Cool Technologies and Strategies

ENERGY STAR Monthly Partner Web Conference

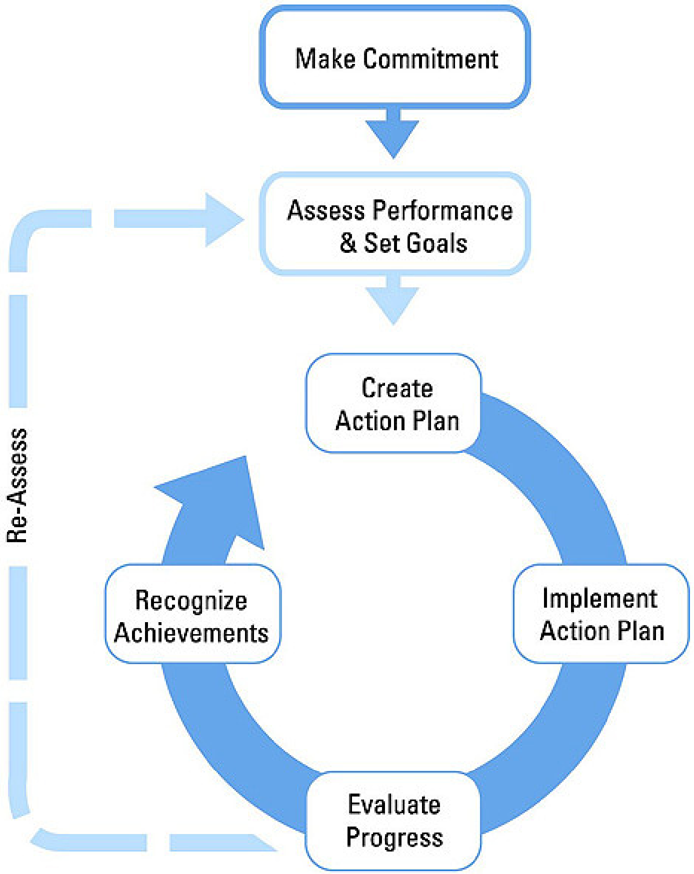
May 17, 2006

Call-in Number: 1-866-299-3188

Conference Code: 202 343 9965

About The Web Conferences

- Monthly
- Topics are structured on a strategic approach to energy management
- Opportunity to share ideas with others
- Slides are a starting point for discussion
- Open & Interactive



Web Conference Tips

- Mute phone when listening! Improves sound quality for everyone.

  Use * 6 – to mute and # 6 to un-mute

- Hold & Music – If your phone system has music-on-hold, please don't put the web conference on hold!

- Presentation slides will be sent by email to all participants following the web conference.

Today’s Web Conference

- Welcome
- Peter Criscione – E Source
- Philip Haves -Lawrence Berkeley National Laboratory
- Announcements

Energy Star Monthly Partner Meeting

Low-Energy Cooling Technologies

Peter Criscione
Research Associate, E SOURCE

May 17, 2006
Energy Star Web Conference

Today’s Talk

E SOURCE

Turbocor

Rooftop Air Conditioners

Demand-Controlled Ventilation

Freus’ Evaporatively Cooled Condenser Air Conditioner

E SOURCE

We provide unbiased, independent analysis of retail energy markets, services, and technologies.

The *E SOURCE Corporate Energy Managers' Consortium* (CEMC) helps energy-management professionals measure, manage, and procure energy in the most cost-effective and efficient manner possible.

Today’s Talk

E SOURCE

Turbocor

Rooftop Air Conditioners

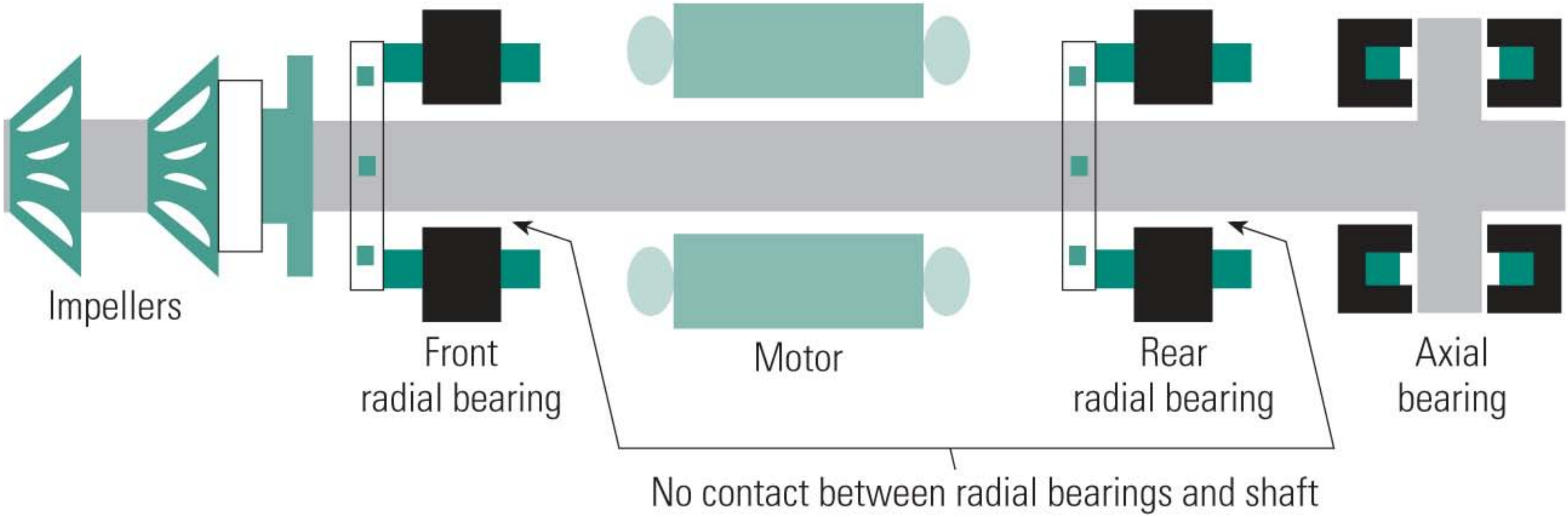
Demand-Controlled Ventilation

Freus’ Evaporatively Cooled Condenser Air Conditioner

Turbocor Chiller Compressor

Courtesy: Danfoss Turbocor

Turbocor Uses Magnetic Fields to Levitate the Compressor Shaft



Courtesy: Turbocor

Benefits of the Turbocor Centrifugal Compressor

33% improvement in IPLV
(integrated part-load value) efficiency

- Through reduced friction and variable-speed operation (new feature for small chillers)

Reduced maintenance costs

- No mechanical bearings so no oil needed

It's smaller, lighter, and generates less noise

Reduced startup current:
2 amps versus 100 to 500 amps

Turbocor Applications

Now: Chillers under 300 tons

Future: Working into larger-capacity chiller market

Available in new chillers from McQuay, Direct Energy, Axima, and others

Can be retrofit onto existing reciprocating and screw chillers.

Example Rough Paybacks

	City[a]			
	Miami, FL	Phoenix, AZ	Stockton, CA	Minneapolis, MN
Equivalent full-load cooling hours	3,931	2,141	1,148	662
Energy use of an average screw (kWh)	339,049	184,661	99,878	57,098
Energy use of McQuay WMC-150 (kWh)	221,119	120,431	65,138	37,238
Savings (kWh)	117,930	64,230	34,740	19,860
Simple payback period (years)	1.6	2.9	5.3	9.3

Notes: IPLV = Integrated part load value

a. These examples assume a screw chiller cost of $280/ton, a cost premium of 35 percent for the WMC-150, and an electricity rate of $0.08/kWh.

Source: E SOURCE; data from manufacturers

Today’s Talk

E SOURCE

Turbocor

Rooftop Air Conditioners

Demand-Controlled Ventilation

Freus’ Evaporatively Cooled Condenser Air Conditioner

High-Efficiency Packaged Rooftop Air Conditioners

Efficiencies of rooftop units have grown

- Average new unit has a 14% higher energy- efficiency ratio (EER) than the 1992 federal standard
- Best available is 52% higher than 1992 federal standard
- Global Energy Group has some of the highest-efficiency units at ~13.5 EER

Evaluation tool: http://www.pnl.gov/uac/costestimator/main.htm

Federal Standards for EER Changing in 2010

Standards effective date	Air-conditioner capacity 65 to 135 kBtu/h	135 to 240 kBtu/h	240 to 760 kBtu/h
January 1, 1994	8.9	8.5	Not applicable
January 1, 2010	11.2	11	10

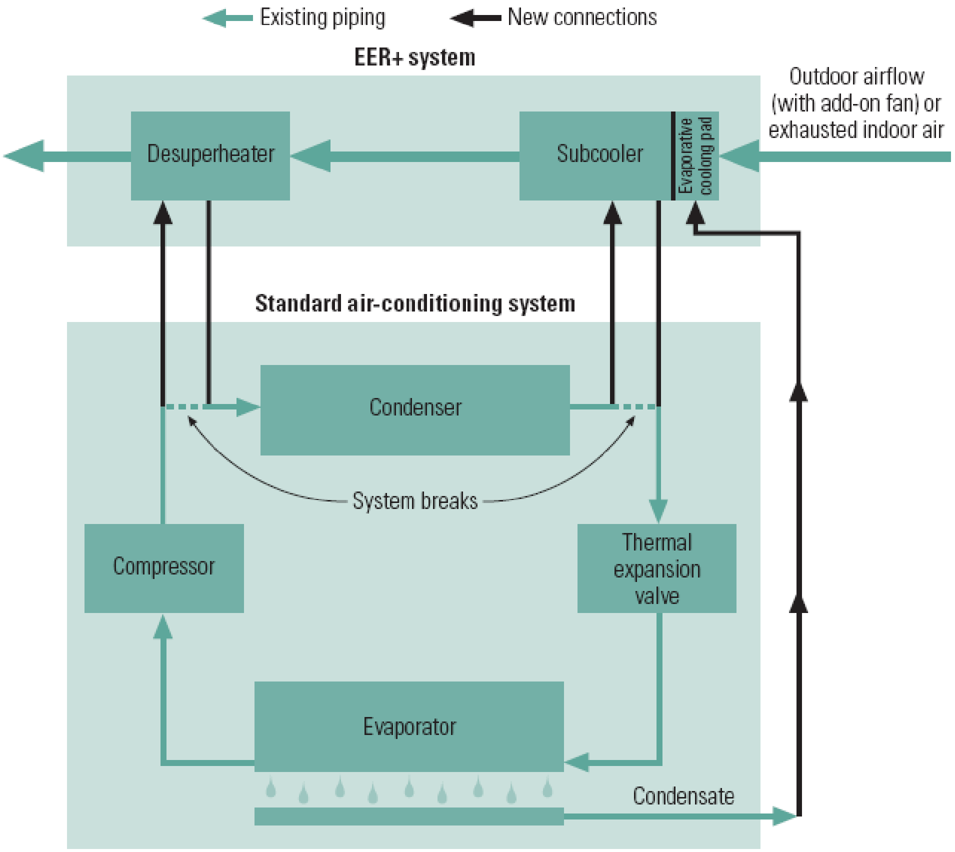
Source: E SOURCE; data from U.S. federal standards

