HVAC Trajectories toward Zero

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at WCEC Affiliate Forum

Western Cooling Efficiency Center

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CPUC Big Bold EE Strategies

Big Bold Energy Efficiency Strategies

Commercial New Construction

- All new commercial construction in California will be zero net energy by 2030.

Residential New Construction

- All new residential construction in California will be zero net energy by 2020.

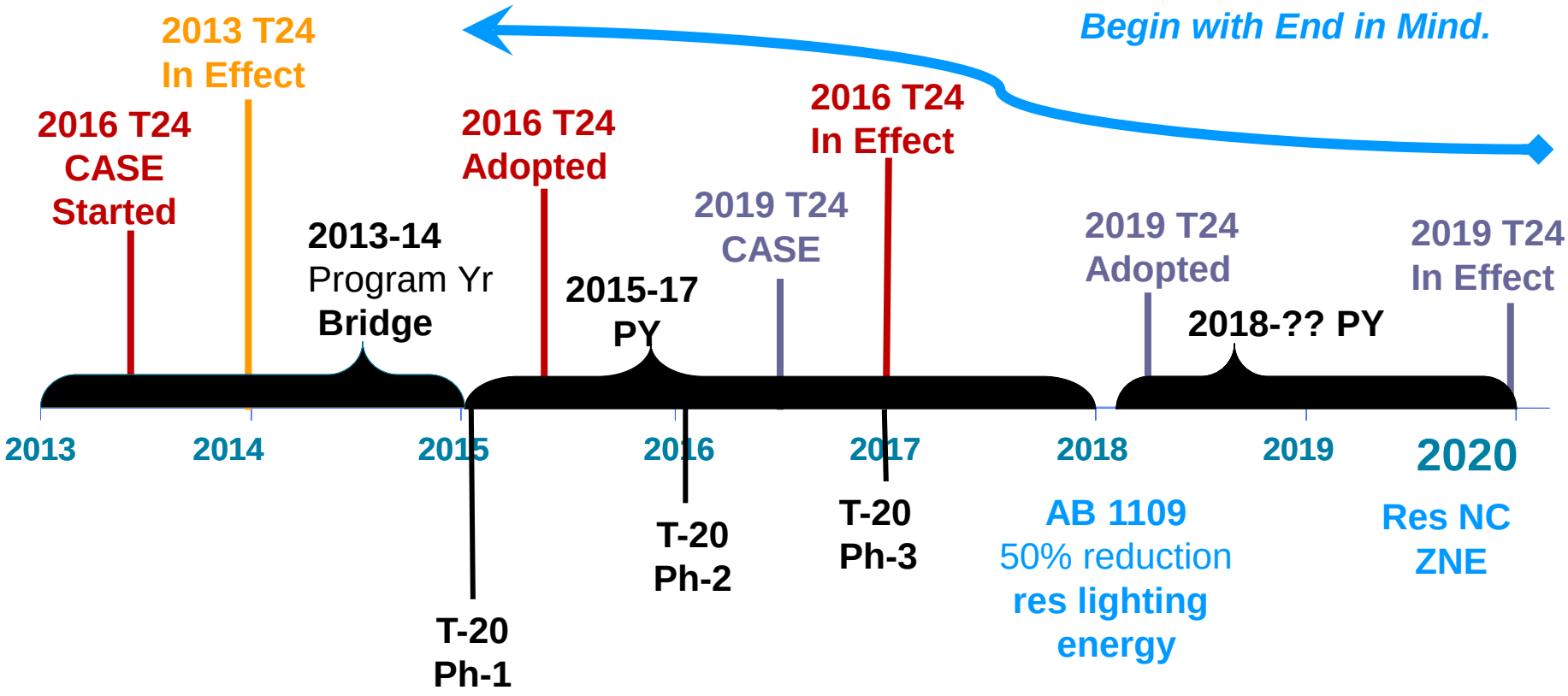
Residential / Small Commercial HVAC

