US Trends towards Energy Efficient Conditioning of the Indoor Environment – 1B

Presenter

V.P. New Business Development -
Price Industries.
HNc. Mechanical & Production
Engineering.

35+ Years of Experience in HVAC
Industry, working in UK, Europe,
Middle East, Asia & Australia.
Resident in US since 2004, citizen since 2012

30 years with Trox,
followed by 4 years with Dadanco.

Sold my first chilled ceiling job in 1992.
Sold largest passive beam job in Europe with 18km (11 miles) of beams.
Sold largest active beam job in US with over 7000 beams

USA reflecting the changes made in Europe.

Adoption
of Kyoto protocol to reduce man made CO_2 emissions.

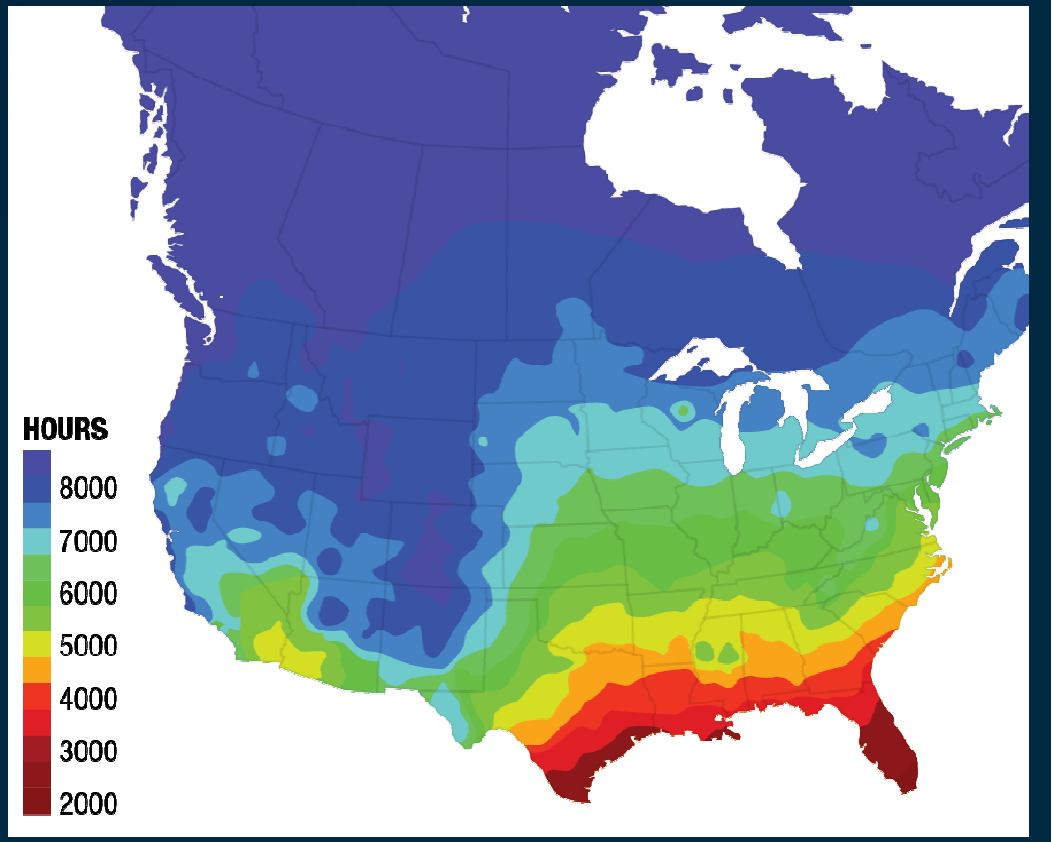
Changed their building codes.

US moved from fashion - recommendations to code & goals such as 90.1, 2020 and local law 87.

Energy Efficient HVAC

Location Suitability

- Climate will have an impact on operable hours throughout the year
- 60-70 F is the ideal exterior temperature range



Energy Efficient HVAC

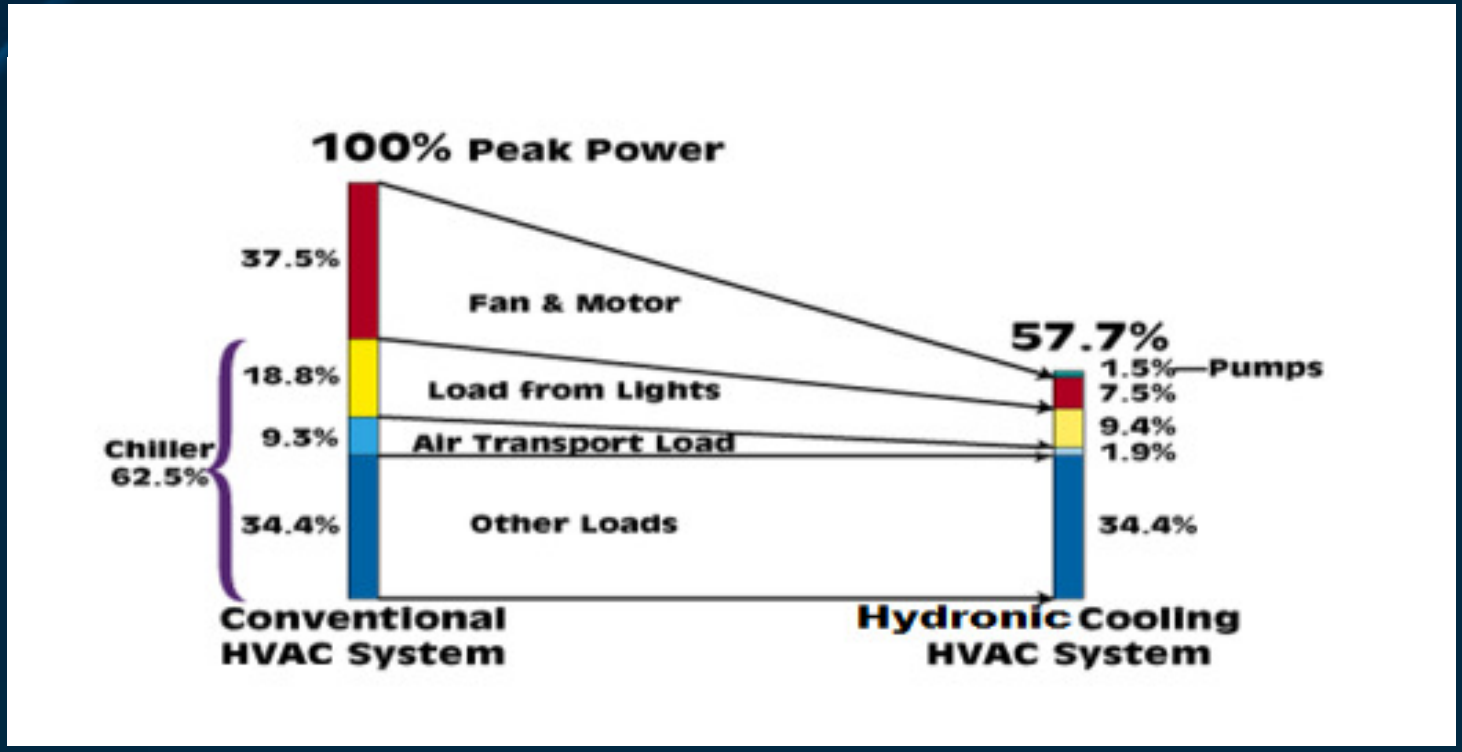
Design Considerations

- Climate
- Indoor Air Quality
- Floor/wall space
- Thermal mass
- Glazing area
- Occupancy profile
- G-value
- Additional heat gains (ex. IT)

Building HVAC Energy

Building Energy Consumption Characteristics

- **The Goal:**
  - Reducing energy required for air
  - Transport and/or removal of heat

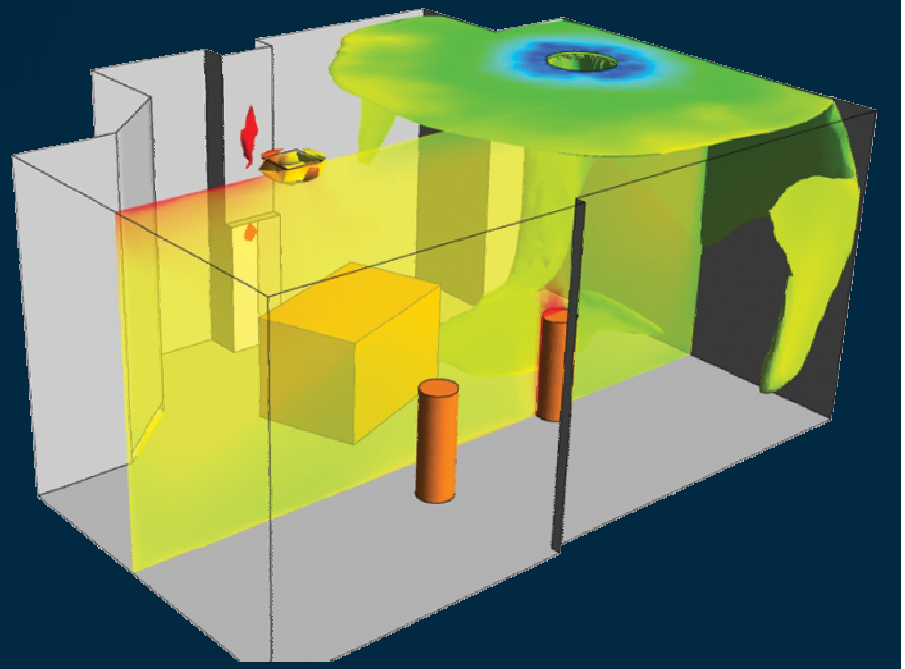


Trend – the move away from all air mixed to hybrids

- Thermal Displacement Ventilation
- Displacement Chilled Beams
- Chilled Beams, Active & Passive
- Chilled Sails
- Chilled Sails and TDV
- Mixed Mode Hybrids - natural vent/hydronic (future)

