Steven Winter Associates, Inc.

J827

Moisture Control in Multifamily Passive Houses

MCMFPH5182018

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Steven Winter Associates

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Our services for new and existing commercial and residential properties include:

- Green Building Consulting Services
- Energy Efficiency Consulting Services
- Building Enclosure Design and Consulting
- Accessibility Compliance and Consulting

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Passive Houses are built 8 to 10 times more airtight than a typical code-level building. As a result, less moisture transfer occurs through the exterior wall assembly via air leakage through the façade. This can lead to high interior relative humidity levels and pose increased risk of condensation on the building structure. The primary means of controlling humidity levels in a Passive House is through the ventilation and heating & cooling systems. This talk will outline an example of how this risk was assessed for a current PH project and will detail what design options are available to reduce this risk. The presentation will be multifamily focused.

Learning Objectives

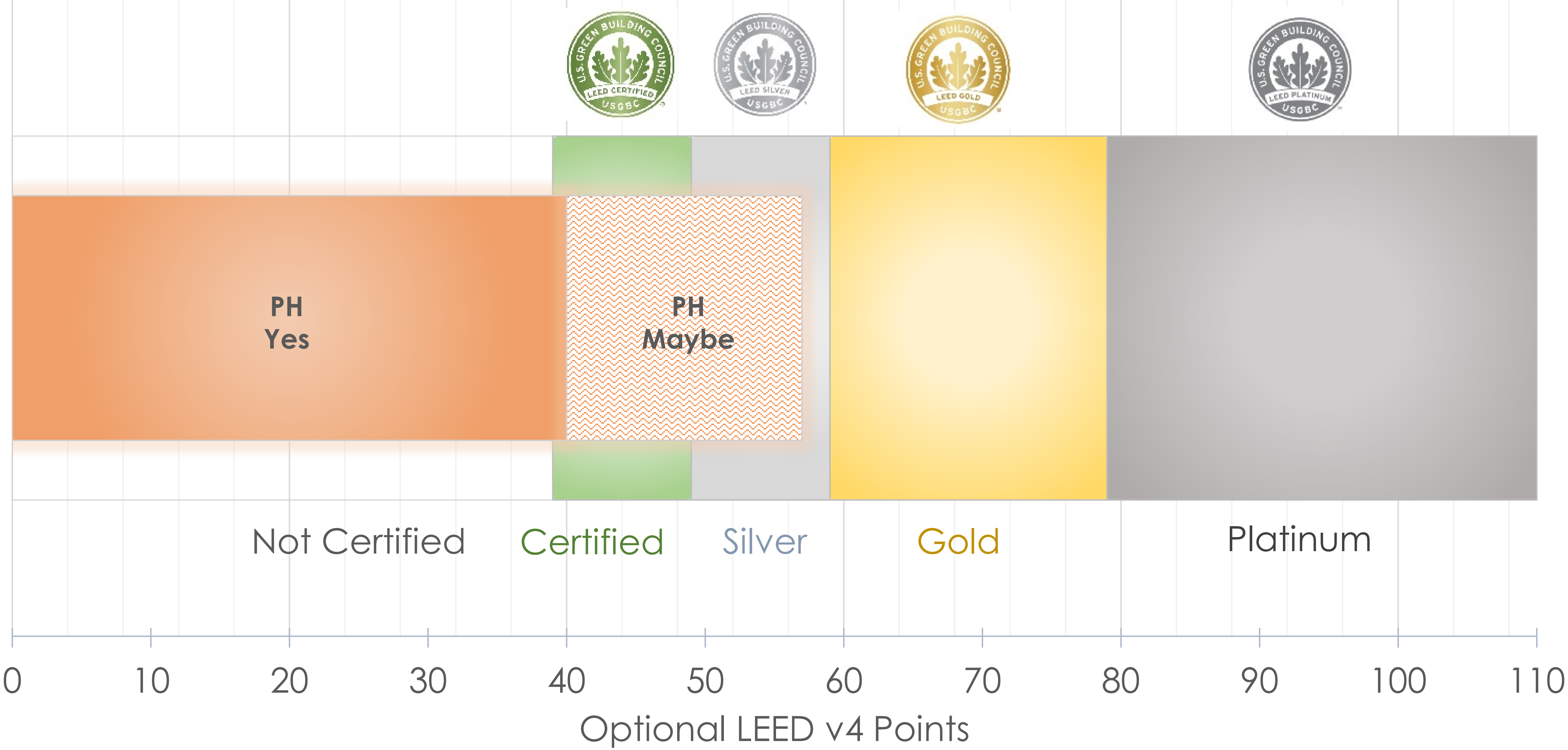
At the end of the this course, participants will learn:

1. Why internal moisture concerns are amplified in an air tight building
2. How ventilation design relates to internal moisture and seasonal
3. Modeling exercises to evaluate the risk of high internal moisture
4. About the potential solutions to control humidity levels in high-efficiency buildings

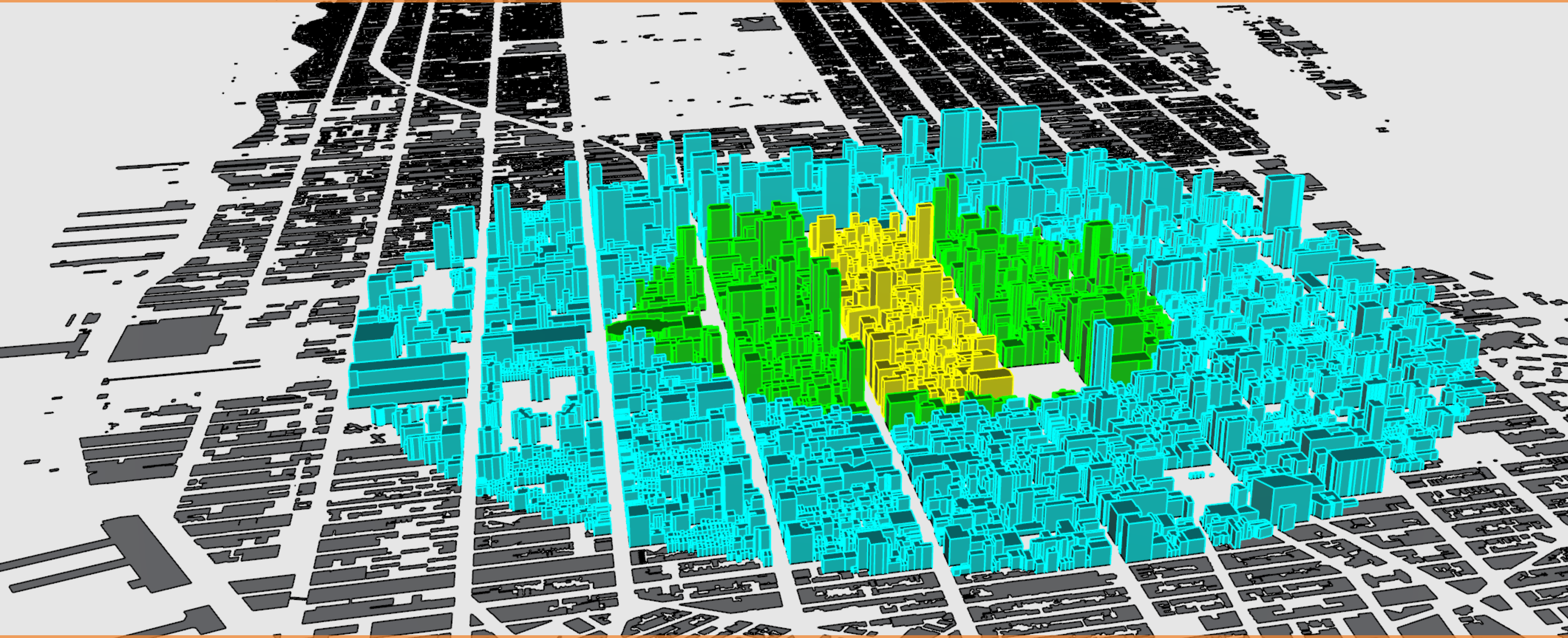
A Primer…

THE PASSIVE HOUSE PATH TOWARDS A SUSTAINABLE, LOW CARBON FUTURE

Passive House → LEEDv4



Passive House → Net Zero



New York City Block: 40th–23rd St & 5th–6th Ave

Roof Area of PV for Net Zero:

\+ → PH Site EUI (22 kBtu/sf.yr)

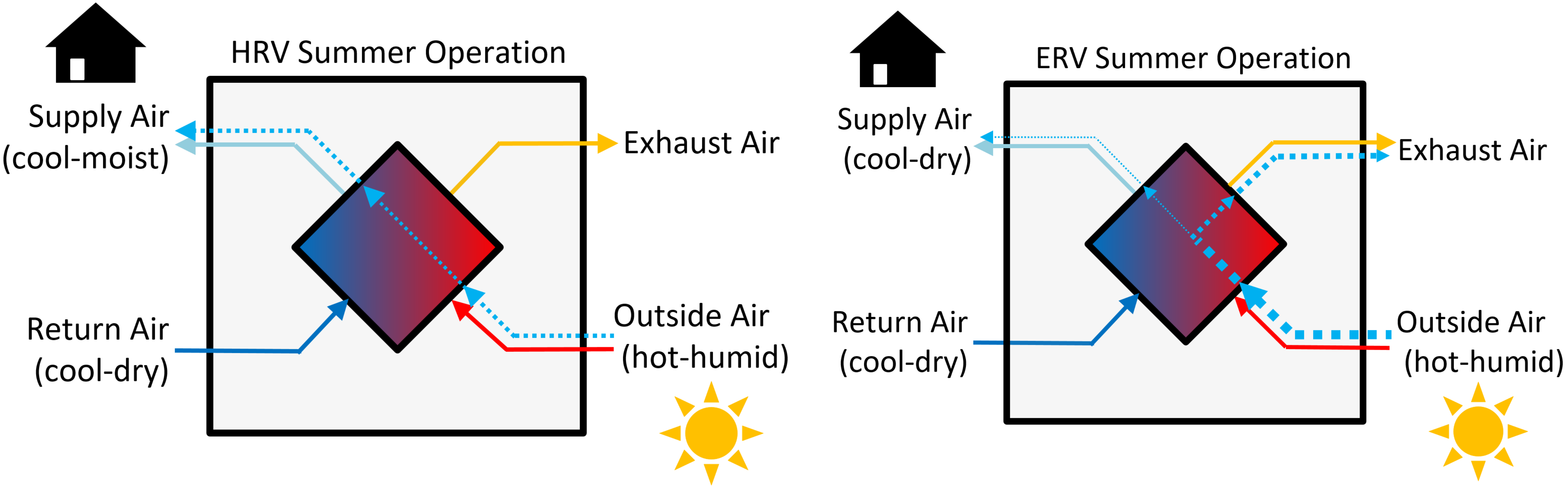
\+ + → Current Site EUI (~82 kBtu/sf.yr)