- Heating, Ventilation, and Air Conditioning (HVAC) industry will be reshaped

Low-Income Energy Efficiency

- All eligible homes energy-efficient by

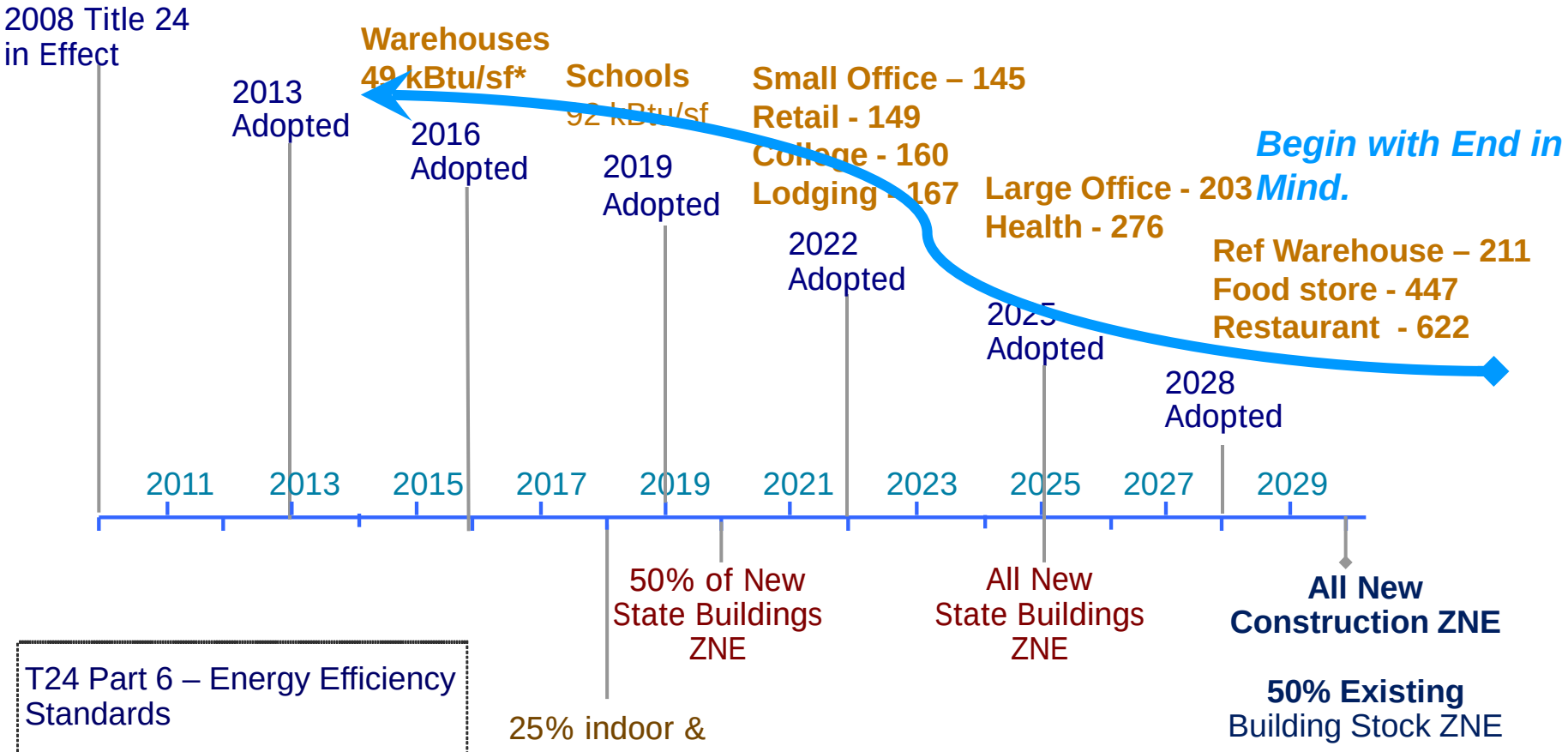
Residential ZNE-Ready Planning



Scope for 2020 residential ZNE goal is single family and low rise multi-family
Definition of ZNE includes plug loads, thus appliances are very important

See *"Code Driven Portfolios."* ACEEE 2012 Summer Study
http://www.aceee.org/files/proceedings/2012/data/papers/0193-000177.pdf

Nonresidential Buildings Policy Timeline



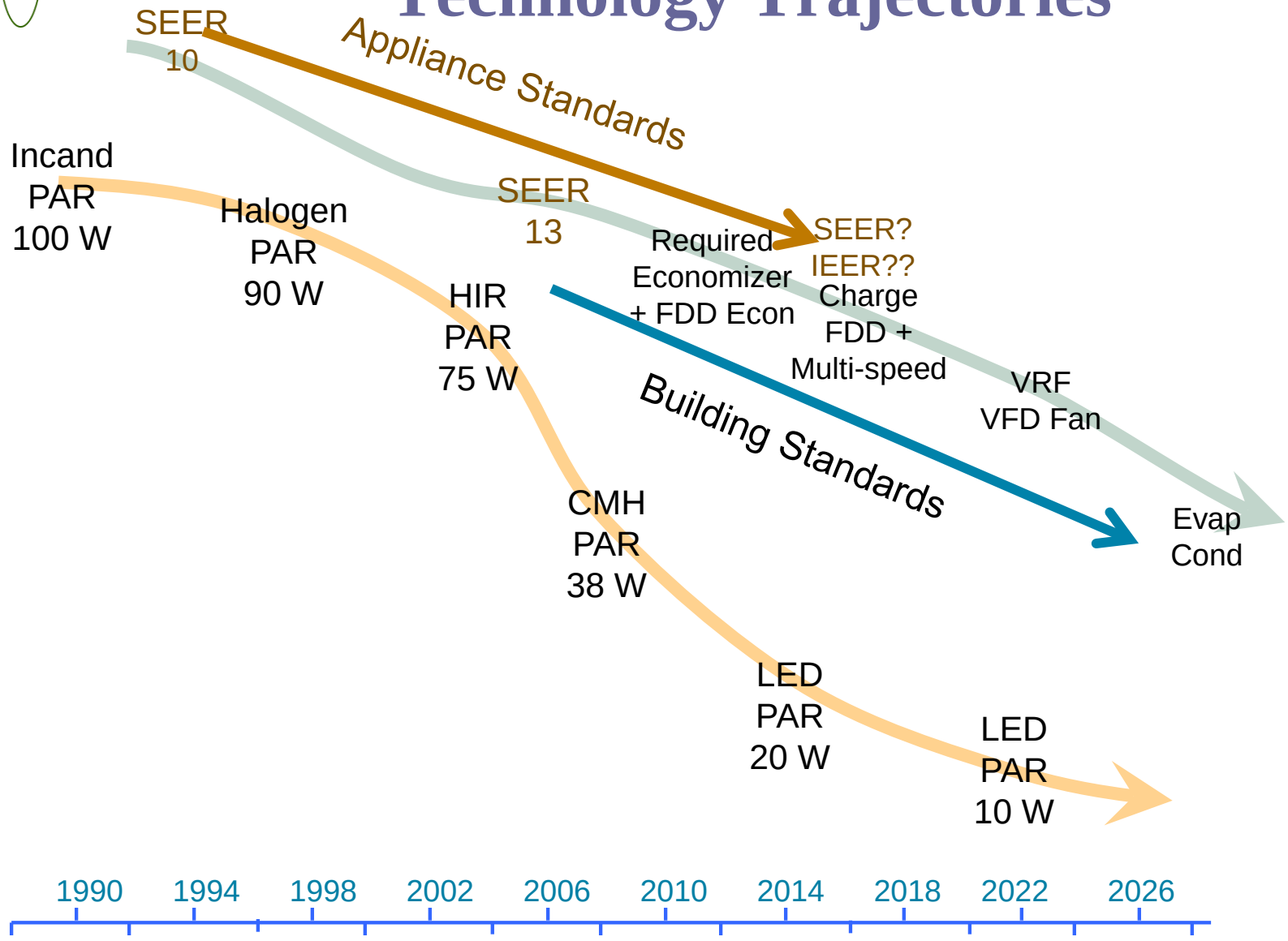
T24 Part 6 – Energy Efficiency Standards

