2008 Nonresidential Standards Mechanical Change Proposals

Martyn C. Dodd
EnergySoft, LLC

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HVAC Measure Templates

- Fault Detection & Diagnostics (FDD)
  - Rooftop Air Conditioners
  - Air Handling Units & VAV Boxes
- Displacement Ventilation (DV) Systems
- Underfloor Air Distribution (UFAD) Systems
- Natural Ventilation for Cooling
- Building Performance Monitoring

FDD for Rooftop Air Conditioners

FDD for Rooftop Air Conditioners

- 54% of systems in California are Rooftops.
- Poor Maintenance Practices.
- NBI Study – 503 Rooftops
  - 64% of economizers faulty.
  - 42% of systems had improper airflow.
  - 20% had failed sensors.
  - 72% had improper refrigerant charge.

FDD for Rooftop Air Conditioners

Key Concepts

- Sensors monitor conditions at various points in cooling cycle.
- Uses data including
  - ambient dry bulb temperature
  - dry- and wet bulb temperatures of return, mixed, and supply air
  - evaporator temperature
  - suction superheat, condenser temperature, condenser subcooling, and compressor hot gas temperature
  - differences in condenser and evaporator air temperatures
- Calculates the difference between monitored and expected temperatures.
- Analyzes the data to determine what problems may be imminent

FDD for Rooftop Air Conditioners

- 1st Cost = $300.
- Field testing of systems
- Climate zones 3, 8, 10 & 12.
- Schools, retail buildings & restaurants.
- 71% had faults.
- Annual savings - $400 - $1,000.

FDD for Rooftop Air Conditioners

Change Proposal – Compliance Option

- Only affects Performance Method.
- Optional Credit.
- Adjust operation of Standard Rooftops.
  - Reduce cooling efficiency to 90%.
  - Reduce economizer capability to 90%.

FDD for Rooftop Air Conditioners

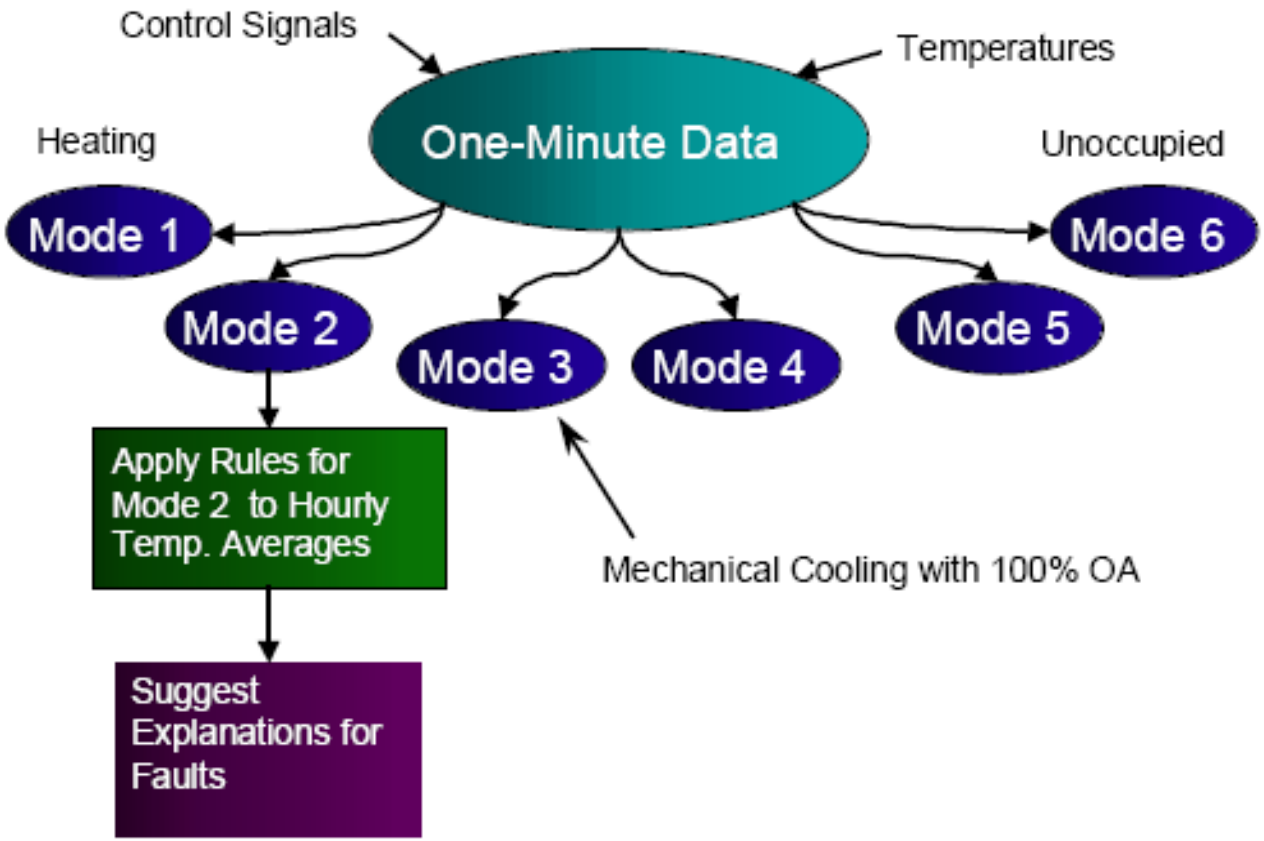
- System with FDD.
  - Cooling efficiency increased to 96%.
  - Economizer capability restored to 100%.
- Similar to the adjustments made in the performance method for TXVs.
- Incorporate verification into Acceptance Requirements.

