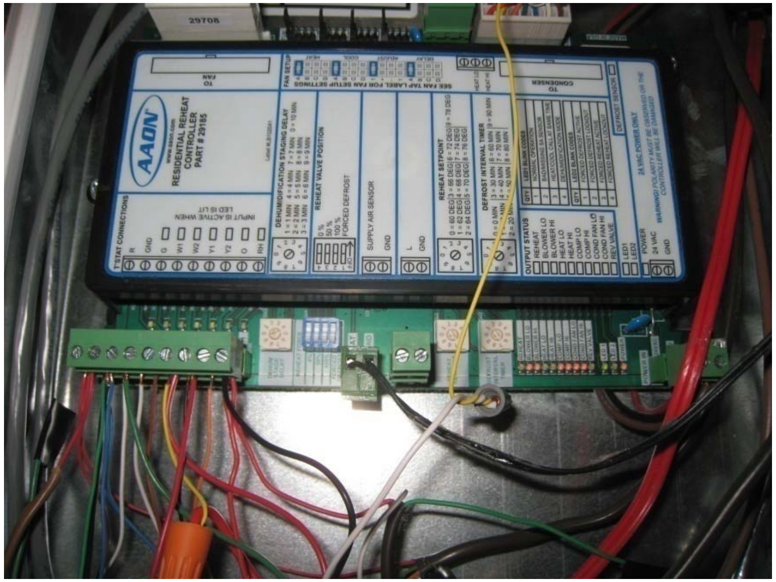


Humidity Control Strategies

Armin Rudd

Residential Building Energy Efficiency Meeting 2010
20 July 2010; 2:40 pm

Humidity control goals

- Comfort, and Indoor Air Quality
  - Control indoor humidity year-around, just like we do temperature

- Durability and customer satisfaction
  - Reduce builder risk and warranty/service costs

Humidity control challenges

1. In humid cooling climates, there will always be times of the year when there is little sensible cooling load to create thermostat demand but humidity remains high
   - Cooling systems that modify fan speed and temperature set point based on humidity can help but <u>are still limited in how much they can over-cool</u>
2. More energy efficient homes have less sensible heat gain to drive thermostat demand but latent gain remains mostly the same
   - Low heat gain windows
   - Ducts in conditioned space
   - More, and better-installed, insulation
   - Less heat gain from appliances and lighting

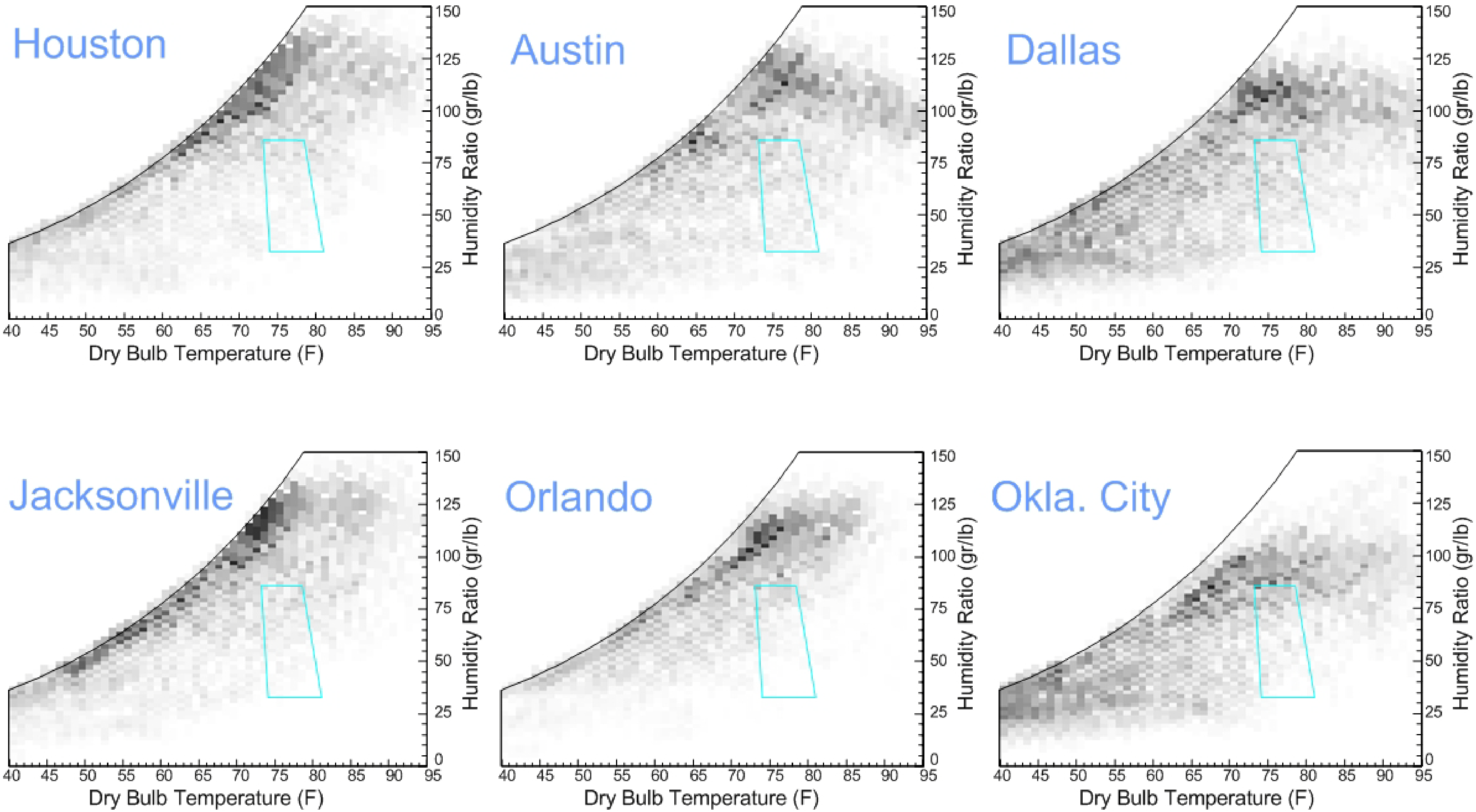
Humidity control challenges, cont.

