Conditioning Energy Recovery Ventilation

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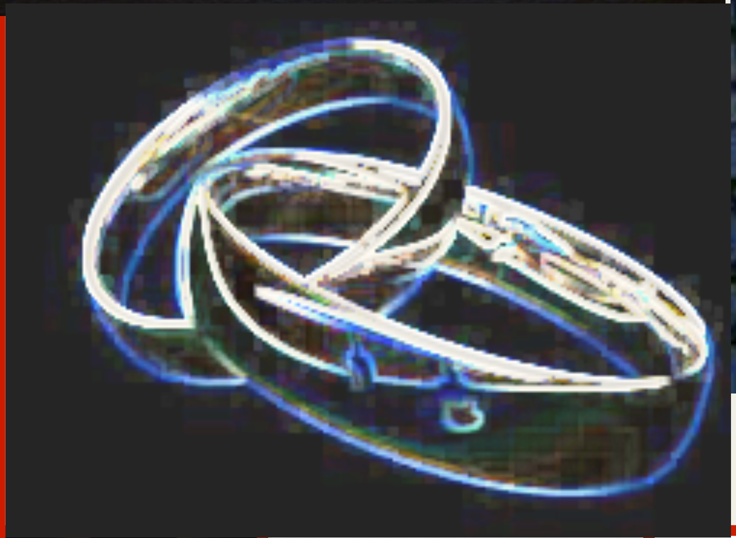
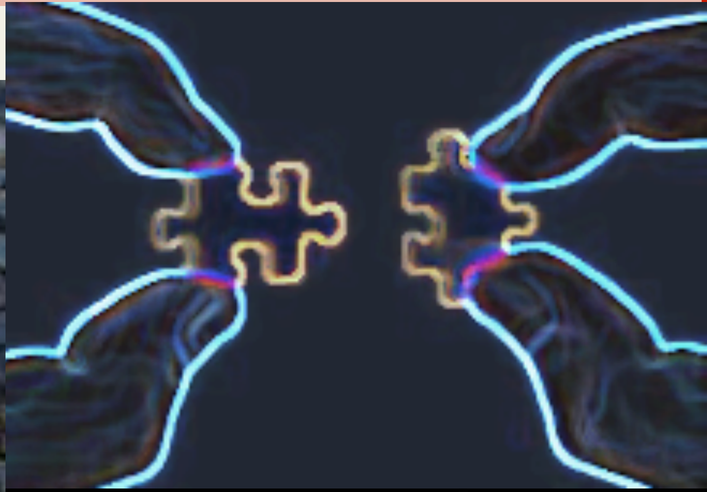
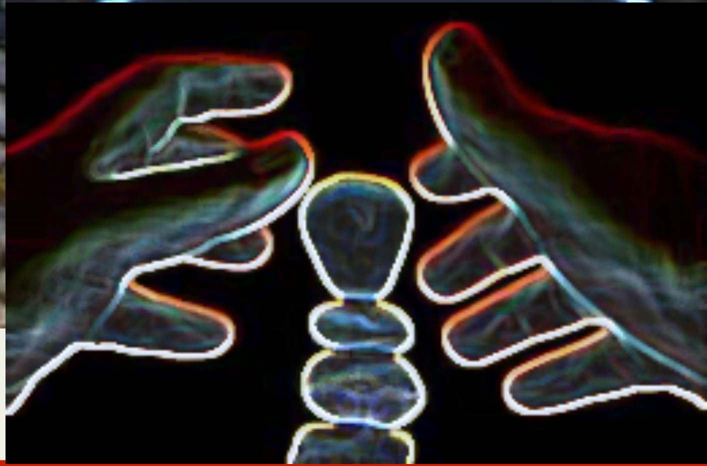



North American PASSIVE HOUSE Conference Chicago, IL Sept. 9-13, 2015

UltimateAir® Fresh Air, Filtration + Energy Recovery

BUILDSMART Energy efficiency made simple

Conditioning Energy Recovery Ventilator

Do we need this?

