Residential Humidity Control Strategies

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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

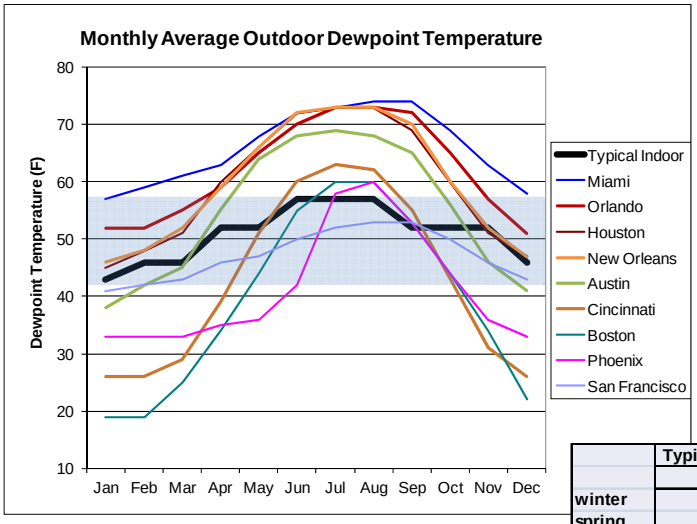
1. In humid cooling climates, there will always be times of the year when there is little sensible cooling load to create thermostat demand but humidity remains high
   - Cooling systems that modify fan speed and temperature set point based on humidity can help but are still limited in how much they can over-cool
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.

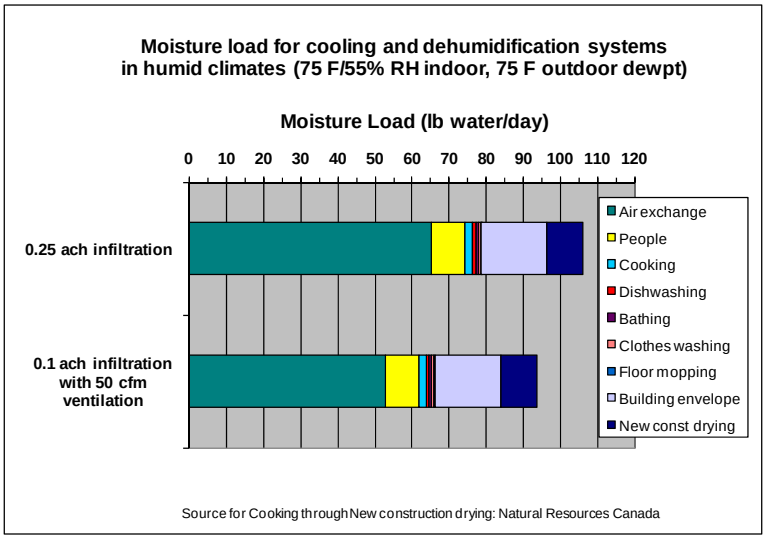
3. More energy efficient cooling equipment often has a higher evaporator coil temperature yielding less moisture removal
   - Larger evaporator coil by manufacturer design, or up-sized air handler unit or airflow by installer choice
4. Conventional over-sizing to cover for lack of confidence in building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

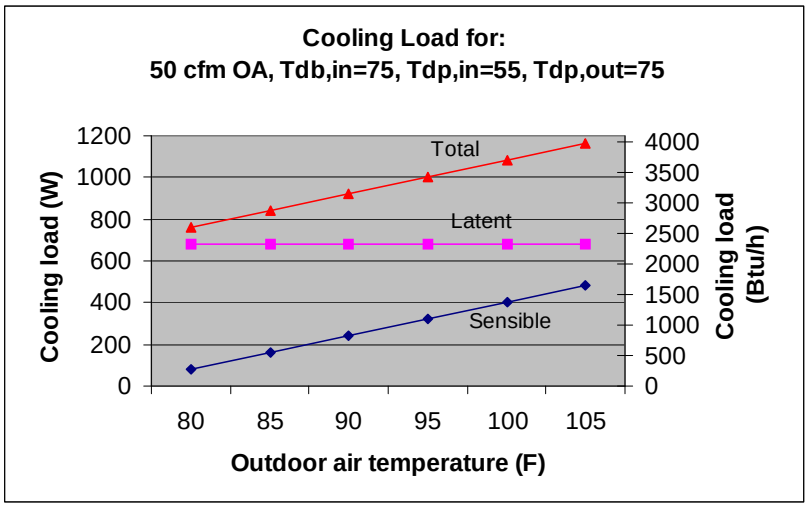
System engineering trade-offs

- Start with high-performance building enclosure
  - Improves the more permanent features of a home which has longer-term sustainability benefits
    - Bulk water management, 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



	Typical Indoor (humid climate)		
	Tdb	RH	Tdp
winter	72	40	46
spring	75	45	52
summer	77	50	57
fall	75	45	52