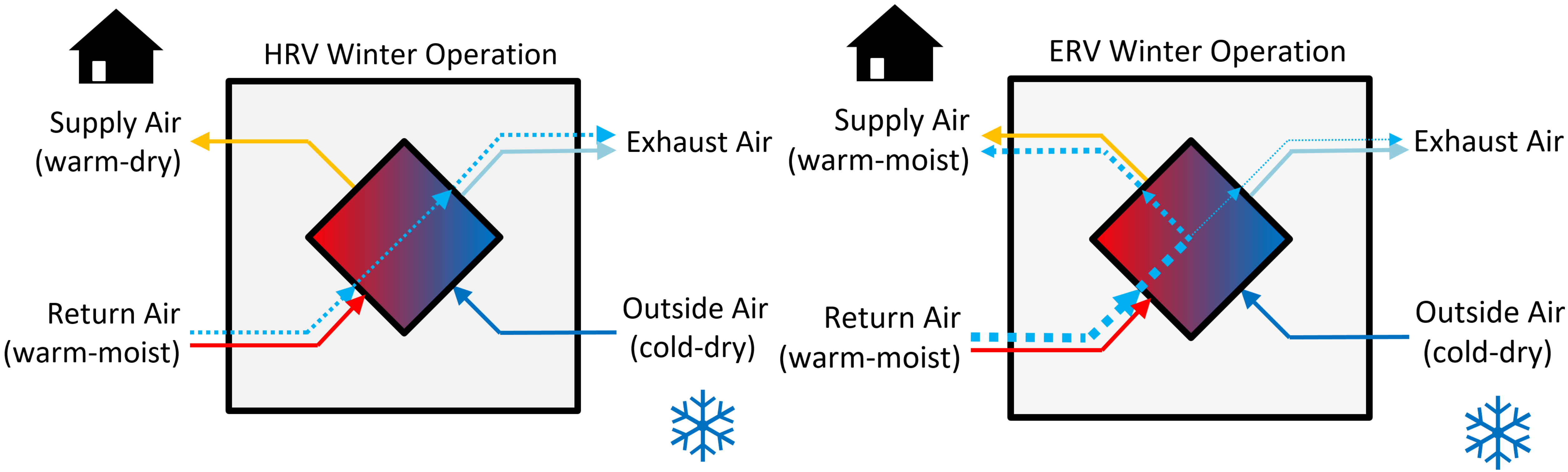
Moisture Control in Multifamily Passive Houses

THE SCIENCE

Moisture Control & Affordable Housing

- Greater occupant density
- Interior moisture generation rates ↑
- All exhaust air through an H/ERV
- PH natural infiltration very low (0.03 cfm/sf. @ 10 mph wind)
  - 5 to 10 times less than typical buildings
  - Moisture must get out through ventilation air
- ERV vs HRV…


HRV Summer Operation
Supply Air
(cool-moist)
Exhaust Air
Return Air
(cool-dry)
Outside Air
(hot-humid)
ERV Summer Operation
Supply Air
(cool-dry)
Exhaust Air
Return Air
(cool-dry)
Outside Air
(hot-humid)



HRV Winter Operation
Supply Air
(warm-dry)
Exhaust Air
Return Air
(warm-moist)
Outside Air
(cold-dry)
ERV Winter Operation
Supply Air
(warm-moist)
Exhaust Air
Return Air
(warm-moist)
Outside Air
(cold-dry)

Internal Moisture – Ventilation Units

ERV

- **Pros - *Summer***
  - Keeps moisture out of interior spaces
  - Cooling loads minimized
- Cons - *Winter*
  - If internal moisture generation high, keeps moisture in

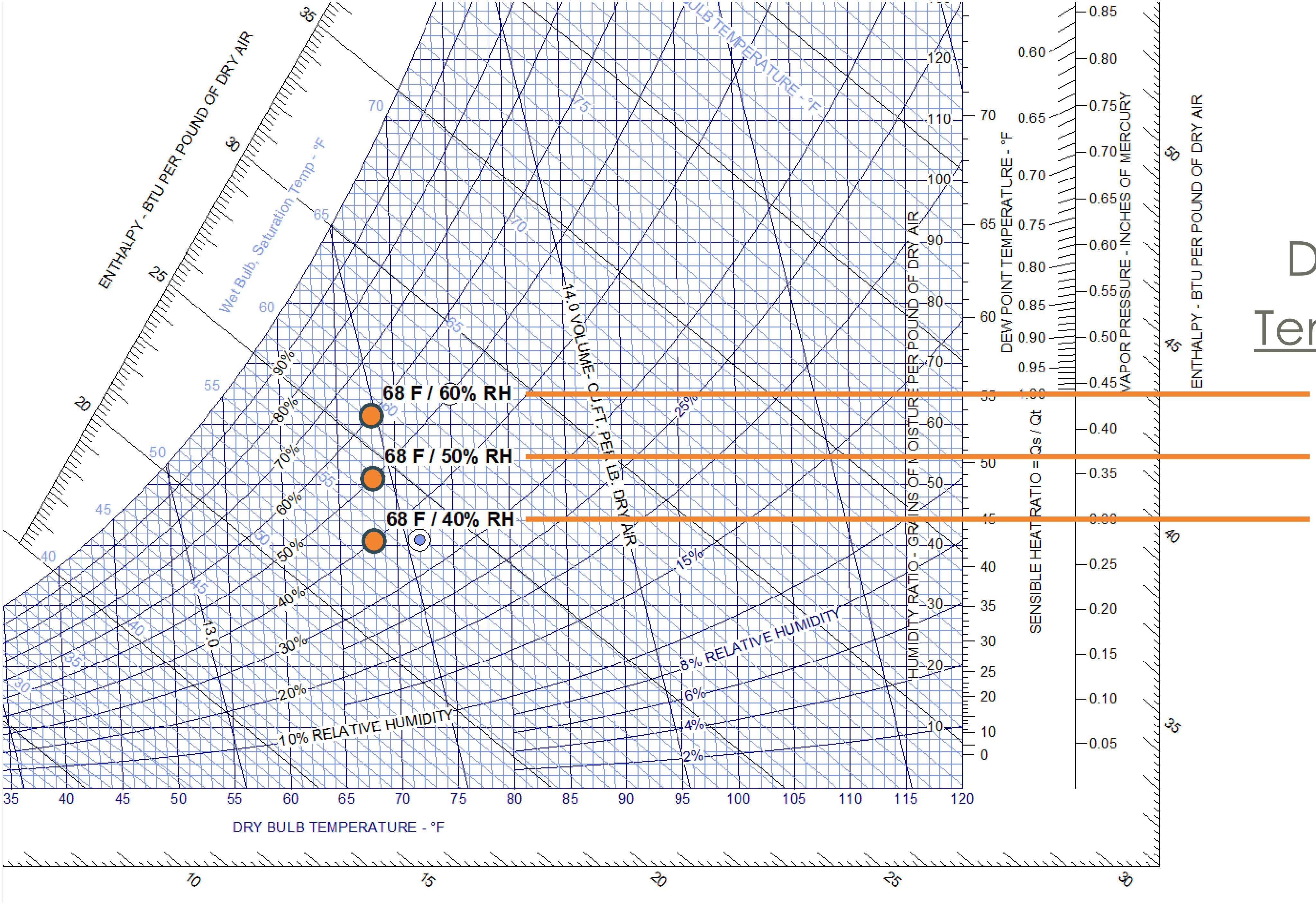
HRV

- **Pros - *Winter***
  - Flushes moisture out of building
- Cons - *Summer*
  - High moisture exterior air brought indoors
  - Cooling loads increased

Why Care About Internal Moisture?

Condensation Prevention

- Interior surface temperature analysis
  - Dew point at interior temp and RH?
  - Keep interior surface temps above dew point
- Weakest (lowest R-value / most thermal bridging) point in thermal envelope?
  - Walls – R-20
  - Roof – R-30
  - **Windows** – U-value = 0.25 Btu/hr.ft2.F [R-4 equivalent]
    - Frame and frame-to-wall performance will be key



