FLORIDA SOLAR ENERGY CENTER

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Impact of Energy-Efficiency Parameters on Home Humidity

Rob Vieira

Florida Solar Energy Center

A Research Institute of the University of Central Florida

Purpose

- Some energy efficiency measures only address sensible loads. As these measures are implemented
  - Can today's HVAC equipment maintain acceptable humidity levels?
- Are there some key efficiency measures that could improve humidity in homes that implement sensible load reduction strategies?

Terms

- Sensible: Heat
- Latent: Moisture

Presentation Scope

- Single-family detached homes
  - Multi-family residences can often have less envelope sensible load due to fewer exposed surfaces but have not been the focus of many research studies – they are not covered in this presentation
- Existing studies that focus on humidity levels in homes

Parameters Studied

- Efficient Windows (experimental & simulated)
- Various Efficiency Measures (simulated)
- Duct Leakage (experimental)
- HVAC Operations (experimental)
- HVAC Flow and Fan Operation (experimental)
- HVAC Time Delay Relay (experimental and simulated)
- Internal Loads

Progress Energy Funded FSEC Study – 1999

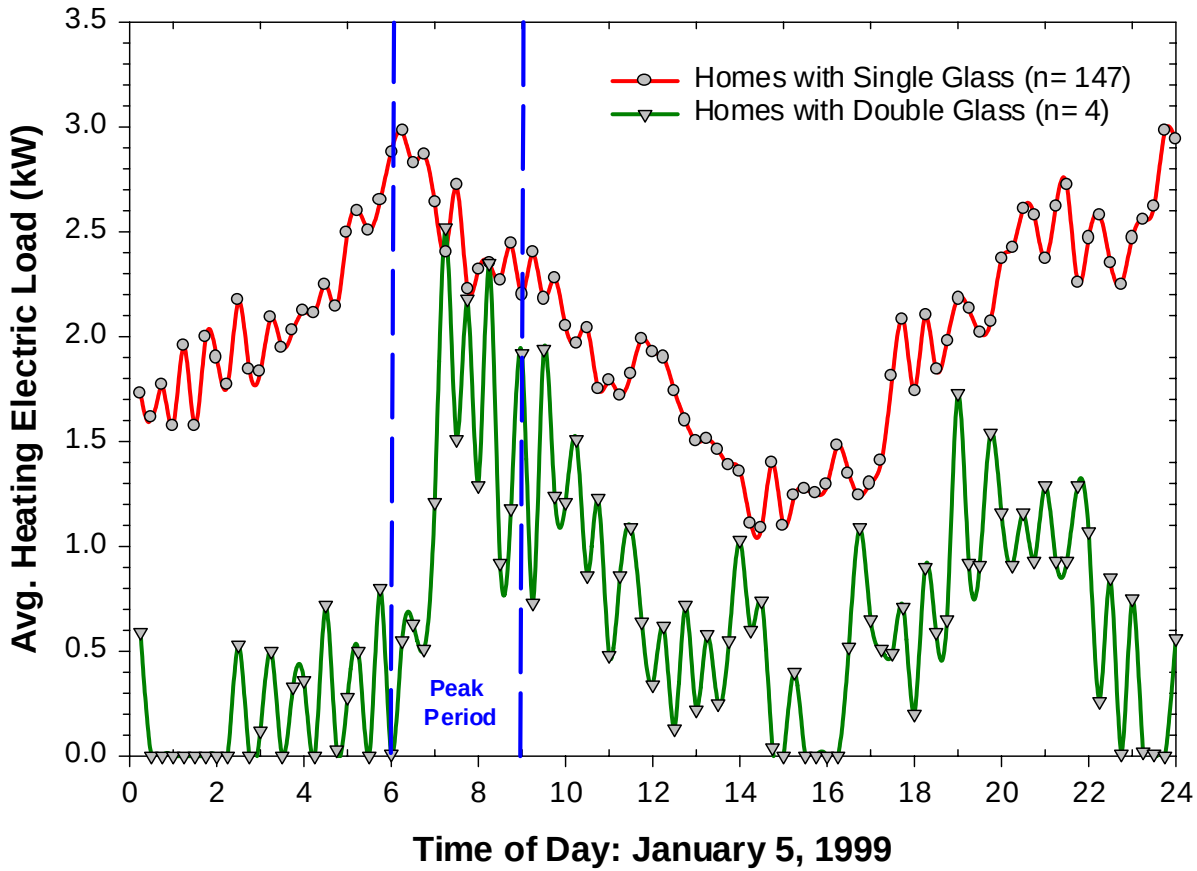
Site #198 – insulated double-pane windows (4 of 170 homes)

Influence of Windows on Heating and Cooling Energy and Demand

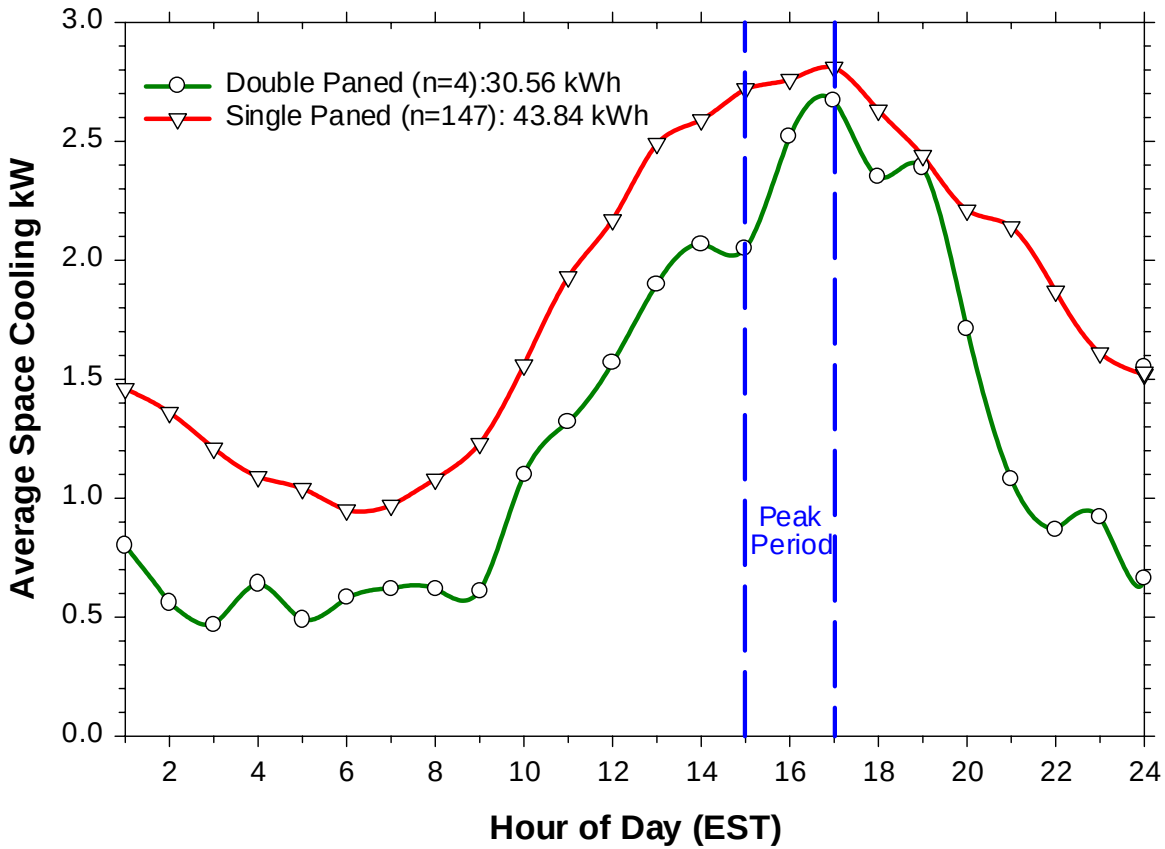
Case	Annual Heating	Annual Cooling	Peak Heating	Peak Cooling
Single Glass	1067	5754	2.60	2.93
Double Glass	485	3318	1.85	2.77

Note: Homes with all double glass: sites 23, 32, 110 and 198.There were 166 homes in the single glass sample.