Moisture load for cooling and dehumidification systems
in humid climates (75 F/55% RH indoor, 75 F outdoor dewpt)
Moisture Load (lb water/day)
0 10 20 30 40 50 60 70 80 90 100 110 120
0.25 ach infiltration
0.1 ach infiltration with 50 cfm ventilation
Air exchange
People
Cooking
Dishwashing
Bathing
Clothes washing
Floor mopping
Building envelope
New const drying
Source for Cooking through New construction drying: Natural Resources Canada

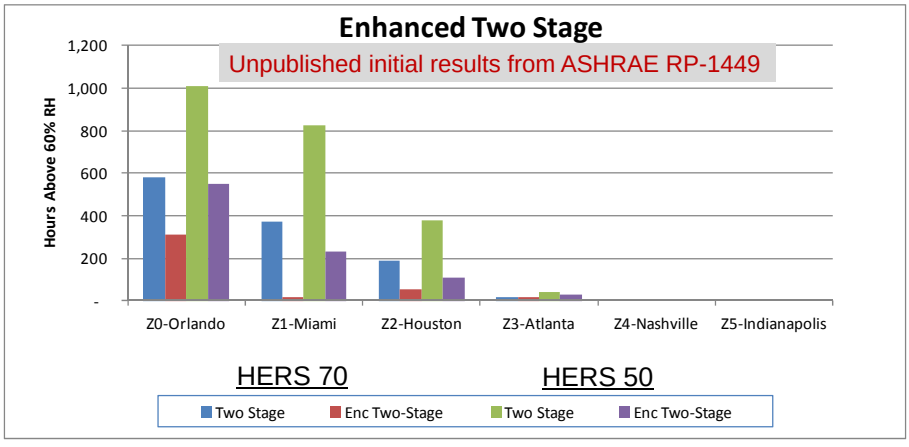

Cooling Load for:
50 cfm OA, Tdb,in=75, Tdp,in=55, Tdp,out=75
Cooling load (W)
1200
1000
800
600
400
200
0
Total
Latent
Sensible
4000
3500
3000
2500
2000
1500
1000
500
0
Cooling load (Btu/h)
80 85 90 95 100 105
Outdoor air temperature (F)

Conventional Cooling System Dehumidification Enhancements

AHU Dehumidification Enhancement Features	Carrier[1]	Lennox	Goodman[2]	ICP[3]	Nordyne[4]
Variable speed airflow	FV4	CBX32MV	AVPTC	FVM	B4VM
Selectable cooling/heat pump/heating fan speed/airflow	✓	✓	✓	✓	✓
Selectable airflow Adjustment (+/- %)	✓	✓	✓	✓	
Selectable constant fan speed/airflow	✓		w/ communicating tstat	✓	✓
Selectable fan delay after cooling can be zero	✓	✓		✓	✓
Dehum fan profile with lower airflow for a time		82% for first 7.5 min	82% for first 7.5 min		75% for first 10 min
Receives Dehum signal from tstat or dehumidistat	✓	✓	✓	✓	✓
Dehum logic is 0 Vac on humidity rise	✓	✓	✓		✓
Dehum logic is 24 Vac on humidity rise				✓	
Lower cooling airflow if RH is above RH setpoint	80%	60% to 70%		80%	✓
Extended cooling after thermostat setpoint reached	✓	✓			
Intermittent super-low cfm/ton during extended cooling	50%, 10 min on/off				

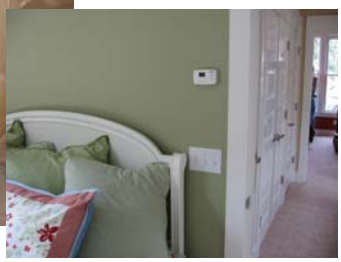
[1] Carrier includes Bryant
[2] Goodman includes Amana
[3] ICP includes Comfortmaker, Tempstar, Heil, Arcocaire, Day&Night, Keep Rite
[4] Nordyne includes Frigidaire, Gibson, Westinghouse, Tappan, Kelvinator, Philco, Nutone

Two-Stage Cooling with all Enhanced Approaches (low airflow and overcooling with intermittent very-low airflow)