Building HVAC Energy

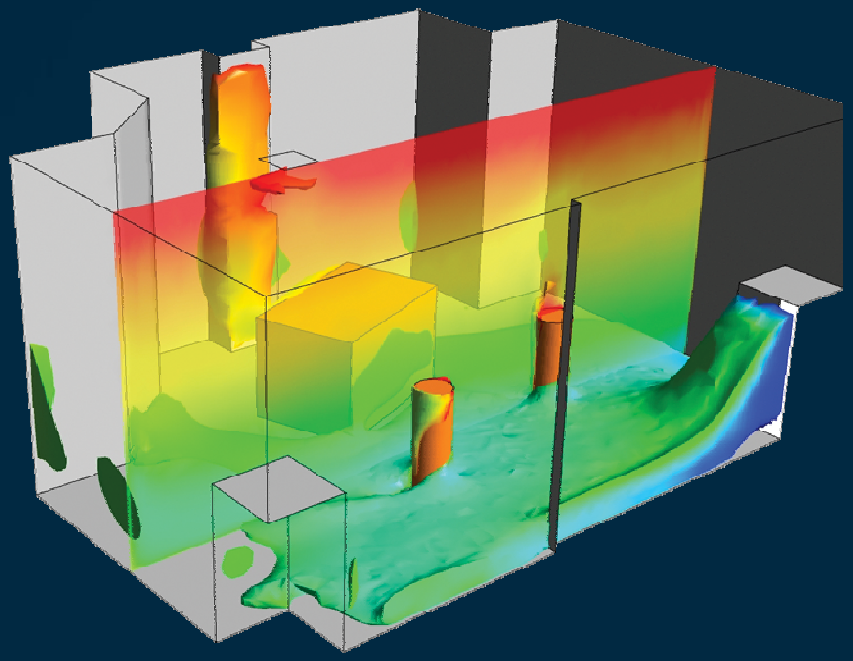
- Mixing systems:
- 55° F Supply Air
- Mix the entire space
- Diffusers drive air motion
- High velocity supply



Displacement Ventilation

Displacement Systems:

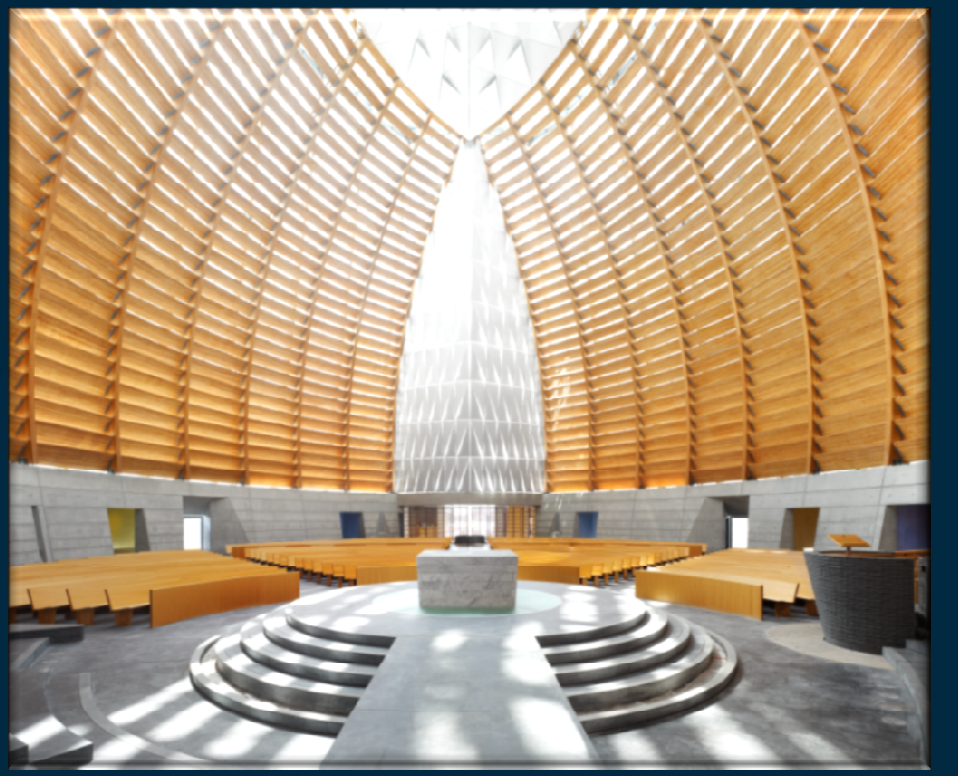
- 65-68° F supply air
- Low velocity
- No mixing in space
- Heat sources drive air motion
- Only conditions the occupied zone
- Heat and contaminants rise to ceiling



Displacement Ventilation

Common Applications

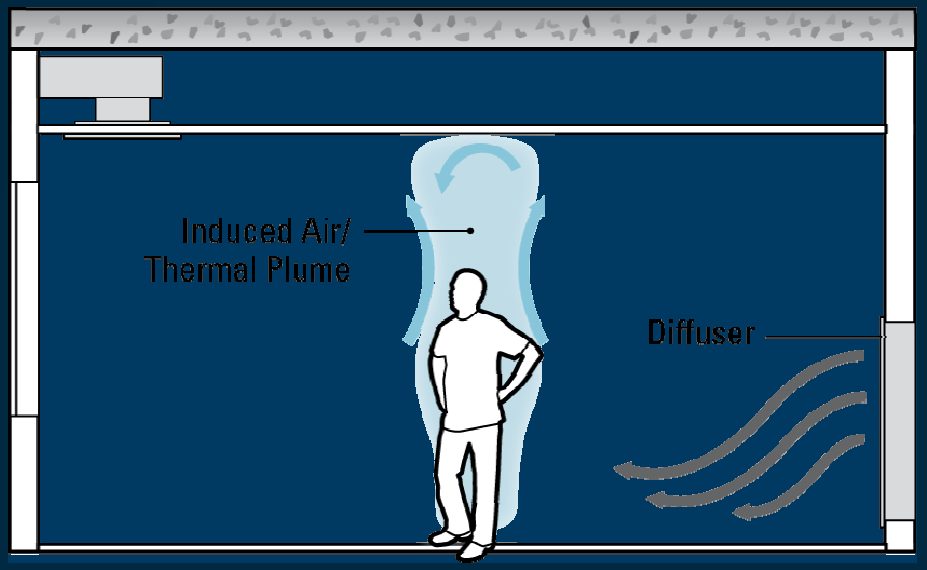
- Healthcare
- Schools
- Theaters / Casinos
- Airports
- Halls & Conference Rooms
- Offices & Lobby Areas
- Restaurants & Cafeterias
- Industrial Spaces



Displacement Ventilation

How DV Works:

- Thermal Plumes:
  - Create temperature stratification
  - Carry contaminants from breathing zone
  - Improve air quality in occupied zone



Displacement Ventilation

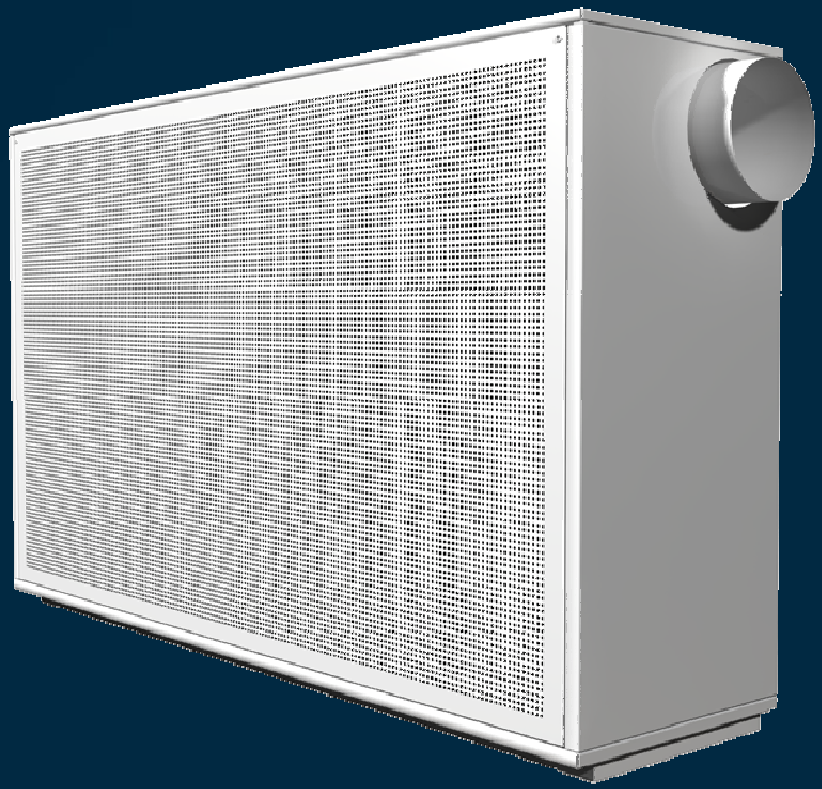
Schools

- Largest application for displacement ventilation
- Higher IAQ can lead to:
  - Higher student test scores
  - Reduced absenteeism
  - Reduced transmission of airborne illness and asthma/ allergy symptoms
- School Rating Systems:
  - CHPS
  - LEED for Schools

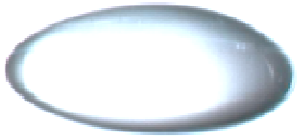
Active Displacement Ventilation

Schools

- In order to reduce energy further, the combination of active chilled beam (induction) and DV is starting to be widely adopted
  - These make use of DV
  - Transportation of cooling via chilled water



