

2009 ACI Home Performance HVAC 4

Downsizing Mechanical Systems After Retrofits

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What Is Being Improved

- Home design (thermal loads)
 - Infiltration
 - Glazing
 - Insulation Quality
- Air Distribution Efficiency
 - Air handler efficiency
 - Duct efficiency
- AC Efficiency and Size
 - Charge/airflow
 - Better understanding of sizing

What Does An Air Conditioner Do

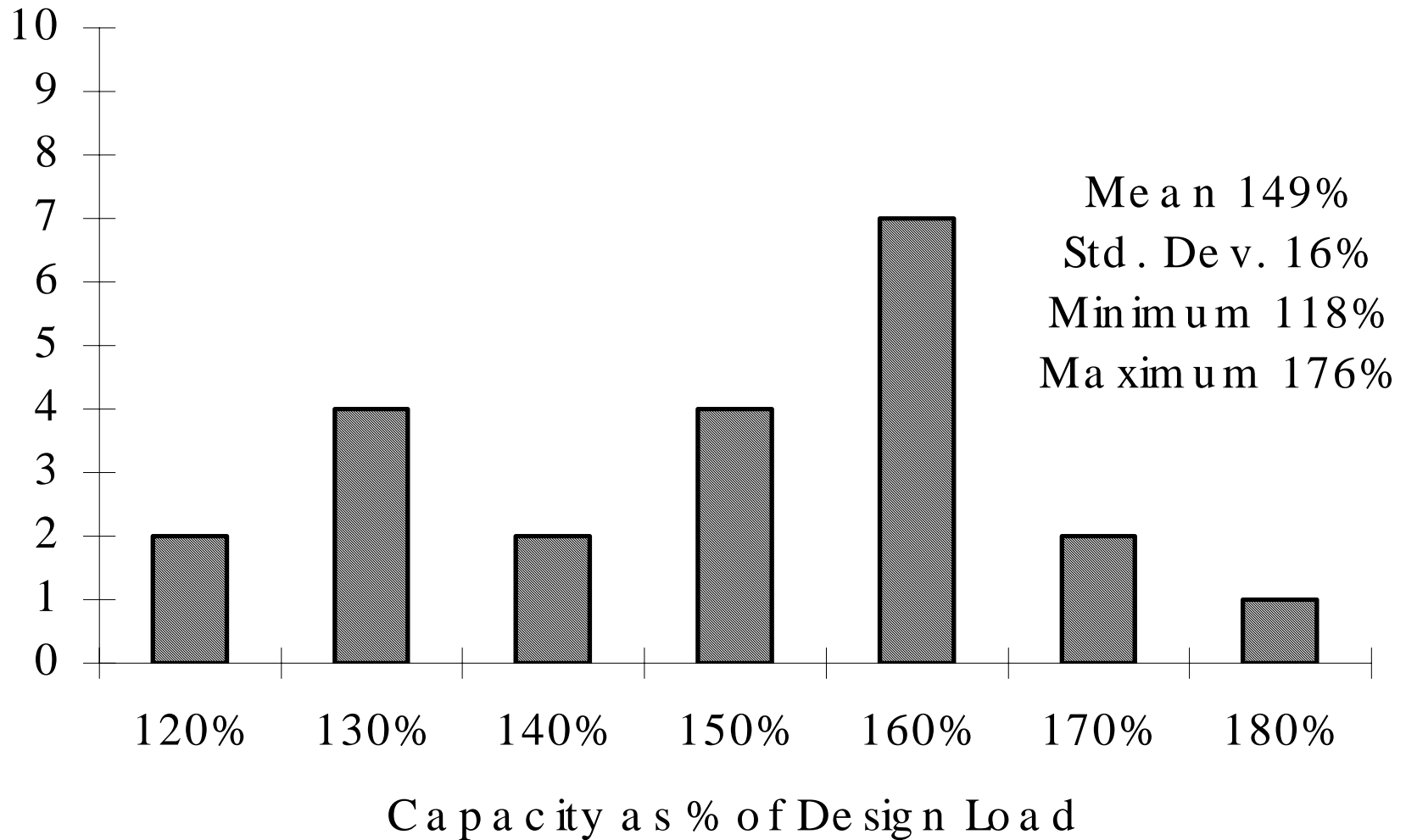
- Reduces the Temperature –
Sensible Cooling
- Removes Moisture –
Latent Cooling