Dew Point Temperature

53°F

49°F

43°F

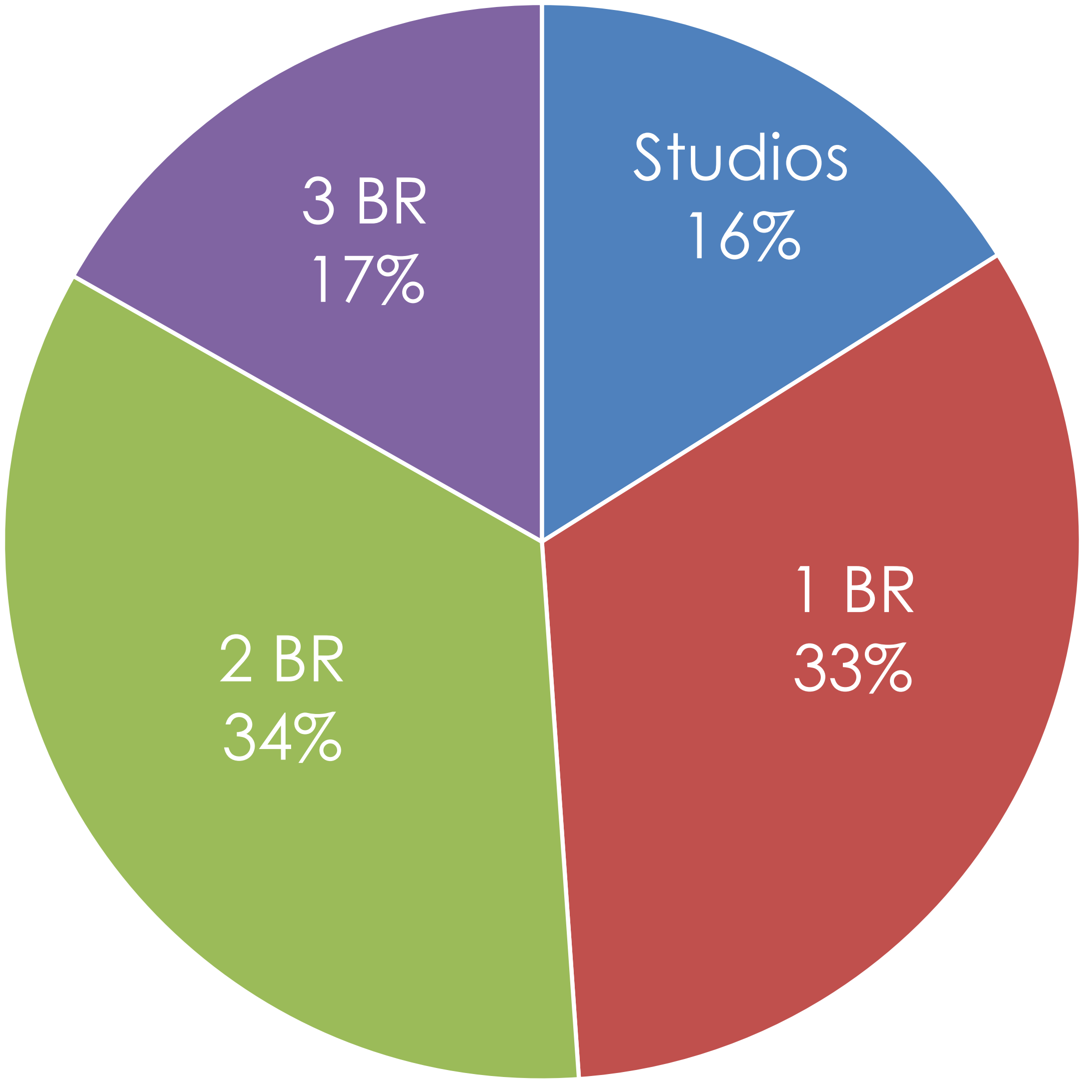
Moisture Control in Multifamily Passive Houses

425 GRAND CONCOURSE OVERVIEW

USE DIAGRAM


PASSIVE HOUSE ENCLOSURE
RESIDENTIAL
RESIDENTIAL TERRACE
EDUCATIONAL FACILITY
CULTURAL
MEDICAL
RESIDENTIAL LOBBY
RETAIL

425 Grand Concourse - 277 units



RESNET Density
- Studios = 187 sf/p
- 1-BR = 254 sf/p
- 2-BR = 229 sf/p
- 3-BR = 234 sf/p

Owner's Expected Density
- Studios = 249 sf/p
- 1-BR = 338 sf/p
- **2-BR = 197 sf/p**
- **3-BR = 187 sf/p**

ENVELOPE EFFICIENCY REQUIREMENTS

ROOF	R-30
ABOVE GRADE WALLS	R-20
BELOW GRADE WALLS	R-10
WINDOWS - INSTALLED EFFECTIVE U-VALUE	0.25 Btu/hr*ft^2*F
GLAZING SHGC	0.27
FACADE AIR TIGHTNESS REQUIREMENT	0.08 cfm/sf-facade @ 50 Pascals

Moisture Analysis Timeline

June 2016 — Ventilation Design #1
- In unit, decentralized
- ERVs

Feb - July 2017 — Energy Modeling
- High RH risk assessment
- Condensation evaluation
- Identification of potential solutions

Aug 2017 — Ventilation Design #2
- Centralized
- ERVs

Moisture Analysis Timeline

Sep – Oct 2017 — **Energy Modeling**
- High RH risk assessment
- Condensation evaluation
- Identification of potential solutions

Oct 2017 - now — **Vetting of Solutions**
- Ventilation based
- Heating/cooling based
- Supplemental equipment

TBD — **Final Specs & Evaluation**
- Pending…

Moisture Control in Multifamily Passive Houses

425 GRAND CONCOURSE IN-DEPTH LOOK

June 2016

Ventilation Design #1

- In unit, decentralized
- ERVs

Feb - July 2017

Energy Modeling

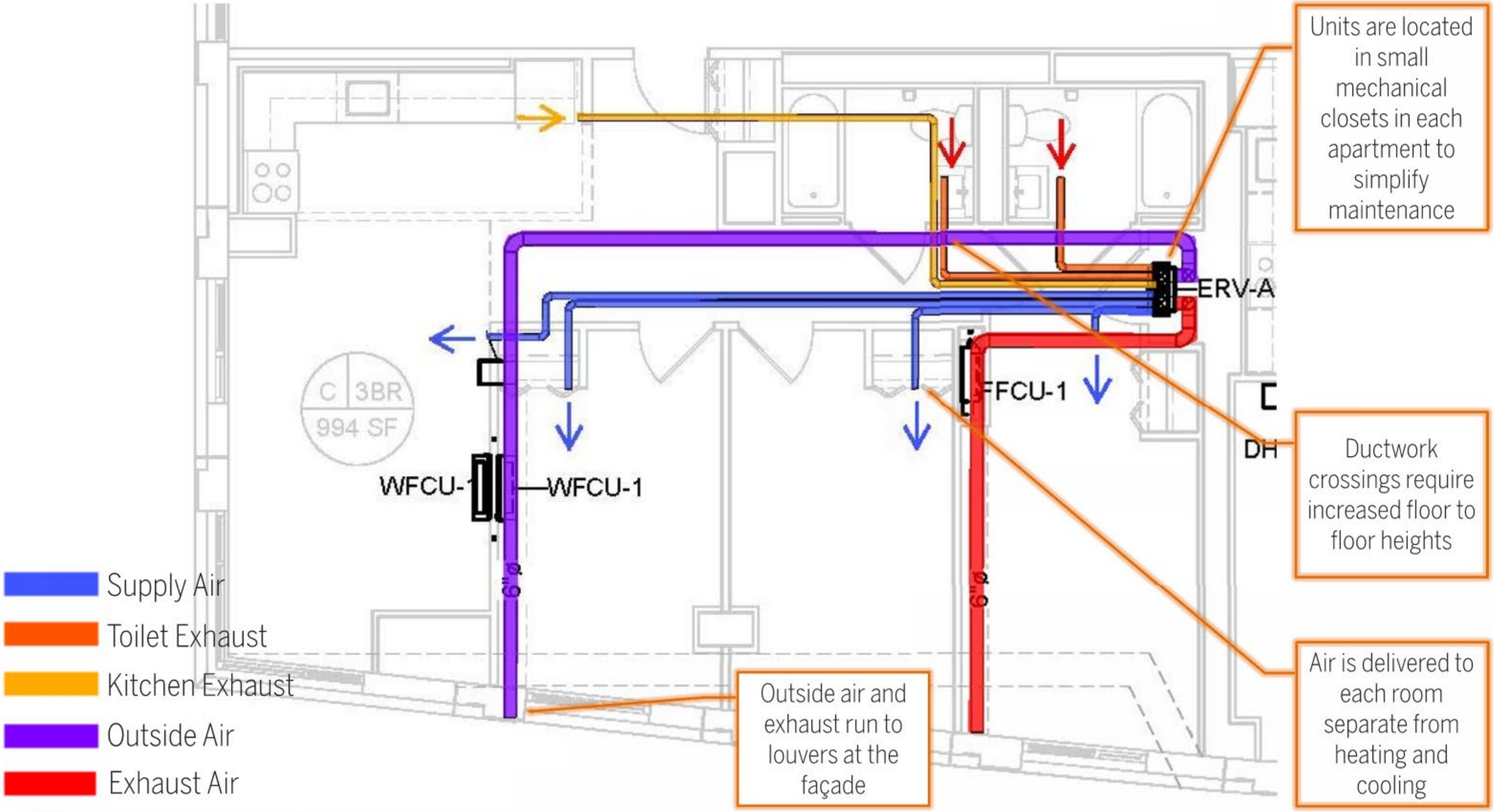
- High RH risk assessment
- Condensation evaluation
- Identification of potential solutions

