ENERGY CENTER OF WISCONSIN

Promoting quality installation of central AC (and heat pump) systems and gas furnaces

Energy Design Conference and Expo

Duluth, MN

February 26, 2014

YOUR PARTNERS IN ENERGY RESEARCH, EDUCATION & CONSULTING

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"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying 1.5 hours of credit toward Building Officials and Residential Contractors continuing education requirements."

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Topics for today

- What do we know about the incidence and impacts of QI issues in the Midwest?
- What is the current landscape of utility programs addressing QI issues?
- What do we most need to learn to make programs better?

Central AC systems are not plug-and-play

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- Size
- Refrigerant charge
- Airflow
- Controls
- Duct leakage

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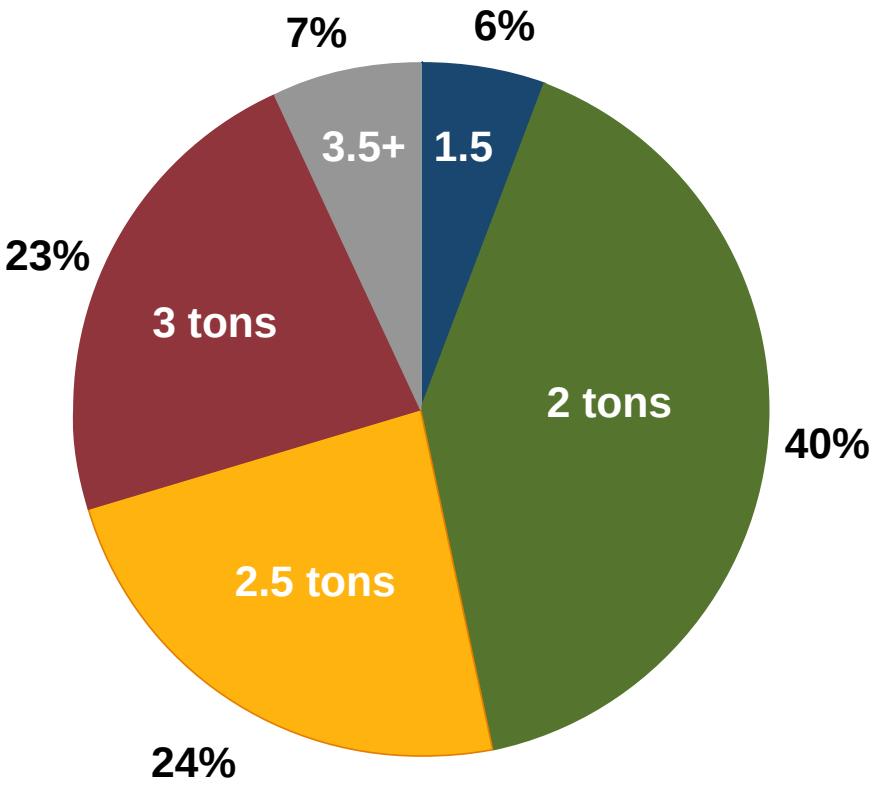
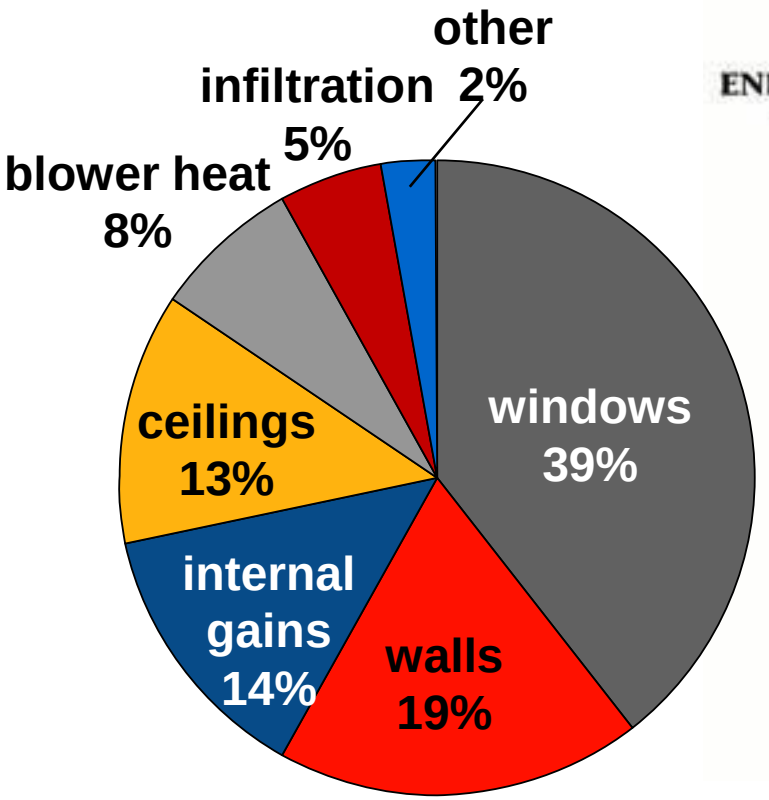
Sizing

What's out there (in WI)?



Source: ECW Residential Characterization Study (1999)



Aggregate Manual-J estimated contribution to design cooling load for 37 homes in Madison, WI

What's often missing from Manual J calculations?