Influence of insulated glass for windows on peak winter day heating – Jan. 5, 1999



Peak summer day air conditioning demand profile – August 30, 1999



High Performance Windows – Mercedes Home Study

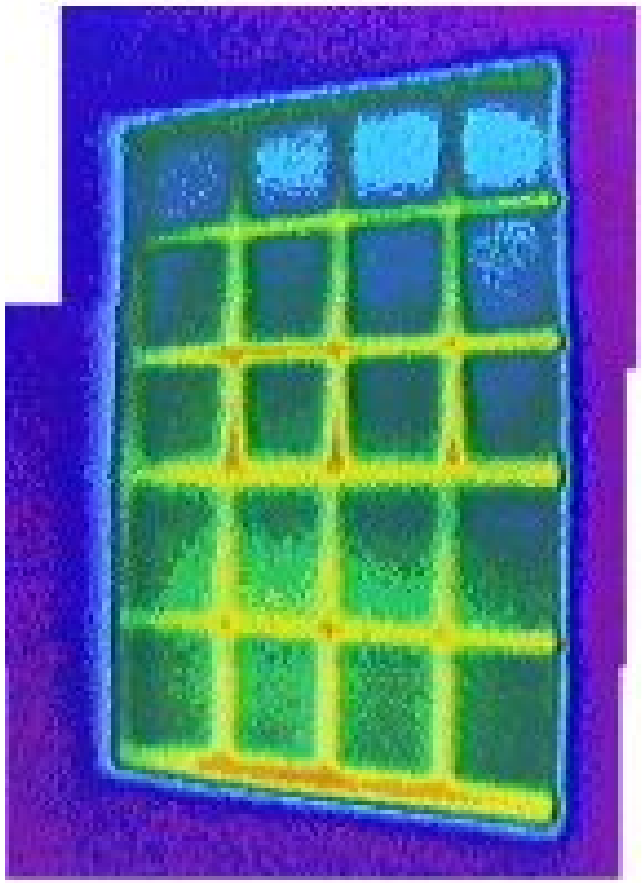
- Monitoring can answer direct and indirect questions
- What will they save?
  - Energy
  - Peak demand
- How will it impact interior humidity?

Base and Improved Window Specs Mercedes Homes Research Project

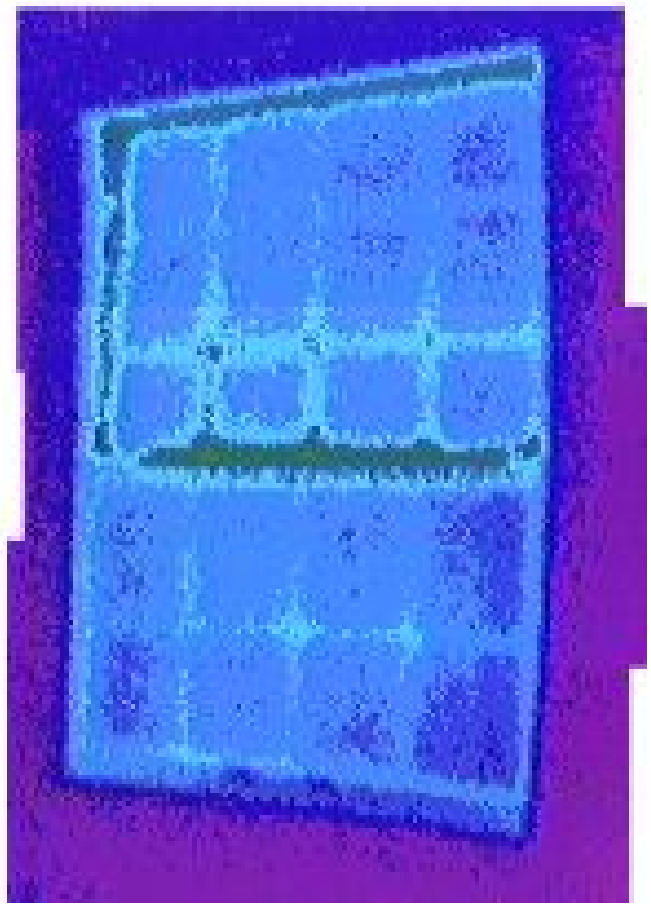
	Solar Heat Gain Coefficient	Winter Night U-Factor
Standard Single Pane Aluminum Windows	0.77	1.23
High Performance Windows - Spectrally Selective, Thermally broken	0.36	0.47

