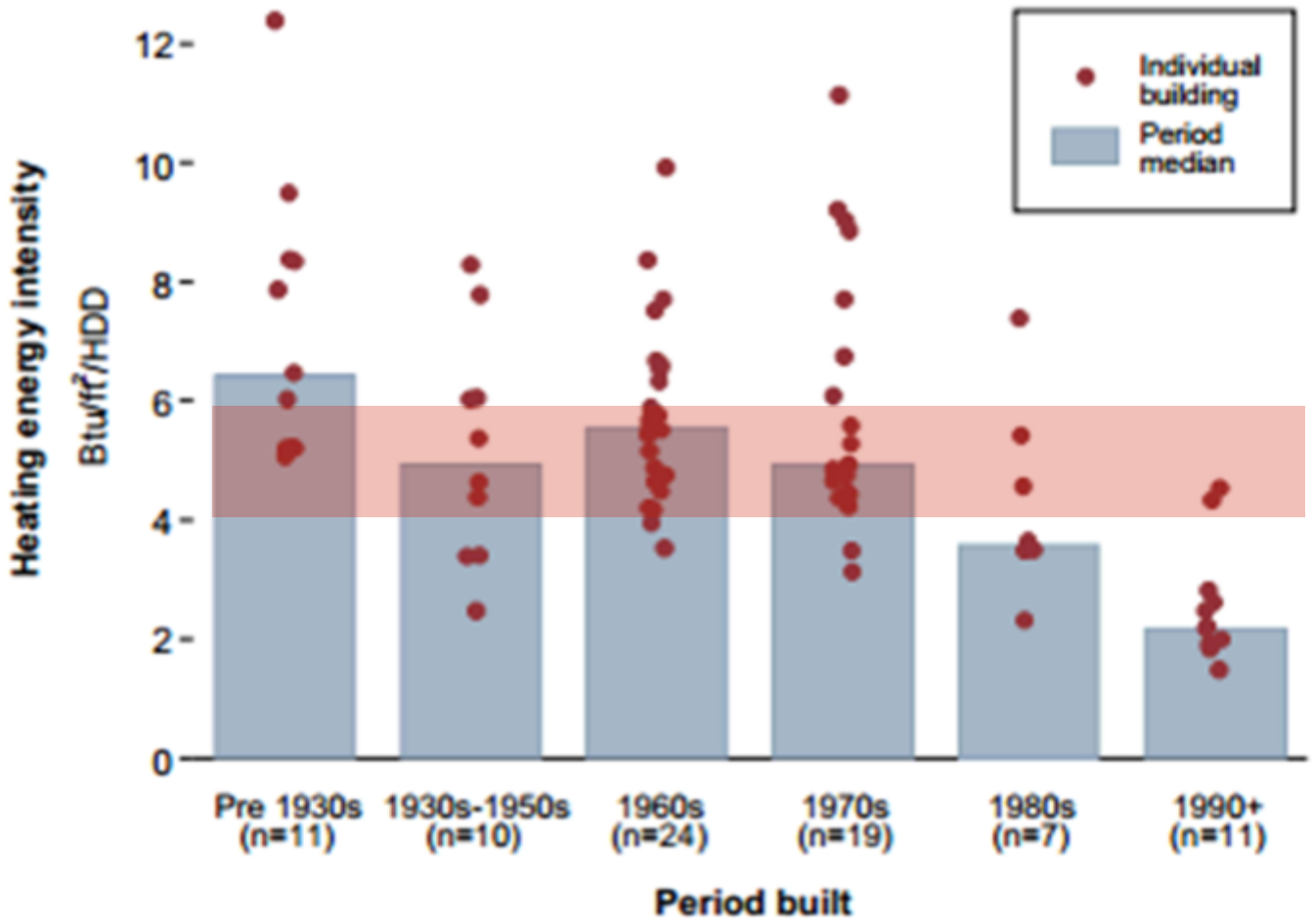
…And yet they are a small piece of the expense pie

Average MN Multifamily operating expenses



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

High energy users in (almost) every age category



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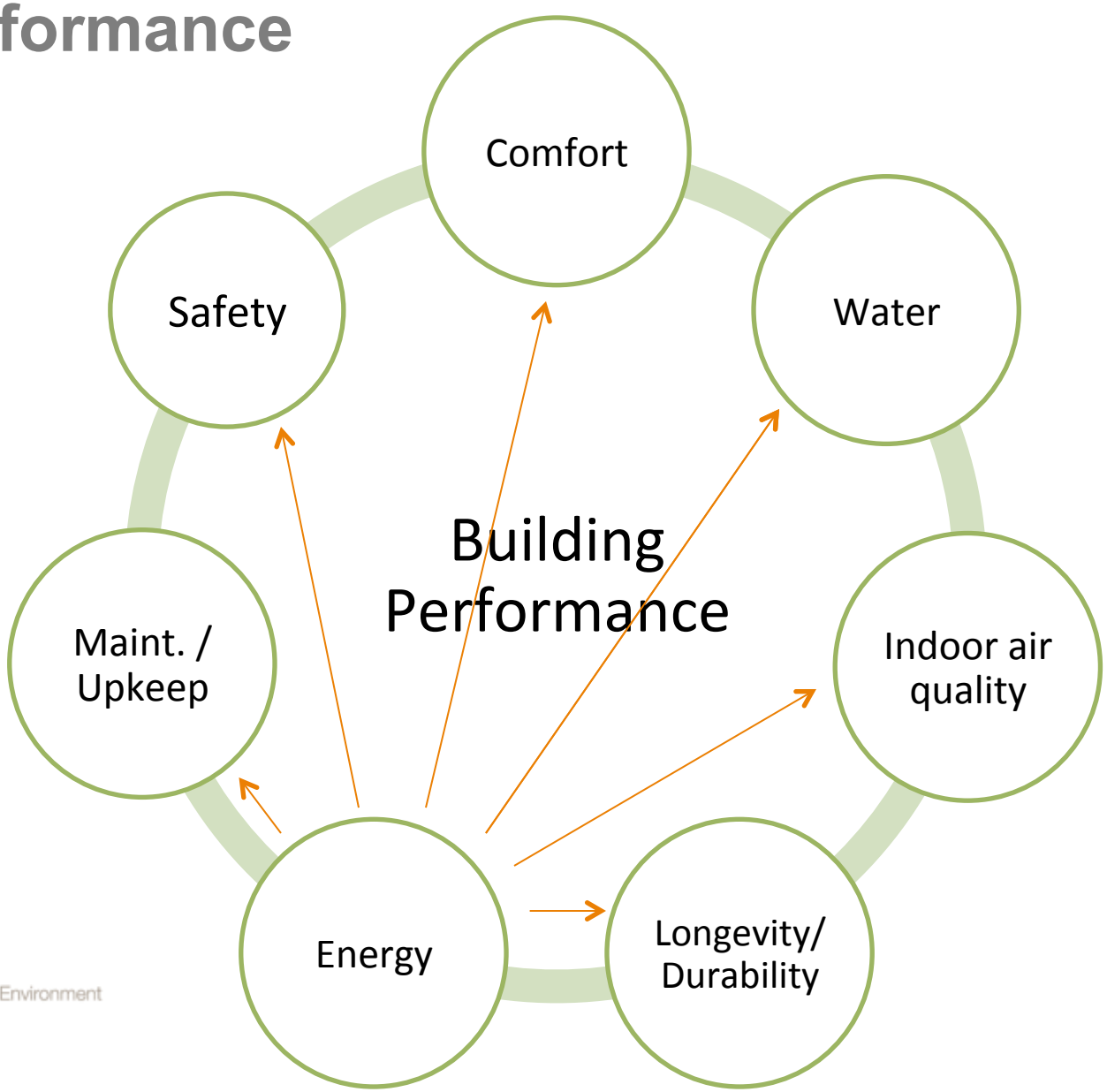
SOURCE: Minnesota Multifamily Rental Characterization Study, Energy Center of Wisconsin and Franklin Energy, 2013; sampled 120 bldgs in MN (78 in Twin Cities, 66 Greater MN)

Drivers of building energy use

- Efficiency of equipment (Boilers, water heaters, lighting, appliances, ventilation equipment, etc)
- Windows, insulation and envelope details
- Building maintenance protocols
- Staff practices & building operation
- Weather
- Location of building
- Resident habits

Building energy use affects building performance



Energy efficiency should improve building performance

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
- Improves equip. durability

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Marketable energy efficiency strategies for MN multifamily

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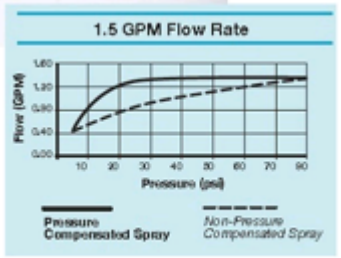
Laundry list items

- Low flow water fixtures
  - Showerheads, aerators, toilets
- Lighting
  - LED replacement, occupancy sensors
- High efficiency washing machines
- Programmable thermostats for common spaces
- Pipe insulation
- Attic insulation and air sealing
- Water heater setting (120 degrees F)

High-efficiency fixtures

Low-flow showerhead, 1.5 gpm
Standard, 2.5 gpm



WaterSense
Meets EPA Criteria
Certified by CSA International

Low-flow aerator, 0.5-1.0 gpm
Standard, 2.2 gpm

Payback on investment: 1-3 years

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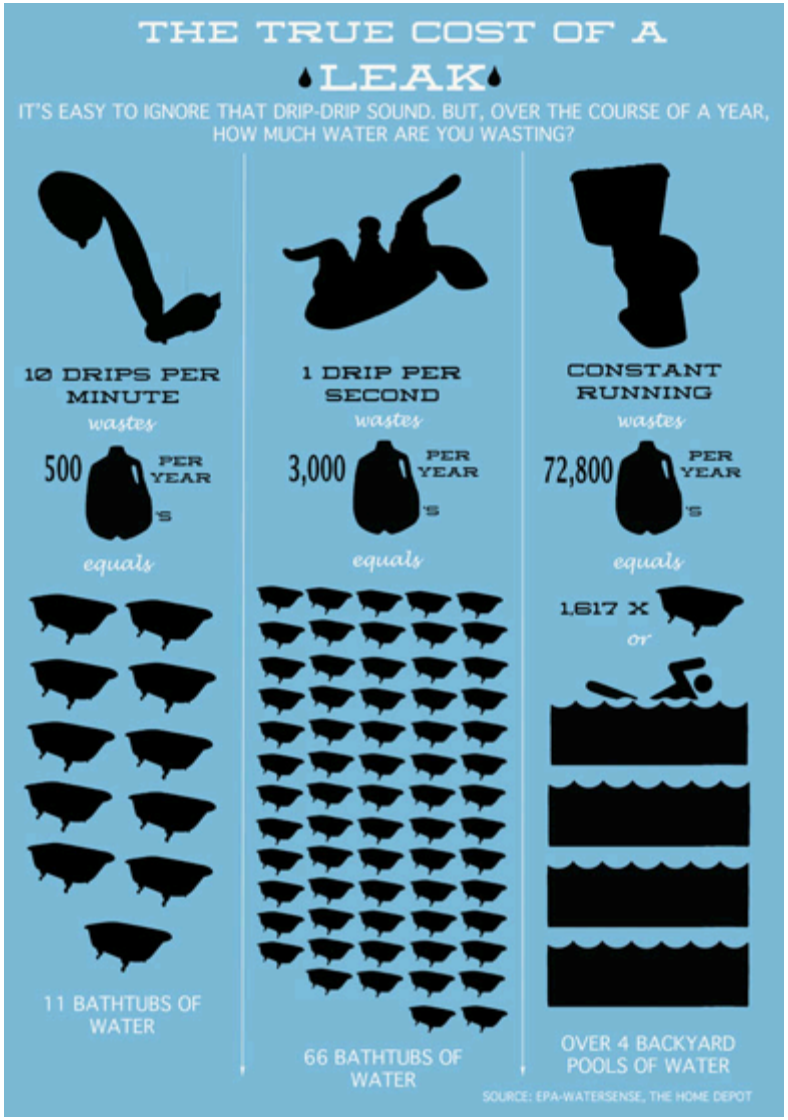
Curbing leaks

- Encourage reporting of faucet drips and running toilets



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savewatersantafe.com

Get rid of *all* incandescent bulbs

- CFL or LED replacements are both good options
- $5+ / year / bulb energy savings when you replace an incandescent
- LED last 50,000 hours rather than 8-10,000 for CFL or 1,200 for incandescent
  - Maintenance costs saved on longer bulb life

Lineal fluorescent corridor or garage lighting

- T12 lamps to T8
- Magnetic ballasts to electronic
- Look for rebates

"Change them now"

Payback:
2-3 years

Other lighting upgrades: Occupancy sensors or timers

- Community rooms
- Computer rooms
- Laundry rooms
- Stairwells
- Garages (partial)
- Hallway (partial)

Pipe insulation

Insulate all accessible pipes

Heating pipes

Payback ≈ 3.5 years

Hot water pipes

Payback ≈ 3 years

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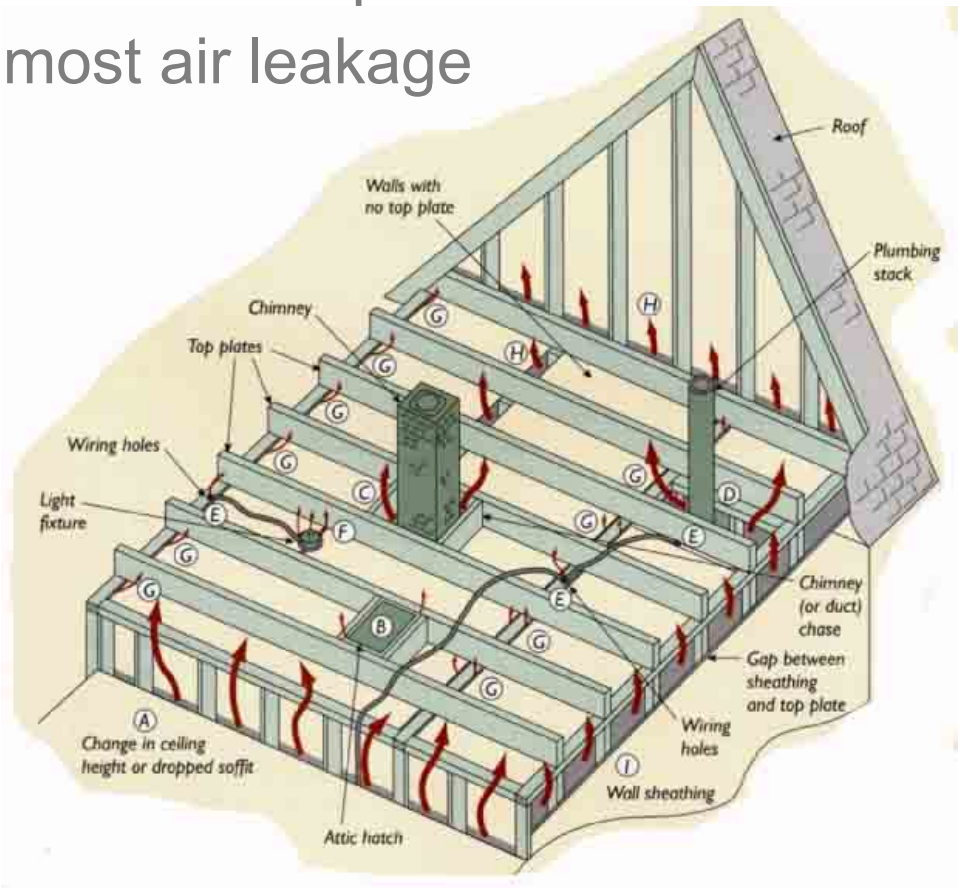
Air-sealing: Stop attic air leaks