FDD for Rooftop Air Conditioners

Eligibility Criteria

- Packaged Systems.
- Splits not covered since controls not integrated.
- Economizer (to qualify for economizer credit)
- Controls allow for self detection and diagnostic of faults.

FDD for Air Handling Units & VAV Boxes



FDD for Air Handling Units & VAV Boxes

- Similar proposal to the Rooftop FDD.
- Expert rules applied to the AHU operation.
- APAR (AHU Performance Assessment Rules).
- Uses control signals and occupancy information to identify the mode of operation of the AHU.

FDD for Air Handling Units & VAV Boxes

- Applies rules based on conservation of mass and energy along with the sensor information that is typically available for controlling the AHUs.

FDD for Air Handling Units & VAV Boxes

- VAV Box Performance Assessment Control Charts (VPACC)
- Uses a small number of control charts to assess the performance of VAV boxes.
- Field testing
  - Office building
  - Restaurant
  - Community college
  - University campuses
  - Constant-volume systems
  - Variable-air-volume systems.

FDD for Air Handling Units & VAV Boxes

Change Proposal – Compliance Option

- Only affects Performance Method.
- Optional Credit.
- Adjust operation of Standard AHUs.
  - Reduce economizer capability to 90%.
- Adjust operation of Standard VAV Boxes.
  - Increase minimum flow by 10% (example 30% box modeled as 33%).

FDD for Air Handling Units & VAV Boxes

- System with FDD.
  - Economizer capability restored to 100%.
  - VAV box minimum flow restored to normal.
- Incorporate verification into Acceptance Requirements.

FDD for Air Handling Units & VAV Boxes

Eligibility Criteria

- Built-up Systems (CHW Coil).
- Economizer (to qualify for economizer credit)
- VAV Boxes (to qualify for VAV credit)
- Controls allow for self detection and diagnostic of faults.

Displacement Ventilation Systems

Displacement Ventilation Systems

- In use in Europe since 1970's.
- Higher Supply Air Temperature (63°F to 68°F)
- Greater number of hours of economizer operation.
- Less reheat energy due to higher SAT.
- Larger volumes of air at very low velocities.
- Very low mixing of air, greater stratification.
- 30-50% Cooling energy savings.

Displacement Ventilation Systems

Change Proposal – Compliance Option

- Optional Credit assigned for use of system in Performance Method.
- Modeling language currently in ACM for UFAD systems.
- More precise language to cover DV systems.
- Enough latitude in ACM manual to permit simulation by DOE-2.1E, DOE-2.2 or EnergyPlus
  - EnergyPlus doesn't need default load splits.

Displacement Ventilation Systems

- Assigns a portion of loads to return air plenum.

Load Component	Percent To Space	Percent to Plenum
People	67%	33%
Lights	50%	50%
Equipment	50%	50%

- Verification via the Certificate of Acceptance (in particular, Economizer)
- 2008 EnergyPlus DV model used in sidebar energy calculations.

Displacement Ventilation Systems

Eligibility Criteria

- Could be restricted to CHW systems.
- Manufacturers introducing DX systems with multiple compressors.
- ACMs default the assignment of loads to plenums.
- Special Features message on PERF-1.

Underfloor Air Distribution Systems

Underfloor Air Distribution Systems

- Surge in popularity in recent years.
- Utilizes Access Floor.
- Flexibility in space configuration.
- Energy efficiency benefits.
- Occupant comfort benefits.
- Indoor Air Quality (IAQ) benefits.
- Still being studied by PIER and Center for Built Environment (CBE).