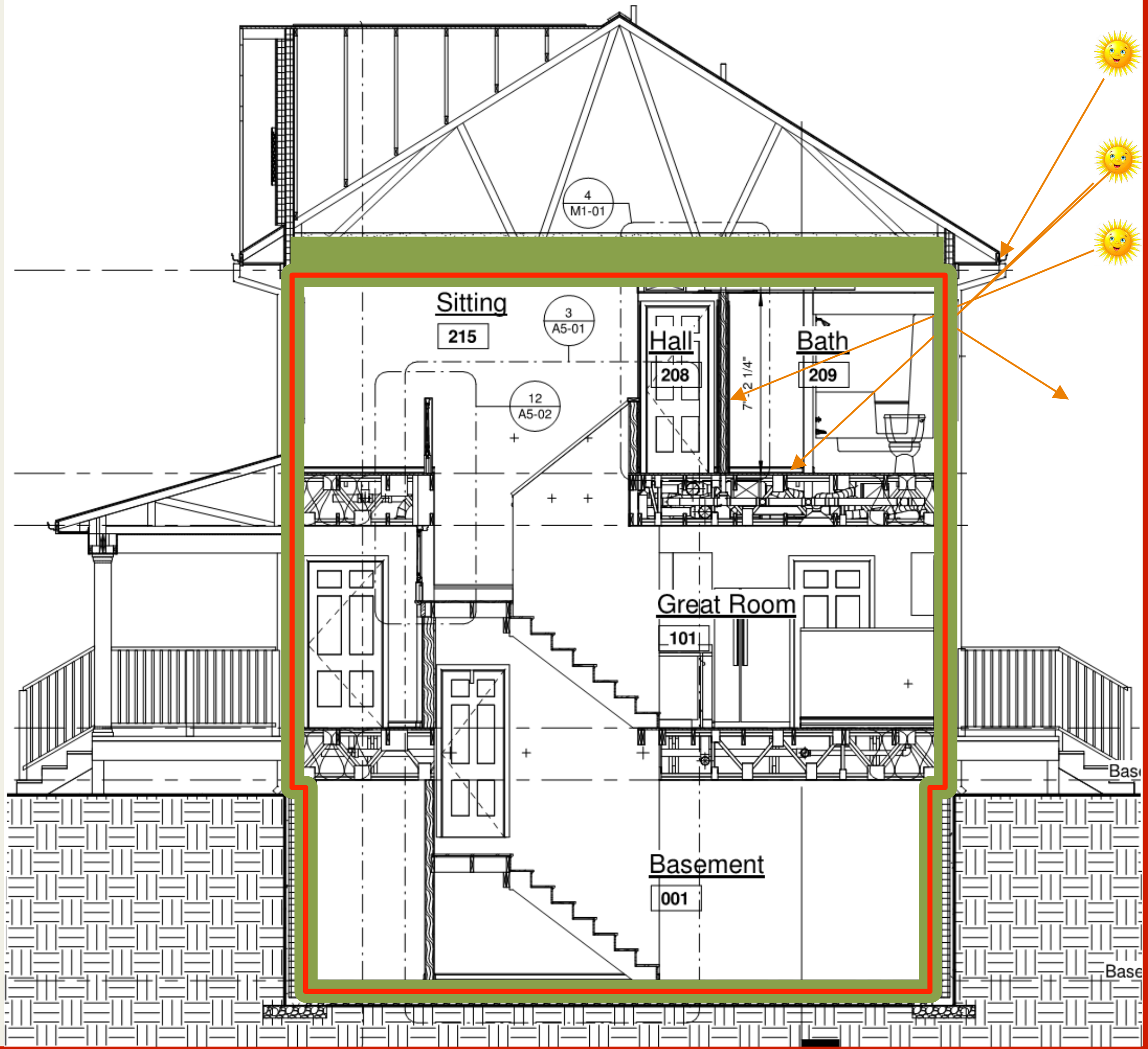
North American Climate

NOT NORTHERN EUROPE

Passive House Design & Humidity

Why it becomes a problem

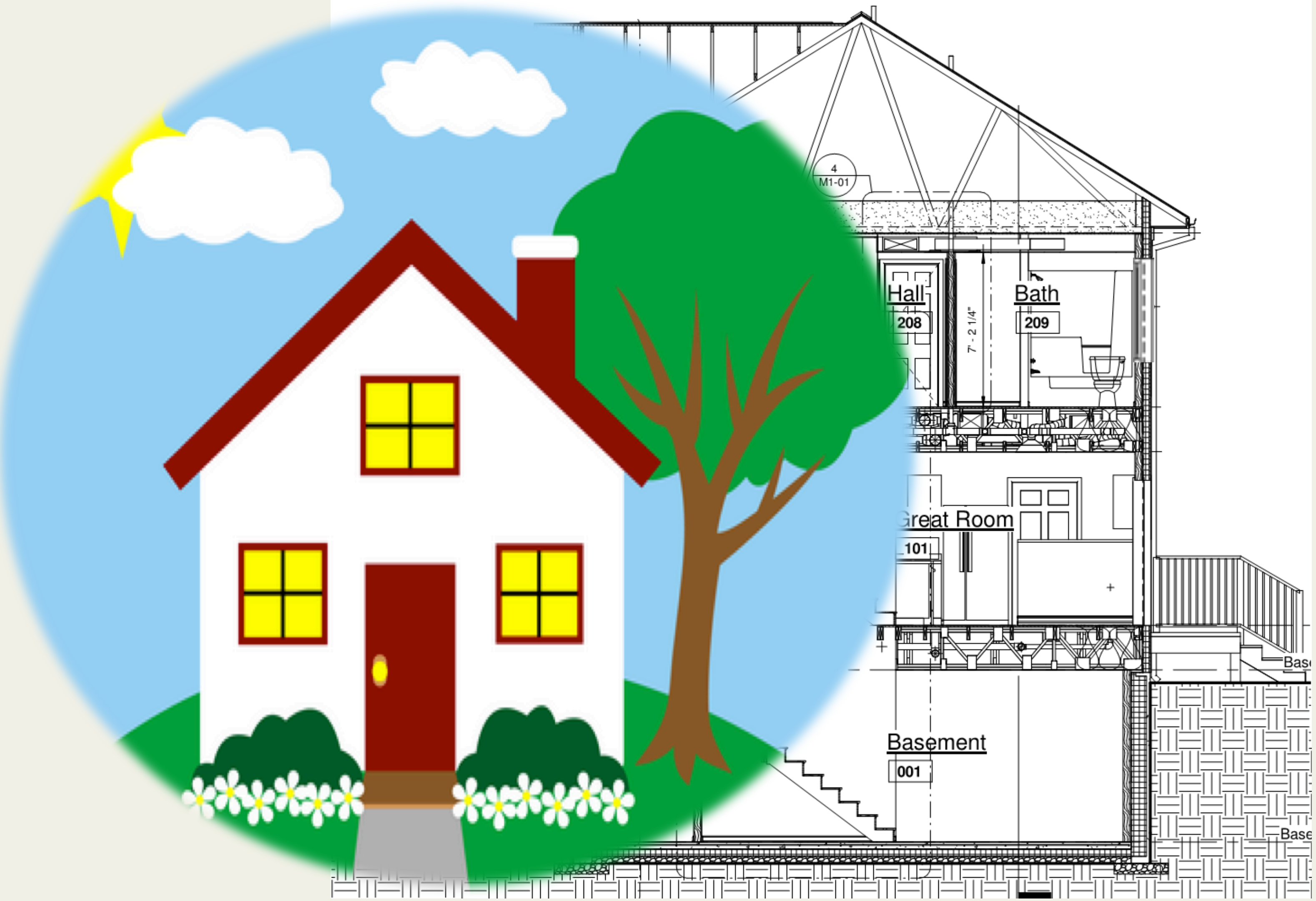
- Applying PH Principles
  - Enhanced Thermal Envelope
  - Proper Shading
    - Significantly reduced sensible load
  - Robust Air Barrier
    - Reduces air infiltration by factor 10+
    - Reduces both sensible and latent heat through infiltration



Passive House Design & Humidity

Why it becomes a problem

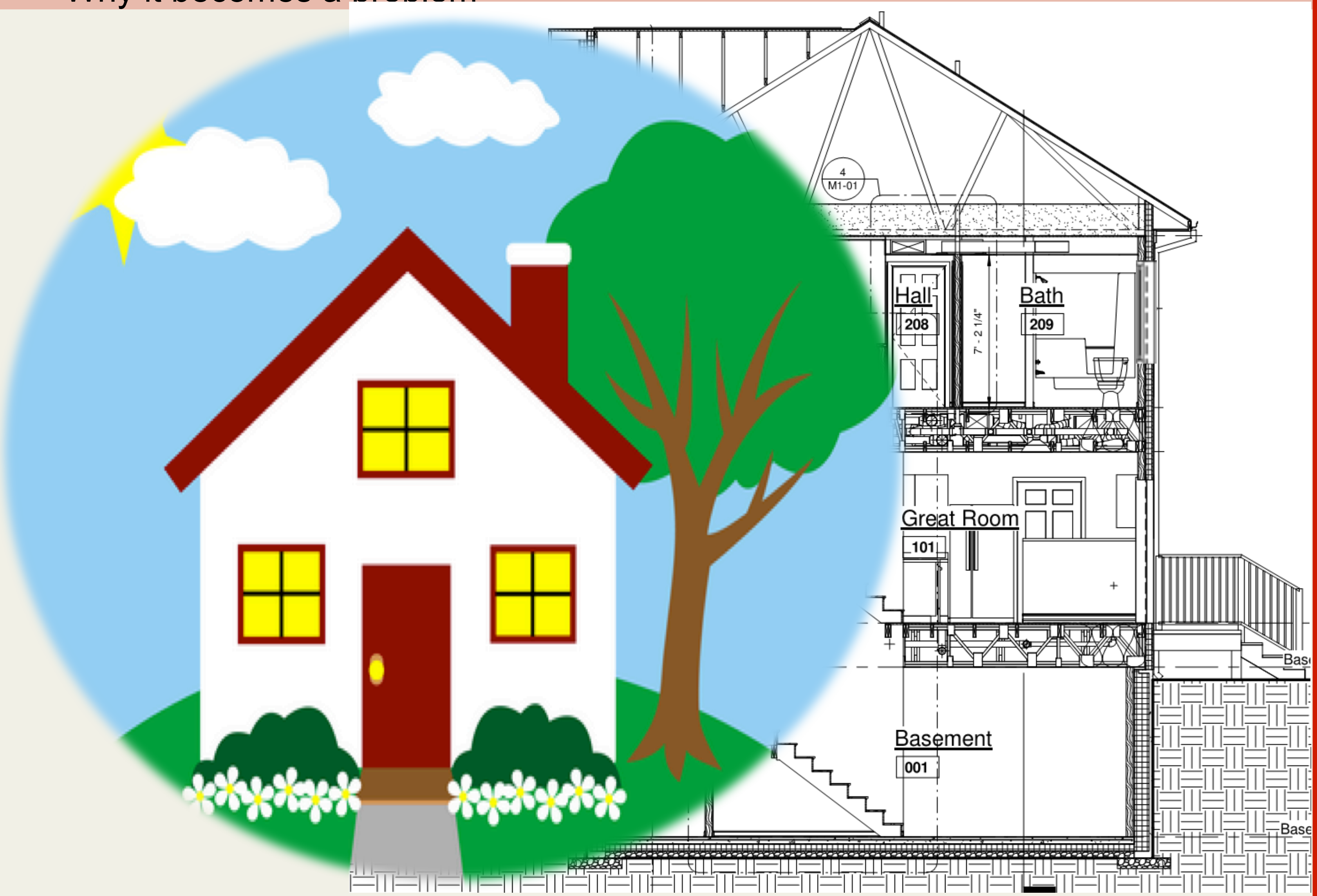
- What if I stop there?



