Minnesota BLUE FLAME GAS Association

September 20, 2016

NATURAL GAS CONSERVATION CONFERENCE

COMMERCIAL CONDENSING BOILER OPTIMIZATION

cee Center for Energy and Environment

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Minnesota Department of Commerce Division of Energy Resources

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How Condensing Boilers Outperform Conventional Boilers

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- Conventional Boilers
  - All *steam* goes out the vent
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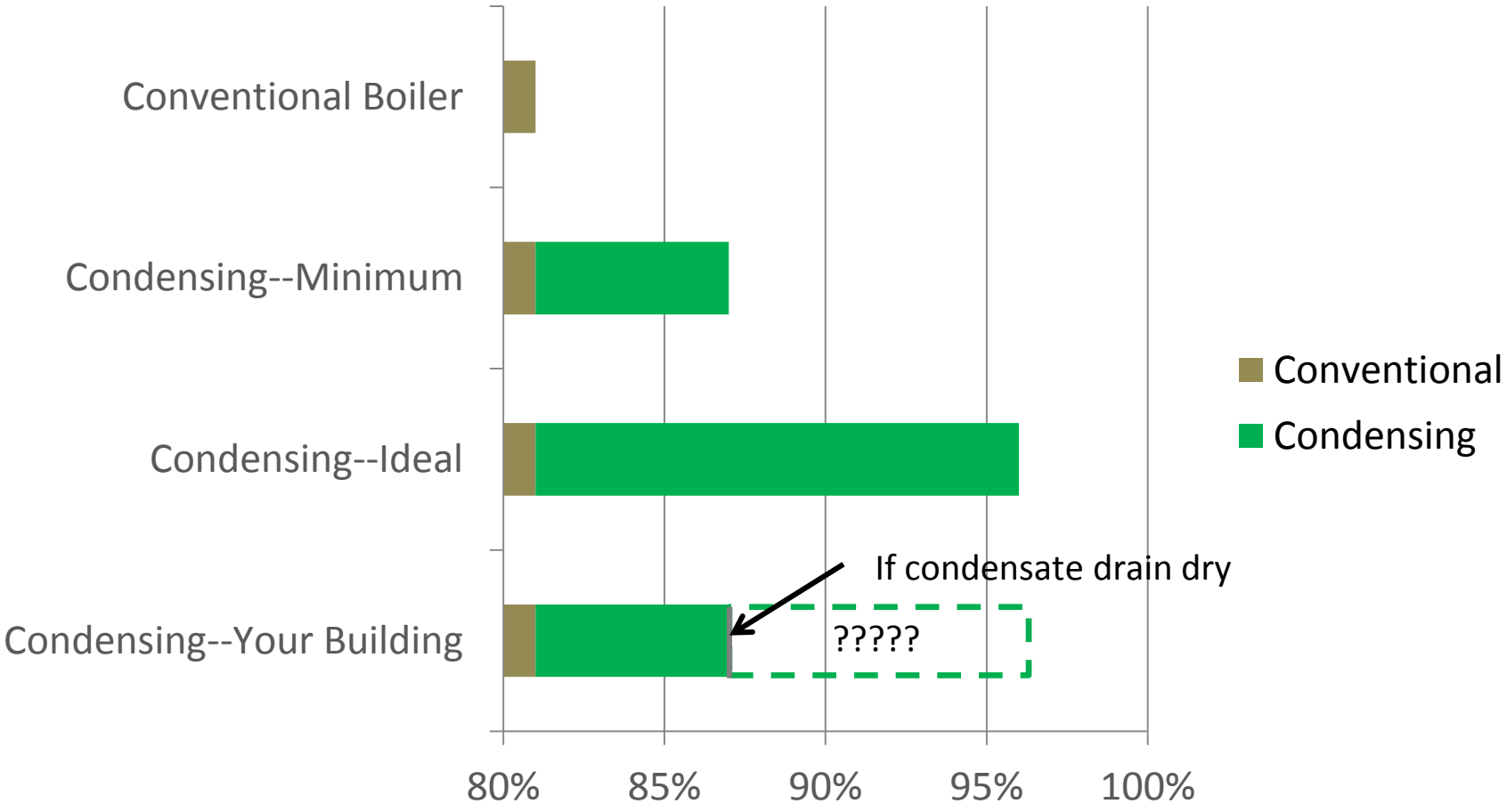
- Condensing Boilers
  - A portion of the *steam* is used for heating
  - No safety factor

Condensing Efficiency "Boost"

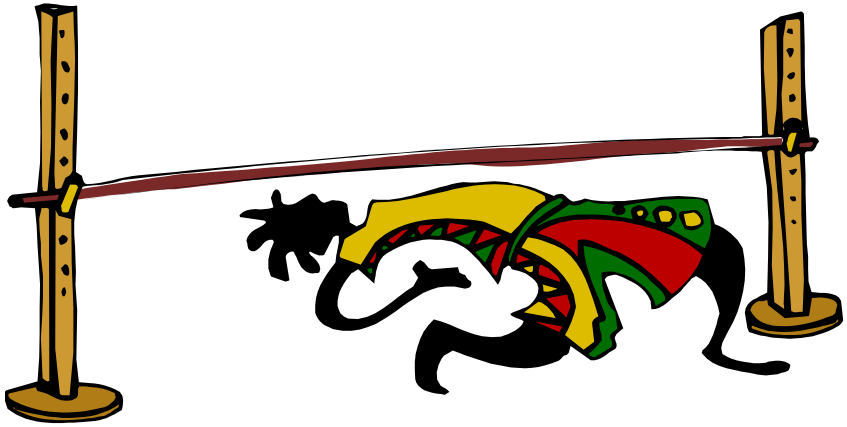
- 1 pound of captured *steam* heats 50 pounds of water