Are Air Conditioners Oversized

Summary of Studies of A/C Oversizing Compared to Manual J Design Loads

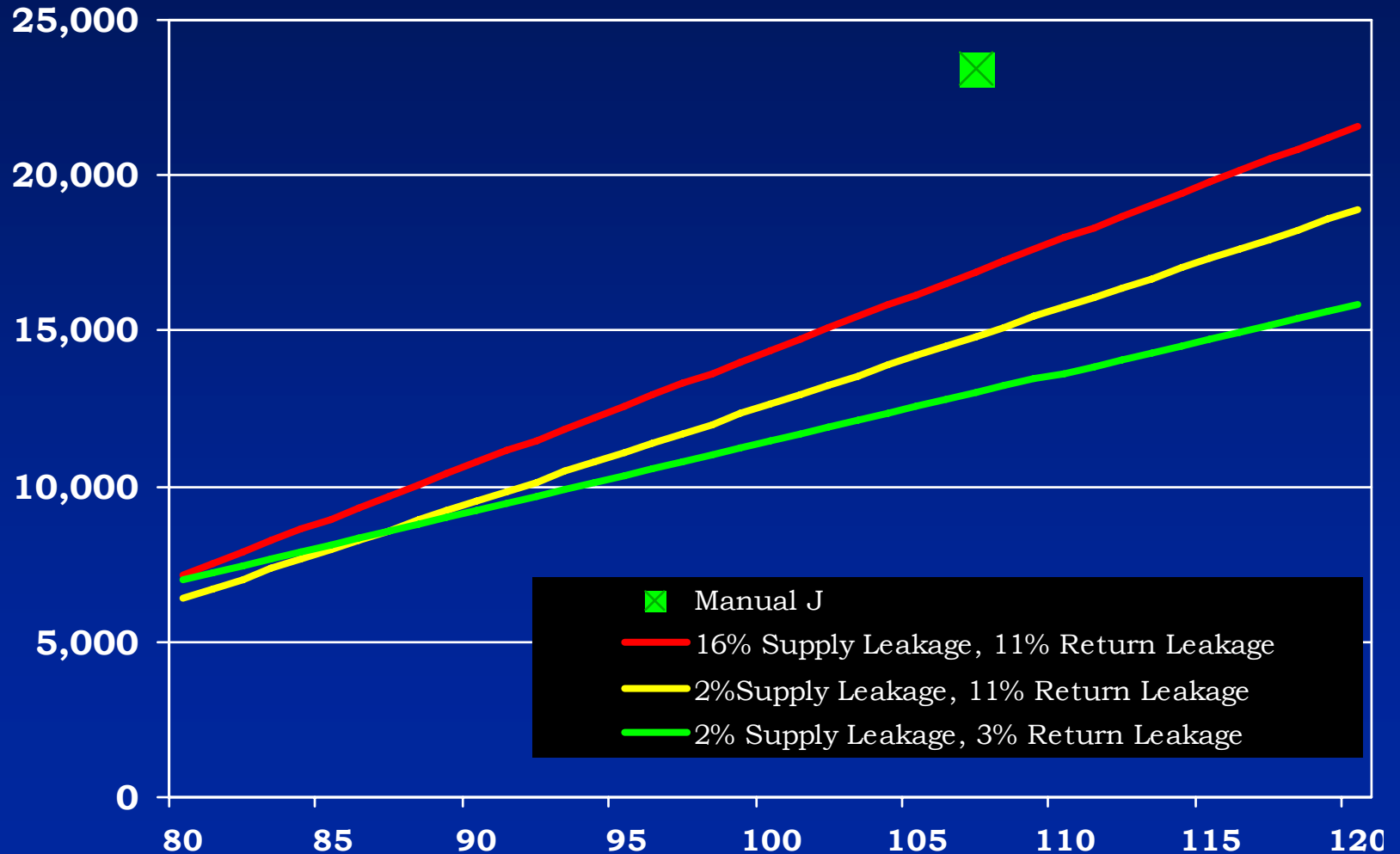
State	<u>Avg % Oversizing vs. Man J</u>	<u>Avg Tons Oversizing vs. Man J</u>
Nevada	33%	
Arizona	48%	1.21
Texas	64%	
Florida	23%	0.61
Carolinas		0.81
Iowa	56%	0.98
Pacific NW	44%	0.68
Maryland	59%	1.11
California	16%	0.3
New Jersey	60%	1.58
New Jersey	70%	
New York	67%	
Average	49%	0.91

New Construction Sizing



Does ACCA Manual J Underestimate Sensible Load

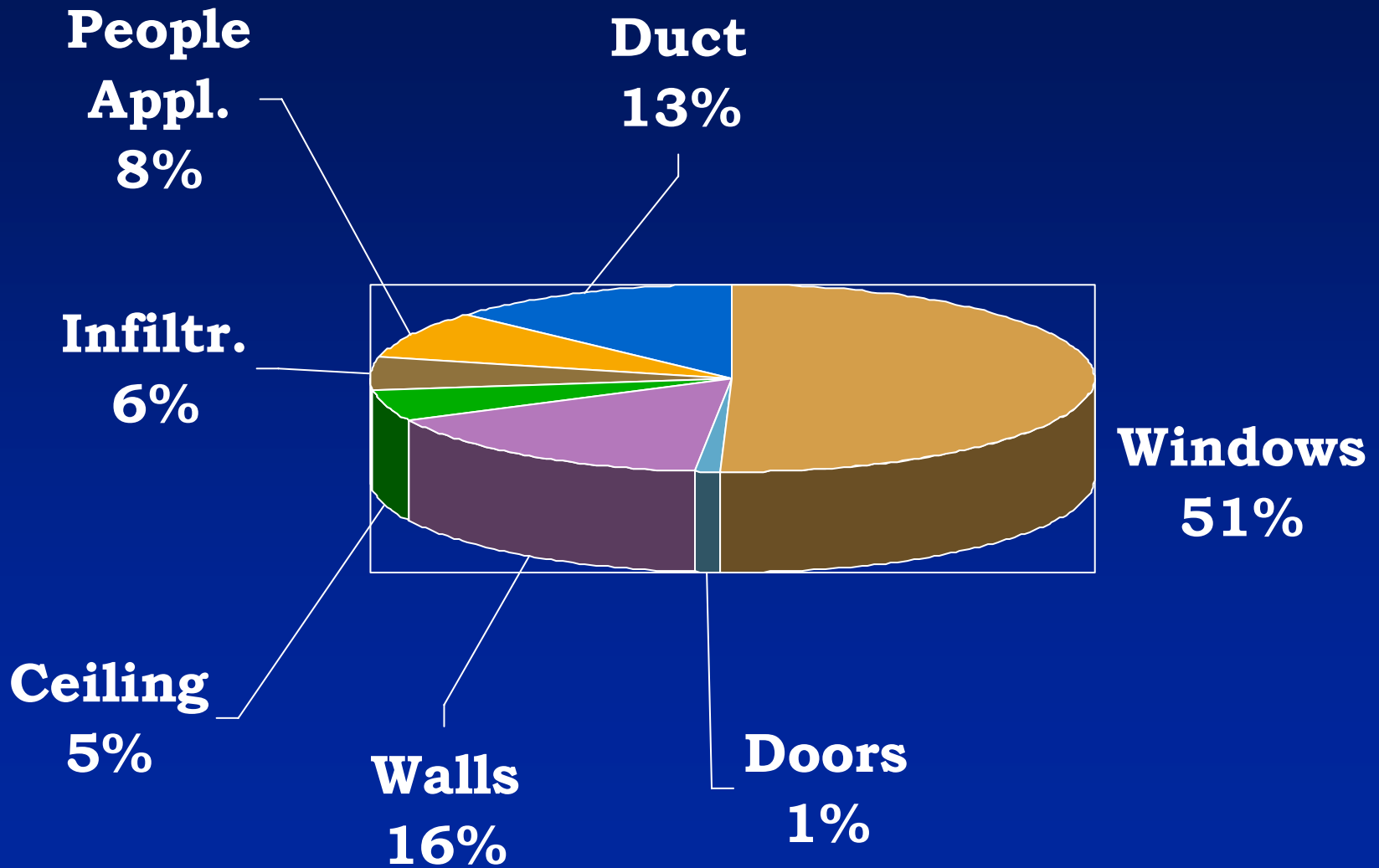
Required Sensible Cooling (BTUh)



