Electrification & Low Lift Systems

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Introduction

Presenters

Matt Bhumbla, MBA, BSME

V.P. – Business Development, Sustainable Systems

- 20+ years of HVAC system design experience
- 15+ years at Price industries. Worked in various roles including; Engineering Sales, Product Management, Business Unit Leadership, Category Development, Product Launch, System Integration
- Involved in system design & construction of 20+ million sq. ft. of commercial, institutional, healthcare, lab and K-12 spaces
- Serves at national level of ASHRAE, TC 5.3 & 6.5

Braydon Whittington, BSME

Project Engineering Team Lead – Air Moving Products

- 7+ years at Price industries. Worked in various roles including; R&D specialist at Price Research North (PRCN), Product Designer for Stratified/Critical Environment/Air Moving Products, and Application Engineering for Air Moving Products

Electrification & Low Lift Systems

Course Description

HVAC Systems have seen a lot of changes over the last decade. This includes energy reduction goals, calls for decarbonization, reduction in fossil fuel use, embodied carbon, and net zero stretch goals. The presentation will explore the key drivers, i.e., electrification, systems with lower compressor lift and the role Hydronic systems and Low Temperature Terminal Units can play in potentially alleviating some of the challenges. Low lift systems like Chilled Beams, Sensible Cooling Systems and Terminal Units will be the primary focus of the discussion.

Electrifcation & Low Lift Systems

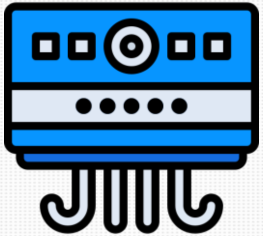
Learning Objectives

- How has the HVAC system energy consumption and carbon footprint paradigm shifted over the last decade?
- What is Low Lift and how it can help both with energy usage reduction and electrification?
- What are Decoupled Cooling Systems and associated design considerations?
- How do the new Low Temperature Terminal Units work?

Electrification & Low Lift Systems

Agenda

- HVAC Energy Code & Local Law Trends
- Low Lift Systems
- Decoupled Systems
  - Introduction
  - Design Considerations
  - Applications
- Discussion



HVAC Systems

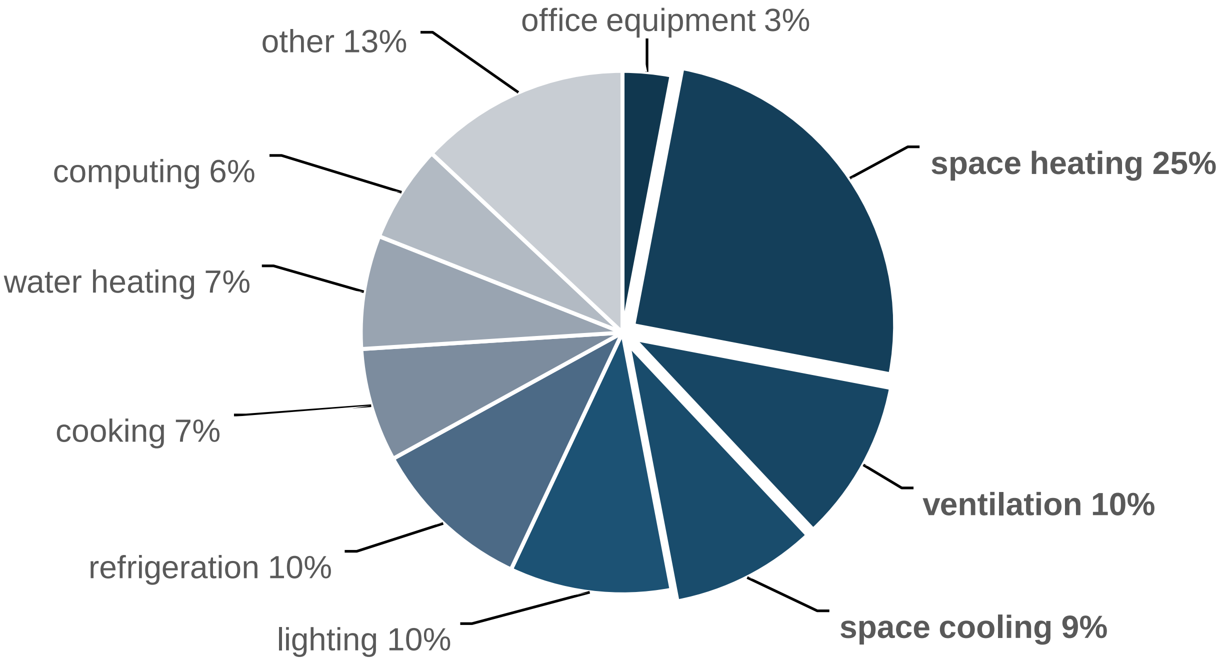
Codes and Local Law Trends

HVAC Systems – Codes and Local Law Trends

Building Energy Consumption

- 40 - 50% of the building energy consumption can be attributed to HVAC systems.

CBECS 2012 Breakdown of Energy Use

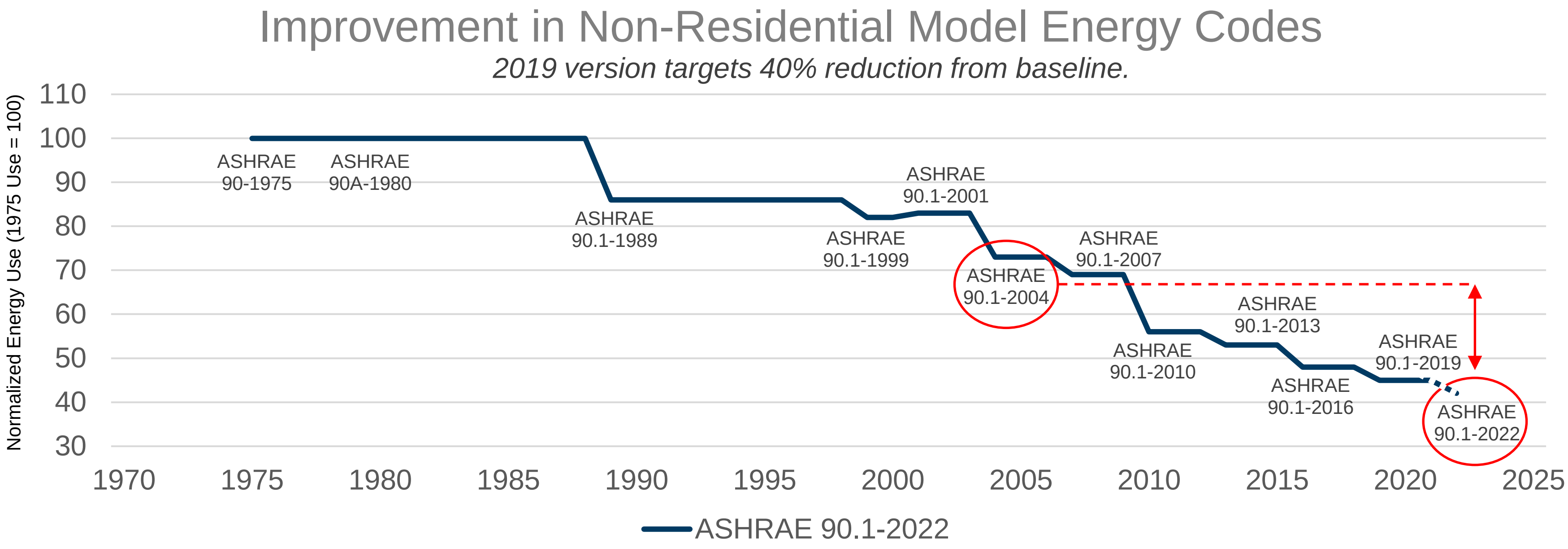


total energy use
6,963 trillion Btu

(Source: U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey)

