BUILDINGENERGY NYC

Net Zero Ready Multi-Family Buildings: How Are We Doing?

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Steven Winter Associates

Curated by Christina Aßmann and Sara Bayer

Northeast Sustainable Energy Association (NESEA) | October 16, 2025

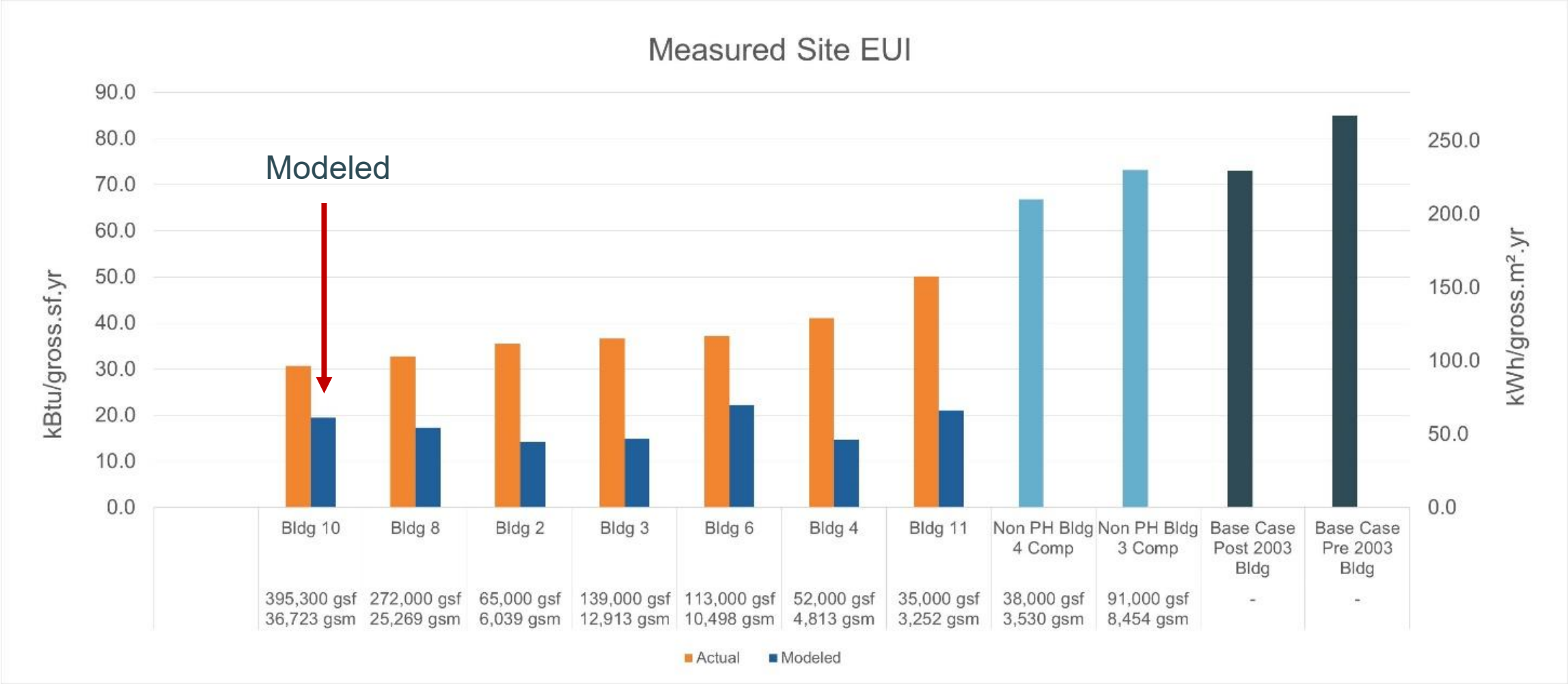
Research Questions

- How does the whole building predicted site energy use intensity (EUI) compare to actual performance?
- How do peak heating and cooling demands of PH buildings compare to typical building stock of the same typology?
- How do predicted site domestic hot water (DHW) EUIs compare to actual performance?
- Are control strategies utilizing VRF in combination with ERVs to control temperature and relative humidity effective in PH, multifamily buildings?
- Does oversizing VRF systems reduce system efficiency in multi-family buildings?

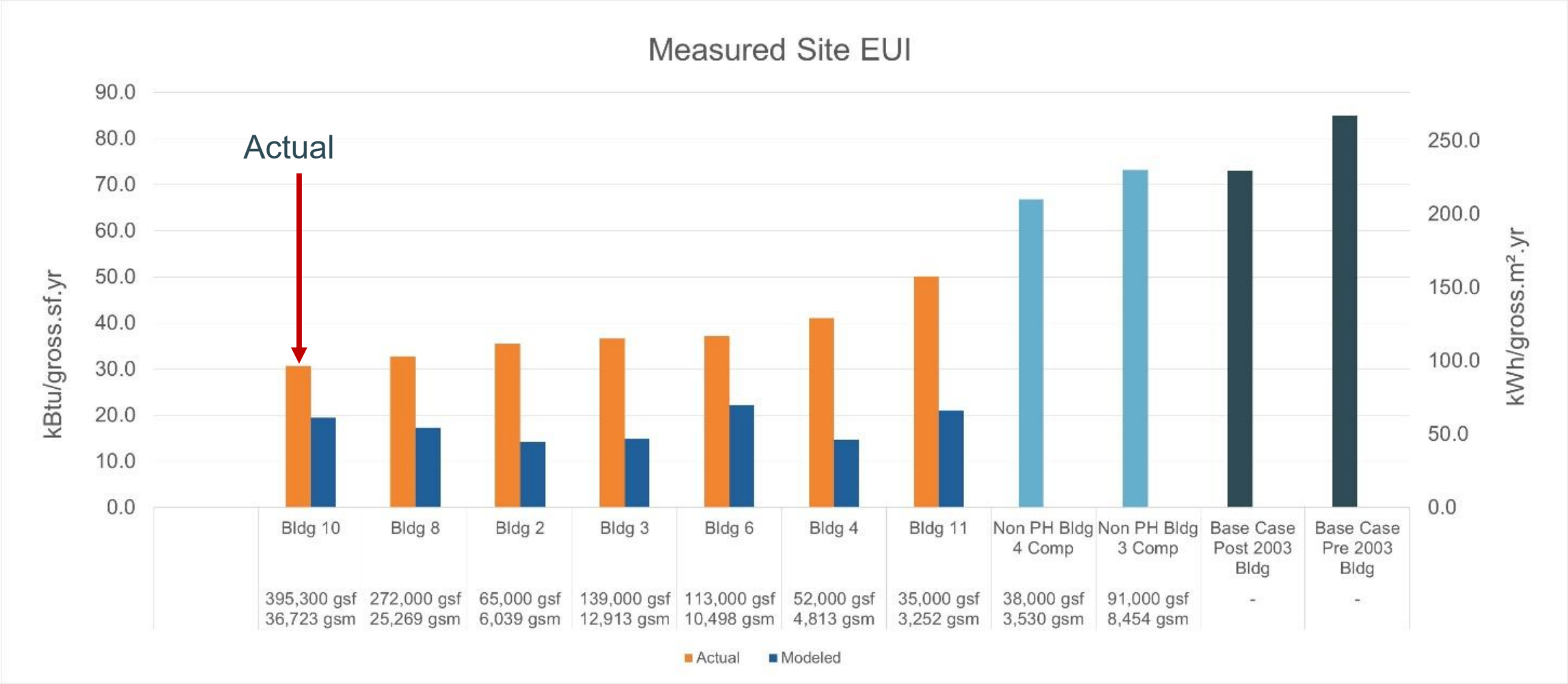
Approach

- Data sources:
  - Monthly utility bill data
    - NYC OpenData platform through ESPM – 33,000 unique property IDs, 17,000 – MF over 25,000 ft2
    - Individual building data from ESPM and owner paid accounts
  - 15-minute electric and gas data from ConEd
  - Buildings Operation Data as part of the DOE BA program

Whole Building Performance



Whole Building Performance



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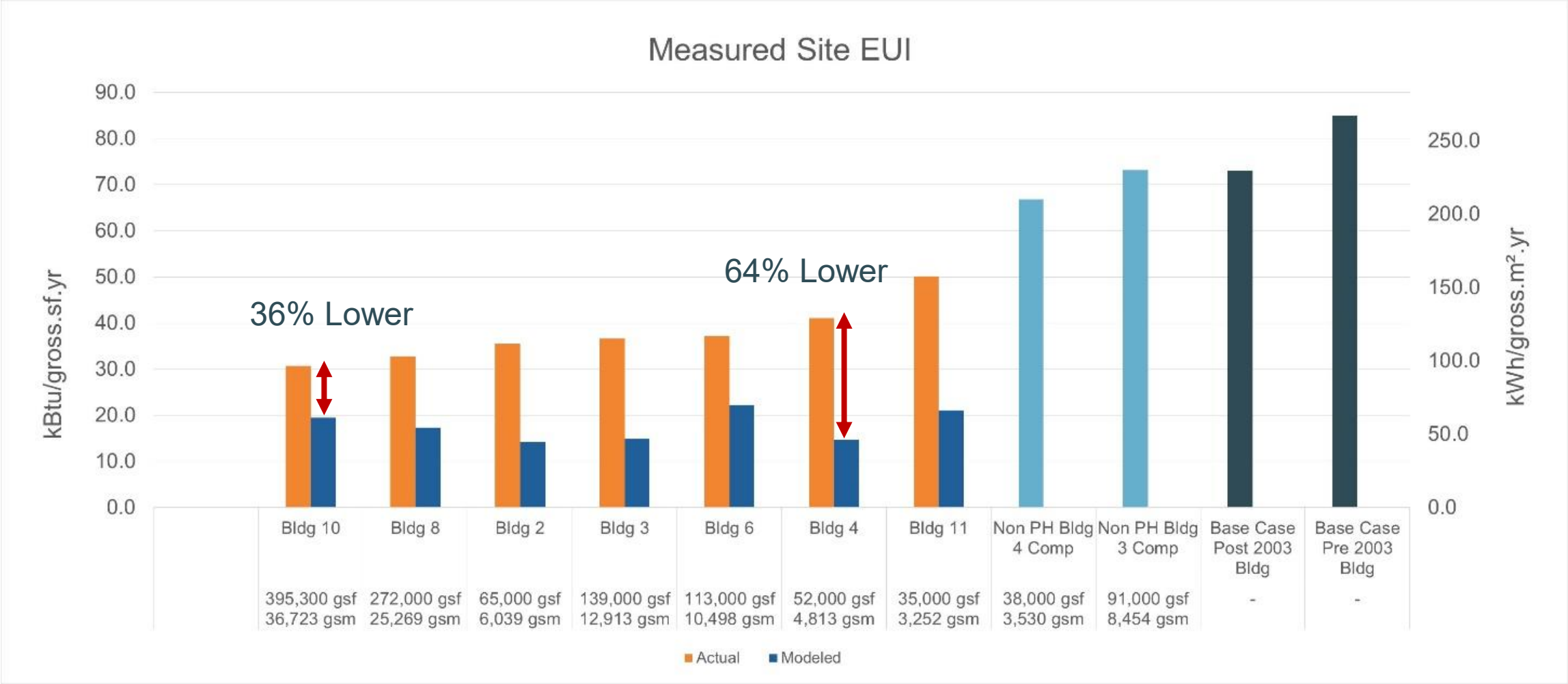
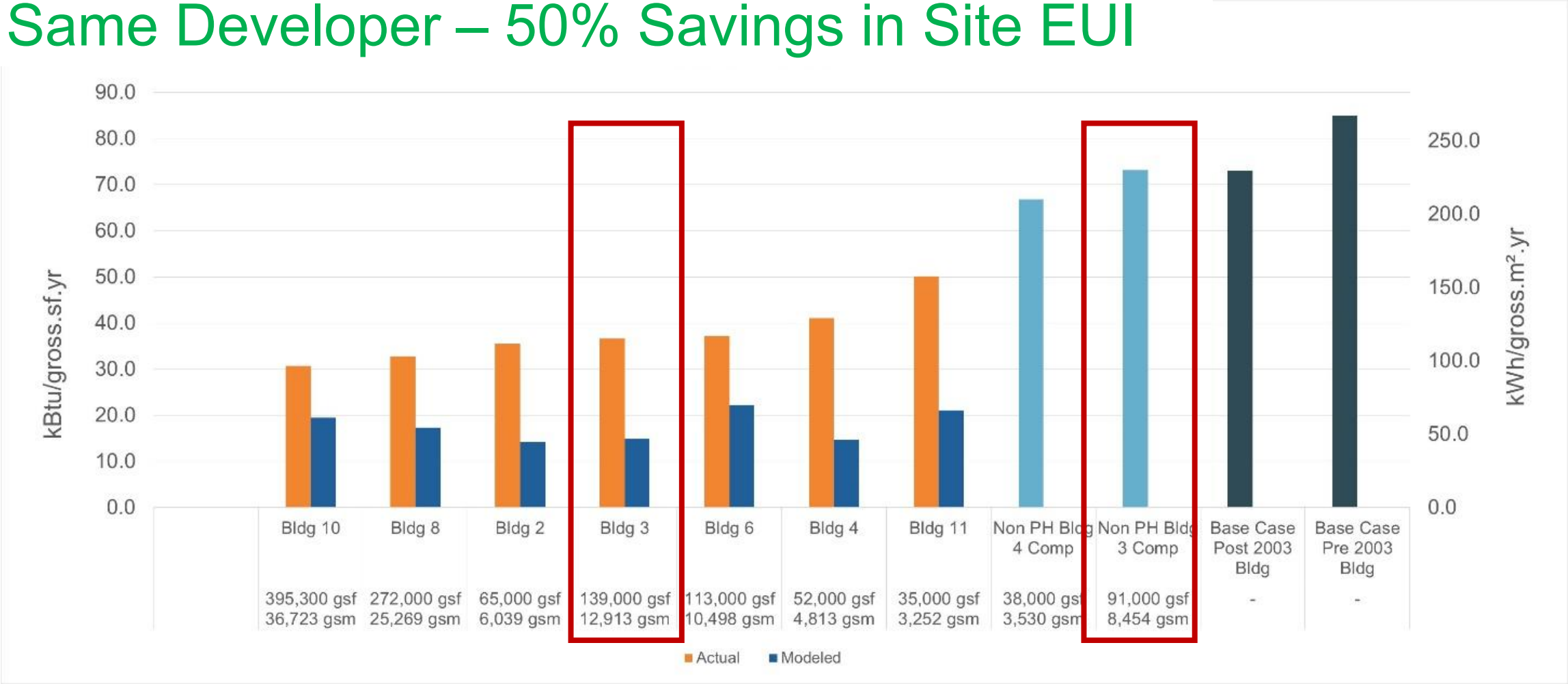