Hydronic Chilled Water



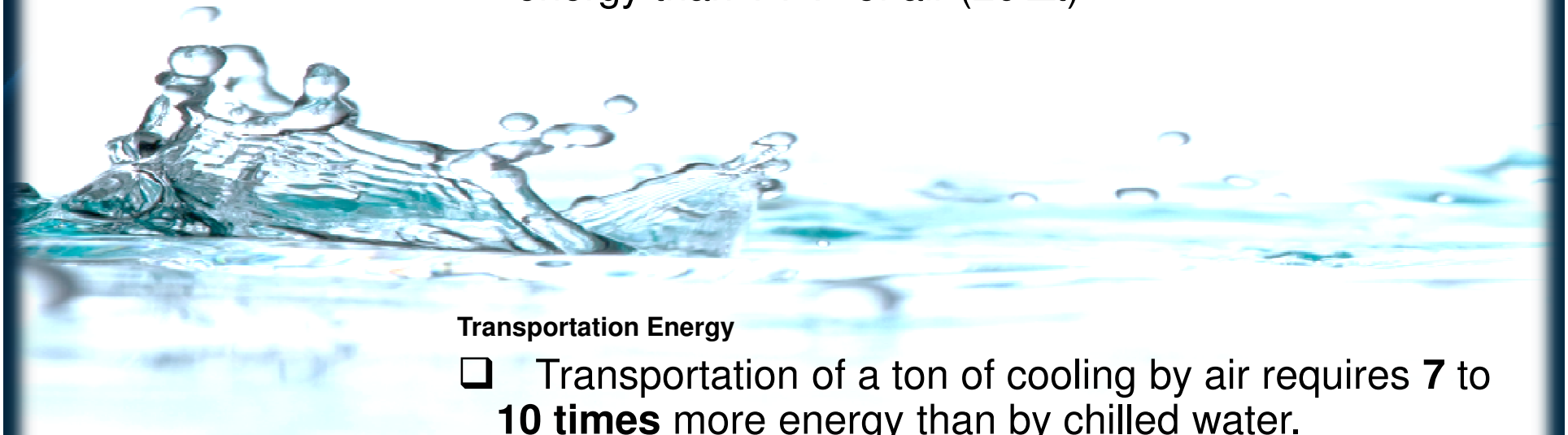
On a Mass Flow Rate Basis:-

- 1 lbs of chilled water (6˚ Δt) transports 4x more cooling energy than 1 lbs of air (20˚ Δt)

As water weighs 800 times that of air

On a Volume Flow Rate Basis:-

- 1 FT^3 of chilled water transports 1000 more cooling energy than 1 FT^3 of air (20 Δt)



Transportation Energy

- Transportation of a ton of cooling by air requires **7** to **10 times** more energy than by chilled water.

DV vs. Active Displacement Ventilation

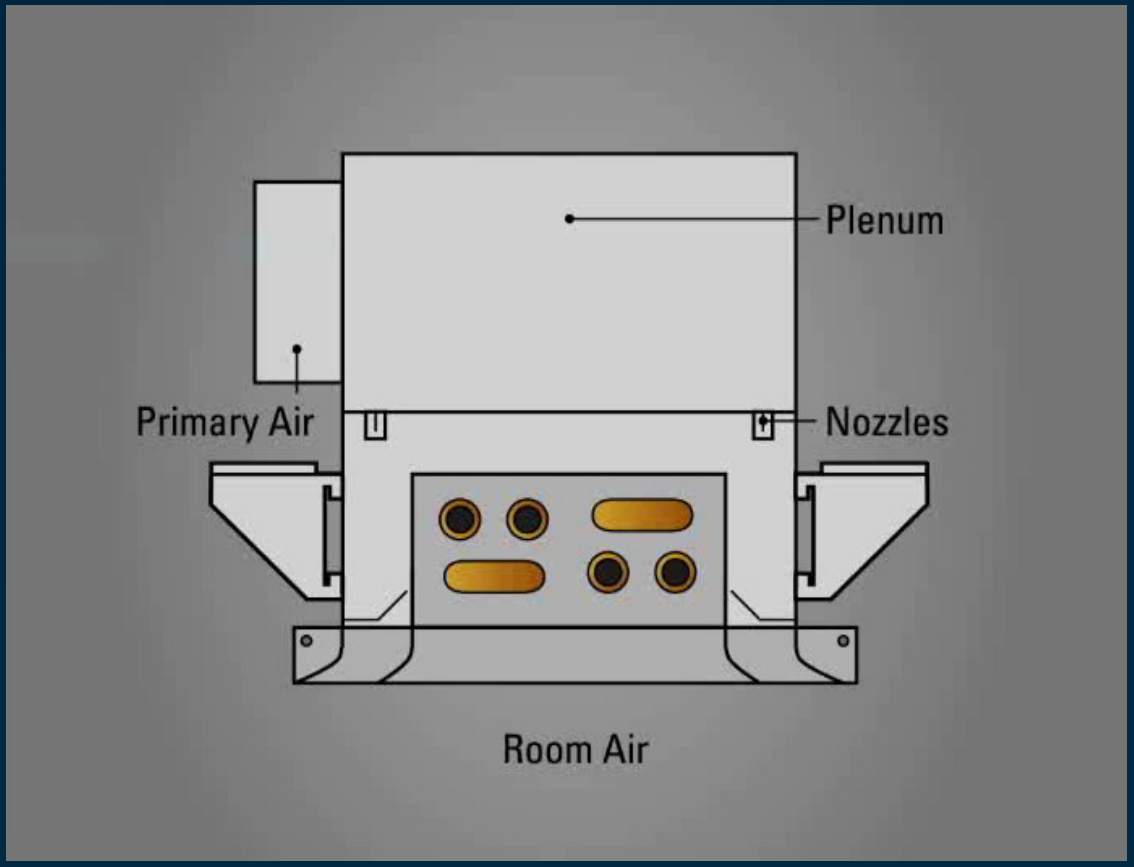
DV

- Air temperature & volume
- Free cooling

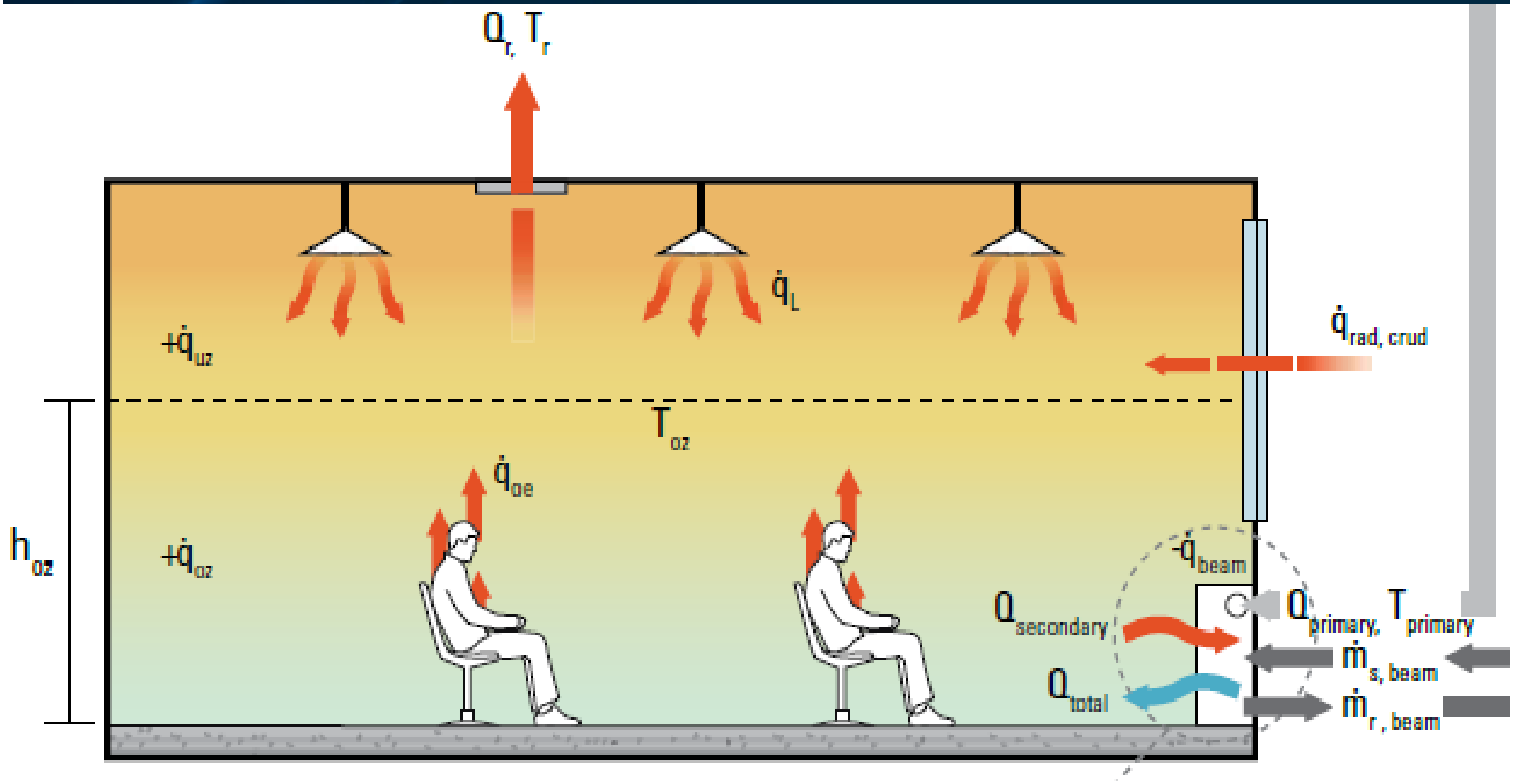
- ADV
- Reduced air temperature & volume
- Longer free cooling hours
- Tighter control over latent gains
- Lower energy