Passive House Design & Humidity

Why it becomes a problem

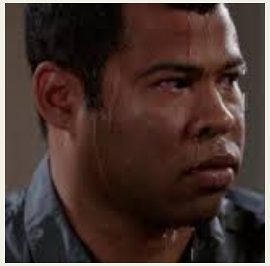
- We don't stop there!

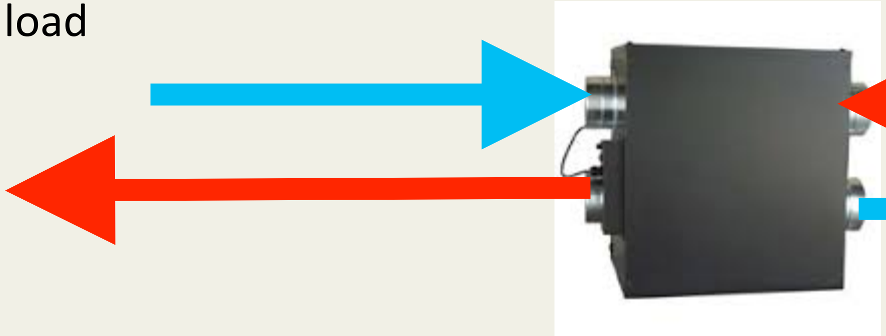


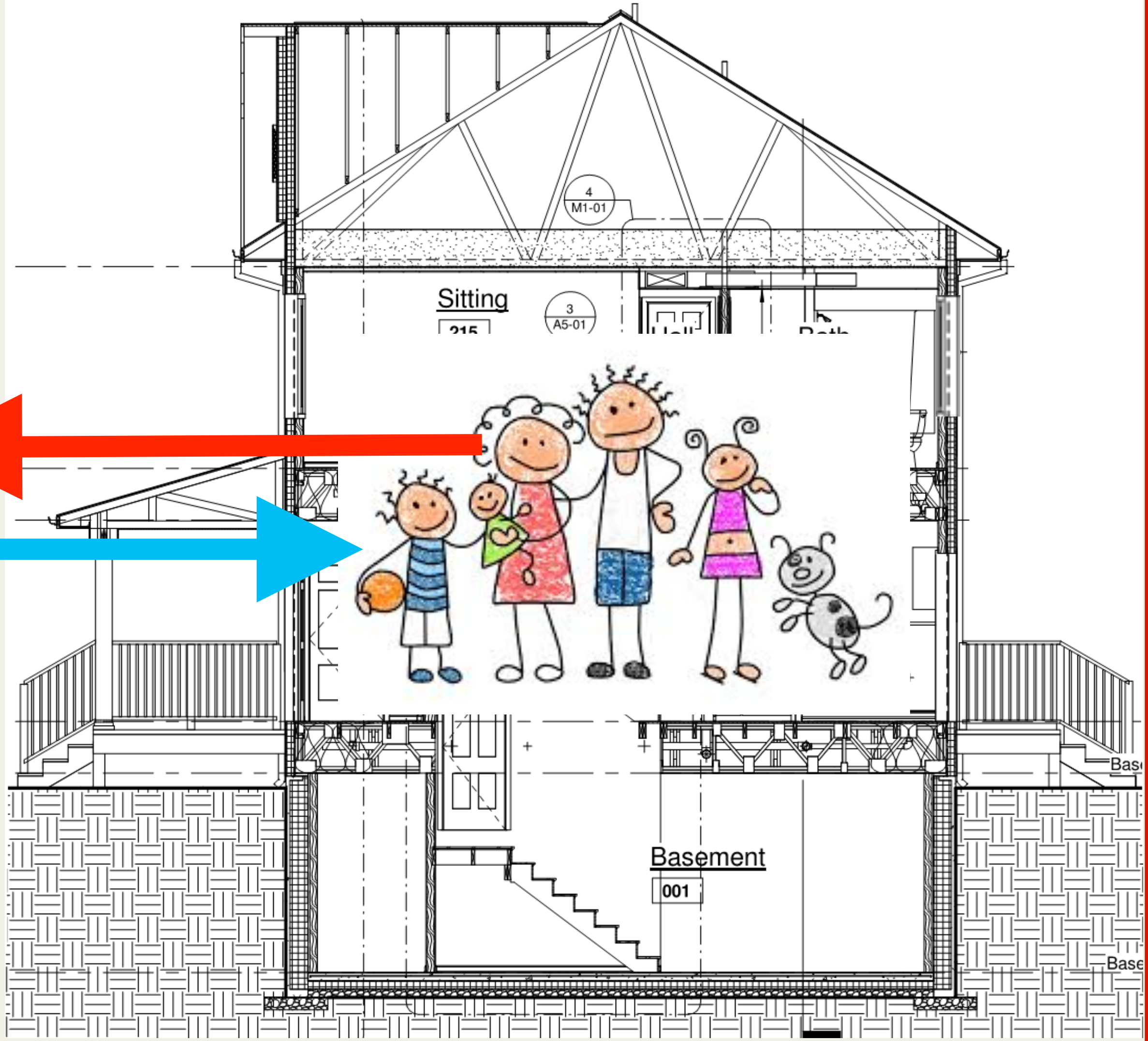
Passive House Design & Humidity

Why it becomes a problem

- We don't stop there!
- We put PESKY humans in our wonderful Passive Houses
    - They have to breathe O_2
        - We install mechanical ventilation
- Humans also do things like: breathe, shower, cook, sweat, water plants
- This creates latent load







