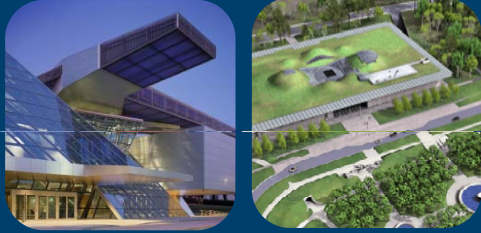




# ASHRAE Expo



## Radiant Cooling Overview



- Dan Sullivan, LEED AP, CEM
- Casey Swanson
- Uponor, Inc.
- Commercial Radiant Senior Manager, Product Offerings



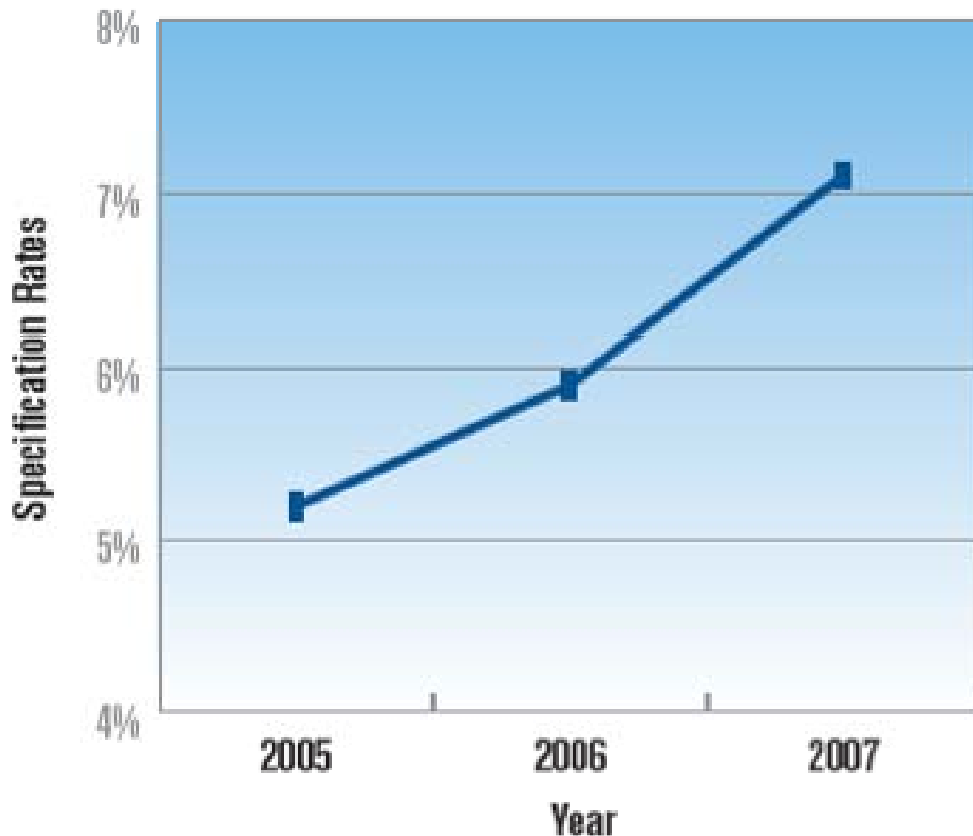
# Agenda

- Radiant Trends & Market Drivers
- Radiant Cooling Fundamentals & Benefits
- Energy Modeling and LEED Specification Credits
- Radiant Heating and Cooling Installation and Control Strategies
- Case Study Examples

# Radiant Trends and Market Drivers

- Green Building/LEED
- Net Zero, Low Exergy Designs
- Government Mandates and Rebates

# Specification Rates for Radiant



Source: *Products and Players' Trends*, McGraw-Hill Construction, 2008

- Since 2005, radiant system specs **increased 36%**
- 7.5% of new construction spec'd with radiant
- **Expected to double by 2013!**

**Green building is expected to grow over the next five years to be a \$96-\$140 billion market.**

Currently \$36-\$49B, 23% CAGR

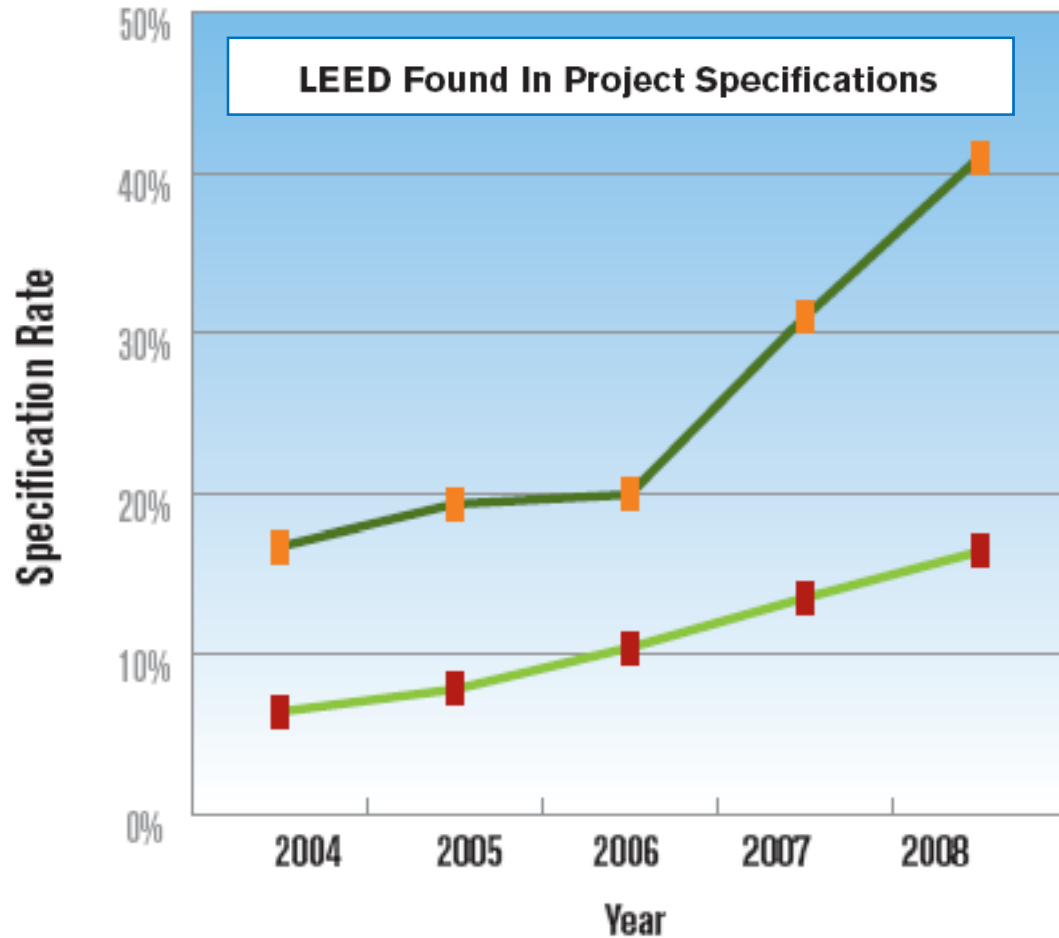
**Green = Radiant Systems = Green\$**

# What Makes Radiant Systems Green?

- Low-temperature heating and high-temperature cooling
- Flexible to integrate with use of alternative energy sources:
  - Geothermal
  - Solar
  - Waste/Biomass
  - Other free sources

**Realizing Energy Savings 30-45%**

# How is Green Growth Measured?

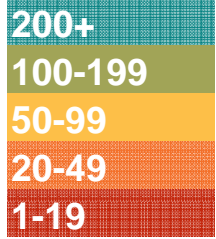


- Project Valuation
- Project Number

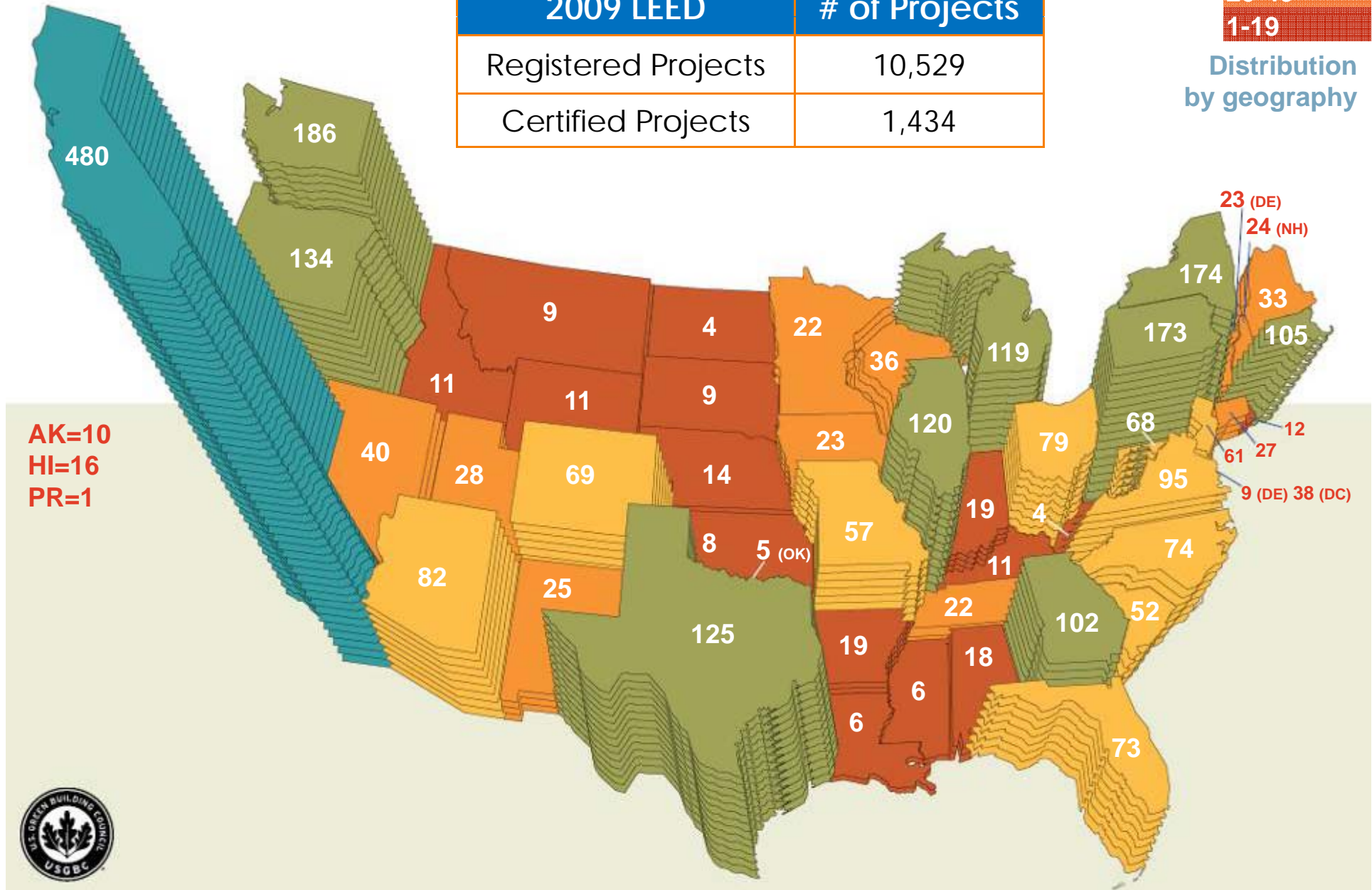
Source: *Products and Players' Trends*, McGraw-Hill Construction, 2008