- Shading
- Lo-e windows
- Hidden insulation
- Thermostat setpoint
- Air leakage

After-the-fact Manual J Calculations for 37 WI homes

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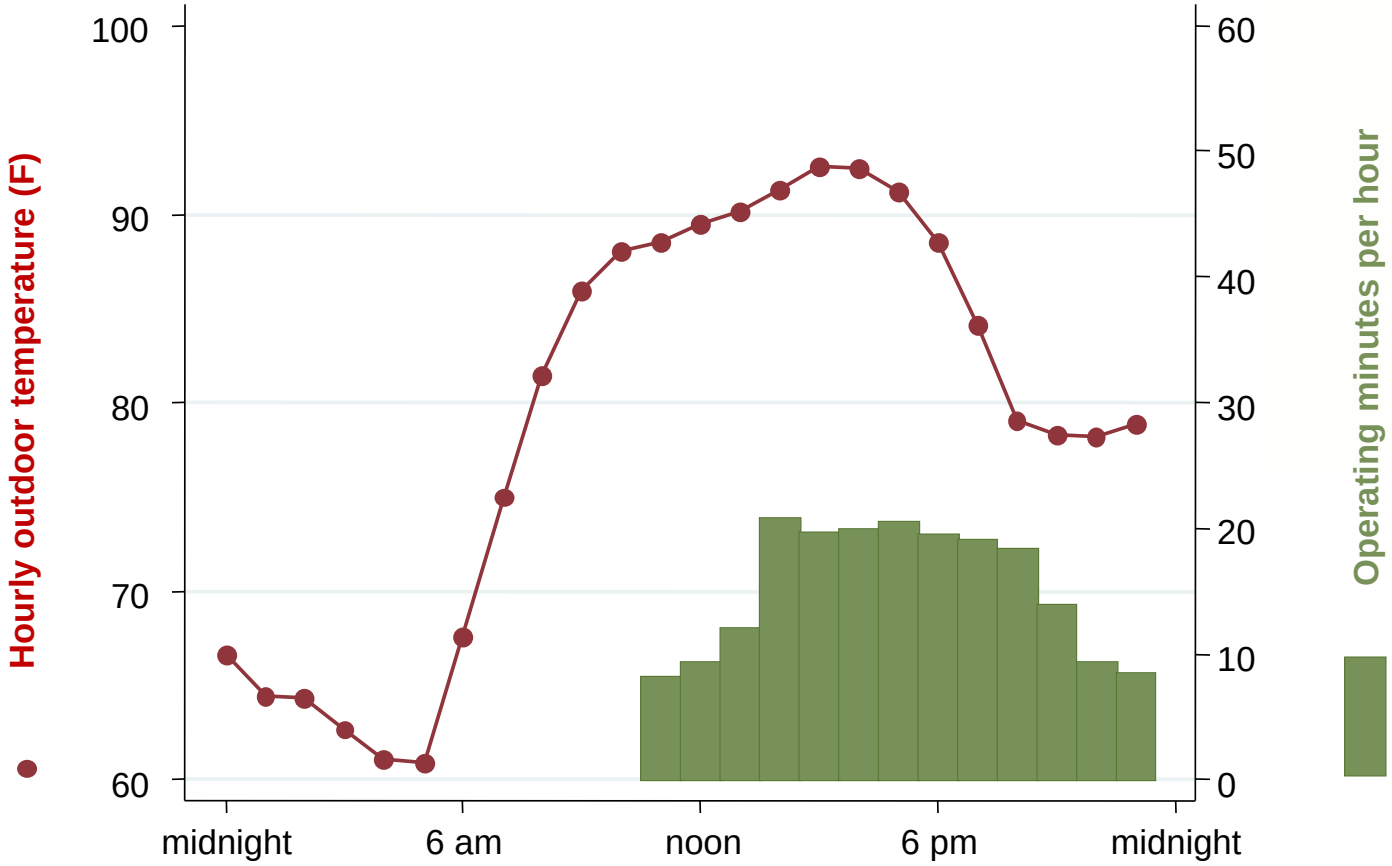
Undersized by…	...1 ½ ton	1	3%	
	…1 ton	3	8%	
	…½ ton	9	24%	
Appropriately sized		13	35%	86% within ½ ton
Oversized by…	... ½ ton	10	27%	
	…1 ton	1	3%	
	Total	37	100%	

What do run-time data say about sizing?