Condensing Boiler Efficiency Improvement

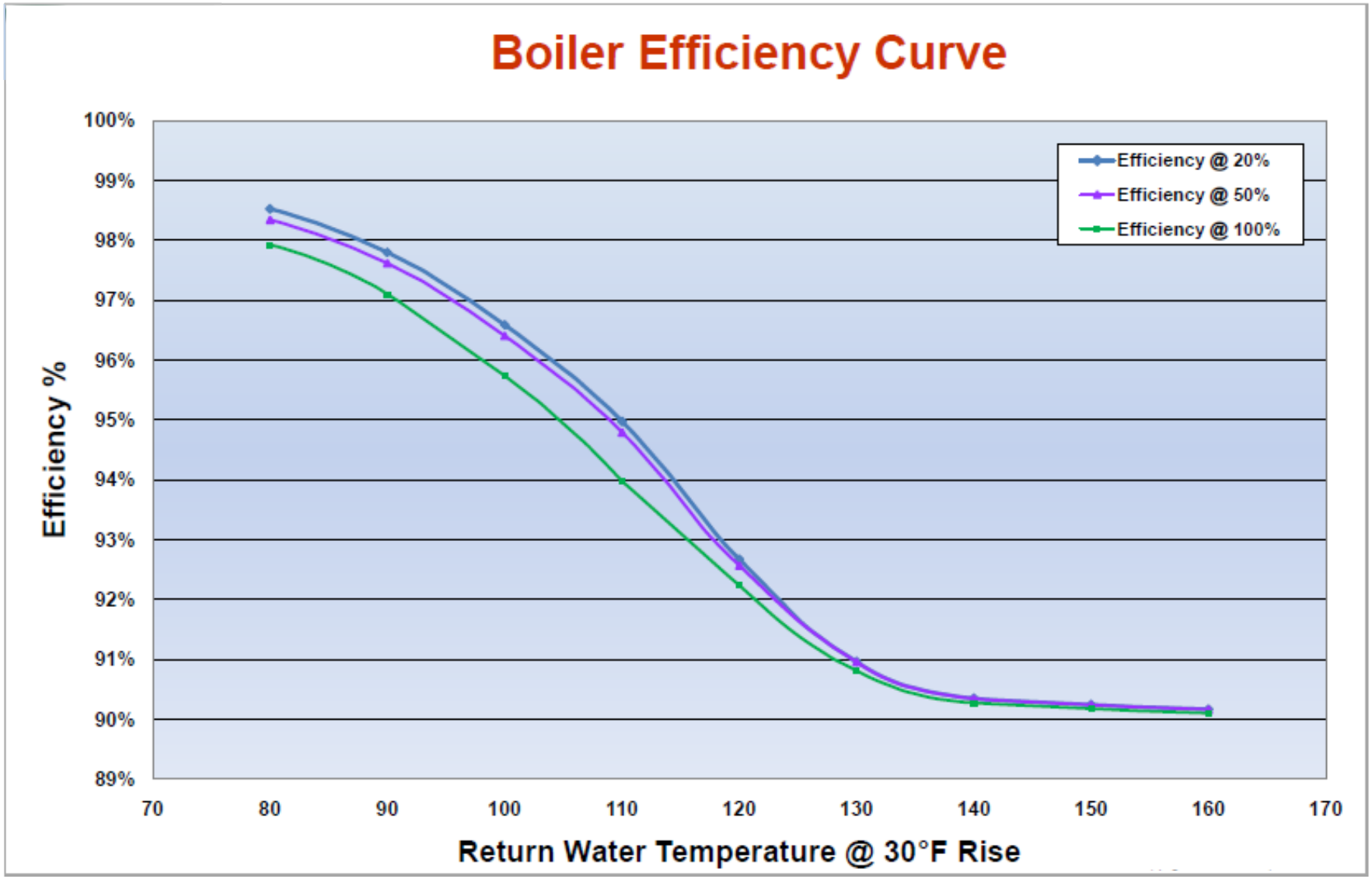


3 Rules for “Energy Value” of Condensing Boiler System

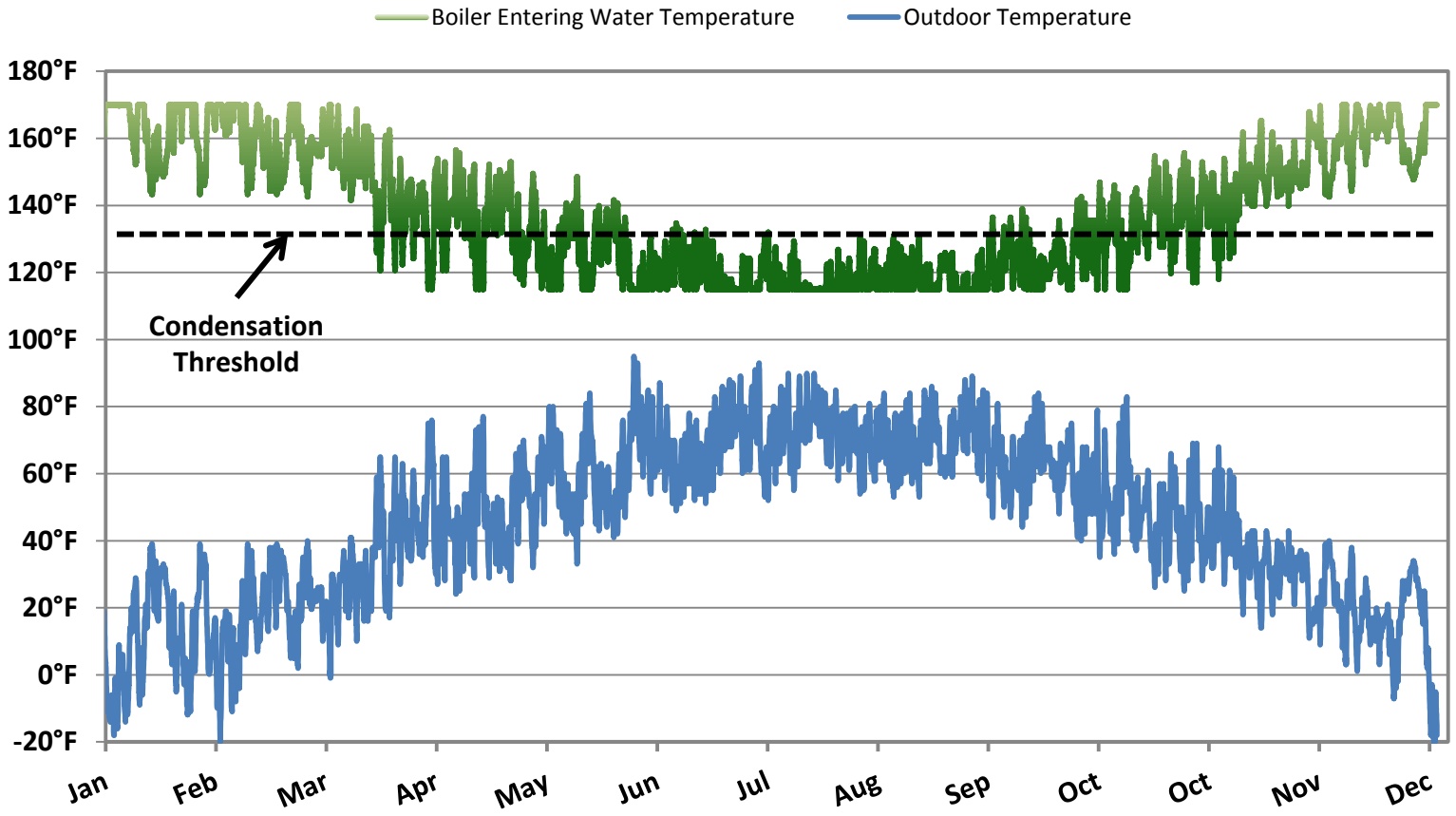
1) Low Return Water Temperature!
2) Low Return Water Temperature!
3) Low Return Water Temperature!