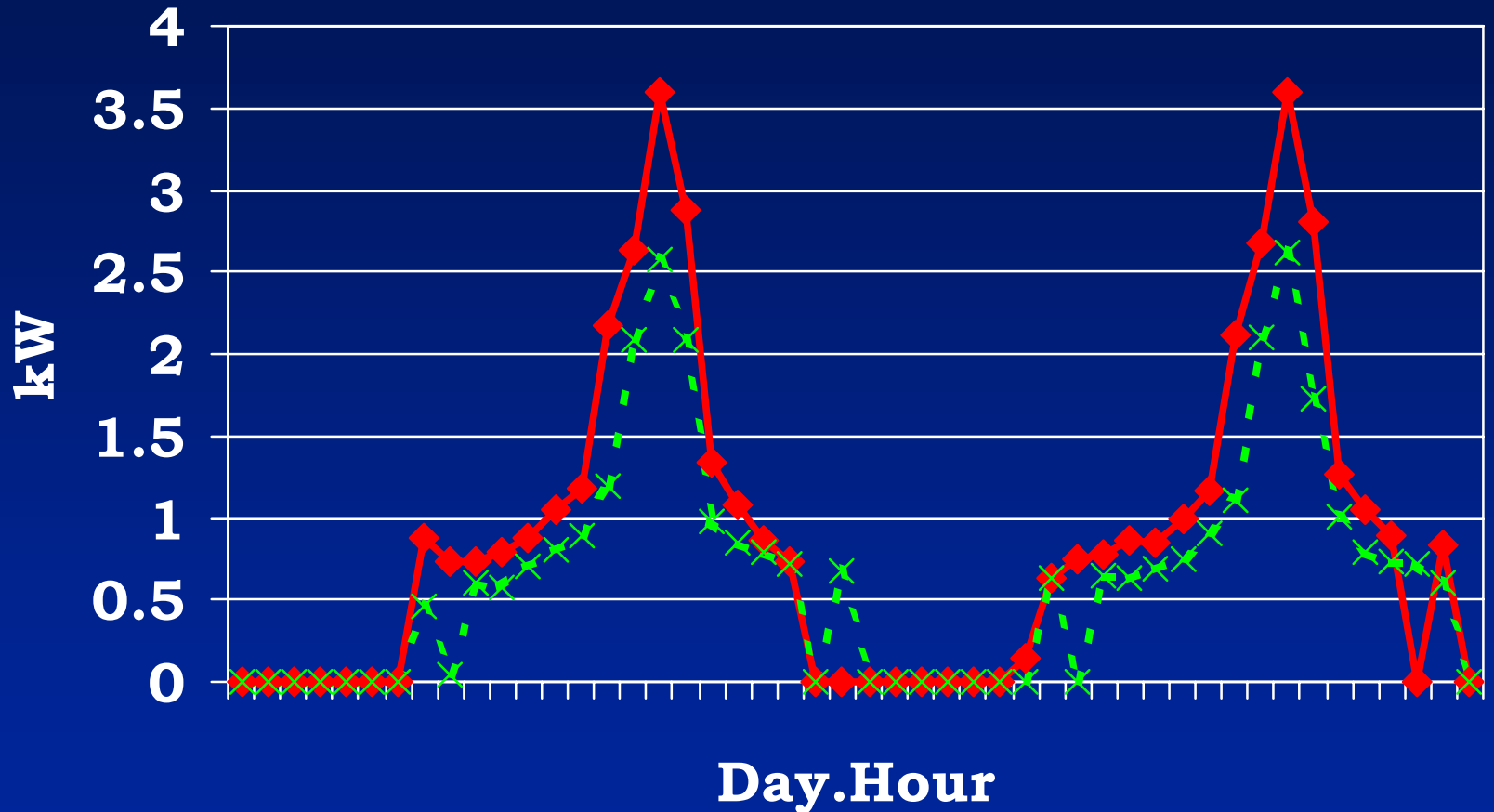
A Path to HVAC Optimization

- Sensible Load Reduction
- Latent Load Control
- Reduce Distribution Losses
- Design Components at their *Interactive Highest Efficiency* (sizing and operating range)
- Improve Installation and Maintenance Practices

