CALIFORNIA ENERGY COMMISSION

2013 Building Energy Efficiency Standards Staff Workshop

Residential Zoned AC

July 15, 2011

Background

- Proposal sponsored by the California Statewide Utilities Codes and Standards Program as a Codes and Standards Enhancement (CASE) study

- CASE study authors
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  - Rick Chitwood, Chitwood Energy Management, Inc

Agenda

- Summary of current code requirements
- Typical practice
- Summary of code change proposals
- Data/findings
- Code change proposals

Current Code Requirements

- Prescriptive air flow requirement for 350 CFM/ton in every zonal mode, can be traded away.
- Performance credit (easier heating and cooling setpoints) for zonal systems capable of maintaining different set points in “living” and “sleeping” zones.
  - Return in each zone.
  - 40 sq. ft. maximum uncontrolled opening between zones.
  - No measurable airflow at registers in any location except zone(s) calling for conditioning.
- No restrictions on variable capacity, control type, number of units, commissioning etc.
- Mandatory set back thermostats for all systems

Typical Practice

- Two types of zonal systems are common:
  - Multiple systems, one for each zone
    - High performance & higher cost
  - Single system with dampered supply ducts
    - Return ducts are not zoned
    - Single speed compressors and fans can't modulate to track load
    - Supply air flow is low, even with all zones calling.
    - Bypass ducts (short circuit from supply into return) are common
    - Results -- low EER

Code Change Proposals

- Eliminate bypass ducts
- Delete the current zonal AC performance compliance credit.
- Mandatory airflow and fan Watt verification in all zonal cooling modes

  (the airflow and Watt draw mandate also apply to single zoned systems)

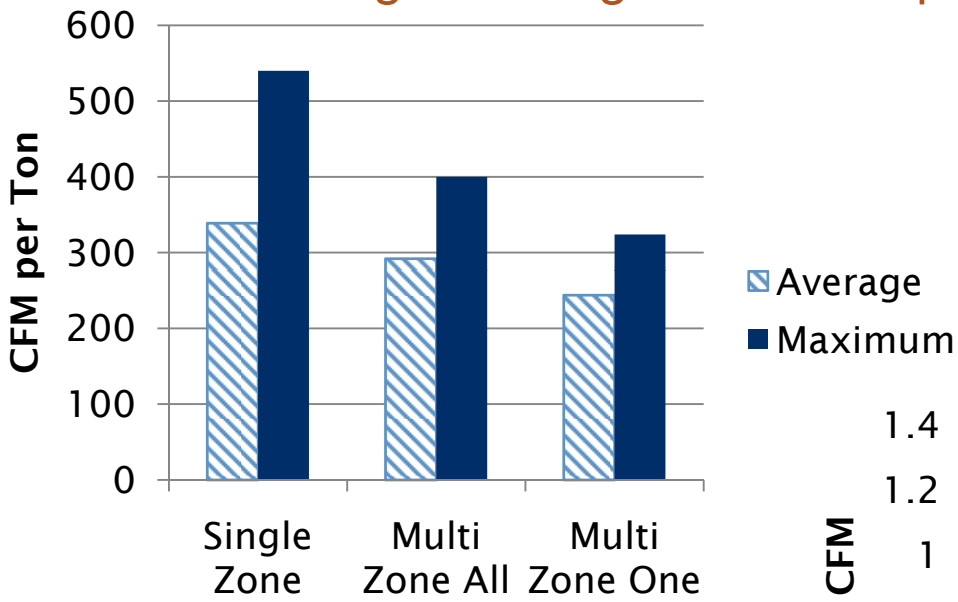
California New Home Energy Survey

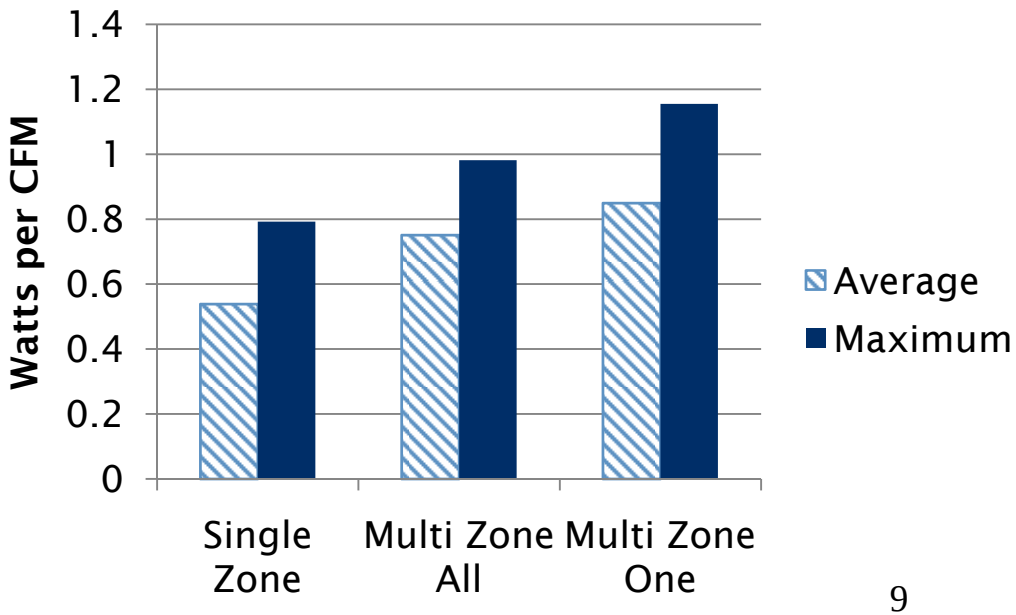
- Field survey of a sample of 80 new 2007 CA homes and found:
- AC systems have low capacity and efficiency
- Cooling duct pressures are very high
- Cooling Fan Watts are high