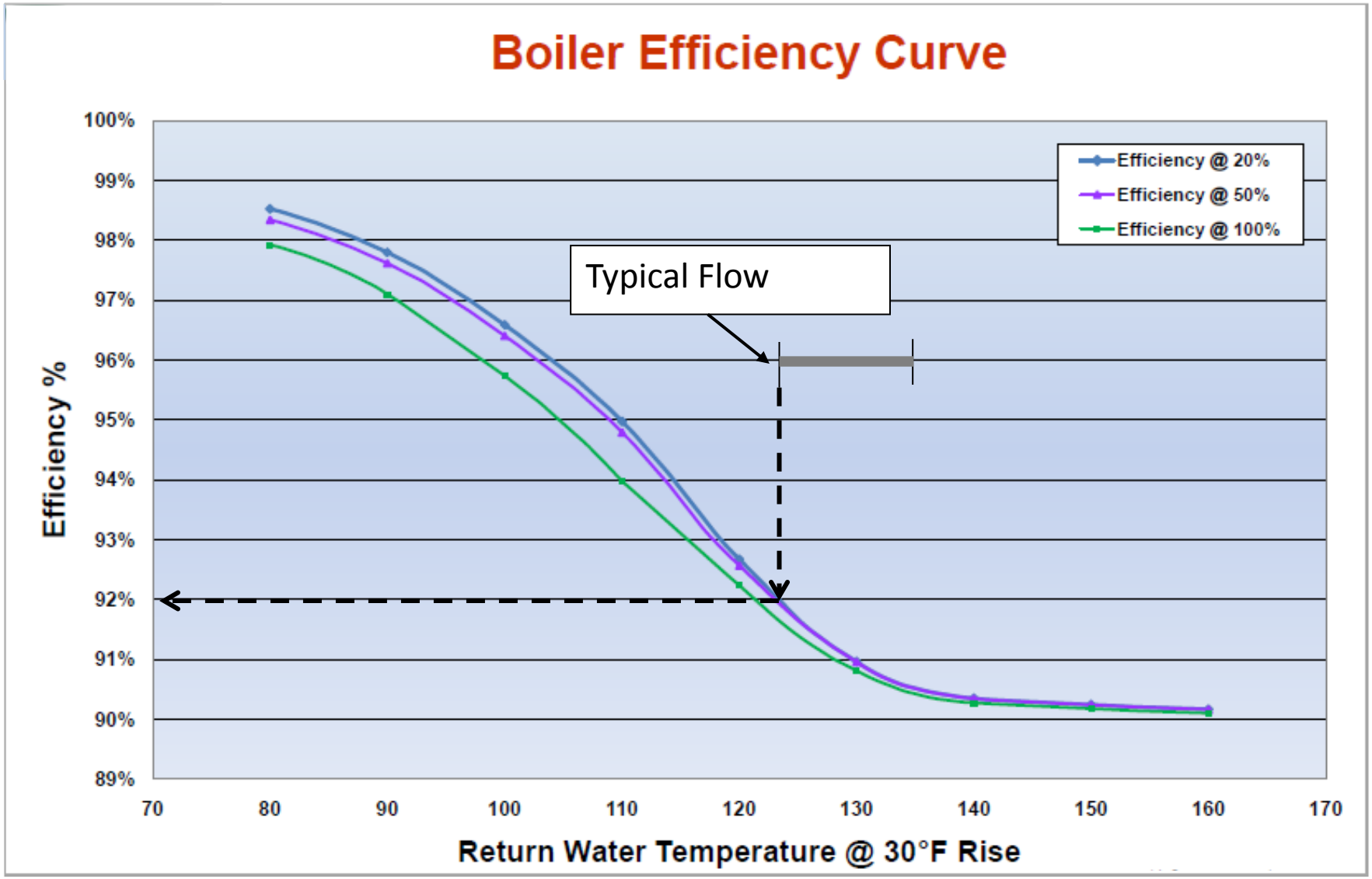
Condensing Boiler Efficiency Dependence on Operating Conditions