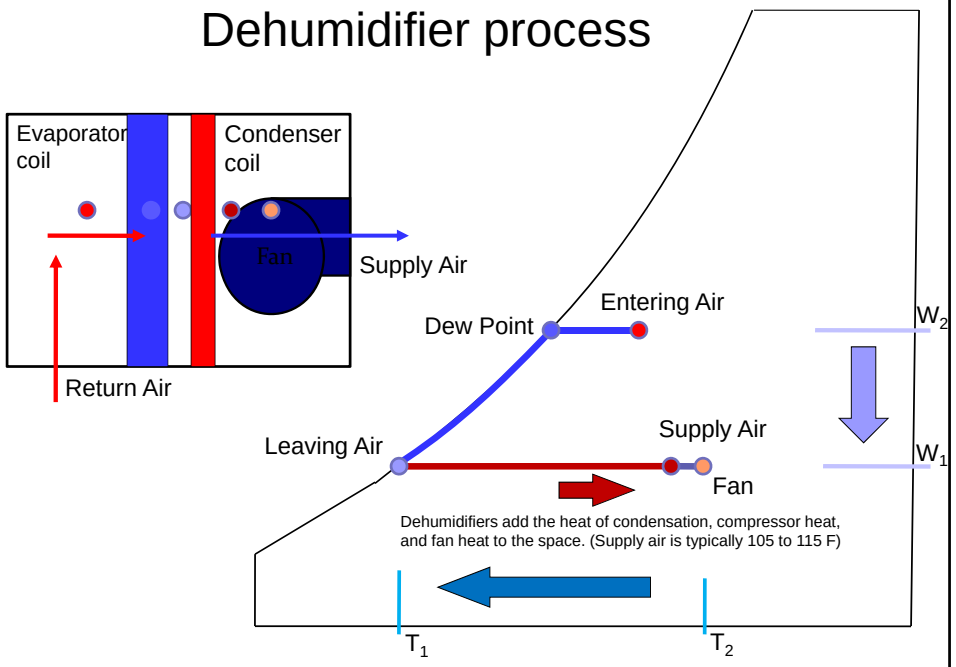


Dehumidifier and ventilation duct in interior mechanical closet with louvered door

Ducted dehumidifier in conditioned space with living space control



Dehumidifier process

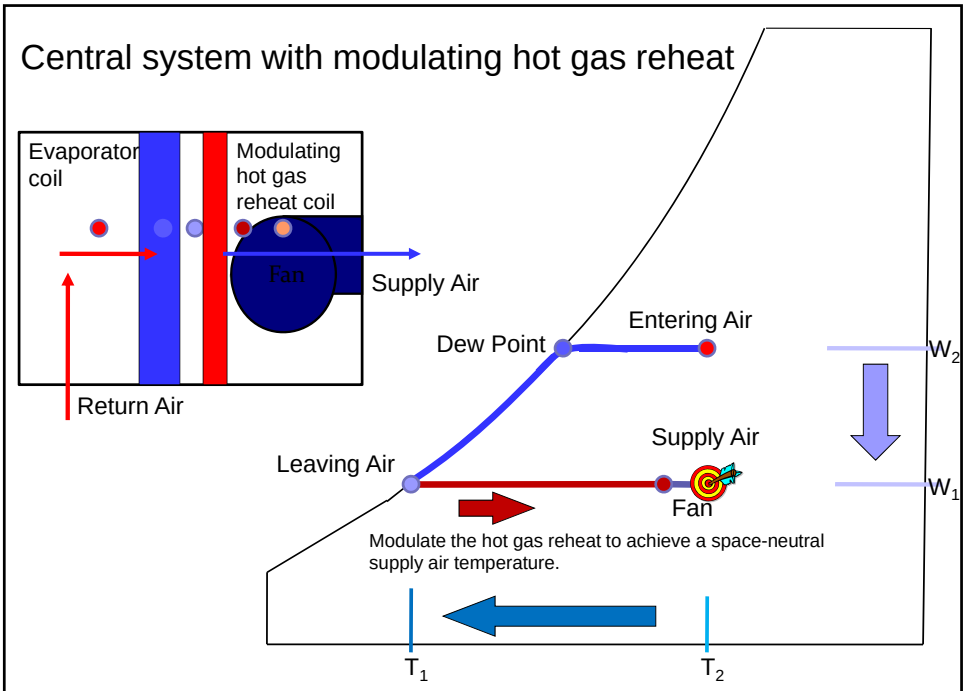


What about making the existing cooling or heat pump equipment also do the supplemental dehumidification?

