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Basic HVAC Controls and Energy Codes ?

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PACIFIC NORTHWEST NATIONAL LABORATORY

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ICC PPP Course #19958

PNNL-SA-142346

Course Description and Learning Objectives

Brief introduction to basic HVAC controls and compliance strategies, followed by results from a recent field study on new building control systems. Many basic control systems will be covered, including space temperature controls, outside air economizers, ventilation dampers, and demand controlled ventilation. Strategies for commissioning of control systems will also be discussed.

Learning Objectives:

1. Identify basic HVAC controls and their uses
2. Identify energy code provisions requiring HVAC controls
3. Demonstrate how to comply with basic energy code provisions using appropriate HVAC controls
4. Describe which HVAC controls generally are not meeting energy codes
5. Explain the benefits of commissioning HVAC controls

Outline

- Basic Controls Background
- HVAC system controls
  - Basic controls that save energy
  - Outside air economizers
  - Demand Controlled Ventilation
- Complex systems:
  - High energy impact complex controls
  - Hydronic system controls
- Field Study on Energy Code Control Compliance

References to energy code sections in this presentation are to the commercial provisions of the

2015 International Energy Conservation Code (IECC).

Similar requirements may exist in the 2012 IECC or ASHRAE Standard 90.1-2013, but section numbers will be different, and there will be slight variation in requirements.

For basic HVAC system background, see the webinar:
https://www.energycodes.gov/resource-center/training-courses/hvac-systems

New Building Controls

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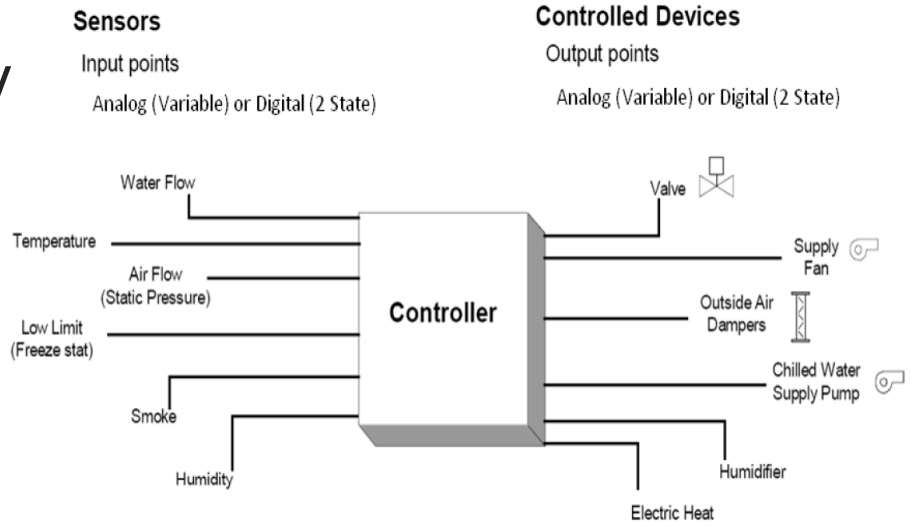
Background

- Building controls automatically adjust a building's:
  - Lighting,
  - Service hot water,
  - HVAC (heating/cooling), and
  - Sometimes envelope



- Controls sequence of operation responds to:
  - Environmental parameters,
  - Time schedules, or
  - Occupancy
- Include sensors, controllers, and controlled devices
- Can save energy by reducing energy services to match loads

Background

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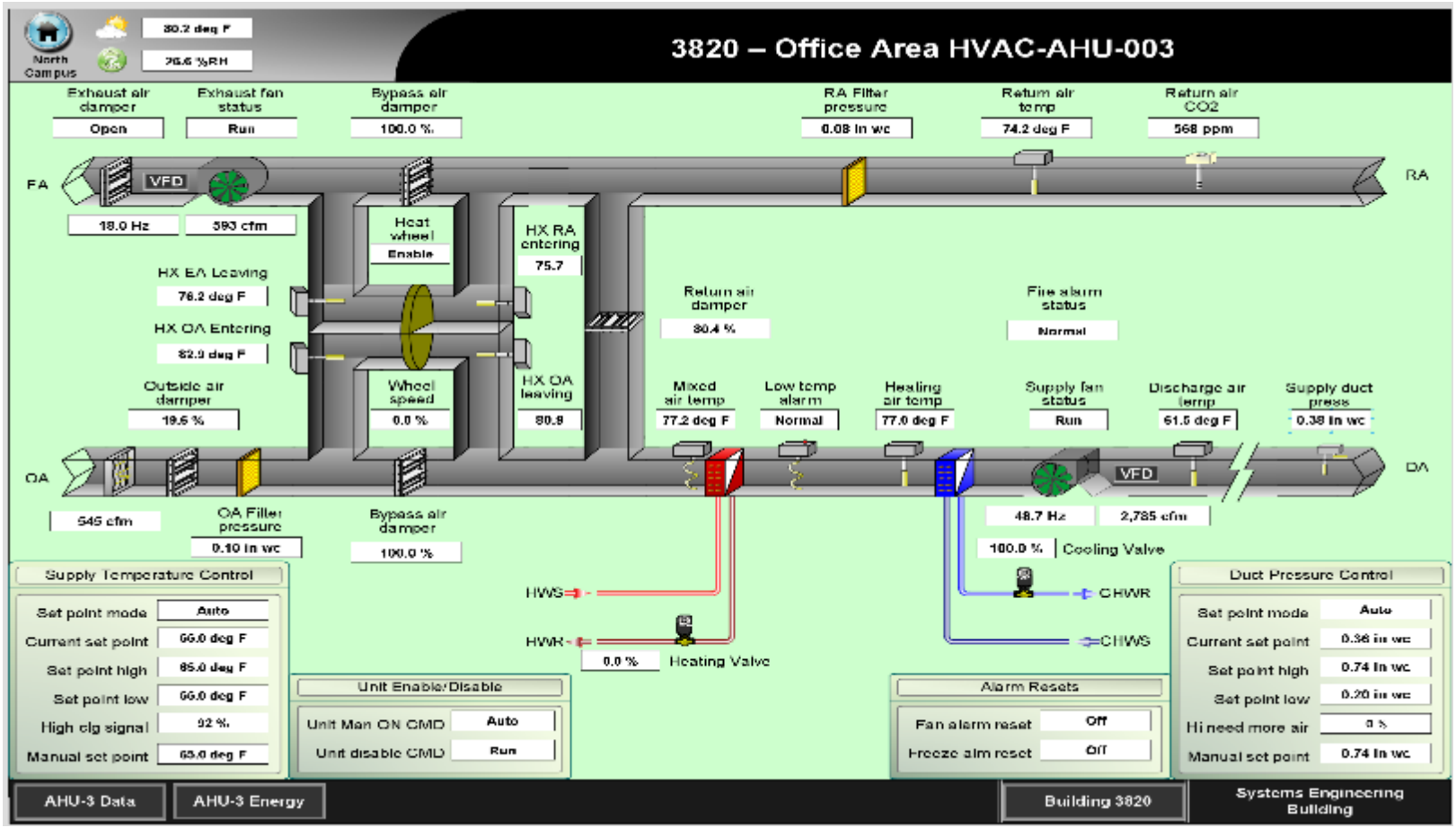
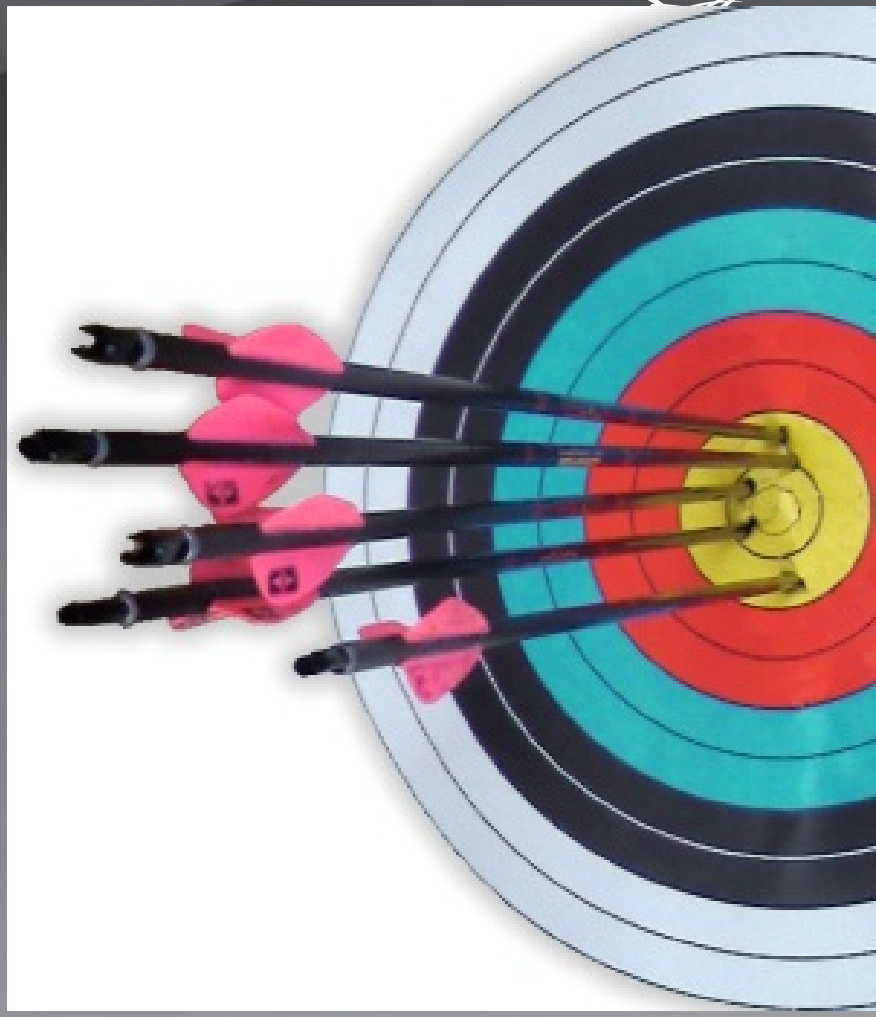
Often HVAC is under the management of a building automation system, energy management system or DDC system



General Energy Code Changes Related to HVAC Controls

- Old control code language
  - Controls are capable of …
- New control code language
  - Controls are configured to …
- Occurred as global update in these editions:
  - 2018 IECC
  - 90.1-2016
- What is required
  - Actual code required sequences and setpoints need to be implemented at the time of inspection

Basic HVAC Controls that Save Energy



HVAC Schedule or Time Control

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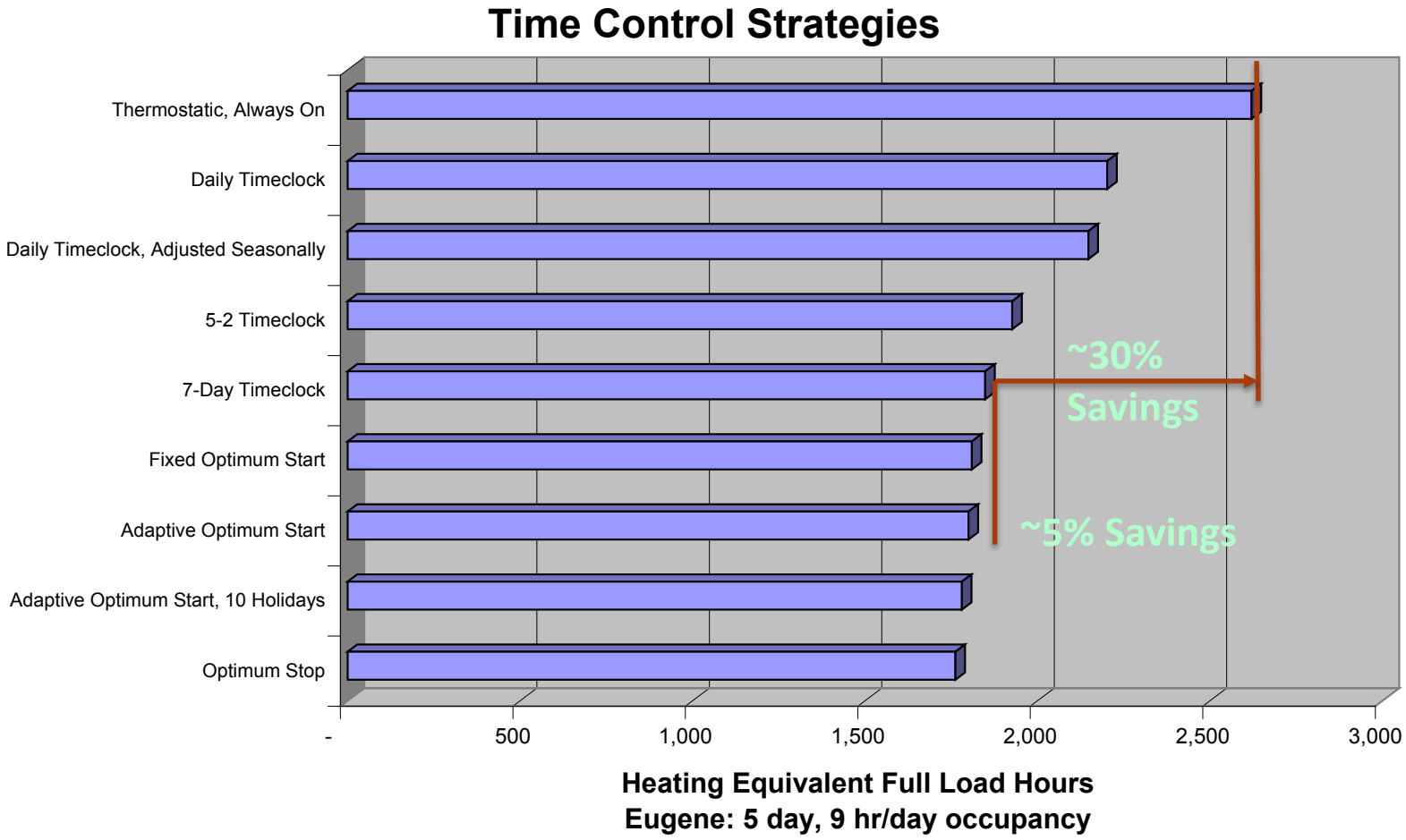
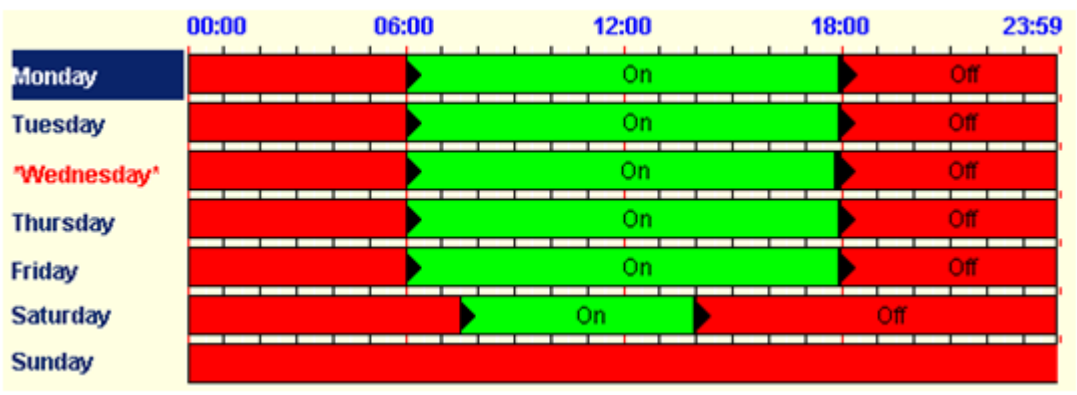


Temperature Setback Scheduling

- Simple control systems
  - Programmable thermostats
    - Seven different daily schedules/week
    - Manual override
  - Occupant sensor is an alternative
- DDC (direct digital control) systems
  - Central scheduling of all units
  - Optimum start activated



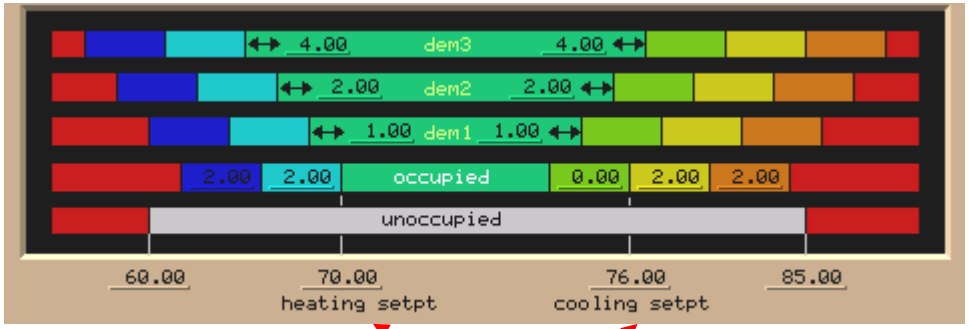
Source: http://docplayer.net/5893734-Chapter-5-introduction-to-building-automation-system-bas.html