Aug 2017

Ventilation Design #2

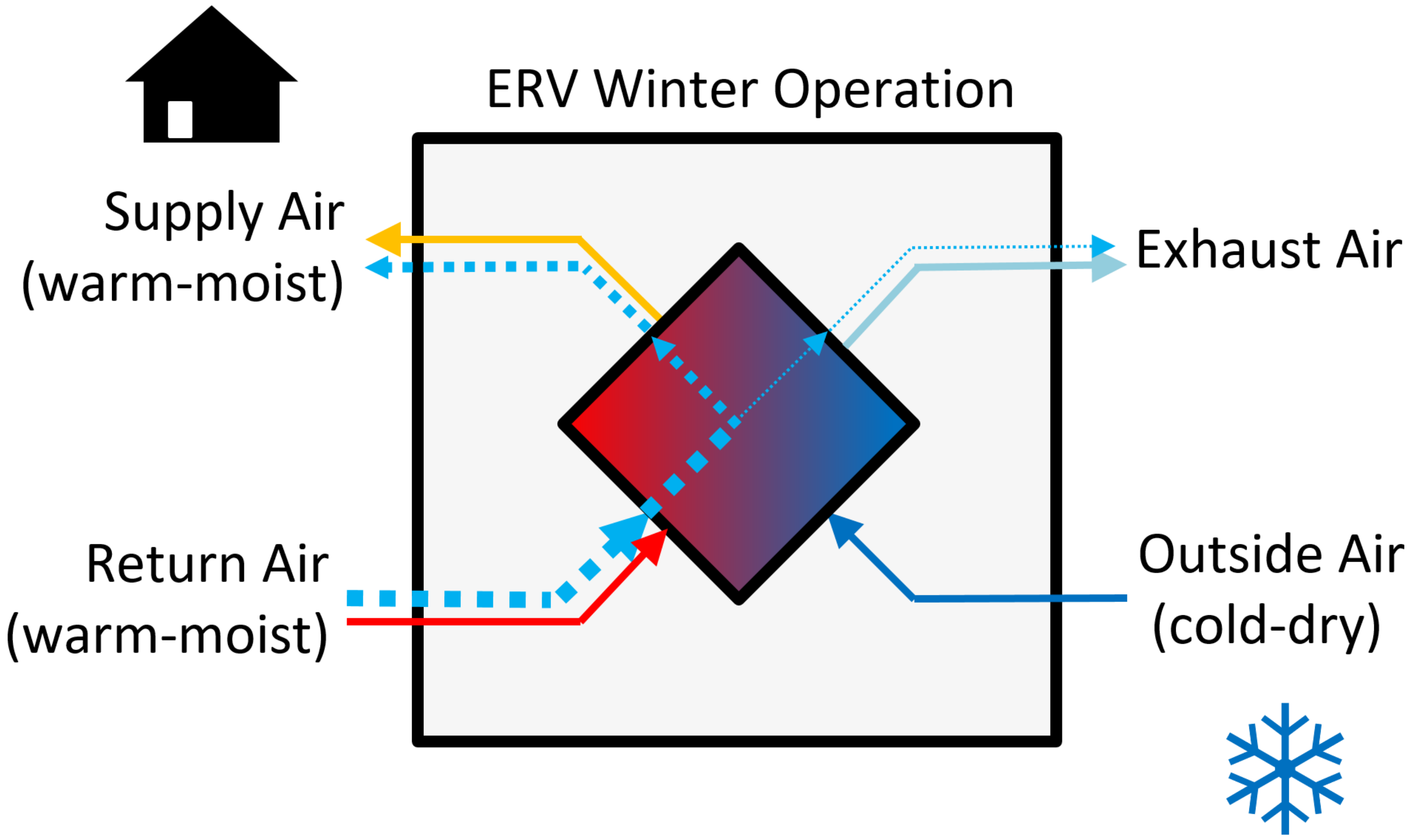
- Centralized
- ERVs

Individual ERV Design



Individual ERV Design

- Sensible recovery efficiency = 80%
- **Moisture recovery efficiency**
  - Summer = 61%
  - **Winter = 77%**
- Code minimum vent rates
  - 0.48 ACH for dwelling units on average
  - Option to boost (1.11 ACH)



June 2016 — **Ventilation Design #1**

- In unit, decentralized
- ERVs

Feb - July 2017 — **Energy Modeling**

- Risk of high RH & low exterior temperatures
- Condensation evaluation
- Identification of potential solutions

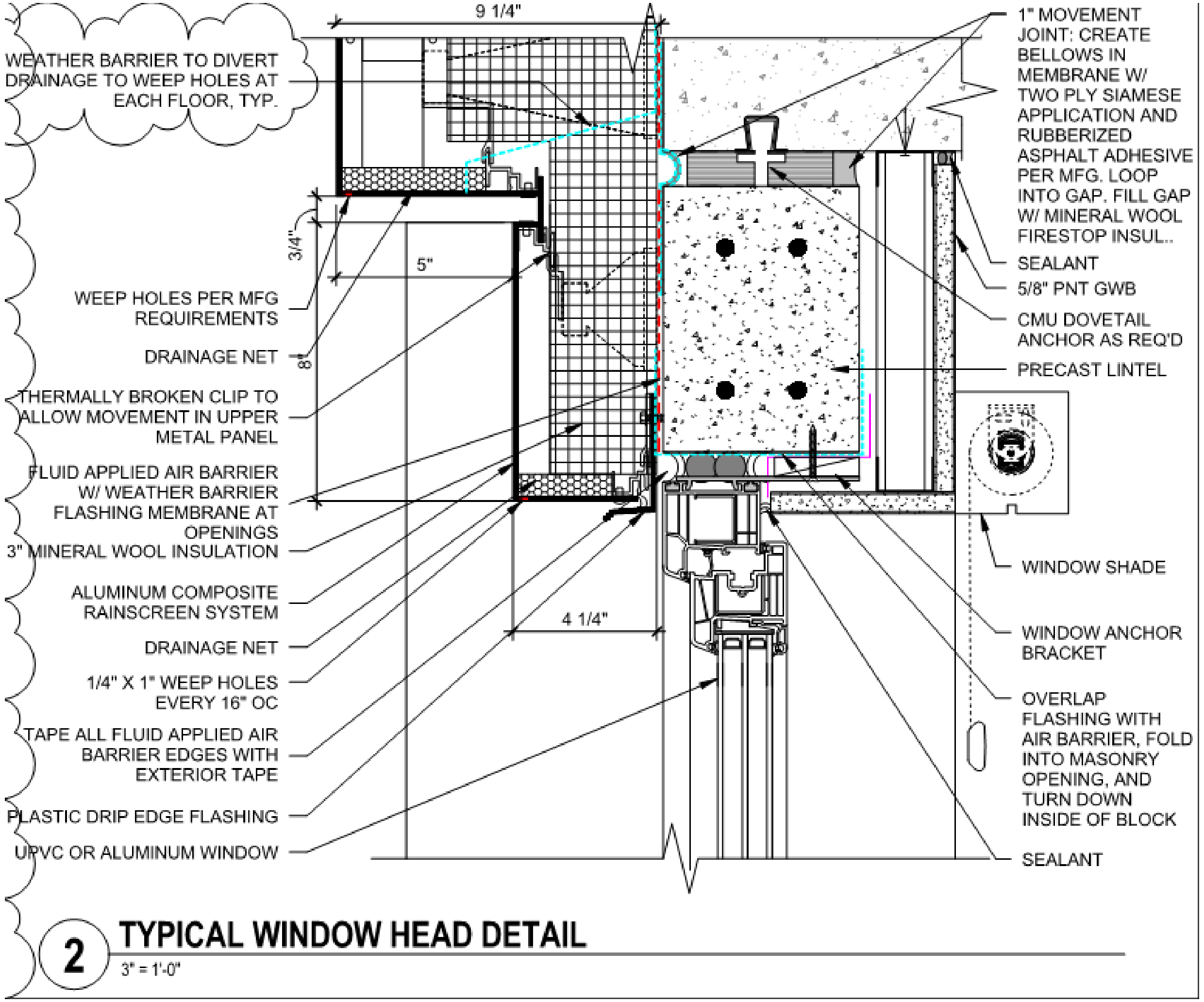
Aug 2017 — **Ventilation Design #2**

- Centralized
- ERVs

Exterior Temperature Assessment

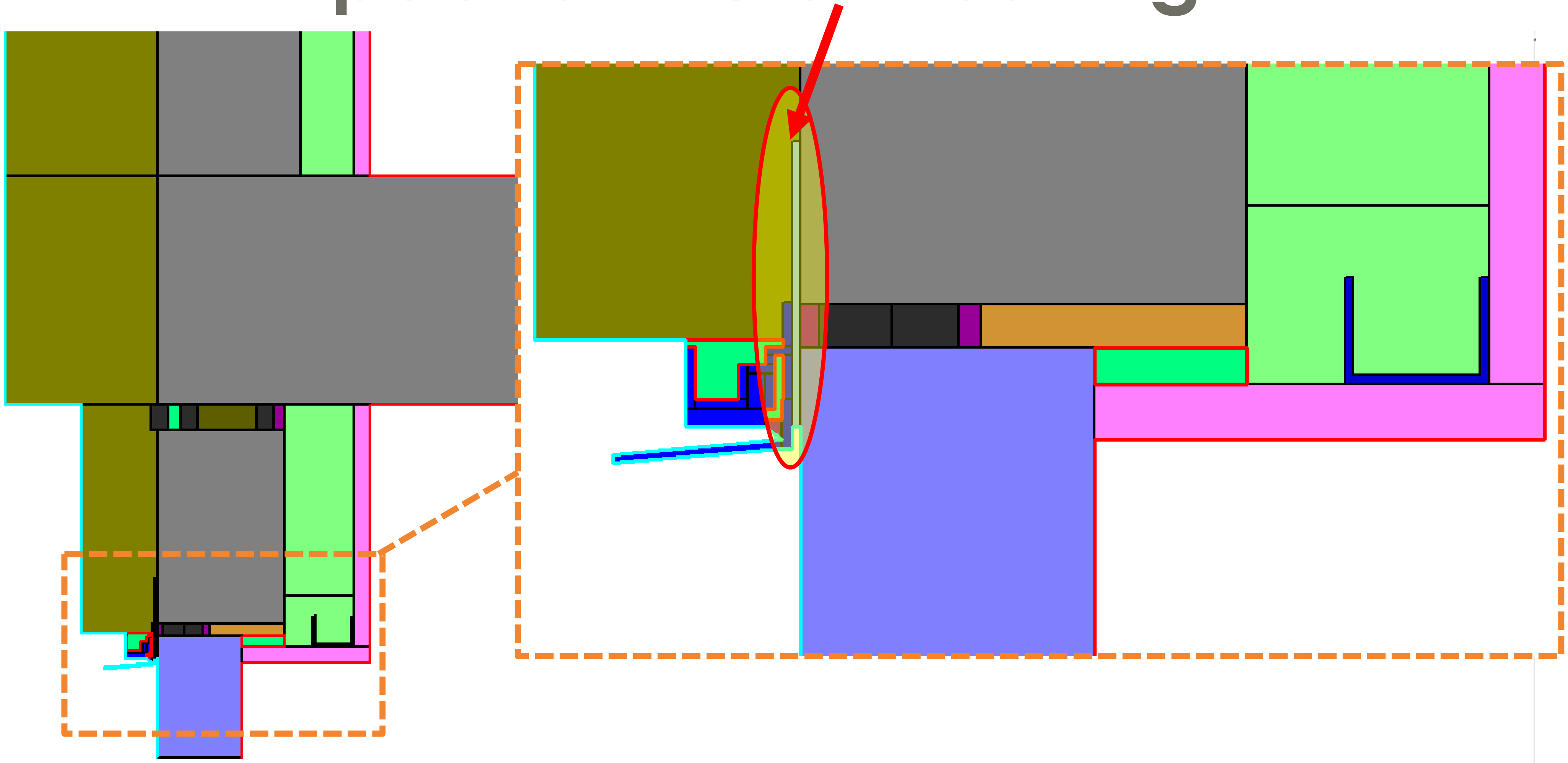
425 Grand Concourse - Condensation Analysis for Interior Surface of Window Frame												
Window Frame U-value	Exterior Temp (degF)			Minimum Interior Surface Temp from THERM (degF)			Bin % hours per year	Cumulative % hours per year	Condensation Risk?			
	Low		High	Low		High			@ 40% RH	@ 50% RH	@ 60% RH	@ 70% RH
0.275 Btu/hr.ft2.F (from THERM file U-factor tag)	35	to	39	57.0	to	58.3	8.49%	21.78%	No	No	No	Yes
	30	to	34	55.4	to	56.7	6.13%	13.29%	No	No	No	Yes
	25	to	29	53.7	to	55.0	3.55%	7.16%	No	No	No	Yes
	20	to	24	52.1	to	53.4	2.04%	3.61%	No	No	Yes	Yes
	15	to	19	50.4	to	51.8	1.03%	1.56%	No	No	Yes	Yes
	10	to	14	48.8	to	50.1	0.37%	0.54%	No	No	Yes	Yes
	5	to	9	47.2	to	48.5	0.14%	0.17%	No	Yes	Yes	Yes
	0	to	4	45.6	to	46.9	0.03%	0.03%	No	Yes	Yes	Yes
							Dew Point Temperature: @ 68°F Interior Temp		43°F	49°F	54°F	58°F