HVAC Systems – Codes and Local Law Trends

90.1 Development

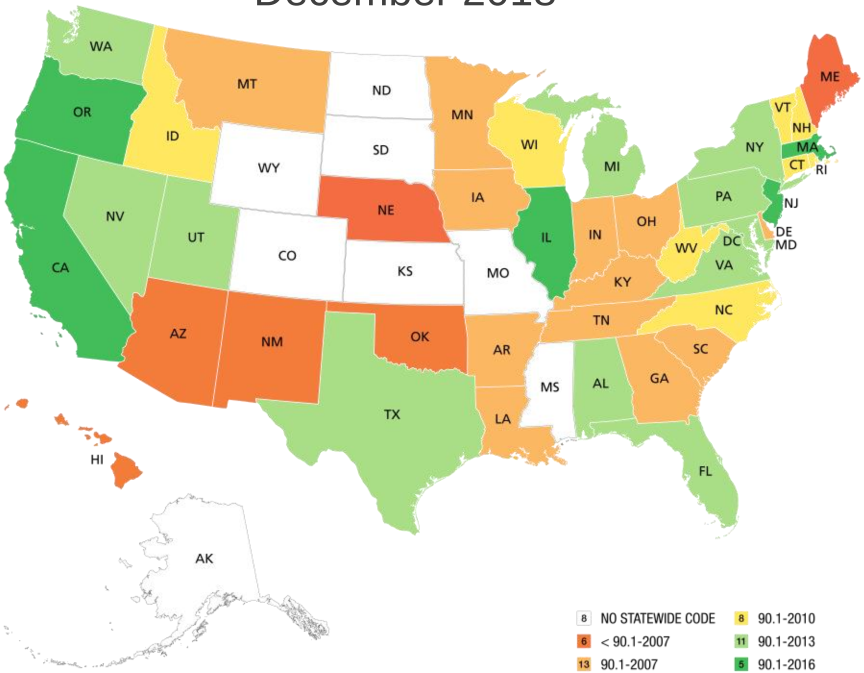


Source: Pacific Northwest National Laboratory

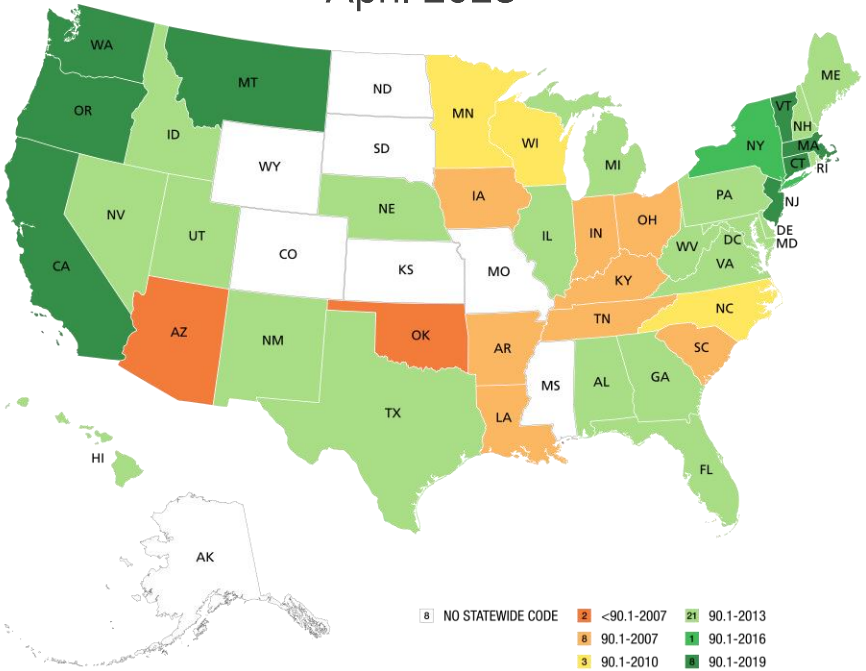
HVAC Systems – Codes and Local Law Trends

Energy Code Adoption

December 2018



April 2023

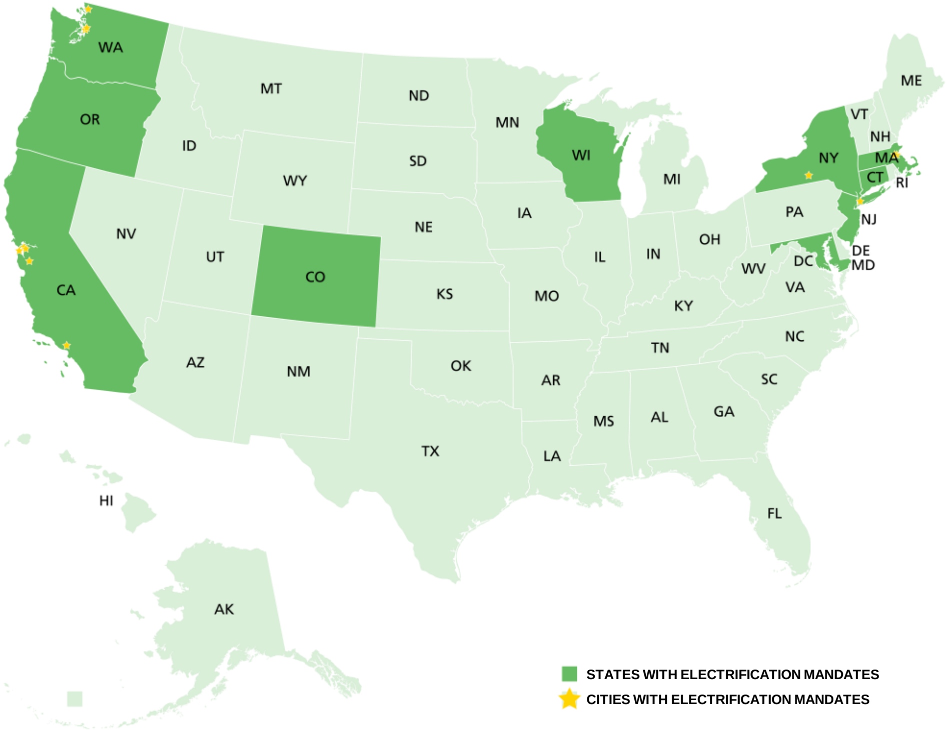


HVAC Systems – Codes and Local Law Trends

Electrification

US Cities and States Moving to All-Electric Buildings

In the following slides are recent examples of cities and states transitioning away from gas in homes and buildings and moving to all-electric power.