Air sealing is sealing holes that leak heated air in a building shell with a material that stops air (caulk or foam)

- Attic air leaks can cause ice dams on pitched roofs
- Pre-WWII buildings have most air leakage



Garage Ventilation: CO monitoring controls and garage thermostat 50°F max

- Monitors Carbon Monoxide levels and operates ventilation system only when CO levels are high
- Garage thermostat at 50°F maximum

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

- Optimizing existing 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 Boiler Controls

Control boilers for optimal efficiency

- Condensing & non-condensing boilers
- Optimized outdoor reset
- Finding the lowest max output temp for the building
- Sequencing and staging for optimal efficiency

Boiler outdoor reset and warm weather shutdown controls

10-15% savings on heating costs

Reduced over-heating

Longer boiler cycles

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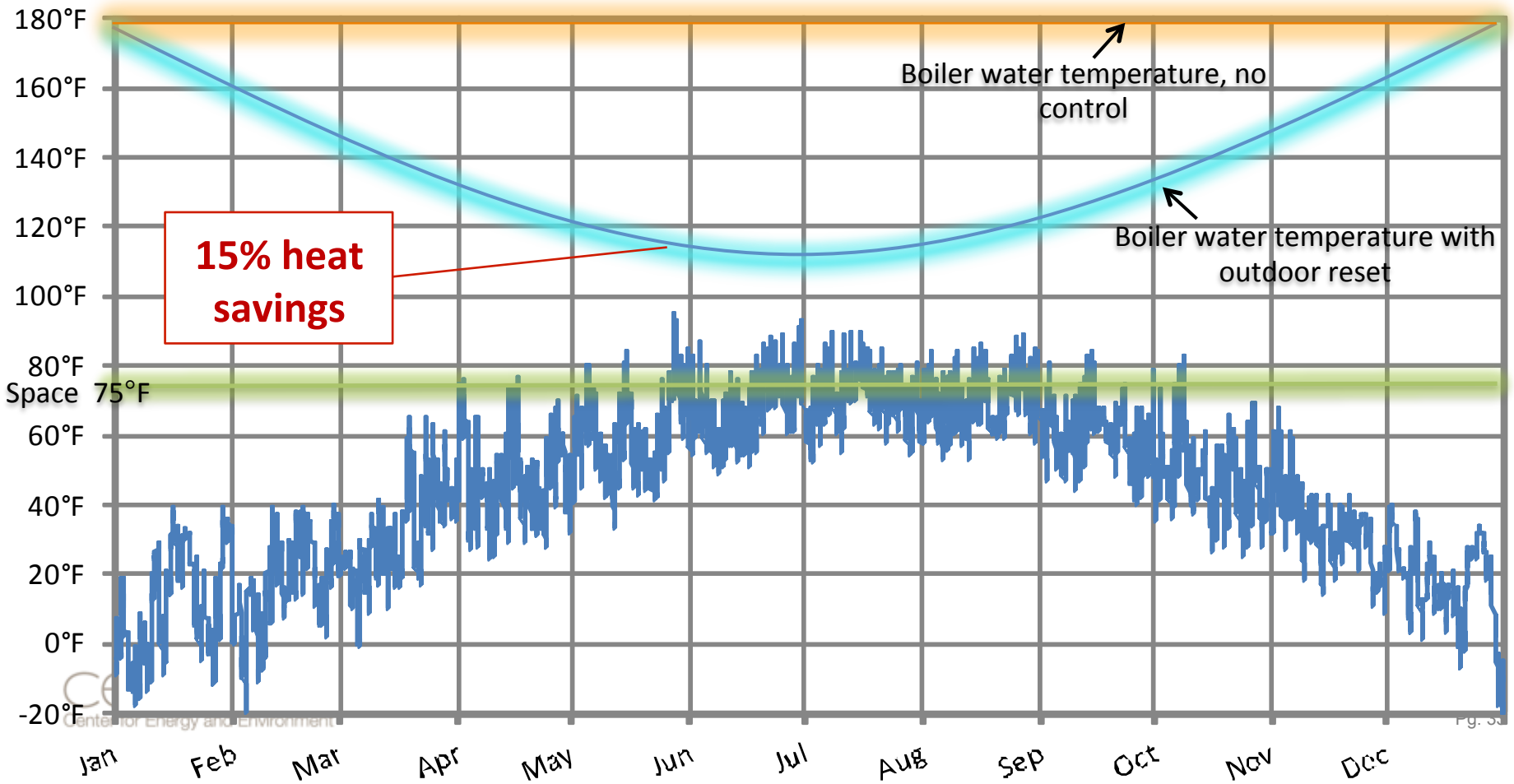
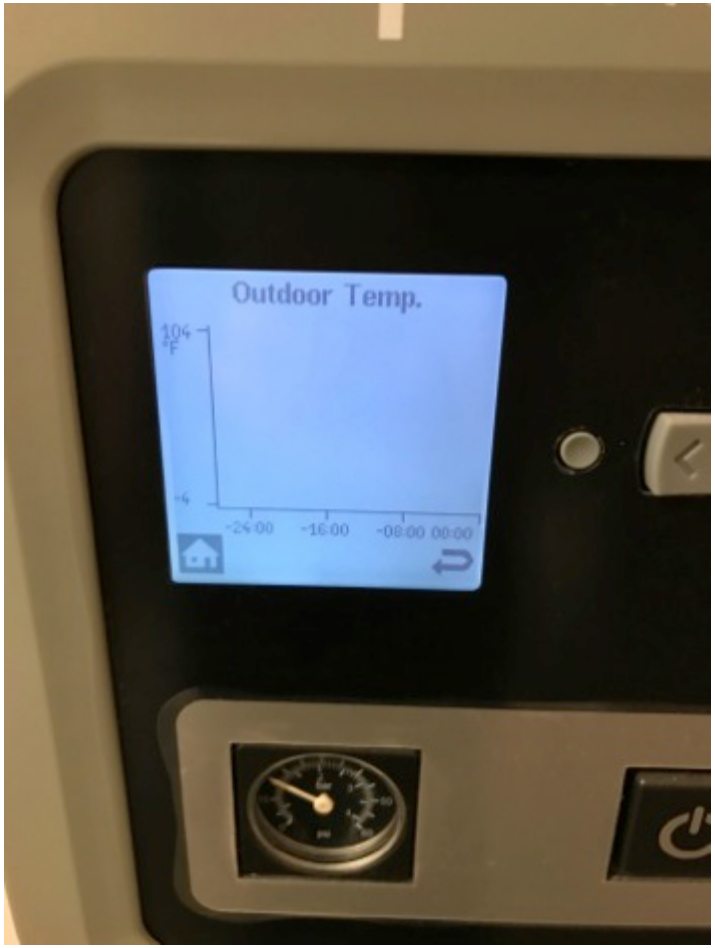
Control the boiler so it doesn't exceed demand

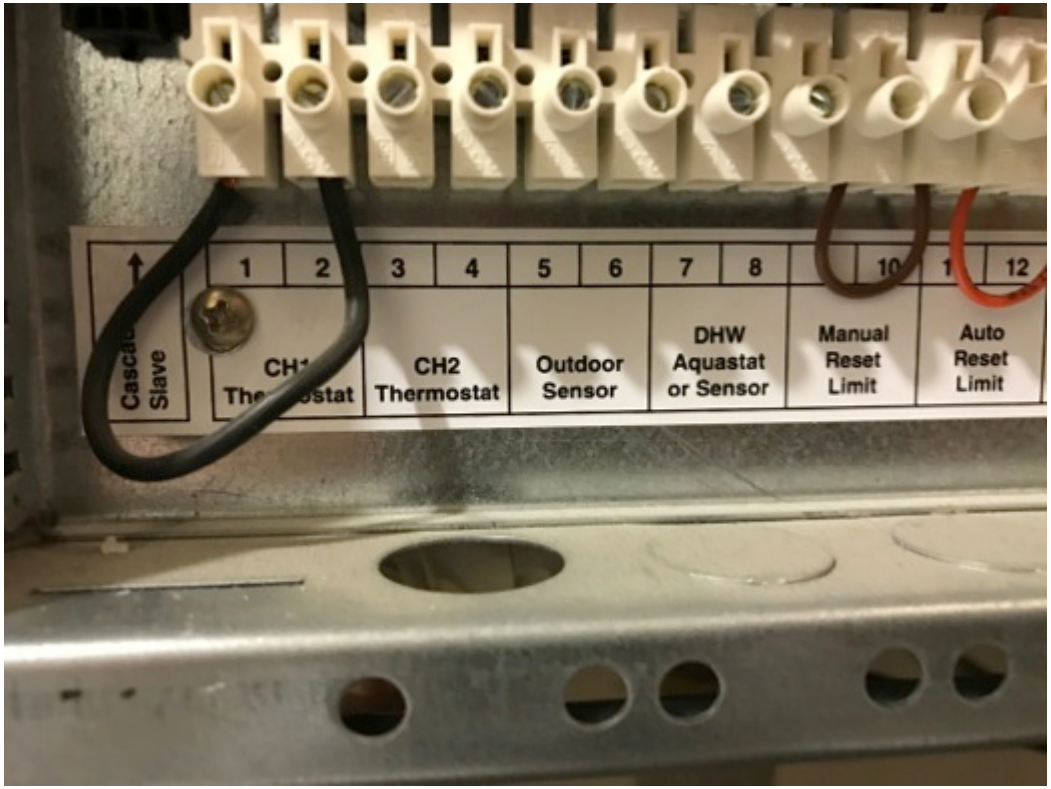
Outdoor reset lowers boiler water temperature

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



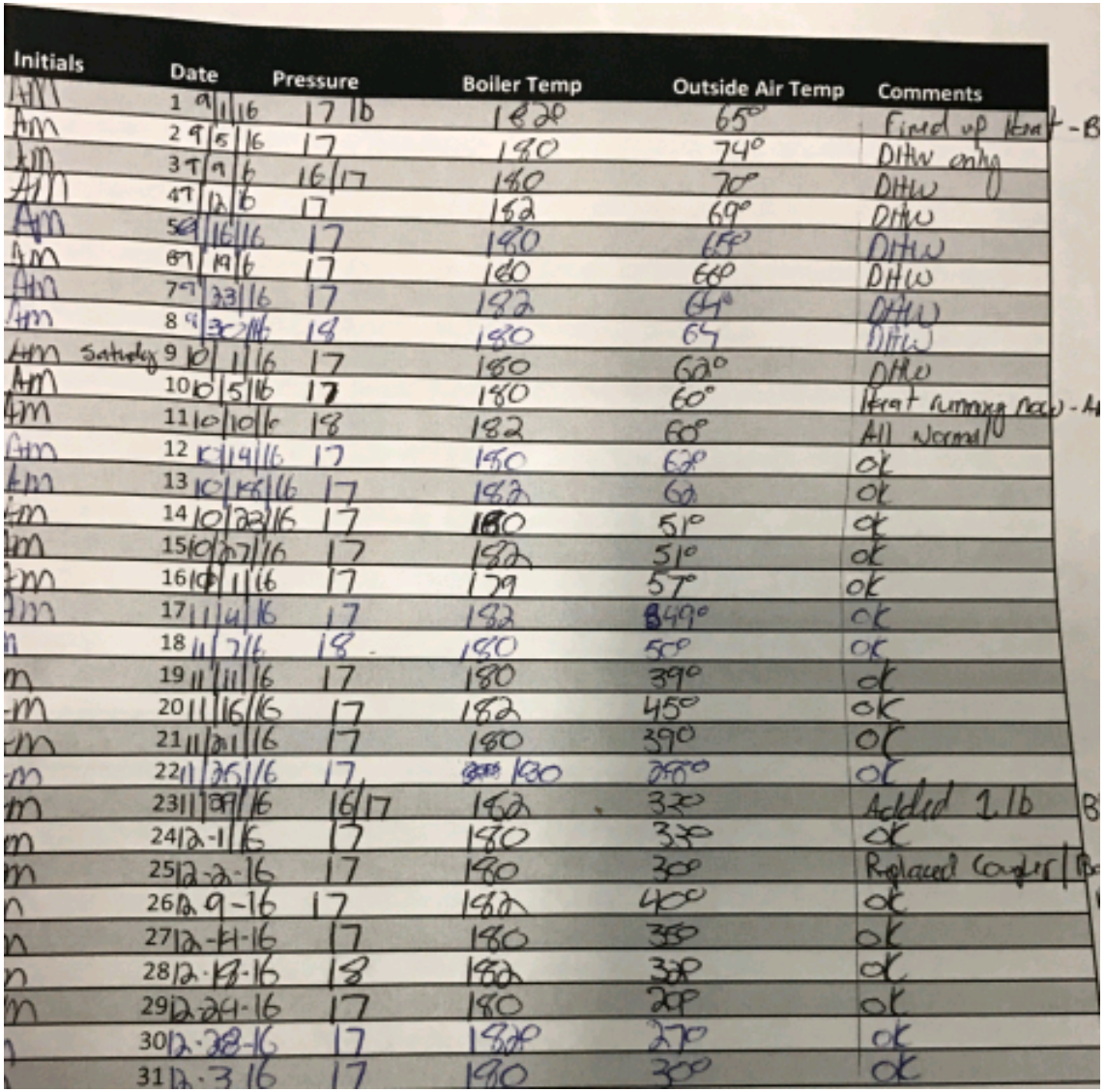
There’s something wrong with these pictures





15 minutes could save you 15% on your heating bill

Boiler Room Log: Note the boiler temp vs. outside air temp



Initials	Date	Pressure	Boiler Temp	Outside Air Temp	Comments
AM	1 9/1/16	17 lb	180	65°	Fired up Heat - B
AM	2 9/5/16	17	180	74°	DHW only
AM	3 9/9/16	16/17	180	70°	DHW
AM	4 9/12/16	17	182	69°	DHW
AM	5 9/16/16	17	180	65°	DHW
AM	6 9/19/16	17	180	68°	DHW
AM	7 9/23/16	17	182	64°	DHW
AM	8 9/30/16	18	180	64	DHW
AM Saturday	9 10/1/16	17	180	62°	DHW
AM	10 10/5/16	17	180	60°	Heat running now - A
AM	11 10/10/16	18	182	68°	All Normal
AM	12 10/14/16	17	180	62°	ok
AM	13 10/18/16	17	182	60	ok
AM	14 10/22/16	17	180	51°	ok
AM	15 10/27/16	17	182	51°	ok
AM	16 11/1/16	17	179	57°	ok
AM	17 11/4/16	17	182	49°	ok
AM	18 11/7/16	18	180	50°	ok
AM	19 11/11/16	17	180	39°	ok
AM	20 11/16/16	17	182	45°	ok
AM	21 11/21/16	17	180	39°	ok
AM	22 11/25/16	17	180	35°	ok
AM	23 11/29/16	16/17	182	32°	Added 1 lb B
AM	24 12-1-16	17	180	32°	ok
AM	25 12-2-16	17	180	30°	Replaced Cooler B
AM	26 12-9-16	17	182	40°	ok
AM	27 12-11-16	17	180	35°	ok
AM	28 12-18-16	18	180	32°	ok
AM	29 12-24-16	17	180	20°	ok
AM	30 12-28-16	17	180	27°	ok
AM	31 12-31 16	17	180	30°	ok