West facing window in the two test homes during a hot afternoon

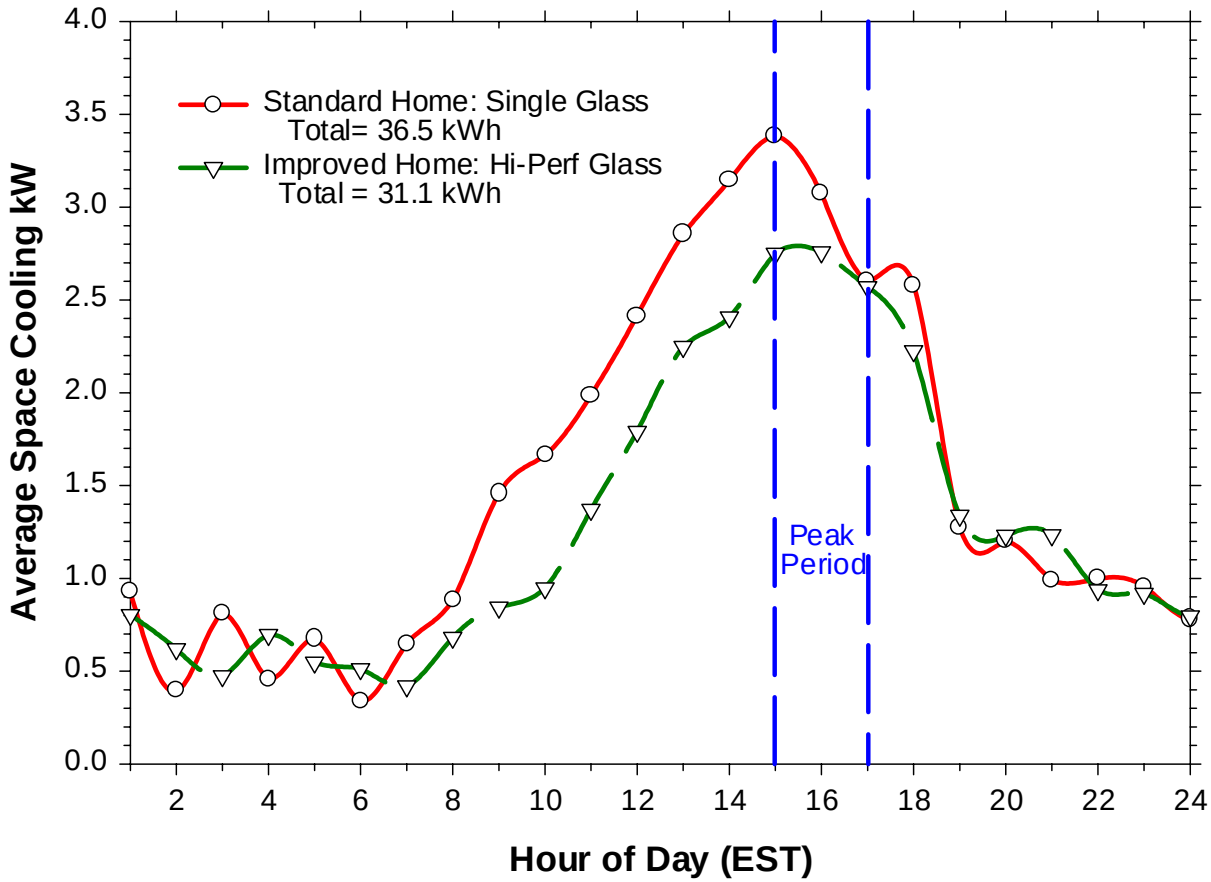
Base



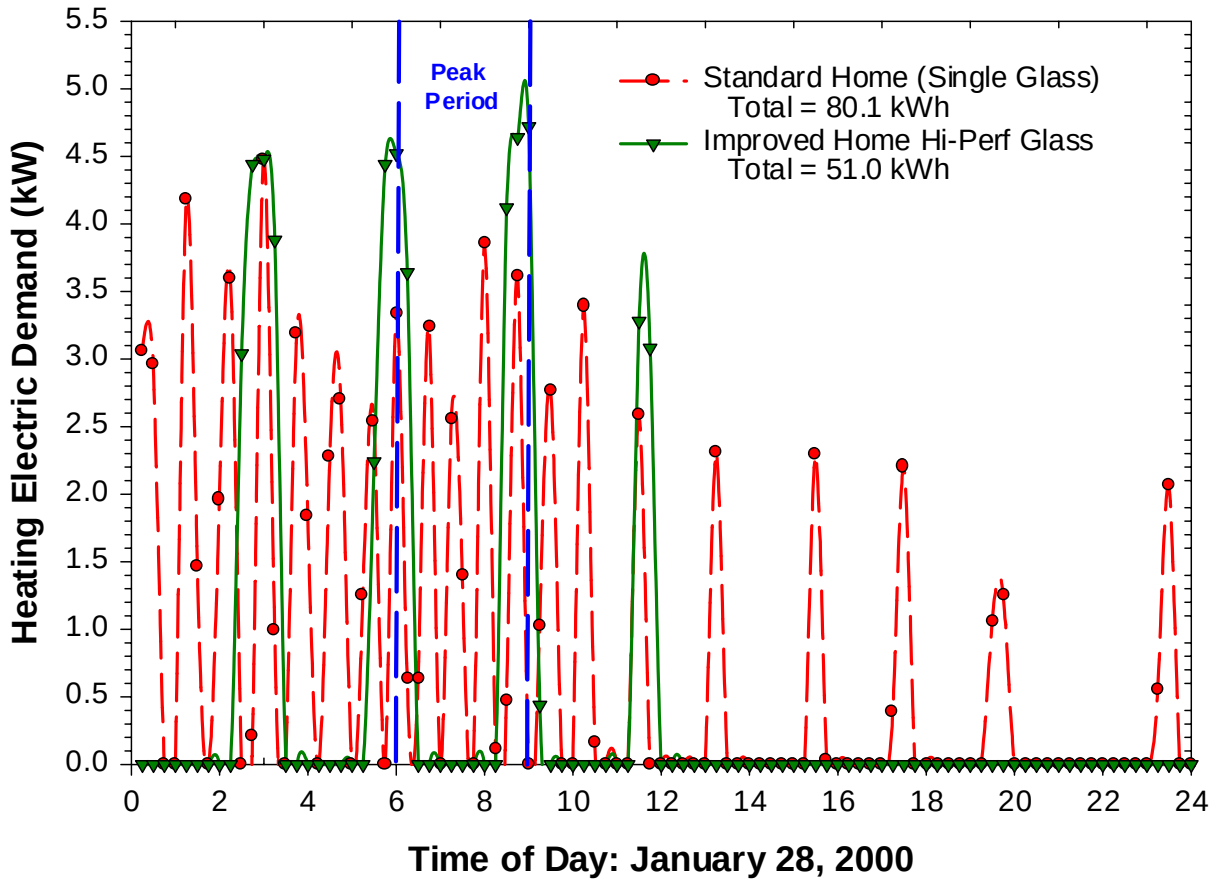
Improved



Comparative space cooling demand profile of two test homes over the hot 17-day period in Sept.

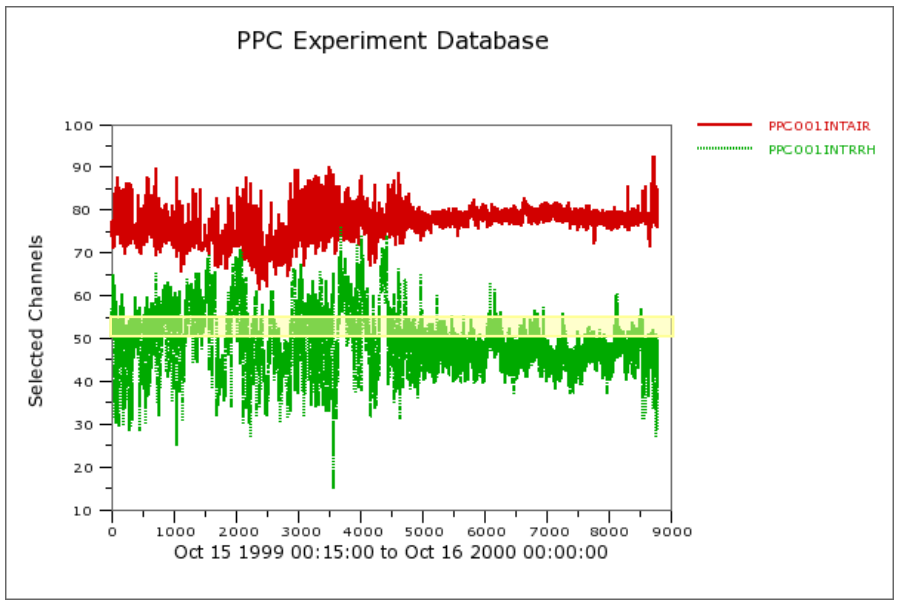


Comparative space heat demand profile on January 28, 2000. Morning low temperature was 43ºF