LEED for New Construction Buildings  
as of 07/06

2009 LEED	# of Projects
Registered Projects	10,529
Certified Projects	1,434



Distribution  
by geography



# Net Zero Mandates

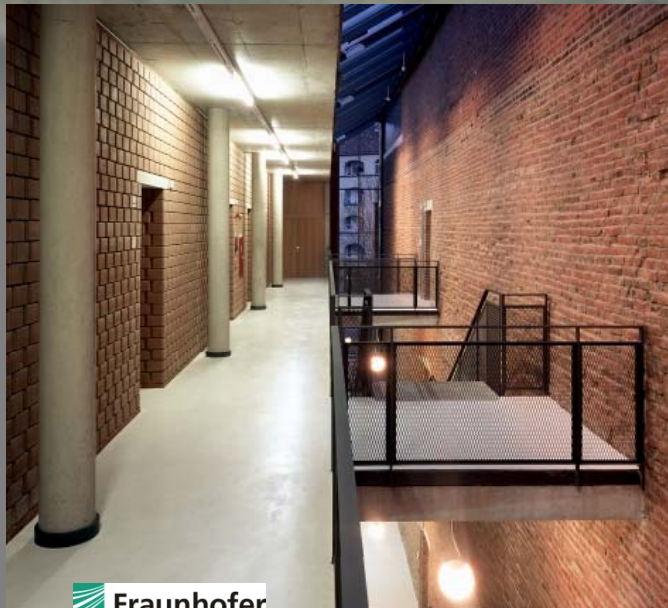
- All commercial buildings built after 2025 to achieve zero net energy use:
  - U.S. Dept of Energy
  - Energy Independence and Security Act of 2007
  - American Institute of Architects
  - California, residential 2020, commercial 2030
- Members
  - [http://www1.eere.energy.gov/buildings/real\\_estate/](http://www1.eere.energy.gov/buildings/real_estate/)
- Building Database
  - <http://eere.buildinggreen.com/mtxview.cfm?CFID=48718817&CFTOKEN=79563317>
  - <http://www.ashrae.org/events/page/2094>
- High percentage of net zero design include radiant heating and cooling
  - First phase is 30% energy reduction by 2015 for federal buildings

# Low Exergy, Passive Case Study

Centre for Sustainable Building,  
Kassel

- In operation 2001
- 19 offices
- 1 lecture hall
- 14.500 ft<sup>2</sup> (*1.347 m<sup>2</sup>*)  
net floor area





Fraunhofer  
IBP

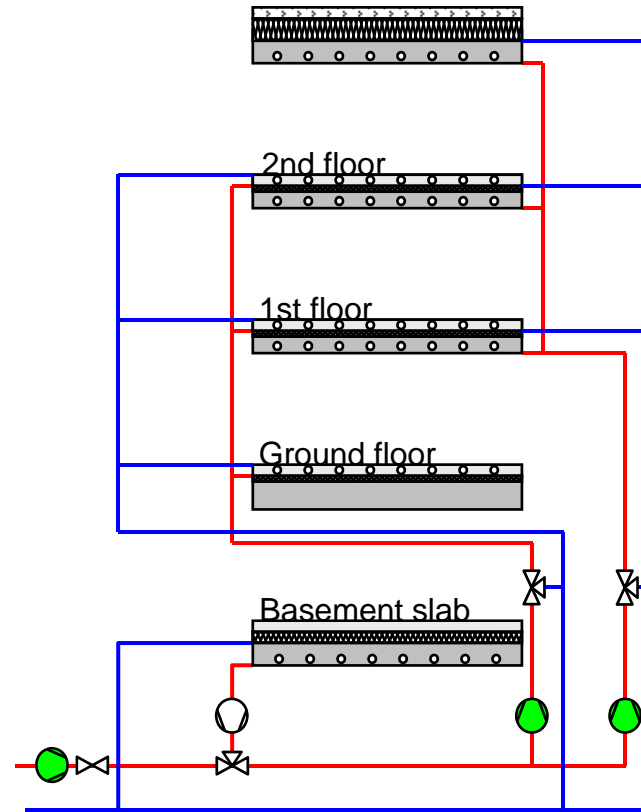
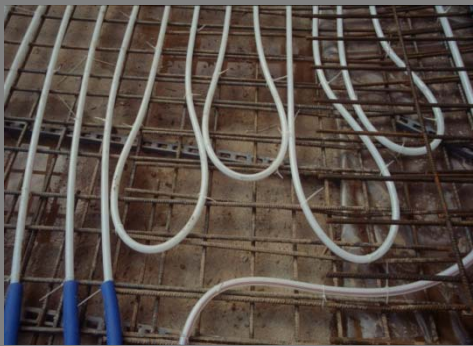
## Energy efficient office buildings

- Good insulation standard
- Solar optimized facade
- Effective solar shading
- Thermally activated slabs
- Passive cooling
- Demand controlled ventilation



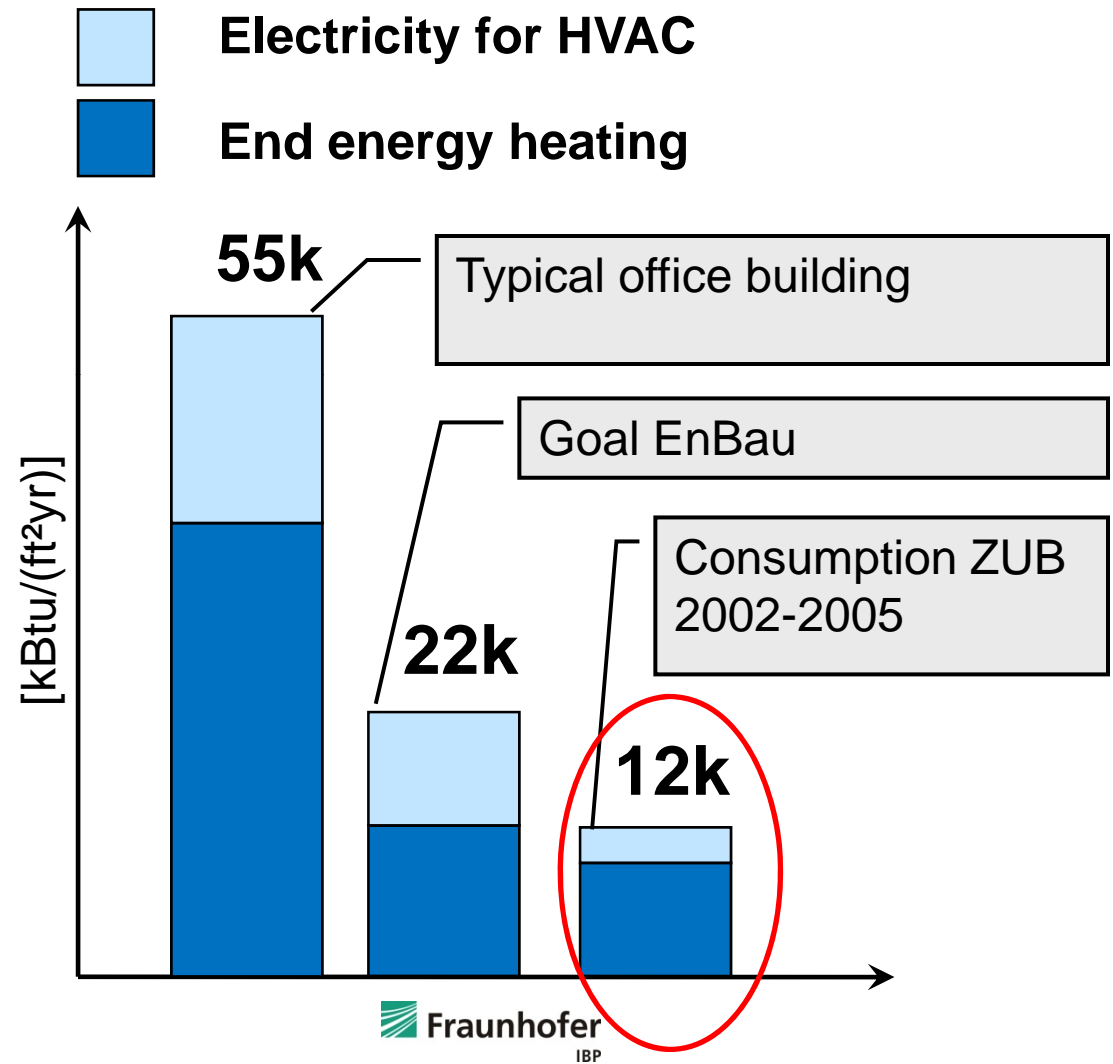
**High Comfort**  
**Low Energy Use**

# Thermally Activated Constructions

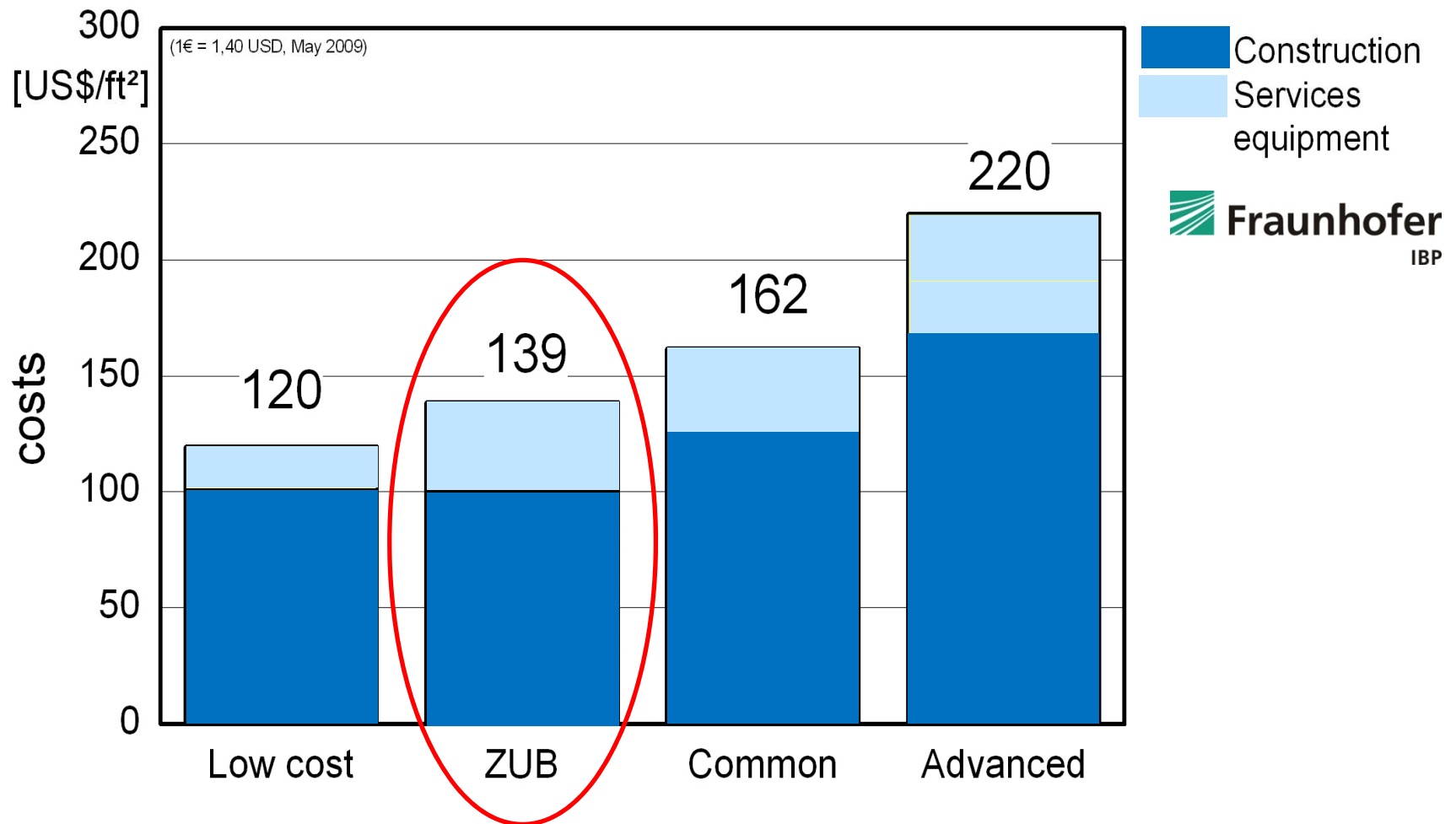


- Heating source: district heating
- Passive cooling source via ground slab exchanger