RTU Retrofit Opportunity

"EER+" from

Global Energy Group

- Uses condensate water and exhaust air to subcool and desuperheat
- GEG claims this can improve efficiency by up to 40 percent



Source: E SOURCE; adapted from Global Energy Group

The Future of RTUs

Built-in RTU monitoring, diagnostics, and reporting on the way

- Will help maintain permanence of savings
- Thermostat can display call for service
- Already in high-end residential units

Monitoring service for small commercial units

- Invisible Service Technician LLC

Today’s Talk

E SOURCE

Turbocor

Rooftop Air Conditioners

Demand-Controlled Ventilation

Freus’ Evaporatively Cooled Condenser Air Conditioner

Demand-Controlled Ventilation (DCV)

Regulating the supply of outdoor air to match the fresh air needs of a building's occupants based on the concentration of carbon dioxide

New opportunities due to declining implementation costs

Benefits of DCV

Can save cooling and heating energy use

Can improve indoor air quality if a space was previously underventilated

Shows that buildings are in compliance with building codes

Payback Periods for DCV (years)

Location	Office	Restaurant	Retail store	School
Oakland, California[a]	6.8	2.1	1.0	4.0
El Centro, California[a]	1.9	0.6	0.3	0.9
Phoenix, Arizona	3.4	0.9	0.6	1.5
Charleston, South Carolina	1.1	0.7	0.4	0.9
Fargo, North Dakota	1.5	0.3	0.2	0.5

Note: a. Oakland is the representative city in California Climate Zone 03 and El Centro is the representative city in California Climate Zone 15.

Source: E SOURCE; adapted from Jim Braun et al.

Best Applications

Unpredictable, highly variable occupancy

Moderate to long operating hours

Moderate to high heating and/or cooling loads

- Supermarkets
- Congregations
- Sports arenas
- Auditoriums
- Libraries
- Retail stores
- Theaters
- Hotel lobbies and meeting rooms
- Restaurants and bars
- Airports
- Train and bus stations

DCV Cost-Savings Evaluation Tools

Organization	Evaluation tool	Web site
Carrier	Hourly Analysis Program	www.commercial.carrier.com/commercial/hvac/general/1,,CLI1_DIV12_ETI496,00.html
Honeywell	Savings Estimator	http://customer.honeywell.com/Business/Cultures/en-US/Products/Applications+and+Downloads/
AirTest	CO2 Ventilation Control & Energy Analysis	www.airtesttechnologies.com/support/energy-analysis/
California Energy Commission	Ventilation Strategy Assessment Tool	www.energy.ca.gov/pier/buildings/tools.html

Today’s Talk

E SOURCE

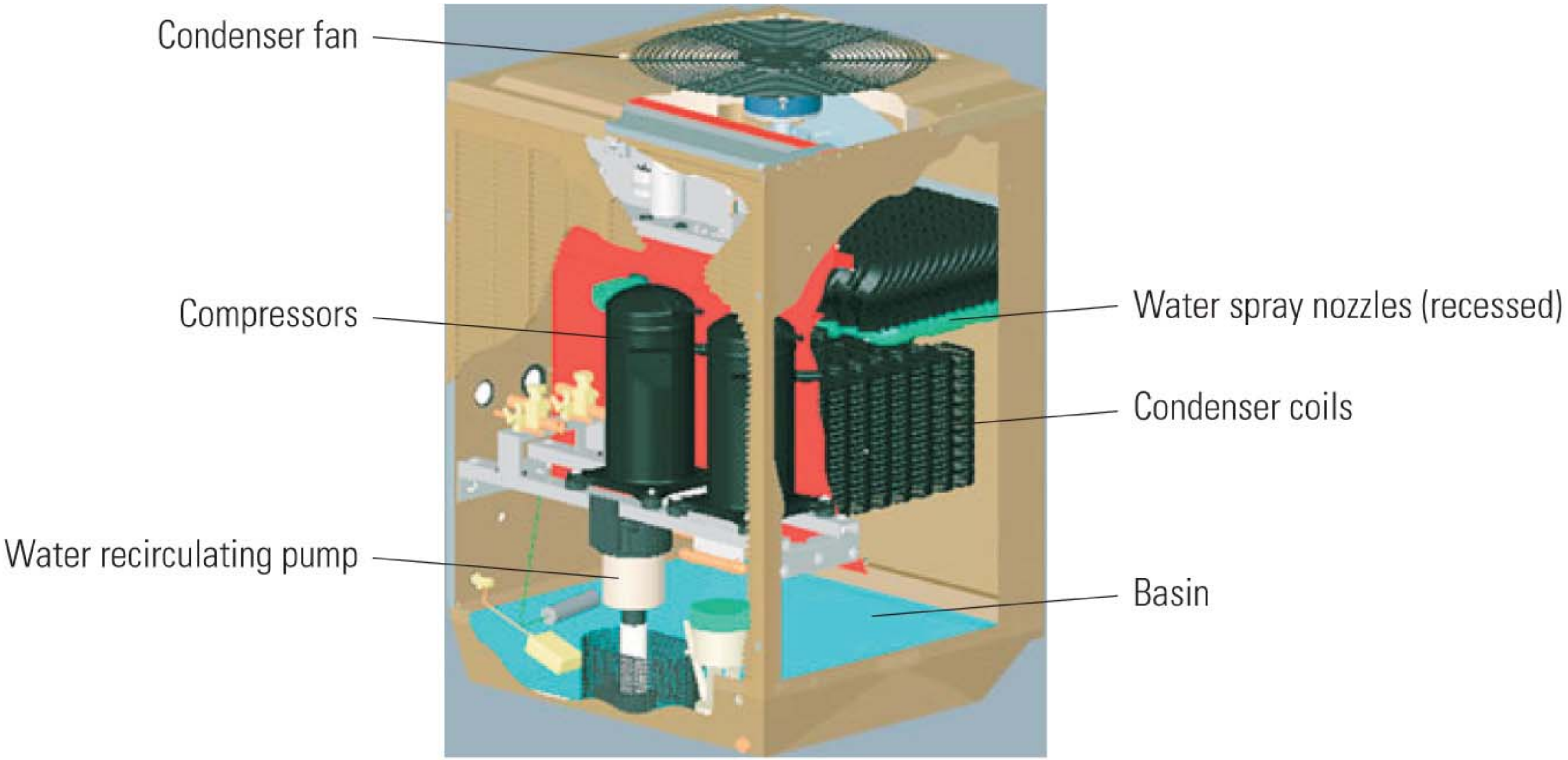
Turbocor

Rooftop Air Conditioners

Demand-Controlled Ventilation

Freus’ Evaporatively Cooled Condenser Air Conditioner

The Freus Uses an Evaporatively Cooled Condenser



Courtesy: Freus Inc. [1]

