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Leveraging Solid Wood in Passive House Enclosure

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placetailor.com

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

Course Description

What is passive house design and why is it a good fit for multi-family projects? How can the use of mass timber and light wood-frame structural wall and roof framing materials influence and benefit a project's energy performance? What are the critical building enclosure assemblies and details that establish passive house levels of energy use reduction? How do site orientation and mechanical heat recovery and air ventilation factor in? And perhaps the biggest question on everyone's mind: Does passive house design result in significant cost premiums over traditional approaches, or is it a small cost increase, which can be quickly repaid once the building is operational?

This webinar will provide unique insights into the implementation of passive house design techniques on multi-family, mid-rise projects in the US. The team that designed the all-mass timber 201 Hampden in Boston will highlight the use of CLT as exterior wall and roof panels, and the impact this had on enclosure design and passive house performance. The architect for the light wood-frame Orchards at Orenco, Phases I and II, one of the largest certified passive house buildings in North America, will also discuss enclosure detailing, challenges, and lessons learned on these projects.

Learning Objectives

1. Review the defining principals of passive house design and how it differs from traditional energy-efficiency design.

2. Highlight areas of the building enclosure that are critical to design, detail and install correctly in order to achieve deep energy savings.

3. Explore effective detailing techniques in building enclosures that minimize thermal bridging and improve energy performance.

4. Discuss the role that the structural wall and roof framing has on building enclosure design, and highlight the differences between an all-mass timber system vs. a light wood-frame system.

Placetailor, Elton+Hampton

Roxbury, MA

Who we are

- Architectural design + build firm
- 16 team members
- Specializing in hyper sustainable and affordable housing

Case study- 201 Hampden

Roxbury, MA

Fully CLT in Boston

- Triple bottom line introduction to CLT
- Why it works well at Hampden
- Cost + Construction Benefits
- Municipal Compliance Considerations

Triple Bottom Line

People + Planet + Profit

People

- Healthy Homes
- Biophilic design
- Quiet resiliency
- Climate resilience

Triple Bottom Line

People + Planet + Profit

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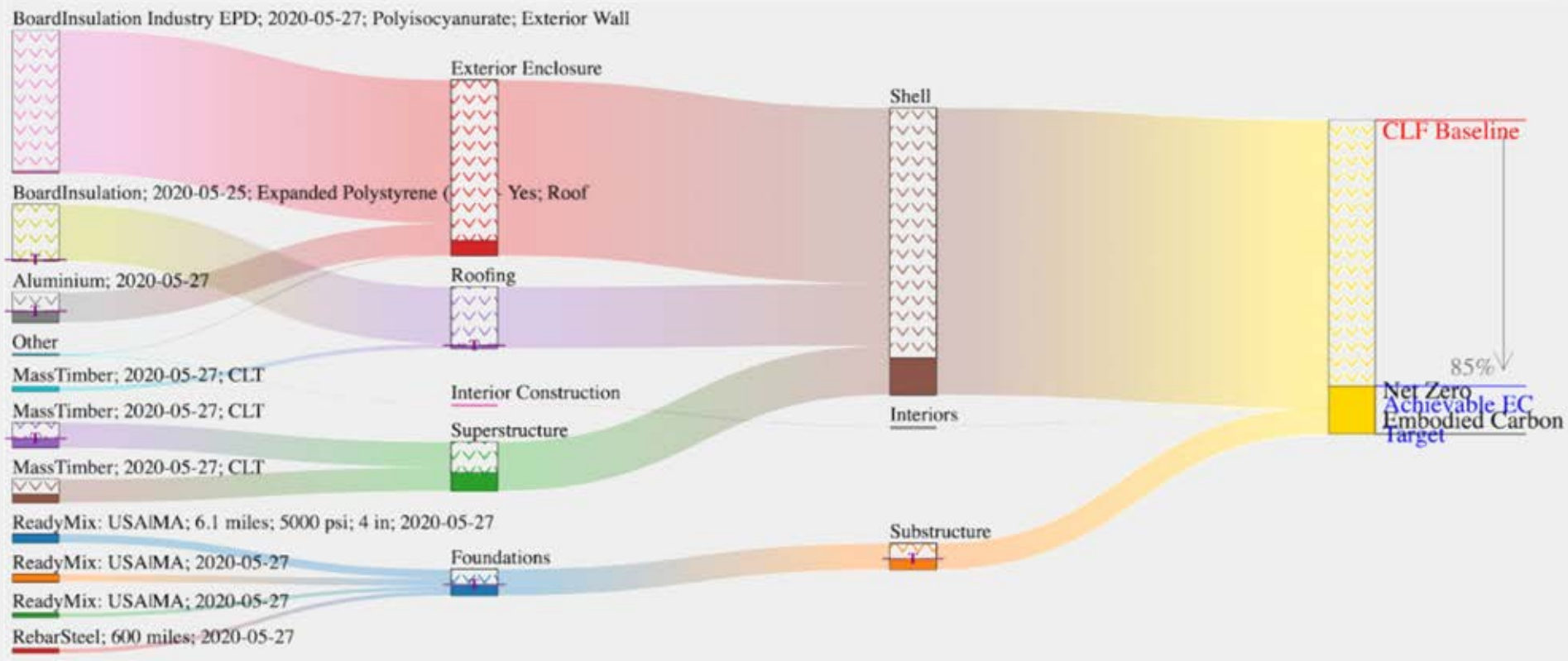
Triple Bottom Line

People + Planet + Profit

Planet

- Carbon Sequestration
- Lower embodied carbon



Triple Bottom Line

People + Planet + Profit

Planet / Profit

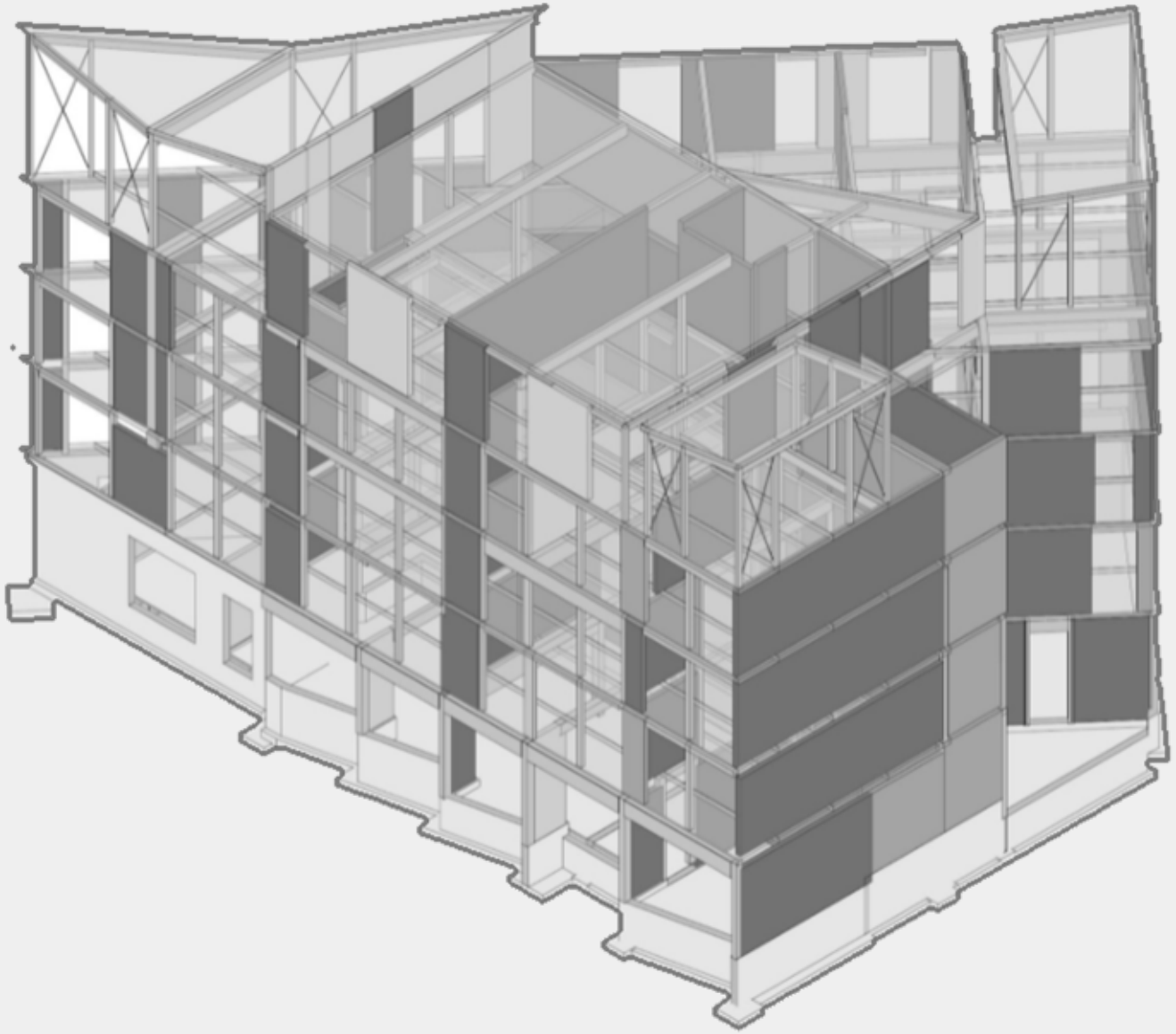
- Material species
- Climate uncertainty