Underfloor Air Distribution Systems

- Higher Supply Air Temperature (60°F to 68°F)
- Greater number of hours of economizer operation.
- Less reheat energy due to higher SAT.
- Larger volumes of air at lower velocities.
- Less mixing of air, greater stratification.

Underfloor Air Distribution Systems

Change Proposal – Compliance Option

- Optional Credit assigned for use of system in Performance Method.
- Modeling language currently in ACM for UFAD systems.
- More precise language for UFAD.
- Enough latitude in ACM manual to permit simulation by DOE-2.1E, DOE-2.2 or EnergyPlus
  - EnergyPlus doesn't need default load splits.

Underfloor Air Distribution Systems

- Assigns a portion of loads to return air plenum.

Load Component	Percent To Space	Percent to Plenum
People	75%	25%
Lights	67%	33%
Equipment	67%	33%

- Verification via the Certificate of Acceptance (in particular, Economizer)
- 2008 EnergyPlus UFAD model used in sidebar energy calculations.

CBE Recommendations

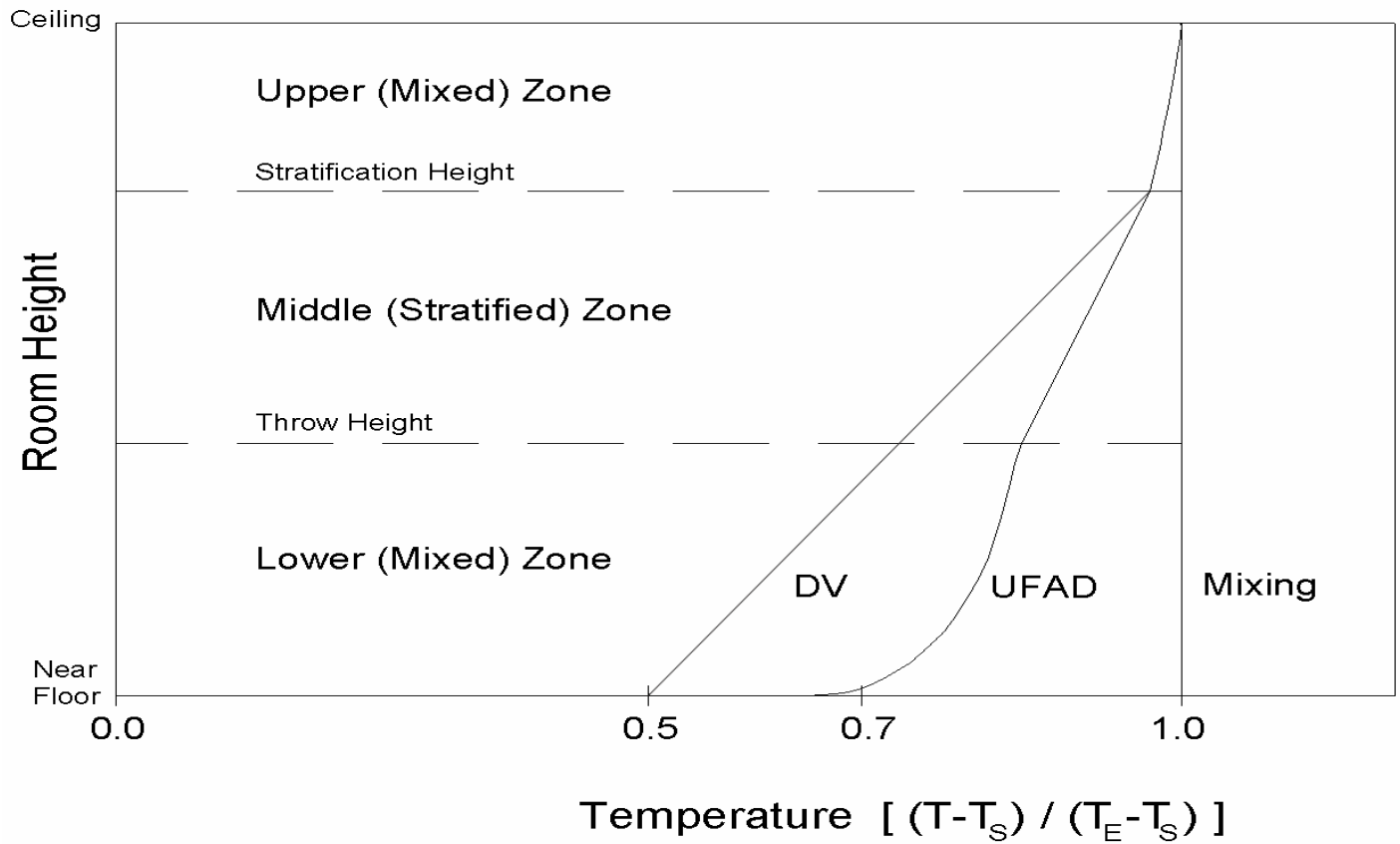
- Revise Template to include:
  - Refined/expanded load split method
  - Supply plenum temperature gain for UFAD
  - Allowance for lower fan static pressure for primary AHUs
  - Humidity control methods
  - Modified heating solutions that reflect actual operation
  - Expanded and revise discussion and additional guidance
  - Correction factors where capabilities are limited

