Effects of Air Conditioner Sizing on Energy Consumption and Peak Demand in a Hot-Dry Climate

ACEEE Summer Study on
Energy Efficiency in Buildings

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I Am Not the Primary Author

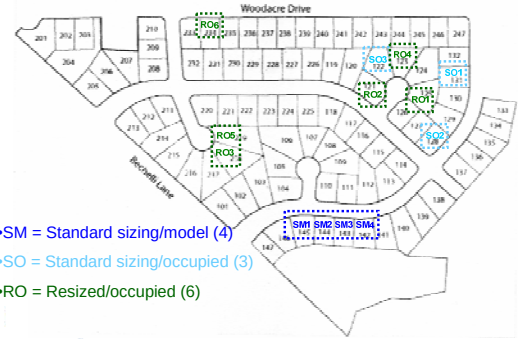
Background

- Oversizing of cooling systems common
  - Greater first cost
  - Short cycling → less latent removal
  - Greater utility coincident demand (FSEC)
  - Reduced energy efficiency (startup losses)
- 150% → 120% of Manual J ≈ 6% energy savings (James 1997)
- 2-3% savings w. ducts in conditioned space; negligible if in attic (Sonne 2006)

Experimental Background

- Involvement with homebuilder during buildout of development
- High performance enclosure & mechanicals
- Reduction of cooling equipment size
- AC monitoring to reassure builder and HVAC contractor
- Building enclosure identical before/after recommended changes

Test Houses



- SM = Standard sizing/model (4)
- SO = Standard sizing/occupied (3)
- RO = Resized/occupied (6)

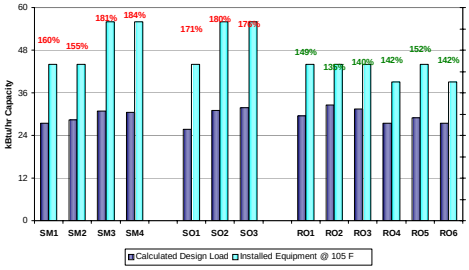
Test Houses

Test Houses

Test Houses

- Duct leakage ~4% (same Standard/Resized)
- Airtightness ~3 ACH 50 (same Standard/Resized)

Cooling Equipment Sizing



Calculated sensible + ½ unused latent
Standard ~ 150% Right-sized ~ 130%

Monitoring Equipment

- Monthly AC condenser consumption (T.E.D.)
- AC on/off runtime
- Coarse measurements

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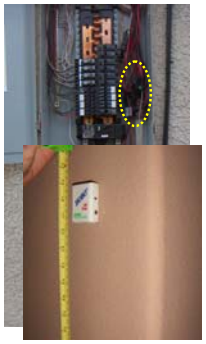
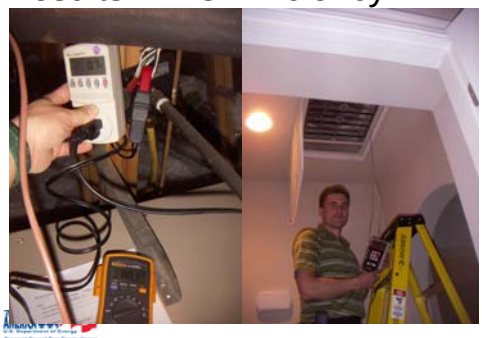
- Interior temperature/RH (3 locations/house)
- Exterior temperature/RH
- Airport weather T/RH



Results: AHU Efficiency



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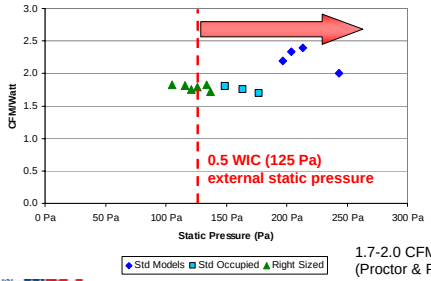
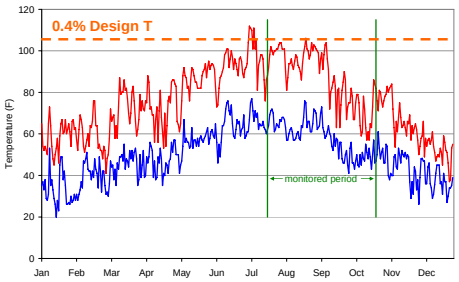


1.7-2.0 CFM/watt
(Proctor & Parker)

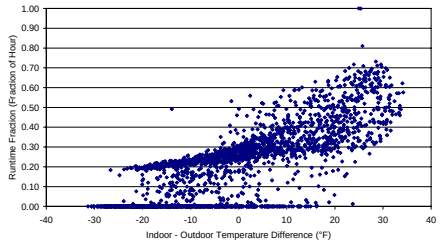
Monitored Period (Daily Hi/Low)



Occupant Thermostat Behavior

- Thermostat operation categories
  - Constant off
  - Constant setpoint
  - Daily set up/set back
  - Manual on/off
- Model homes unoccupied (locked T-stat)
- Substantial occupant variation in data/usage
- Programmable features not used
- Pay homeowners to maintain constant thermostat setpoint?