Triple Bottom Line

People + Planet + Profit

Profit

- Cost implications
- Speed of Installation
  - Type 4HT
  - CLT panels
  - GluLam for beams



Triple Bottom Line

People + Planet + Profit

Profit

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- Speed of Installation
  - Type 4HT
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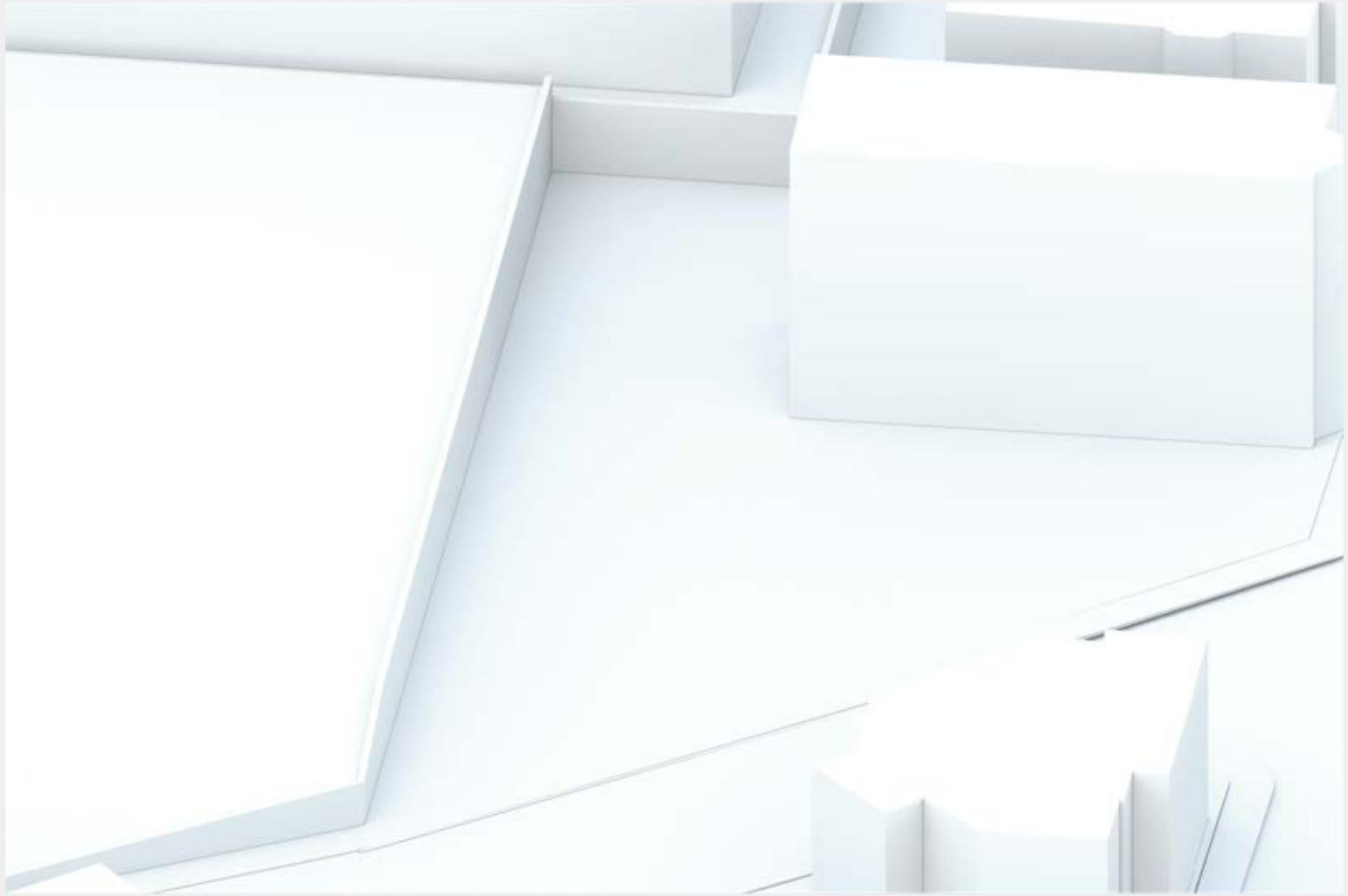
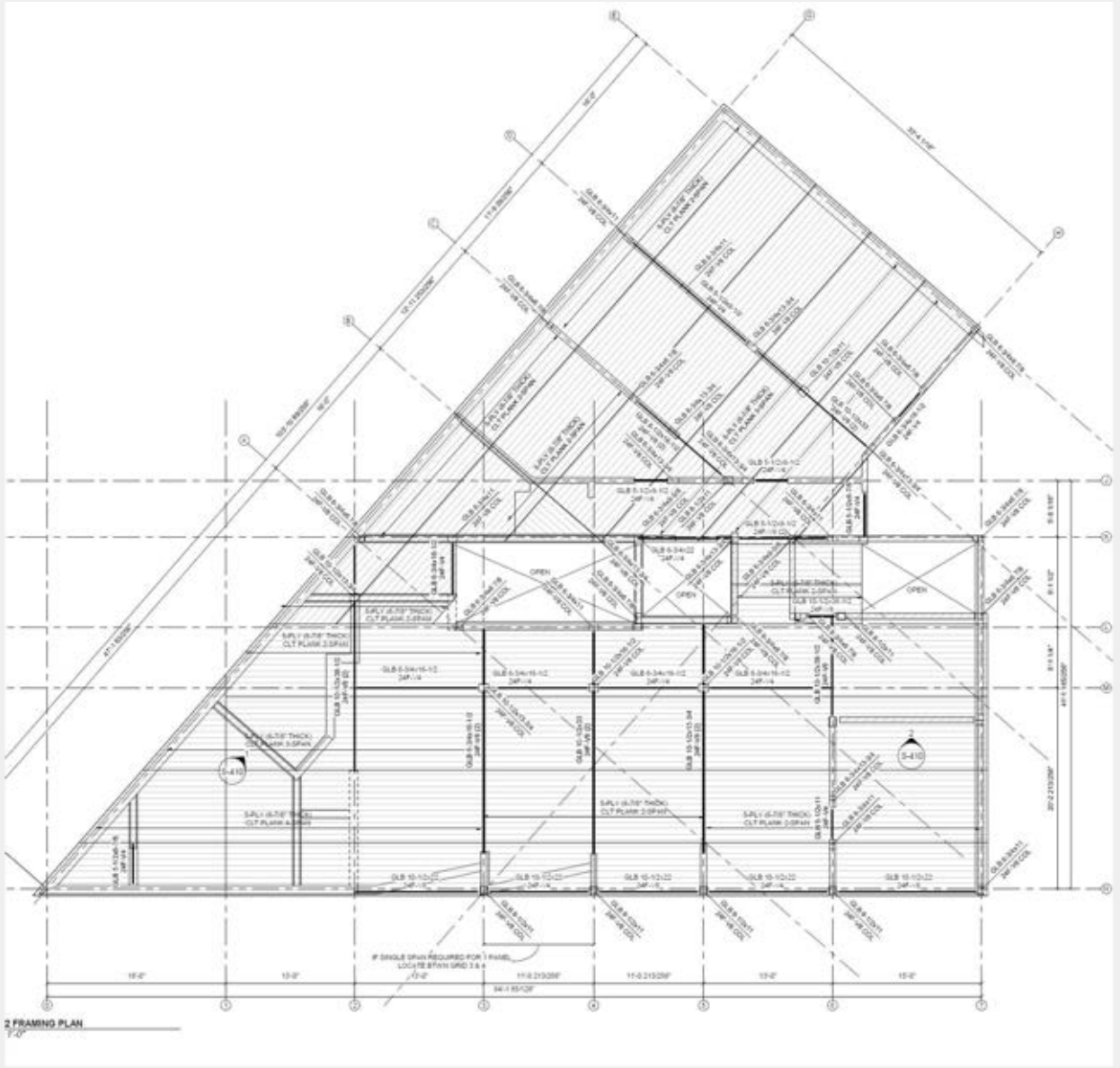


