Better Buildings
U.S. DEPARTMENT OF ENERGY

Better Buildings Summit Space Conditioning:

Advanced Solutions for Packaged HVAC

Michael Deru

NREL

Washington, DC

May 7, 1:00-2:15

Agenda

- Introductions
- Update on RTU Challenge and controls demonstrations
- Advanced RTU Campaign update
- Ventilation strategies in retail and small office
  - Scott Williams, Target and Lisa Ng, NIST
- High-Efficiency Gas Heaters – What's possible?
  - Marc Braun, Cambridge Engineering
- Open discussion
  - New challenges and opportunities

Advanced RTU Campaign Update

- 84 Supporting partners and 27 Participating partners
- Webinars – 12, over 1,100 participants
- In the News – 25 articles by third parties
  - "Facility managers who have already done low-hanging-fruit lighting upgrades know the RTU is the largest target." Greentech Media, Dec 13, 2013.
- Installations and energy saved

Year	High-Efficiency RTU Installations	RTU Retrofits	Estimated Annual Savings (kWh)
2013	7,080	6,279	137,310,863
2014 commitments	7,096	7,000	144,059,982

RTU Challenge and Advanced Controls Updates

- RTU Challenge (officially over, but)
  - Two more manufacturers with products coming soon
  - RTU Comparison Calculator will be updated to include RTU challenge data and variable speed controls
  - Reports
    - PNNL – Modeled performance
    - NREL – Navy demonstration
  - More demonstrations in the works
- RTU Advanced Controls
  - Reports
    - PNNL – retail and office demonstrations
    - NREL – Navy demonstrations
  - More demonstrations in the works

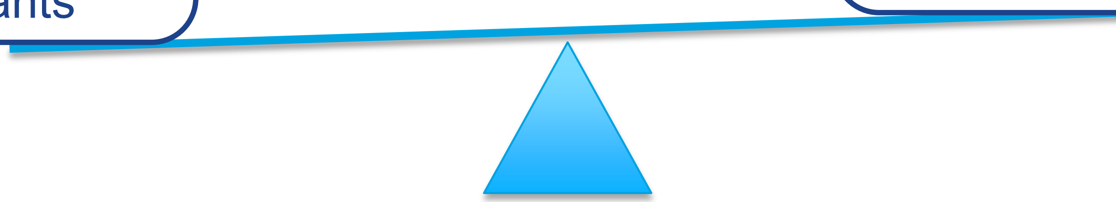
Why is Ventilation a Big Deal?

Ventilation is ~ 9% of CB energy consumption[1]