www.ecw.org

Site 1019 on July 17, 2005

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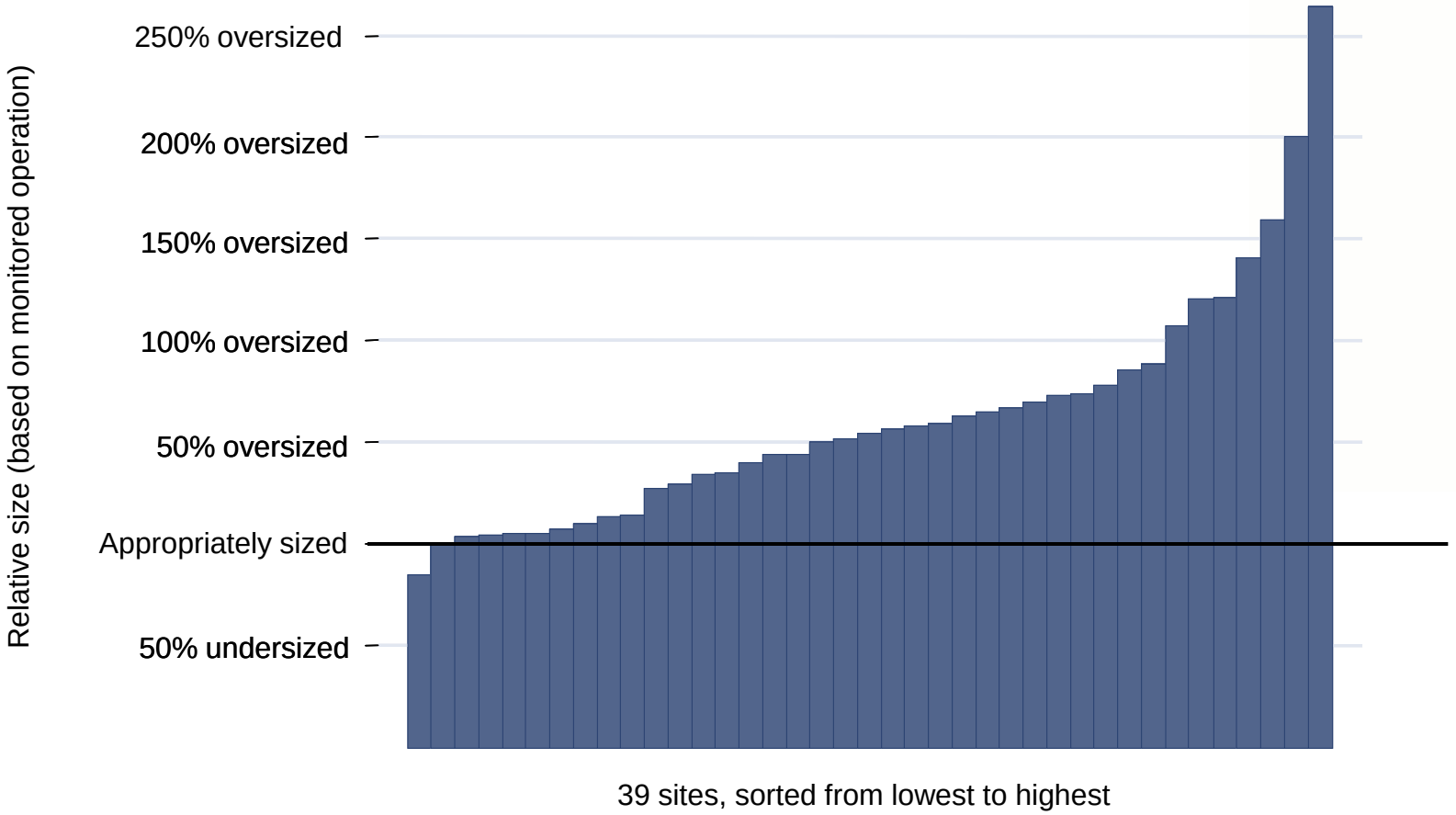
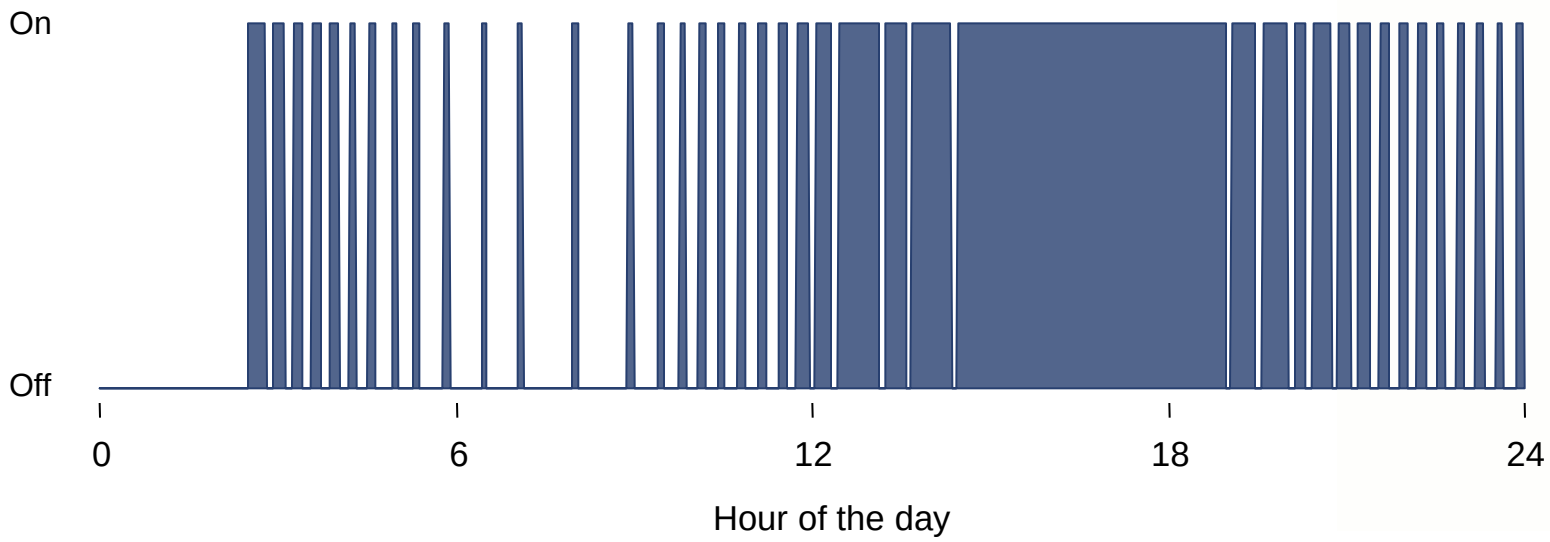


Cycling for some systems looks like this…



…and like this for others

Sizing Experiment

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- Load calcs said: 1.5 tons needed
- New 3-ton unit installed in 2005
- New 2-ton unit installed in 2006
  - (same make/model)
- Monitoring over both summers

No difference in energy consumption!