Triple Bottom Line

People + Planet + Profit

Profit

- Grants + funding

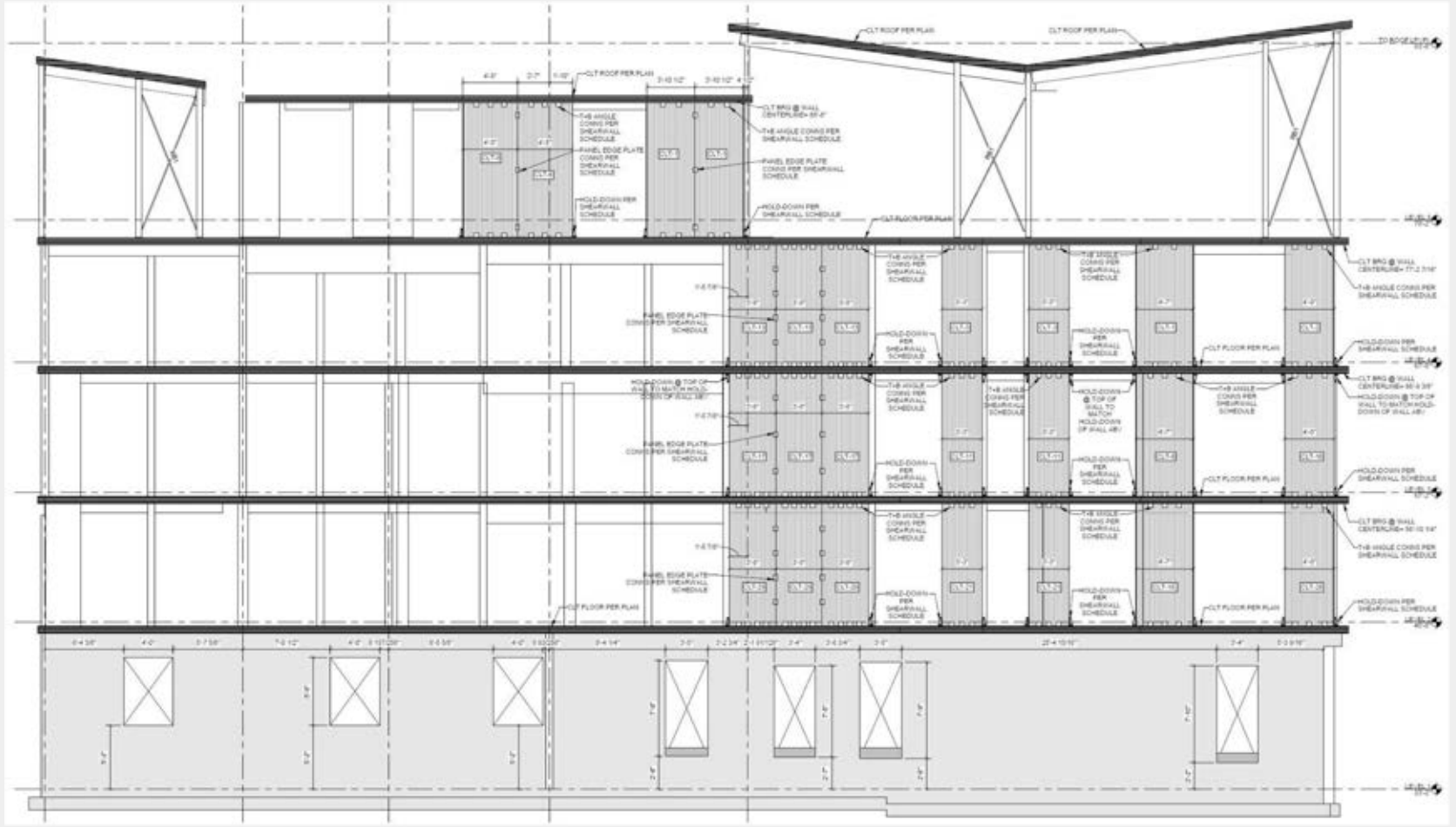


Triple Bottom Line

People + Planet + Profit

Profit

- Marketing

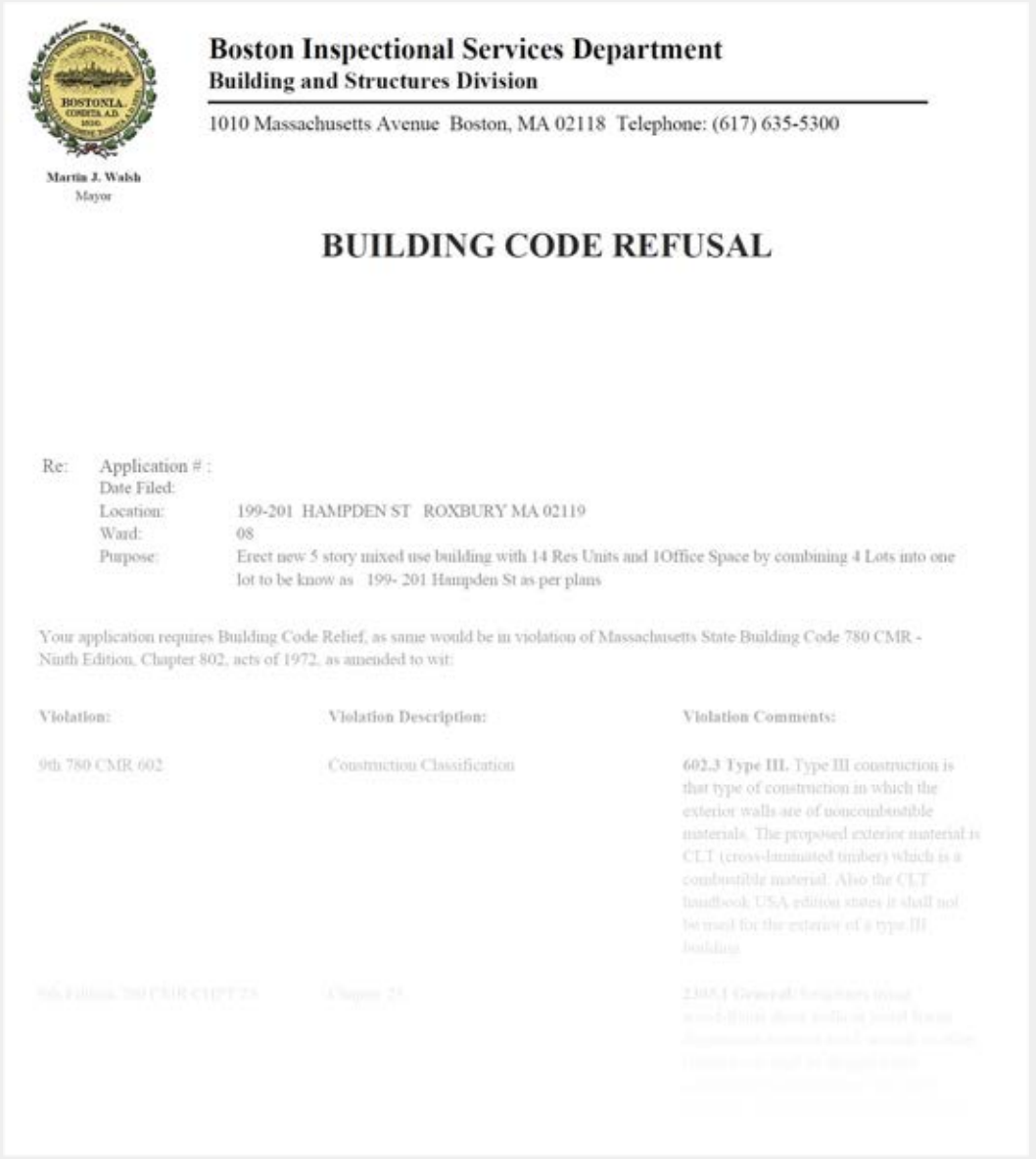


Municipal Compliance Considerations

Hurdles in the approval process

Building Permitting

- First of its kind
- Variances
- How did we finally get approval?