Energy Myth:
Setback does not save energy because it takes so long to warm up in the morning
Not true:
Savings can be 5%-20% of HVAC energy Use

Full 5 Degree Temperature Deadband

- A most significant control feature is temperature deadband (C403.2.4.1.2)
- If heating is set at 70°F, then cooling should be ≥ 75°F
- Should be the found condition during an inspection
- Why?
  - Simple systems can fight each other in open office areas
  - VAV systems have excessive reheat if settings are too tight
- Energy Star recommended factory default setpoints of:
  - Heating 70°F
  - Cooling 78°F

Source: http://oscac.com/what-you-need-to-know-about-programmable-thermostat/

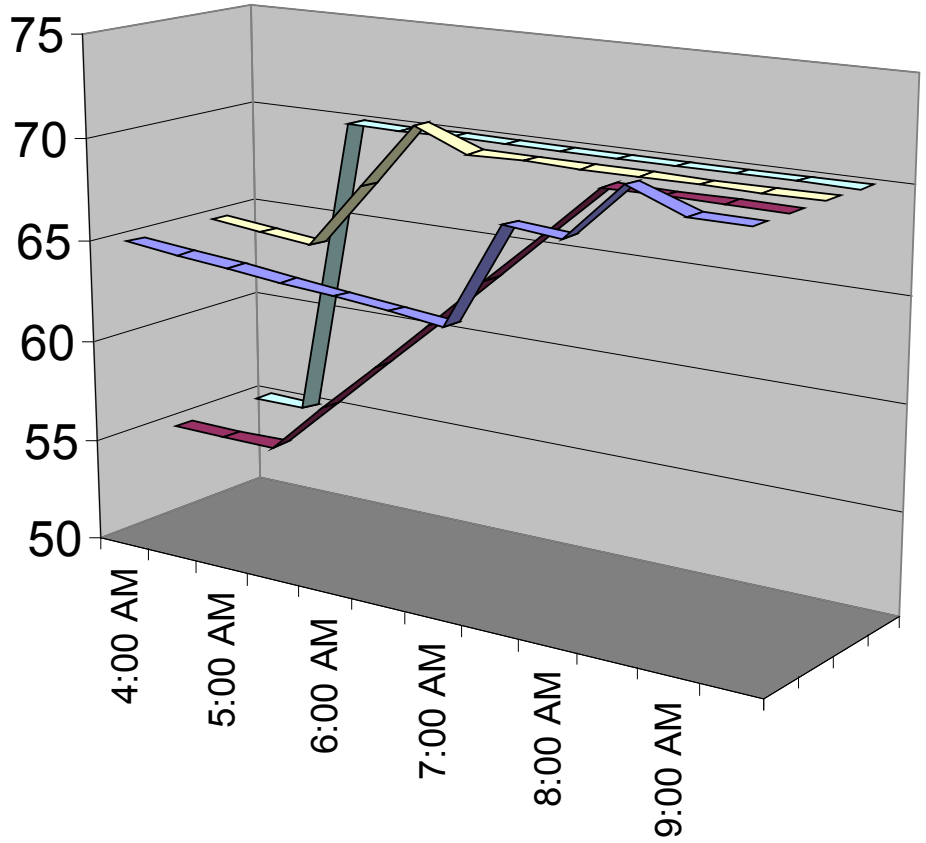


Source: www.AutomatedLogic.com

Dead band

Optimum Start Setpoints

Compare Optimum Start vs. TimeClock (TC) in Moderate Weather

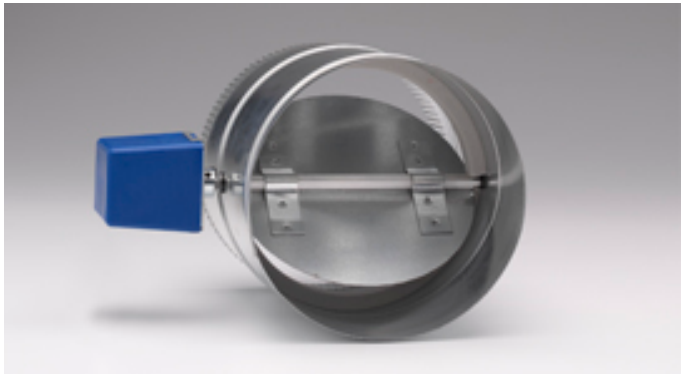


Optimum Start typically adjusts the setpoint up from setback during a warmup period. When the setpoint hits the control point the HVAC System operates.

Adaptive optimum start varies th warmup period depending on recent "experience."

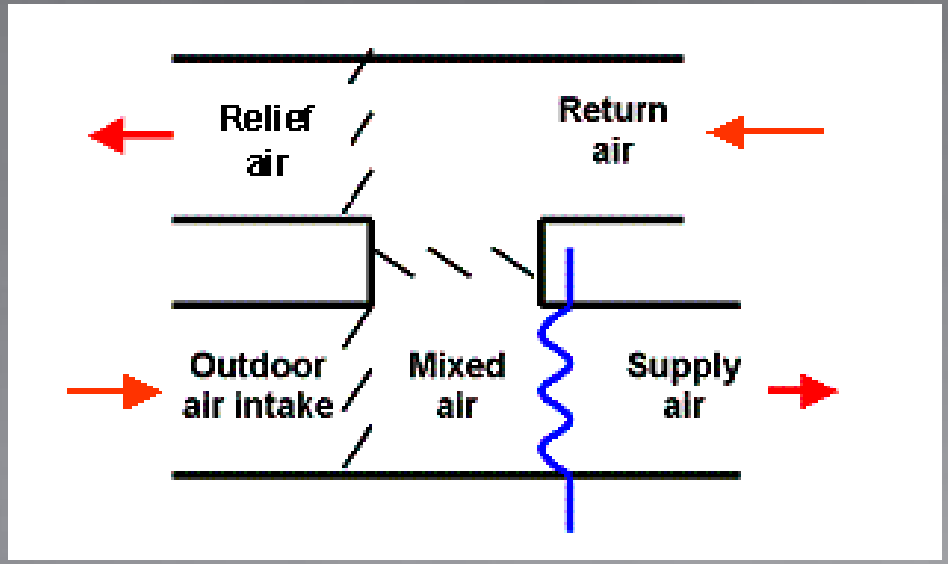
Outside Air Damper Control

- Related to Schedule or Setback Control
  - Shutoff outside air dampers during unoccupied periods
  - Fan operates for night setback and warmup
  - Don't want to heat or cool outside air when not needed
- Damper Leakage
  - 4 cfm/ft^2 or less @ 1"w.g.
- Controls shut off dampers
  - During unoccupied periods
  - During setback operation
  - During warmup operation
- Gravity dampers without motor OK for exhaust:
  - Any building in climate zones 1/2/3
  - Buildings < 3 stories
  - Design exhaust capacity < 300 cfm



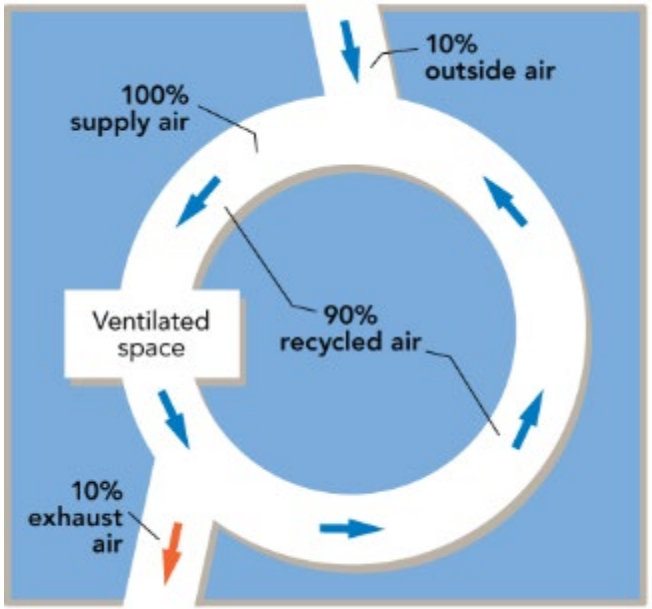
http://www.ruskin.com/model/ard25

Outside Air Economizers



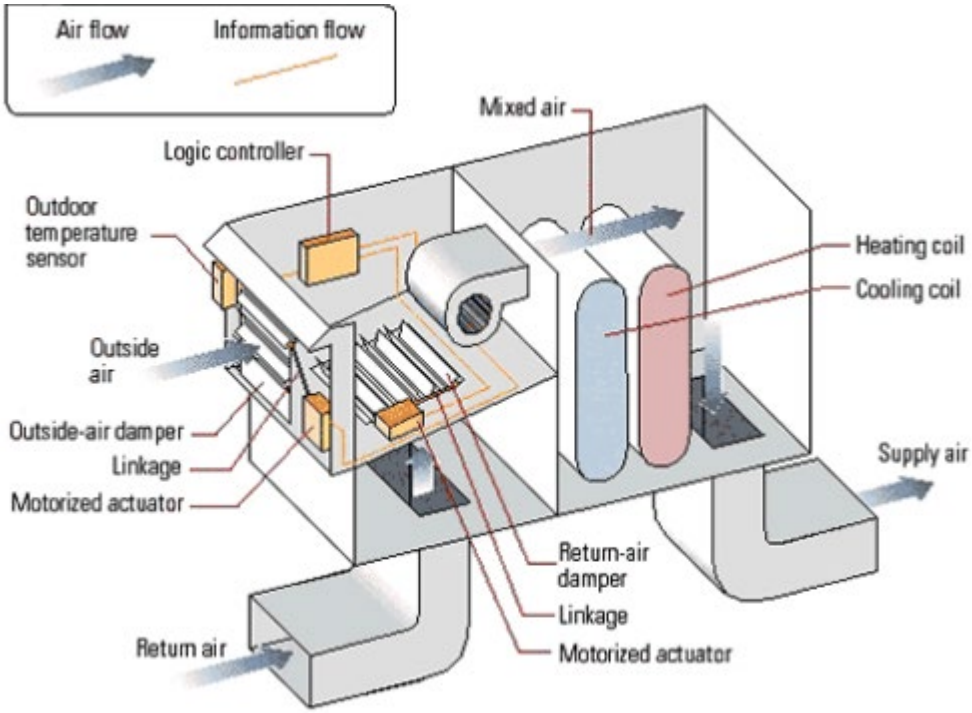
HVAC – Economizers "Free Cooling"

- Quantity of OSA: Meet Minimum Ventilation Requirement
- Economizer Function: Flush out building heat with cool outside air



Ventilation Air

Economizer



Packaged Rooftop Cooling Unit

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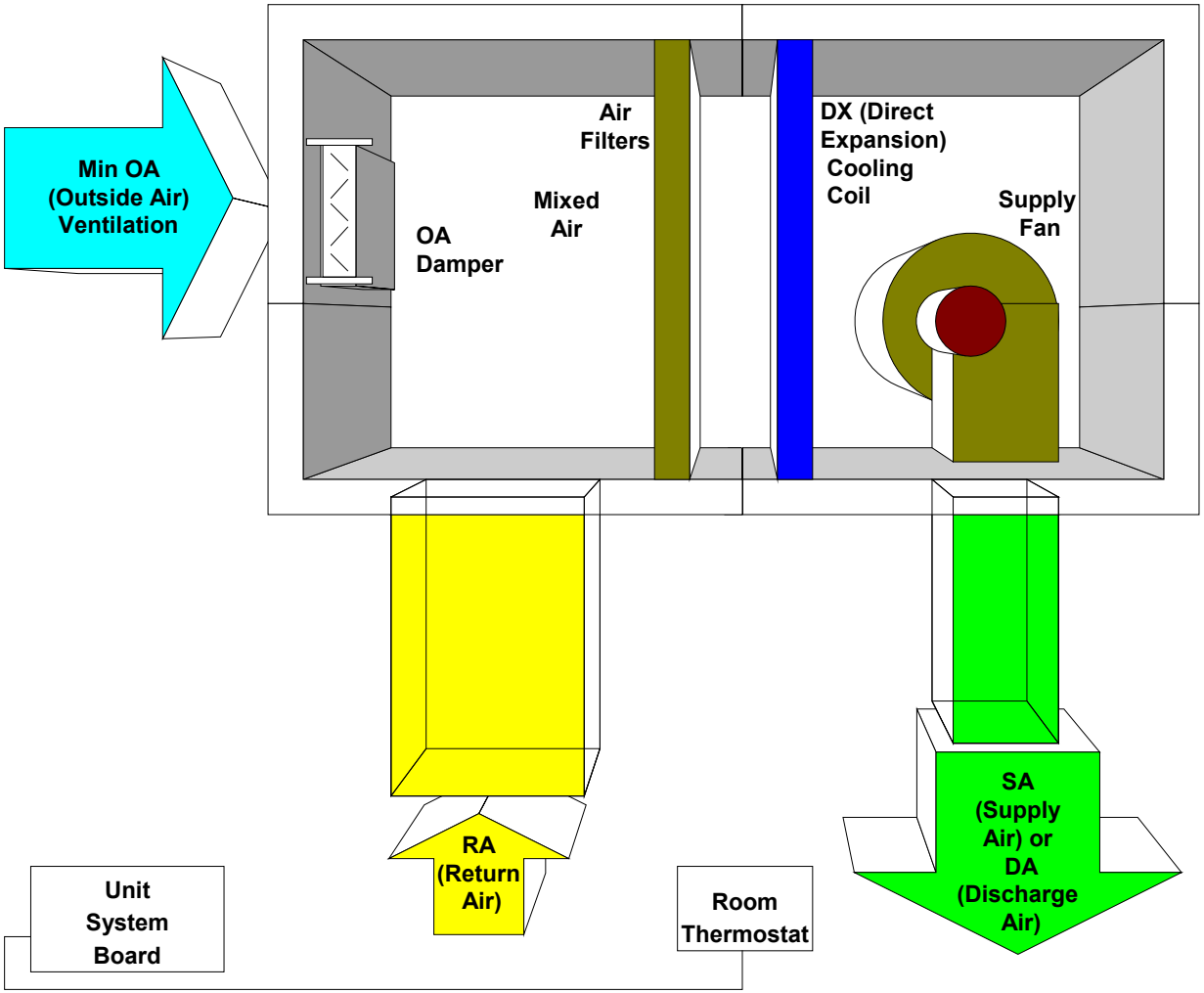
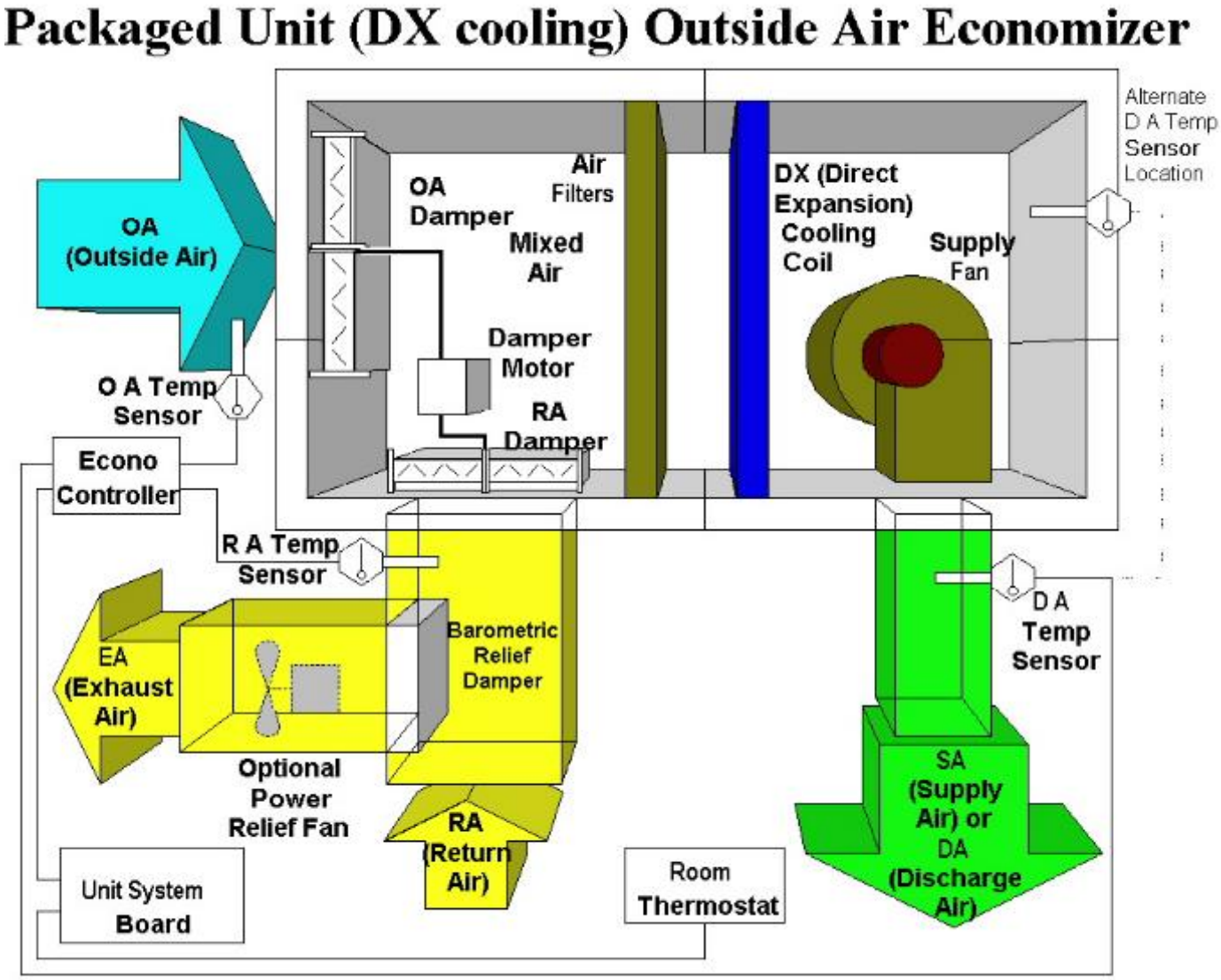
Packaged Unit (DX cooling) Outside Air Ventilation