# End Energy Consumption



# Initial construction costs



# Incentives



- Emergency Economic Stabilization Act of 2008, under Division B, H.R. 1424, ushered in incentives for sustainable building and renewable energy
- Could give significant boost to green projects over next several years
- **Energy-efficient** commercial buildings **eligible for tax deduction of up to \$1.80 per square foot** (\$.30-1.80/ft<sup>2</sup>)
- To qualify, owner of new or existing building must show interior lighting, envelope or HVAC system reduces by 50% minimum requirements set by ASHRAE 90.1-2001
- \$.60 per square foot for installing tubing (radiant ready)
- <http://www.dsireusa.org/incentives/index.cfm?state=us>

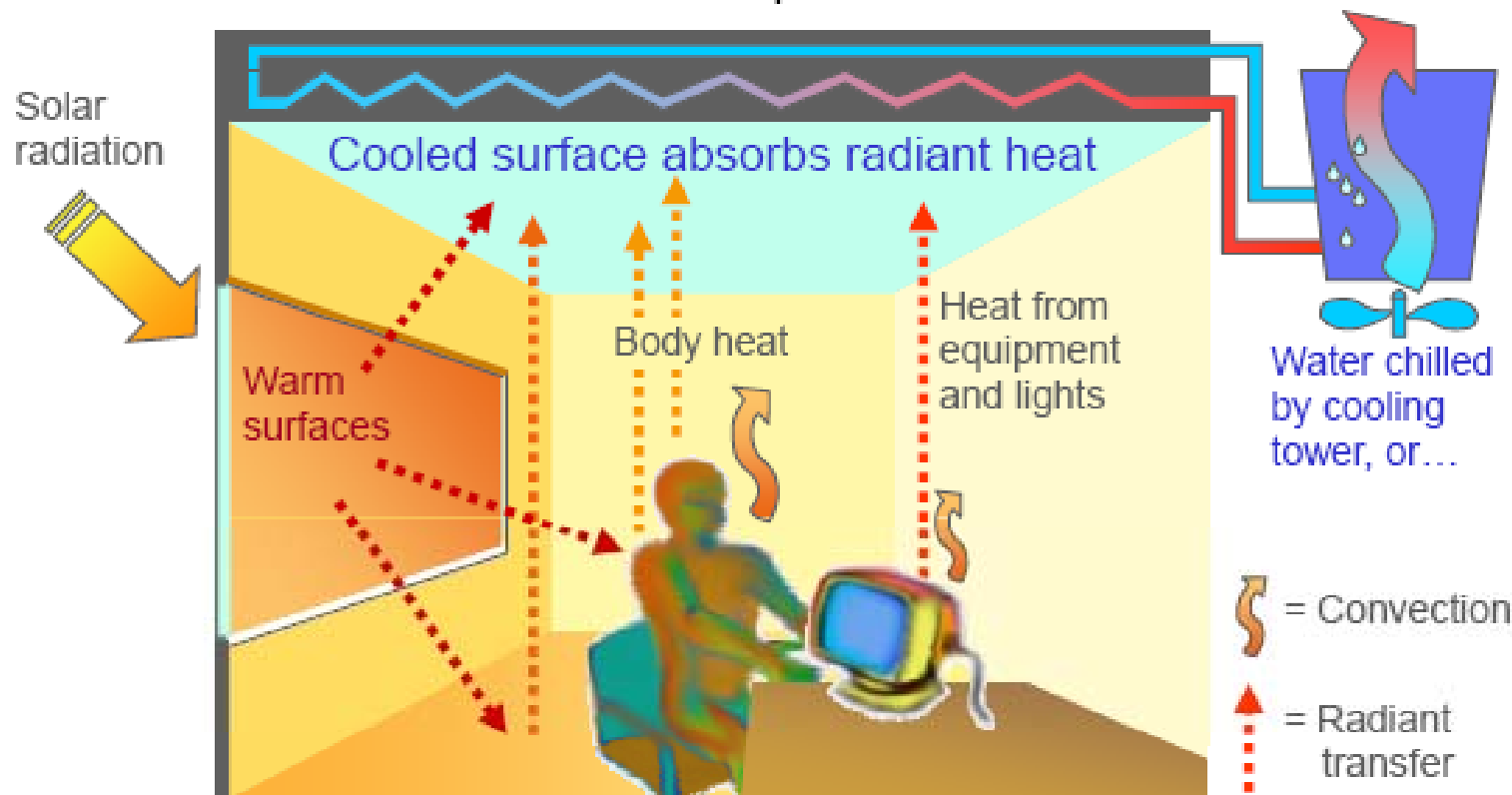
# Radiant Cooling Fundamentals, Benefits, and Load Design

- Common Applications
- Hydronic Fundamentals
- Benefits and Advantages
- Load Design Strategies

# Radiant Cooling

## Background: radiant cooling basics

Chilled surfaces absorb thermal energy (line-of-sight transfer) and remove it from the conditioned space





## Radiant Cooling, Common Applications

- Museums
- Institutional, educational and recreational facilities
- High-rise hotels/offices
- Manufacturing and retail spaces
- Hospitals, health care and assisted living facilities
- Dormitories, barracks and prisons
- Churches
- Airports
- Outdoors (snow and ice melt)
- Residential



## Growth Advantages Of Radiant Cooling

- Comfort
- Energy efficiency
  - Better distribution efficiency(pump vs. fan motor)
  - Average 30% energy saving
- Architectural freedom, increases available space
- Air Quality, no noise, no draft
- Low temp heating; High temp cooling
- LEED Points & High Performance Bldgs.
- Low Maintenance & Operating Cost
- High Glazing, Solar/Short Wave Absorption
- Off Peak, Thermal Storage
- Synergies with UFAD, DOAS, DV

# Hydronic Fundamentals & Efficiencies

## Air

- Air Density = .074 lb/ft<sup>3</sup>
- Specific Heat = .24 BTU/lb°F
- Volumetric Heat Capacity  
= **.02 BTU/ft<sup>3</sup>°F**

## Water

- Water Density = 62.4 lb/ft<sup>3</sup>
- Specific Heat = 1 BTU/lb°F
- Volumetric Heat Capacity  
= **62.4 BTU/ft<sup>3</sup>°F**

**Water has over 3100 times the volumetric heat capacity compared to air!**

\*Analysis and statistics provided by the  
Lawrence Berkeley National Laboratory  
(LBNL)

# Transport Medium Efficiencies

- Transport of 340,000 BTU/hr
- Fan Power, 13,250 cfm, .247 psi

$$P = \frac{Q \cdot \Delta p}{\eta_{air}} = \frac{13,250 \text{ ft}^3 / \text{min} \cdot 35.57 \text{ lb} / \text{ft}^2}{0.75} = 628,360 \text{ ft} \cdot \text{lb} / \text{min} \cdot 0.0226 \approx 14,200 \text{ W}$$

(Converts to 19hp)

- Pumping Power, 95 gpm, 11.6psi

$$P = \frac{Q \cdot \Delta p}{\eta_{water}} = \frac{12.7 \text{ ft}^3 / \text{min} \cdot 1674 \text{ lb} / \text{ft}^2}{0.30} = 70,896 \text{ ft} \cdot \text{lb} / \text{min} \cdot 0.0226 \approx 1602 \text{ W}$$

(Converts to 2.1hp)

**Water Transport Is 88% more power efficient than air transport**



The [Hearst Tower](#), New York City

## Radiant System Efficiencies

- LBNL modeled office buildings in 9 US cities comparing radiant with ventilation and all other forced air VAV systems
  - Findings:
    - Radiant cooling, on average, saves 30% overall energy for cooling and 27% on demand
    - Energy savings of
      - 17% in cold, moist climates
      - 42% in warmer, dry climates

ANSI/ASHRAE Standard 55-2004  
(Supersedes ANSI/ASHRAE Standard 55-1992)



# ASHRAE STANDARD

## Thermal Environmental Conditions for Human Occupancy

Approved by the ASHRAE Standards Committee on January 24, 2004; by the ASHRAE Board of Directors on January 29, 2004; and by the American National Standards Institute on April 16, 2004.

ASHRAE Standards are scheduled to be updated on a five-year cycle; the date following the standard number is the year of ASHRAE Board of Directors approval. The latest copies may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2395. E-mail: [orders@ashrae.org](mailto:orders@ashrae.org). Fax: 404-521-5476. Telephone: 404-639-5489 (worldwide) or toll free 1-800-527-4723 (for orders in U.S. and Canada).

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ISSN 1081-2336

When addenda or interpretations to this standard have been approved, they can be downloaded free of charge from the ASHRAE web site at:

<http://www.ashrae.org/template/TechnologyLinkLanding/category1631> or  
<http://www.ashrae.org/template/TechnologyLinkLanding/category1636>.



**AMERICAN SOCIETY OF HEATING,  
REFRIGERATING AND  
AIR-CONDITIONING ENGINEERS, INC.**

1791 Tullie Circle, NE • Atlanta, GA 30329

## National Building Code Requirements Refers to ASHRAE 55 on thermal comfort:

“produce thermal environmental conditions acceptable to a majority /80% of the occupants within the space.”

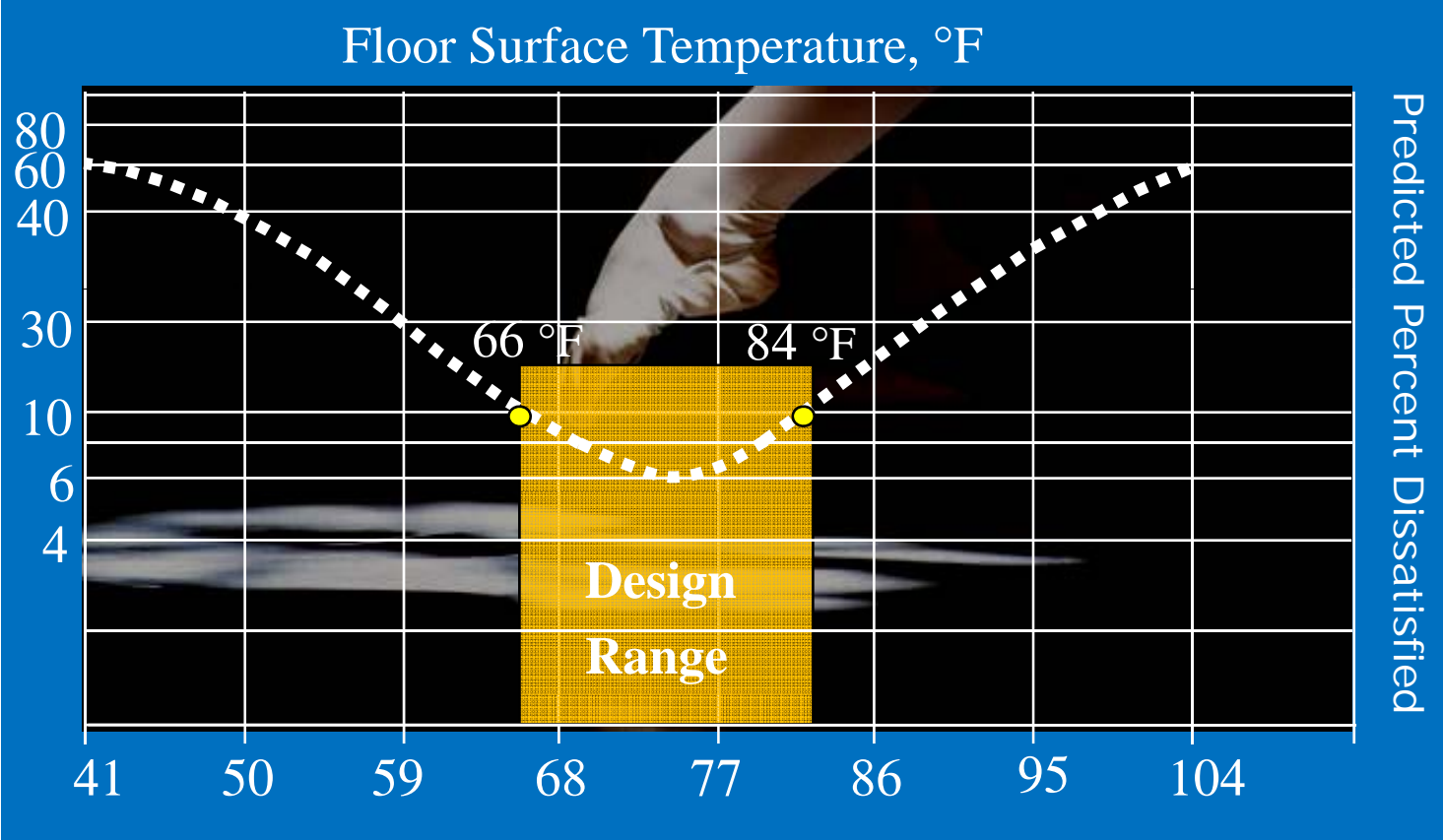
### Factors:

- Metabolic rate / activity
- Clothing
- Air Temperature
- Air Speed
- Humidity
- Radiant Temperature

### Body Heat Transfer:

- Radiation = 62%
- Convection = 20%
- Evaporation = 15%
- Respiration = 3%

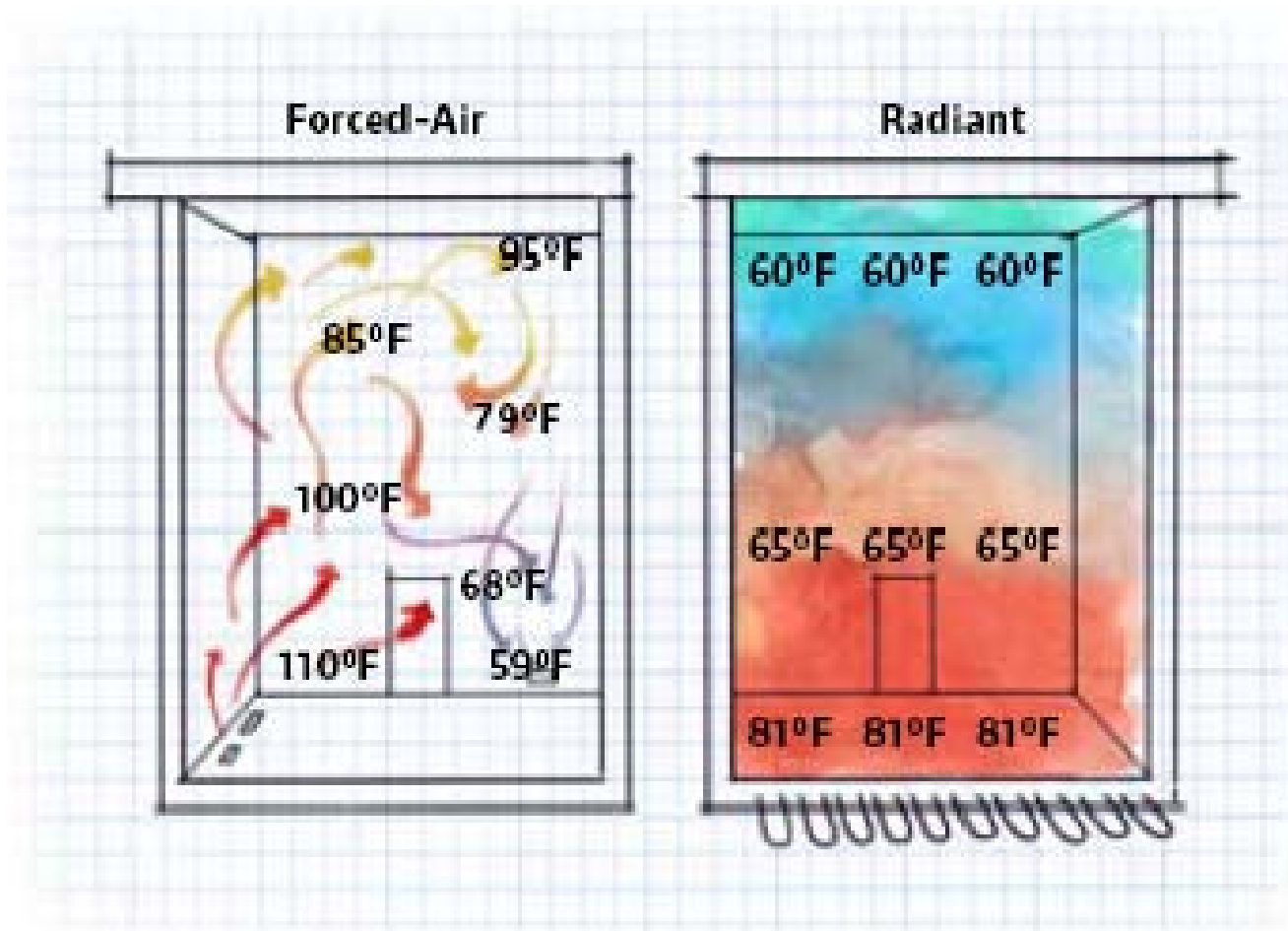
# Thermal Comfort | ASHRAE Standard 55



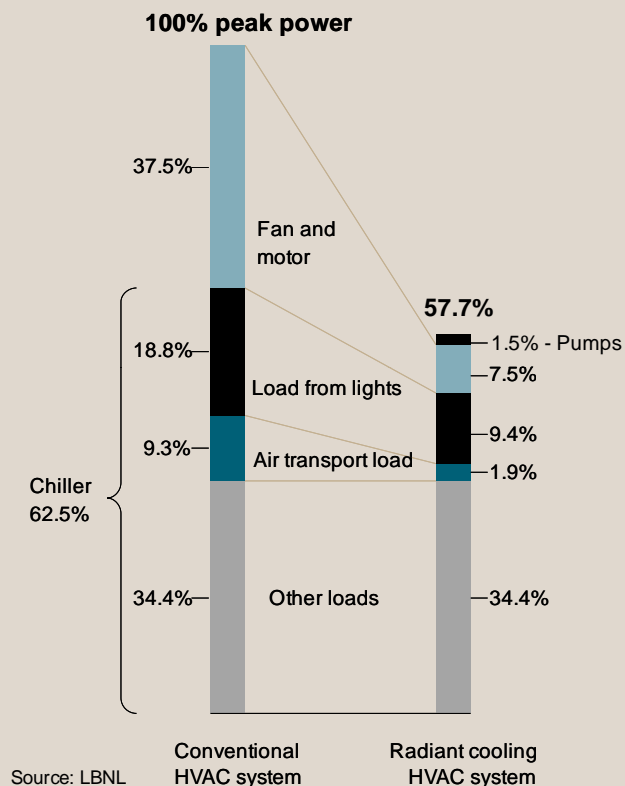
Ref. : ASHRAE Standard 55-2004

# Radiant Floor Thermal Stratification

## Temperature Distribution



# Sensible Load



A typical office building in Los Angeles as modeled by LBNL

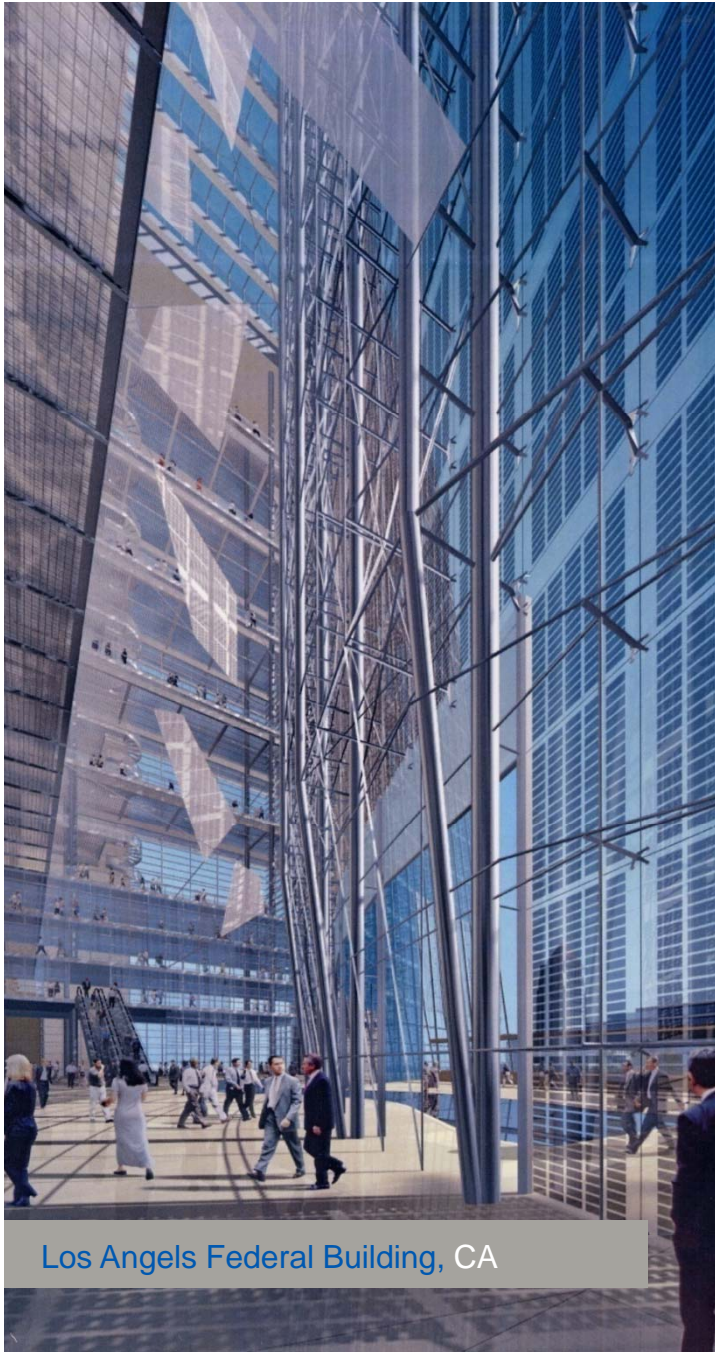
- The external loads account for only 42% of the thermal cooling peak
  - 28% of the internal gains were produced by lighting
  - 13% by air transport
  - 12% by people
  - 5% by equipment
- This is the dry bulb heat or heat gain in the space
- Radiant cooled systems can handle a significant portion of this load
- Absorption is dependant upon a decreased surface temperature

# Latent Load

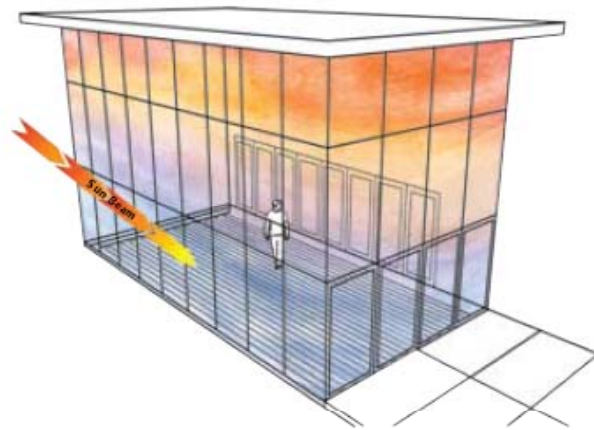
- This is the energy that is contained in the moisture in the air, the wet bulb load or gain
- A phase change is required to address this load
- Radiant cooling systems can not address this load
  - The ventilation system must:
    - Address the latent load
    - Balance of the sensible load if any exists
    - Control the level of humidity within the air system
      - Meet the requirements of the Indoor Air Quality Standards for fresh air
- Dew point is determined by the relative humidity and temperature within the space
- Supply water temperature to radiant slab maintained above dew point
- Humidity level in the building must be controlled through the ventilation system

# Direct Solar Load

- This is the solar or short wave energy that directly impacts the cooling surface
- It can be absorbed before it has a chance to reflect into the space and to become part of the sensible load
- Absorption does not require a decreased surface temperature



Los Angeles Federal Building, CA



# Radiant Design considerations:

- Heat Loss calculations
- Which of the 5 methods of radiant installation will you be choosing
- Type of flooring to be installed. I.e. carpet, tile, or wood flooring
- Maximum length of tubing
- Tubing layout
- Radius of curves
- Inches on center
- $\Delta_T$  might be different for each application





The [Water + Life Building](#), Southern California

## Radiant Cooling Common Design Results

- Most radiant cooling designs fall within these parameters:
  - 12 to 14 Btu/h/ft<sup>2</sup> of sensible cooling
  - Up to 30 Btu/h/ft<sup>2</sup> of solar absorption
  - 66°F minimum floor surface temperature
  - 76°F to 78°F room set point temperature
  - 55°F thru 58°F supply fluid temperature

# Energy Modeling & LEED Credits

Overview & Case Study

# Radiant Modeling – Energy and Comfort

- Capture Fundamentals
- Thermal Modeling
- Energy Modeling

## Available features and capabilities

- **eQuest / DOE-2**

- U.S. DOE, LBNL → Hirsch Assoc.