12% of the Ducted Systems are Dampered Multi-Zoned

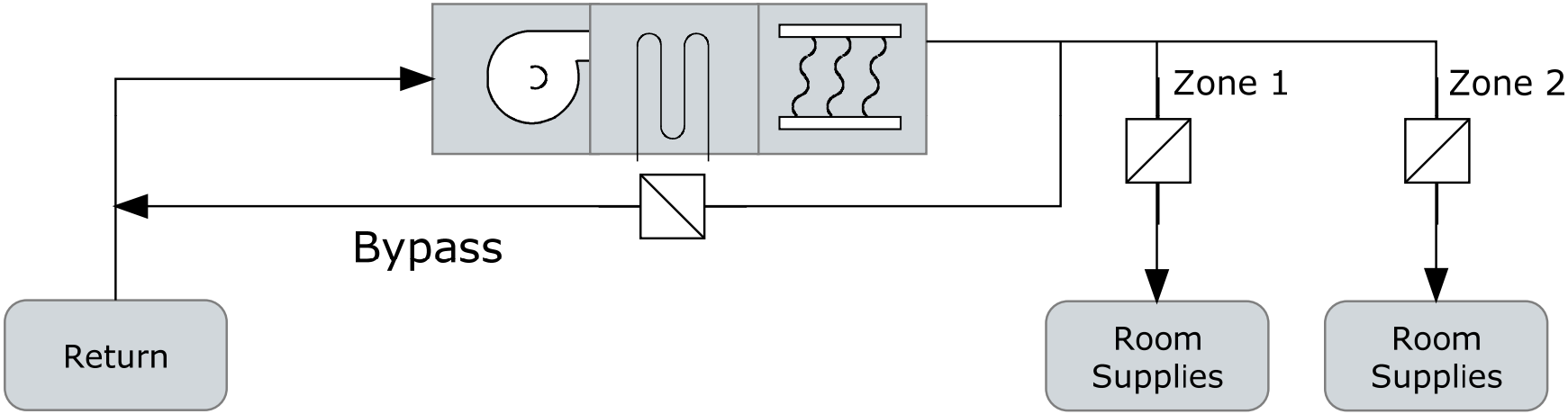
Single Split System	38 (Zoned and not Zoned)
Combined Hydronic Systems	11
Multiple Split Systems	17
Heat Pumps	6
Zoned Split Systems	10 (1 Heat Pump)
Package System	6
Furnace Only Systems	3
Radiant Floor System	3
PTAC systems	2
Resistance Electric System	1
Wall Furnace	1

Dampered Multi-Zone Systems have Low CFM per Ton and High Cooling Fan Power per CFM





Typical Dampered Multi-Zone AC System With Bypass Duct



How Zoning with Bypass Works

- In Theory
  - With all zones calling damper closes and bypass has no effect. All zones get the design air flow
  - When only one zone calls, whatever isn't delivered to that zone is bypassed to the return to maintain coil air flow avoiding increased velocity and noise.

- Actually
  - Mixing in bypass air lowers the return air temperature entering the cooling coil and this ALWAYS significantly lowers the EER.
  - Because of dampers and duct design the air flow is typically very low even when all zones are calling
  - Extra dampers and ducts make systems more prone to construction error, failures are common, and duct conduction losses increase.

Bypass Duct
Flex From Supply to Return

16” Bypass Duct in House 41

Stakeholders Comments

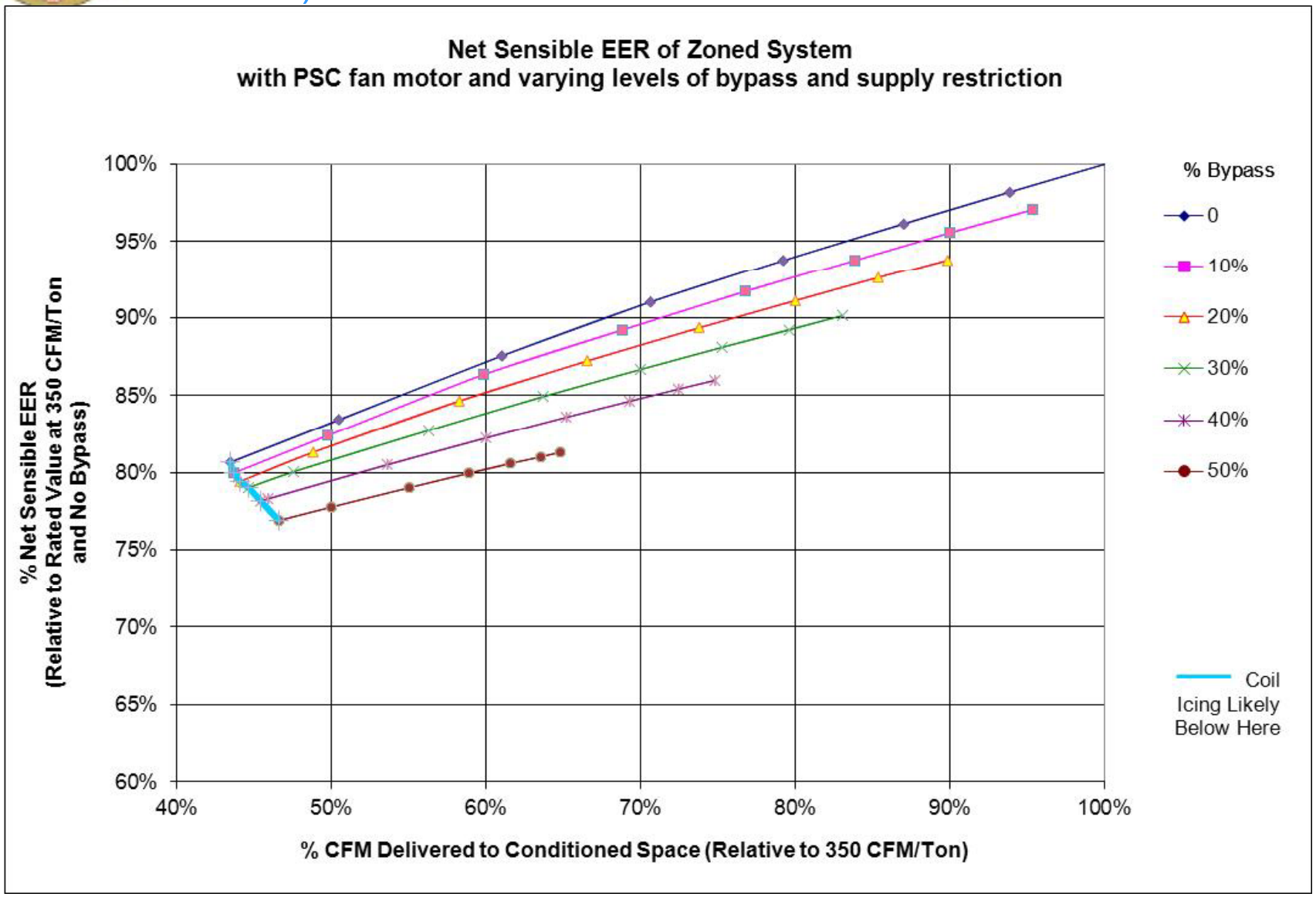
- Air Conditioning Contractors of America and American Heating and Refrigeration Institute (Manufacturers)
  - Want to maintain the current credit for zoned systems, arguing that in some cases there is an energy savings.
  - Want to maintain the use of the bypass duct.