Passive House Design & Humidity

Why it becomes a problem

- So what we have done is:
  - Decrease sensible load through good PH design
  - Deliberately introduce fresh air that has with moisture
  - Created a container to retain interior moisture gain (good in cold northern EU climes, not so good for much of North America)

Passive House Design & Humidity

Understanding the Problem

- **Sensible heat ratio (SHR)** is the term used to describe the ratio of sensible heat load to total heat load.
- This can be formulated as: SHR = qs / qt.
  - qs = sensible heat (kW or BTU)
  - qt = total heat (kW or BTU)

	Sensible Load BTU/Hr	Latent Load BTU/Hr	Total Load BTU/Hr
Ventilation Air (100 CFM)	370.40	2484.30	2854.70
Interior Heat Gain	1540.00	660.00	2200.00
Fabric Gains	2240.00	200.00	2440.00
TOTAL LOAD	4150.40	3344.30	7494.70
Heat Ratio	55.38%	44.62%	

Entering Air	
°F	90
% RH	75%
ERV	
Sensible Eff	81%
Latent Eff	49%
Room Condition	
°F	74
% RH	50%
Bldg Size	2000

	Sensible Load BTU/Hr	Latent Load BTU/Hr	Total Load BTU/Hr
Ventilation Air (150 CFM)	555.60	3726.45	4282.05
Interior Heat Gain	1540.00	660.00	2200.00
Fabric Gains	2240.00	200.00	2440.00
TOTAL LOAD	4335.60	4586.45	8922.05
Heat Ratio	48.59%	51.41%	

Passive House Design & Humidity

Understanding the Problem

	Sensible Load BTU/Hr	Latent Load BTU/Hr	Total Load BTU/Hr
Ventilation Air (100 CFM)	370.40	2484.30	2854.70
Interior Heat Gain	1155.00	495.00	1650.00
Fabric Gains	1680.00	150.00	1830.00
TOTAL LOAD	**3205.40**	**3129.30**	**6334.70**
Heat Ratio	50.60%	49.40%	

Entering Air	
°F	90
% RH	75%
ERV	
Sensible Eff	81%
Latent Eff	49%
Room Condition	
°F	74
% RH	50%
Bldg Size	1500

	Sensible Load BTU/Hr	Latent Load BTU/Hr	Total Load BTU/Hr
Ventilation Air (150 CFM)	555.60	3726.45	4282.05
Interior Heat Gain	1155.00	495.00	1650.00
Fabric Gains	1680.00	150.00	1830.00
TOTAL LOAD	**3390.60**	**4371.45**	**7762.05**
Heat Ratio	43.68%	56.32%	

	Sensible Load BTU/Hr	Latent Load BTU/Hr	Total Load BTU/Hr
Ventilation Air (100 CFM)	370.40	2484.30	2854.70
Interior Heat Gain	924.00	396.00	1320.00
Fabric Gains	1344.00	120.00	1464.00
TOTAL LOAD	**2638.40**	**3000.30**	**5638.70**
Heat Ratio	46.79%	53.21%	

Entering Air	
°F	90
% RH	75%
ERV	
Sensible Eff	81%
Latent Eff	49%
Room Condition	
°F	74
% RH	50%
Bldg Size	1200

	Sensible Load BTU/Hr	Latent Load BTU/Hr	Total Load BTU/Hr
Ventilation Air (150 CFM)	555.60	3726.45	4282.05
Interior Heat Gain	924.00	396.00	1320.00
Fabric Gains	1344.00	120.00	1464.00
TOTAL LOAD	**2823.60**	**4242.45**	**7066.05**
Heat Ratio	39.96%	60.04%	

Passive House Design & Humidity

Why it becomes a problem

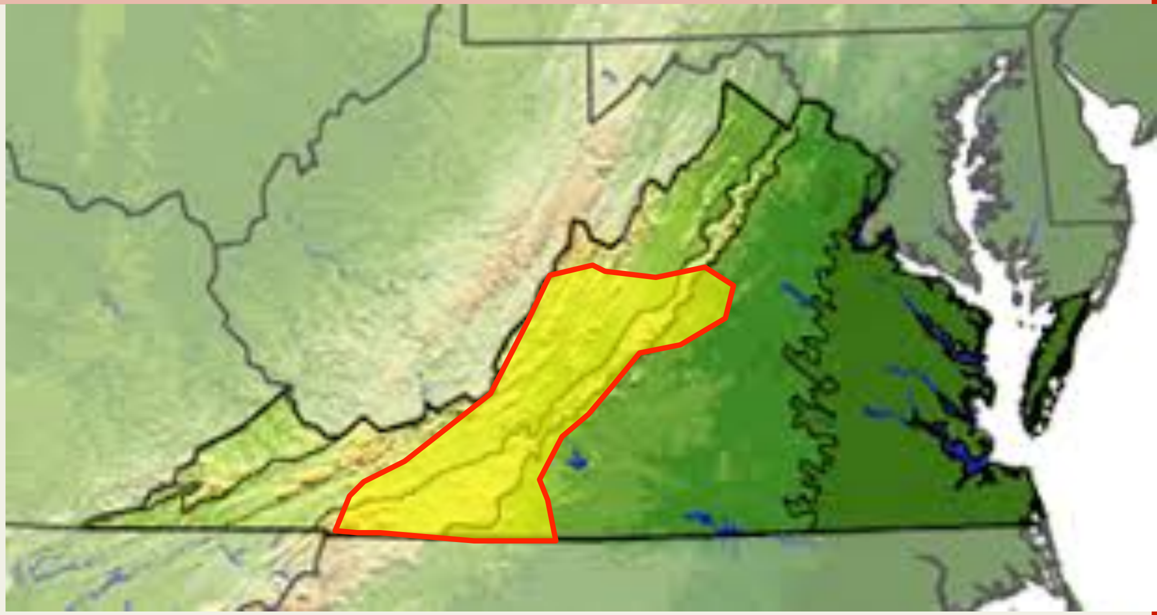
- So what we have done is:
  - Decrease sensible load through good PH design
  - Deliberately introduce fresh air that has with moisture
  - Created a container to retain interior moisture gain (good in cold northern EU climes, not so good for much of North America)

Manufacturer	NominalCapacity (BTU/ HR)	SHR
Mitsubishi	9000	82%
Mitsubishi	12000	74%
Mitsubishi	15000	80%
Mitsubishi	18000	71%
Mitsubishi	24000	75%

Passive House Design & Humidity

Mid Atlantic Solutions

- I have been designing and building in the Mixed Humid Climate of SW Virginia
- Relatively Mild Climate
  - We were able to control humidity through combination of:
    - Enthalpy Wheel
    - Ground Loop with Water to Air Coil
    - Properly sized Cooling Equipment