- **Tas**

- EDSL (England)

- **EnergyPlus**

- U.S. DOE, national labs, universities

- **TRNSYS**

- Transsolar (Germany) + TESS (U.S.)

- **Virtual Environment <VE>**

- Integrated Environmental Solutions (Scotland)

- **RadTherm**

- ThermoAnalytics (U.S.)

- **CBE Thermal Comfort Model**



Whole-building energy model in eQuest

# Modeling Summary

## Tool features & capabilities

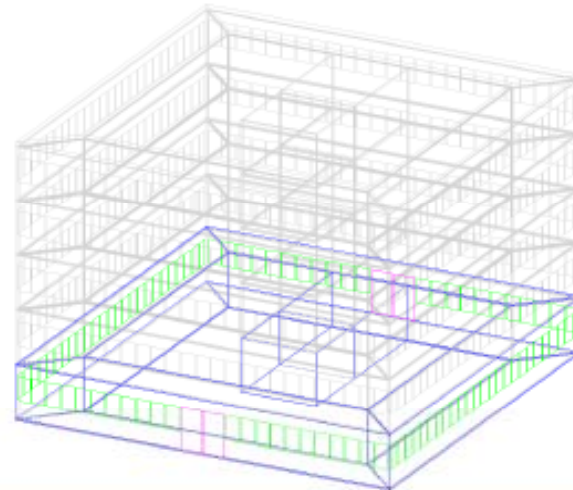
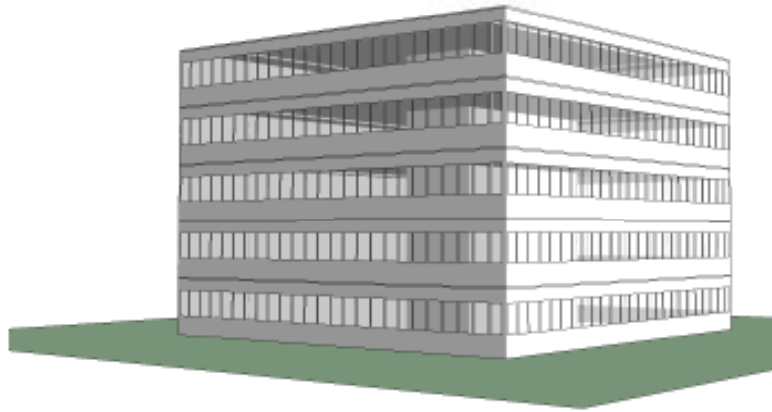
X = Included

\* = accommodated (with caveats)  
or additional tool/calcs required

	eQuest DOE-2	Tas	EnergyPlus	TRNSYS	IES <VE>	RadTherm	CBE Comfort Model
Dynamic thermal model incl. humidity	X	X	X	X	X	*	
Integrated HVAC energy modeling	X	X	X	X	X		
Radiant exchange: geometric model		X	X	*	X	X	X
Radiant cooling – simple terminal unit		X		X	X		
Radiant cooling – chilled surface/mass		*	X	*	*	*	*
Chilled element as HVAC thermal zone		*	*	*	X		
Hydronic loop with chilled slab		*	*	*	*		
Dynamic surface temperature control			*	*	*		
Low-energy cooling water sources		*	X	*			
Integration with air-side systems		X	*	*	X		
Stratified thermal environments	*	*	*	*	*	*	*
Surface temperature results		X	X	*	X	X	*
Local thermal comfort		X	*	*	*	*	X

# Energy Model Comparison – Denver, CO

## Whole-building Radiant vs. VAV comparison



- Model
  - 1st Floor
    - 0 Core Floor Slab Zn
    - 0 E Perim Floor Slab Zn
    - 0 N Perim Floor Slab Zn
    - 0 S Perim Floor Slab Zn
    - 0 W Perim Floor Slab Zn
    - 1 Core Occ Zn
    - 1 Core OH Slab Zn
    - 1 Core Svs Zn (conc, no lds)
    - 1 Core WkRm Zn
    - 1 E Perim Occ Zn
    - 1 E Perim OH Slab Zn
    - 1 N Perim Occ Zn
    - 1 N Perim OH Slab Zn
    - 1 S Perim Occ Zn
    - 1 S Perim OH Slab Zn
    - 1 W Perim Occ Zn
    - 1 W Perim OH Slab Zn
  - 2nd Floor
  - 3rd Floor
  - 4th Floor
  - 5th Floor

## Primary differences in systems

### **All-air VAV system**

- Efficient water-cooled chiller
- Airside economizer
- Cooling coil temperature reset

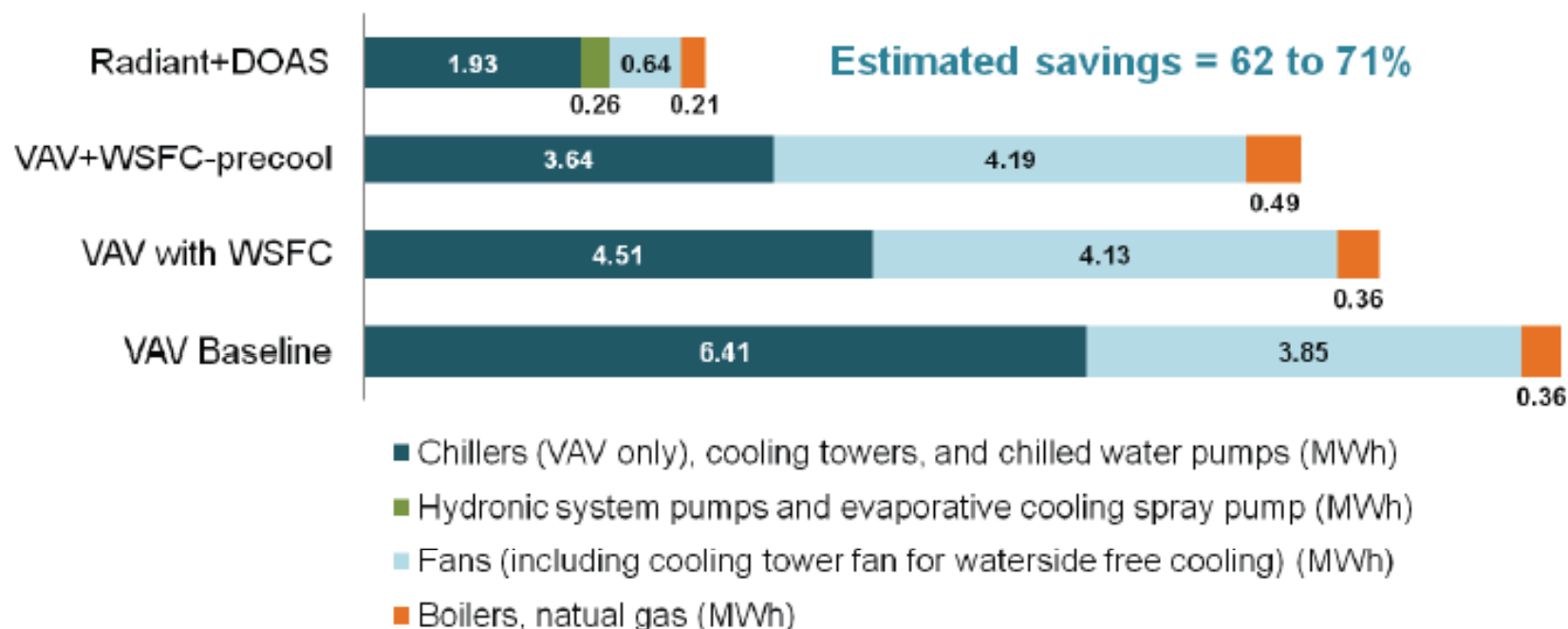
### **Radiant cooling**

- Cooling tower only – no chiller
- Nighttime pre-cooling of building mass
- Dedicated 100% Outside Air System (DOAS) for ventilation
- Smaller air volume:  $1.5 \times$  ASHRAE 62 req.  $\sim 29\%$  of VAV
- Indirect evaporative cooling of OA + coils using tower water

# Radiant vs. VAV comparison - recap

## Cooling Season HVAC System Energy

May – September Denver, Colorado (TMY climate data)



- Results after further refinement of radiant systems and pre-cooling controls

# Radiant Cooling LEED Summary

- **LEED is an internationally recognized green building certification system**

- Energy savings, Atmosphere (CO<sub>2</sub> emissions reduction) – 35pts
- Water efficiency – 10 pts
- Sustainable Site Development – 26 pts
- Materials Reuse and Recycling – 14 pts
- IEQ, IAQ – 15 pts
- Regional Content - 4 pts



Section	Credit	Description	Possible Pts	Associated System
(EA) Energy & Atmosphere	Prereq 2	Minimum Energy Performance	Required	Radiant Heating and Cooling Systems
(EA) Energy & Atmosphere	Prereq 3	Fundamental Refrigerant Management	Required	Radiant Cooling Systems
(EA) Energy & Atmosphere	1	Optimized Energy Performance	1 - 19	Radiant Heating and Cooling Systems
(EA) Energy & Atmosphere	4	Enhanced Refrigerant Management	2	Radiant Cooling Systems
(EQ) Indoor Environmental Quality	4.1	Low Emitting Adhesives and Sealants	1	ProPEX Fitting Systems
(EQ) Indoor Environmental Quality	6.2	Controllability of Systems, Thermal Comfort	1	Radiant Heating and Cooling Systems
(EQ) Indoor Environmental Quality	7.1	Thermal Comfort Design	1	Radiant Heating and Cooling Systems
(EQ) Indoor Environmental Quality	7.2	Thermal Comfort Verification	1	Radiant Heating and Cooling Systems
(ID) Innovation & Design	1	Innovation in Design	1 - 5	Radiant Heating and Cooling Systems



**Cooper Union** | New York

Case Study

# LEED 2.2 | ASHRAE 90.1 -2004 Results

Cooper Union Project

## Energy Cost Savings:

- Using the ASHRAE 90.1, 2004 standard, the resulting utility cost savings are \$400,770 compared to \$602,672 for the budget case.
- The total **energy cost savings is 34%** and is therefore eligible for **12 LEED points**.