Find the right balance

Indoor air quality
Ventilation dilutes internally-generated contaminants

Energy
Outdoor air must be heated/cooled and humidified/dehumidified

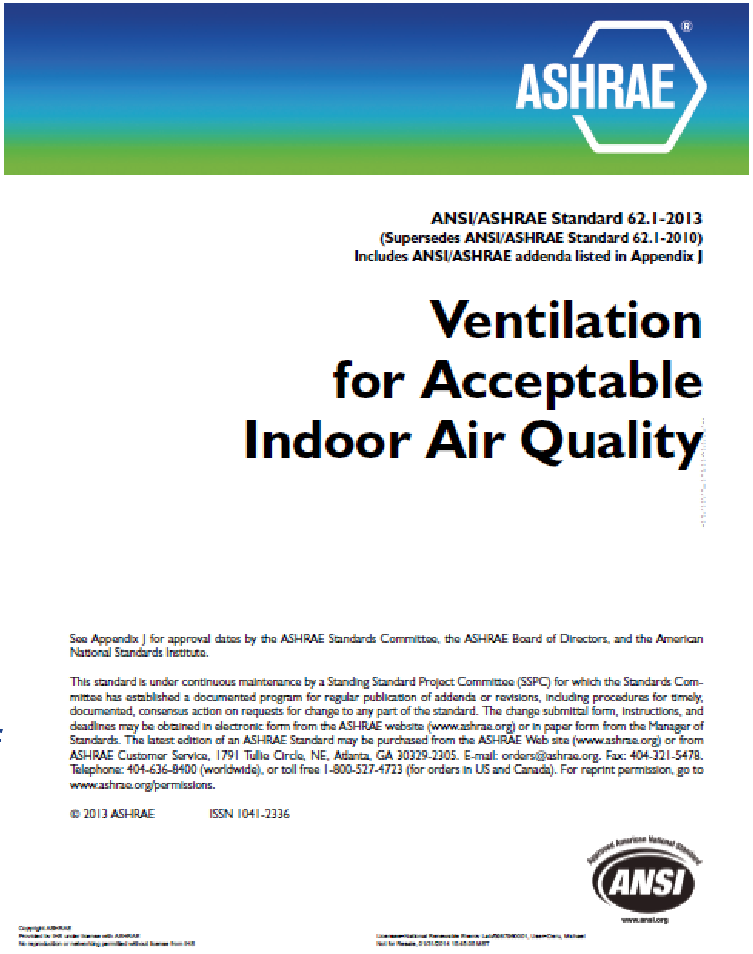


IAQ costs >> Energy costs
(health, comfort, productivity)

[1] DOE (2012). 2011 Buildings Energy Data Book, U.S. Department of Energy

ASHRAE Standard 62.1

- Prescriptive path
  - Prescribed ventilation rates by space type
    - Per area (cfm/ft^2) and per person (cfm/occupant)
- Performance path
  - Determine Contaminants of Concern
  - Determine maximum threshold levels
  - Measure indoor contaminant levels at various conditions
  - Provide subjective feedback on acceptability of indoor air
  - Apply results to determine operational ventilation rate


ANSI/ASHRAE Standard 62.1-2013
(Supersedes ANSI/ASHRAE Standard 62.1-2010)
Includes ANSI/ASHRAE addenda listed in Appendix J

Ventilation for Acceptable Indoor Air Quality

See Appendix J for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE Web site (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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ASHRAE Research Project 1596
Ventilation and Indoor Air Quality in Retail Stores

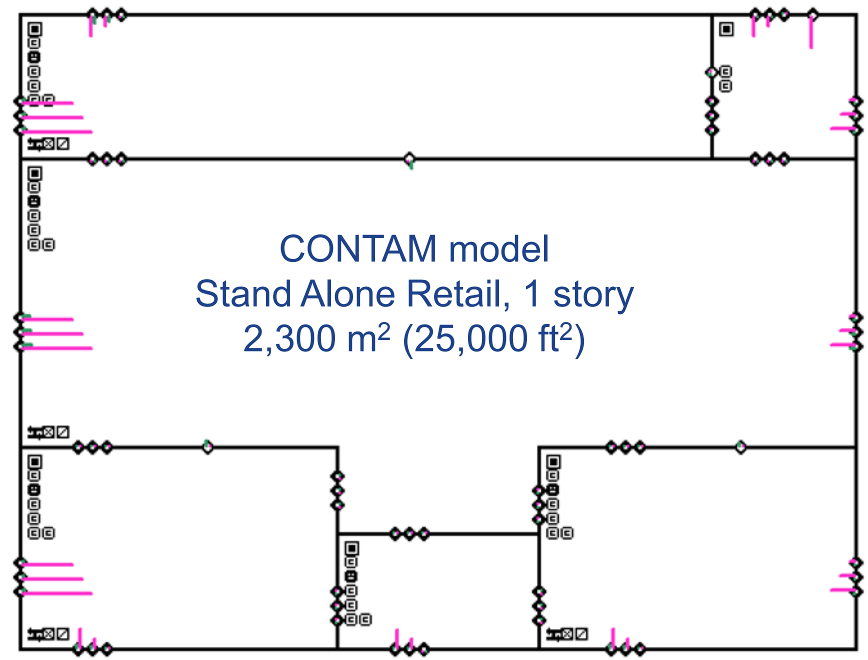
- Tested 14 retail stores (Texas and Pennsylvania)
- Few complaints about IAQ
- Formaldehyde was the contaminant of concern
  - 86% of stores exceed California 8-hour recommended exposure limit
  - 43% exceeded the NIOSH 8-hour exposure limit
  - Air exchange rates would have to increase significantly
  - More effective to control the contaminant
    - Pressed wood products, permanent press clothing, floor coverings

