IAQ/Safety/Energy/Value

Better Buildings
U.S. DEPARTMENT OF ENERGY

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The Secret to High Performance Space Heating in High Bay Buildings

Genuine Cambridge Since 1963 Nothing Else Like It | ASHRAE 90.1 COMPLIANT | ENERGY STAR PARTNER | U.S. Green Building Council Member | AHRI MEMBER | ASHRAE

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Boilerplate from ASGE

Goals Today

Education

Advocacy

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Key Takeaways from Today's Session

1. Understand how a building can meet its space heating and ventilation needs through 100% outside air HTHV direct fired heating technology

2. Recognize the difference between standard efficiency and high efficiency heating technologies for high-bay commercial buildings

3. Review the energy savings and other key findings from a recent field study of HTHV technology, and

4. Analyze the potential for widespread energy savings with HTHV technologies.

WHY FOCUS ON HIGH-BAY APPLICATIONS?

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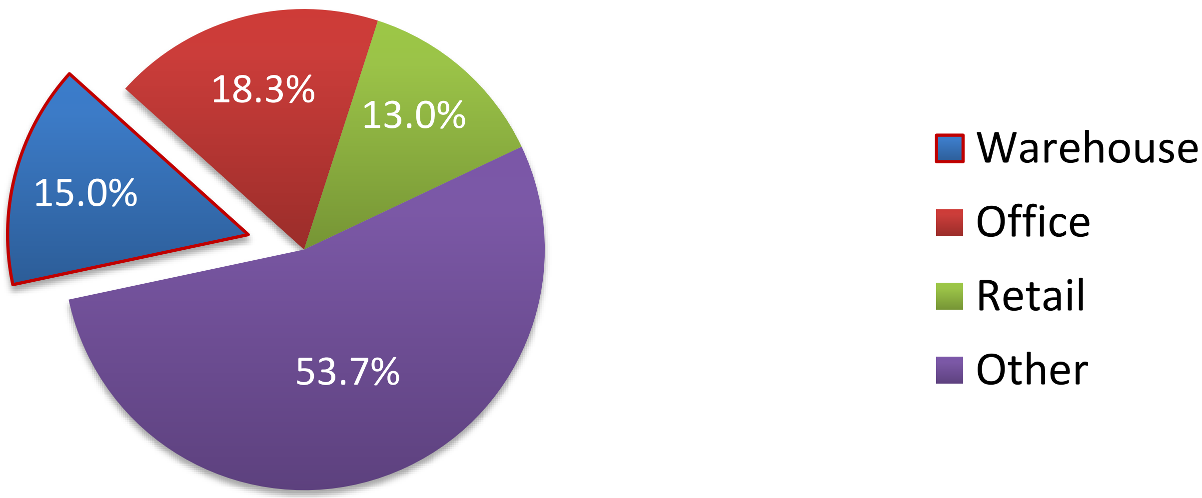
Why Focus on Warehouses?

Large Number of Buildings and Floor space

- Approximately 15% of U.S. commercial buildings and floor space (2012 CBECS early release*)
- Larger segment than retail and almost as much floor space as all commercial office buildings

U.S. Commercial Floor space by Sector



***U.S. Energy Information Agency. 2015. Commercial Buildings Energy Consumption Survey (CBECS). http://www.eia.gov/consumption/commercial/data/2012/**

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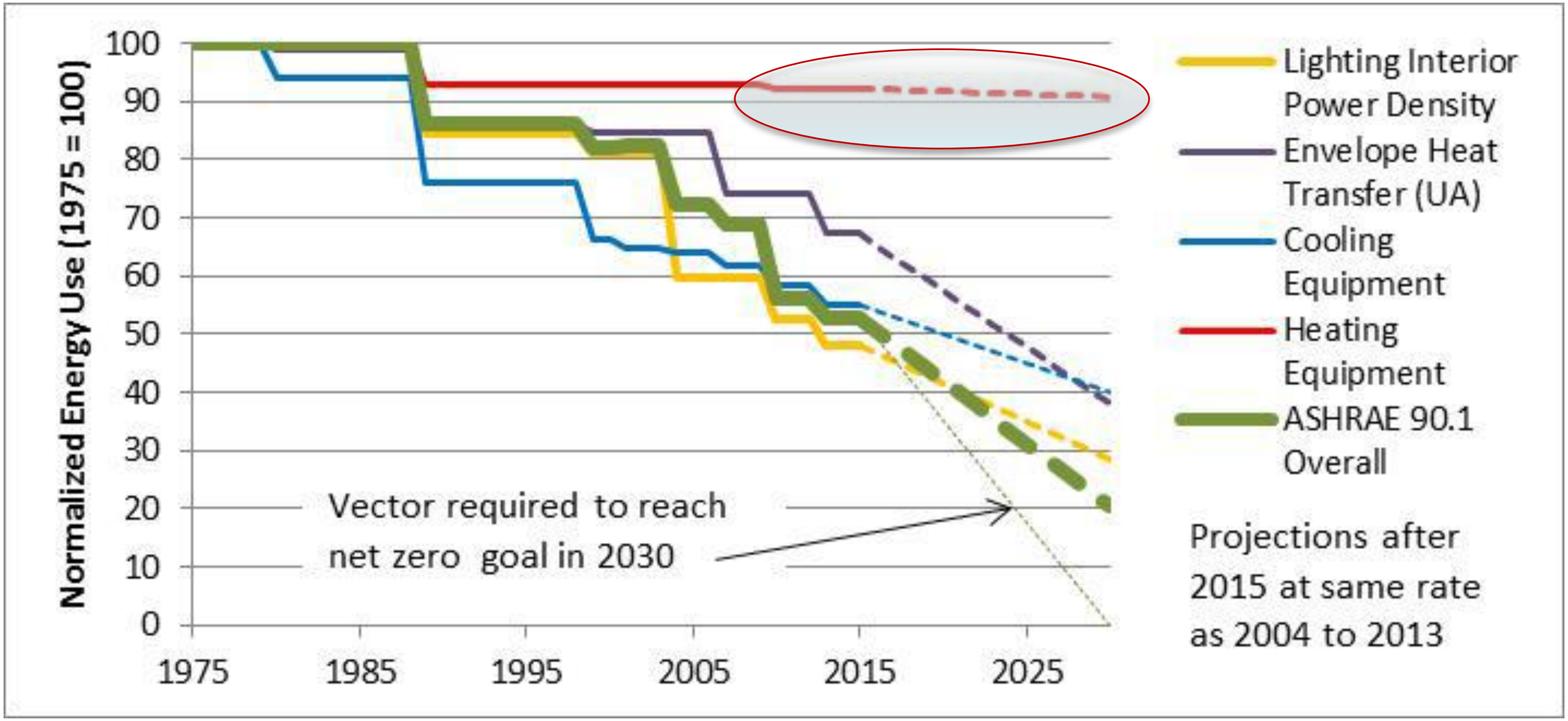
Plateaued Heating Equipment Savings

- Where ASHRAE 90.1 has reduced other end-uses, heating equipment efficiency is largely untouched



Rosenberg et al. 2015. "Roadmap for the Future of Commercial Energy Codes." Pacific Northwest National Laboratory. January 2015.