Research on Dampered Multi-Zone Systems

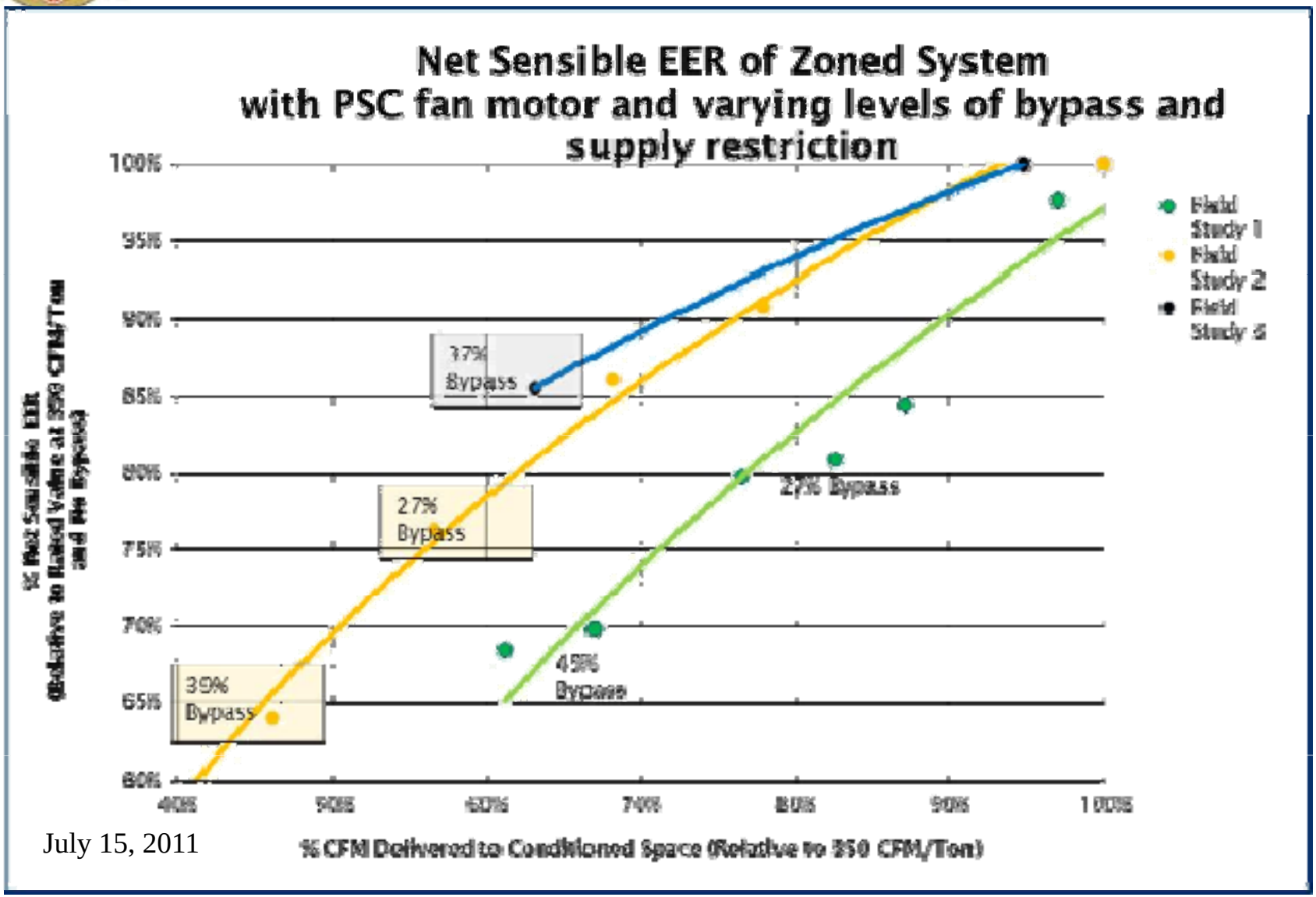
- National Association of Home Builders and Carrier (Kenney & Barbour 1994)
  - "Studies have demonstrated that a multi-zone system will use more energy than a central thermostat system when a constant setpoint is used. **A 35 percent increase was documented** (Oppenheim 1991) as a direct result of a multi-zone system being more responsive to the cooling needs of the entire house.".