Freus

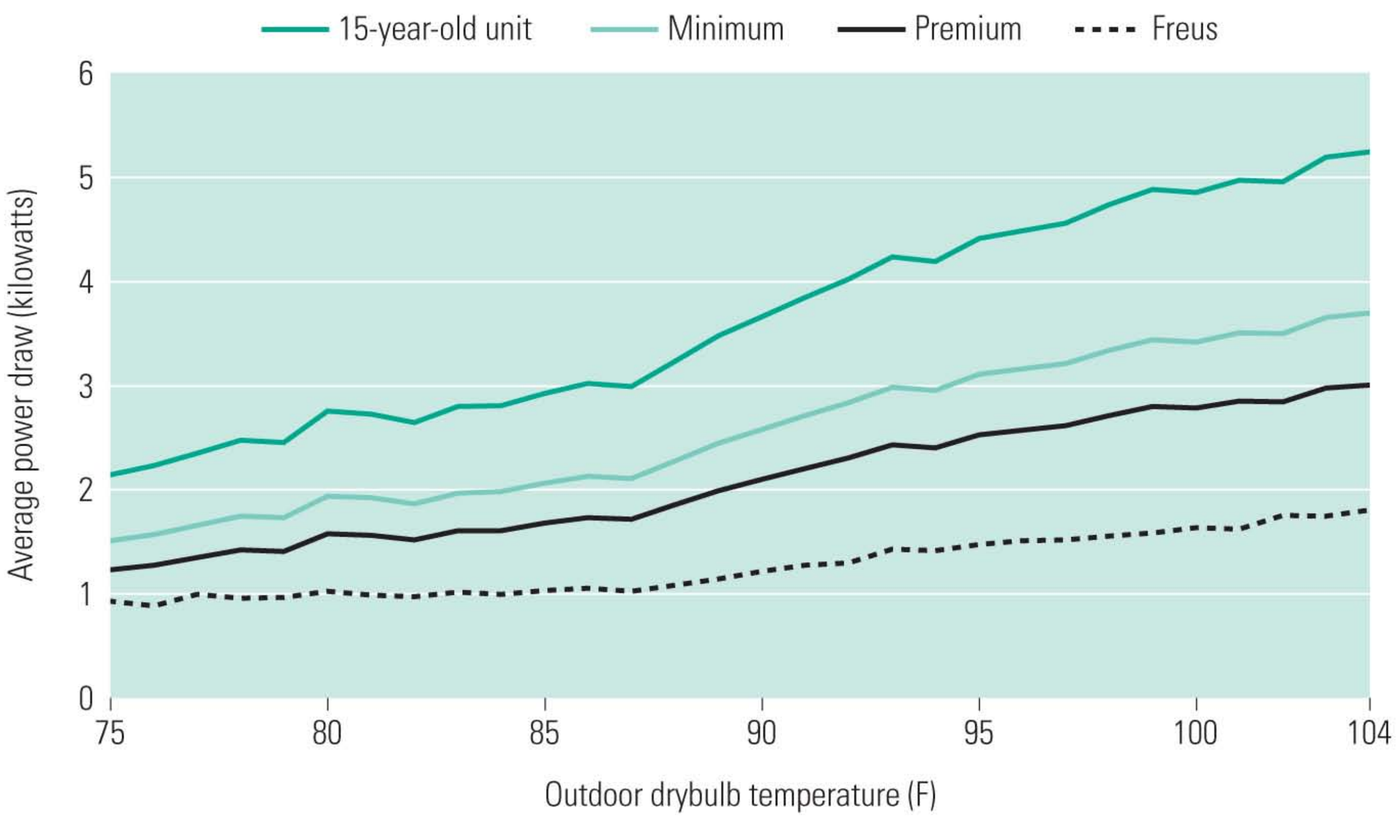
EER: 17.5

Capacity: Up to 4 compressors and 10 tons

Cost: About that of a 14 SEER unit

Region: Best in hot, dry climates, but can be cost-effective in others

Freus Maintains Efficiency Better Than Air-Cooled Units



Courtesy: Sacramento Municipal Utility District [5]

Freus Is Still "Emerging"

No established track record for trouble-free operation (available since 2000)

- Issues encountered so far not unexpected for a new product
- Freus Inc. has made progress in resolving issues
- HVAC contractors that work with the Freus unit express confidence in it

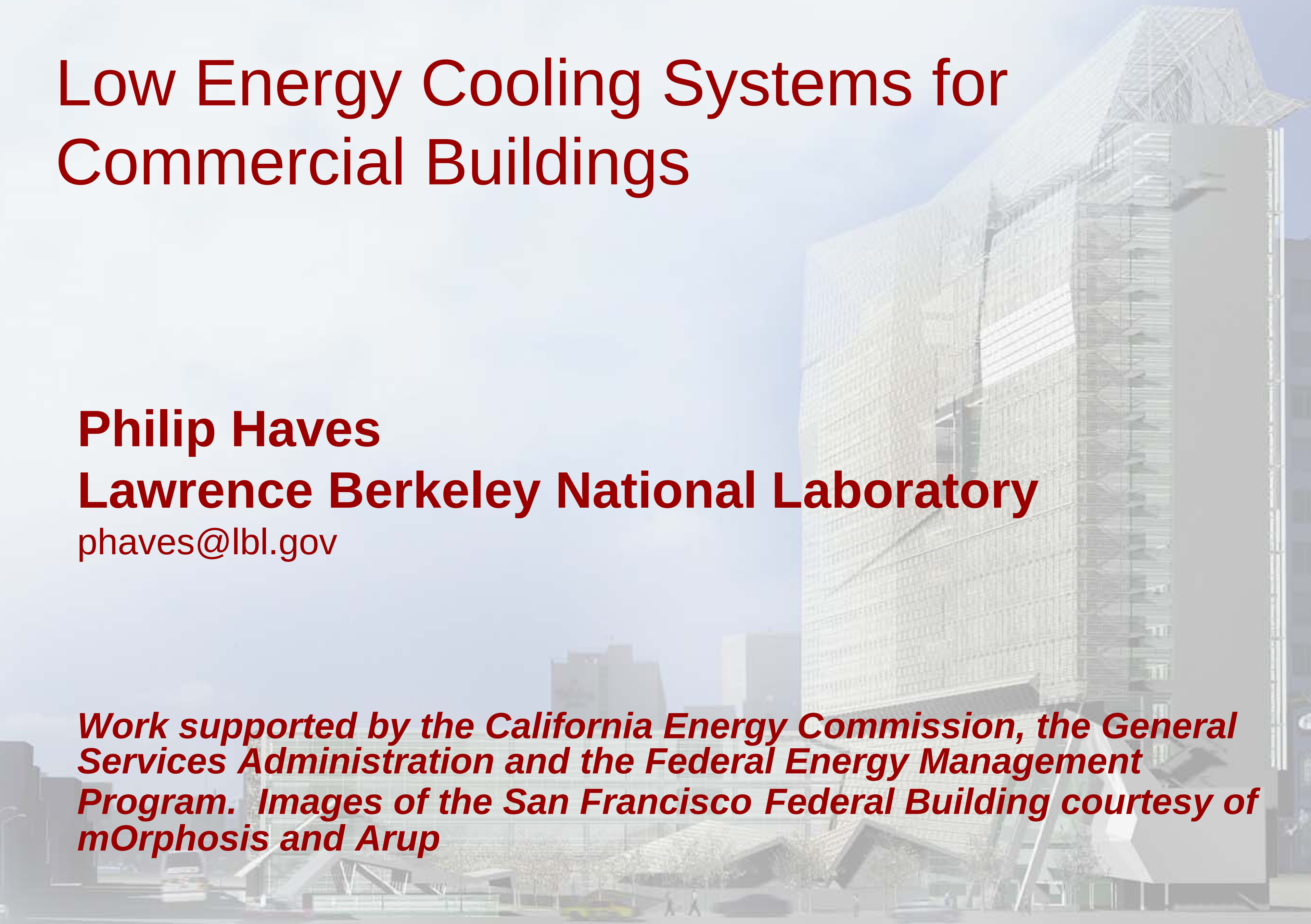
For More Information

Peter Criscione

E SOURCE Research Associate

Tel 303-444-7788 ext 109

E-mail peter_criscione@esource.com



Low Energy Cooling Systems for Commercial Buildings

Philip Haves
Lawrence Berkeley National Laboratory
phaves@lbl.gov

Work supported by the California Energy Commission, the General Services Administration and the Federal Energy Management Program. Images of the San Francisco Federal Building courtesy of mOrphosis and Arup

Presentation Overview

- Introduction
- Principles
- Energy Savings Potential
- Operational Issues
- Design and Analysis Tools
- San Francisco Federal Office Building
  - Building
  - Selection of the Natural Ventilation System
  - Control System Pre-commissioning
- Conclusions

Building Science R&D at LBNL

LBNL:

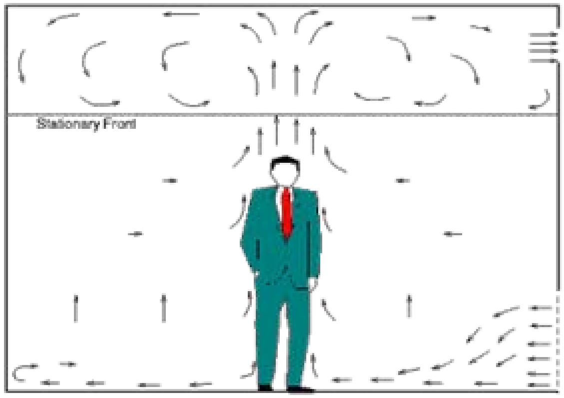
- 4000 people – pure and applied science and engineering
- 400 people in Environmental Energy Technologies Division
- 200 people working on buildings:
  - HVAC, lighting, daylighting, IAQ, controls, demand response, …
- Operated by the University of California for the Department of Energy

DOE's vision for buildings:

Zero (Net) Energy Buildings by 2025

Low Energy Cooling: Technical Approach

- **Eliminate or reduce chiller use**
  - evaporative cooling, natural ventilation …
- **Cool spaces more effectively**
  - displacement ventilation, radiant cooling …
- **Shift/smooth peak demand with thermal mass**
  - exposed slabs, raised floors …
- **Improve distribution systems**
  - reduce leakage and thermal losses
  - hydronic distribution systems



Low Energy Cooling: Applicability

Synergistic System Combinations

- Displacement ventilation + evaporative cooling
- Radiant cooling + water-side free cooling
- Radiant cooling + natural ventilation
- Desiccant dehumidification and evaporative cooling