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Barriers to High Efficiency

- Low baseline equipment cost
- Split incentives for building owner and tenant
- Limited objective field data
- Site vs. Source Energy
- AC Focused HVAC Supplier Base

High Efficiency Heating Options

	Standard Unit Heater	Infrared Heaters	Direct-Fired Heater
Photo			
Indirect or Direct Combustion	Indirect	Indirect	Direct
Recirculation vs. Outside Air	Recirculation	N/A	Outside Air, some recirculation
High-Efficiency	Yes	Yes	Yes
Features	Condensing, high-pressure blowers	Condensing units	HTHV, high-pressure blowers

Photos from Reznor, Space-Ray, Modine, Cambridge

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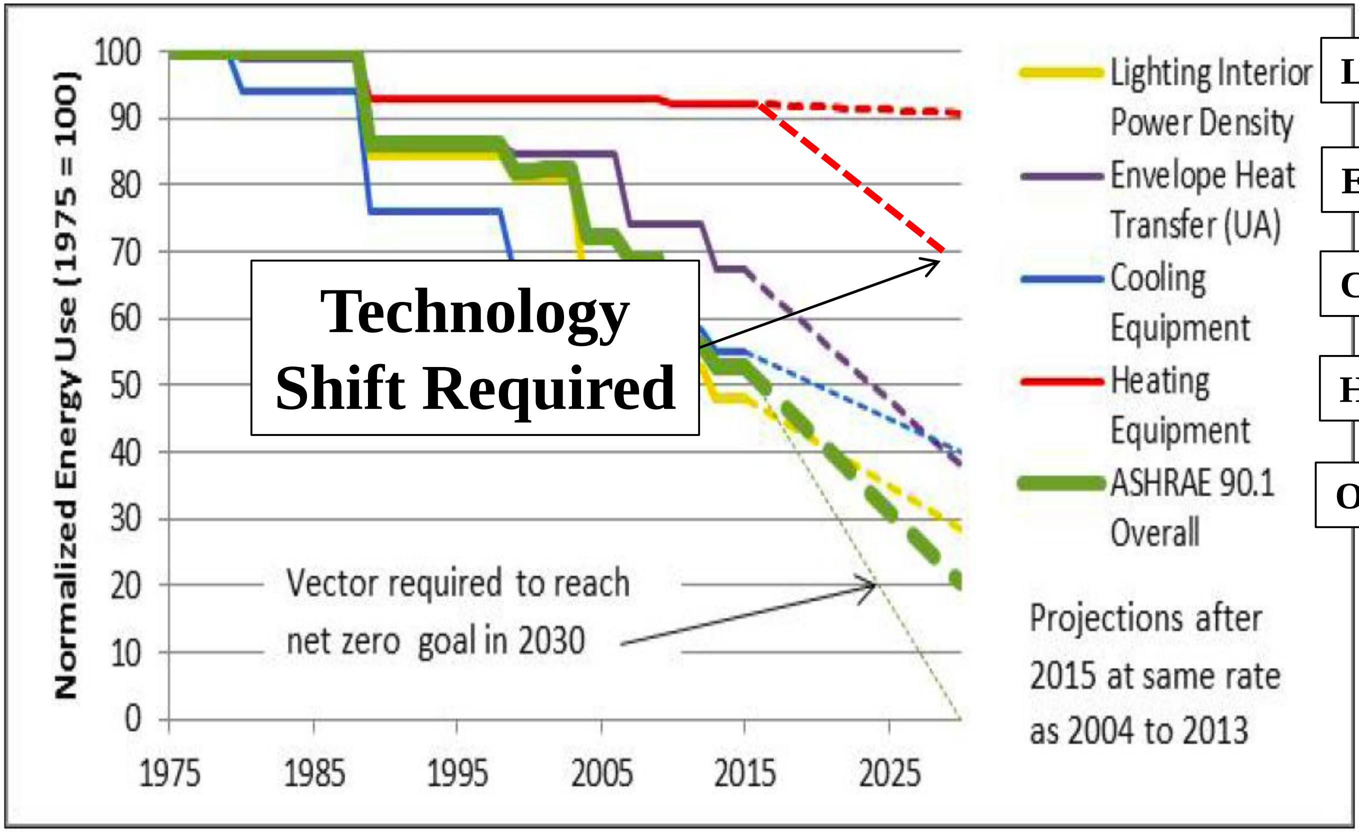
Energy Savings Goal

To reach the energy savings goals for the whole building, heating system efficiency must improve



Lighting – 44% Improvement

Envelope – 21% Improvement

Cooling – 27% Improvement

Heating – 1% Improvement

Overall – 37% Improvement

25 Years

Source: End Use Opportunity Analysis from Progress Indicator Results for ASHRAE Standard 90.1-2013
Pacific Northwest National Laboratory

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OVERVIEW OF HTHV TECHNOLOGY

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- Leaders in High Efficiency Heating & Ventilating
- Market Leading S-Series >2 Billion Sq Ft Warehouse/Distribution (30,000 Installations)

Core Educational Messages

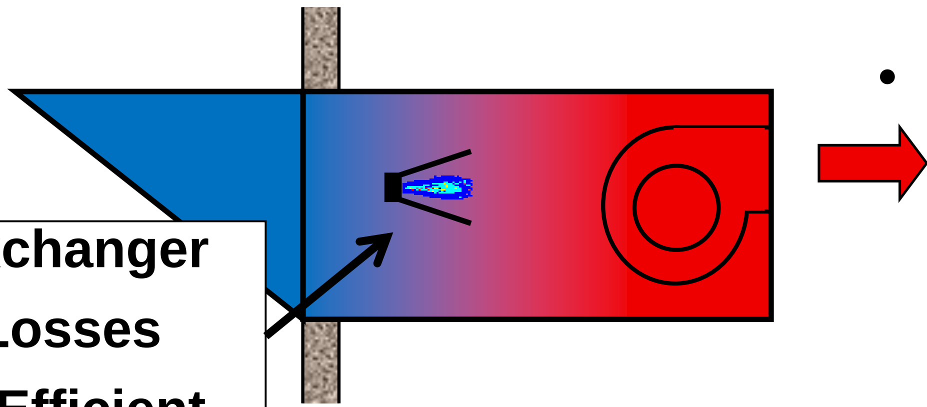
- Inherent Safety (IAQ) of Direct Fired

- Energy Efficiency
  - Ventilation Only Applications
  - Ventilation and Space Heating Combined Applications
  - Space Heating Only Applications