Sensible Heat Gains



Reduced Sensible Load - Windows



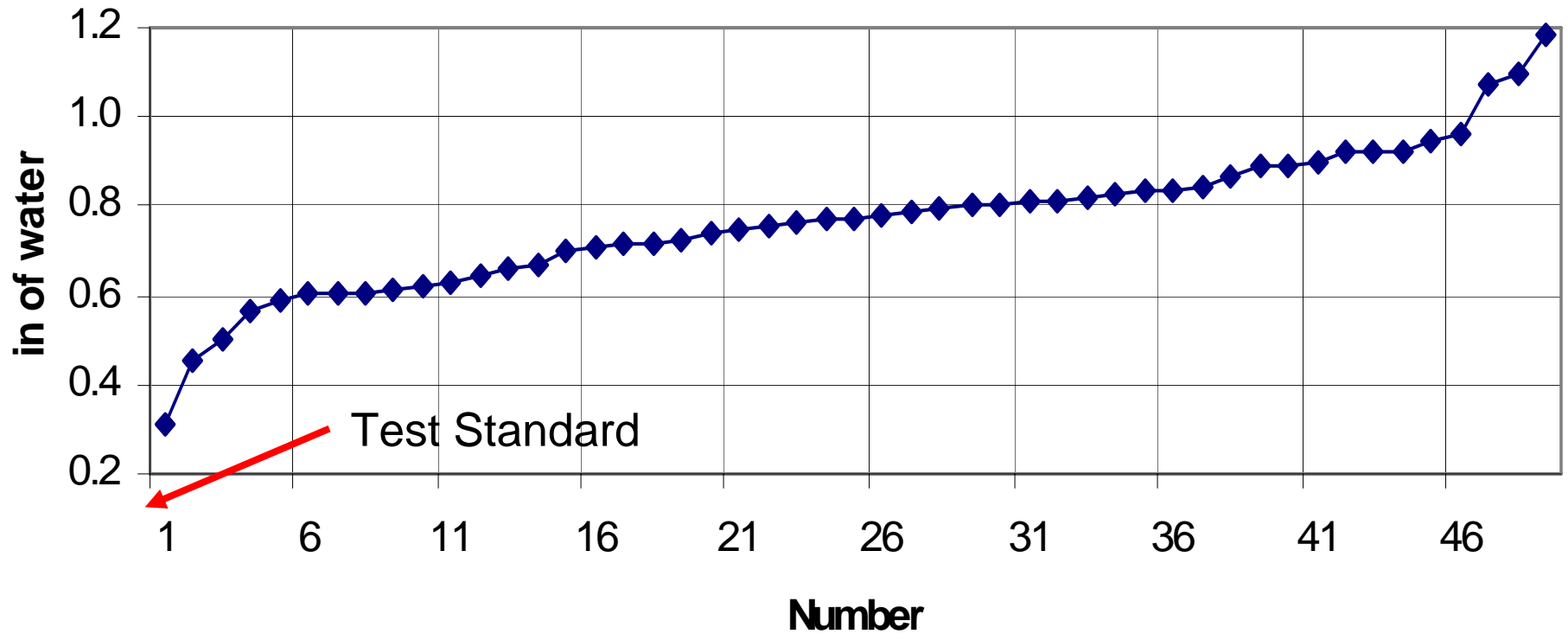
—◆— Double Pane kW - × - Low E Squared kW

Reduced Sensible Load - Ducts

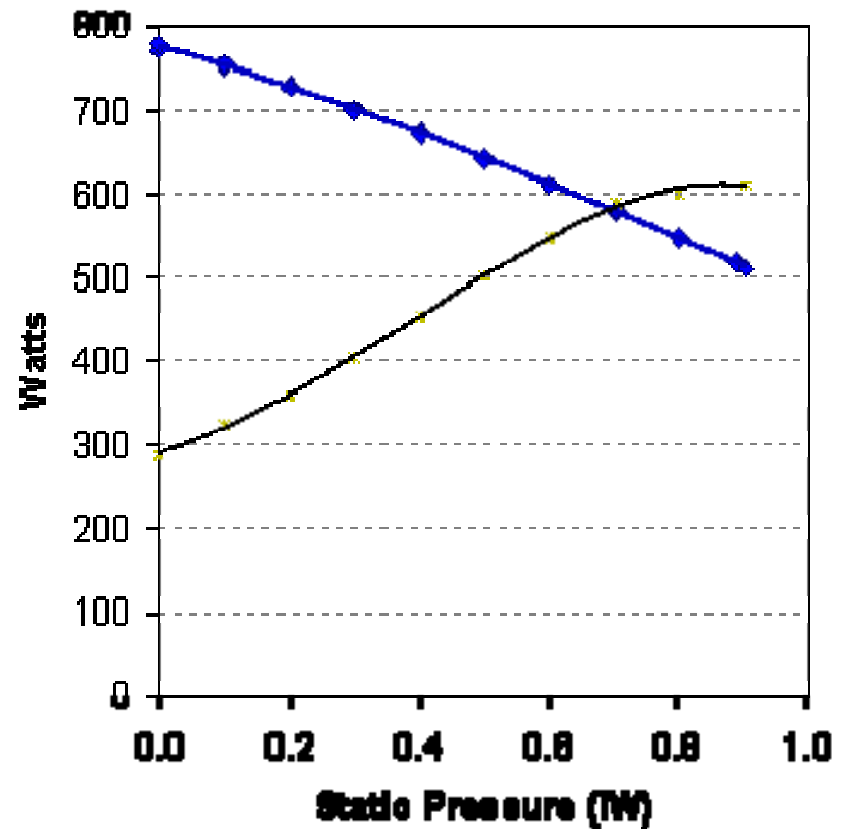
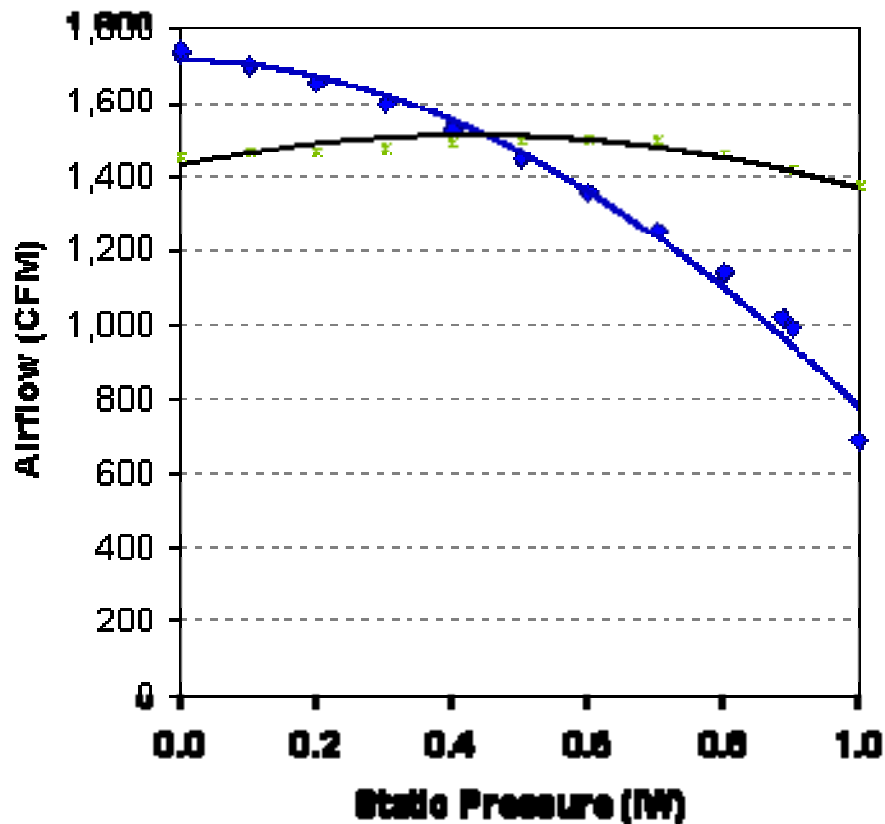
- Short duct runs
- Low static pressures
- Inside conditioned space or improved R-values
- Proper register placement and selection