Cooling – Load splits for UFAD and DV

- Apportioning internal gains to return plenum seems to be a reasonable approach, but methods proposed need refinement…
  - Fix OA ventilation rate to account for people loads assigned to return plenum
  - Base methods on understanding of stratification *and* heat transfer to supply plenum for UFAD
  - Differentiate splits based on system type & configuration (i.e., degree of stratification)
- Modeling methods aimed at accurate prediction of fan energy and economizer performance

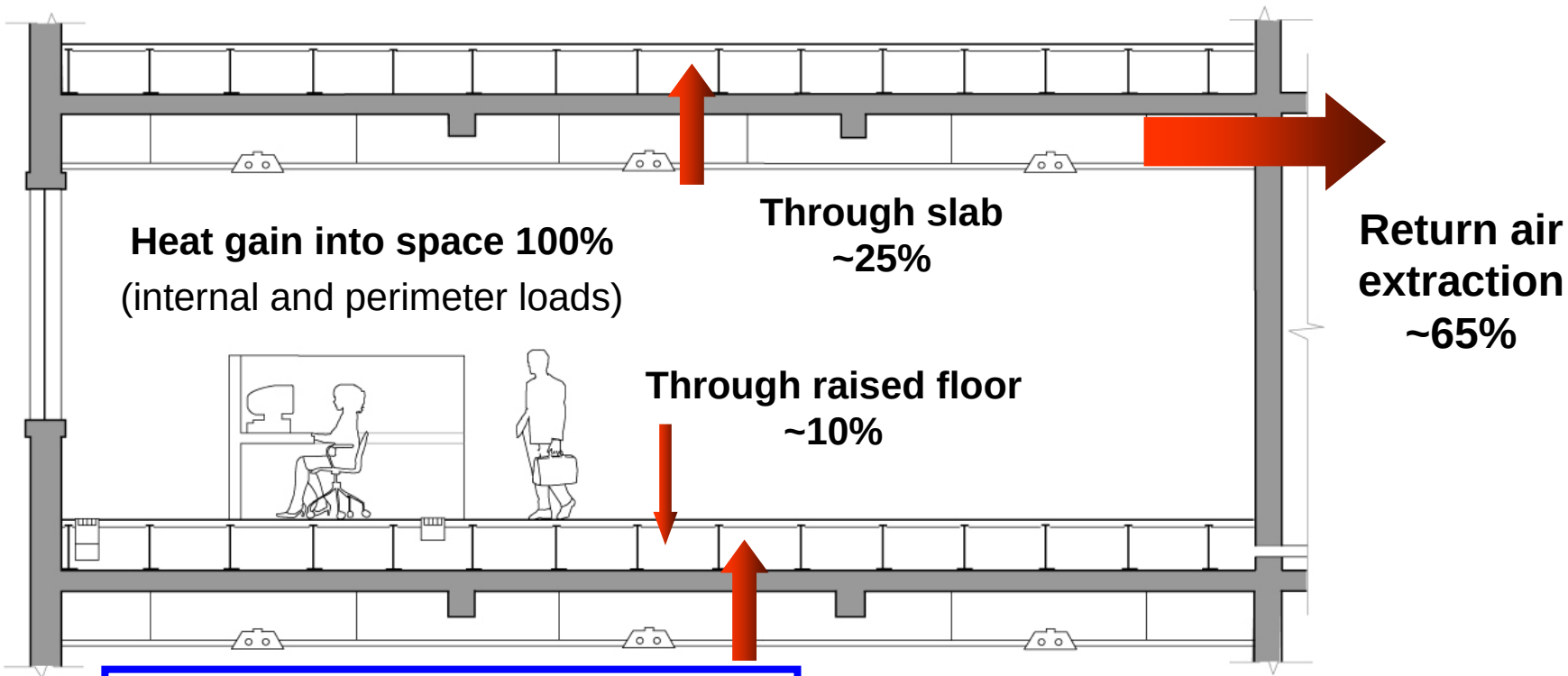
Cooling – Load splits

- Stratification continuum



Cooling – Load splits

- Supply plenum heat gain for UFAD system



Cooling – Perimeter loads

- Skin & perimeter loads
  - Develop method for skin loads that supports daylighting
  - Provide guidance for stratification limitations and variable splits
    - » Limits to stratification for comfort (ASHRAE Std. 55)
      - DV not recommended for zones with high loads (Requires high airflow or added sensible load removal - e.g., radiant cooling)
    - » Splits vary with airflow and stratification
  - Include splits for different diffuser types and closed blinds