NIST Project on Ventilation and IAQ in Retail Buildings

Lisa Ng

NIST Ventilation Simulations

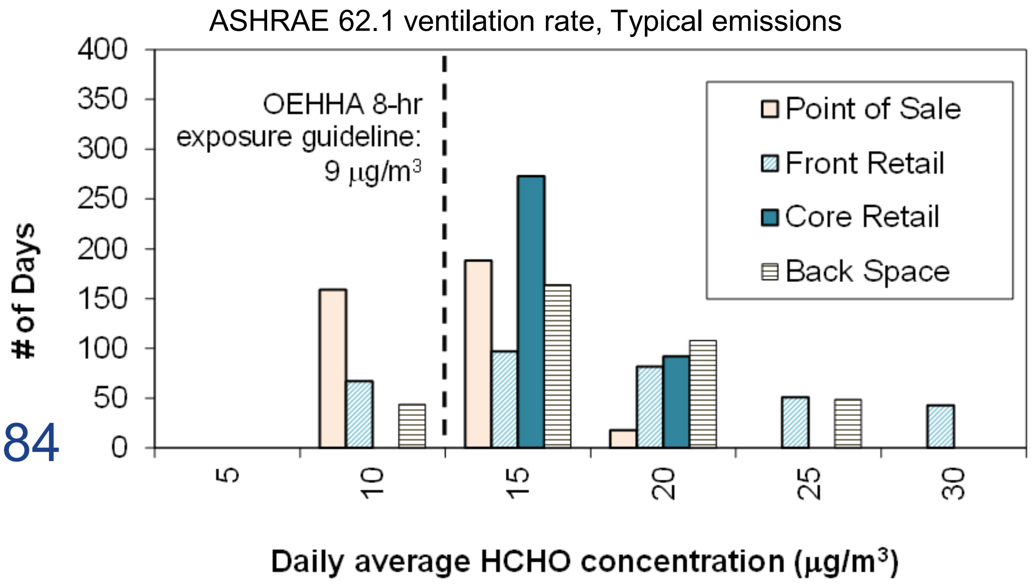
- CONTAM Simulations
  - Formaldehyde emissions
    (50 µg/h-m^2 | 5 µg/h-m^2)
  - Occupant-generated CO_2
  - Ventilation rates
    - ASHRAE Standard 62.1, 50%, and 2X requirements
  - Chicago weather; hourly for one year



Ng et al. (2013), The IAQ and Energy Impacts of Reducing Formaldehyde Emissions in Commercial Buildings, Proceedings of ASHRAE IAQ2013

Research Results

- Doubling ventilation rate:
  40% increase in energy use,
  15% reduction in formaldehyde
- Reducing formaldehyde emissions (Standard 62.1 ventilation rate):
  63% reduction in formaldehyde
- Reduced emissions & 50% ventilation:
  60% reduction in formaldehyde,
  21% reduction in energy use
- CO_2 levels below 1800 mg/m^3 (984 ppm$_v$)



Ng et al. (2013), The IAQ and Energy Impacts of Reducing Formaldehyde Emissions in Commercial Buildings, Proceedings of ASHRAE IAQ2013