100% OA Direct Fired Familiarity

Draw Thru

- Blower in hot air stream
- 120°F max discharge



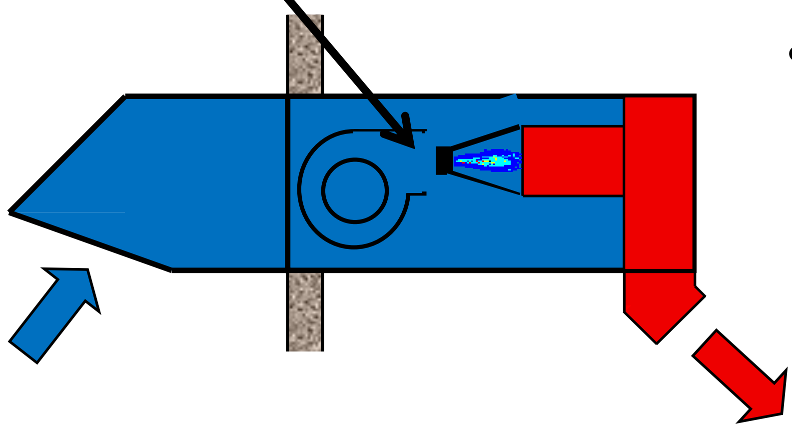
No Heat Exchanger

No Flue Losses

92%/100% Efficient

Push Thru (High Temp)

- Blower in cold air stream
- 160°F max discharge



Cold Air

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Safety/IAQ

- ANSI Z21.83 – Parent Technical Committee
- 1990's – Harmonization of US/Canadian Safety Codes
  - ANSI Z83.4 – 100% Outside Air Technologies <5 ppm CO
  - ANSI Z83.18 – Recirculation (80/20) <25 ppm CO
    - Banned in Canada

Cambridge has sat on Both US and Canadian Safety Boards For 30+ Years

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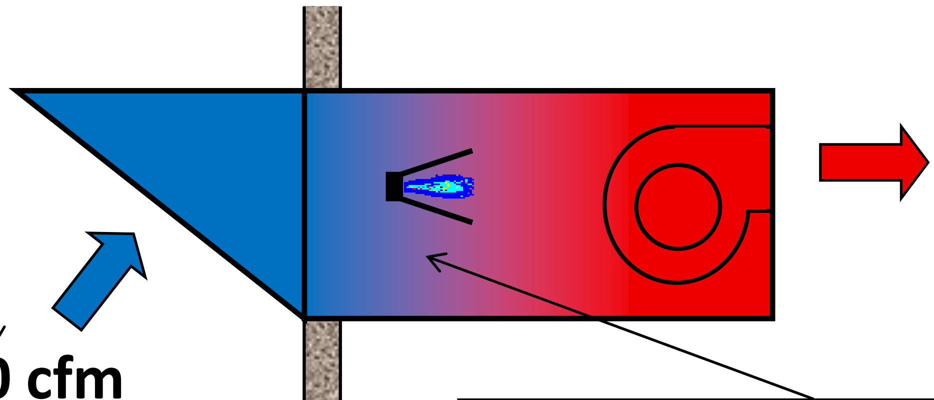
HTHV - Inherently Safer Design

- **Reason #1 – Proper Ventilation is the Key to Safety with all Gas fired equipment and the Key to IAQ.**
- **Reason #2 – Ventilation and combustion are delivered by the same blower.**
- **Reason #3 – There are triplicate engineering controls in ANSI Z83.4 to insure proper ventilation.**
- **Reason #4 – Even if all 3 ventilation engineering controls fail, the systems can't build up products of combustion.**

Z83.4 Ventilation Only System

5500 sf Gymnasium

@ 0.18 cfm/sf



1,000 cfm

0° Inlet Air

87 MBH Output

70°F Discharge

No Heat Exchanger

No Flue Losses

92%/100% Efficient

Energy Efficient for Air Load and Very Competitive 1st Cost

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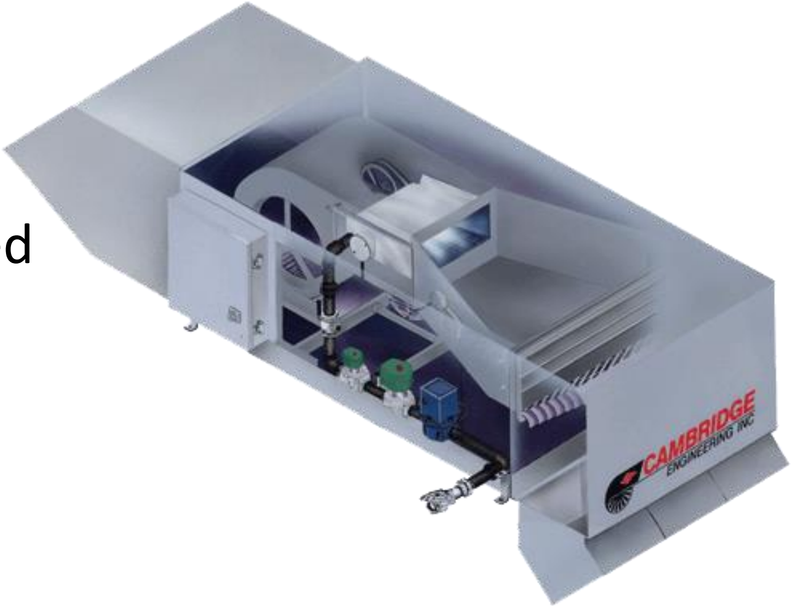
Optional: Cooling Coils, Filtration, Fully Custom

What would happen if you?

- Turned Up Discharge Temperature of 100% OA Direct Fired System
  - 92%-100% AFUE
  - No Flue Losses
- Every Degree Above Space Temperature is Usable for Conduction Losses or any other loss

History of High Temperature Heating and Ventilation (HTHV)

- Cambridge introduced "S-Series" in 1990's
- 160F discharge temperature achieved
- Transformed heat only, non-ducted market (Warehouse/Distribution/ Manufacturing)



Reason #1	+	Reason #2	+	Reason #3
40% Lower Install $		40-70% Less Energy		Free Ventilation (IEQ)

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How can it be efficient to use outside air to heat?