HVAC Systems – Codes and Local Law Trends

Inflation Reduction Act 2022

price

At $ 370B, this is the largest federal investment ever passed into law that will combat climate change through energy and other climate-related initiatives.

179D: ENERGY EFFICIENT COMMERCIAL BUILDING TAX DEDUCTION

Tier 1 has lower base deduction of $ 0.50/ sq. ft. if buildings outperform code baseline by 25% and up to $ 1/ sq. ft. if annual energy savings is reduced beyond 25%.
Tier 2 has higher base deduction of $2.5/ sq. ft. if the building also meets the prevailing wage and apprenticeship requirements.

ENERGY CODES

$330M for states and local governments to adopt or exceed the ASHRAE 90.1-2019 and / or IECC 2021 energy codes, and $ 670M to implement zero-energy stretch codes.

FEDERAL BUILDINGS AND INFRASTRUCTURE

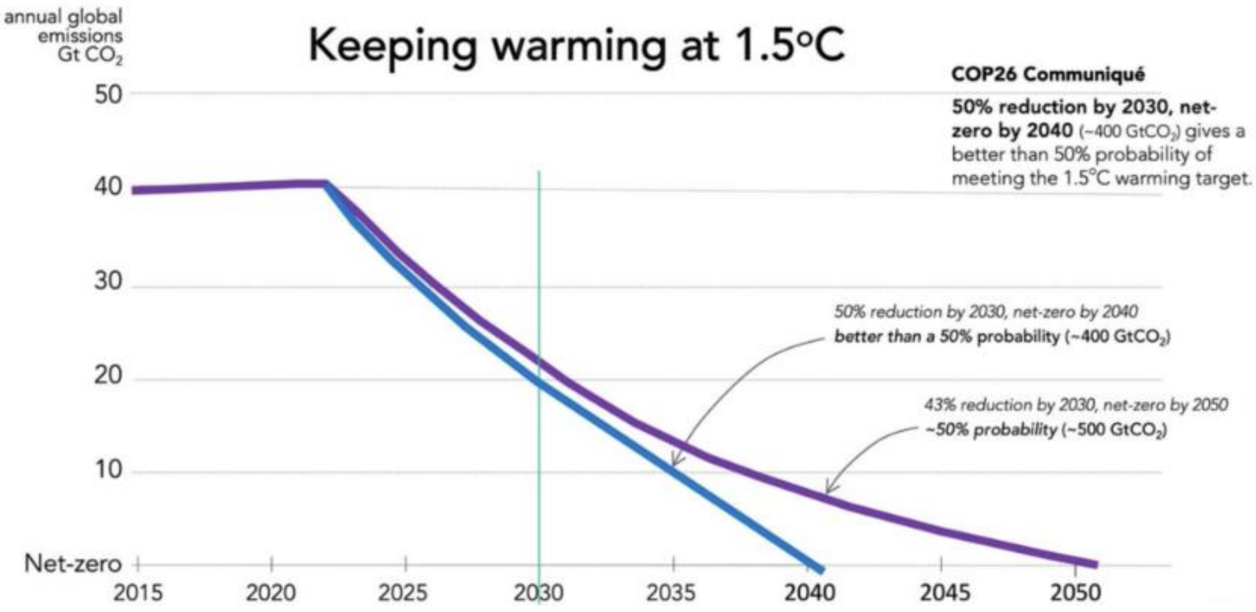
Multiple investments in the energy efficiency of federal buildings including $250M for GSA retrofits, $2.1B for Federal Buildings Fund for lowering embodied impacts of materials and products used in buildings and construction., and $975M for GSA Investments to sustainable technologies and programs.

HVAC Systems – Codes and Local Law Trends

MEP2040 – Committing to Zero

MEP 2040
Committing to Zero

"All systems engineers shall advocate for and achieve **net-zero carbon** in their projects: operational carbon by 2030 and embodied carbon by 2040."



(Source: architecture2030.org)

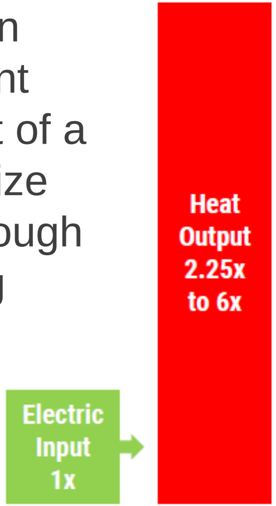
(Adapted from IPCC AR6 Figure SPM. 5(b), 2023)

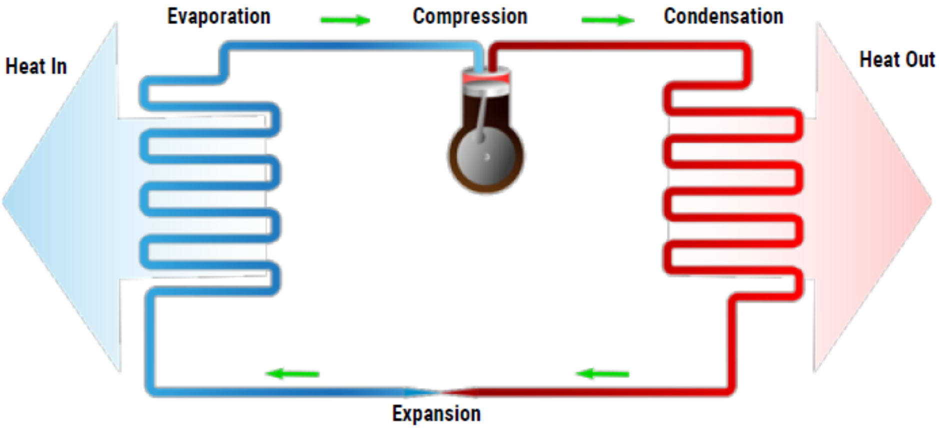
Low Lift Systems

Low Lift Systems

How Do We Electrify Our Buildings?

Heat Pumps are an emerging equipment category driven out of a desire to decarbonize HVAC systems through **electrified heating solutions**.