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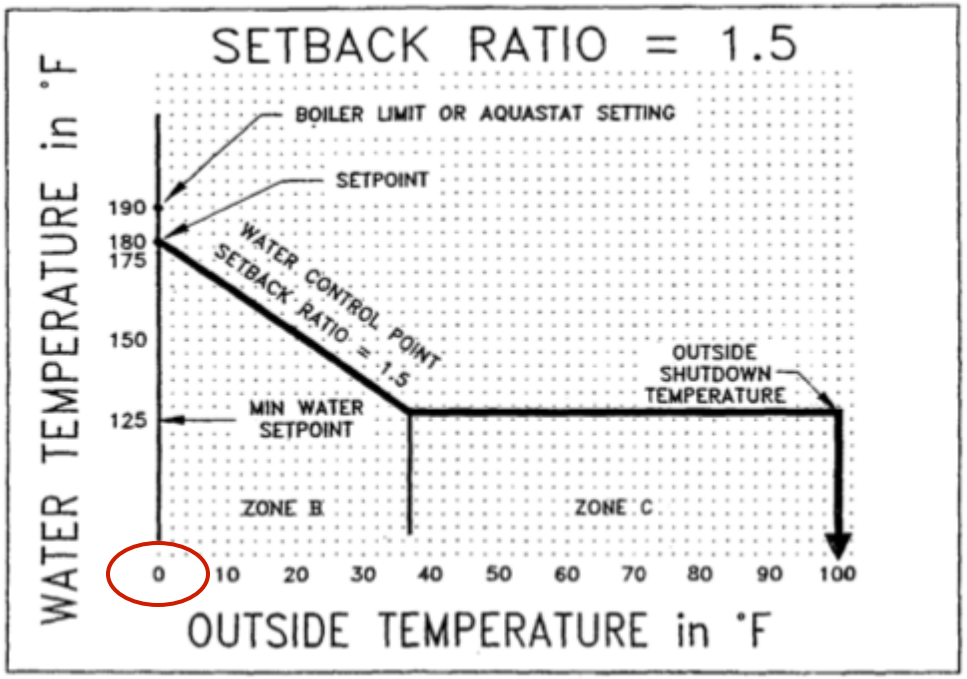
Outdoor reset adjustment

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

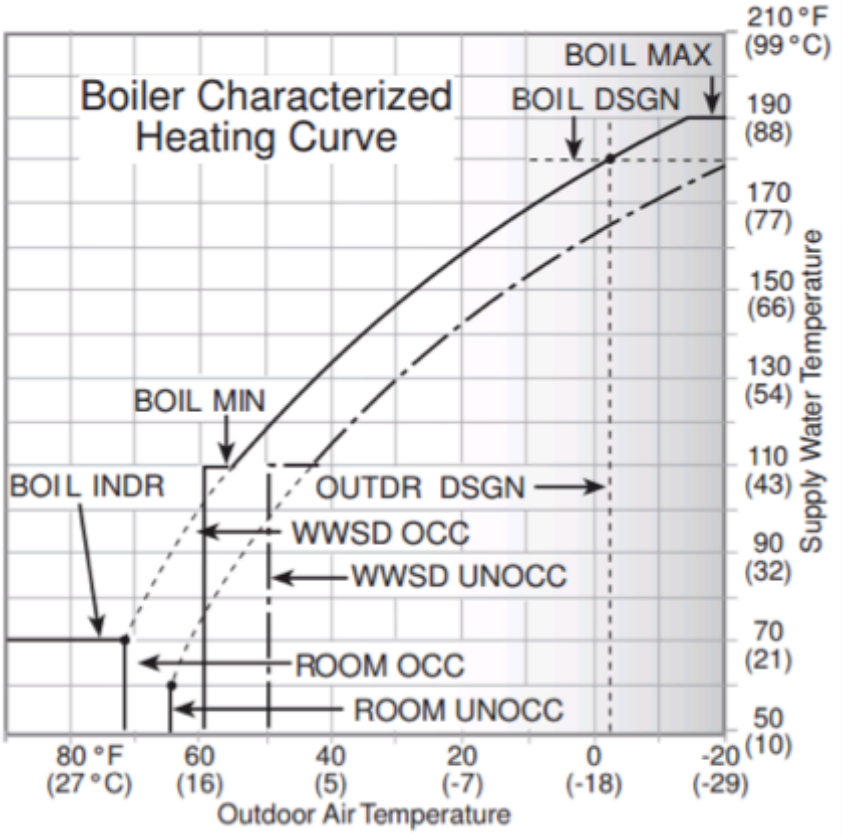
At replacement: Identify boiler control limitations

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

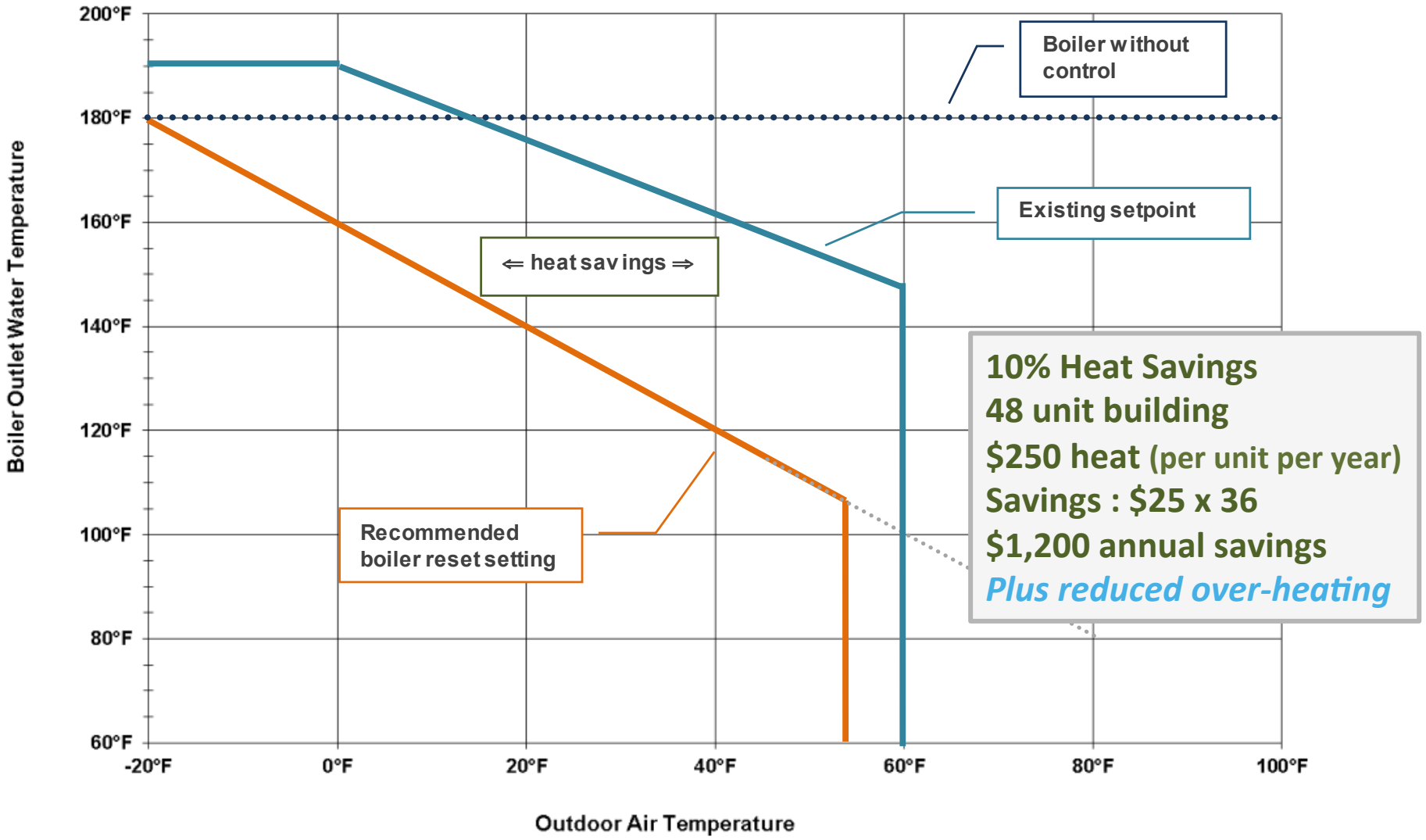


Understanding reset control settings

- Outdoor design
- Boiler indoor/indoor design/Room design
- Boiler design
- Boiler max
- Boiler min
- WWSD/Shutdown



Adjusting outdoor reset—dollars and cents



Make it easy!!

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Tekmar 254
settings for
Reset/Cutout
control

Multifamily Boiler Outdoor Reset / Cutout Control
Operating Guidelines©

The tables and charts that follow are CEE's recommended operating guidelines for your building's boiler outdoor air reset and cutout control. Recommended initial settings are based on actual field experience with typical multifamily buildings. However, your specific building may require fine-tuning of the controller settings, as specified in the fine-tuning adjustments instructions later in this document. The final controller settings are expected to lie within the adjustment ranges noted in the attached tables and charts.

Your basic process is as follows:

1- Make adjustments to your reset and cutout control settings according to our "Recommended Initial Settings" instructions

2- Observe building operation

3- Utilize Zone-Specific Issues Checklist (below) to address any zone-specific problems

4- Make adjustments to the reset controller utilizing the "Fine Tuning Adjustments"

5- Record all adjustments or over heating/under heating complaints and subsequent control adjustments on the "Control Settings Log"

Zone-Specific Issues Checklist

Zone-specific problems must be identified and corrected before fine-tuning the boiler control settings in response to a tenant complaint or observed over/under heating. Below is a list of common zone-specific problems that should be checked when there is a problem.

- **Thermostat is inaccurate** (check against thermometer), is improperly located (next to heater or window), or doesn't provide proper signal (check for proper on-off of 24 volt output to zone valve as thermostat is adjusted above and below the current temperature).
- **Zone valve isn't operating or doesn't close tightly.** Feel pipe temperature in the zone compared to the main line temperature to see if hot water is circulated when it should and shouldn't be. Manually opening and closing the valve a few times often corrects problems with the valves being temporarily stuck open or closed. If a valve still doesn't respond properly to the thermostat, it may need to be replaced. (Note: Feel the pipe temperature at least one foot from the connection to the main line. Allow time for the pipe and radiators to warm or cool after hot water circulation is changed.)
- **Radiator blockage** by dust, curtains or furniture will reduce the heat output.
- **Unrealistic resident expectations** of apartment temperatures above 75°F may not be met. Similarly, it may not be possible to keep an apartment below 70°F because of heat coming from surrounding apartments. Measure and document apartment temperature with a thermometer when responding to heating complaints to address this potential issue with a resident.

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Keep a record of adjustments

Tekmar 256 control settings log. For best results, record all adjustments made to the boiler control settings and reasons for adjustment.

		Setting	*ROOM OCC*	*OUT DSGN*	*BOIL DSGN*	*BOIL MIN*	*BOIL DIFF*	*WWSD OCC*
		Recommended Initial Setting	80°F	Start with Default (-20°F)	Start with Default (180°F)	115°F	Au (auto differential) or 22°F	55°F
		Normal Range	60°F to 100°F	-30°F to 0°F	150°F to 200°F	105°F to 140°F	10°F to 30°F	50°F to 65°F
Date	Outdoor Temp	Complaint / Problem	Log of Setting Adjustments					
		Measured room temp: _____ Unit # _____						
		Measured room temp: _____ Unit # _____						
		Measured room temp: _____ Unit # _____						
		Measured room temp: _____ Unit # _____						
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Optimizing condensing boilers

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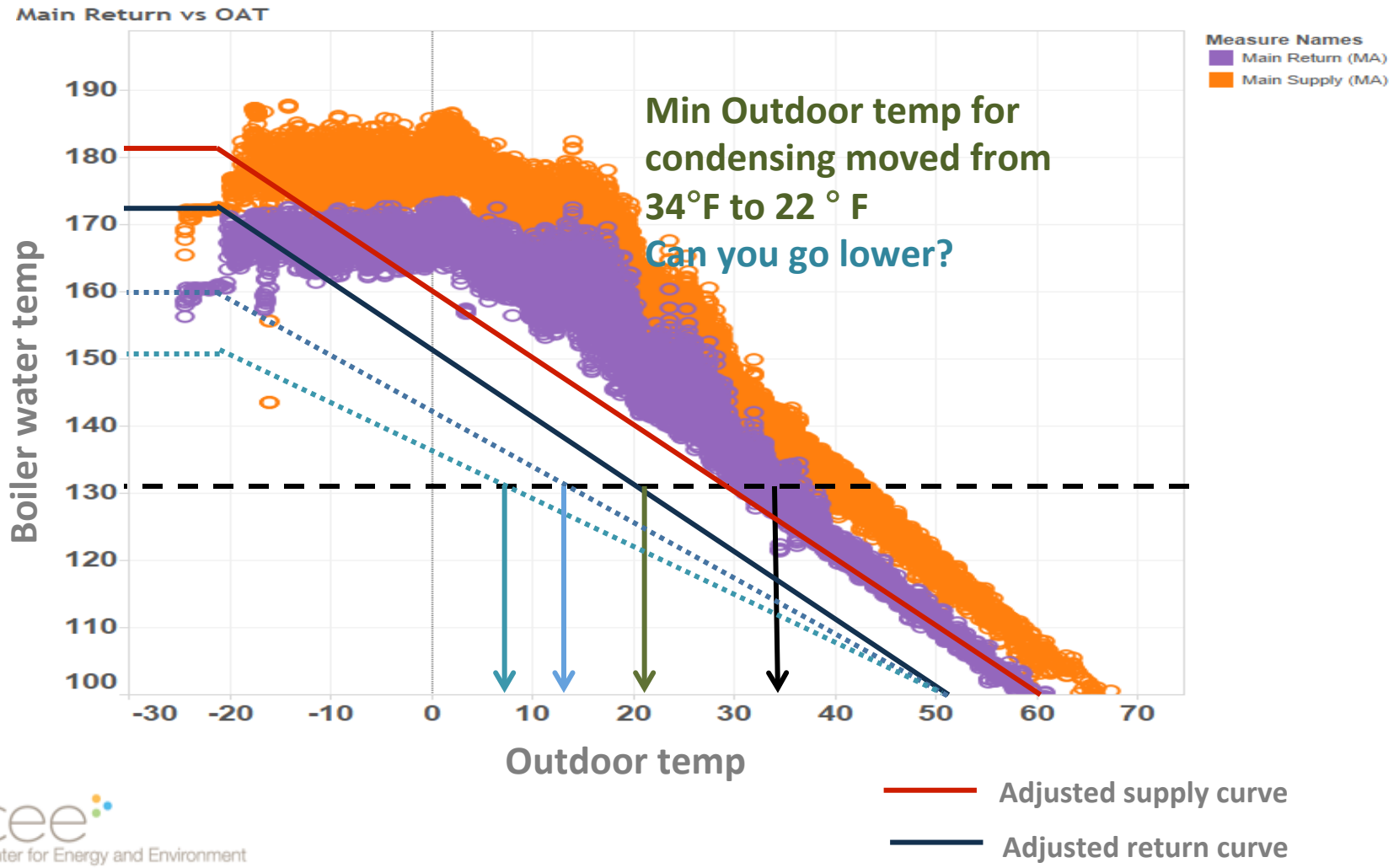
Optimizing outdoor reset