- American Society of Heating Refrigeration and Air-Conditioning Engineers Paper
  - "**Zoning with a no-thermostat setup used more electricity for cooling than the system in a central configuration with no thermostat setpoint scheduling.** The reason is that by having temperature control at three points instead of just one, the air-conditioning unit was more responsive to the house load."

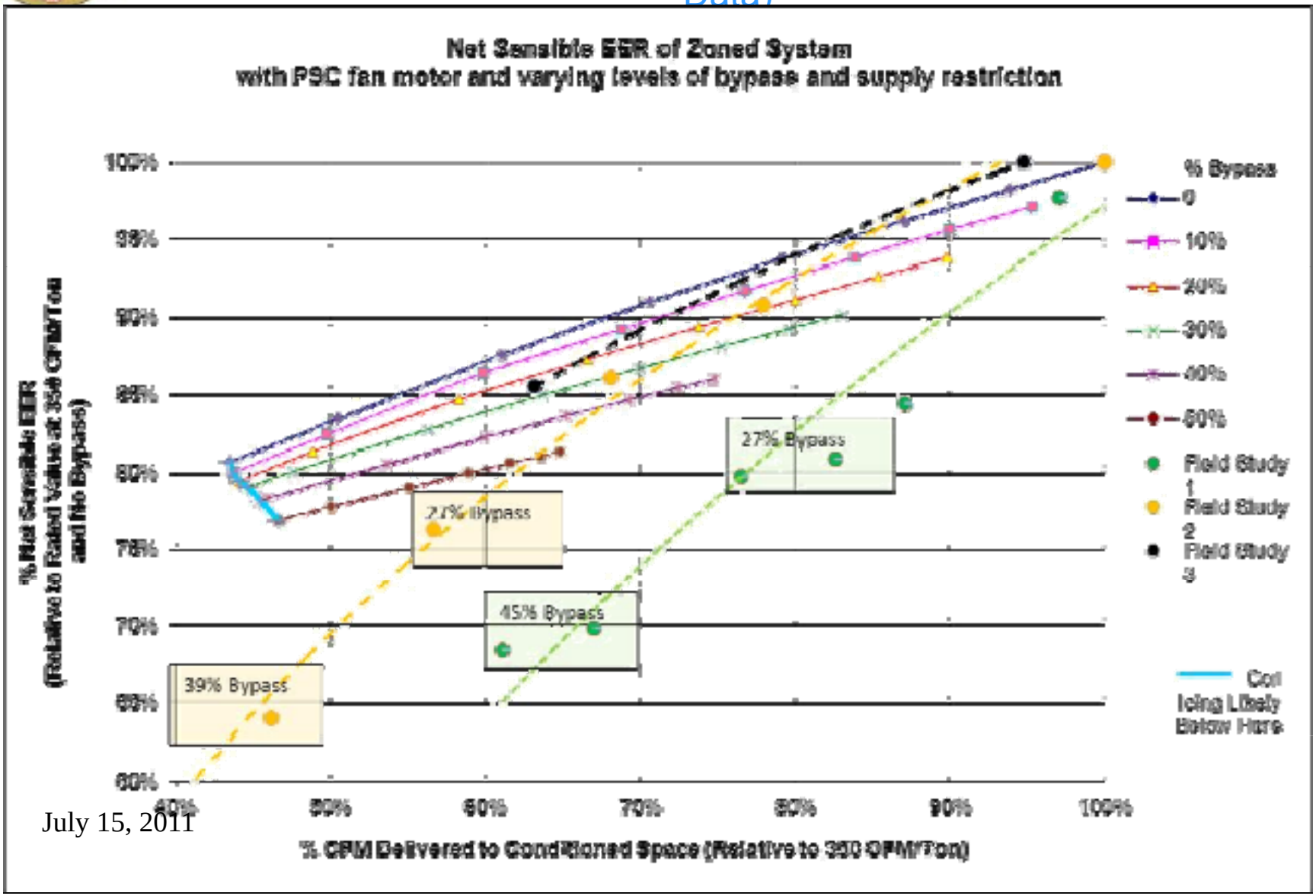
Impact of Bypass and Supply CFM (from expanded data tables)