Condensation Prevention:
Window-Wall Connection THERM Modeling



Window Modeling – Surface Temperature

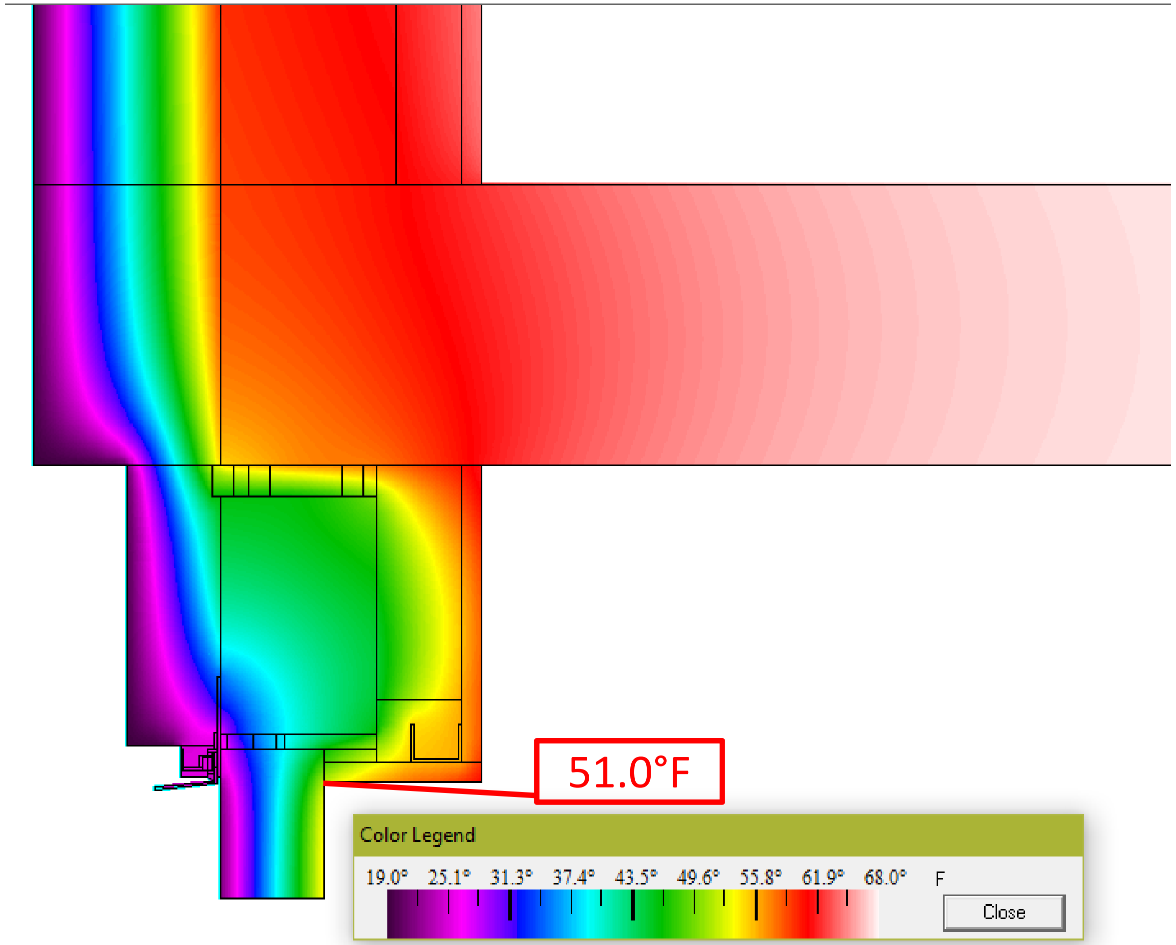
Impact of Metal Flashing



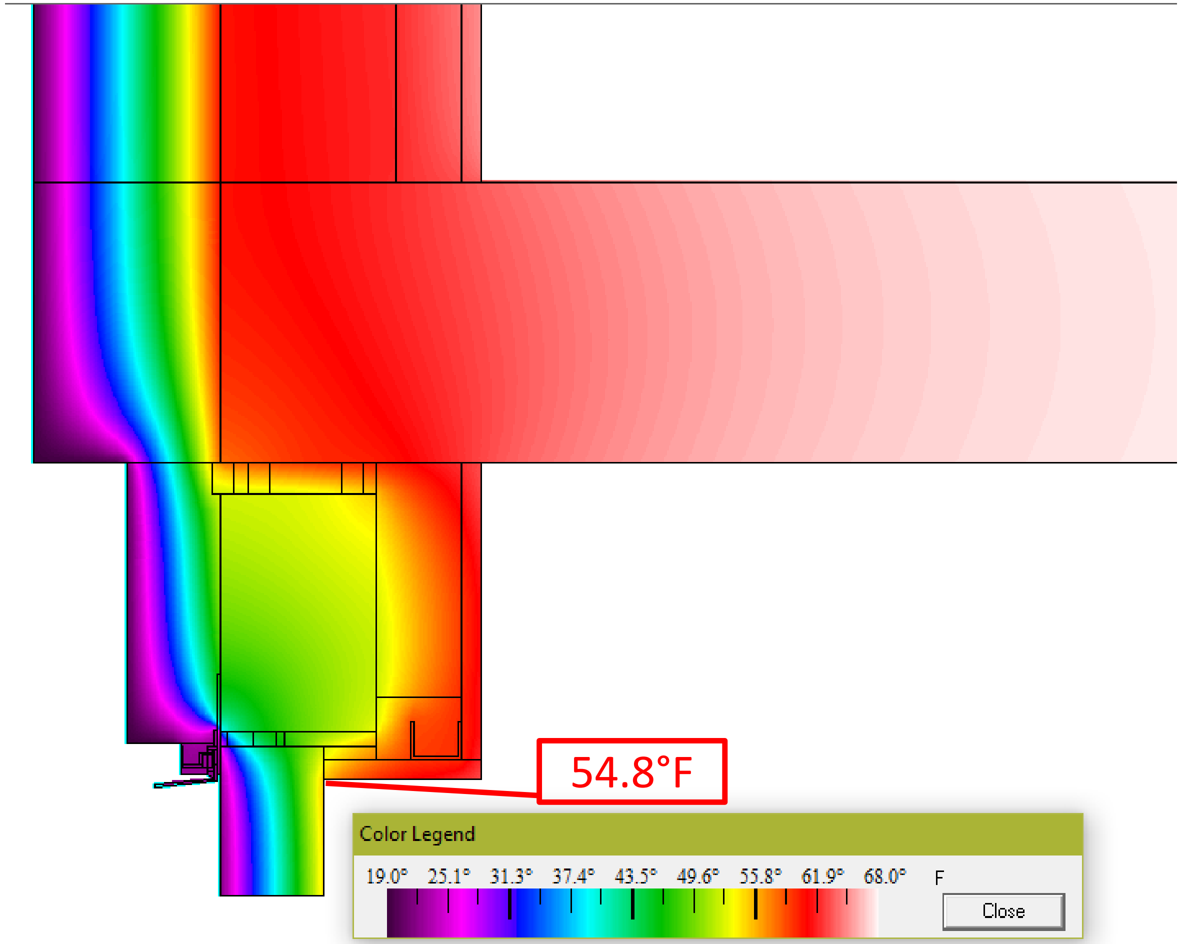
Window Modeling – Surface Temperature

Impact of Metal Flashing

Stainless Steel Flashing



Plastic Flashing



Moisture Modeling

- **Goal:** how high will interior RH get?
- **Goal:** is ERV flow-boost enough?
- 2 BR unit
  - 700 sf
  - 3-4 occupants
- Hourly excel model outputting RH
- Moisture generation assumptions
  - Occupants, cooking, showers, pets, plants
  - ASHRAE lbs/hr
  - Low, medium, high

Moisture Modeling - Results

- **Goal:** how high will interior RH get?
  - Answer
    - Weekdays – peak conditions between 50-63%
    - Weekends – most of the day between 50-70%
- **Goal:** is ERV boost enough?
  - Answer
    - Does help, but not enough
    - Supplemental dehumidification required

Potential Solutions – **Supplemental Dehumidification**

- Building infrastructure
  - Electrical
  - Condensate drains
- In-wall dehumidifier
- Located in kitchen-living room corridor
- Utility cost impact

What We Learned & Key Factors

1. Occupant density is extremely important
   – As low as 200 sf/person in 2 & 3-BR units
2. Winter-time ERV moisture transfer
   – About 70-80%
   – Summer-time efficiencies can be much lower
3. Façade exfiltration rates
   – Very low for in super-airtight construction
4. Condensation risk @ thermal weak-points in façade
   – Usually window to wall connections
5. Potentially significant utility costs for supplemental dehum.
   – $2-$15 per unit per month