Target Ventilation Approaches

Scott Williams,
Group Manager of Mechanical Engineering

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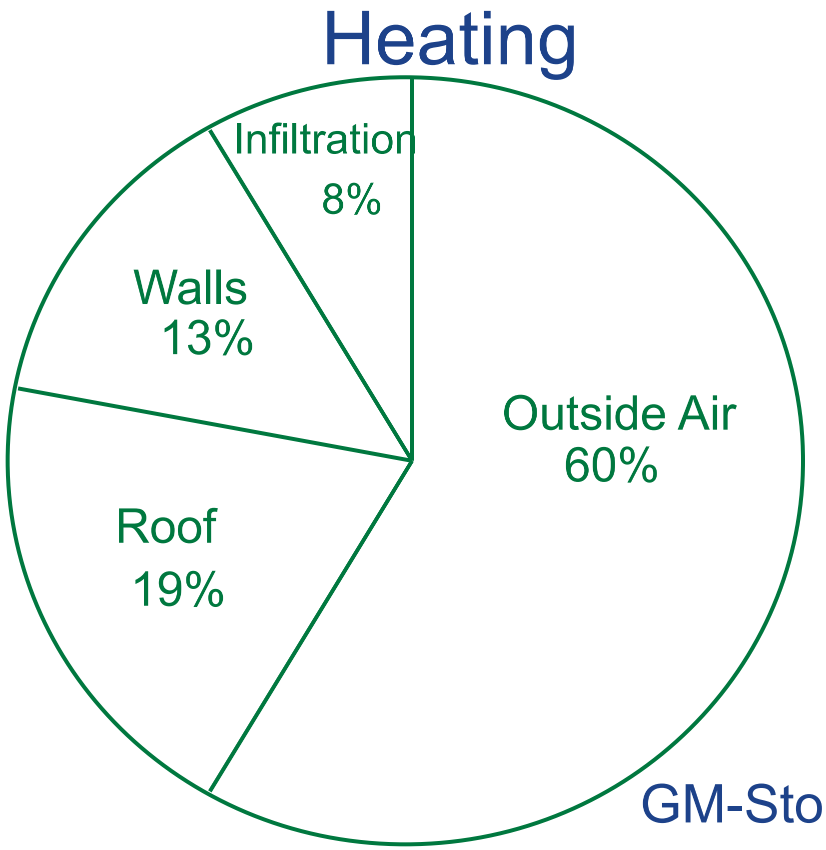
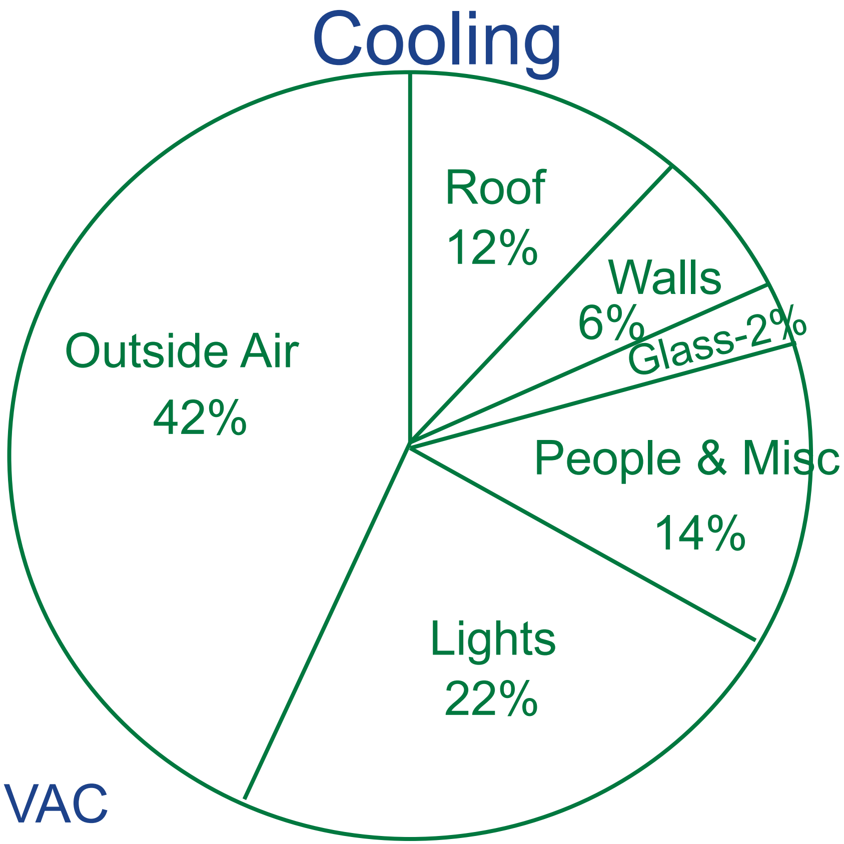
Why is optimized ventilation important?