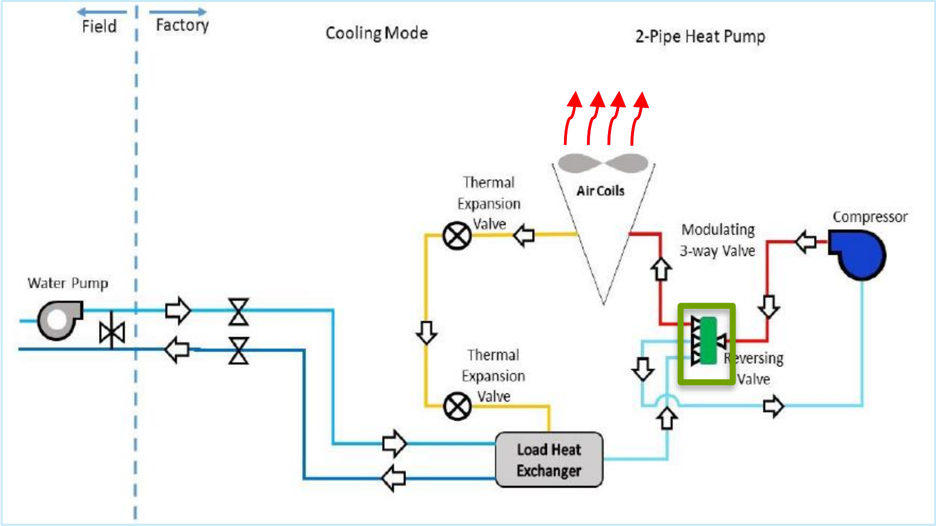




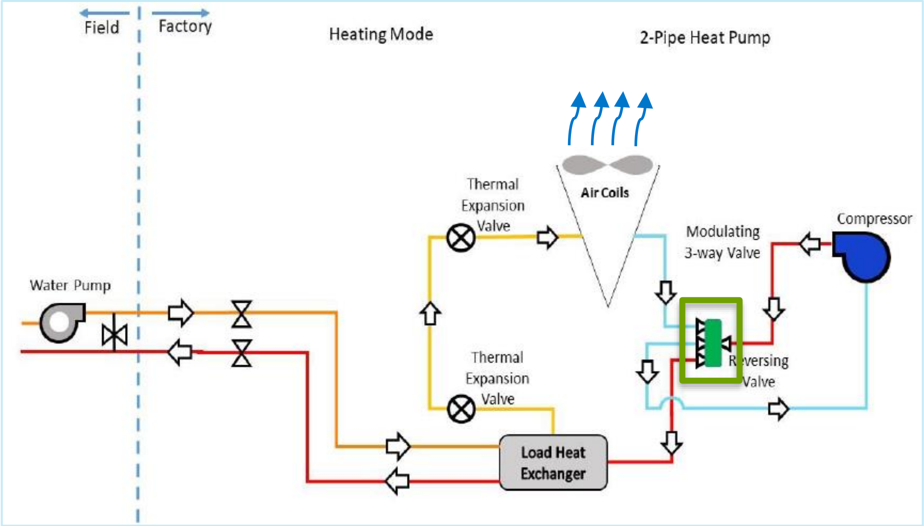
Low Lift Systems

Heat Pump Technology – How Does It Works?

Air-to-Water Heat Pump
(Cooling Mode)



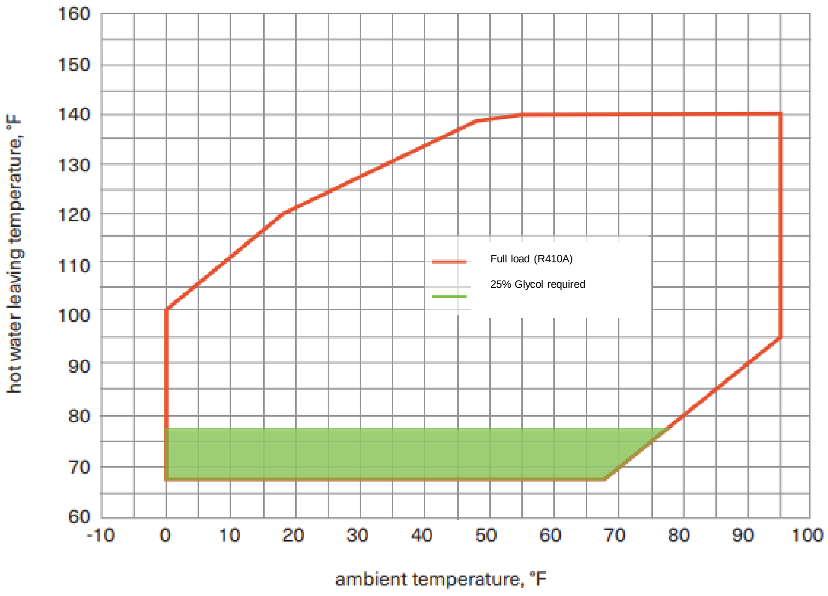
Air-to-Water Heat Pump
(Heating Mode)



Low Lift Systems

Heat Pump Technology – Fluid Temperature Range

operating map, heating mode

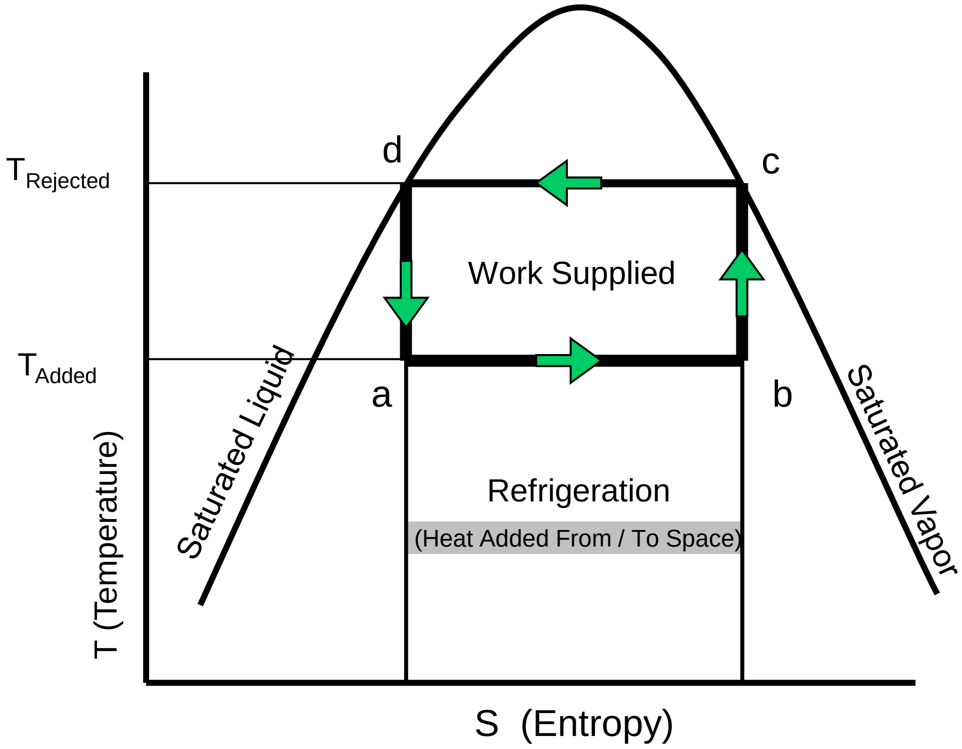


Limited Lift on Heating side

- **Leaving Heating Water Temperature: 75-140F**
  - Below 75 may be achievable with glycol
- **Operating Flow Delta T Range: 6F to 20F**