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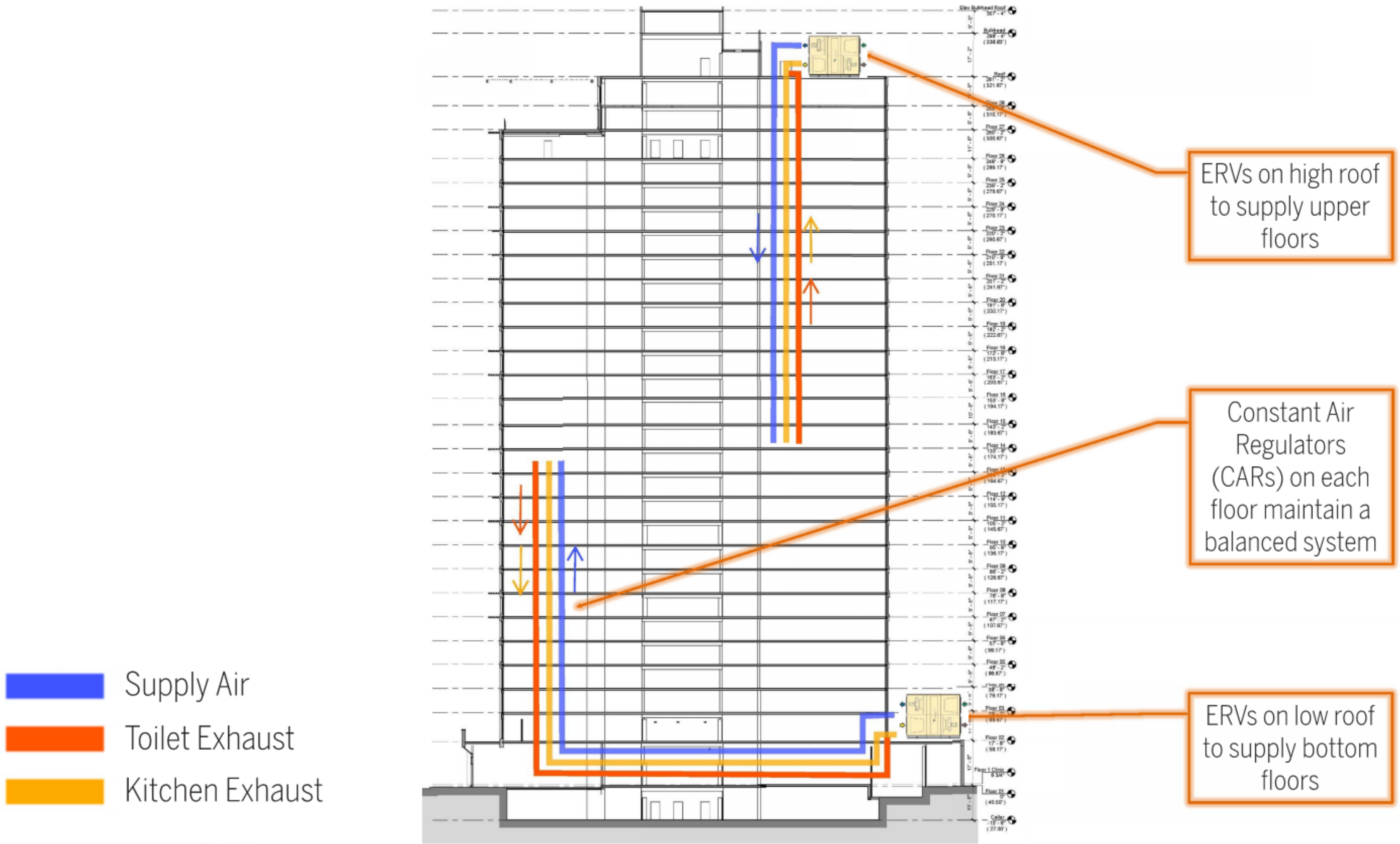
Aug 2017 — Ventilation Design #2

- Centralized
- ERVs

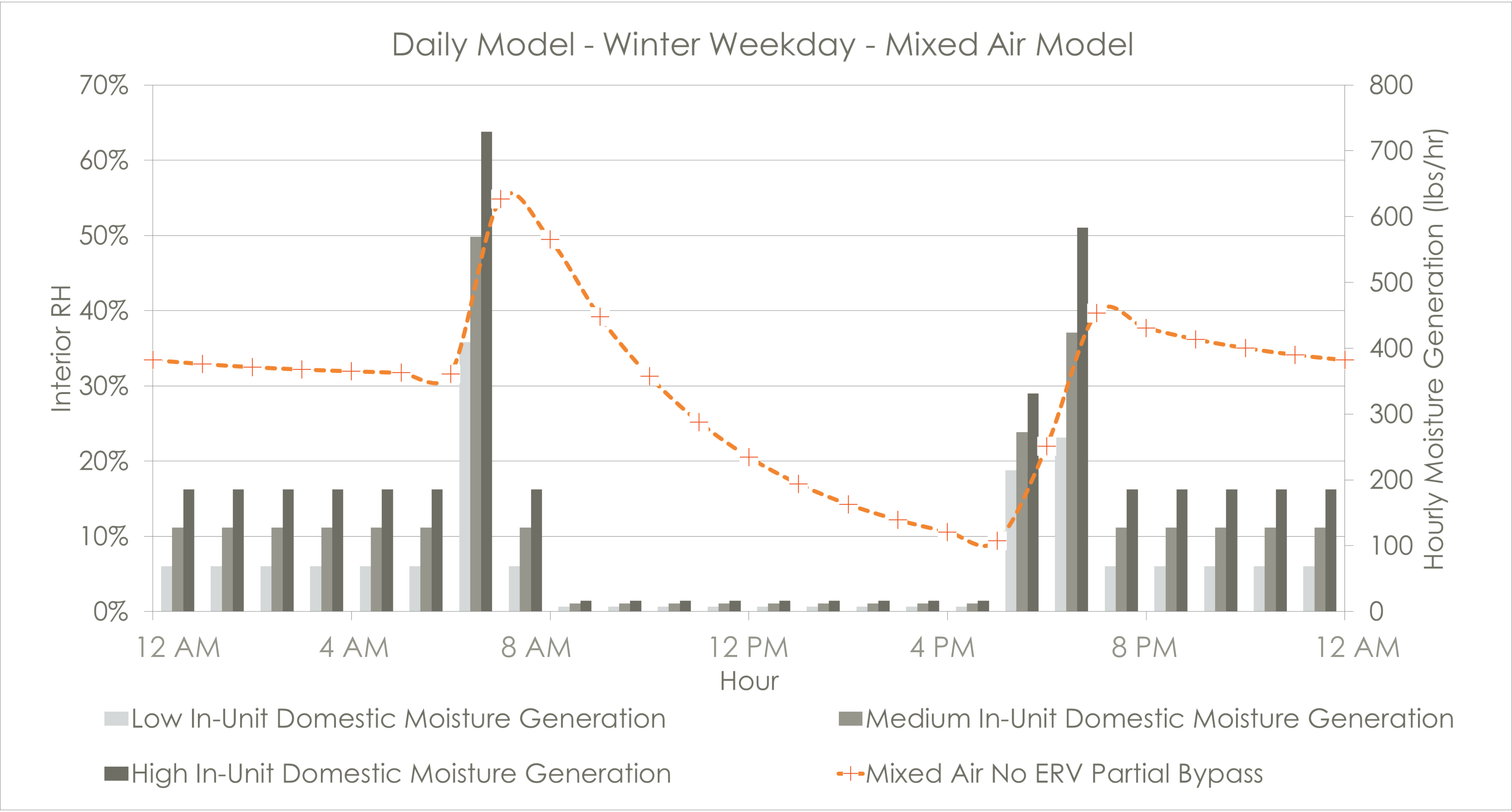
Central ERV Design



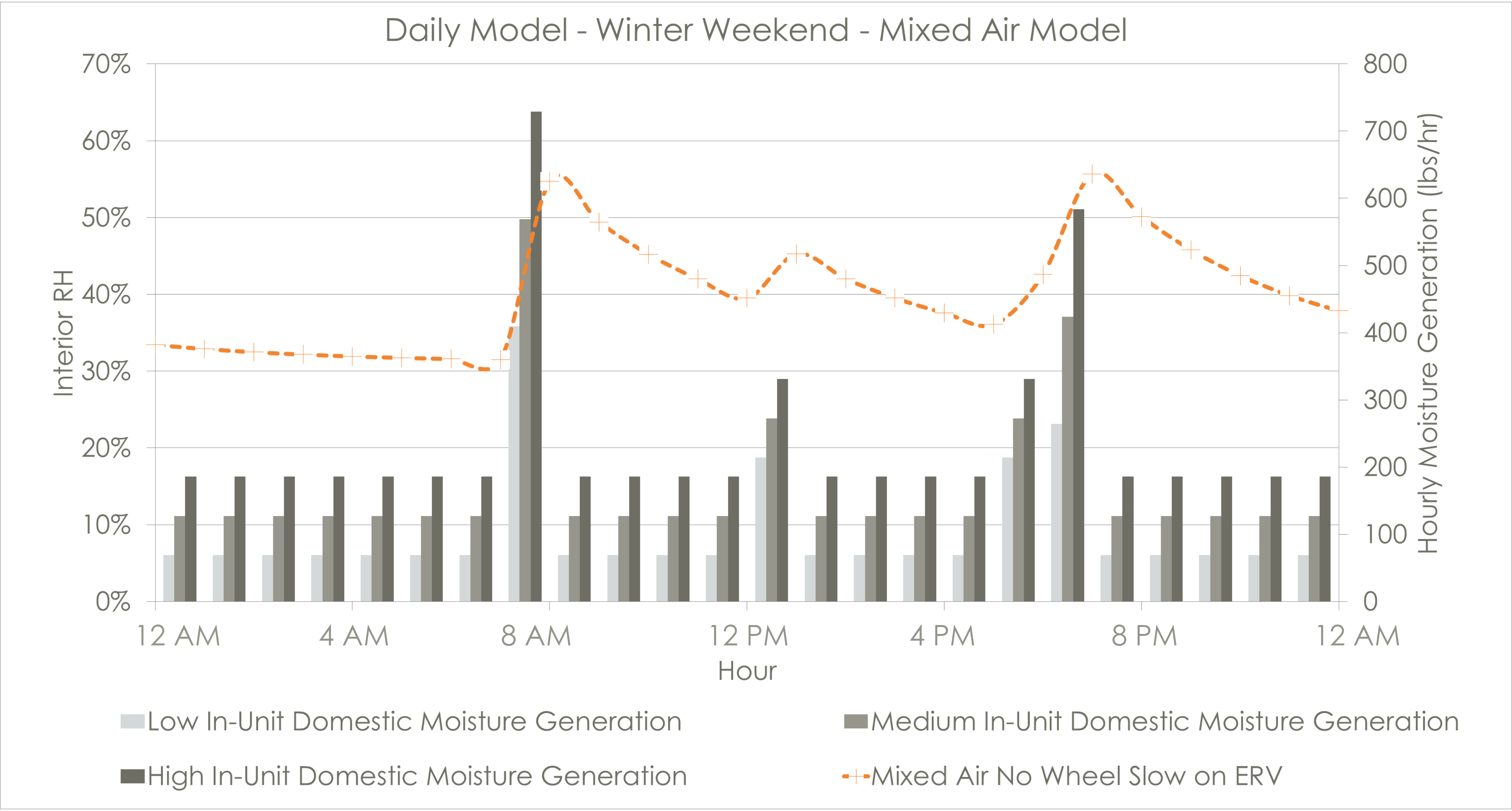
Sep – Oct 2017	Energy Modeling	• High RH risk assessment • Condensation evaluation • Identification of potential solutions
Oct 2017 - now	Vetting of Solutions	• Ventilation based • Heating/cooling based • Supplemental equipment
TBD	Final Specs & Evaluation	• Pending…