Peak Load Analysis





GM-Store HVAC

Target Experience: Ventilation Strategy

- Prescriptive rates in off sales floor areas
- Indoor Air Quality Procedure (IAQP) is used on Sales floor

Credit: Michael Deru NREL

NREL/PIX 19503

Target Experience: Ventilation Strategy (History)

- 1997 U of MN Study at Stillwater MN
  - Tested 4 times over a year to account for varied product mix
  - Formaldehyde was found to be primary contaminant approaching threshold limit
  - Good air quality at 0.15 cfm/ ft^2 outdoor air during occupied periods (about half prescriptive rate)
- 2007- 2009 U of MN Study at three various format stores in different climate zones
  - Tested 4 times over a year to account for varied product mix
  - Formaldehyde was found to be primary contaminant approaching threshold limit
  - Results showed 0.068 cfm/ft^2 outdoor air with continuous ventilation provided good IAQ
  - Stores since 2009 designed at 0.08 cfm/ft2 outdoor air on Sales Floor

Target Experience: Ventilation Strategy (Application)

- IAQP method puts responsibility on Engineer of Record for proper application.
- Optimized ventilation significantly reduces ventilation load (sensible and latent) allowing reduction in equipment size (25%) and energy savings (up to 40% of HVAC).
- Identification of Contaminants allows application of source control.
- Recent testing has found significant reduction of airborne Formaldehyde levels due to reduction in product use.
- Source control removes contaminants from manufacturing, distribution, store environments, and customer's homes.

Ventilation – Energy and IAQ

- Questions
- Challenges
- Opportunities

High-Efficiency Gas Heaters with 100% outside air requirements

Marc Braun,
Cambridge Engineering

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High Efficiency Heating Technologies

High Efficiency Heating Technologies

- Currently entering the commercial marketplace
  - High Efficiency Packaged RTU's
    - Condensing, Indirect Fired RTU (and Duct Furnaces) *Research by Gas Technology Institute
  - High Efficiency Unit Heaters (DOE/BBA Advanced Technology Specification)
    - Condensing
    - Direct Fired

Efficiencies > 90%

What Options Exist

Summary of Thermal and Seasonal Efficiency for Gas-Fired Heaters (Sachs, 2003)

Technology	Thermal Efficiency	Seasonal Efficiency
Pilot Light, Gravity Vent	78%-82%	63%
Intermittent Ignition Device, Gravity Vent	78%-82%	66%
Intermittent Ignition Device, Power Vent	80%-83%	80%
Separated Combustion	80%-83%	80%
Pulse Combustion	90%	82%
Condensing Heat Exchanger	>90%	90%
Direct-Fired Heater *	>90%	90%

* Sourced from Cambridge Engineering, Inc. (2011). Sachs (2003) only discusses unit heaters and not other gas heating technologies.

Ultra Efficient (HTHV) Space Heater

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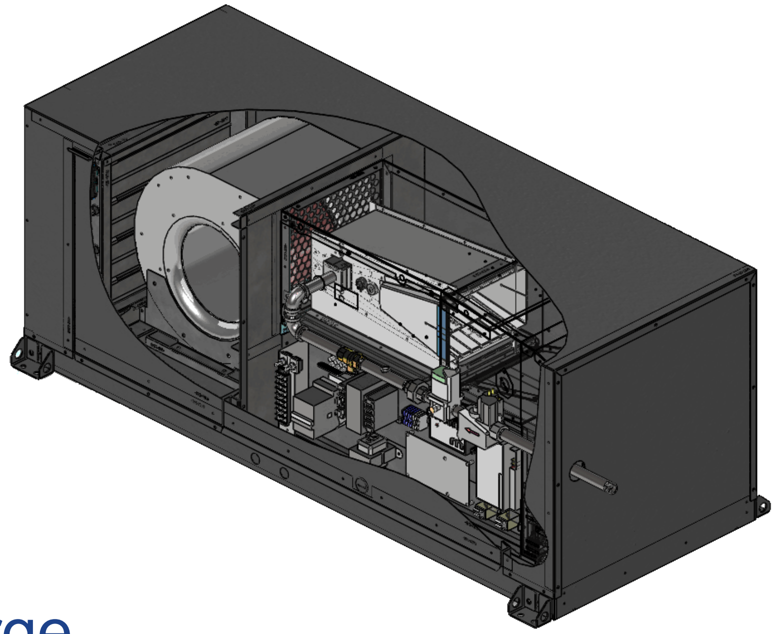
Energy Study