New Buildings	Existing Building Renovations	Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

Alternative	Total Electric	Total Fuel	Total Utility	Energy savings
Base Case	\$542,139	\$60,533	\$602,672	
Alt-1 Base + VRE-146	\$540,093	\$57,801	\$597,894	
Alt-2 Base + VRE-146/screen	\$537,182	\$58,084	\$595,266	
Alt-3 Base + VRE-146/screen + HE Equip	\$436,926	\$42,761	\$479,687	
Alt-4 Base + VRE + HE + RAD/VAV	\$368,374	\$31,041	\$399,415	
Alt-5 Base + VRE + HE + RAD/VAV min OA	\$369,860	\$30,846	\$400,706	
Alt-6 Based on Alt 6 w/ reduced Lighting	\$369,835	\$30,935	\$400,770	<b>\$201,902</b>

34%

Table 9: End Use Totals – LEED ASHRAE 2004 Results

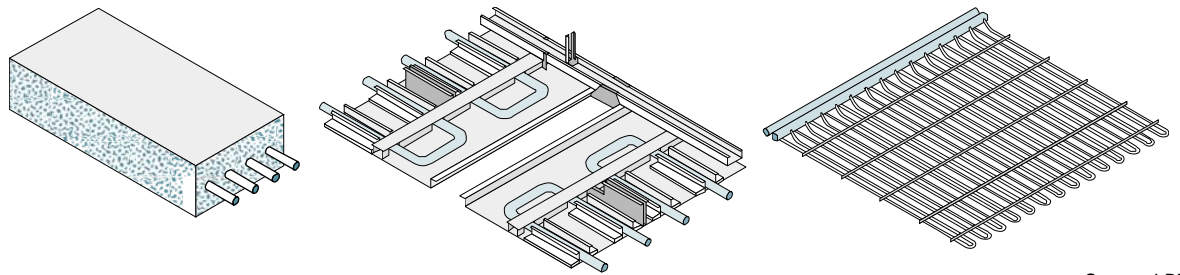
# Installation and Control Strategies

- System Types
- Radiant Cooling Control Strategies
- Rollout Mat

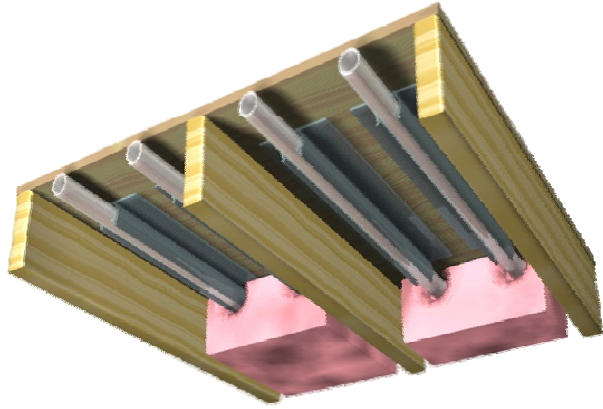


# System Strategies

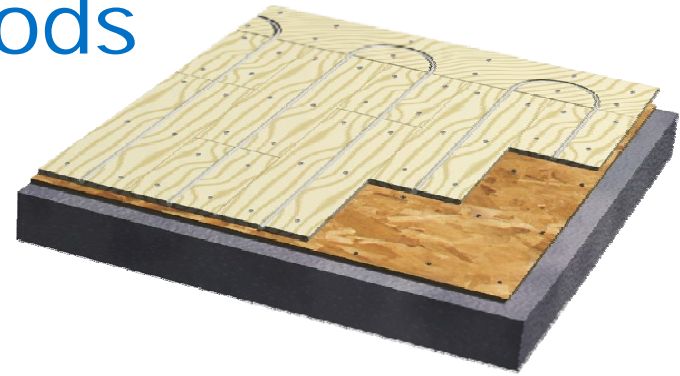
- Active/Low Mass systems are systems that run during the occupied time
  - Low Mass Cooling (Fenger Concept)
  - They provide a nearly steady set-point
  - Typically cost more to operate
  - Better for Retrofit
  - Lower SW temps, more dependent on dehumidification
- Passive/High Mass systems also called activated core or activated concrete systems. They operate most often during the unoccupied time.
  - High Mass Cooling
  - Occupants may experience a slight drift in set point temperature across the day
  - Take advantage of off-peak energy rates to lower operating costs



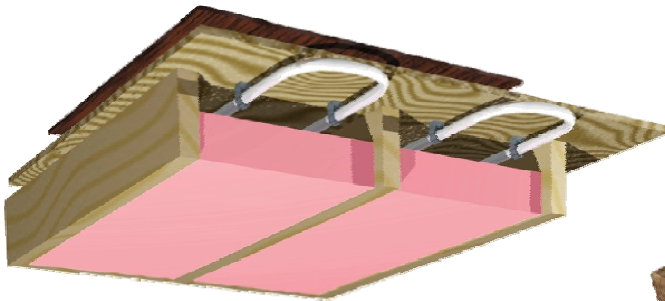
# Radiant Installation Methods



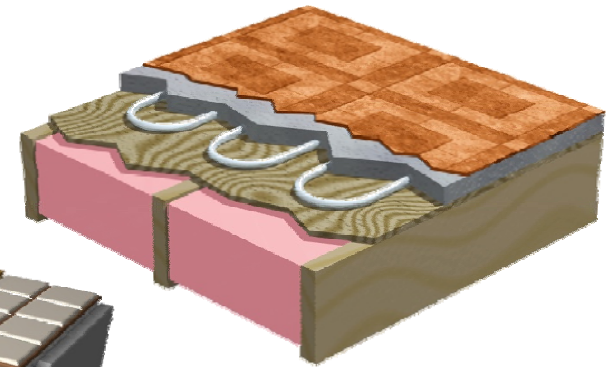
Joist Heating



Quik Trak

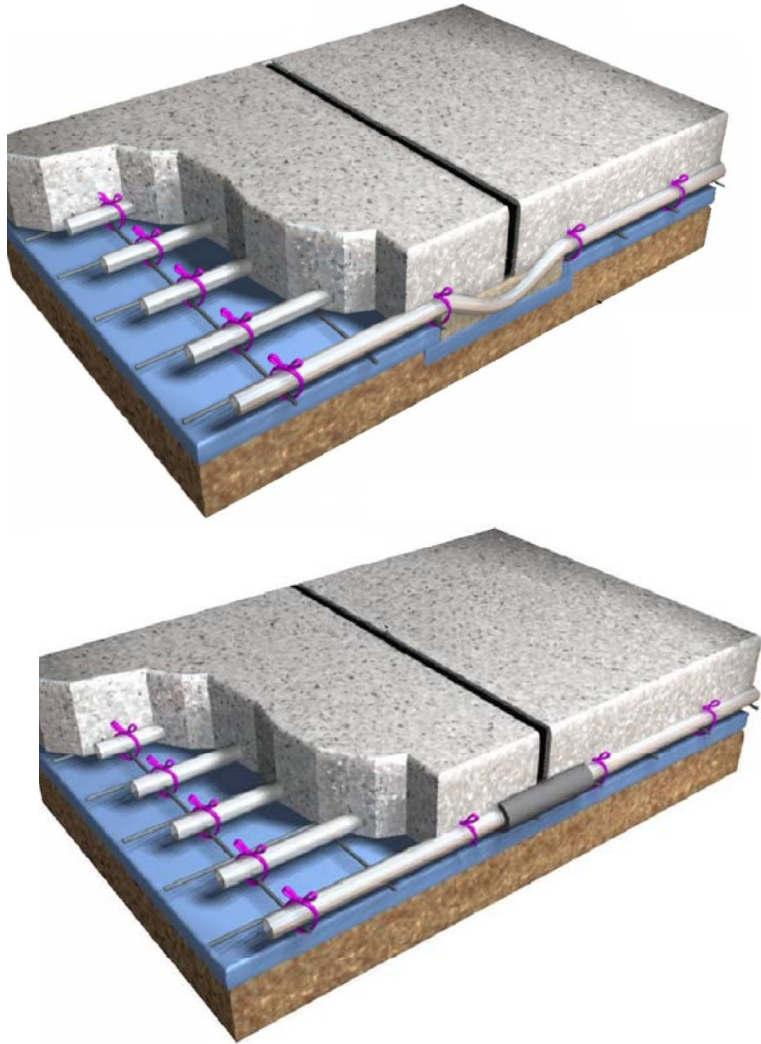


Concrete Slab



Poured Floor Underlayment

# Panel Options – Floors, ThermoActive



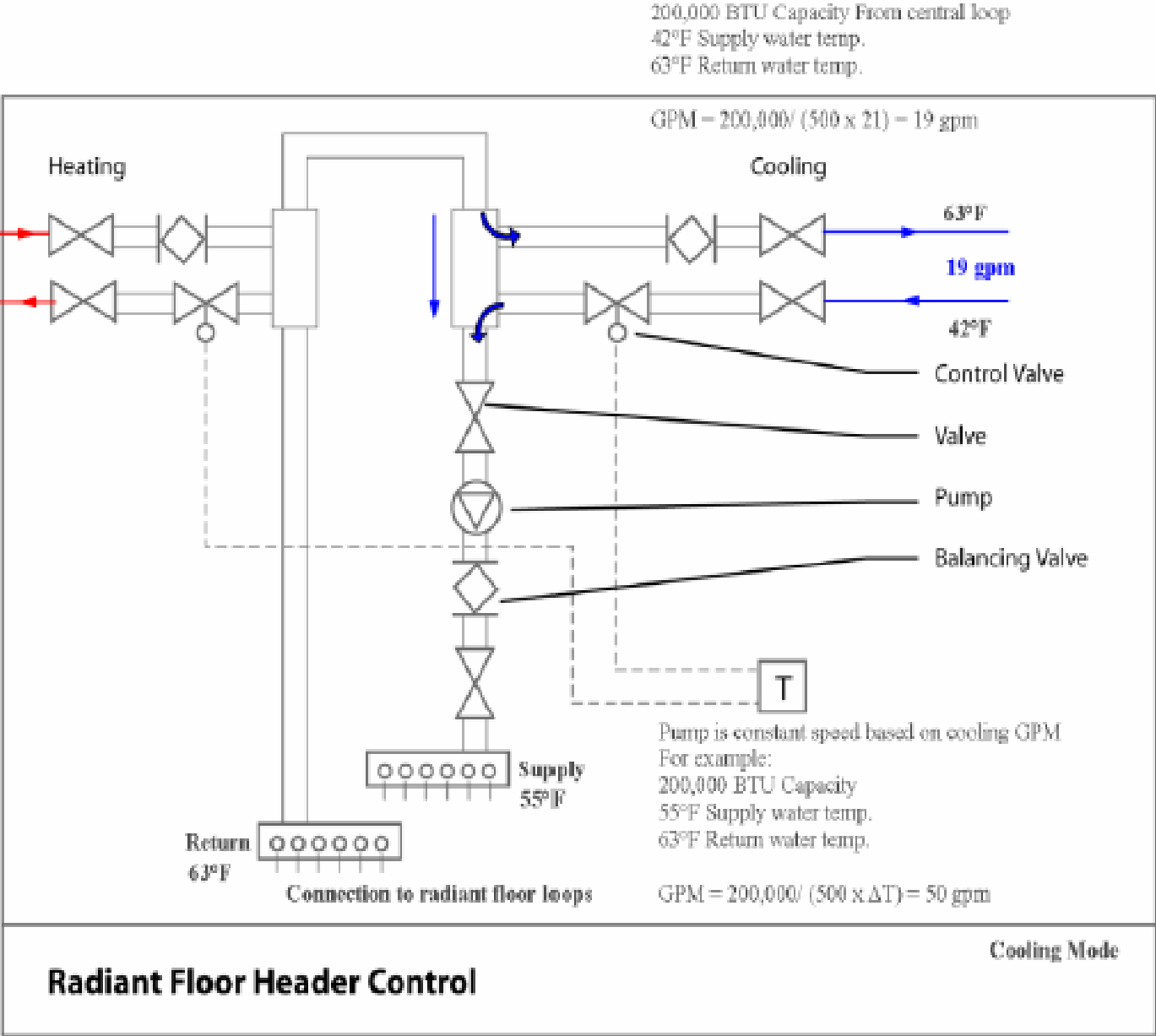
- Structural
  - High Mass
  - On Grade, Below, Above
  - Concrete/Steel
  - Reinforcing
  - Control Joints
- Coupling With Thermal Mass
  - Capturing Energy and Peak Demand Benefits
  - Acoustic Considerations with Exposed Ceilings
  - Moderate Supply Water Temps (>60 F)