Basic OSA Economizer Idea



Economizer Components

- Dampers (not shown)
- Damper Motors
- MAT/DAT sensors
- Solid State Controller
- OAT/RAT sensors
  - Dry bulb
  - Enthalpy
- Code economizer requirements
  - OSA ductwork = large enough
  - Relief damper provided
  - Integrated
    - Operates with compressor
    - Coordinated with cooling

(Honeywell shown, often basis of OEM brands, out there for 30+ years)

OSA Economizer Savings

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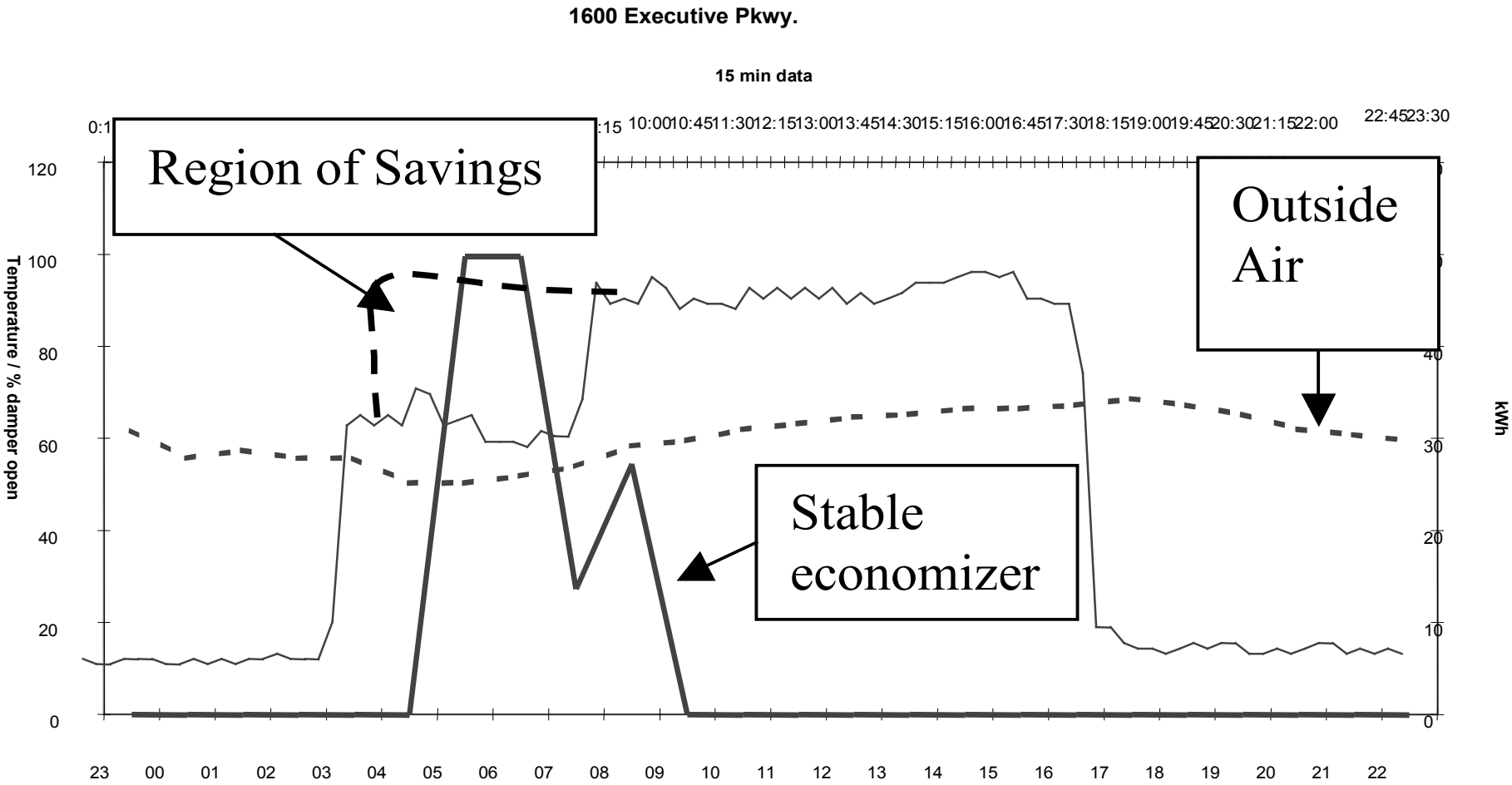


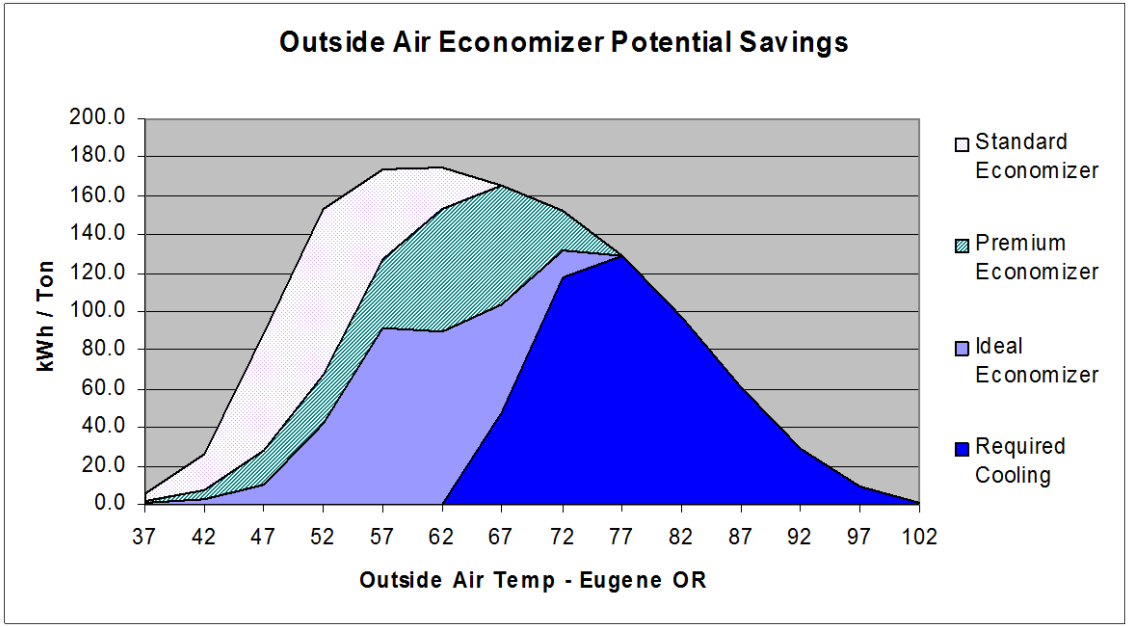
Economizer Savings – It's in the Settings!

- High limit needed to turn off economizer when not beneficial!
  - Fixed dry bulb cuts off above 75°F, 70°F, or 65°F—depending on CZ
  - Differential dry bulb cuts off when OSA > RA

    Differential DB no longer allowed in Climate Zones 1A, 2A, 3A, 4A
  - Fixed or differential **enthalpy** high limit adjusts for humidity of OSA

    Enthalpy requires a paired dry bulb high limit in event of sensor inaccuracy

- Economizer savings
  - Theoretically ~60%
  - Low high limit settings: 10%-20%
- "Premium economizer" = Code economizer
  - Settings correct
  - Relief air
  - Integrated
  - Checkout & FDD



Economizer: Things to Check in the Energy Code

- Damper and ductwork
  - Full sized OSA damper
  - Relief damper; powered or barometric
- High limit or changeover setting (C403.3.3.3/C403.5.3.3)
- Proper setpoint a mystery to most field technicians
  - Settings typically too low; reducing or eliminating savings (55°F vs. 75°F)

New 2015 IECC Fault Detection & Diagnostic (FDD) Requirements: Sensor and damper faults & setup.
(2015 IECC: C403.2.4.7 2018: C403.5.5)
The controller at the top right does not meet the new requirements.

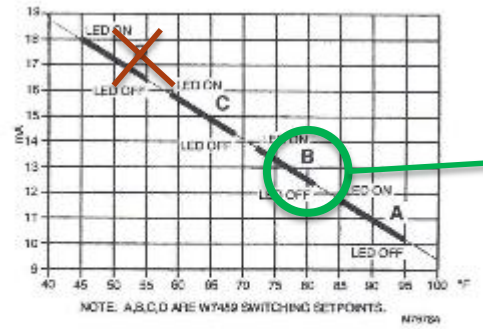
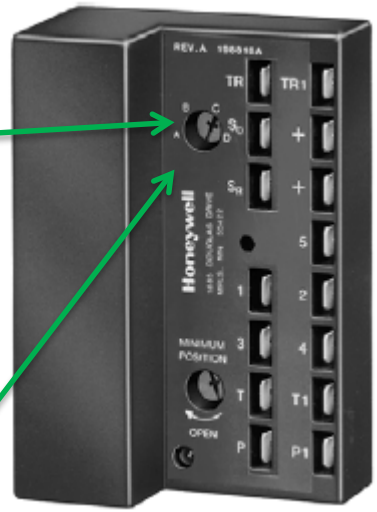


Fig. 17. C7650A Solid State Temperature Sensor output current vs. temperature.

High Limit Set per table C403.3.1.1.3(2) for climate zone



Source: https://customer.honeywell.com/en-US/Pages/Category.aspx?cat=HonECC+Catalog&category=W7459&catpath=1.1.2.1.14

Source: http://www.zipeconomizer.com/

https://buildingcontrols.honeywell.com/products/Jade-Economizer

Demand Controlled Ventilation (DCV)


Aspiration Duct Probe

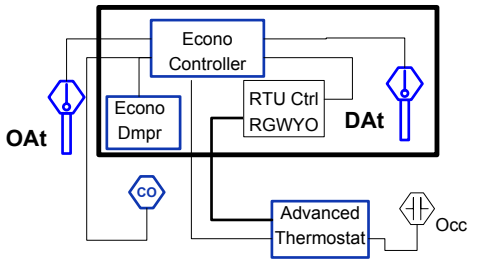
Demand Controlled Ventilation (DCV)

- Where Required
  - Generally where you have an economizer
  - Zones > 500 sq. ft. with 25 people per 1000 sq. ft. or more
- What it takes for single zone:
  - CO_2 sensor
  - Connect to economizer controller
  - Adjust outside air (OA) damper minimum
- What it takes for multi-zone VAV
  - CO_2 sensor
  - Connect to VAV box controller
  - Adjust box minimum—OA optimization

2015 IECC: C403.2.6.1

2018 IECC: C403.7.1

Configuration 3
(Honeywell T7351/JADE)



DCV with Economizer

- Controls already present
  - Economizer control with required FDD has built in DCV controls
  - Just add CO_2 Sensor
- Setpoint higher than expected for savings

ASHRAE 62.1-2010 Area Type	Pz	sf/p	met	Rp cfm/p	Rs cfm/sf	**CR ppm**	OA% area	OA% full	Ratio
Art Classroom	20	50	1.2	10	0.18	**824**	19%	40%	2.1
Office - default	5	200	1.2	5	0.06	**874**	6%	9%	1.4
Office - open	7	143	1.2	5	0.06	**994**	6%	10%	1.6
Class (age 9+)	35	29	1.2	10	0.12	**1001**	13%	49%	3.9
Retail Sales	15	67	1.5	7.5	0.12	**1050**	13%	24%	1.9
Grocery	8	125	1.7	7.5	0.06	**1162**	6%	13%	2.0
Call Center	12	83	1.2	5	0.06	**1206**	6%	13%	2.0
Lecture Class	65	15	1.1	7.5	0.06	**1278**	6%	57%	9.1
Movie Theater (actual)	77	13	1.0	5	0.06	**1563**	6%	46%	7.4
Conference	50	20	1.1	5	0.06	**1592**	6%	32%	5.2
Restaurant	70	14	1.4	5	0.18	**1643**	19%	55%	2.9
Assembly	150	7	1.0	5	0.06	**1644**	6%	84%	13.5
Rock Concert (dance)	100	10	2.0	5	0.06	**2800**	6%	58%	9.3

*For all types: area is 1000 square feet, COa = 400 ppm, Ez is 80%, unit cfm 1.2 cfm/sf

Aspiration Duct Probe

Source: http://www.zipeconomizer.com/

https://www.bpa.gov/EE/Technology/EE-emerging-technologies/Projects-Reports-Archives/Pages/Premium-Ventilation-Packages-for-RTU.aspx

CO_2 Accuracy & Multiple Rooms

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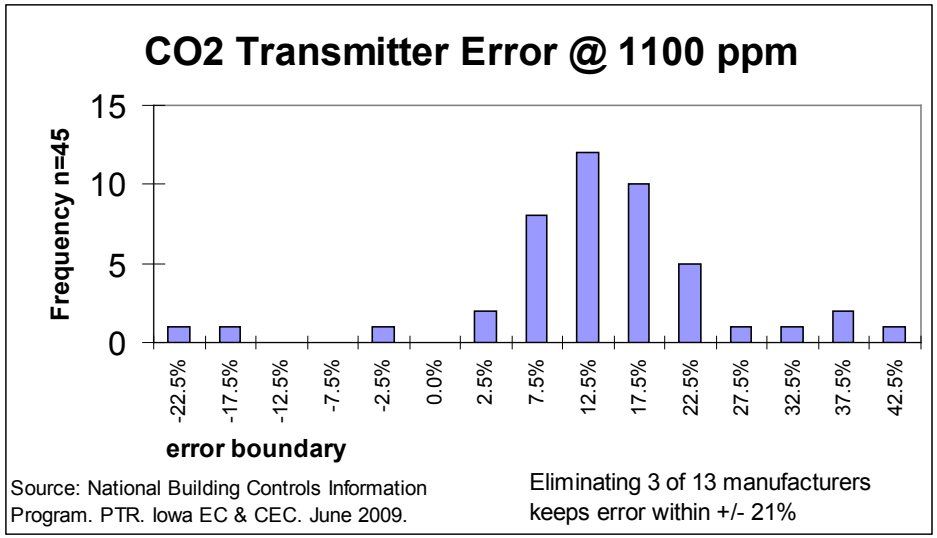
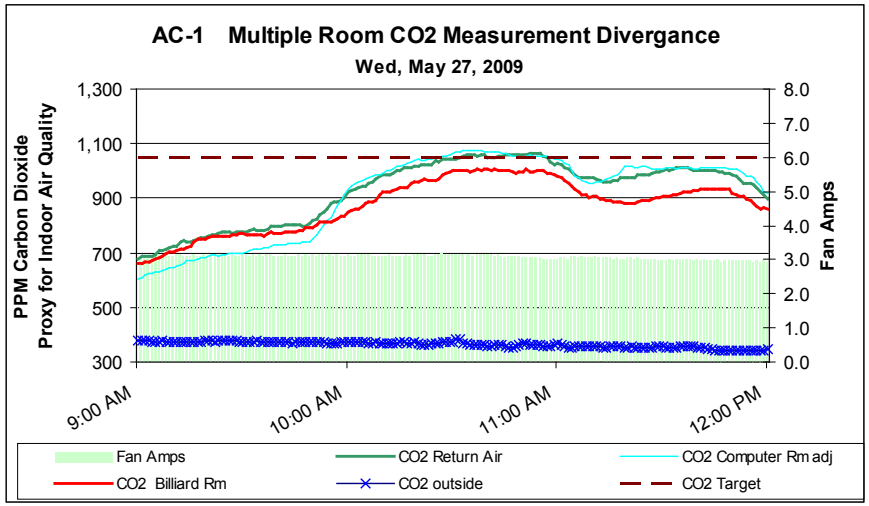
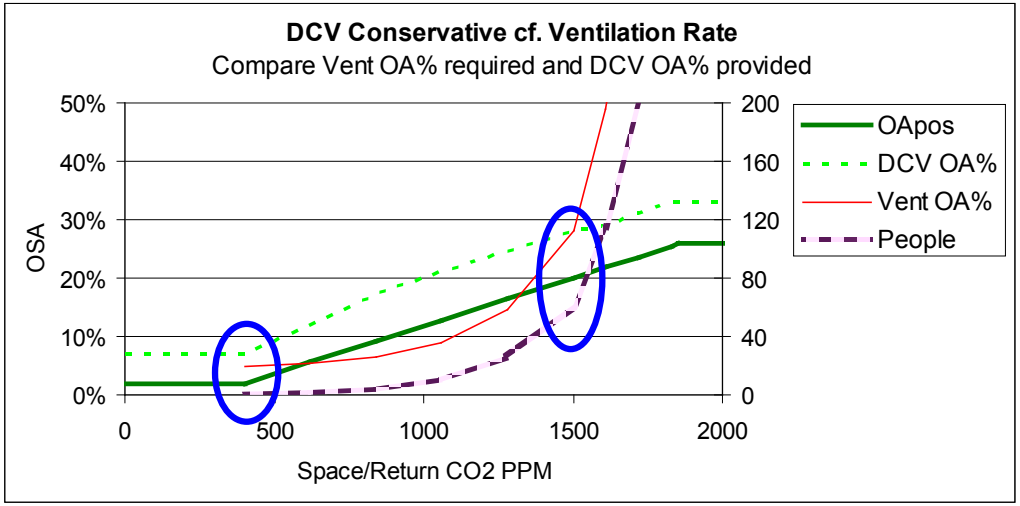
- Some inaccuracy, but good enough with auto calibration
- Multiple rooms served by
  - return air sensor
  - high occupancy room sensor
- CO_2 linear control is conservative
  - More OA provided than required



Source: National Building Controls Information Program. PTR. Iowa EC & CEC. June 2009.