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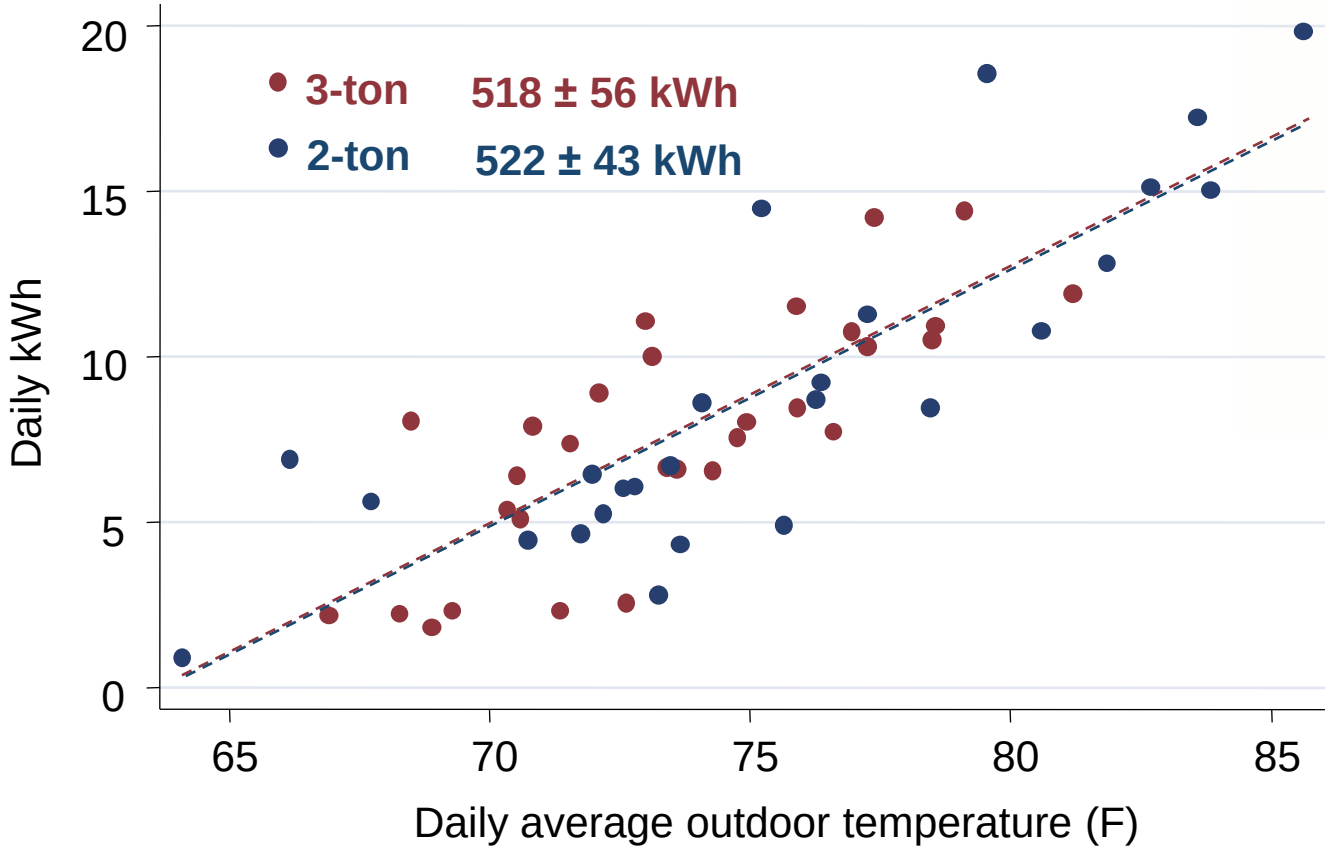

Sizing bottom line (from WI research)

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- Most systems are over-sized
  - Think twice before installing anything over 2.5 tons
  - Many homes would be fine w/ 1.5 tons
- But it's difficult to size accurately
- Proper sizing will…
  - …not likely save much energy (unless you're WAY off)
  - …save some money on installed cost
  - …help avoid indoor hurricanes (if airflow is reduced)
  - …perhaps provide better humidity control

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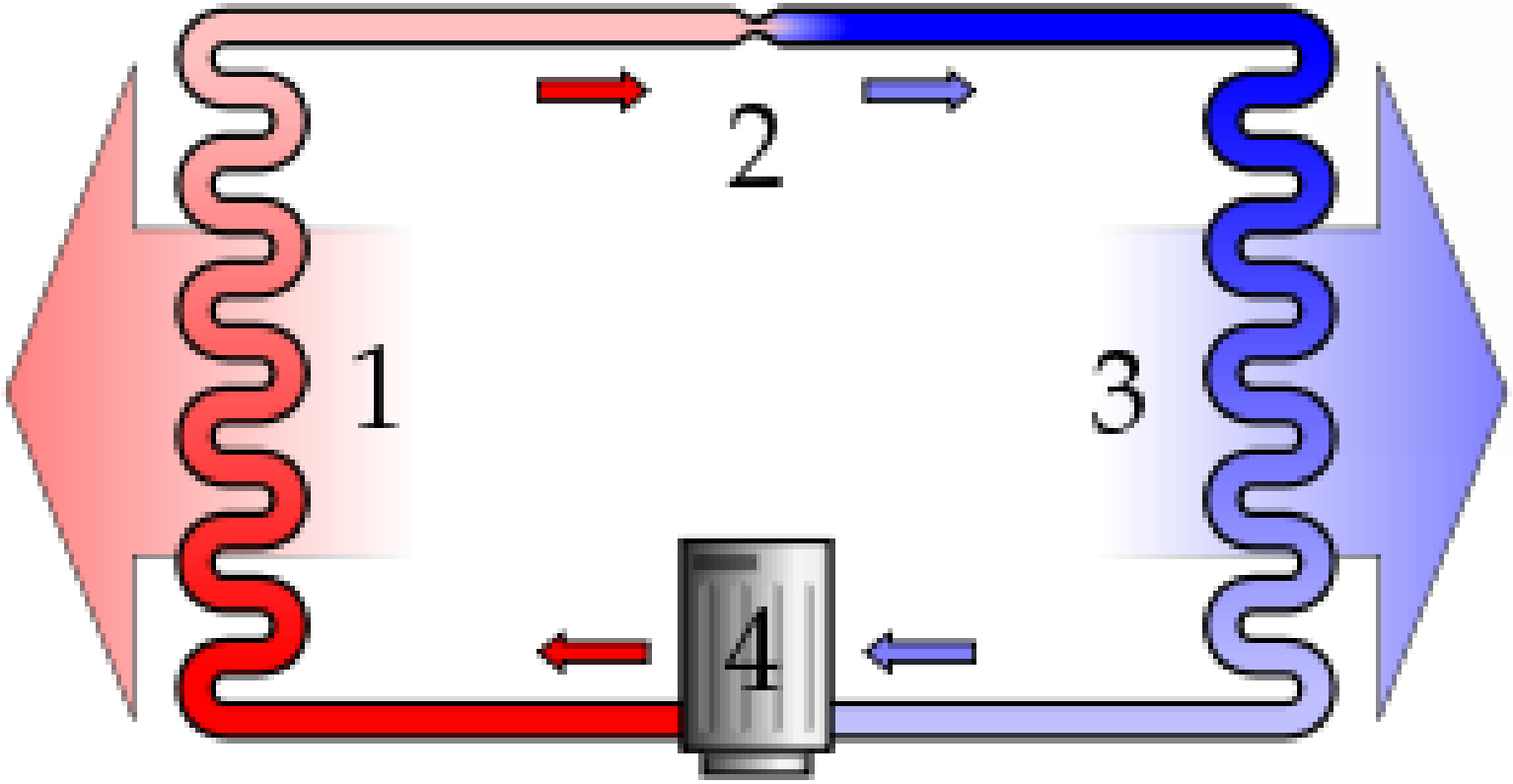
REFRIGERANT CHARGE