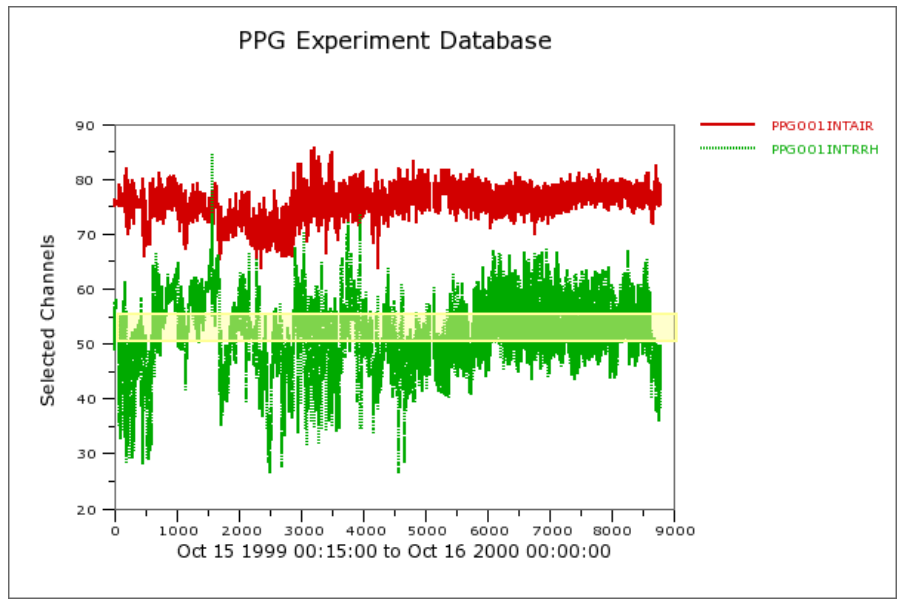


Annual Interior Temp & RH

Control

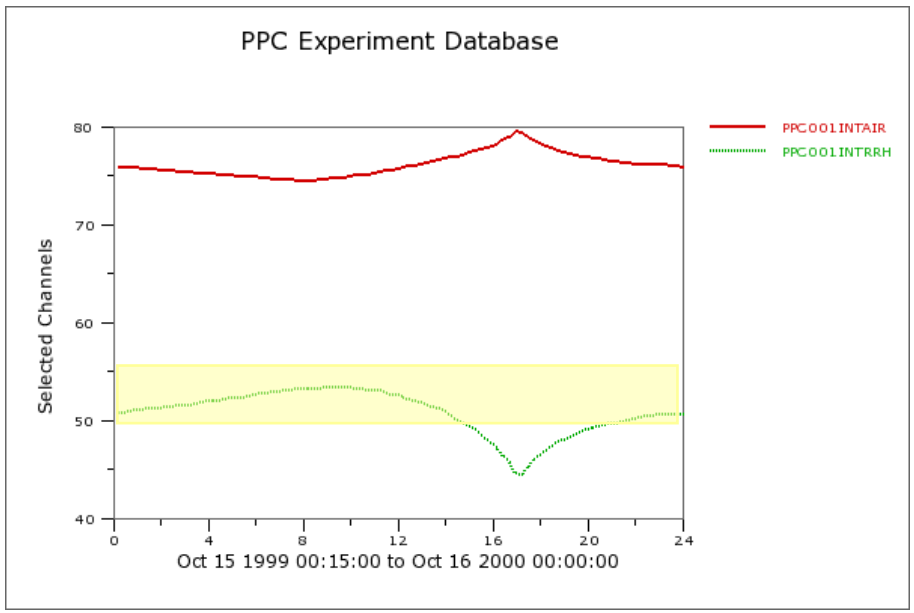


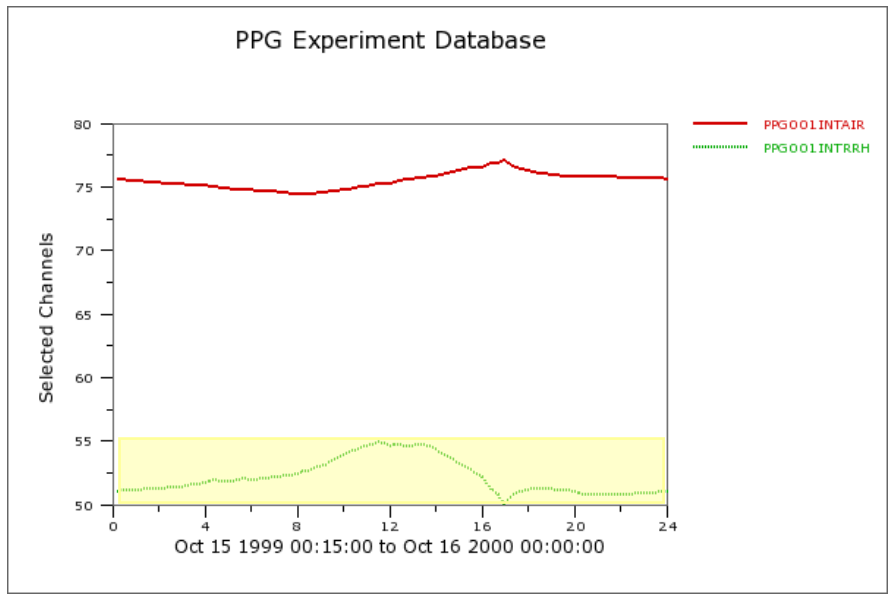
Experimental



Annual Interior Temp & RH

Control, Single Glass: Avg Temp= 76.0 F, RH= 50.7%



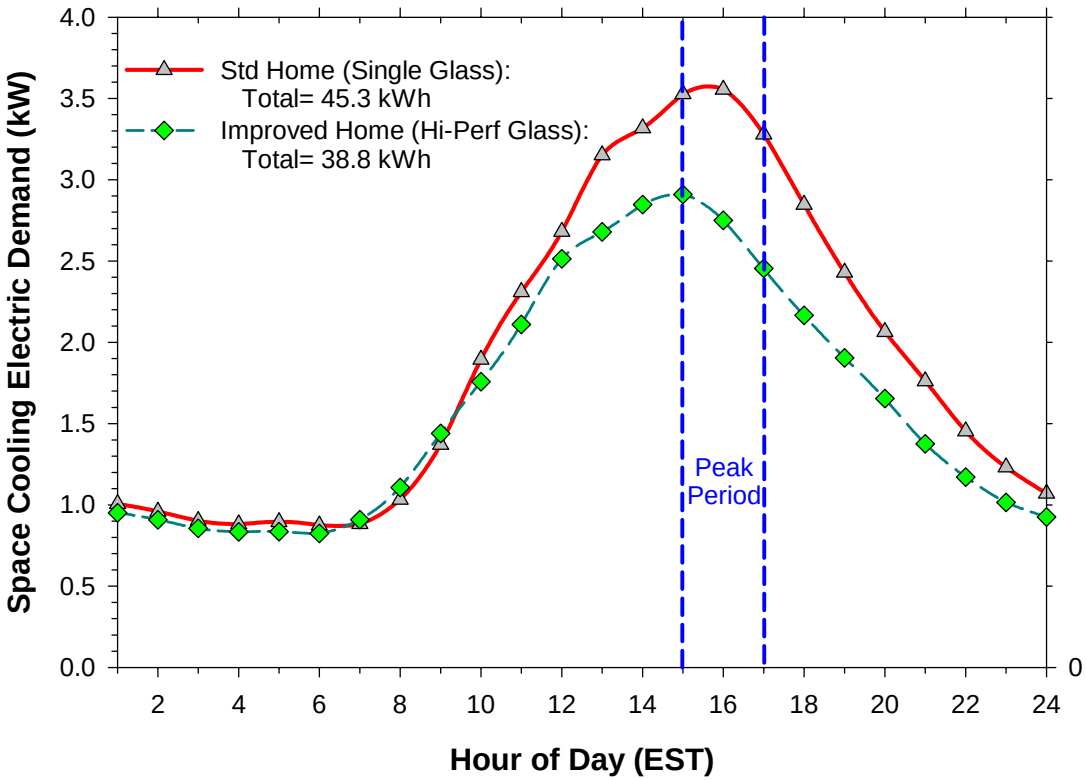


Solar Control Glass: Avg Temp= 75.5 F, RH= 52.1%

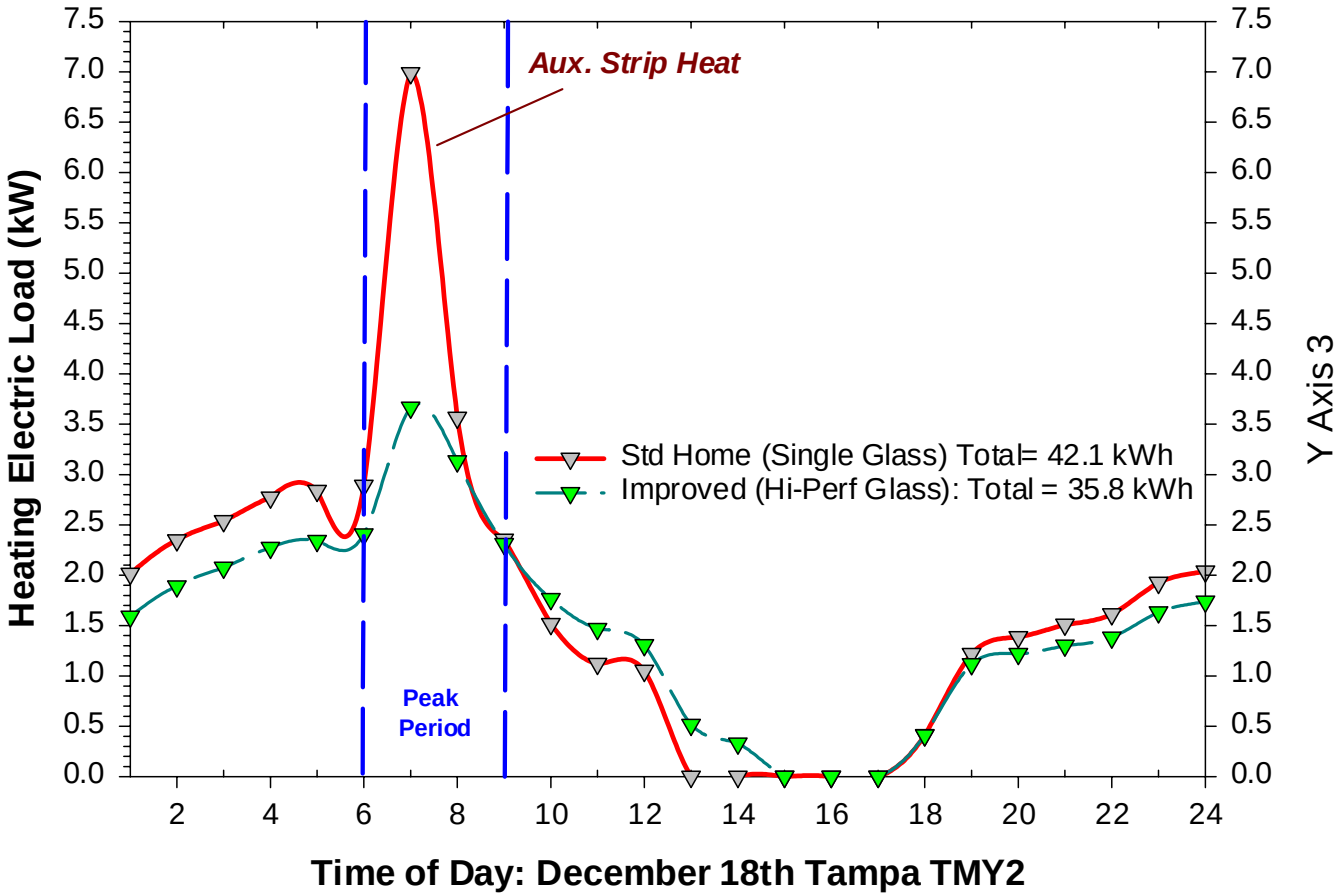
Simulated Impact of Solar Control Windows