Cooling – Load splits matrix

- Expanded load split table (example for discussion purposes)

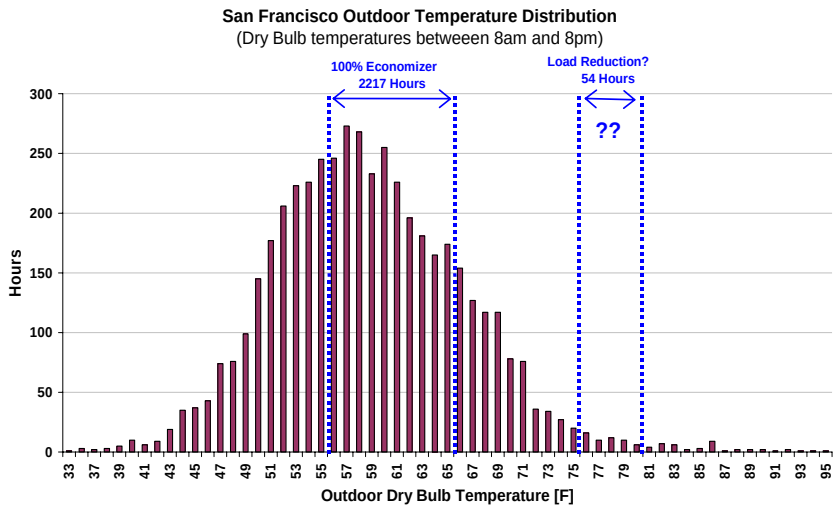
Case	% Heat Gains to Space
UFAD interior, high throw diffuser	
UFAD interior, low throw diffuser	
UFAD interior, slab on grade	
UFAD Perimeter, blinds open, high throw diffuser	
UFAD Perimeter, blinds open, low throw diffuser	
UFAD Perimeter, blinds closed	
DV interior	
DV perimeter (low loads or loads reduced by radiant cooling, etc.)	
UFAD Atrium (two-story fully glazed atrium)	
DV Atrium (two-story fully glazed atrium with chilled slab)	

Heating operation

- DV
  - DV is not a heating system, separate system required
  - Model mixed space for heating operation
- UFAD
  - Model mixed space for heating operation
  - Add equipment options for baseboards or heating only fan coils

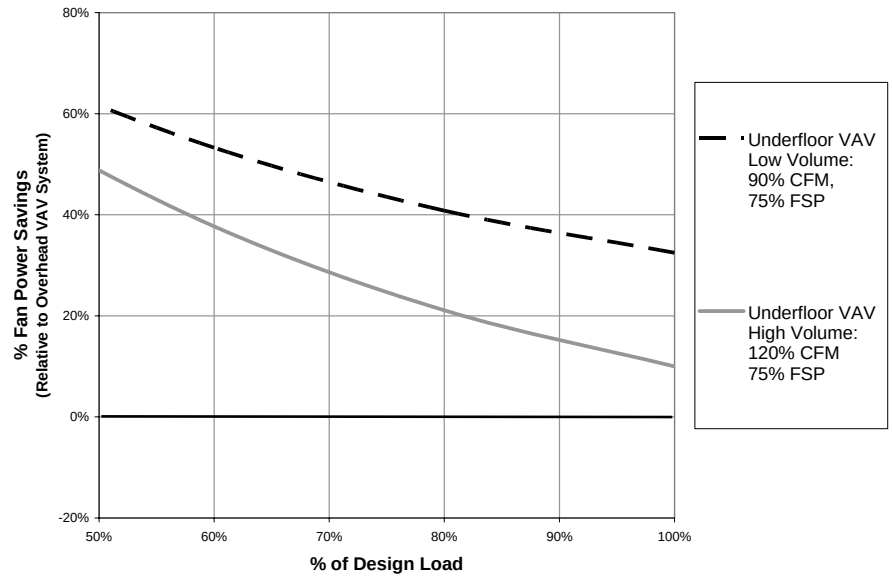
Cooling – Economizer

- Account for temperature gain in supply plenum (thermal decay) for UFAD
  - Economizer performance sensitive to supply air setpoint
  - Savings for Oakland with AHU supply air temperature (SAT) :
    - 65°F = 83%
    - 60°F = 31%
  - Decay depends on airflow and plenum configuration, provide guidance