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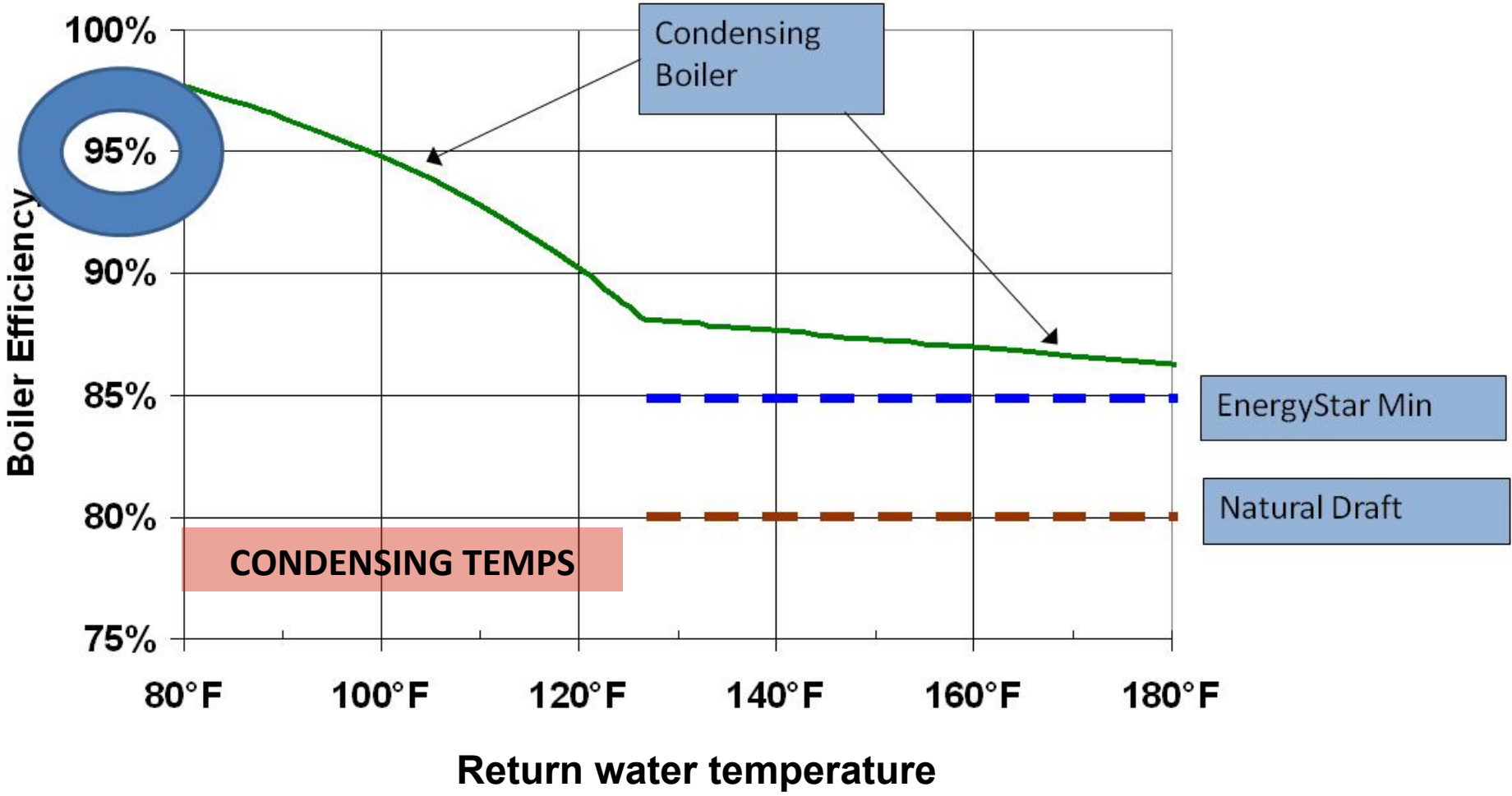
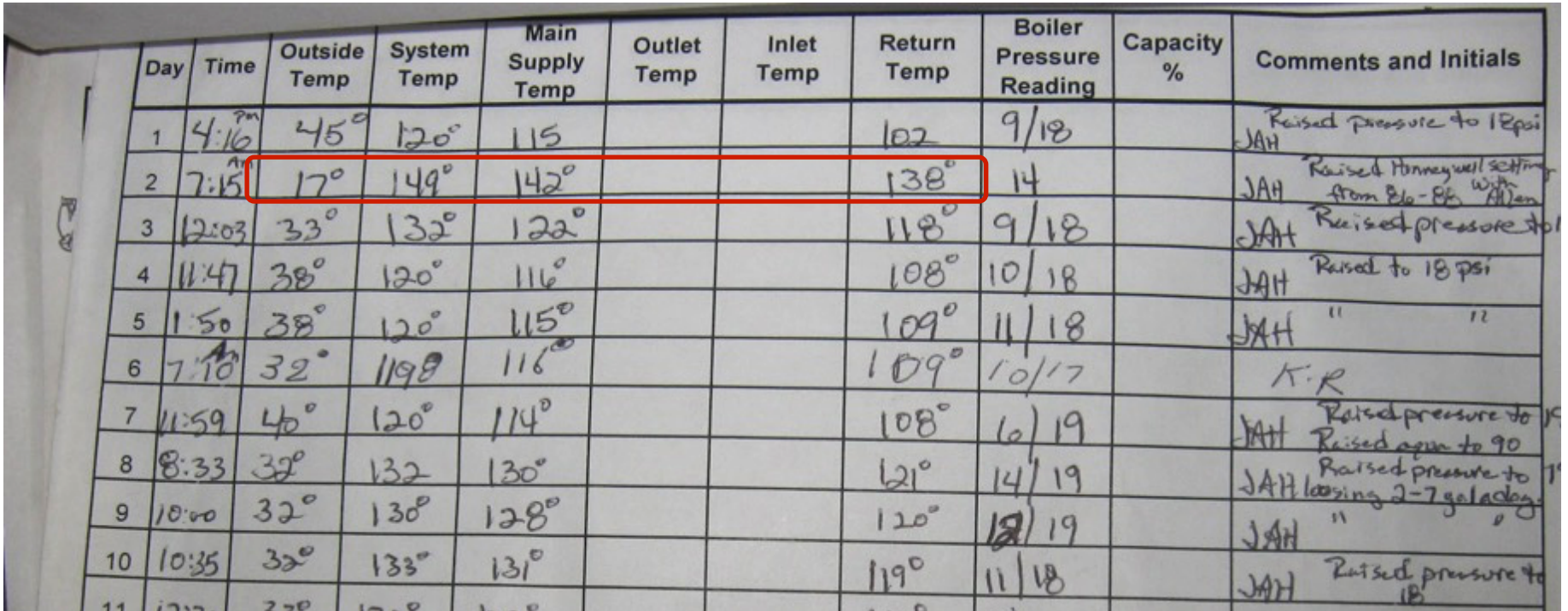
Achieving rated efficiency (>90% efficiency)



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

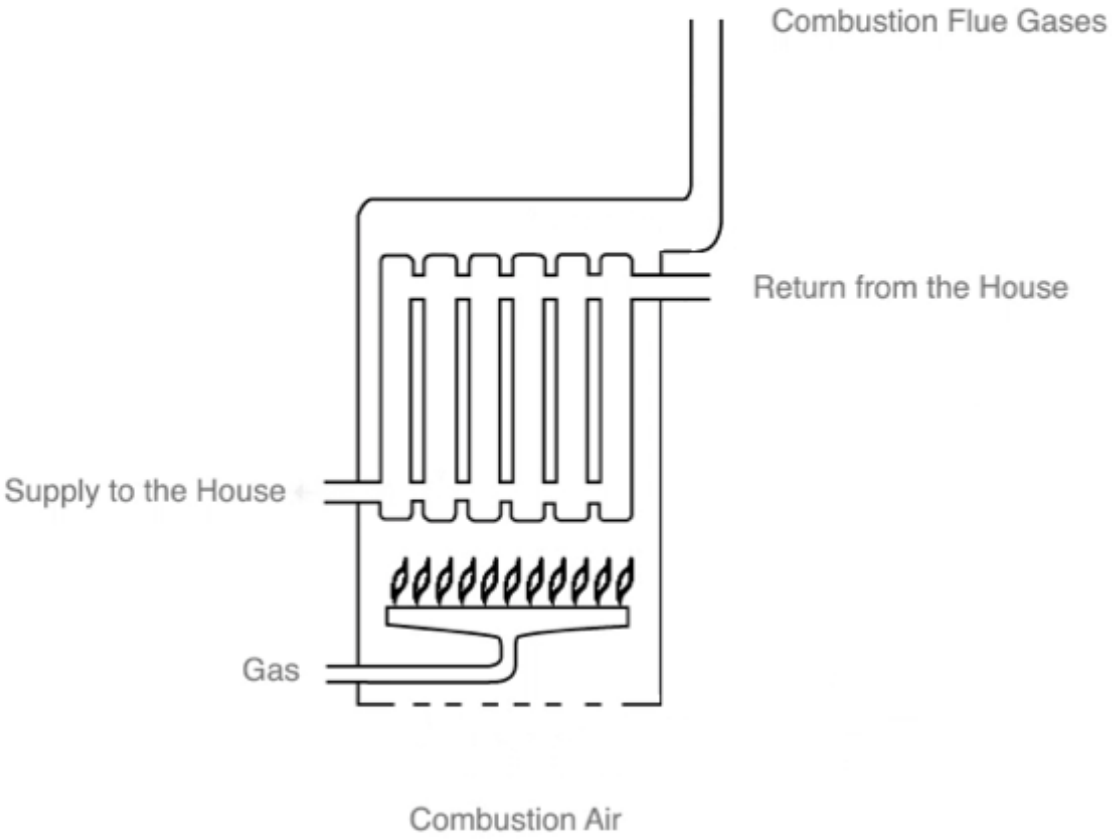
1- Adjust reset temps as low as possible

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

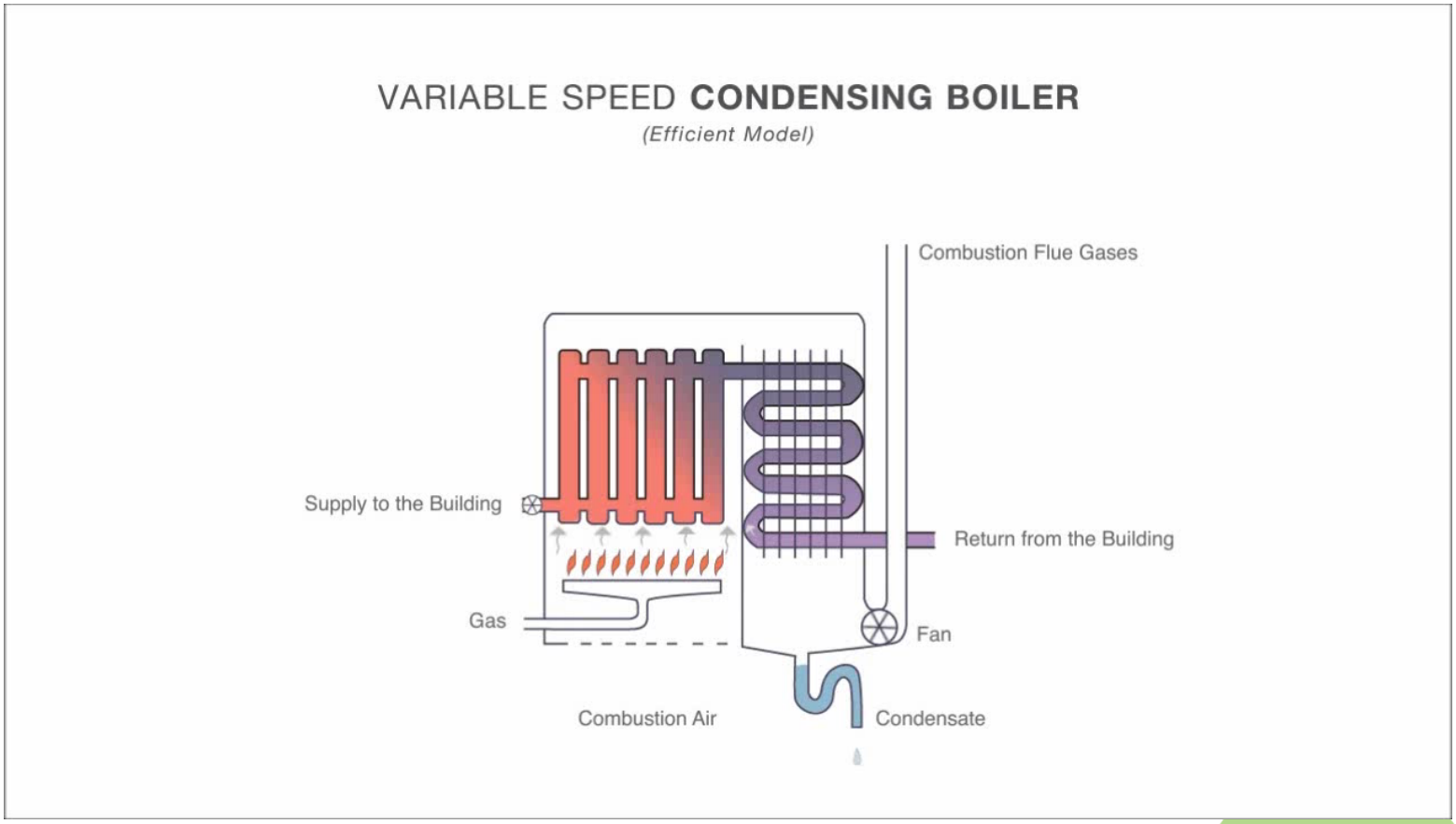


Day	Time	Outside Temp	System Temp	Main Supply Temp	Outlet Temp	Inlet Temp	Return Temp	Boiler Pressure Reading	Capacity %	Comments and Initials
1	4:16 PM	45°	120°	115			102	9/18		Raised pressure to 18psi JAH
2	7:15 AM	17°	149°	142°			138°	14		JAH Raised Honeywell setting from 86-88 with Allen
3	12:03	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 Raised again to 90
8	8:33	32°	132	130°			121°	14/19		JAH Raised pressure to loosing 2-7 go ladies
9	10:00	32°	130°	128°			120°	12/19		JAH " "
10	10:35	32°	133°	131°			119°	11/18		JAH Raised pressure to 18