Occupant Thermostat Behavior



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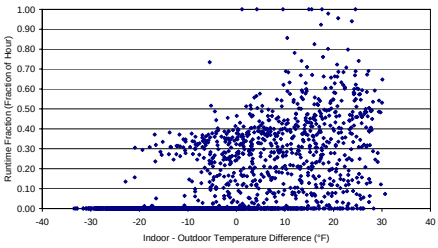

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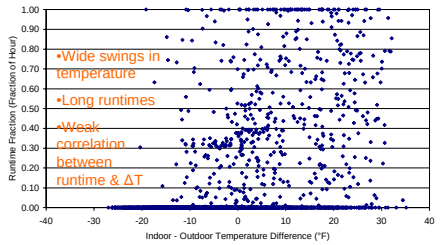
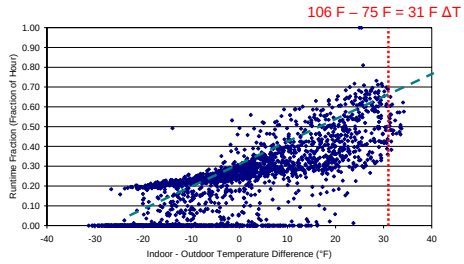
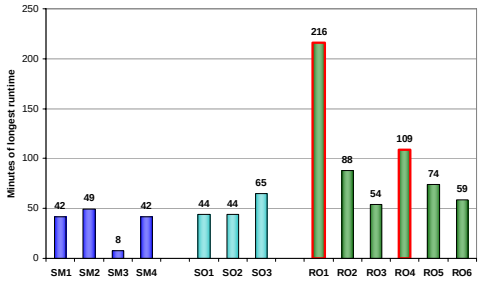


AC Sizing vs. Runtime

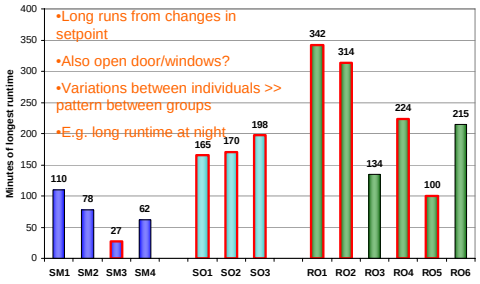


AC Runtime (Hottest Day)

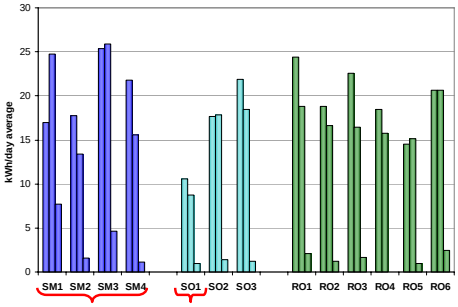


AC Runtime (Longest Runtime)

- Long runs from changes in setpoint
- Also open door/windows?
- Variations between individuals >> pattern between groups
- E.g. long runtime at night

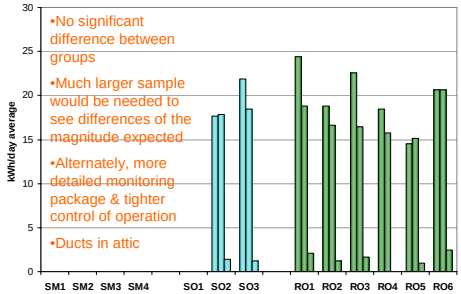


Condenser Daily Avg. Use



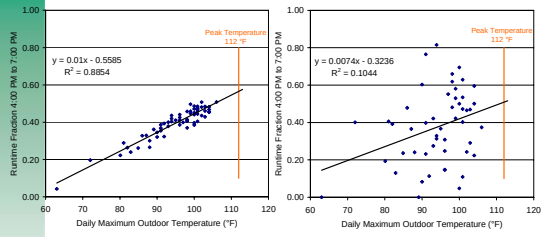
Condenser Daily Avg. Use

- No significant difference between groups
- Much larger sample would be needed to see differences of the magnitude expected
- Alternately, more detailed monitoring package & tighter control of operation
- Ducts in attic



Peak Demand Effects

Run time fraction at peak time (4-7 PM) vs. daily maximum outside T



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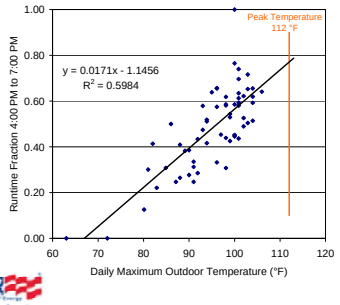

Conclusions

- Resized equipment meets cooling demand (homeowners satisfied; no complaints)
- Resized has longer response to thermostat temperature change
- Difference in energy use too small to see given data variability, sample size, measurement resolution, duct location
- Cooling resizing limits likely due to recovery from setback rather than static/Manual J limits

Acknowledgements

- U.S. Department of Energy Building America Program
- D.R. Horton Inc.

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Questions & Comments

Part Load Efficiency

- Startup losses: C_D (coefficient of degradation/cycling loss)
- $SEER = EER_{82} \times (1 - C_D / 2)$
- $C_D \approx 0.05$ to 0.10 (Sonne, Sachs)
- Manufacturers motivated to reduce C_D in order to increase SEER