Expansion Device (Fixed or Thermostatic)



Refrigerant Charge Field Test

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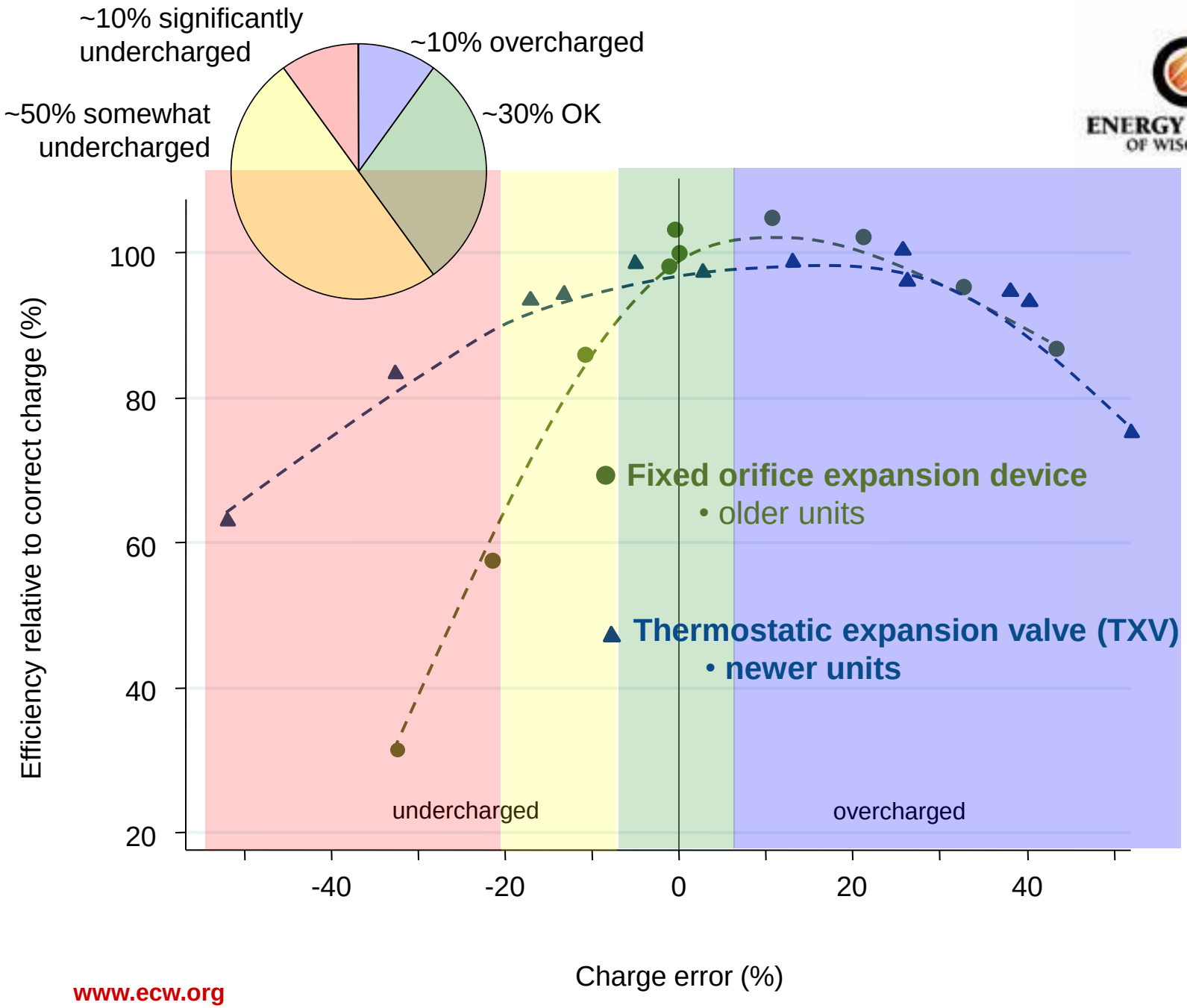
~10% significantly undercharged
~10% overcharged
~50% somewhat undercharged
~30% OK
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Efficiency relative to correct charge (%)
100
80
60
40
20
-40
-20
0
20
40
Charge error (%)
undercharged
overcharged
Fixed orifice expansion device
• older units
Thermostatic expansion valve (TXV)
• newer units