Conventional boiler



Condensing boiler



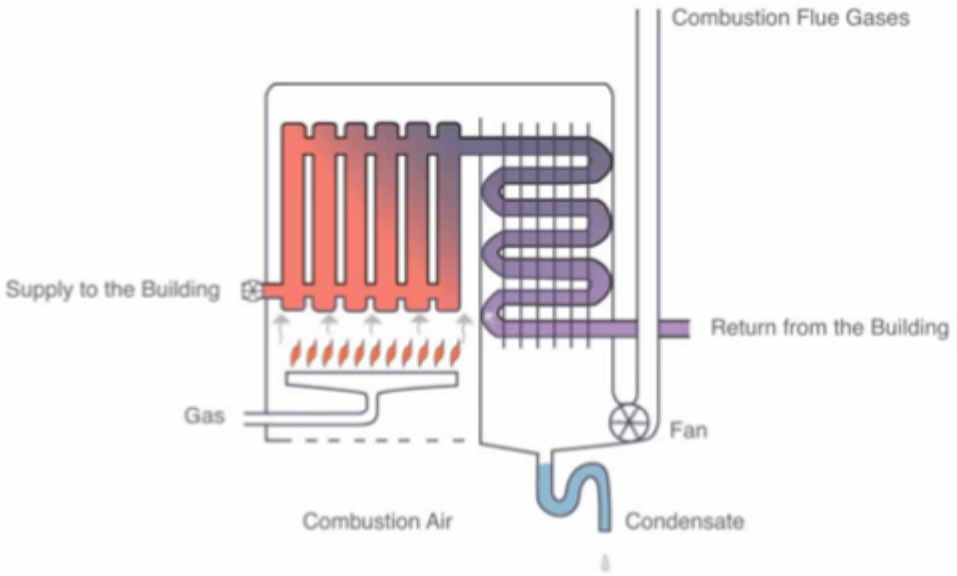
Benefits

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

The key:

Driving down return water temperature and managing excess air

- 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



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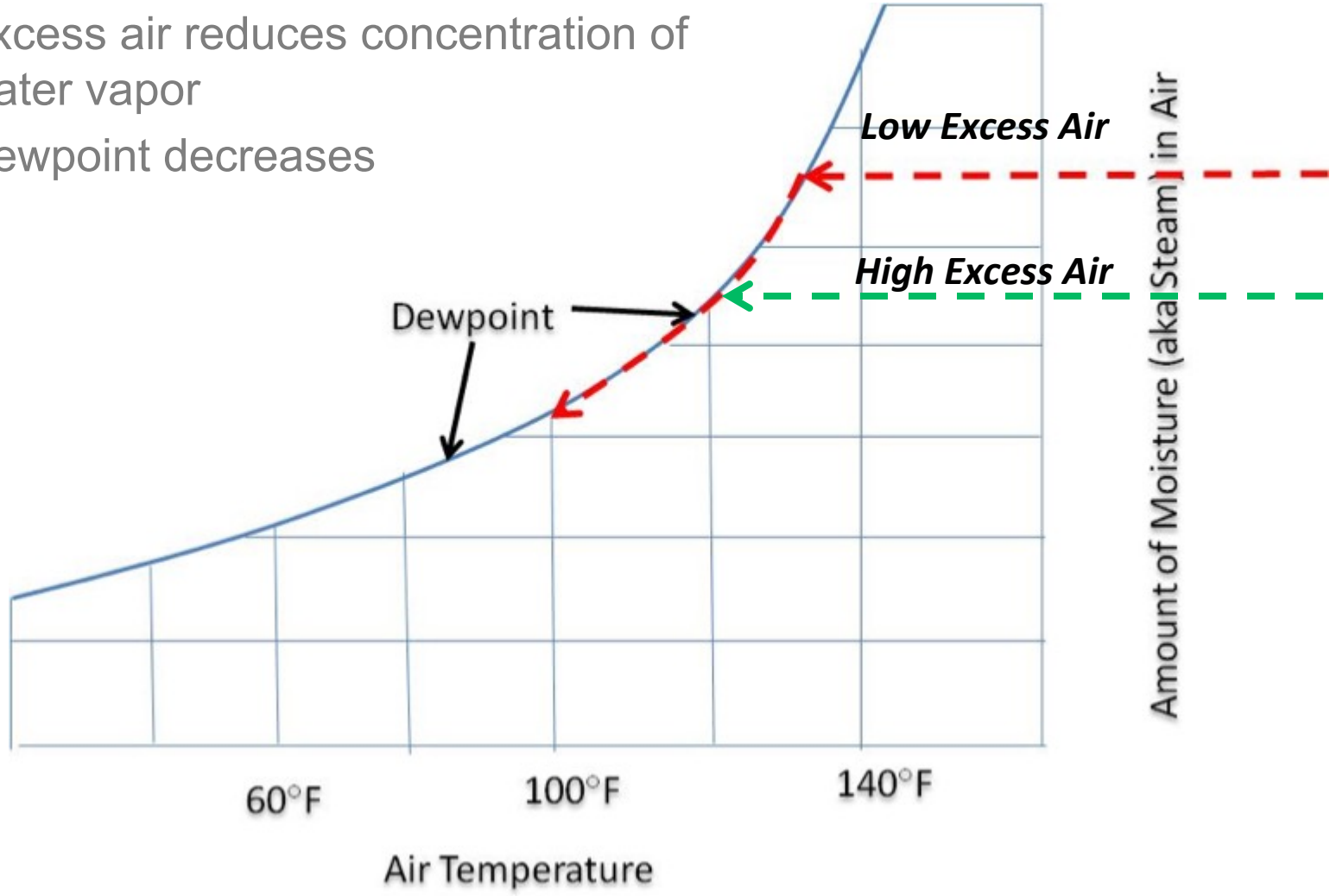
How?

- **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

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
0ppm	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
0ppm	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-_____

Excess air can dictate boiler efficiency

Measured as % Oxygen in flue gas

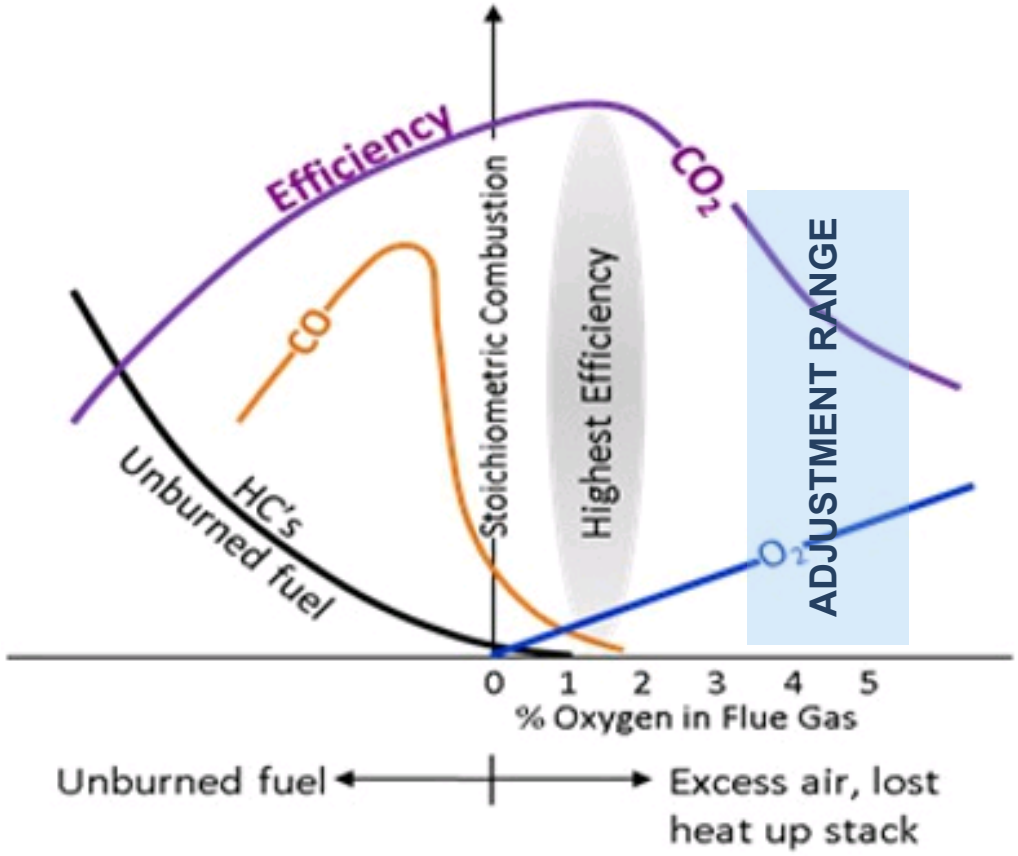


Image source: industrialheating.com

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

Lower output firing stages have increased thermal efficiency

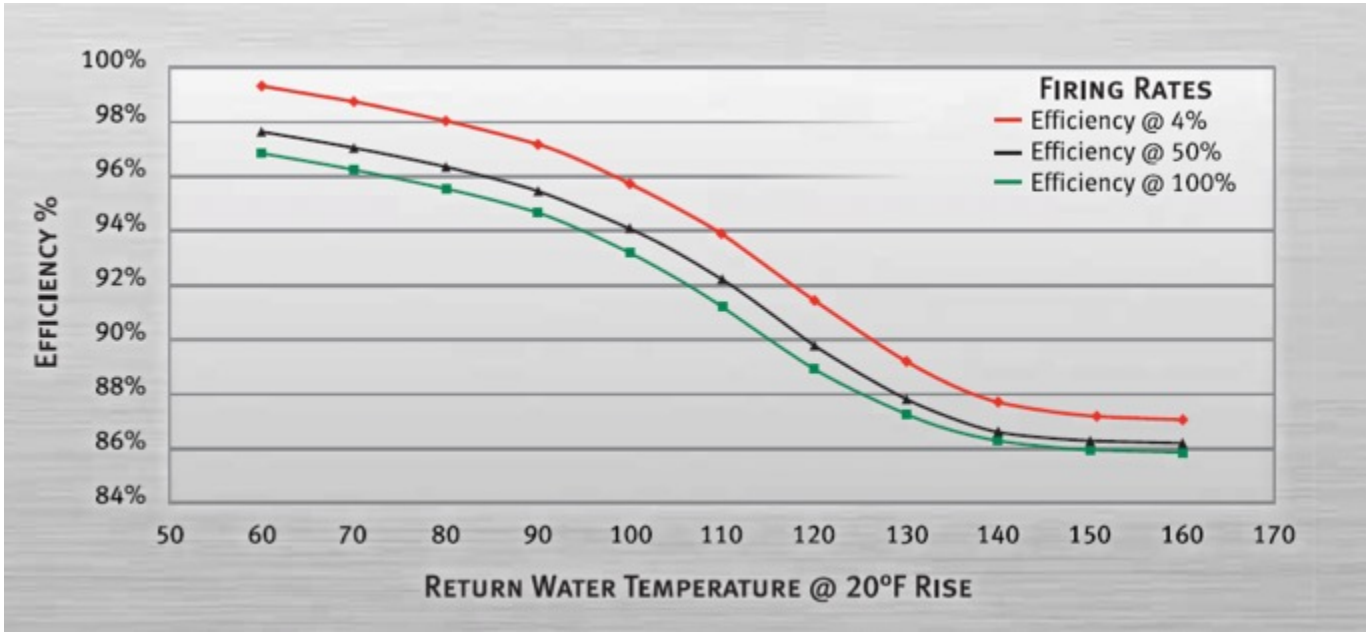


Image source: Lochinvar.com

Lochinvar Knight boiler cascade strategies:

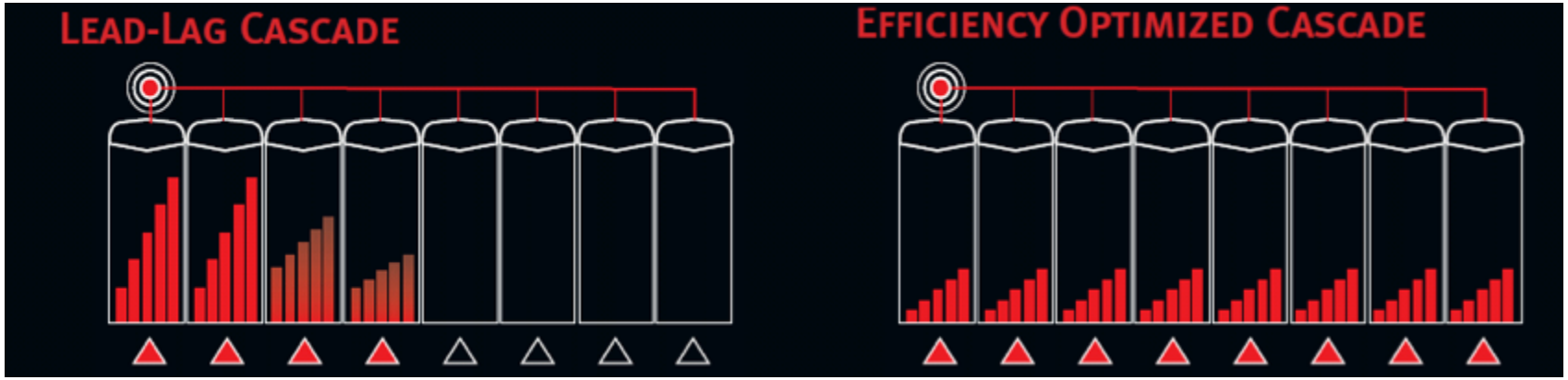
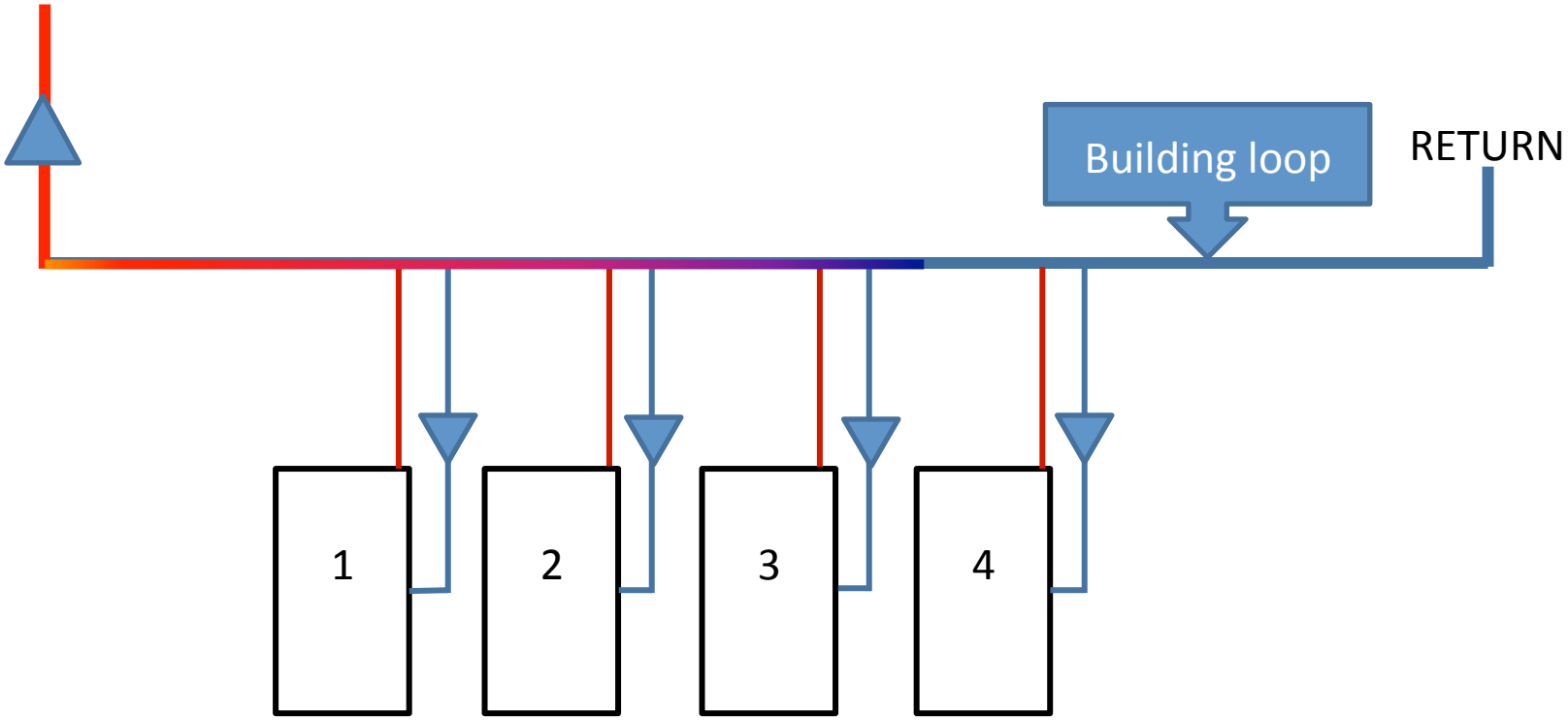