Boiler System Temperatures in Real Buildings & Impact on Efficiency



Flow Impact on Boiler Efficiency Via Entering Water Temperature



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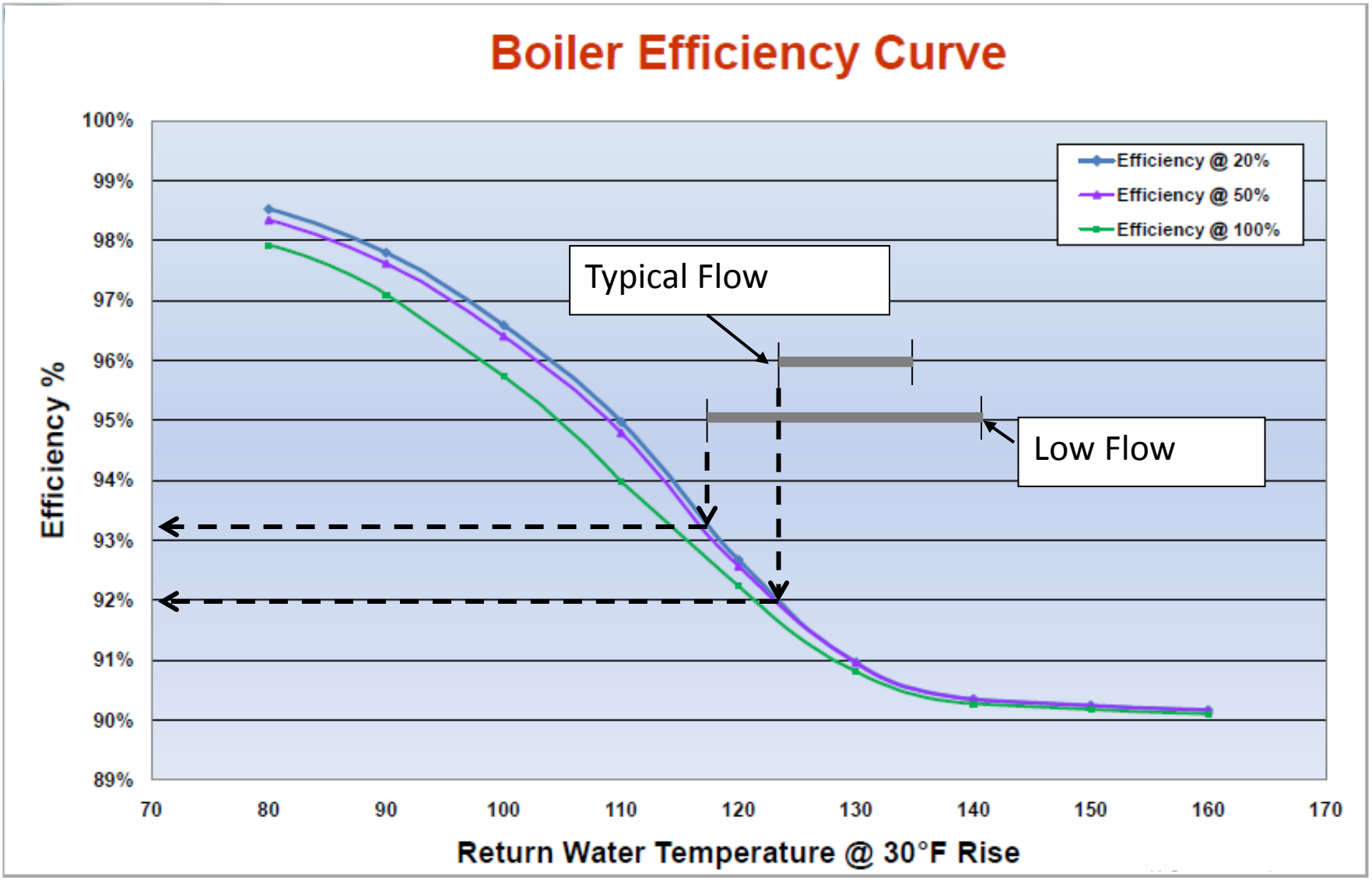
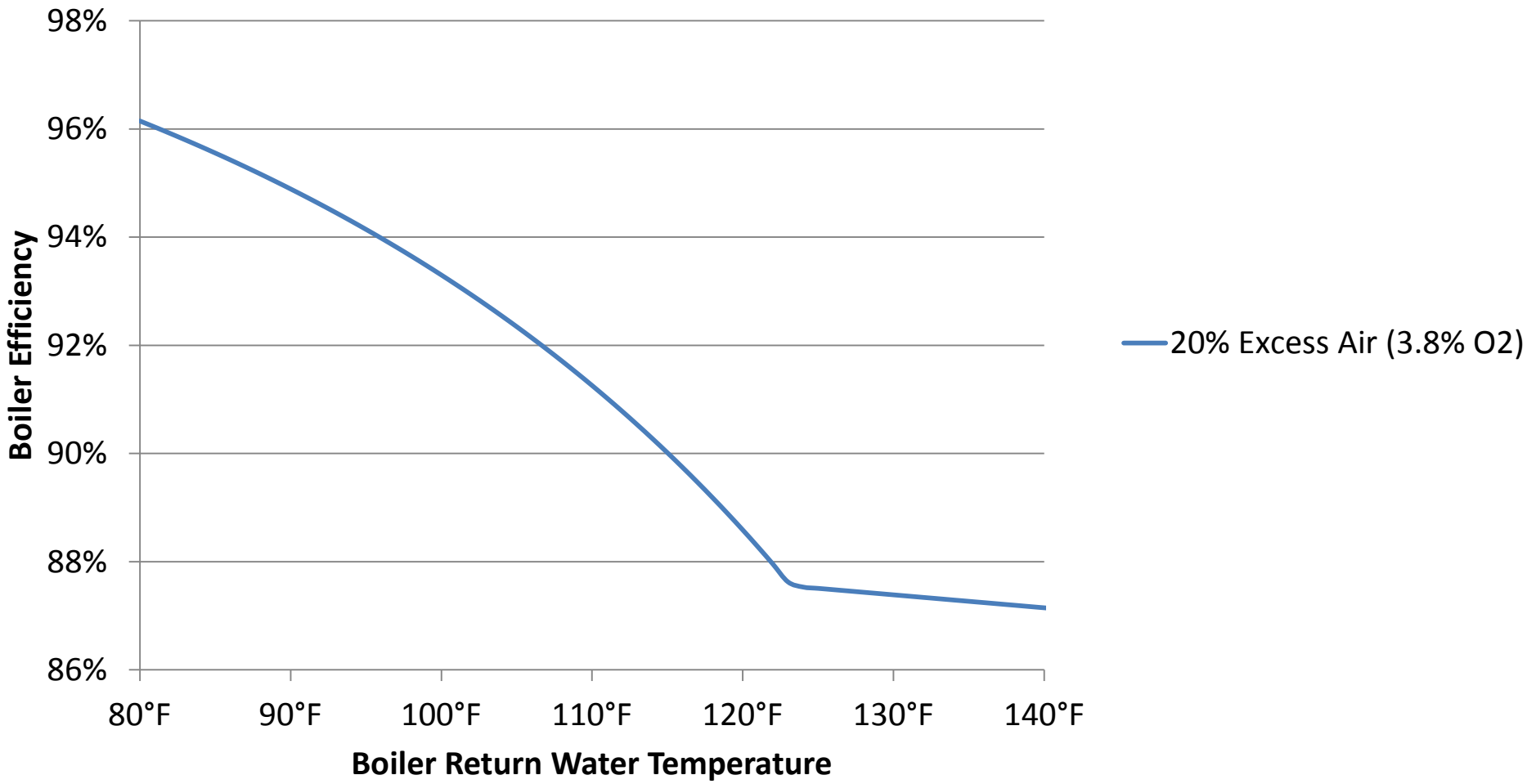