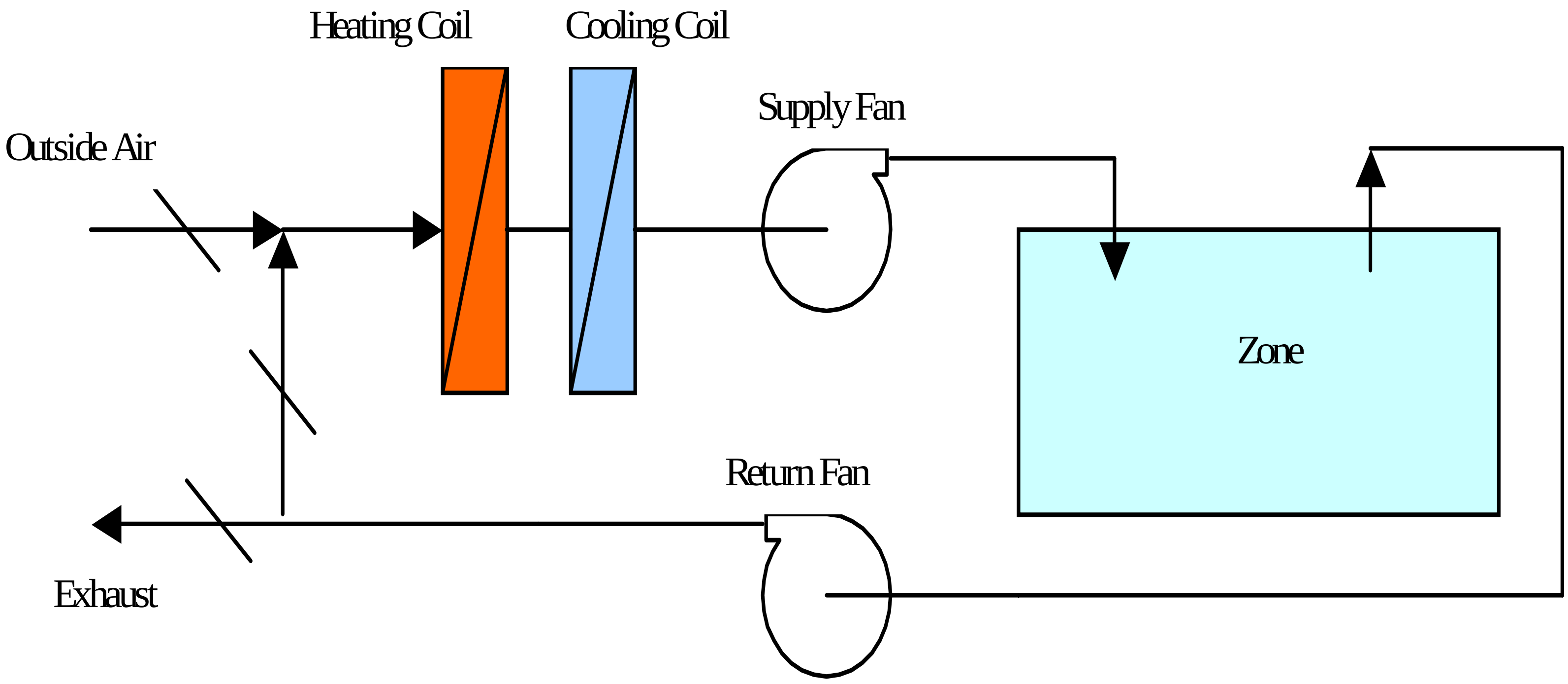
Greatest Potential

- Low humidity
- Large diurnal swing
- Flexible comfort requirements

Western states most favorable but significant energy savings possible in more humid climates

System Configurations - I

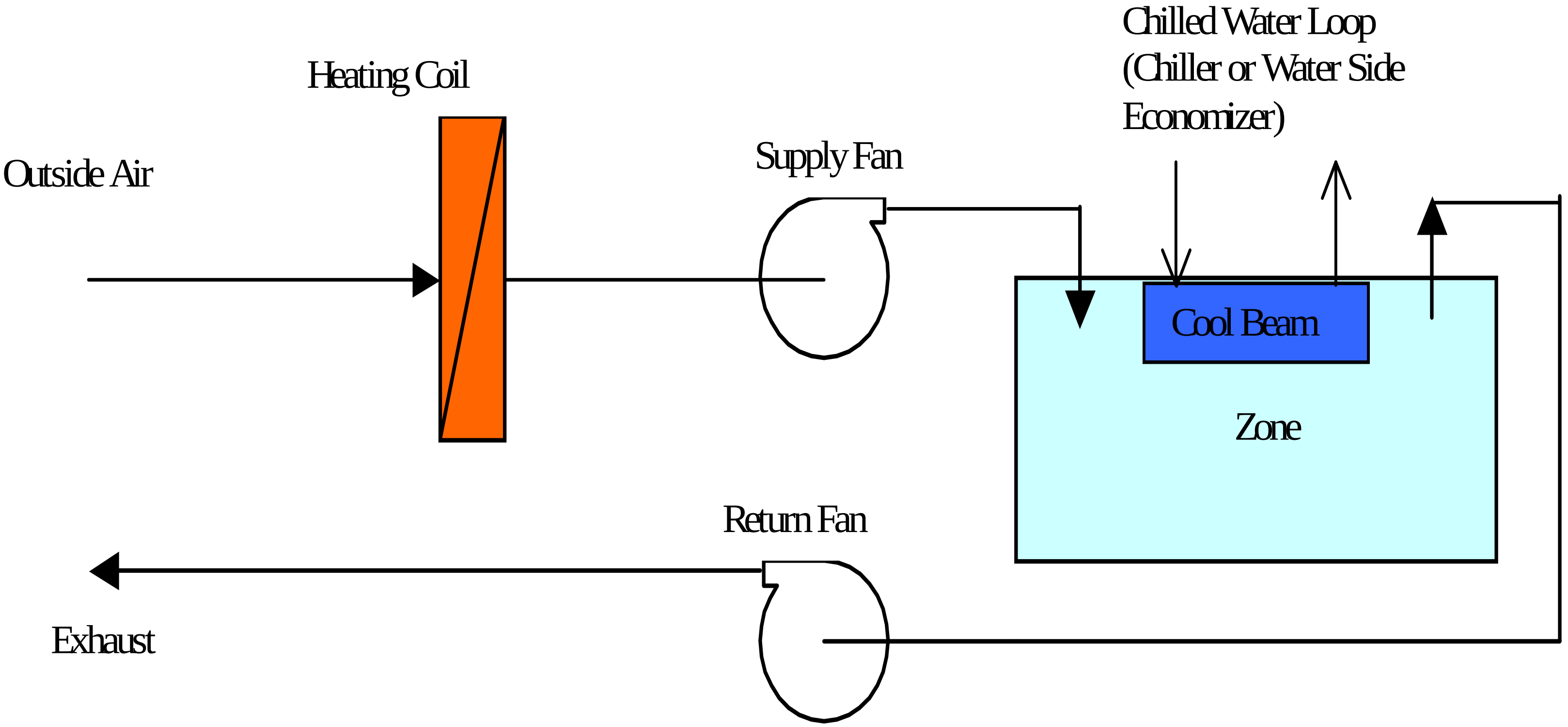
Baseline: vapor compression, VAV, mixing ventilation



Humid climates: add reheat for dew-point control

System Configurations - II

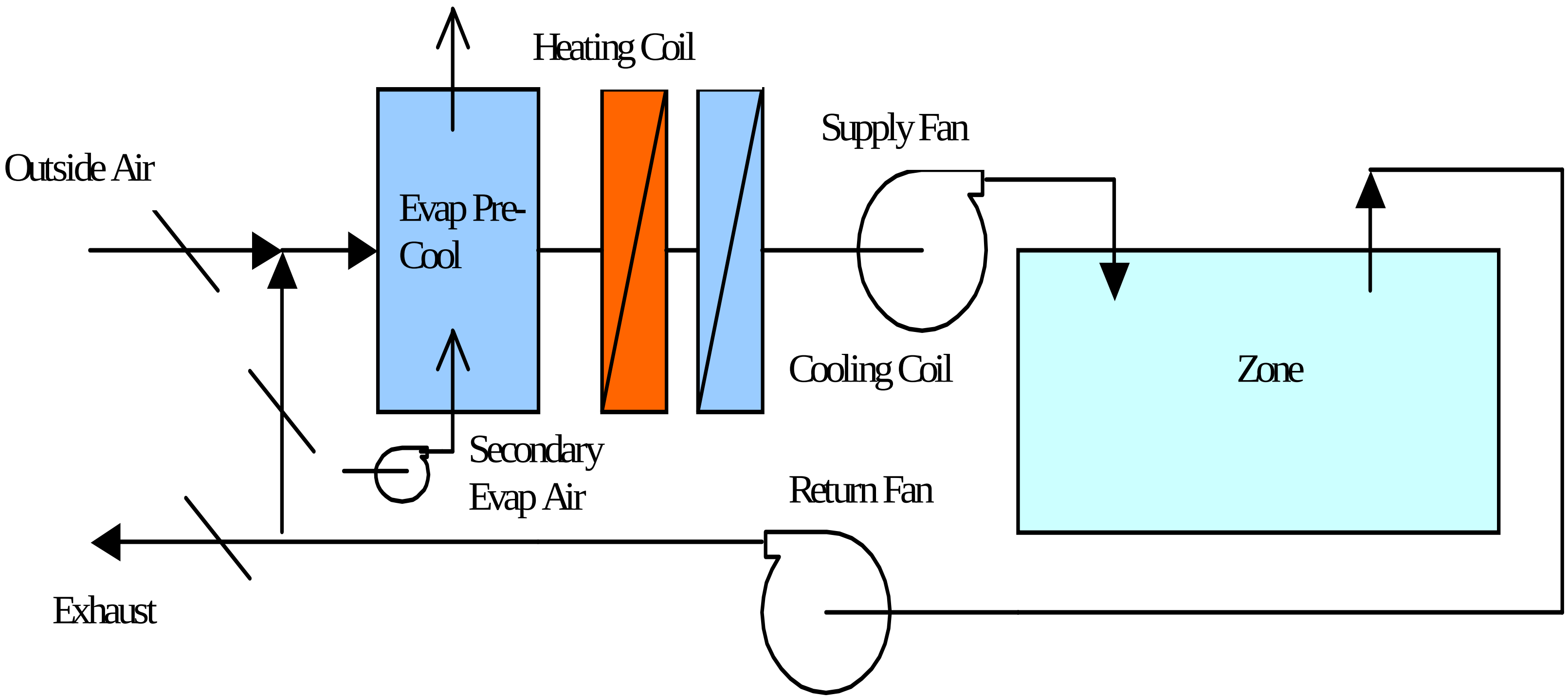
Chilled beams or ceiling panels



Ventilation air only – reduced fan energy
Humid climates: add dehumidification – desiccant or cooling coil