Active Beams

Induction unit by any other name



Floor mounted Active displacement Beams

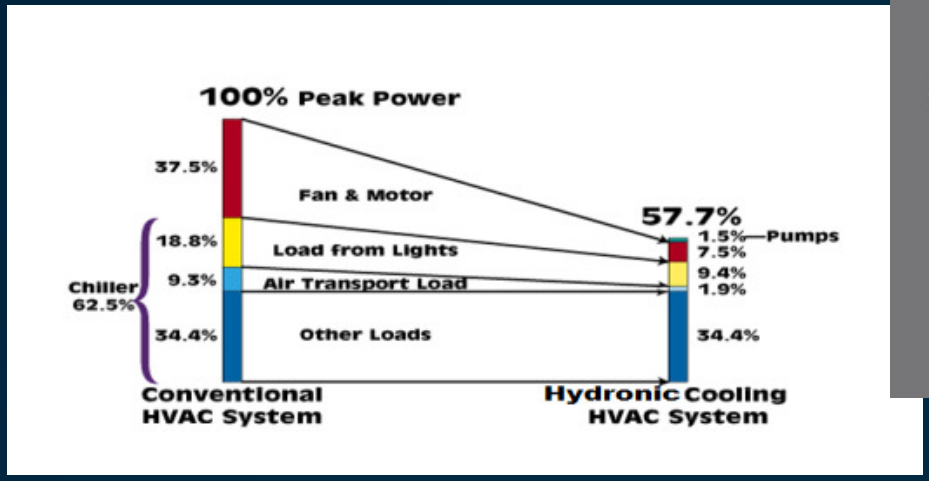


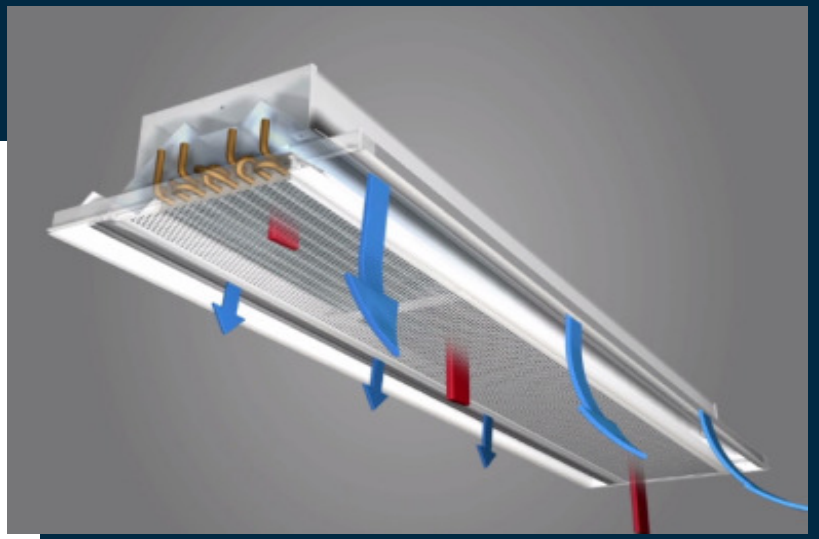
ACBV-D – Active Displacement Beam 2.0

Déjà **vu – all over again**

Building HVAC Energy
Hydronic

- Use of Water as media for bulk of sensible heat transfer
- Commonly used 20's to mid 70's
- Still a recirculation system, just localized to the space.





Smaller Ductwork

Reduced Slab - Slab heights

More floors - maximizes rentable floor space

Minimal Maintenance

Improved Indoor environment

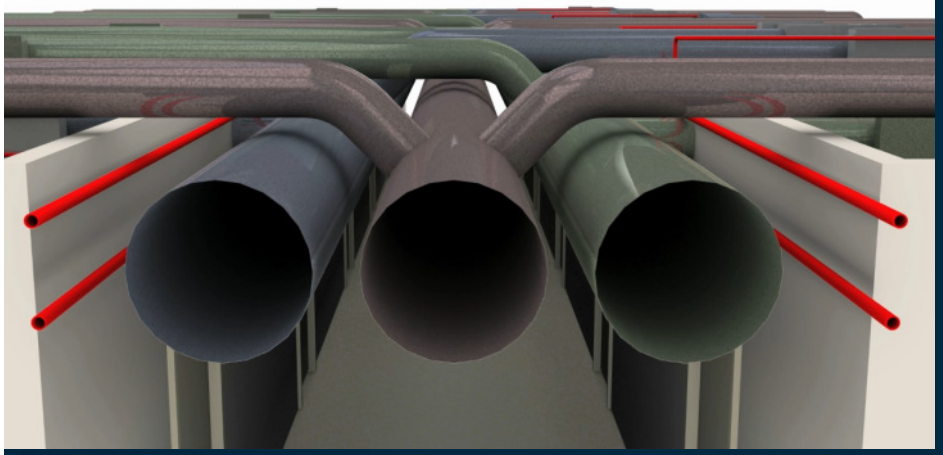
Sustainable

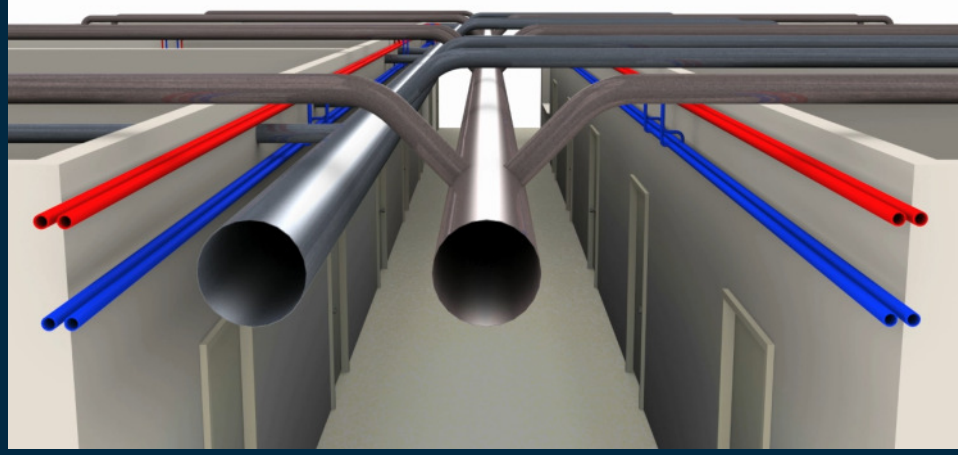
Building HVAC Energy

Benefits of Hydronic Systems

Less ductwork and smaller risers

- Higher ceilings
- Lower floor-to-floor height
- Lower first cost
- Increased space for revenue





Building HVAC Energy

Active chilled beams

- Traditionally used in higher education sector, universities for classrooms and life science teaching labs or MOBs
- Emerging into healthcare after ASHRAE 170 Addendum H
- Positive use into mid to high rise office towers

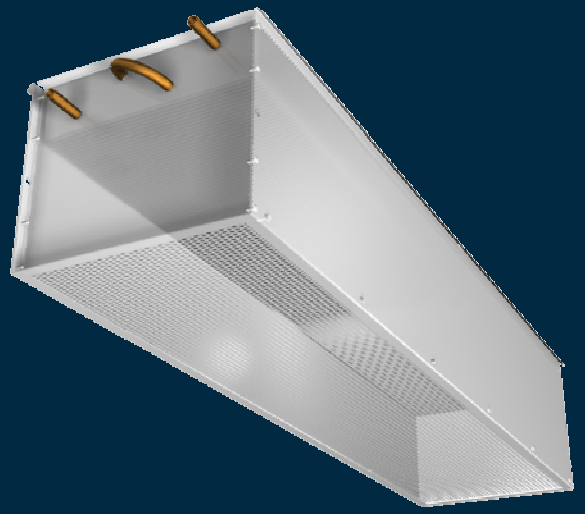
Building HVAC Energy

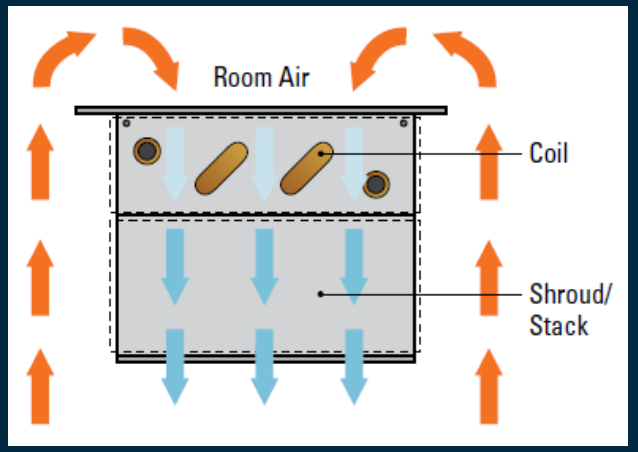
Pittsburg PNC New 40-story Office tower

- 800,000 SF
- $400m
- 2500 jobs
- Worlds ‘Greenest’ skyscraper
- Comcast & CHOP - Philly

Passive Beams

- Water coil in plenum
- Application:
  - Cools through natural convection
  - No primary air flow is supplied
  - Concealed, Exposed and T-bar





