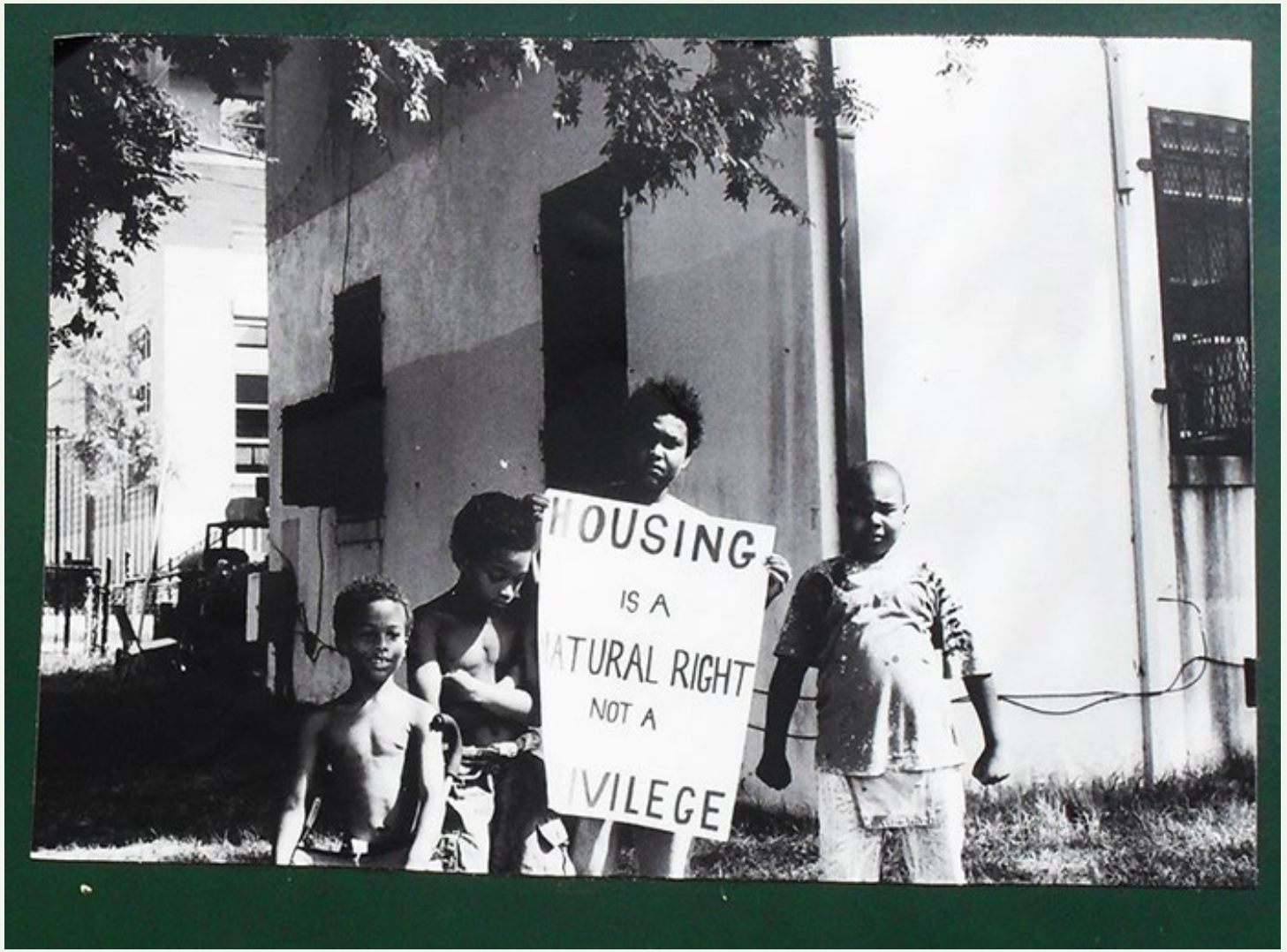
BARRY FARM

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

Envelope, Equity, Engagement

The Barry Farm Passive House Case Study



PASSIVE TO POSITIVE

Passive to **POSITIVE**
PASSIVE HOUSE AND LOW IMPACT DESIGN

HOLISTIC ENERGY EFFICIENCY, PASSIVE HOUSE, AND LOW CARBON DESIGN CONSULTING

MICHAEL HINDLE, MFA, CPHC

ANDY ALLWINE, AIA, CPHC, LEED

CATHERINE ROSAS

AMORY JONES

PRESERVATION OF AFFORDABLE HOUSING

Preservation of Affordable Housing

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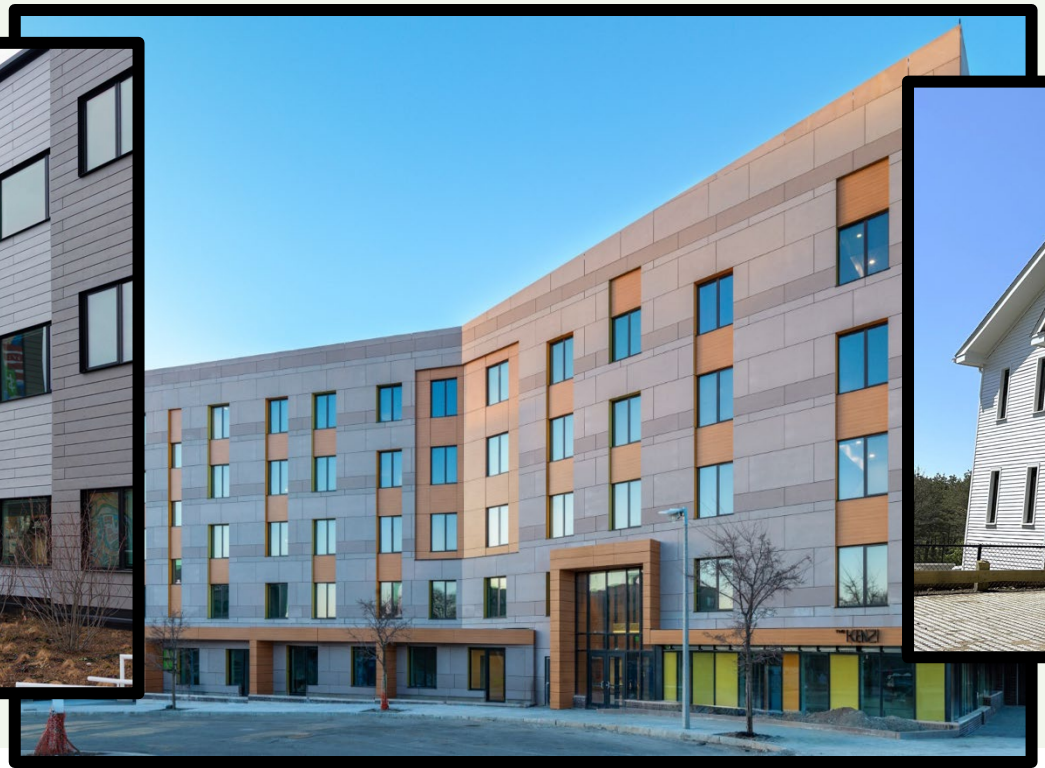
Evan Watson

Aviad Kopelowitz

Jackie Powell

Tayna Philips

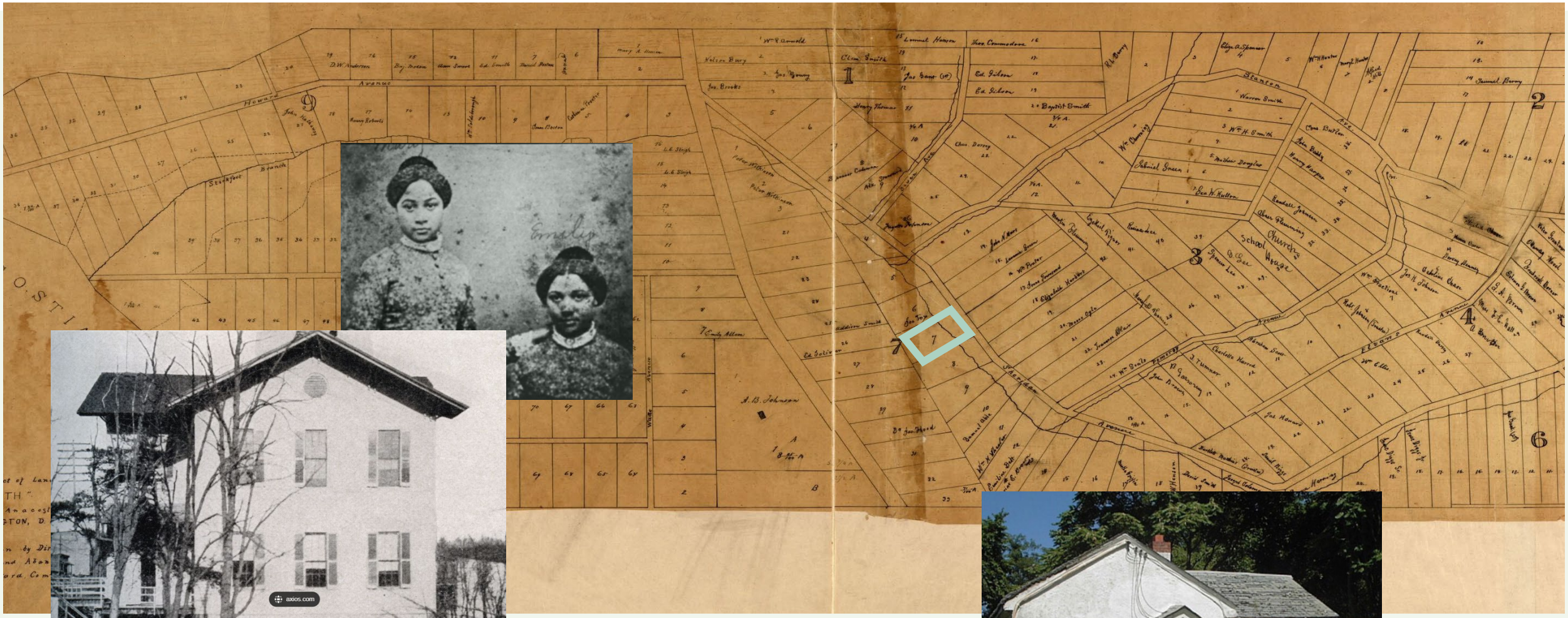
Maia Shanklin-Roberts



BARRY FARM – HISTORY: 1867

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing



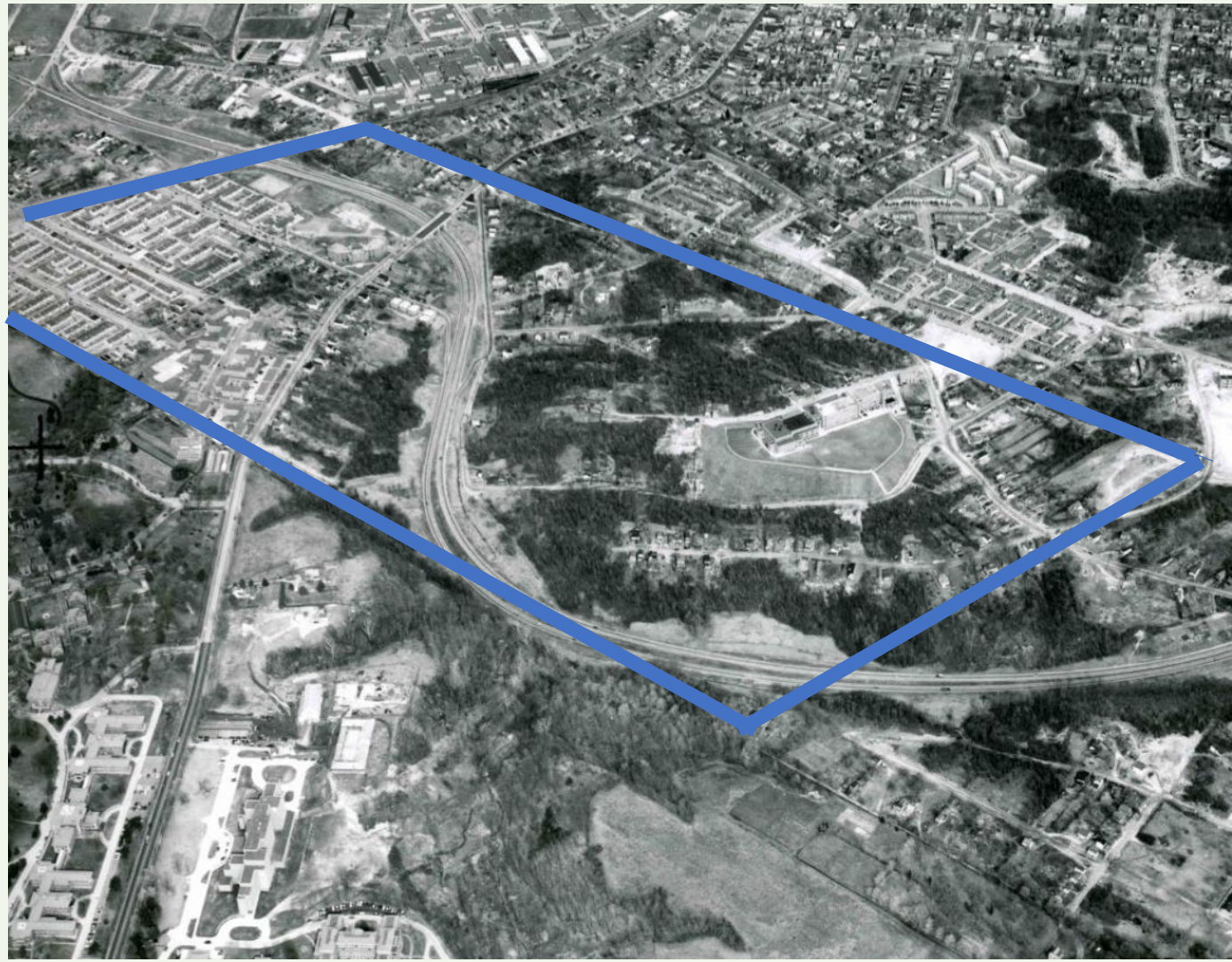
Men who until within five years ago had not even owned their hands…now had an acre of land and a house (they built) that they were to call their own.

BARRY FARM – HISTORY: 1940s

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

n aerial view of Barry Farm–Hillsdale before the construction of the Suitland Parkway and Barry Farm Dwellings.
ourtesy of District of Columbia Housing Authority Records, Anacostia Community Museum, Smithsonian



BARRY FARM – HISTORY 1940s

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

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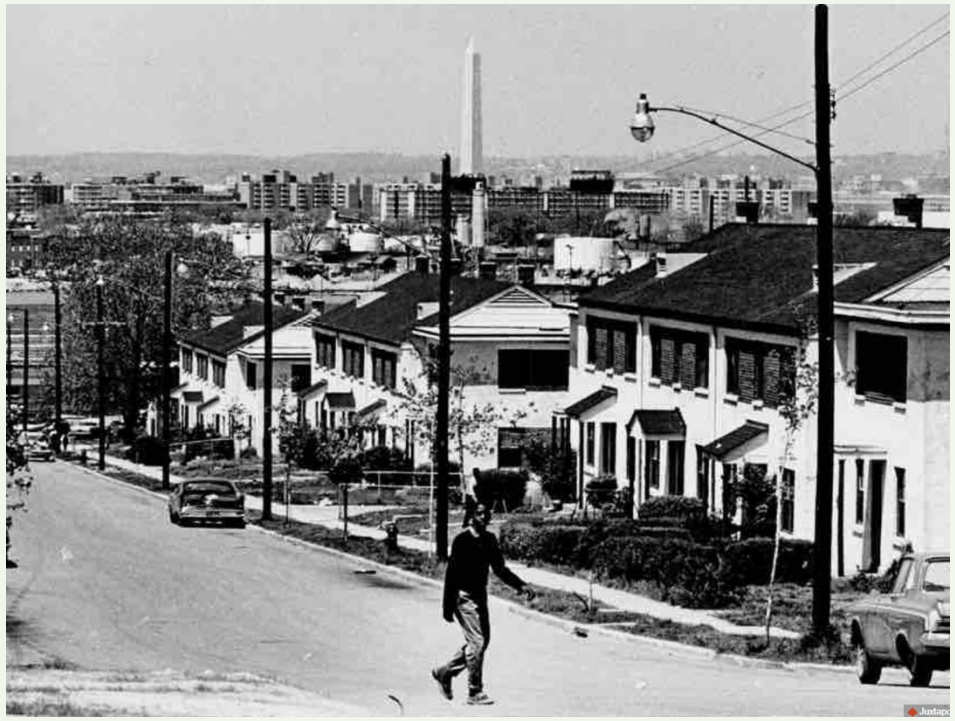
Barry Farm Dwellings (NCHA, 1944)



BARRY FARM – Engagement

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

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People, not buildings and street grids, will define Barry Farm's future.

Barry Farm Dwellings

BARRY FARM – HISTORY 2010

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PASSIVE HOUSE AND LOW IMPACT DESIGN

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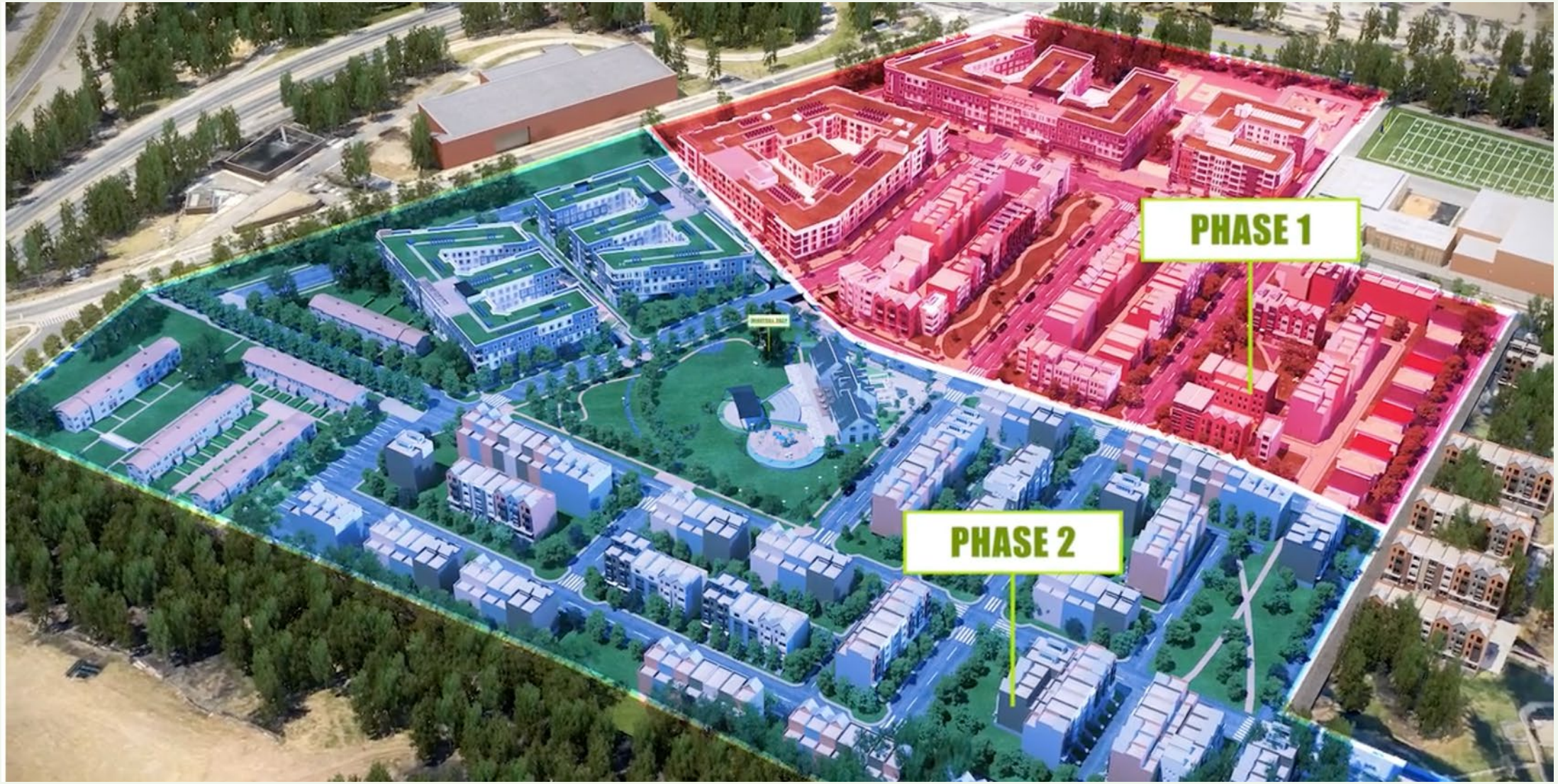
Proposed Barry Farm

BARRY FARM – REDEVELOPMENT

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing



BARRY FARM – REDEVELOPMENT

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

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BARRY FARM – REDEVELOPMENT

Passive to **POSITIVE**
PASSIVE HOUSE AND LOW IMPACT DESIGN

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BARRY FARM – REDEVELOPMENT

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

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BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

Team

Developer:
Preservation of Affordable Housing
Architect: **EDG**
Structural: **Wolfman and Associates**
MEP: **Engenium Group**
Civil: **Bowman Consulting**
Landscape : **Bradley Site Design**
Passive House Consulting:
Passive to Positive

Program

99,058sf
108 units of affordable, senior housing, first floor amenities and retail space

Program

99,058sf
108 units of affordable, senior housing, first floor amenities and retail space

Stats

Certified PHIUS 2021 Certification
EUI 13.4 kBtu/sf yr

Roof-top solar array for further reductions of operational energy.

Phase

Under Construction

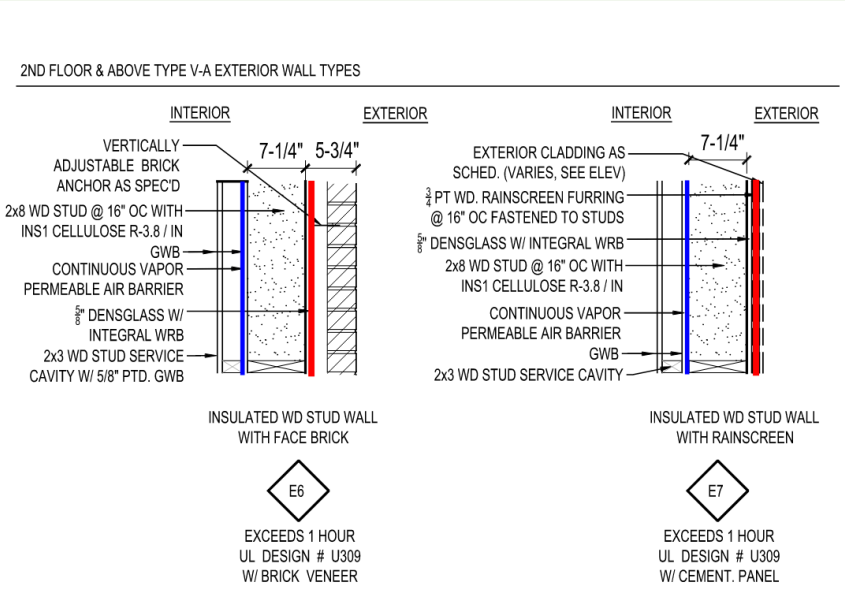
BARRY FARM – THE ASBERRY

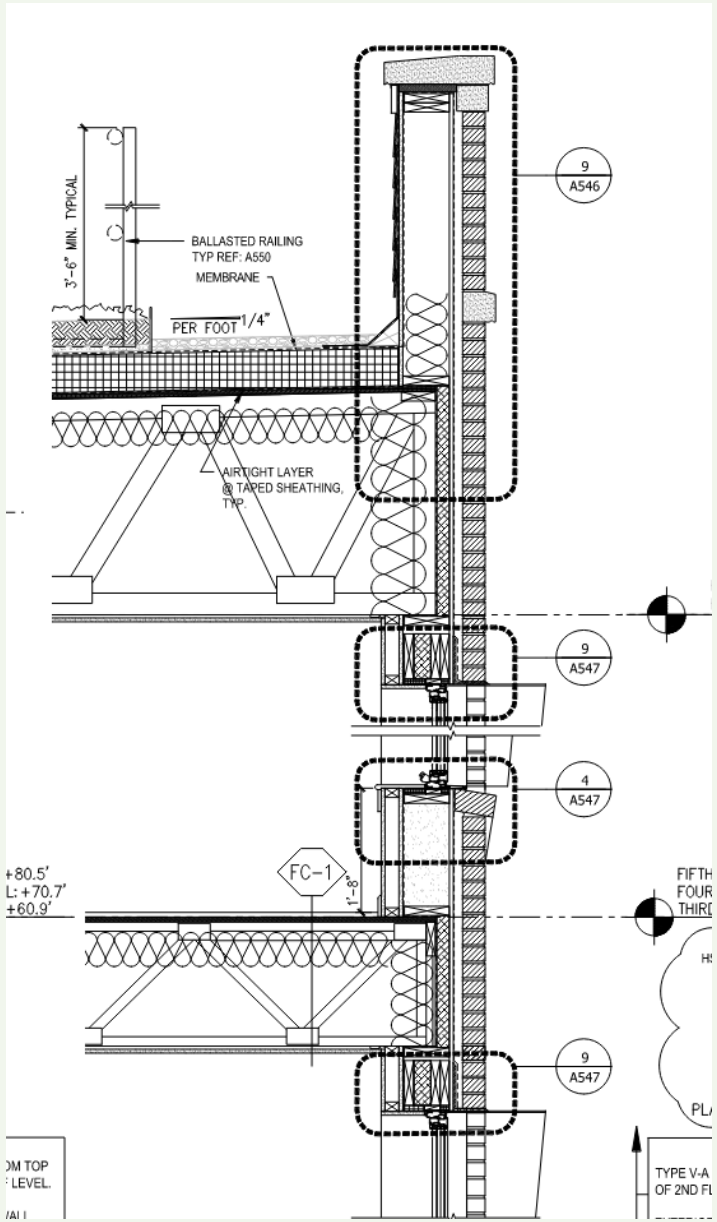
Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

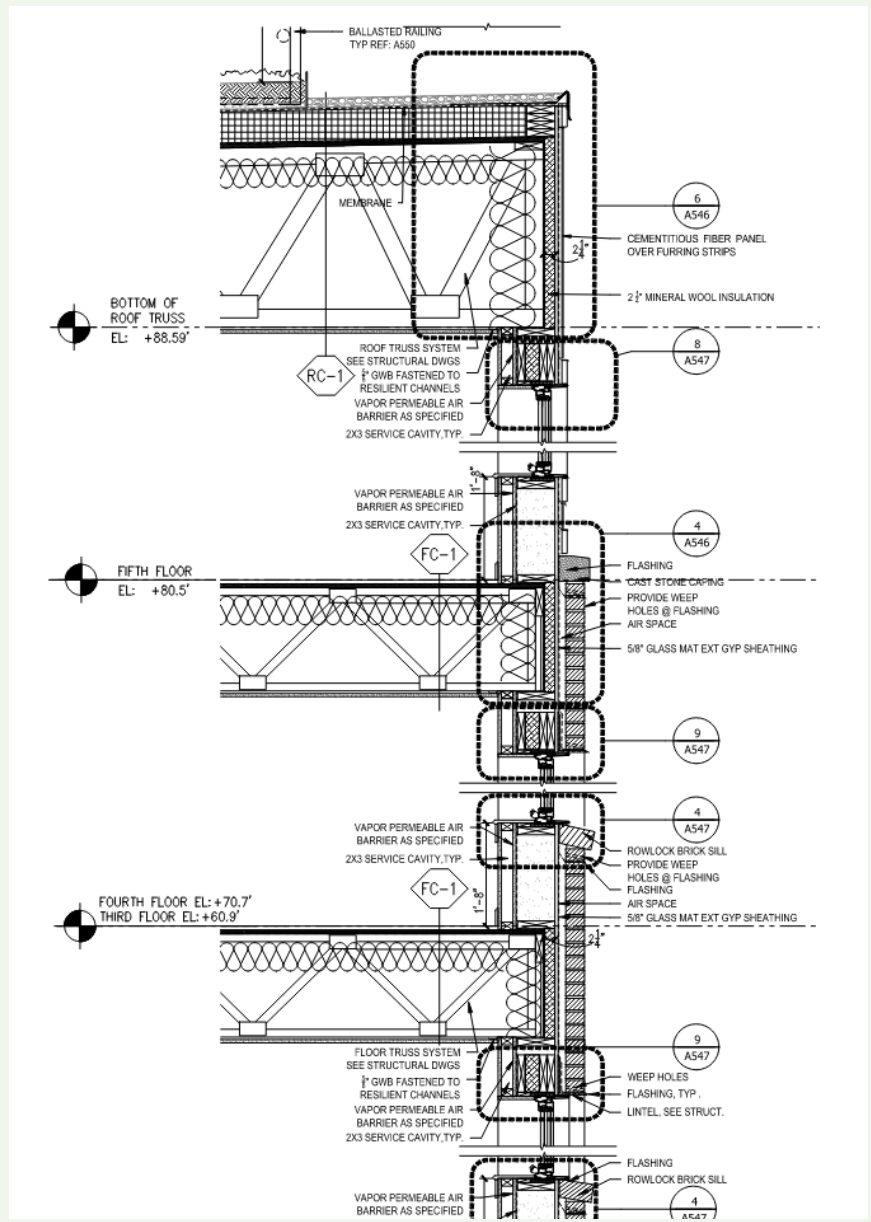
Preservation of Affordable Housing

Assemblies

What is missing here?







BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

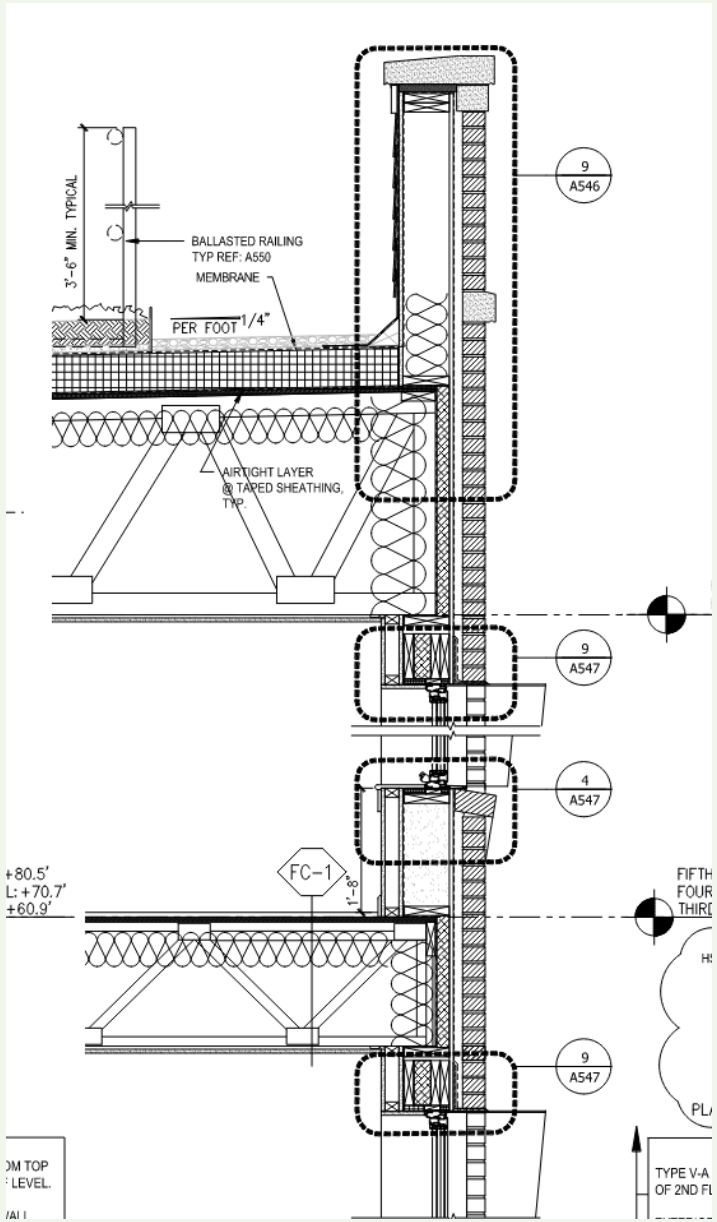
Assemblies

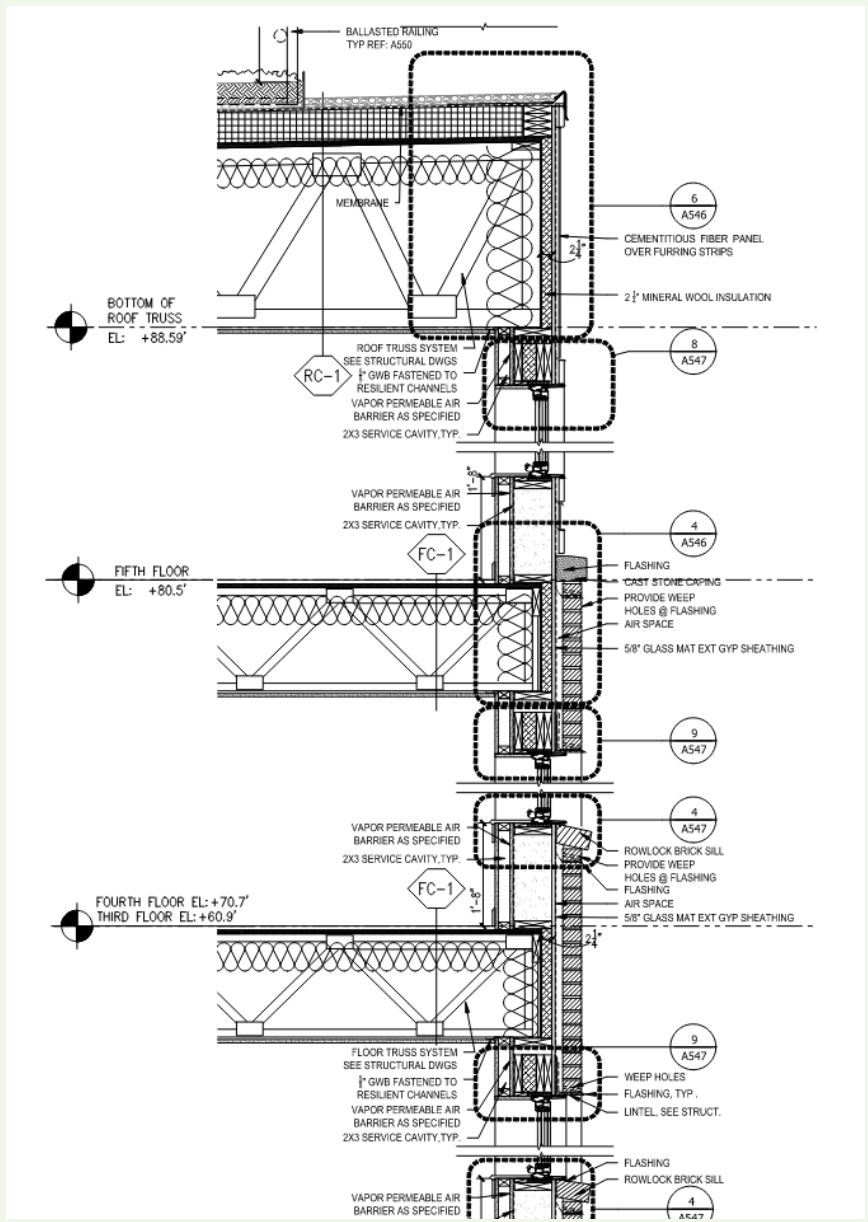
What is missing here?

