HVAC Equipment Sizing Strategies: Taking Advantage of High-Performance Buildings

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Building Science Corporation
www.buildingscience.com
Other Resources

• Proctor Engineering Group (San Rafael, CA)
  www.proctoreng.com

Article: “Bigger is Not Better: Sizing Air Conditioners Properly”

• Florida Solar Energy Center (FSEC)
  www.ucf.fsec.edu
Benefits of ‘Right-sizing’ Equipment

• Reduces short cycling (lower efficiency)
• More moisture removal (latent load)
• Reduces electrical peak load
• Smaller and simpler HVAC system—easier to fit inside conditioned space
• Comfort & noise—“blast of cold air” effect & mixing
• Lower equipment cost—recoup costs of energy-related upgrades
Reasons for Equipment Oversizing

• Rule of thumb sizing strategies (e.g., 400 sf/ton)
• Tradition—always done this way
• Avoiding callbacks (covers up problems with underperforming equipment)
• Room for expansion or for unforeseen loads

• Oversizing from rule of thumb is worse in buildings with high-performance envelopes
So how is equipment sized correctly?

• Load calculation: ACCA Manual J

• Computes heat flow in/out of the building at design conditions (1% design temperature)

• Manual J has safety factors built in—fudging above that load is unnecessary
Components of a load calculation

• Regular heat conduction—walls, roofs, floors
• Windows—add radiation (sunlight)
• Air movement—infiltration & ventilation

• Latent load—moisture/humidity to be removed by cooling system
Heat conduction

• \( U \times A \times \Delta T = \text{heat flow through wall/roof/etc} \)

• \( U = 1 / \text{R-value} \) (e.g., R-30 \( \sim U=0.033 \))

• \( A = \text{area} \)

• \( \Delta T = \text{temperature difference} \)

• Be sure that upgraded building components (e.g., 2x6 walls, insulating sheathing) are accounted for
Windows

- 1/3 to 2/3 of cooling load typically from windows
- U-value (insulation)
- SHGC (solar heat gain coefficient) or SC (shading coefficient)
- Shading—external and internal
- House orientation—if known, use it.
Air movement

• Infiltration—unintentional air movement. Measured in ACH (air changes per hour)

• Ventilation—intentional air movement. Measured in CFM (cubic feet per minute)

• Well-sealed buildings have lower infiltration—0.1 ACH measured in Building America houses

Therefore lower infiltration loads.
Other Items

• Latent load—don’t use “30%” rule of thumb

• Duct losses—vary with location and insulation level. Are zero with ducts inside conditioned space.

• “Swing multiplier”—used to account for equipment capacity loss at high outdoor temperatures. Sometimes used incorrectly as general fudge factor.
Equipment Resizing Example
(Northern CA)

Modifications included:
• Spectrally-selective windows
• Unvented roof/ducts inside conditioned space
• Tighter building envelope
• Thicker wall insulation
Sizing equipment below Manual J Loads: Las Vegas, NV (Arbor View)
Arbor View Plan 2260 On-Time Frequency

Frequency of cooling on-time

Number of 0.5 h intervals

On-time fraction

Percent of 0.5 h intervals

Lot 6 Arbor View
Arbor View Plan 2260 Runtime vs. ÄT

Cooling On-time fraction vs. Outside to Inside Temp. Diff.

Temperature Difference (F) vs. Cooling On-time fraction
Problems Seen When Resizing Equipment

• Customer perceptions—“Why do I have 3 tons when my neighbor has 5 tons?”

• Customer complaint—“Why is my equipment running so long? It’s never done that before.”

• Greater vulnerability to poorly installed systems—duct leakage, improper refrigerant charge, or low airflow.

• Higher recovery times from deep setbacks— instruct customers to “set & forget” thermostats.
Window Effects on Loads & Efficiency

Glazing Ratios vs. Energy Star

- Floor Glazing Rest
- Wall Glazing Rest
- Wall Glazing
Window Effects on Loads & Efficiency

Cooling Load vs. Window Area

- Design Load (kBtu/hr)
- Window area (sf rough opening)

Graph showing the relationship between cooling load and window area.