- 75 F set point in summer
- 72 F set point winter
- No change in AC size
- Annual average relative humidity
  - 41.6% Single Glass
  - 43.7% Solar Control Glass
  - 2% increase in interior RH
  - Similar to empirical study

Simulated AC demand on peak cooling day



Simulated impact of generic high performance solar control window on peak heating day for Tampa Dec. 18th



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Efficiency Measures vs. RH for Simulated Tampa Home

Case	CoolingkWh	HeatingkWh	Avg RH%
Standard Building:	5958	585	48.4%
Low-E solar windows	4213	292	51.3%
White Roof	5186	595	49.3%
100% CFL Lighting	5602	625	48.7%
Reduce Infiltration	5517	481	46.1%

FSEC EnergyGauge USA analysis, 2007

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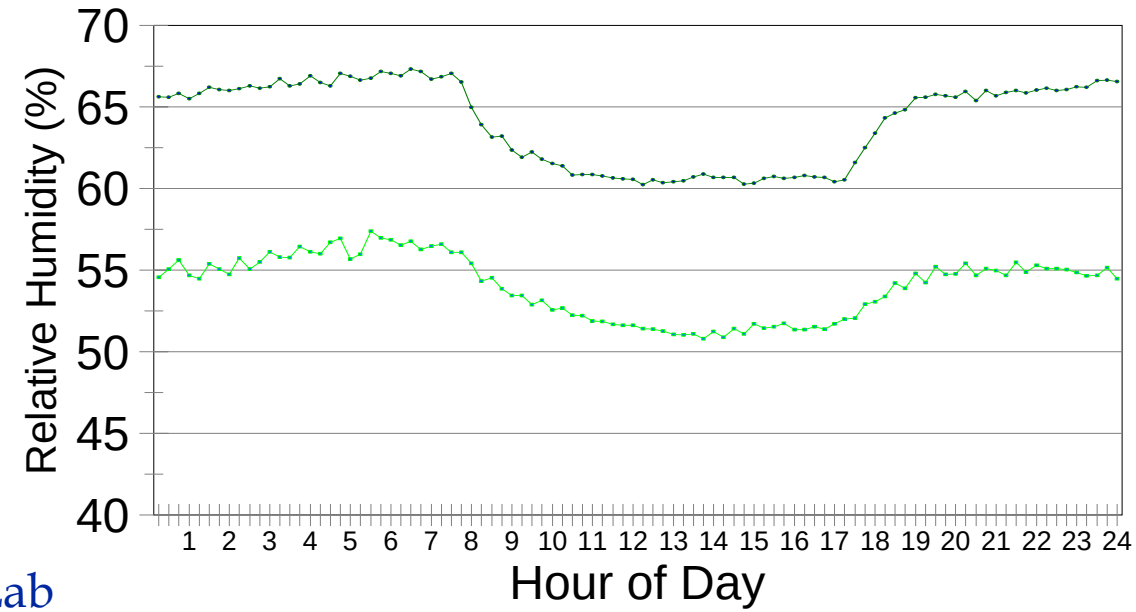
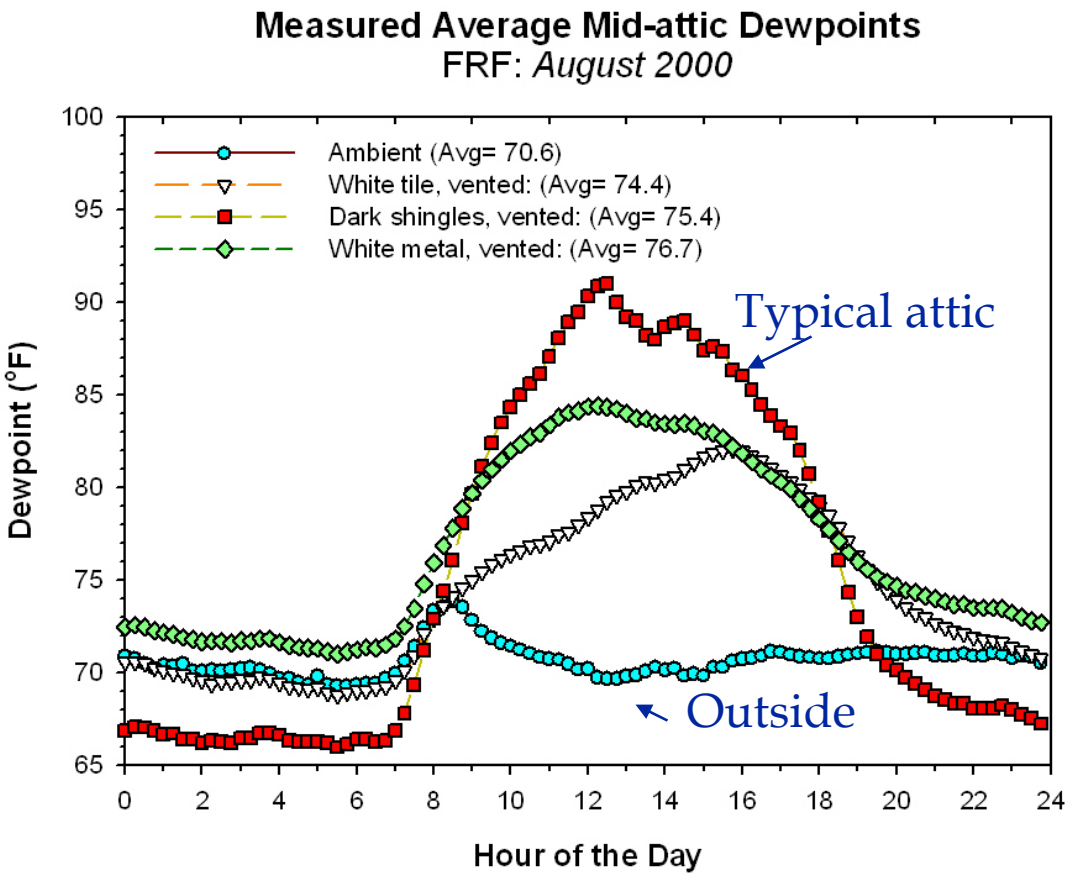
Impact of Duct Leakage – FSEC lab experiment