Eliminating 3 of 13 manufacturers keeps error within +/- 21%





https://www.bpa.gov/EE/Technology/EE-emerging-technologies/Projects-Reports-Archives/Pages/Premium-Ventilation-Packages-for-RTU.aspx

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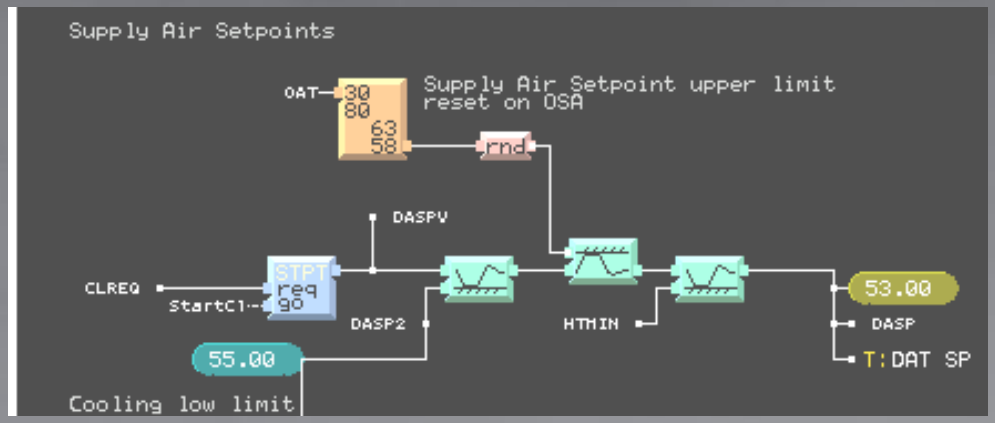
High Energy Impact Complex Controls



Warning! Controls can be complicated!

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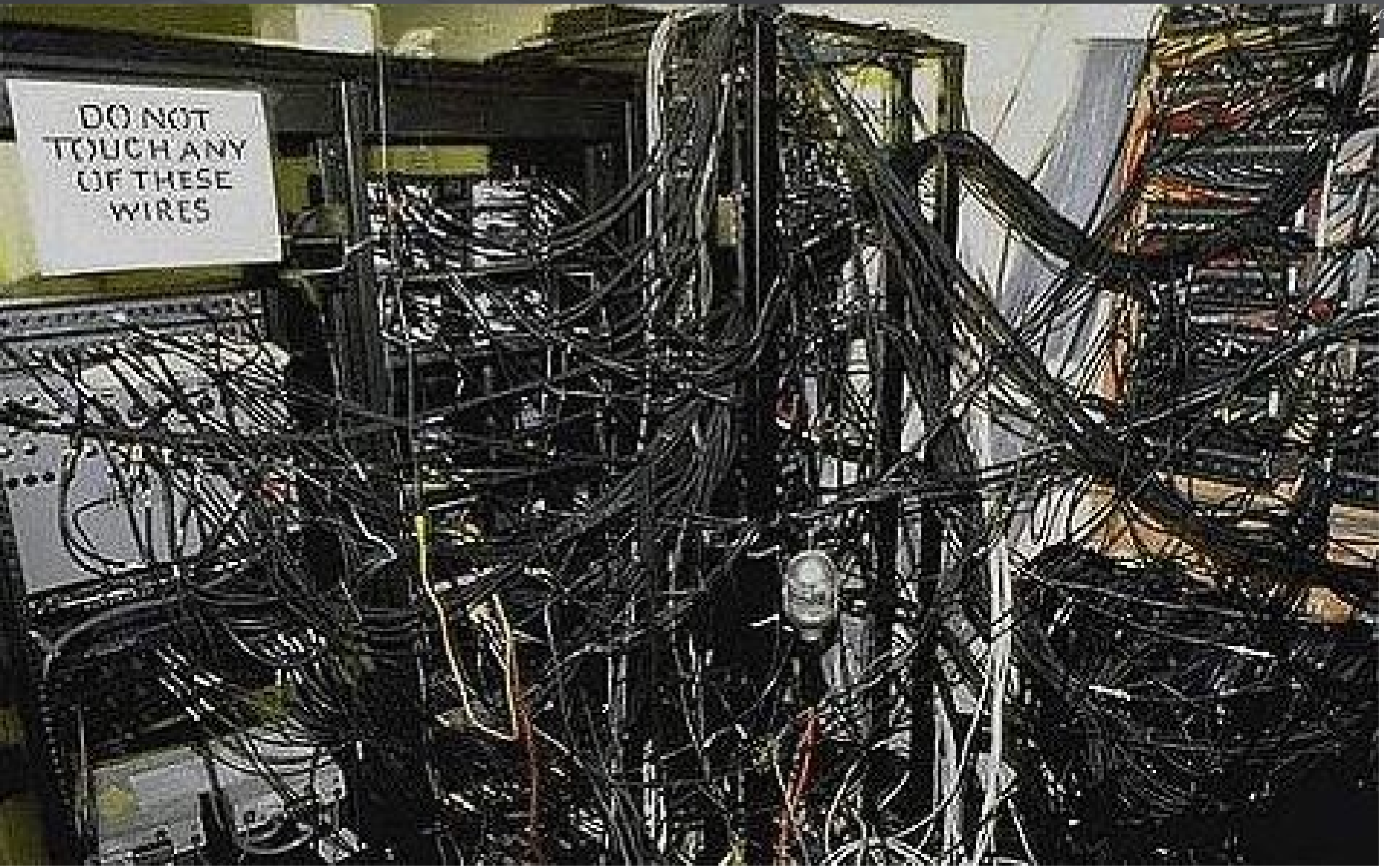

Photo: Bob Davis at Ecotope

In Fact, Controls are Complicated

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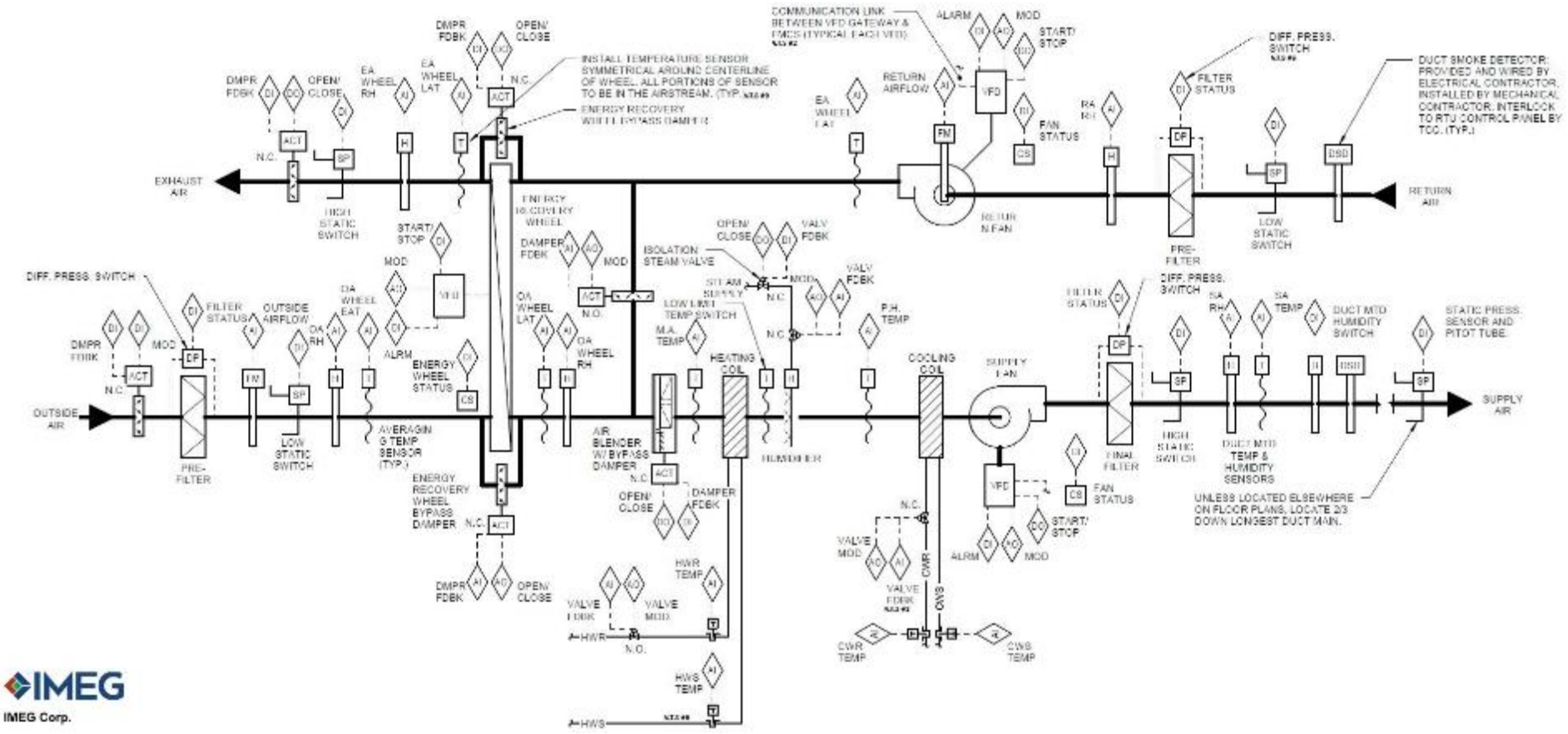
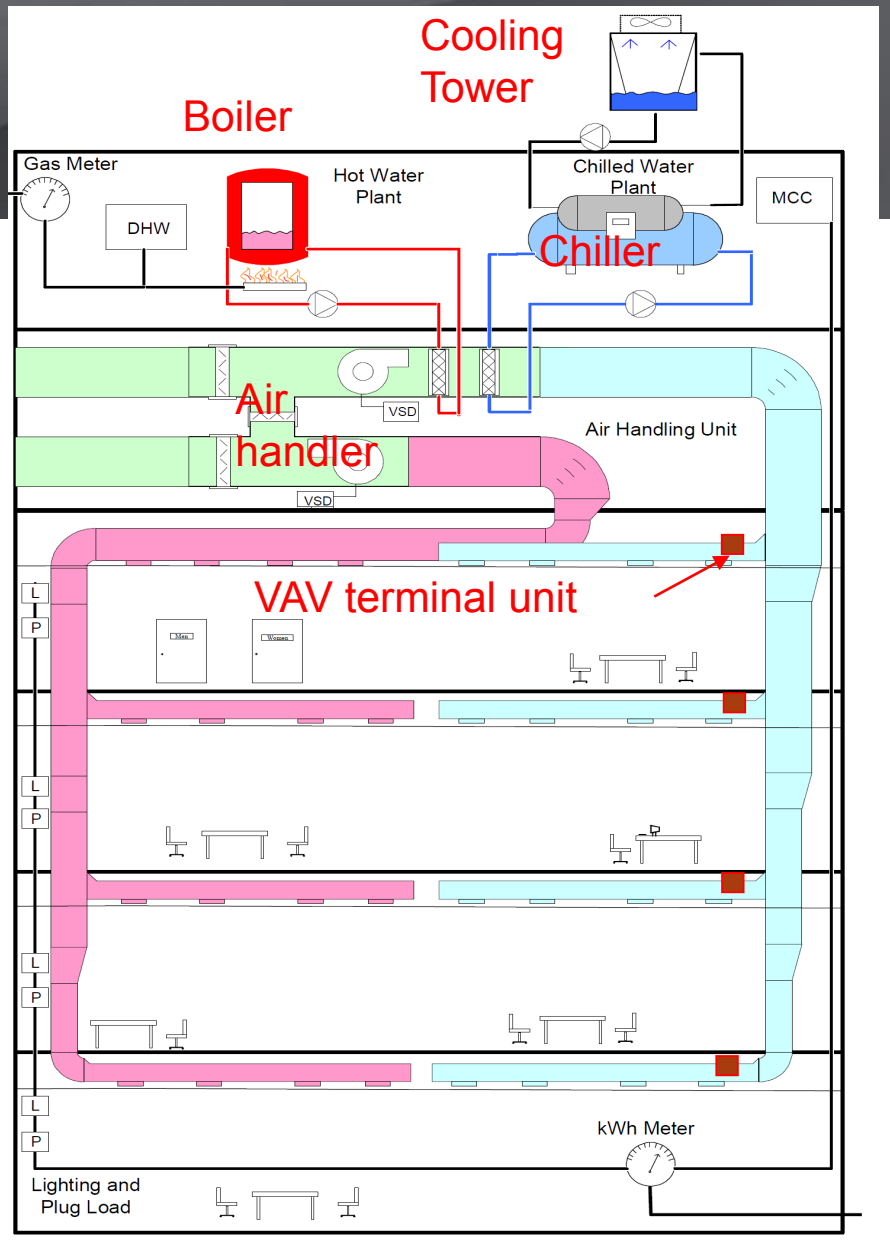


Tying it all Together

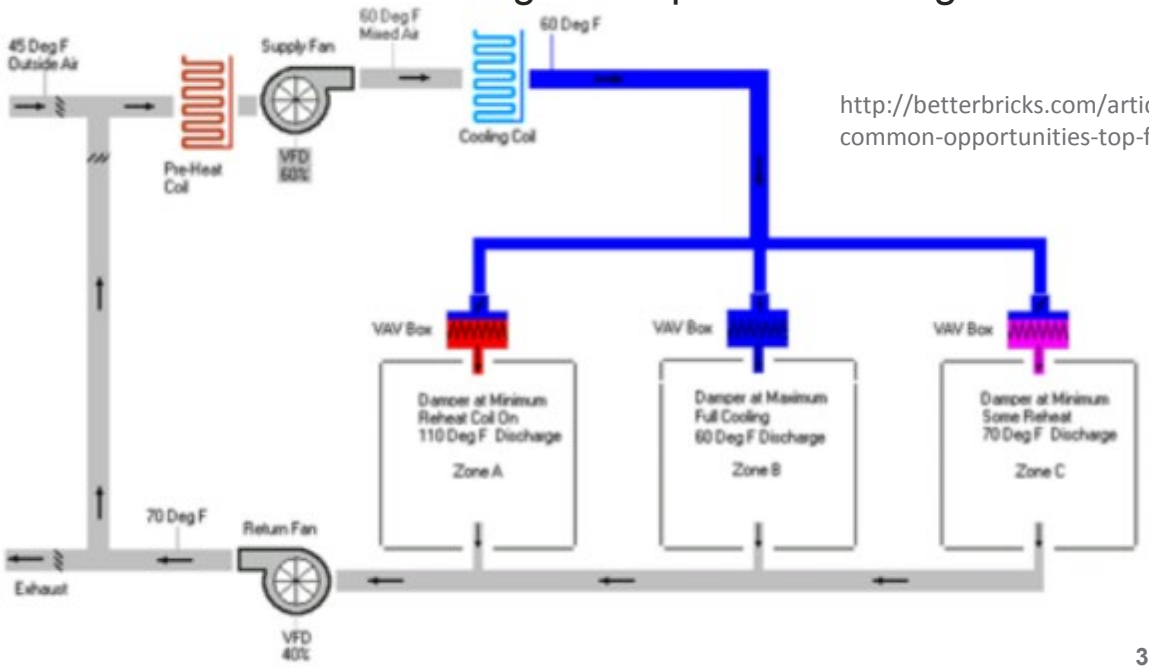
A typical large building commercial HVAC system:

- Central plant:
  - Boiler
  - Cooling Tower
  - Chiller
- Distribution
  - Pumps
  - Pipes
  - Control valves
- Secondary System
  - Air handler
  - VAV terminal units



VAV Multiple Zone System Concept

- One variable air volume (VAV) central air system serves several zones
  - The air handling unit (AHU) maintains the desired
    - Primary supply air temperature (SAT)
    - Duct static pressure (SP) using a variable speed drive
    - The setpoints for both SAT & SP can be reset
    - Has preheat capability and may subcool air to reduce humidity
    - Coordinates the OSA economizer with the cooling coil to provide cooling
- Each zone has a VAV box or terminal unit that:
  - Modulates air flow based on cooling load
  - Maintains minimum airflow for ventilation needs
  - Reheats air to meet heating needs



http://betterbricks.com/articles/common-opportunities-top-five

Multiple zone system example: VAV terminal unit (VAV Box)

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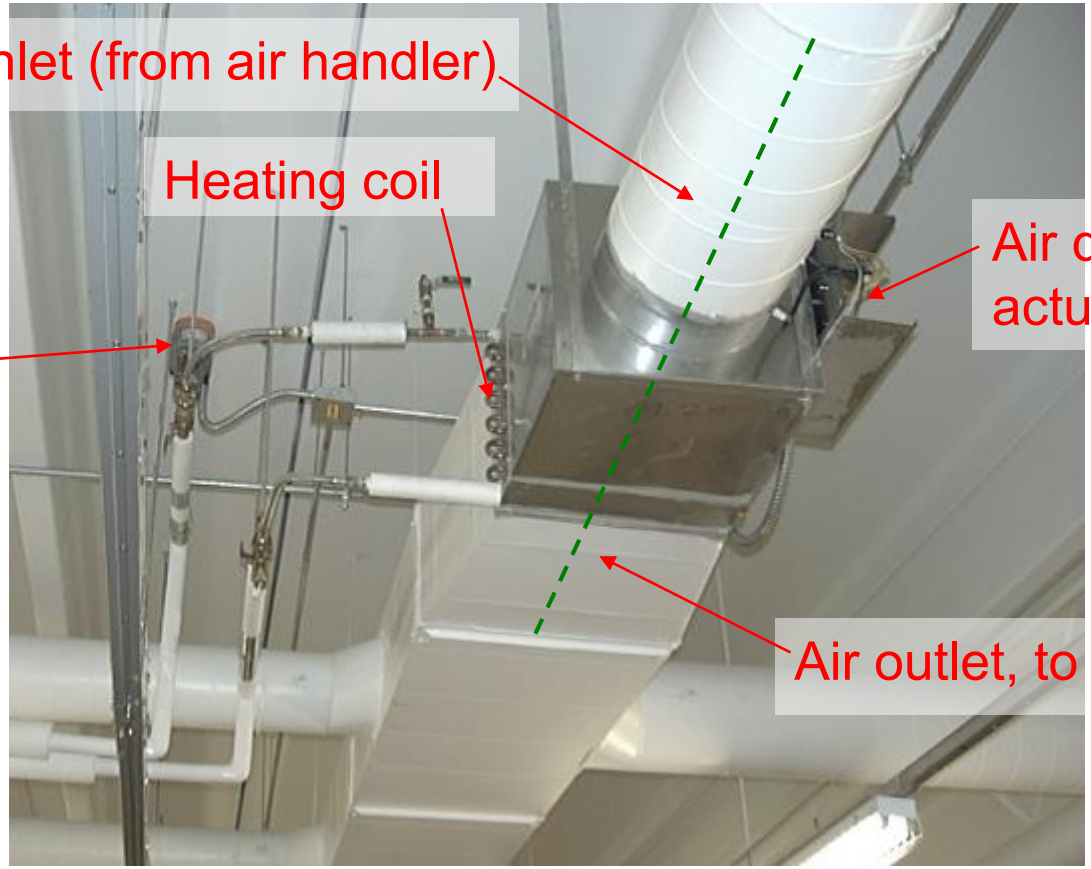

Deadband & Reheat Limit for VAV Boxes

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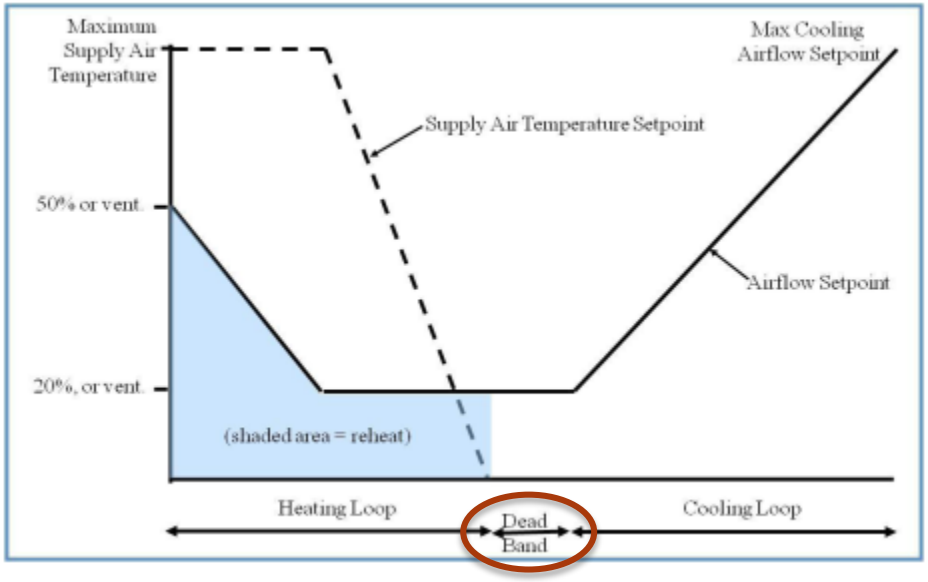
- The deadband requirement applies to VAV boxes too!
  - Just because the lease specification says "temperature shall be maintained at ± 2°F," does not allow a 1°F deadband
  - A 5°F temperature deadband is still required
  - This means separate heating and cooling setpoints are needed
- Between the heating and cooling operation:
  - VAV minimum damper positions shall be maintained
  - The reheat valve is closed
- Minimum ventilation reduces reheat of cooled air
  - 30% of design airflow, or
  - Higher % if saves energy, or
  - Required ventilation



Source: http://energycodeace.com/site/custom/public/reference-ace-2013/index.html#!Documents/56hvaczonelevelsystems.htm

VAV System Ventilation Optimization

- A new requirement in 2015 IECC (C403.4.4.6)
  - Adjusts the primary system outside air rate based on actual box operation
    - Ventilation design is based on VAV boxes at minimum setting
    - When zone supply air is higher than minimum, less outside air is needed at the primary fan to meet ventilation needs in all zones
    - The critical zone for ventilation changes, based on actual cooling loads
- Related to the multi-space ventilation equation in IMC & 62.1
- Significant ventilation air savings at part occupancy loads and higher cooling loads
- *Usually requires commissioning (C408) to verify*

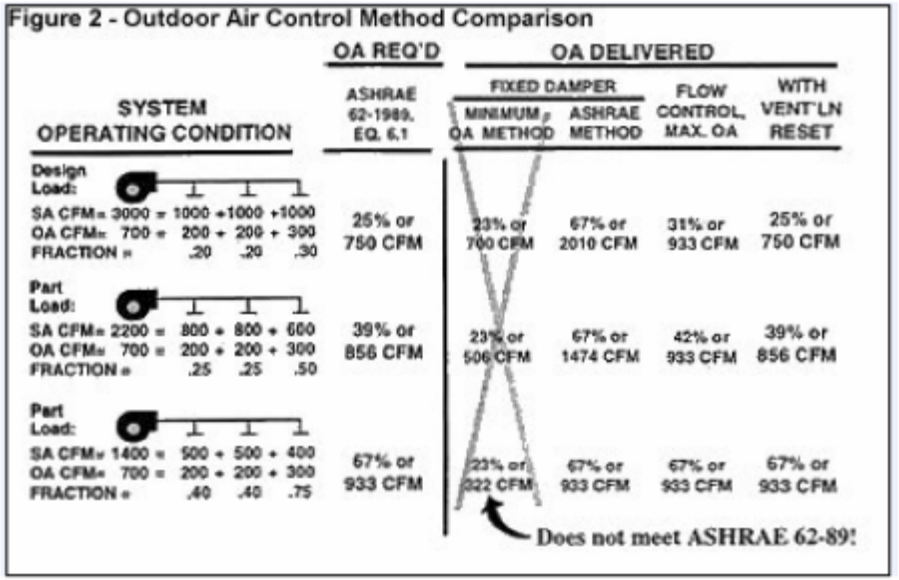


Figure 2 - Outdoor Air Control Method Comparison

SYSTEM OPERATING CONDITION	OA REQ'D: ASHRAE 62-1989, EQ. 6.1	OA DELIVERED: FIXED DAMPER, MINIMUM OA METHOD	OA DELIVERED: FIXED DAMPER, ASHRAE METHOD	OA DELIVERED: FLOW CONTROL, MAX. OA	OA DELIVERED: WITH VENT'LN RESET
Design Load: SA CFM= 3000 = 1000 + 1000 + 1000; OA CFM= 700 = 200 + 200 + 300; FRACTION = .20 .20 .30	25% or 750 CFM	23% or 700 CFM	67% or 2010 CFM	31% or 933 CFM	25% or 750 CFM
Part Load: SA CFM= 2200 = 800 + 800 + 600; OA CFM= 700 = 200 + 200 + 300; FRACTION = .25 .25 .50	39% or 856 CFM	23% or 506 CFM	67% or 1474 CFM	42% or 933 CFM	39% or 856 CFM
Part Load: SA CFM= 1400 = 500 + 500 + 400; OA CFM= 700 = 200 + 200 + 300; FRACTION = .40 .40 .75	67% or 933 CFM	23% or 322 CFM	67% or 933 CFM	67% or 933 CFM	67% or 933 CFM

Does not meet ASHRAE 62-89!

Source: http://internal.trane.com/commercial/uploads/pdf/866/VentilationFanPressureOptimization.pdf

VAV Primary SAT and SP Reset Saves

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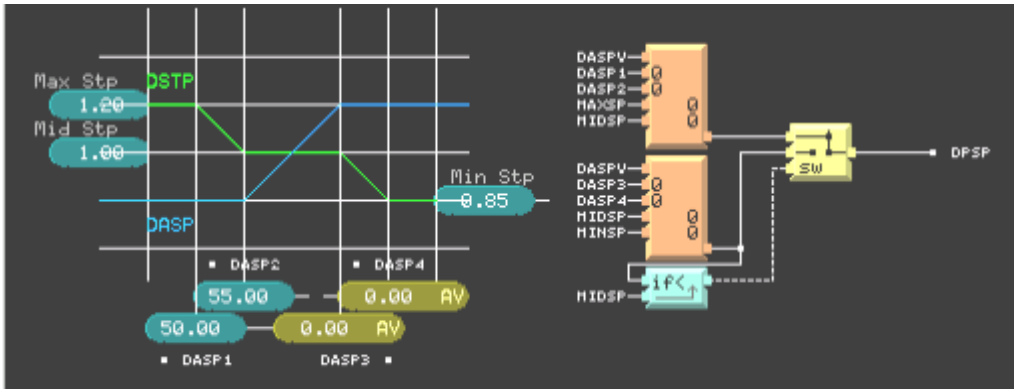
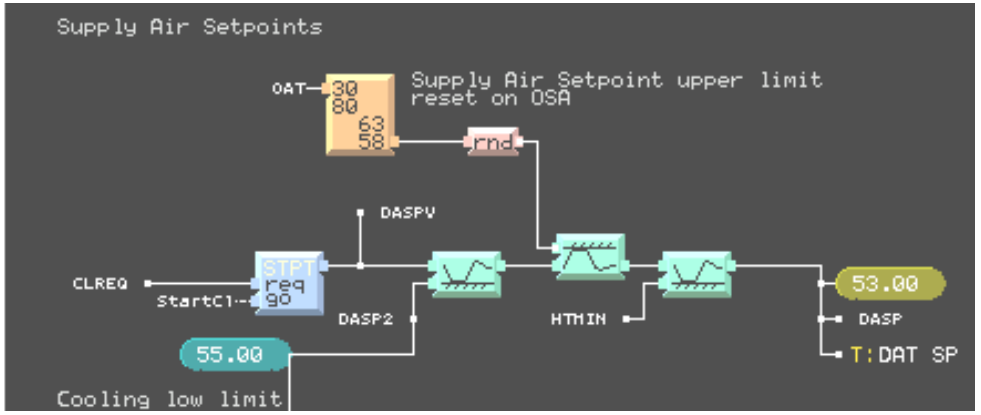
- Reset primary supply air temperature (SAT) (C403.4.4.5)
  - Save with less reheat
  - Tradeoff with fan energy: reduce upper limit when no economizer
  - Improves comfort by reducing terminal gain

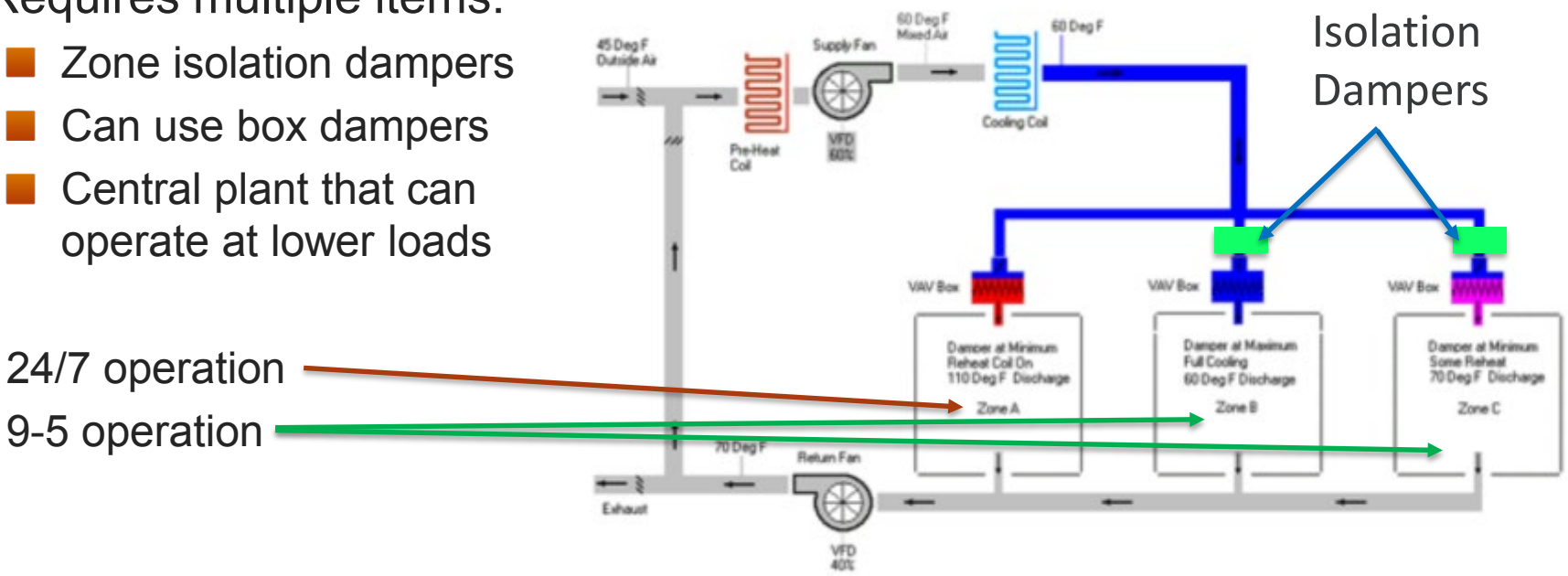


- Coordinate with static pressure reset (C403.4.1.3)
  - Saves fan energy
  - Static pressure sensor location near terminal boxes (C403.4.1.2)
- *Usually requires commissioning to verify*