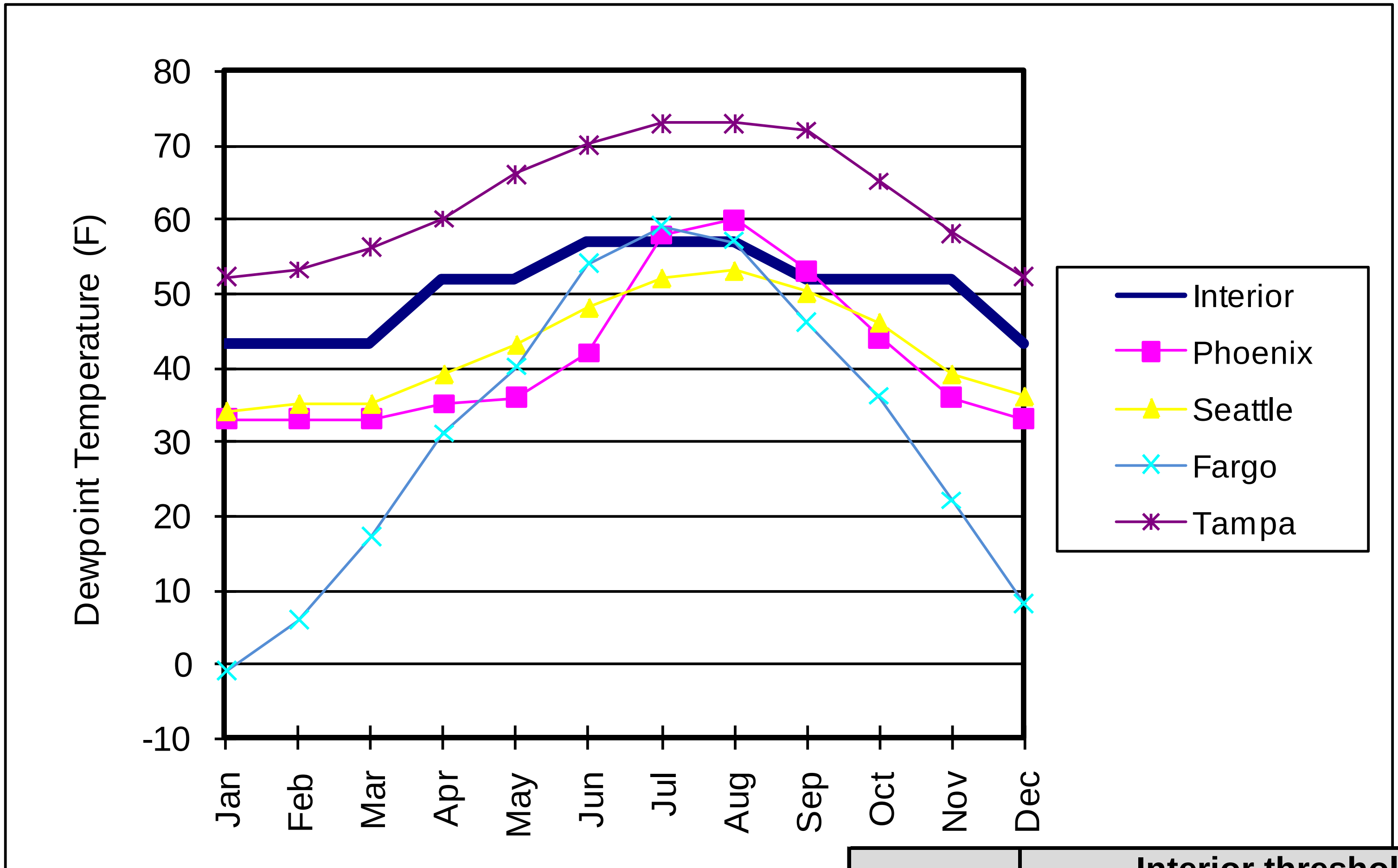
3. More energy efficient cooling equipment often has a higher evaporator coil temperature yielding less moisture removal
    - Larger evaporator coil by manufacturer design, or up-sized air handler unit or air flow by installer choice
4. Conventional over-sizing to cover for lack of confidence in building enclosure or conditioning system performance causes short-cycling yielding less moisture removal

System engineering trade-offs

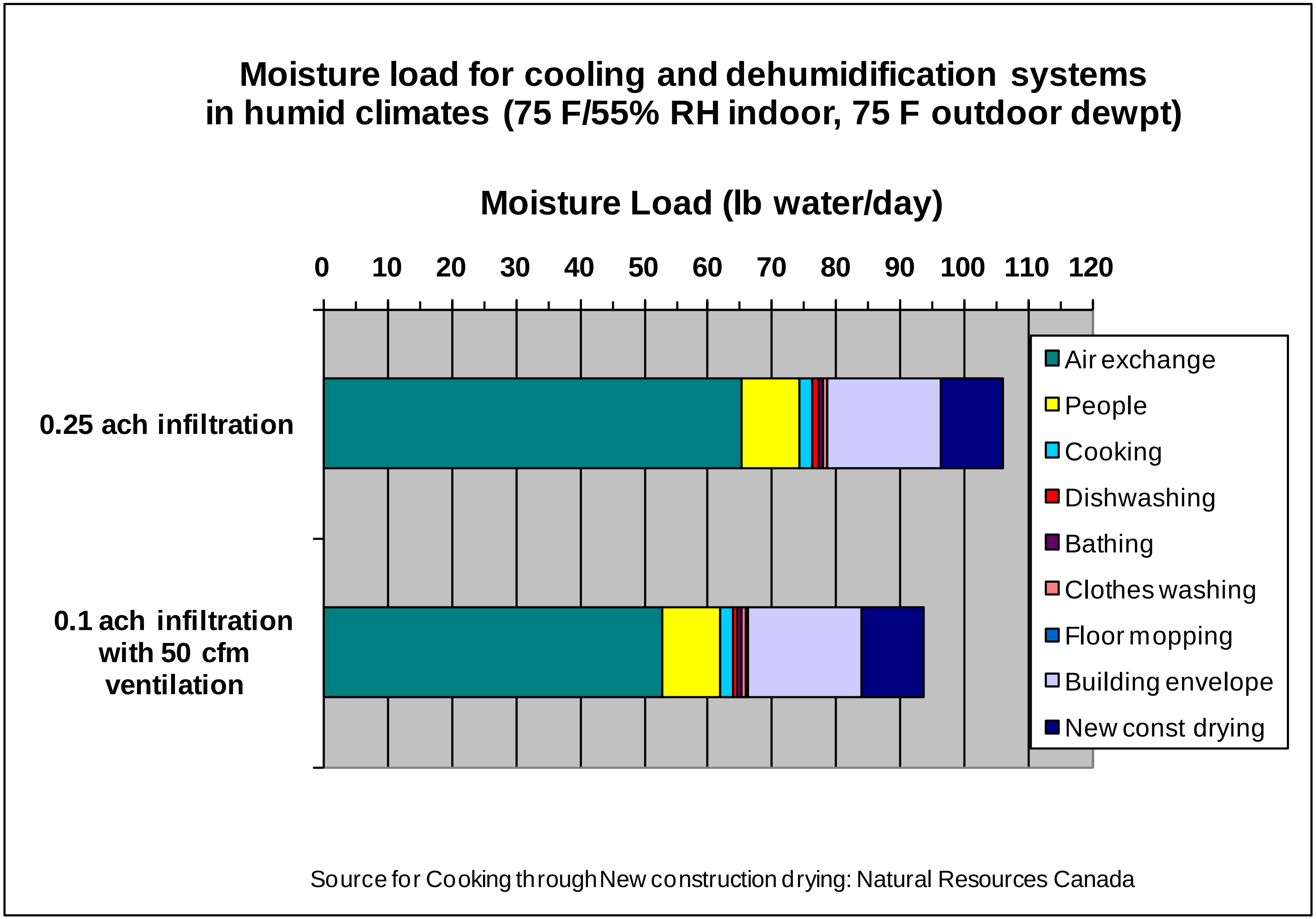
- **Start with high-performance building enclosure**
  - Improves the more permanent features of a home which has longer-term sustainability benefits
    - Low loss/gain glass, controlled air change, ducts inside conditioned space, pressure balancing
  - Allows for reduced cooling system size
    - Helps pay for the enclosure improvements
    - More compact duct system lowers cost and helps get the ducts inside
  - Makes overall building performance more predictable
    - Gives confidence for right-sizing equipment
      - No short-cycling: Better moisture removal, Higher average efficiency, Better spatial mixing
    - Controlled ventilation instead of random infiltration
  - Results in decreased energy consumption along with increased occupant comfort