Martin J. Walsh
Mayor

Boston Inspectional Services Department
Building and Structures Division

1010 Massachusetts Avenue Boston, MA 02118 Telephone: (617) 635-5300

BUILDING CODE REFUSAL

Re: Application # :
Date Filed:
Location: 199-201 HAMPDEN ST ROXBURY MA 02119
Ward: 08
Purpose: Erect new 5 story mixed use building with 14 Res Units and 1Office Space by combining 4 Lots into one lot to be know as 199- 201 Hampden St as per plans

Your application requires Building Code Relief, as same would be in violation of Massachusetts State Building Code 780 CMR - Ninth Edition, Chapter 802, acts of 1972, as amended to wit:

Violation:	Violation Description:	Violation Comments:
9th 780 CMR 602	Construction Classification	**602.3 Type III.** Type III construction is that type of construction in which the exterior walls are of noncombustible materials. The proposed exterior material is CLT (cross-laminated timber) which is a combustible material. Also the CLT handbook USA edition states it shall not be used for the exterior of a type III building.
9th Edition 780 CMR CHPT 25	Chapter 25	2305.1 General. Structures shall

Case study- 201 Hampden

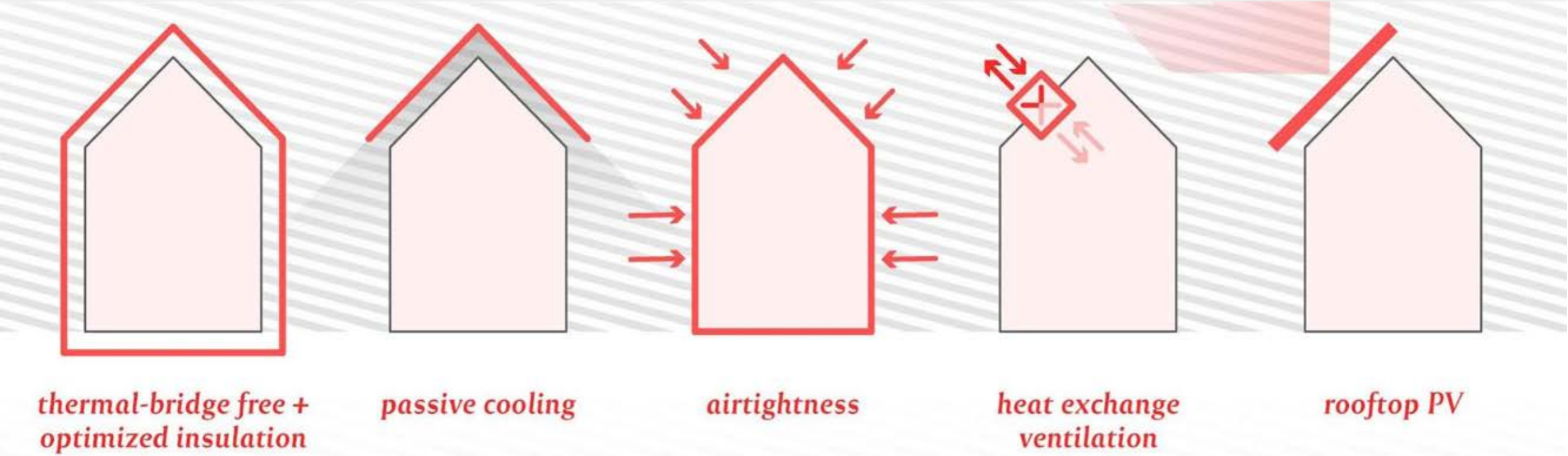
Roxbury, MA

Passive House Certification

- Introduction to PH concepts + requirements
- How energy modeling informed the design
- How Hampden is performing
- Critical details + assemblies
- Proposed systems

Basic Passive House Principles

Zero Energy Buildings (ZEB) Guidelines



Sister Certifications

1. **EPA Energy Star**
   - Specific HVAC / MEP efficiency targets
   - Envelope/windows/doors designed to IECC 2012 @ minimum.
   - Must have **programmable T-stats** per unit
   - **WaterSense bathroom fixtures**
   - **Energy Star rated appliances and lighting**

1. **EPA Indoor AirPLUS**
   - **Meet Energy Star requirements** listed above
   - Radon mitigation (where required)
   - **Pest Control**
   - Reduce combustion pollutants (**no open flames**!)
   - **Low VOC materials**

1. **DOE Zero Energy Ready Home**
   - **Meet Energy Star & EPA Indoor AirPLUS requirements** listed above
   - Insulation/assemblies to meet IECC 2015 @ minimum
   - HVAC and duct systems inside the envelope
   - DHW systems to hit specific efficiency criteria
   - **Be solar ready @ minimum**

Preliminary Analysis

Step 1

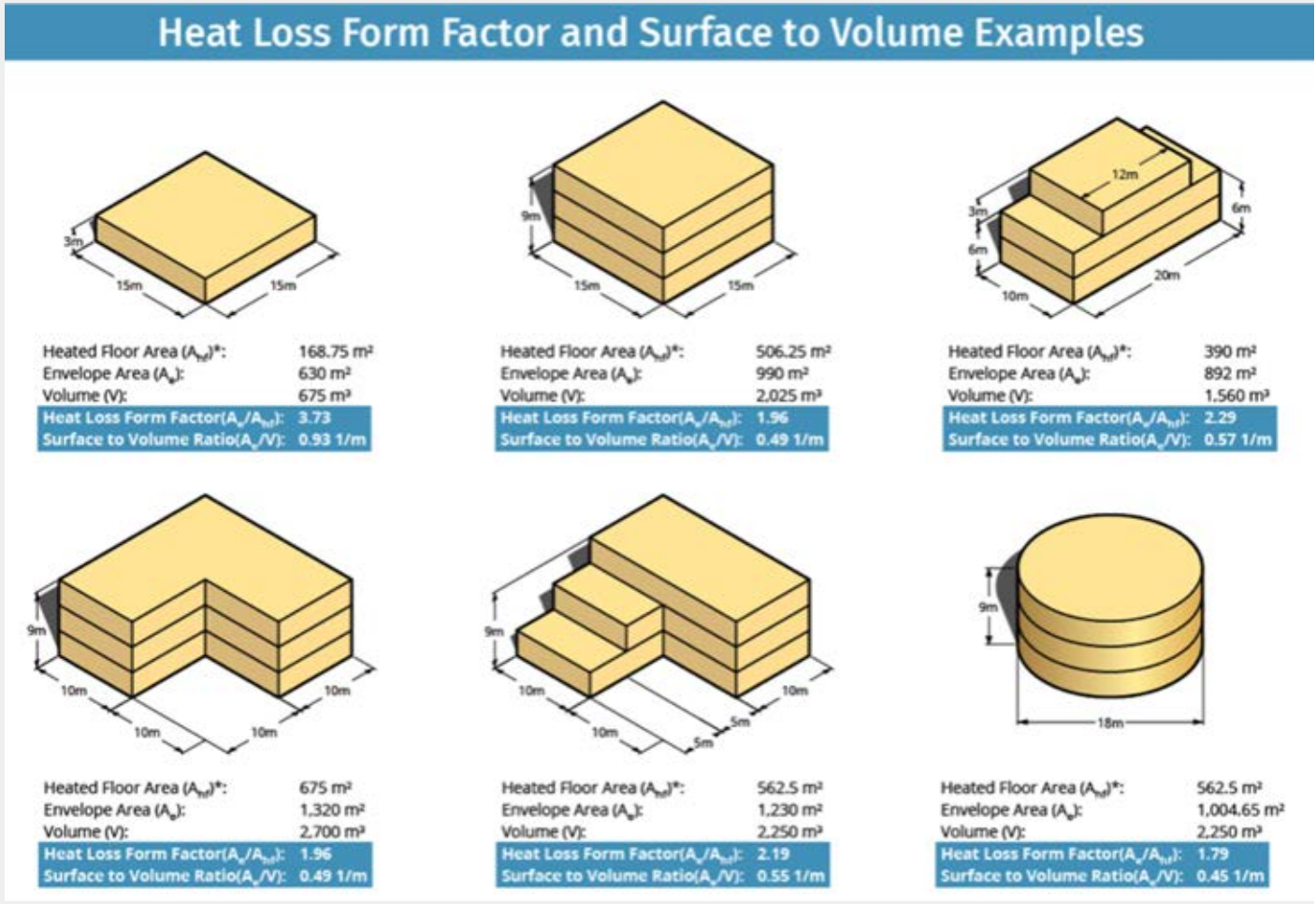
Solve for...