Executive Order B-18-12

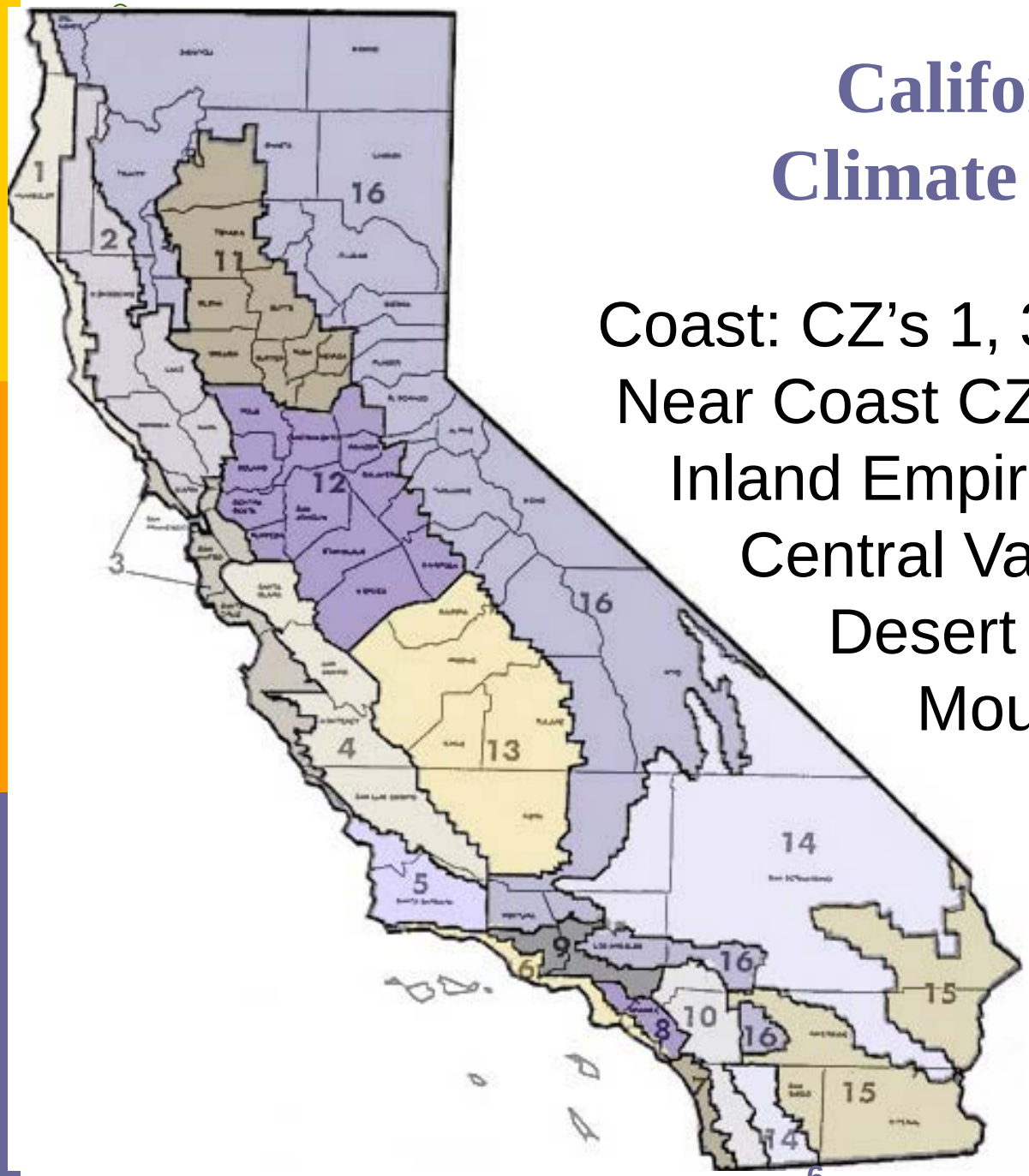
AB 1109

*Source energy kBtu/sf from CEUS CA Commercial End-Use Survey

Innovation: HVAC and Lighting Technology Trajectories



California
Climate Zones



Coast: CZ's 1, 3, 5, 6, 7

Near Coast CZ's 2, 4, 8, 9

Inland Empire CZ 10

Central Valley CZ 11-13

Desert CZ 14 & 15

Mountains CZ 16

2013 Title Residential HVAC

- HERS verified duct sealing in all CZs. **(§ 150.0(m)11)**
- Mandatory fan power and airflow testing OR Return duct design (Residential HVAC Quality Installation Improvements). **(§150.0(m)13)**
- Prescriptive refrigerant testing and HERS verification
- Duct insulation raised from R-4.2 to R-6.0 in climate zones 6, 7, and 8. **(§150.1(c)9)**
- Whole house fan or Smart Vents and Night Breeze as alternatives in CZs 8-14. **(§150.1(c)12)**
- Occupant Controlled Smart Thermostat as a tradeoff against the solar ready zone