FSEC Lab
Attic with steel joists, good connection to conditioned space

Attic Dew Point



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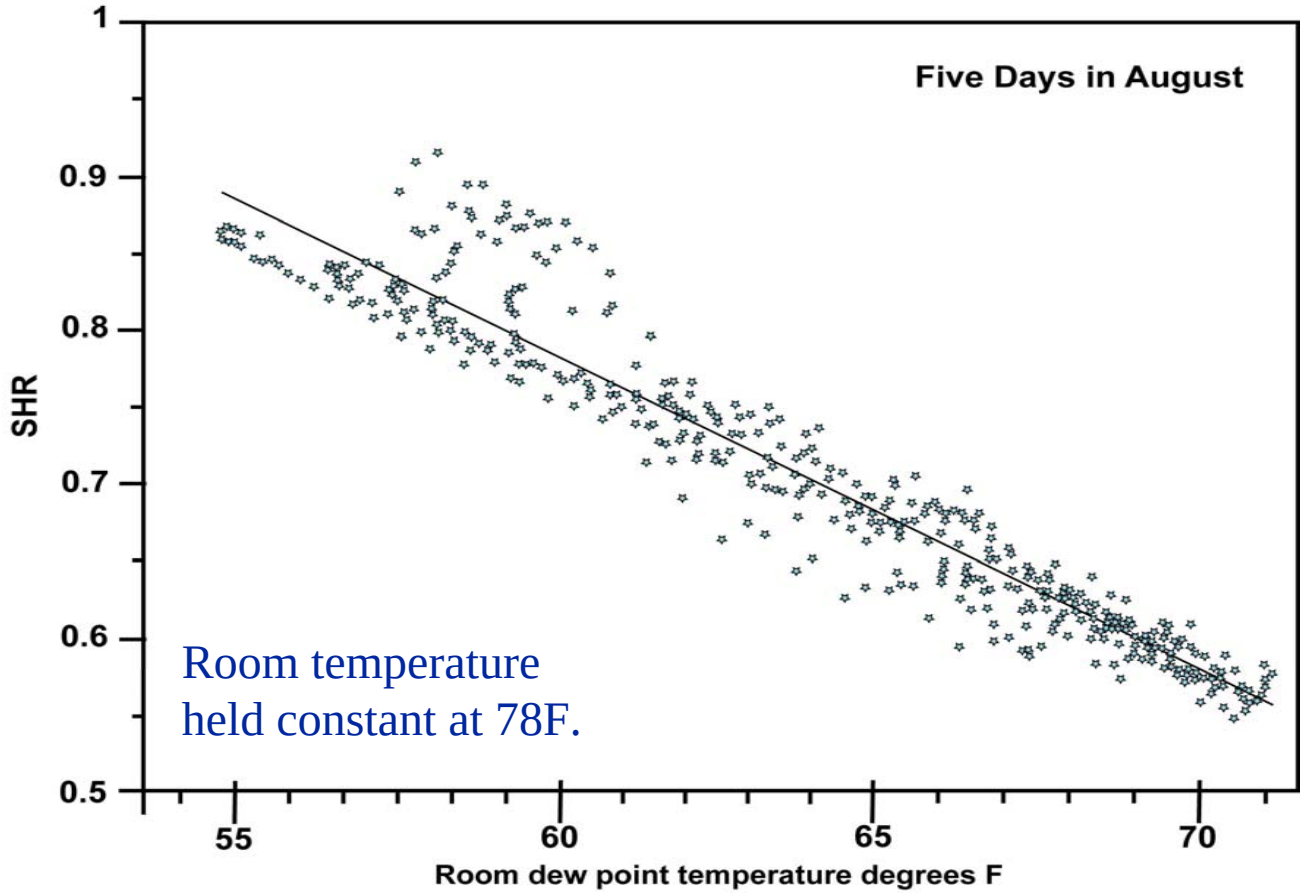
Cooling Equipment

- Rated sensible heat ratio (SHR) is about 75%
- Latent heat ratio (LHR) is about 25%
- However, LHR increases
  - With higher room humidity
  - With lower system air flow rates

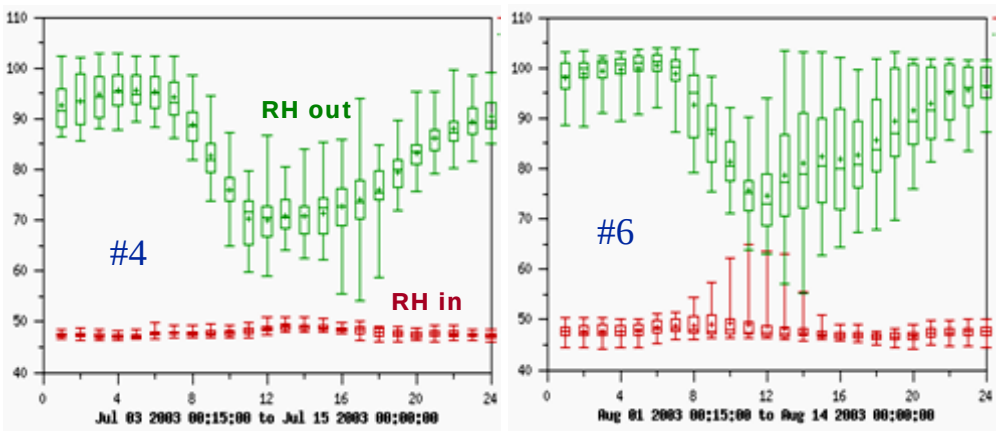
Measured SHR as a Function of Room Dew Point Temperature



RH Maintained Even with Mechanical Ventilation

- Automatic simulation of sensible and latent occupancy loads.
- 6 ventilation strategies
- Cooling set point 75F, A/C adequate to maintain RH below 60% for all strategies examined.

Hourly profiles



Case 4 uses ~15% more energy than case 6

Strategies
No mechanical ventilation
Spot ventilation
Outside air
OA - 10/20 cycle - Dehumidification
OA - 10/20 cycle
Energy recovery ventilator
OA - Humidistat

Presented paper: "Assessing Six Residential Ventilation Techniques in Hot and Humid Climates," Proceedings of ACEEE 2004 Summer Study on Energy Efficiency in Buildings, Washington, DC, August 2004. .

SEER and latent removal are independent at steady state

"We conclude that the latent removal of small unitary equipment is not a function of efficiency.

Furthermore, the latent removal characteristics of this type of equipment have not changed significantly over time…"