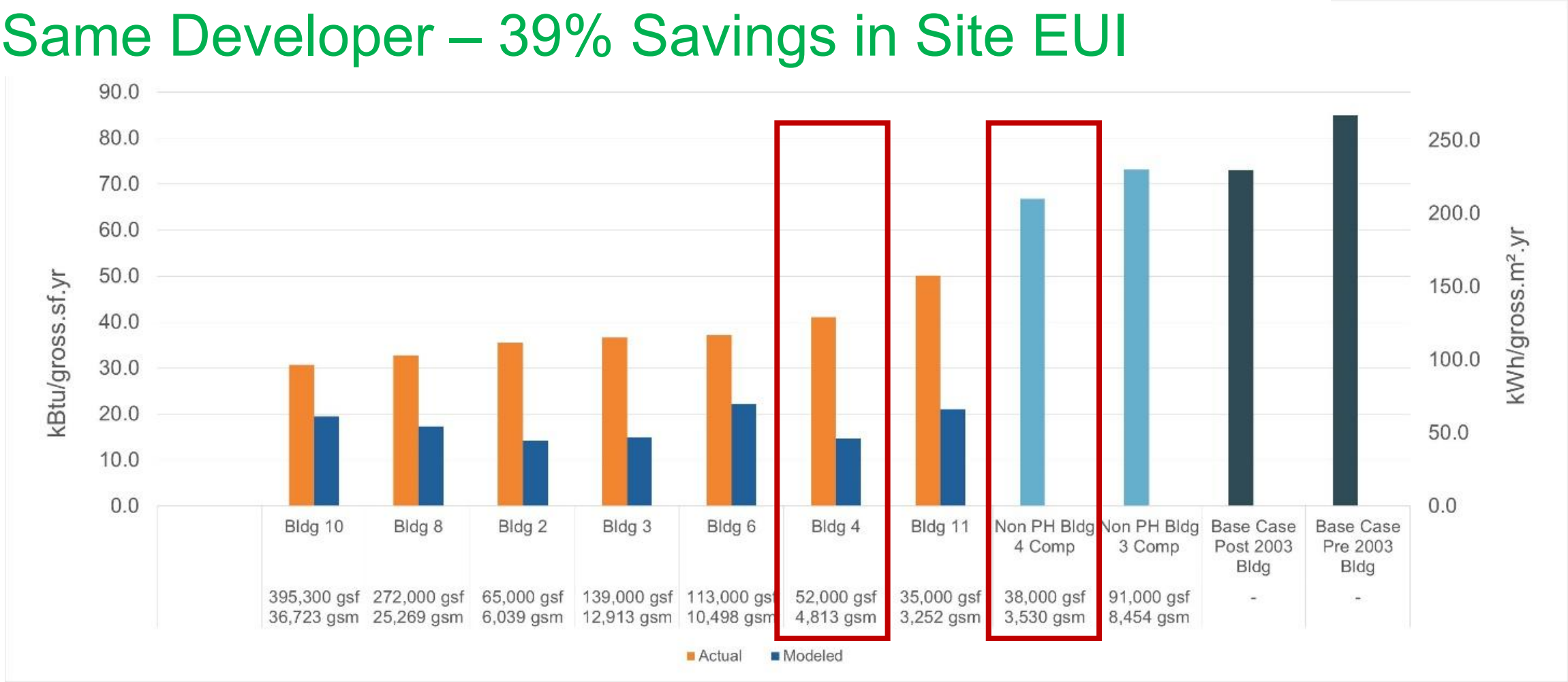
PH vs. Non-PH (Market Rate)

Same Developer – 50% Savings in Site EUI

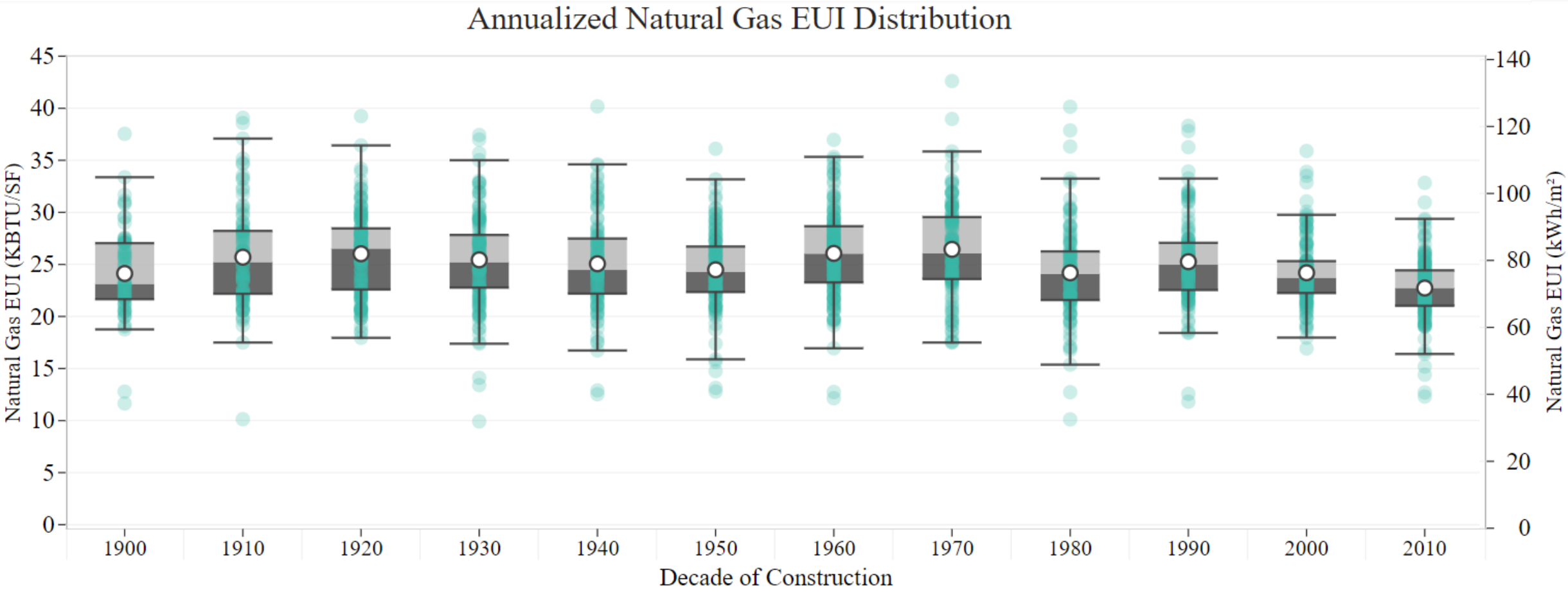


PH vs. Non-PH (Affordable)

Same Developer – 39% Savings in Site EUI



NYC MF Central DHW Energy Use ~ 17,000 bldgs



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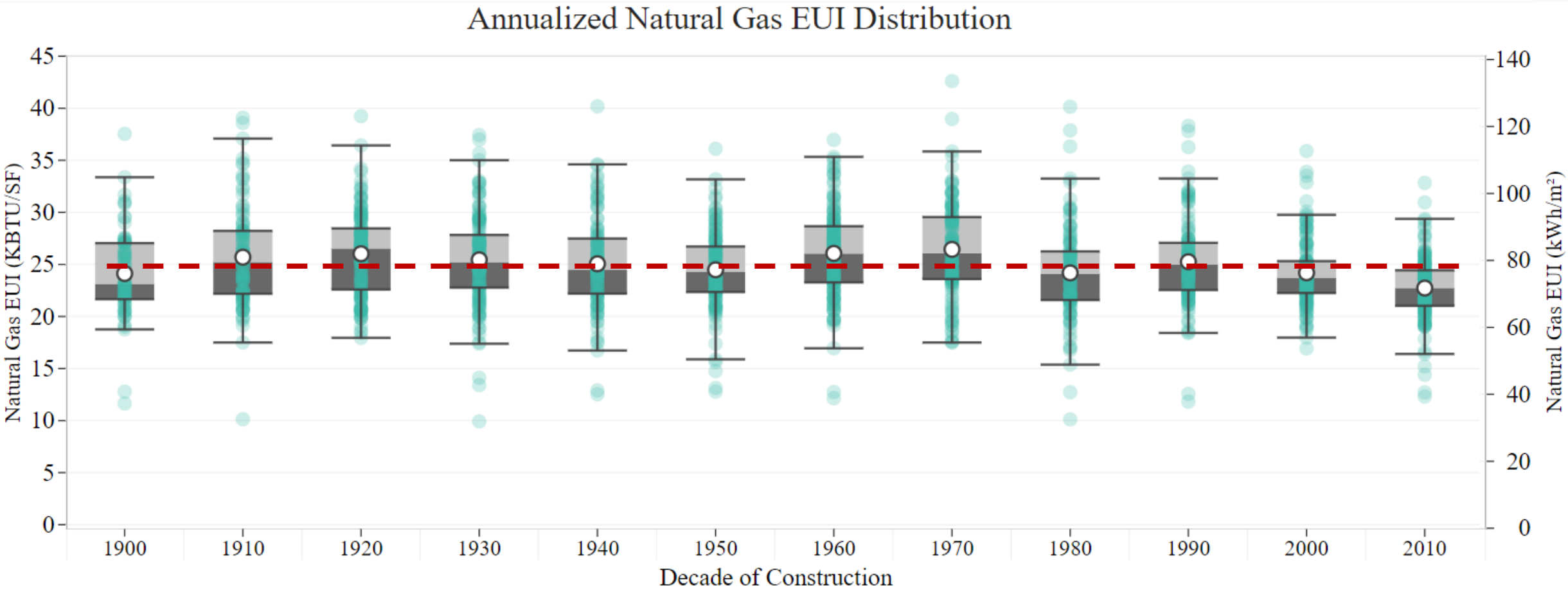

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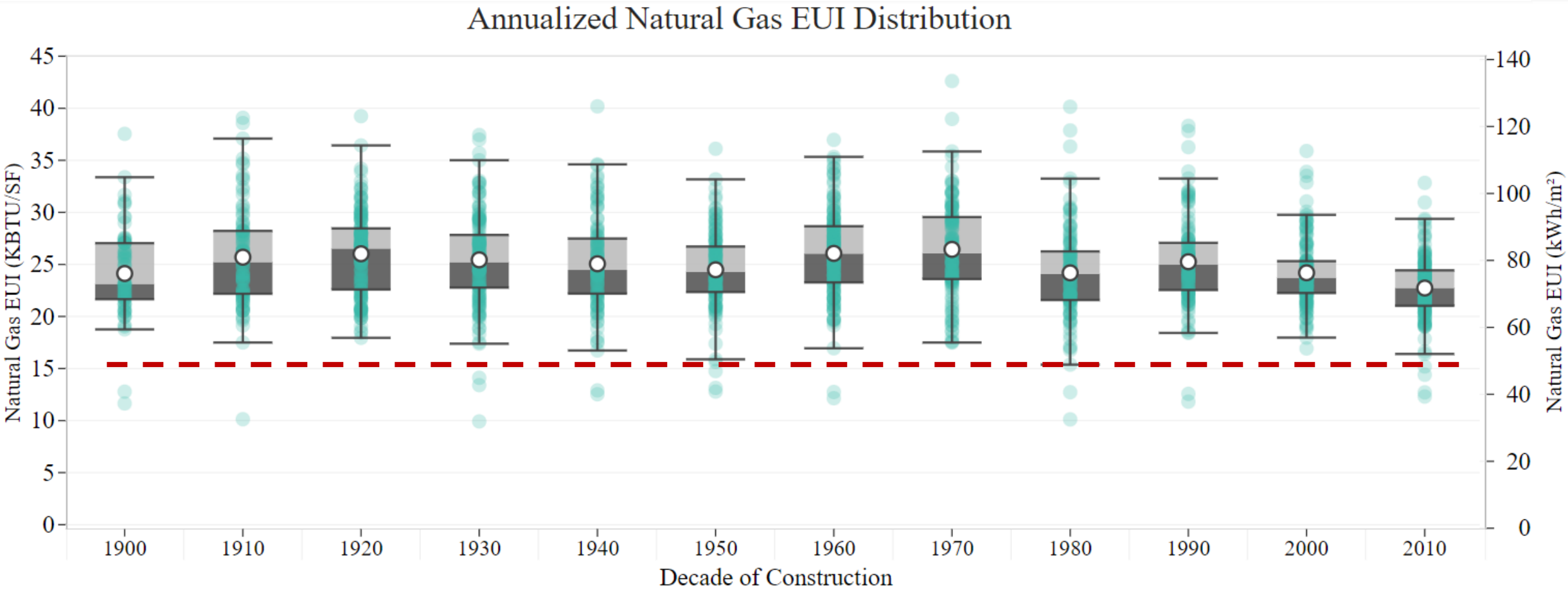
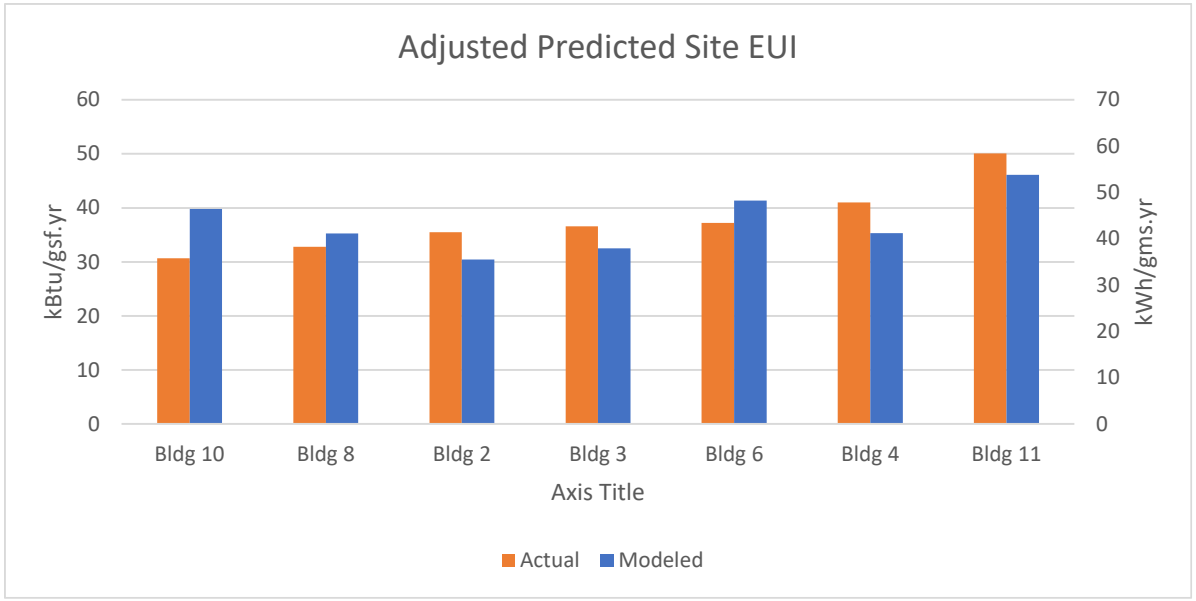
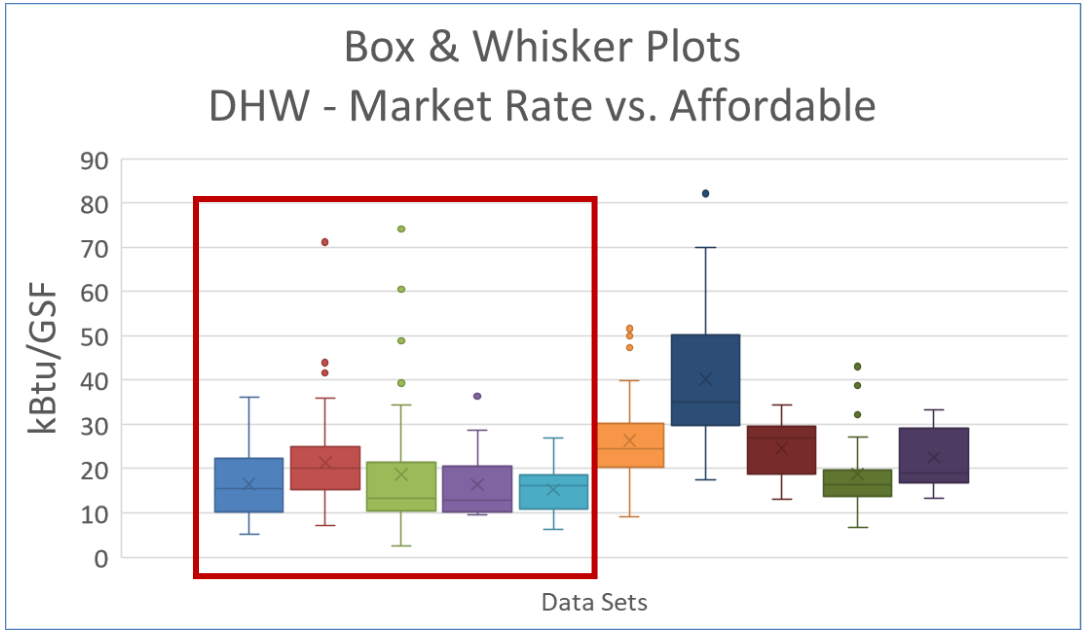