Traditional Burner Tuning: Excess Air Up Chimney & Reduced Condensing



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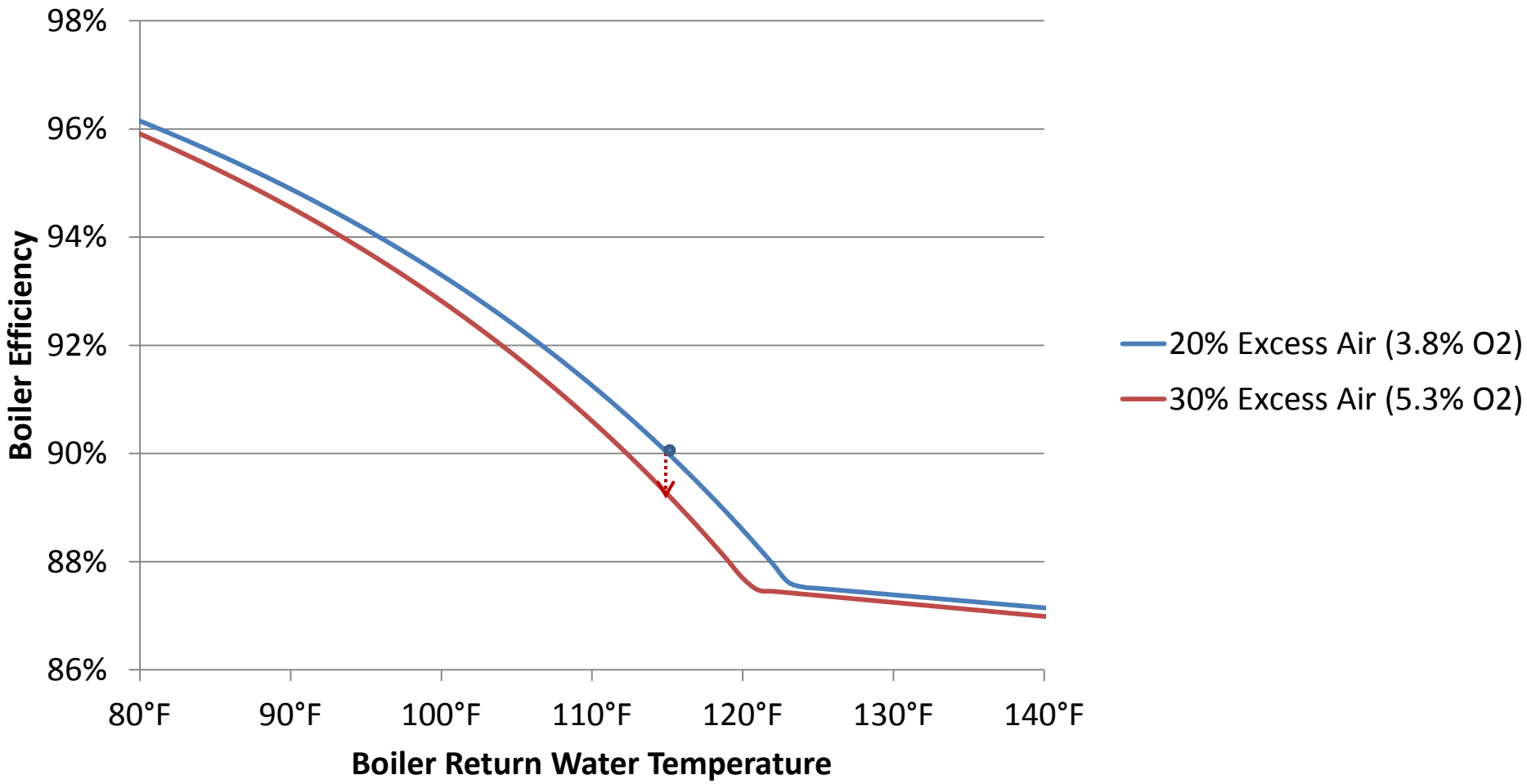