VAV Multiple Zone Isolation

- Limited Application
  - Systems serving multiple floors or areas > 25,000 sq. ft.
  - Designed to be occupied non-simultaneously.
  - Example: 24/7 IT or security operation in larger building
- Requires multiple items:
  - Zone isolation dampers
  - Can use box dampers
  - Central plant that can operate at lower loads



http://betterbricks.com/articles/common-opportunities-top-five

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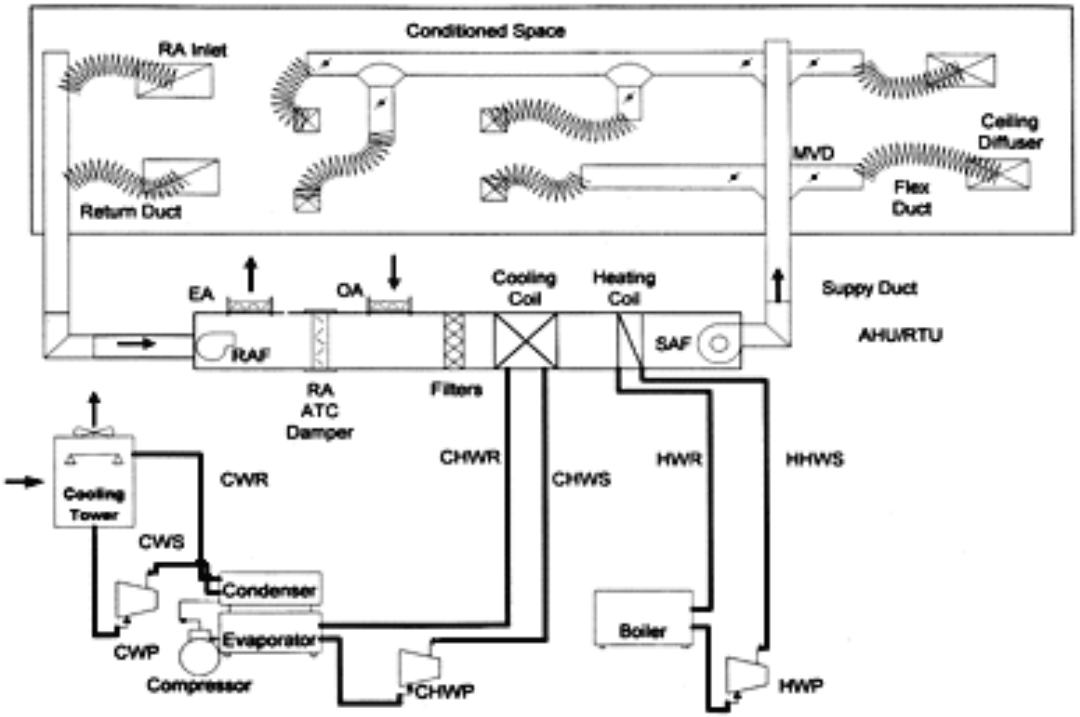
Hydronic System Controls

Hydronic System Variable Flow

- The hydronic system connects the central plant sources of chilled and heated water to the cooling and heating coils in the secondary HVAC systems
- The system includes
  - Pumps
  - Piping
  - Control valves
  - Heat exchangers (coils)
- Most hydronic systems are required to have variable flow (C403.4.2.4)

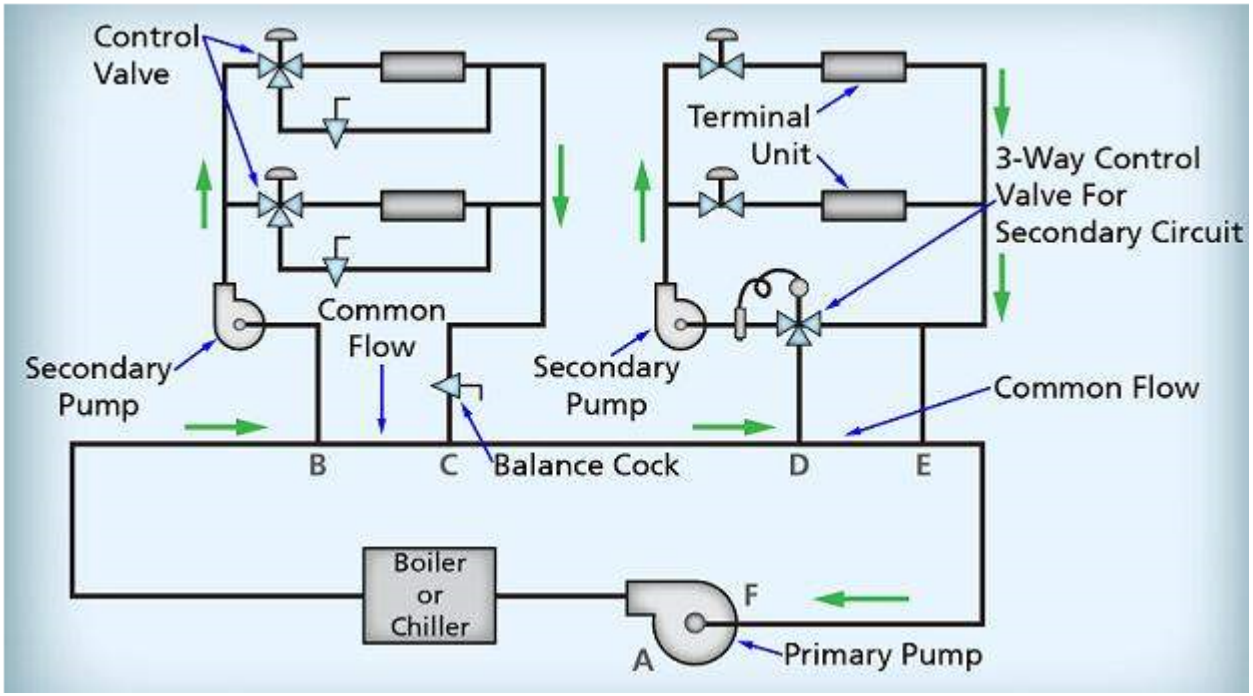


Source: http://affordablehousinginstitute.org/blogs/us/2014/08/thats-rich-harbor-towers-part-8-the-hvac-replacement-a-certain-godlike-remoteness.html

Hydronic Flow Requirements for Chillers/Boilers

- Hydronic systems have two main flow requirements (C403.4.2.4):
  - Variable flow when total pumping is ≥10 hp and capacity ≥ 500 MBH
    - That means mostly 2-way valves!
  - Isolate large primary equipment when not needed for load
- Verify on plans or in the construction documents

Constant Flow Variable Flow



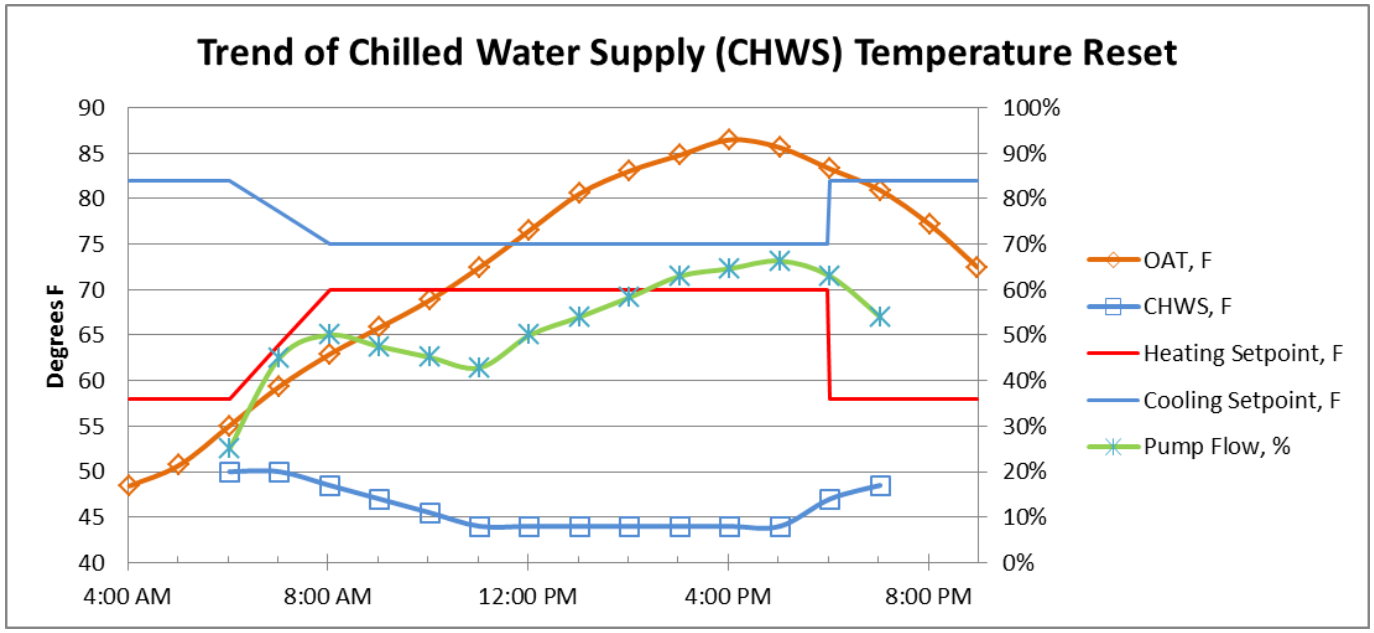
https://www.myodesie.com/wiki/index/returnEntry/id/2990

Source: https://www.belimo.us/americas/ccv.html

Hydronic Temperature Requirements for Chillers/Boilers

- Automatically reset supply water temperature (C403.4.2.4):
  - Reset by at least 25% of difference between design and return
  - Reset can be based on OSA, return temperature, or zone demand
  - Chilled water reset allows the chiller to operate more efficiently
  - Heating water reset reduces distribution losses
- Verify in the construction documents/control sequences
  - Commissioning report should indicate temperature reset (C408)
  - Can see in trend plot on DDC system

Operating the chiller at a higher CHWS supply temperature than design conditions reduces the lift done by the compressor and saves significant energy.



WSHP Hydronic Requirements

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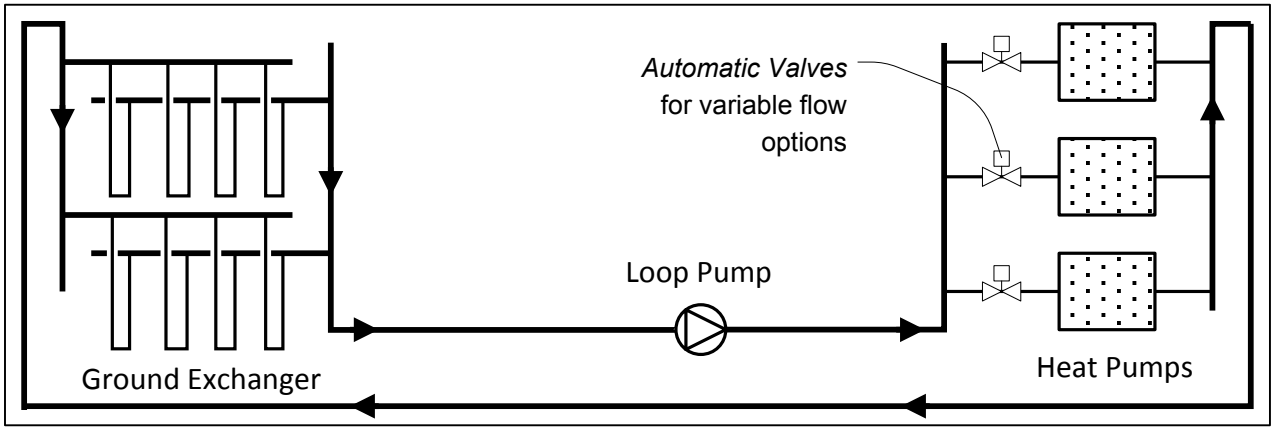
- Water source heat pumps (WSHP) can be:
  - Geothermal
  - Have boiler and heat rejection

  C403.4.2.3 (2015)

  C403.4.3.3 (2018)



Source: Hart, R & W. Price. 2000. "Improving Heat Pump Efficiency." ACEEE 2000 Summer Study.

- Pumping power can be very large in these systems if uncontrolled
  - Minimum requirement when pump motors total more than 10 HP is for a valve on every heat pump to reduce flow and ride the pump curve
  - Heat rejection isolation based on climate zone
- Important controls:
  - Maintain minimum 20°F deadband between loop heating and cooling for loops with boilers and heat rejection cooling towers

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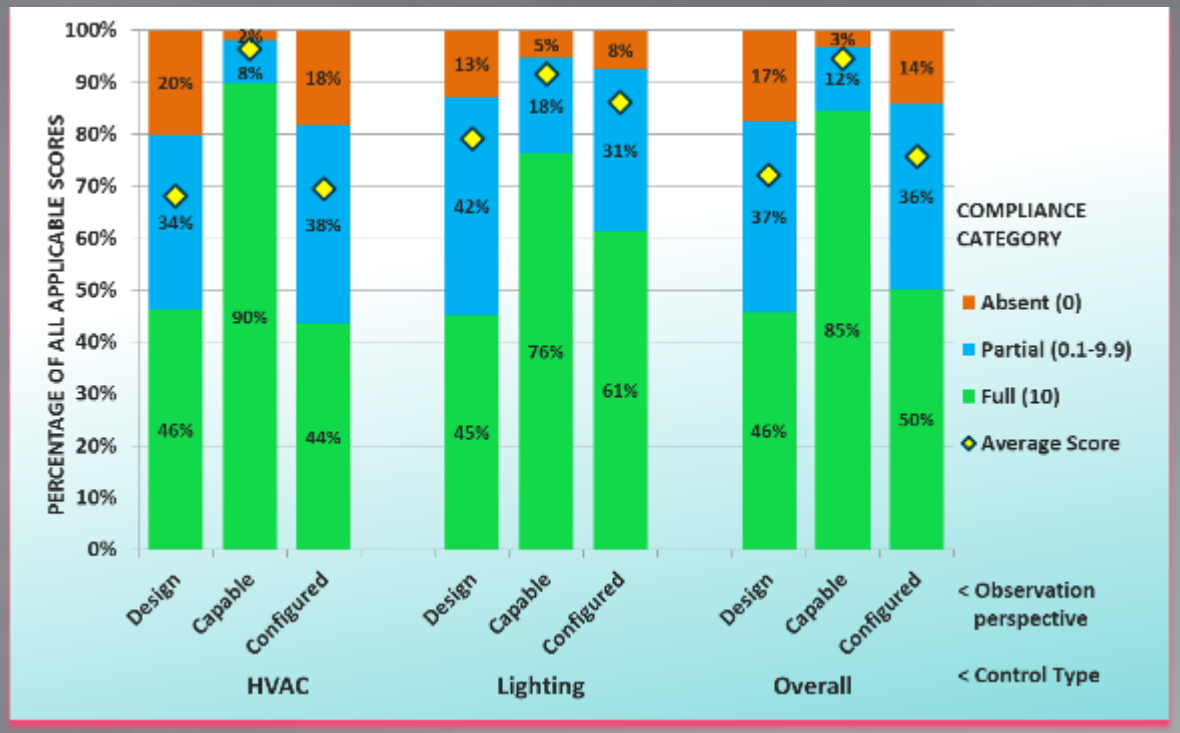
Field Study on Energy Code Control Compliance



Project Introduction

- Background
  - Since 2004, about 30% of all new commercial energy code requirements have been related to building controls
  - Control requirements can be difficult to implement
  - Verification is beyond the expertise of most code officials

Technical Approach for Study

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Implementation of Energy Code Controls Requirements in New Commercial Buildings

Goal: Evaluate high-impact code control requirements

In new buildings, how well are they:

- Designed
- Implemented
- Configured

Identify Requirements

- 14 most impactful code controls requirements

Survey Cx Agents

- Understand the relationship of Cx to energy code controls requirements

Field Study

- Assess the design and implementation of control requirements in 24 new buildings
- Analyze the results for significance and cost impact

Full Project Report (26348)

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26348.pdf

Control Measures Evaluated

- A survey of ASHRAE Standard 90.1 -2013 and the 2015 IECC identified 90 requirements related to controlling building systems or equipment
- Related requirements were grouped into measures
  - Example: Thermostat setback controls
    - Thermostats must have temperature setback when spaces are unoccupied (ex. 55° F heating, 85° F cooling)
    - Programmable controls that start/stop HVAC fan systems with at least 7 schedules
    - Manual unoccupied override for maximum of 2 hours
- Resulted in 51 measures
- Ranked independently by 6 experts for:
  - Applicability in buildings
  - Energy impact of non-compliance
  - Likelihood of non-compliance
- 14 measures selected
  - 10 HVAC
  - 4 lighting

14 Highest Ranked Control Measures Selected

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	Abbreviation	Control Measure Description
HVAC	TstatDdBnd	Five degree thermostat deadband; setpoint overlap prevention
	TstatSetbk	Off-hour automatic temperature setback and system shutoff (fan cycling) with manual override
	OptStart	Optimum start controls
	DCV	Demand controlled ventilation
	AutoDamp	Automatic outdoor air damper shutoff
	EconoInt	OSA economizer exists with integration and proper high limit
	ZoneIso	Zone isolation controls (VAV)
	SimultHtCl	Limits on simultaneous heating and cooling – airside (VAV)
	SP-Reset	Fan static pressure reset controls (VAV)
	SAT-Reset	Supply air temperature reset - reheat systems (VAV)
Lighting	OccSenLtg	Occupant-based interior lighting controls
	DayLtgCtl	Daylighting controls implemented correctly when required
	ExtLtgCtl	Exterior lighting controls
	IntLtgCtl	Timer-based interior lighting controls

Field Study

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- 24 buildings of varying type:
  - 4 Office
  - 1 Fitness Center
  - 2 Dormitory
  - 2 Retail
  - 3 Medical Office
  - 2 Hospital
  - 9 Education: Higher Ed & K-12
  - 1 Multipurpose:
    (studio, cafe, office, hot yoga)
- Building floor area range
  - from 10,000 to 240,000 square feet
  - Median size of 70,000 square feet
- Six states, 3 climate zones; PNW & Mountain regions

Location (State)	Climate Zone	No. of Buildings
Colorado	5B	1
Idaho	5B	3
Oregon	4C	4
Utah	5B	6
Washington	4C	2
Washington	5B	4
Wyoming	6B	4

Field Study Perspectives

- 14 Measures were evaluated
  - 10 HVAC (including 4 VAV-RH)
  - 4 lighting
- Evaluate three perspectives
  - **Design**: Is the requirement completely specified in design documents?
  - **Capability**: Can the installed components achieve the code required controls sequence?
  - **Configuration**: Are the controls correctly implemented and configured in the building?