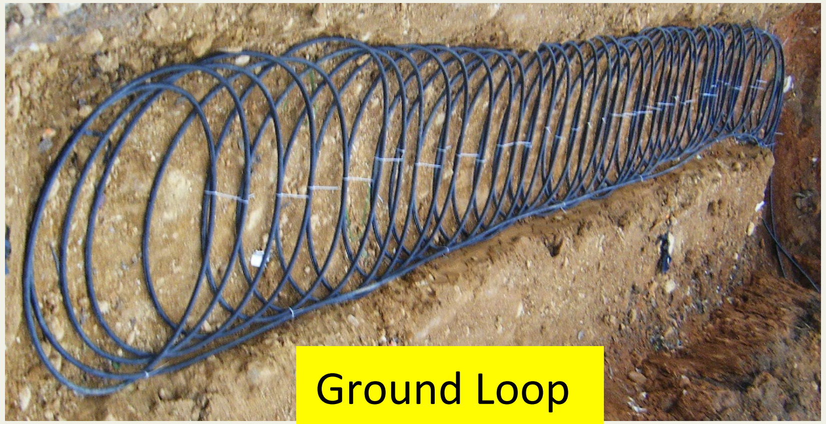


Water to Air Coil

Enthalpy Wheel

Cooling Equipment

Ground Loop

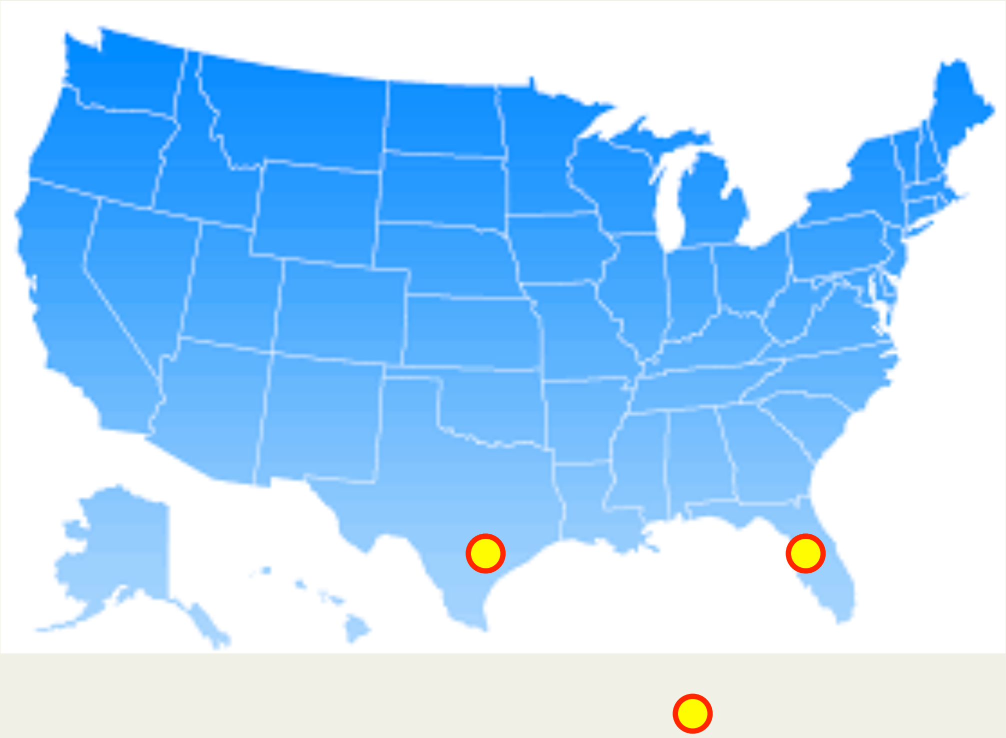


Ground Loop

Passive House Design & Humidity

Mid Atlantic Solutions don't work everywhere

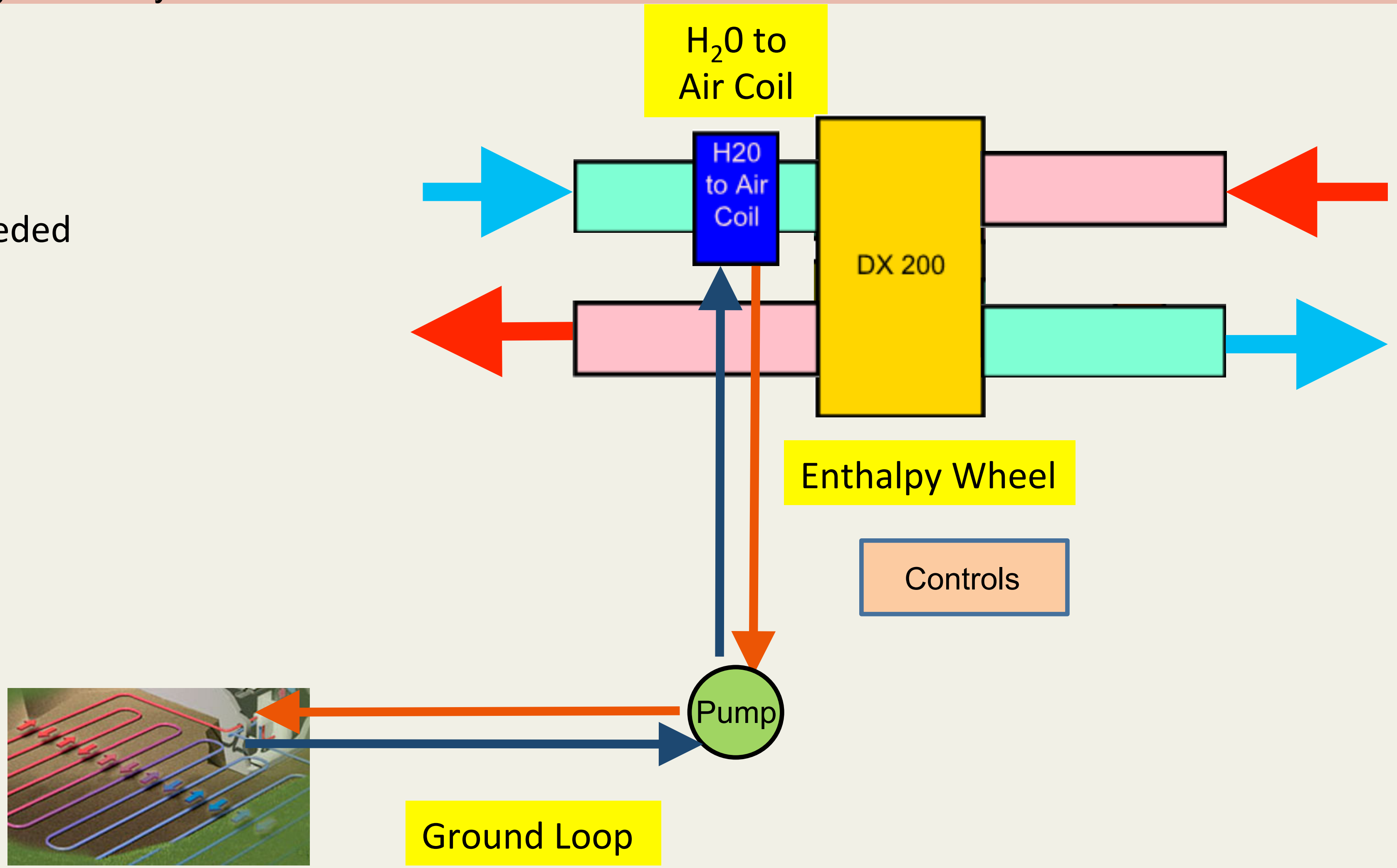
- We were asked to do projects in Houston, Orlando & Grand Cayman (although to me a Passive House in the Grand Caymans is just called a house)
- Analysis found:
  - There were times of the year when we needed only latent removal without the need for sensible cooling
  - If we relied on traditional methods we would end up with:
    - Dedicated dehumidification (Energy penalty)
    - Overcooled spaces (Uncomfortable)
    - High interior humidity (Uncomfortable)
- We needed a more elegant low energy solution