Surface to Volume Ratio (SVR)
Equation: envelope area / gross volume

Target range: 0.24 - 0.3

Heat Loss Form Factor (HLFF)
Equation: iCFA / envelope area

Target: <2.5



Preliminary Analysis

Step 1

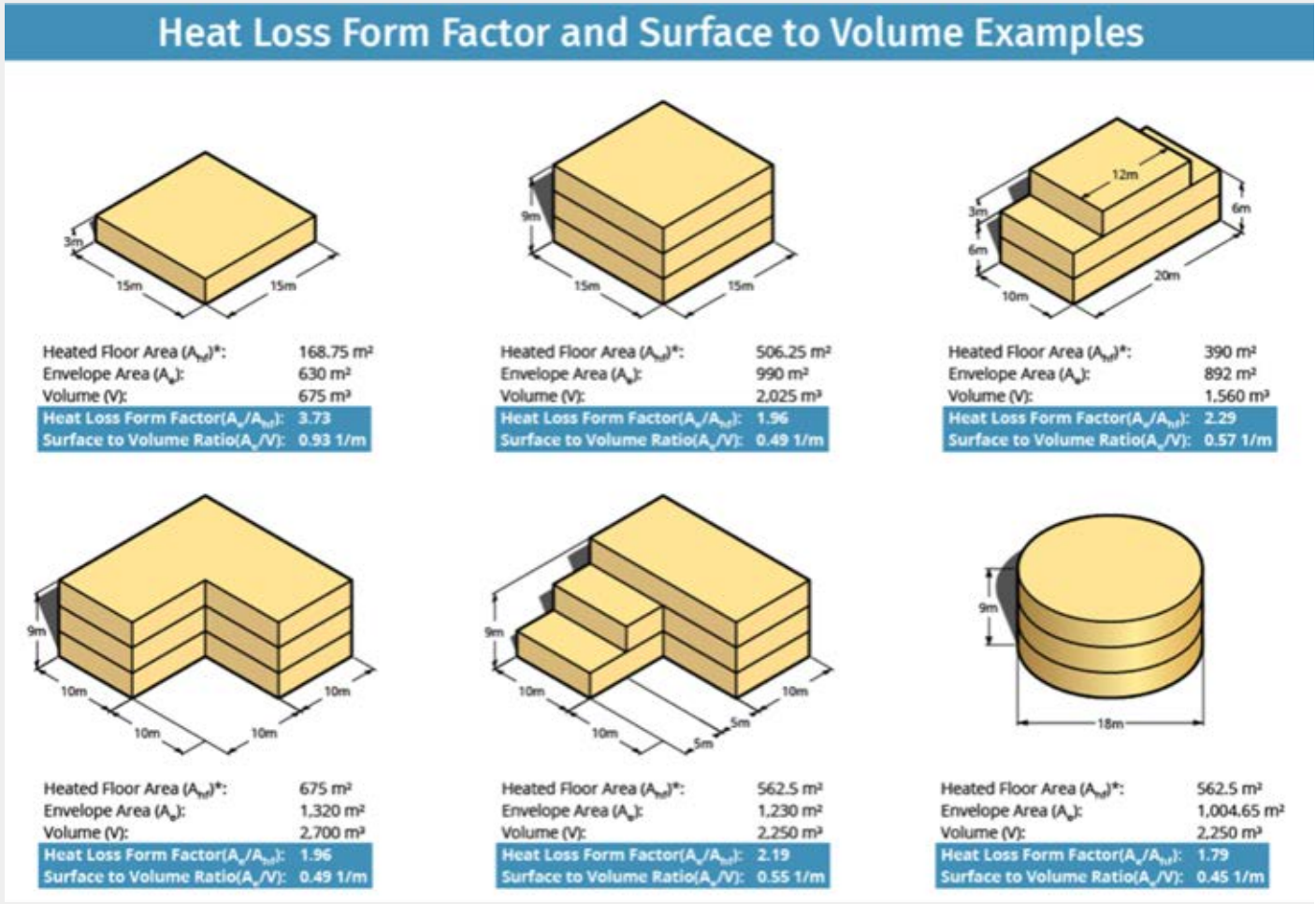
How Hampden performs...

Surface to Volume Ratio (SVR)

Gross volume	228,340
Envelope area	25,233
SVR	**0.11**

Heat Loss Form Factor (HLFF)

Envelope area	25,322sf
iCFA	18,588
HLFF	**0.73**



Preliminary Analysis

Step 2

Calculate glazing to wall percentages

Hampden Percentages:

- North: 4%
- N. East: 10%
- East: 46%
- South: 18%
- Southwest: 26%
- Northwest: 3%
- **Total WWR: 18%**

(Target: 18-20% of overall envelope)

Preliminary Analysis

Step 3

Hampden Solar and Day Lighting Analysis

1.) Sun Hour Diagram

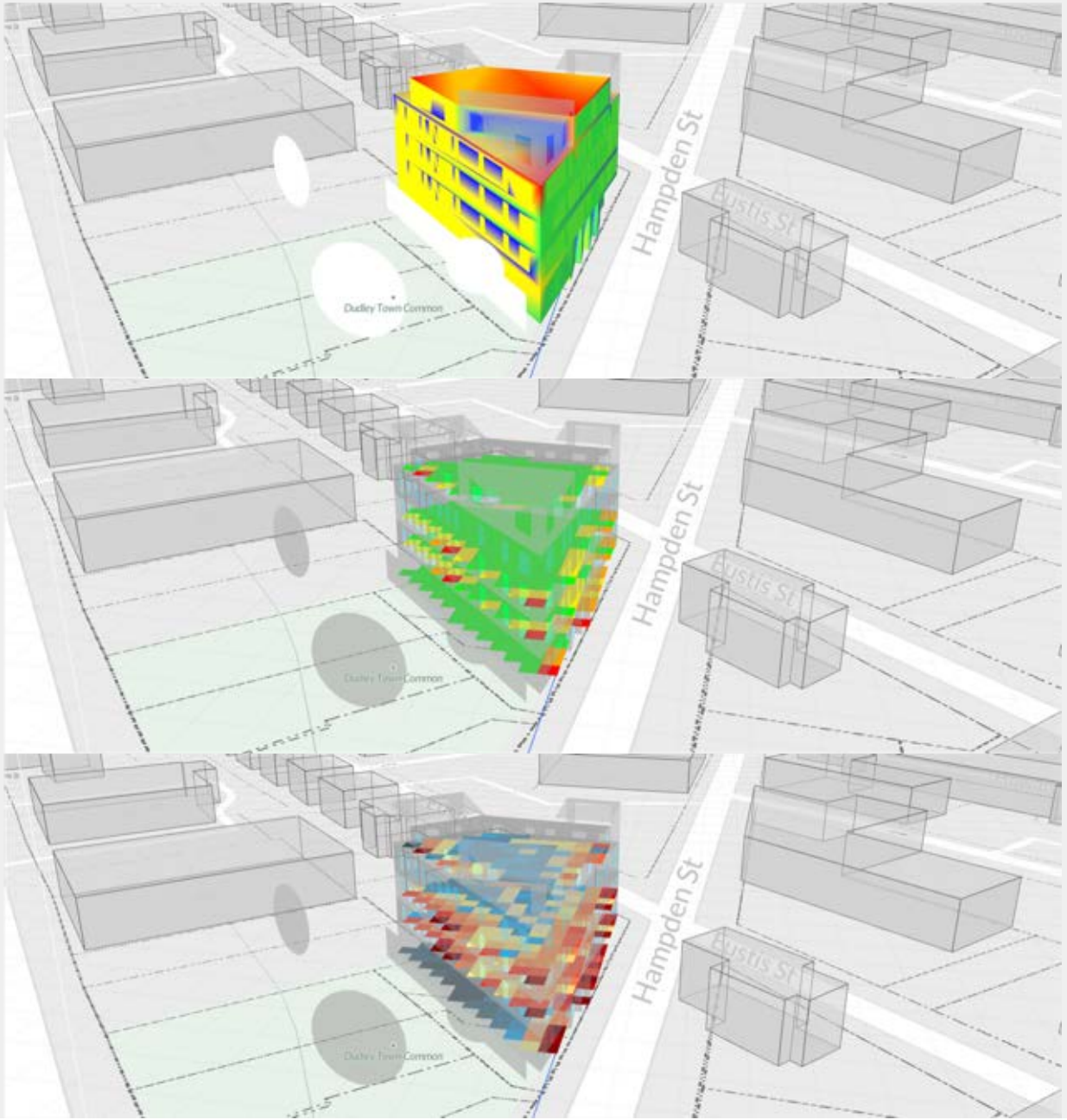
- Helps inform building orientation
- Southwest wall - 80% solar exposure throughout the day
- East wall - 50% solar exposure throughout the day