2013 Title 24 Nonresidential Economizers

- Prescriptive threshold for economizers lowered
  - Moved from 75,000 Btuh down to 54,000 Btuh (4.5 tons) and > 1,800 cfm of airflow
  - Removed exemptions related to computer equipment and telecommunications
- Mandatory Fault Detection and Diagnostics (FDD)
  - All air-cooled unitary direct-expansion units with an economizer and
  - Mechanical cooling capacity >= 54,000 Btuh
  - Applies to:
    - *Packaged DX rooftops*
    - *Split-systems*
    - *Heat pumps*
    - *Variable refrigerant flow systems*

Fans

- Each system listed in Table 140.4-B shall be designed to vary the airflow rate as a function of actual load.

Variable Airflow Control of Fans			
Cooling System Type	**Fan Motor Size**	**Cooling Capacity**	**Effective Date**
Direct Expansion	any	>= 110,000 Btuh	Jan 1, 2012
Direct Expansion	any	> 65,000 Btuh	Jan 1, 2015
Chilled Water	> ¼ hp	any	Jan 1, 2012
Evaporative	> ¼ hp	any	Jan 1, 2012

Prescriptive Requirements for Computer Rooms §140.9(a)

- New process measure – similar to ASHRAE 90.1-2010 requirements
- Air or water side economizers required for:
  - Individual computer rooms > 5 tons cooling
  - New systems in existing computer room > 50 tons cooling
  - New system in a new room in existing bldg > 20 tons
- Simultaneous heating and cooling prohibited
- Heating water to humidify air not allowed (non-adiabatic)
  - Use evaporative media or ultrasonic humidification (adiabatic)
- Fan system power ≤ 27 W/kBtuh at design conditions
- Fan speed control for DX > 5 tons and all chilled water systems
  - Fan power ≤ 50% design fan power at 66% of design fan speed.
  - Simple payback < 5yr
- Containment prevent recirculation (return from mixing with supply)

10

2013 Title-24 Occupancy Controls

- Occupancy sensors allowed as a control option for demand control ventilation
- May reduce the ventilation rate to zero
- One sensor per room
- Must do one hour pre-purge prior to normal occupancy
- Must shut off outside air within 30 minutes of vacancy
- If single zone system, must also cycle off the fan

Occupancy Sensing Thermostats

- Mandatory Occupancy sensor based HVAC control in:
  - Multipurpose rooms < 1000 sq ft
  - Classrooms > 750 sq ft
  - Conference rooms > 750 sq ft
- Must automatically setup the cooling set point by 2°F or more and setback the heating temperature set point by 2˚F or more and ….
- …Automatically reset the minimum required ventilation rate to zero or turn the supply fan off when the zone is unoccupied
- Hotel/Motel Guestrooms
  - Card key control or occupancy sensing controls to control:
    - *thermostat,*
    - *lights and*
    - *half of the receptacles.*

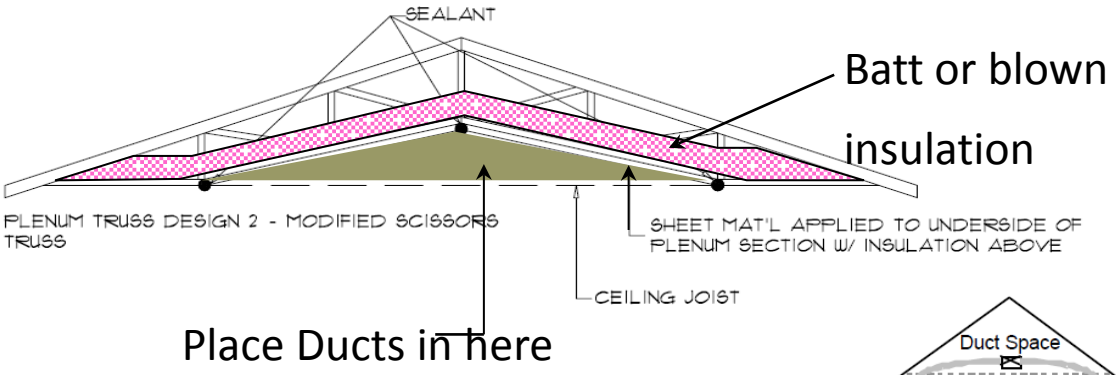
Demand Responsive Communicating Thermostatic Controls