Revised Modeling Parameters

- Output – RH of interior air in apartments @ 68°F
- Same moisture generation assumptions
- Central ventilation → **air mixing**
  - 25% low moisture, 50% medium, 25% high
- Moisture recovery efficiency
    - Summer Time = 72%
    - Winter Time = 83%
- Continuous code minimum exhaust
  - 0.60 ACH for dwelling units on average



Daily Model - Winter Weekday - Mixed Air Model
Interior RH
70%
60%
50%
40%
30%
20%
10%
0%
Hourly Moisture Generation (lbs/hr)
800
700
600
500
400
300
200
100
0
12 AM
4 AM
8 AM
12 PM
4 PM
8 PM
12 AM
Hour
Low In-Unit Domestic Moisture Generation
Medium In-Unit Domestic Moisture Generation
High In-Unit Domestic Moisture Generation
Mixed Air No ERV Partial Bypass



Daily Model - Winter Weekend - Mixed Air Model
Interior RH
70%
60%
50%
40%
30%
20%
10%
0%
Hourly Moisture Generation (lbs/hr)
800
700
600
500
400
300
200
100
0
12 AM
4 AM
8 AM
12 PM
4 PM
8 PM
12 AM
Hour
Low In-Unit Domestic Moisture Generation
Medium In-Unit Domestic Moisture Generation
High In-Unit Domestic Moisture Generation
Mixed Air No Wheel Slow on ERV

Moisture Control in Multifamily Passive Houses

POTENTIAL SOLUTIONS

Sep – Oct 2017

Energy Modeling

- High RH risk assessment
- Condensation evaluation
- Identification of potential solutions

Oct 2017 - now

Vetting of Solutions

- Ventilation based
- Heating/cooling based
- Supplemental equipment

TBD

Final Specs & Evaluation

- Pending…

Potential Solutions –
VRF Dry Mode in Heating Season

- Cannot automatically cycle from heating mode to dry mode (cooling)
- VRF heat recovery

Potential Solutions –
VRF Dry Mode in Heating Season

- Cannot automatically cycle from heating mode to dry mode (cooling)

Potential Solutions – **Supplemental Dehumidification**

- Building infrastructure
  - – Electrical
  - – Condensate drains
- In-wall dehumidifier
- Located in kitchen-living room corridor

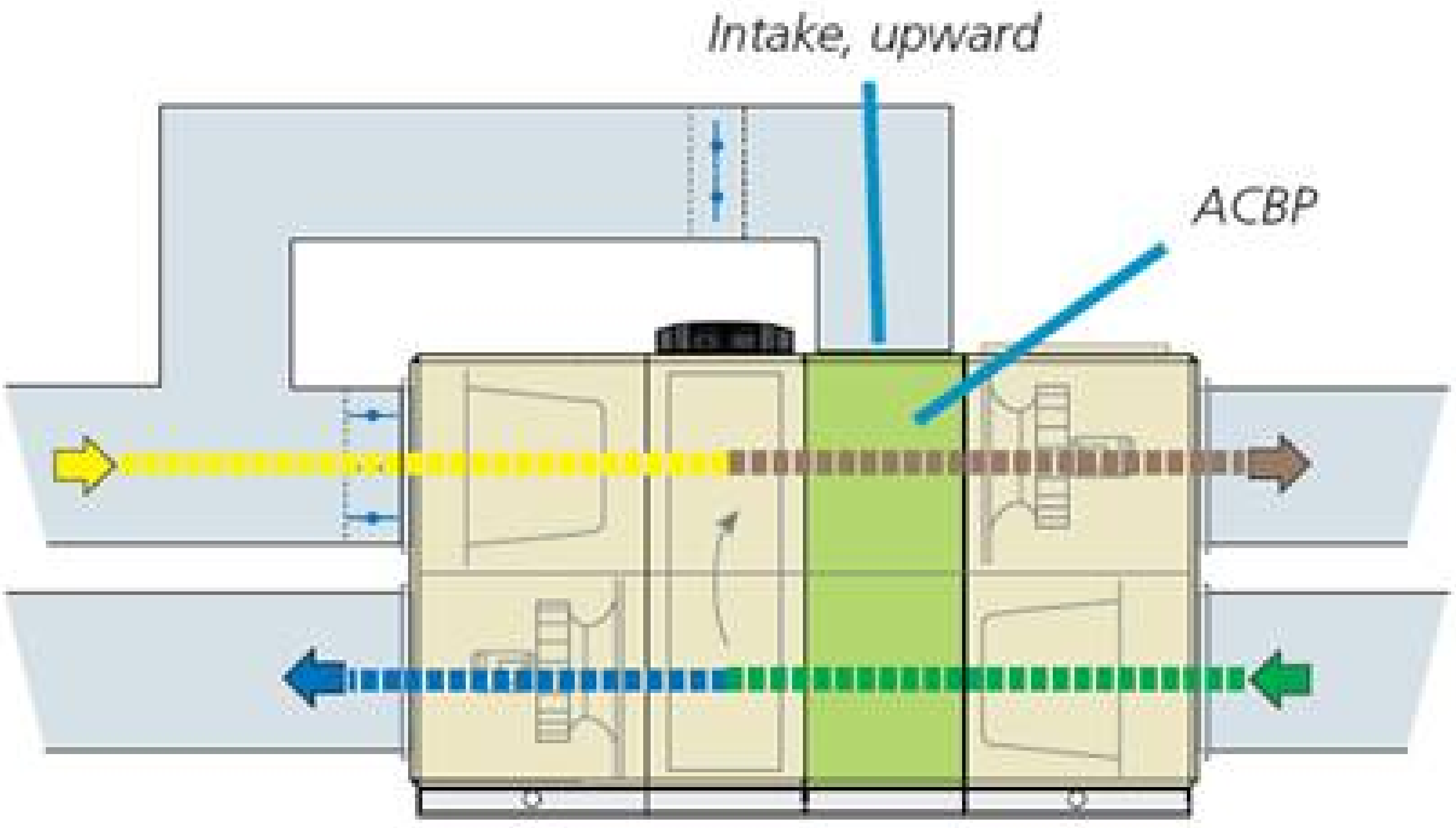
Potential Solutions – Supplemental Dehumidification

MAYBE

- Building infrastructure
  - ...ctric...
  - Conde... ...drai...
- ...-w... ...eh...mid...
- ...ca...d in... ...n-living room corridor

Potential Solutions – **Partial ERV Core Bypass**

- Initial intent = slow enthalpy wheel down
- Only during extreme conditions
  - Very cold exterior air temps
  - High return air RH to ERV