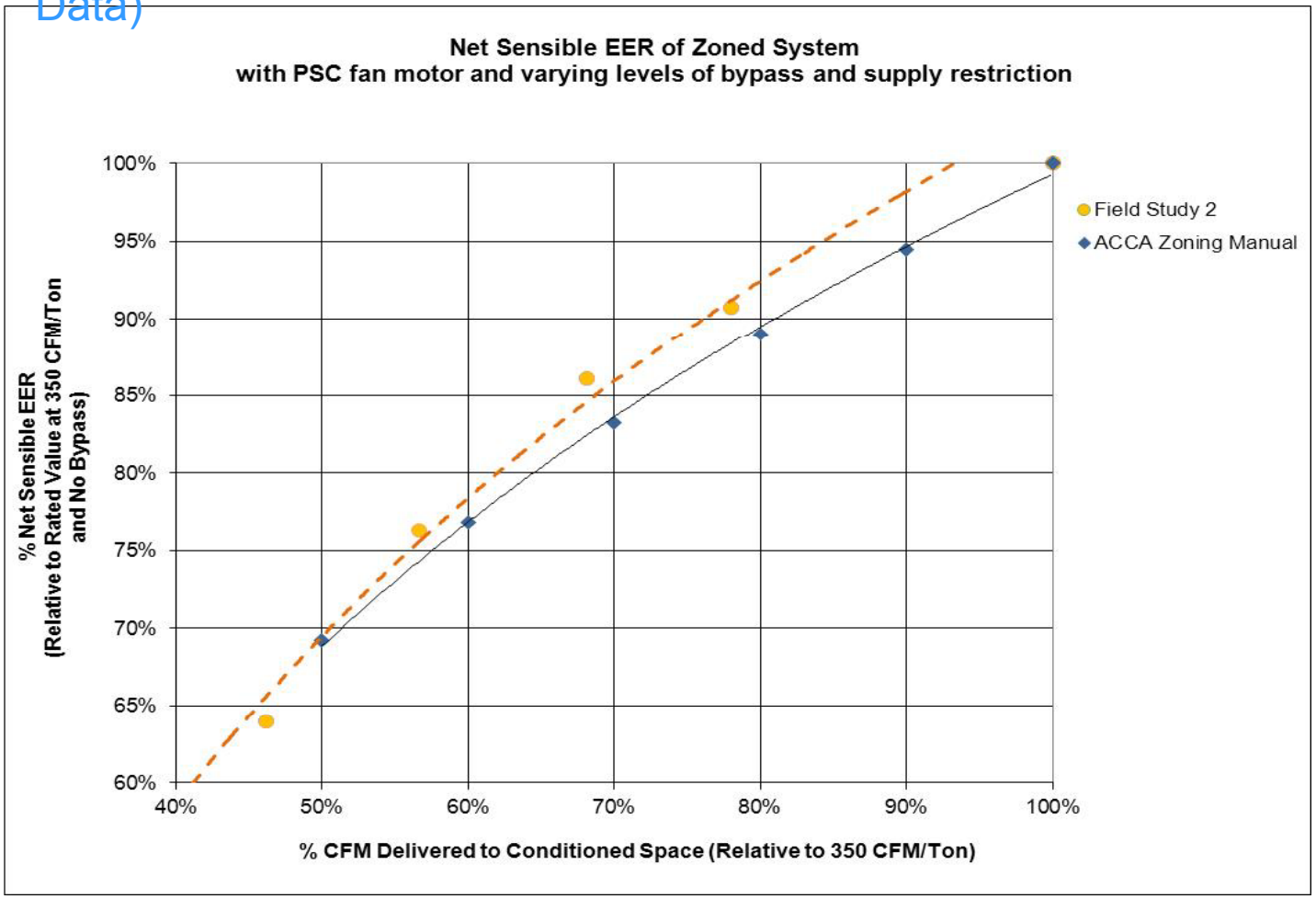
Impact of Bypass and Supply CFM (Field data)



Impact Bypass and Supply CFM (Comparison Model 1 and Field Data)



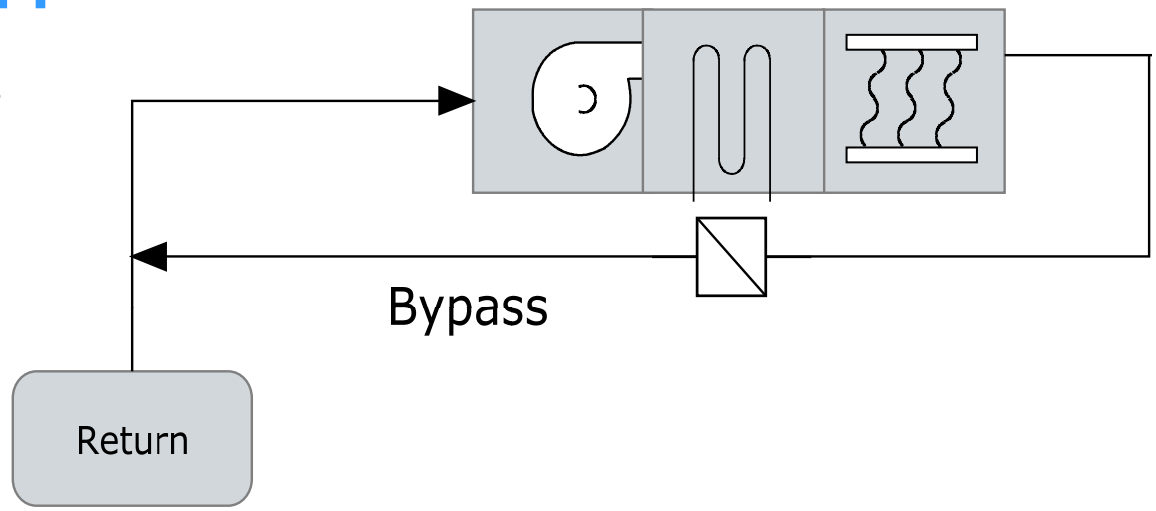
Impact Bypass and Supply (ACCA Manual* and Field Data)



Manual Zr, **Zoned Comfort Systems for Residential Low-Rise Buildings First Edition, Version 1.00 Review Draft 8.10anc — April 21, 2011**

Bypasses: Why are They so Bad?