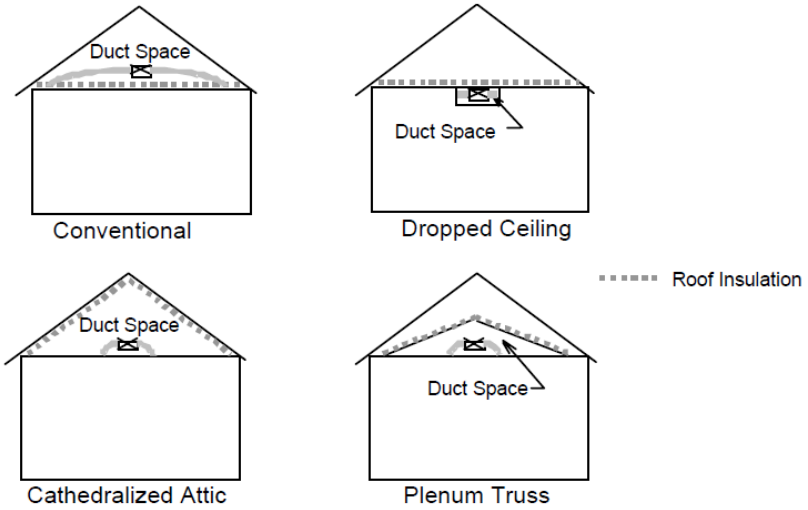
- All unitary heating and/or cooling systems including heat pumps that are not controlled by a central energy management control system (EMCS) shall have an Overrideable Communicating Thermostat (OCST)

2016 Key Residential HVAC and Envelope product development

- Residential construction patterns that bring ducts out of unconditioned space and address code requirements concerning venting attics to prevent moisture
- Construction methods that allow thicker exterior insulation while addressing moisture, durability and cost
- Construction and design practices that increase wall thickness and decrease thermal bridging
- Training and construction practices that are able to meet QII specs without taking significantly more time.
- Fault Detection and Diagnostic (FDD) Equipment that can measure refrigerant charge and non-condensibles.
  - FDD already required for nonres economizers

Greater Comfort and Energy Savings via Improved Building Envelope

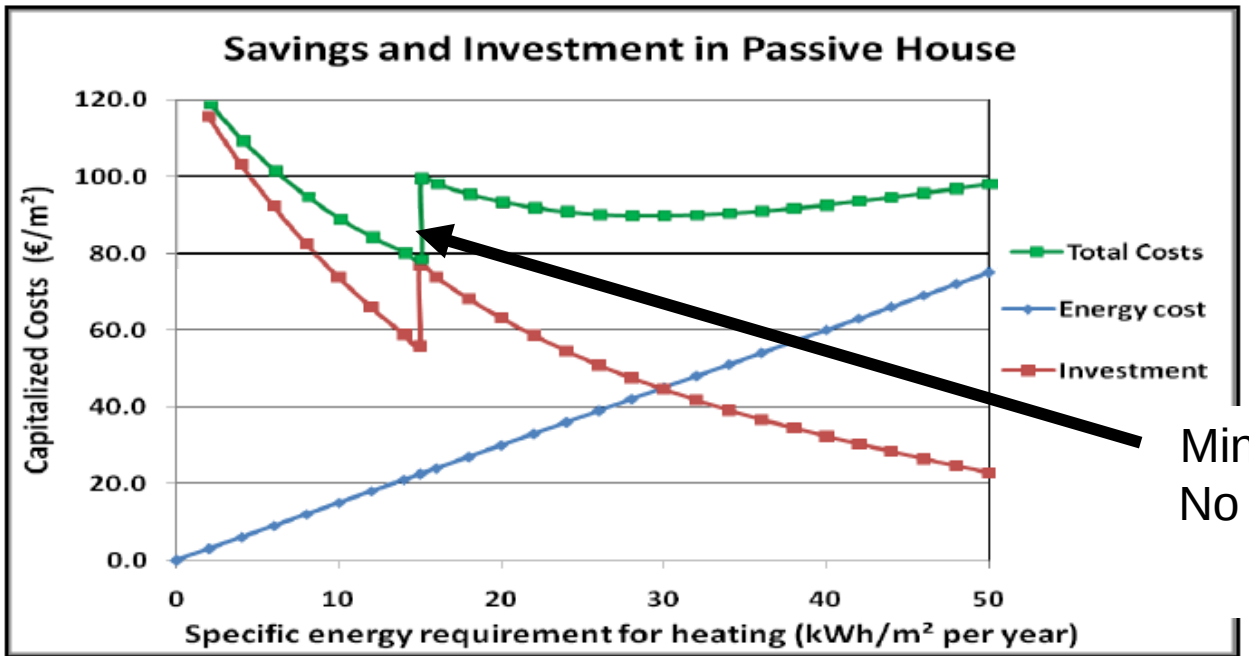




- IAQ must be addressed to tighten envelope and properly ventilate
  - Bring ducts and sealed combustion equipment inside conditioned space
  - Feasible, reliable super-insulation