Real Duct Pressures

Cooling External Static Pressure



Motor Performance PSC vs. "Target CFM ECM"



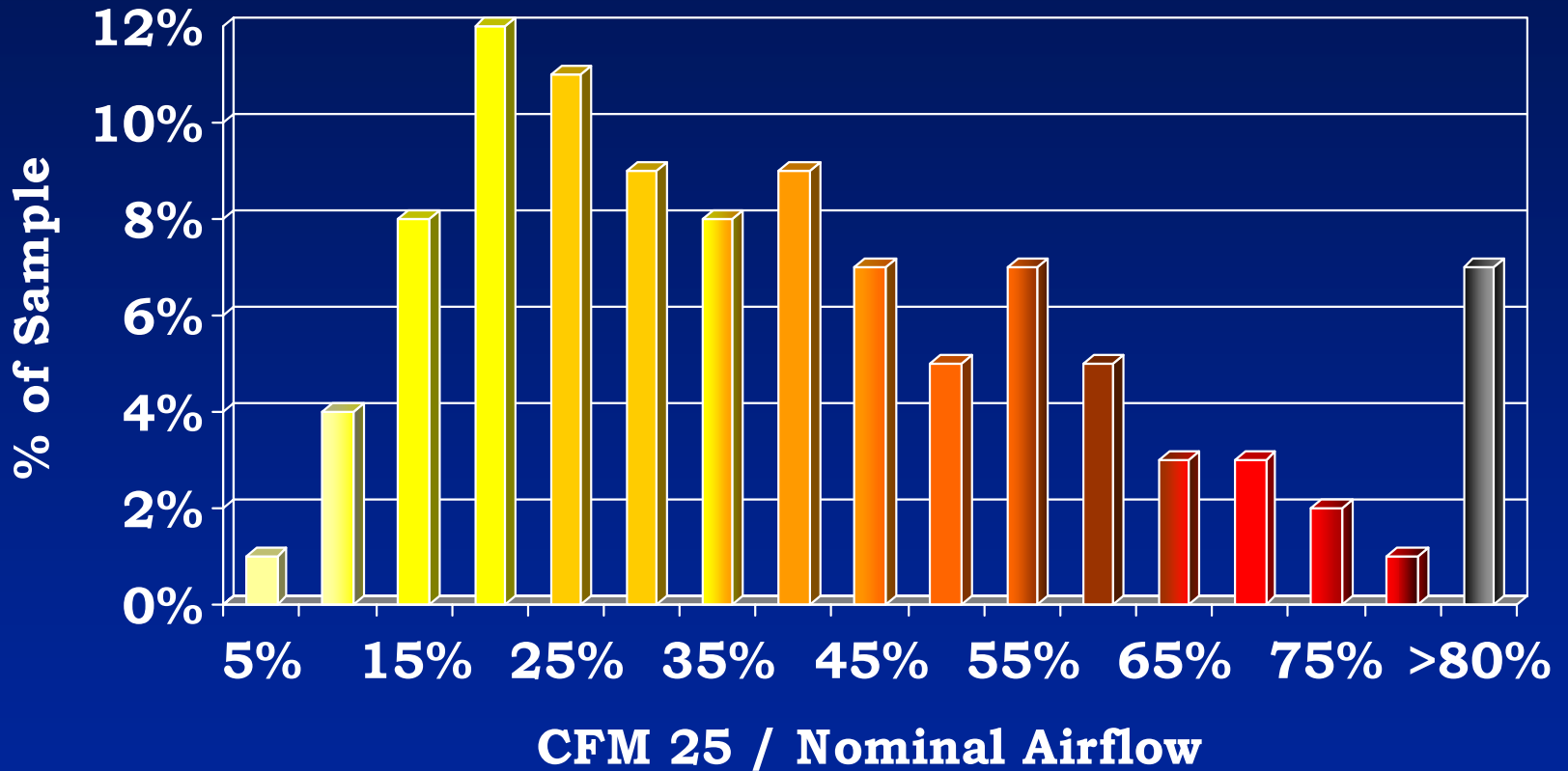
Reduced Latent Load

- Control Infiltration
- Eliminate Duct Leakage

Reduced Infiltration with Mechanical Ventilation

- “Natural Ventilation” (Infiltration) varies between no ventilation and excessive ventilation.
- If the house leakage is reduced sufficiently all the ventilation air will pass through the mechanical ventilation system where it can be treated.
- Reduces both sensible and latent loads
- Allows the dehumidification or other conditioning of ventilation air (e.g. HRV)
- Ventilation Goal
 - 0.35 outside air exchanges per hour (ASHRAE 62)
 - 93 CFM for a 2000 square foot home

Duct Leakage Is A Problem



Test method: Duct Blaster® at 25 pa. (0.10"WC)