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AIRFLOW

Three types of blower motors

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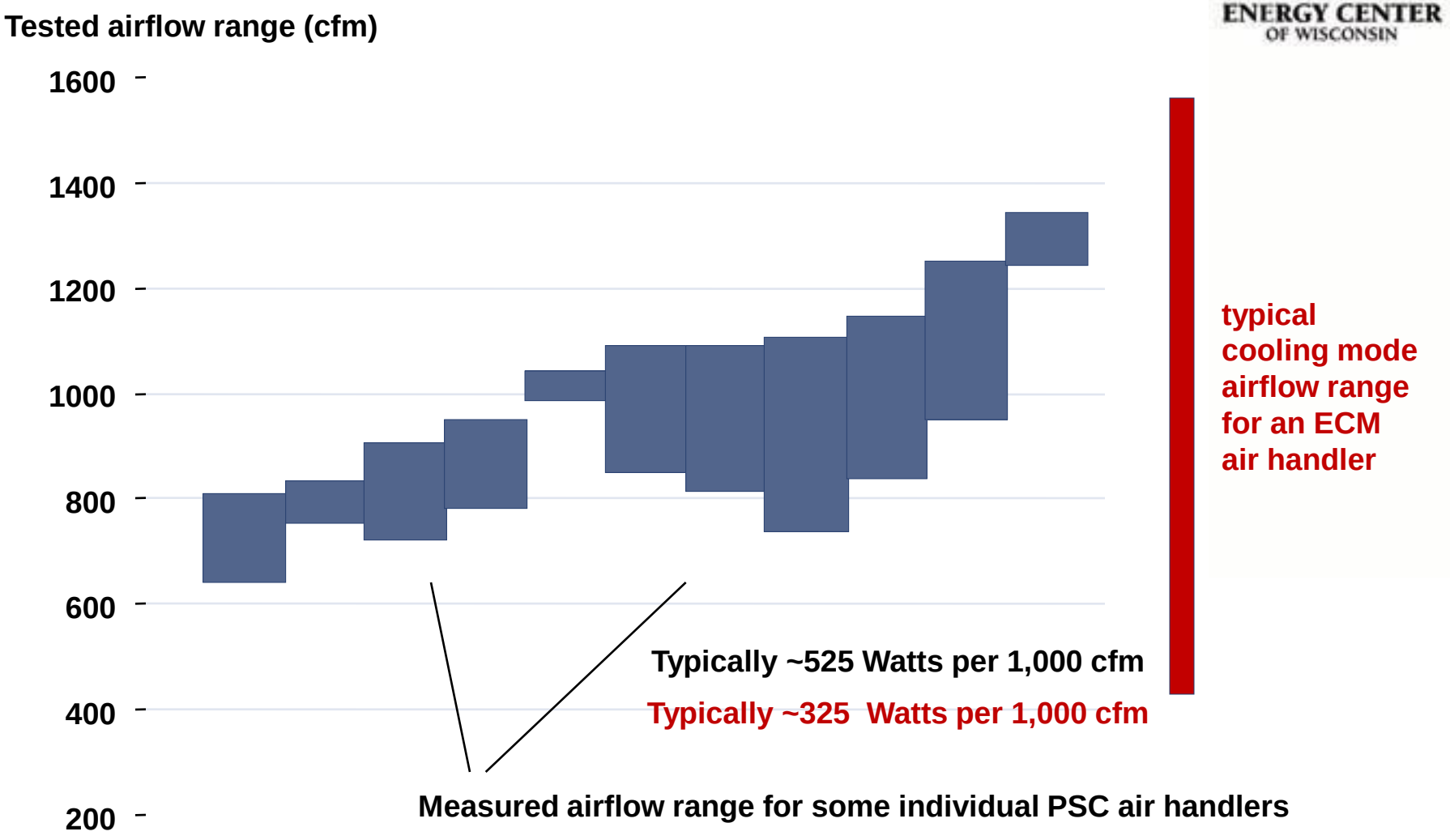
- **PSC** (permanent magnet split capacitor)
  - Low cost, lower efficiency, limited airflow range, doesn't maintain airflow
- **ECM** (electronically commutated motor)
  - Higher cost, higher efficiency, large airflow range, maintains airflow
- **Constant Torque (aka "X13")**
  - Not as expensive as ECM
  - ECM efficiency
  - Capable of large airflow range, but limited selection (set by OEM)
  - Maintains airflow better than PSC