- Compressorless comfort home
  - Envelope and building simulation

Coastal Compressorless Comfort Home



Minimum LCC
No Forced Air
System

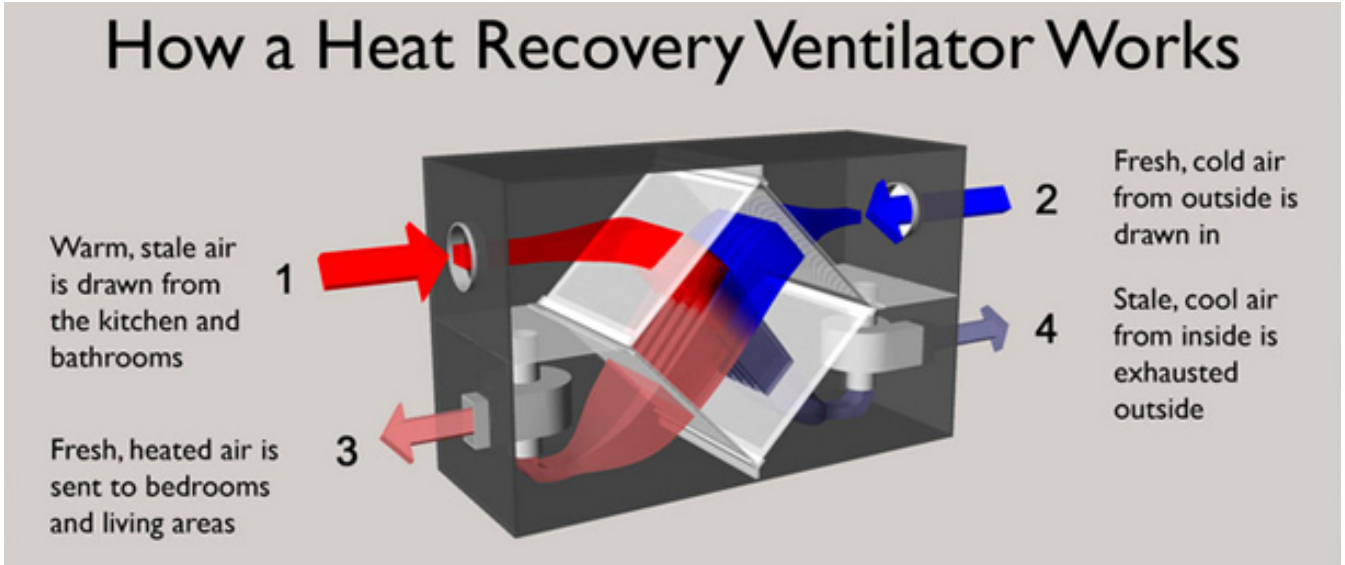
- Reduce loads enough so that AC is not needed
  - Added envelope costs are partially offset by reduced HVAC system costs. Not prohibiting AC but not required
  - Justifies more insulation and better windows in mild CZs
  - Justifies indirect evap cooling in hot climate zones
    - *Similar to basis of European Passive House Standard*
- Must have good comfort model in CA Simulation Engine

No Ducts in UnConditioned Space Impacts HVAC equipment

- Ducts in conditioned space or ductless HVAC
  - Includes conditioned attics, scissor truss, other methods of adding conditioned plenum space, and the use of ductless systems. Different methods of addressing heating in the conditioned space include sealed combustion furnaces, combined water heating and space heating and heat pumps.
- Simulation of ducts in conditioned space group of measures
  - conditioned attic space, ducts in conditioned spaces, ductless systems, sealed combustion, combined heating and water heating and how does it impact efficiency of condensing water heaters.
- VRF and CV mini-split
  - Develop methodology and rating data needed to provide accurate model of water heating for VRF.

Res Ventilation

- Controlled supply mechanical ventilation
  - Evaluate the costs, the energy benefits and the air quality benefits from replacing exhaust based ventilation with supply based ventilation
- Heat recovery ventilation
  - Evaluate whether heat recovery ventilators are cost-effective in the more extreme climate zones and develop a proposal if so. This would replace the other mechanical ventilation requirements.



Res HVAC Measures

- Dual path - higher HVAC efficiency in alternative path
  - include higher HVAC efficiency in alternate path
- FDD/CID refrigerant charge/condensables (2016?)
  - Propose a requirement for FDD that would verify proper refrigerant charge, lack of condensables in the system and proper airflow.
- Evaporative cooling baseline hot/dry CZs
  - Evaluate and develop and evaporative cooling code baseline for homes in hot/dry climate zones