No external CI

Perceived benefits

- One time around the building
- No long fasteners
- No thermal break materials





BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

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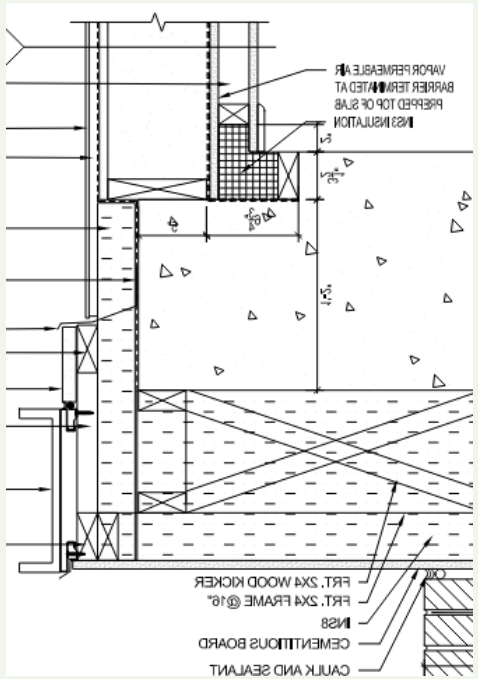
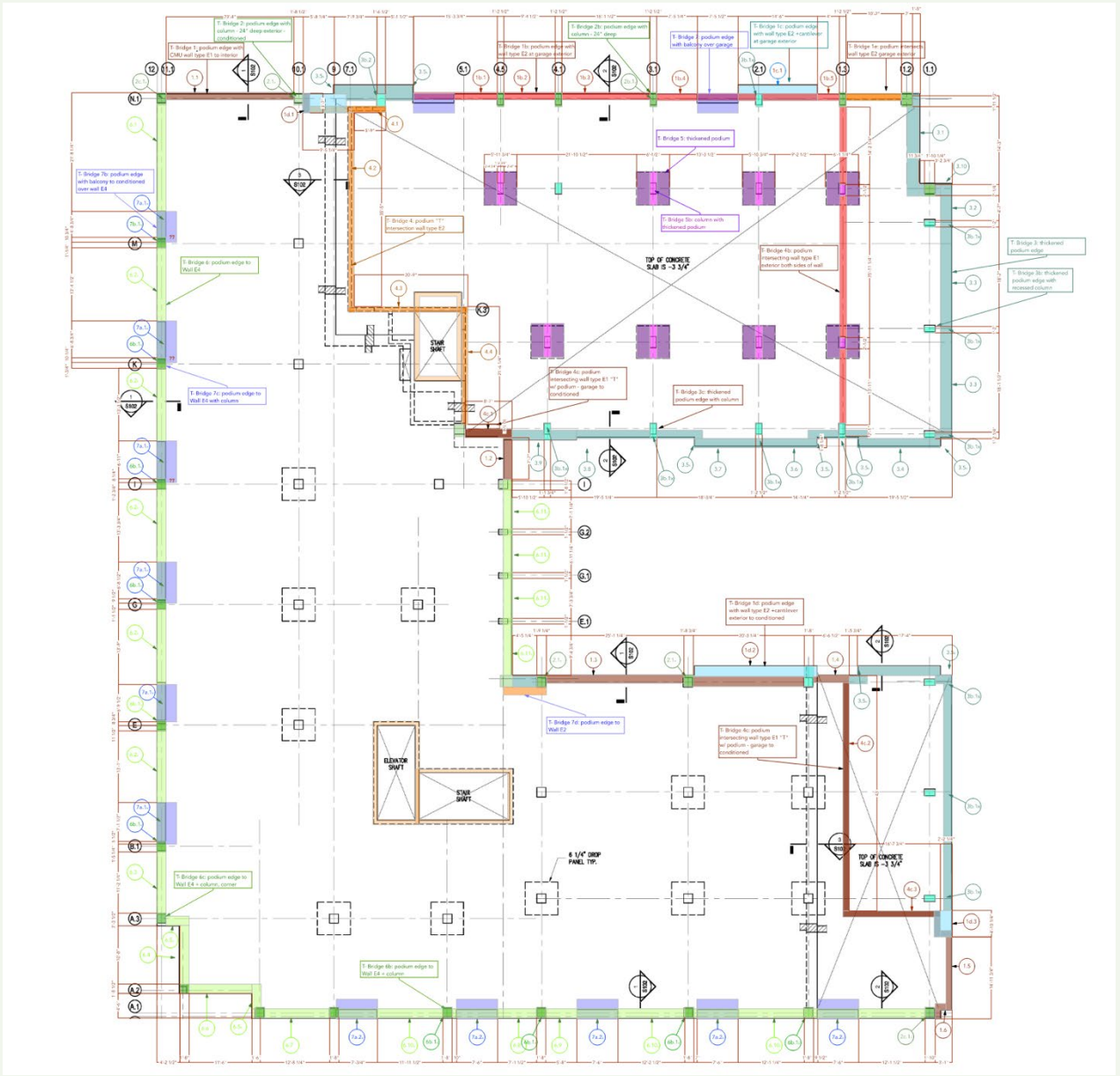
Assemblies

Lessons Learned

- Alternative resolution of perimeter detail
- That is a lot of bridges!
- Single cavity walls simplify assembly but complicate connections

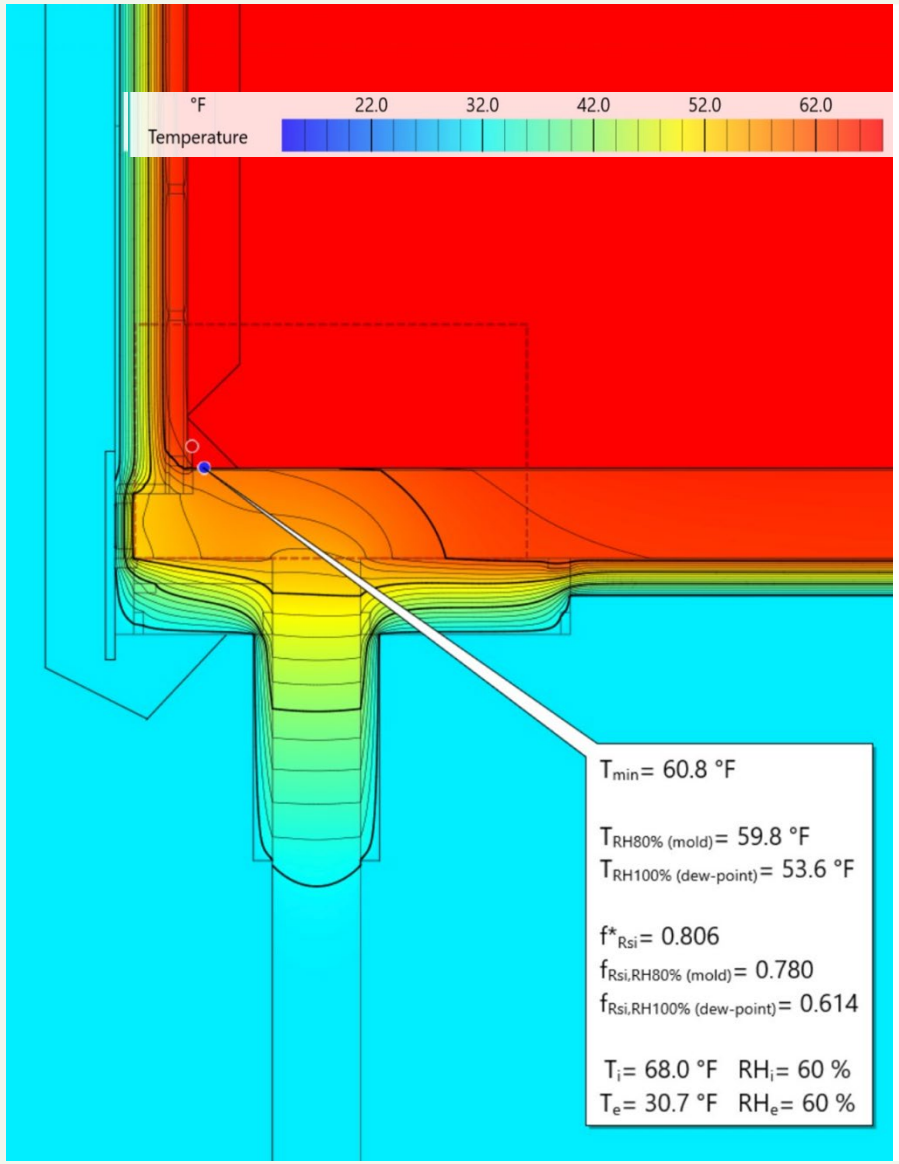


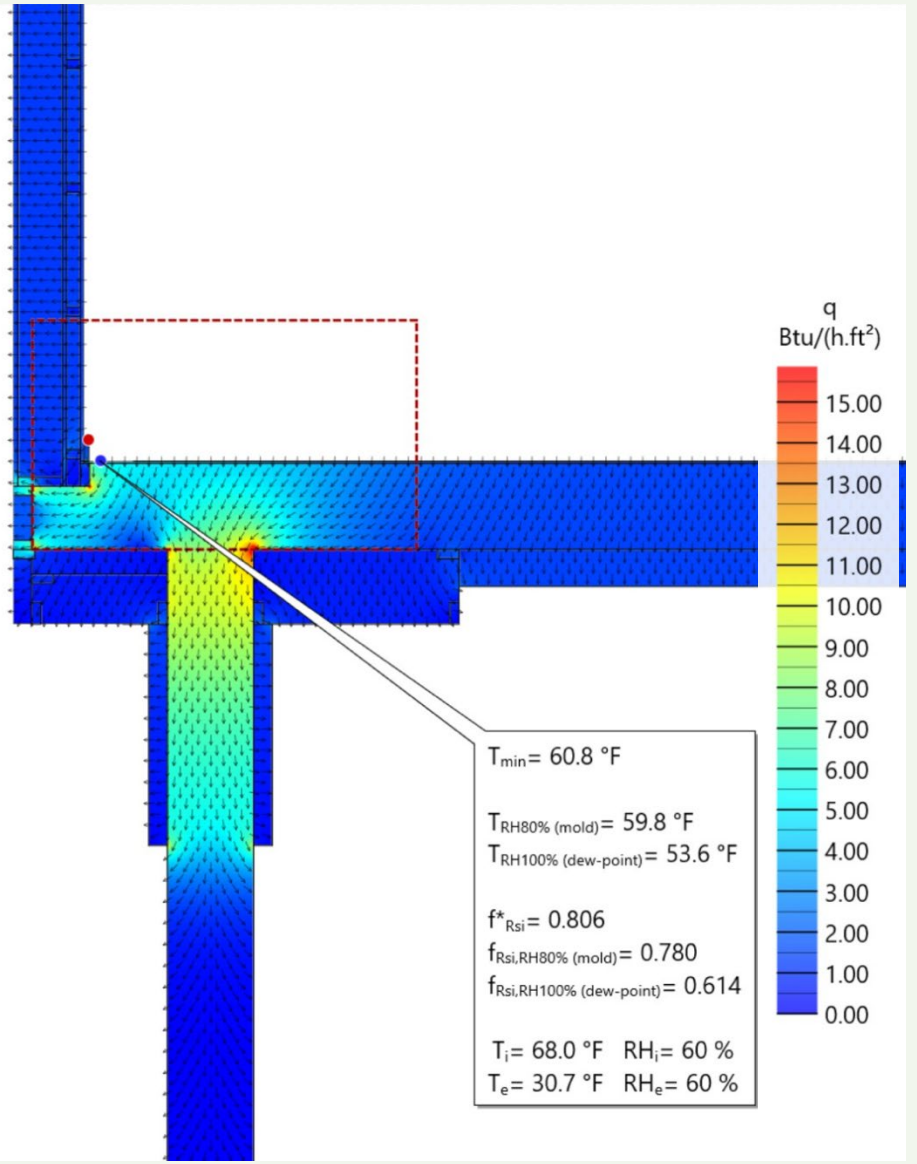


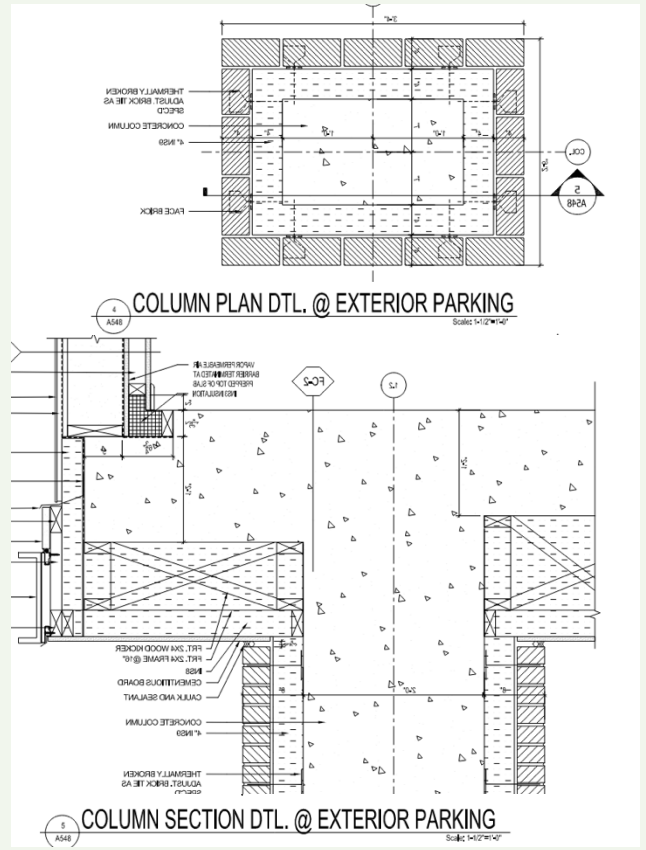
BARRY FARM – THE ASBERRY

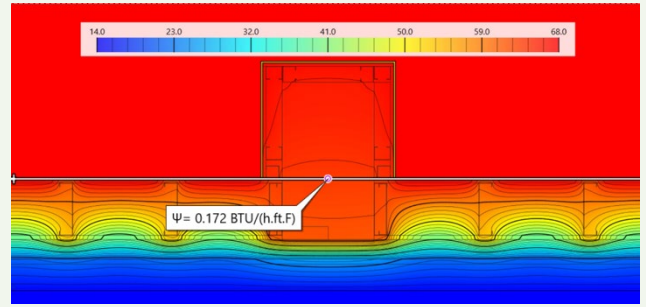
Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing









Lessons Learned. - Simplifying walls, complexifies connections. - balance of reducing heat loss + avoiding mold risk

BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

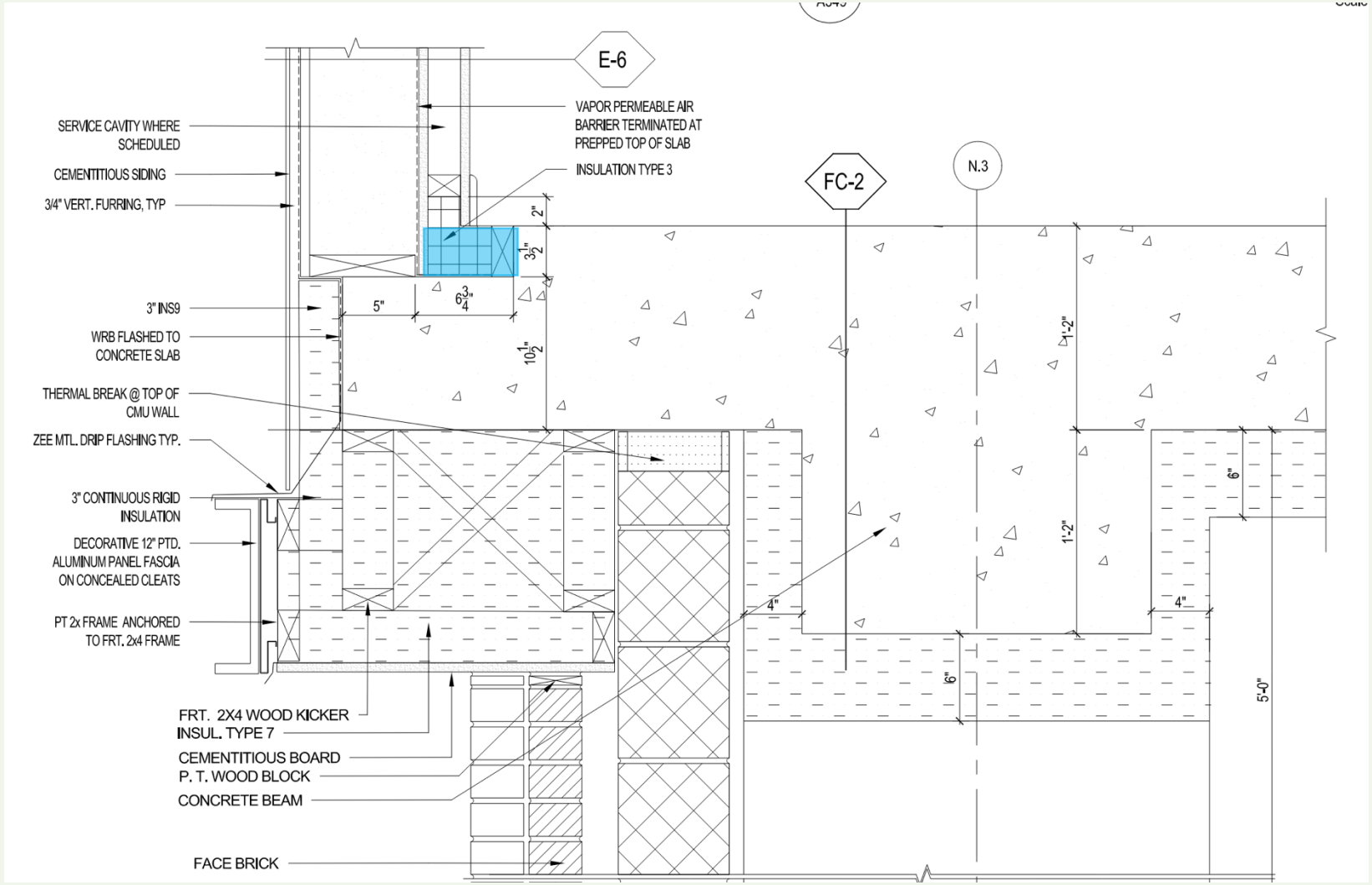
Preservation of Affordable Housing

Assemblies

- Originally to be pre-fabricated by Blueprint w/ windows installed

Lessons Learned

- Panelized – no windows = Mini- water troughs everywhere during construction



BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

Alpen Zenith

Outswing casements saves space for furniture

Built in reveal extension

Alpen Ribbon Windows

Look good – perform well

Don't have doors (we used YKK for doors and side-lites)

Dual Chamber

Found in our Zenith Series ZR-5, ZR-6 and ZR-7 windows, these triple-lite/Argon or Krypton gas IGUs deliver outstanding thermal performance, providing U_{cog} values to 0.11 at the most affordable price points.

Triple Chamber

When your project *needs* to deliver the highest levels of performance and comfort, these quadruple-lite/Krypton gas IGUs are found in our Zenith Series ZR-9 and ZR-10 windows, providing U_{cog} values to 0.06.

PH PHIUS LISTED

PHIUS PHIUS Window Certification

Declare.

First (ever) PHIUS Certified Window

BARRY FARM – THE ASBERRY

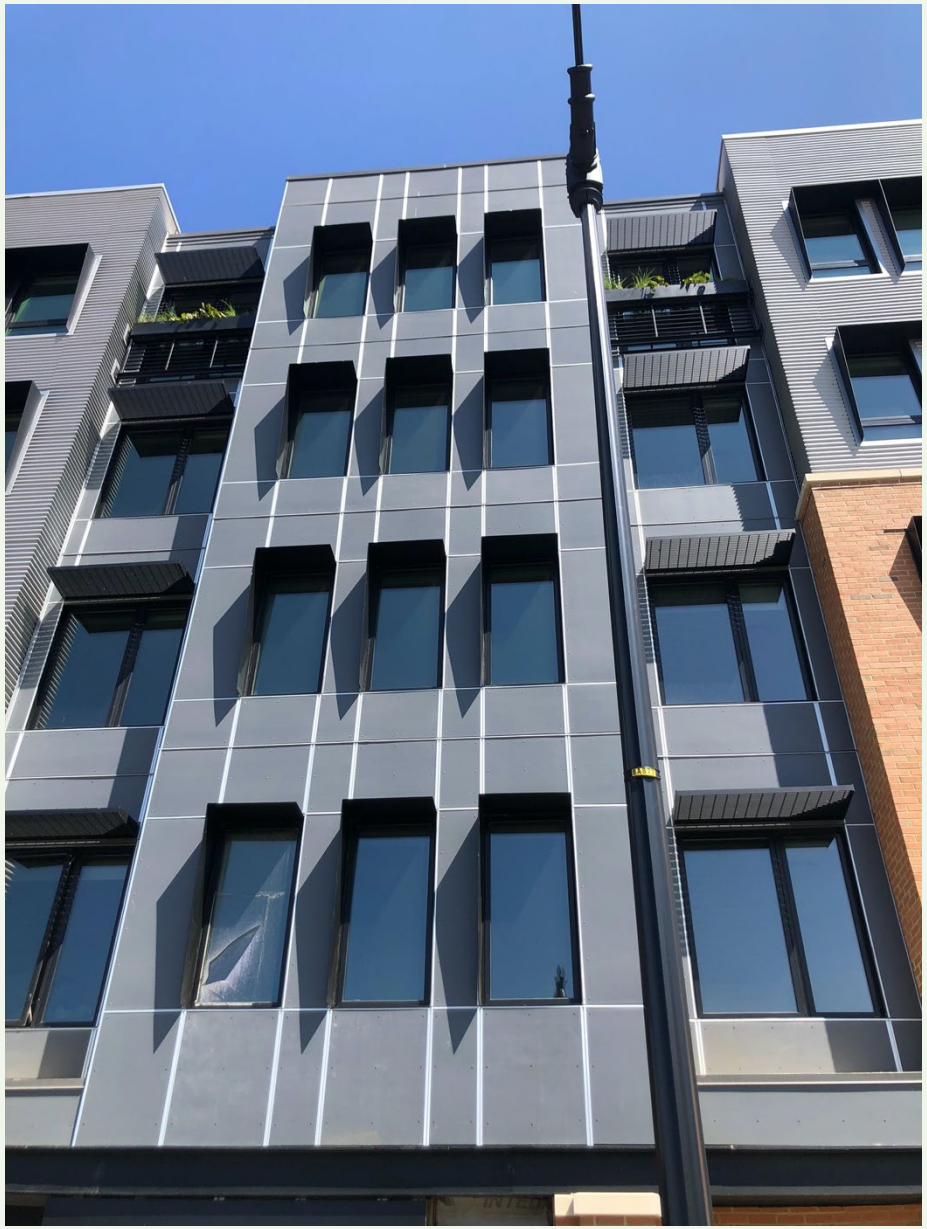
Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

Put the Passive back in Passive Building

Shading really matters!

- Localized Comfort issues
- Peak hour cooling loads



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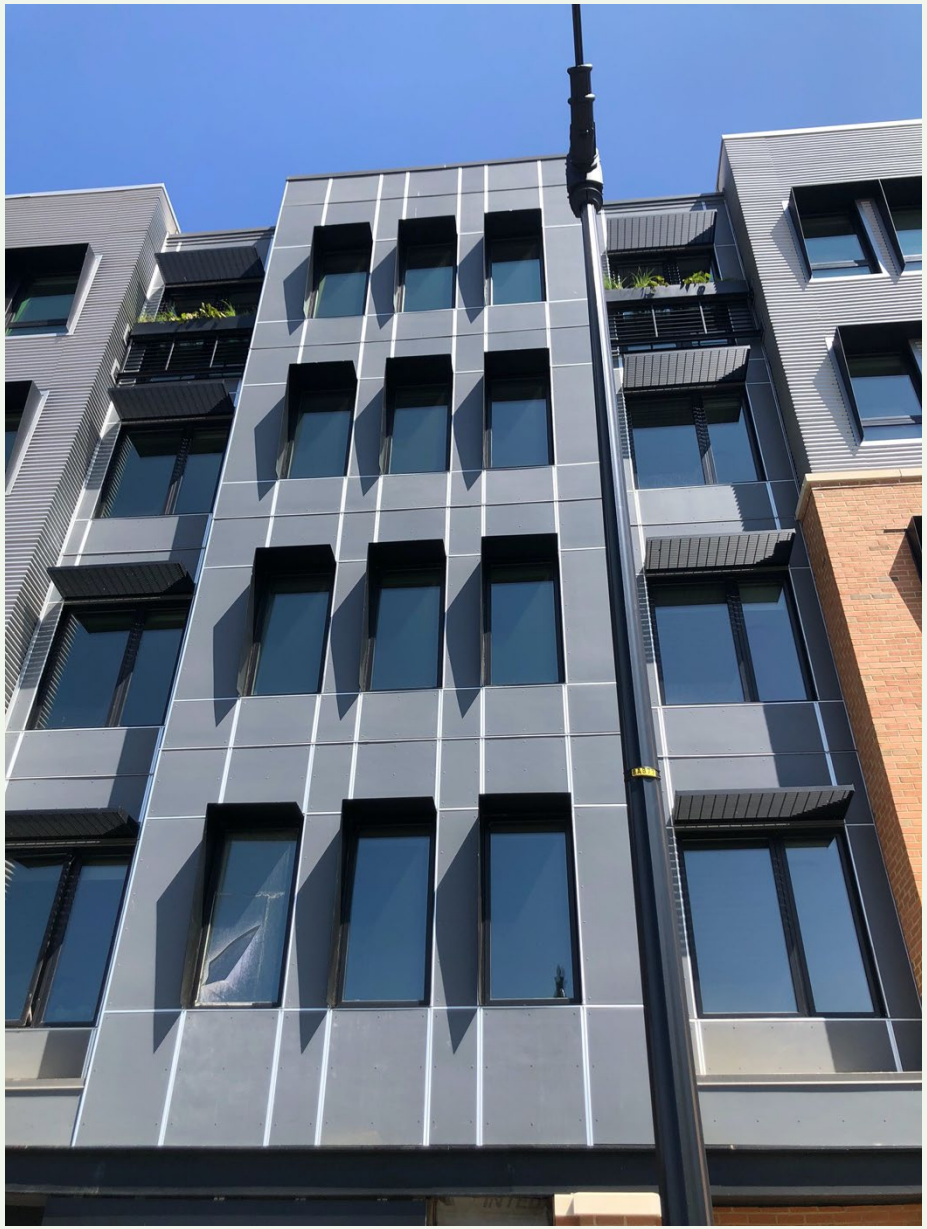
- It makes Andy really happy!



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Preservation of Affordable Housing

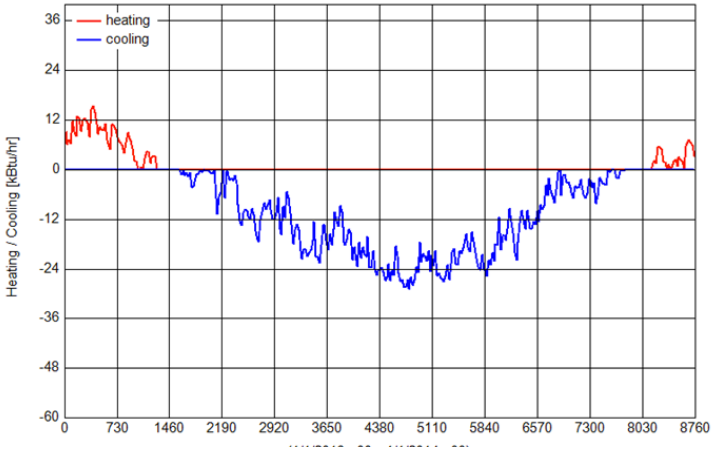
Put the Passive back in Passive Building

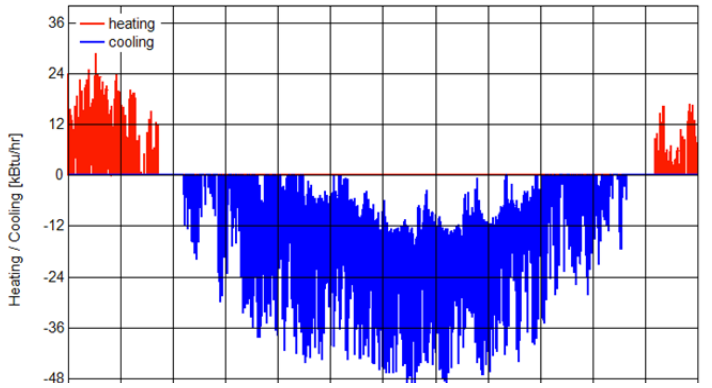
Shading really matters!

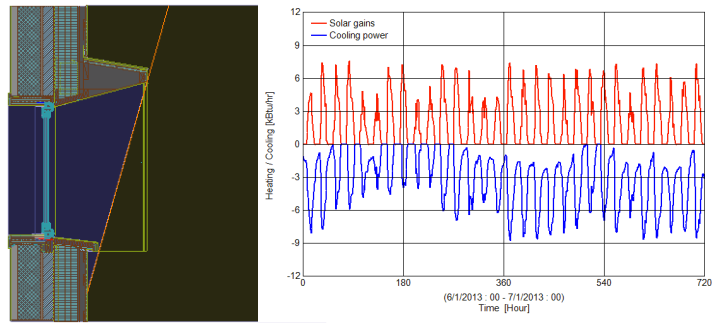
- Localized Comfort issues
- Peak hour cooling loads

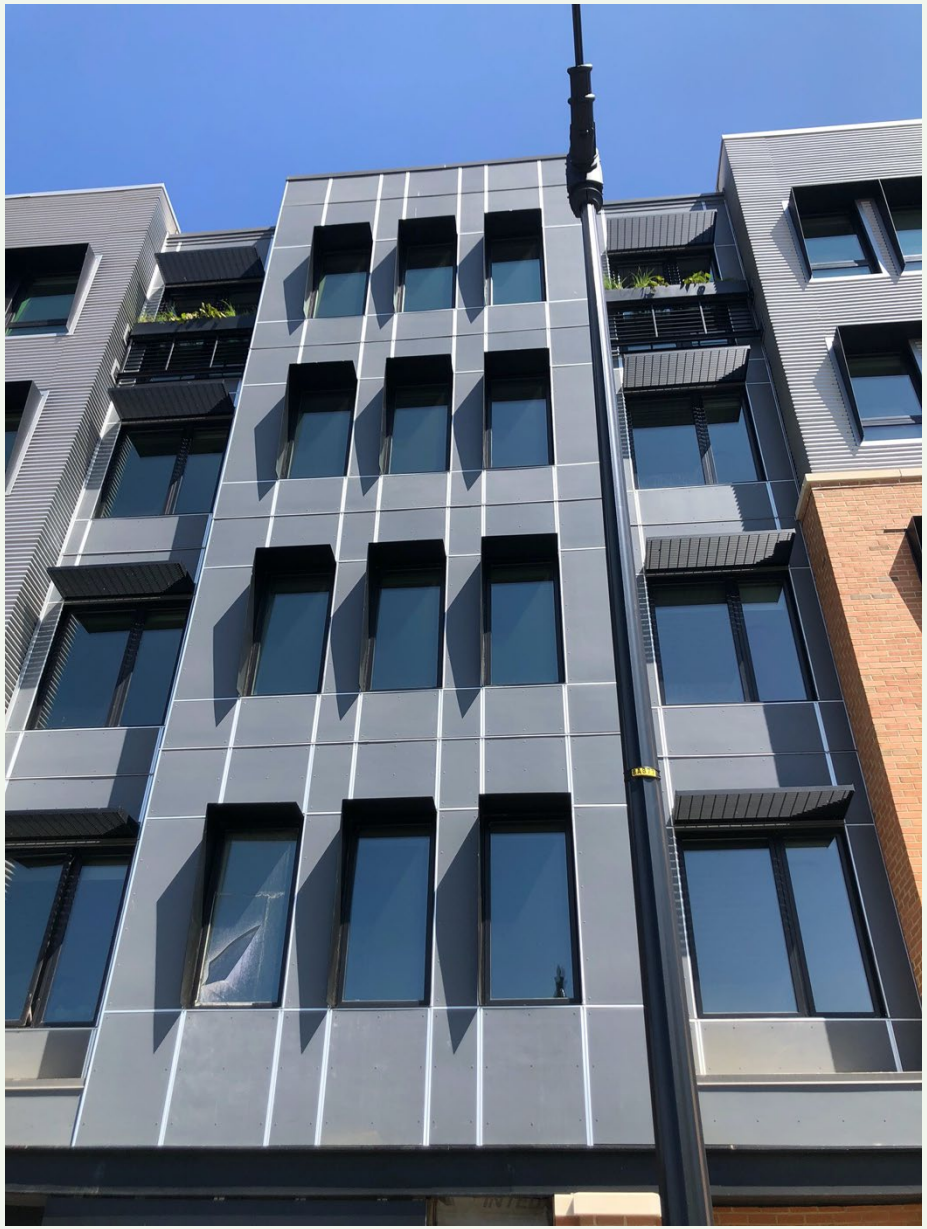
Lessons Learned

- During VE, Wufi Passive/Metr won't reveal these benefits !!
  - Peak hours are averaged out
    - WUFI uses averages of daily solar gain
    - WUFI uses average monthly high and lows
  - So Wufi shows miniscule benefit









BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

Shading

Lessons Learned

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  - Peak hours are averaged out
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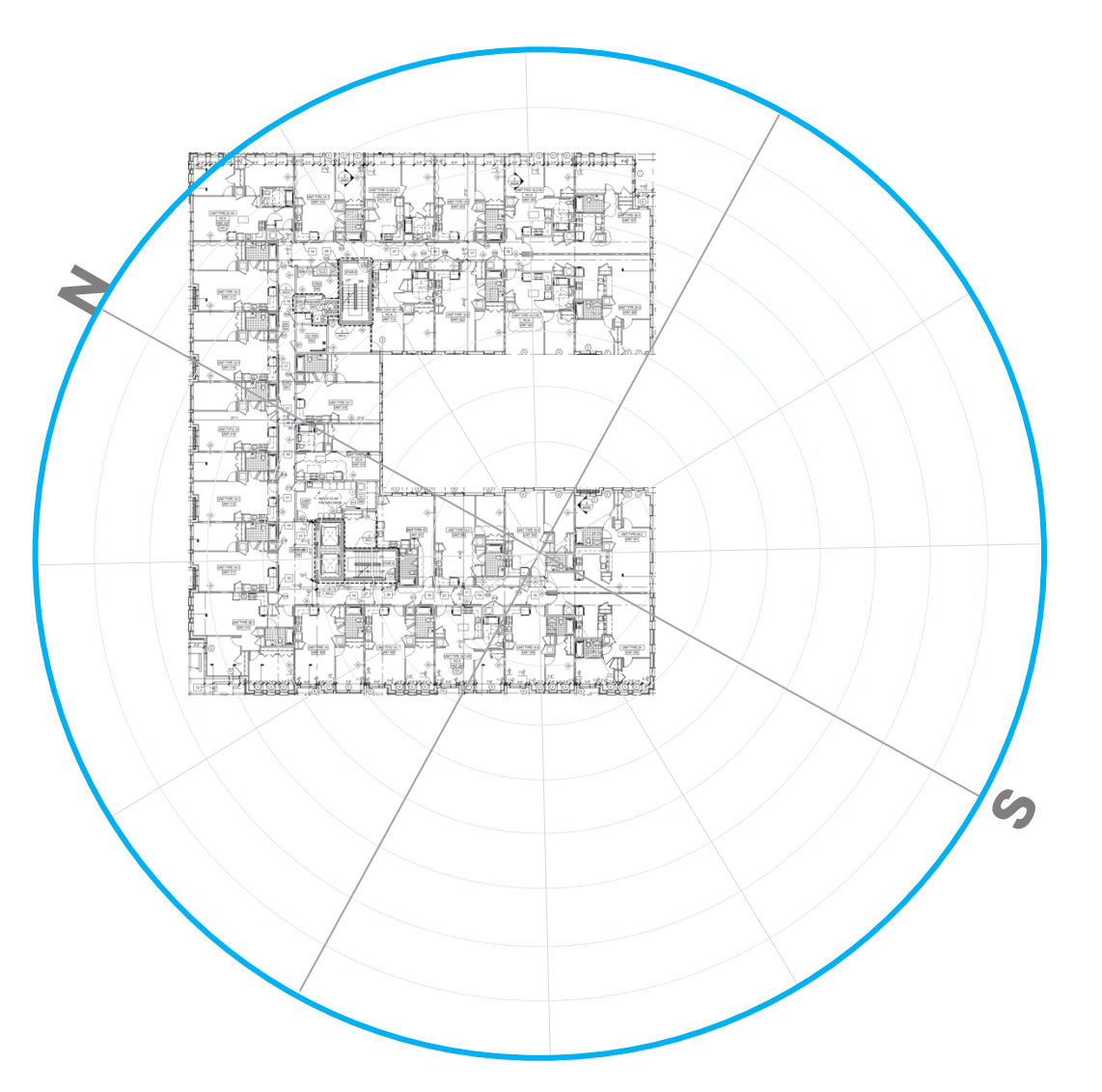
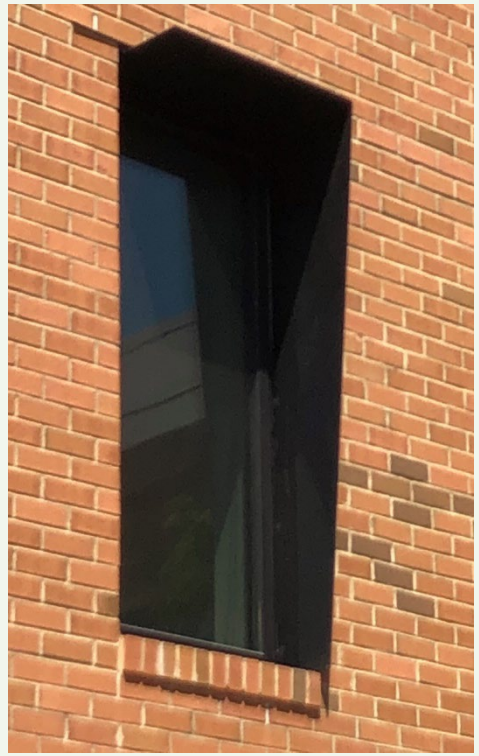
  - One zone models dilute the impact of localized comfort and peak demand





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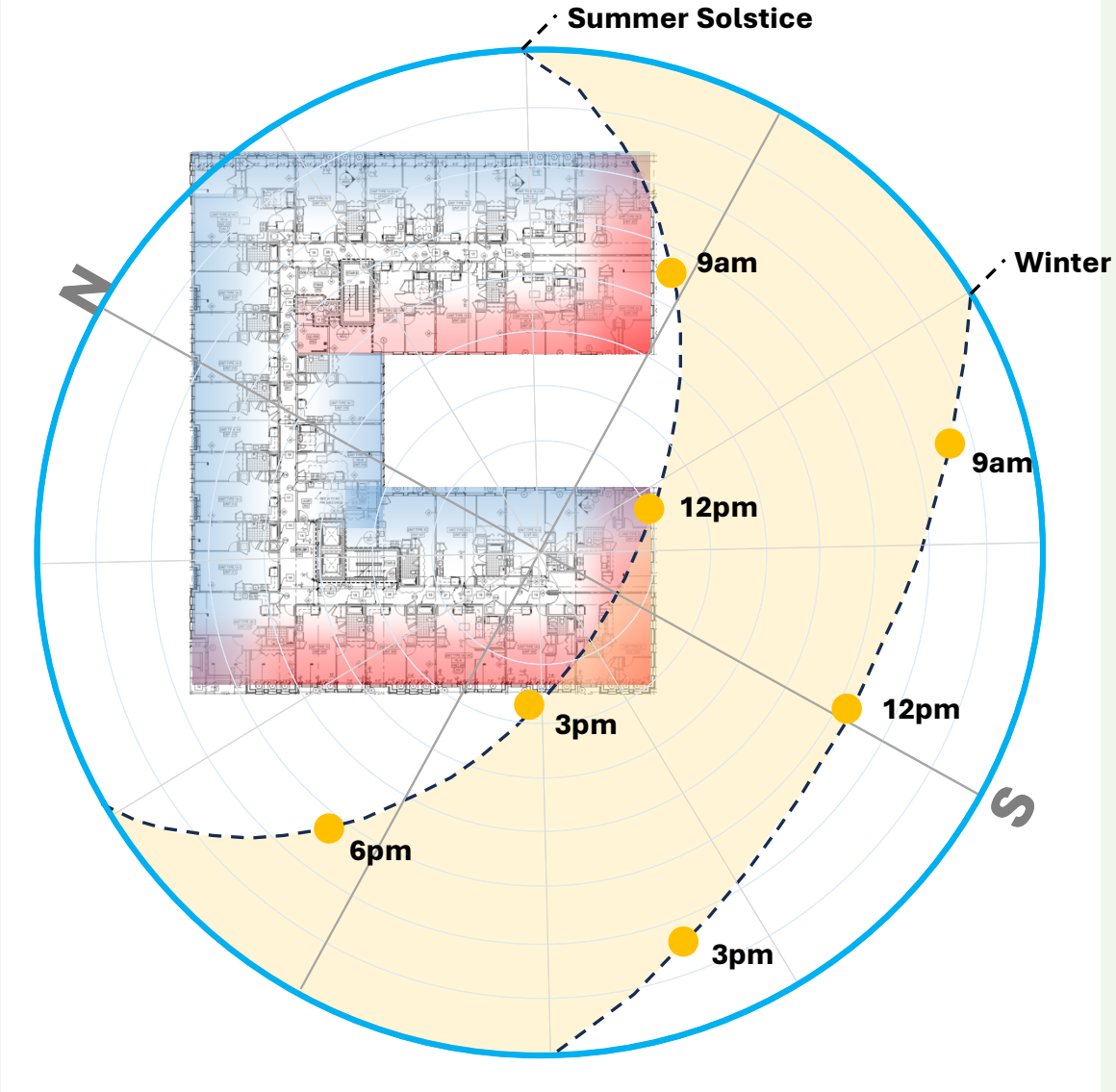