Field Study Scoring

- Past compliance studies use a pass/fail approach
- Here, each measure scored for each perspective (0 to 10)
  - Zero indicates complete non-compliance
  - Ten indicates fully compliant or exceeding compliance
  - Scores between zero and ten based on field observation and scoring system
- Scoring example –thermostat setback controls
  - Required setback: heating at 55° F, cooling at 85° F:
    - 8 points: Full range setback/setup (30° deadband during setback)
    - 4 points: 15° combined setback/setup deadband
    - 0 points: no setback
  - Manual override required:1 point if override included
  - 7-day programming required:1 point if included

Field Study Group Results

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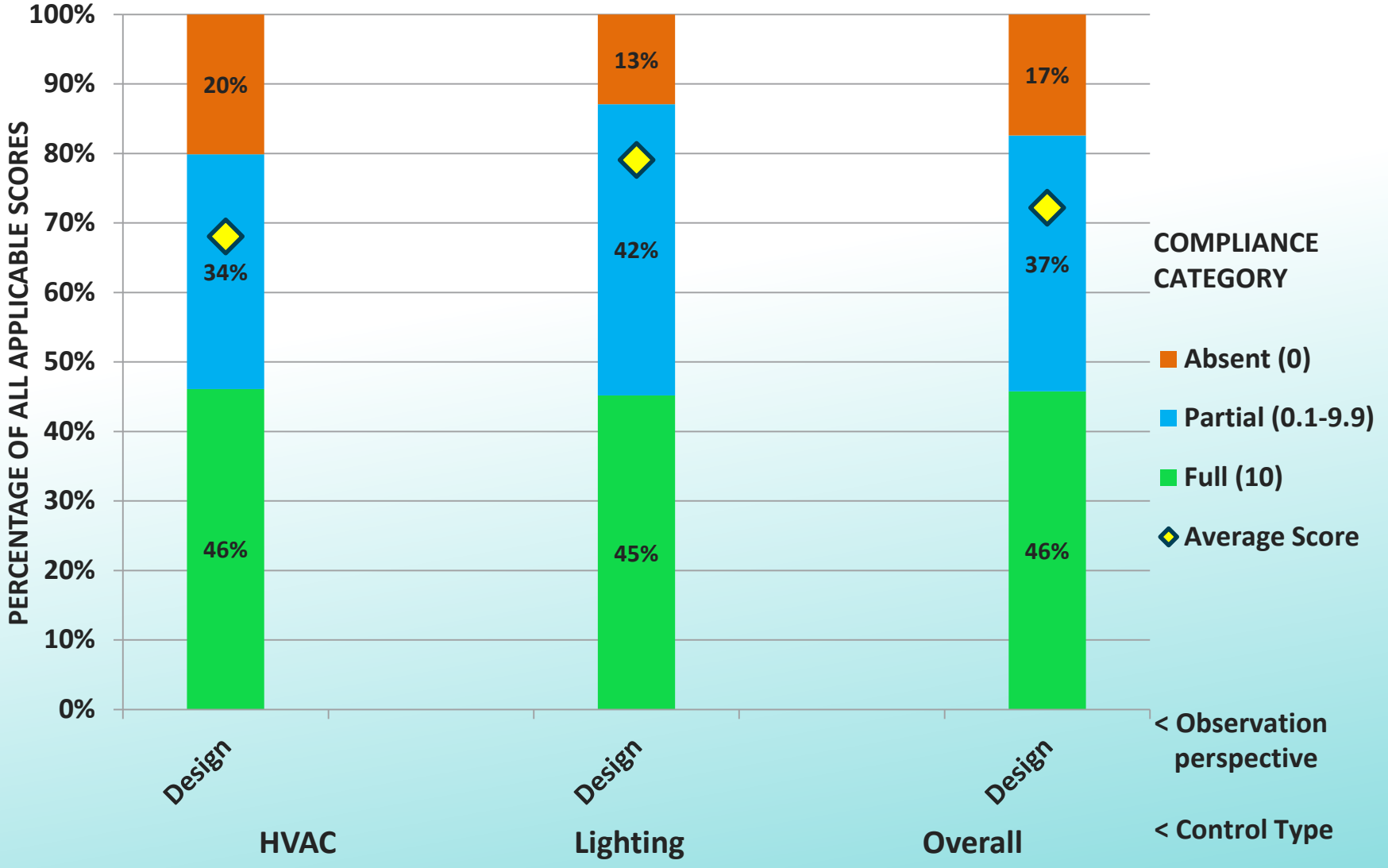

Field Study Group Results

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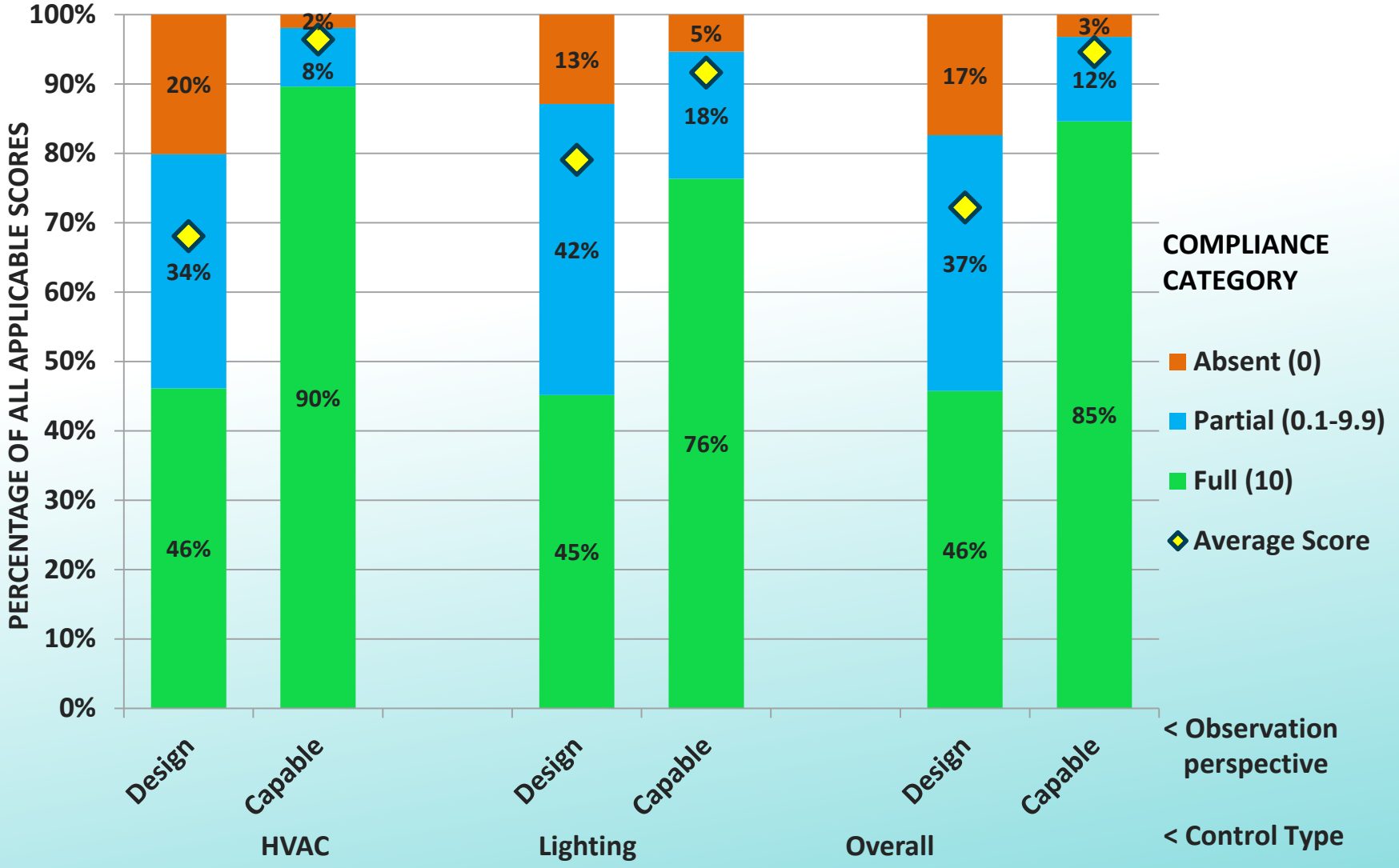

Field Study Group Results

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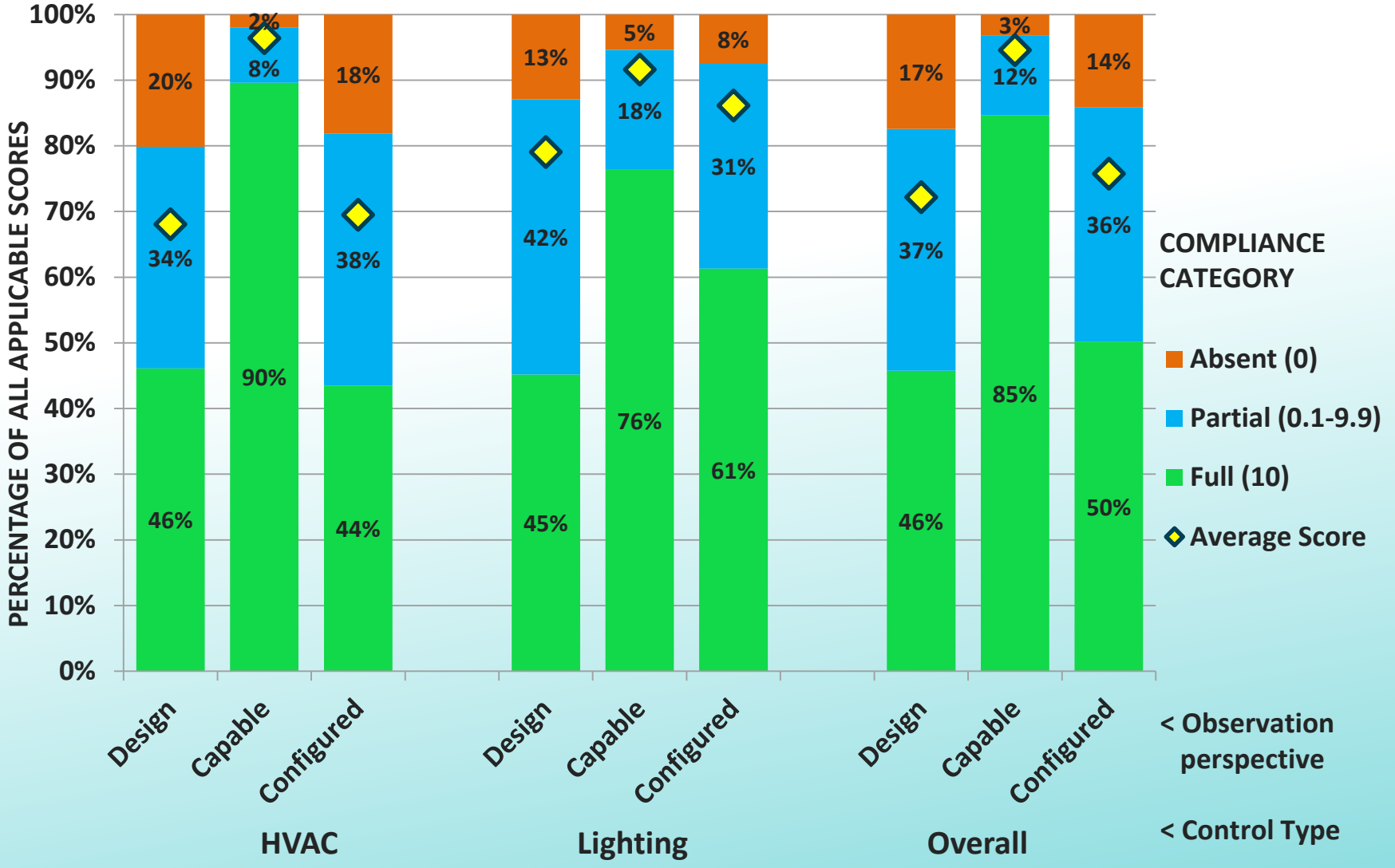

Field Study Measure Results

Shaded measure lost savings not significant

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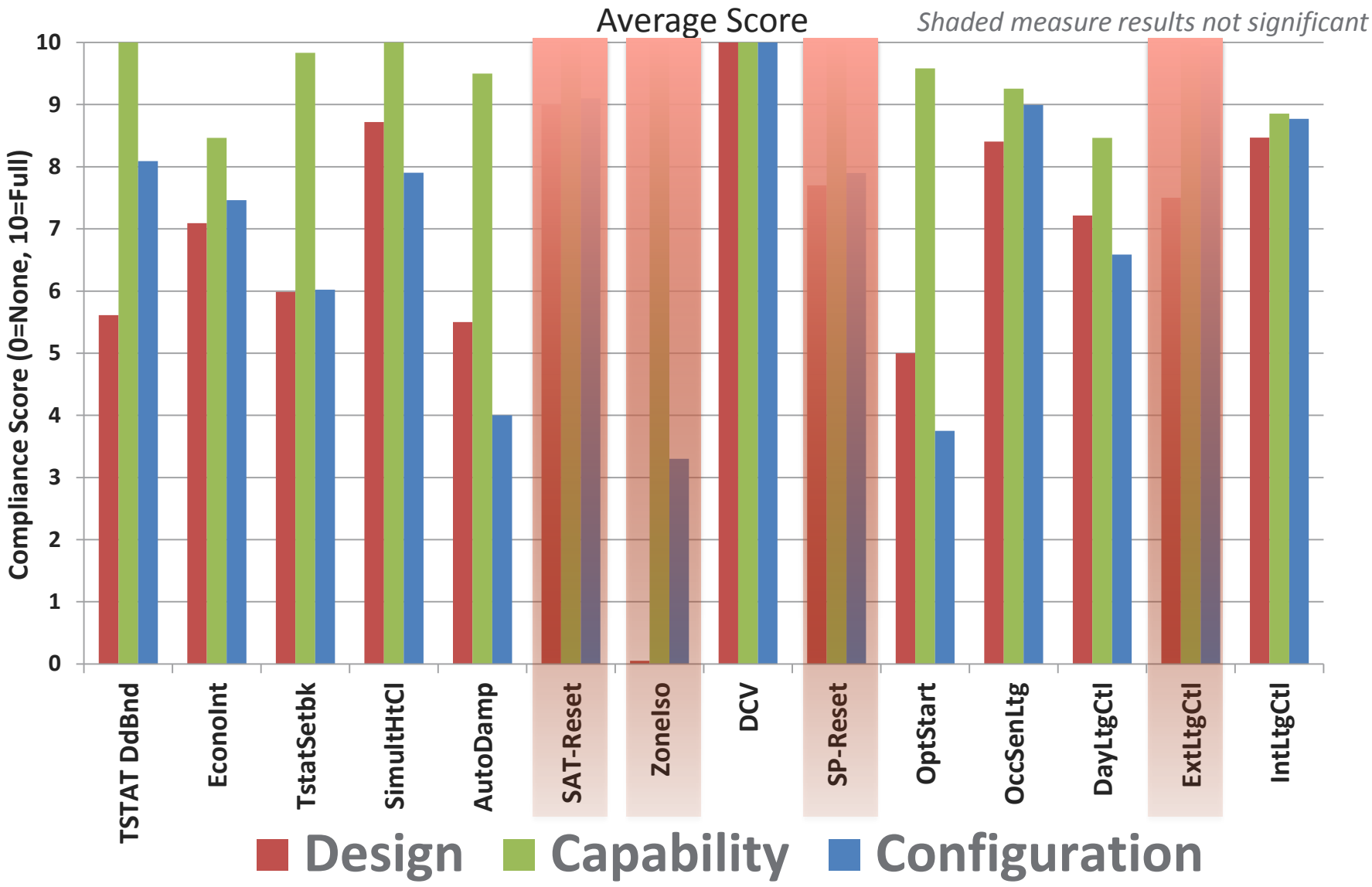