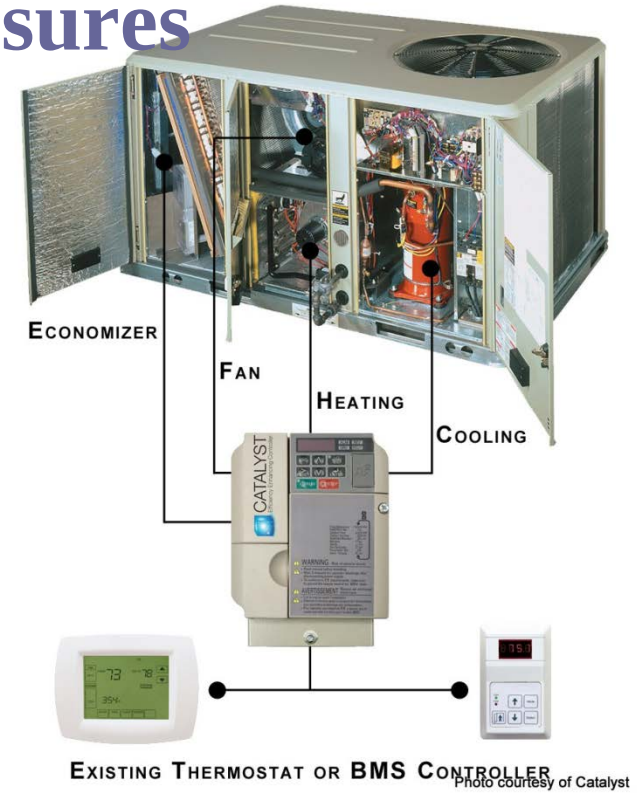


Photo courtesy of Catalyst

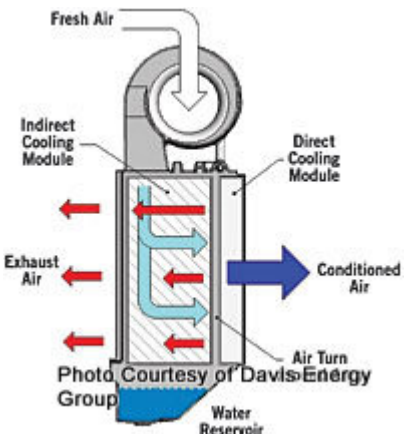
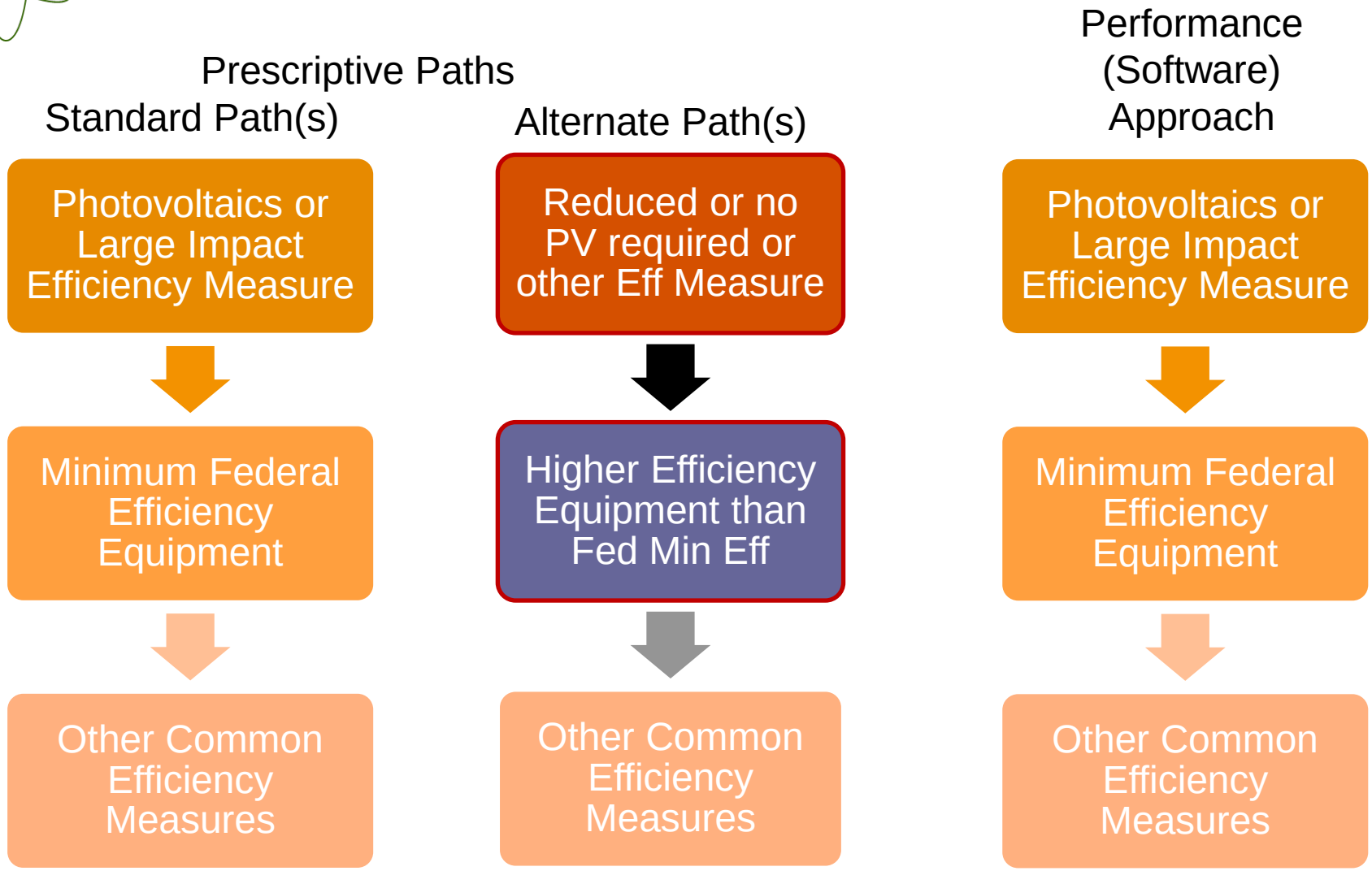