Sizing

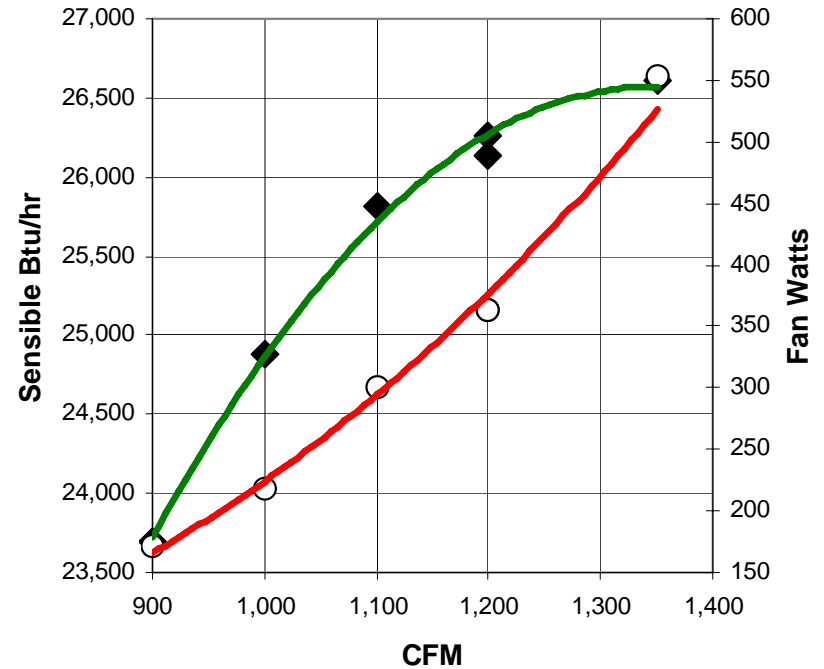
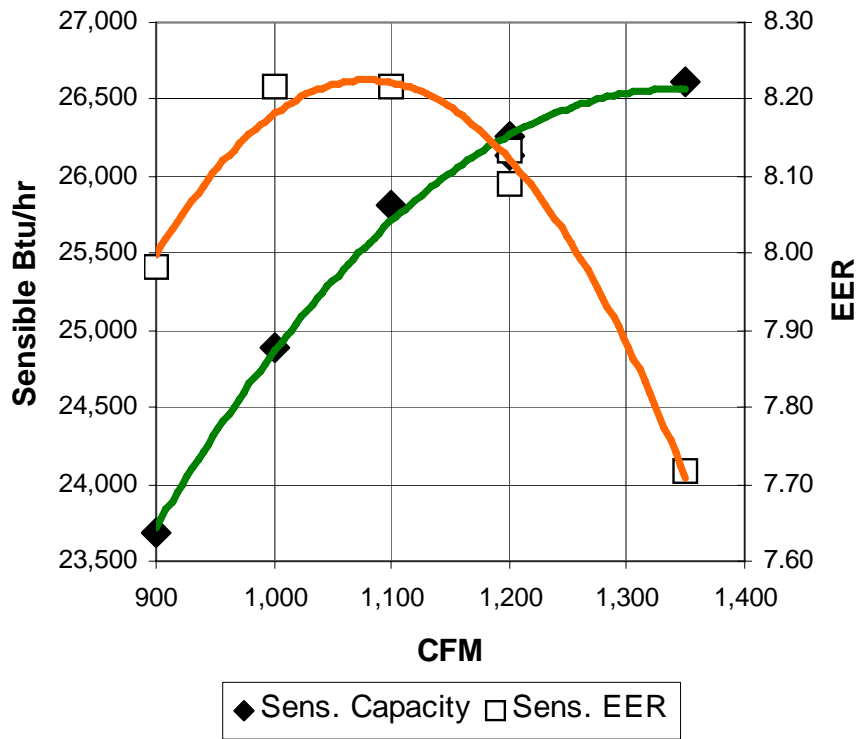
- ACCA Manual J v8 oversizes more than v7
- Central air conditioning and heat pump system sizes must be based on heating/cooling load calculations for the building using ACCA Manual J or equivalent calculation method.
- Air conditioning systems must be sized no larger than 115% of total load at design conditions.
- Heat pump systems must be sized no larger than 125% of total load at design conditions.

Selection and Coil Matching

- Select the system based on ACCA Manual S
- The indoor evaporator coil must be correctly matched to the outdoor coil for the system according to the manufacturer's specifications or ARI standards.

Airflow Optimization

Airflow Test
Dry Conditions 115/80/63, SHR=1



Duct System Design

- Duct systems must be designed to deliver the proper airflow to each space based on the heat loss and heat gain of that space ACCA Manual D.
- Duct system designs should be based on a friction loss rate calculated from the available air handler external static pressure (after all other external device pressure drops are considered) and the equivalent length (considering all transitions and fittings).
- Duct systems must provide for adequate return air pathways to minimize pressure imbalances in the conditioned space

Installation

- Refrigerant lines and indoor coil must be purged with inert gas **during** brazing to prevent oxidation.
- Prior to start-up, systems must be evacuated to 500 microns or less.
- Isolate the system from the vacuum pump and let sit for at least 5 minutes. The micron gauge should not raise more than 300 microns above the initial vacuum level.

Airflow

- Airflow must be measured using the pressure matching method, the flow grid method or a method with equivalent accuracy.
- Measured heat pump airflow must be between 375-450 CFM/Ton, or within manufacturer's specifications when measured through a dry coil ACCA Manual S.
- Measured air conditioner airflow must be at least 350 CFM/Ton when measured through a wet coil, unless the manufacturer specifies a lower airflow for the local design conditions ACCA Manual S.