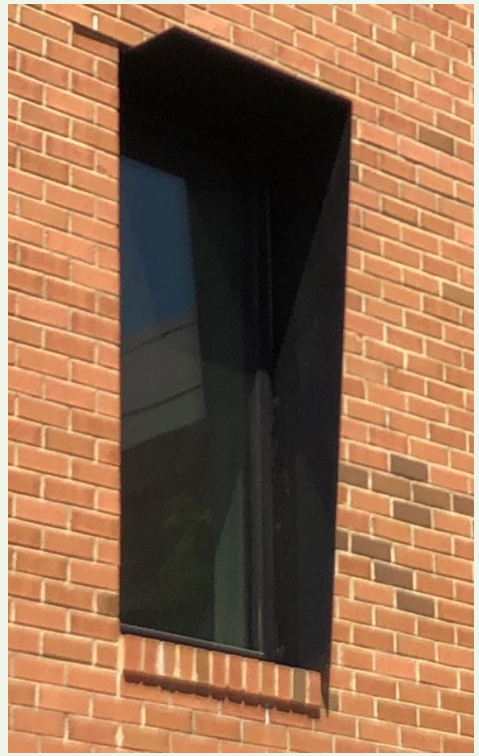

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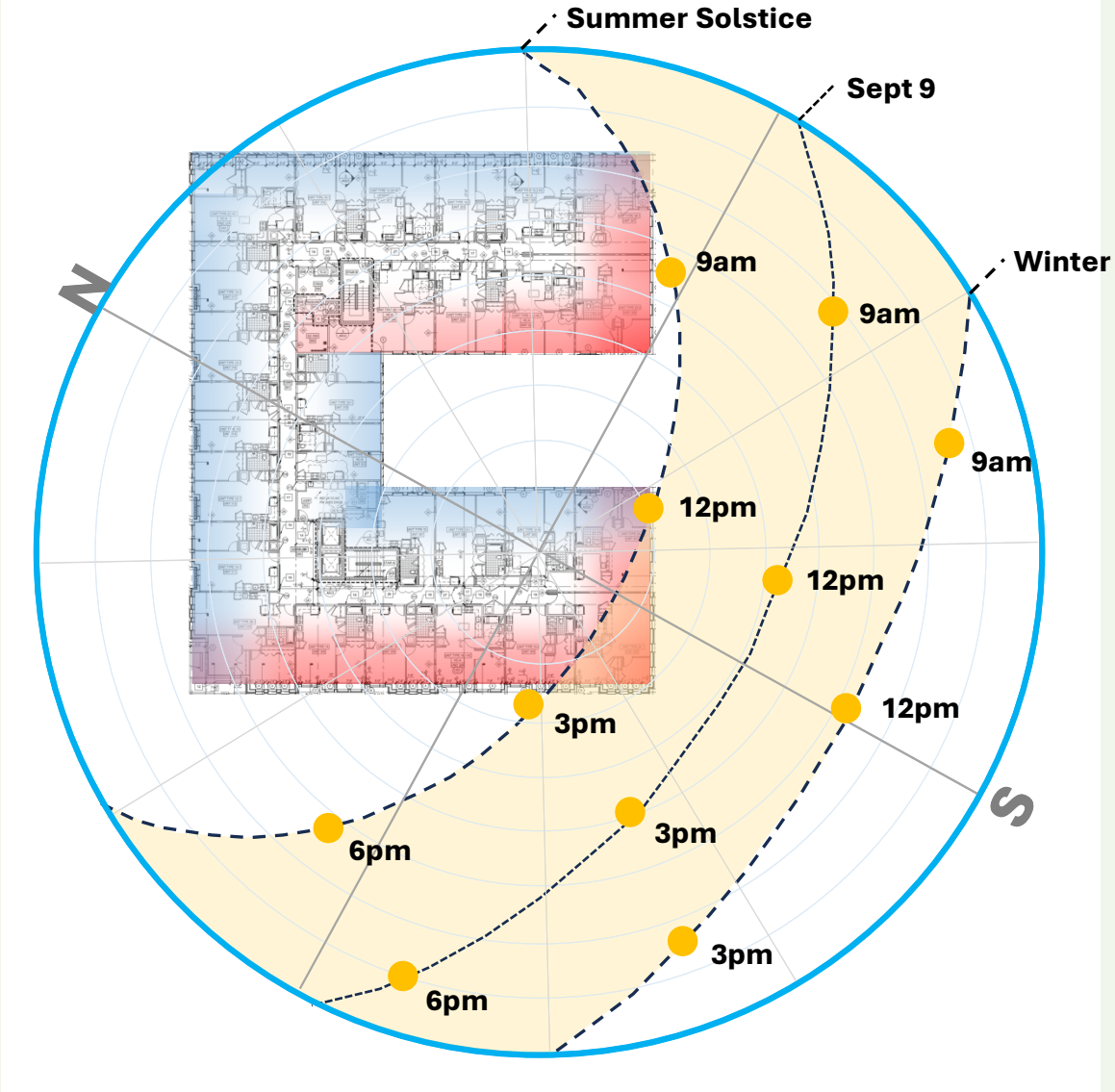

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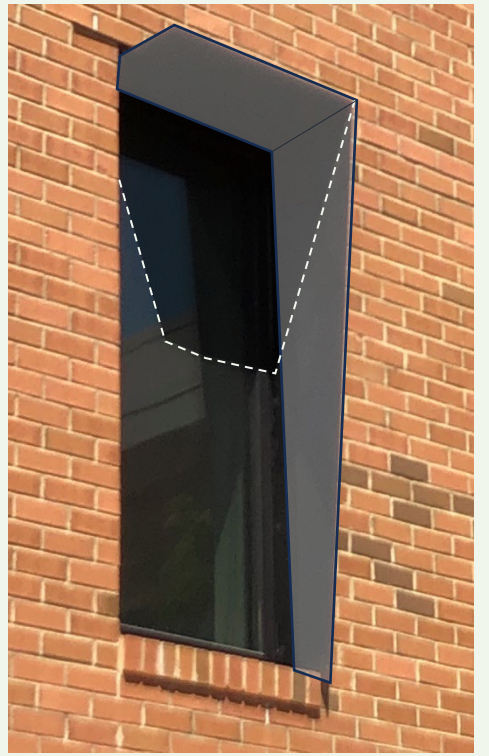


BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

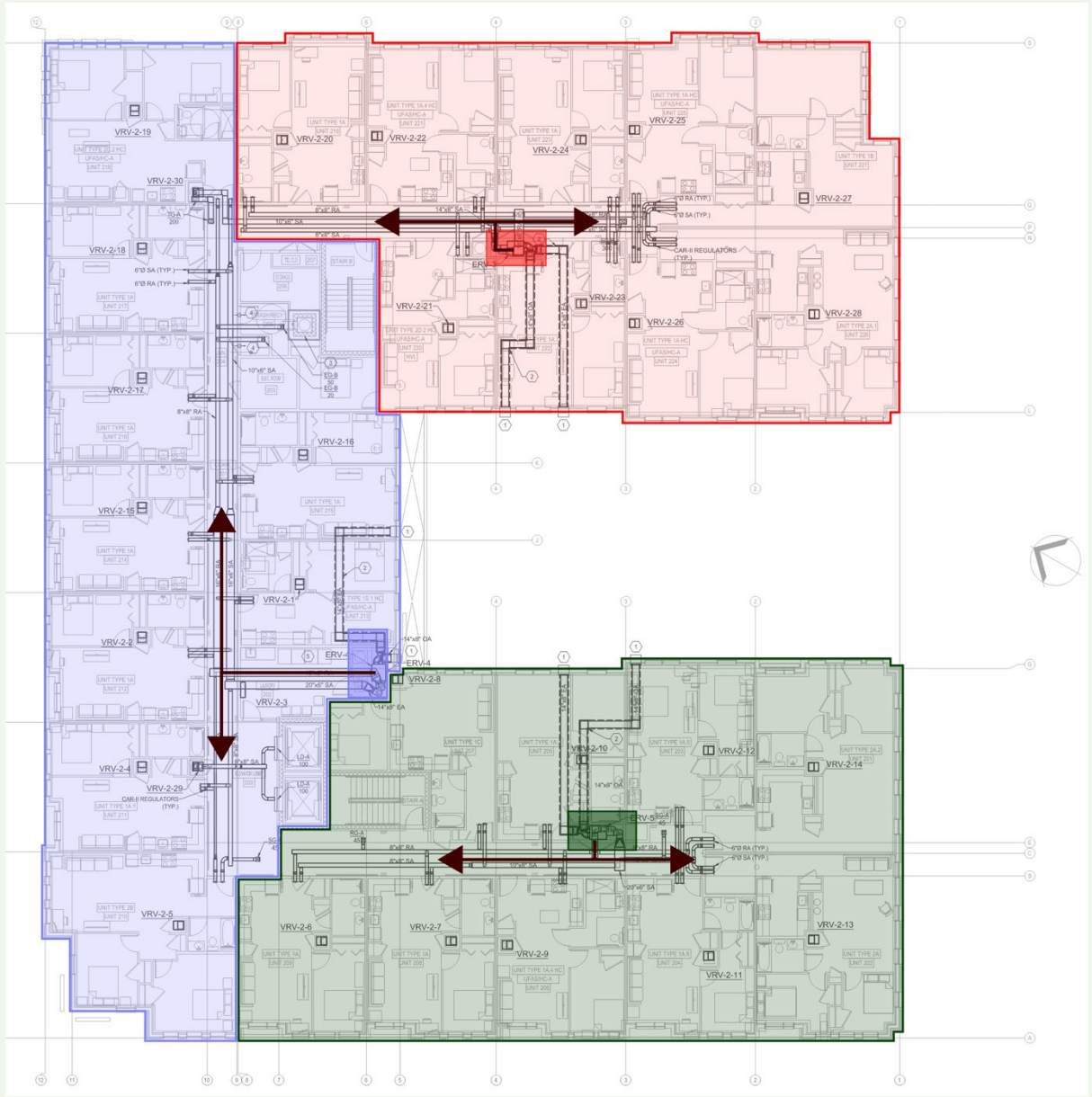
Balanced Ventilation

3 Neighborhood DOAS units per floor

+ Common Space

Each DOAS serves 9 Units / 10-12 Beds

200-500 CFM per DOAS



BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

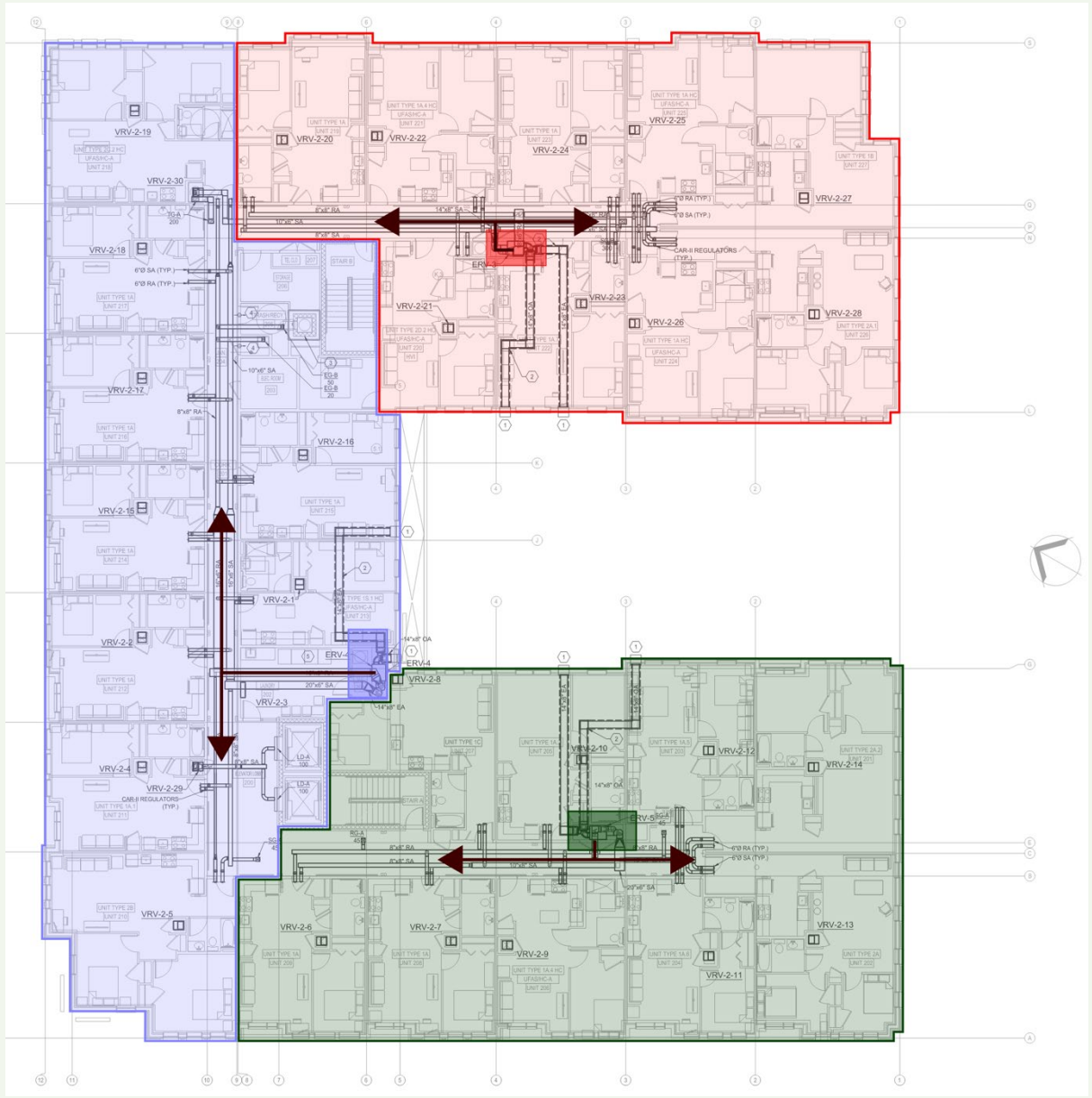
Preservation of Affordable Housing

Balanced Ventilation

3 Neighborhood DOAS units per floor

Perceived benefits

- reduces the size of ductwork
- Enthalpy controlled by-pass
- Greater humidity control



BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

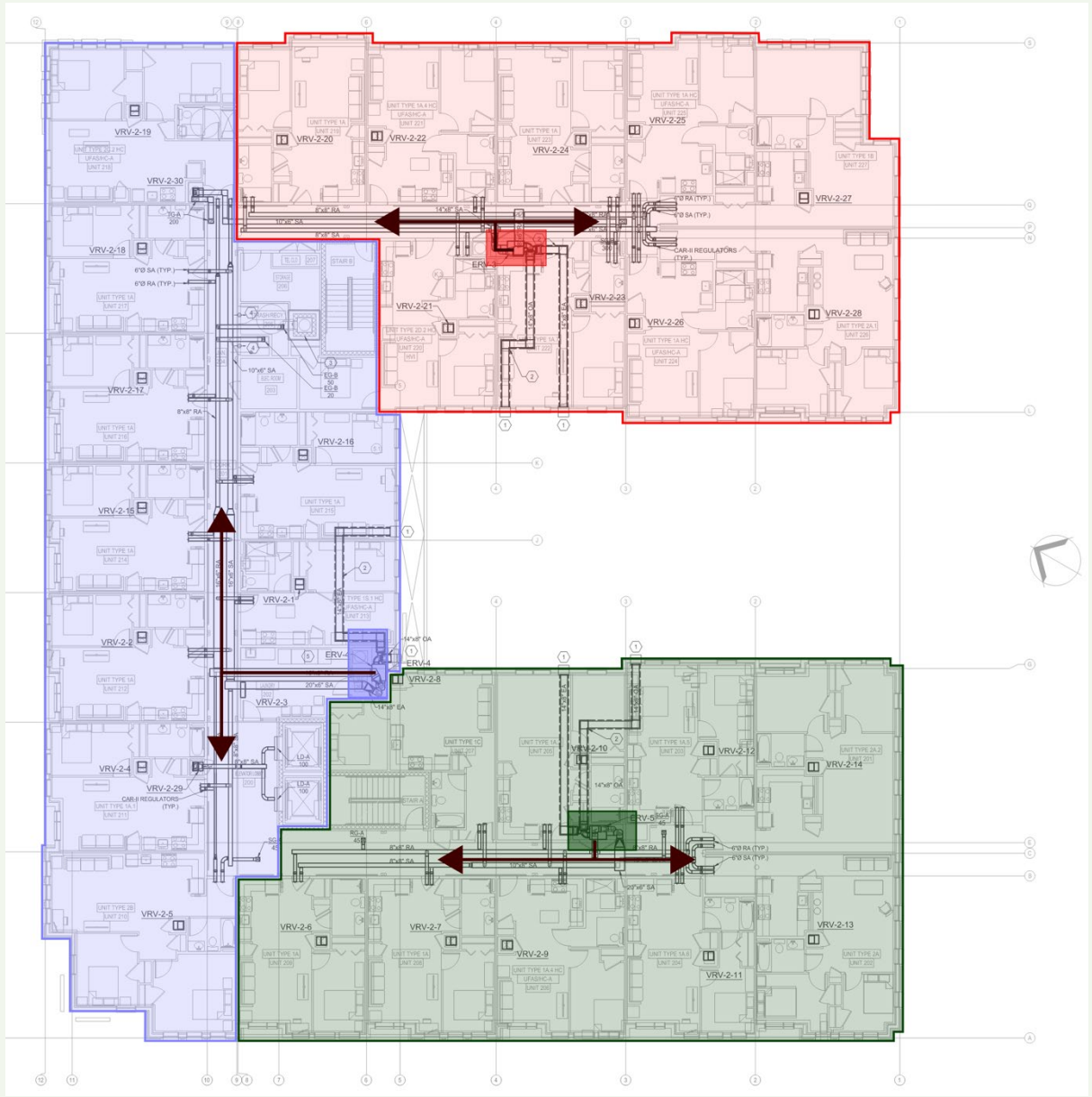
Preservation of Affordable Housing

Balanced Ventilation

3 Neighborhood DOAS units per floor

Lessons learned:

- DOAS/ERV Capacity must be over-sized
  - Phius requirements are “equal or greater than”, not +/-
  - Review MEP docs carefully
- CAR dampers - ?!
  - Set wrong – Backwards?



BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

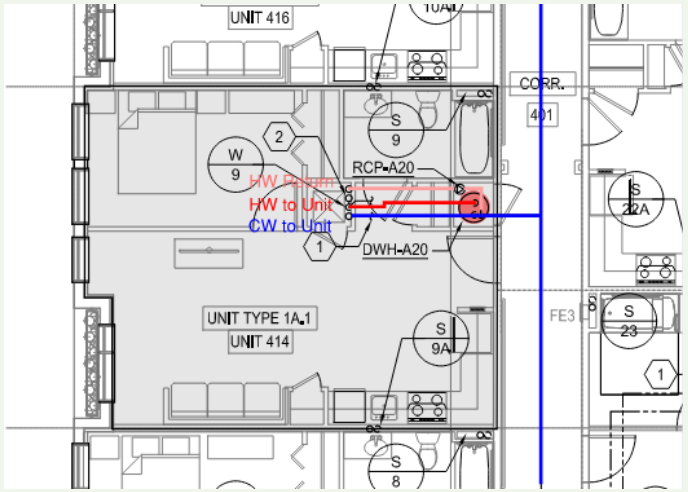
Domestic Hot Water

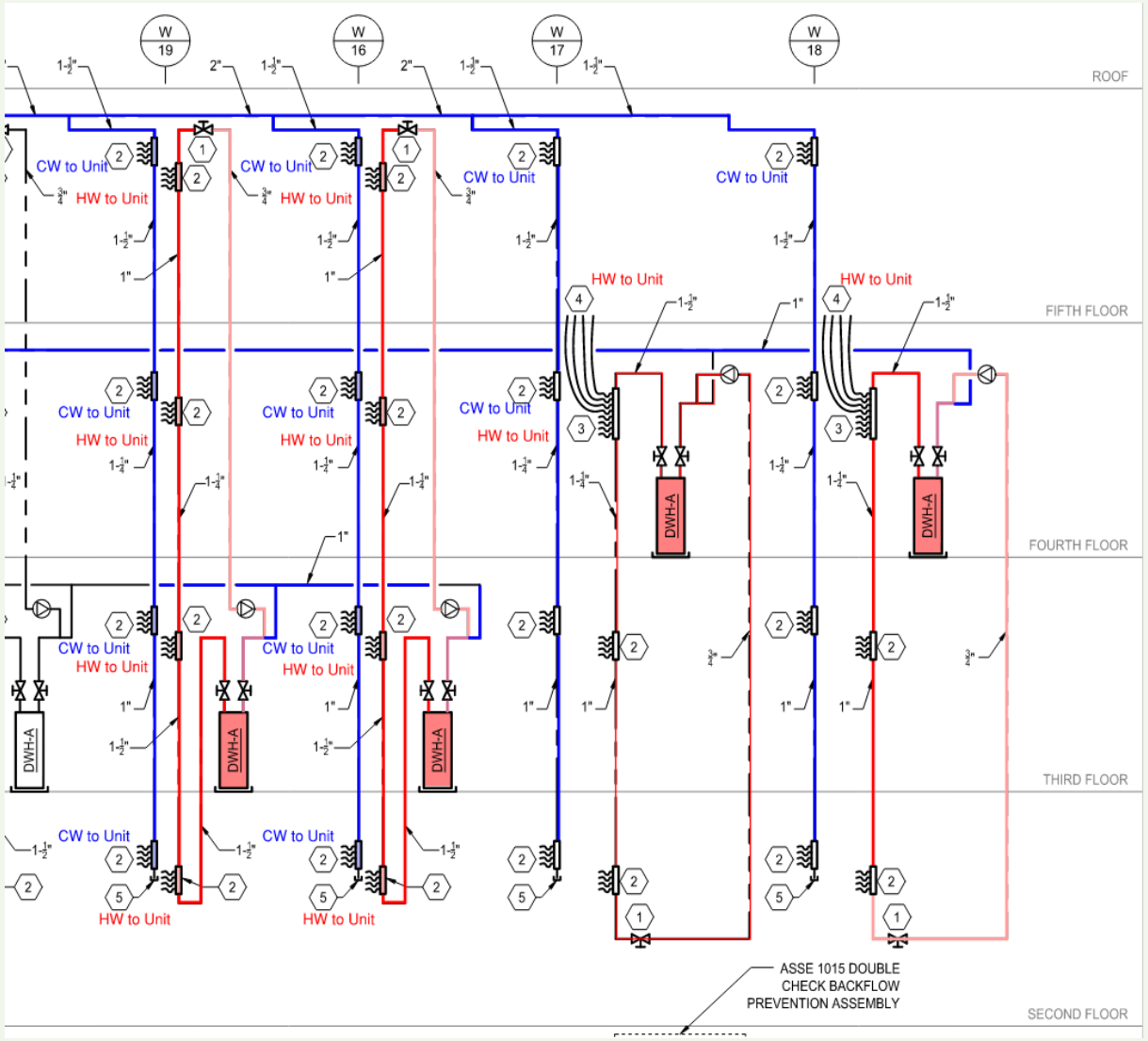
Heat Pump Water Heaters

Corridor-facing mechanical closets

serving vertical 4-unit stacks

HPWH's Split between two floors





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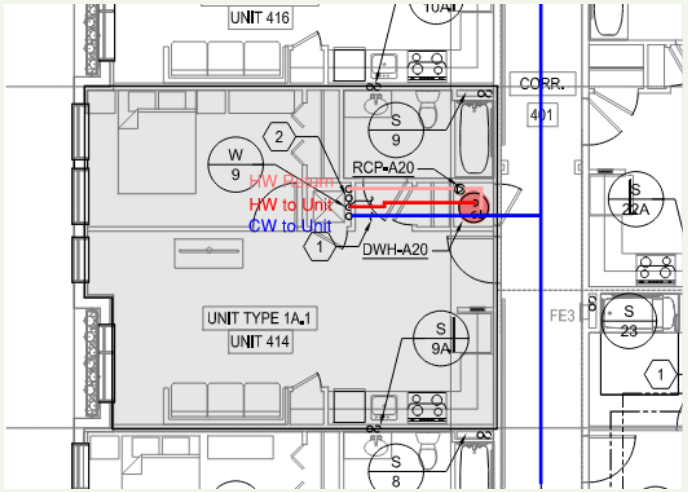

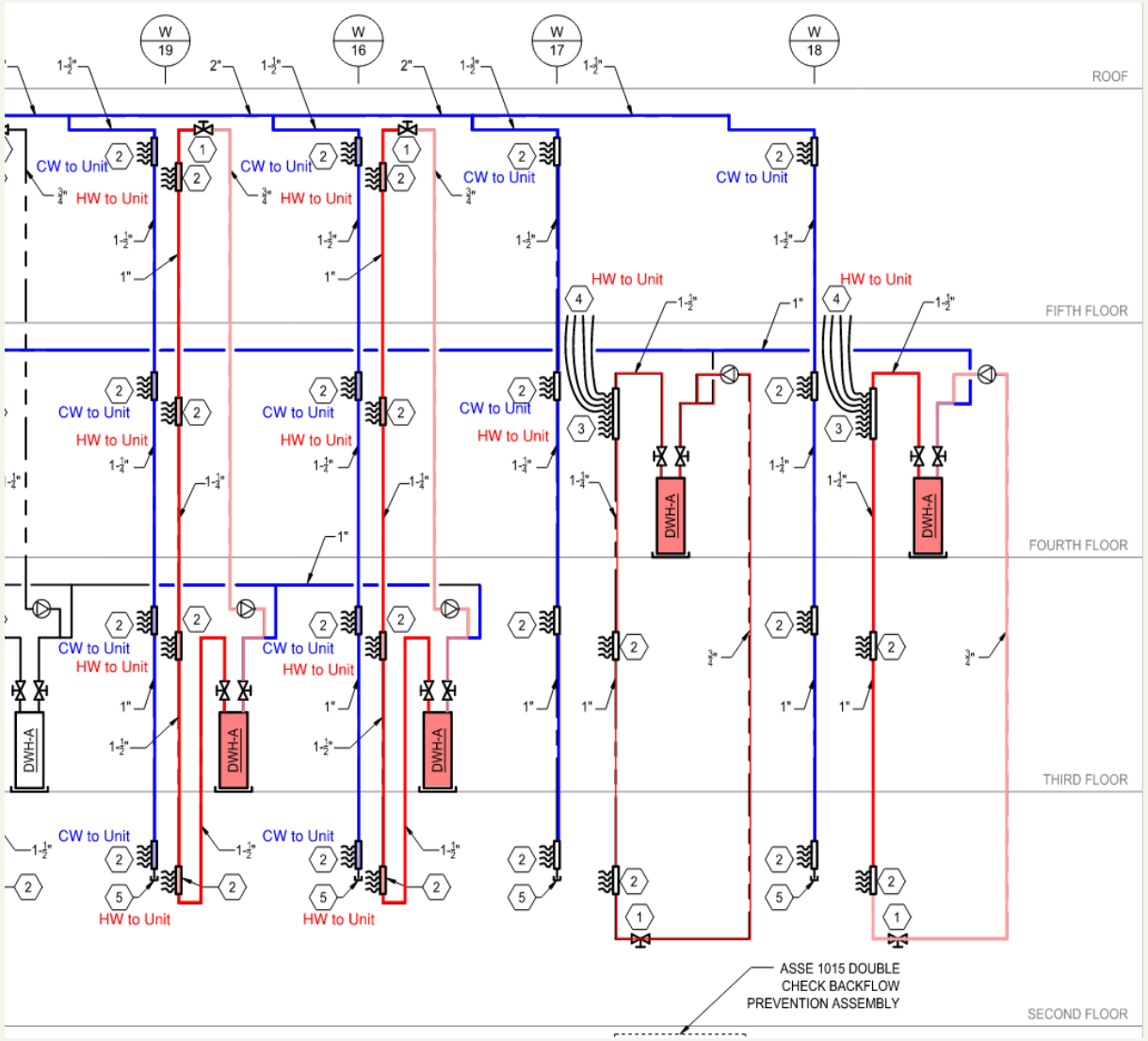

BARRY FARM – THE ASBERRY

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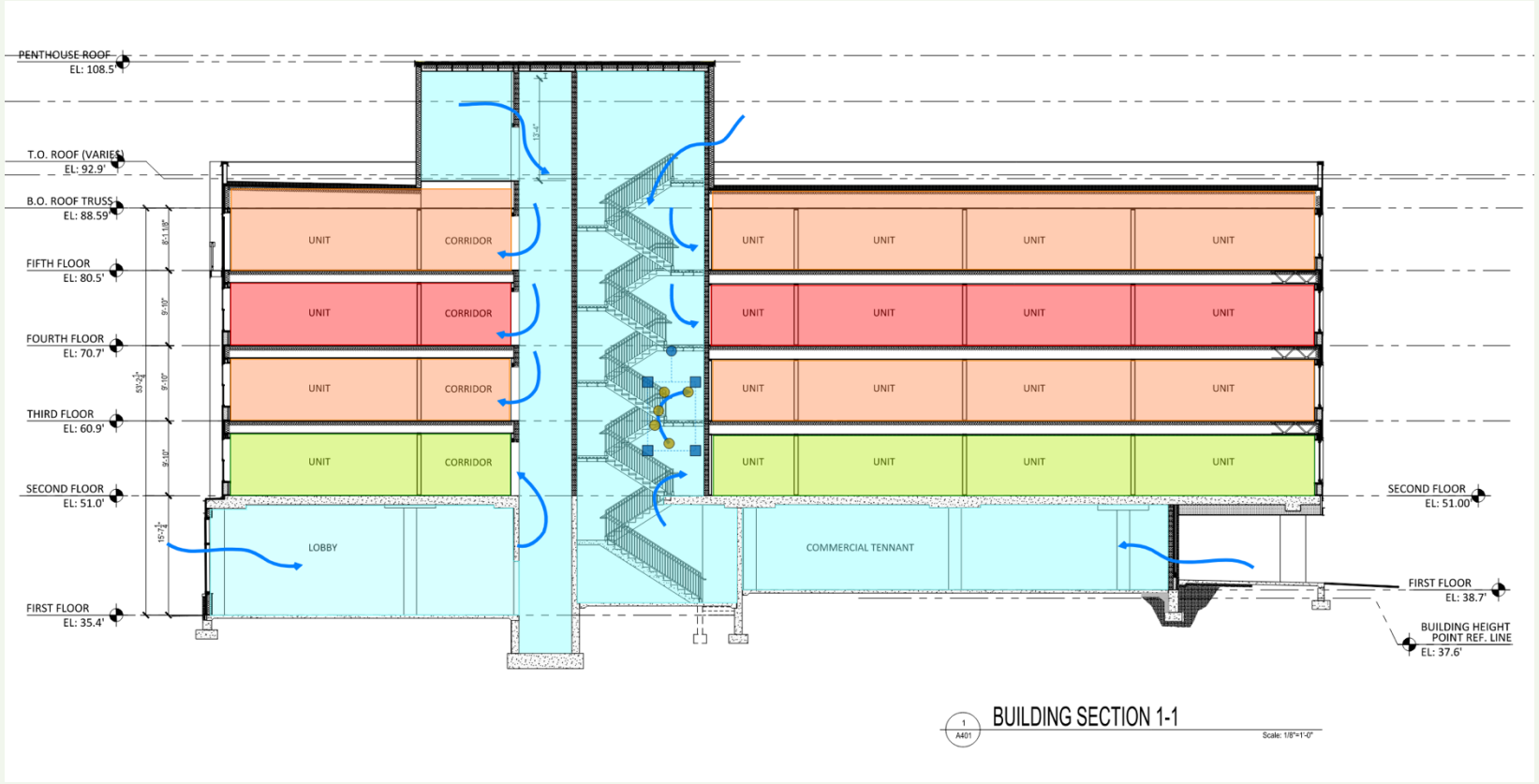
Preliminary Blower Door Test?

Not so simple . . .

Lesson learned

- Sequencing of whole project is affected by the need for a preliminary test.
- Guarded blower door testing is hard on a project of this scale



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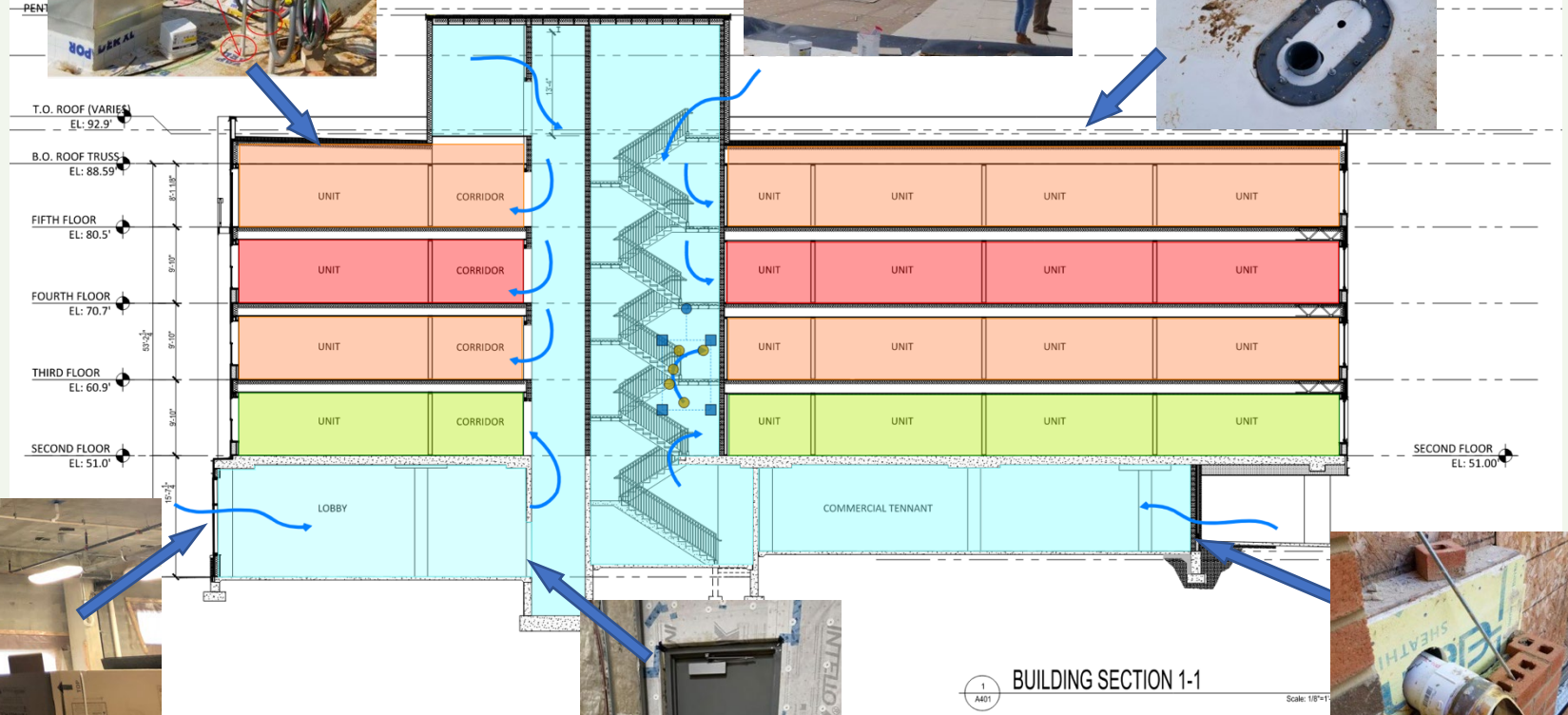

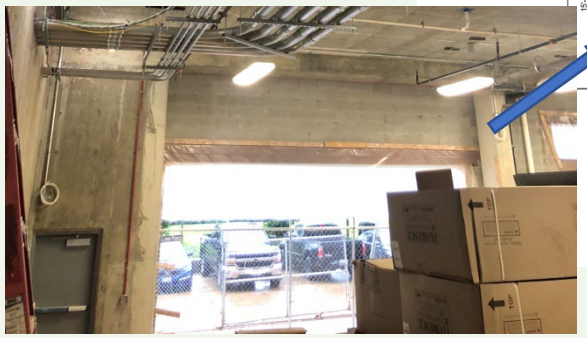

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Lesson learned

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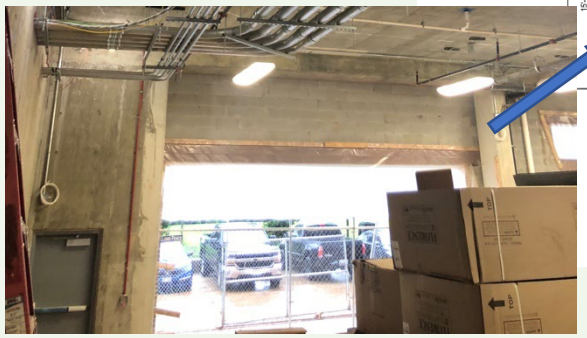
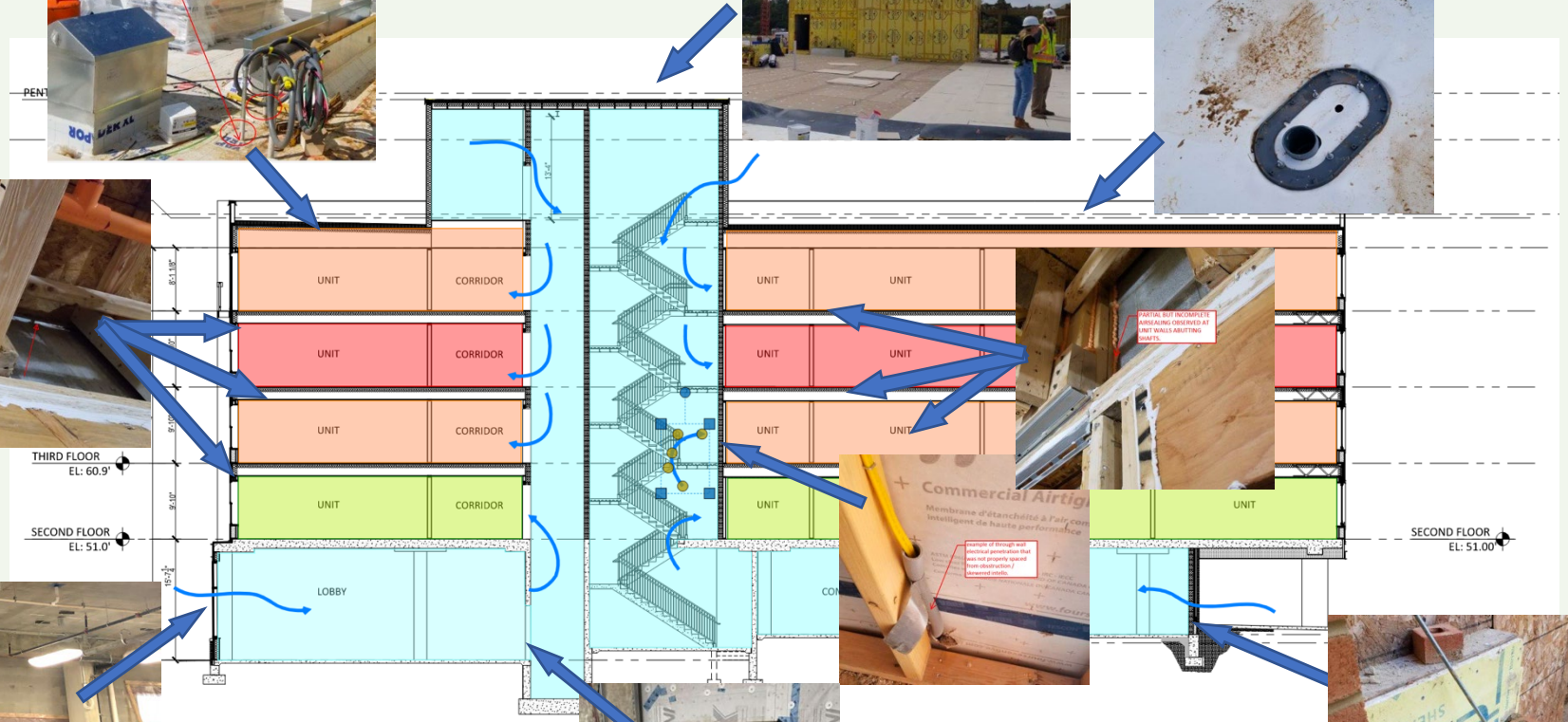




BARRY FARM – THE ASBERRY

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

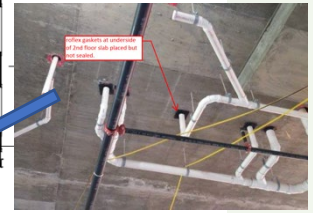
Preservation of Affordable Housing

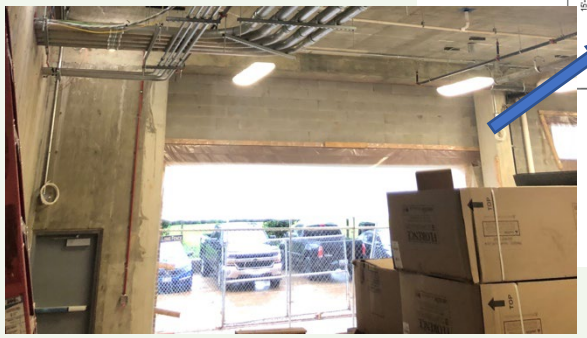
Preliminary Blower Door Test?