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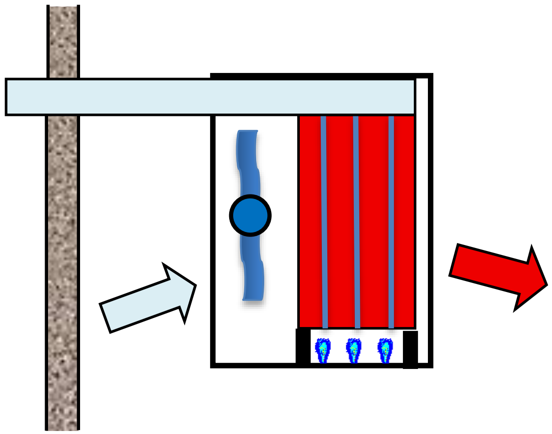
Outside Air Compliance

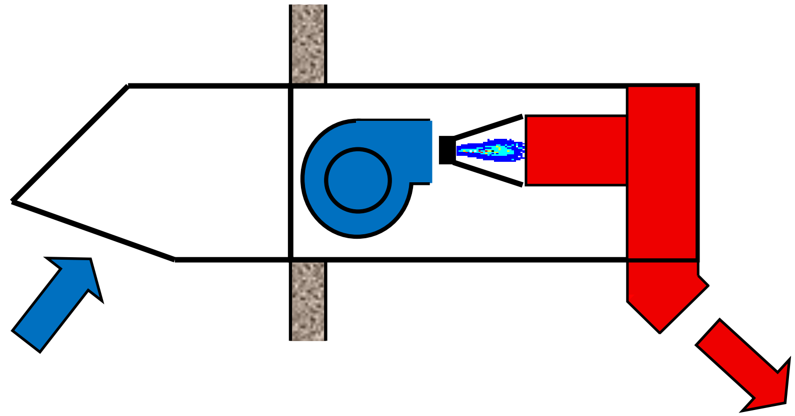
1. Every building requires outside air for human occupancy - ASHRAE 62.1
2. Every building must get this air from either mechanical ventilation or natural infiltration.
3. Ventilation significantly offsets infiltration when operational
4. Infiltration occurs during unoccupied times (always air load).
5. Air load is significant portion of heat load (30-70% with balance being conduction losses)

Indirect- vs. HTHV Direct Fired Space Heating

Indirect-Fired Unit Heater



100% Outside Air, HTHV Direct-Fired Heater



- Recirculates indoor air, may use outside air for combustion
- Baseline efficiency ~80%
- No ventilation airflow
- Neutral pressurization

- Only uses outside air for combustion, non-recirculating
- Baseline efficiency >90%
- Provides ventilation airflow
- Positive pressurization

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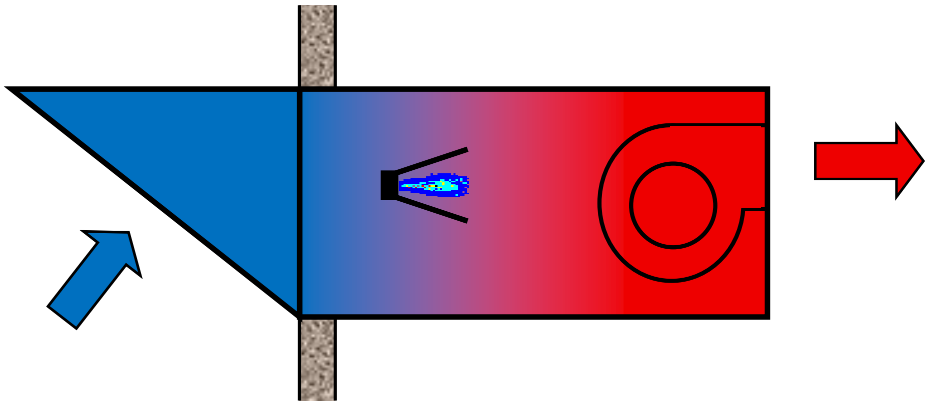
Ventilation Only Applications



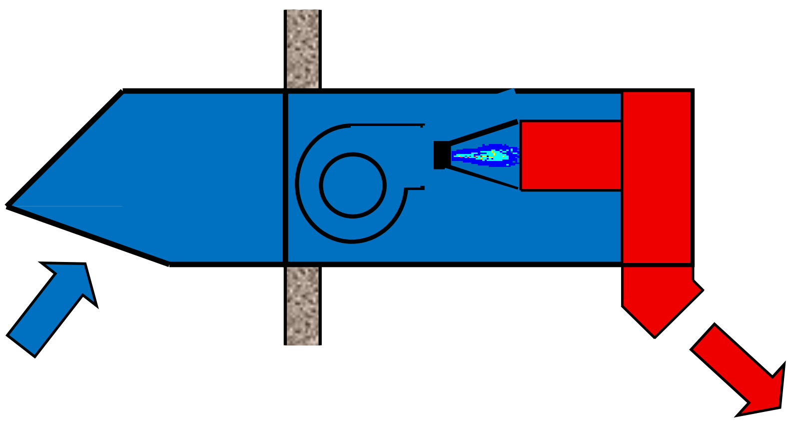
1,000 cfm

0° Inlet Air

87 MBH Output

70°F Discharge

Heating & Ventilation (Continuous Operation)



1,000 cfm

0° Inlet Air

87-199 MBH Output

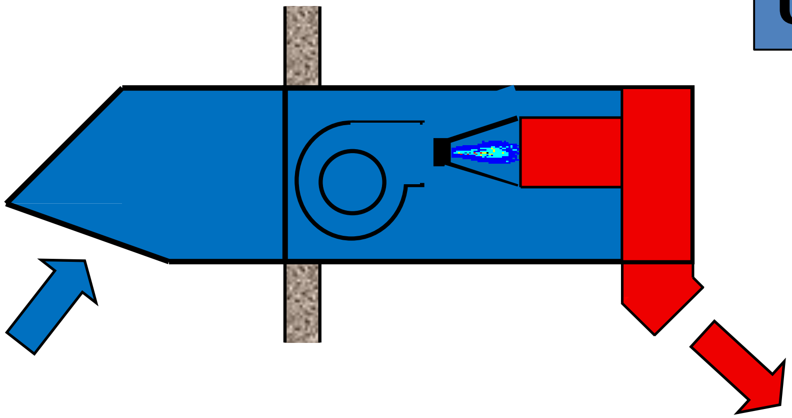
70°F-160°F Discharge (Fully Modulating)

Additional 90°F provides 112 MBH of Usable Btu's

(Available for Conduction or Other Losses) = 199 MBH – 87 MBH

Space Heating Only (Intermittent)