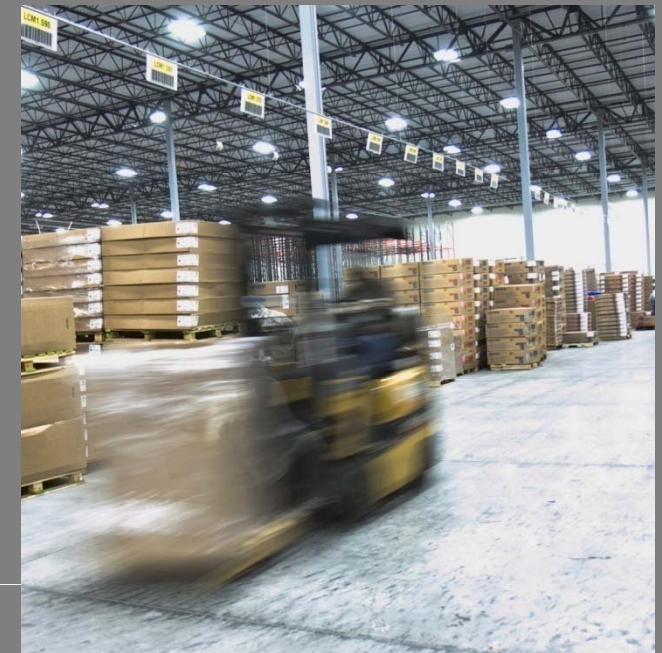
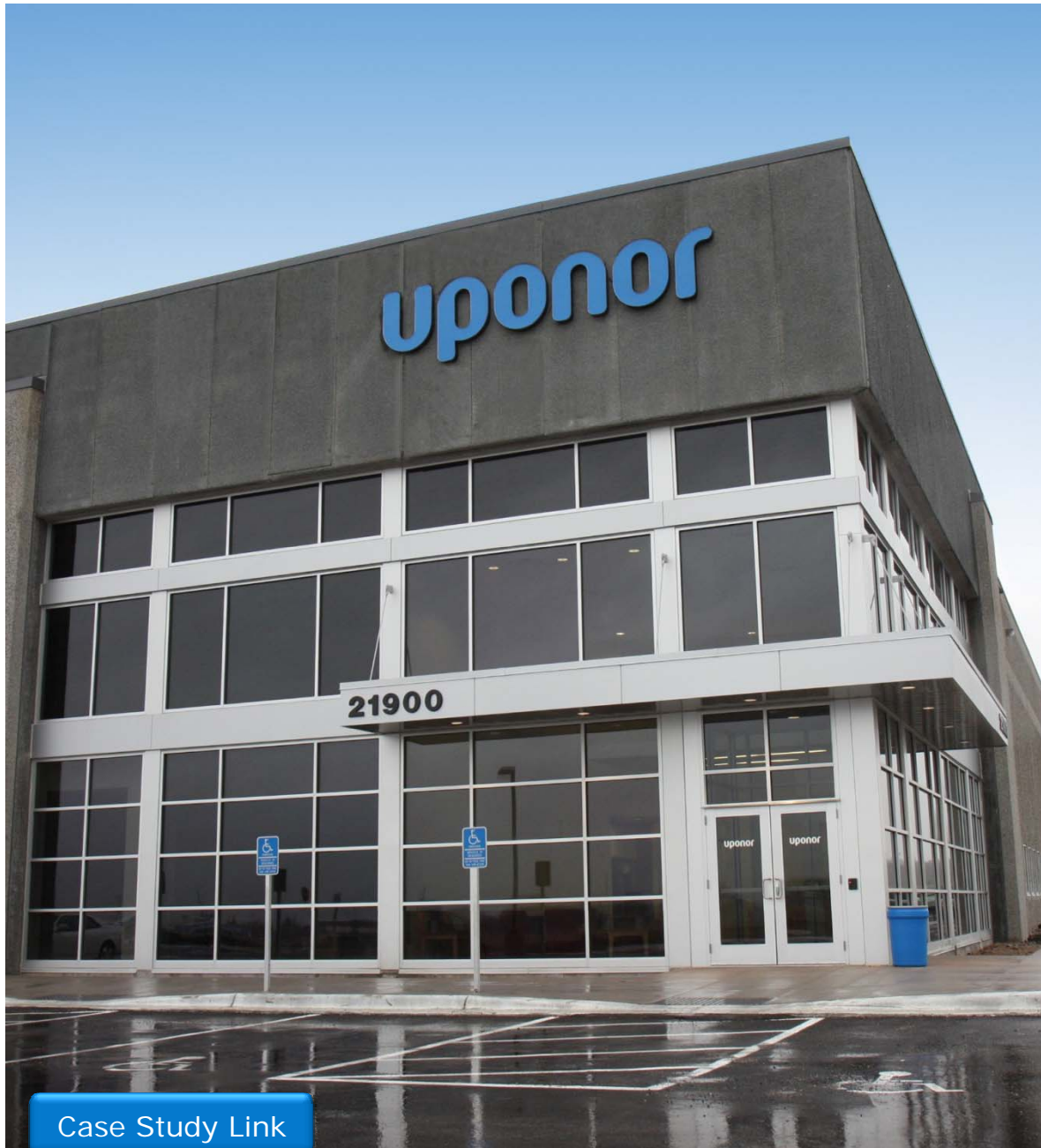
# Radiant Controls

- Control Radiant System Independently of Air System
  - Use Air System for IAQ, Ventilation, and Latent Load Control
  - Use Radiant System for Comfort and Sensible Load, Solar Load, and Energy Efficiency
- Dew Point
  - Radiant System Supply Water Temp 2°F above dew point
- Constant Flow Rate
  - More advanced designs can duty cycle pumps
- Modulate Supply Water Temperature
  - Control supply water temp from DT average water setpoint
  - Control from slab setpoint



# Controls – Cooling Mode





## Uponor Distribution Center

Radiant Heating/Cooling

AquaPEX Plumbing System

285,000 Sq Ft | LEED Silver

Best in Real Estate Award 2009

Case Study Link

<http://twincities.bizjournals.com/twincities/stories/2009/04/20/focus17.html>

# WalMart Press Release

## INDIRECT EVAPORATIVE PROCESS



Cooling towers

Walmart's HE.6 store combines indirect evaporative cooling with a radiant floor. In the evaporative process, water travels through cooling towers on the roof of the building, which lowers the temperature of the liquid as some of the water evaporates. The resulting water is projected to reduce the building's cooling needs by approximately 60 percent and is more efficient than using electricity to cool the water. Once cooled, the water is circulated to the water-source format refrigeration system to chill grocery and freezer cases, and to the radiant floor to cool the store. Even in extremely hot temperatures, the store is designed to stay cool and comfortable for customers and associates while saving energy.

Because water has approximately four times the heat-carrying capacity of air, all of Walmart's high efficiency prototypes were designed to use water for transference between systems. The HE.6 store's indirect evaporative process is an even more efficient use of water that also optimizes electricity use.

- Floor Cooling reduced number of Rooftop units from 40 to 10 Air Handlers



## Walmart | Burlington, Ontario

### Radiant Heating & Cooling

79,895 sq. ft. of Uponor  
Radiant Rollout® Mats –a  
Packaged Design Solution

Radiant Rollout Mats Install  
7.7 Times Faster than Traditional  
Systems –Lower Radiant Costs