Adjusted Predicted Values

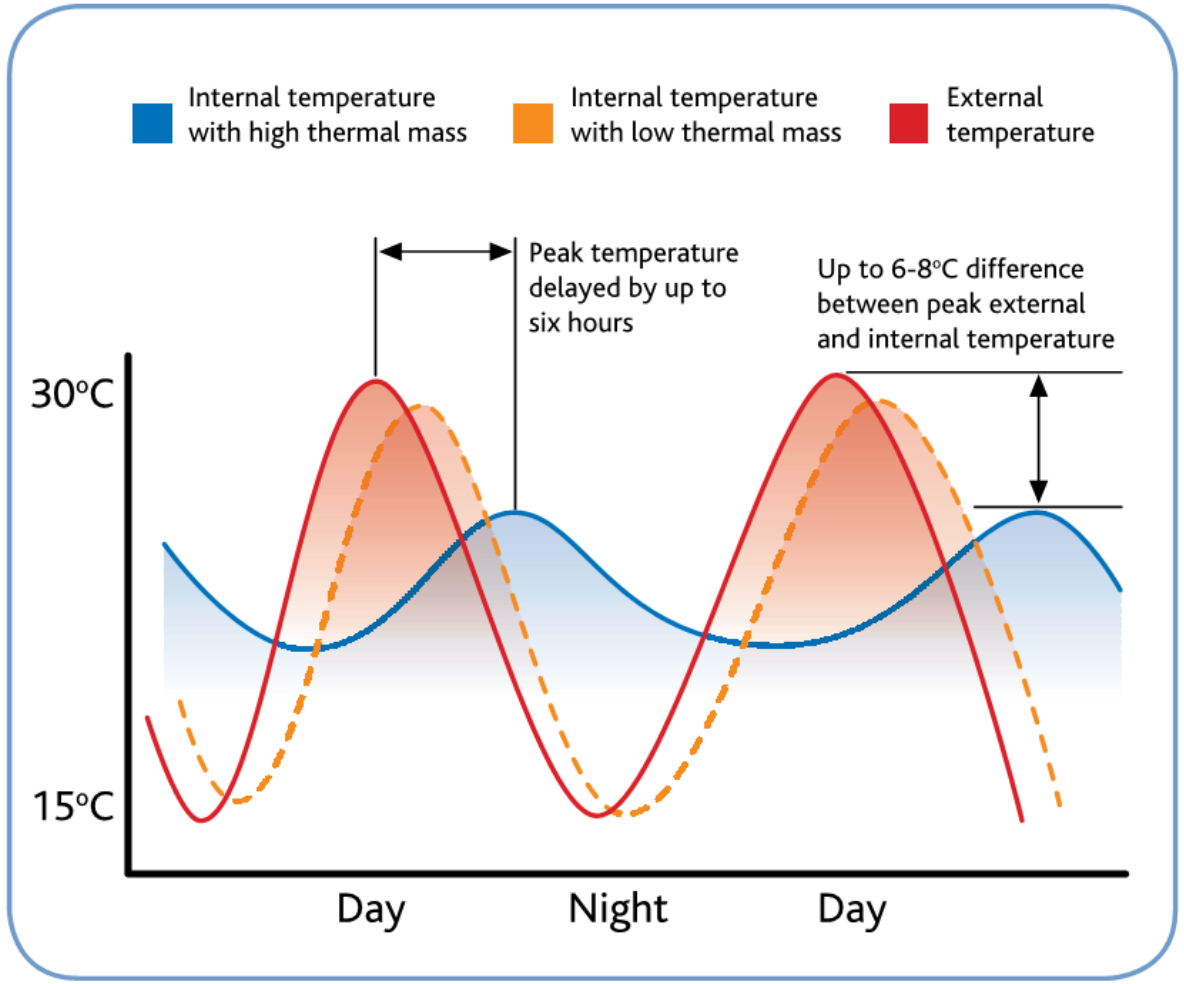




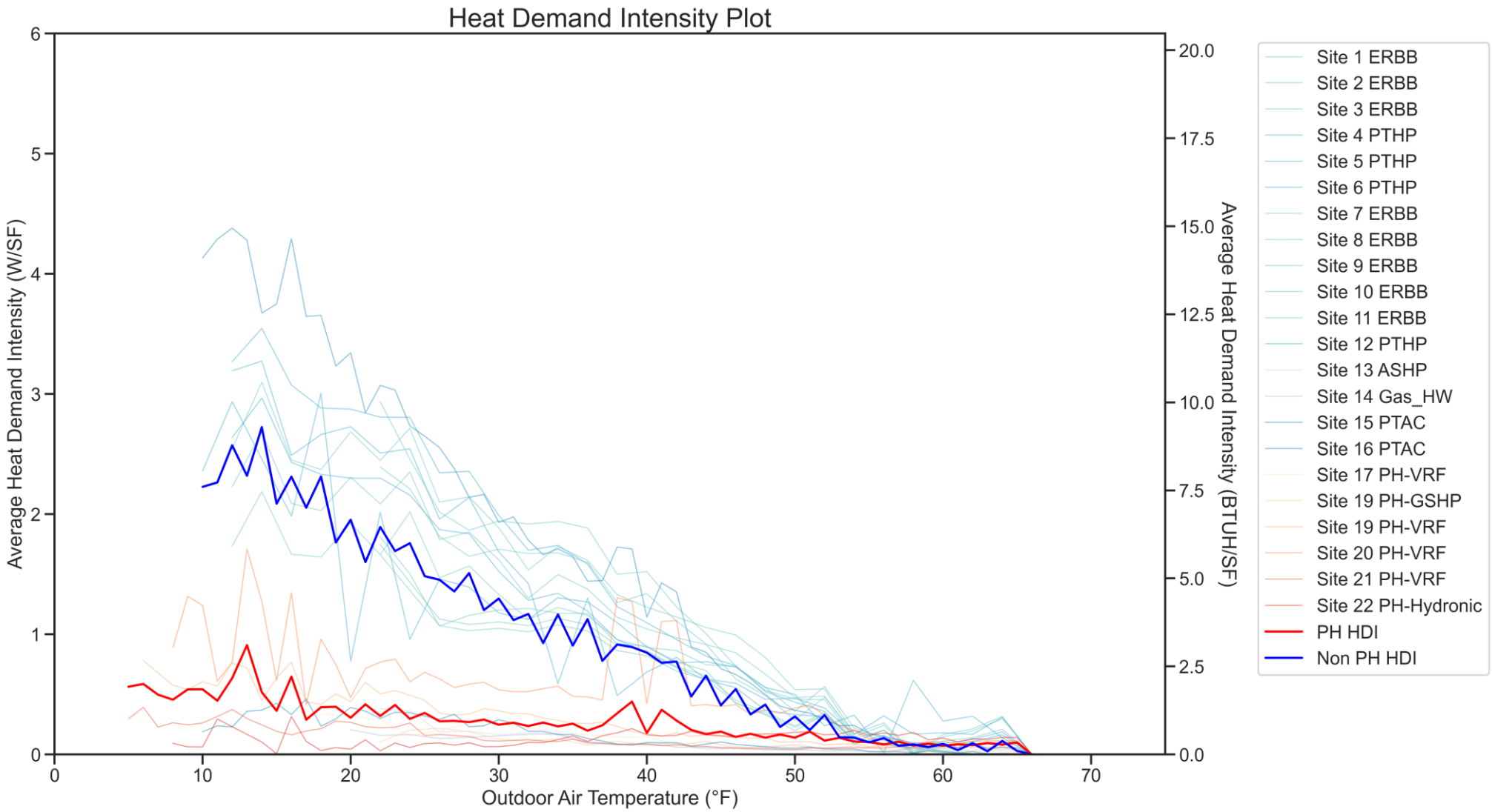
Post Adjustment: 7-30% difference (average 14%, ranged from 30% overpredicted to 14% undererpredicted)

Pre Adjustment: 36-64% difference (average 52%, all underpredicted)

Claim: Passive House buildings are more resilient



Peak Heating vs. Outdoor Temperature



VRF & Humidity in Multifamily

US DOE Study

US DOE Study

Data collection & analysis from Summer 2023 to Spring 2024

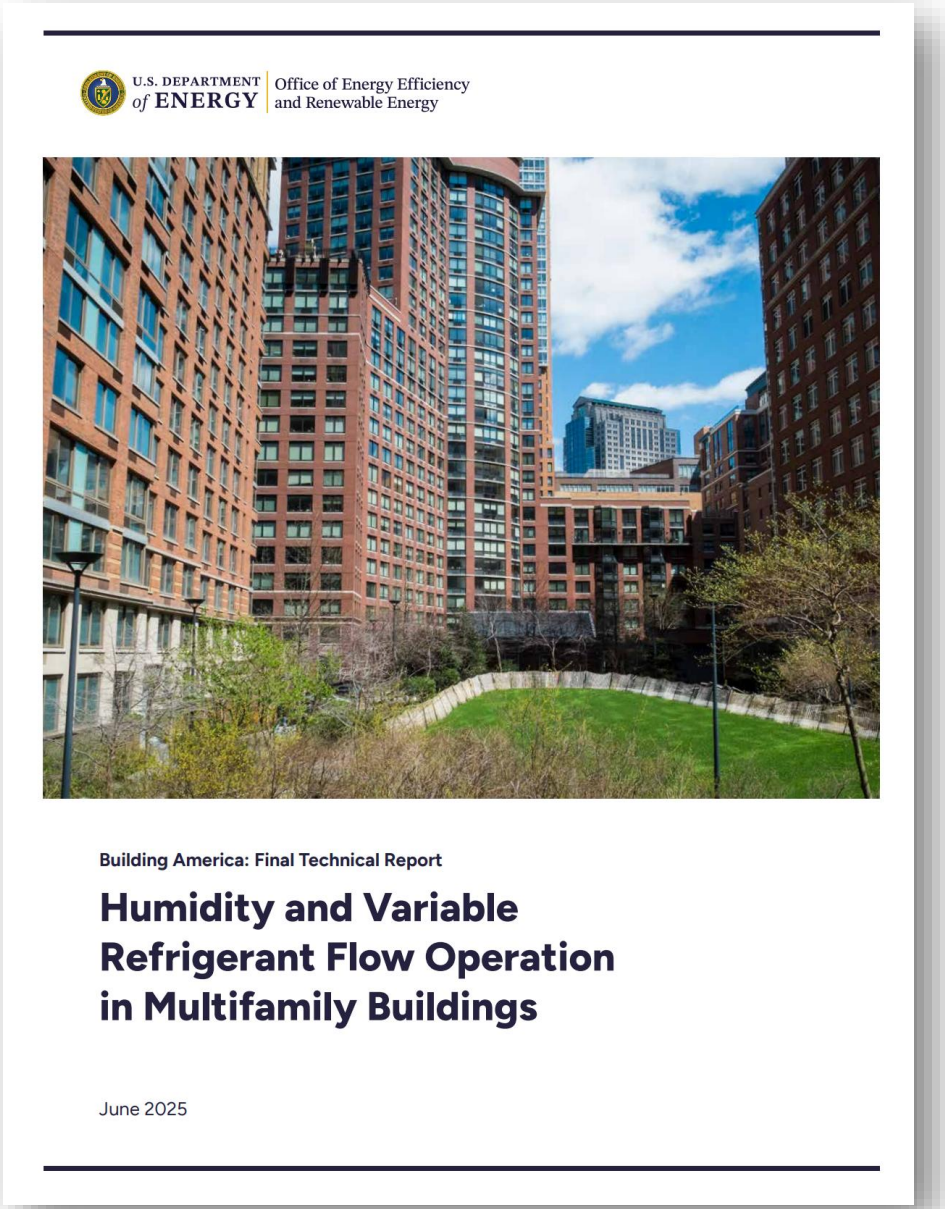
Published in June 2025

Full report:

https://docs.nrel.gov/docs/fy25osti/89805.pdf

Short blog post summary:

https://www.swinter.com/research-programs/cost-of-oversizing-vrf-systems/



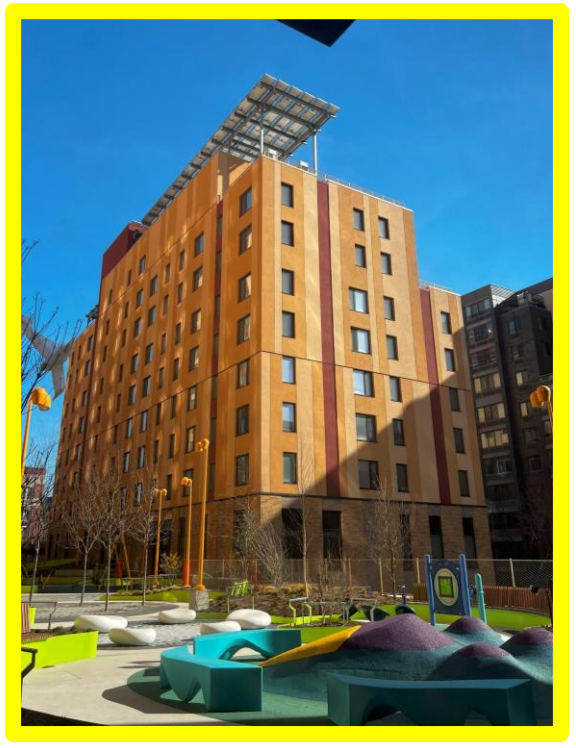
US DOE Study – 3 Buildings in NYC

Building A

Passive House,
Affordable

Building B

Passive House,
Affordable



Building C

LEED NC,
Market Rate

US DOE Study – 3 Buildings in NYC

Building A

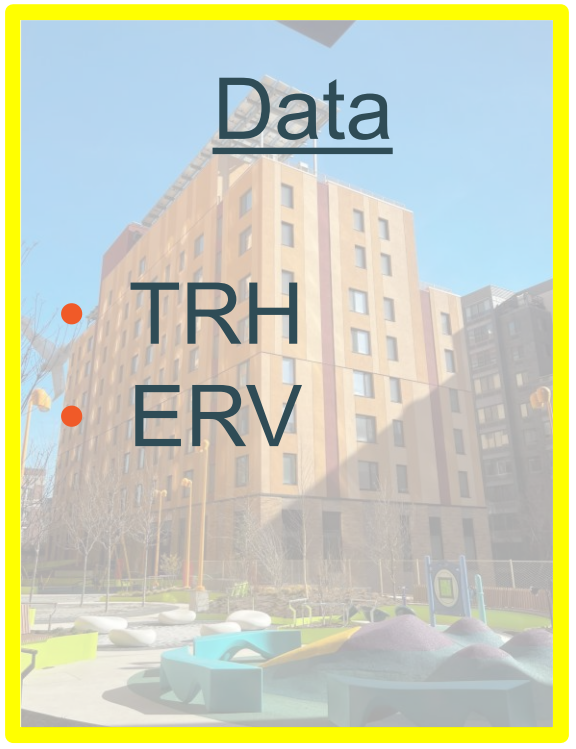
Passive House, Affordable

Data

- TRH
- VRF
- ERV

Building B

Passive House, Affordable

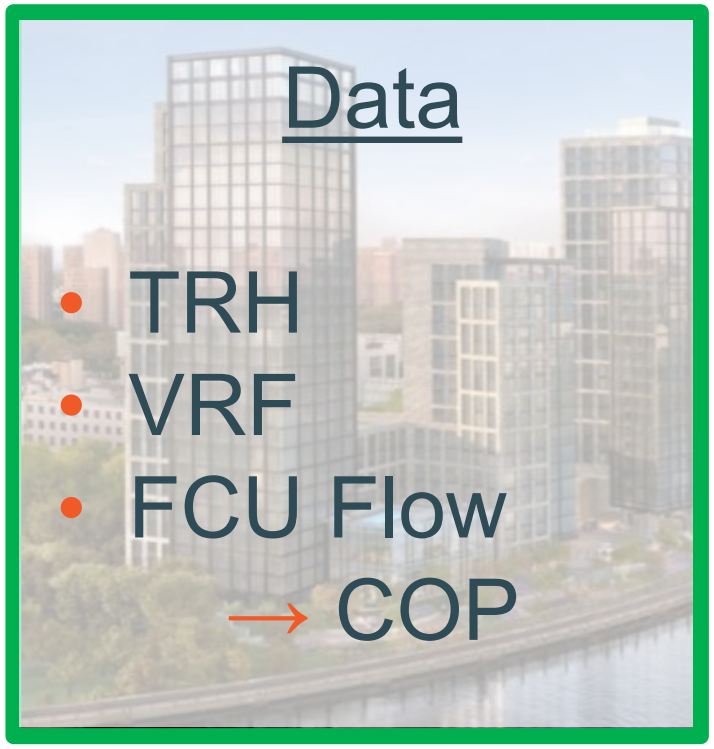


Data

- TRH
- ERV

Building C

LEED NC, Market Rate



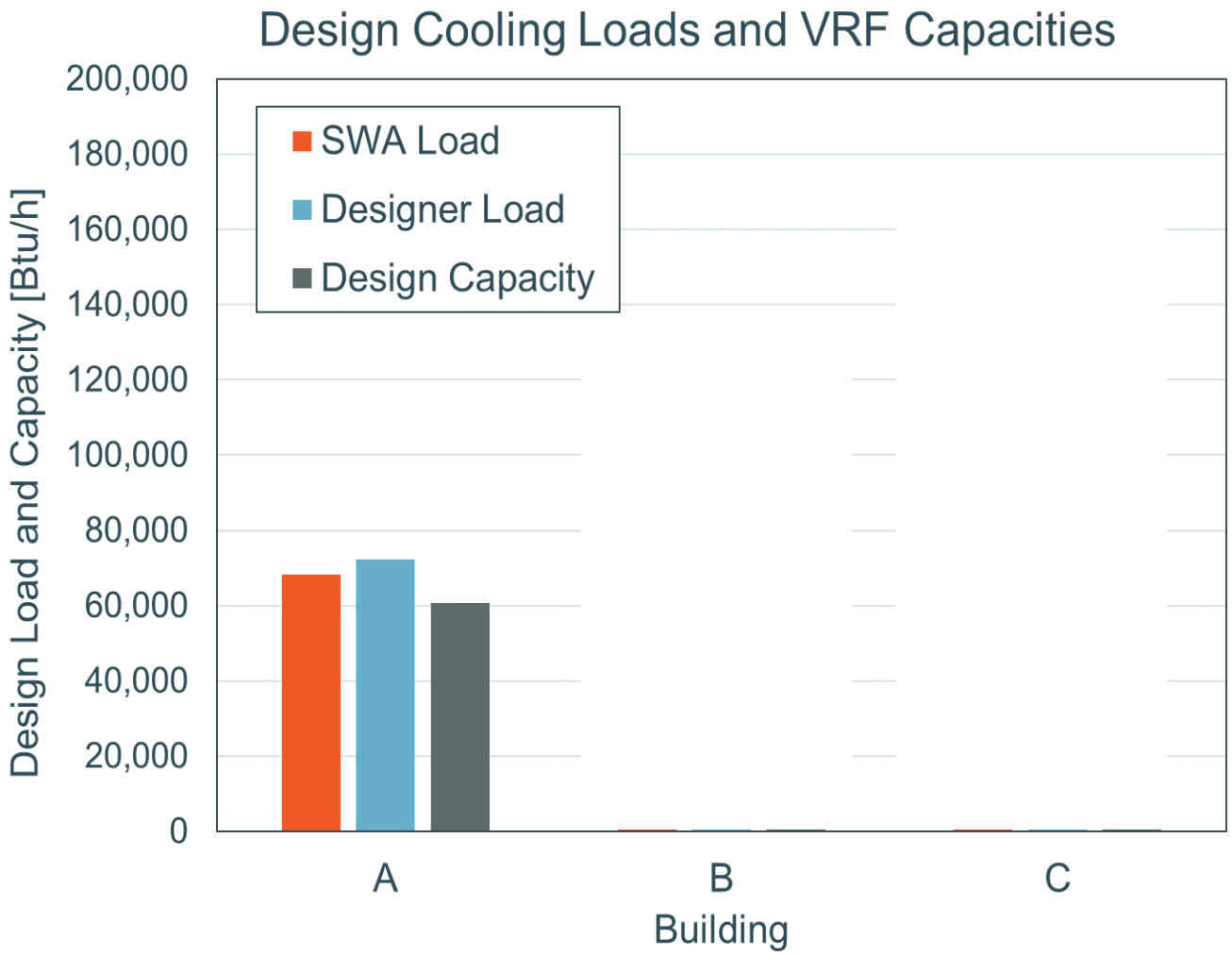
Data

- TRH
- VRF