System Configurations - III

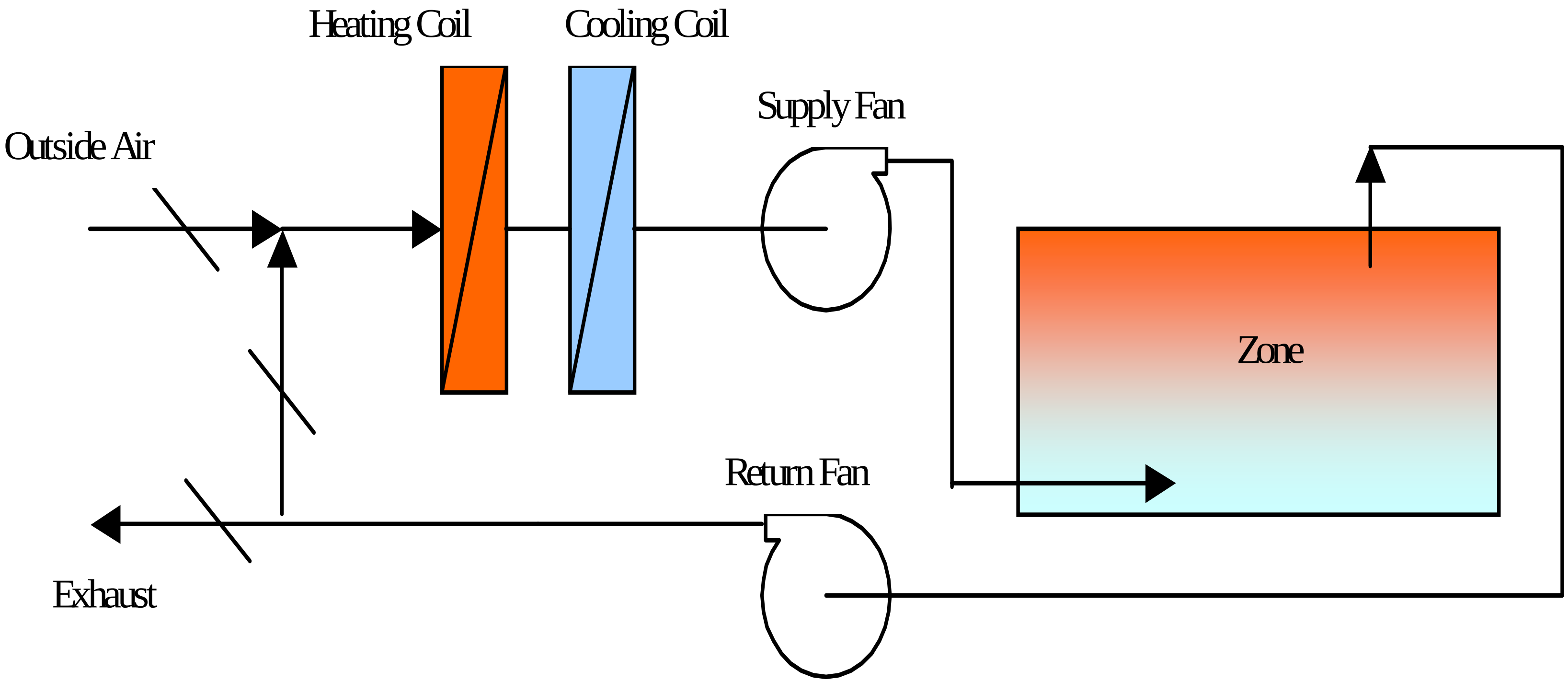
Evaporative pre-cooling (indirect/direct)



Evaporative cooling section reduces load on cooling coil but introduces additional pressure drop - eliminate cooling coil in some climates

System Configurations - IV

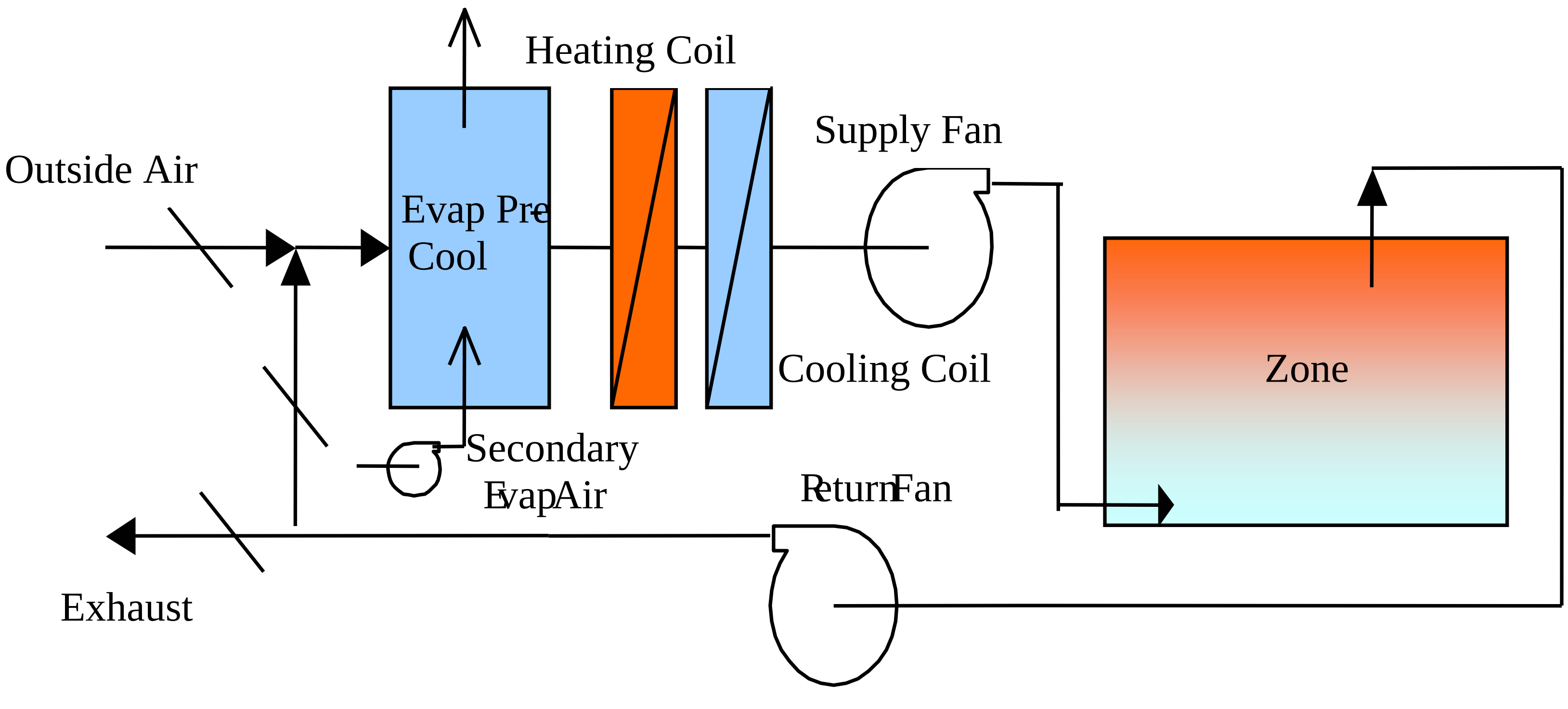
Displacement ventilation / UFAD



Displacement ventilation uses higher supply air temperature than UFAD
Humid climates: return air by-pass improves dehumidification performance