2.) Annual Solar Exposure Diagram

- Daylighting analysis
- Solar heat gain potential

3.) Spatial Daylight Autonomy

- Interior visible light transmittance
- Helpful in identifying risk for internal glare and fabric bleaching



Preliminary Analysis

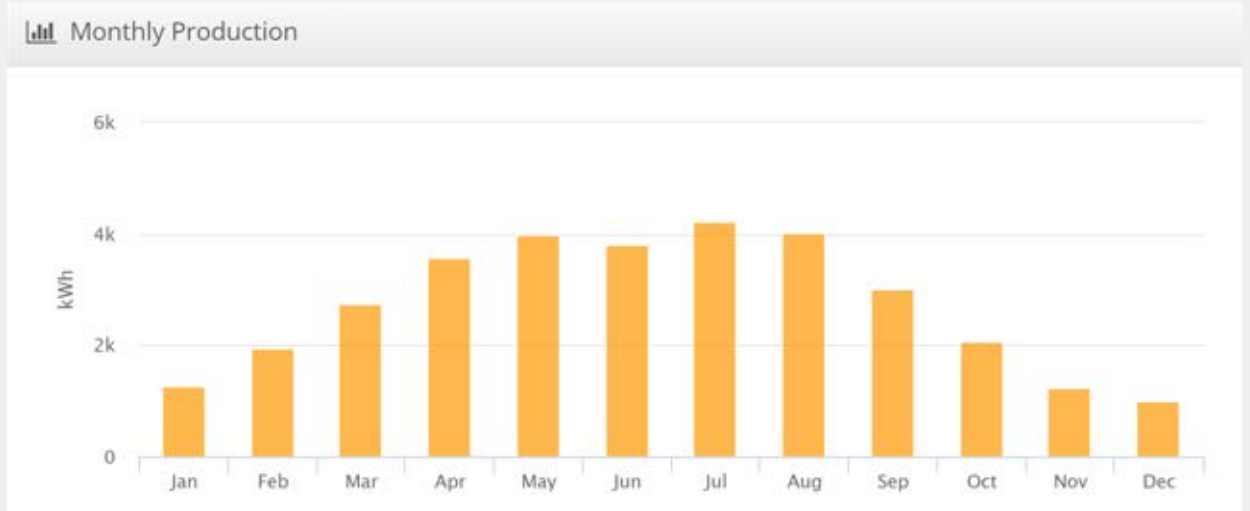
Step 4

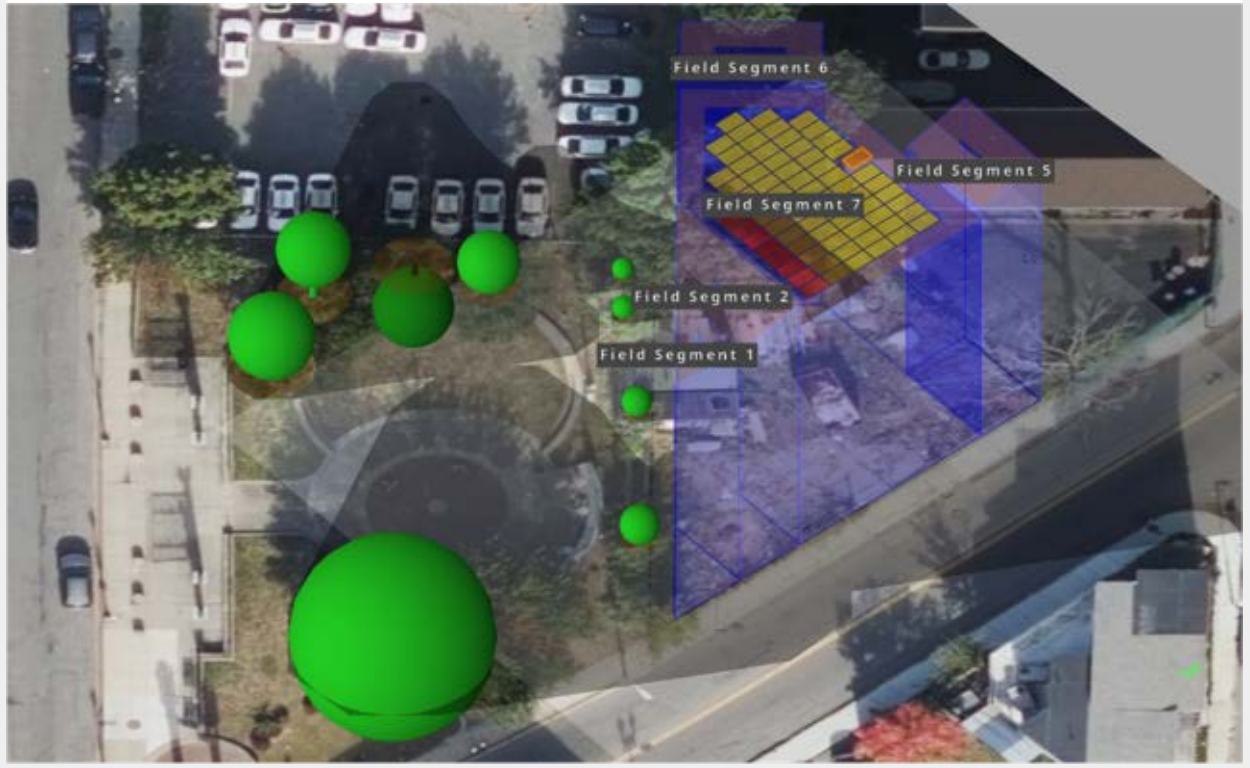
Solar Potential Analysis

- Quick way to determine a site's potential output
- Can use online PV Watts or Heliscope software

Hampden's Performance:

- 40% Roof Coverage yields ~24.7 kW/yr
- PV will cover 30-40% of on-site energy use.
- Additional off-site renewables will be required to meet the AIA 2030 Challenge.