Unoccupied Times



1,000 cfm

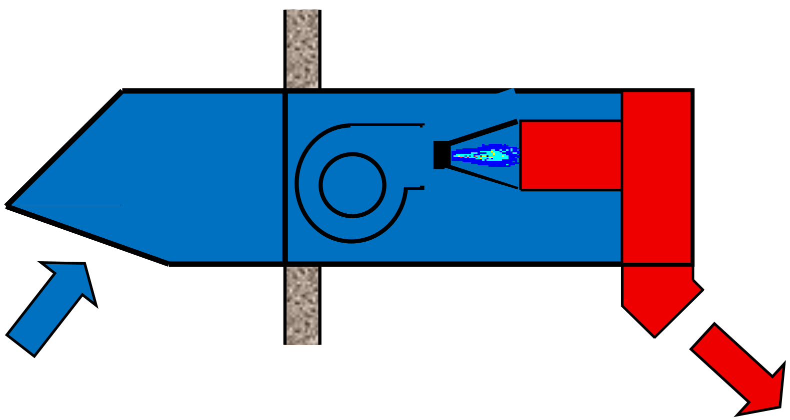
0° Inlet Air

199 MBH Output

160°F Discharge

Heating & Ventilation (Continuous Operation)

Occupied Times



1,000 cfm

0° Inlet Air

199 MBH Output

70°F-160°F Discharge (Fully Modulating)

Additional 90°F provides 112 MBH of Usable Btu's (Available for Conduction or Other Losses) = 199 MBH – 87 MBH

High Discharge Temperature (HT) Importance

Equipment $$/ Installation $$

- Example Design Load
  - 112 MBH Conduction Load

Wasted Energy $$

Unit Type	Discharge Temp	Design Temp	Usable BTU's/1,000 CFM	CFM Required to Cover Conduction Load
Push Thru	160	70	112 MBH	1,000
Draw Thru	120	70	49 MBH	2,400
Draw Thru	100	70	31 MBH	3,900
Draw Thru	70	70	0	∞

Is this efficient?

92%/100% Efficient

100% Outside Air

Direct Fired

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Hot Air Rises

How do we address?

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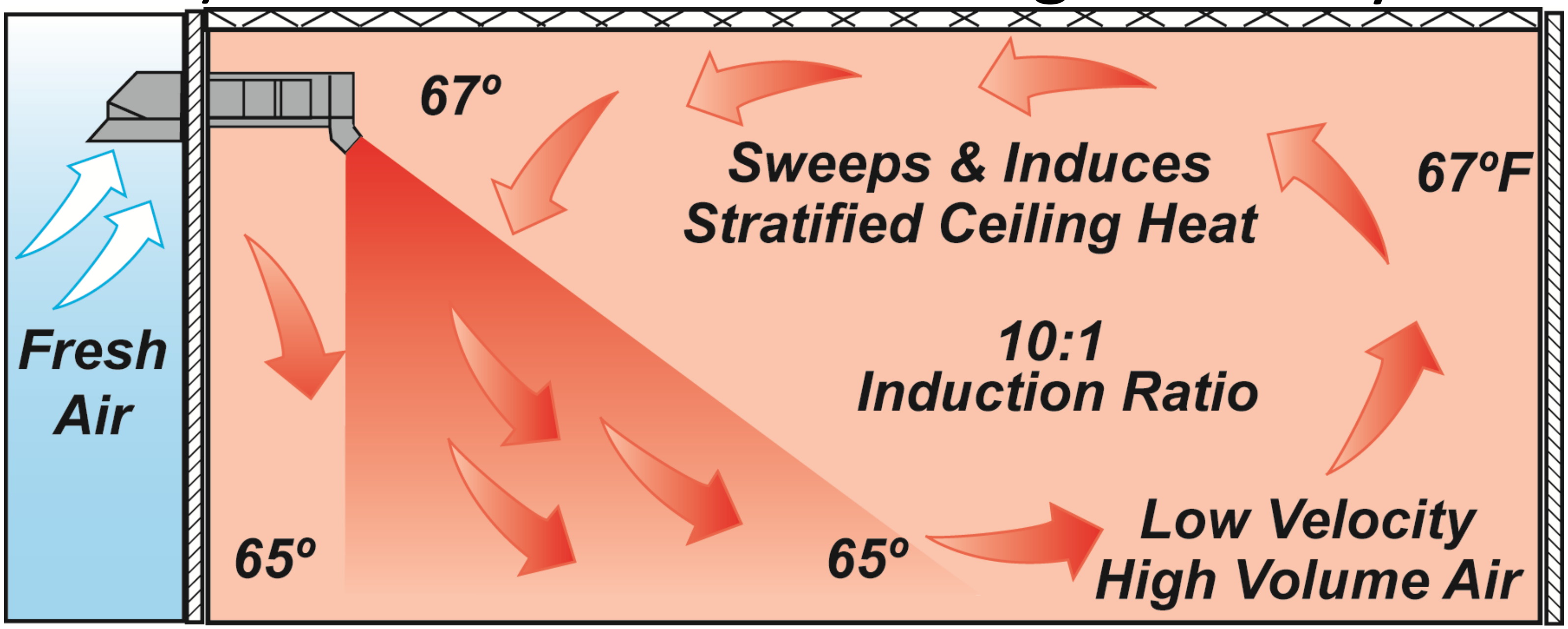
Must Destratify Space

- High Velocity Discharge
- High Volume Low Speed Fans (Big $#@ Fans)1500-2000 FPM Discharge Velocity



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TECHNOLOGY DEMONSTRATION

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Better Buildings Alliance

- The Better Buildings Alliance is a U.S. Department of Energy (DOE) effort to promote energy efficiency in U.S. commercial buildings through collaboration with building owners, operators, and managers.

- Members are committed to addressing energy efficiency needs in their buildings by:
  - Setting energy savings goals,
  - Developing innovative energy efficiency resources, and
  - Adopting cost-effective technologies and market practices.