- FCU Flow → COP

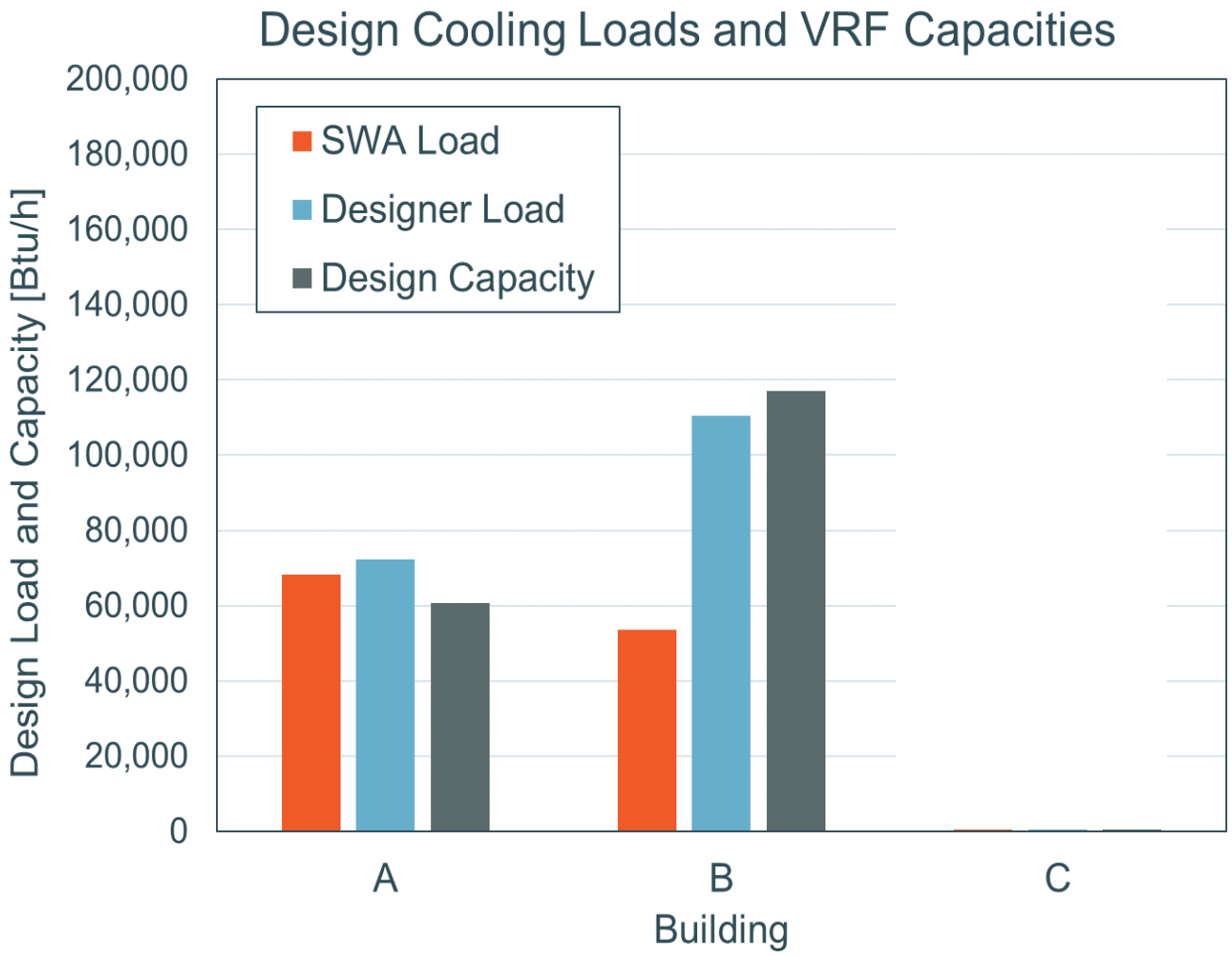
VRF & Humidity in Multifamily

Space cooling load calculations & VRF sizing

Sizing Impacts on VRF



Sizing Impacts on VRF



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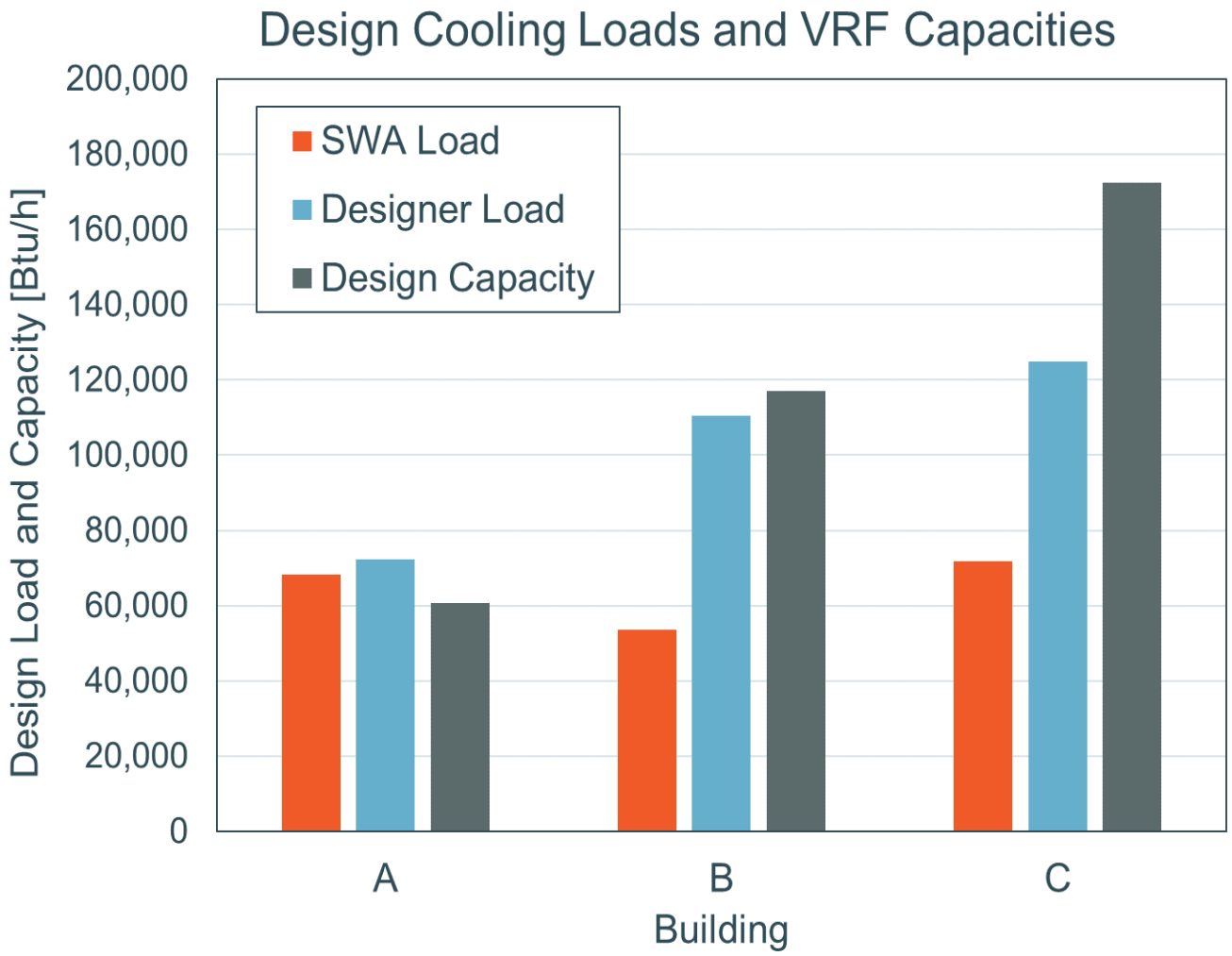

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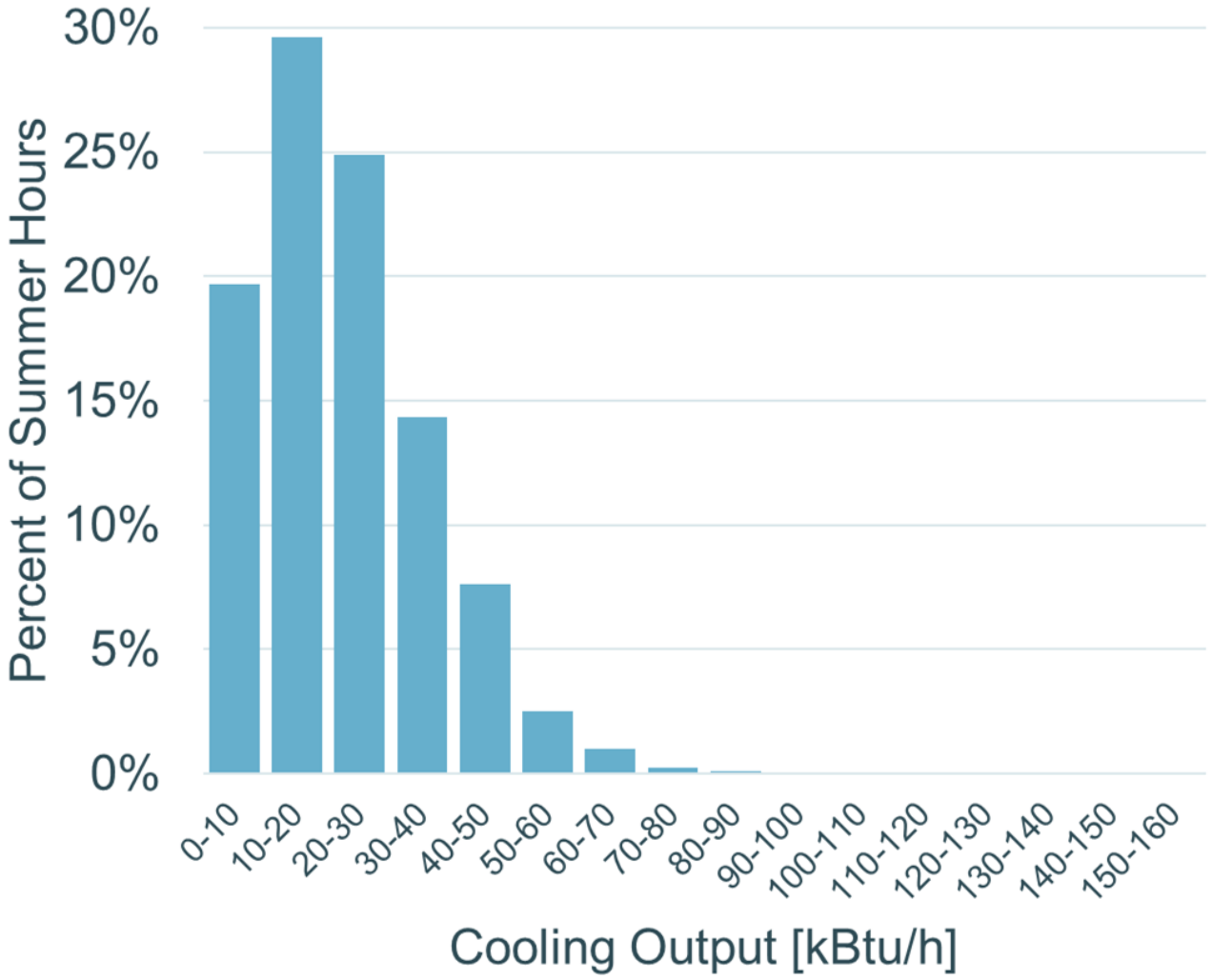
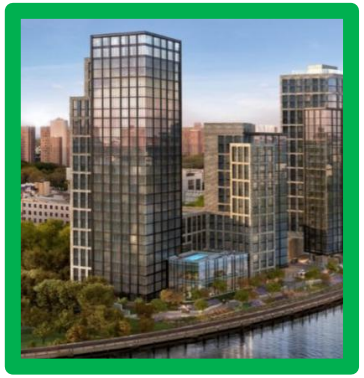
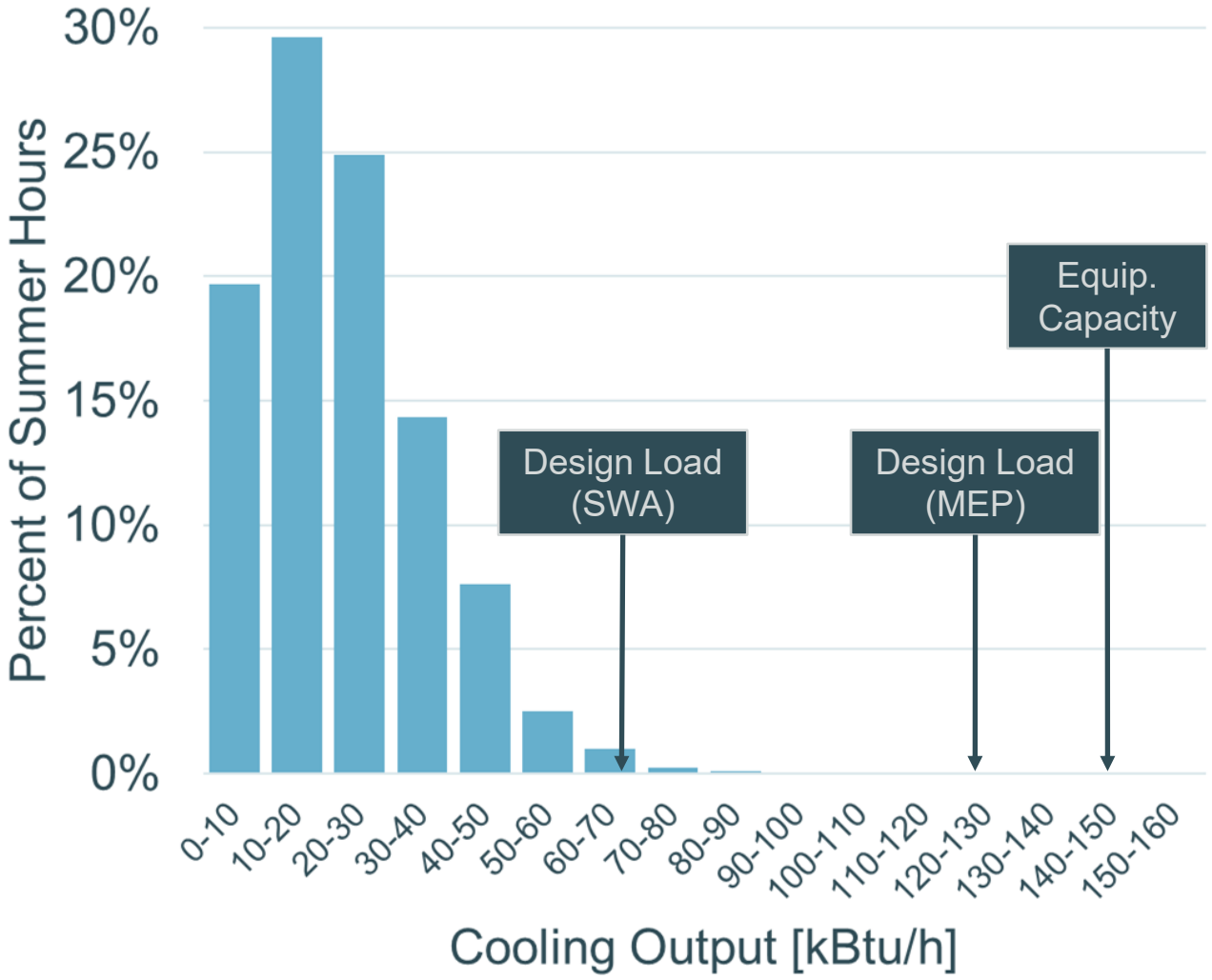


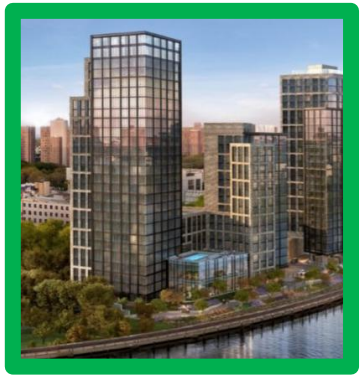
Building C



Sizing Impacts on VRF



Building C



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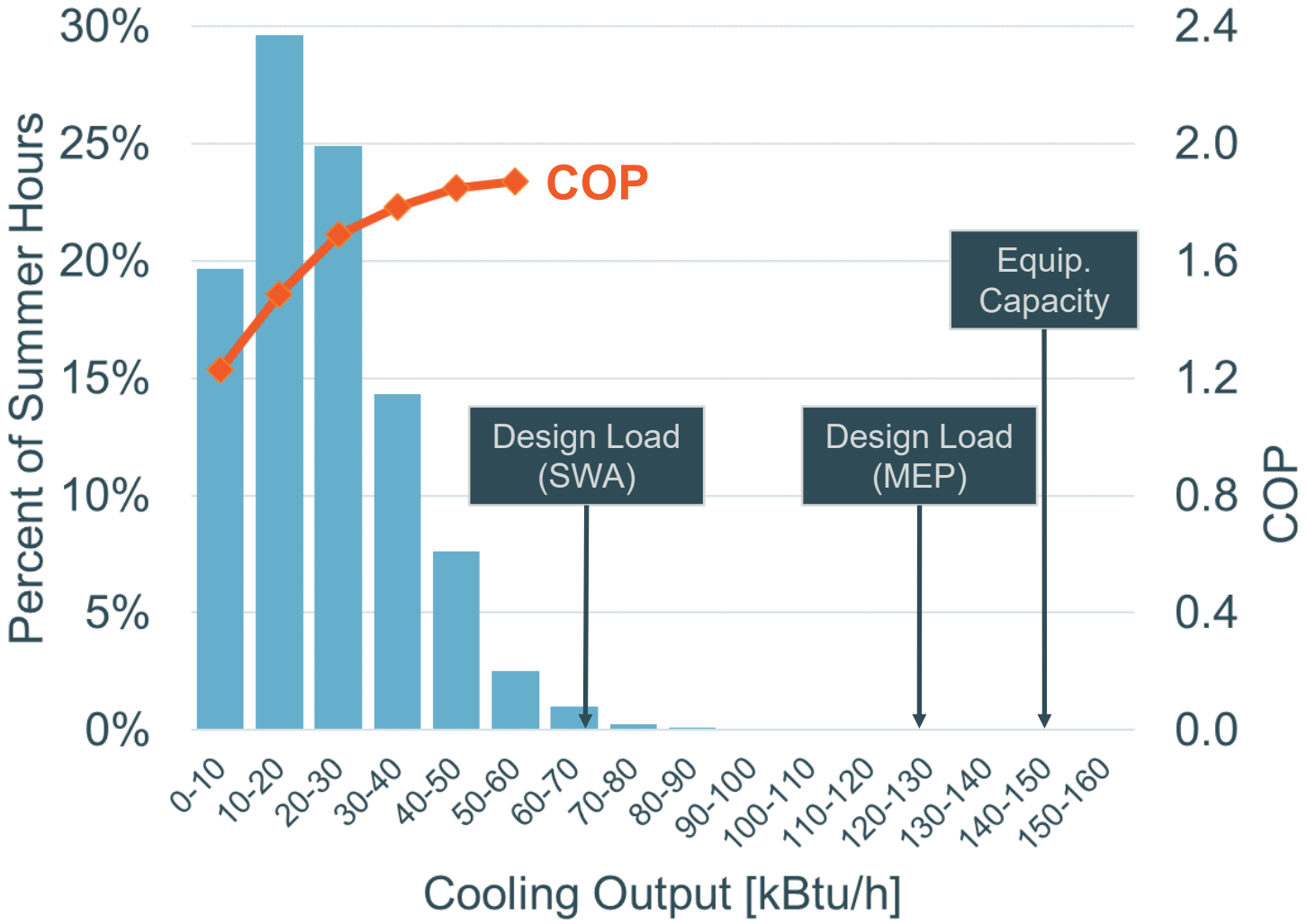
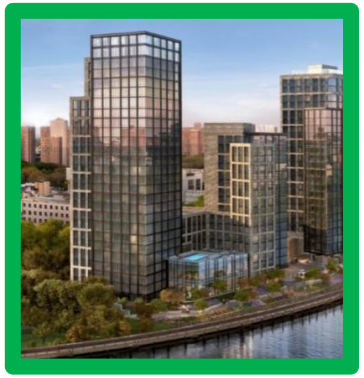