Outdoor Conditions

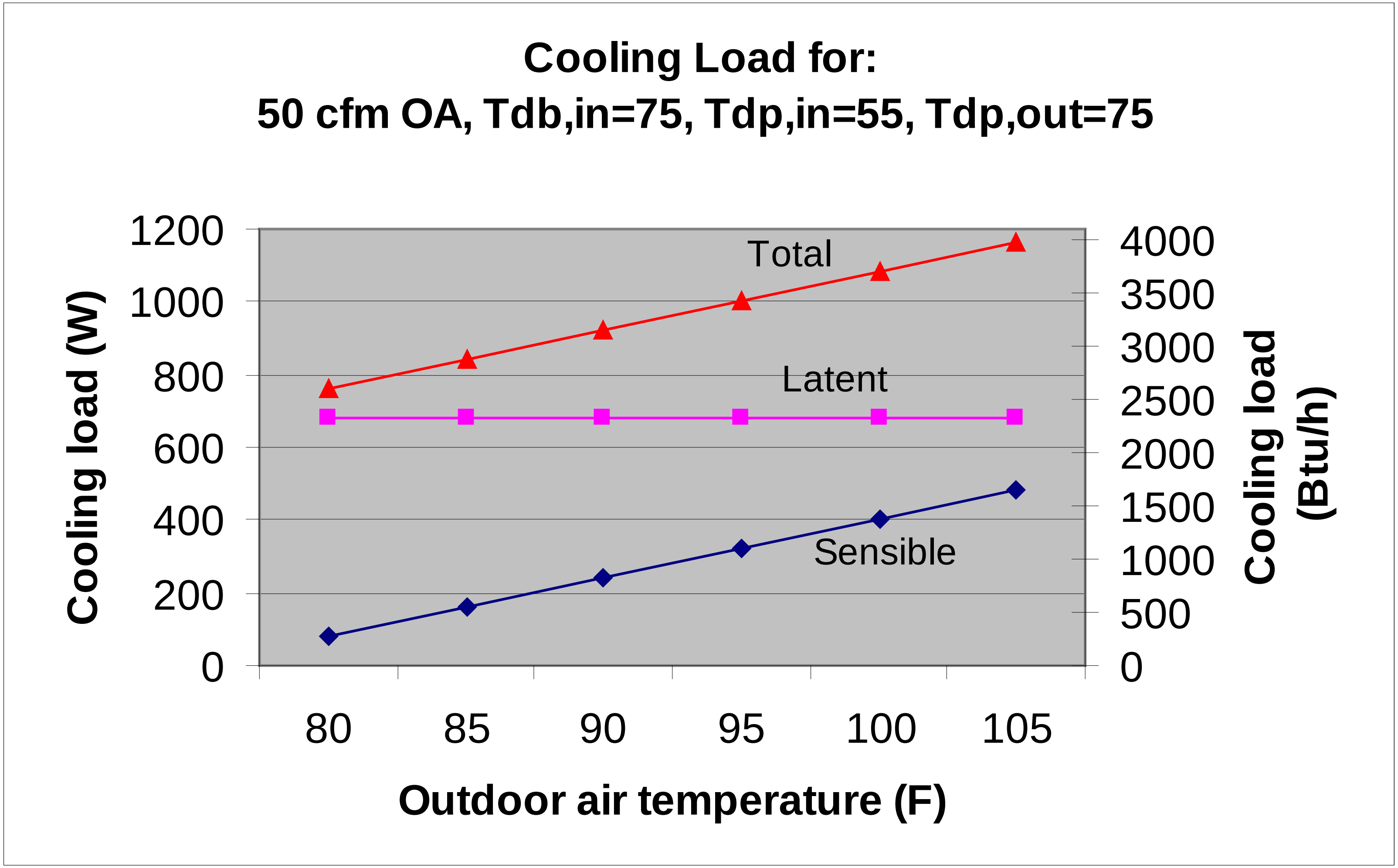




	Interior threshold		
	Tdb	**RH**	**Tdp**
winter	72	35	43
spring	75	45	52
summer	77	50	57
fall	75	45	52



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



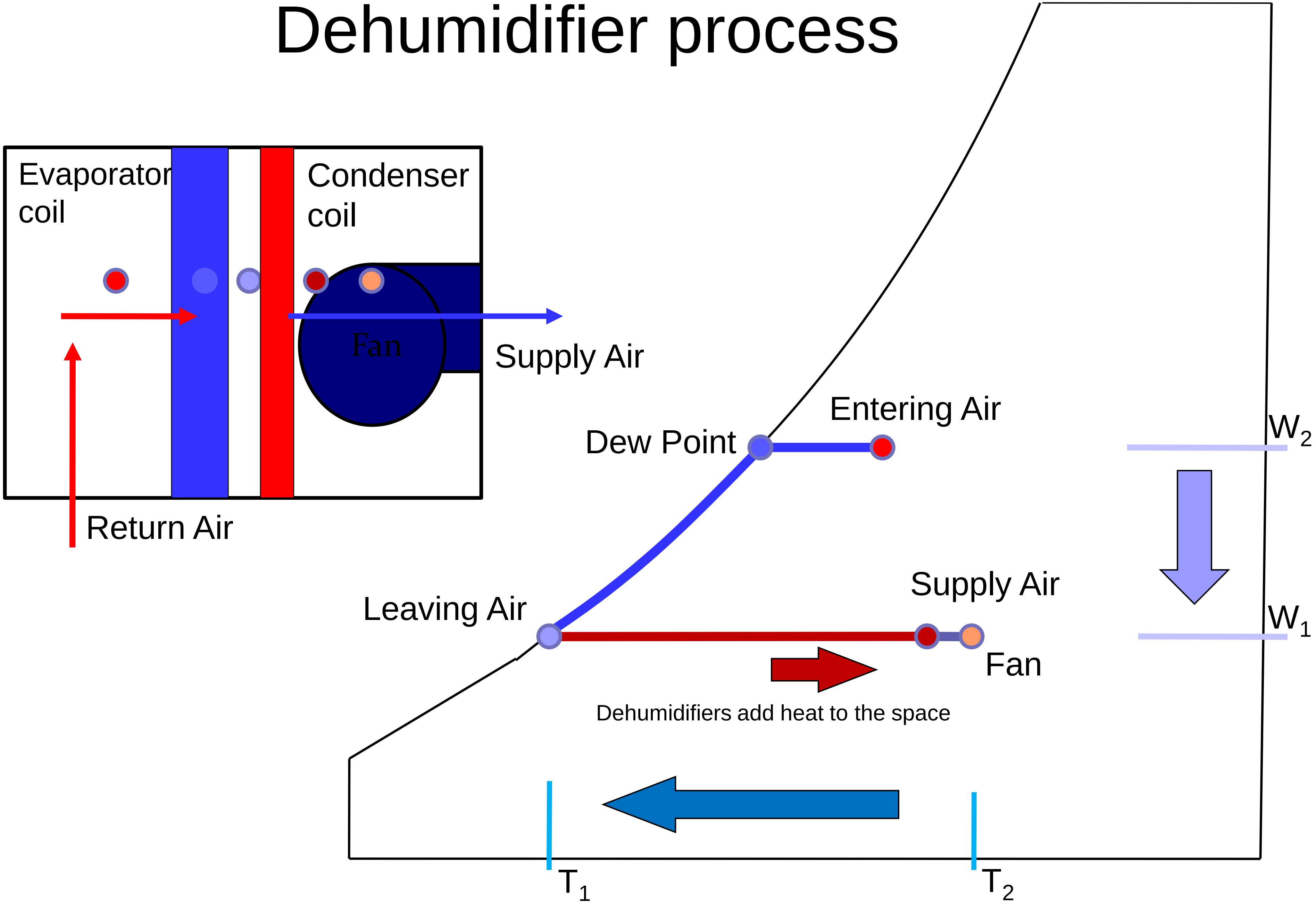
Cooling Load for:
50 cfm OA, Tdb,in=75, Tdp,in=55, Tdp,out=75
Cooling load (W)
1200
1000
800
600
400
200
0
Total
Latent
Sensible
4000
3500
3000
2500
2000
1500
1000
500
0
Cooling load (Btu/h)
80
85
90
95
100
105
Outdoor air temperature (F)