Better Buildings U.S. DEPARTMENT OF ENERGY

Membership (2014)

- **185 member organizations**
- **10 billion sq.ft. represented**
- **11% of U.S. commercial buildings**

https://www4.eere.energy.gov/alliance/join

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Field Study Overview

What	Field study of advanced technology
Why	Provide independent verification of energy savings and other benefits
How	Side-by-side comparison of new and existing heaters
Who	Langendorf Supply Co. (an HVAC distributor)
Where	Bridgeton, MO (outside of St. Louis, MO)
When	2013-2014 heating season (Oct–Mar)

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Demonstration Site Overview

- Approximately 42 ksq.ft. of warehouse and loading space
- 24 ft. ceilings with several interior barriers (e.g., storage racks)
- Bridgeton, MO, a suburb of St. Louis
- Thermostat settings at 60°F

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Technology Comparison

- New units installed side-by-side to existing units and operated in alternating months
- **Existing Units**
  - 4 sets of standard efficiency unit heaters
- **New Units (HTHV)**
  - 4 x 250,000 Btu/hr. Cambridge SA-Series units
- On thermal efficiency alone, expectation of ~11% natural gas savings

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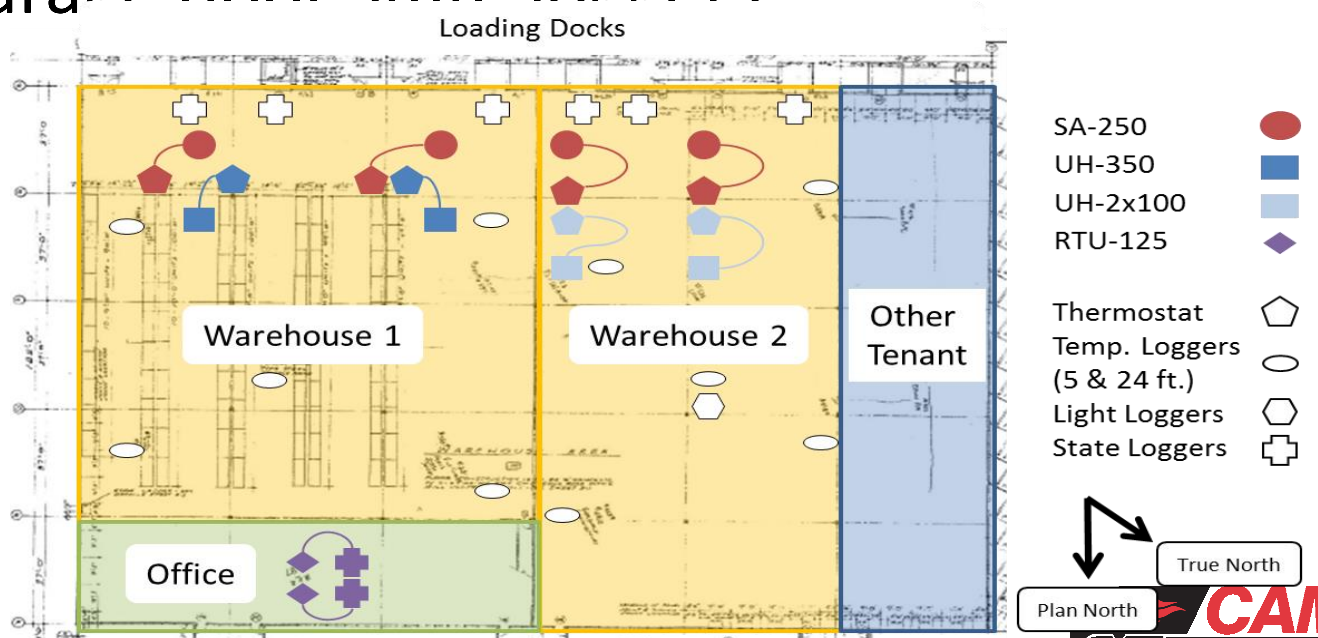
Monitoring Plan

- WiFi thermostats w/ remote monitoring & control
- Temperature loggers (5 & 24 ft. from floor)
- Runtime loggers
- Garage door state loggers



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Energy Results (Gas)

- Over the course of the 2013-2014 heating season, the new units reduced natural gas consumption by 20%.
  - Greater than the ~11% savings predicted by thermal efficiency alone.

Month	HDD (Base 60°F)	Utility Meter Values (Therms)	Modeled RTU Consumption (Therms)	Adjusted Utility Meter Values (Therms)	Consumption per HDD (Therms/HDD)
Existing Heaters (October & December)	965	2,338	311	2,027	2.10
New Heaters (November & February/March)	1,501	3,005	497	2,508	1.67
				% Savings	20%

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Energy Results (Combined)

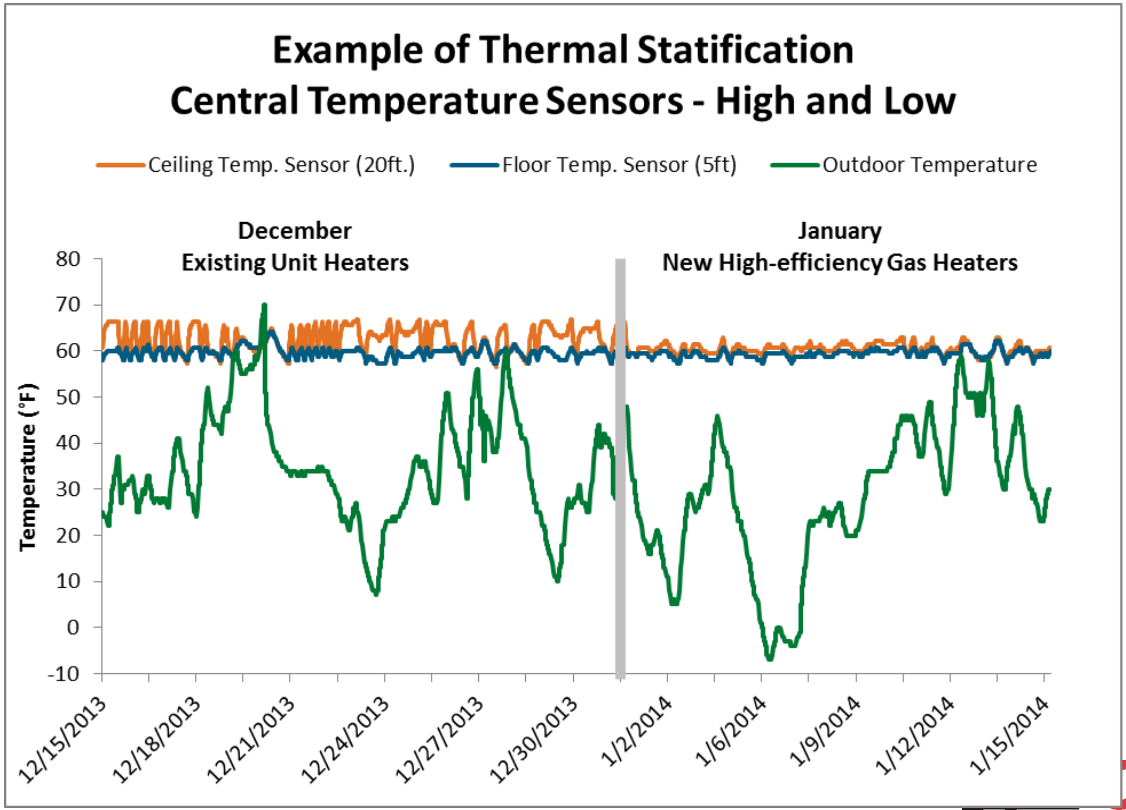
- Despite higher electricity consumption, the significant natural gas savings result in 15% source energy savings for the new units.