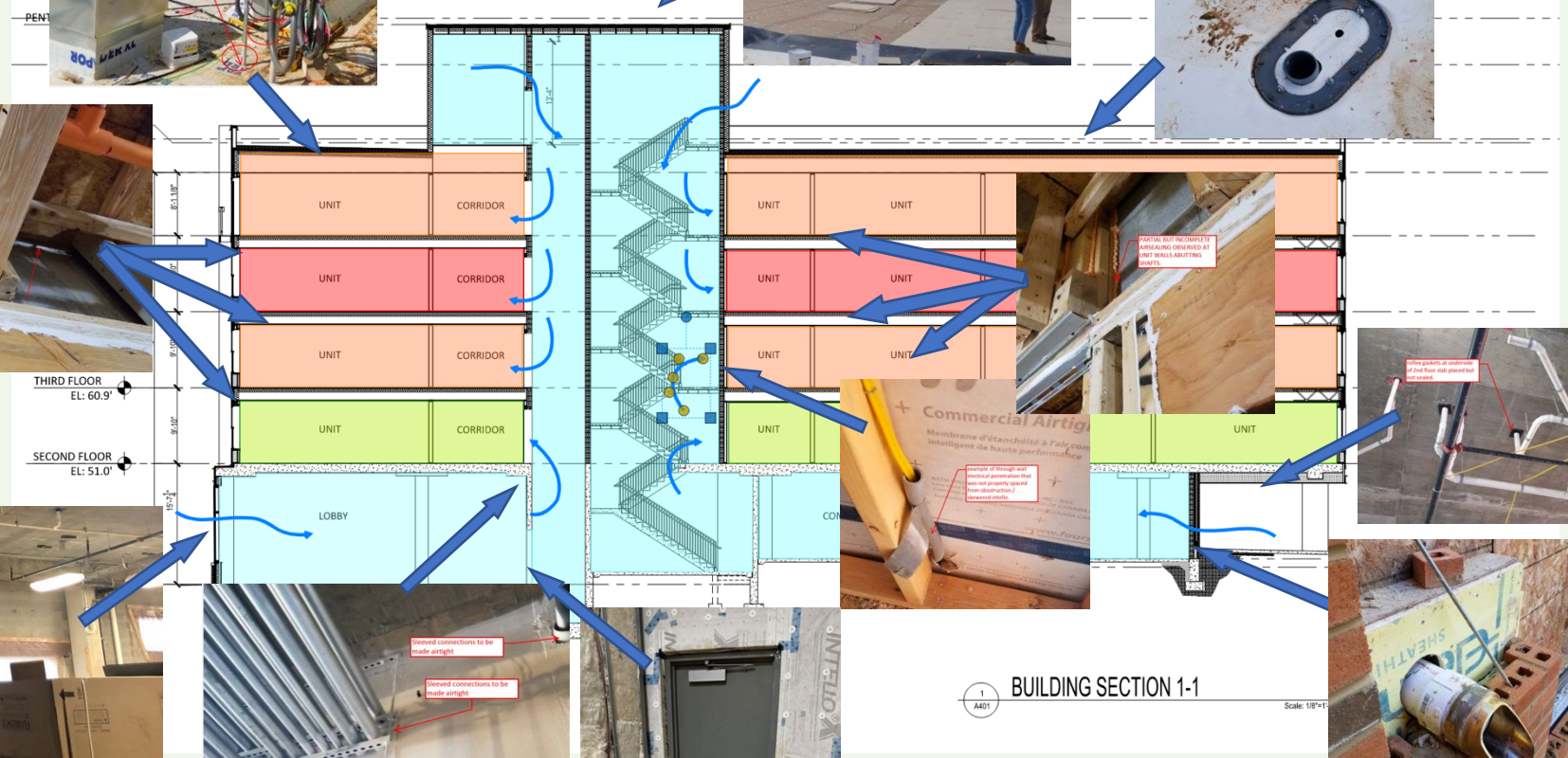
Not so simple . . .

Lesson learned

- Sequencing of whole affected by the need preliminary test.







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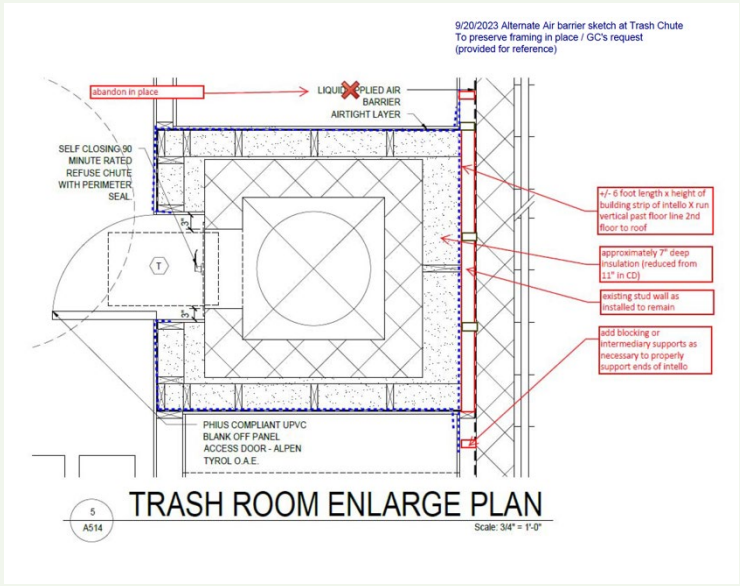
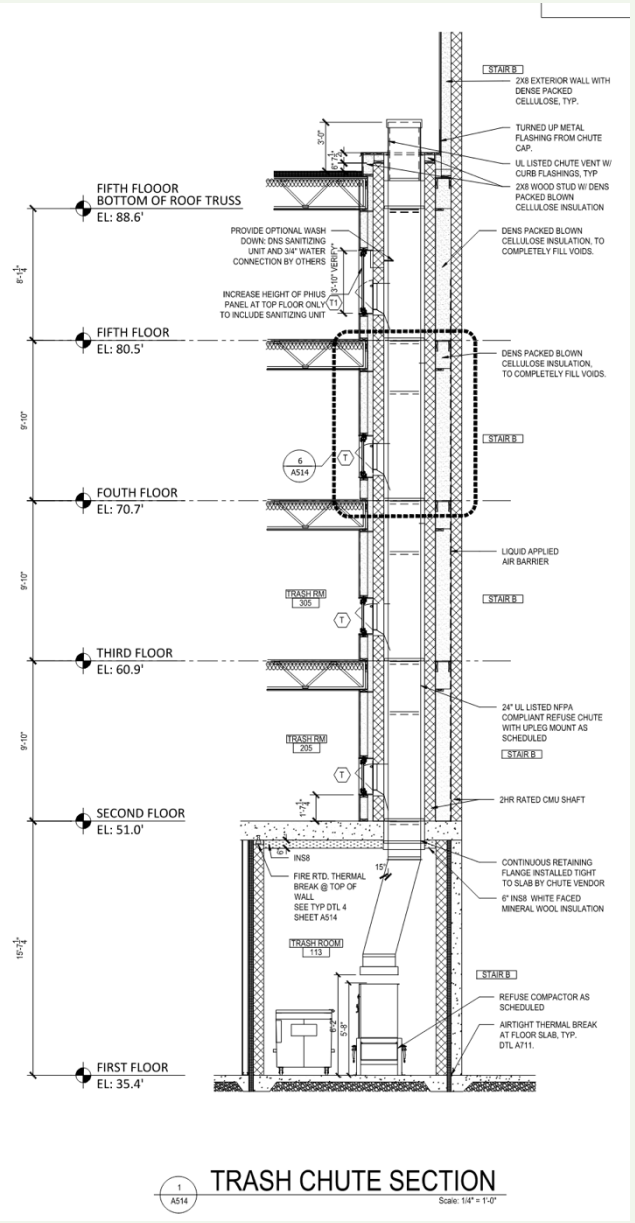
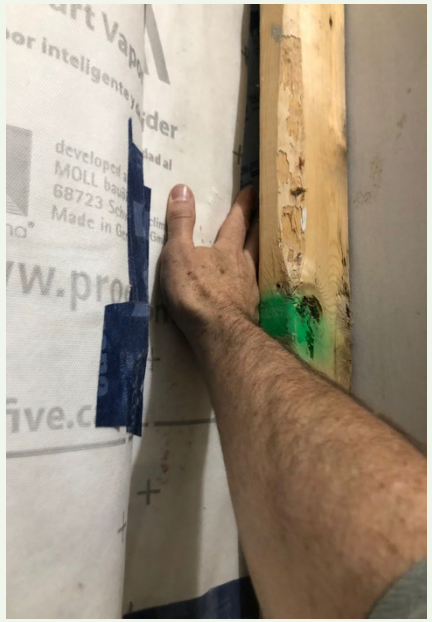
- Sequencing of whole project is affected by the desire for a preliminary test.







BARRY FARM – THE ASBERRY

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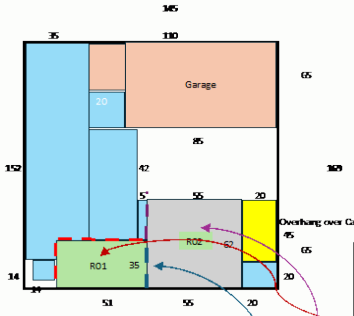
Preservation of Affordable Housing

Preliminary Blower Door Test?

Lesson learned

- Guarded blower door tests are very challenging
  - Temporary sealing of stair towers, elevator shafts, trash chutes
  - drywall going in on the 5th floor before windows are in on the 2nd
  - Store front not installed until months later

Whole Building Blower Door Test Results
Barry Farms, Building 1B
Last Updated: 07.13.24

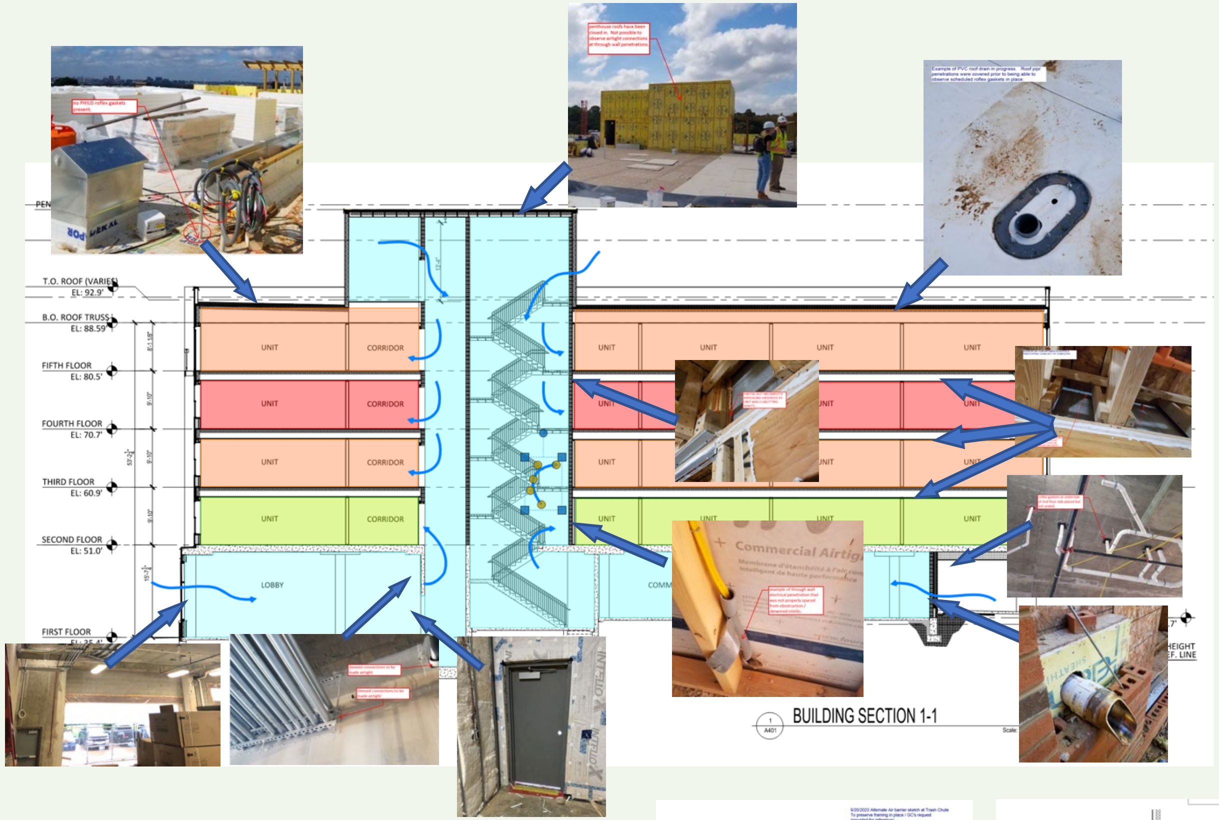


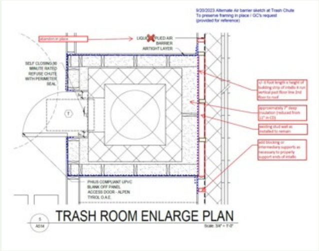
	JHA Test Results – Air Leakage (W/ Guarded Testing)				PHIUS Target (Excluding Retail)		Overage
	Measured 7/13/24 CFM25		Measured 7/13/24 CFM50	CFM50/Sq Ft	CFM50	CFM50 /Sq Ft	CFM at -50 Pa
Whole Building BD Test Results	6,543		10,231	0.11	5,408	0.06	4,822
Previous Air Leakage Floor from Floors 3-5							
Penthouse		??	250	Estimated	150	0.06	100
Floor 5	561	??	1900	Confirmed on 4/03/24	1861	0.06	39
Floor 4	394		880	Confirmed on 4/03/24	521	0.06	359
Floor 3	683		1000	Confirmed on 4/03/24	521	0.06	479
Floor 2	898	??	1500	Estimated	1295	0.06	205
Net Floor 1	5,069		4,951	0.6	1,060	0.06	3,890
North Stairwell	2,556	??	3,996	0.8	303	0.06	3,693

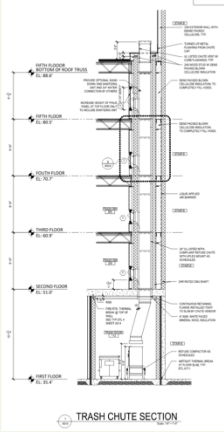
Floor 1 Area		
Lobby /Amenity	7,941	Sq Ft
Retail 01	1,785	Sq Ft
Retail 02	3,575	Sq Ft
Water Room	400	Sq Ft
Sub-Total	5,760	Sq Ft
Garage	6,350	Sq Ft
Total	20,051	Sq Ft

1st Floor Leaks
Air Leakage into Retail - based on Guarded Testing of Retail Spaces

			Measured CFM25	Estimated CFM50
Lobby and R01				
Wall	1215	sq ft		
Clg	1785	sq ft		
Total	3000	sq ft	88	138
Lobby and R02		ft		
Wall	1215	sq ft		
Clg	3410	sq ft		
Total	4625	sq ft	416	629
R01 and R02				
Wall	525	sq ft	405	633
Net BD Test Result (with Retail Leaks Fixed)				Estimated CFM50 4,183







BARRY FARM – THE ASBERRY

Passive to **POSITIVE**
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

BARRY FARM – THE EDMONSDON

Passive to POSITIVE
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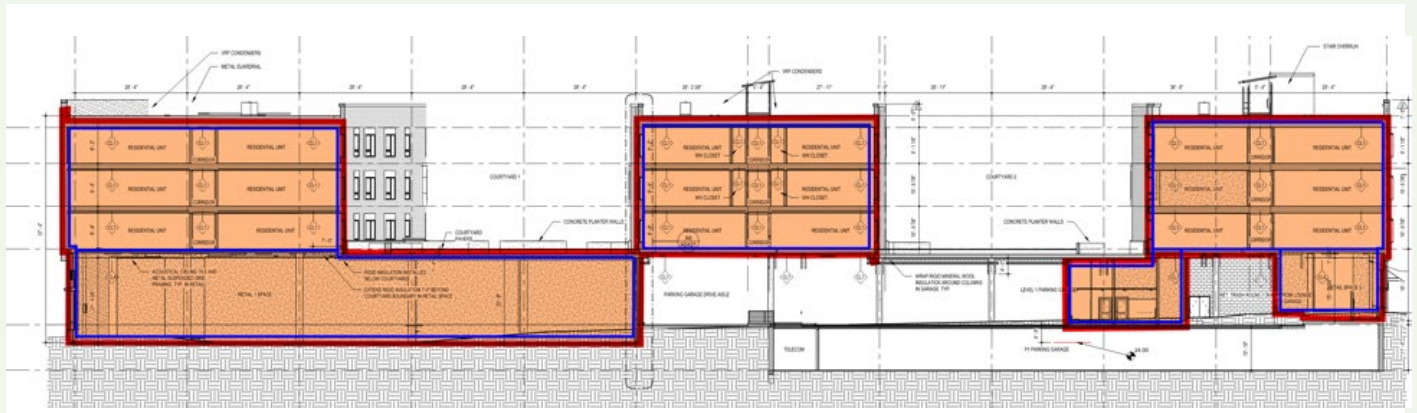

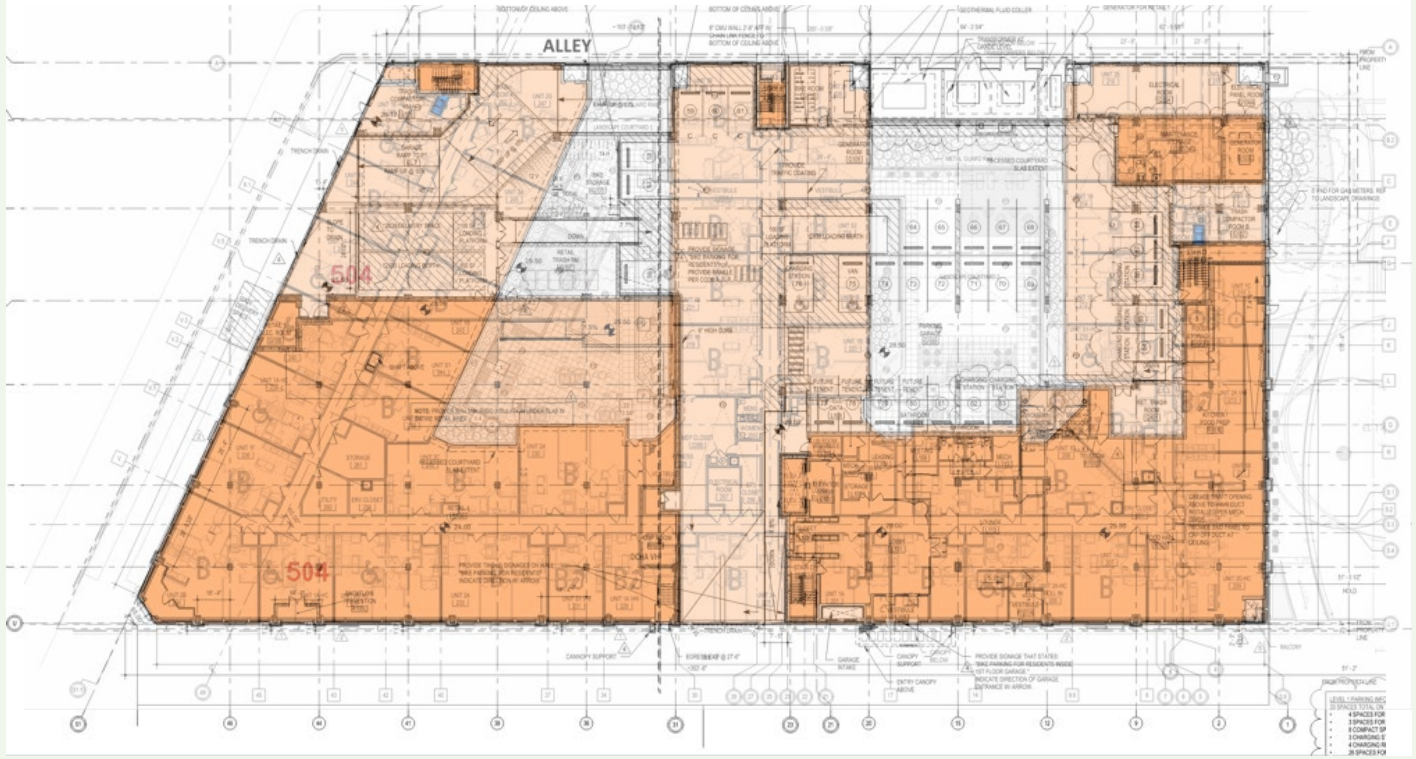

BARRY FARM – THE EDMONSDON

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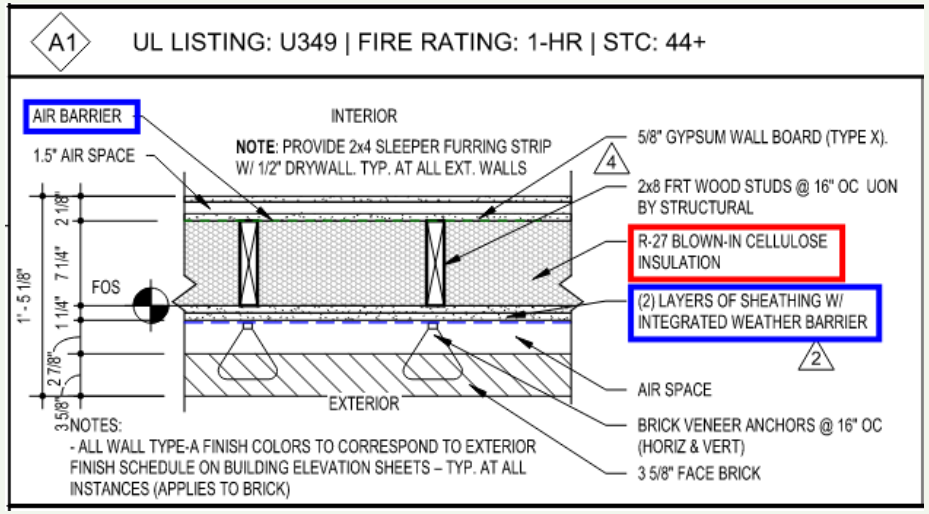
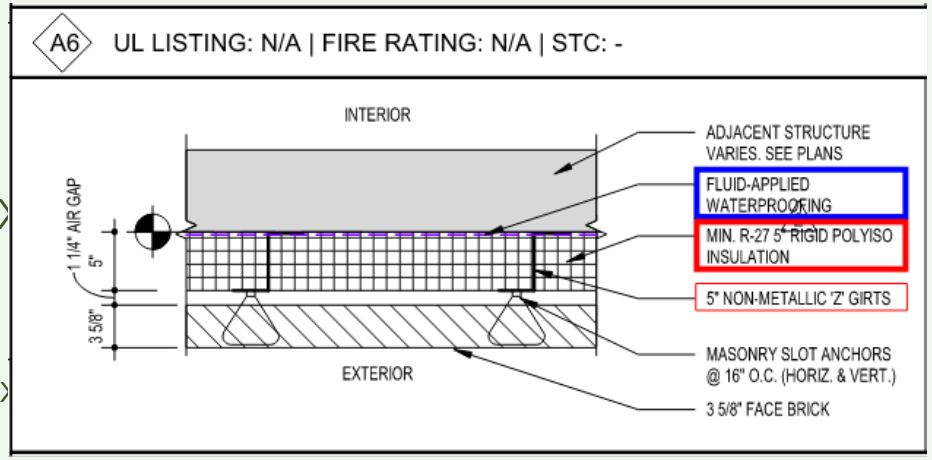
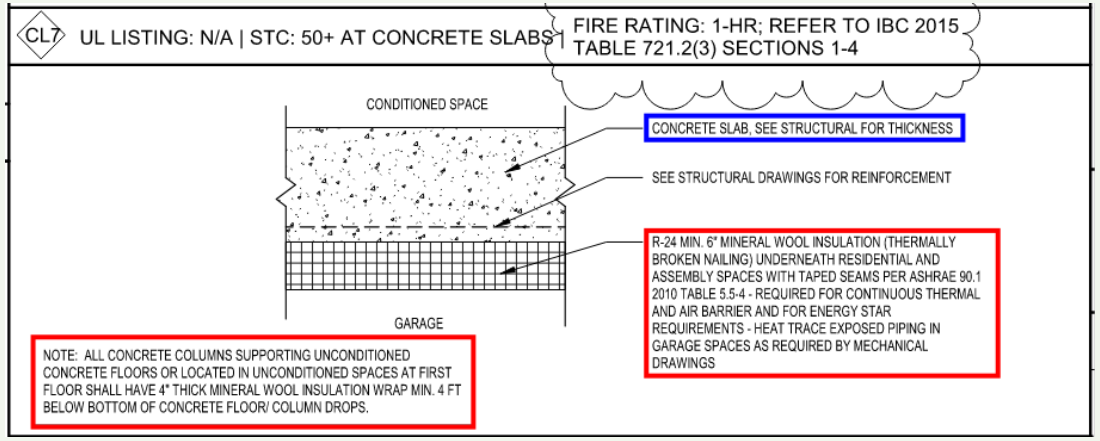
Preservation of Affordable Housing



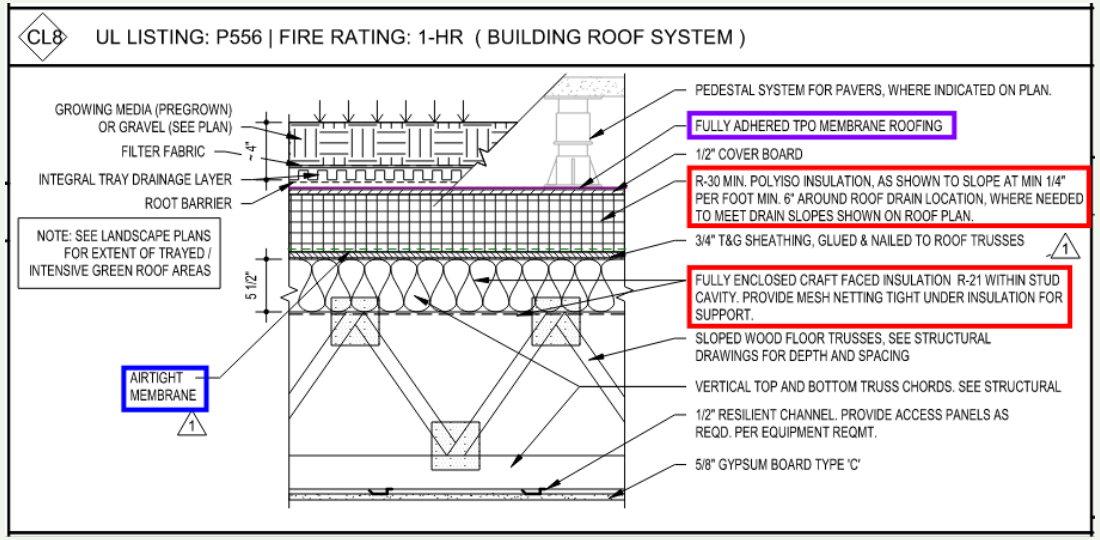
R-26



R-28 CI over masonry



R-28



R-39

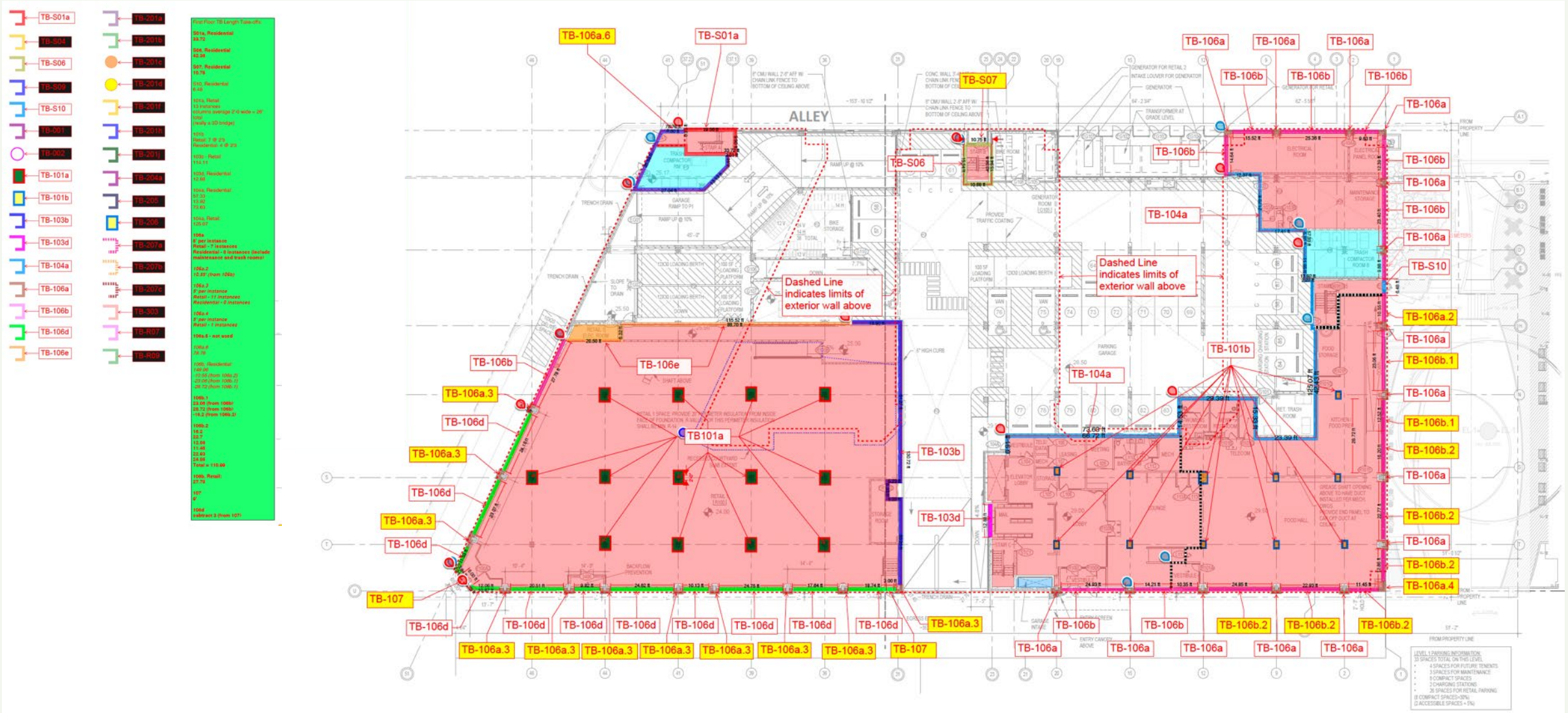
BARRY FARM – THE EDMONSDON

Passive to **POSITIVE**
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

The Edmondson

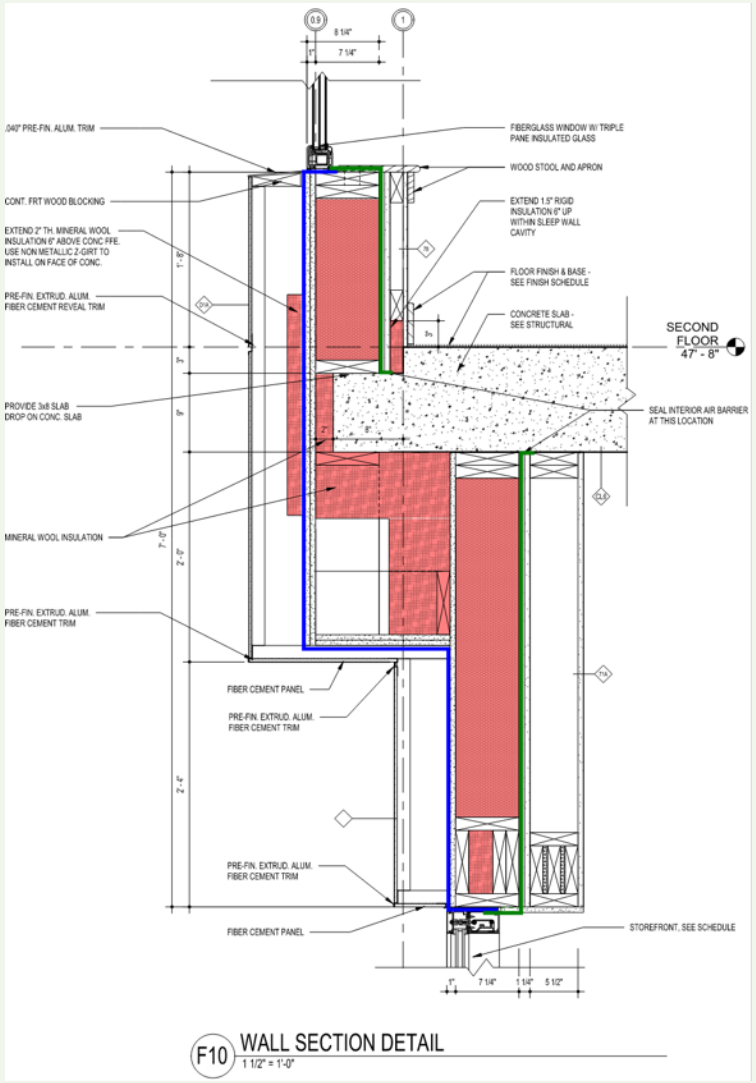
Passive House Stuff - Thermal Breaks + air-tightness challenges