**Estimated Energy savings of  
over 60% and reduction of  
carbon emissions by 141 tonnes**

<http://ca.csrwire.com/News/14304.html>

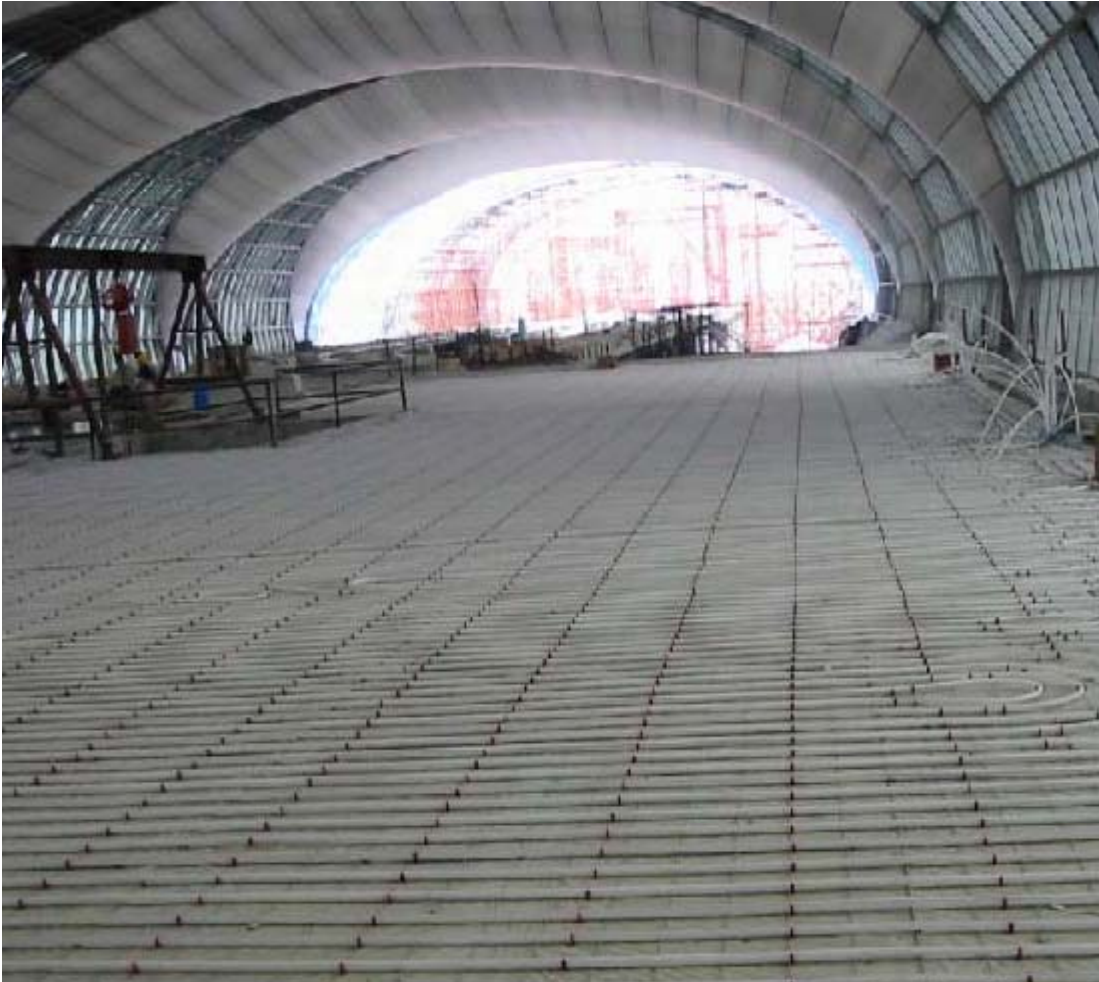
# Case Studies

Overview



## Bangkok Int'l Airport

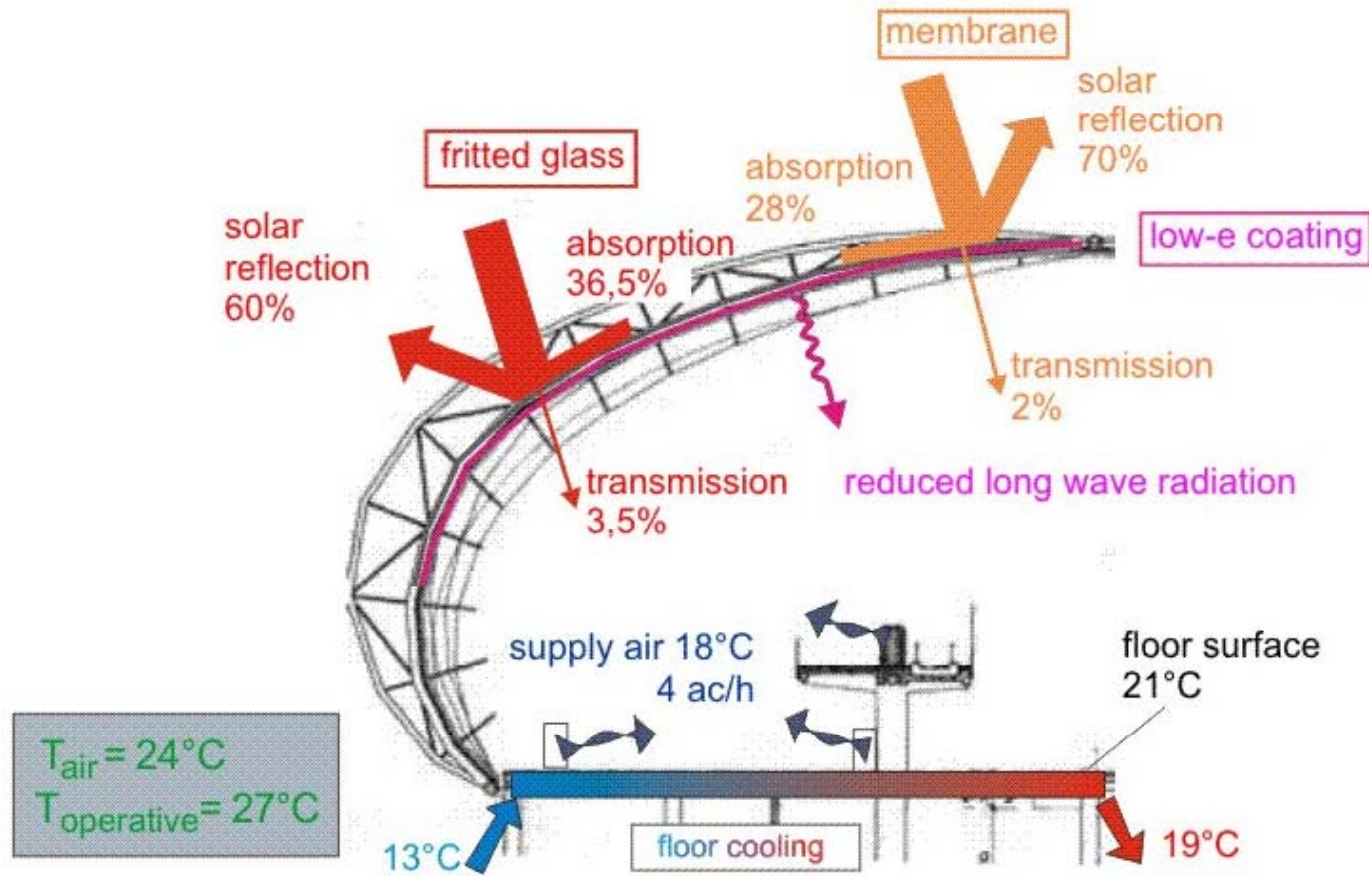
- Outdoor Temperature at 77-95°F and year round high RH relative humidity
- 45,708 m<sup>2</sup> (492,000 ft<sup>2</sup>) radiant cooling
- Humidity is conditioned in the airport to 50-60%
- Ventilation is four air changes/hour



## Bangkok Int'l Airport

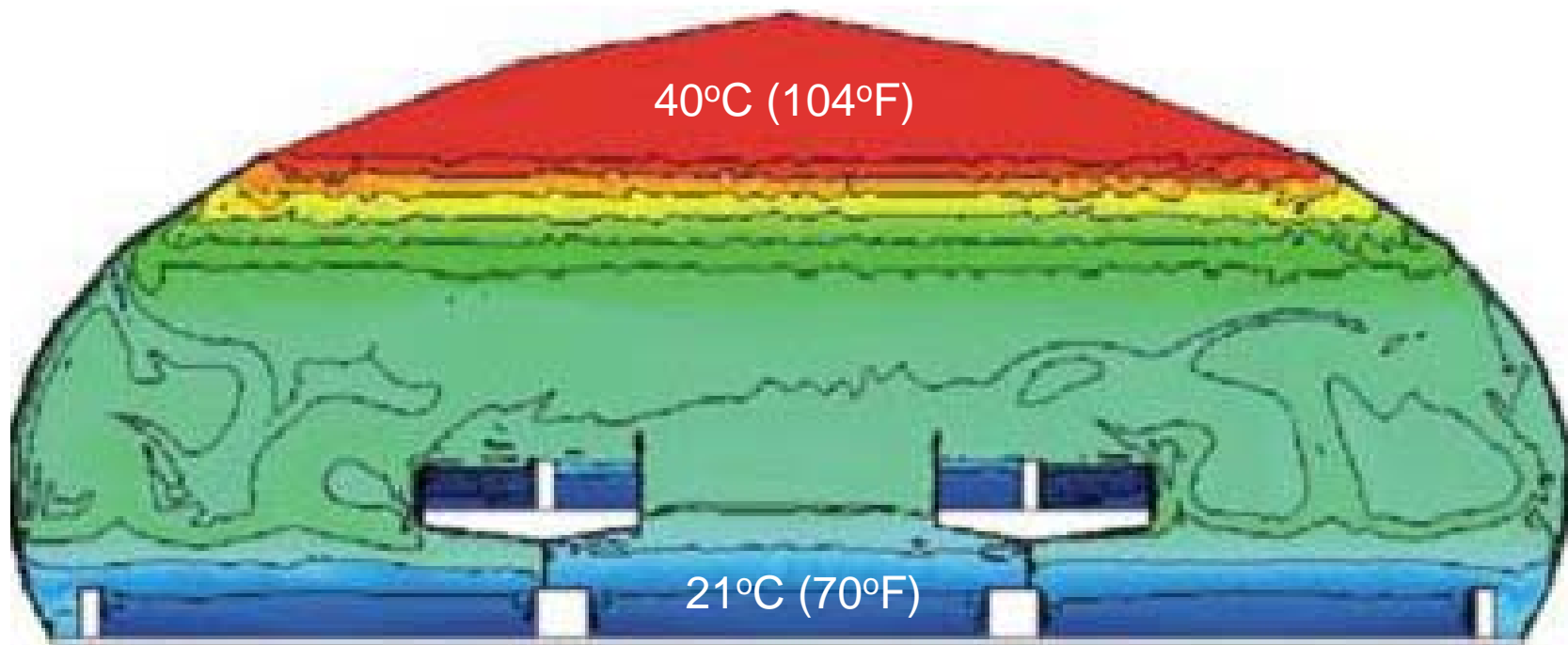
- Radiant Cooling Supply Water Temp is 13°C (55°F)
- Return Water Temperature of 19°C (66°F)
- Cooling capacity of 80 W/m<sup>2</sup> (25.5 btu/ft<sup>2</sup>)
- 40% of the total load Airport Load is handled by the radiant cooling

# Bangkok International Airport



# Bangkok International Airport

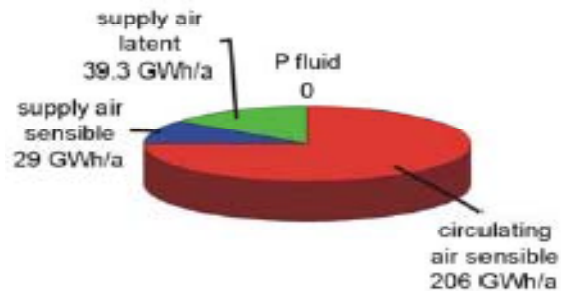
## Temperature Distribution



# Bangkok International Airport

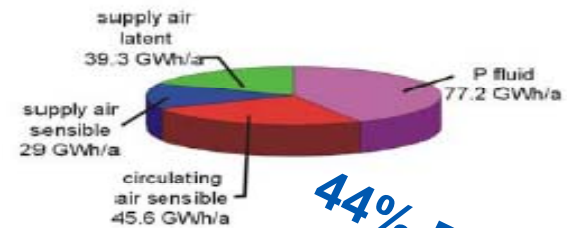
Comparison of cooling loads for the entire airport

## Original Concept



Total Load: 275 GWh/a  
739 kWh/m<sup>2</sup>a

## Optimized Concept



Total Load: 191 GWh/a  
513 kWh/m<sup>2</sup>a

**44% DECREASE**



Thank You

- Dan Sullivan, LEED AP, CEM
- Casey Swanson
- Uponor, Inc.
- Commercial Radiant Senior Manager, Product Offerings

uponor

<b>Project Name</b>	<b>Location</b>	<b>Engineer</b>	<b>System</b>	<b>Building Type</b>
Akron Art museum	Akron, OH	IBE/Simmonds	RFH-RFC-SIM	Museum
Bellevue Town Hall	Bellevue WA	Keen Eng	RFH	Municipal Bldg
L.A. Federal Court House	Los Angeles, CA	IBE/Simmonds	RFH-RFC	Municipal Bldg
San Diego Zoo Lion Exhibit	San Diego, CA	GEM/Hernandez	Pad Cooling	Cool Rocks
Westminster Cultural Center	Westminster, CA	IBE/Simmonds	RFH-RFC	Performing Arts
Hunter Museum	Chattanooga, TN	March Adams/McKenzie	RFH-RFC	Museum
Hurst Building	New York, NY	Cosentinni/Scarmadella	RFH-RFC	Low rise-residential
Museum Of Water and Life	Hemet, CA	IBE/Simmonds	RFH-RFC	Museum
Salem Conference Center	Salem, OR	Interface/Quesenberry	RFH-RFC	Conference Center
San Jose Civic Center	San Jose, CA	Arup/McKinnely	RFH-RFC	Civic Center
University of Oregon	Oregon	PAE Engineering	RFH-RFC	Classrooms
Barron Factory	Bellingham, WA	Contractor/Owner	RFH-RFC	Office-storage
OSP Crissey Field	Oregon	PAE Engineering	RFH-RFC	Offices
USC Cinematic Arts	Los Angeles, CA	IBE/Simmonds	RFH-RFC	Common Areas
Marin County Day School	CA	Stantec	RFH-RFC	Class rooms and common area's
Hall Winery-1st & 2nd Phase	St Helena, CA	IBE/Simmonds	RFH-RFC	Production and Storage Areas
Smithsonian Institute	Washington DC	URS	RFH-RFC	Atrium
Dartmouth University	Dartmouth, NH	Flack & Kurtz NY	RFH-RFC	Class rooms and dormitories
Academy of Sciences	SF, CA	Arup	RFH-RFC	Lobby and common areas
Urban Outfitters	Philadelphia, PA	Consolidated/Harris	RFH_RFC	Retail Space

# Radiant Overview

- Hydronic system consists of installation of embedded tubes or surface-mounted panels
- Radiant heating and cooling systems use structure and surfaces of an area to transfer energy
  - In radiant heating systems, energy moves away from heated surface toward cooler area
  - In radiant cooling systems, energy moves toward cooled surface from warmer area

# This is a text slide (Verdana 32 pt)

- Enter bullet-point text here (Verdana 18 pt)
  - Footer information can be deleted if that is the presenter's preference (Verdana 16 pt)