Building C



Sizing Impacts on VRF

Building C

VRF System	Summer COP	Fall COP	Winter COP	All Seasons
C-18	1.7	0.9	1.2	1.3
C-19	2.0	1.3	1.6	1.8
C-20	1.4	0.9	1.0	1.1
All Systems	1.7	0.9	1.2	1.3

Sizing Impacts on VRF

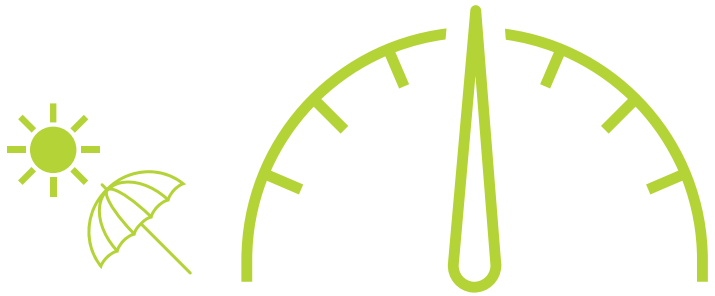
Building C

VRF System	Summer COP	Fall COP	Winter COP	All Seasons
C-18	1.7	0.9	1.2	1.3
C-19	2.0	1.3	1.6	1.8
C-20	1.4	0.9	1.0	1.1
All Systems	1.7	0.9	1.2	1.3

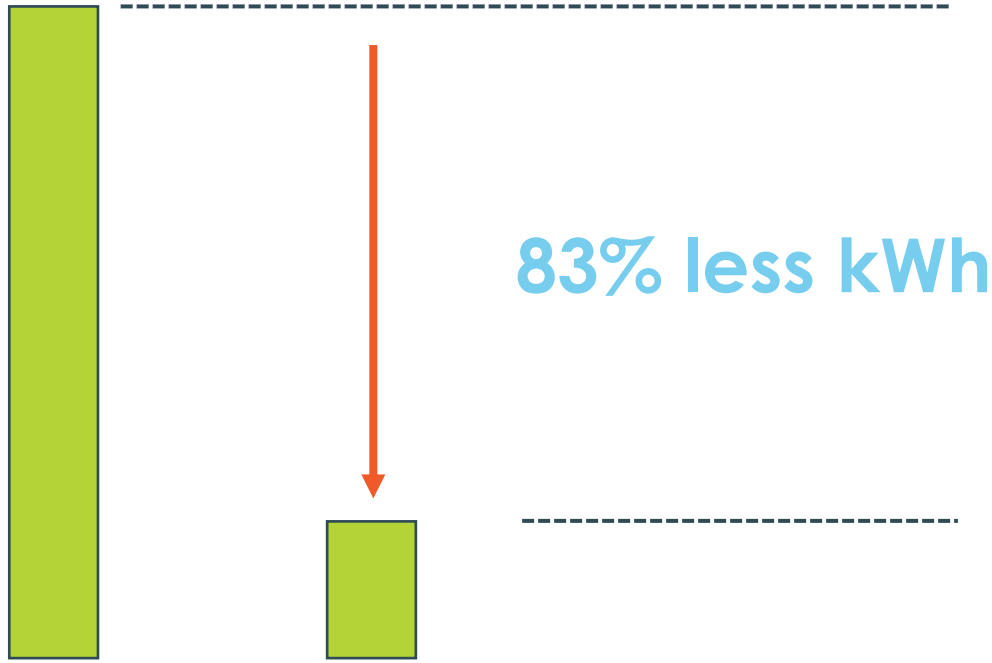
Building A vs. Building C

Building	Summer Electricity [kWh/ft^2]	Design Cooling Loads [Btu/hr-ft^2]	Installed Capacity [Btu/hr-ft^2]	Winter VRF Electricity [kWh/ft^2]	Design Heating Loads [Btu/hr-ft^2]	Installed Capacity [Btu/hr-ft^2]
A	0.26	8.5	7.6	0.20	4.6	6.2
C	1.54	12.7	30	0.89	12.6	32.7

Sizing Impacts on VRF



VRF Cooling Energy



Building C

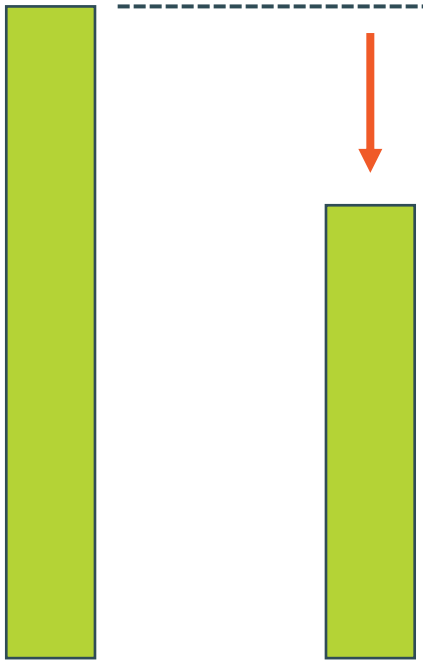
Oversized VRF
By ~2.5x peak cooling load

Building A

Right-sized VRF

Sizing Impacts on VRF

VRF System First Costs



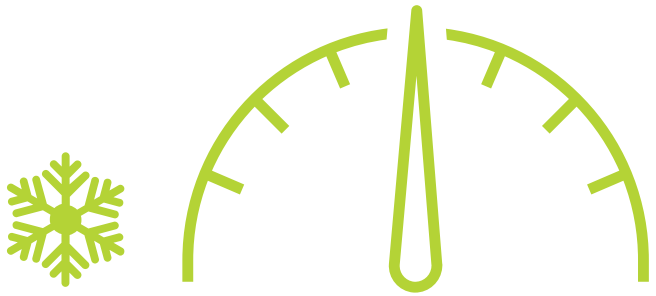
Building C

Oversized VRF
By ~2.5x peak cooling load

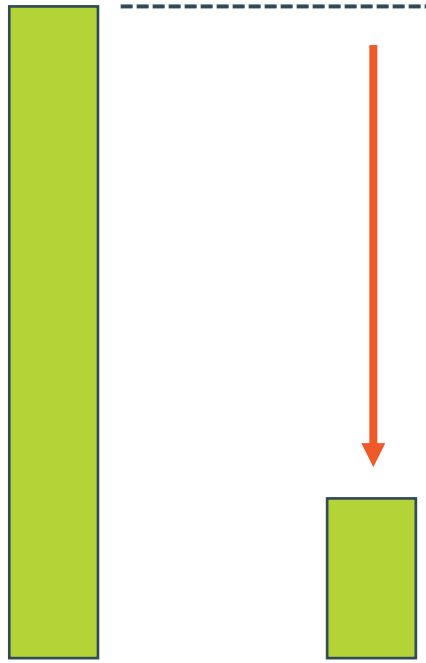
Building C

Right-sized VRF
(hypothetical scenario)

Passive House Design Impacts on VRF



VRF Heating Energy



78% less kWh/sf

Building C

LEED-compliant
code level design

Building A

Passive House /
low-load design

VRF & Humidity in Multifamily

Impact of VRF Sizing

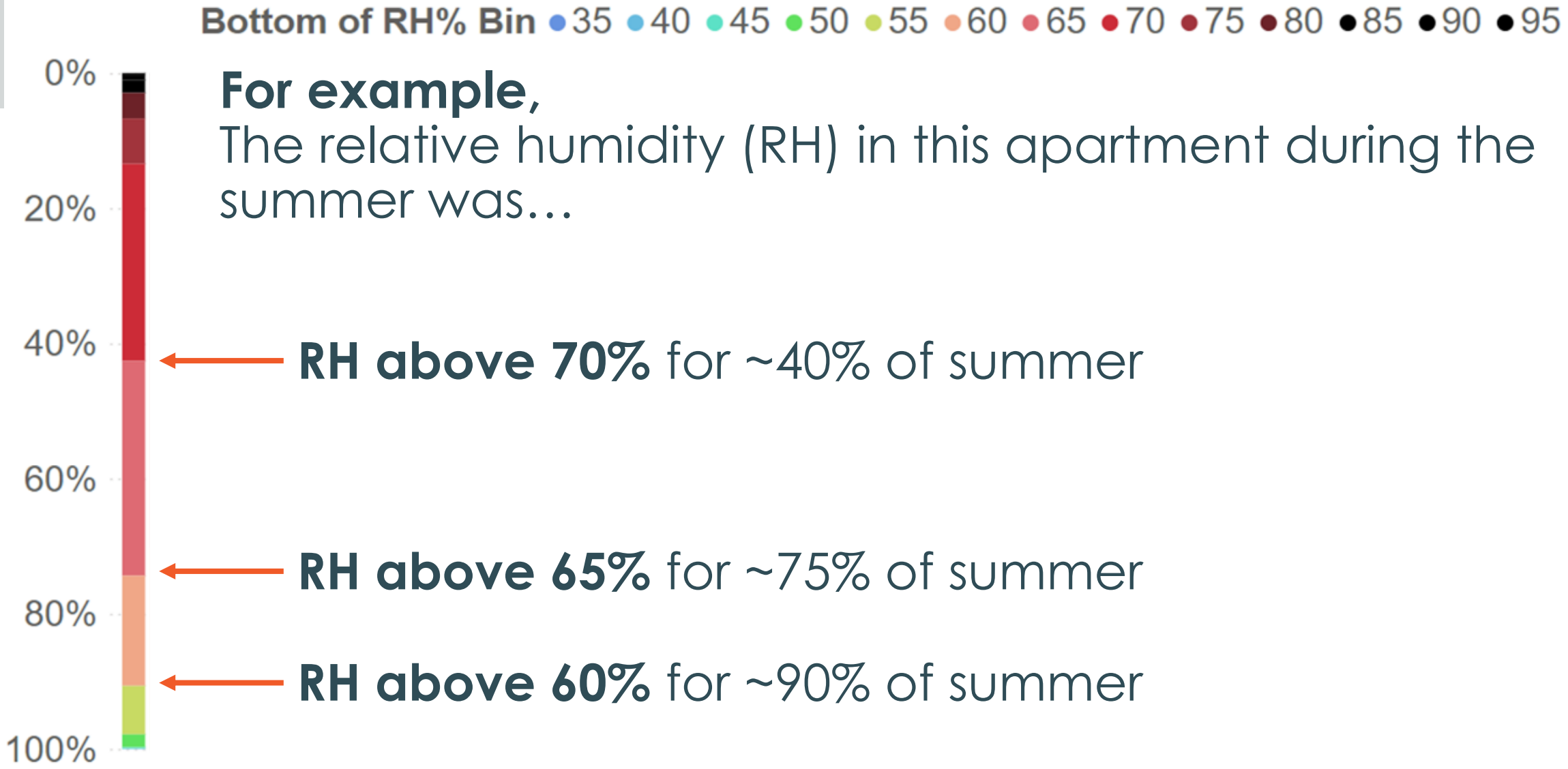
No big correlation between VRF Sizing and Humidity

VRF & Humidity in Multifamily

How Humid is it in Apartments in Summer?

Each color band w/in bar represents % of time in season inside of relative humidity band

Each bar is 1 apartment



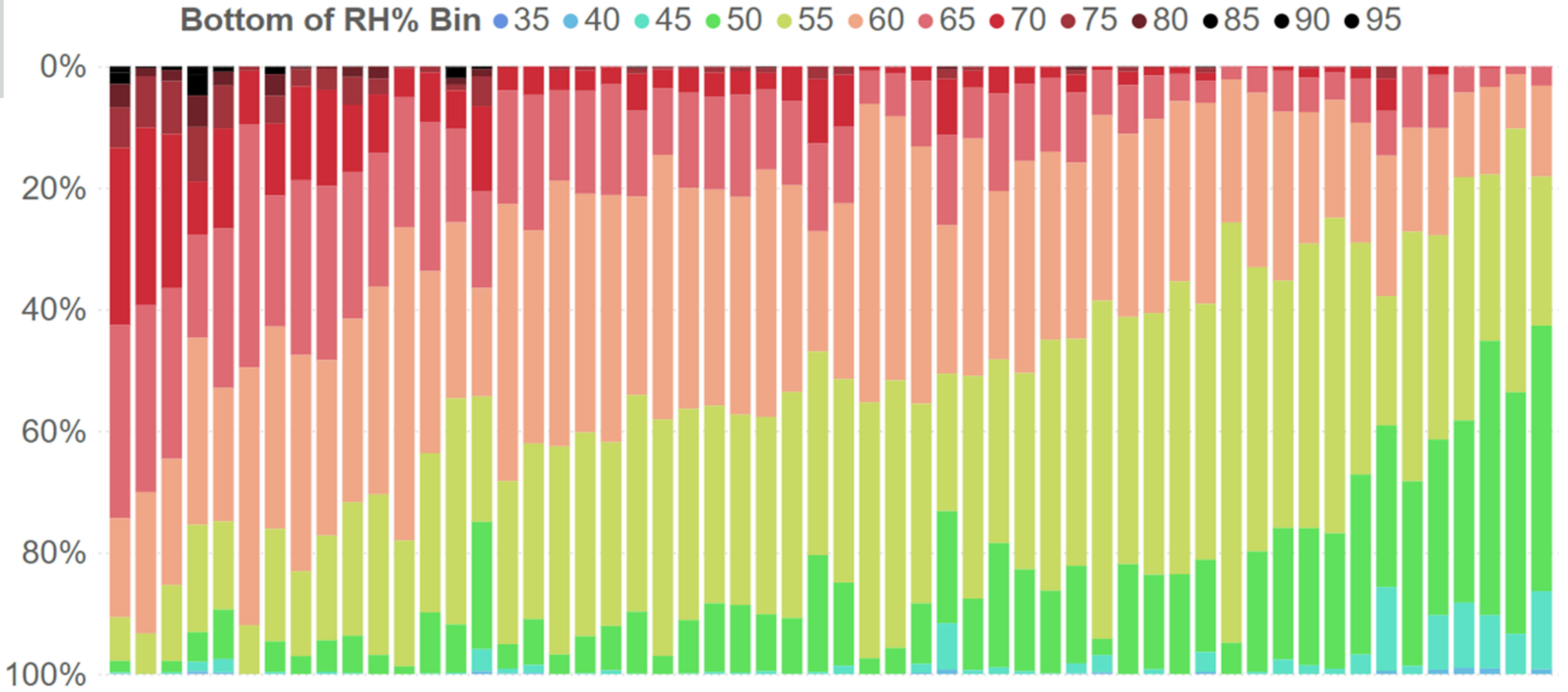
For example,
The relative humidity (RH) in this apartment during the summer was…