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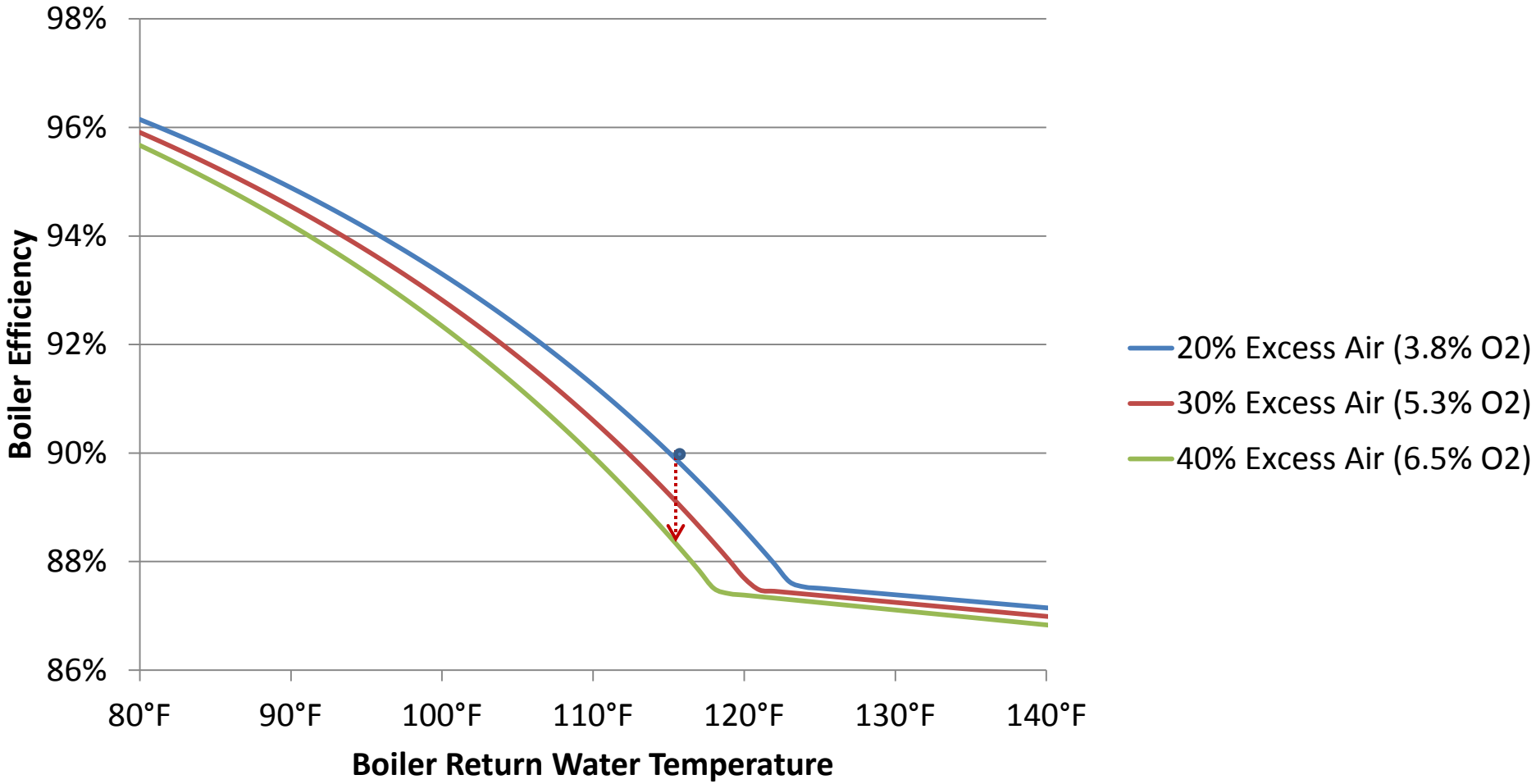

Project Overview: Condensing Boiler Optimization

- Preliminary Market Study & Site Selection
- Monitoring & Analysis of 12 Buildings
  - 4 Education
  - 4 Multifamily
  - 4 Government/Office
- Industry Survey
- Dissemination

Minnesota's Condensing Boiler Market Study Findings

- Market Dominance of Condensing Boilers
  - Condensing boilers have become the default choice
  - Used in all building types that have space heating boilers
- Efficiency Concerns Noted
  - Manufacturer's reps acknowledge often suboptimal situations
  - Part-load efficiency improvements may be significantly overstated in some cases per tuning recommendations