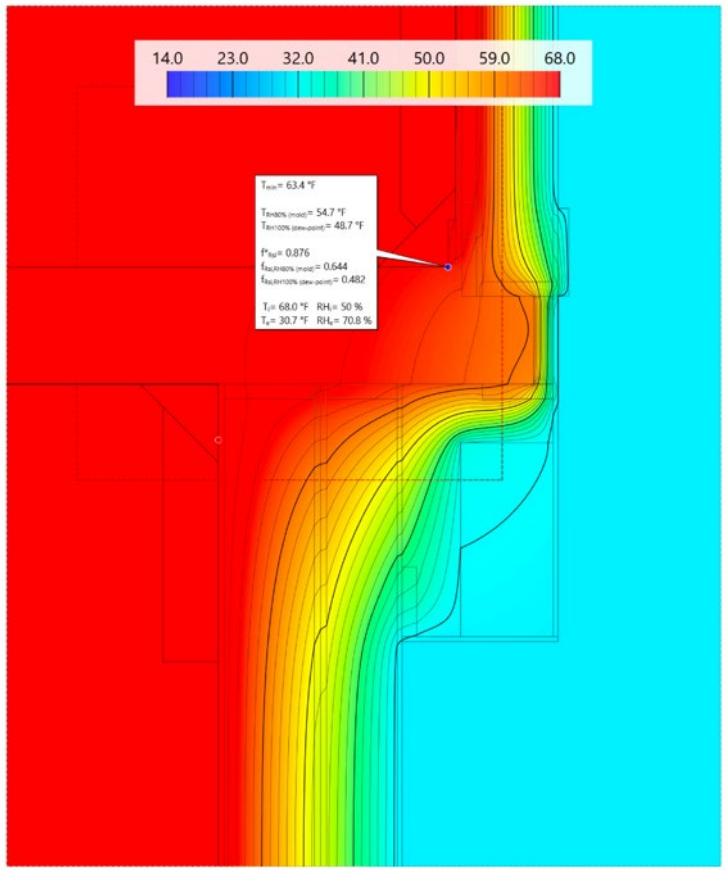


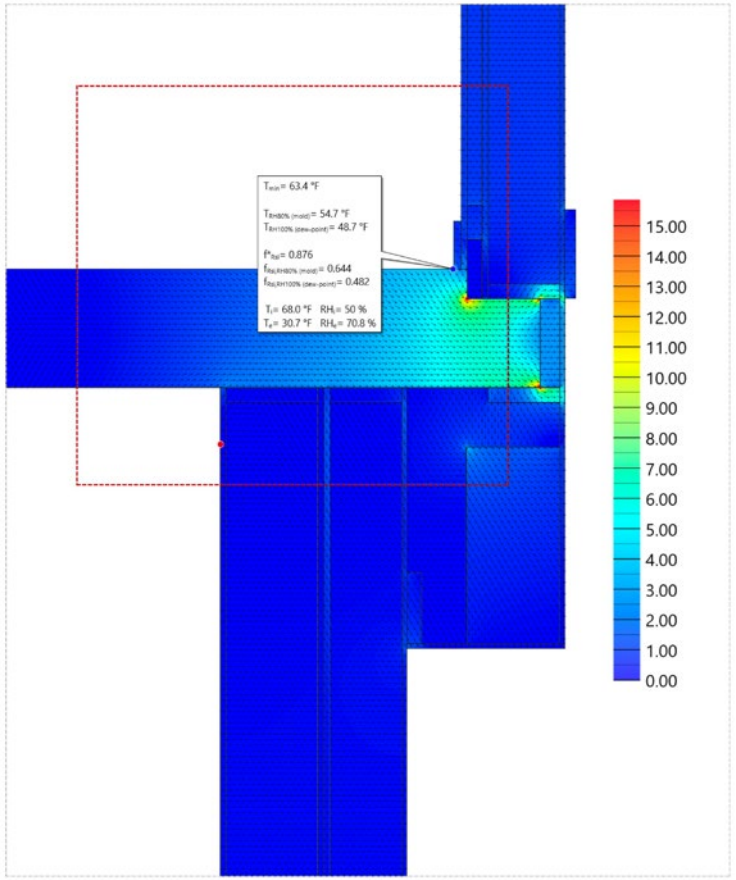
BARRY FARM – THE EDMONSDON

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing





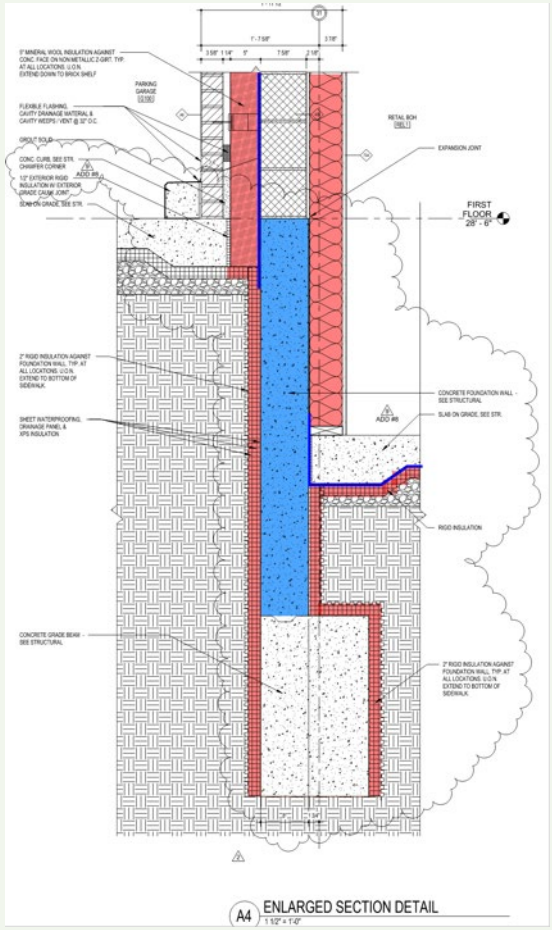


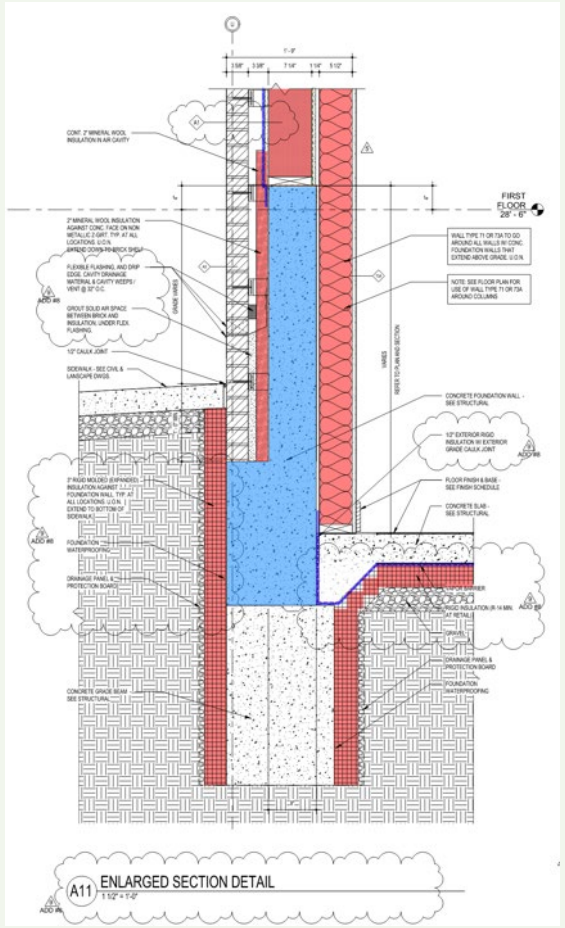
Lessons Learned. - Simplifying walls, complexifies connections. - balance of reducing heat loss + avoiding mold risk

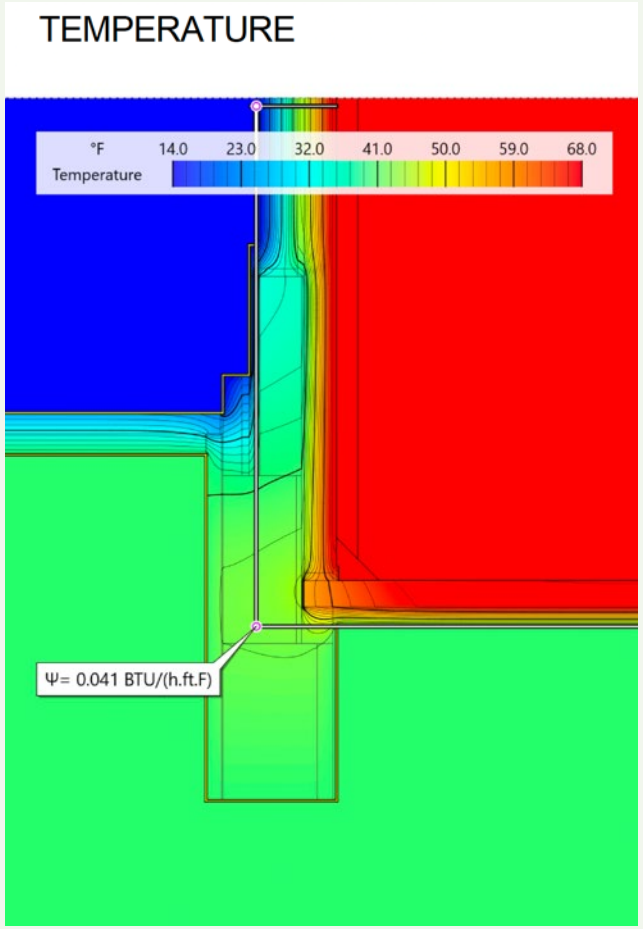
BARRY FARM – THE EDMONSDON

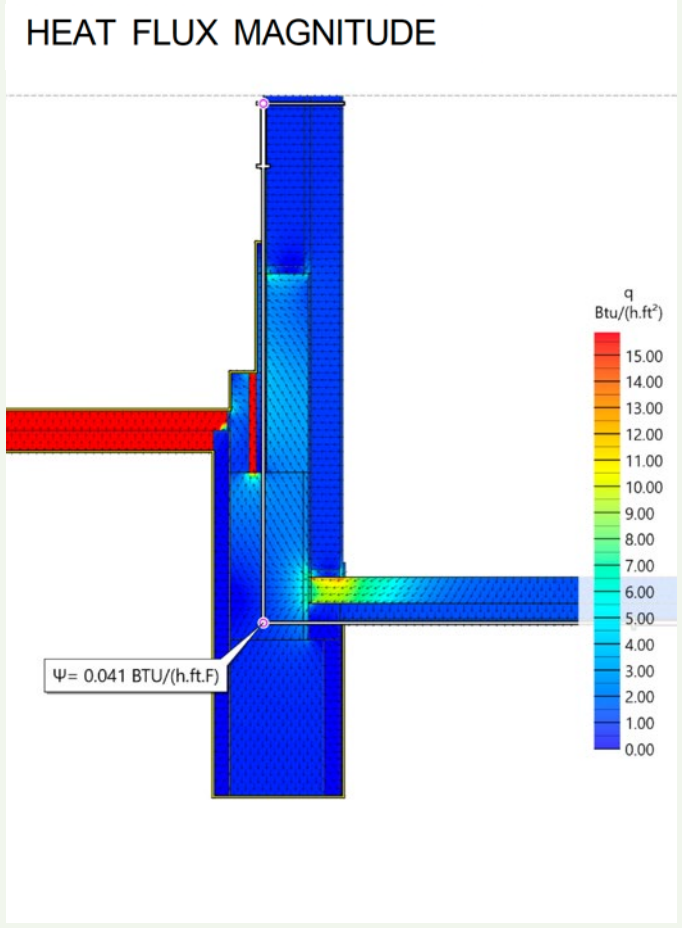
Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing







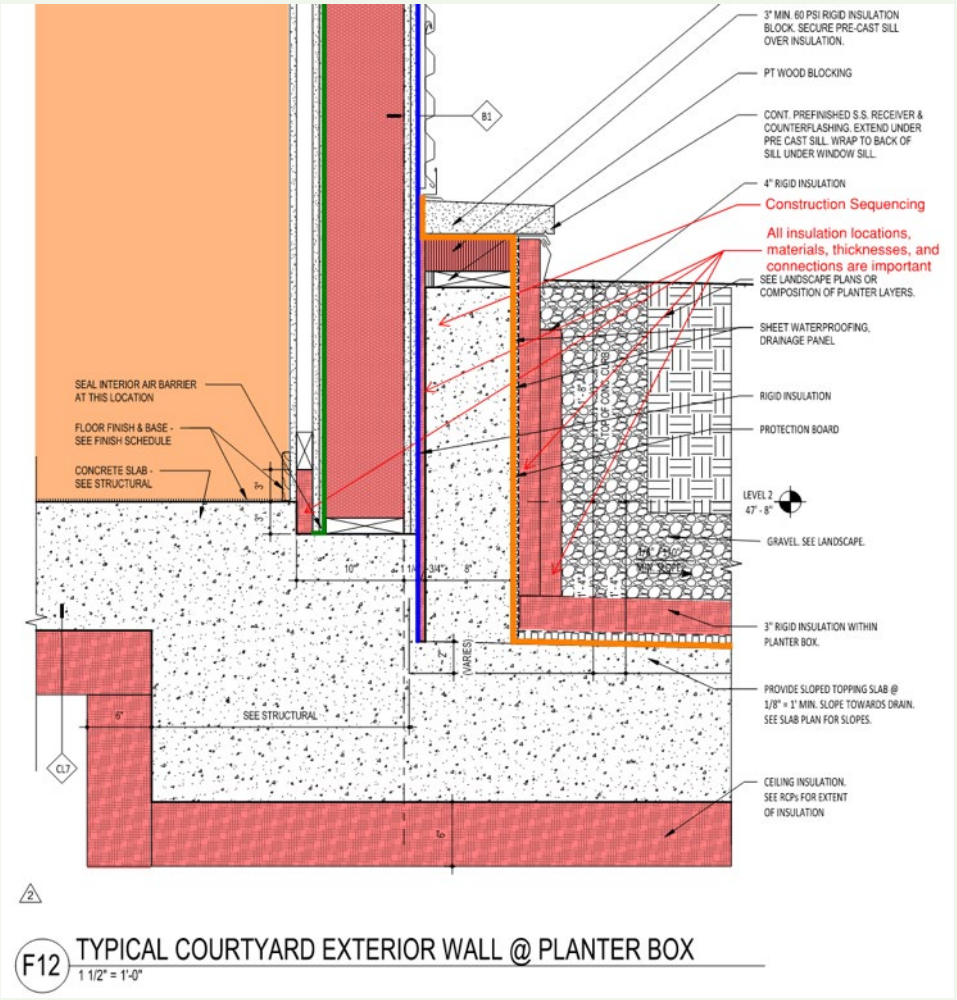


Thermal and air tightness challenges

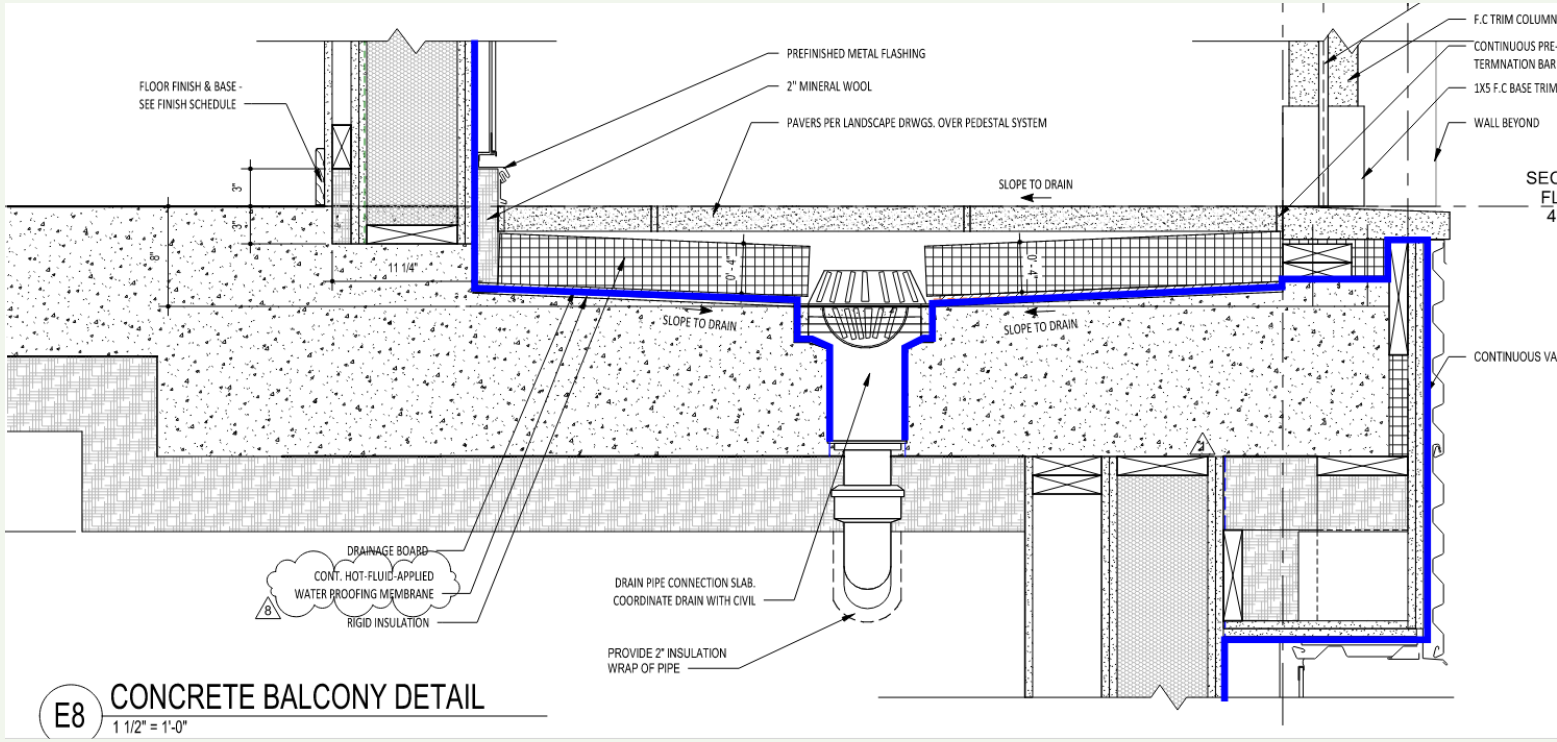
BARRY FARM – THE EDMONSDON

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing



F12 TYPICAL COURTYARD EXTERIOR WALL @ PLANTER BOX
1 1/2" = 1'-0"



E8 CONCRETE BALCONY DETAIL
1 1/2" = 1'-0"

Thermal and air tightness challenges

BARRY FARM – THE EDMONSDON

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

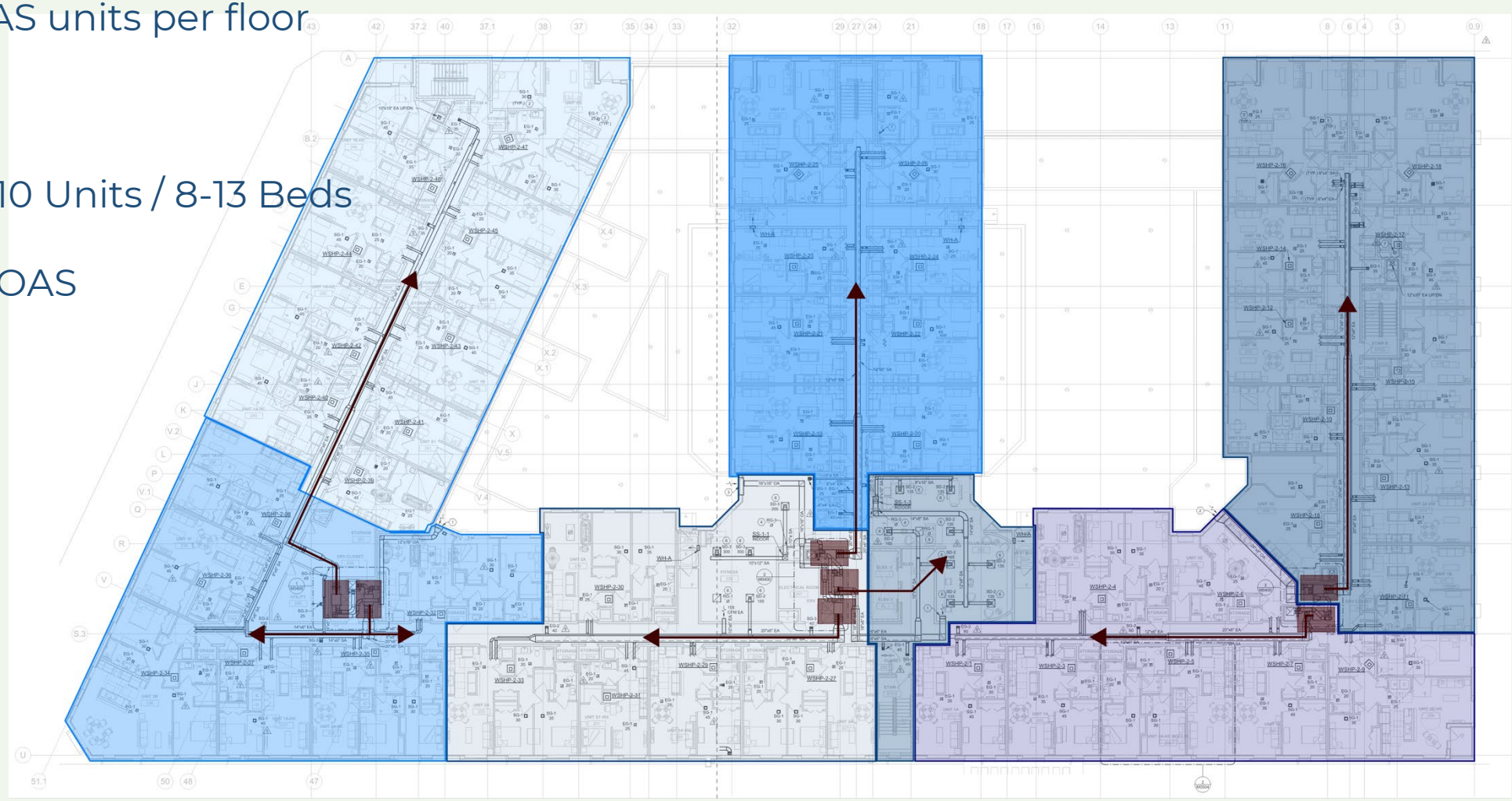
Balanced Ventilation

7 Neighborhood DOAS units per floor

+ Common Space

Each DOAS serves 5-10 Units / 8-13 Beds

700-1,500 CFM per DOAS



BARRY FARM – THE EDMONSDON

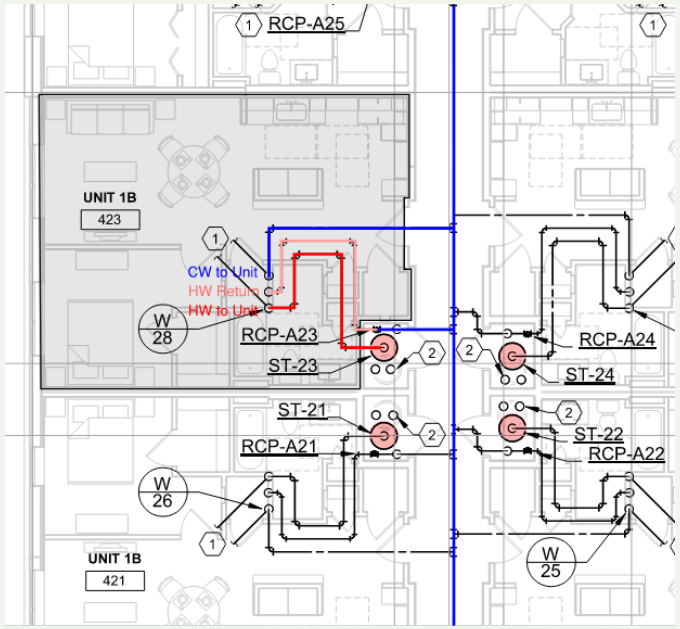
Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

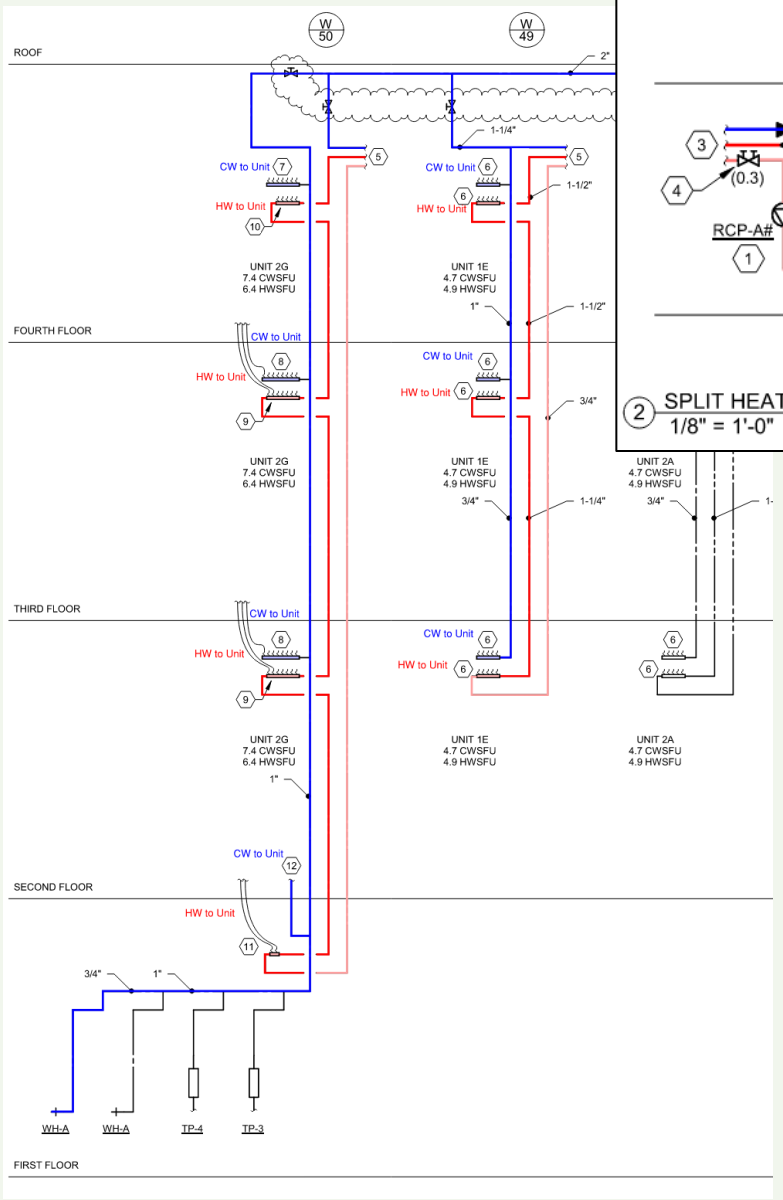
Preservation of Affordable Housing

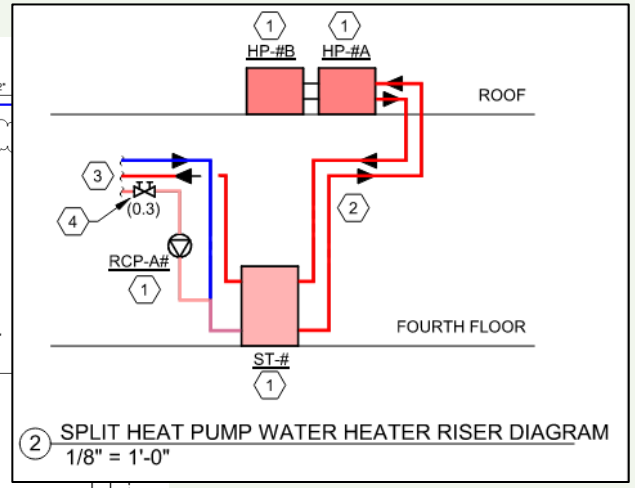
Domestic Hot Water

Split Heat Pump Water Heater

Storage Tank located







BARRY FARM – RENTAL FLATS

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing

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Program

97 units of affordable
Rental flats

Stats

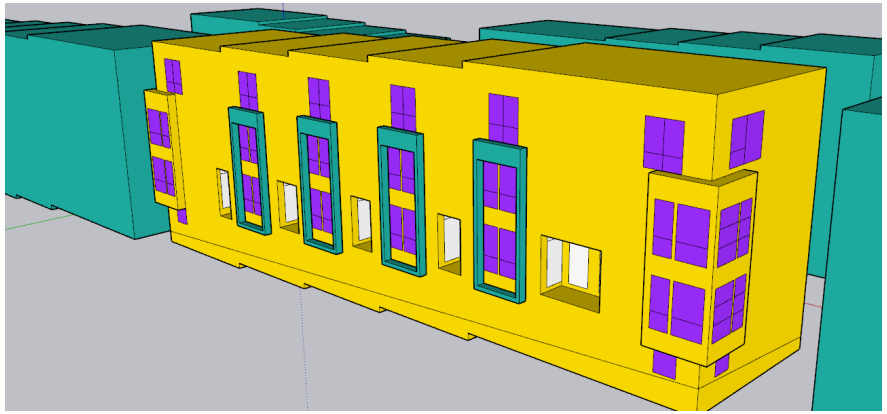
Passive House Performance
Roof-top solar array for further reductions of operational energy

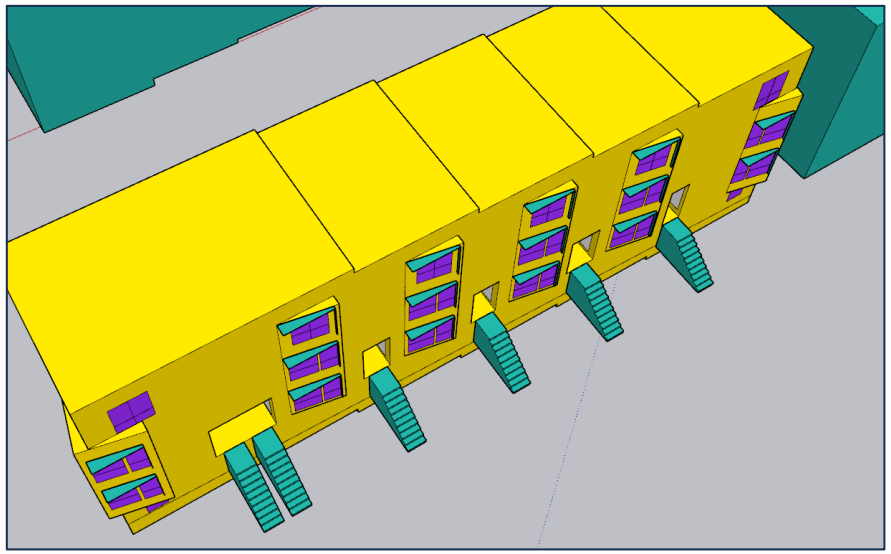
10 Additional Buildings in the District Geothermal System

Phase

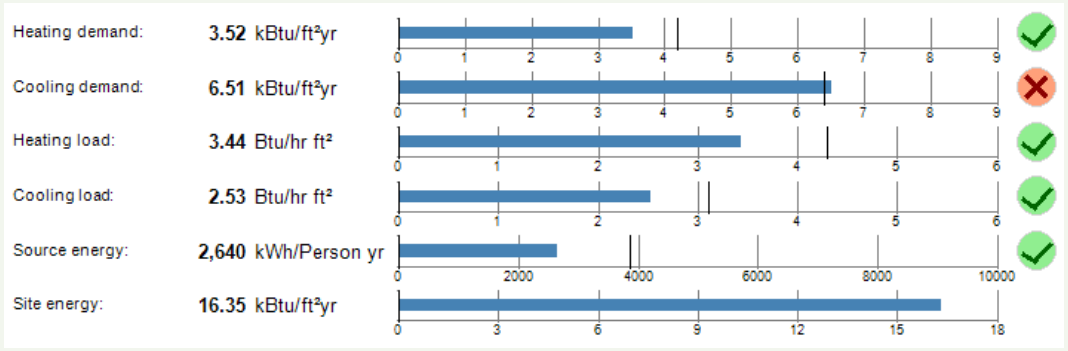
50% Construction Documentation

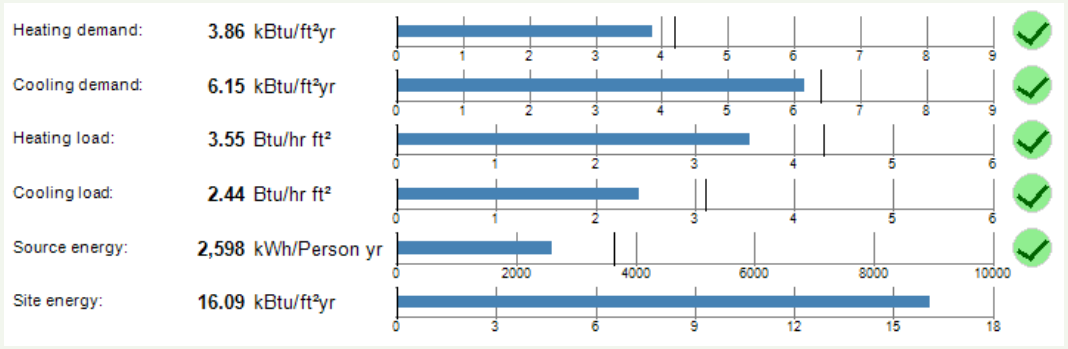
BARRY FARM – RENTAL FLATS

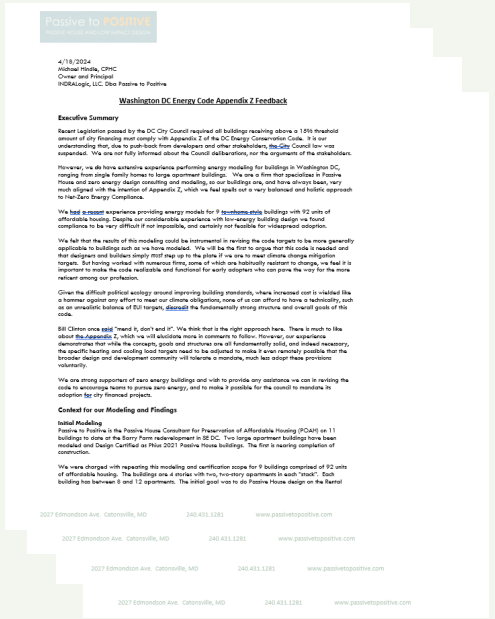




DC Energy Code : Appendix Z







4/18/2024
Michael Hindle, CPHC
Owner and Principal
INDRALogic, LLC. Dba Passive to Positive

Washington DC Energy Code Appendix Z Feedback

Executive Summary

Recent legislation passed by the DC City Council required all buildings receiving above a 15% threshold amount of city financing must comply with Appendix Z of the DC Energy Conservation Code. It is our understanding that, due to push-back from developers and other stakeholders, this Code Council law was suspended. We are not fully informed about the Council deliberations, nor the arguments of the stakeholders.

However, we do have extensive experience performing energy modeling for buildings in Washington DC, ranging from single family homes to large apartment buildings. We are a firm that specializes in Passive House and zero energy design consulting and modeling, so our buildings are, and have always been, very much aligned with the intention of Appendix Z, which we feel spells out a very balanced and holistic approach to Net-Zero Energy Compliance.

We had a recent experience providing energy models for 9 townhome-style buildings with 92 units of affordable housing. Despite our considerable experience with low-energy building design we found compliance to be very difficult if not impossible, and certainly not feasible for widespread adoption.

We felt that the results of this modeling could be instrumental in revising the code targets to be more generally applicable to buildings such as we have modeled. We will be the first to argue that this code is needed and that designers and builders simply MUST step up to the plate if we are to meet climate change mitigation targets. But having worked with numerous firms, some of which are habitually resistant to change, we feel it is important to make the code realizable and functional for early adopters who can pave the way for the more reticent among our profession.

Given the difficult political ecology around improving building standards, where increased cost is wielded like a hammer against any effort to meet our climate obligations, none of us can afford to have a technicality, such as an unrealistic balance of EUI targets, discredit the fundamentally strong structure and overall goals of this code.

Bill Clinton once said "mend it, don't end it". We think that is the right approach here. There is much to like about the Appendix Z, which we will elucidate more in comments to follow. However, our experience demonstrates that while the concepts, goals and structures are all fundamentally solid, and indeed necessary, the specific heating and cooling load targets need to be adjusted to make it even remotely possible that the broader design and development community will tolerate a mandate, much less adopt these provisions voluntarily.

We are strong supporters of zero energy buildings and wish to provide any assistance we can in revising the code to encourage teams to pursue zero energy, and to make it possible for the council to mandate its adoption for city financed projects.

Context for our Modeling and Findings

Initial Modeling

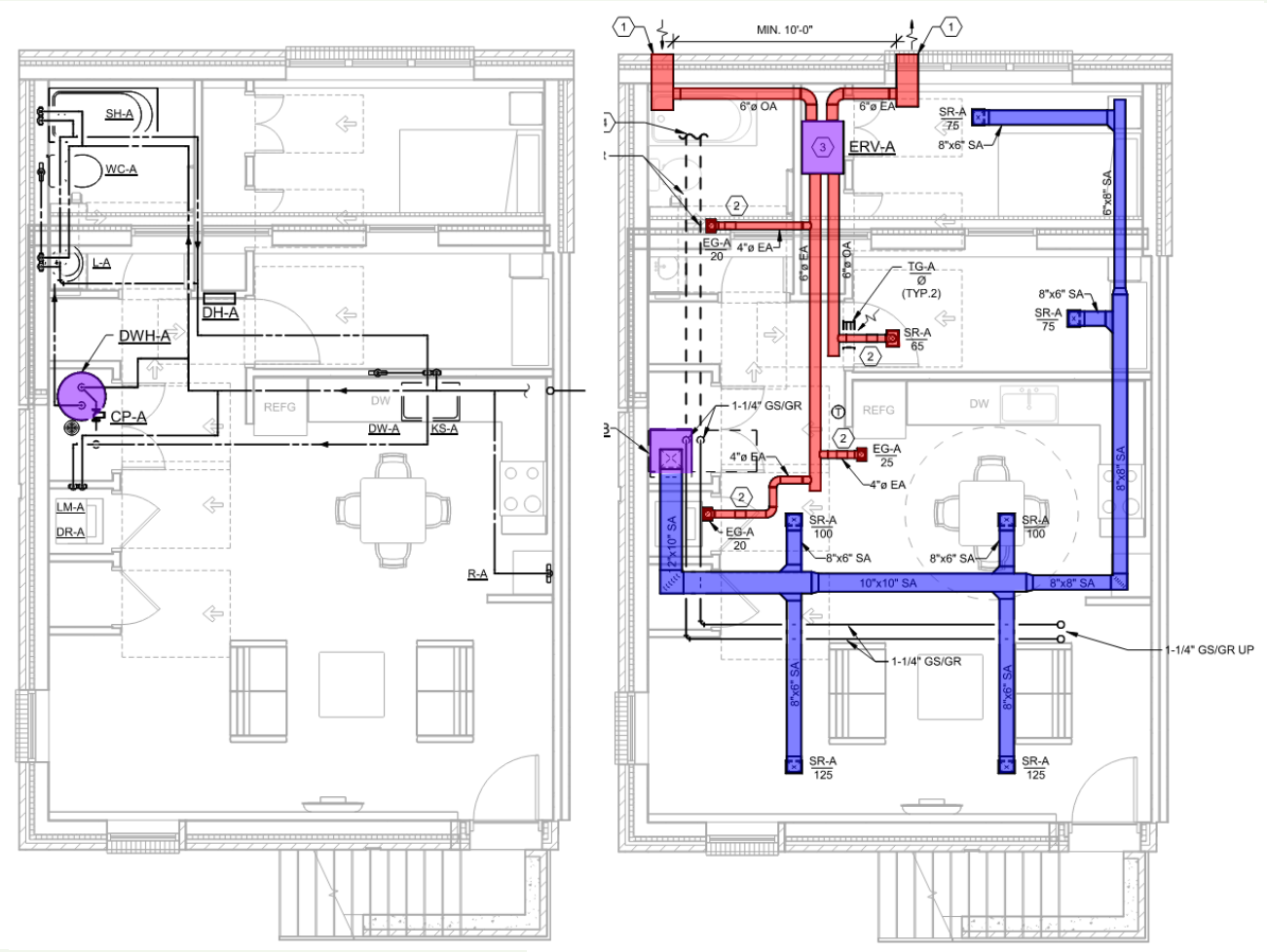
Passive to Positive is the Passive House Consultant for Preservation of Affordable Housing (POAH) on 11 buildings to date on the Barry Farm redevelopment in SE DC. Two large apartment buildings have been modeled and Design Certified as Phius 2021 Passive House buildings. The first is nearing completion of construction.