GEN 1 CONCEPT

Energy Recovery Ventilator with Dehumidification Assist

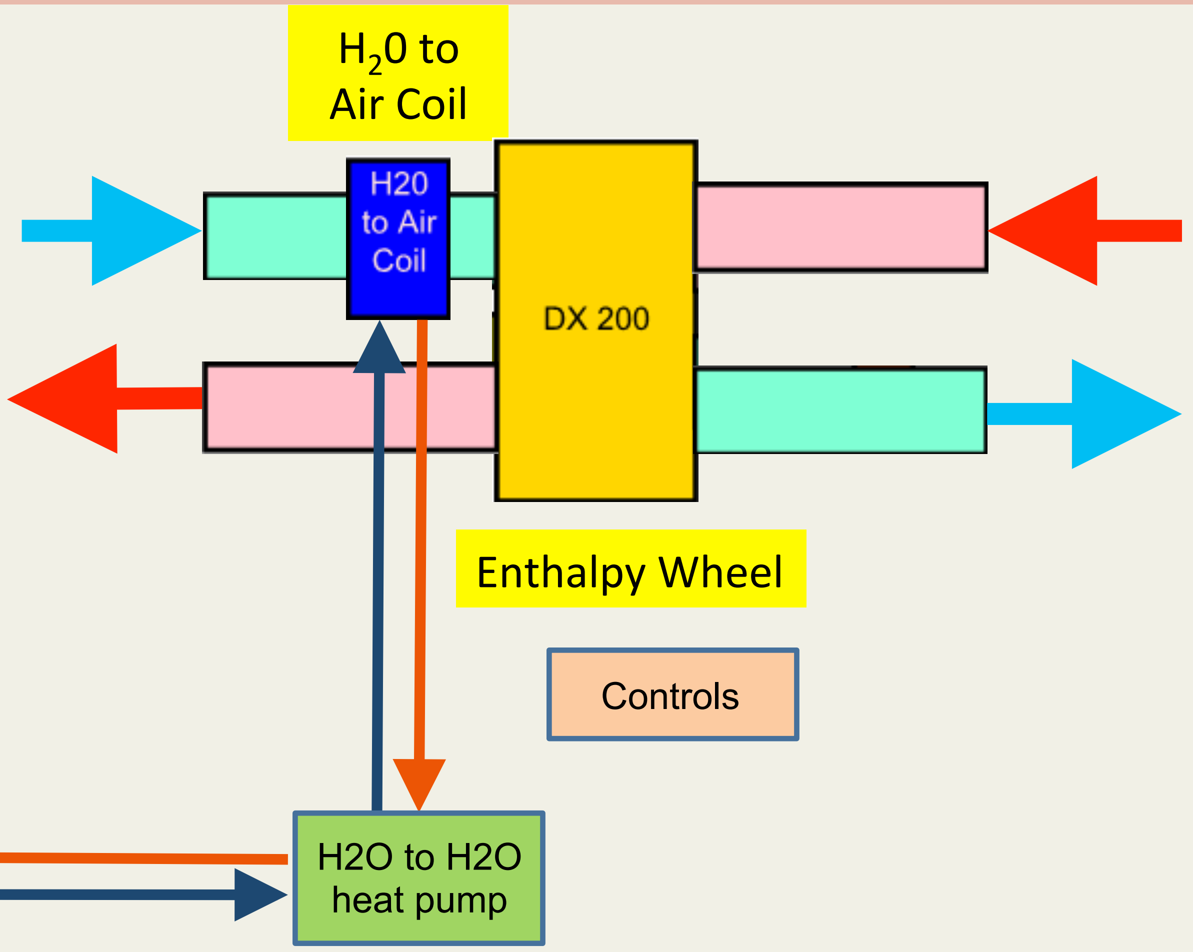
- SW Virginia solution
    - Enthalpy Wheel
    - Ground Loop with Water to Air Coil
    - Controls
- Would not provide dehumidification needed



Gen 1 Concept

Energy Recovery Ventilator with Dehumidification Assist

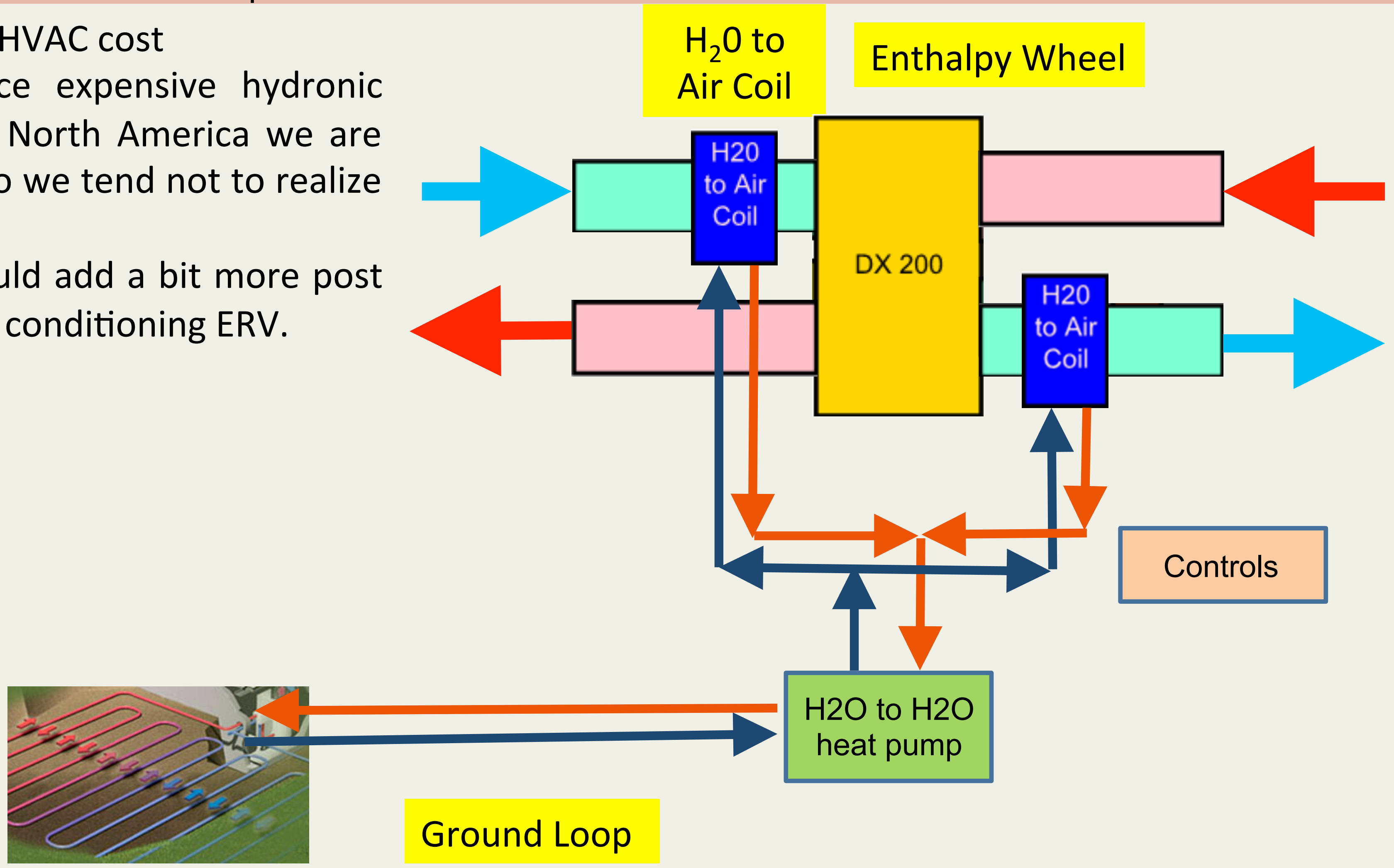
- SW Virginia solution
    - Enthalpy Wheel
    - Ground Loop with Water to Air Coil
    - Controls
- Realized if we added a small H_2O to H_2O heat pump we could provide dehumidification and use the ERV for passive reheat during times of the year when we needed only latent removal without the need for sensible cooling
- Also by using advanced logic controls we could optimize the energy use by only engaging the heat pump when conditions require it