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



Outdoor Unit

Modulating Hot Gas Reheat Valve
3193 steps between open and closed

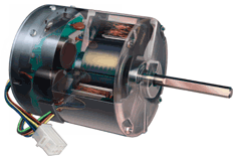
Indoor Unit

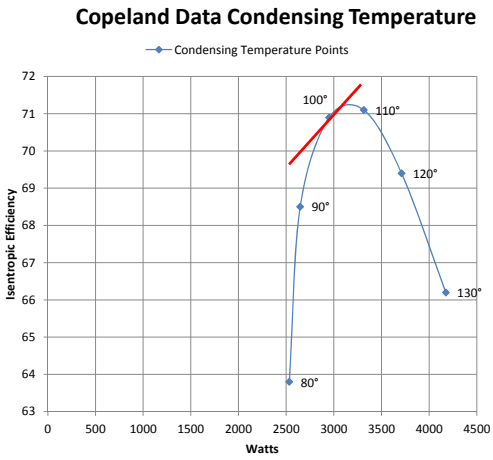
Hot Gas Condenser Reheat Coil

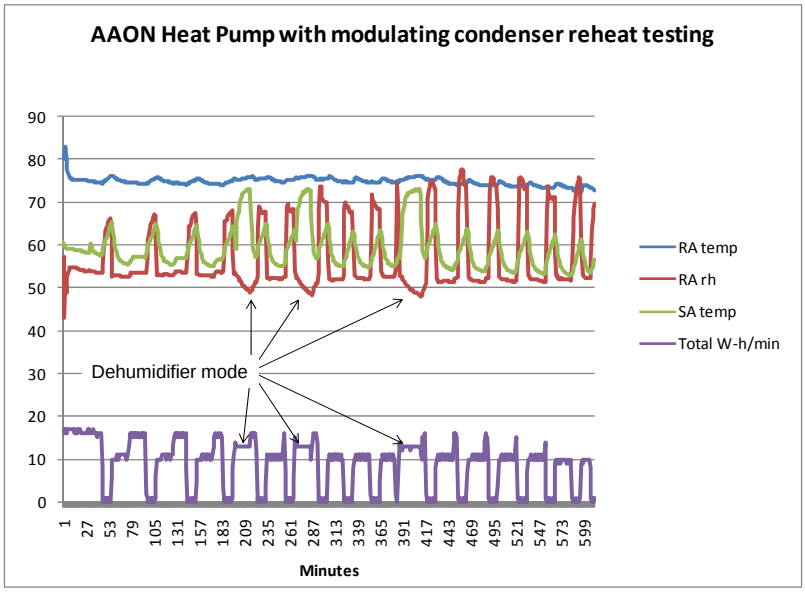
Efficiency AMPLIFIED by tracking an optimal condensing temperature by condenser fan cycling

Copeland Scroll UltraTech®

ECM® Condenser Fans







Gaps, Barriers, and Future Work

- ✓ Smaller capacity ducted dehumidifier equipment
- Further cost reduction of dehumidifiers and central dehumidifying equipment through design and manufacturing optimization
- Better understanding of actual dehumidification design load, including moisture storage effects and occupant behavior
- More laboratory testing of dehumidifiers to establish better design criteria and performance maps for simulation models
- ✓ More laboratory and field testing of central dehumidifying equipment to establish better design criteria and performance maps for simulation models

Gaps, Barriers, and Future Work, cont.

- Work with industry (AHRI) on new rating standard for dehumidifiers and central dehumidifying equipment to aid in proper humidity control design and equipment selection
- More buy-in from cooling equipment manufacturers regarding the need for a focus on dehumidification performance
- Better understanding of humidity control impacts of sensible heat gain reduction in mixed-humid climates
- All BA teams working in warm-humid and mixed-humid climates should be routinely collecting temperature and relative humidity data in several indoor locations

Proposed humidity control test conditions for central dehumidifying equipment

Performance map data needs at each test condition and at each equipment control state
For dehumidifer equipment with both indoor and outdoor heat transfer components

		Outdoor T/RH/Tdp (F/%/F)	Inlet T/RH/Tdp (F/%/F)	Outlet T/RH/Tdp (F/%/F)	Indoor Wet-coil Airflow (cfm)	Sensible Cooling Capacity[1] (Btu/h)	Latent Cooling Capacity (Btu/h)	Moisture Removal Capacity (L/h)	Total Power (kW)	Moisture Removal Efficiency[2] (L/kW-h)
Summer, full sensible load[3]	Test 1a	95/58/78	80/60/65							
	Test 1b	""	78/55/61							
	Test 1c	""	75/50/55							
Summer, part sensible load[3]	Test 2a	80/85/75	80/60/65							
	Test 2b	""	78/55/61							
	Test 2c	""	75/50/55							
Spring-Fall, part sensible load[3]	Test 3a	75/85/70	78/60/63							
	Test 3b	""	78/55/61							
	Test 3c	""	75/50/55							
Winter, latent load only[3]	Test 4a	65/90/62	72/60/57							
	Test 4b	""	70/52/52							
	Test 4c	""	68/45/46							

[1] Negative cooling capacity denotes net heat added from inlet to outlet
[2] Same units as the USDOE and USEPA Energy Factor for dehumidifiers
[3] All tests with steady wet coil

	Air entering outdoor unit			Air entering indoor unit			Comment
	drybulb (F)	RH%	dewpoint (F)	drybulb (F)	RH (%)	dewpoint (F)	
ARI ratings (67 indoor wetbulb)	95	40	67	80	51	60	45 F saturated suction
AHAM dehumidifier rating				80	60	65	