We were charged with repeating this modeling and certification scope for 9 buildings comprised of 92 units of affordable housing. The buildings are 4 stories with two, two-story apartments in each "stack". Each building has between 8 and 12 apartments. The initial goal was to do Passive House design on the Rental

BARRY FARM – RENTAL FLATS

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing



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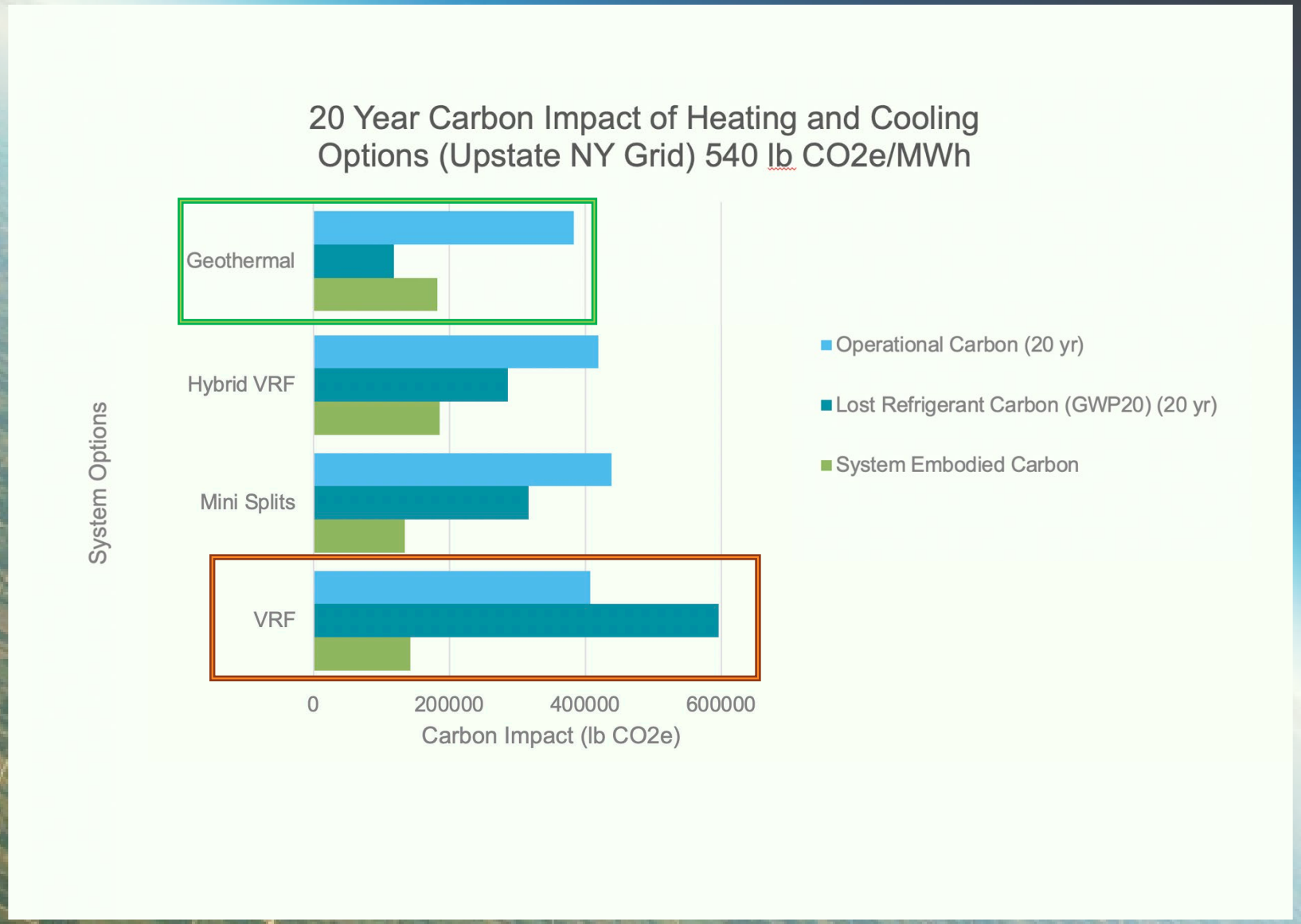
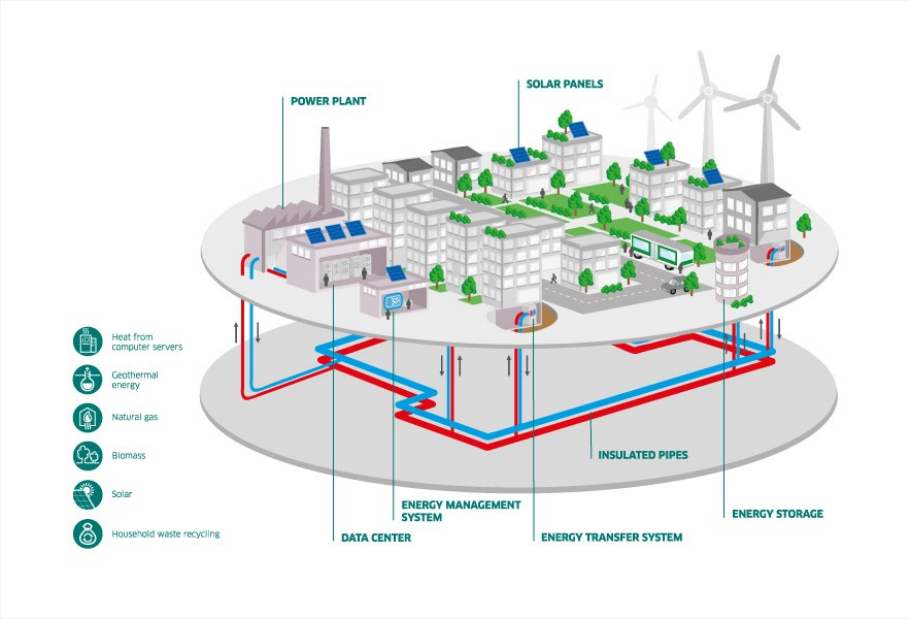
REFRIGERANT IMPACTS ON **EMBODIED CARBON**

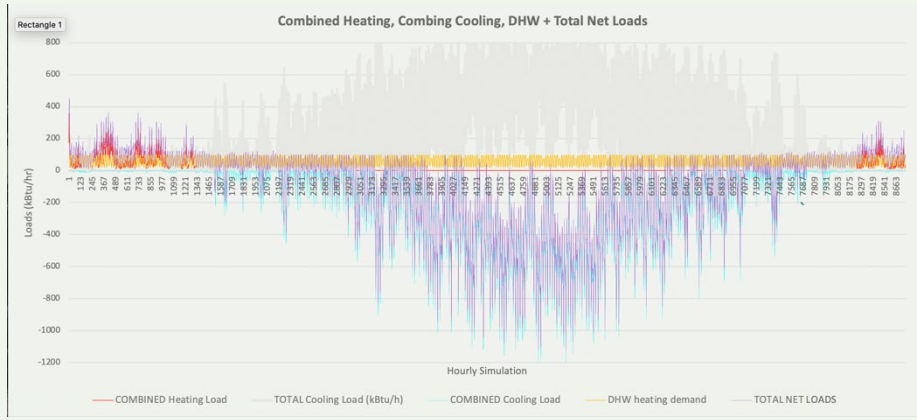


BARRY FARM – DISTRICT GEOTHERMAL

Passive to POSITIVE
PASSIVE HOUSE AND LOW IMPACT DESIGN

Preservation of Affordable Housing





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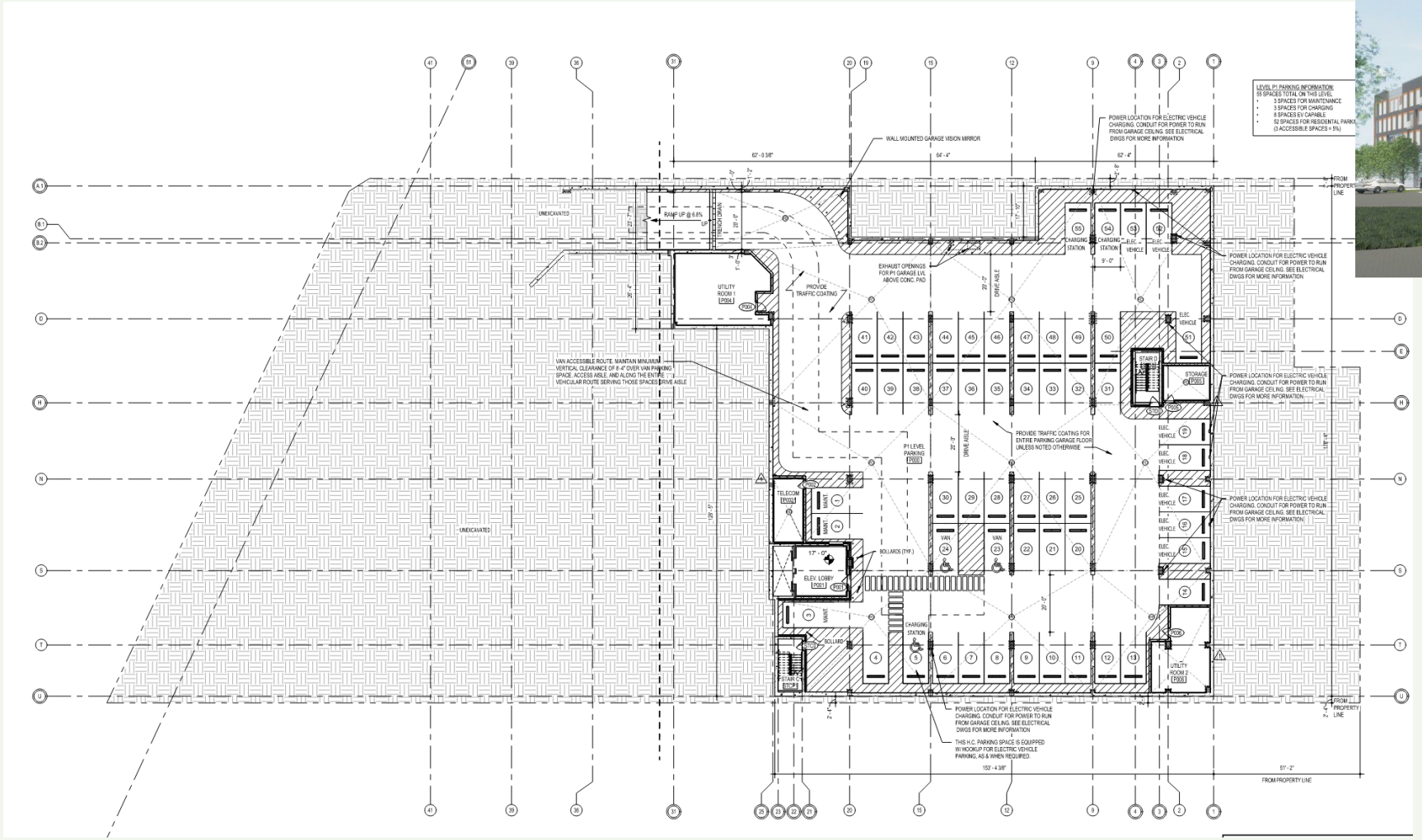
Brightcore
BUILDING ENERGY PERFORMANCE™

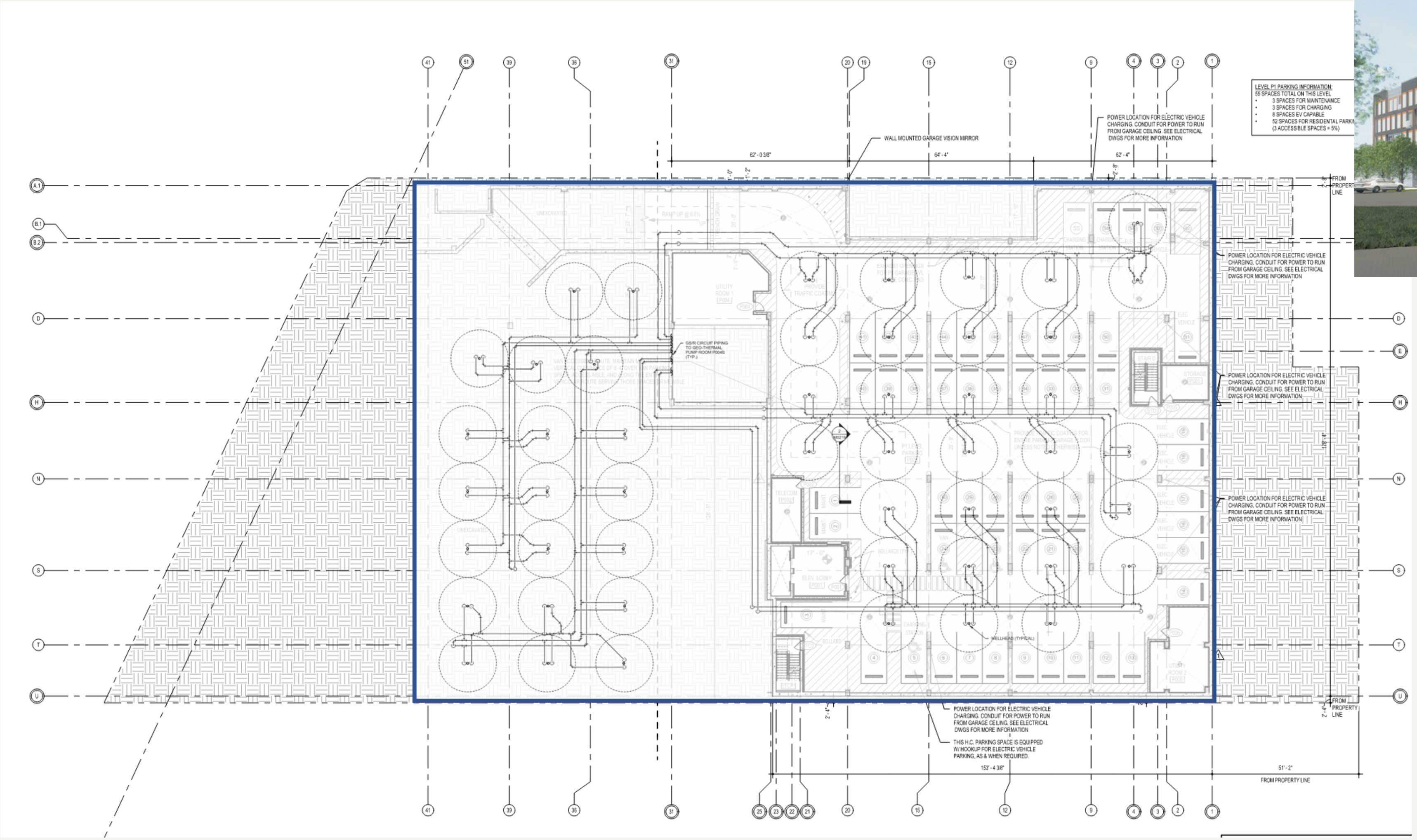
Engenium Group

The District Geothermal System



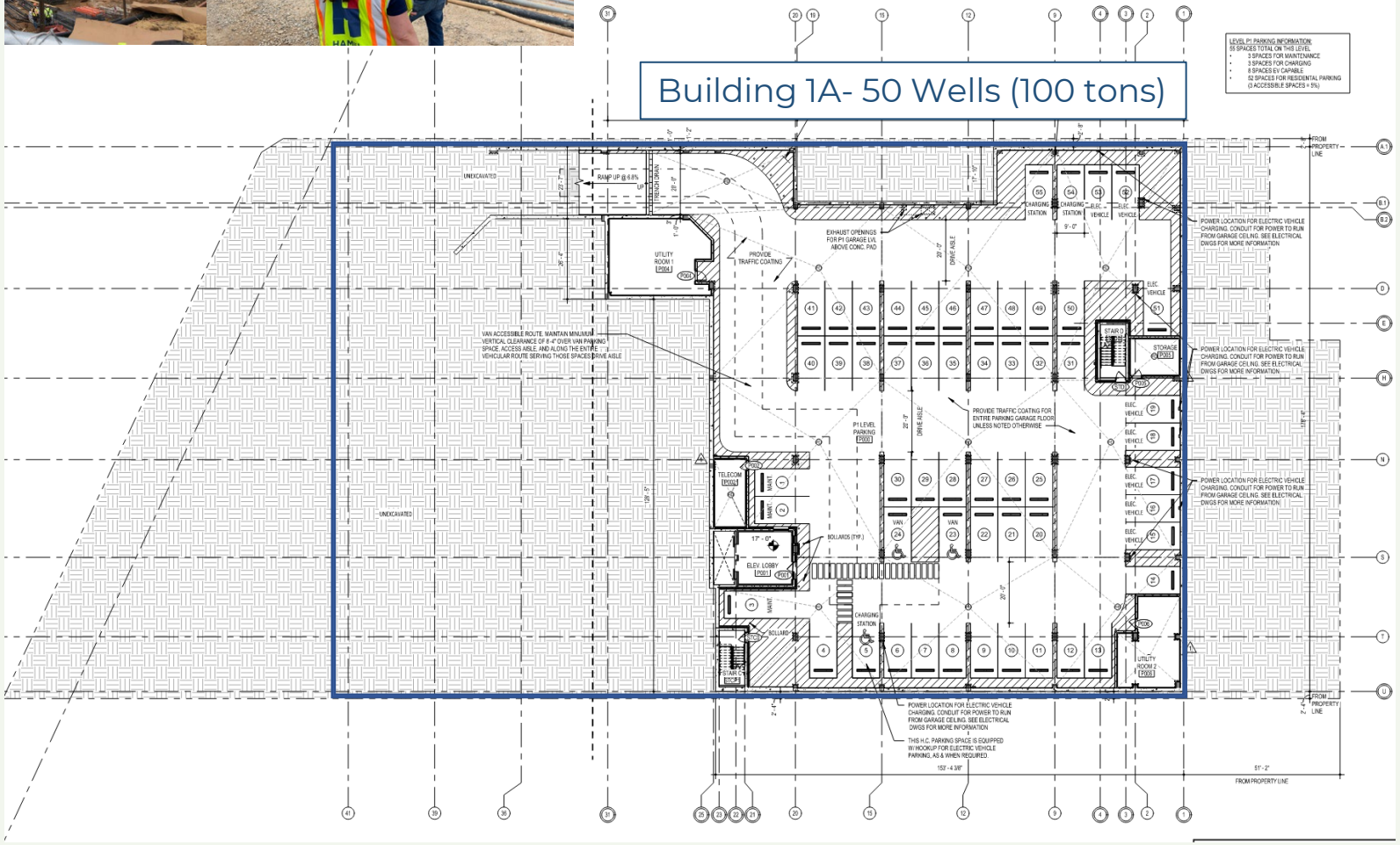
Building 1A houses its own geothermal wells + the pump system for the whole project.

The District Geothermal System

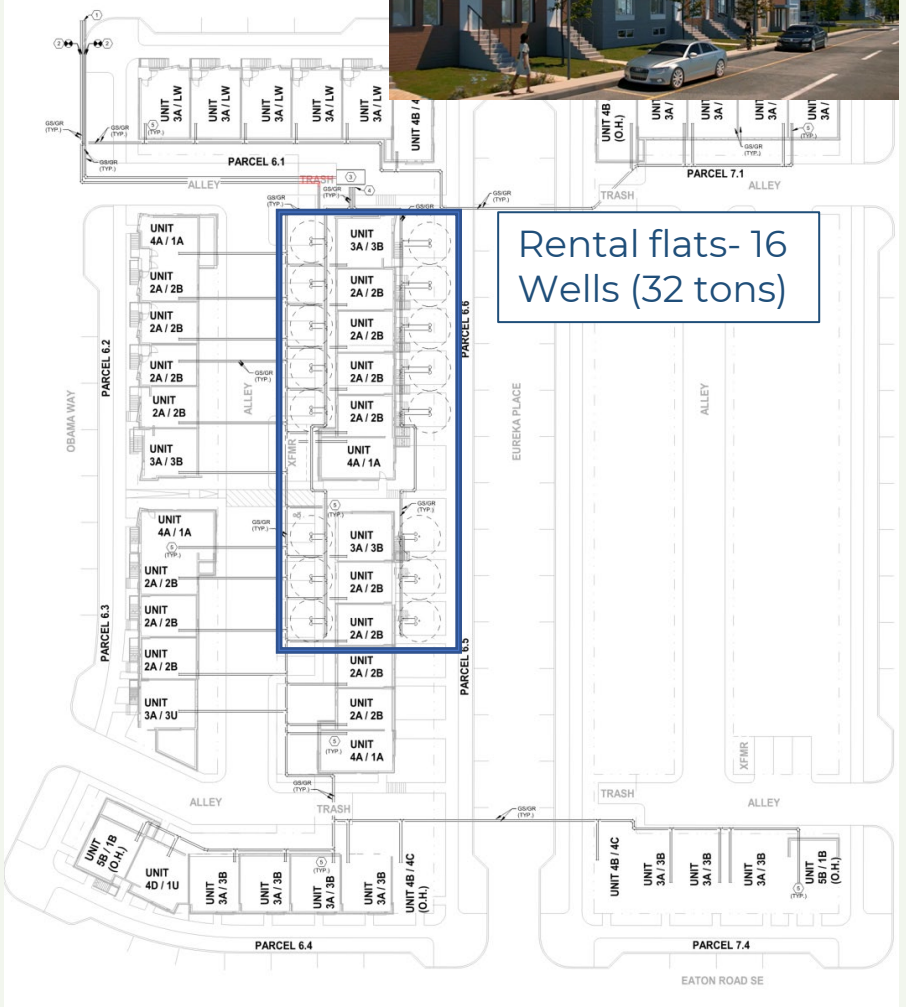


The District Geothermal System

Building 1A- 50 Wells (100 tons)



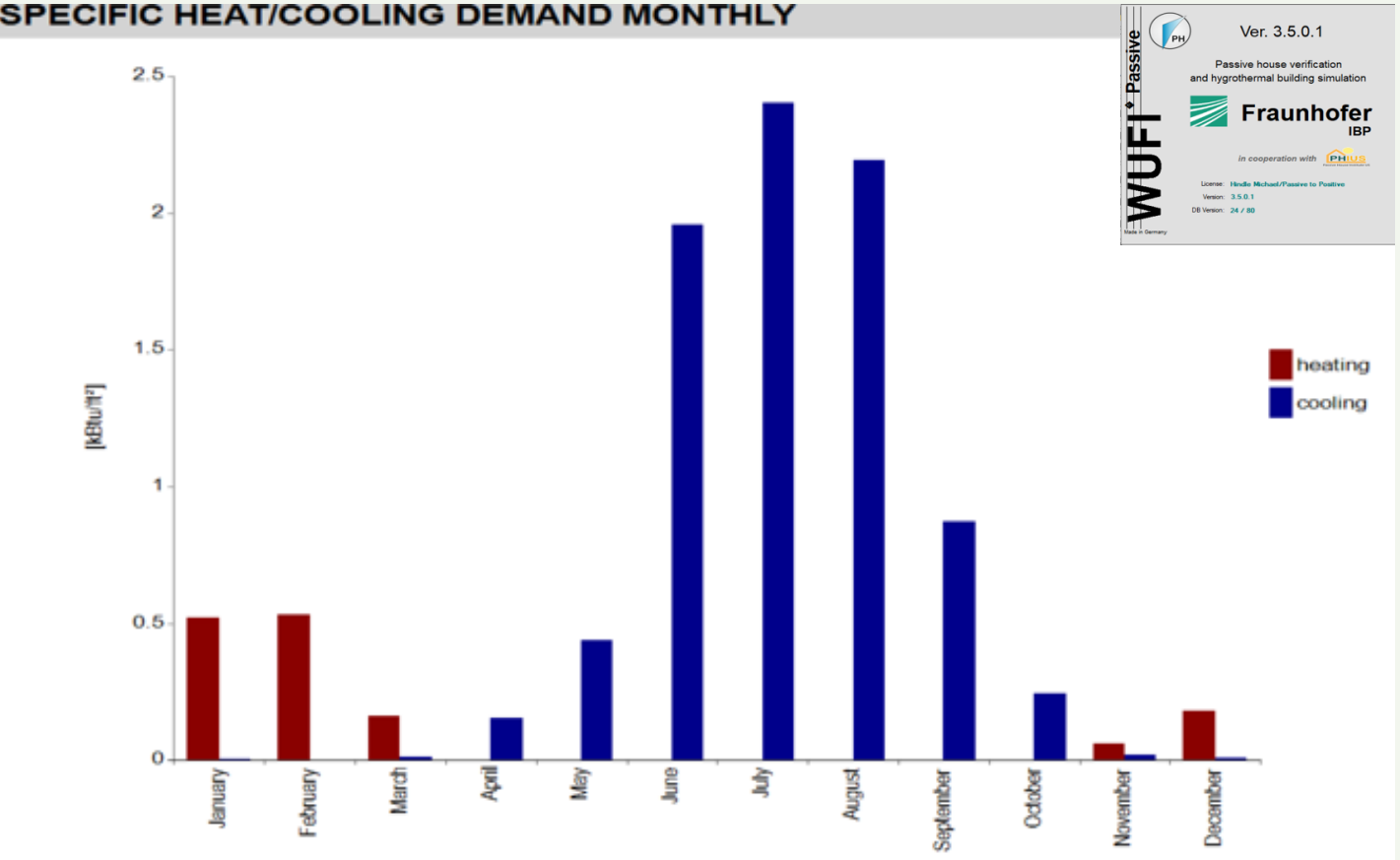
Rental flats- 16 Wells (32 tons)



Geothermal Loads

Modeling Process

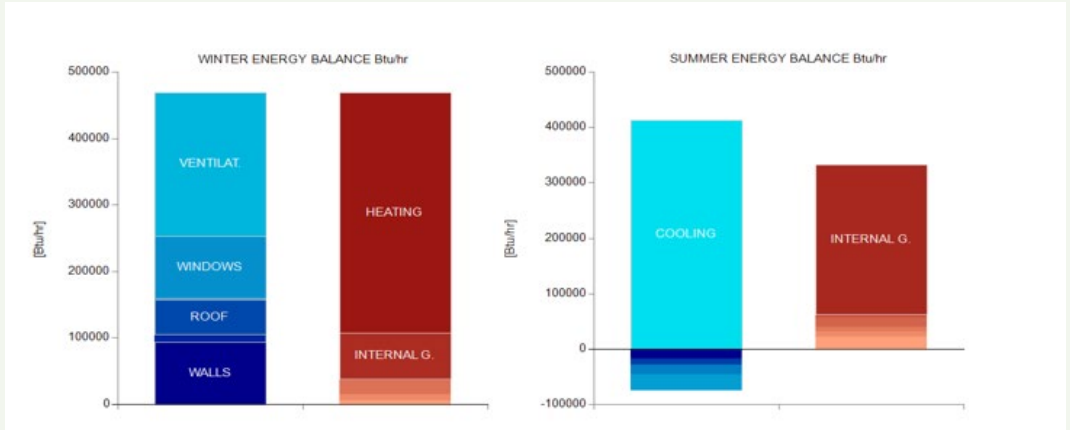
Preliminary modeling in WUFI Passive – can we trust this?



Monthly heating and cooling

Heating and Cooling Imbalance

BARRY FARM, THE EDMONDSON, WASHINGTON, DC: POAH



“Peak” Heating + Cooling

The Edmondson

Modeling Results –

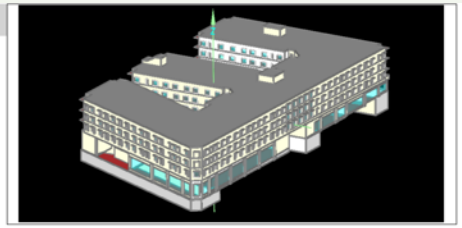
Meets Phius criteria with relative ease

Site EUI – 18.98 kBtu/sf.yr
With 120 kW rated PV array

- Internal IHG Dominated
- Cooling Load Dominated Annually

BUILDING INFORMATION

Category:	**Residential**
Status:	**In planning**
Building type:	**New construction**
Year of construction:	**2020**
Units:	**139**
Number of occupants:	**316 (Design)**
Occupant density:	**427.8** ft²/Person



Boundary conditions

Climate:	**WASHINGTON DC REAGAN AP VA**
Internal heat gains:	**1.6** Btu/hr ft²
Interior temperature:	**68** °F
Overheat temperature:	**77** °F

Building geometry

Enclosed volume:	**1,592,015** ft³
Net-volume:	**1,228,657** ft³
Total area envelope:	**143,011.8** ft²
Area/Volume Ratio:	**0.1** 1/ft
Floor area:	**135,188.1** ft²
Envelope area/iCFA:	**1.058**

PASSIVEHOUSE REQUIREMENTS

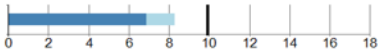
Certificate criteria: **Phius CORE 2021**

Heating demand

specific:	**1.46** kBtu/ft²yr
target:	**4.5** kBtu/ft²yr
total:	197,101.42 kBtu/yr

Cooling demand

sensible:	**6.86** kBtu/ft²yr
latent:	**1.44** kBtu/ft²yr
specific:	**8.3** kBtu/ft²yr
target:	**9.9** kBtu/ft²yr
total:	1,121,883.18 kBtu/yr



Heating load

specific:	**3.23** Btu/hr ft²
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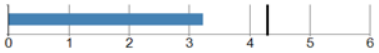
total:	437,165.13 Btu/hr



Cooling load

specific:	**3.06** Btu/hr ft²
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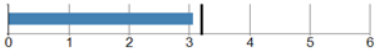


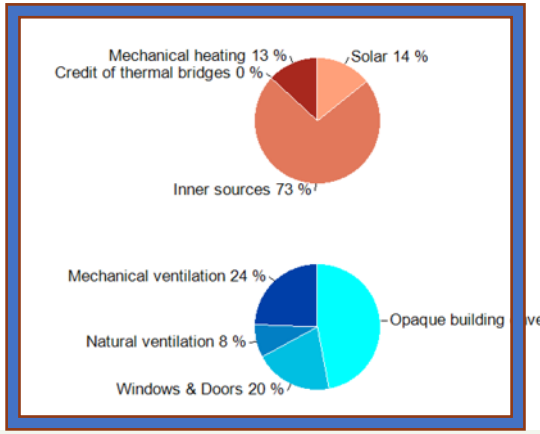
HEAT FLOW - HEATING PERIOD

Heat gains

Solar:	**166,796** kBtu/yr
Inner sources:	**847,444** kBtu/yr
Credit of thermal bridges:	**0** kBtu/yr
Mechanical heating:	**197,101** kBtu/yr

Heat losses

Opaque building envelope:	**556,251** kBtu/yr
Windows & Doors:	**237,979** kBtu/yr
Natural ventilation:	**100,416** kBtu/yr
Mechanical ventilation:	**288,493** kBtu/yr



The Edmondson

Modeling Results –

Peak loads relatively balanced

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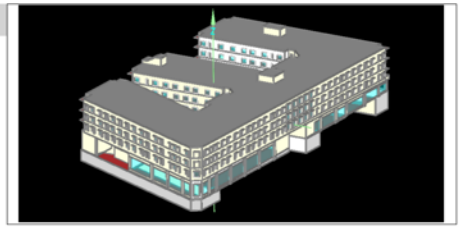

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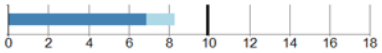

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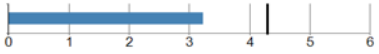

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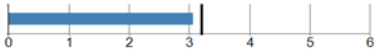

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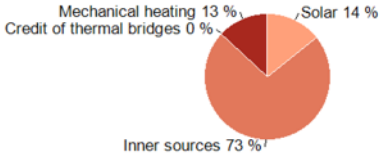

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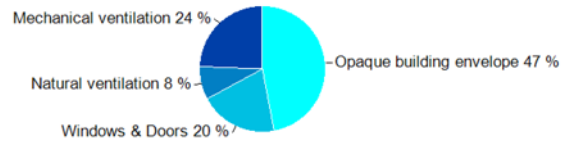
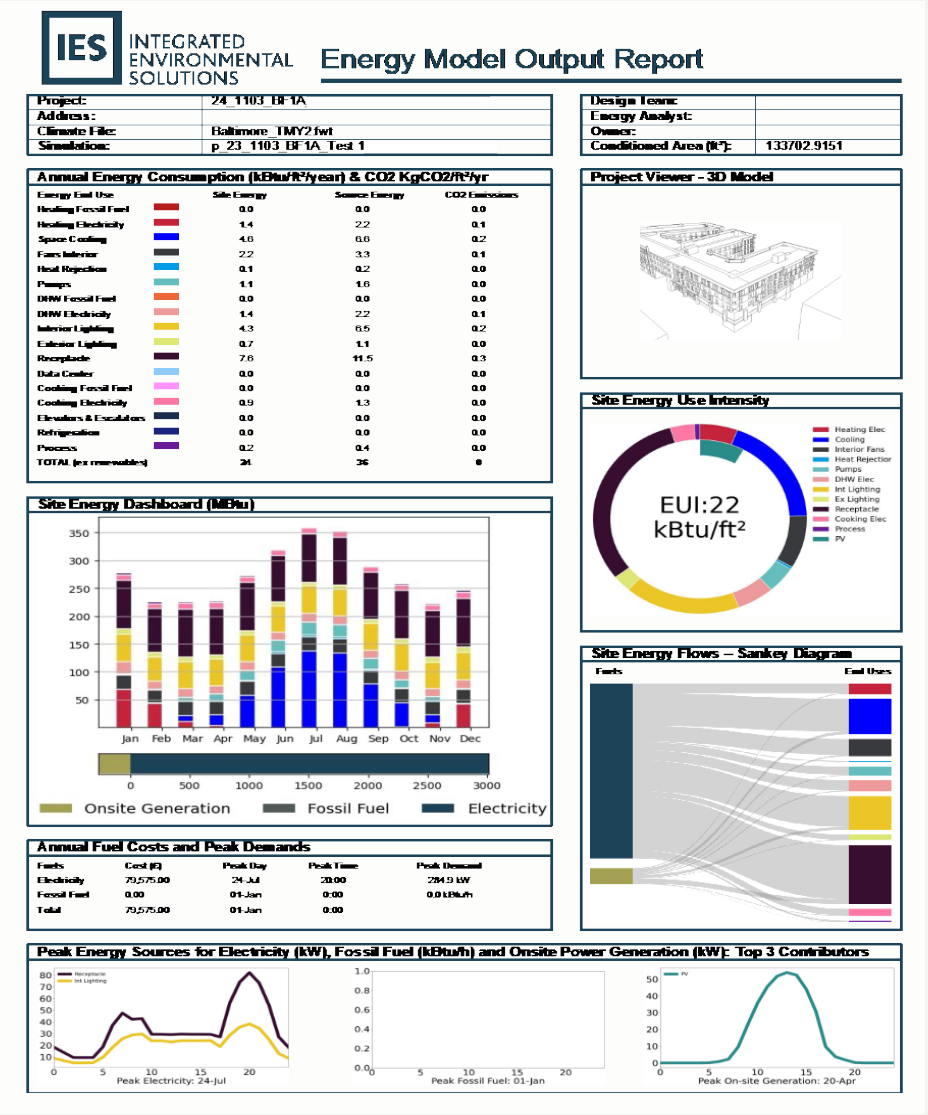


Dynamic Simulation

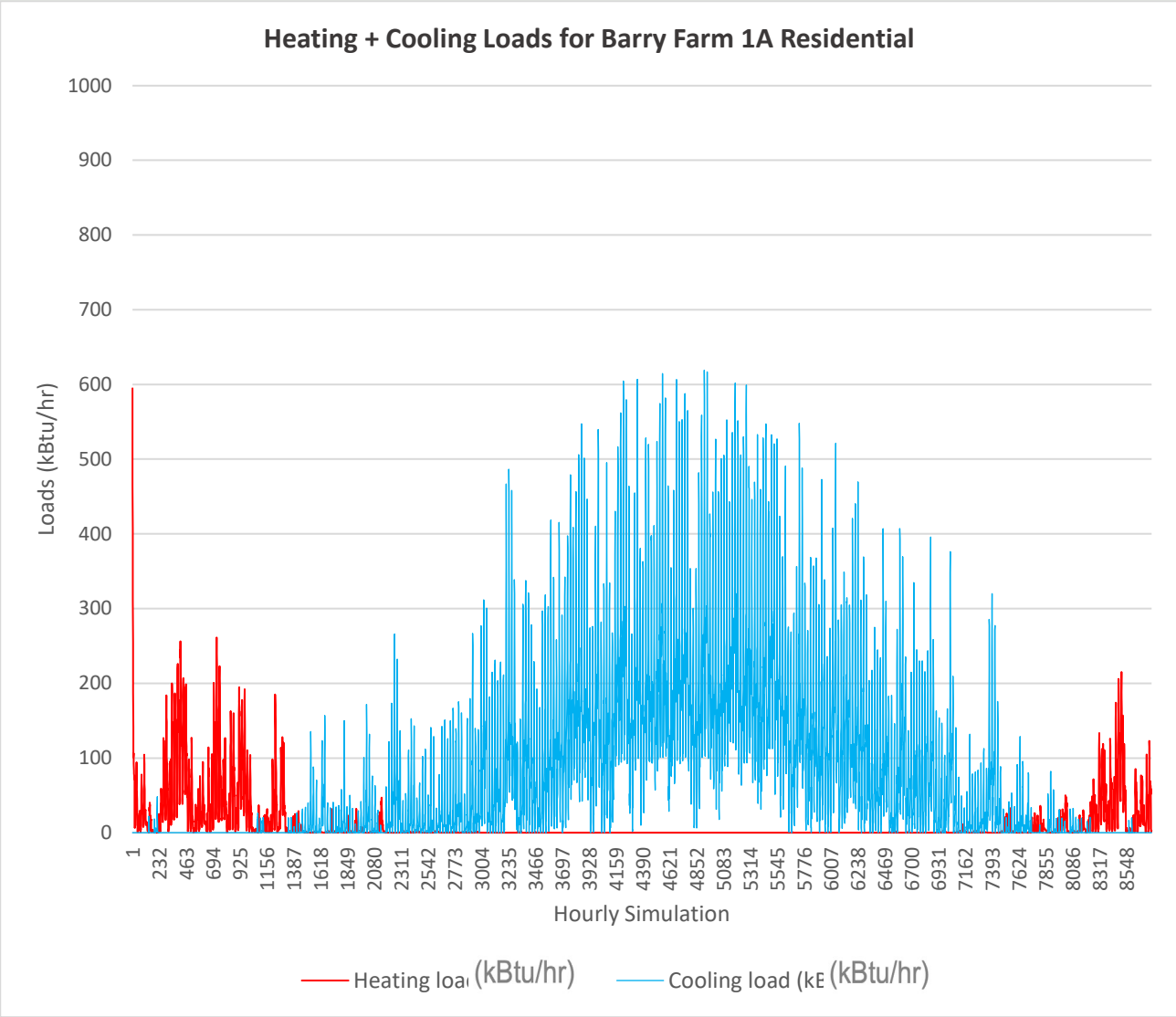


Hourly simulation of heating and cooling conditions

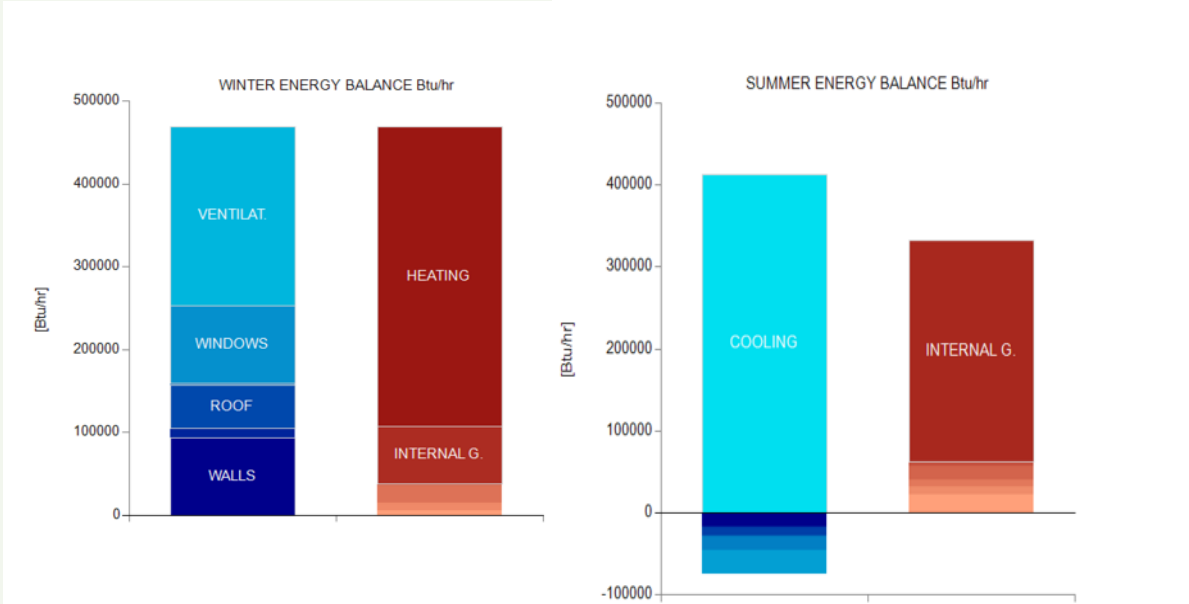
Dynamic simulation of HVAC systems themselves