Systems Tested – Houston, TX

STAND-ALONE IN CLOSET	
19803 Ash.,	2 story, 2386 ft^2
19902 Ash.,	2 story, 2397 ft^2
STAND-ALONE IN ATTIC	
19950 Ash.,	2 story, 2397 ft^2
2731 Sun.,	2 story, 2448 ft^2
ULTRA-AIRE	
19915 Ash.,	1 story, 2100 ft^2
19938 Ash.,	2 story, 2448 ft^2
19923 Ash.,	2 story, 2397 ft^2
FILTER-VENT + STAND-ALONE	
19934 Ash.,	1 story, 1830 ft^2
19922 Ash.,	1 story, 2100 ft^2
19954 Ash.,	2 story, 2386 ft^2
ERV	
19926 Ash.,	1 story, 1830 ft^2
19942 Ash.,	1 story, 2197 ft^2
19930 Ash.,	2 story, 2448 ft^2
2-STAGE + ECM AHU	
19422 Col.,	1 story, 2197 ft^2
ENERGY EFFICIENT REFERENCE	
2802 Sun.,	2 story, 2386 ft^2
2814 Sun.,	1 story, 2197 ft^2
19906 Ash.,	2 story, 2386 ft^2
STANDARD REFERENCE	
19622 Her.,	2 story, 2448 ft^2
4818 Cot.,	1 story, 2197 ft^2
6263 Clear.,	2 story, 3300 ft^2

Dehumidifier and ventilation duct in interior mechanical closet with louvered door

Dehumidifier process



Ducted dehumidifier in conditioned space with living space control

Pulling the data together

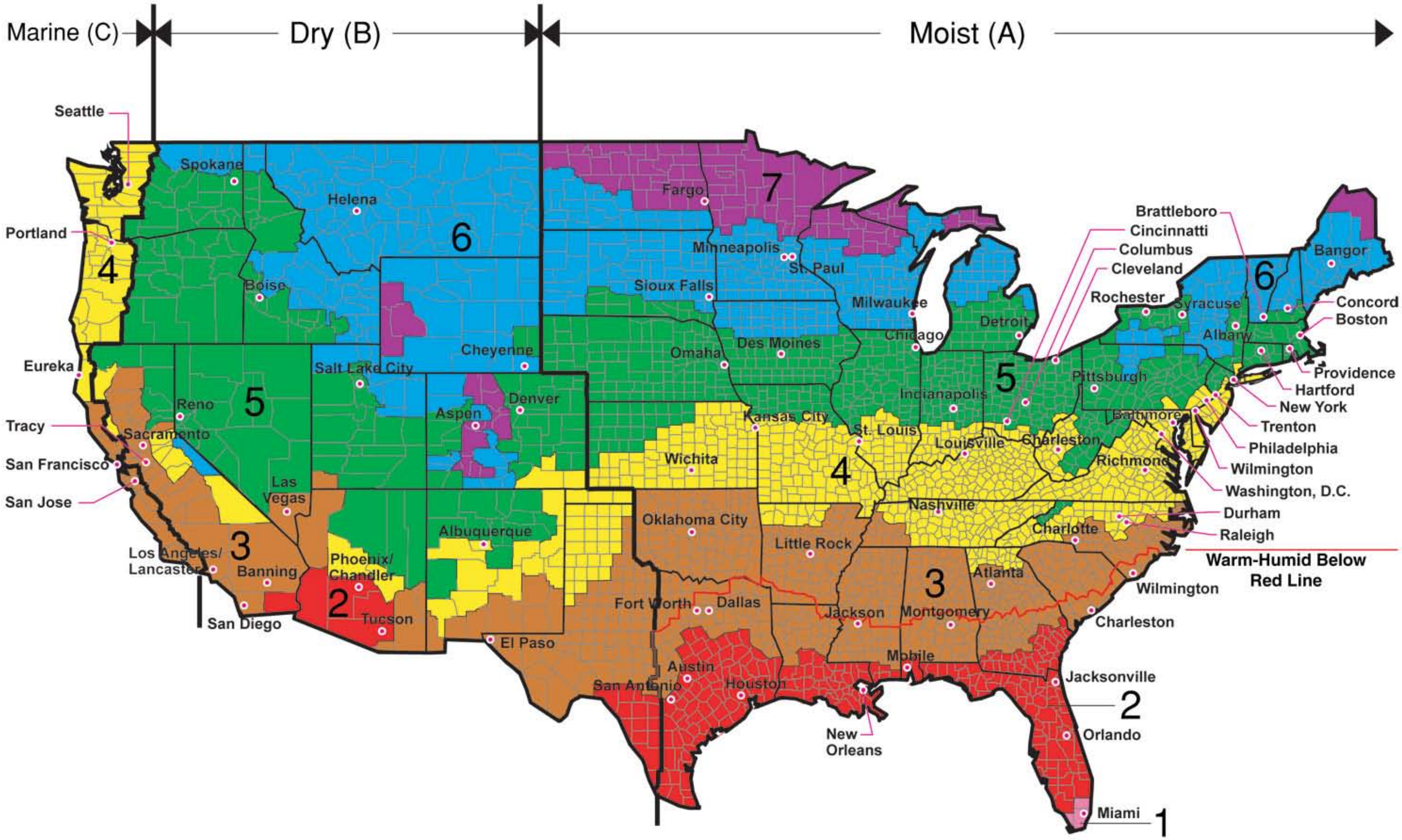
- Data set
  - 43 homes, each with one to four T/RH space measurements
  - Data recorded hourly for a year or more
  - 27 homes also had equipment runtime measurements (cool, heat, fan, dehumidifier)








Houston (29), Austin (3), Dallas (3), Jacksonville (2), Ft. Myers (2), Orlando (1), Oklahoma City (3)



All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

Observations and Conclusions for Higher-Performance houses

- All Higher-Performance houses with ventilation showed a marked increase in space humidity compared to Standard and Medium houses with ventilation.
- The combination of Higher-Performance low sensible heat gain buildings and mechanical ventilation significantly increases the number of hours that require dehumidification without sensible cooling.
  - Higher cooling balance point temperature than for conventional Standard houses
  - High space humidity occurs mostly during spring and fall swing seasons, rainy periods, and summer nights
- The effect of reducing the latent ventilation load through energy recovery was insufficient to avoid high humidity at part-load and no-load conditions.
- Humidity loads in Higher-Performance homes cannot consistently be met by conventional or enhanced cooling systems. Supplemental dehumidification is needed.

Moral of the story:

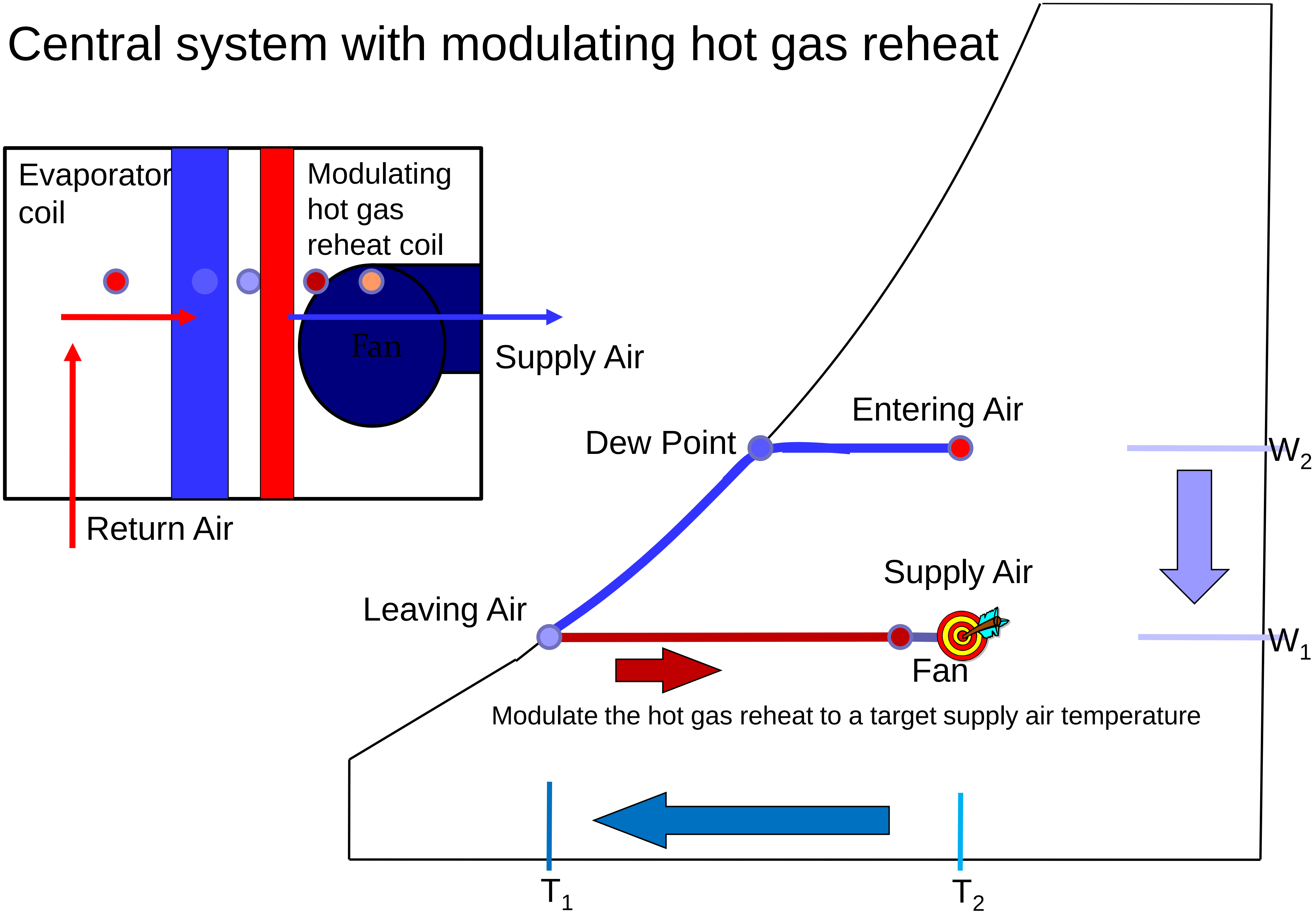
The addition of supplemental dehumidification to Higher-Performance homes in warm-humid climates enables continued improvements in energy efficiency while ensuring against elevated indoor humidity.

But what about making the existing cooling or heat pump equipment also do the supplemental dehumidification?

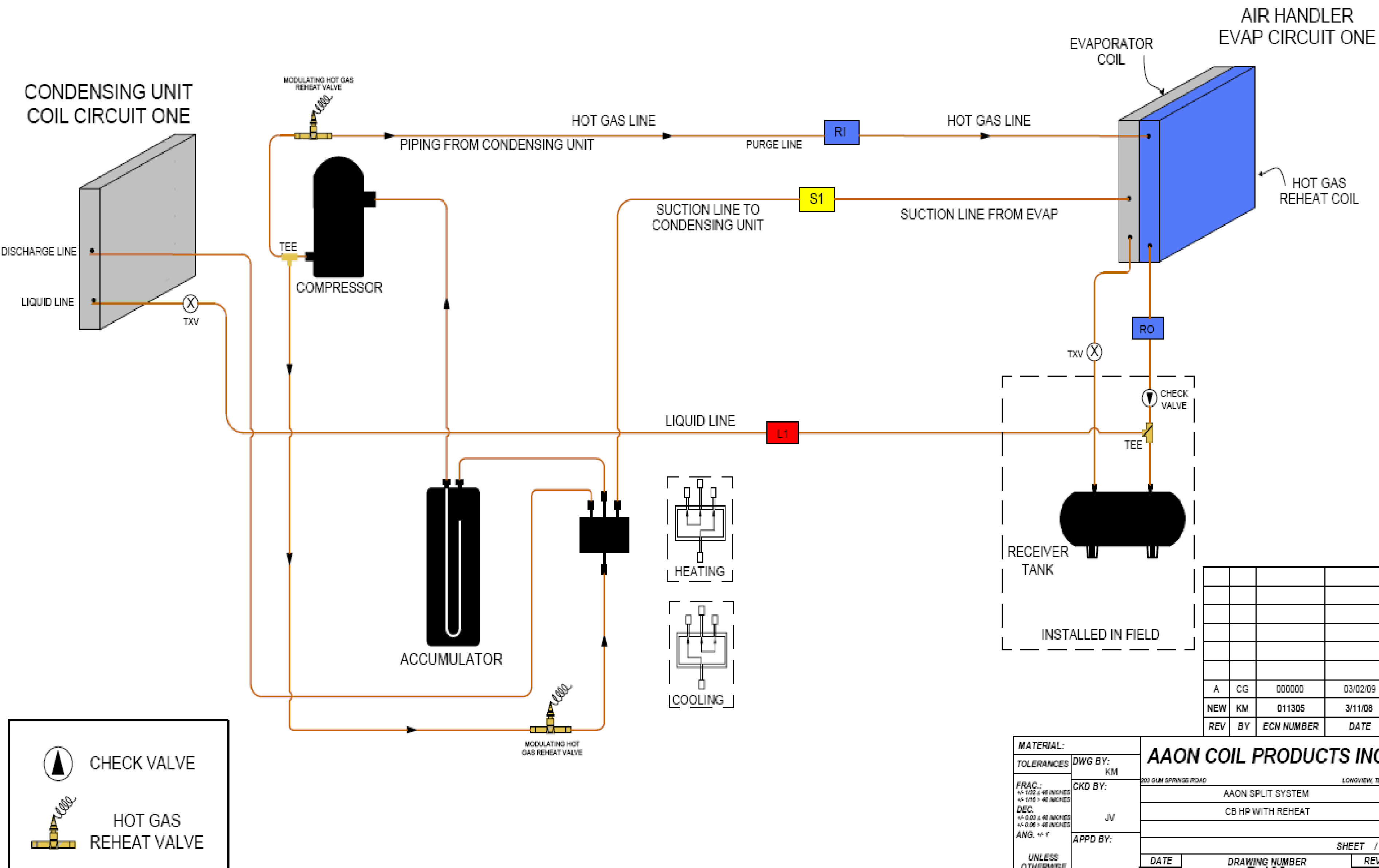
Goals:

- Provide year-around relative humidity control in high-performance (low-sensible gain) houses
- Without over-cooling the space
- At lower installed cost than the same efficiency heating and cooling system with an additional high efficiency dehumidifier
- By making standard DX cooling equipment switchable between normal cooling and dehumidification-only using condenser reheat

Central system with modulating hot gas reheat



Modulate the hot gas reheat to a target supply air temperature



A	CG	000000	03/02/09
NEW	KM	011305	3/11/08
REV	BY	ECN NUMBER	DATE

MATERIAL:

TOLERANCES — DWG BY: KM

FRAC.:

DEC.

ANG. +/- 1°

CKD BY: JV

APPD BY: JV

UNLESS OTHERWISE SPECIFICED

AAON COIL PRODUCTS INC.