David Godwin, "Latent Capacity of Unitary Equipment," ASHRAE TO-98-9-2

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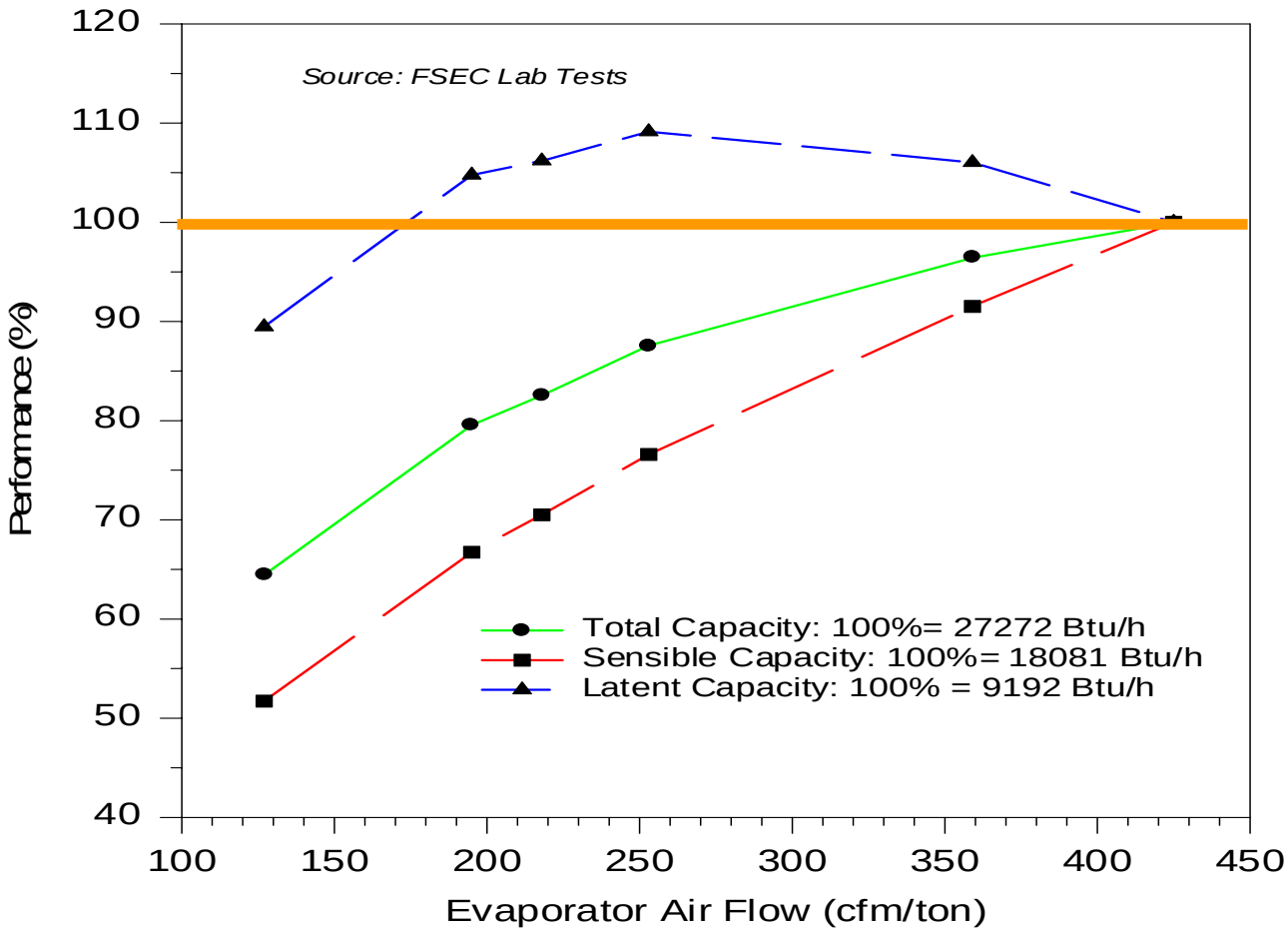
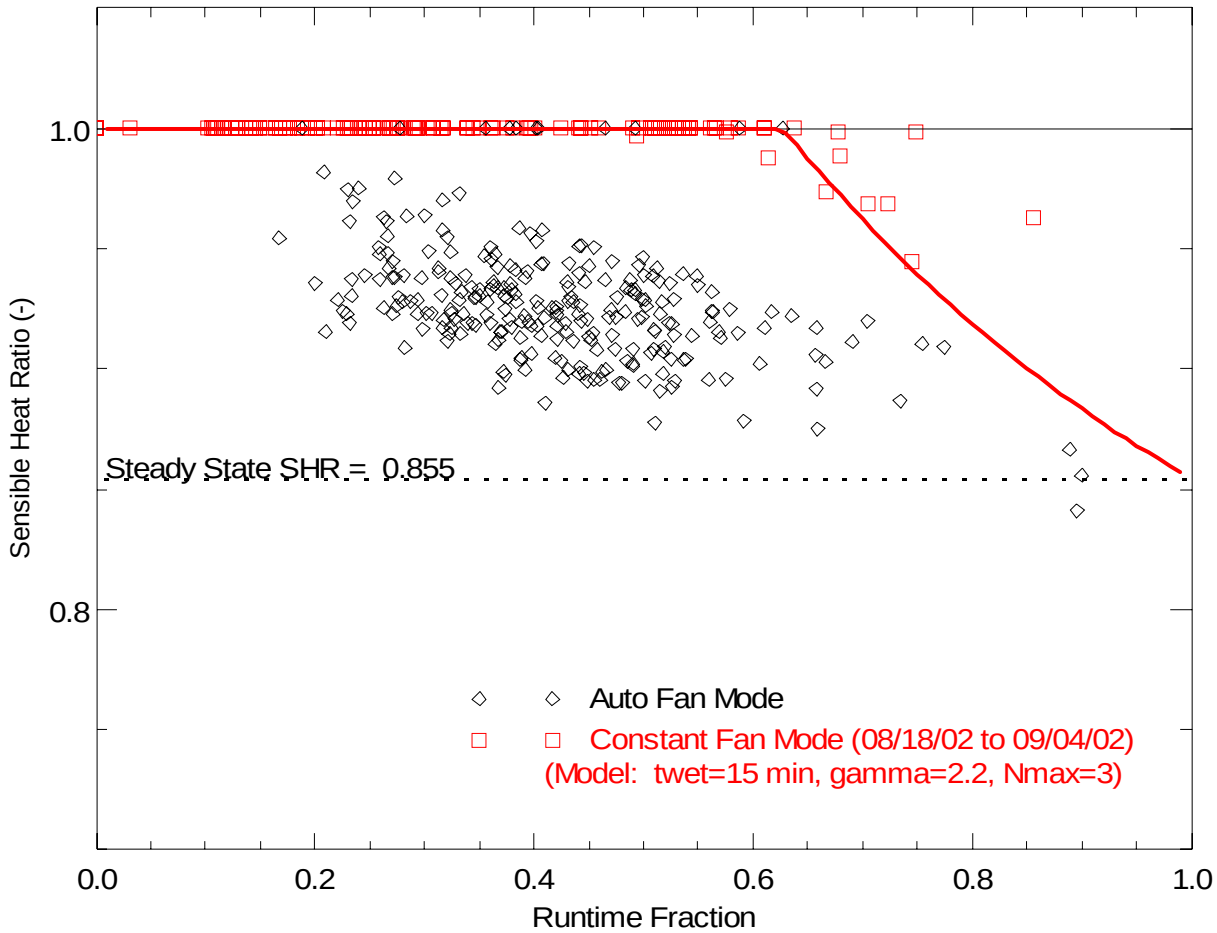
Optimization of Latent vs Sensible Cooling

- During hot and humid weather, there is a sensible cooling load and a latent cooling load.
  - A high air flow rate will produce the highest sensible cooling efficiency.
  - A lower air flow rate will produce the highest latent cooling efficiency.

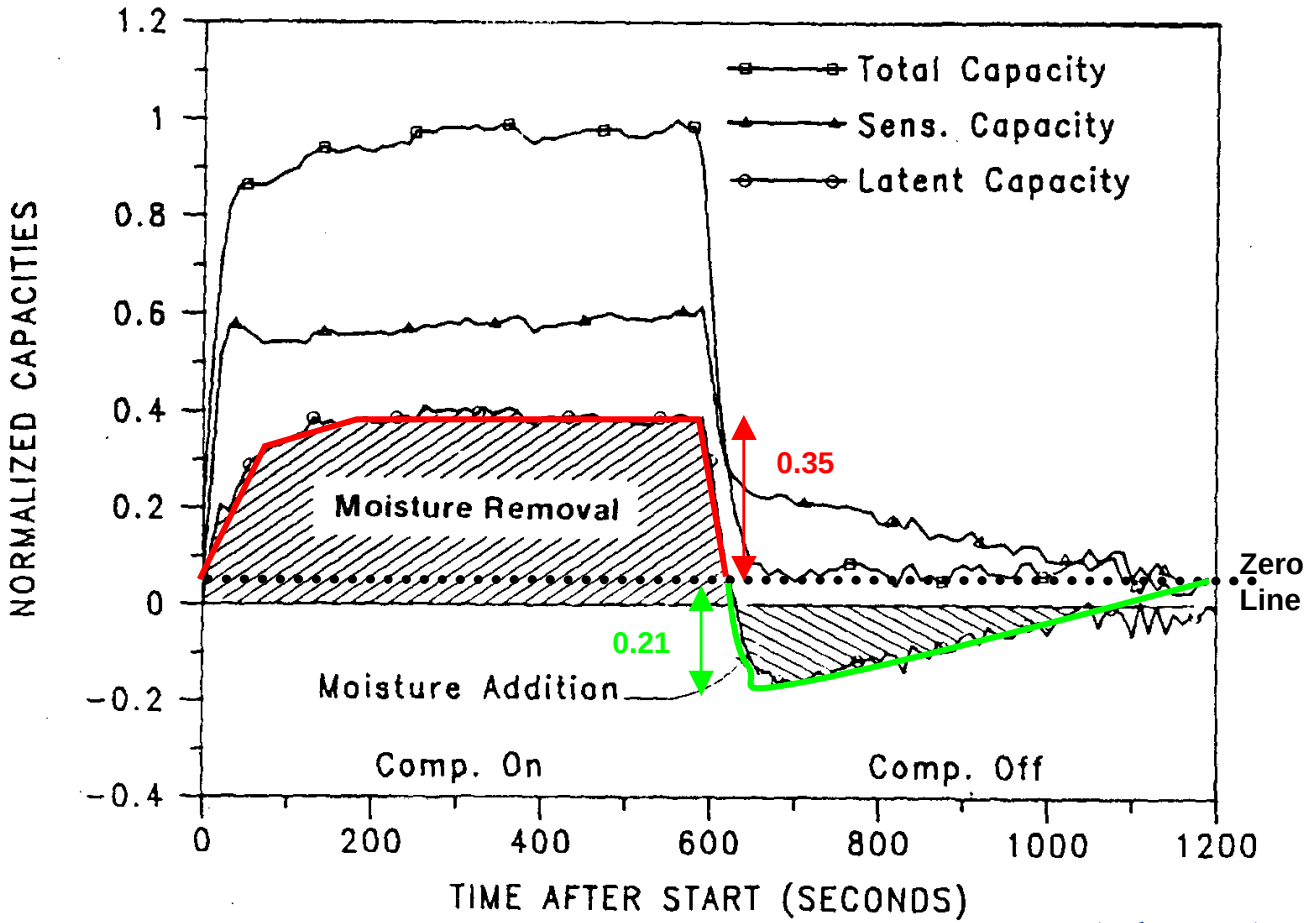
Impact of Air Flow



Field Data: Latent Performance Fan "Auto" vs. "On"



FSEC Data – Continuous Fan



(Khattar)