Low Lift Systems

Heat Pump Technology – Refrigeration Cycle



ab = Heat added from evaporator (space)

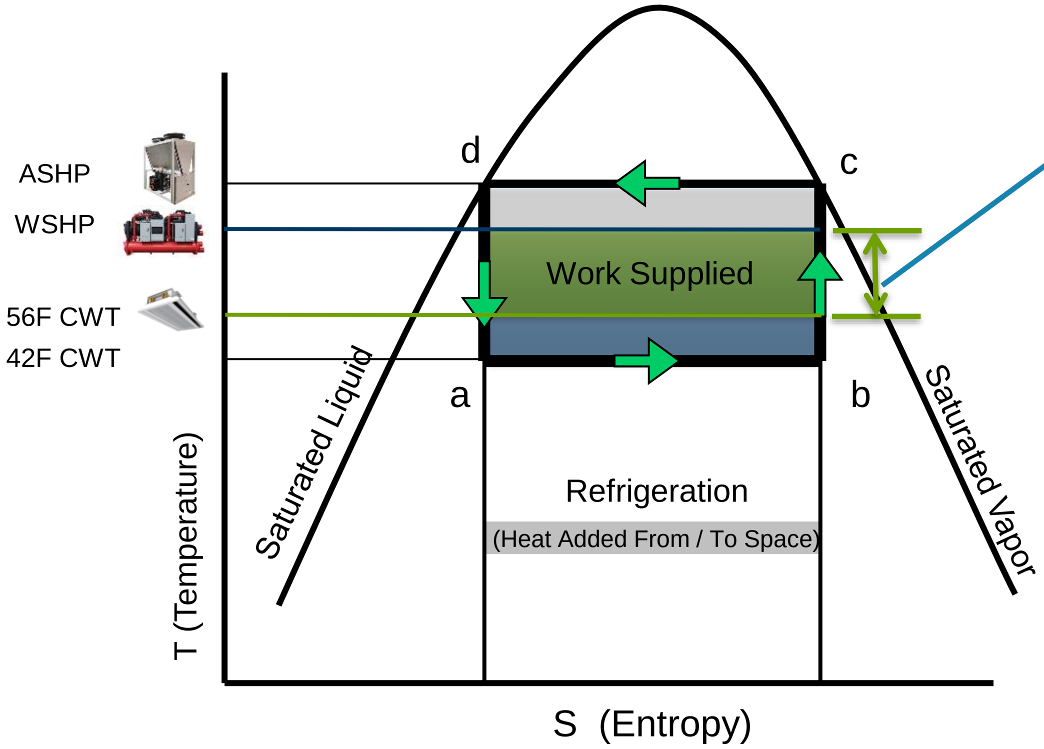
bc = Work added by compressor

cd = Heat rejected by condenser

da = Work produced by expansion (throttling) valve

Low Lift Systems

Heat Pump Technology – Refrigeration Cycle



Lower the "lift," higher the COP!

ab = Heat added from evaporator (space)

bc = Work added by compressor

cd = Heat rejected by condenser

da = Work produced by expansion (throttling) valve

Low Lift Systems

Heat Pumps – Cooling Efficiency Comparison

TABLE 1 Effect of chilled water temperature on chiller performance.

STANDARD 90.1-2016 STANDARD CONDITIONS		STANDARD 90.1-2016 55°F CHILLED WATER		STANDARD 90.1-2016 42°F CHILLED WATER	
FL	IPLV	FL_{adj}	PLV_{adj}	FL_{adj}	PLV_{adj}
KW/TON					
0.585	0.390	0.463	0.309	0.611	0.407

D. H. Nall, "Dual Temperature Chilled Water Plant & Energy Savings," ASHRAE Journal, vol. 59, no. 6, pp. 71, Jun. 2017.

26% efficiency increase by using 55F vs 42F

Approximately 2% energy savings per degree rise in CWT

Low Lift Systems

Heat Pumps – Heating Efficiency Requirements

ANSI/ASHRAE/IES 90.1–2019 Chiller/Heat Pump Efficiency Requirements

Table 1. Air-source heat pump: minimum efficiency requirements (Source: ANSI/ASHRAE/IES Standard 90.1-2019, Table 6.8.1-16 and Addendum Y, Table 6.8.1-16)

Equipment type	Size category refrigerating capacity (tonR)	Cooling-operation efficiency air-source (EER, FL/IPLV), Btu/W-hr		Heating source conditions OAT (db/wb) °F	Heat pump heating full load efficiency (COPH), W/W — Entering/Leaving heating liquid temperature			Test procedure
		Path A	Path B		Low 95°F/105°F	Medium 105F/120°F	High 120°F/140°F	
per ANSI/ASHRAE/IES Standard 90.1-2019 as originally published								
air-source	all sizes	≥9.595 FL ≥13.02 IPLV.IP	≥9.215 FL ≥15.01 IPLV.IP	47 db 43 wb	≥3.290	≥2.770	≥2.310	AHRI 550/590
		≥9.595 FL ≥13.30 IPLV.IP	≥9.215 FL ≥15.30 IPLV.IP	17 db 15 wb	≥2.230	≥1.950	≥1.630	
per ANSI/ASHRAE/IES Standard 90.1-2019 Addendum Y (approved December 9, 2021)								
air-source	<150.0	≥9.595 FL ≥13.02 IPLV.IP	≥9.215 FL ≥15.01 IPLV.IP	47 db 43 wb	≥3.290	≥2.770	≥2.310	AHRI 550/590
				17 db 15 wb	≥2.029	≥1.775	≥1.483	
	>150.0	≥9.595 FL ≥13.30 IPLV.IP	≥9.215 FL ≥15.30 IPLV.IP	47 db 43 wb	≥3.290	≥2.770	≥2.310	
				17 db 15 wb	≥2.029	≥1.775	≥1.483	

Note: See ANSI/ASHRAE/IES Standard 90.1-2019 and Addendum y for details and footnotes related to the date shown above.