Imagine this

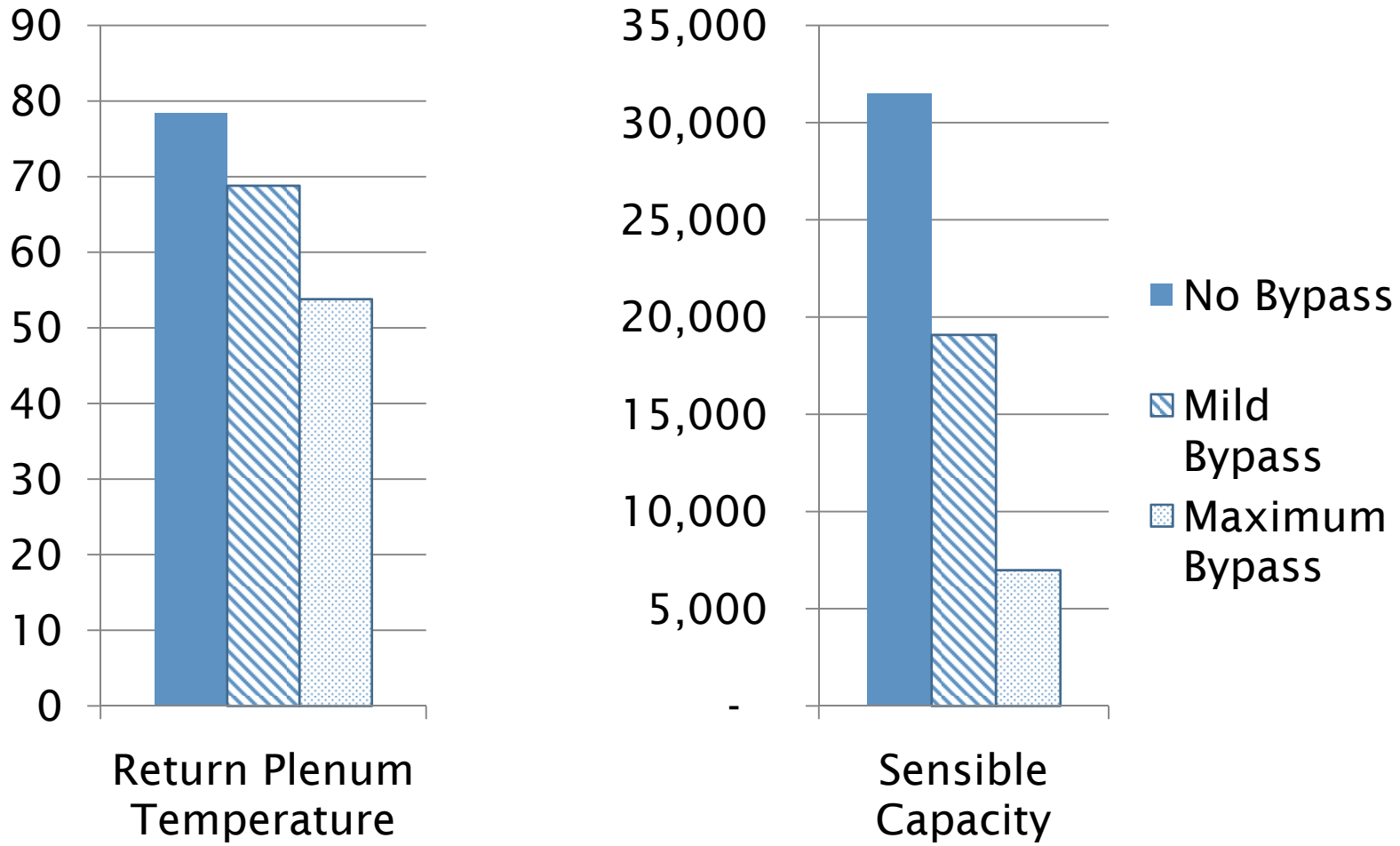


Think of what the return temperature rises to in heating and drops to in cooling.