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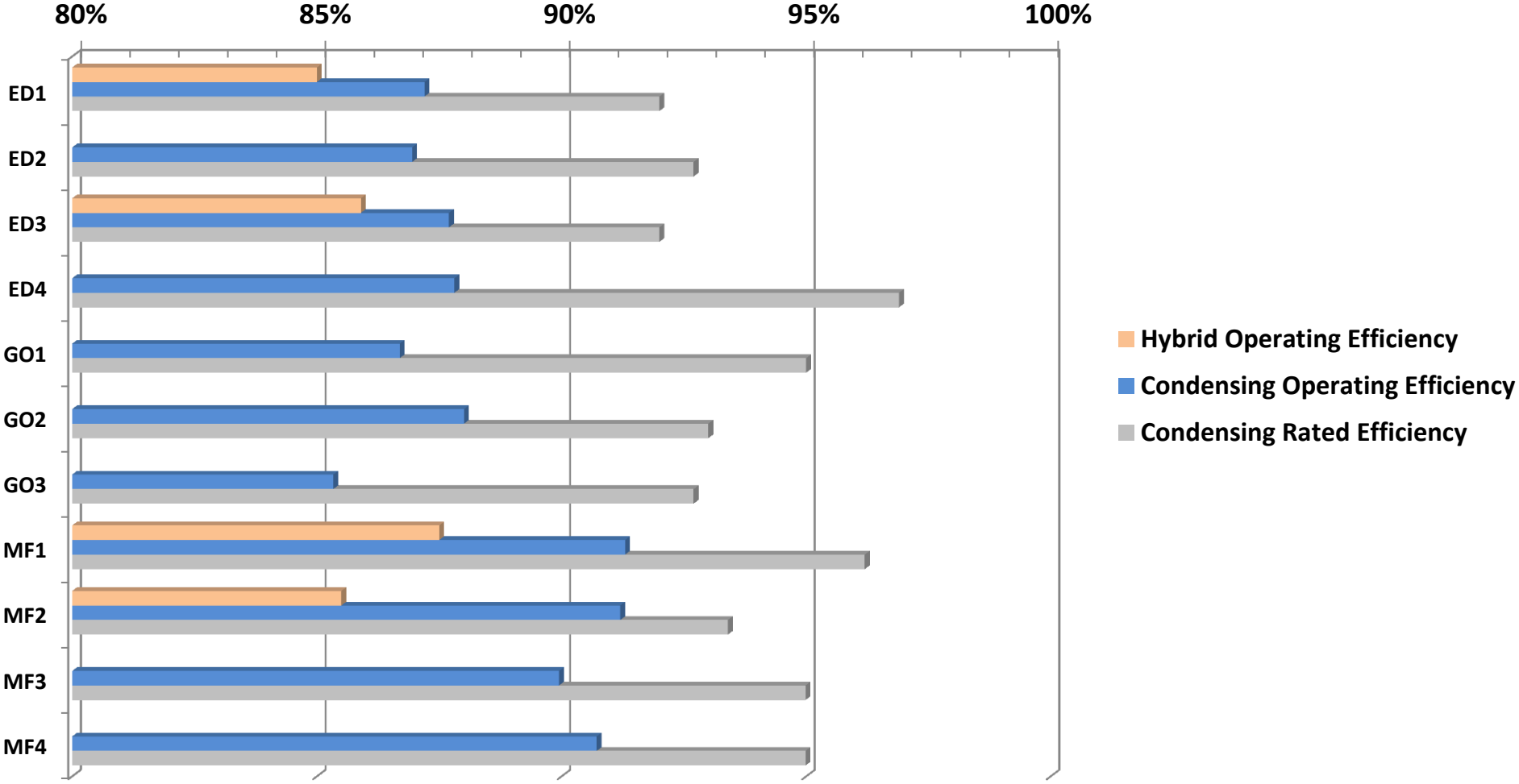
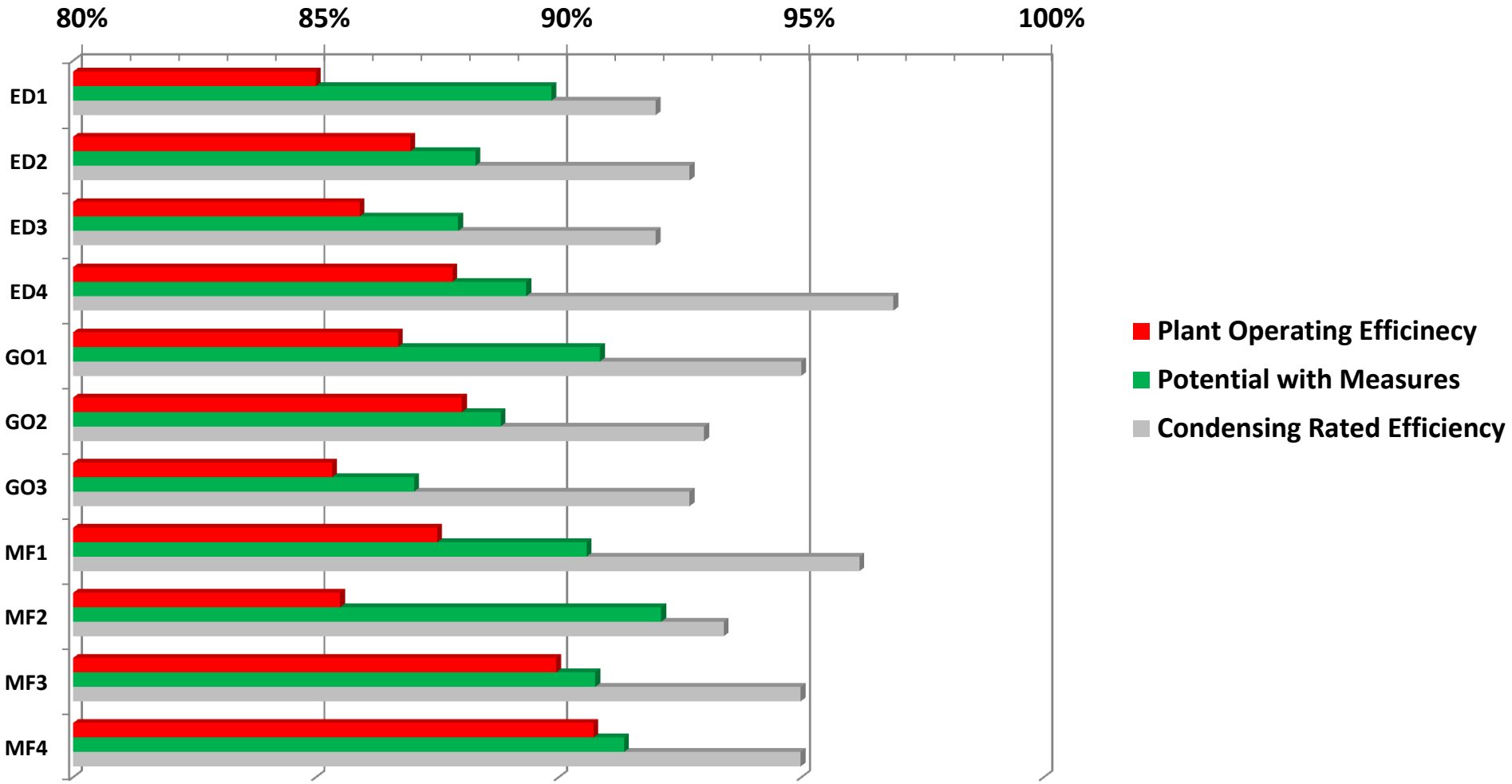
Estimated Annual Efficiency Based on Monitored Conditions



Potential Efficiency with Proposed Features



Potential Savings by Design Feature

Measure Type	# of Sites	Average of Sites with Measure	Average Across All Sites
Reset Control	10	1.54%	1.40%
Burner Tune Up	10	0.80%	0.72%
Staging Control	8	1.15%	0.83%
Variable Speed Pumping	10	0.48%	0.44%
Piping Change	5	2.06%	0.94%
Total	11		3.97%

Cost-Effective Retrofits After Installation Completed

Site	Outdoor Reset	Burner Tune-Up	Staging Control	Variable Speed Pumping	Piping	Package Cost	Package Savings (Therms)	Payback (Years)
ED1	X	X	X	O	X	$8,800	4,437	2.8
ED2	X	X		O		$1,600	789	2.9
ED3	X	X	X	O		$3,100	2,822	1.6
ED4	X		X	X	O	$2,600	768	4.8
GO1	X		X	X		$13,500	4,379	4.4
GO2	X	X				$2,750	5,248	0.7
GO3	X	O		O	O	$250	229	1.6
MF1	X	X		O	O	$3,400	1,217	4.0
MF2		O	O	O	O	NA		NA
MF3	X	X	O	O		$620	376	2.4
MF4	X	X	X	O		$800	420	2.7
Sum	10	8	5	2	1	$37,420	20,686	2.6