RH above 70% for ~40% of summer

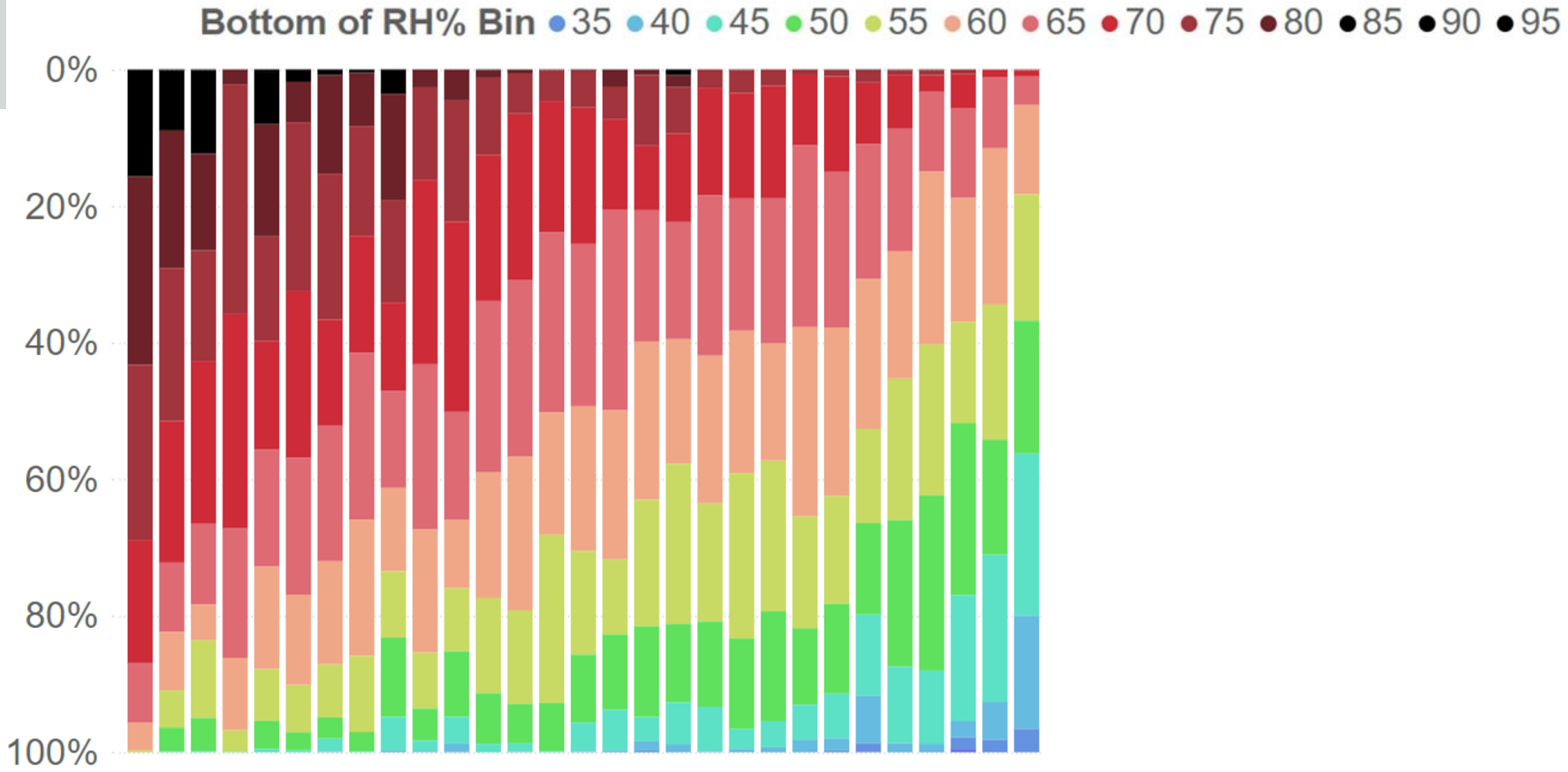
RH above 65% for ~75% of summer

RH above 60% for ~90% of summer

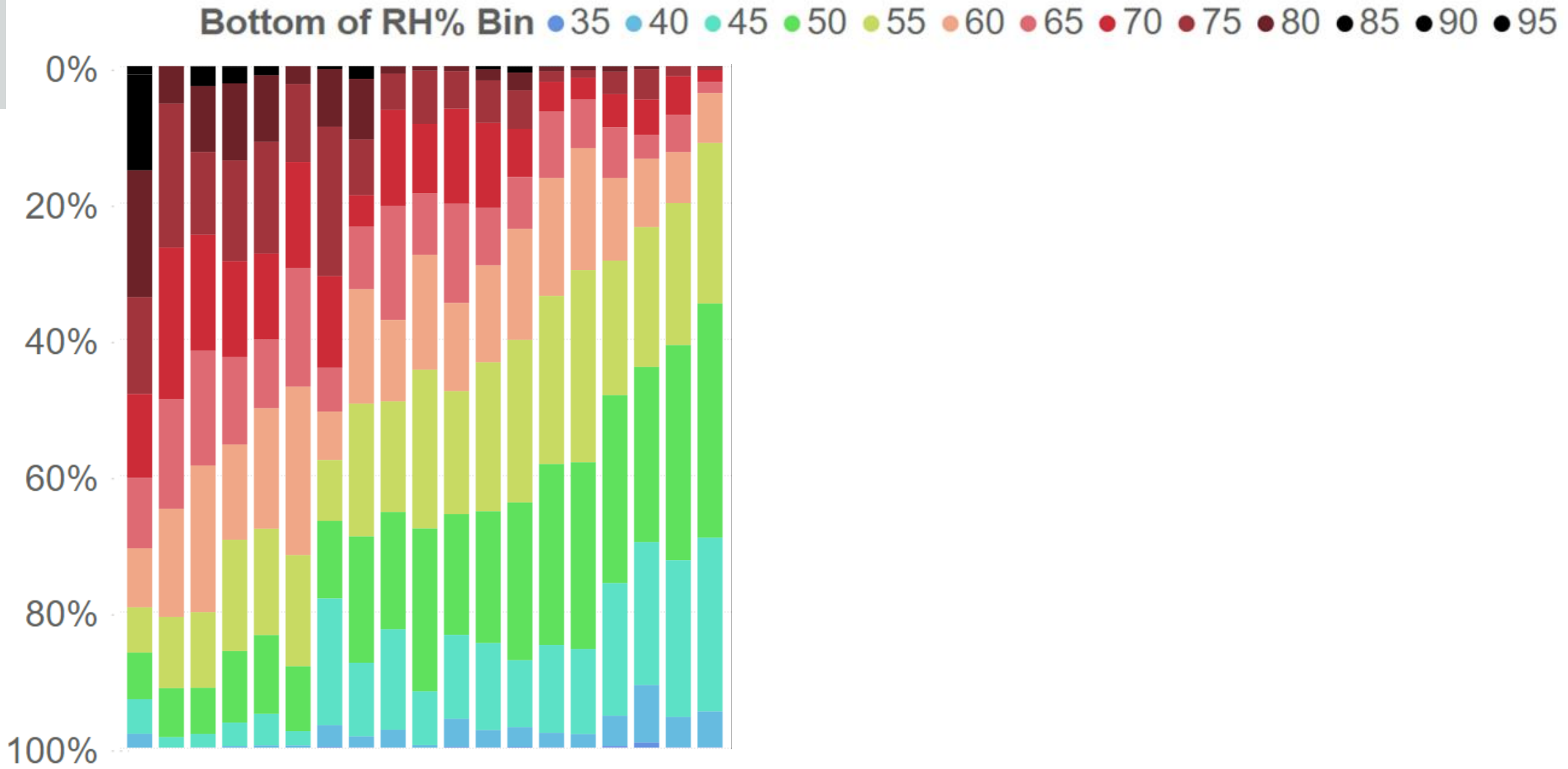
RH in Summer (% of Summer) **Building A:** 56 apts.



RH in Summer (% of Summer) **Building B:** 29 apts.



RH in Summer (% of Summer) **Building C:** 19 apts.



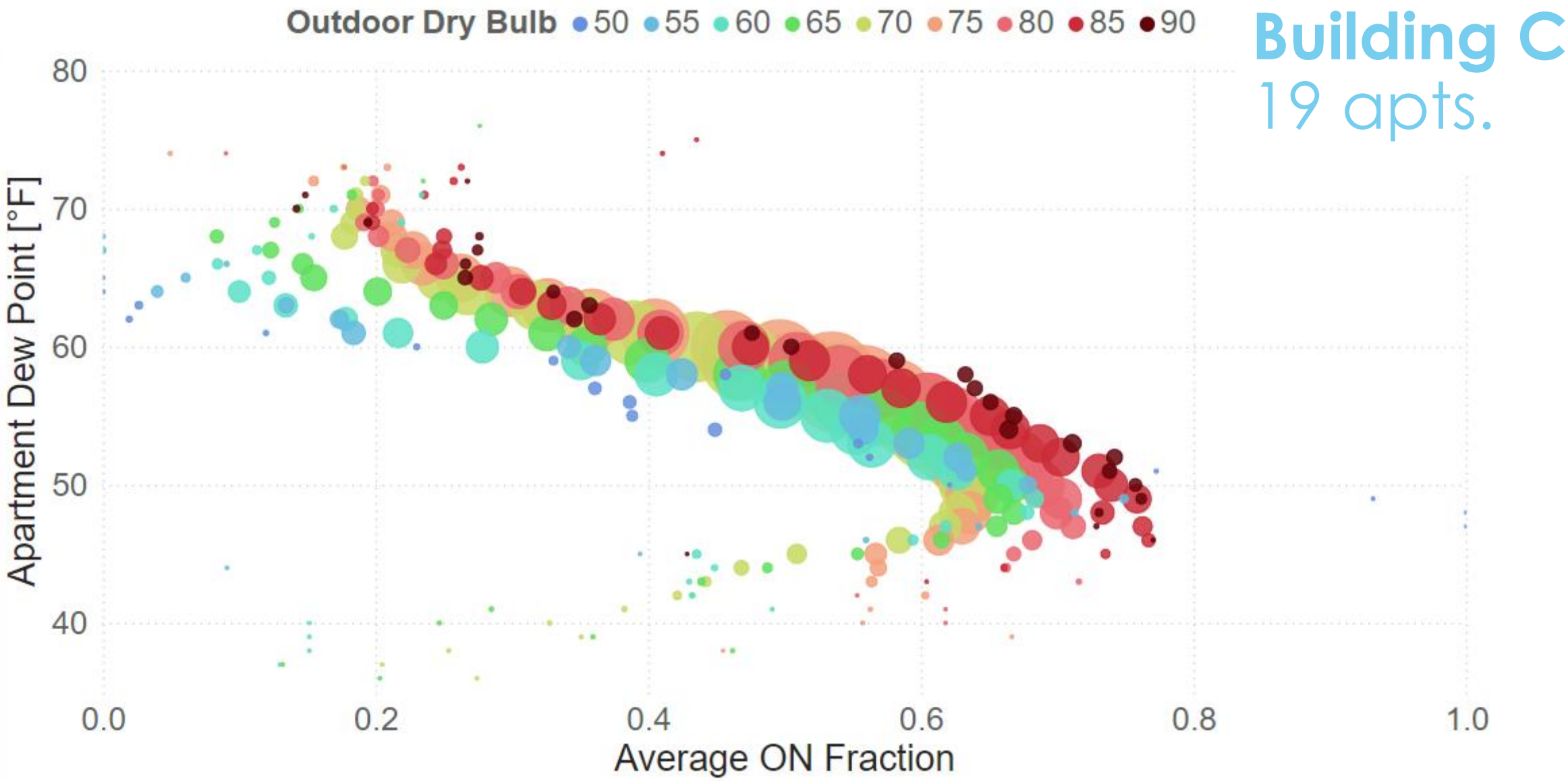
VRF & Humidity in Multifamily

How are residents using VRF systems in summer?

Strong correlation

between VRF thermostat being on and lower humidity levels

Apt Dewpoint vs. Thermostat ON fraction



Building C
19 apts.