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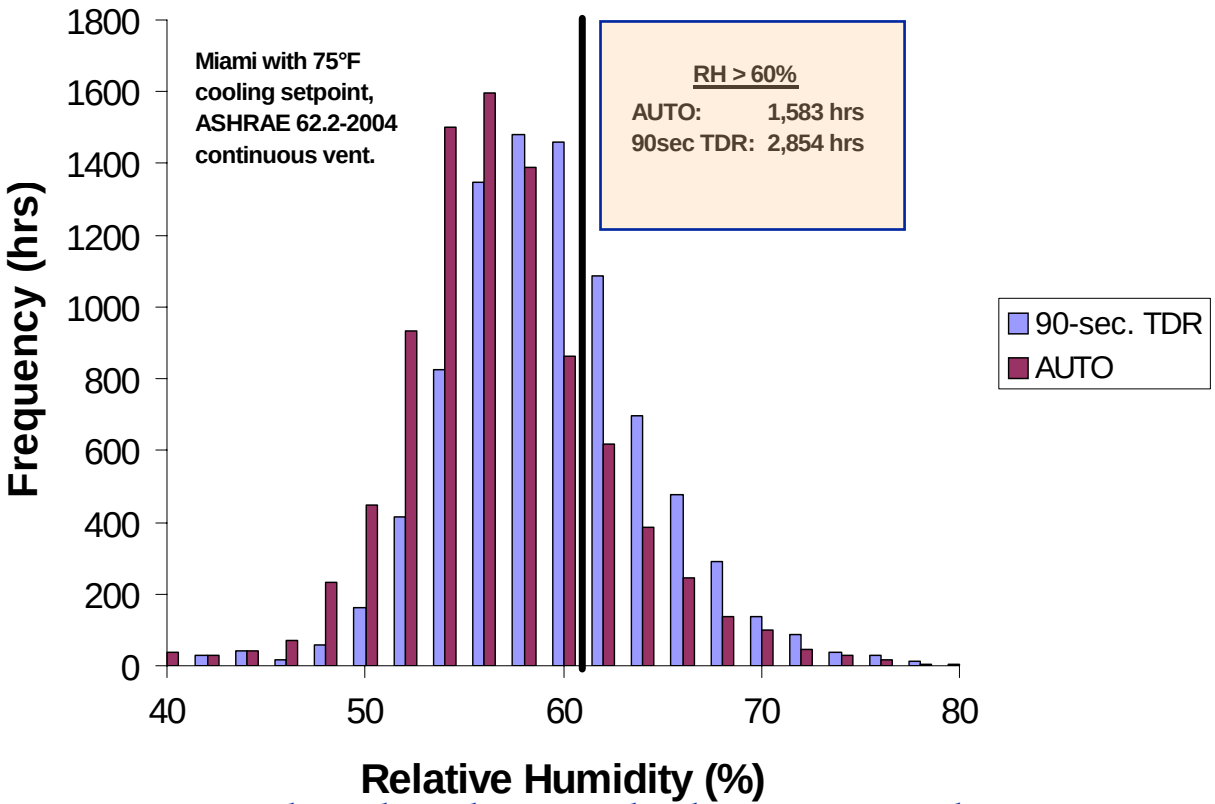
Time Delay – Lab Results

Wet-coil: 80F air inlet, 60.4F dew point

Fan Operation	Gross EER (Btu/Wh)	Net EER considers fan heat and power (Btu/Wh)
Auto, no overrun	11.15	9.47
90 second overrun	11.09 (-1%)	9.10(-4%)

Time Delay Relay - simulated

Indoor Humidity - AUTO Fan vs 90-sec Overrun



Notes: Mechanical ventilation simulated into space not coil.
Used TRN-ResDH, a TRNSYS-based hour-by-hour building energy simulation tool

Shirey, D.B., H.I. Henderson and R.A. Raustad. 2006.
Understanding the Dehumidification Performance of Air-Conditioning Equipment at Part-Load Conditions. Final Report, FSEC-CR-1537-05

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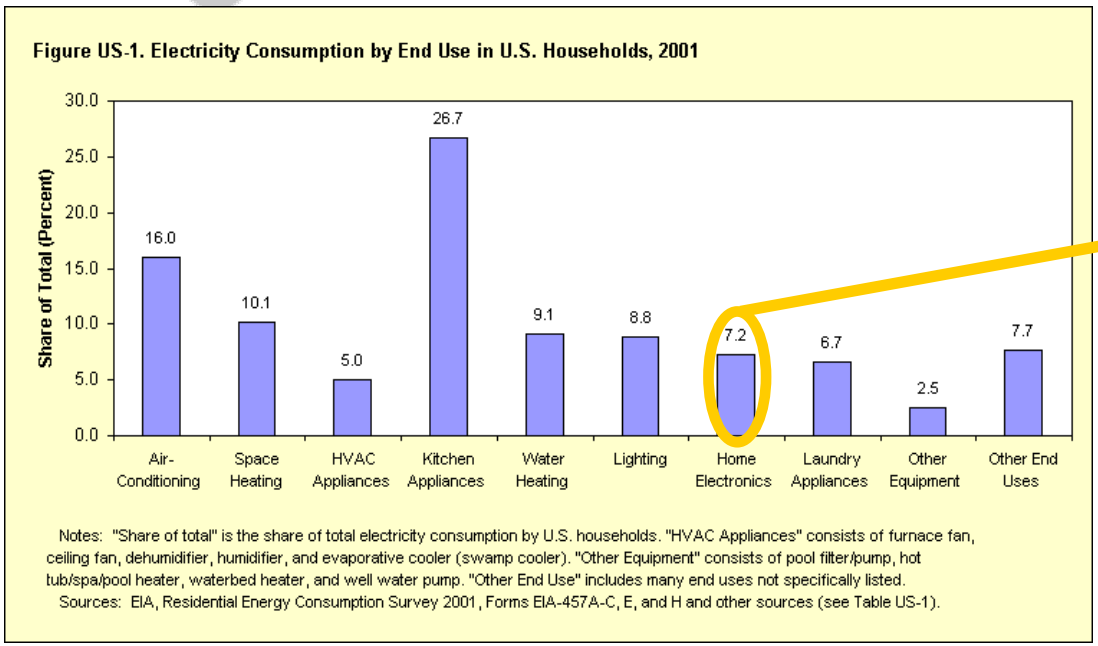
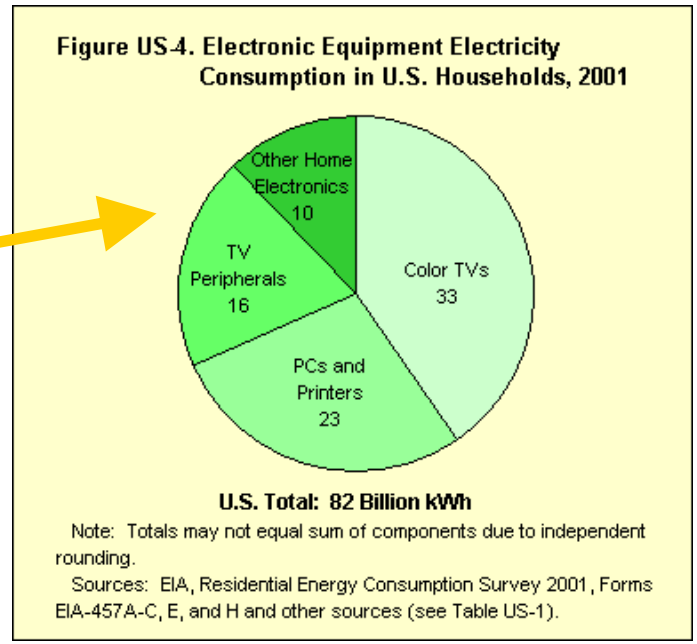
Growth in Consumer Electronics Will Increase Sensible Heat Load





- EIA projects electricity consumption to grow 3.5 percent annually for color TVs and computer equipment through 2025, to more than double the level of consumption in 2003.

Conclusions

- More efficient windows or other envelope measures can reduce sensible loads and save energy, with slight increases in RH in typical single-family homes
- Duct leakage, time delay relay and fan speed settings of HVAC equipment can have moderate to large effect on ability of equipment to remove moisture
- Fan set to continuous “on” mode greatly reduces moisture removal
- Plug loads (sensible heat) are increasing and may counter some reductions in sensible heat from envelope improvements