27-30% efficiency increase by using 105F vs 140F for heating

Low Lift Systems

System HP - Standard vs “Low” Lift

	Standard Lift	Low Lift
Water ΔT	12°F	6°F
CHWT	42°F	56°F
GPM	167 gpm	334 gpm
Pump HP	3.15 HP	6.30 HP
Chiller HP	103 HP	75 HP
Total System HP	**106.15 HP**	**81.30 HP**

23.5% total HP reduction by using 56F vs 42F

*Pump HP = GPM * Head / 3690 / pump & motor efficiency*
Compressor HP = Load btuh / COP / 3413 btuh/kwh / 0.75kw/HP

Assumptions:

- *Sample building of 200’ × 200’*
- *Load at 25 btuh/sq. ft. = 25 × 200’ × 200’ = 1,000,000 btuh*
- *Delta T = 10F*
- *Head = 50 ft. (400 ft. of pipe run, + other equipment PD)*
- *Pump Eff. = 80%*
- *Motor Eff. = 90%*
- *Chiller COP = 3.8*
- *2% energy savings per degree rise in CWT*

Introduction to Decoupled Systems

Introduction to Decoupled Systems

Hydronic vs Air

Water Side Design

- Water heat transfer vs Air heat transfer
  - On Mass Flow Rate Basis
    - 1 lb of chilled water (6° Δt) transports 4x more cooling energy than 1lbs of air (20° Δt)
  - Transportation Energy
    - Transportation of a ton of cooling by air requires **7 to 10 times more** than chilled water

7” Diameter Air Duct

1/2” Diameter Water Pipe

18” x 18” Air Duct

Introduction to Decoupled Systems

All-Air vs. Decoupled Systems

Traditional VAV

Total Sensible

Latent & Ventilation (At the AHU)

Chilled Beams / Fan Powered DOAS

Partial Sensible (Waterside)

Latent & Ventilation (Airside)

Introduction to Decoupled Systems

What is a Chilled Beams?

- What is a Chilled Beam?
  - A ***SENSIBLE ONLY*** device that uses chilled or heated water supplied above the room dew point to cool or heat the space in which it is installed.
    - *Primary air is used to treat Latent loads*

Introduction to Decoupled Systems

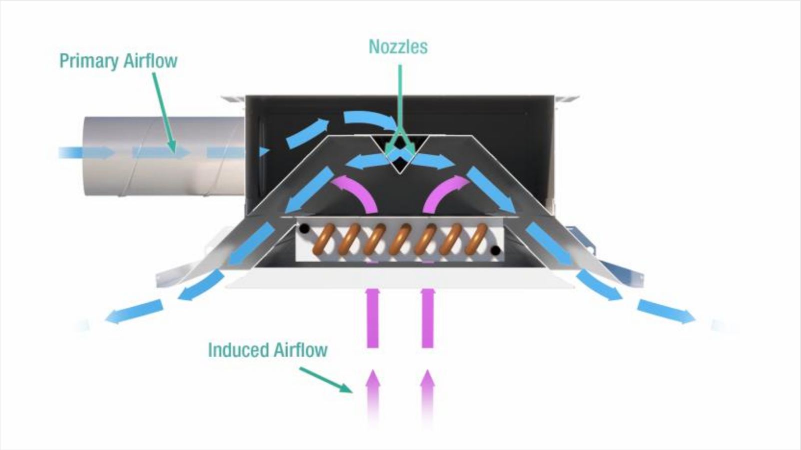
Decoupled Systems – Chilled Beams

Decoupled Systems allow the separation of primary air load from majority or all the space heating and cooling load.

Primary Air **Induced Air** **Total Airflow**

$$\boxed{50} + 4 * 50 = \boxed{250}$$

*Ex IR=4.0



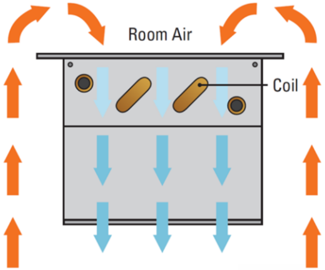
Parameter		All Air System	Beam System
Cooling Capacity	Btu/h / cfm	1.08*dT ≈ 20	60 – 100

Chilled Beams can deliver 3-5 times the btu/h/cfm

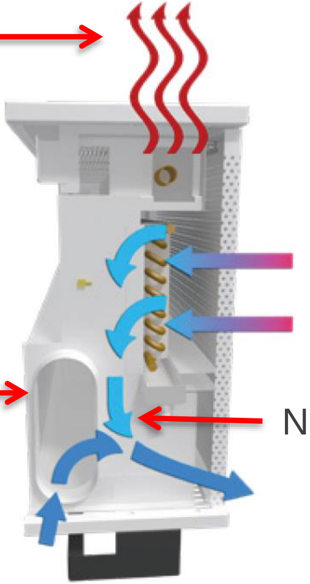
Introduction to Decoupled Systems

Other Chilled Beam Types

Passive Chilled Beams



Floor Mounted Chilled Beams

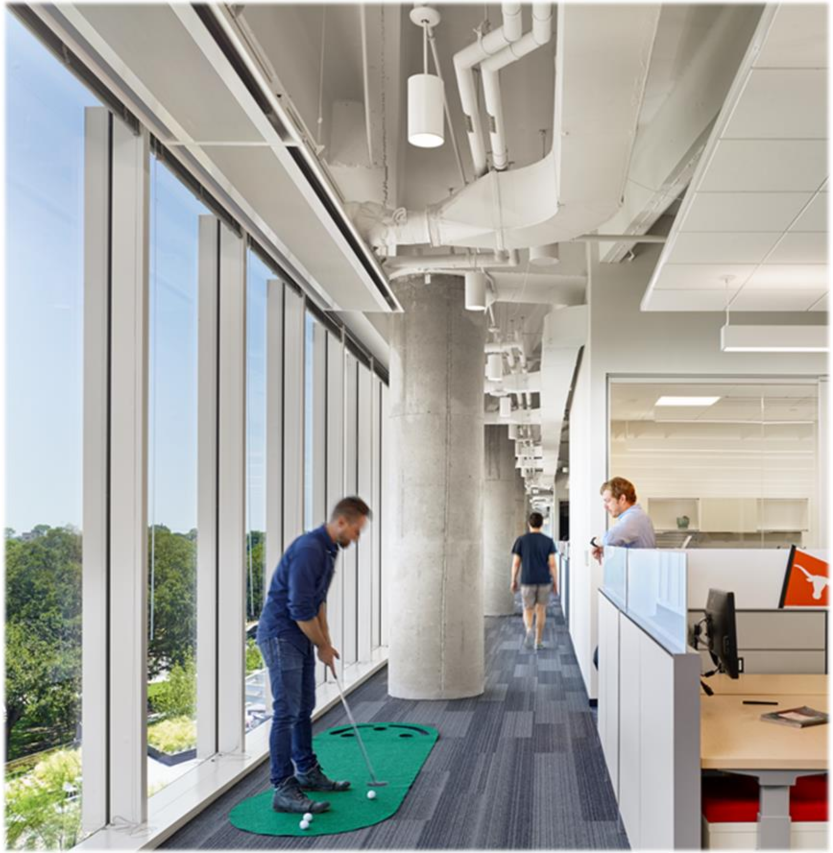


Introduction to Decoupled Systems

Why Chilled Beams?