Simulated Energy Modeling

Step 5

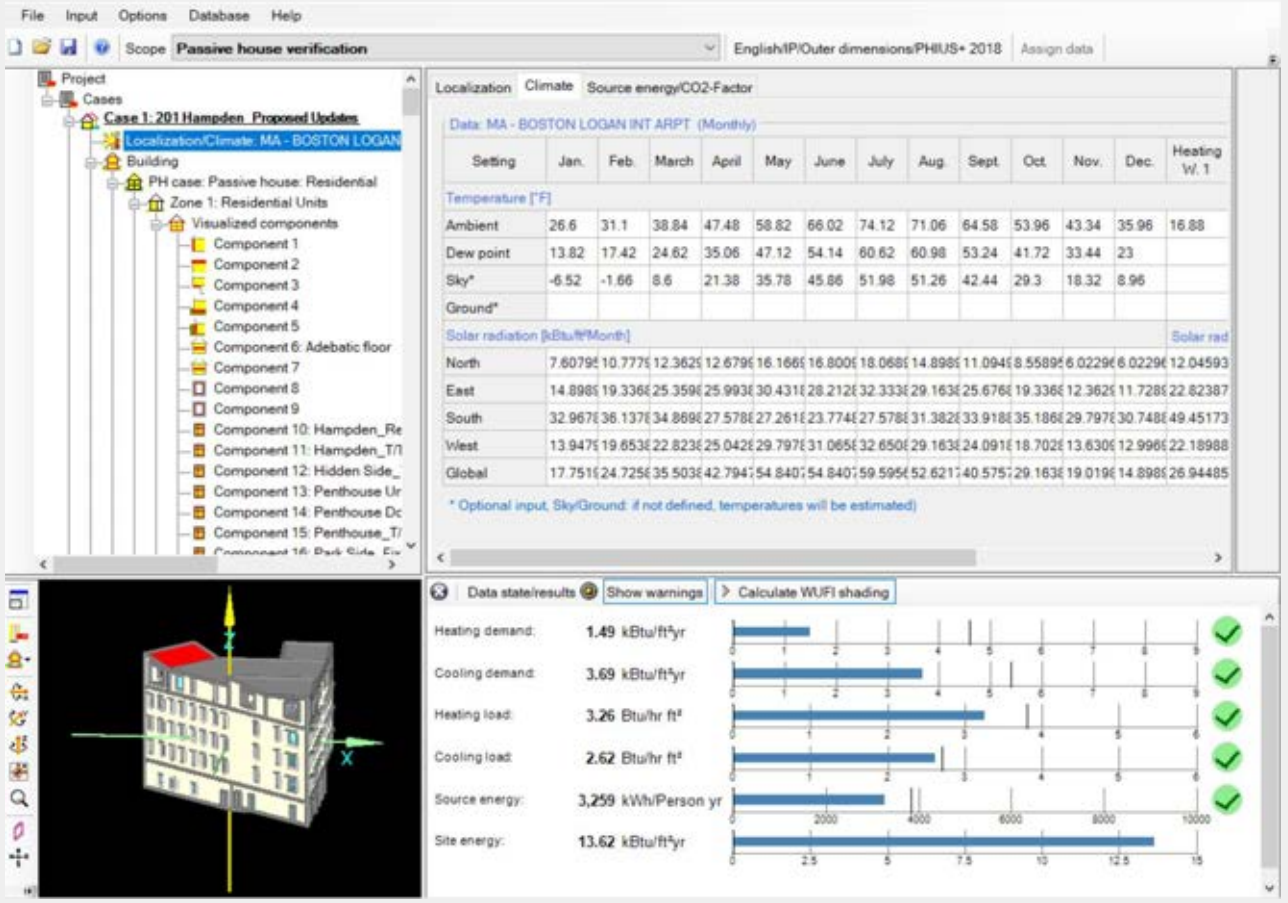
Wärme-und Feuchtetransport instationär (WUFI) Passive
"Transient heat and moisture transport"

Hampden's Passive House Target Design Criteria:

- HEATING DEMAND: 4.6 kBtu/sf/yr
- COOLING DEMAND: 5.4 kBtu/sf/yr
- PEAK HEATING LOAD: 3.8 Btu/hr/sf
- PEAK COOLING LOAD: 2.7 Btu/hr/sf
- SOURCE ENERGY CONSUMPTION: 4,683 kWh/person /yr

Hampden's AIA 2030 Energy Use Intensity Target:

- pEUI: 11.15 kBtu/ft2yr (80% energy reduction from baseline)



Simulated Energy Modeling

Case Studies

Case 1

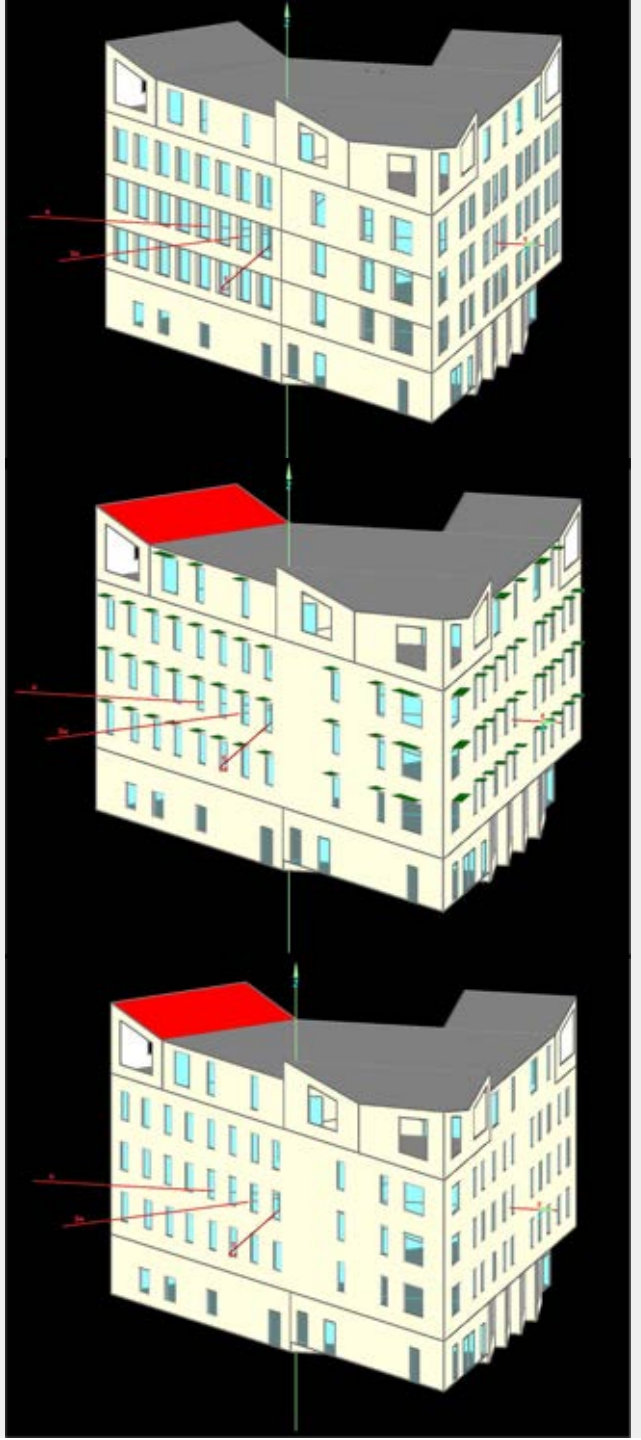
- Base comparison model
- Modeled to local energy code requirements

Case 2

- Modeled to match the architect’s proposed assemblies
- Design requirements set to PH standard

Case 3

- Modeled to reach PH level
- Design requirements set to PH standard
- Look for VE options such as reduced window count