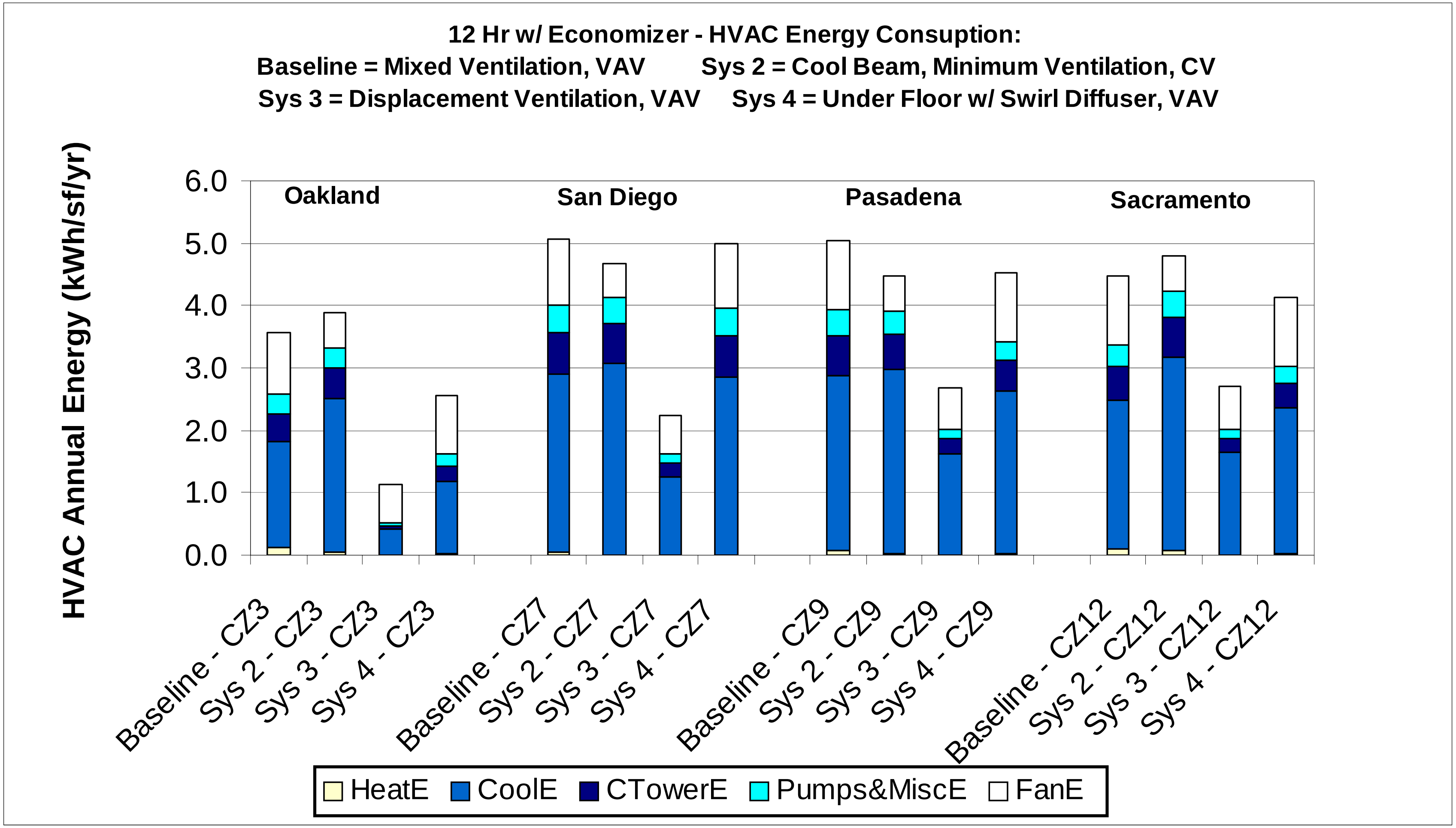
System Configurations - V

Evaporative pre-cooling & displacement ventilation



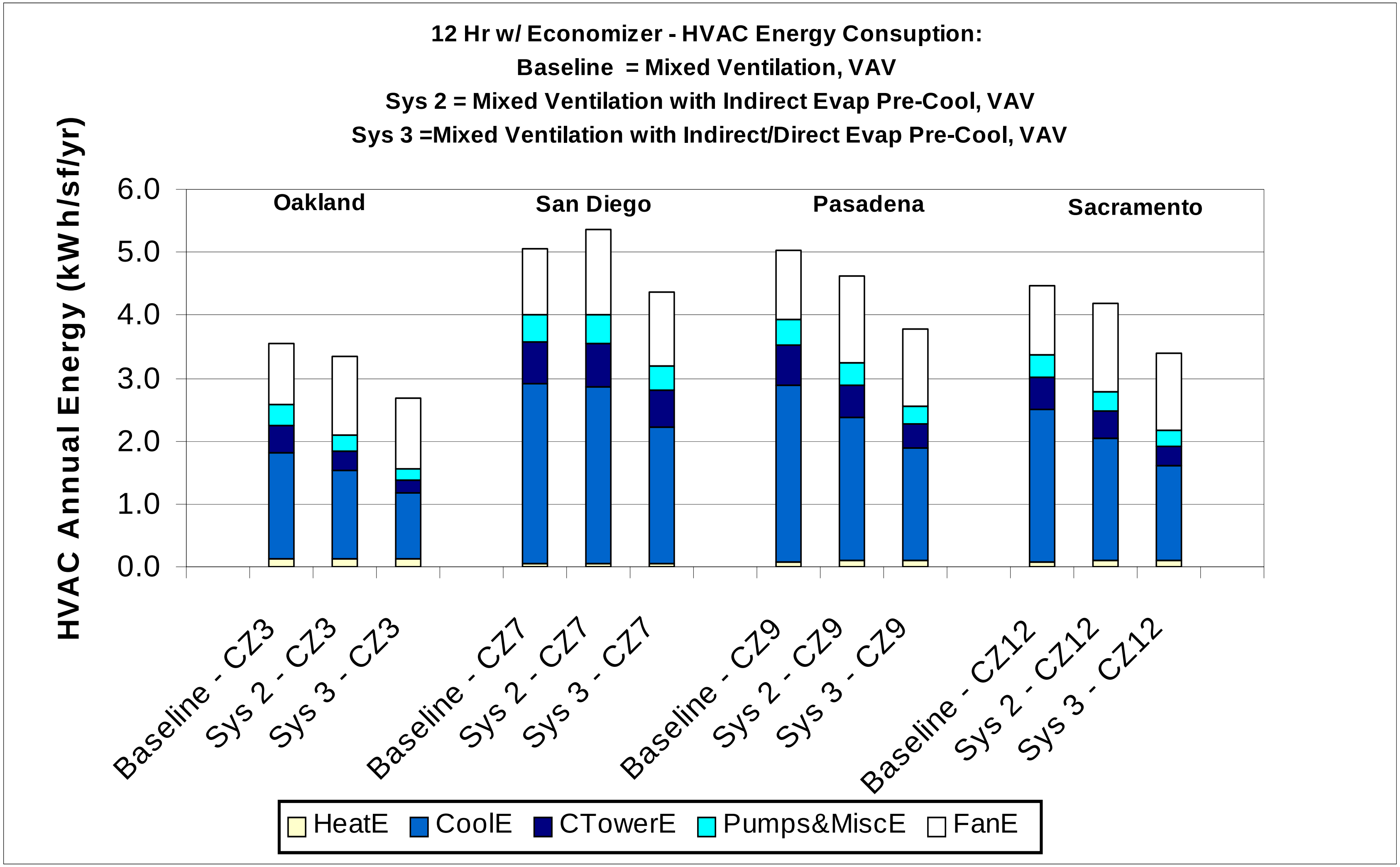
Higher supply air temperature can be met by evaporative cooling more of the time than with mixing ventilation

Simulation Assessment – I
Cool Beams, Displacement Vent & UFAD



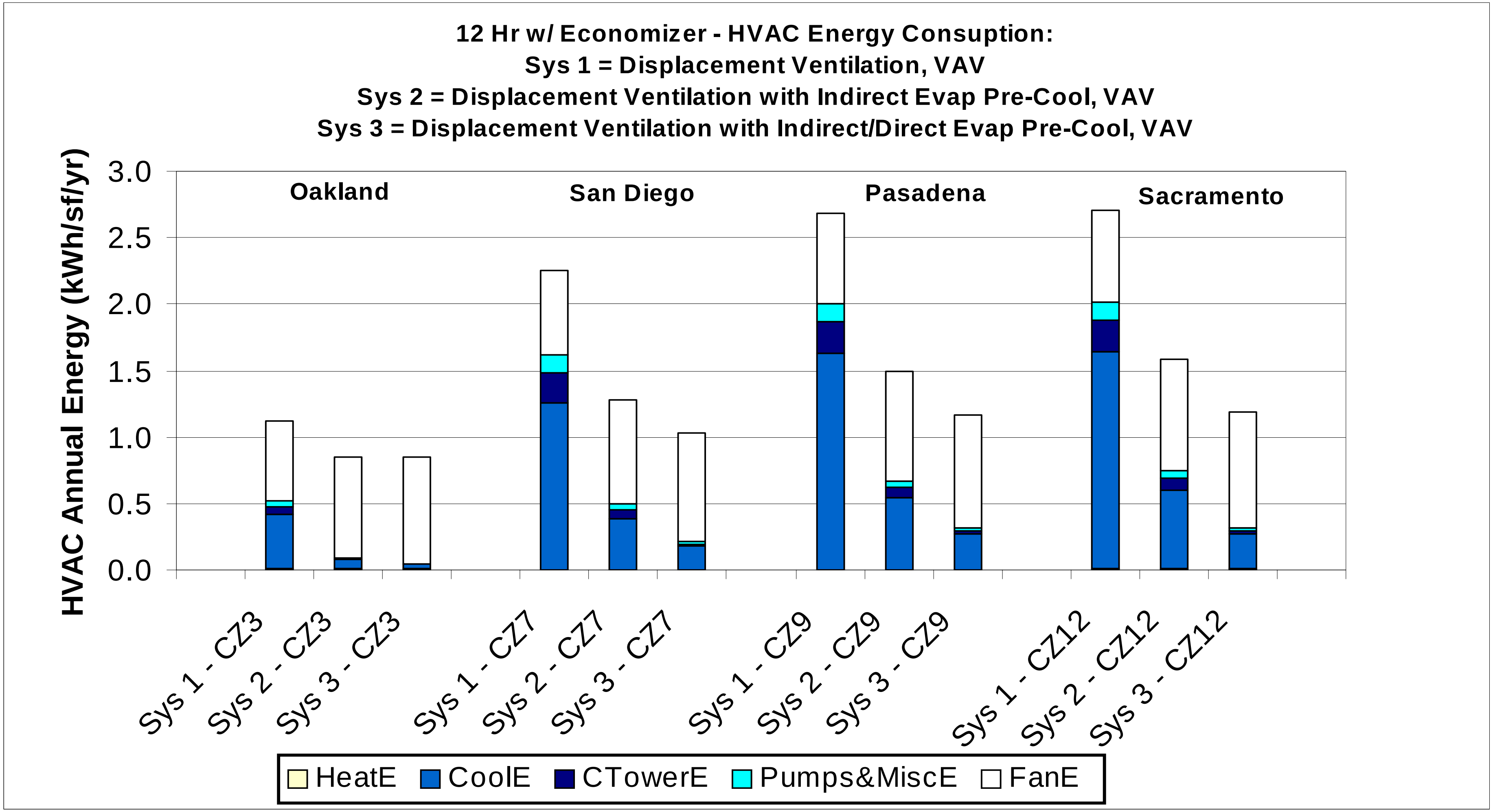
- Chilled beams: no savings without water-side free cooling
- More air-side free cooling with displacement than UFAD

Simulation Assessment – II
Evaporative Cooling and Mixing Ventilation



- Modest savings from evaporative cooling with mixing ventilation

Simulation Assessment – III
Evaporative Cooling & Displacement Ventilation



- Larger savings from evaporative cooling with displacement ventilation

Conclusions

- How a space is cooled affects energy use:
  - displacement ventilation / UFAD
  - cool beams
- Evaporative pre-cooling is beneficial, even on the coast, especially with displacement ventilation
- Cool beam systems don’t save energy in moderate climates because they can’t use free cooling but reduce peak load because pumps use less power than fans
- Peak demand reduced by increased distribution system efficiency (or thermal storage)
- Evaporative cooling and displacement ventilation reduce load factor but may mitigate load shedding

Operational Issues - Five Case Studies

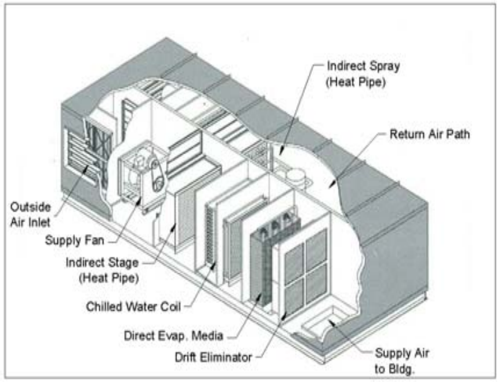
Small office - roof spray + radiant slab: *clogged filter*