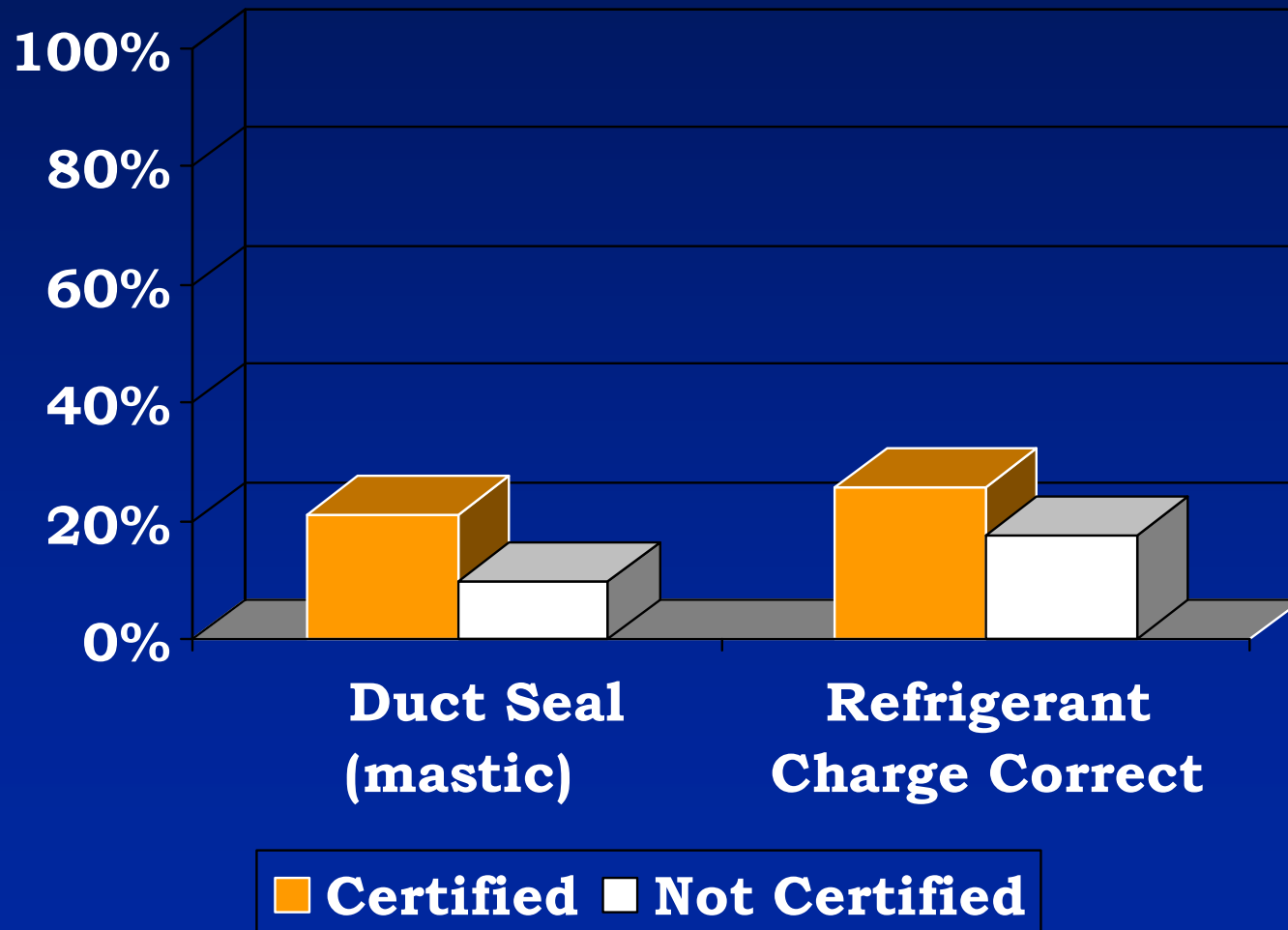
Refrigerant Charge

- Air conditioner or heat pump airflow must pass the airflow criterion above before refrigerant charge tests.
- Proper charge must be verified using the superheat or sub-cooling method. When weather conditions do not allow superheat or sub-cooling, the charge may be “weighed in”. The charge adjustment must be calculated based on the differences between the standard coil and the installed coil as well as the standard lineset and the installed lineset.