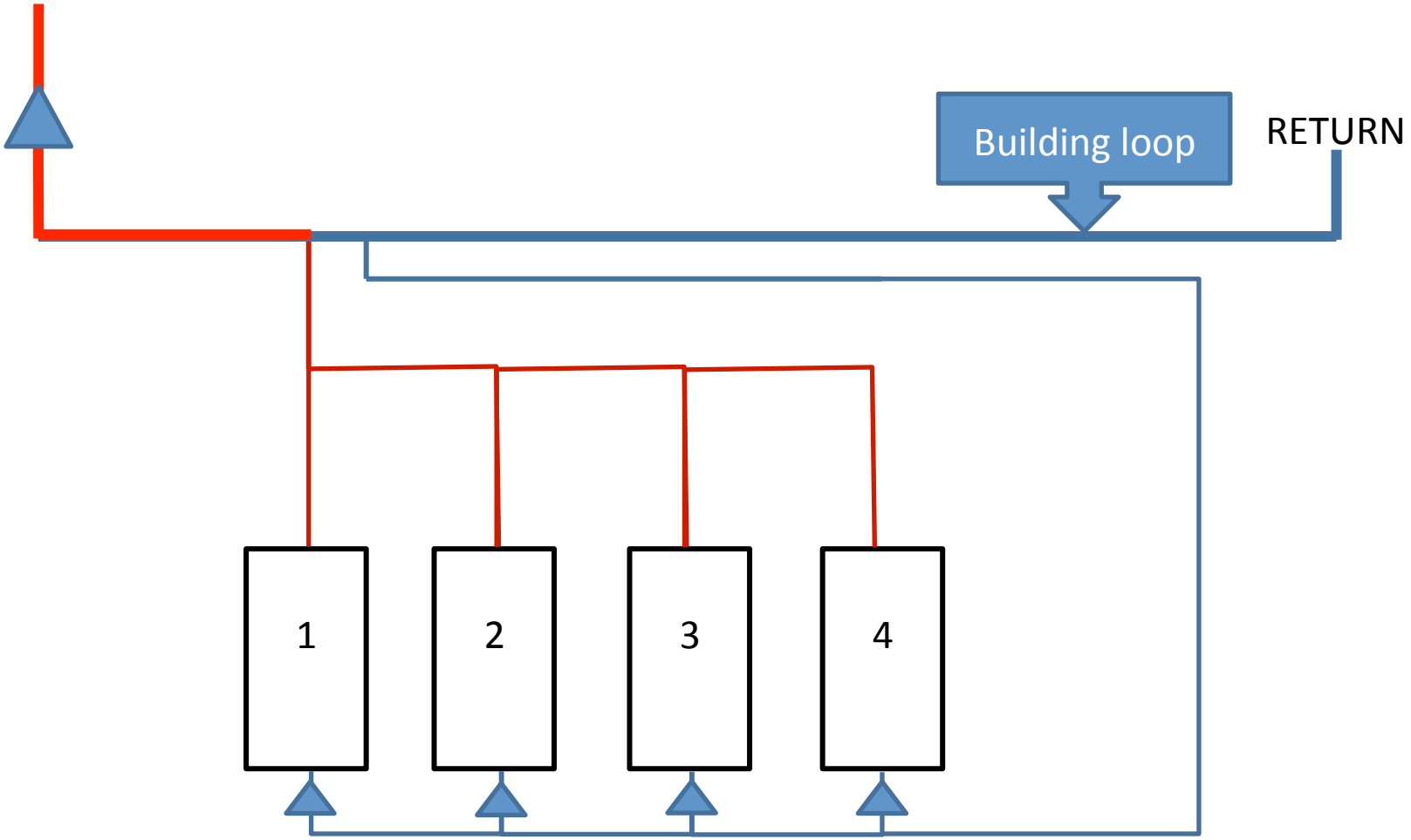
Image source: lochinvar.com

Boiler room piping: address at replacement



Not ideal: Adjacent boilers warm return water

Better piping



Summary: getting condensing boilers to condense!

- Proper oxygen levels in flue gas contribute to optimal condensing conditions
- Maintaining aggressive control settings prolongs condensing capabilities
- VFD pump controls reduce pump speeds at part loads to optimize heat transfer
- Boiler room piping can dictate return water temps

Optimizing ventilation systems

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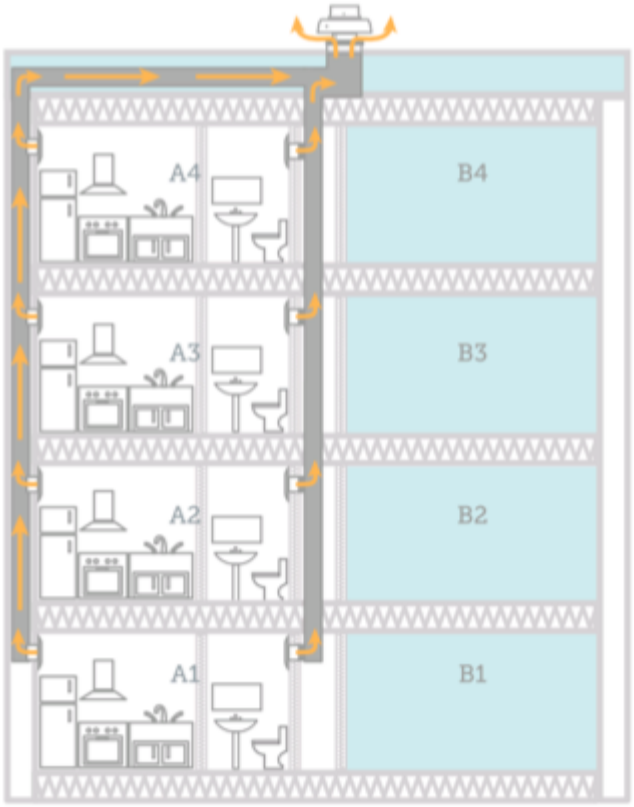
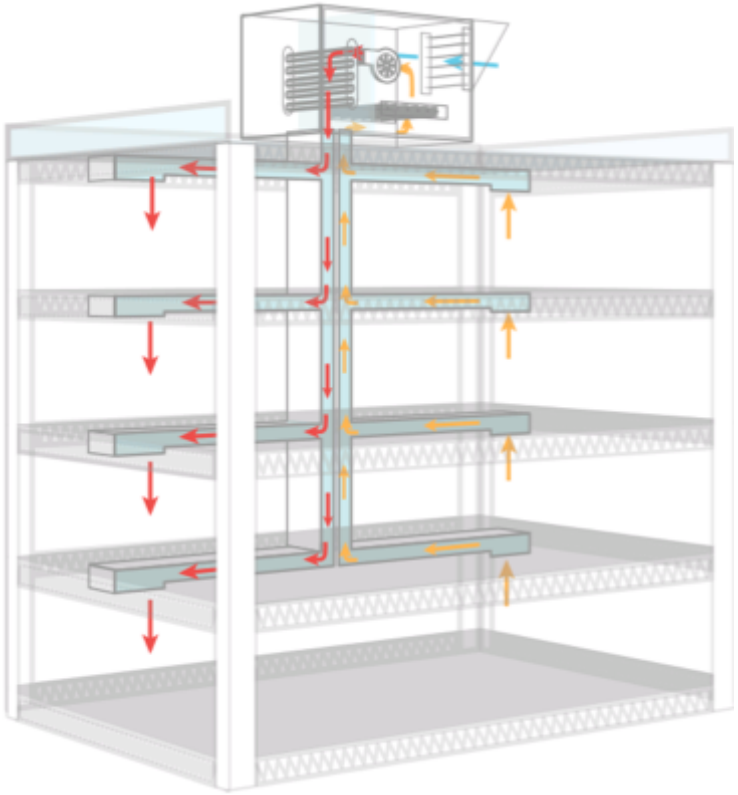
Individual ventilation systems

- Ducted individually
- On/Off Switch in apartment
- Commonly under-ventilating (no energy savings)

Central ventilation systems

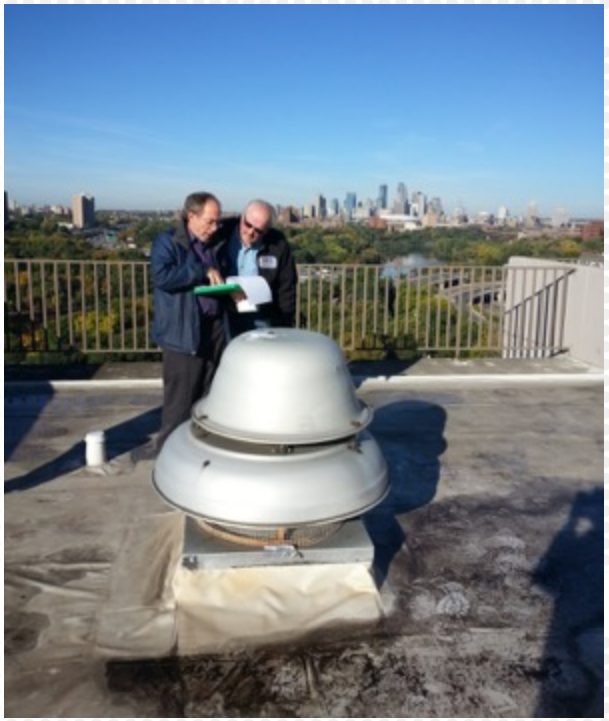




Multifamily central ventilation: What are the issues?

- Excessive ventilation flow rates
  - Electric use of motors
  - Cost of ventilating excessive heated or cooled air
- Lack of effective airflow distribution
  - Inlets clogging over time
  - Balancing dampers tampered with
- Difficulty measuring airflows

Central Apartment Exhaust



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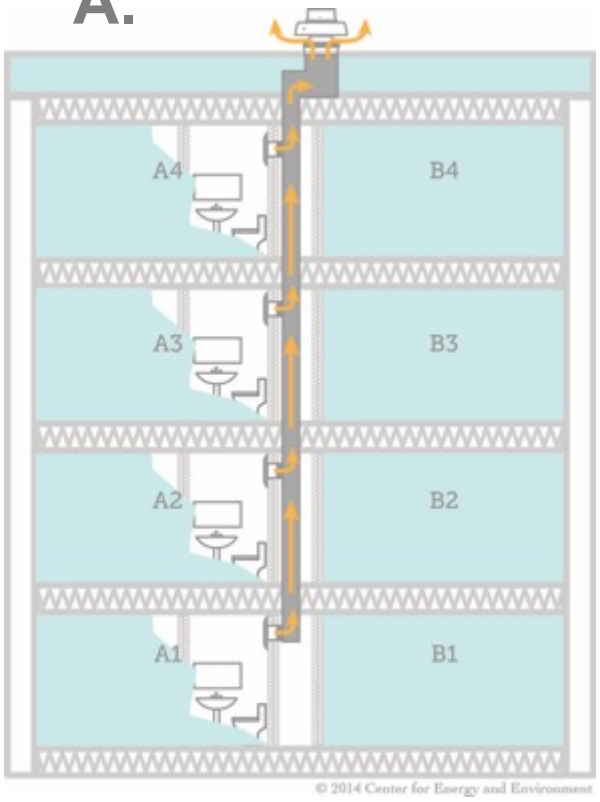
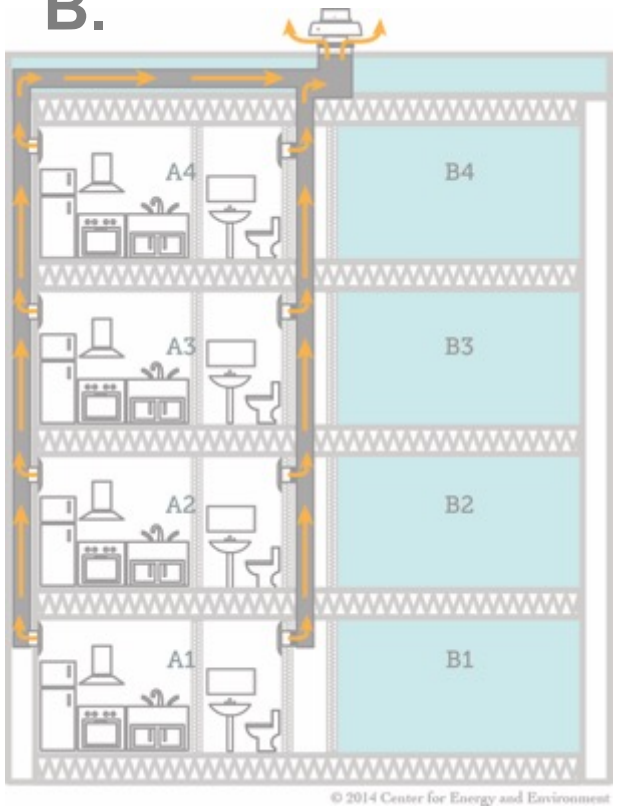
Exhaust systems draw air from apartments

A.