VRF & Humidity in Multifamily

Impact of Ventilation System Operation

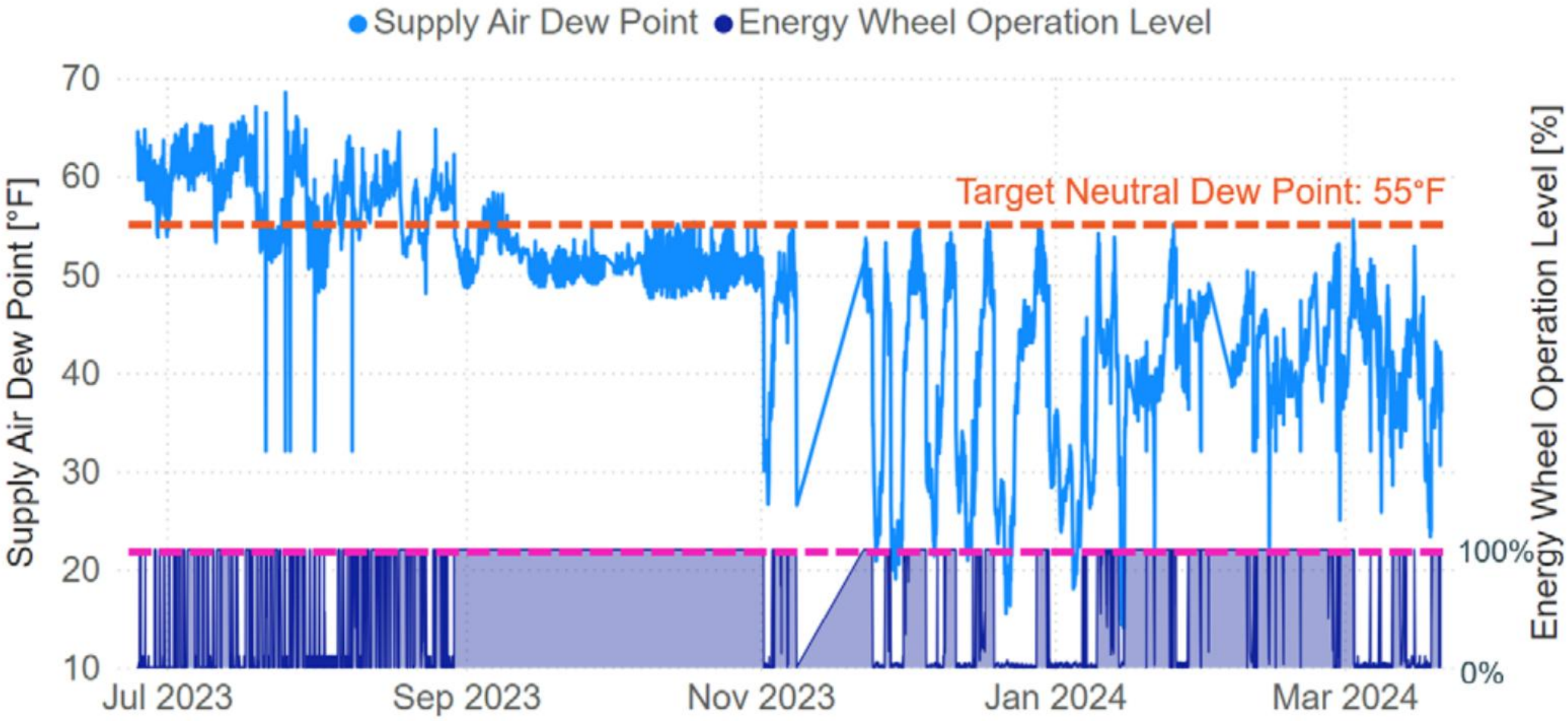
Impact of Ventilation System Operation

- **Building A:** Central energy recovery ventilation system w/ balanced supply and exhaust air to/from apartments

- Numerous operational issues w/ ERV system observed at Building A during data collection period. Some corrective measures were implemented.

Impact of Ventilation System Operation

Building A: ERV Supply Air Dewpoint and Enthalpy Wheel Operation



Impact of Ventilation System Operation

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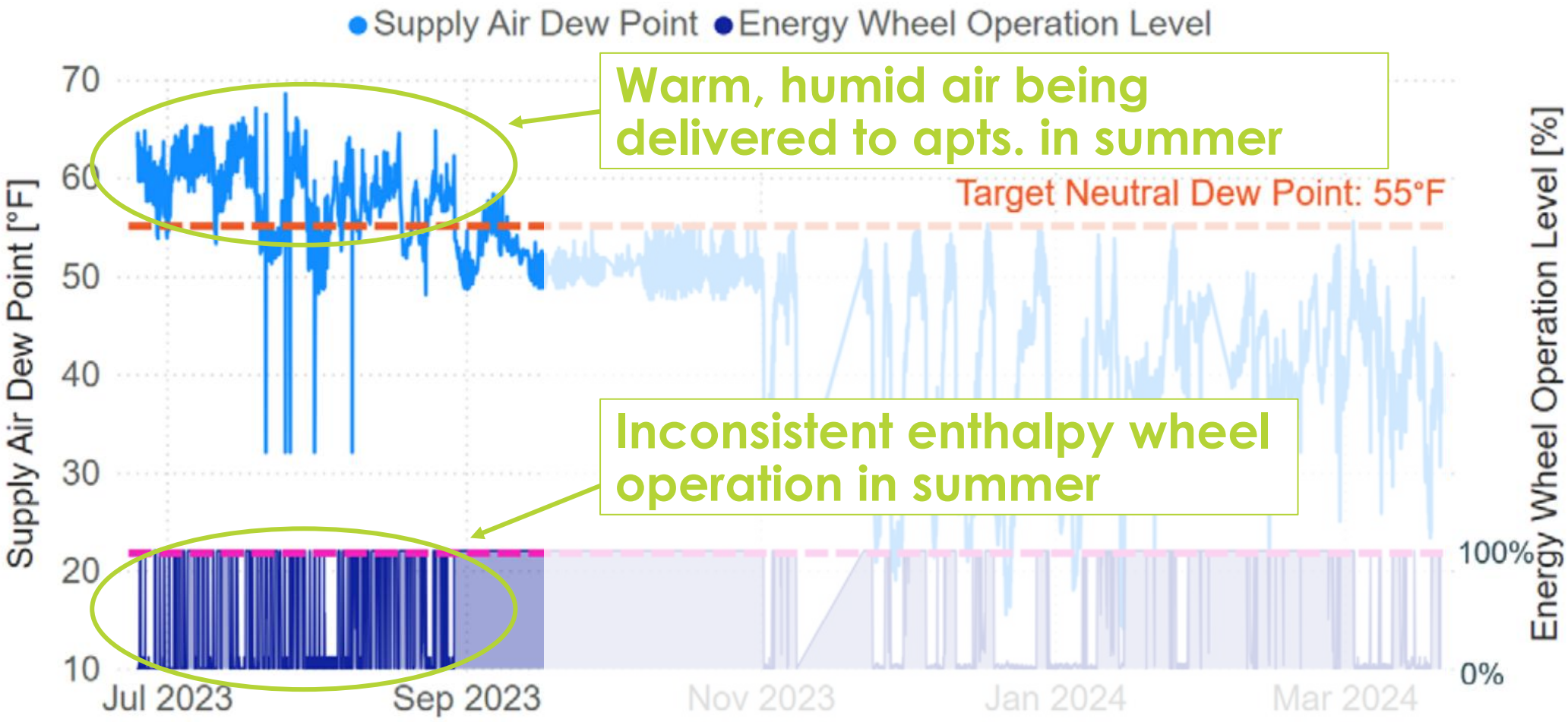

Impact of Ventilation System Operation

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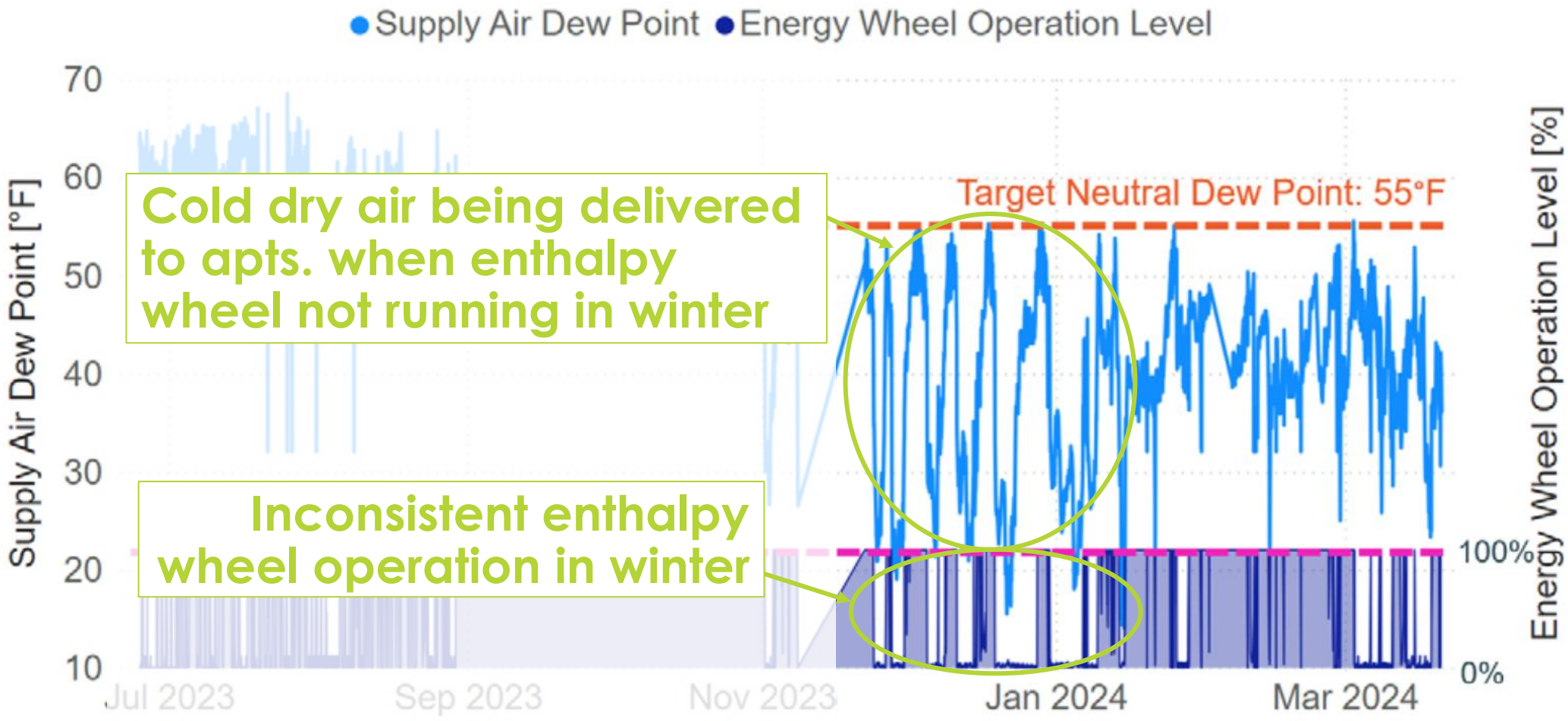

Impact of Ventilation System Operation

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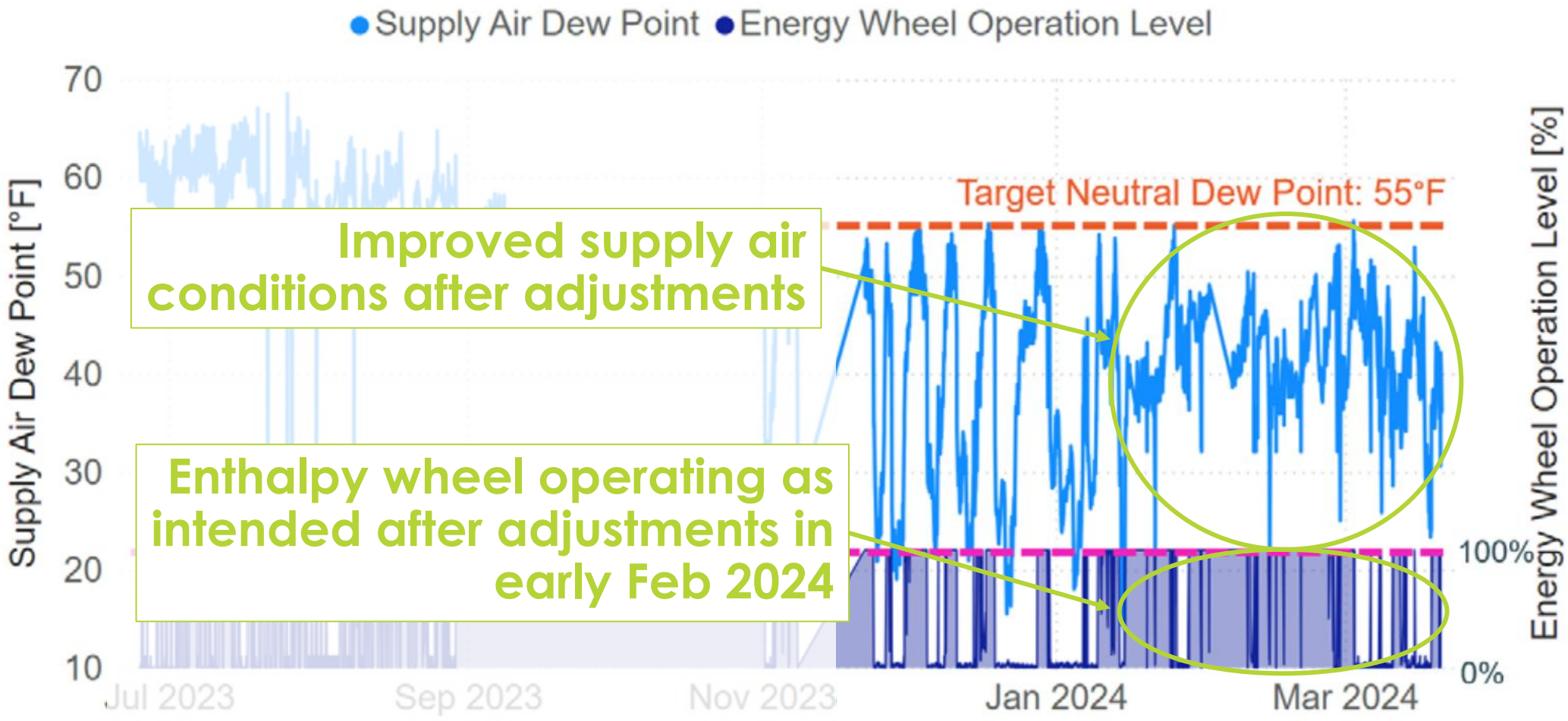

VRF & Humidity in Multifamily

Conclusions

Conclusions

- Multifamily buildings built to the PH standards consistently outperform the existing building stock and recently constructed code compliant buildings by 40% to 50%.
- Peak demands for heating in buildings built to the PH standard are 80% lower than conventional buildings.
- Since these buildings barely respond to outdoor temperatures, they make excellent shelter in place options .
- Modeled site EUIs using the PH assumptions drastically underestimates both whole building and DHW EUI's.
- A key component of ensuring that operational energy is kept low is proper sizing of the heating and cooling systems.
- Oversizing VRF systems appears to have a significantly negative impact on the overall COP of the system and the heating and cooling energy use.
- Large scale central ERVs rarely work as designed in multifamily buildings.
- For large central ERVs, specification language should require:
    - on-board datalogging and data storage,
    - multiple startup/tuning visits, and
    - execution phase commissioning requirements to show three weeks of maintained performance in different seasons.

Acknowledgements

- I would like to thank my colleagues for their assistance compiling this paper:

  - Robb Aldrich – Steven Winter Associates, Inc.
  - Kelly Mark – Steven Winter Associates, Inc.
  - Joanna Grab – Steven Winter Associates, Inc.
  - Neal Misquitta – Steven Winter Associates, Inc.
  - Eric Skiba – Steven Winter Associates, Inc.
  - Eleanor Fulkerson – Steven Winter Associates, Inc.
  - Shari Rauls – Steven Winter Associates, Inc.

Questions

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BUILDINGENERGY NYC

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