X = Included; O = Excluded; Blank = No Opportunity

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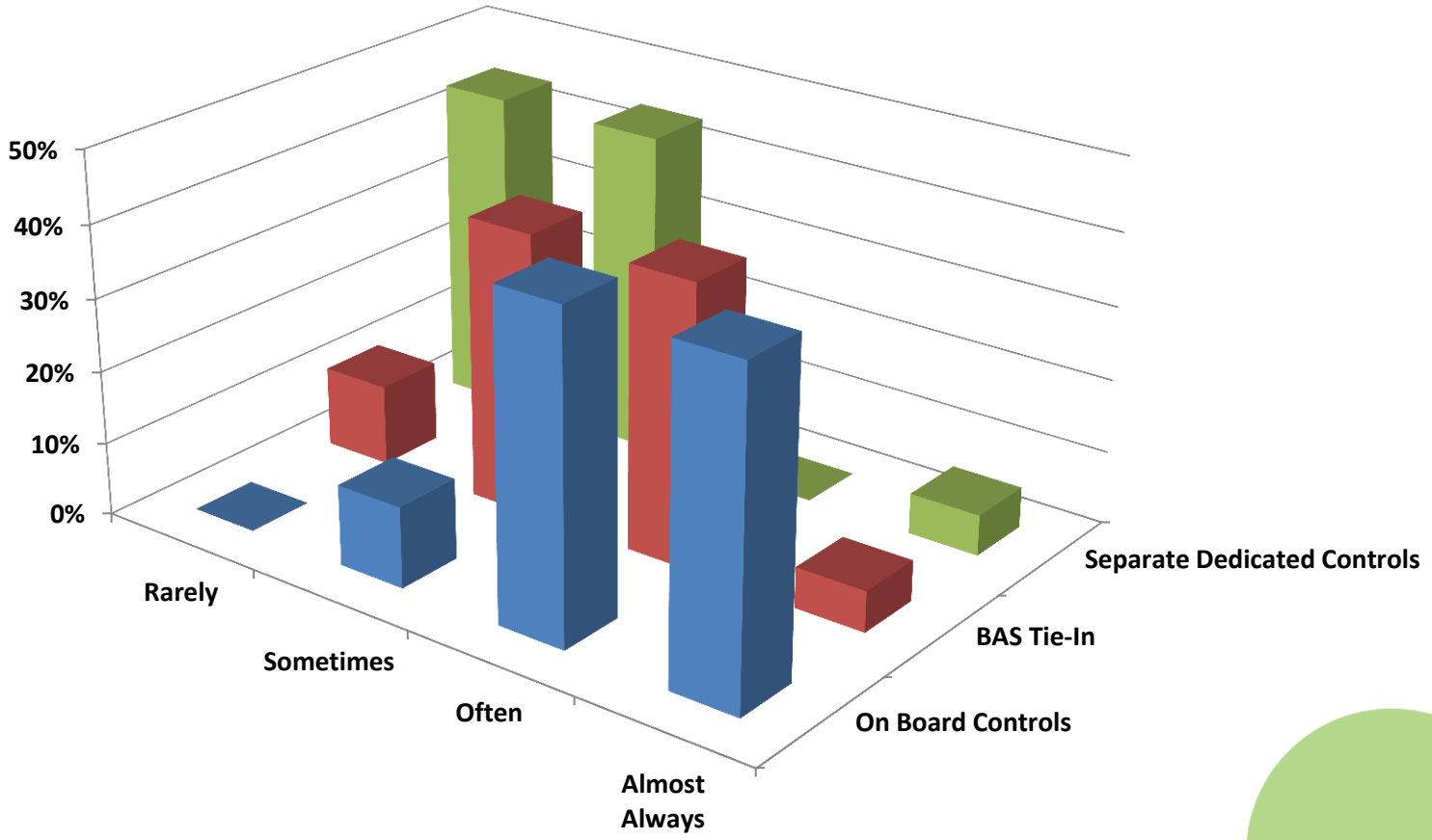
Survey Findings:
Primary Boiler Control System



Survey: Most Commonly Witnessed Issues Impacting Efficiency

Issue	Percent
Turning off and on frequently (short cycling)	67%
Difficulties coordinating control between a BAS and the boiler(s)	61%
Piping arrangements circulate water through an idle, non-condensing boiler	44%
Boiler minimum temperature limited by the need to heat service hot water	44%
Outdoor reset control does not lower temperature as much as it could in mild weather	39%

Survey: What Would be Most Worthwhile to the Owner for Future Installations

Potential Program Element	Percent
a. Piping Design Review	11%
b. Control Sequence Review	11%
c. Site-Specific Savings Estimate	6%
d. Bonus Rebate for Quality Design	11%
e. Bonus Rebates for Individual Design Features	6%
f. Commissioning of Installation and Controls	***44%***
g. New Training Options for Designers & Installers	11%

Survey: What Would be Most Worthwhile to the Owner for Previous Installations

Potential Program Element	Percent
a. Specialized Engineering Review	11%
b. Gas Rebate for Variable Speed Drive	6%
c. Rebates for Control Upgrades	6%
d. Rebates for Optimizing Control Settings	*17%*
e. Resources on Optimal Control & Operation	11%
f. Site-Specific Guide for Controls	6%
g. New Training Options for Operators	***44%***

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Dissemination of Project Findings

- Presentations:
  - 2014 CenterPoint Energy Technology Conference
  - 2015 AEE/ASHRAE Twin Cities Energy Expo
  - 2016 Minnesota Blue Flame Gas Association's Natural Gas Conservation Conference *[will be downloadable on Minnesota Blue Flame Gas Association website]*

- Detailed final report--available soon (pending review)

- Future webinar--utility program issues focus

In Conclusion…

- While less than simple rating values suggest, condensing boiler savings is still large in nearly all buildings

- Maximizing savings depends on:
  - Minimizing temperature settings (outdoor reset adjustment)
  - Optimal boiler staging control programming
  - Burner tuning of air-fuel ratio to lower limit of recommended oxygen range
  - Avoiding sub-optimal piping

- Possible utility program developments
  - Support for specialized commissioning
  - Support for new operator training options
  - Rebates for optimization of control settings

Thank You

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