The Edmondson

Heating and Cooling Imbalance

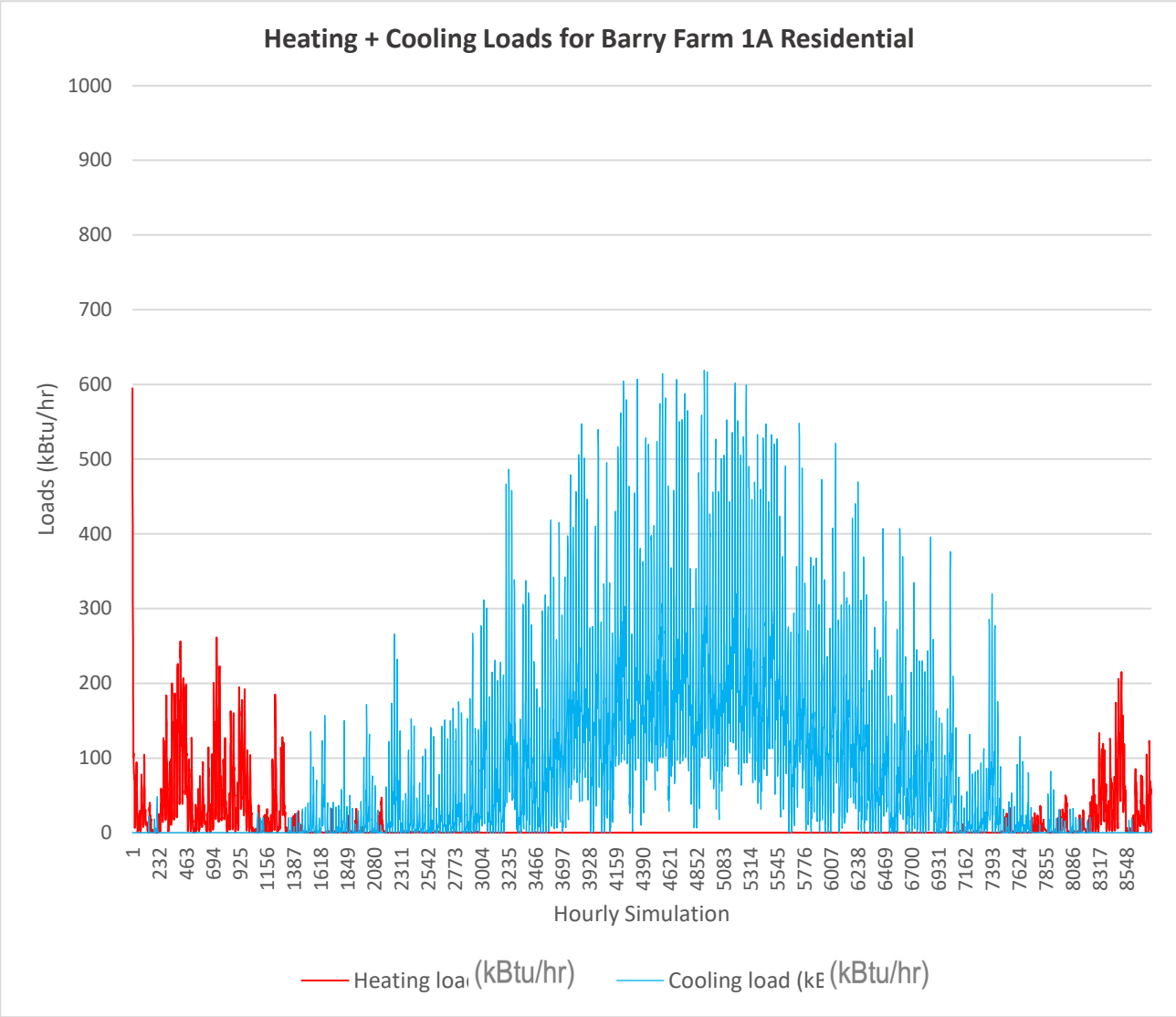


Comparison between IES dynamic simulation and WUFI Passive



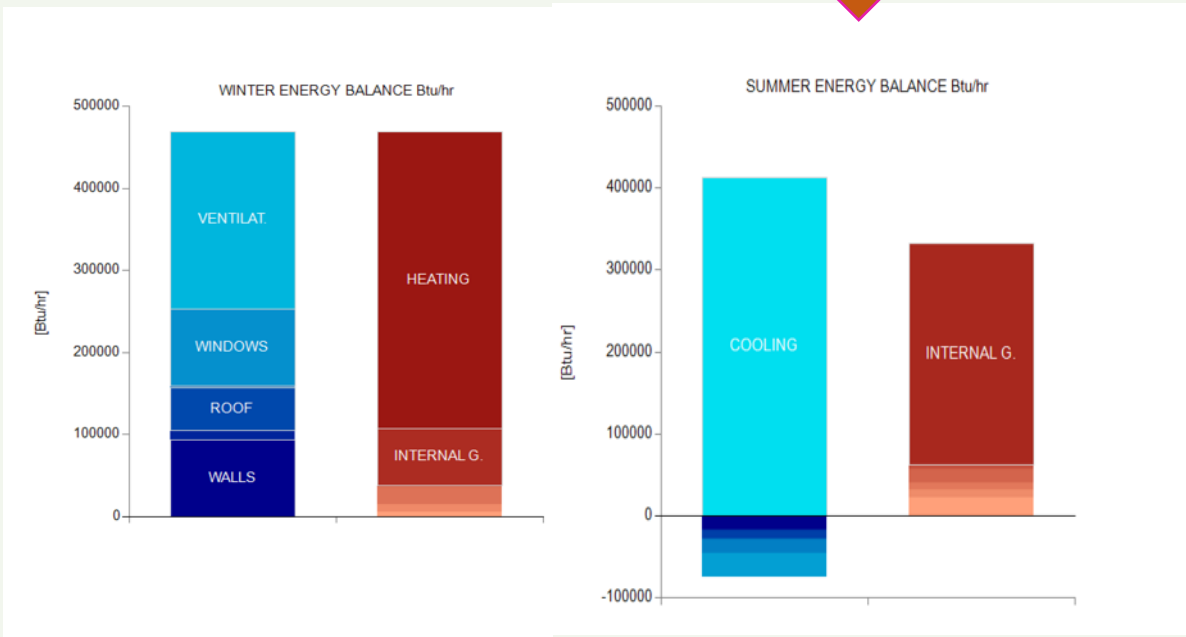
The Edmondson

Heating and Cooling Imbalance



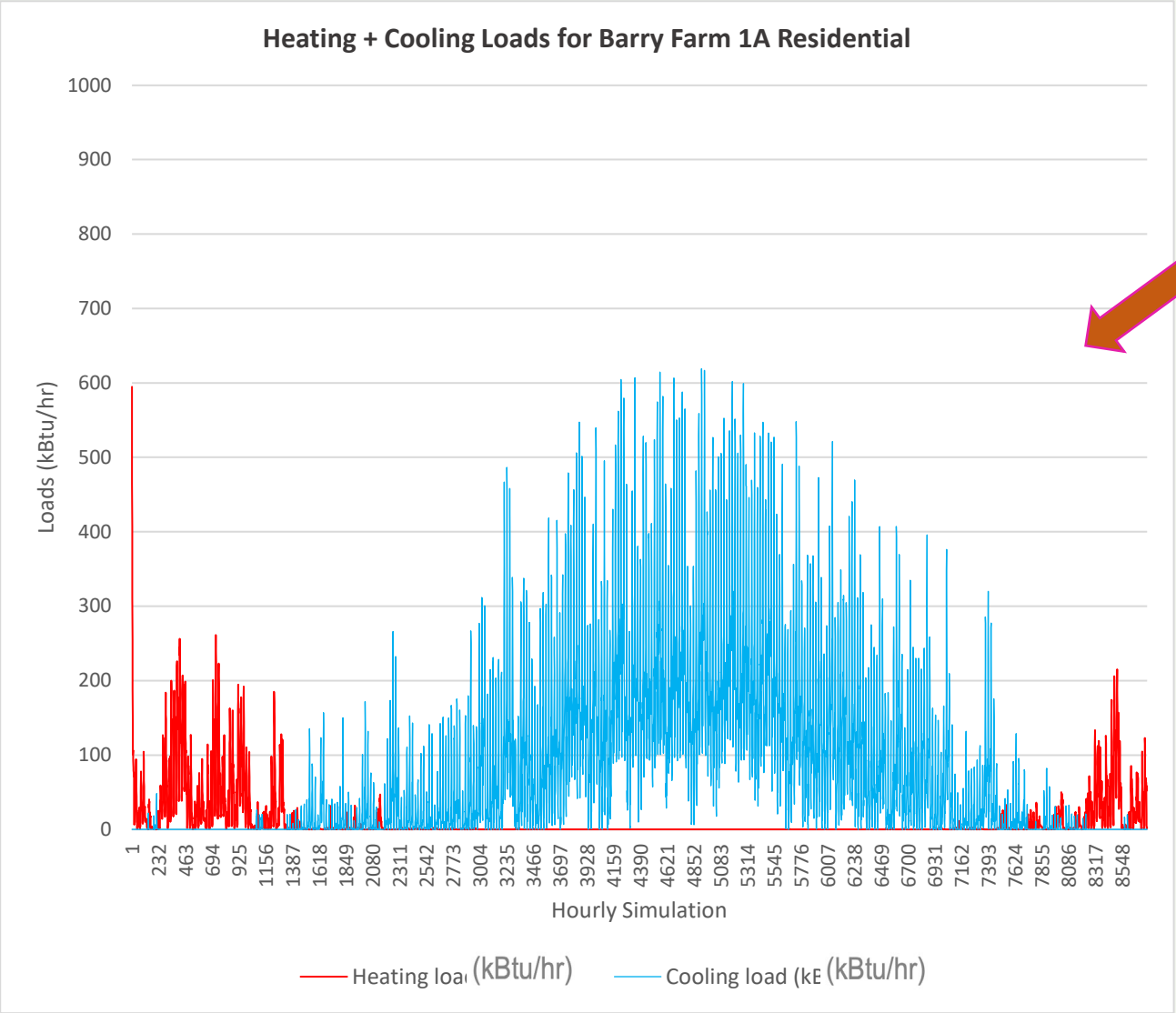
Comparison between IES dynamic simulation and WUFI Passive

This is for the whole building!



The Edmondson

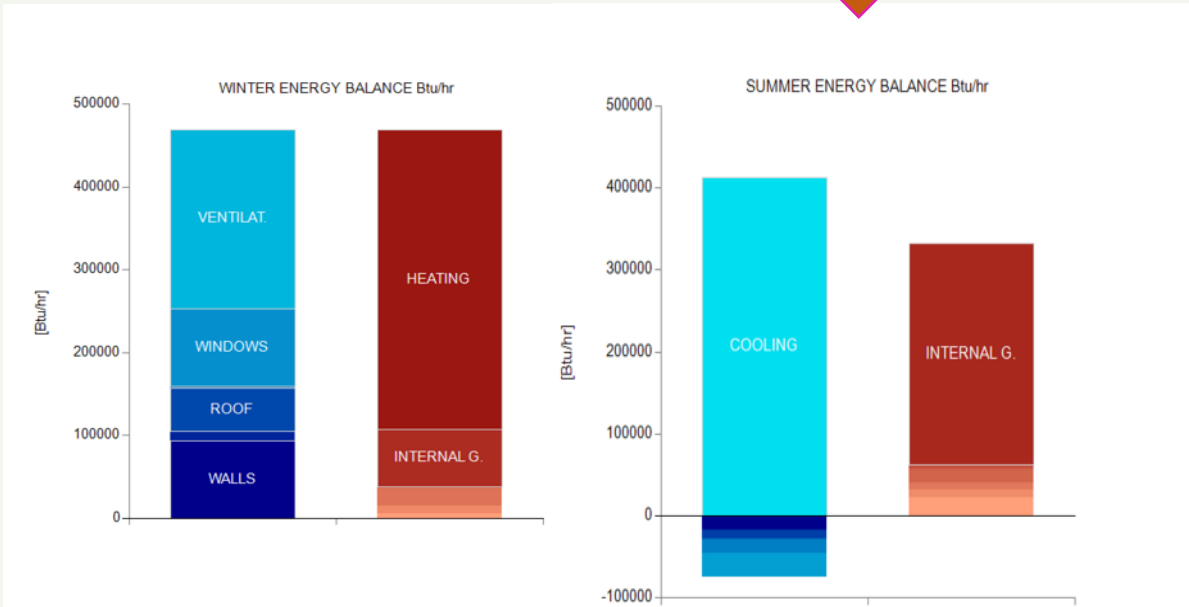
Heating and Cooling Imbalance



Comparison between IES dynamic simulation and WUFI Passive

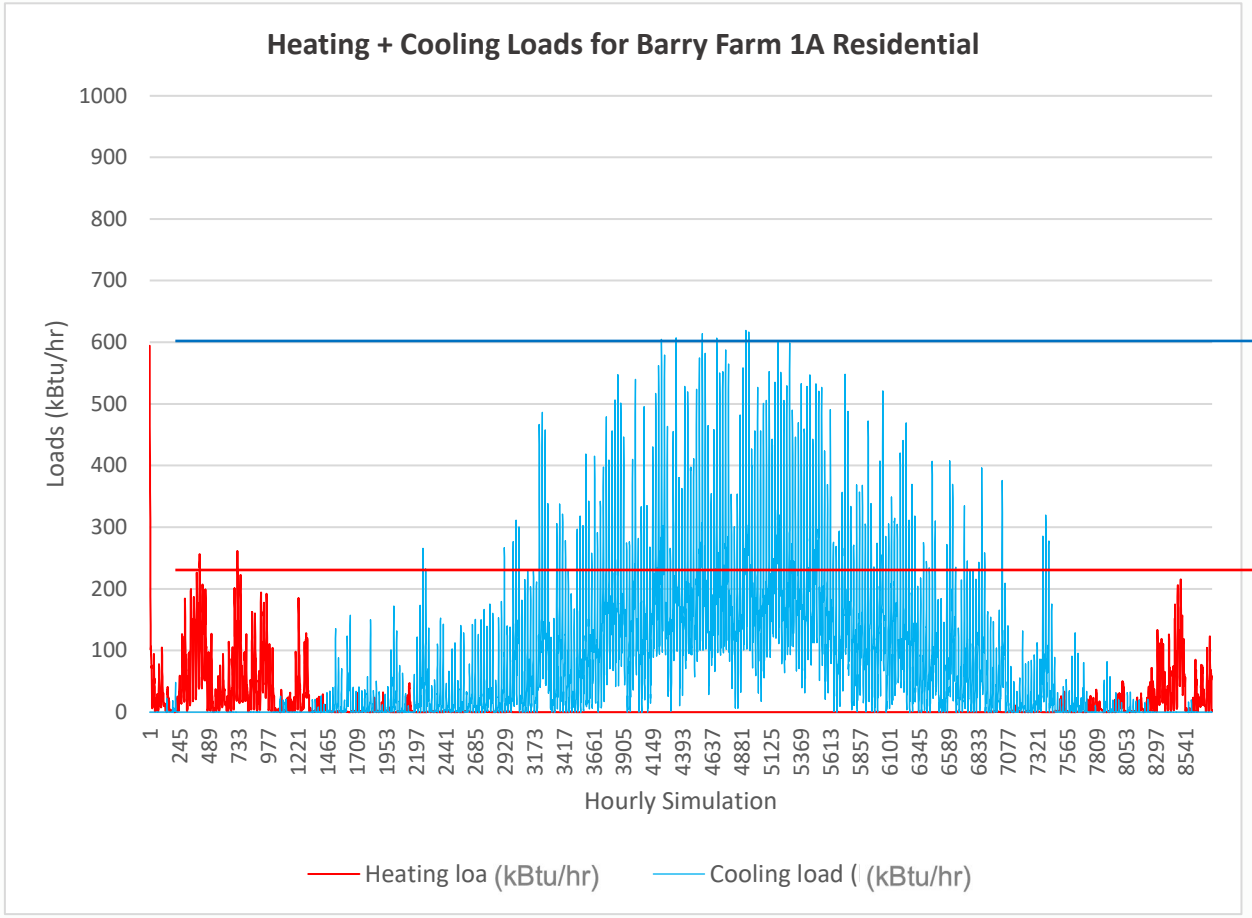
This is just for residential

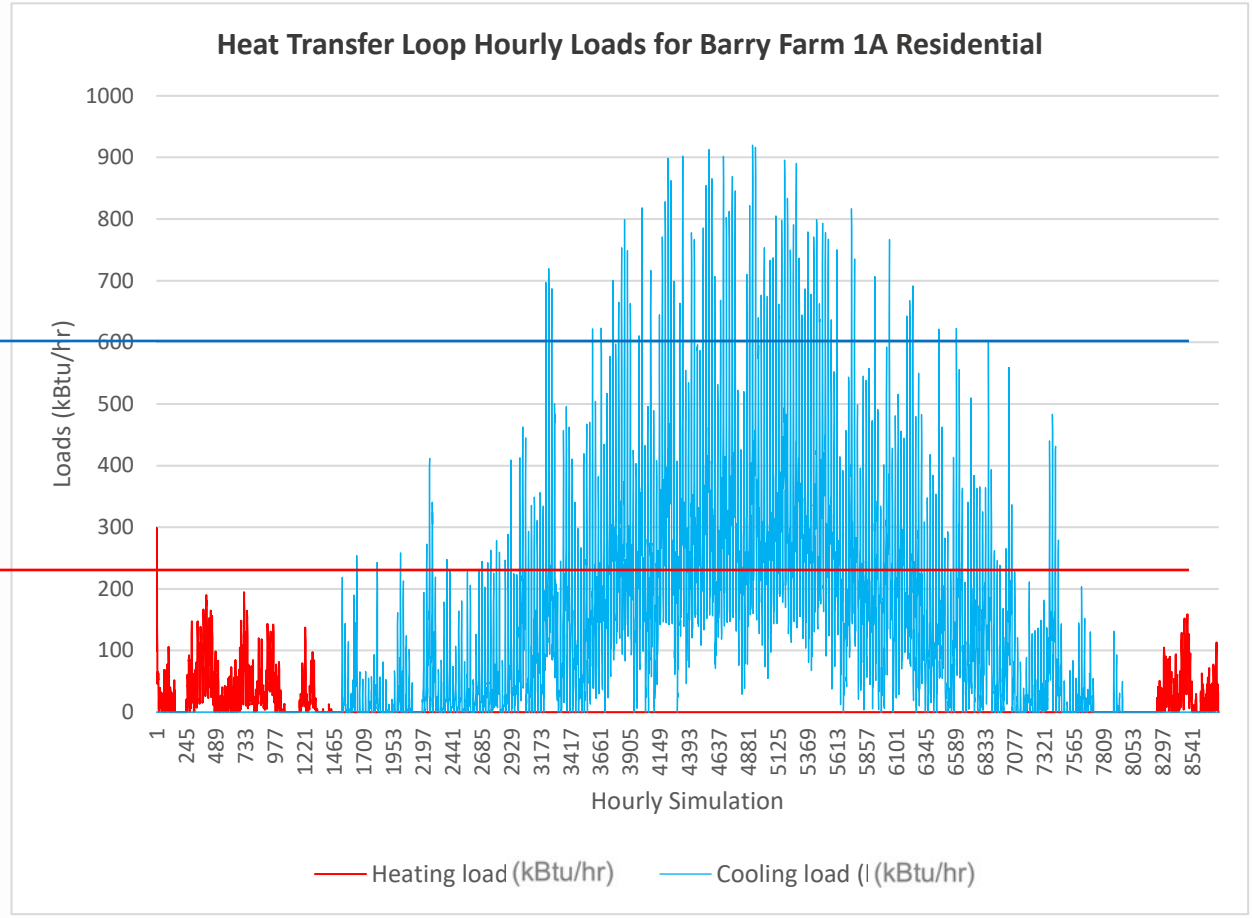
This is for the whole building!



The Edmondson

What are the impacts of the system itself?





Due to the heat of the water-source heat-pump compressors, heating falls and cooling increases – exacerbating the imbalance !!

Cooling to Heating ratio: 2.5/1 Peak - 7.5/1 Annual

Cooling to Heating ratio: 4.5/1 Peak - 18/1 Annual

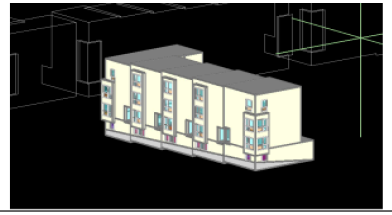
The Rental Flats

Modeling Results –

DC decided to relax Appendix Z

BUILDING INFORMATION

Category:	**Residential**
Status:	**In planning**
Building type:	**New construction**
Year of construction:	**2024**
Units:	**10**
Number of occupants:	**42 (Design)**
Occupant density:	**314.9** ft²/Person



Boundary conditions

Climate:	**WASHINGTON DC REAGAN AP VA**	
Internal heat gains:	**1**	Btu/hr ft²
Interior temperature:	**68**	°F
Overheat temperature:	**77**	°F

Building geometry

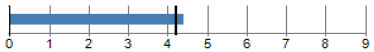
Enclosed volume:	**148,811.6**	ft³
Net-volume:	**124,101.8**	ft³
Total area envelope:	**22,198.9**	ft²
Area/Volume Ratio:	**0.1**	1/ft
Floor area:	**13,227.8**	ft²
Envelope area/iCFA:	**1.678**	

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: **Phius CORE 2021**

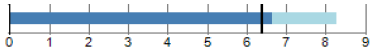
Heating demand

specific:	**4.4**	kBtu/ft²yr
target:	**4.2**	kBtu/ft²yr
total:	58,247.11	kBtu/yr



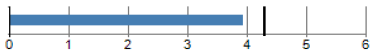
Cooling demand

sensible:	**6.65**	kBtu/ft²yr
latent:	**1.61**	kBtu/ft²yr
specific:	**8.26**	kBtu/ft²yr
target:	**6.4**	kBtu/ft²yr
total:	109,298.04	kBtu/yr



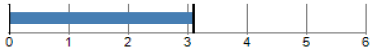
Heating load

specific:	**3.94**	Btu/hr ft²
target:	**4.3**	Btu/hr ft²
total:	52,052.19	Btu/hr



Cooling load

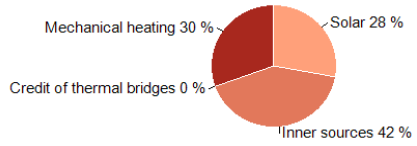
specific:	**3.08**	Btu/hr ft²
target:	**3.1**	Btu/hr ft²
total:	40,766.82	Btu/hr



HEAT FLOW - HEATING PERIOD

Heat gains

Solar:	**42,447**	kBtu/yr
Inner sources:	**63,402**	kBtu/yr
Credit of thermal bridges:	**0**	kBtu/yr
Mechanical heating:	**58,247**	kBtu/yr



Heat losses

Opaque building envelope:	**66,986**	kBtu/yr
Windows & Doors:	**43,284**	kBtu/yr
Natural ventilation:	**12,126**	kBtu/yr
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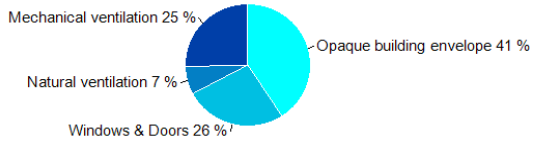

The Rental Flats

Modeling Results –

Not meeting Passive House

More balanced Internal + solar gains

Moderately Cooling Load Dominated Annually

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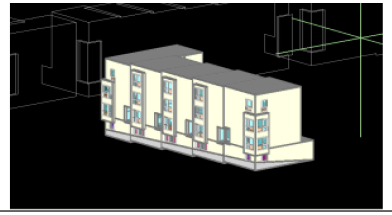

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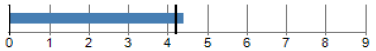

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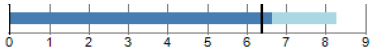

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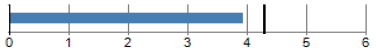

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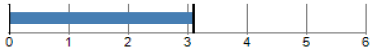

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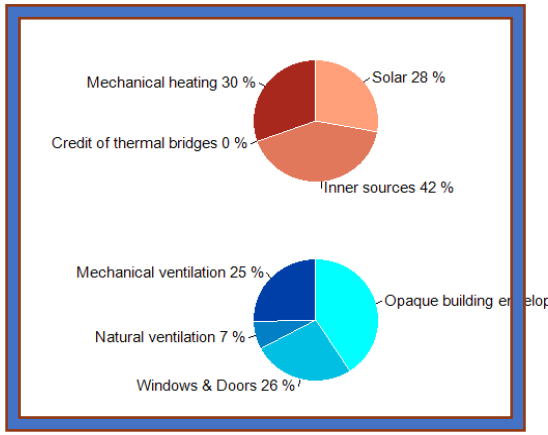

The Rental Flats

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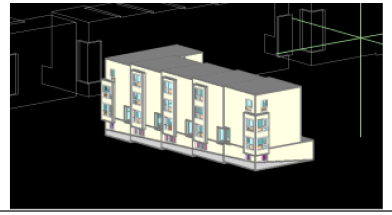
Number of occupants:	**42 (Design)**
Occupant density:	**314.9** ft²/Person



Boundary conditions

Climate:	**WASHINGTON DC REAGAN AP VA**
Internal heat gains:	**1** Btu/hr ft²
Interior temperature:	**68** °F
Overheat temperature:	**77** °F

Building geometry

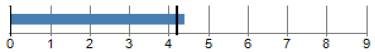
Enclosed volume:	**148,811.6** ft³
Net-volume:	**124,101.8** ft³
Total area envelope:	**22,198.9** ft²
Area/Volume Ratio:	**0.1** 1/ft
Floor area:	**13,227.8** ft²
Envelope area/iCFA:	**1.678**

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: **Phius CORE 2021**

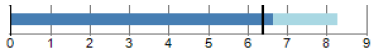
Heating demand

specific:	**4.4** kBtu/ft²yr
target:	**4.2** kBtu/ft²yr
total:	58,247.11 kBtu/yr



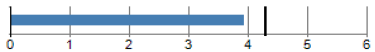
Cooling demand

sensible:	**6.65** kBtu/ft²yr
latent:	**1.61** kBtu/ft²yr
specific:	**8.26** kBtu/ft²yr
target:	**6.4** kBtu/ft²yr
total:	109,298.04 kBtu/yr



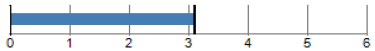
Heating load

specific:	**3.94** Btu/hr ft²
target:	**4.3** Btu/hr ft²
total:	52,052.19 Btu/hr



Cooling load

specific:	**3.08** Btu/hr ft²
target:	**3.1** Btu/hr ft²
total:	40,766.82 Btu/hr

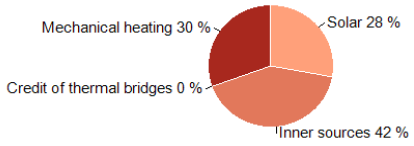


Peak loads relatively balanced

HEAT FLOW - HEATING PERIOD

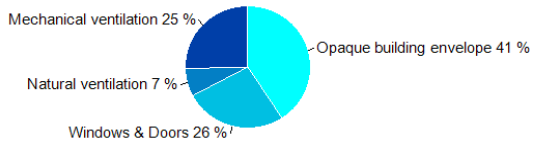
Heat gains

Solar:	**42,447** kBtu/yr
Inner sources:	**63,402** kBtu/yr
Credit of thermal bridges:	**0** kBtu/yr
Mechanical heating:	**58,247** kBtu/yr



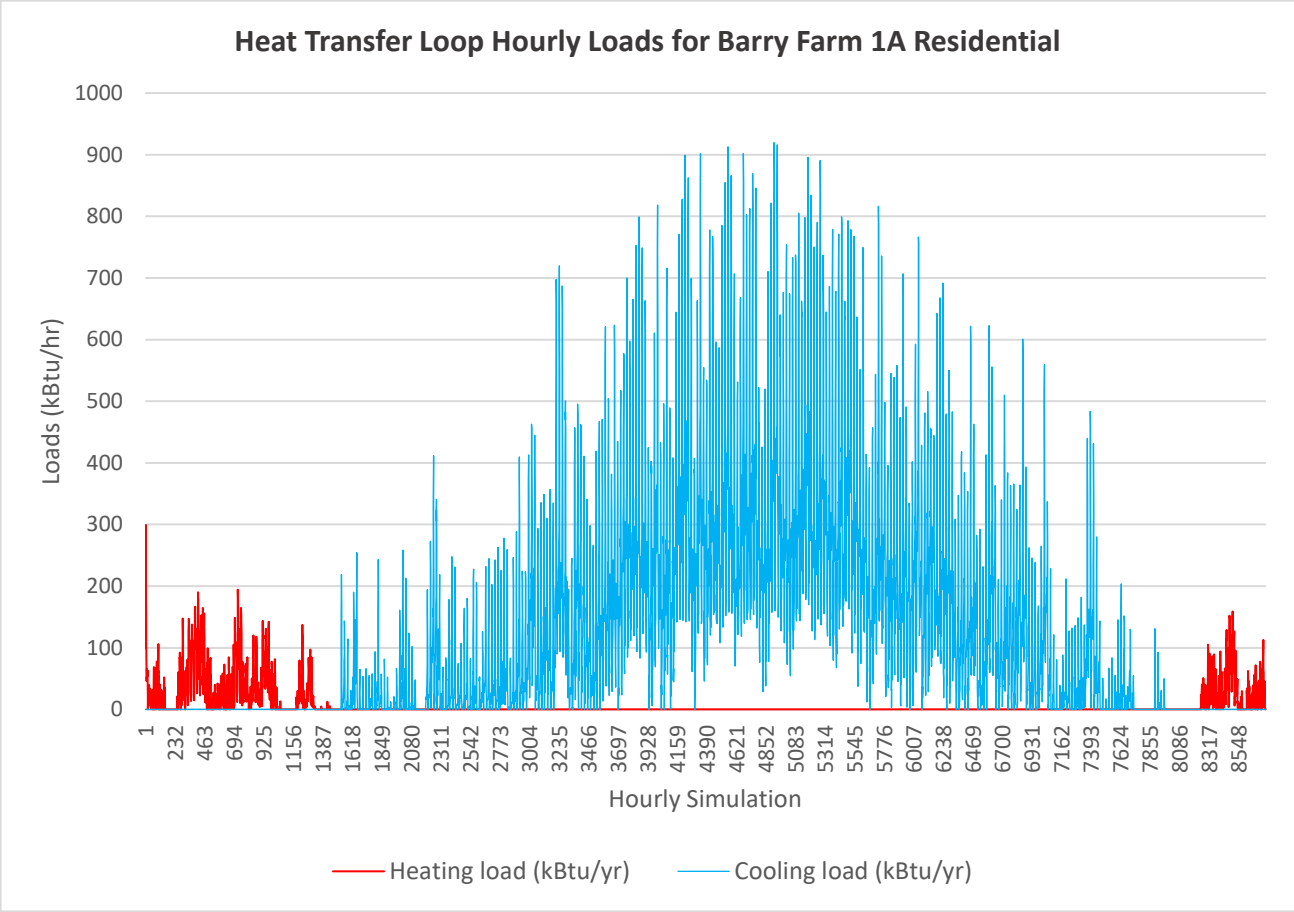
Heat losses

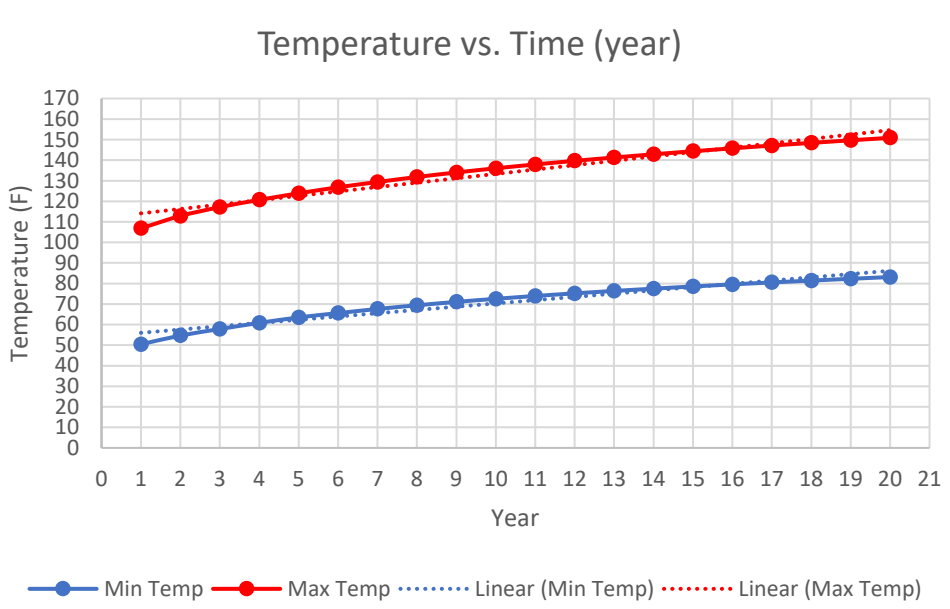
Opaque building envelope:	**66,986** kBtu/yr
Windows & Doors:	**43,284** kBtu/yr
Natural ventilation:	**12,126** kBtu/yr
Mechanical ventilation:	**41,701** kBtu/yr