Benefits

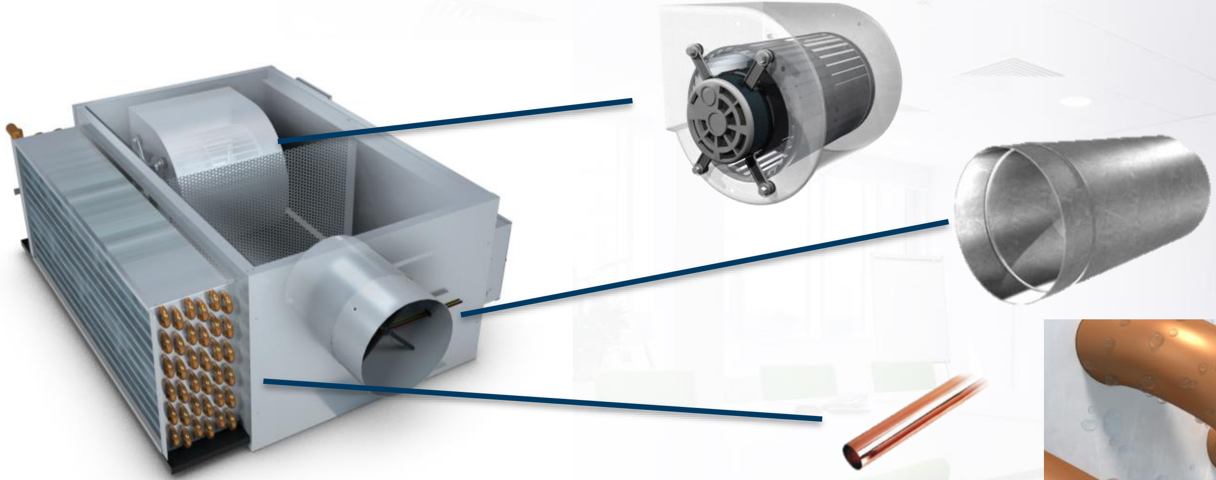
- Energy Savings
- Reduced Ductwork
- Reduced Mechanical Equipment Size
- Comfort
- Maintenance
- Quieter Operation

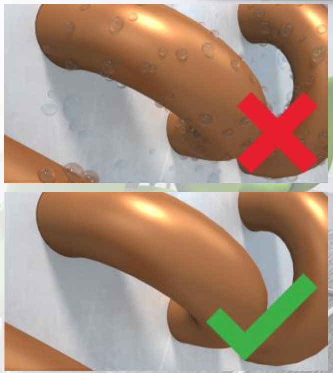


Introduction to Decoupled Systems

Decoupled Systems - Sensible Cooling Fan Powered Terminal Units

Fan powered terminal units with sensible cooling coils
are an effective solution to capitalize on the benefits of DOAS.





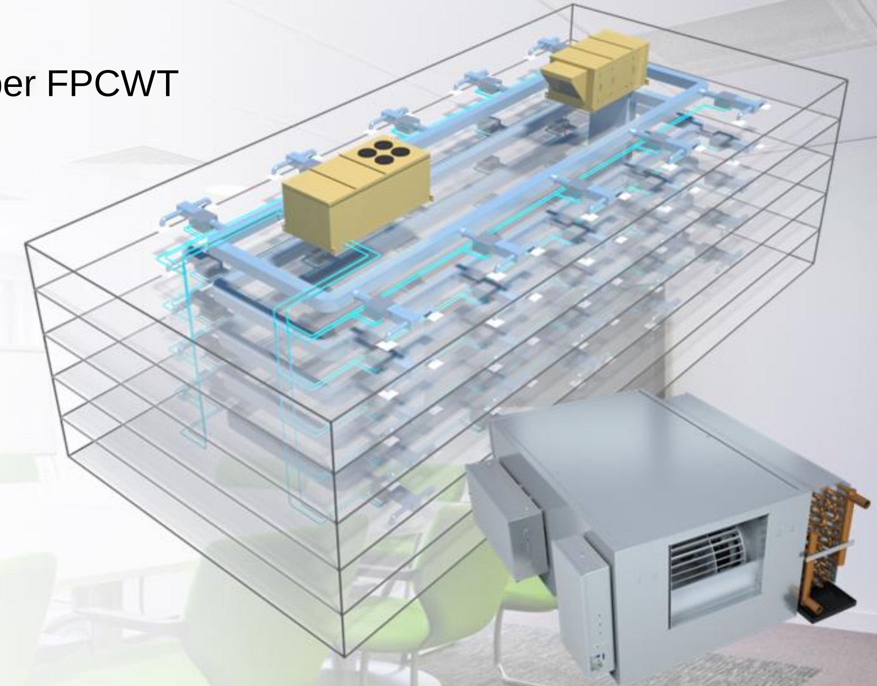
- ***Valve*** **-** maintains flow of ventilation air and meets latent (wet) load,
- ***Sensible Cooling Coil*** - handles space sensible (dry) cooling load,
- ***ECM Fan*** **–** accounts for all downstream pressure requirements.

Introduction to Decoupled Systems

Decoupled Systems - Sensible Cooling Fan Powered Terminal Units

System Design Considerations

- Up to~ 36,000 btuh space sensible cooling per FPCWT
- Same Primary Air Volume as Chilled Beams
- Primary air condition ~ 47-55F
- HWT ~ 100F – 140F (works well with Heat Recovery Chillers & Condensing Boilers)
- CWT ~ 56F – 57F



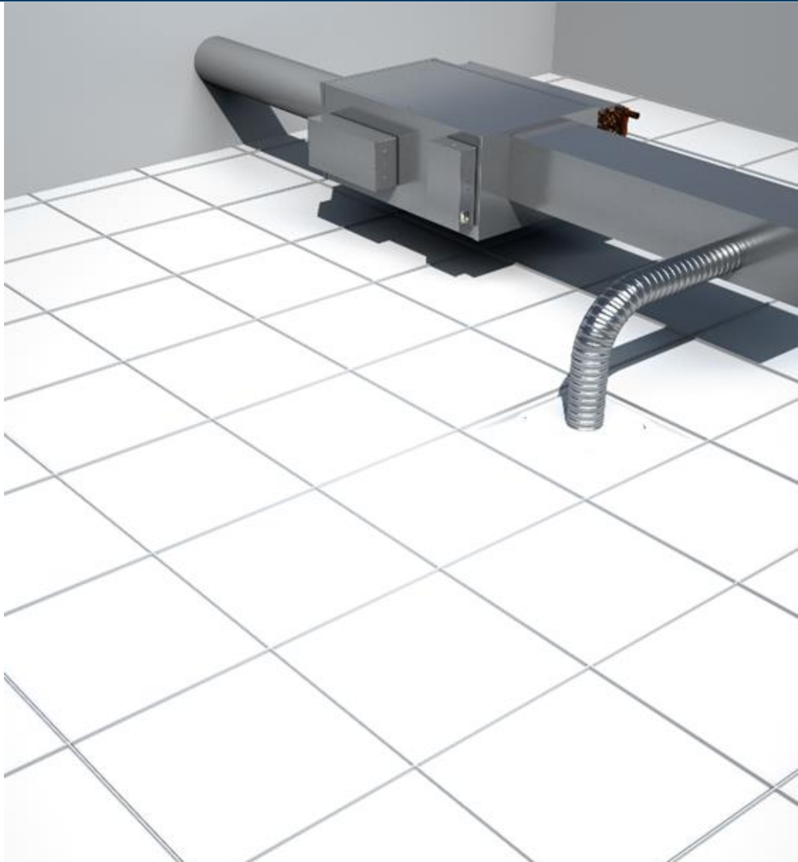
Chilled Beam Performance with Fan Power Terminal Unit System Layout!