Passive Beams
PCB

Laboratory

Audi Museum

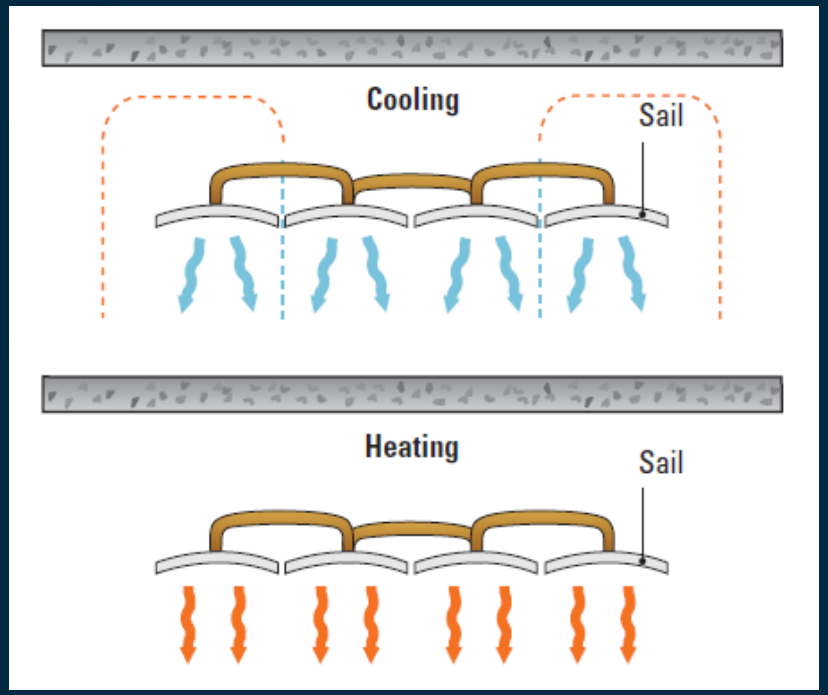
100 Howe Building, Covington, KY

- Call center, 350,000 sq ft
- 2,200 occupants, LEED design
- ASHRAE 2010 Award winner
- Real energy results based on comparison with another building on the same campus running VAV
- Energy usage data collected over 1 year
- Electrical energy consumption reduced by 41%
- Natural gas consumption reduced by 24%

	UFAD Alone	UFAD With Radiant Cooled Ceilings	UFAD With Passive Chilled Beams
Supply Air Quantity (cfm)	560,000	240,000	240,000
Supply Fan Power (hp)	600	280	280
Return Fan Power (hp)	280	120	120
Total Swirl Diffusers Required	5,600	2,400	2,400
Weighted Airflow (cfm/ft^2)	1.6	0.7	0.7
Qualitative Flexibility	Good	Fair	Good
First Cost ($)	Reference	4,250,000	100,000
Operating Cost Payback	N/A	>50 years	<2 years

Chilled Sails

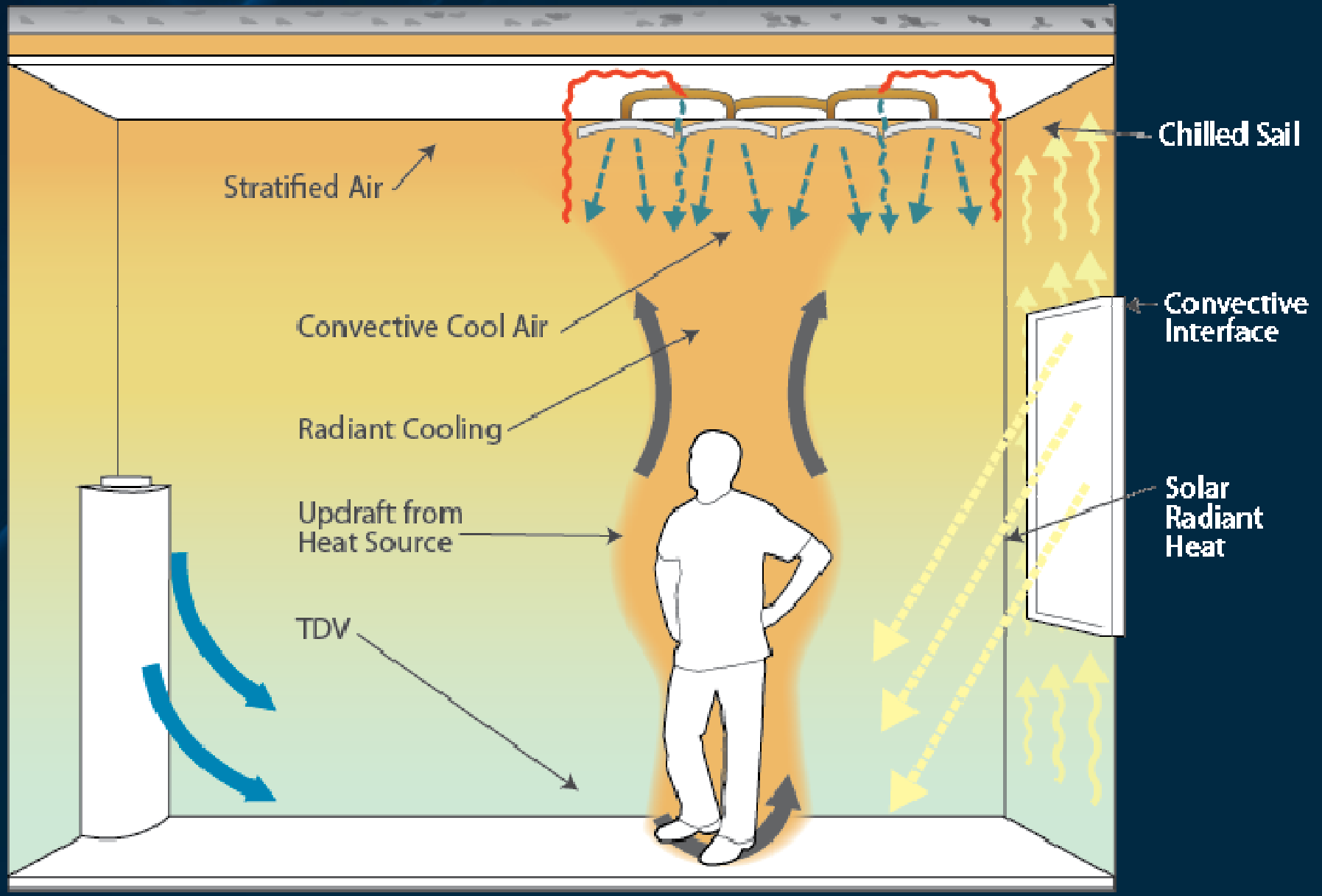
- Chilled sail
  - High capacity panel
  - Induces room air
    - Radiant and convective modes of heat transfer
  - Exposed and concealed applications
  - Often used in interior zones