Naturally ventilated office: *cooling worked well, boiler control problems*

Factory - indirect/direct evaporative cooling: *sensor problems, indirect section inoperative*

Operational Issues - Five Case Studies

University offices - indirect/direct evaporative cooling: *worked well in spite of sensor problems*



Gym – displacement ventilation: *local fans disrupt stratification*

Operational Issues - Conclusions

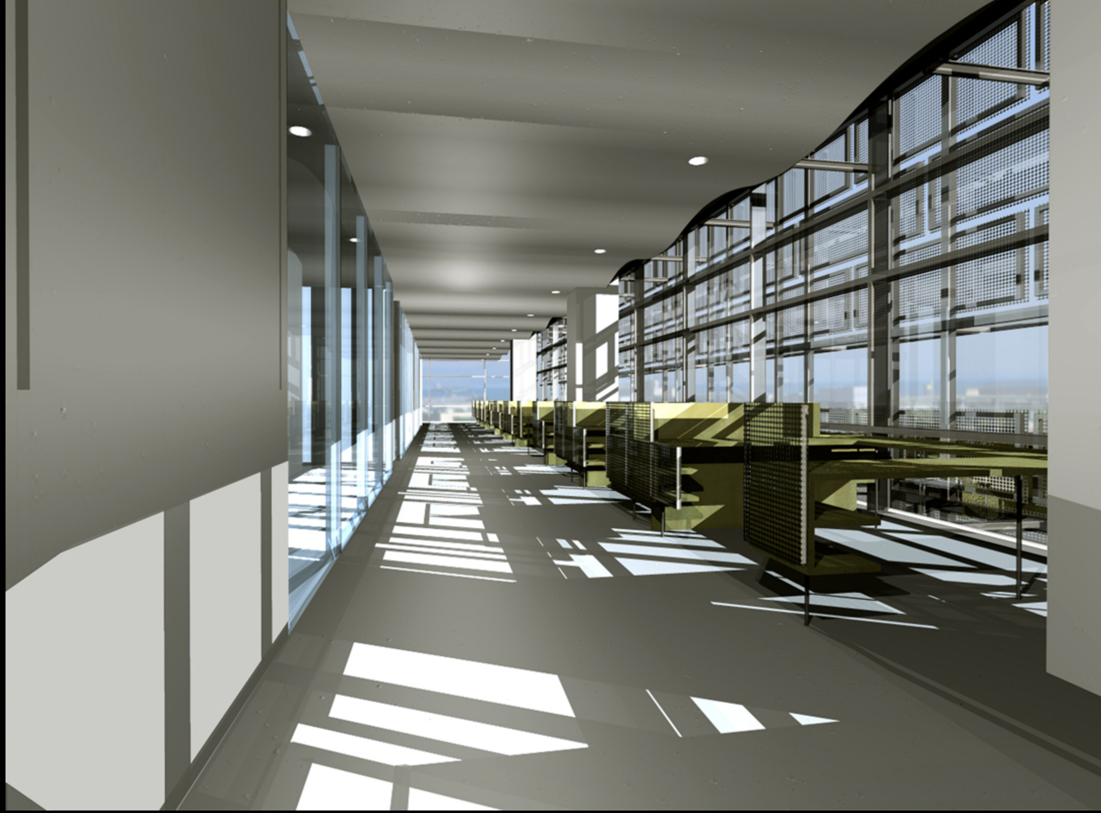
- Working systems showed substantial energy savings (NV office: 13th percentile, IDEC office: 2nd percentile)
- Problems:
  - Design/maintenance
  - Controls
  - Sensor calibration, maintenance
  - Sensor calibration
  - Design/use
- Some generic problems, some specific problems – no substitute for good design and good maintenance

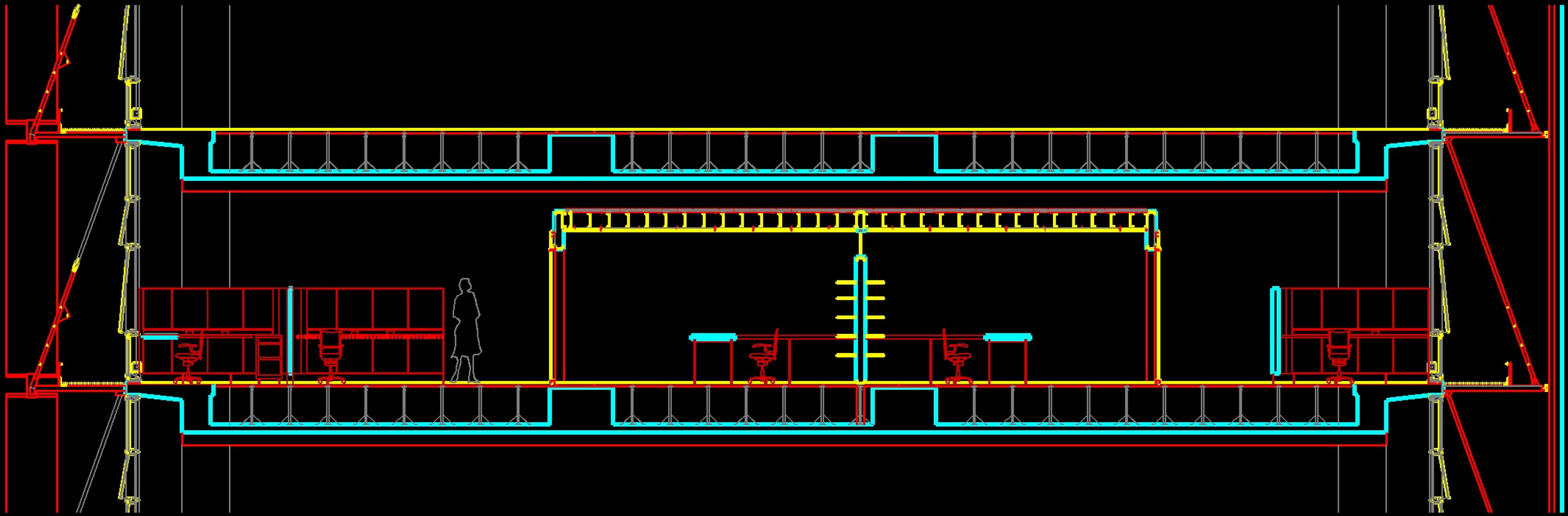
Design – Analysis Tools

- Some mechanical systems can be modeled with DOE-2 – e.g. evaporative cooling, desiccant systems
- Other systems need EnergyPlus (or foreign tools!):
  - Displacement ventilation
  - Natural ventilation
  - Radiant heating/cooling
  - UFAD (fall 2006)

New San Francisco Federal Building

A Naturally Ventilated Office Tower



Design Issues

- Is buoyancy needed to supplement wind?
- If so, are external chimneys needed to supplement internal buoyancy?

Use coupled thermal and airflow simulation (EnergyPlus) to predict performance of different design options:

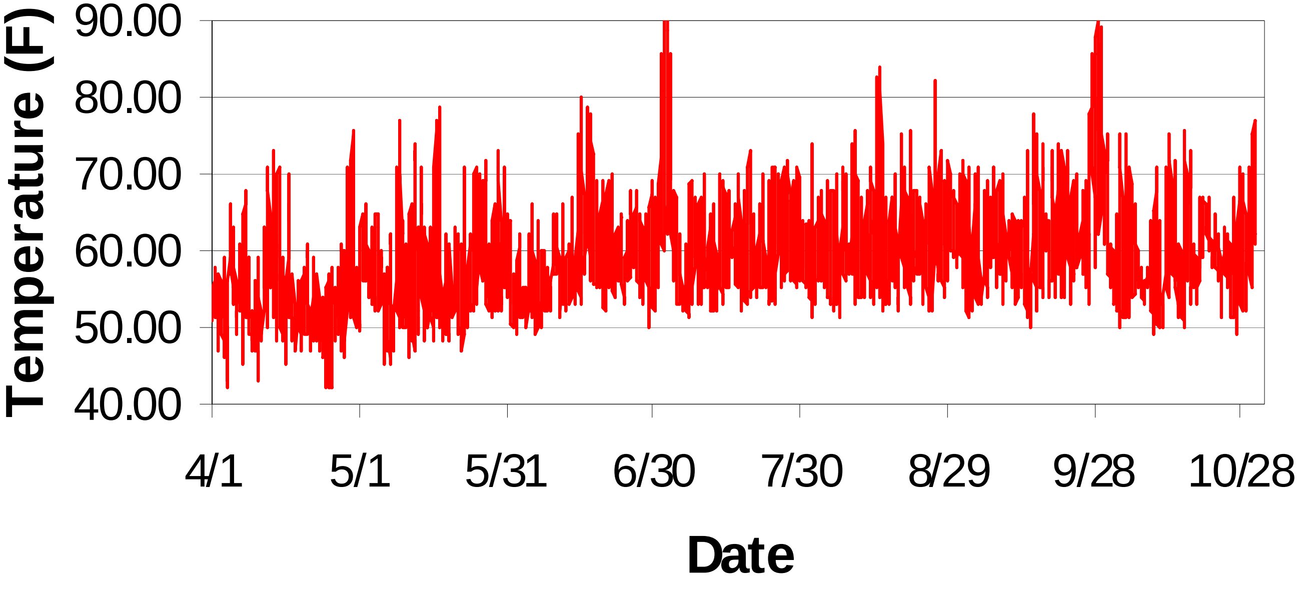
- wind-driven cross-flow ventilation
- wind + internal stack
- wind + internal + external stack

Role of simulation:

- *give designers and client confidence that natural ventilation will work*
- *select system*