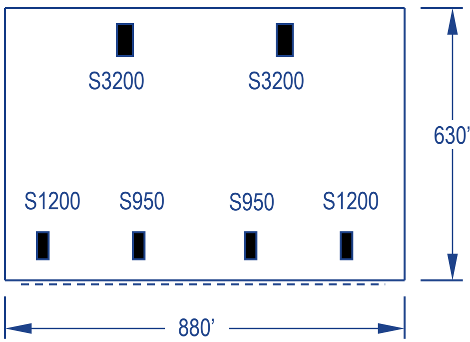


- Ultra Efficient 92%
- 250 MBH/1200 CFM
- (HT) Blow Thru® 160F Discharge
- (HV) Induced Air Turnover
- Optional Ventilation (Summer/Winter)
- Simulated savings – 38% gas and 93% electric (fan)

RETROFIT CASE STUDY

High-efficiency Space Heaters vs. Unit Heaters

Food Distribution Warehouse



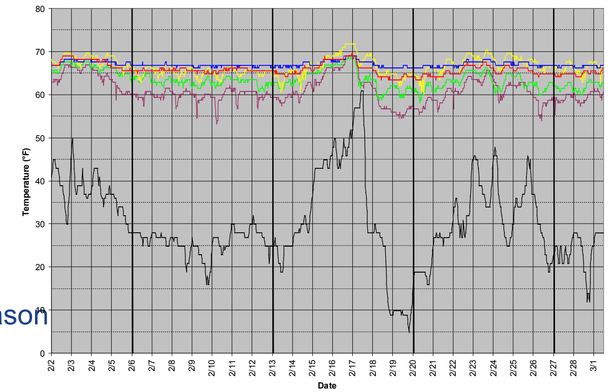
Building Specifications

- 540,700 ft^2
- Located in Cleveland, OH
- 61 Dock Doors

Before – Unit Heaters

Performance

- Uneven temperatures
- Cold dock areas
- High gas costs
- Poor Indoor Air Quality



Operating Costs

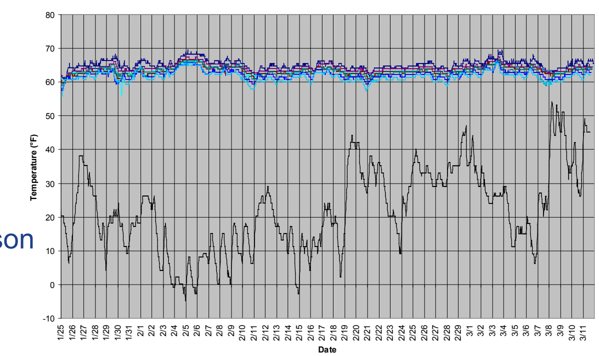
Based on:
196,918 therms for 2006 -07 heating season
Normalized to 30 year averages

$0.36/$ft^2$ Total cost

After – High-efficiency Space Heaters

Performance

- More even temperatures
- Better Indoor Air Quality
- Lower Energy Cost



Operating Costs

Based on:
136,042 therms for 2007-08 heating season
Normalized to 30 year averages

0.25ft^2$ Total cost

Summary

The high-efficiency system saved **31% in gas** while providing better overall temperatures in the building.
The high-efficiency system saved approximately **$59,500/year** operating at $0.25/$ft^2$ vs. $0.36/$ft^2$.

Open Discussion

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Open Discussion

- Recent Successes
- Challenges
- New opportunities

Backup Slides

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Size of the Opportunity

3rd Party Energy Modeling (EnergyPlus)

Energy Consumption	Gas (therms)	Fan Electric (kWh)
ASHRAE 90.1 Baseline	32,563	78,594
Blow-Thru (HTHV)	20,220	5,758
Draw-Thru (LTLV)	27,506	7,589
Recirculation	27,805	52,644
Unit Heater	32,833	16,875
Air Turnover	26,822	17,153
Infrared	32,156	11,164
% Savings vs. 90.1 Baseline		
Blow-Thru (HTHV)	37.9%	92.7%
Draw-Thru (LTLV)	15.5%	90.3%
Recirculation	14.6%	33.0%
Unit Heater	-0.8%	78.5%
Air Turnover	17.6%	78.2%
Infrared	1.2%	85.8%

38% Gas Savings and 93% Electrical Savings over AHRAE 90.1 Energy Standard

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/10,000 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