200 GUM SPRINGS ROAD — LONGVIEW, TEXAS

AAON SPLIT SYSTEM

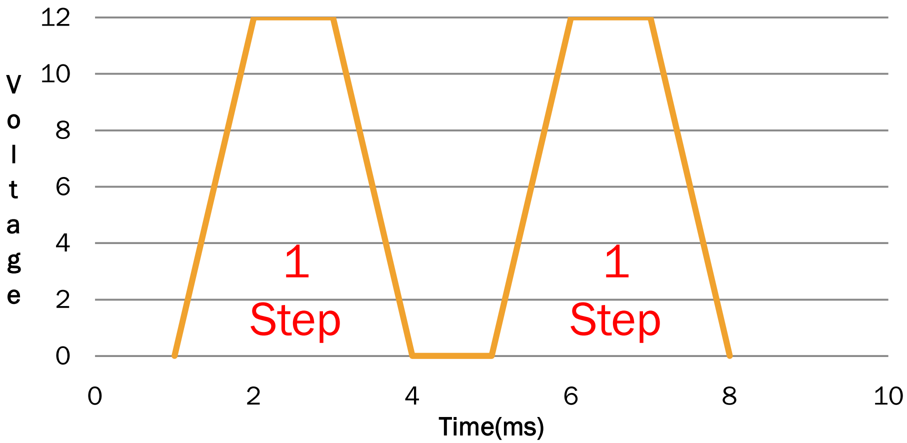
CB HP WITH REHEAT

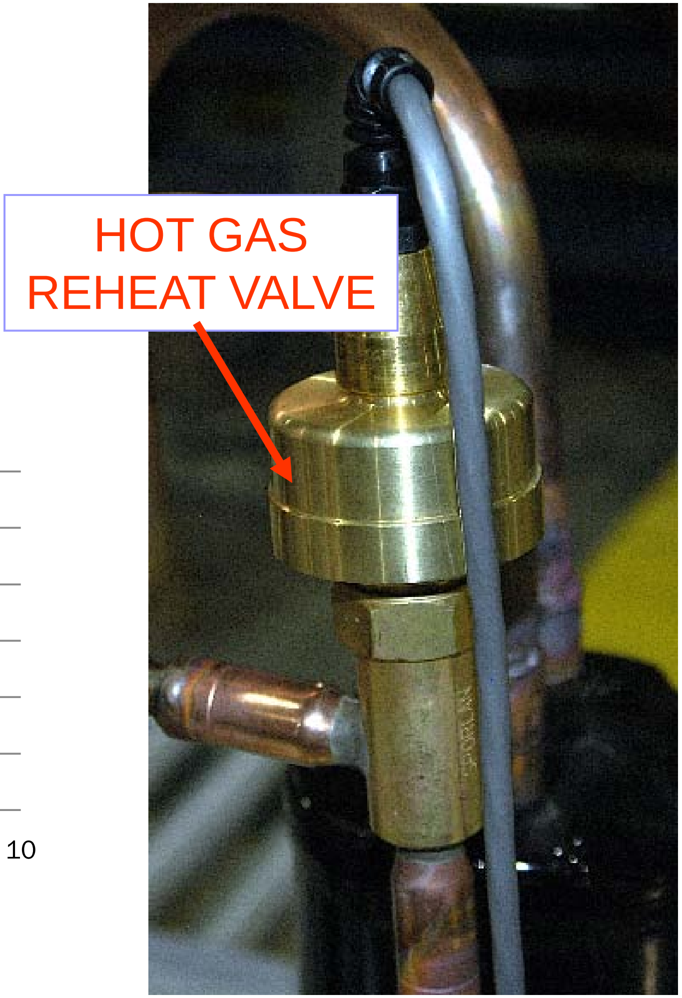
SHEET /

DATE	DRAWING NUMBER	REV
3/11/08	P-103	A

Modulating hot gas reheat valve

- DIGITAL STEPPER VALVE
- STEPPER MOTOR WITH 3193 STEPS
- NOT AN OPEN/CLOSE VALVE





Efficiency

Matching CB and F1, Air Conditioner Performance			
Condensing Unit	Air Handler	Nominal Capacity	SEER/EER
CB-024	F1-024	24 MBH / 2 Tons	Up to 17.30 SEER/ Up to 13.80 EER
CB-036	F1-036	36 MBH / 3 Tons	
CB-048	F1-048	48 MBH / 4 Tons	
CB-060	F1-060	60 MBH / 5 Tons	

Matching CB and F1, Heat Pump Performance				
Condensing Unit	Air Handler	Nominal Capacity	SEER/EER	HSPF
CB-024	F1-024	24 MBH / 2 Tons	Up to 15.80 SEER/ Up to 13.05 EER	Up to 9.70
CB-036	F1-036	36 MBH / 3 Tons		
CB-048	F1-048	48 MBH / 4 Tons		
CB-060	F1-060	60 MBH / 5 Tons		

AAON®

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Ph (918) 583-2266 • Fax (918) 583-6094
www.aaon.com

PSYCHROMETRIC CHART

Normal Temperature

SI Units

SEA LEVEL

BAROMETRIC PRESSURE: 101.325 kPa

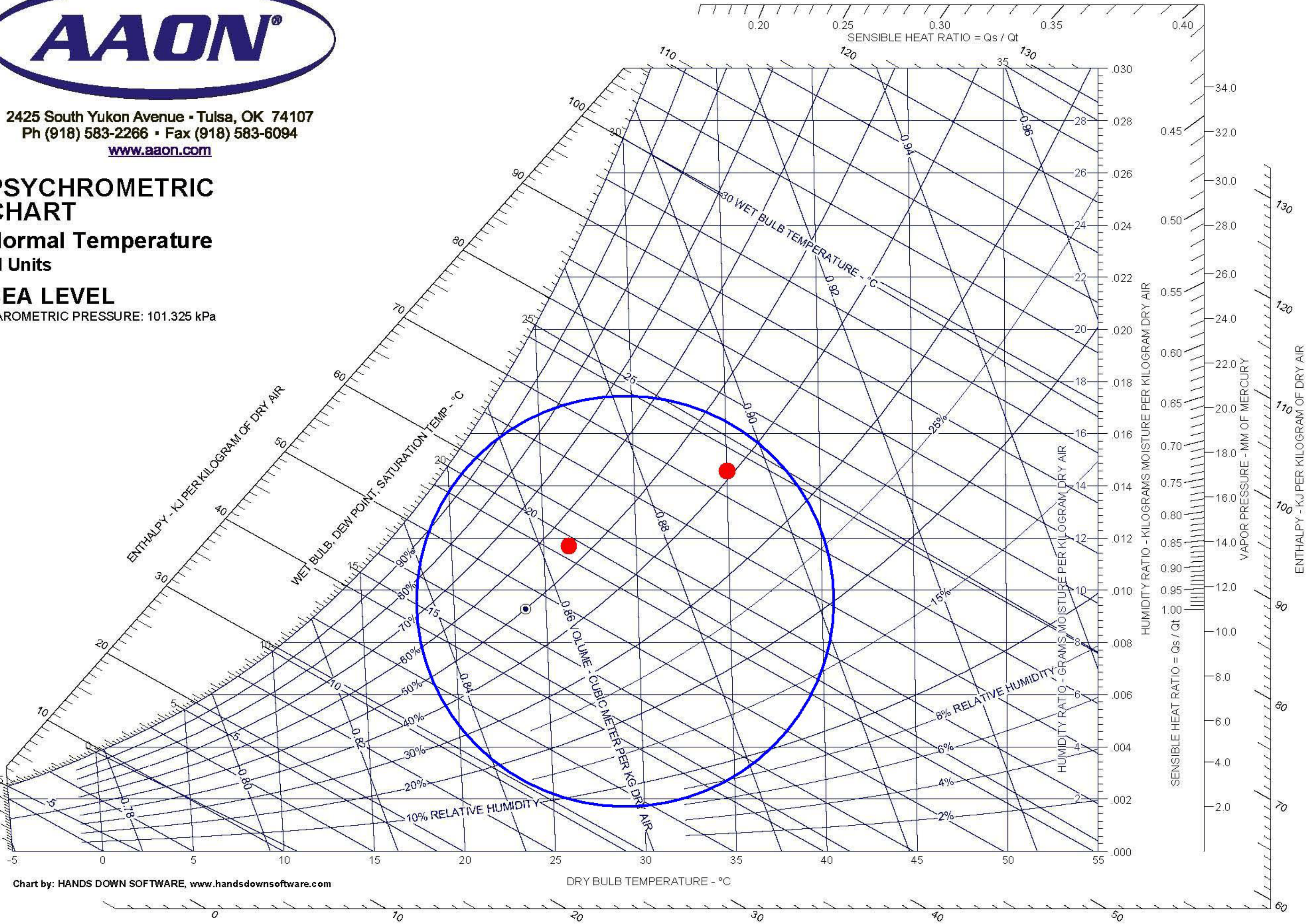
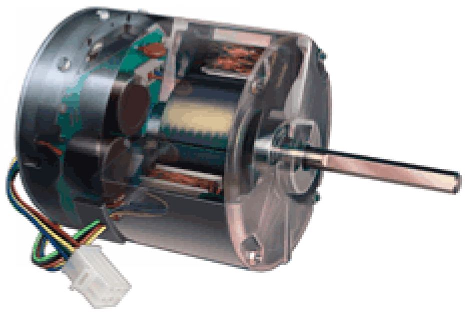