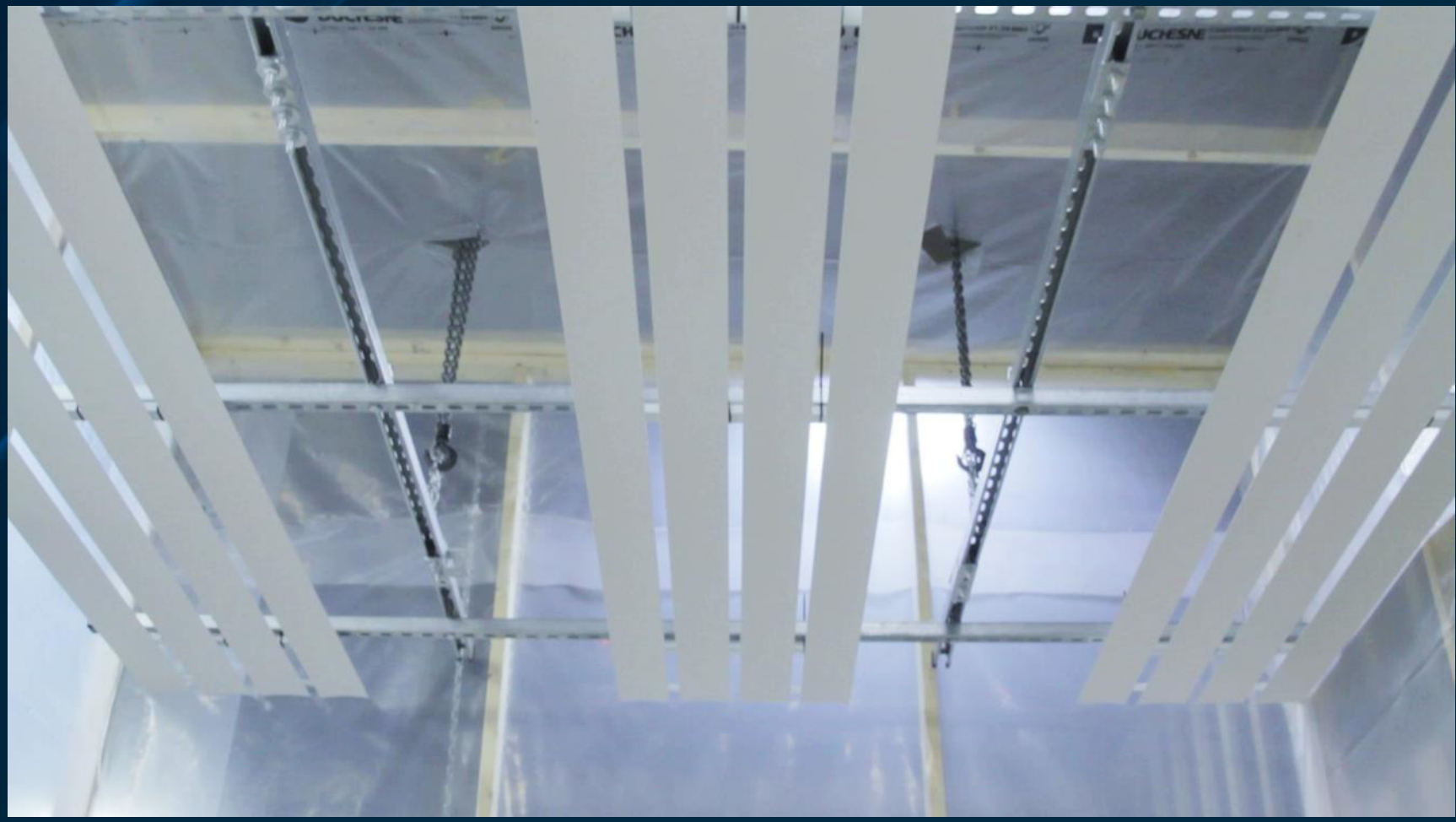
Chilled Sails

Exposed Installation

Chilled Sails and TDV



Research – CBE / Hybrid



Radiant Light Shelf

Application

Liberal Arts Building, Fayette, Iowa

Application

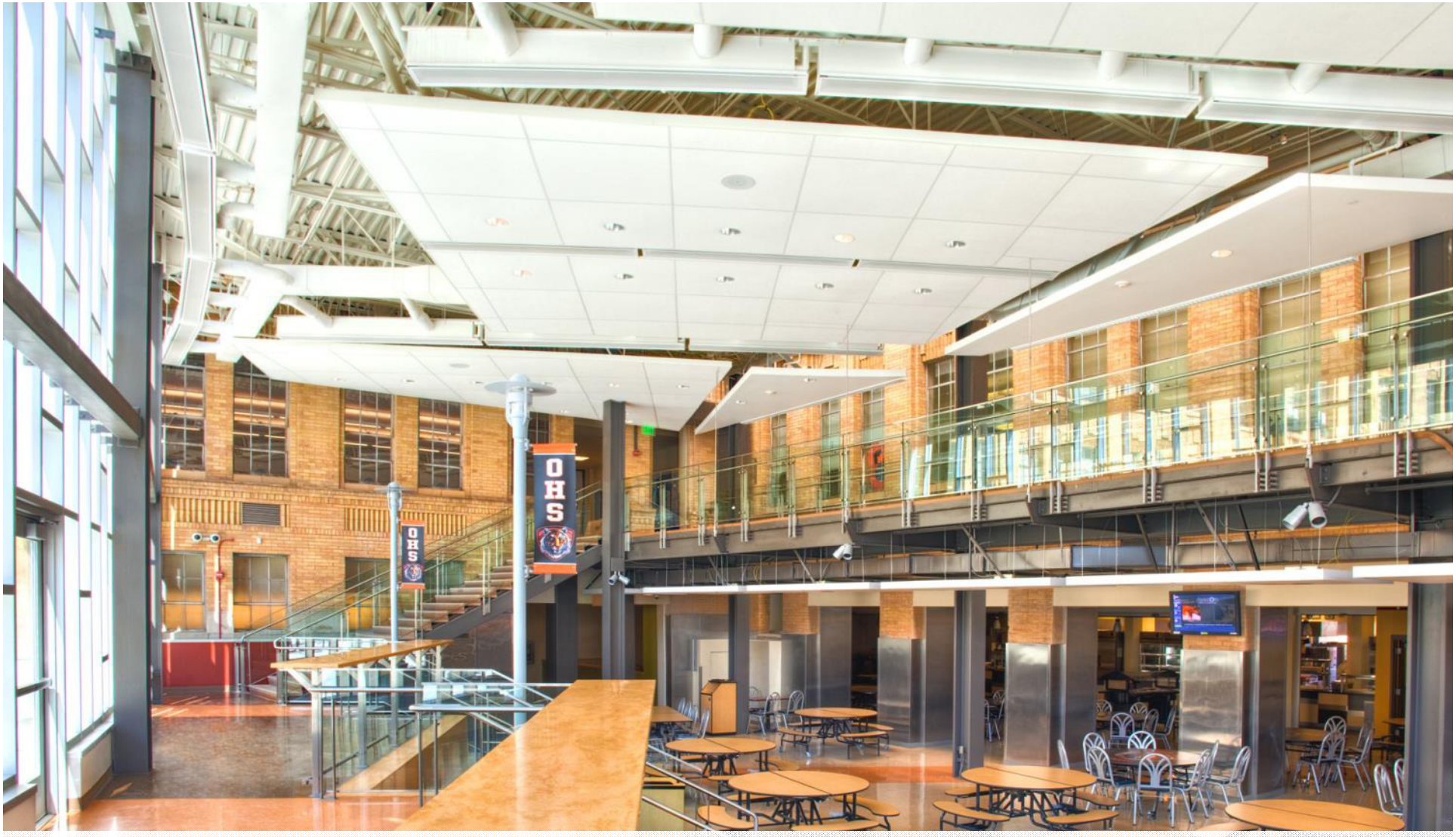
- Liberal Arts Building
  - LEED Silver
  - TDV (underfloor) and Chilled Sails
    - 100 % OA system
    - Ground source heat pumps for hydronic cool/heat
  - When compared to the base model 90.1 2004
    - Alliant Energy found the building to have a 67% energy cost performance gain compared to similar buildings in the area
      - Building owner was offered by Alliant a six figure rebate
    - Payback for investment cost is around 3 ½ years

UGA JACKSON STREET BUILDING

The first historic building on the University of Georgia Campus to receive **LEED certification (Gold)**.

OGDEN HIGH SCHOOL

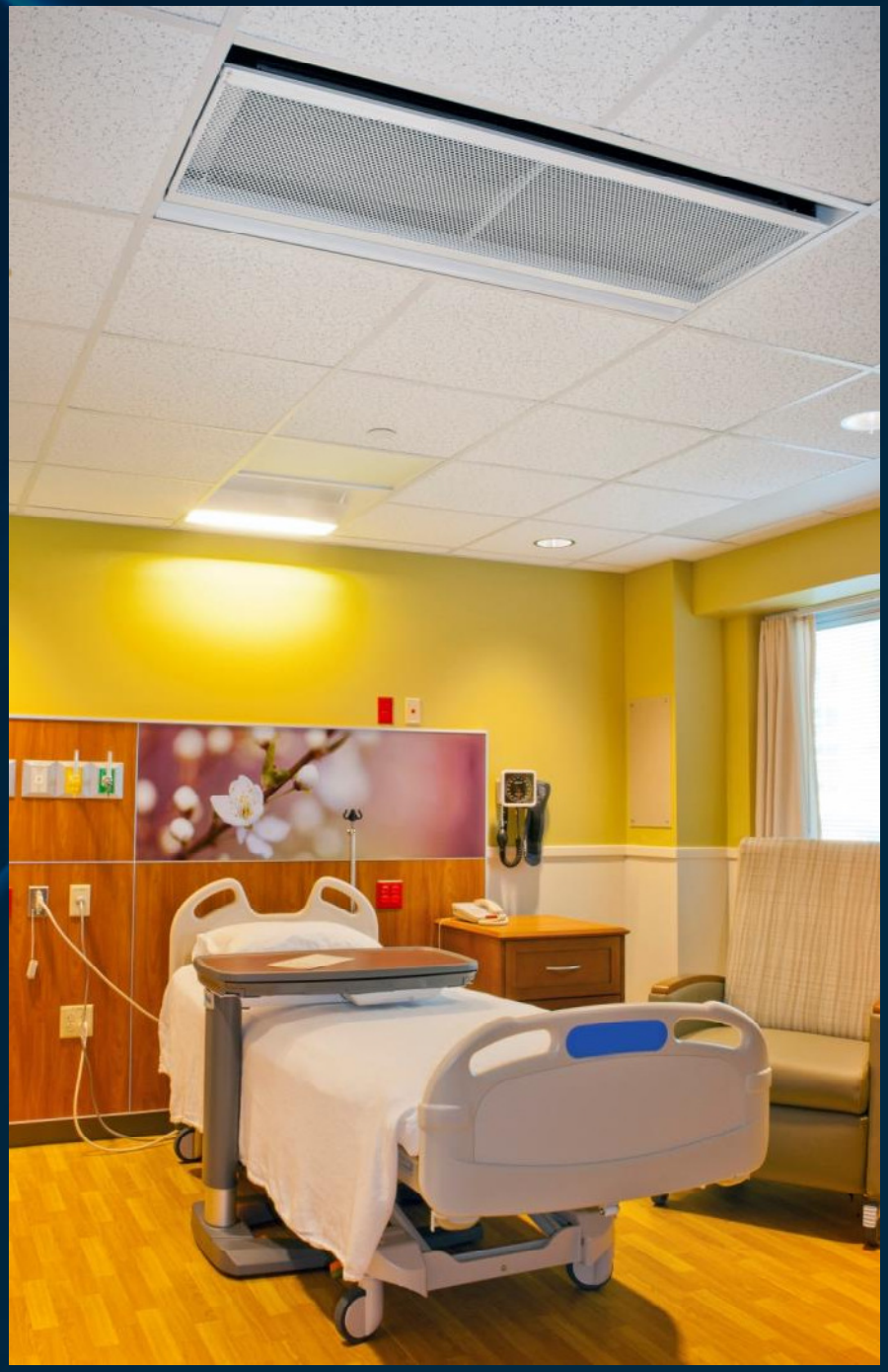
Architect: EDA Architects Inc.
Engineer: Colvin Engineering Assoc.