Photo Courtesy of Davis Energy Group

Avoiding Preemption: Multiple Path Energy Codes

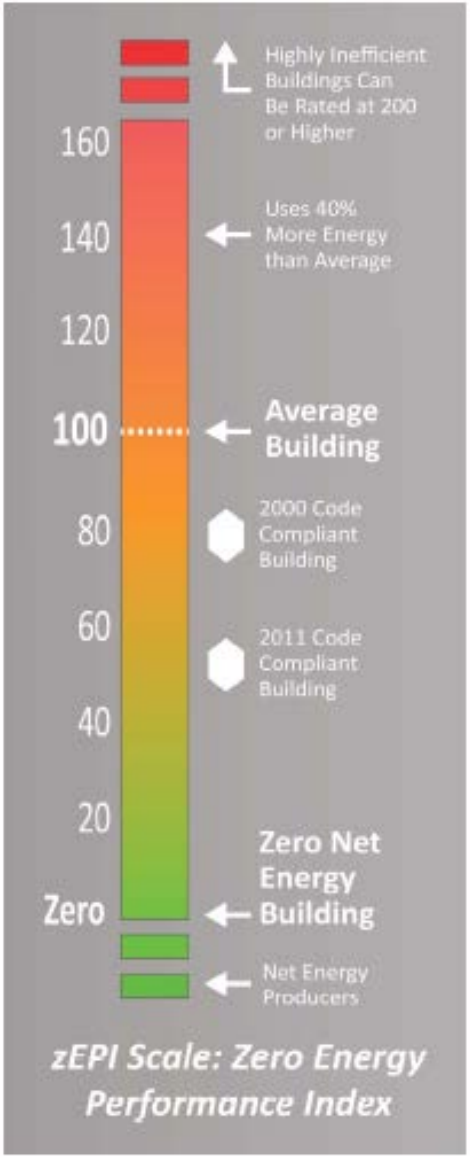


At least one standard path for every alternate path with higher efficiencies

See *"Federal Appliance Standards Should be the Floor, Not the Ceiling…"* ACEEE 2012 Summer Study
http://www.aceee.org/files/proceedings/2012/data/papers/0193-000415.pdf

Dual Path Approach and BEARS

- Dual path approach PV vs. high eff equipment
  - PV in base case: trade-off with equip eff: HVAC, water heating, refrigeration
- PV model offsets consumption
  - Performance method base case with PV and method for trade-offs
- BEARS (Building Energy Asset Rating) System) whole building rating model including deemed plug loads.
  - Evaluate plug load data from a number of sources including CEUS and COMNET and incorporate into ACM so that performance runs also generates a BEARS design rating
  - ZNE: BEARS = 0



Nonres HVAC measures

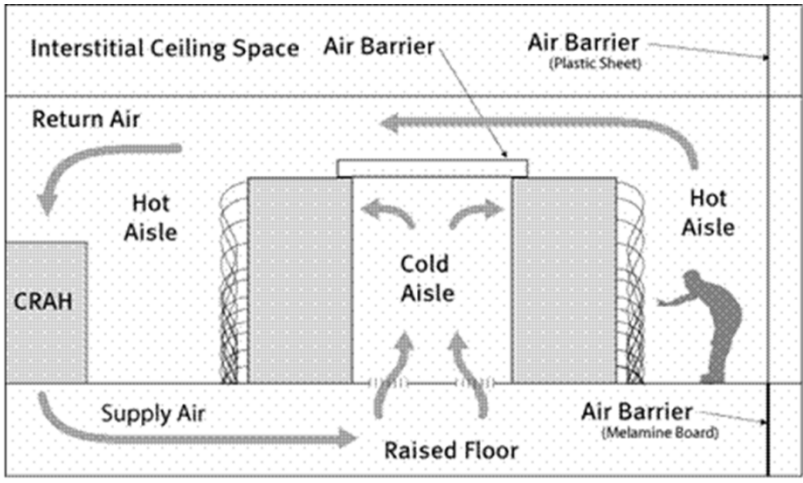
- Low W/sf HVAC systems
  - Limit connected HVAC connected load. Don't double count interlocked loads. Consider a fan efficiency requirement or W/cfm requirement
- Heat recovery
  - Heat recovery with thresholds by cfm of O/A and climate zone
- ACM - Base Case HVAC rule set
  - Performance rule set without exceptions (VAV reheat?), max W/sf, validated EPlus algorithms, base case and proposed case when AC not used, comfort model. Economizer simulation model for two speed AC.
- ACM - Improved and validated VRF simulation
  - Rigorous method of incorporating VRF test data into simulation that results in accurate estimate of energy impact.
  - ACM - VAV w/reheat, integration with DCV, chilled beam and DCV. Validate and improve Eplus simulation of nonresidential HVAC simulation types. Compare to eQUEST and rationalize or fix the discrepancies

Advanced HVAC

- Improved Natural Ventilation and displacement ventilation simulation
  - Evaluate Eplus natural ventilation model and make recommendations for the ACM. Evaluate the feasibility and cost-effectiveness of a natural ventilation and displacement ventilation base case by climate zone..
- Radiant model including comfort
  - Evaluate Eplus radiant heating/cooling model and make recommendations for the ACM. Update Eplus model if necessary. Adjust setpoint temperatures based on ASHRAE 55 and operant temperature.

Process - Fume Hoods & Computer Rooms

- Lab fume hoods, Occupancy sensing control of sash
  - Evaluate the feasibility and cost-effectiveness of an automatic control of vent hood sashes.
  - Similar to automatic doors at stores
  - Requires VAV fume hood exhaust system
- Lab HVAC measures
  - reset general room airflow rate and setpoint when unoccupied after hours,
  - max W/cfm at peak air flow,
  - no simultaneous heating and cooling (dual duct, chilled beam, 4PFC etc.,),
    - *Internal gains in labs can vary widely over time and they become the "rogue" zone*
  - sizing calculated,
  - exhaust duct sealing.
- Computer rooms
  - Economizers on smaller equipment
  - Measures applied to smaller computer rooms and data centers



Opportunities ahead

- Aggressive goals for 2020, 2025 and 2030
- $2.6 Billion for school energy upgrades over the next 5 years (2013-2018) Prop 39
- Significant changes to 2013 Title 24
  - Significant niches in eff HVAC and controls
  - Similar changes from ASHRAE 90.1 and IECC
- New opportunities for 2016 codes
  - Emphasis on individual measures
    - *Incremental cost*
    - *Energy savings*
    - *Feasibility*
    - *Enforceability (ratings etc.)*