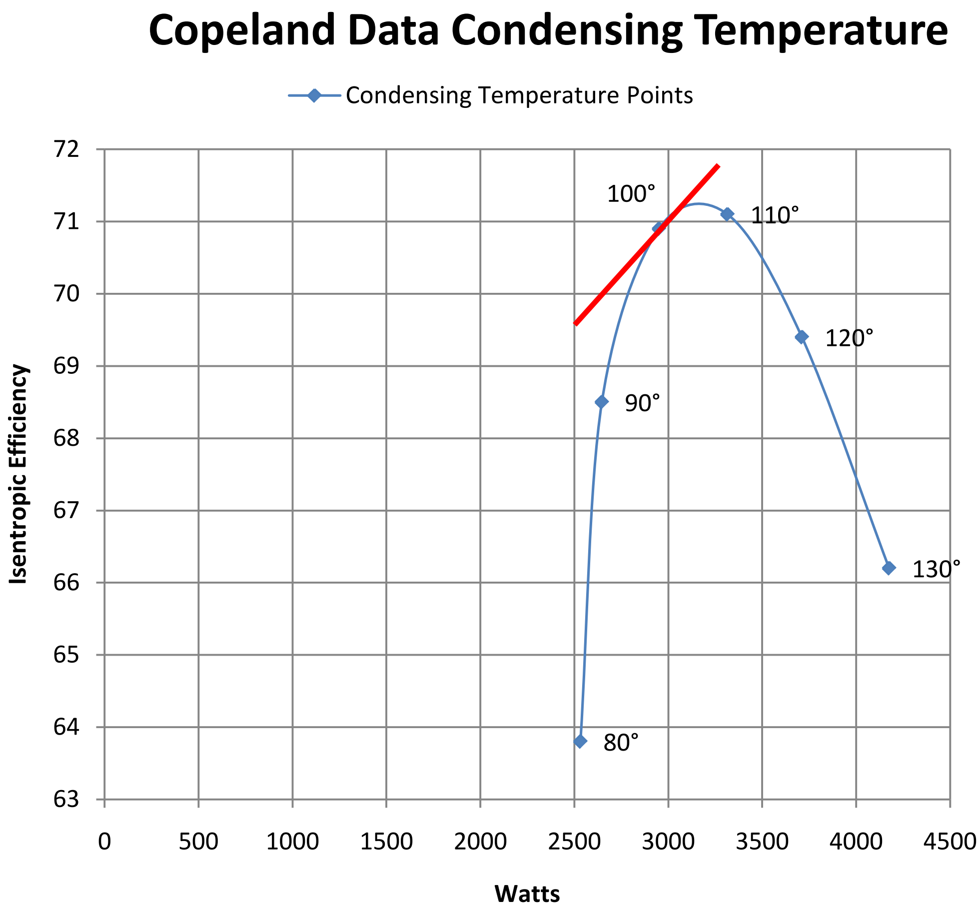
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com