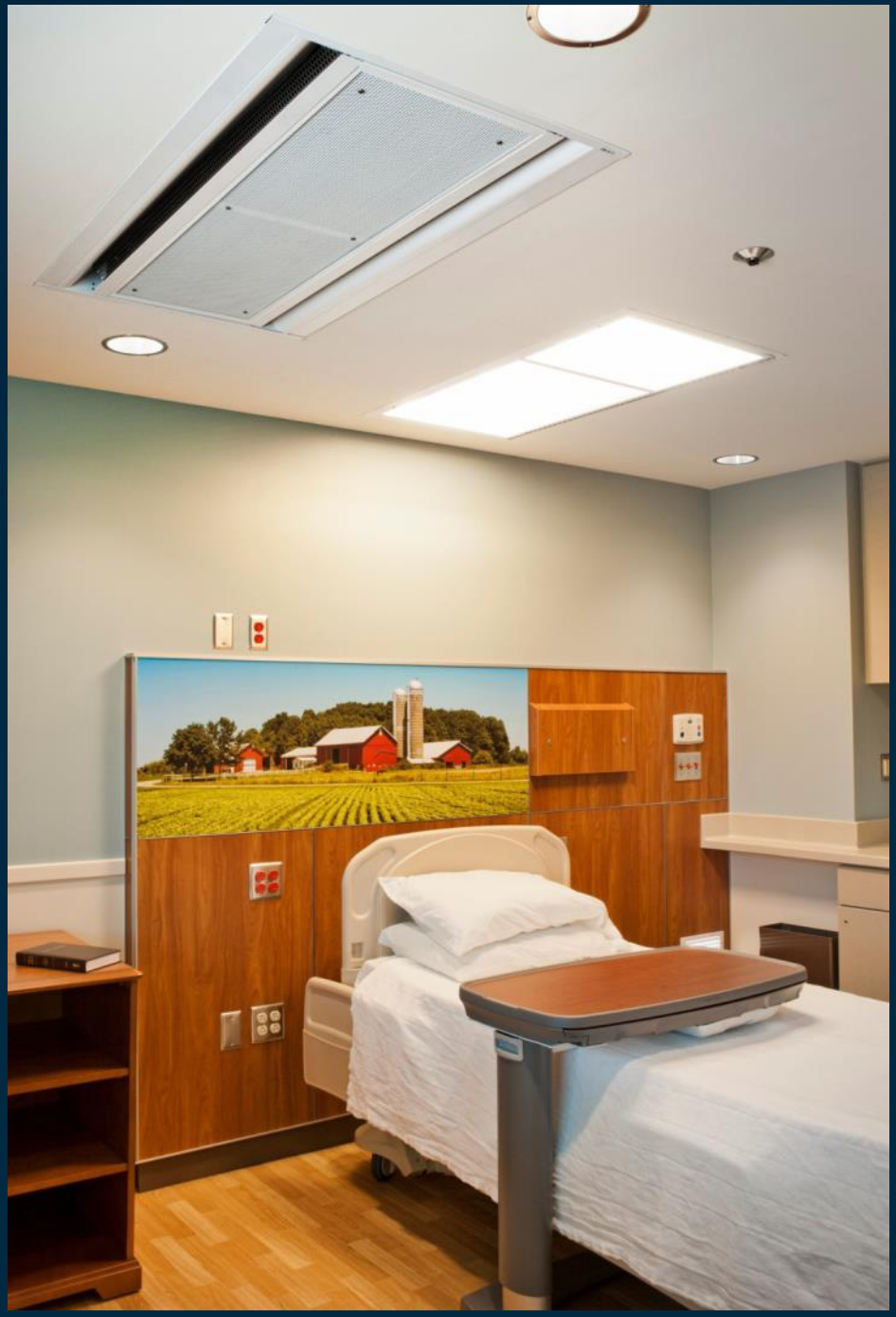


Active Beams were **strategically positioned** along the perimeter to manage the skin loads off the large glass curtain wall.

MEMORIAL HOSPITAL

Architect: BSA LifeStructures
Engineer: BSA LifeStructures





DARLA MOORE SCHOOL OF BUSINESS

Architect: Rafael Vinoly

Image Courtesy: Rafael Vinoly Architects


Image Courtesy: Rafael Vinoly Architects

Image Courtesy: HOK

CONSOLIDATED FORENSIC LAB

Architect: HOK
Engineer: R.G. Vanderweil


Image Courtesy: HOK

FRAUNHOFER CSE BOSTON HEADQUARTERS

Left: Active beams with wings for exposed application are installed on the second floor.

Above: A cloud ceiling on the third floor houses beams and linear slot diffusers.

Case Study
UC Davis Heath & Wellness Center

Facility Overview

- Primary Care Facility
- 75,000 sq ft, 3 story new build
- Non-OSHPD “B-occupancy”
- In operation since early 2009
- Not a 24/7 facility
- Came in slightly over VAV

Owner Experience

- University surveyed 100 occupants and received a 91% satisfaction rating
- No operational problems attributable to beams - ACB coils have not been cleaned yet

- Projected to be 35% better than Title 24 from energy modeling
- Actual energy savings from metering are 50% better than Title 24

Viterbo School of Nursing, WI

- New $15.8m facility (original estimate $20m)
- 68,000 ft2, 7 floors
- Consists of labs, lecture halls and classrooms
- LEED Silver Certification
- Completion fall 2011

HVAC First Costs

Savings Compared to VAV

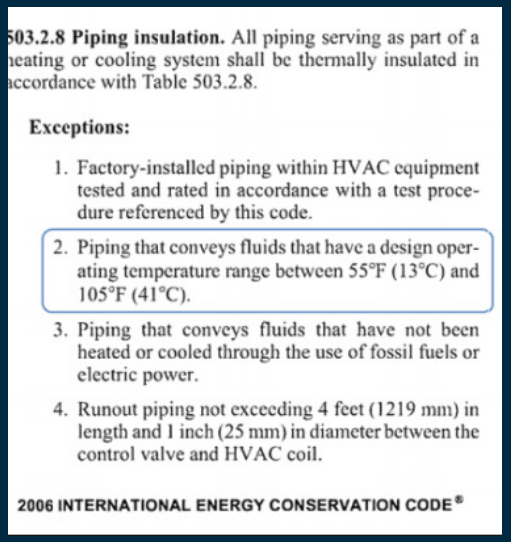
- Smaller AHU's
- Smaller ductwork
- Controls
  - Simple two position zone valves
- Electrical infrastructure costs
  - Increased pump HP more than offset by reduced fan HP

HVAC First Costs

Increases Compared to VAV

- More terminals (beams)
- More distribution piping
- More piping insulation
  - Requirement depends on chilled water temperature and dewpoint

Overall HVAC cost increase = $260,000 compared to VAV ($3.82/SF)



503.2.8 Piping insulation. All piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table 503.2.8.

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Piping that conveys fluids that have a design operating temperature range between 55°F (13°C) and 105°F (41°C).
3. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electric power.
4. Runout piping not exceeding 4 feet (1219 mm) in length and 1 inch (25 mm) in diameter between the control valve and HVAC coil.

2006 INTERNATIONAL ENERGY CONSERVATION CODE®

Construction Costs

Construction Costs

Savings due to reduced height

Building Component	Savings
Structural Ste	$ 7,200
ry (int	$,692
Fire	600
St	
	87
Ins	424
E	
Curtain	0,500
Stairs	$ 2,500
Exterior Dry	$ 249
Elevators	$ 5,000
Electrical	$ 30,000
Total Cost Savings	$ 245,298

Overall cost neutral

Pricing provided by CD Smith Construction

Case Study
TCU – Bass Building - School of Nursing (Midwifery)