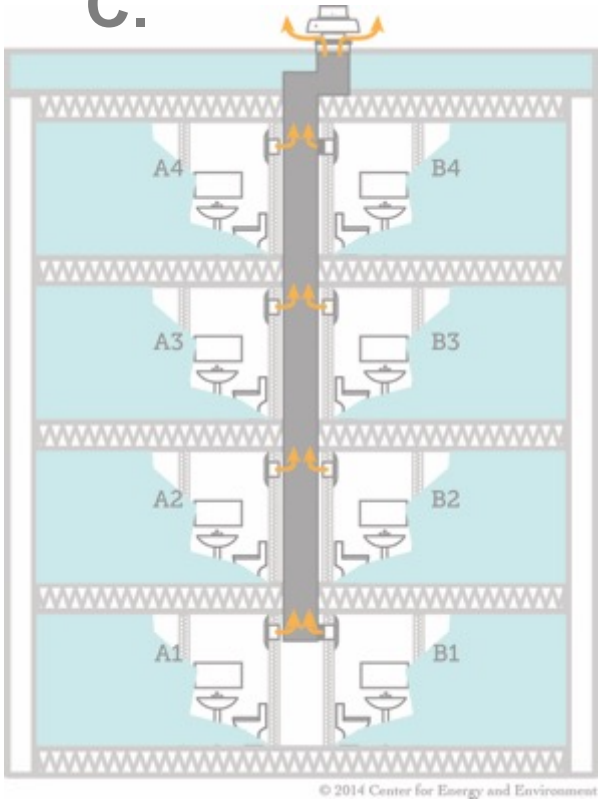
Bathroom

B.



Kitchen & Bathroom

C.



Two Bathrooms

Clogged or blocked inlets are a problem!

Flow balancing device behind the grill is often clogged or blocked

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Solution:
Fixed Orifice -“Sheet Metal With a Hole”

- Less prone to clogging
- Tamper proof
- Least cost
- Sealed to ceiling
- Hole is sized for correct flow at targeted duct pressure

Case study: Central exhaust retrofit in Minneapolis

- High utility bills
- Ventilation fan noise
- Repeated fan belt replacement
- Odor problems from blocked inlets

Retrofit: clean and unclog ducts

Remove balancing dampers and replace with fixed hole

Replace fan with high-efficiency type and turn it down!

Air seal at curb below fan

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Results: Improved distribution

Pre – retrofit >	x05
	4
	63
	56
	147
	161
	171
	30
	50
	26
	15
	100
	190
	NA
	84

Post– retrofit >	x05
	4
	34
	32
	34
	31
	30
	33
	34
	34
	31
	35
	35
	34
	30
	NA
	33

Very High	> 45	67%	0
High	> 36	67%	0
Good	+/- 20%	17%	100%
Low	< 24	17%	0%
Very Low	< 15	17%	0%

Savings Details

Whole building	
CFM savings	2,299 cfm
Gas savings (NG)	4,706 therms
Fan power savings	21,979 kWh
Cooling savings	5,539 kWh
Energy Cost savings*	$5,535
Payback	6.1 yrs

Per unit annual savings	
Gas savings (NG)	58 therms
Electric savings	339 kWh
Energy Cost savings*	$67/unit

*Based upon $0.65/therm and $0.09/kWh

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Trash Chutes

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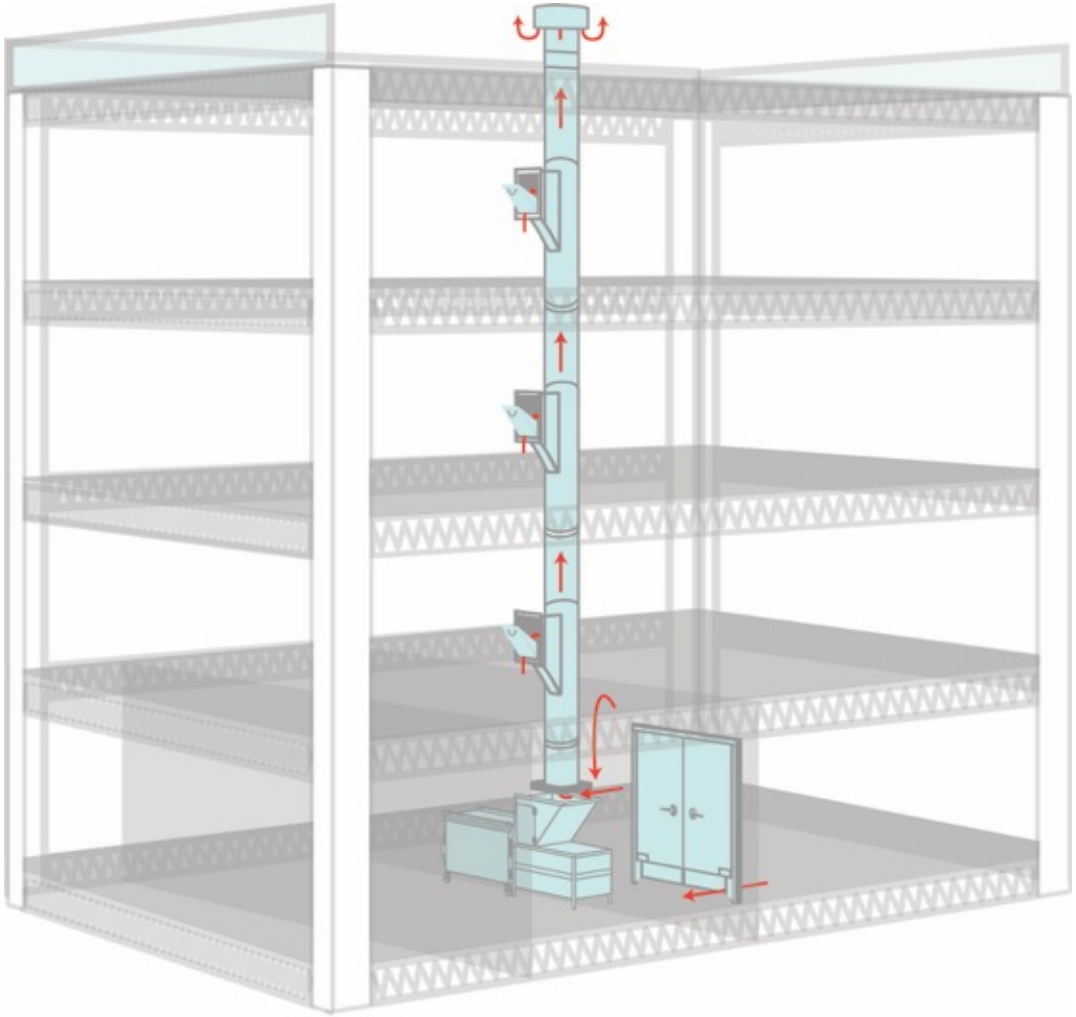
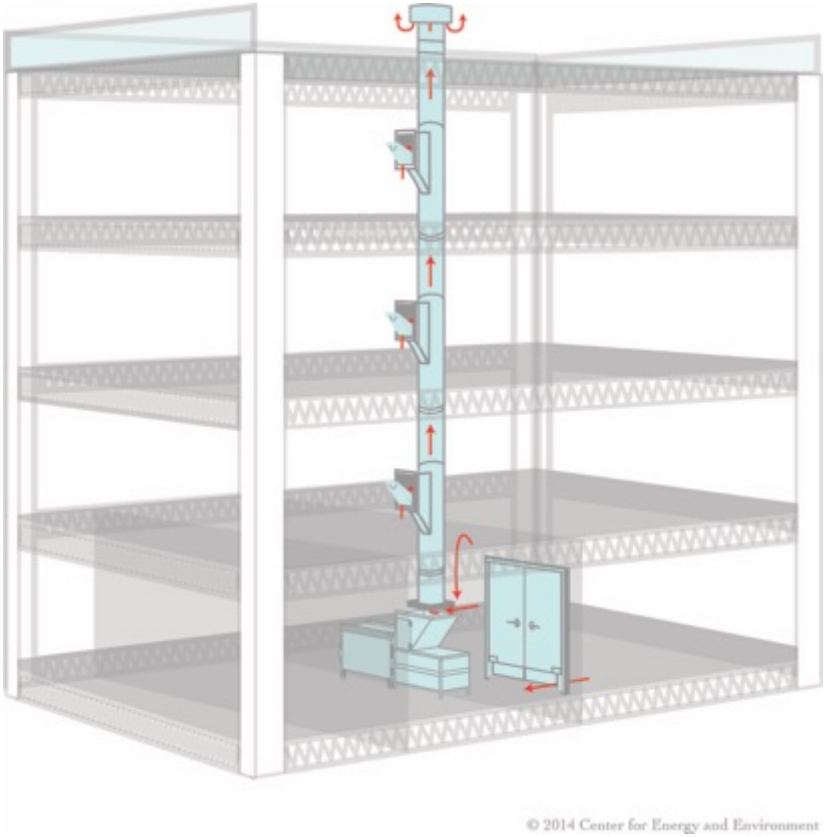
Typical Trash Chute Configuration



Improving trash chute performance

- Keep trash room doors shut
- Weatherstrip and seal off trash rooms
- Adjust cap height



Case study: Trash Chute retrofit in Minneapolis

- Reduced rooftop cap height to restrict stack flow
- Sheet metal housing at dumpster isolated trash chute from building air

Energy Savings, Reduced Odors

- Estimated $1,500 annual heating savings
- Reduced odors in nearby lobby, management offices
- 1.3 year payback

Make sure the chute door is closed

Ventilation summary

- Over or under-ventilating systems have big impacts on building performance
- Reducing ventilation flow saves on operating costs
- Using a fixed orifice flow balancer will save costs and improve long-term performance
- Trash Chute modifications can improve odor issues and save energy

For more ventilation information

Minnesota Department of Commerce
Division of Energy Resources

Multifamily Ventilation Assessment and Retrofit Guide

Conservation Applied Research & Development (CARD) Report

Prepared for: Minnesota Department of Commerce, Division of Energy Resources

Prepared by: Center for Energy and Environment

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Controlling hot water recirculation loops

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Hot water recirculation loops

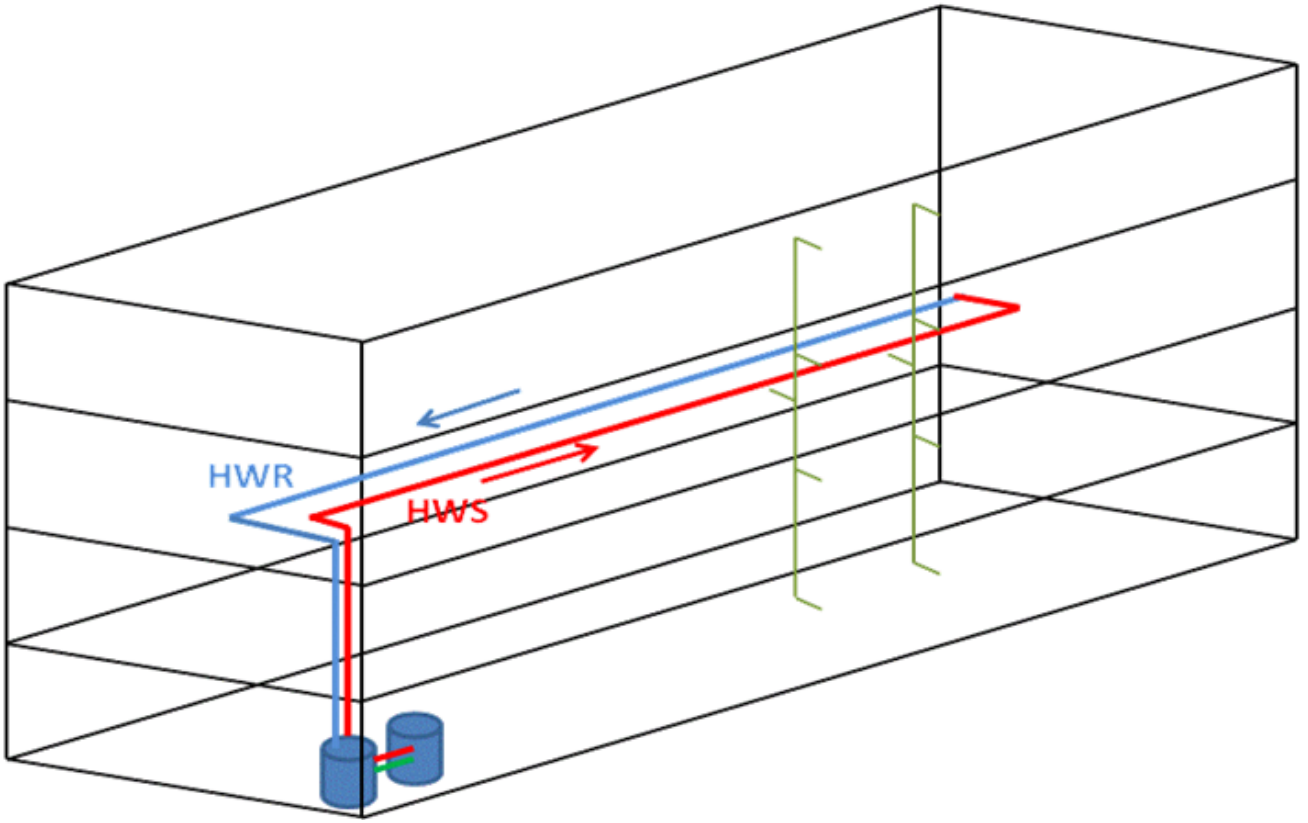

Image source: HMG, Inc

DHW energy losses

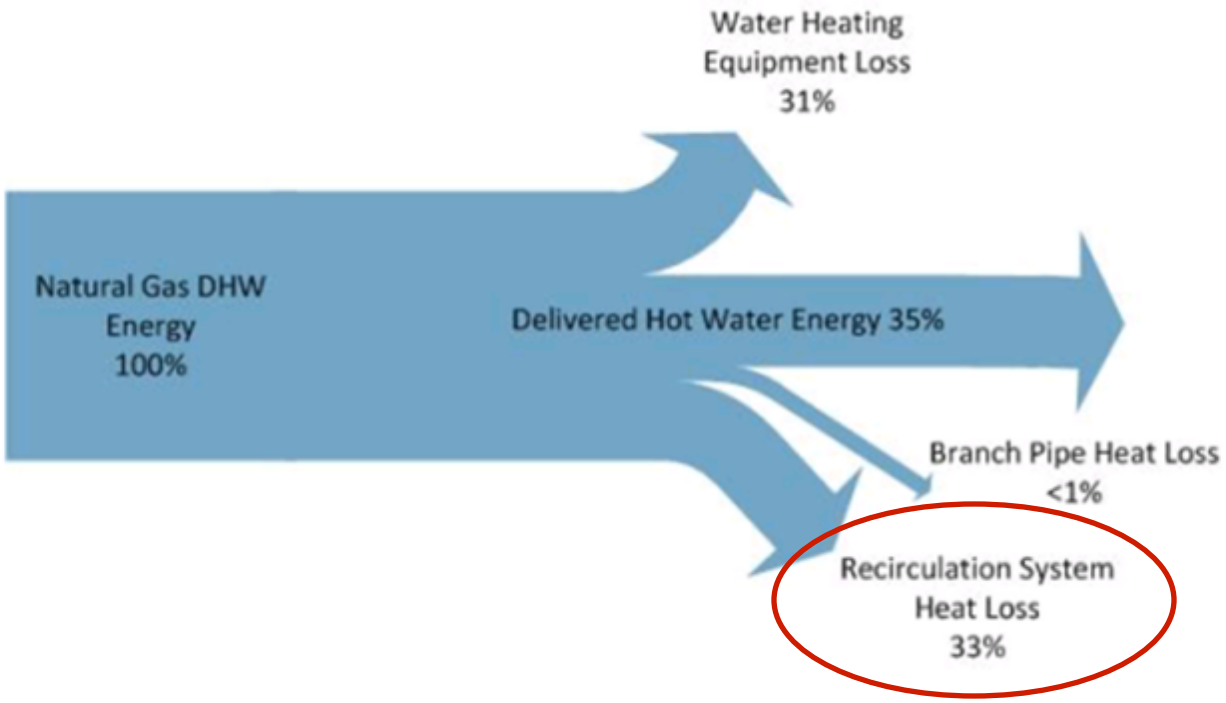

Image source: HMG, Inc. Multifamily Central Domestic Hot Water Distribution systems. 2013