Concept Evolution

What other problems can we solve

- Another issue with Residential PH is the HVAC cost
- Whereas in Northern EU folks replace expensive hydronic systems with lower cost air system, in North America we are typically using inexpensive air systems so we tend not to realize savings in HVAC.
- With the GEN 1 unit we realized we could add a bit more post ERV hardware and logic and then have a conditioning ERV.



Gen 2 Concept

Energy Recovery Ventilator with Dehumidification Assist & Conditioning

- Gen 2 Concept

Return Air Sensor Set Points: Temperature	Return Air Sensor Set Points: Humidity	Call: Temperature	Call: Humidity	Outside Air: Temperature	Outside Air: Humidity	Stage	Enthalpy Wheel	Fans	Pump	Solenoid A	Solenoid B	Compressor	Compressor Mode
Above Set Point	Above Set Point	Cool	Dehumid	OA > Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
						Two	on	Min	on	open	open	on	cool
						Three	on	Max	on	open	open	on	cool
Above Set Point	Above Set Point	Cool	Dehumid	OA > Setpoint	OA<= Setpoint	One	on	Min	on	open	closed	on	cool
						Two	on	Max	on	open	open	on	cool
Above Set Point	Above Set Point	Cool	Dehumid	OA = Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
						Two	on	Max	on	open	open	on	cool
Above Set Point	Above Set Point	Cool	Dehumid	OA = Setpoint	OA<= Setpoint	One	on	Min	on	closed	open	on	cool
						Two	on	Max	on	closed	open	on	cool
Above Set Point	Above Set Point	Cool	Dehumid	OA < Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
						Two	on	Max	on	open	open	on	cool
Above Set Point	Above Set Point	Cool	Dehumid	OA < Setpoint	OA<= Setpoint	One	off	Min	off	closed	closed	off	nil
						Two	off	Max	off	closed	closed	off	nil
						Three	off	Max	on	closed	open	on	cool
Above Set Point	Set point or Blow Set Point	Cool	Do Nothing	OA > Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
						Two	on	Max	on	open	open	on	cool
Above Set Point	Set point or Blow Set Point	Cool	Do Nothing	OA > Setpoint	OA <=Setpoint	One	on	Min	on	closed	open	on	cool
						Two	on	Max	on	closed	open	on	cool
Above Set Point	Set point or Blow Set Point	Cool	Do Nothing	OA = Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
						Two	on	Max	on	open	open	on	cool
Above Set Point	Set point or Blow Set Point	Cool	Do Nothing	OA = Setpoint	OA <=Setpoint	One	on	Min	on	closed	open	on	cool
						Two	on	Max	on	closed	open	on	cool
Above Set Point	Set point or Blow Set Point	Cool	Do Nothing	OA < Setpoint	OA > Setpoint	One	off	Min	on	open	closed	on	cool
						Two	on	Max	on	open	closed	on	cool
						Three	on	Max	on	open	open	on	cool
Above Set Point	Set point or Blow Set Point	Cool	Do Nothing	OA < Setpoint	OA <=Setpoint	One	off	Min	off	closed	closed	off	nil
						Two	off	Max	off	closed	closed	off	nol
						Three	off	Max	on	closed	open	on	cool
Set point	Above Set Point	Do Nothing	Dehumid	OA > Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
Set point	Above Set Point	Do Nothing	Dehumid	OA > Setpoint	OA <= Setpoint	One	on	Min	on	open	closed	on	cool
Set point	Above Set Point	Do Nothing	Dehumid	OA = Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