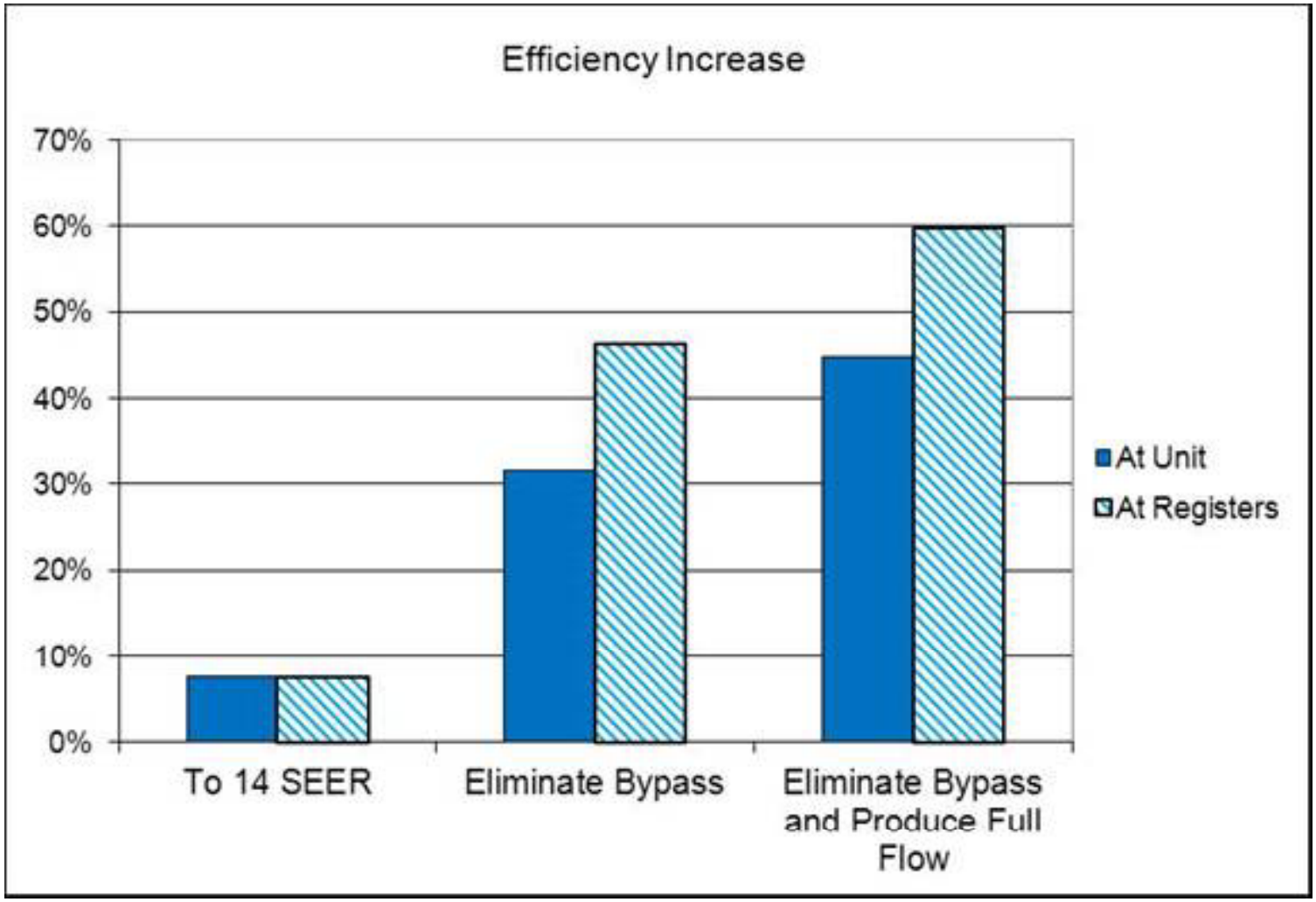
Heating hot air is hard

Cooling cold air is hard

An Example – House 41 Measurements



Survey House 29: Data and Analysis

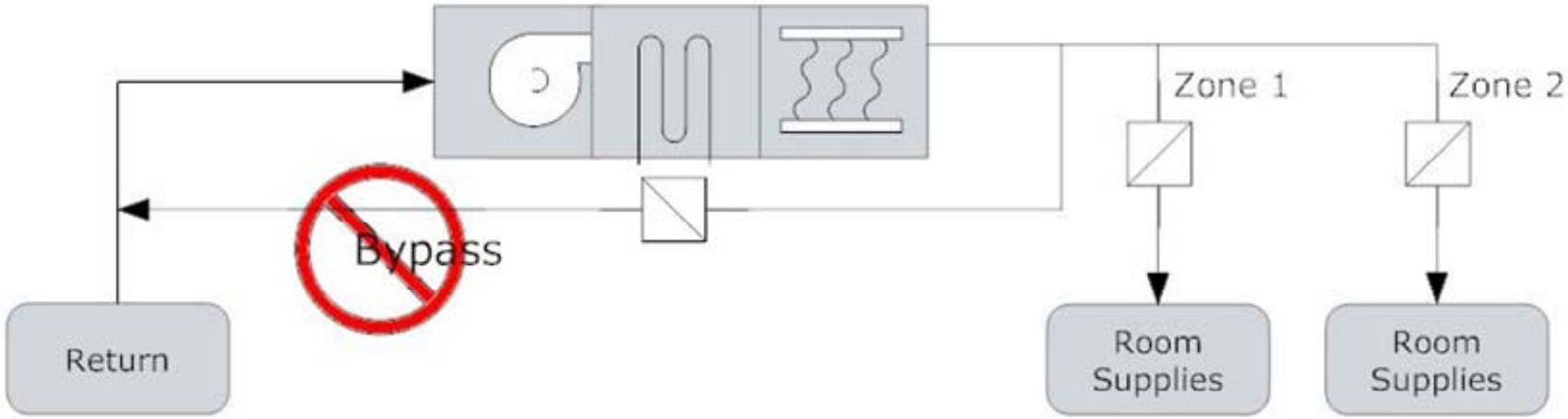


Average Energy Impact

- In typical homes with dampered multi-zone systems:
  - Air Conditioning SEER and EER are degraded by 17%
  - Furnace AFUE is degraded by 4.4%