Rochester installation

- 3-story
- 39 unit building
- Built in 1955
- Failed water heaters
- Shower heads and faucet aerators installed along with building assessment

25% total hot water savings
10% DHW savings from Demand Controller
Payback = 3.5 years

Enovative's Demand Controller

- Control stops pump when there is no building demand *or* the recirculation loop temp is above 100F
- Pump run time reduced from 24/7 to average 14 mins / day
  (ARIES Collaborative/Building America study in 2014)
- Turns pump on upon sensing hot water demand

Payback:
2-4 years

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Aerosol envelope air sealing

Concept:

- **Pressurize apartment unit**
- **Spray air sealing fog**
- **Sealant particles build up on gaps as they exit the room**

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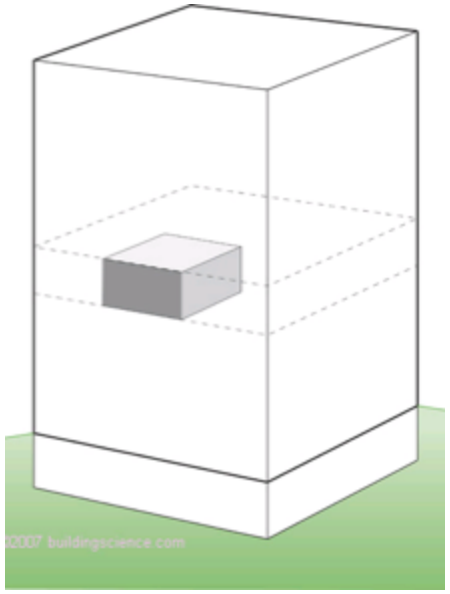
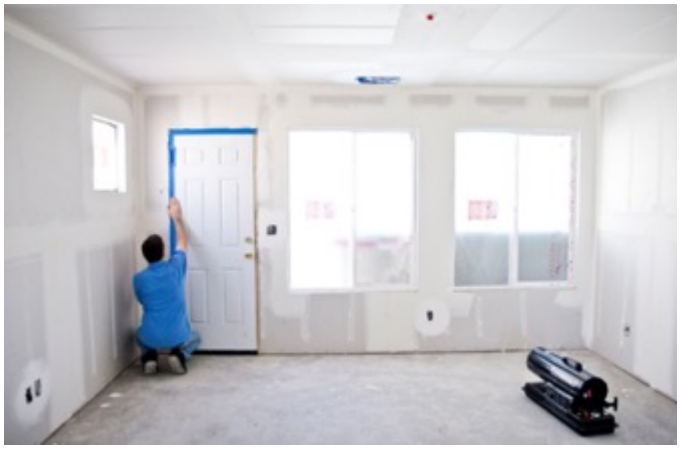
Multifamily compartmentalization

Creating an interior air barrier around each unit

- Reduced stack effect
- Reduced noise transfer
- Reduced odor transfer/improved IAQ
- Increased comfort
- Increased energy efficiency

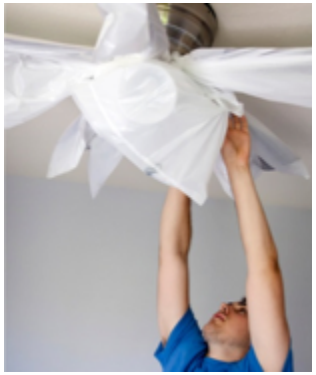


Nuts and bolts



PREP WORK

- Horizontal surfaces covered
- Windows, exterior doors covered
- Finished floor covered (ideal before flooring is installed)
- Door handles covered
- Plumbing fixtures covered
- Ceiling fans covered
- Radiators covered
- Sprinkler head openings covered
- Remove outlet/switch plates



Preliminary results:
Very air-tight

- Air tightness result: 114 to 25 CFM50 total unit leakage (8 units sealed)
- Averaged 0.45 ACH50
- 78% to 95% tighter than the new code requirement of 3.0 ACH50
- 12-13 times tighter than Energy Star requirement for multifamily

Sealed penetrations

Identifying the opportunity

IDEAL CANDIDATES

- Moderate rehabs “floors and cabinets”
- New construction

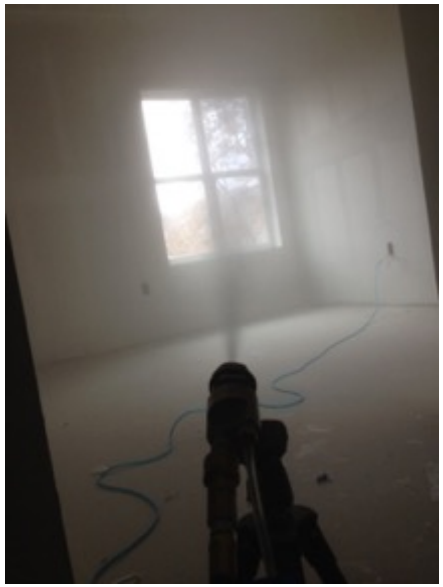
NOT IDEAL

- Where carpet is installed
- If occupied

Air sealing at lower cost?

Aerosol

- Prep
- Sealing process
- Simultaneous air leakage testing ensures results



Vs.

Manual air sealing

i.e. caulking/foaming

- Architectural specification
- Labor
- Air leakage test

=> Uncertain results

Marketable?

BENEFITS

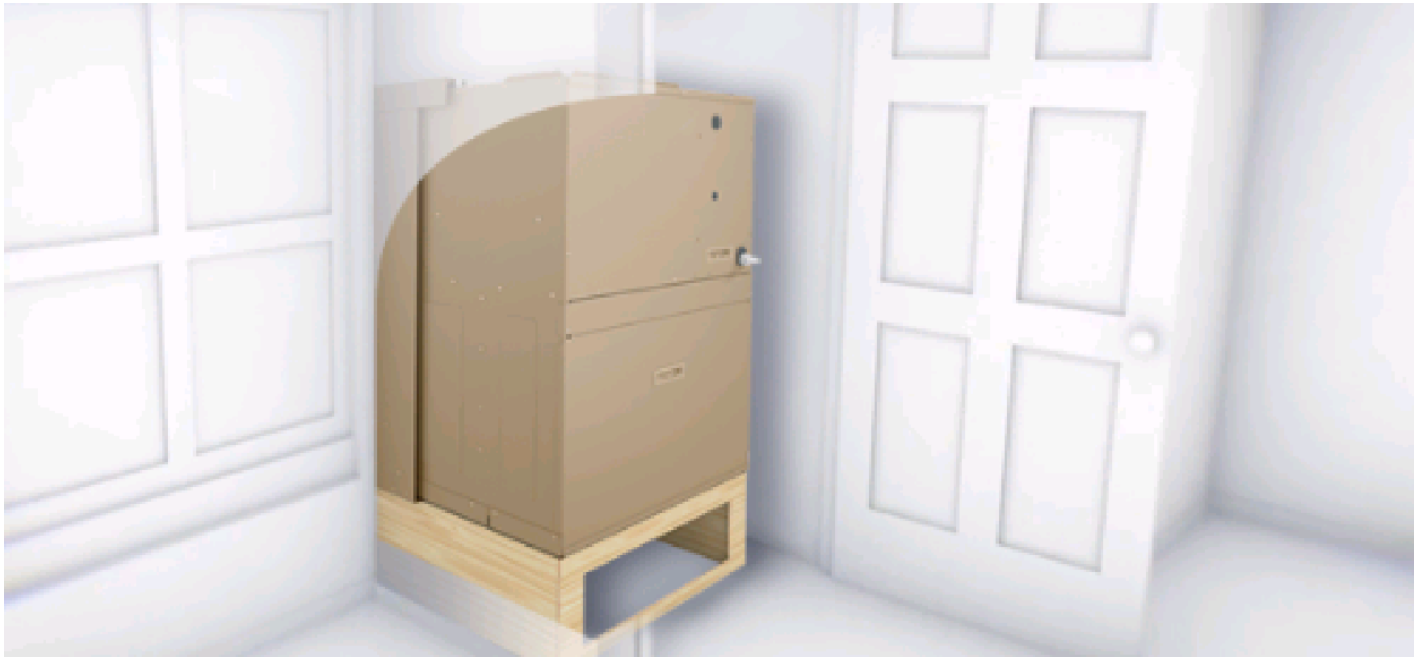
- Reduced noise transfer
- Reduced odor transfer
- Improved comfort
- Simultaneous air leakage testing ensures results
- Expedited process, labor savings potential

CONSIDERATONS

- Cost
- Not a solution for large air leak gaps
- Rehab or new construction only
- Balanced ventilation is crucial

Condensing through-wall furnaces

- Through-wall furnaces becoming more popular in Multifamily buildings
- Recently, 4 out of 5 manufacturers of through-wall furnaces introduced condensing heating products
- Non-condensing: 80% AFUE, Condensing: Up to 95% AFUE



Potential/Unresolved Issues: Existing Buildings

- How will condensate be handled?
  - Drain lines
  - Neutralization requirements
- Potential for icing issues at exterior grille during cold weather?
- Have any impact on occupant comfort?
- How do measured energy savings compare to initial savings estimates?

More of a concern for existing buildings

Round-up

- Controlling boilers (both condensing and non-condensing) effectively is a low-cost way to save energy and improve occupant comfort
- Central ventilation systems that provide too much ventilation air can be modified for significant energy savings (plus improved ventilation performance)
- Demand-controlled recirculation loop controls on hot water systems are low costs controls that save energy without affecting performance
- Aerosol envelope air sealing may be the future's technique for meeting energy performance requirements

Make sure to look for rebates!

2017 Business Lighting Rebate Application

Lighting Equipment Rebate Project Type: ☐ New Construction ☐ Retrofit

Existing/Base Equip.		New Equipment								
Code (from Lighting Tables)[1]	Existing/ Base Quantity	Code (from Lighting Tables)	LED Bulb/Fixture Wattage (if applicable)	Fluor. Ballast Make (if applicable)	Fluor. Ballast Model (if applicable)	Fluor. Lamp Make (if applicable)	Fluor. Lamp Model (if applicable)	New Quantity	Annual Hours of Operation[2]	Is This Space Air Conditioned?
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No
										☐Yes ☐No

[1] Existing T12 fixtures must be working to be eligible for Retrofit Rebate.

Occupancy Sensor/Photocell Rebate Project Type: ☐ New Construction ☐ Retrofit

Controlled Fixtures					Occupancy Sensors/Photocells						
Code (from Lighting Tables)	Total LED Wattage (if applicable)	Low Wattage T5/T8 Lamps (if applicable)	Quantity Controlled by Sensors/ Photocells	Annual Hours of Operation[2]	Code (from Lighting Tables)	Sensor Quantity	% of time Lights Off[3]	Is This Space Air Conditioned?	Total Cost of Sensors/ Photocells	Rebate per Sensor/ Photocell[4]	Total Rebate (Sensor Qty X Rebate per Sensor)
		☐Yes ☐No						☐Yes ☐No	$	$	$
		☐Yes ☐No						☐Yes ☐No	$	$	$
		☐Yes ☐No						☐Yes ☐No	$	$	$
		☐Yes ☐No						☐Yes ☐No	$	$	$
		☐Yes ☐No						☐Yes ☐No	$	$	$

Total Rebate Amount $ _____

[3] Guidelines for % of Time Lights Off (TLO):

Sensor Type	TLO	Sensor Type	TLO	Sensor Type	TLO
Occupancy Sensor - Wall Mount	30%	Photocell - Continuous Dimming	43%	Photocell - On/Off	27%
Occupancy Sensor - Ceiling Mount	30%	Photocell - Multiple Step Dimming	35%	Integrated Occupancy Sensor	30%

Commercial and industrial boiler heating system and components rebate application

STEP 6 **Equipment information**

Please complete all information for the installed equipment for which you seek a rebate. Required information submitted as part of application to be eligible for a rebate.
Please reference all rebate requirements prior to installation to ensure eligibility.
Make a separate entry for each measure installed. If more space is needed, please photocopy this form and subn

Rebate minimum efficiency requirements

Equipment or service	Rebate
Hot water boiler system	
85% to 89.9% AFUE (< 300,000 Btu/h input)	$900 per MMBtu/h input
85% to 89.9% thermal efficiency (300,000 Btu/h or greater input)	
Hot water boiler system	
90% AFUE or higher (< 300,000 Btu/h input)	$2,500 per MMBtu/h input
90% thermal efficiency or higher (300,000 Btu/h or greater input)	
Steam boiler system	
83% AFUE or higher (< 300,000 Btu/h input)	$750 per MMBtu/h input
83% thermal efficiency or higher (300,000 Btu/h or greater input)	
Other boiler heating system components and services	
Continuous modulating burner (retrofit or upgrade only)*	25% of equipment cost
O2 trim control	25% of cost
Linkageless control	25% of cost
Electronic programmable setback thermostat for existing buildings**	50% of cost
Vent damper	50% of equipment cost
Boiler outdoor air reset control (retrofit or upgrade only)*	100% of equipment cost
Boiler cut-out control	100% of equipment cost

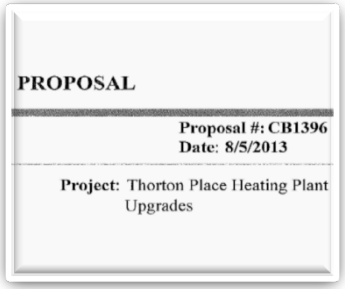
Managers: Take advantage of this program!

- Free install of shower-heads and faucet aerators
- Building assessment
- Start-to-finish oversight of any chosen retrofits

It's FREE

Major cities served:

Cloquet
Grand Rapids
Bemidji
Eagan
Rochester
Park Rapids
Rosemount
Hinckley
+100 other MN cities



Intake → Building Assessment → Product Install → Report → Ongoing Assistance

More info CEE programs and research: mncee.org

Minnesota Solar Pathways

This project undertakes stakeholder collaboration and technical analysis to support Minnesota's deployment of solar electricity.

Dec 15, 2016 | Project

CEE in 2016: Boots on the ground

As our past year shows, here at CEE we know that we can't get to *clean* energy without getting our hands *dirty*. It's all about rolling up our sleeves and digging in.

Dec 12, 2016 | Blog

From the Blog See All Posts

Staff Spotlight: Russ Landry

In this series, learn how each CEE staffer contributes to reducing energy waste while improving the environment. This week, we profile senior mechanical engineer Russ Landry.

Feb 6, 2017 | Blog

Latest Tweets

Ctr for Energy & Env
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#Free energy wrkshp for #WorthingtonMN residents 2/18. Qual. for discounted energy visit-save $ & #energy at home. ow.ly/Vyn6308TpP

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THANK *you!*

Questions?

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