Heating and Cooling Mismatch

Overheating of Borefield



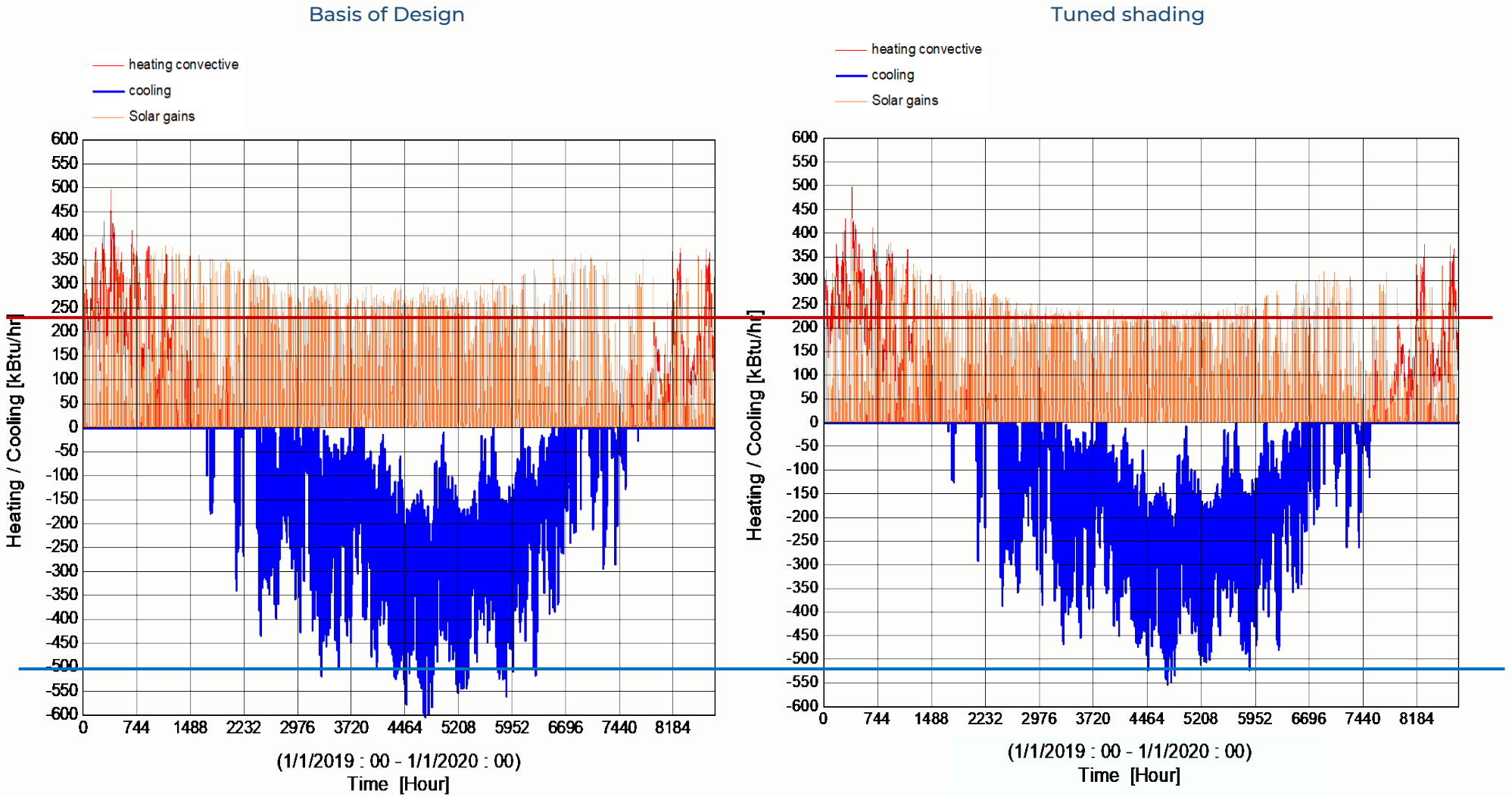


Ground temperatures rise over 20 years to 150 degrees

Cooling Dominant

Solar Gain Contribution

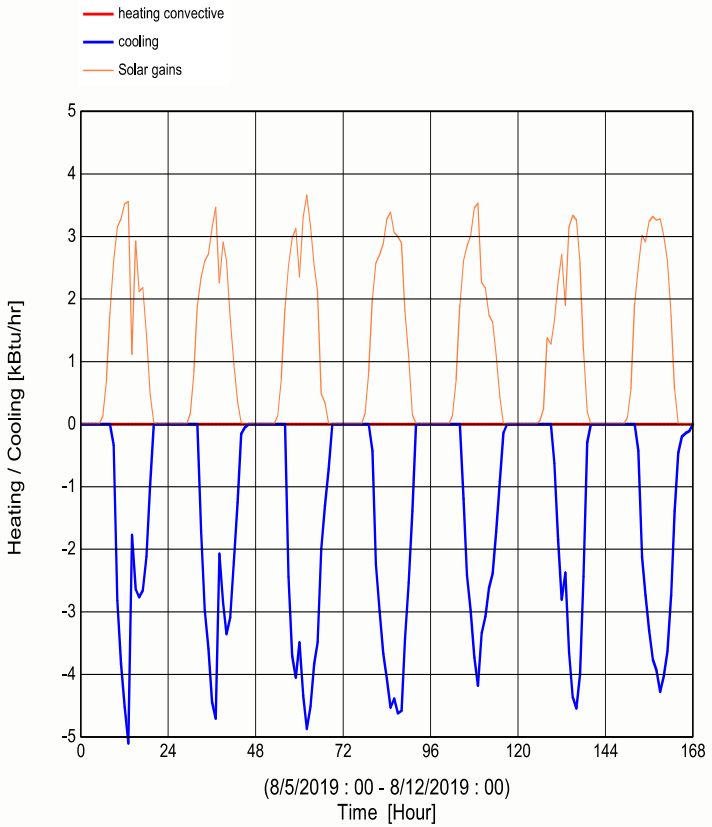
Passive design could have helped



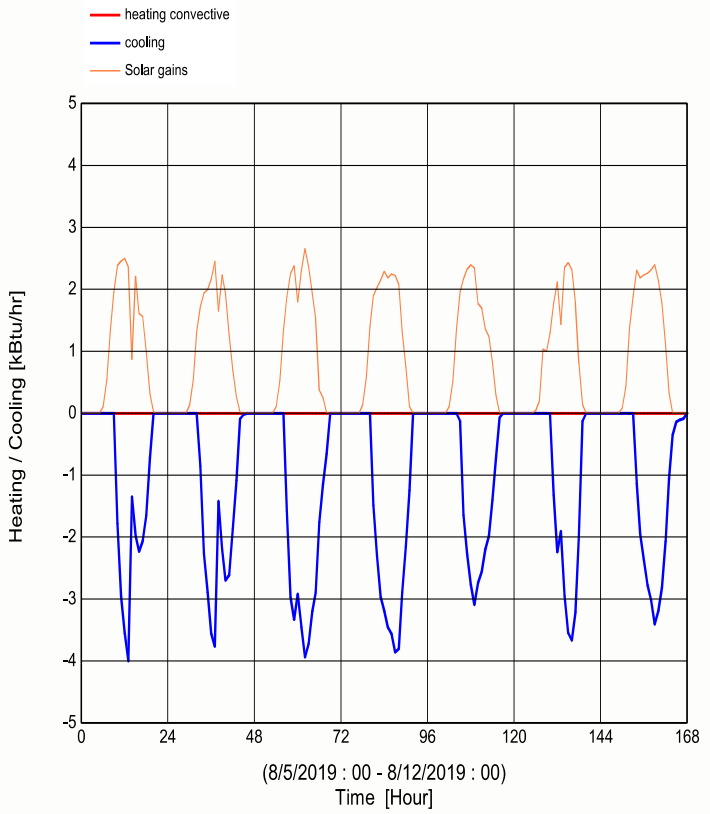
Cooling Dominant

Passive design could have helped

Basis of Design



Tuned shading



25% - 42% reduction in hourly peaks in sample units - proportional to solar gain

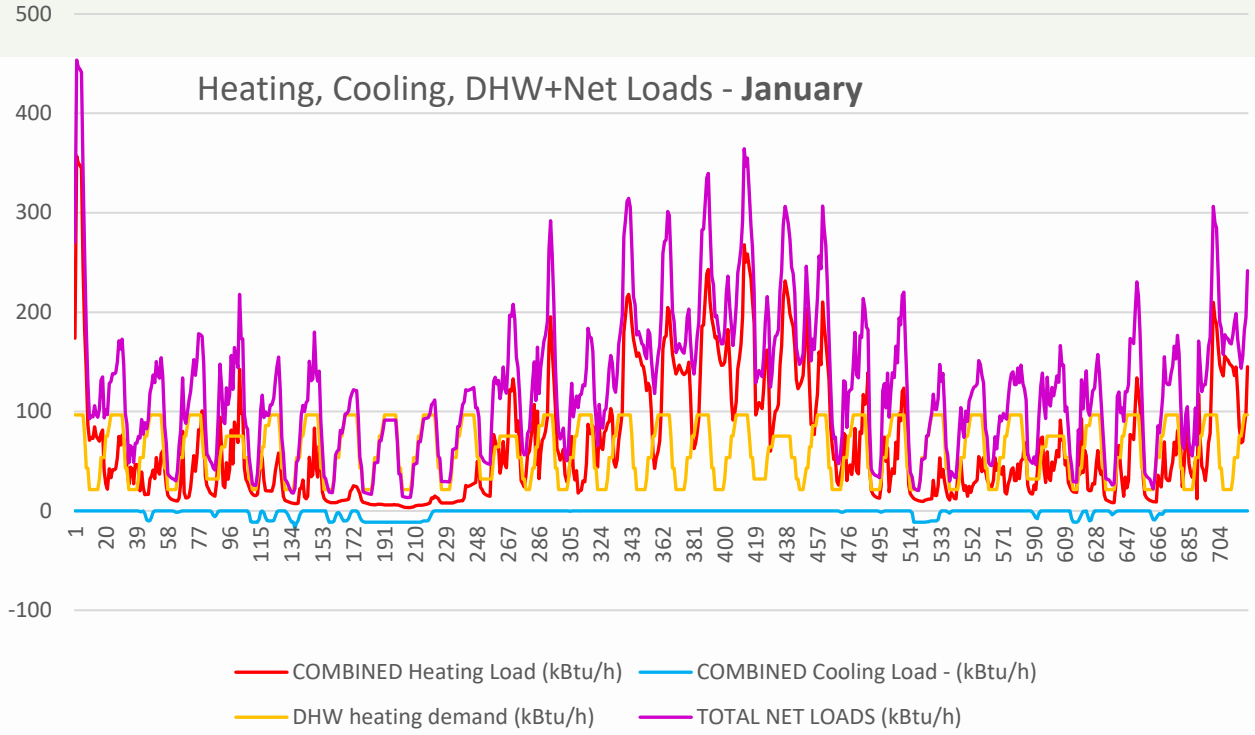
Would this have reduced systems size? Would this have reduced borefields?

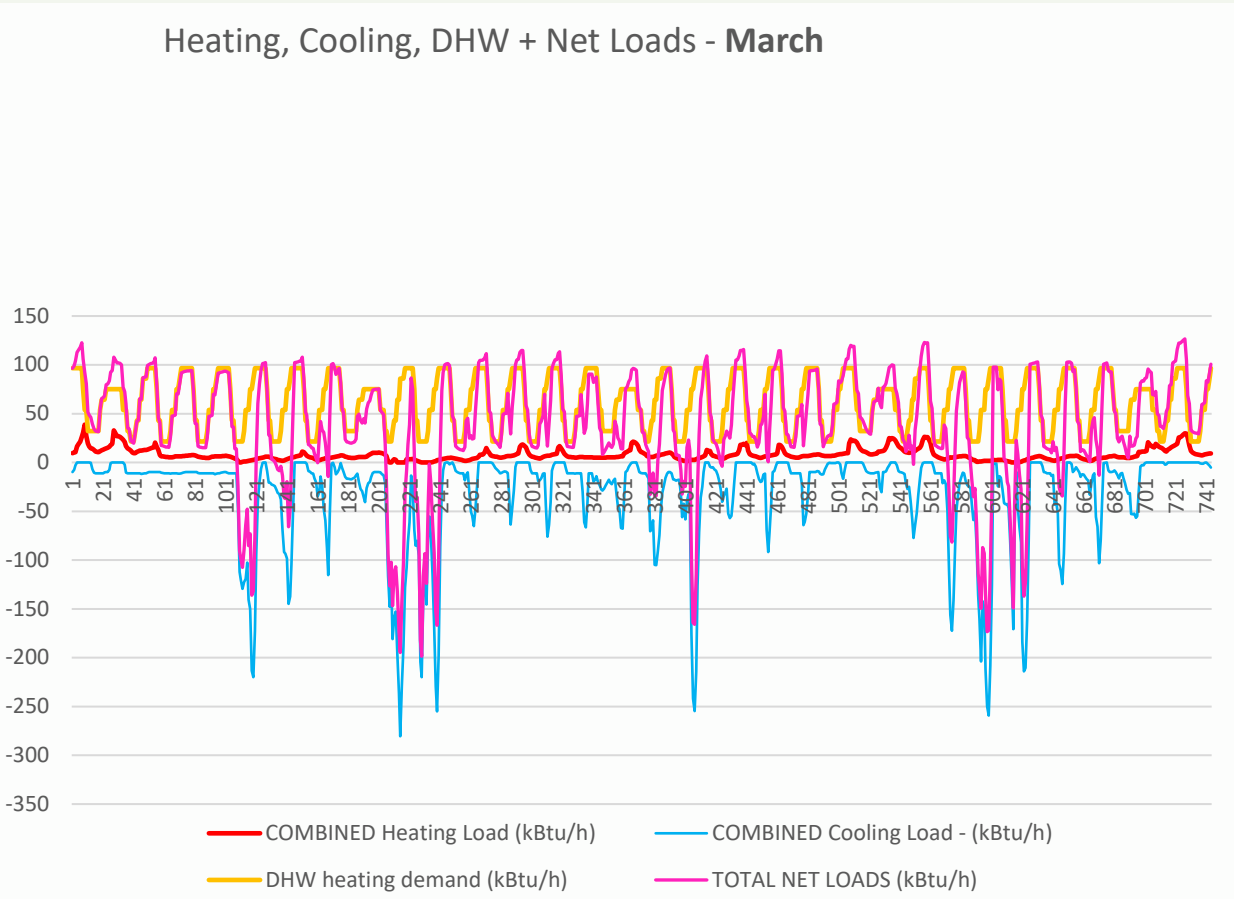
Not Explored During VE.

Balancing the Loop?

Load diversity by adding DHW

Combining diverse loads should seasonally balance the loop and deliver maximum efficiency.

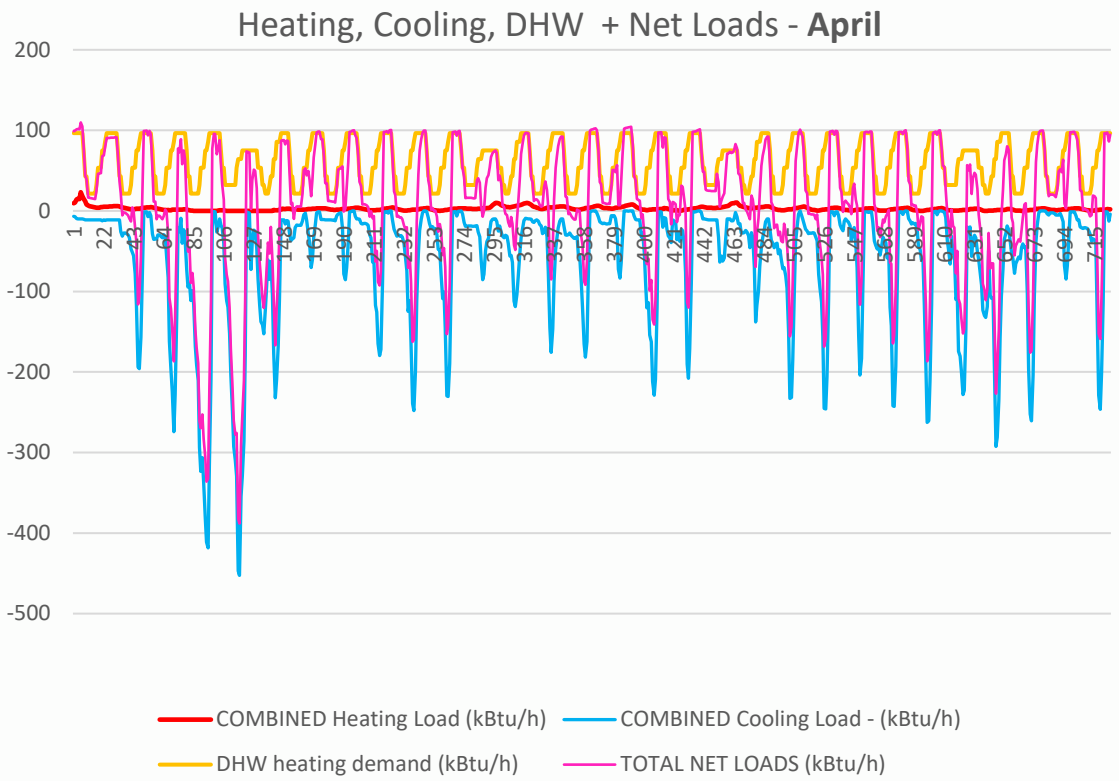


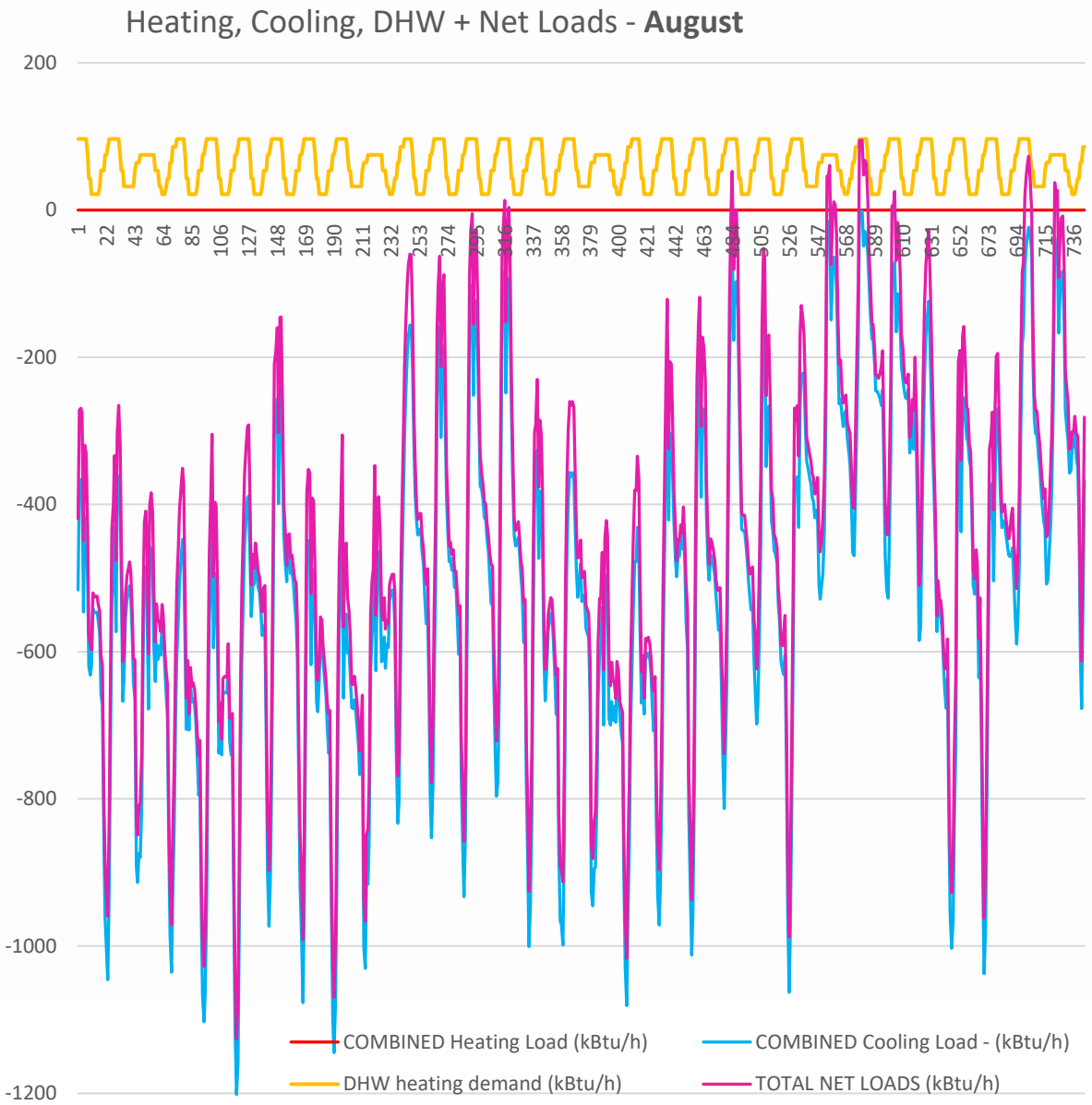


DHW does add to the heating + reduce cooling . . .

Balancing the Loop?

Load diversity by adding DHW



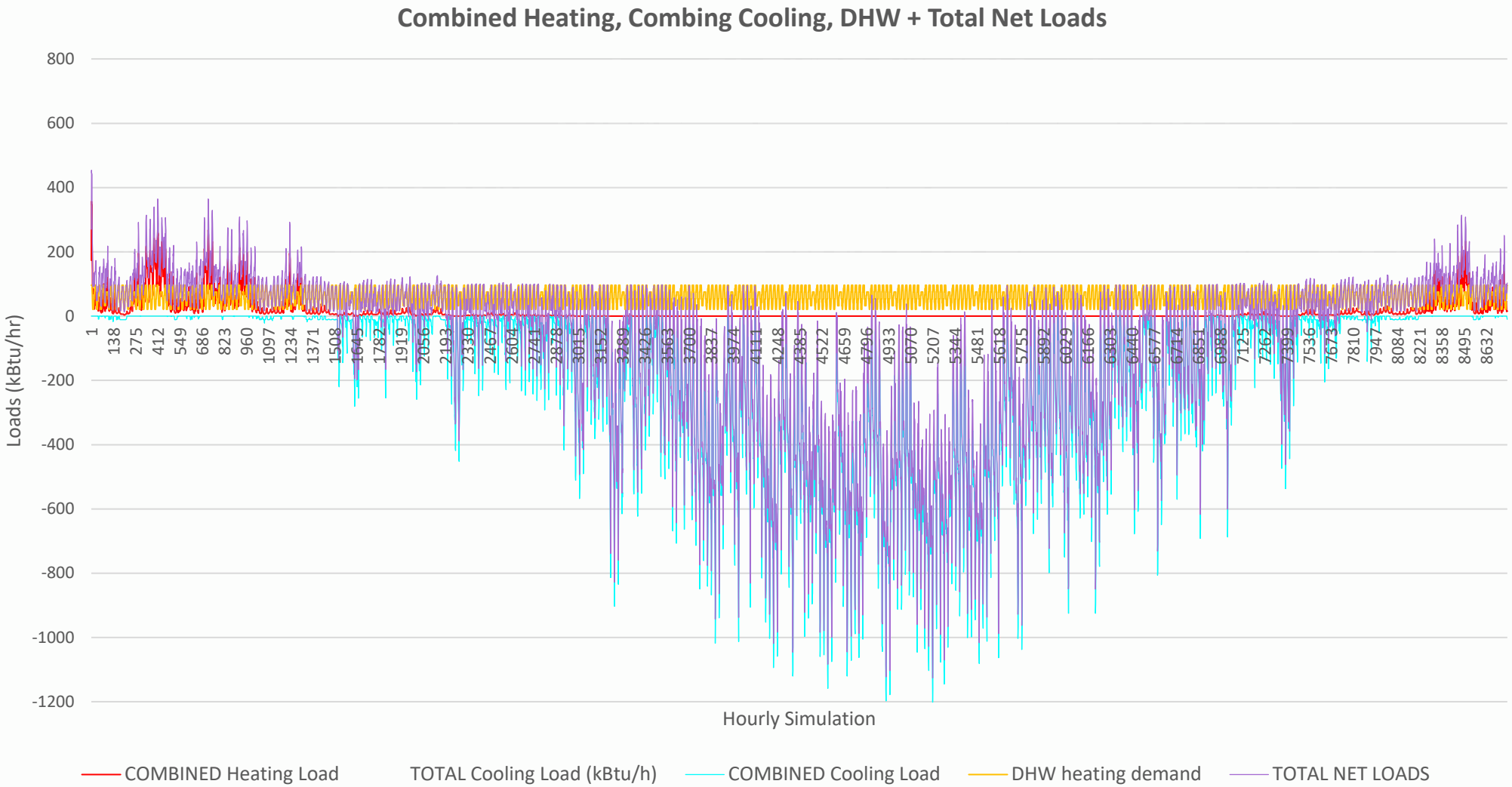


DHW does add to the heating + reduce cooling, but not nearly enough to balance the ground loop.

Balancing the Loop?

Load diversity by adding DHW?

DHW helps, but is not enough! – Now What?

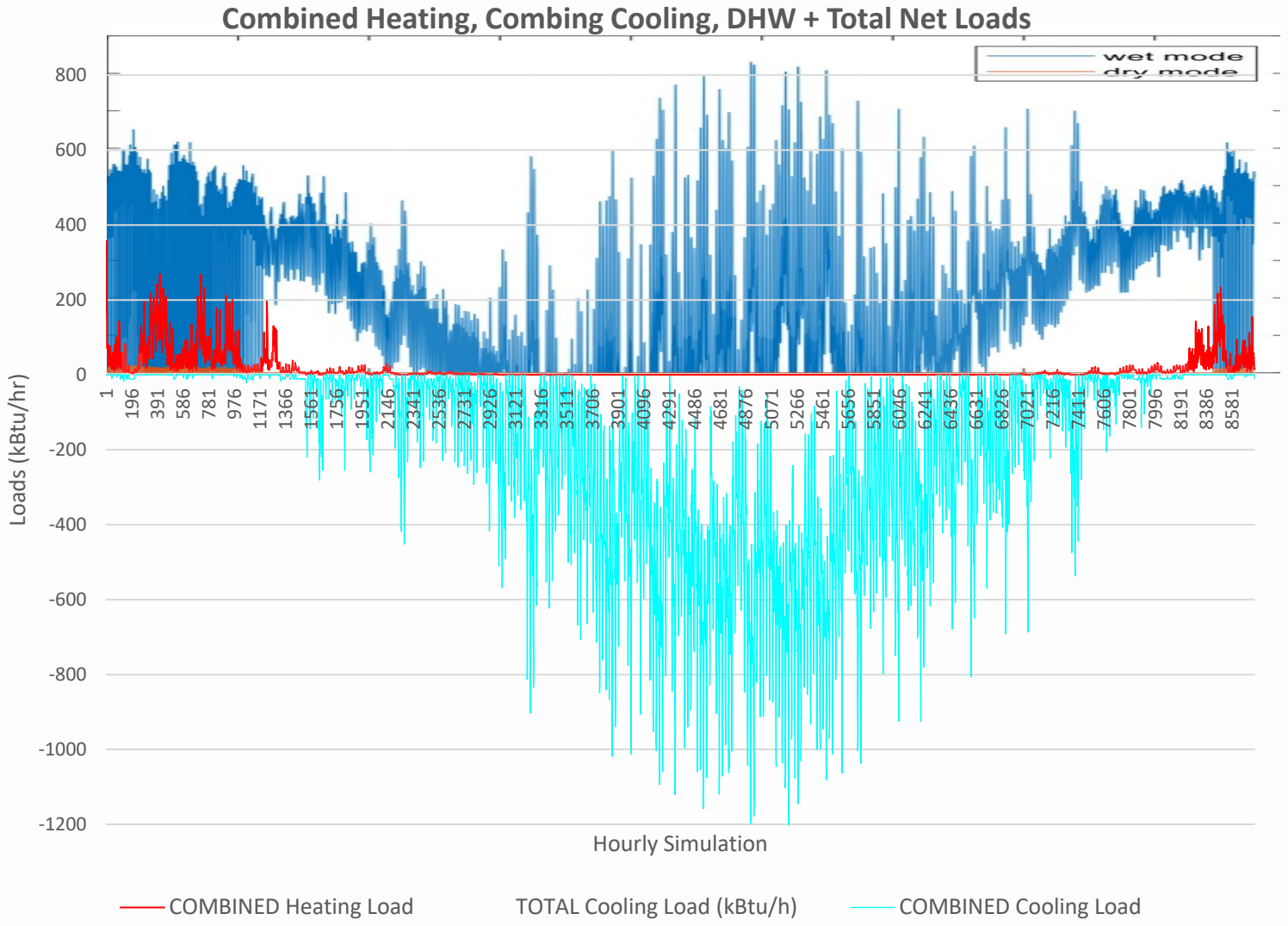


Cooling to Heating ratio = 5/1 Peak. - 13/1 Annual

Balancing the Loop?

How to compensate for lack of Load diversity?

Roof top cooling tower loads balance loop loads

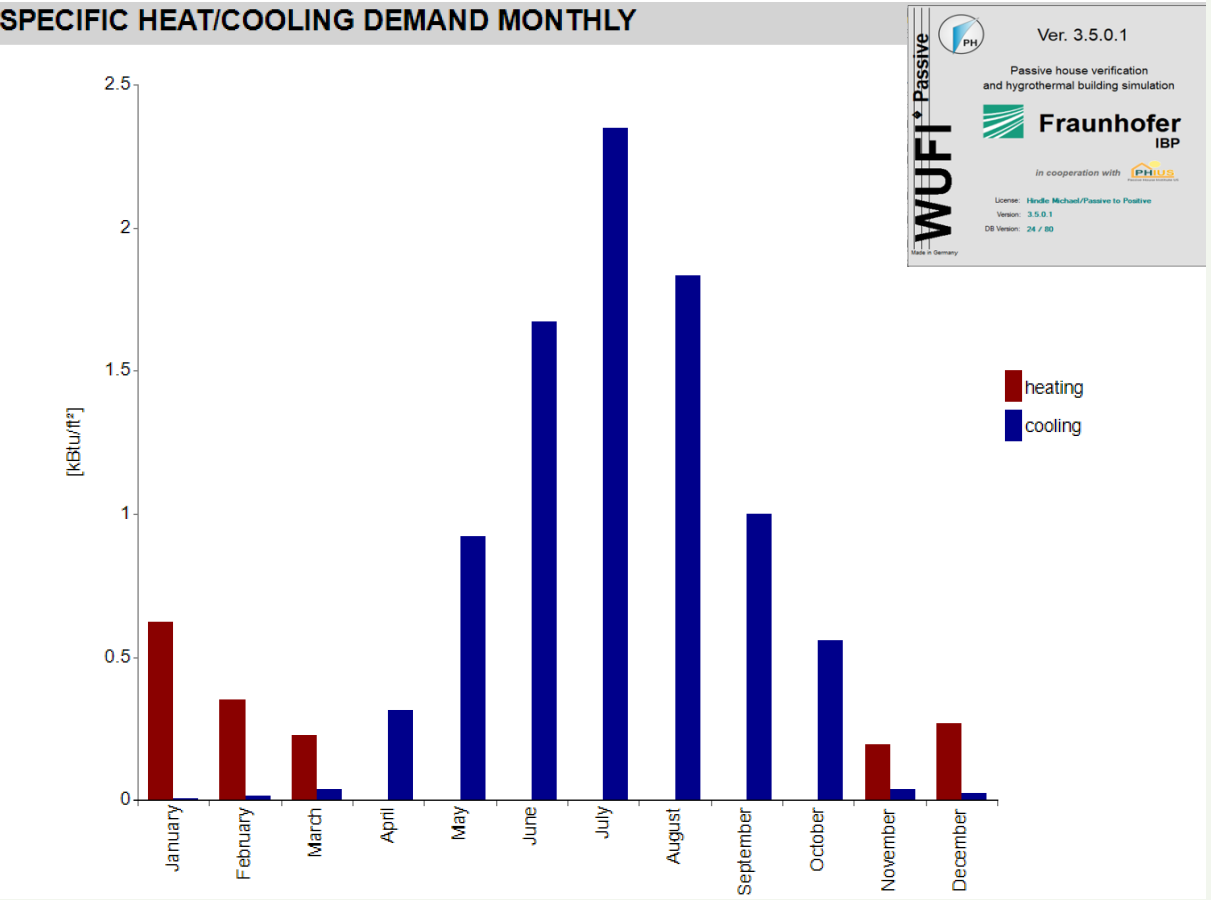


Cooling to Heating ratio = 5/1 Peak. - 13/1 Annual

Geothermal Load

Heating and Cooling Imbalance

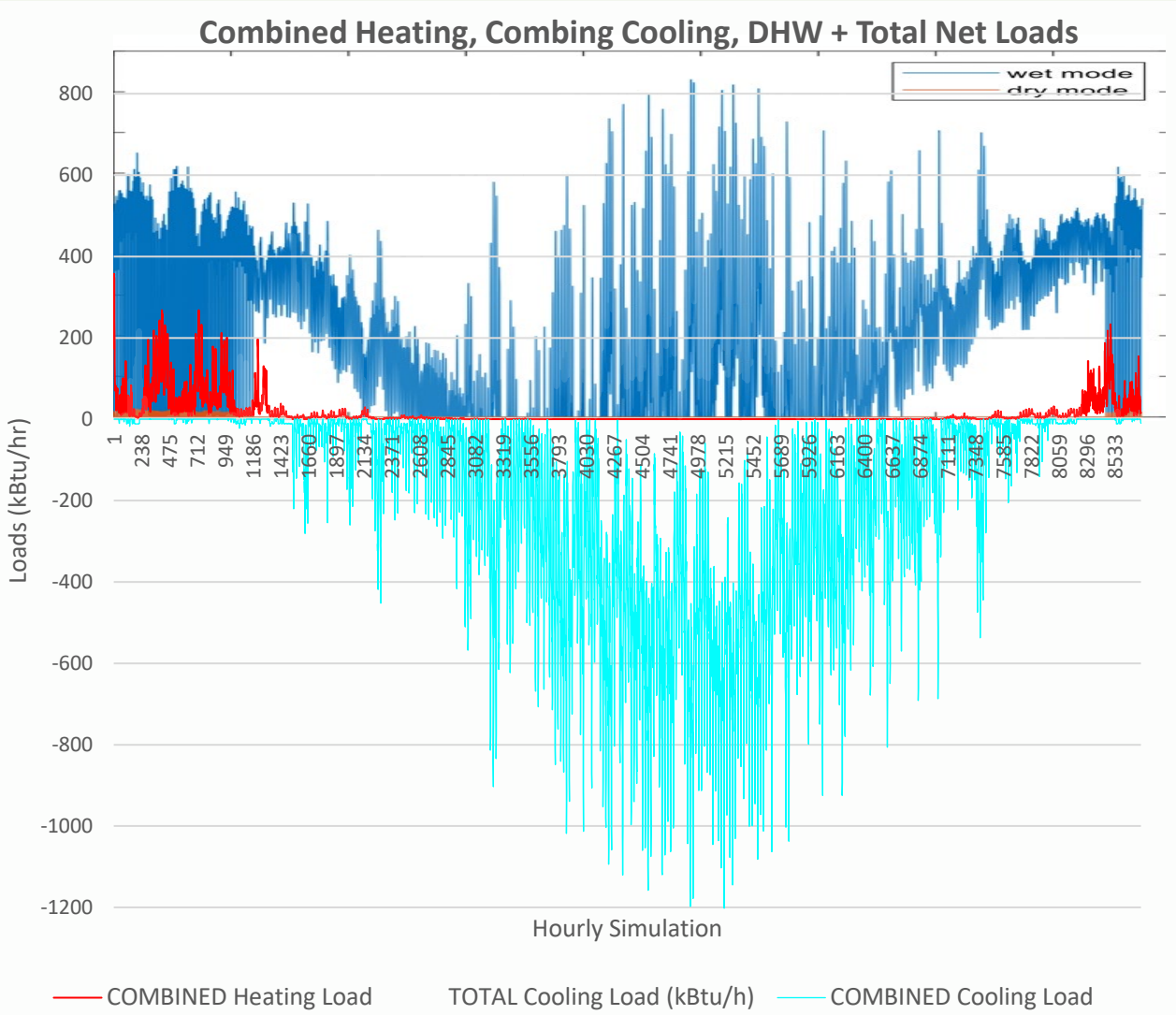
heating and cooling imbalance



Why not heat the Garage? Or melt snow on the sidewalks?

Balancing the Loop?

How to compensate for lack of Load diversity?



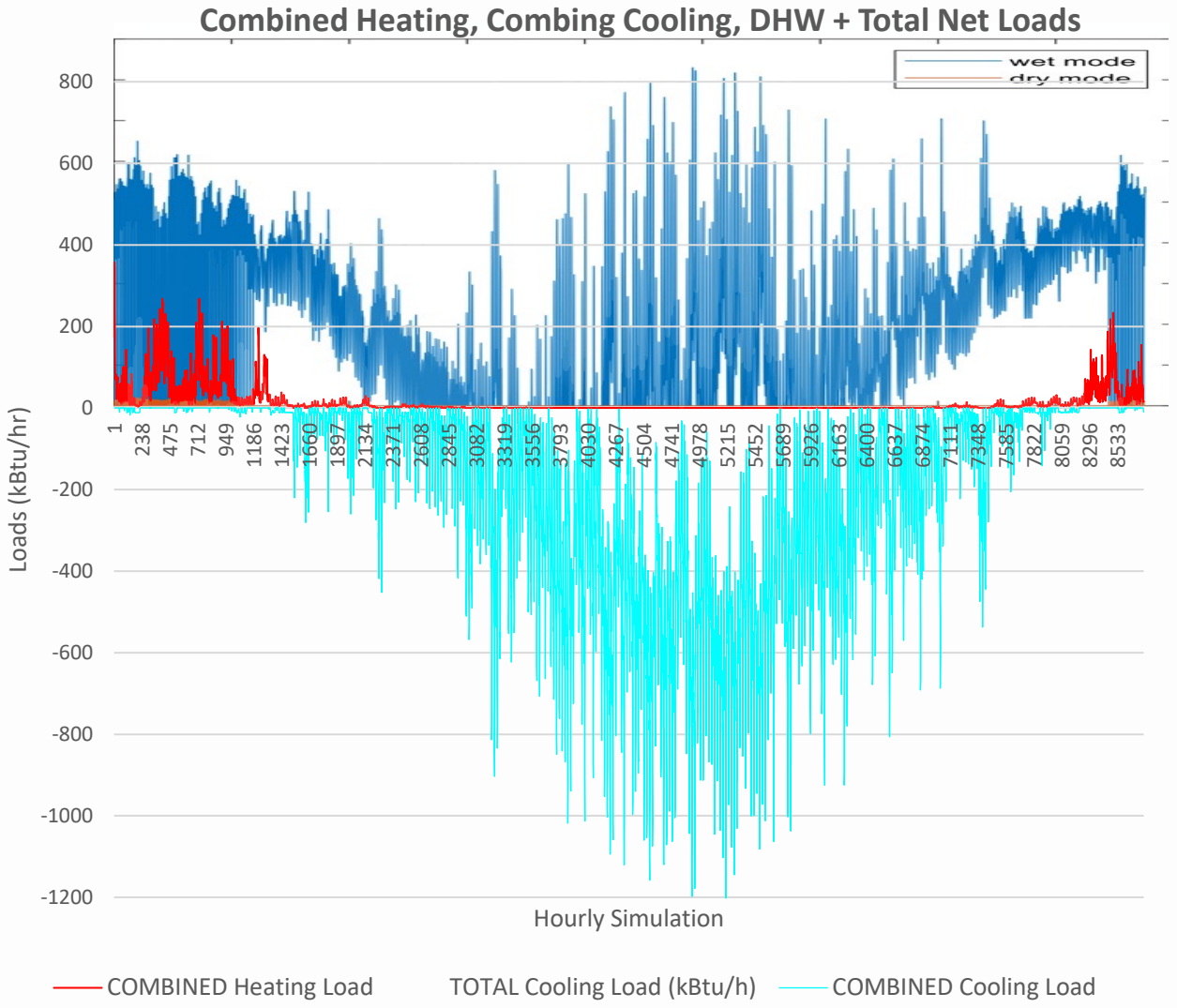
Or provide free heat for the neighbors?

Cooling to Heating ratio = 5/1 Peak. - 13/1 Annual

Balancing the Loop?

How to compensate for lack of Load diversity?

Or to the Rec Center?

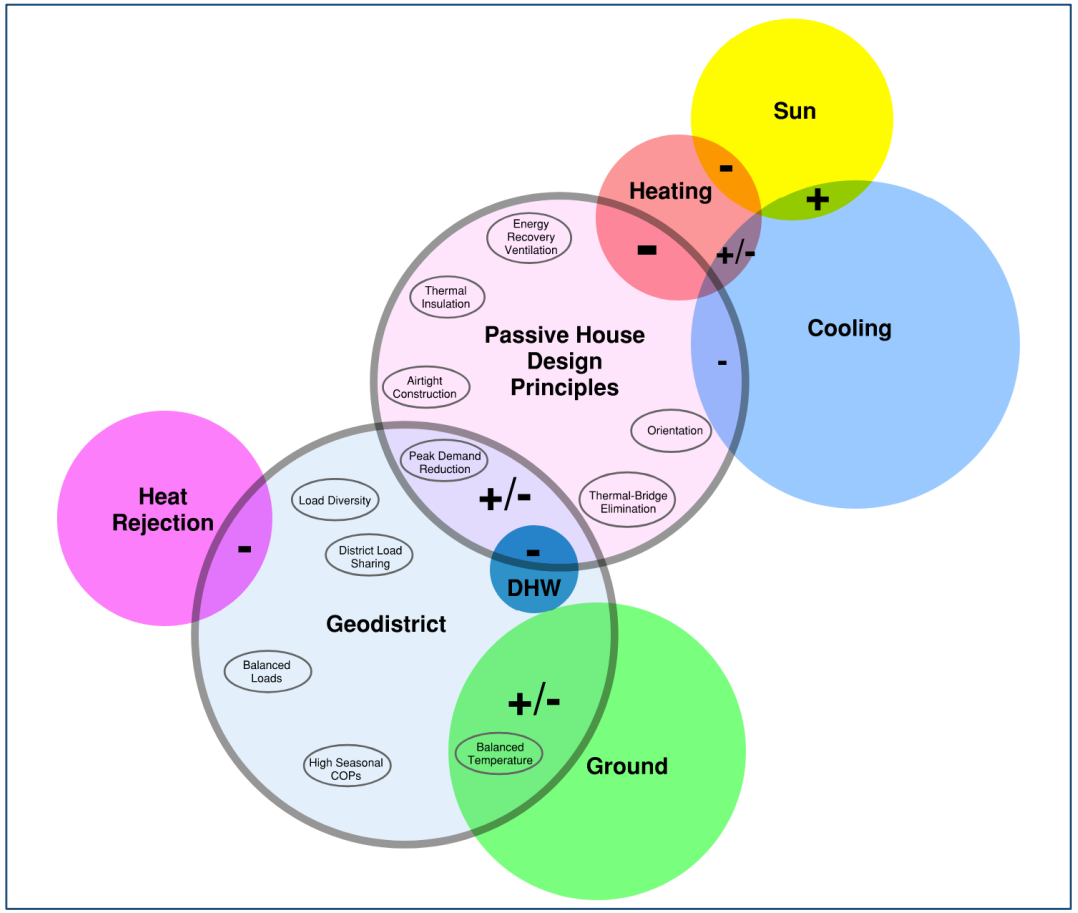


Cooling to Heating ratio = 5/1 Peak. - 13/1 Annual

Balancing the Loop?

How to compensate for lack of Load diversity?

Or to the Rec Center?



Cooling to Heating ratio = 5/1 Peak. - 13/1 Annual

Thank You!