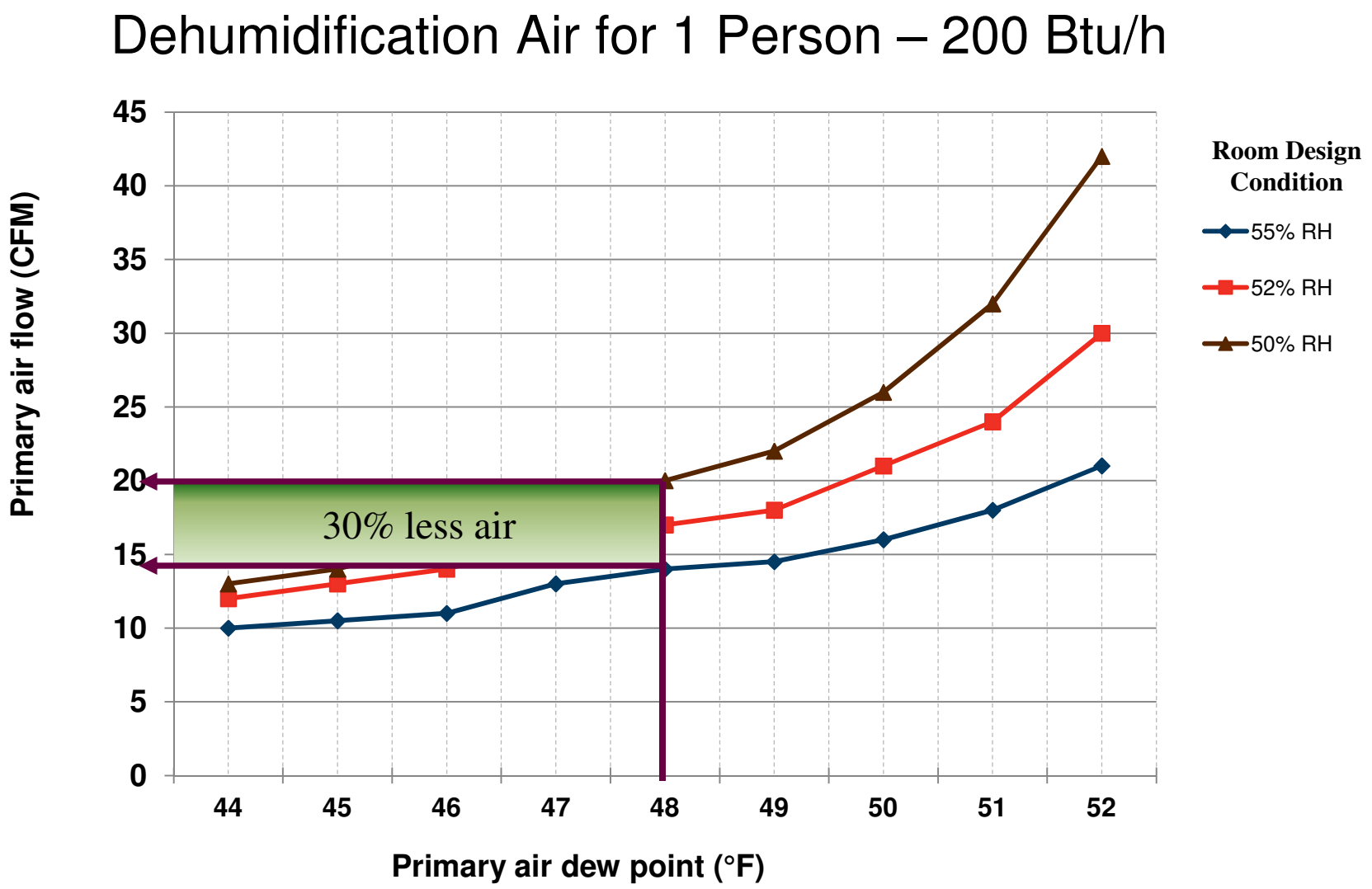
EDUCATING THE DESIGN TEAM & OWNER

- PRODUCT INTRODUCTION
- DESIGN REVIEW MEETINGS
    - EQUIPMENT SELECTION
    - SEQUENCE OF OPERATIONS

CONTRACTOR EDUCATION

- BUILT MOCKUP & ELIMINATE INTERPRETATIONS
  - GAVE OWNER AND CONTRACTORS THE ABILITY TO VIEW WHAT WAS WANTED

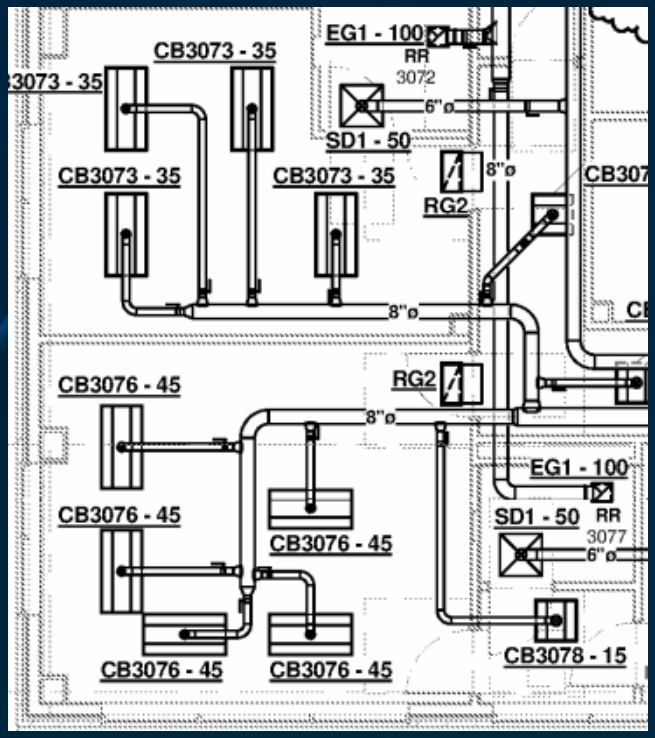
Reconsider discharge condition



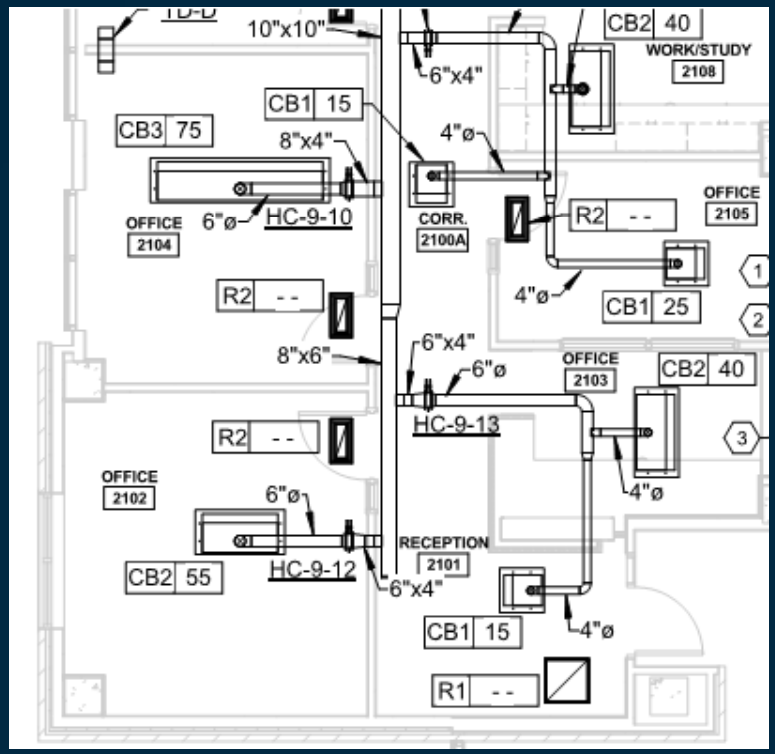
Common Layout Errors – *Too Many Beams*

- ***Least primary vs. fewest beams.***
- ***2 pipe over 4.***

Project "X"



TCU – 2nd Floor



TCU Bass Building
ACB System Design Overview

- VAV all air for the Atrium
- Restrooms constant volume air
- 2-Pipe active chilled beams for rest of building
  - Chilled Water cooling, hot air heating

POST DESIGN

- BIDDING
  - CAME IN AT THE SAME MECHANICAL CONSTRUCTION COST AS AN ALMOST IDENTICAL BUILDING ON CAMPUS WHICH HAD VAV
- CONSTRUCTION
  - VERY FEW QUESTIONS
  - 3 RFIs
- OCCUPATION
  - Happy client
  - ASHRAE CHAPTER TOUR (APRIL 2015)

UC Davis Segundo

Measured Energy Use

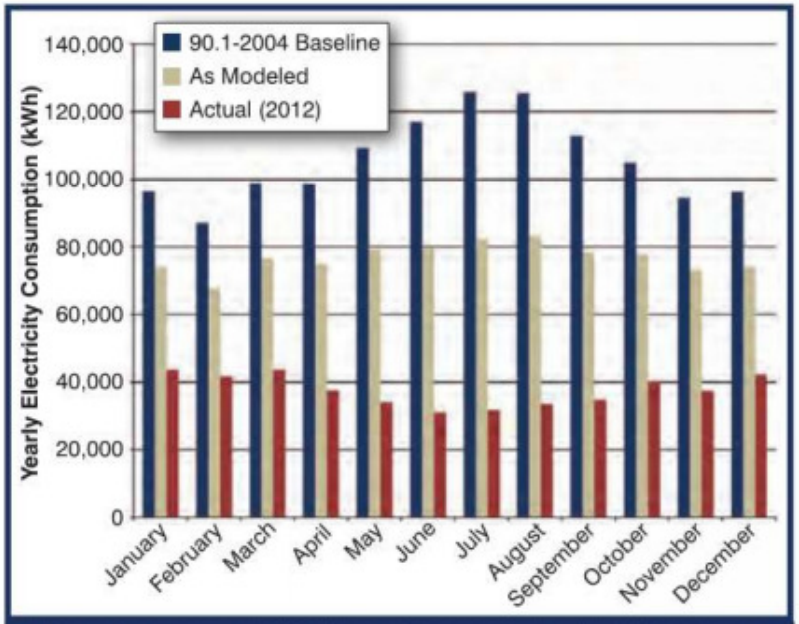


Figure 1: Yearly electricity consumption (kWh) for Segundo Service Center.

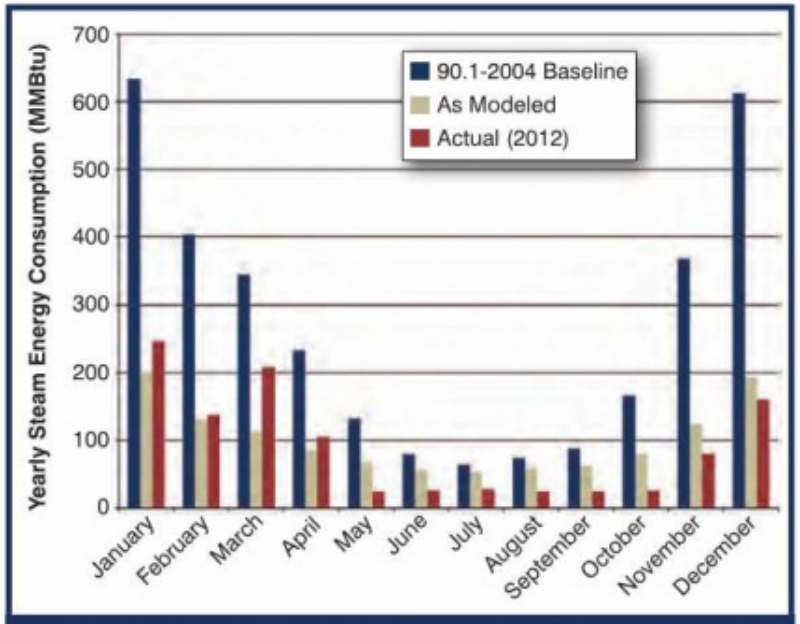


Figure 2: Yearly steam consumption (MMBtu) for Segundo Service Center.

Questions

Thank You