Efficiency AMPLIFIED by tracking an optimal condensing temperature

Copeland Scroll UltraTech®

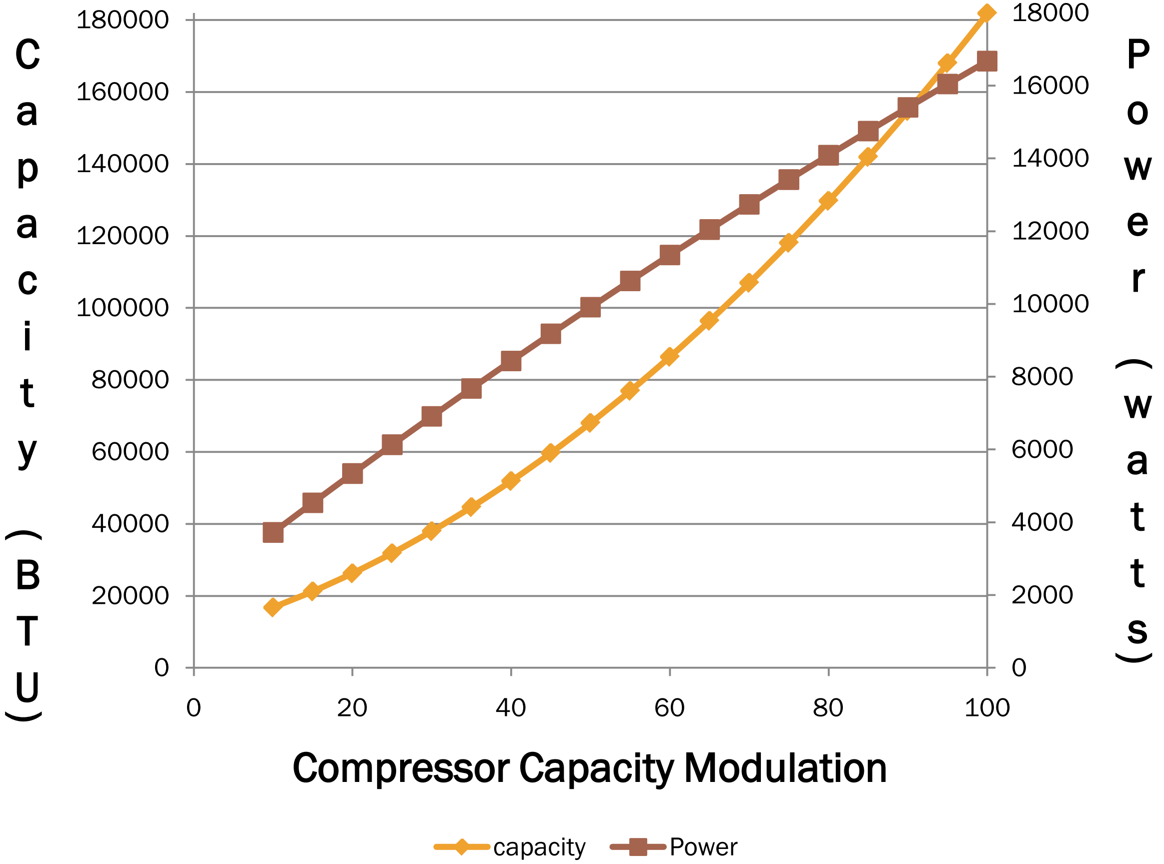
ECM® Condenser Fans

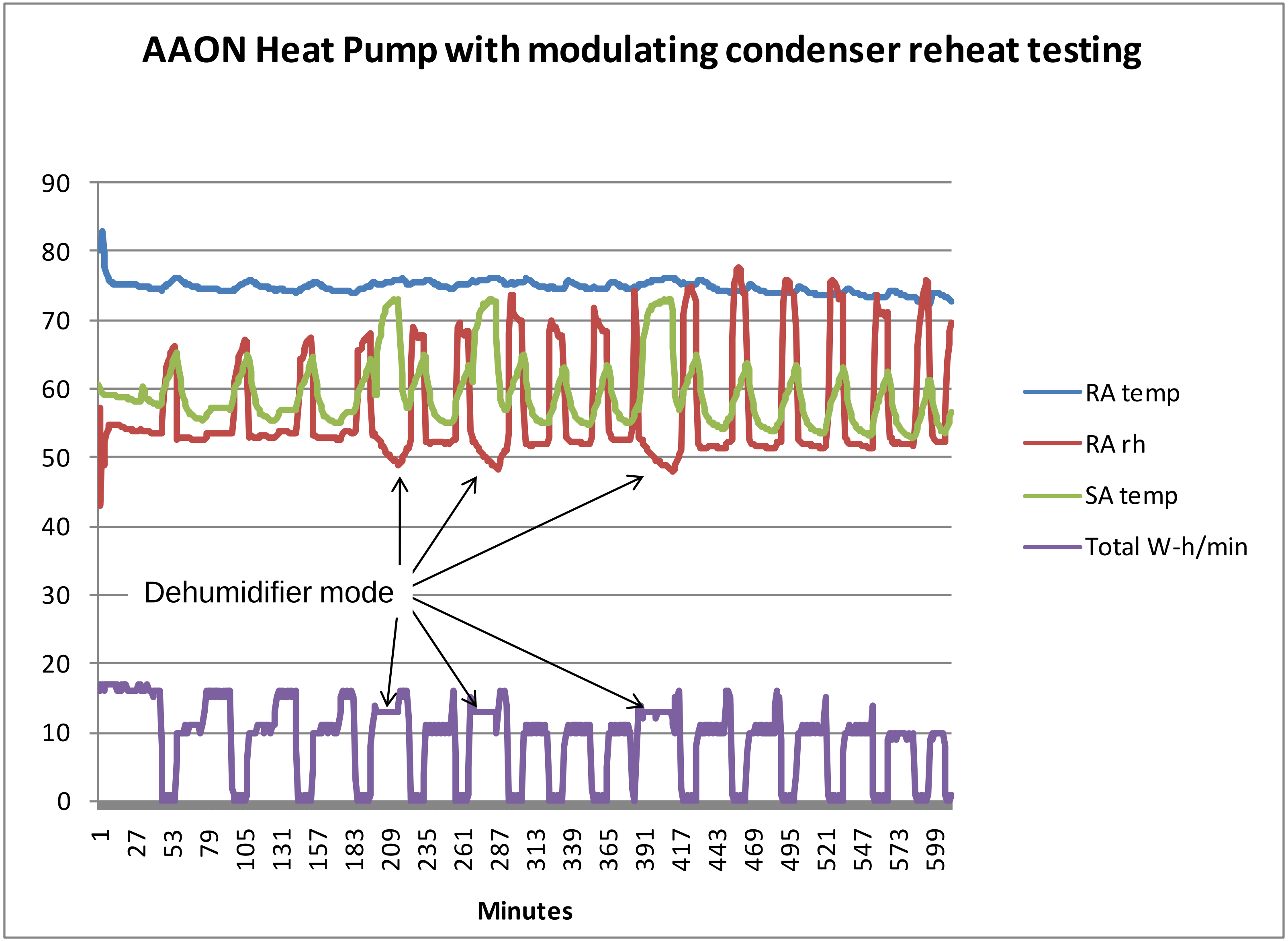




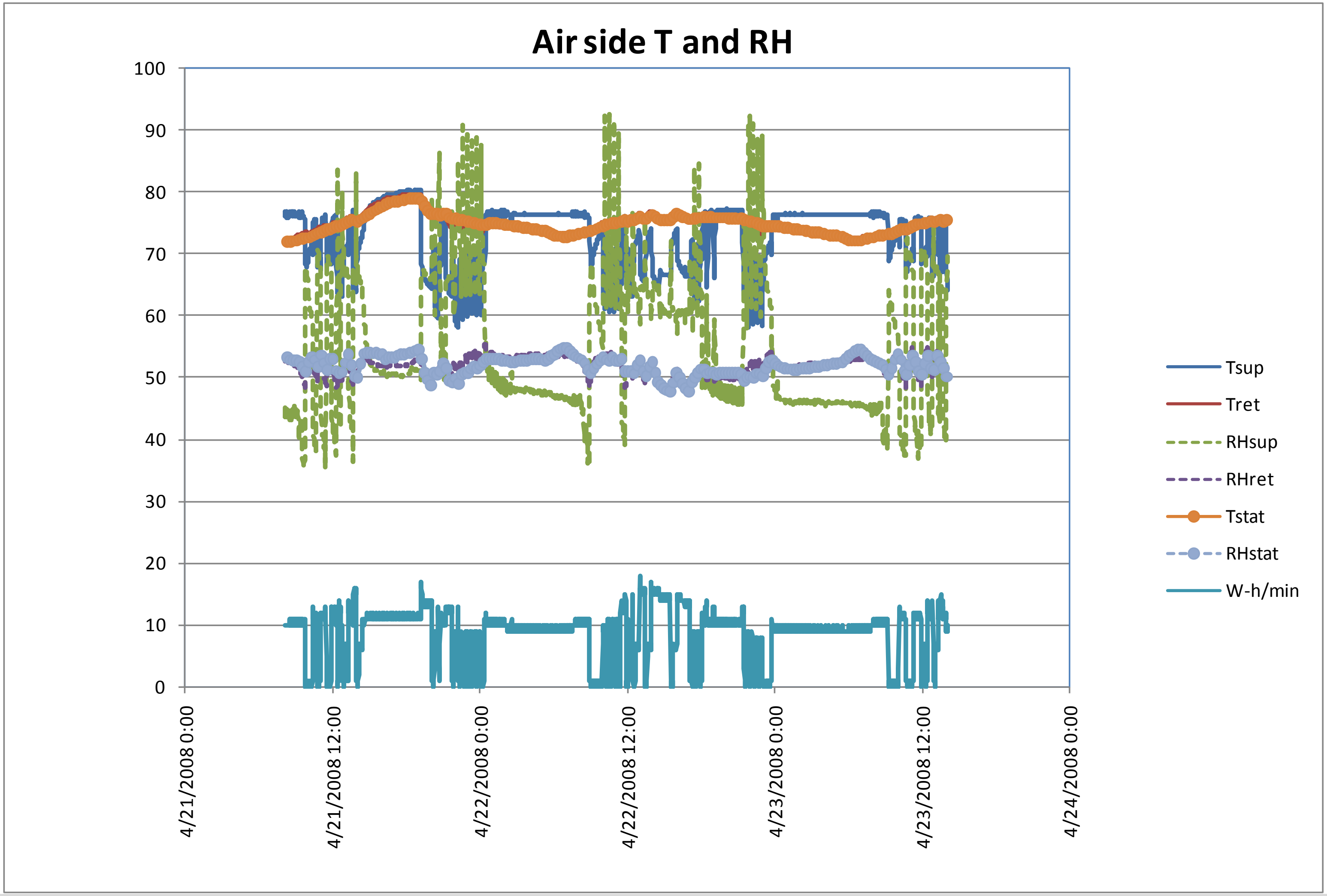
Digital Scroll

Copeland Scroll Digital™




AAON Heat Pump with modulating condenser reheat testing
90
80
70
60
50
40
30
20
10
0
Dehumidifier mode
1
27
53
79
105
131
157
183
209
235
261
287
313
339
365
391
417
443
469
495
521
547
573
599
Minutes
RA temp
RA rh
SA temp
Total W-h/min

Monitoring Data
Heat pump with modulating condenser reheat



Gaps, Barriers, and Future Work

- Smaller capacity equipment with adequate and efficient air distribution
- Further cost reduction of dehumidifying equipment through design and manufacturing optimization
- Better understanding of moisture load factors due to occupant behavior
- Better understanding of humidity control impacts of sensible heat gain reduction in mixed-humid climates
- More laboratory and field testing of cooling and dehumidifying equipment to establish better performance maps for simulation models
- New rating standard for cooling and dehumidifying equipment to aid in proper humidity control design and equipment selection