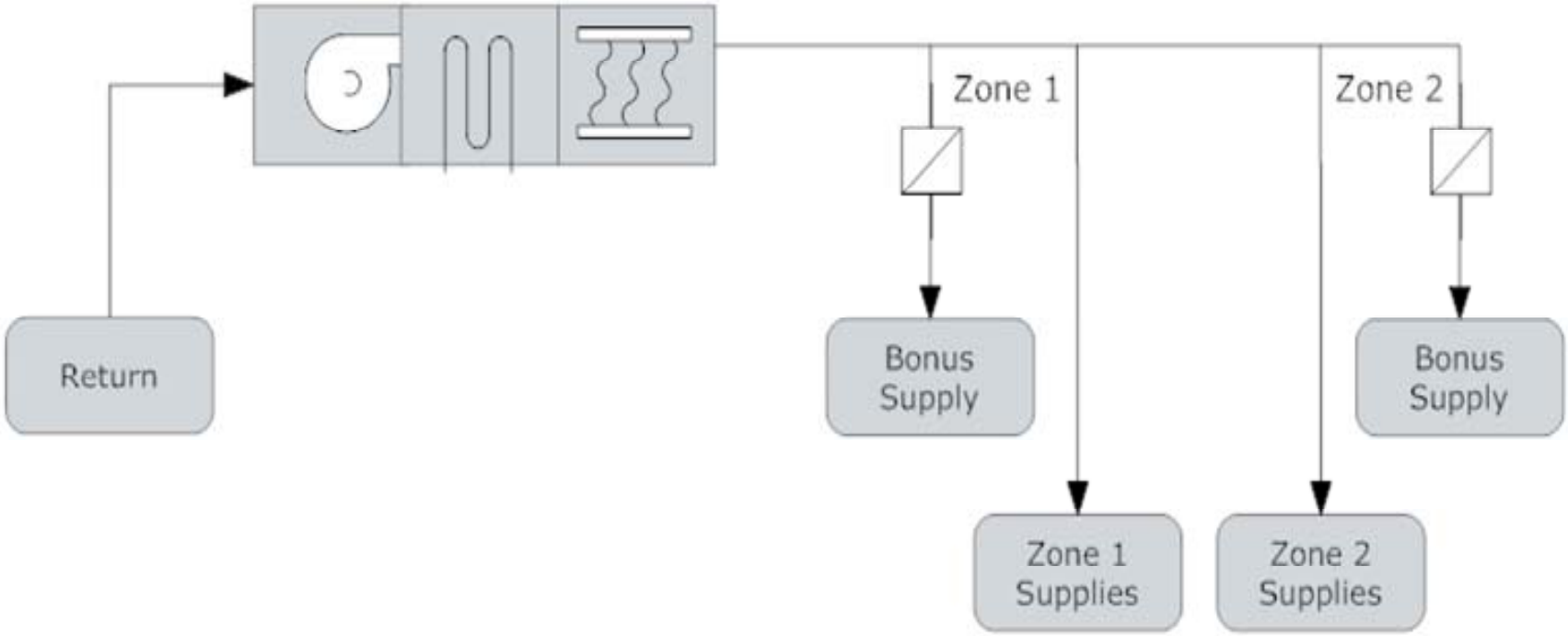
Eliminating the Bypass

- But how to get full CFM and low noise? There are many answers



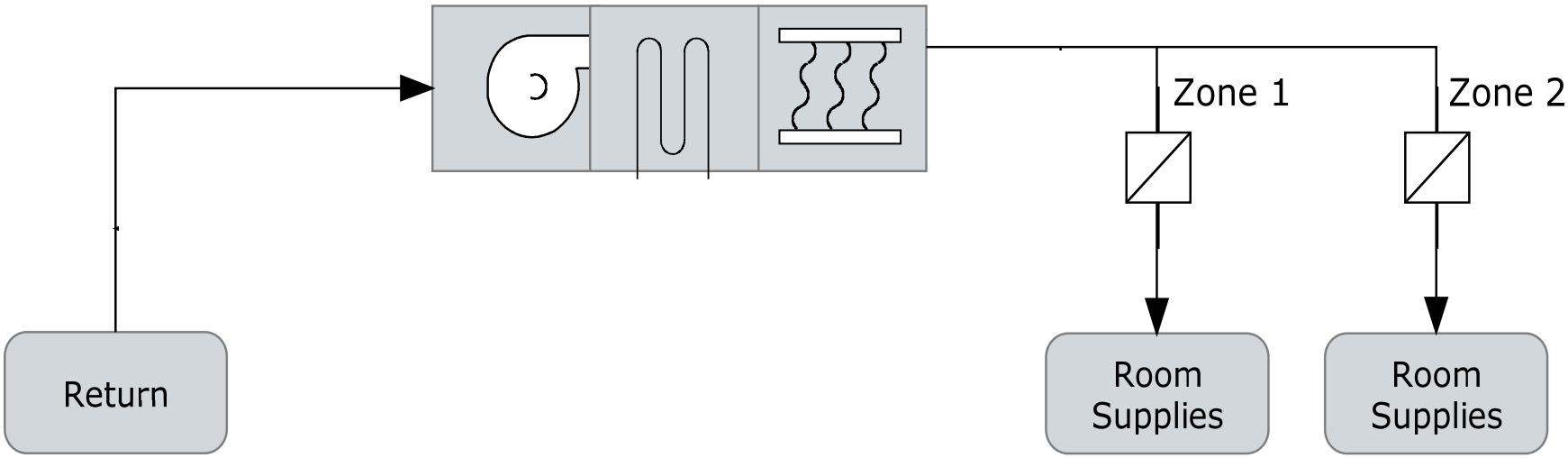
One Answer: No Bypass and No Extra Cost

- Each bonus branch takes the same CFM
- Full CFM through the unit and to the house at all times
- Obviously cost effective



Another Answer

- Damper stop relief



Another Answer

- Separate system for each zone
  - e. g. upstairs and downstairs central forced air systems
  - Mini-split systems for each zone

Another Answer

- Variable capacity equipment
  - Reduce capacity to get CFM/ton
  - Variable speed compressor and fan reduce energy consumption proportional to load

Conclusions

- Bypass ducts should be prohibited because they intrinsically reduce energy efficiency
- Multi-Zoned Systems are for comfort, not energy savings

  "Properly designed and installed systems improve comfort."
  Glenn Hourahan, Senior VP ACCA

- Multi-Zoned Systems can actually increase energy consumption:

  "A properly designed and installed system may or may not save a significant amount of energy, or may increase energy use to some extent." Ibid.

Code Change Proposals

1. New Mandatory Requirements for all Zoned Systems (now part of prescriptive air flow)
   - No Bypasses
   - Minimum CFM/ton and W/CFM in all modes
2. Eliminate performance path zoning credit
   - Zoning is for comfort, not energy savings

2013 Standards Update

Send related comments by August 5, 2011 to:

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