Energy Cost Impact of Non-Compliance

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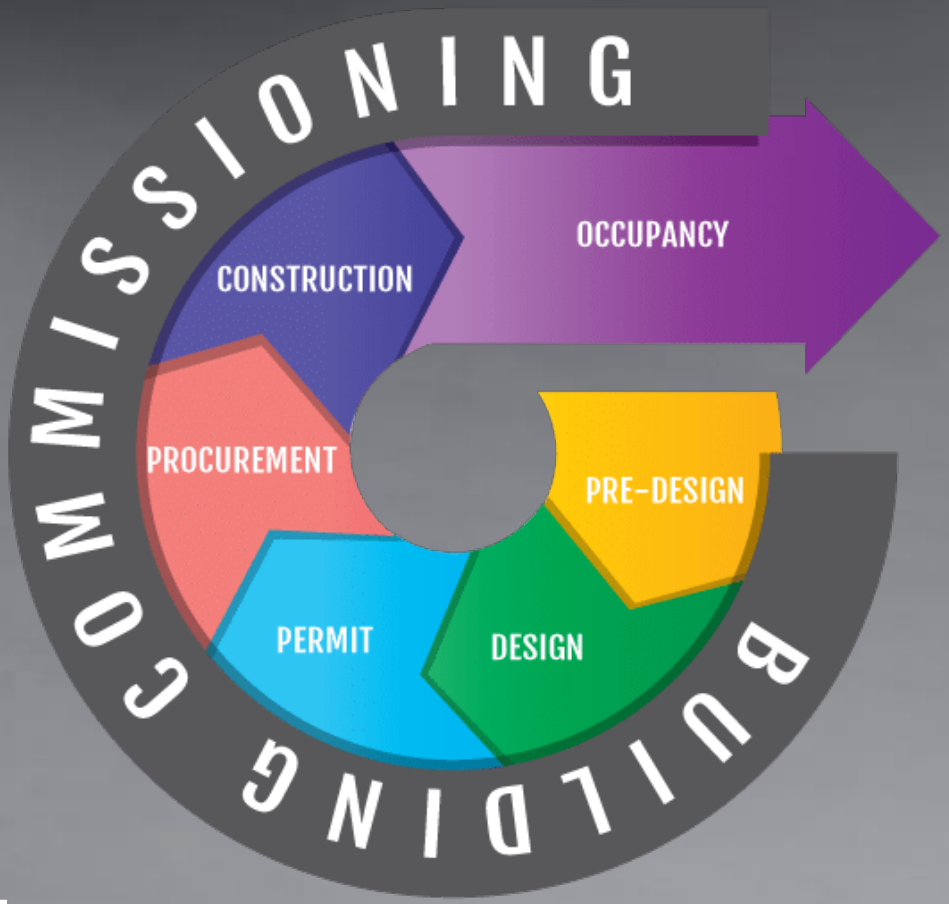
Approximate Lost Savings from Non-Compliance for 24 Buildings

Measure Category	Lost Savings $/year Total Sample	Lost Savings $/year per Building	Lost Savings $/k ft²-yr	Present Value Lost Savings $/k ft²
HVAC	$288,000	$12,000	$160	$2,026
Lighting	$14,000	$570	$8	$96
Overall	$302,000	$12,570	$168	$2,122

If the energy code controls were correctly configured, an **added ~12%** of total building energy cost could be saved.

Basis: application of similar control savings from prior studies (see project report)

Functional Testing and Commissioning



Commissioning (Cx)

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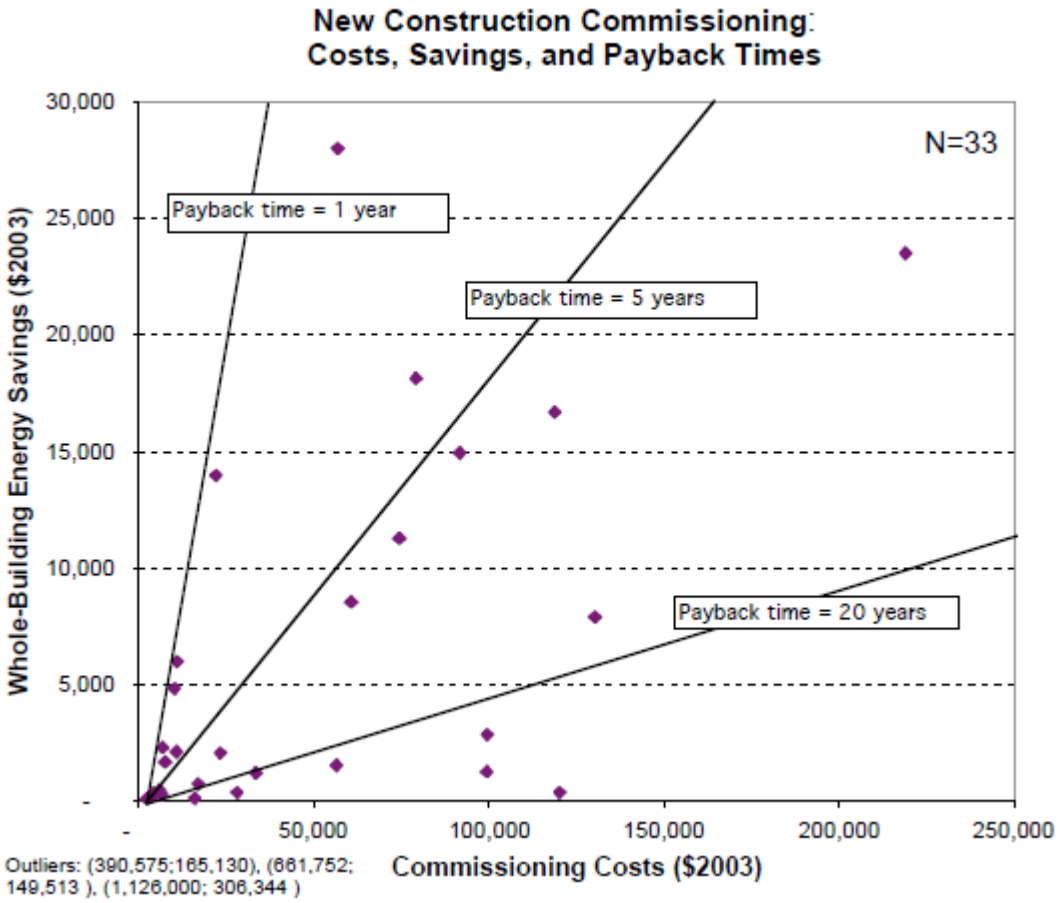
- Commissioning of systems provides savings
  - Commissioning improves both comfort and energy savings
  - Commissioning is a systematic process not directly involved in construction
  - ASHRAE Standard 202 and Guideline 0 provide Cx guidance
- Commissioning required by energy codes
  - 2012 IECC added chapter C408 with
    - HVAC Cx above a certain system capacity
    - Lighting functional testing
  - 2015 IECC added reporting and process clarifications and service hot water
  - 90.1-2007 has HVAC system commissioning
  - 90.1-2010 added lighting functional testing
  - 90.1-2016 added envelope air barrier verification
  - 90.1-2019 clarified functional testing and commissioning
    - Unified documentation across disciplines; includes design phase Cx
    - Added service hot water and power functional testing
    - Requires commissioning report for buildings > 50,000 square feet except warehouses
    - Includes informative appendix showing integration with ASHRAE Standard 202

Why Commissioning?

- New building Cx saves 7% to 16% annual energy
- Total Cx payback mostly less than 7 years.
- Energy related Cx only a part of that, so energy measure payback is actually shorter
- We assume all the field assemblies and controls work: but do they?

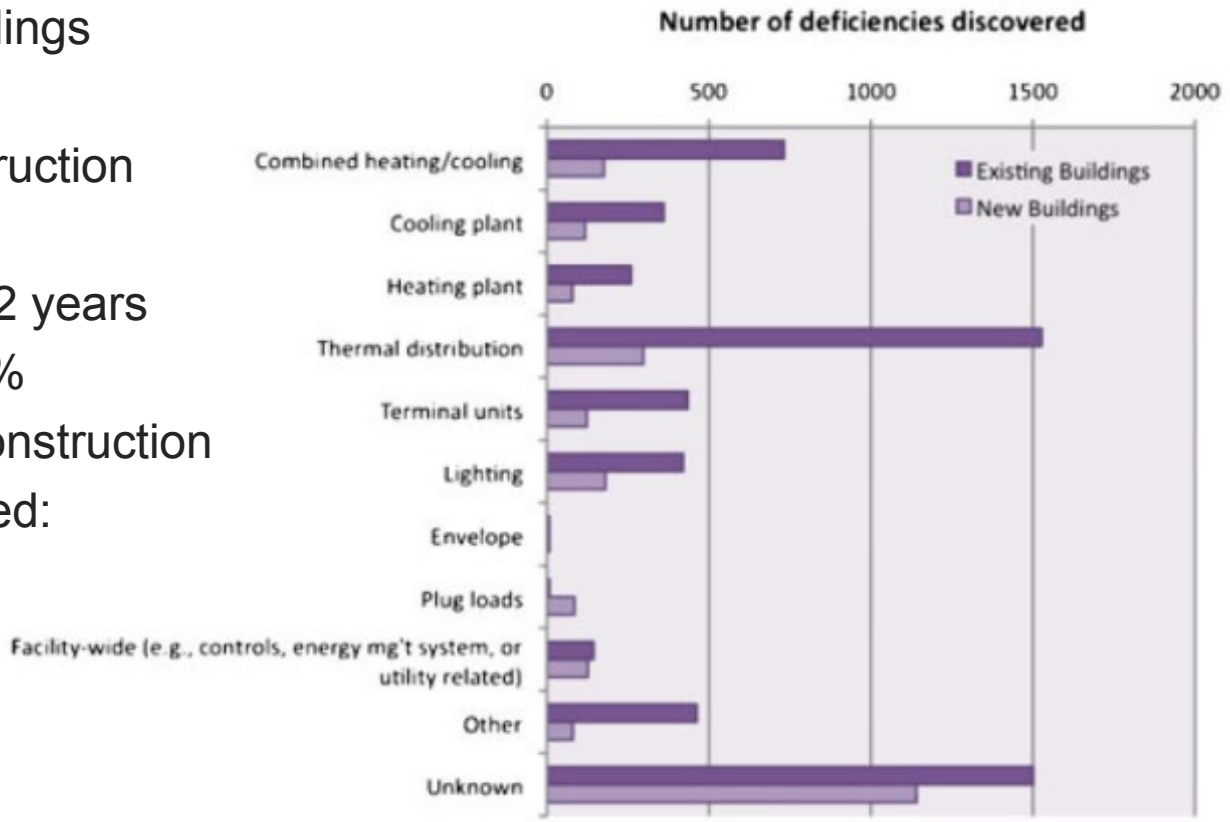


Commissioning is Cost Effective

Cx meta study by Evan Mills, LBNL

- 82 new construction buildings
- In study of 643 buildings
- 26 states
- Cost: 0.4% of construction
- Median BCR: 1.1
- Median payback: 4.2 years
- Energy savings: 13%
- 8.8 million sf new construction
- Deficiencies identified:

  3,528 or 43/bldg.



Conclusions

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- HVAC Controls Required by Energy Codes Save Energy
  - Basic setback, deadband, time controls, and OSA dampers
  - Economizers, DCV, and zone isolation
  - VAV deadband, reheat limits, optimization, SAT/SP resets
  - Hydronic system variable flow, temperature resets
- Field Study Results
  - High correlation between **design** and **configured**
  - Only **50%** control observations fully **configured**; mean score of 7.6
  - **95%** of observations **capable** of compliance
  - Substantial energy savings potential: 12% of energy cost
- Suggestions:
  - Review designs for controls required by Energy Code
  - Clarify energy code commissioning requirements for controls
  - Improve design specificity on controls

Added Conclusions

Are we getting real energy savings from building code control requirements?

YES!

Could we save more?

YES!

U.S. DOE: Building Energy Codes Program Resources

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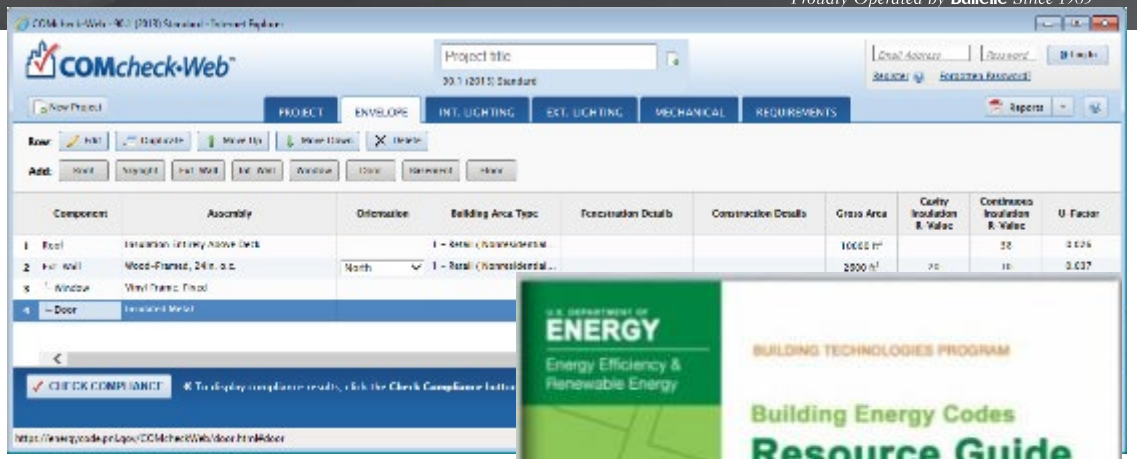
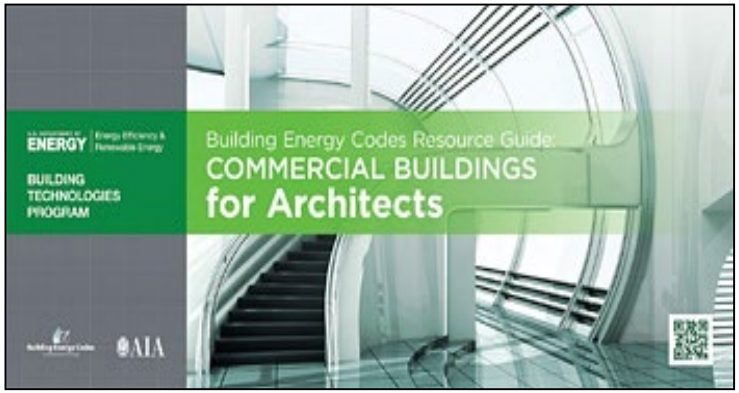
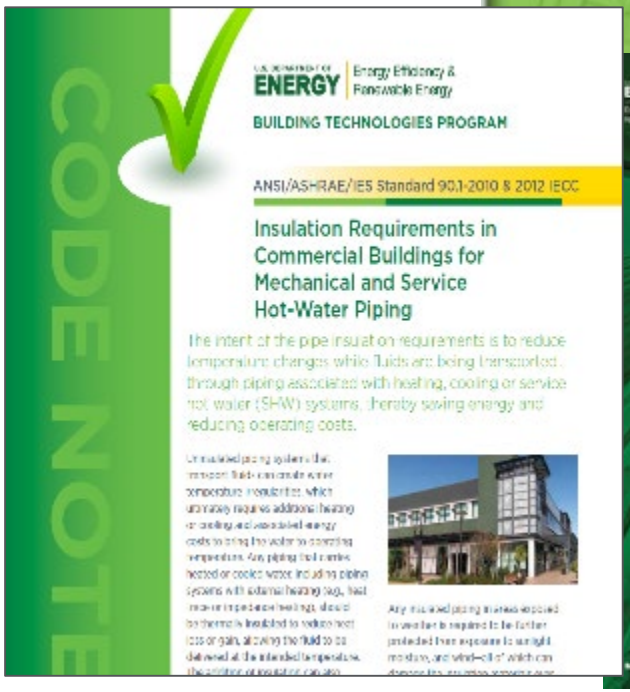
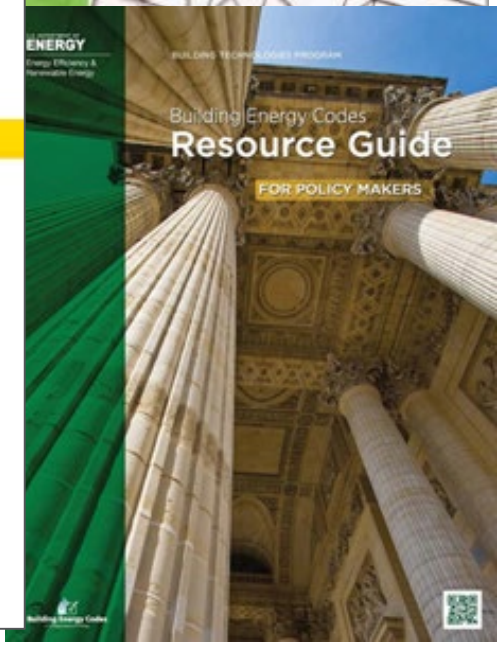
- Compliance software
- Technical support
- Code notes
- Publications
- Resource guides
- Training materials

www.energycodes.gov









THANK YOU!

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Building Energy Codes Program
www.energycodes.gov

BECP help desk
https://www.energycodes.gov/HelpDesk

Questions

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