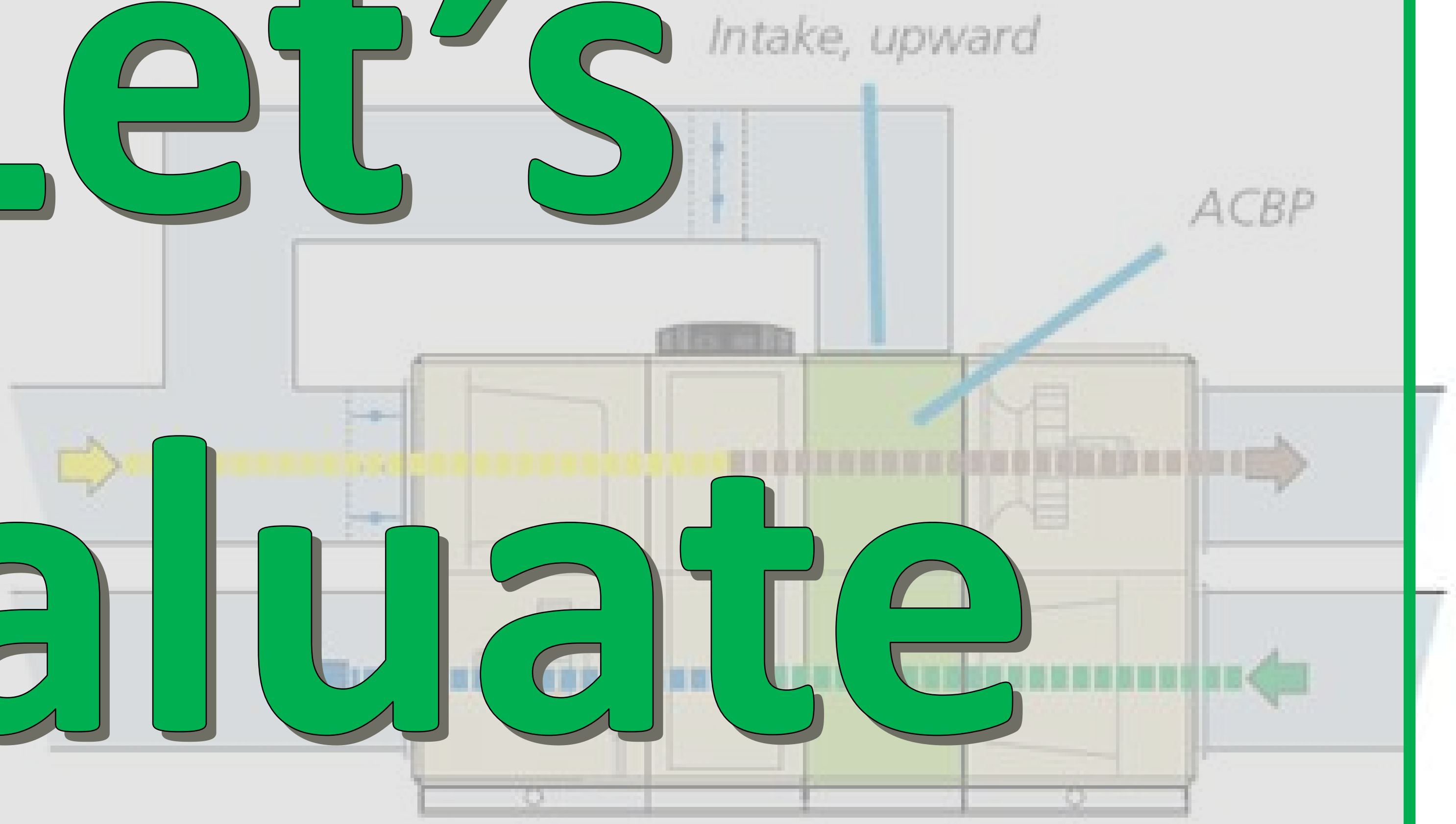


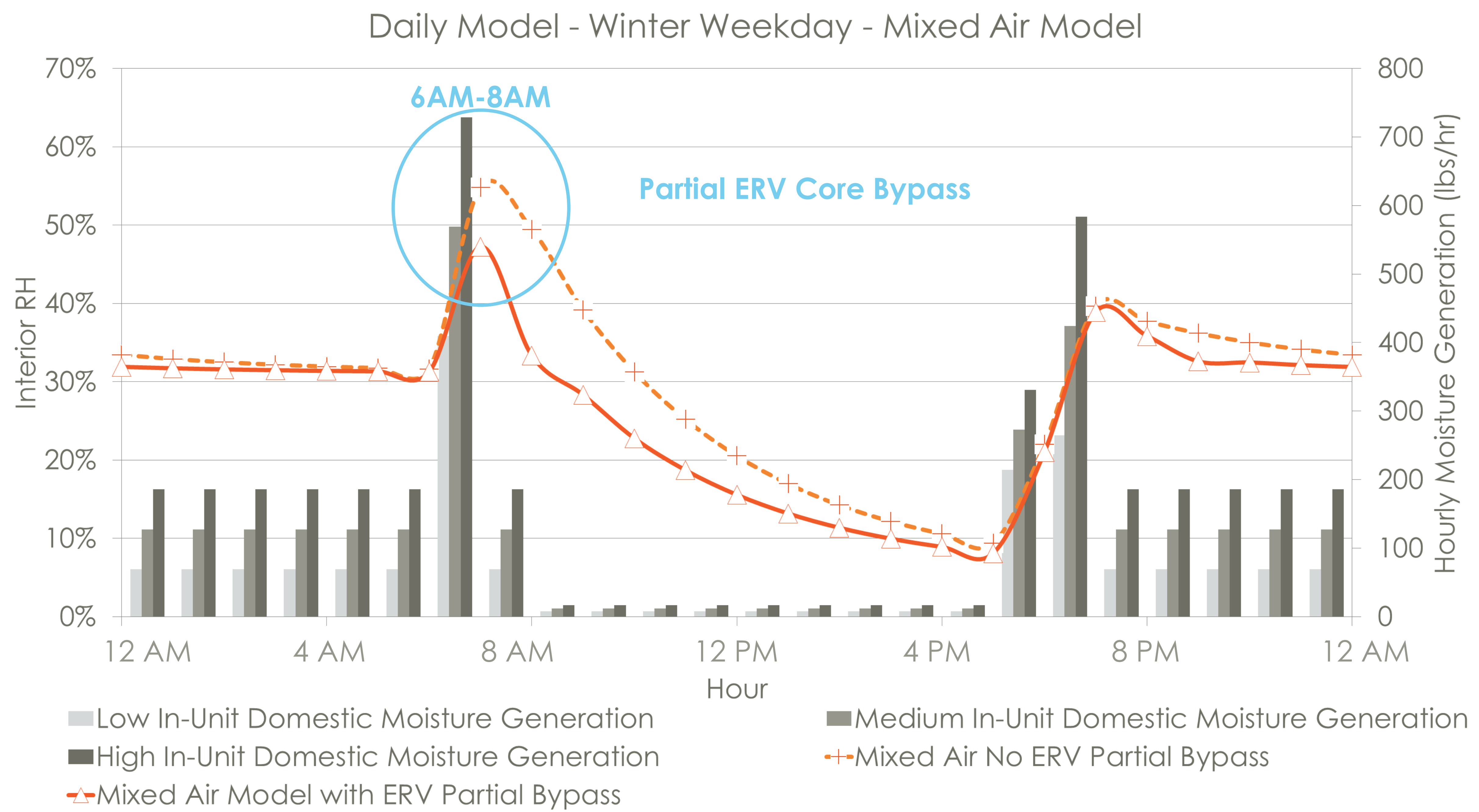
Potential Solutions –

Partial ERV Core Bypass

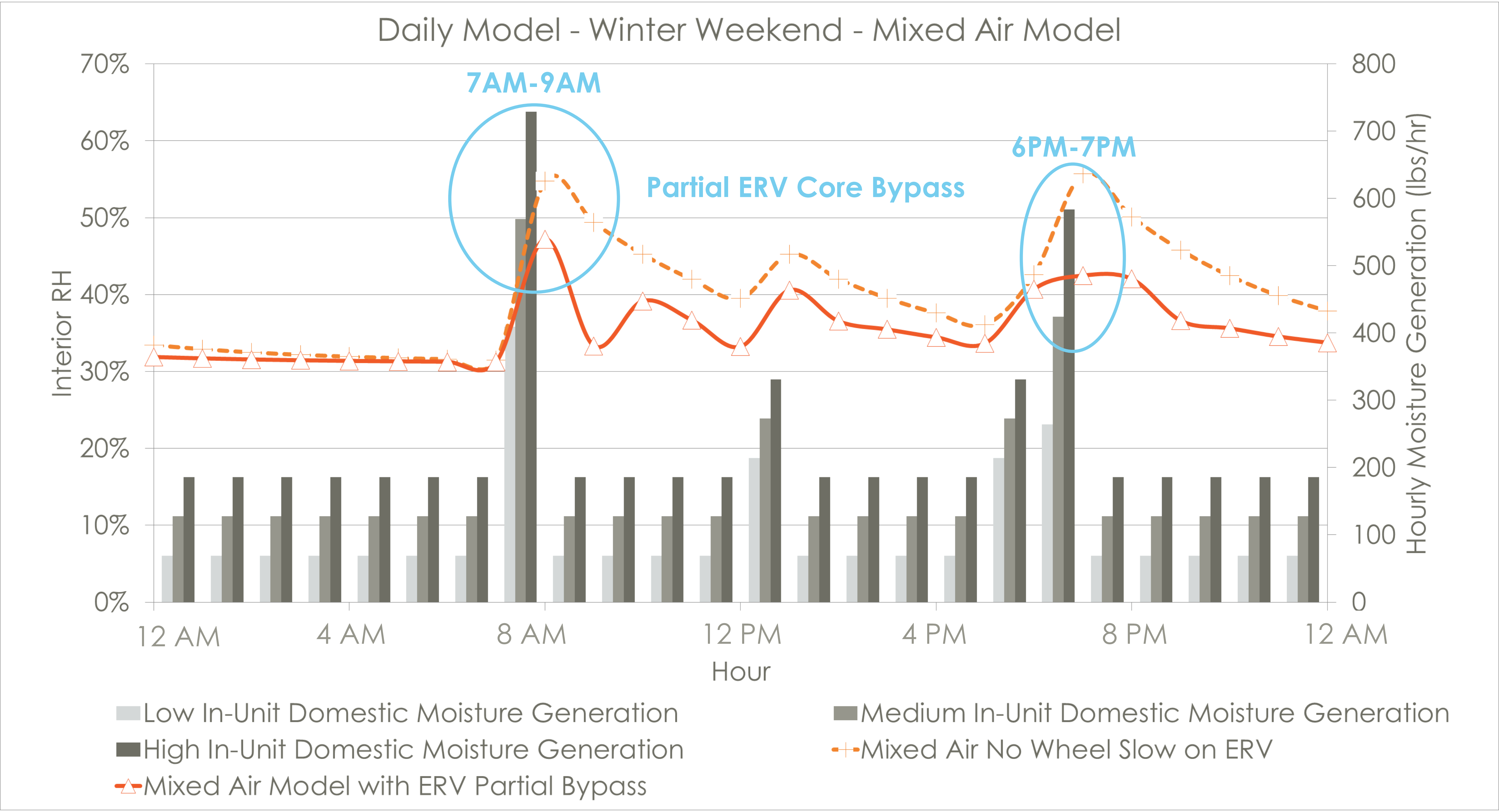
Let's Evaluate

- Initial intent = slov enthalpy wheel down
- Only during extreme conditions
  - Very co d exteri air
  - High return air RH to ERV





Daily Model - Winter Weekday - Mixed Air Model
6AM-8AM
Partial ERV Core Bypass
Interior RH
70%
60%
50%
40%
30%
20%
10%
0%
800
700
600
500
400
300
200
100
0
Hourly Moisture Generation (lbs/hr)
12 AM
4 AM
8 AM
12 PM
4 PM
8 PM
12 AM
Hour
Low In-Unit Domestic Moisture Generation
Medium In-Unit Domestic Moisture Generation
High In-Unit Domestic Moisture Generation
Mixed Air No ERV Partial Bypass
Mixed Air Model with ERV Partial Bypass



Daily Model - Winter Weekend - Mixed Air Model
7AM-9AM
6PM-7PM
Partial ERV Core Bypass
Interior RH
70%
60%
50%
40%
30%
20%
10%
0%
Hourly Moisture Generation (lbs/hr)
800
700
600
500
400
300
200
100
0
12 AM
4 AM
8 AM
12 PM
4 PM
8 PM
12 AM
Hour
Low In-Unit Domestic Moisture Generation
Medium In-Unit Domestic Moisture Generation
High In-Unit Domestic Moisture Generation
Mixed Air No Wheel Slow on ERV
Mixed Air Model with ERV Partial Bypass

Sep – Oct 2017

Energy Modeling

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Oct 2017 - now

Vetting of Solutions

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TBD

Final Specs & Evaluation

- Pending…

In Summary

- Density matters!
- **Airtight = moisture tight**
- ERV – preferable in summer
- HRV – preferable in winter
- Centralized ventilation reduces localized risk
- Target min. winter interior surface temperatures > 54°F
- Supplemental dehumidification
  - Not ideal, but may be required
- **Think passive…**
  - ERV controls in lieu of supplemental dehumidification

Moving Forward…

- Study more projects
- Monitor completed projects
- **Technology**
  - Lower capacity cooling systems
    - Make HRV more favorable
  - Dual-core technology? (H/ERV)
  - Integrated dehumidification in ventilation system
  - Others…

This concludes The American Institute of Architects Continuing Education Systems Course

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