Set point	Above Set Point	Do Nothing	Dehumid	OA = Setpoint	OA<= Setpoint	One	on	Min	on	open	closed	on	cool
Set point	Above Set Point	Do Nothing	Dehumid	OA < Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	cool
Set point	Above Set Point	Do Nothing	Dehumid	OA < Setpoint	OA <= Setpoint	One	on	Min	on	open	closed	on	cool
Set point	Set point	Do Nothing	Do Nothing	All conditions	All conditions	One	on	min	off	closed	closed	off	nil
Set point	Below Set Point	Do Nothing	Do Nothing	All conditions	All conditions	One	on	min	off	closed	closed	off	nil
Below Set Point	Above Set Point	Heat	Dehumid	OA > Setpoint	OA > Setpoint	One	on	Min	on	closed	open	on	heat
						Two	on	Max	on	closed	open	on	heat
Below Set Point	Above Set Point	Heat	Dehumid	OA > Setpoint	OA <= Setpoint	One	off	min	on	closed	closed	off	nil
						Two	off	min	on	closed	open	on	heat
						Three	off	Max	on	closed	open	on	heat
Below Set Point	Above Set Point	Heat	Dehumid	OA = Setpoint	OA > Setpoint	One	on	Min	on	closed	open	on	heat
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Below Set Point	Above Set Point	Heat	Dehumid	OA = Setpoint	OA <= Setpoint	One	on	Min	on	closed	open	on	heat
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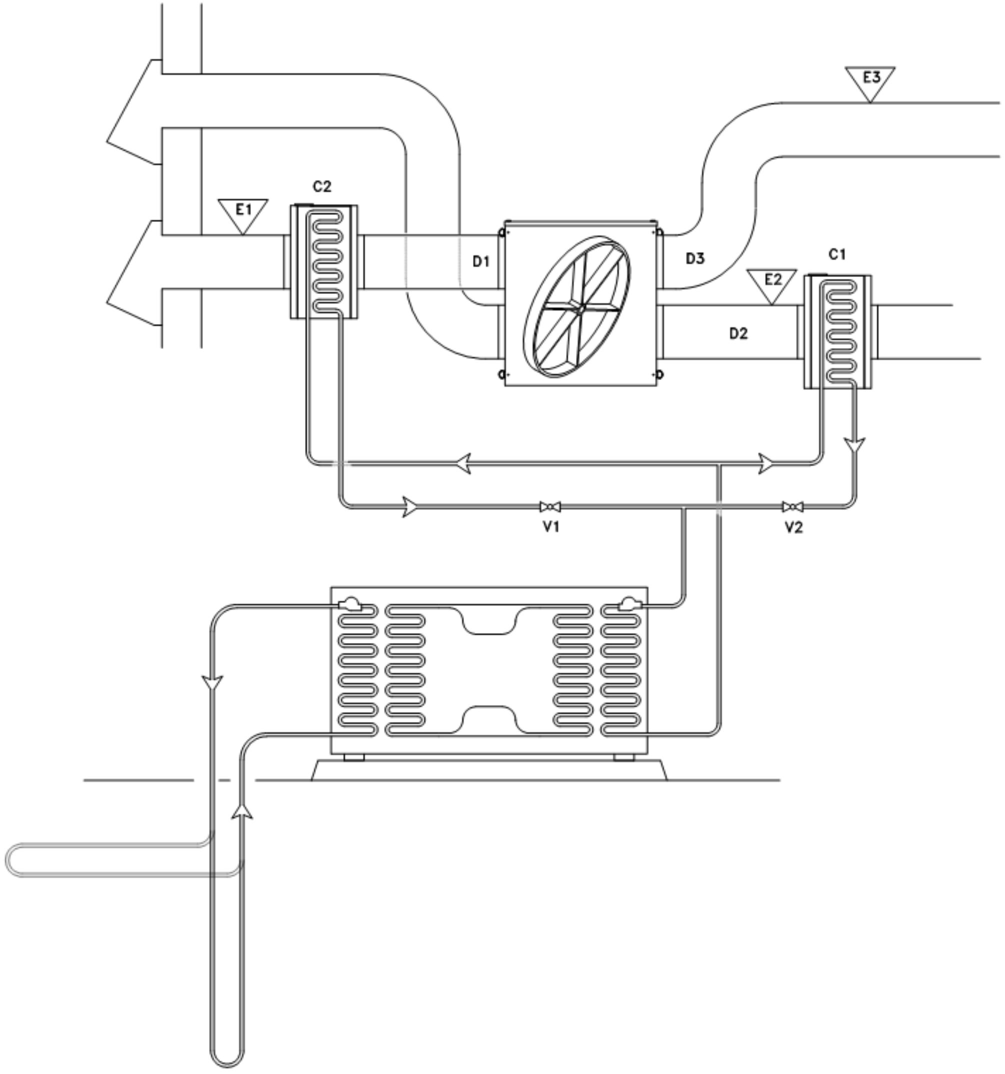
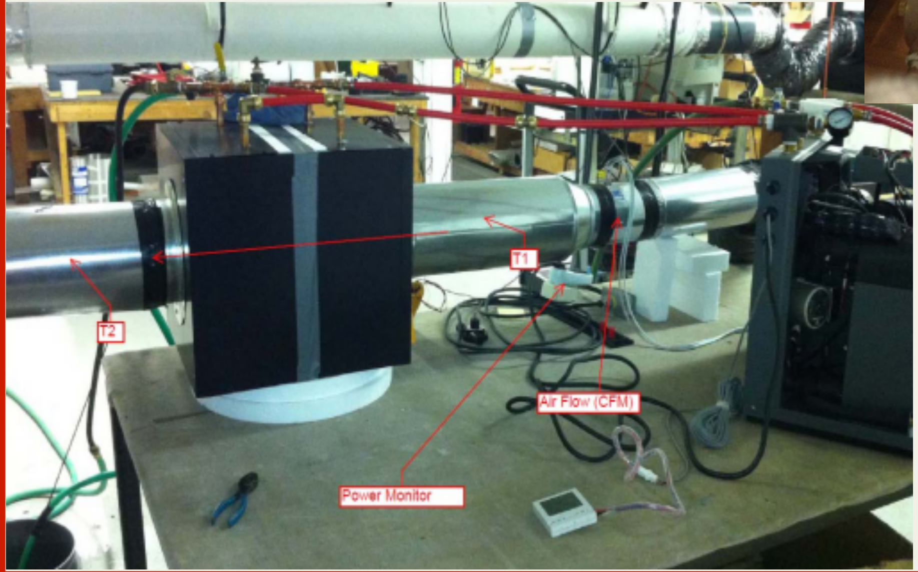
Below Set Point	Above Set Point	Heat	Dehumid	OA < Setpoint	OA > Setpoint	One	on	Min	on	open	closed	on	heat
						Two	on	min	on	open	open	on	heat
						Two	on	Max	on	open	open	on	heat
Below Set Point	Above Set Point	Heat	Dehumid	OA < Setpoint	OA <= Setpoint	One	on	Min	on	closed	open	on	heat
						Two	on	Max	on	closed	open	on	heat
Below Set Point	Set point or Blow Set Point	Heat	Do Nothing	OA > Setpoint	OA > Setpoint	One	on	min	on	closed	open	on	heat
						Two	on	Max	on	closed	open	on	heat
Below Set Point	Set point or Blow Set Point	Heat	Do Nothing	OA > Setpoint	OA <= Setpoint	One	off	min	off	closed	closed	off	nil
						Two	off	min	on	closed	open	on	heat
						Two	off	Max	on	closed	open	on	heat
Below Set Point	Set point or Blow Set Point	Heat	Do Nothing	OA = Setpoint	OA > Setpoint	One	on	min	on	closed	open	on	heat
						Two	on	Max	on	closed	open	on	heat
Below Set Point	Set point or Blow Set Point	Heat	Do Nothing	OA = Setpoint	OA <= Setpoint	One	on	min	on	closed	open	on	heat
						Two	on	Max	on	closed	open	on	heat
Below Set Point	Set point or Blow Set Point	Heat	Do Nothing	OA < Setpoint	OA > Setpoint	One	on	min	on	closed	open	on	heat
						Two	on	Max	on	closed	open	on	heat
Below Set Point	Set point or Blow Set Point	Heat	Do Nothing	OA < Setpoint	OA <= Setpoint	One	on	min	on	closed	open	on	heat
						Two	on	Max	on	closed	open	on	heat



Gen 2 Beta

Energy Recovery Ventilator with Dehumidification Assist & Conditioning

- Laboratory installation and testing
- MacGyver Would be Proud
- First Field Test



Next Steps

Where we go from here

- Looking for BETA sites
- Working with University to fine tune the control algorithms
- Looking for R&D funding

Questions & Contact

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Energy efficiency made simple

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