Introduction to Decoupled Systems

Why Series Fan Powered Chilled Water Terminals?

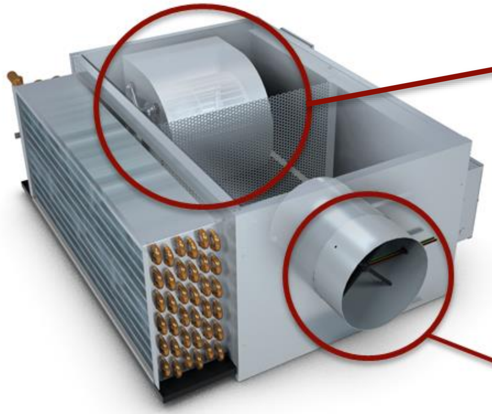
Benefits

- Higher Humidity applications are possible due to variable primary airflow
- Cross-flow sensor + damper on fresh air inlet enables Demand Control Ventilation
- Fan operation allows for morning warm up and night set-back
- Fan operation reduces zone stratification
- Higher static fan motor allows for diverse outlet options and longer duct runs



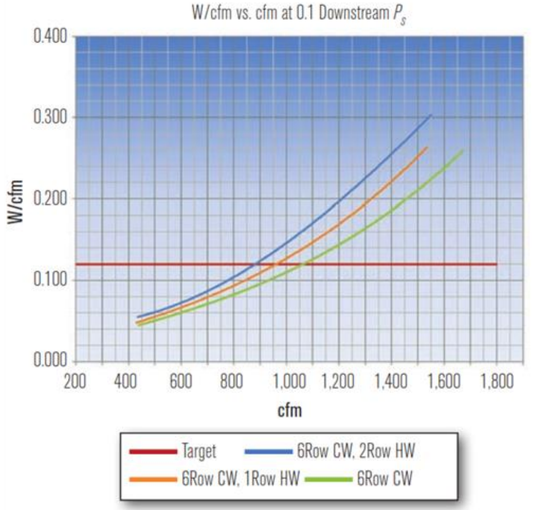
Introduction to Decoupled Systems

Why Series Fan Powered Chilled Water Terminals?



Unit Size	Min CFM	Max CFM	Turndown Ratio
10	100	1000	10:1
20	100	1300	13:1
30	100	1600	16:1
40	100	2100	21:1
50	100	2400	24:1

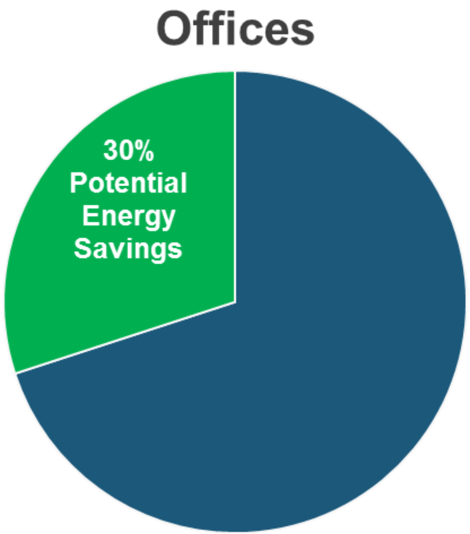
Inlet Size	Min CFM	Max CFM	Turndown Ratio
4	45	400	8.9:1
5	60	500	8.3:1
6	65	550	8.5:1
8	125	1100	8.8:1
10	210	1800	8.6:1
12	300	2600	8.7:1

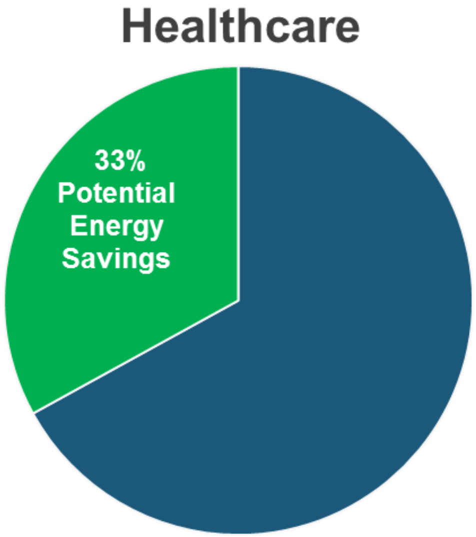


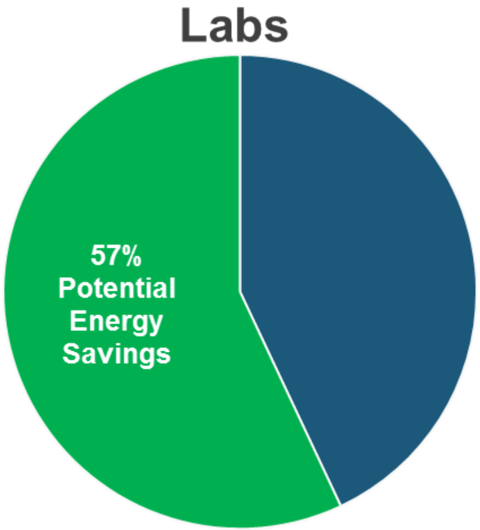
Washington State Energy Code (WESC) requires 0.12 Watts/CFM in dead-band for fan powered terminals.

Introduction to Decoupled Systems

Why Decoupled Cooling?







Rumsey & Weale, Engineered Systems, Jan 11

Rumsey & Weale, ASHRAE Journal, 2009

Introduction to Decoupled Systems

Hybrid Solution

Equipment Type	Acoustics	Heating	Architectural	Maintenance	Variable Loads
	✓ < NC 30 even in smaller zones	✗ Reheat available but less flexible	✓ Viewed as a visual asset by architects and engineers	✓ Low maintenance, no motors or filters	✗ Less turndown for variable occupancy and loads
	✗ Better suited for larger zones and loads	✓ Fully flexible reheat (electric coils and low EWT capable)	✗ Often hidden behind cloud or full ceilings	✗ Motors and filters requiring scheduled maintenance	✓ Perfectly positioned for variable occupancy

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Questions?

Electrification & Low Lift Systems

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