ECM vs. PSC airflow



Airflow

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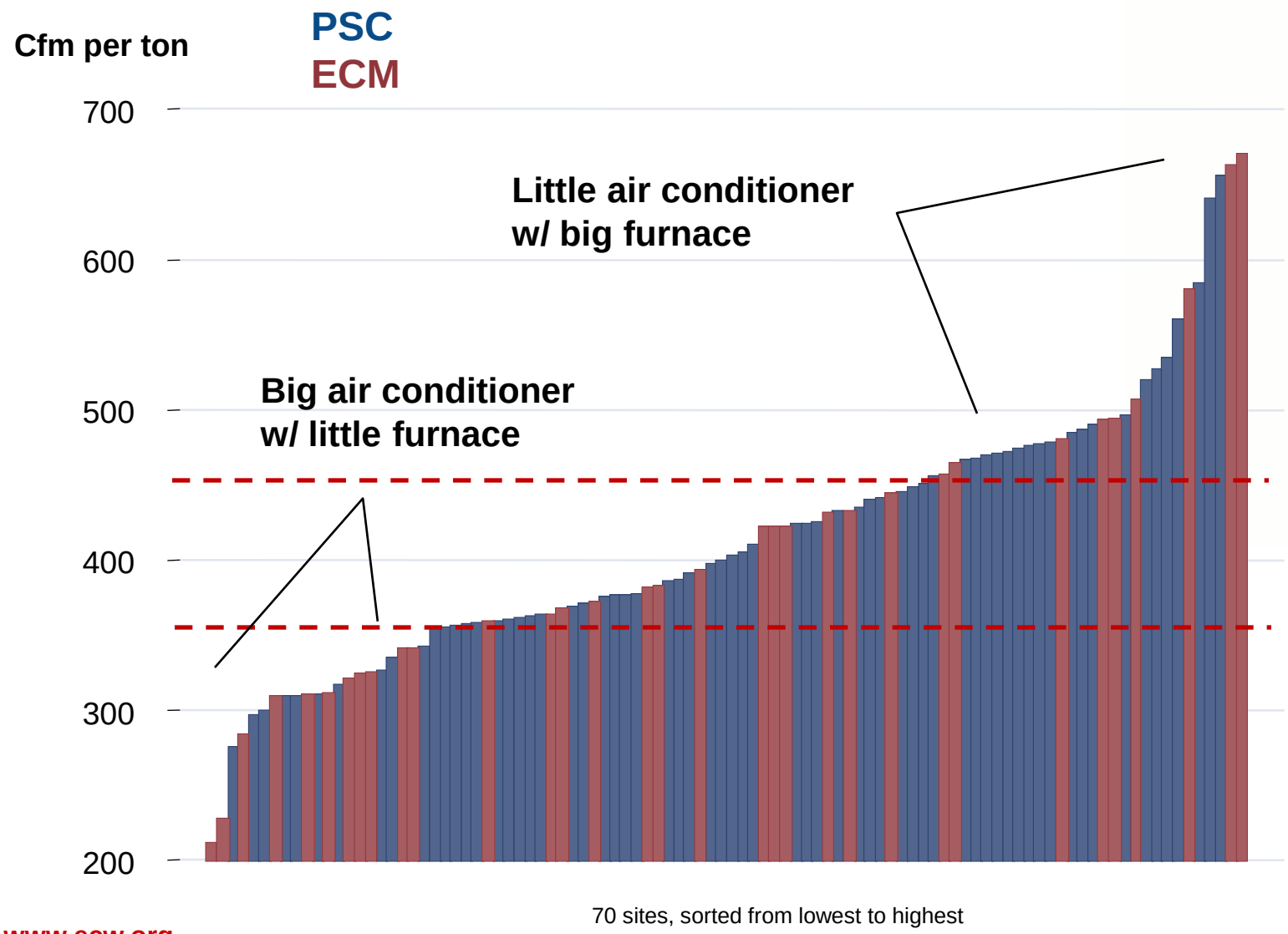
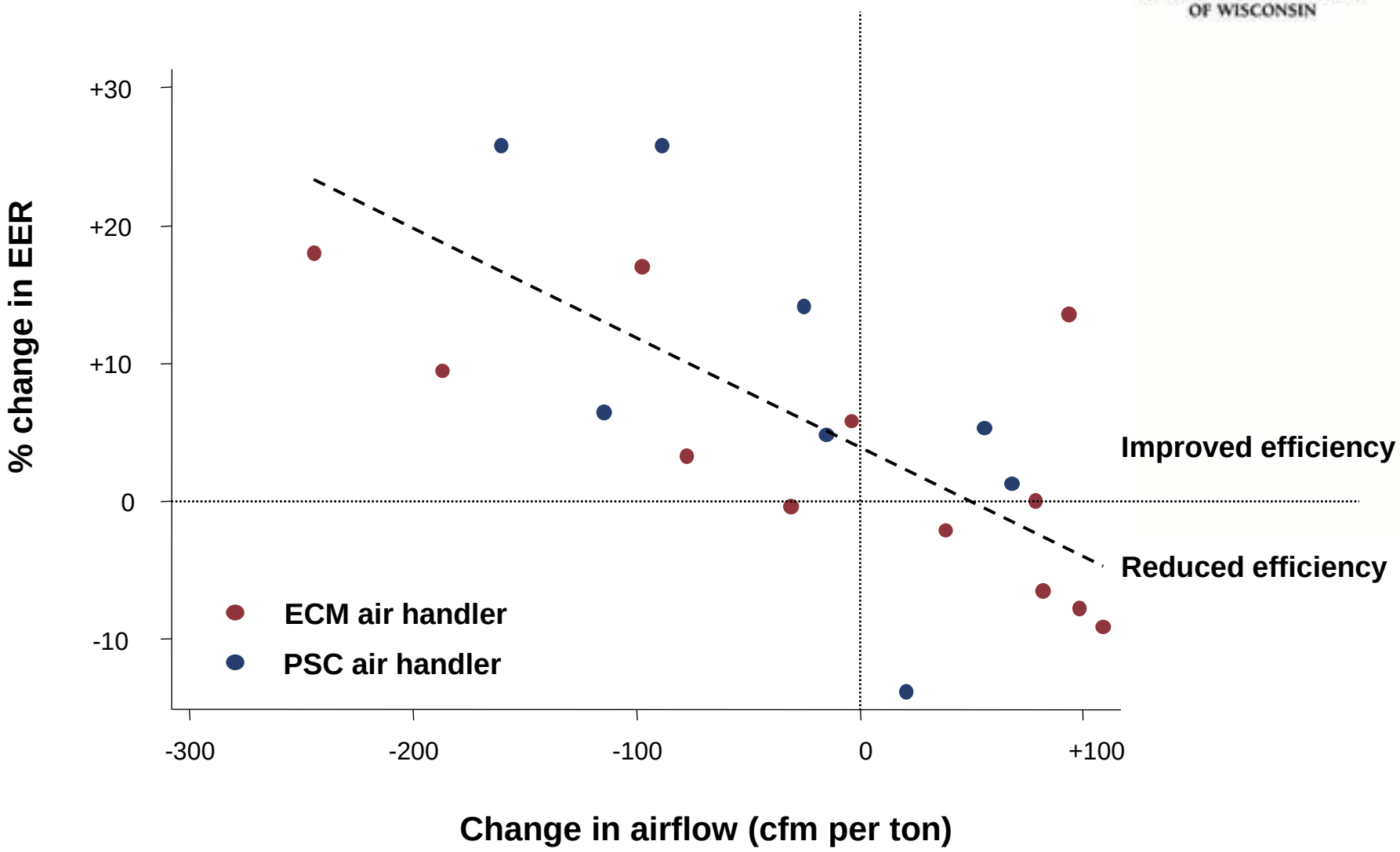


Measured EER impact of changing airflow



Airflow bottom line

- Check airflow
  - Especially if small AC w/ large furnace
- Reduce airflow if possible (to a degree)
- Install an ECM furnace (or maybe X13)