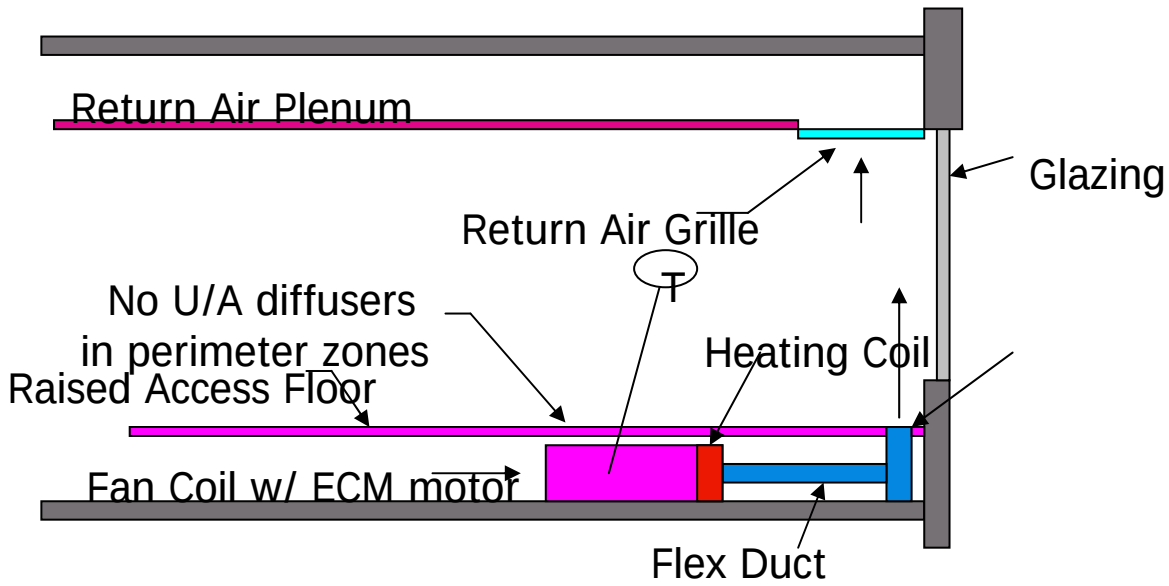
Cooling – Fan energy

- AHU energy
  - Depends on airflow and static pressure requirements
  - Provide for reduced static pressure setpoint for UFAD, 0.5-1.0 iwc less than OH
  - Allow for static pressure reset



Cooling – Perimeter Zone Equipment

- Expand zone HVAC options
  - Series FPB with ECM motor for perimeter zones
  - Cooling only boxes for modulating diffuser systems
  - VAV for DV?