		Gas Heater		% Savings	Notes
		New	Existing		
Natural Gas Consumption	Therms/HDD	1.67	2.10	20%	Natural gas site-to-source ratio of 1.05*, 100,000 Btu/therm
	Btu/HDD (Source)	175,515	220,584		
Electricity Consumption	kWh/HDD	1.44	0.40	-260%	Electricity site-to-source ratio of 3.14*, 3412 Btu/kWh
	Btu/HDD (Source)	15,407	4,285		
Combined Energy Consumption	Btu/HDD (Source)	190,922	224,870	**15%**	-

***Site-to-source ratios assumed as 3.14 for electricity and 1.05 for natural gas, determined from https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf?cb28-29dd.**

Non-Energy Benefits

- The new units also provided improved temperature distribution by reducing stratification between the floor and ceiling and blowing warm air further down aisles.



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Financial Results

- For the demonstration site, the new units would reduce utility bills by approximately 15% or $1,000.
  - Results suggest a payback of 7-8 years over standard efficiency equipment.

Heating Season	Existing Gas Heater Utility Costs ($)*			New Gas Heater Utility Costs ($)*			Net Cost Savings	
	Natural Gas	Electricity	Total	Natural Gas	Electricity	Total	$	%
2013–2014 Season	$7,039	$134	$7,173	$5,600	$482	$6,082	$1,091	15%
70–Year Average	$6,227	$119	$6,346	$4,955	$426	$5,381	$965	

***Assuming $0.8/therm and $0.08/kWh average utility rates for the site.**

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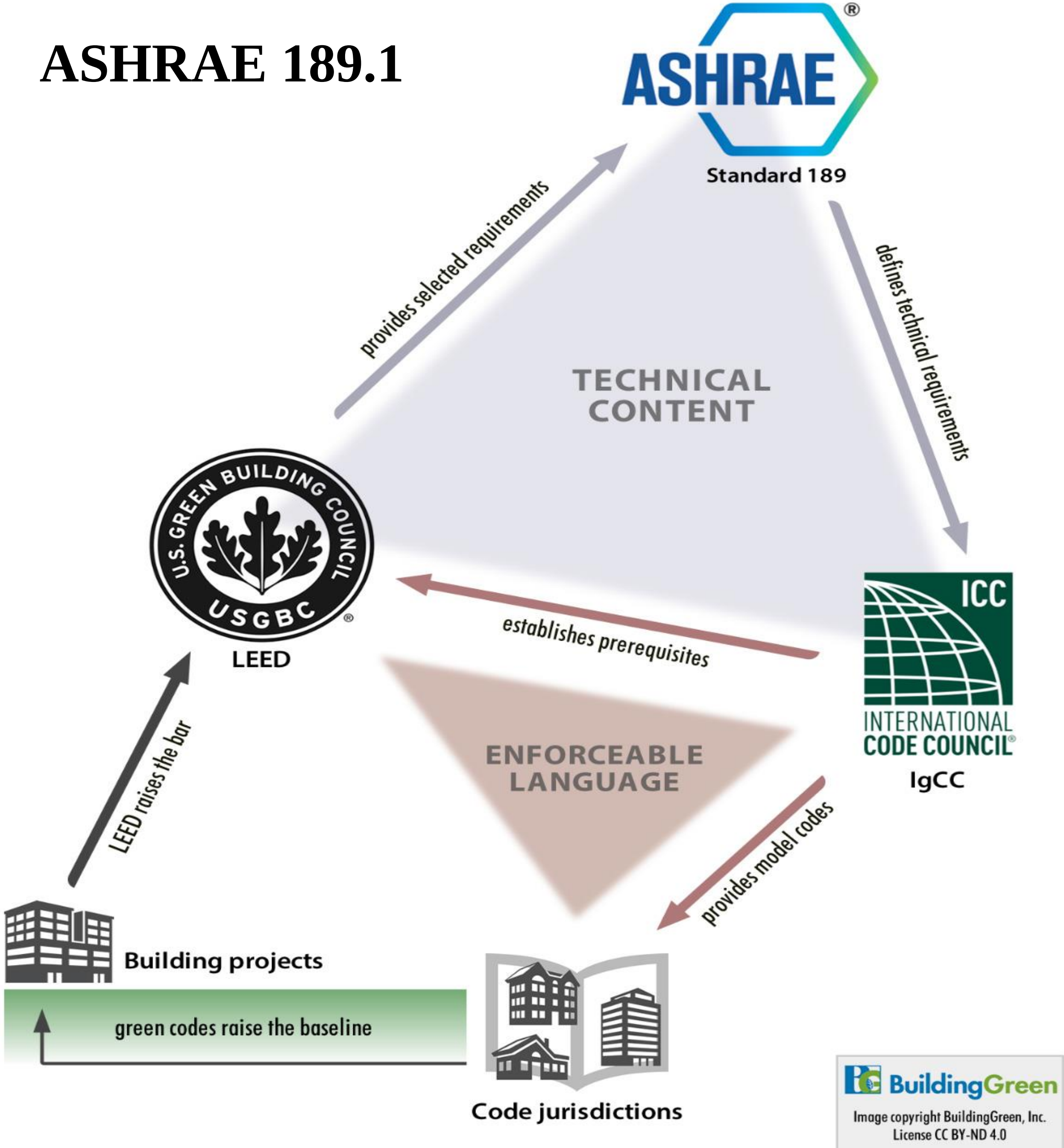
ASHRAE 189.1



ASHRAE
Standard 189
provides selected requirements
defines technical requirements
TECHNICAL CONTENT
U.S. GREEN BUILDING COUNCIL
USGBC
LEED
establishes prerequisites
ICC
INTERNATIONAL CODE COUNCIL
IgCC
ENFORCEABLE LANGUAGE
LEED raises the bar
provides model codes
Building projects
green codes raise the baseline
Code jurisdictions
BuildingGreen
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Advocacy