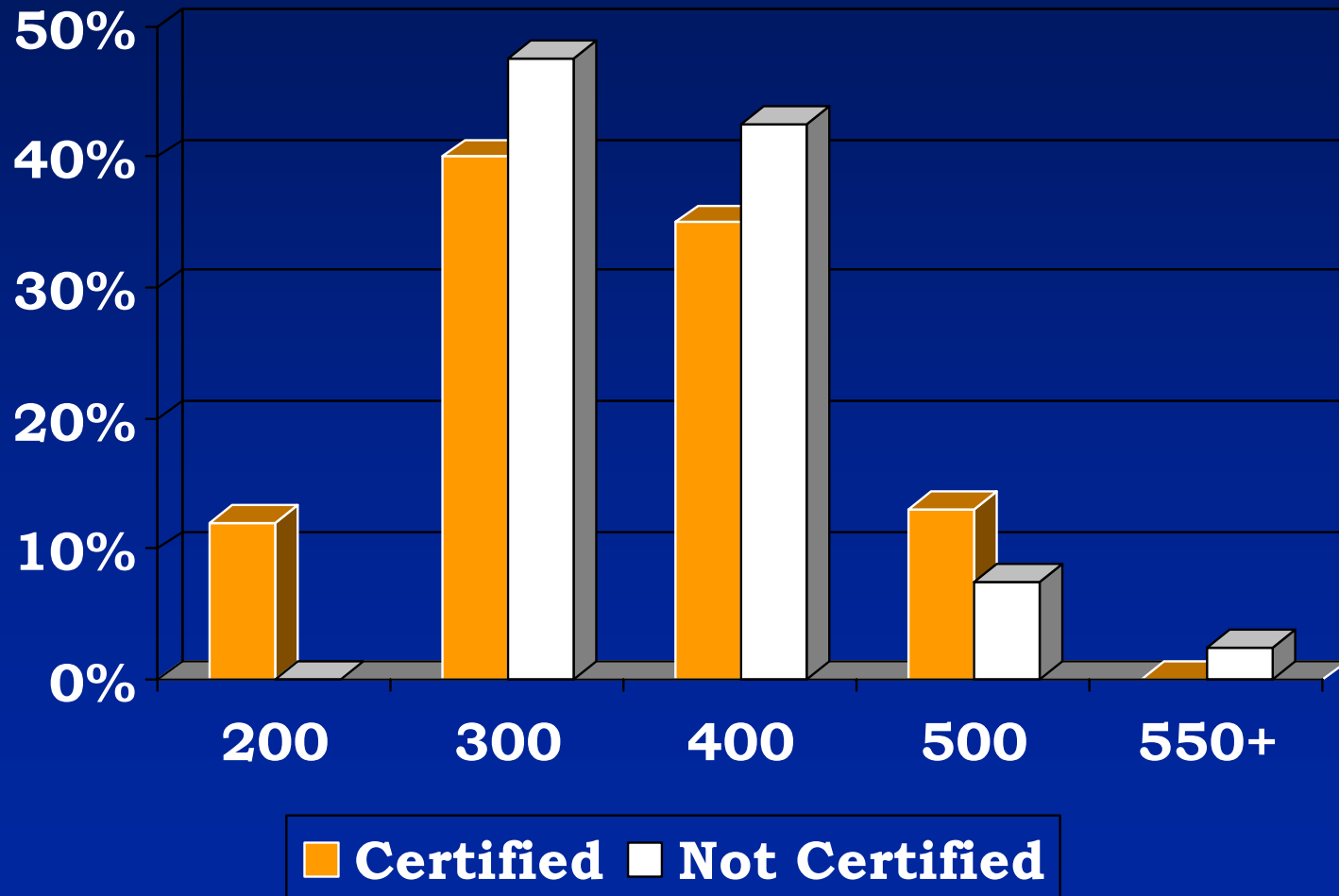
New Installations

- 2 New Construction Studies
 - 52 New Houses with 68 AC/HP's
 - After start-up, before occupancy
 - 19% had correct refrigerant charge
 - 48% had 350 cfm/ton or greater
- New Installations in Utility Rebate Program
 - 76 recently installed AC/HP's
 - 49% of the work completed by certified technicians
 - 16% had correct refrigerant charge
 - 49% had 350 cfm/ton or greater

Certified Does Not Necessarily Mean It's Better



Airflow Through The Indoor Coil



Proctor Articles On Oversizing

- Home Energy Magazine May/June 1995
Bigger is Not Better: Sizing Air Conditioners Properly
- Home Energy Magazine Sept/Oct 1996
Sizing Air Conditioners: If Bigger Is Not Better, What Is?
 - “Oversized AC’s use more energy than properly sized systems”
 - “AC’s are very inefficient when they first start and longer cycles are much more efficient”

Does Correcting Oversizing Save Energy

- Definitely want proper sizing of ALL components in new construction
- Retrofit downsizing reduces peak – good for utilities and the environment
- Not convinced downsizing AC's in a retrofit situation saves energy or is cost effective for the homeowner

Earlier Studies

■ James et al. 1997

- 368 SF single system homes in FL built between 1990 and 1993
- Average oversizing 23%
- 53% > 120% of Manual J
- Billing data regression analysis
 - 13% increase in peak demand
 - 3.7% kWh increase for 120% MJ
 - 9.3% kWh increase for 150% MJ

Earlier Studies

■ EPRI 1995

- Modeling of 28 systems in Las Vegas
- Potential energy savings of 2% - 4% from downsizing systems by 23%

■ EPRI 1996

- Modeling of 37 additional systems in Las Vegas
- Model improved with real monitoring data
- Potential energy savings of 1% from downsizing systems by 23%

■ Proctor et al. 1997

- 51 systems in Northeast
- Potential energy savings of 1% - 2% from downsizing systems

Recent Studies

- Recent studies don't show energy savings
- Parker et al. 2006
 - Pre/post data from replacing 4 oversized systems in FL
 - Average sizing reduction 31%
 - Similar efficiencies for replacement systems (avg slightly higher)

Parker et al. 2006

- House L
 - Downsized 28%
 - Savings estimated at 8% - 13%
- House M
 - Downsized 34%
 - Energy consumption increased 8% - 18%
- House J
 - Downsized 30%
 - Energy consumption increased 0% - 16%
- House J
 - Downsized 32%
 - Limited post data shows energy consumption increased

Parker et al. 2006

- Most likely reason for energy consumption increase is not replacing air handlers and duct systems
- Oversized air handlers with PSC motors
- PSC motors draw almost full power at lower speeds
- Existing duct systems may have been oversized
- Smaller AC's result in longer run times and increase duct losses

Wilcox et al. 2004

- 2 side by side identical houses in CA
- Extensive testing and monitoring to establish they were truly identical
- First summer high –performance, low solar gain, low-emmissivity (LSLE) glass installed in one home
- LSOLE had 29% energy savings compared to clear dual pane house

Wilcox et al. 2004

- LSLE glass reduced load – AC ran 2/3 of time compared to clear dual pane house
- Second summer LSLE house AC & AH downsized by 1 ton (similar efficiency)
- LSLE had 27% energy savings compared to clear dual pane house in the second summer (vs. 29% before replacement)
- 1.8 kW peak reduction in LSLE house

Other Findings

- Field monitoring shows cycling losses are not as great as assumed in standardized tests
 - Evaporative cooling at the start of cycles
 - System cycling losses much lower now
- Downsizing doesn't necessarily increase dehumidification (Parker et al. 2006, Pigg et al. 2008)
- Humid climate – system @ 130% of ACCA Manual J uses less energy than properly sized system (Henderson ACI 2009)
- Downsizing doesn't fix stratification issues (Unpublished – Ft. Wayne)
- High efficiency 2 speed systems aren't any better
 - Much less efficient in high stage cooling
 - Longer cycles & increased duct losses in low stage cooling

Summary

- Get the best - properly sized system you can in new construction
- Make sure the unit is commissioned and delivering correct capacity and efficiency
- Retrofits are good for the utilities and environment, but maybe not for the homeowner
- Smaller retrofit systems that include air handler and duct system replacements may save 6% - 8%
- It's good to question what you believe to be true and search for answers