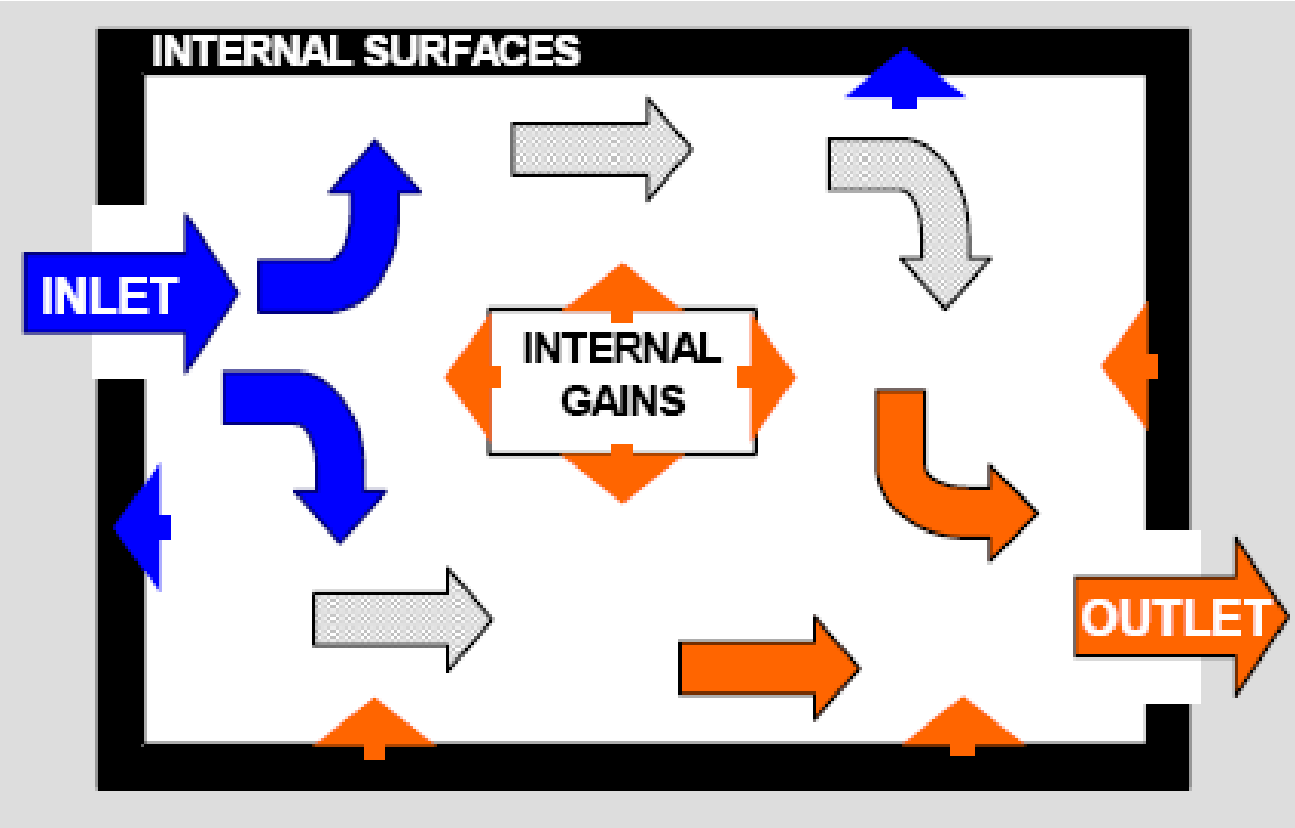


Underfloor Air Distribution Systems

Eligibility Criteria

- Same issues as DV systems.
- Could be restricted to CHW systems.
- Manufacturers introducing DX systems with multiple compressors.
- ACMs default the assignment of loads to plenums.
- Special Features message on PERF-1

Natural Ventilation for Cooling



Natural Ventilation for Cooling

- No cooling energy used to condition space.
- No fan energy used to condition space.
- Standards not configured to credit systems that use no cooling energy.
- PIER work done to enhance EnergyPlus to model NV.
- Current model, DOE-2 unable to model cooling benefits of NV.