Tuning – overall results

Type of adjustment	Older systems (n=21)	New SEER 10-13 systems (n=10)	New SEER 14+ systems (n=30)	All systems (n=61)
Airflow	6 (28%)	0 (0%)	14 (47%)	24 (39%)
Refrigerant	15 (71%)	7 (70%)	11 (37%)	33 (54%)
Coil clean	8 (38%)	0 (0%)	0 (0%)	8 (13%)
Filter replacement	1 (5%)	0 (0%)	3 (10%)	4 (7%)
Mean % EER improvement	3.1 ± 6.1%	13.3 ± 20.9%	4.6 ± 3.9%	5.4 ± 4.1%

Site	System Description	% EER improvement	Adjustments (key savings contributor underlined)
41	3-ton, non-TXV, non-ECM, R-22, SEER 10	68%	**Corrected 88% undercharge.**
65	2-ton, non-TXV, non-ECM, R-22, SEER 13	55%	**Corrected 58% undercharge.**
69	1.5-ton, non-TXV, non-ECM, R-22, SEER 10	31%	**Corrected 33% undercharge. Reduced airflow 131 cfm for 245 watt reduction in air handler power. Cleaned condenser coil.**
28	2.5-ton, non-TXV, ECM, R-22, SEER 10	27%	**Cleaned condenser. Corrected 27% undercharge. Small airflow adjustment had negligible impact.**
15	2-ton, TXV, non-ECM, R410a, SEER 14	26%	**Reduced airflow 320 cfm for 210 watt reduction in air handler power.**
64	2.5-ton, non-TXV, non-ECM, R-22, SEER 10	25%	**Corrected 18% undercharge.**
63	3-ton, non-TXV, non-ECM, R-22, SEER 14	25%	**Corrected 37% undercharge.**
34	2-ton, TXV, ECM, R410a, SEER 14	18%	**Reduced airflow 195 cfm, for 240 watt reduction in air handler power. Correction of 4% overcharge also improved EER slightly.**

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CONTROLS

Two important controls

- **Airflow setting for Fan-on operation**
  - ECM FAR superior—if set correctly!
- **Cooling-mode fan-off delay**
  - Don’t use in humid climates!

How much water is in a "houseful" of summer indoor air?

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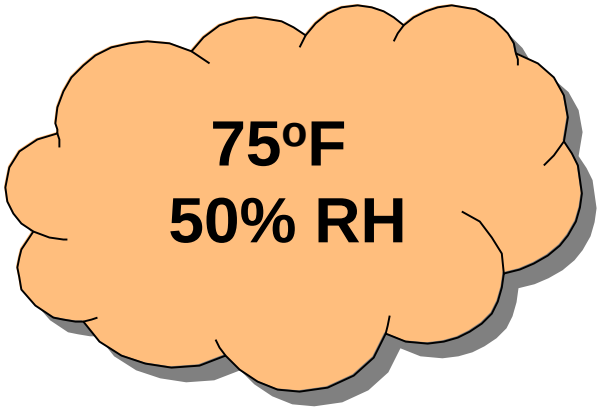
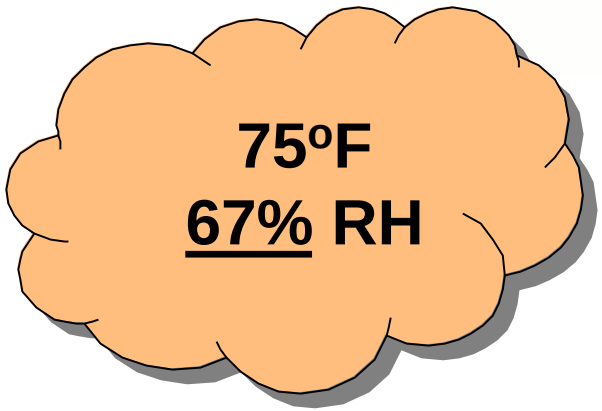
How much water is stored on a 2-ton coil when it is fully saturated?

About ¼ to ½ gallon



1½ gallons

add ½ gallon



Better humidity control associated with

- **Hours of AC operation**
  - **Better (smaller) sizing**
    = more hours of AC operation
    = fewer hours of uncontrolled humidity
- **Home tightness**
  - **Tighter keeps the outdoors out**
- **Auto-Fan operation (not constant fan)**

Condensing Gas furnaces

- Orifice size and gas manifold pressure
  - Affects firing rate
- Airflow and temperature rise
- Controls

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QUALITY INSTALLATION PROGRAMS

Minnesota QI/QM programs

- **Existing unit tune-up**
  - Typically $25 incentive
  - Must be licensed contractor, but not necessarily registered with utility
- **QI for new standard-efficiency unit**
  - Typically $50 incentive
  - Typically must be registered installer
- **QI for new high-efficiency unit**
  - Higher incentives, depending on SEER/HSPF
  - Typically must be registered installer

Minnesota QI/QM programs, cont.

	Existing system tune-up	Offer QI for Std. eff. system?	Require QI for high-eff system?
Xcel	No	Yes	Yes
Great River Co-ops	Some	Some	Yes
MN Power	No	Yes	Yes
Interstate	No	No	No
Ottertail	No	No	No
Municipals	Some	Some	Some

Utility	Number of Registered Contractors
Great River	1,142
Xcel	750
Minnesota Power	154

Other notable QI programs

- CheckMe® (Proctor Engineering Group)
- CoolSaver (CLEAResult)
- HVAC SAVE (MEAA)

Current research in MN (CARD project)

- Market research
  - Interviews with distributors, contractors, utilities and others
  - Homeowner survey
- Field research
  - Field tests on 120 systems
  - Run-time monitoring of 60 systems
- Synthesis
  - What does this tell us?
    - Two facilitated meetings of interested stakeholders

SEEKING A FEW GOOD TECHNICIANS!

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Programs should emphasize installation practices that…

…have a high incidence of issues

…offer good savings from getting it right

…contractors are willing and able to implement

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What do YOU think is important to learn from this research?

Thank you!

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