SUMMARY AND NEXT STEPS

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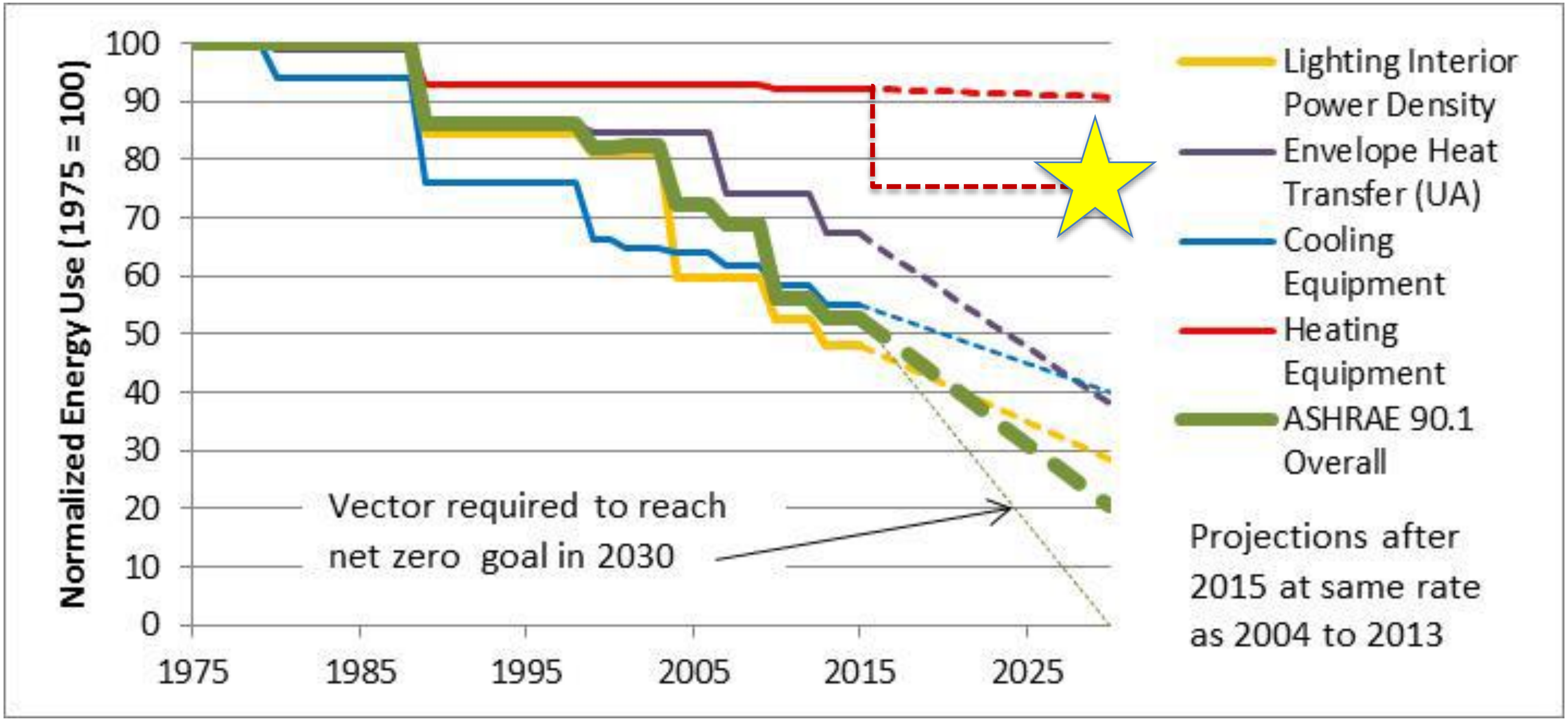
Energy Savings Goal

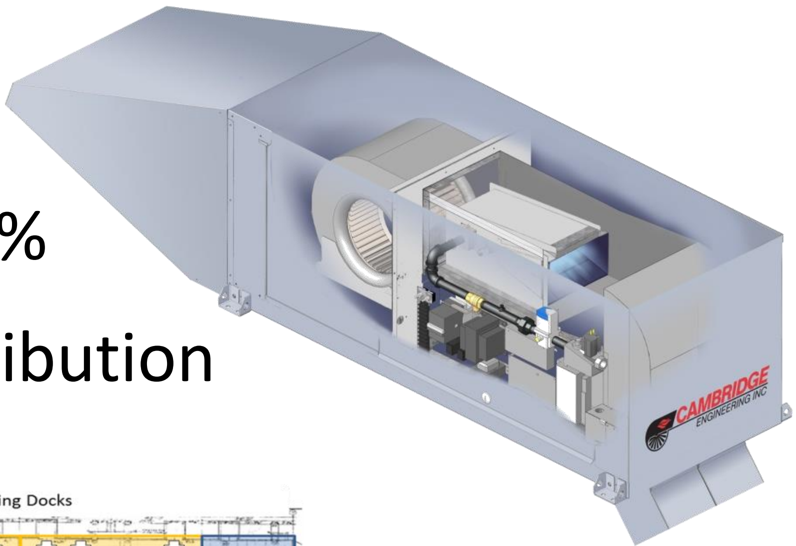
- Technologies are available today to help meet future building codes and energy savings goals

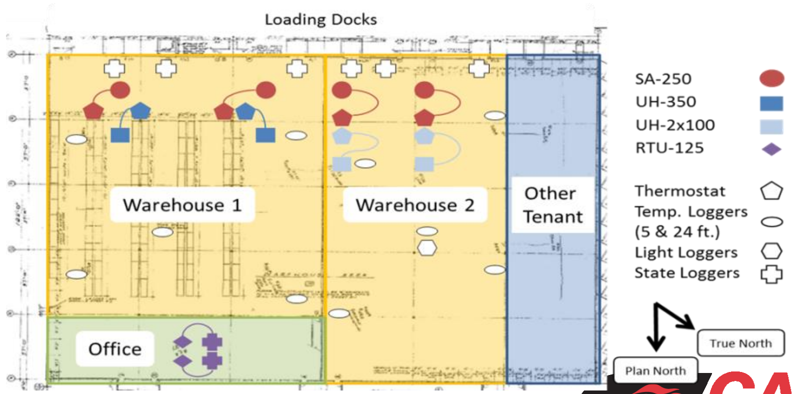


Rosenberg et al. 2015. “Roadmap for the Future of Commercial Energy Codes.” Pacific Northwest National Laboratory. January 2015.

Results Summary

- Field study successfully demonstrated this high-efficiency technology
  - Natural gas savings of 20%
  - Source energy savings of 15%
  - Improved temperature distribution





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Recommended Next Steps

- Consider high efficiency technologies for high-bay applications
  - Space heating
  - Ventilation
  - Destratification
- Discuss potential rebates with gas utility account executives at the start of projects
- Others…

Thank you for your attention

Questions?

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