Natural Ventilation for Cooling

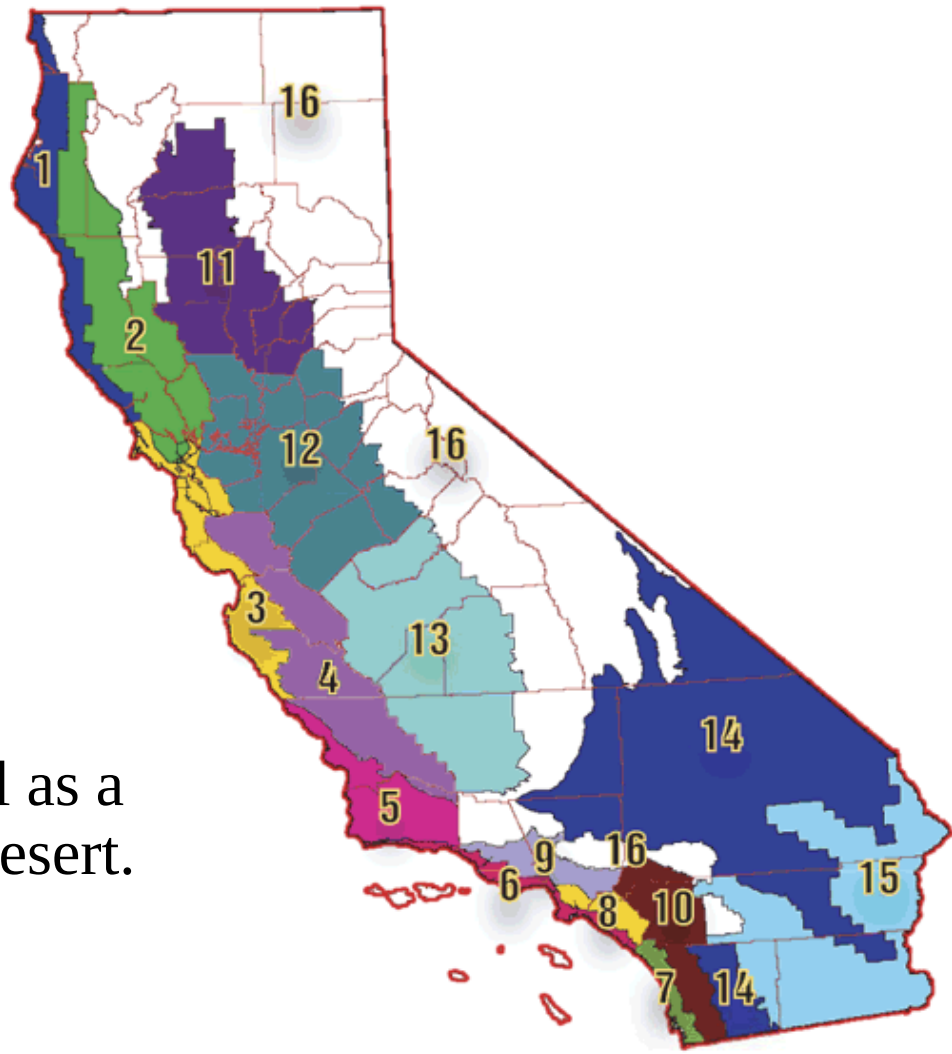
Change Proposal

- Modeling refinement in ACM Manual.
- Standard design fan power assumed to be 0.40 w/cfm.
- Proposed building with NV shall allow fan power to be reduced to zero.
- No credit proposed for Cooling energy savings.

Natural Ventilation for Cooling

Eligibility Criteria

- Climate Zones 1, 3, 5-7 and 16.
- Should 8 & 9 be included?



Natural Ventilation not practical as a means of cooling in valleys & desert.

Natural Ventilation for Cooling

- Only Office and School occupancies shall qualify.

Not realistic to use in high density occupancies.

Excluded occupancies that don't normally get A/C (warehouse, etc.)

Possibly discuss other occupancies to include?

Occupancy Type	#people per 1000 ft$^{2(1)}$
Auditoriums (Note 8)	143
Convention Centers (Note 8)	136
Financial Institutions	10
General Commercial and Industrial Work Buildings, High Bay	7
General Commercial and Industrial Work Buildings, Low Bay	7
Grocery Stores (Note 8)	29
Hotel$^{(6)}$	20
Industrial and Commercial Storage Buildings	5
Medical Buildings and Clinics	10
Office Buildings	10
Religious Facilities (Note 8)	136
Restaurants (Note 8)	45
Retail and Wholesale Stores (Note 8)	29
Schools (Note 8)	40
Theaters (Note 8)	130
All Others	10

Natural Ventilation for Cooling

- Plans and specification shall show minimum ventilation requirements have been met per Standards section 121.
- No supply air fans or exhaust fans (other than bathroom exhaust fans) shall be used for cooling or ventilation.
- The ACM shall note any spaces that use natural ventilation in the special features and modeling assumptions section of the PERF-1.

Building Performance Monitoring

- Monitoring building chilled water and plant power enables the tracking of chiller plant efficiencies, which allows the identification of more efficient operating strategies.
- Enables the detection of degradations in performance that indicate the need for maintenance in order to minimize operating costs and maximize equipment life.
- High quality weather station provides reliable measurement of outside air temperature allows the most effective use of free cooling, minimizing chiller use.
- Reliable measurement of outside wet bulb temperature enables proper cooling tower operation and maximizes chilled water plant efficiency.

Building Performance Monitoring

Change Proposal – Compliance Option

- Similar proposal to FDD.
- Optional Credit under the Performance Method.
- DX Cooling system performance degraded for systems without Performance Monitoring. (90%)
- Adjust operation of Standard AHUs.
  - Reduce economizer capability to 90%.
- Adjust operation of Standard VAV Boxes.
  - Increase minimum flow by 10% (example 30% box modeled as 33%).

Building Performance Monitoring

- System with Performance Monitoring.
  - DX efficiency increased to 93%.
  - Economizer capability restored to 100%.
  - VAV box minimum flow restored to normal.
- Incorporate verification into Acceptance Requirements.

Building Performance Monitoring

Eligibility Criteria

- Controls that monitor system and building performance.
- Class 1- Basic: Applied to a single building with a DX cooling systems.
- Class 2- Intermediate: Applied to conventional buildings with built up systems which include air handlers, boilers and a chilled water plant.

Building Performance Monitoring

Table 1 – Performance Monitoring Requirements

Requirement	Class 1 - Basic	Class 2 - Intermediate
Measurements	OA Temp; OA WB-Temp; Duct static pressure; Main power; RTU power; Zone temperatures	Add: MA Temp RA Temp Air handler # SF & RF power; Air handler # flow (cfm); Air handler # Return Damper %; Air Handler # OA Damper %; Air handler # SF VFD freq (Hz)
Visualization	Graphics for metrics results table and floor plan with zones temperatures	Expand metrics results table to include additional metrics. Add graphics for system tables, time series plots of system block trends and system performance.
Data Archiving Recommended	Access Database	Sequel Server/My SQL