San Francisco Climate

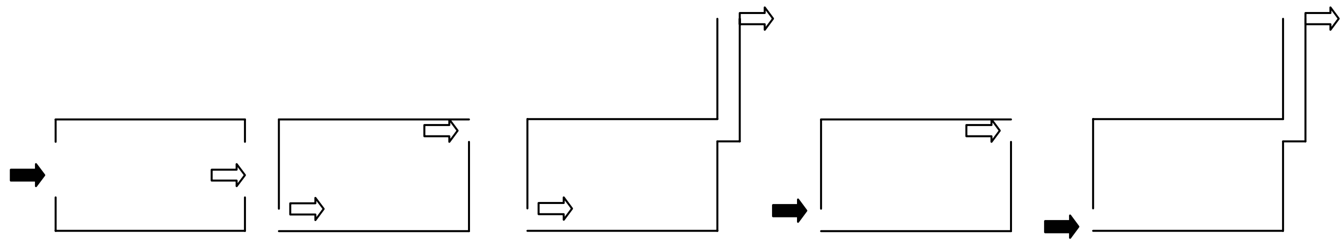
- Prevailing wind from WNW
- Occasional short hot periods



- Daytime summertime temperatures 4-6ºF lower than at airport, night-time temperatures ~equal

EnergyPlus Testing of Design Configurations

Predicted degree-hours above base temperature



Base temperature (^oF)	Wind only	Internal stack	Int & ext stack	Int stack + wind	Int & ext stack + wind
72	288	507	432	279	285
75	80	118	103	76	76
78	13	25	19	11	12

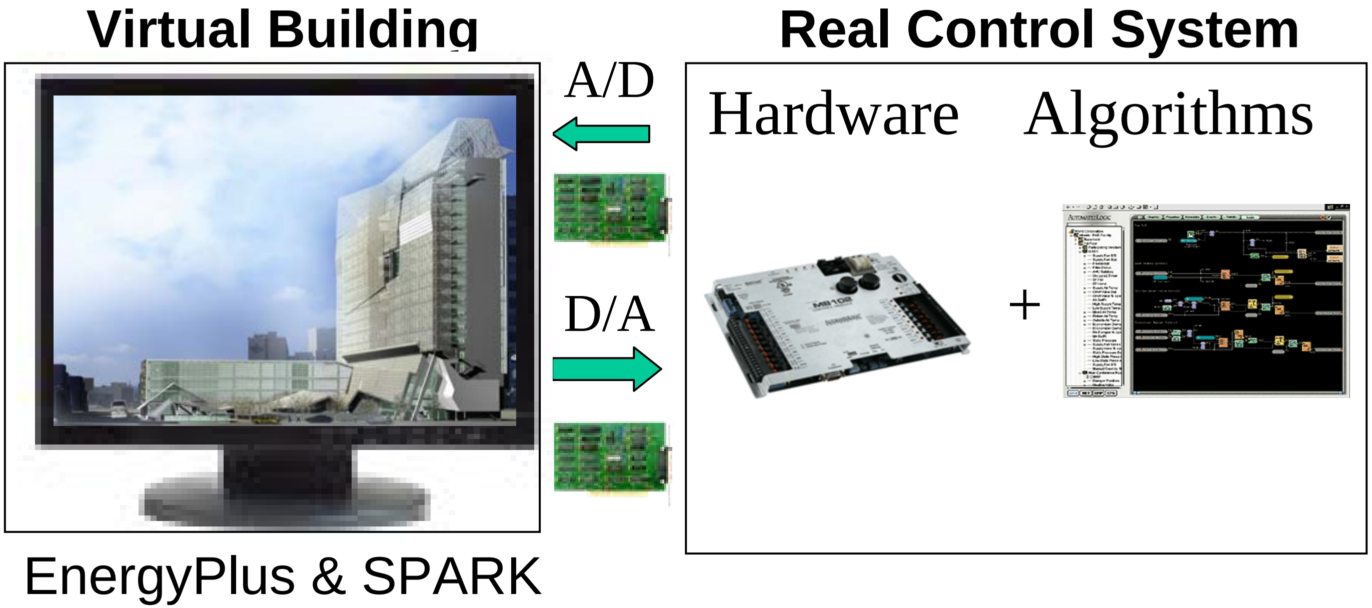
Conclusions of Feasibility Assessment and System Selection

- Natural ventilation is predicted to produce comfort almost all the time
- Wind slightly outperforms buoyancy for this site
- Buoyancy adds little to wind-driven ventilation in this case
- Except during hot spells, nocturnal cooling must be limited to avoid morning discomfort. Performance is then limited by thermal capacity and glazing system performance

Control System Testing Using Design Simulation

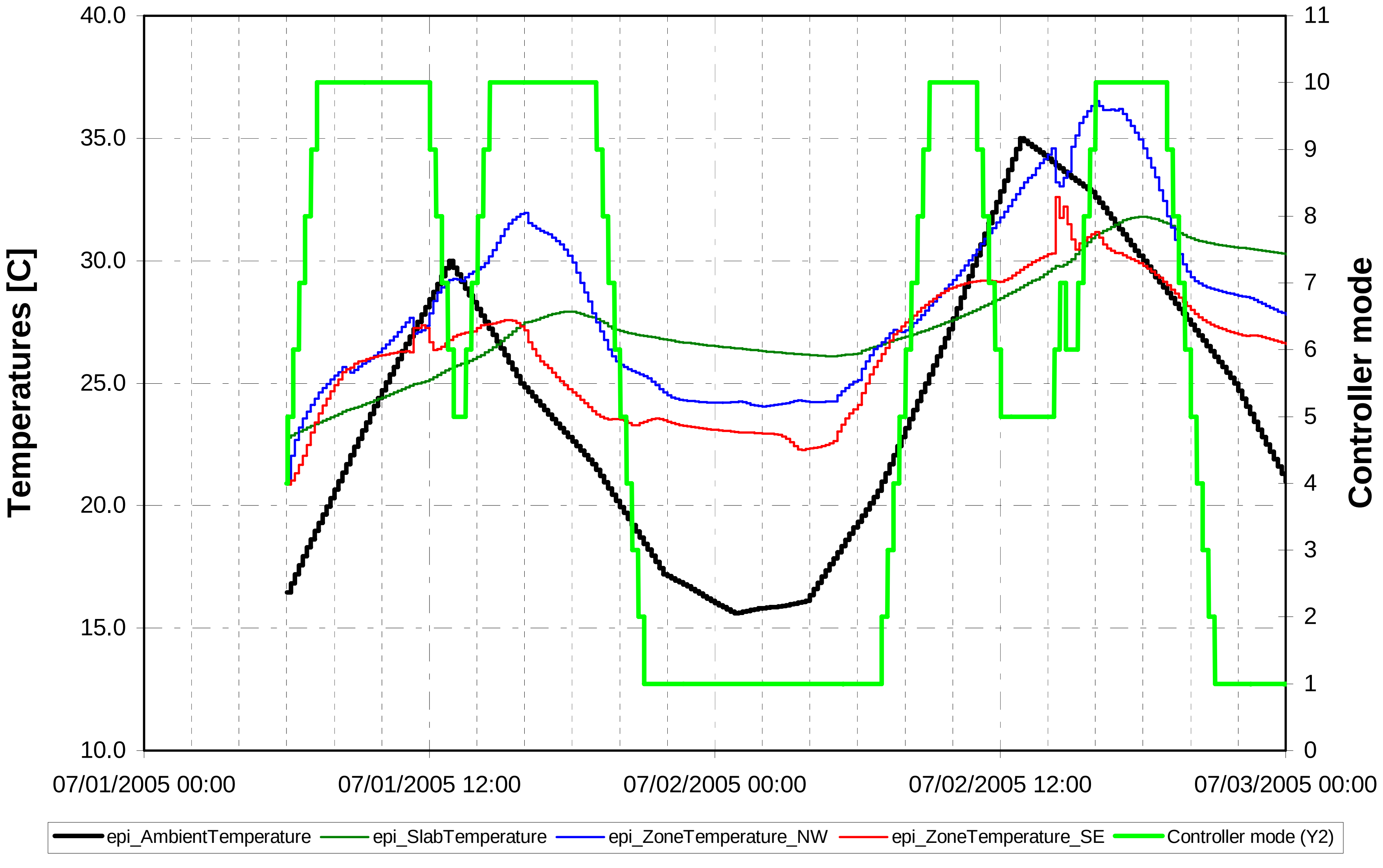
Test control system using design simulation:

- **Real-time EnergyPlus**
- **Hardware interface**
- **Control hardware from the building**
- **Control program produced by controls contractor from sequence of operations**



Does the control program produce the expected performance?

Pre-commissioning Result



Conclusions - SFFB

- Simulation made the adoption of natural ventilation possible by convincing the designers and the client that a naturally-ventilated building would work. Savings include $1.5M for the simpler façade
- Pre-commissioning of the controls before installation allowed programming problems to be identified and fixed well before occupancy
- Simulation can provide a quantitative link between design and operations

Conclusions

- Alternative cooling methods can:
  - replace conventional systems in dryer or milder climates
  - supplement conventional systems in more humid climates
- Systems approach required:
  - complementary space cooling and heat dissipation methods
  - separate latent and sensible cooling, esp. in humid climates
  - air distribution systems are inherently inefficient and often leak
  - hydronic systems save fan energy and are self-diagnosing wrt leaks
- Alternative cooling methods are the only way to achieve substantial reductions in HVAC energy consumption

Questions & Discussion

Announcements

Summer Energy Savings ideas and guidance – on the web next week at:

– www.energystar.gov/buildings

– www.energystar.gov/industry

Change A Light Campaign – Informational Web Meeting:

– May 25, 2006 at 3:00 PM Eastern

Upcoming Web Conferences

June 21 – Day lighting

July 26* – Using Energy Information Services Strategically

August 16 – State-of-the-art Sub Metering

September 20 – Remote Monitoring and Control System

Download past web conference presentations at:
www.energystar.gov/networking

Questions or comments? Contact: tunnessen.walt@epa.gov

Thank You!