CASE 1 - Code Design

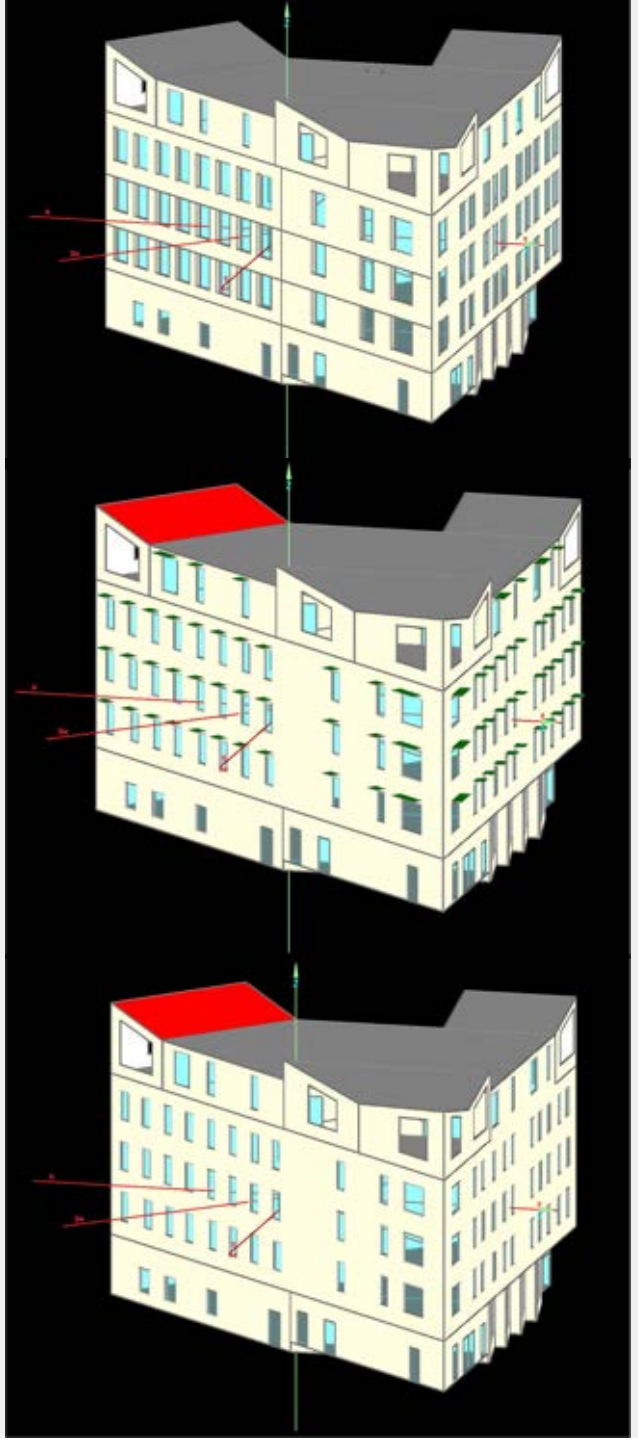
- HEATING DEMAND: 6.75 kBtu/ft2yr
- COOLING DEMAND: 2.64 kBtu/ft2yr
- PEAK HEATING LOAD: 7.8 Btu/hr ft2
- PEAK COOLING LOAD: 2.93 Btu/hr ft2
- SOURCE ENERGY CONSUMPTION: 5,583 kWh/person /yr
- AIA 2030 Challenge pEUI: 23.34 kBtu/ft2yr (58% energy reduction from baseline)

CASE 2 - Architectural Drawing Set

- HEATING DEMAND: 2.43 kBtu/ft2yr
- COOLING DEMAND: 4.36 kBtu/ft2yr
- PEAK HEATING LOAD: 3.89 Btu/hr ft2
- PEAK COOLING LOAD: 3.12 Btu/hr ft2
- SOURCE ENERGY CONSUMPTION: 3,667 kWh/person/yr
- AIA 2030 Challenge pEUI: 15.33 kBtu/ft2yr (73% Energy Reduction from baseline)

CASE 3 - Passive House

- HEATING DEMAND: 1.46 kBtu/ft2yr
- COOLING DEMAND: 3.63 kBtu/ft2yr
- PEAK HEATING LOAD: 3.24 Btu/hr ft2
- PEAK COOLING LOAD: 2.59 Btu/hr ft
- SOURCE ENERGY CONSUMPTION: 3,566 kWh/person yr (with PV installation)
- AIA 2030 Challenge pEUI: 14.91 kBtu/ft2yr (73% Energy Reduction from baseline)



Passive House Assemblies

Continuous Air Sealing “pen test”

Exterior walls

- ArmorWall Panel, taped at all seams
- Siga Majvest 500, taped at all seams

Slab

- Stego Wrap or other BG ABV

Roof

- White TPO, glued and welded at all seams.

Transitions

- It is critical to pay extra attention to areas of material transition
- Apply correct Tape / Filler for the material and location

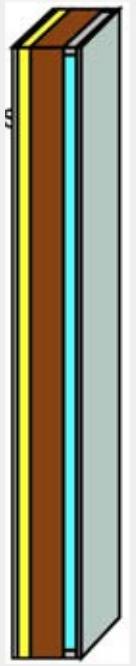
Passive House Assemblies

Thermal Properties

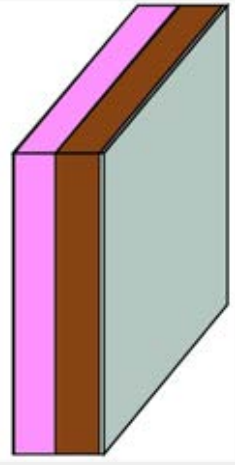
R-Values + U-Values

- Roof: R-50
- Exterior Wall: R-36
- Slab: R-12
- Windows: 0.17 U-value

Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	ArmorWall VP (Coating Only)	2.65	13.12E-5	0.7678	0.03	
2	ArmorWall MgO Panel	4.4	47.92E-6	0.0851	0.625	
3	ArmorWall Urethane Core	0.15	83.86E-6	83.4602E-4	2.5	
4	SmartLam CLT	25.6	0.31	0.0566	6.875	
5	Aluminium	168.56	0.21	115.5582	2.5	
6	Gypsum Board (USA)	53.06	0.21	0.0942	0.625	



Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	TPO membrane	93.64	0.36	0.1156	0.06	
2	Polyisocyanurate Board	2.03	0.35	0.0139	6.5	
3	SIGA Majcoat (valeur sd 0,1m épaisseur 0,001m)	8.12	0.55	1.3289	0.039	
4	SmartLam CLT	25.6	0.31	0.0566	6.875	
5	Gypsum Board (USA)	53.06	0.21	0.0942	0.625	



Passive House Assemblies

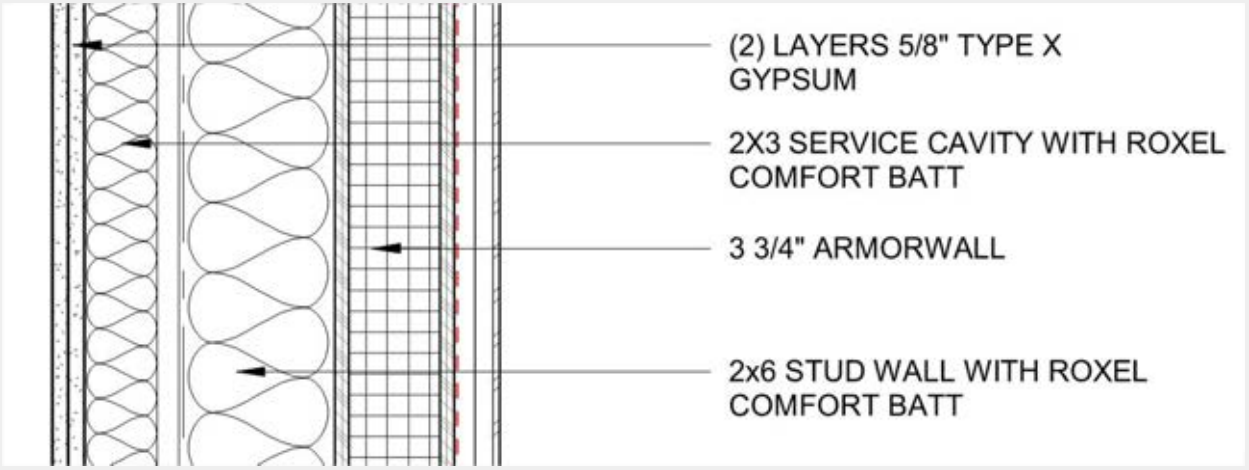
Exterior Wall Details

2x6 Stud Wall

- Gypsum
- 2x3 service cavity w/ mineral wool insulation
- Air space (gap)
- 2x6 wood stud
- Sheathing
- ZIP
- Strapping
- Siding

CLT Panel Wall

- Gypsum
- 2x3 service cavity w/ mineral wool insulation
- CLT panel
- ZIP
- Strapping
- Siding



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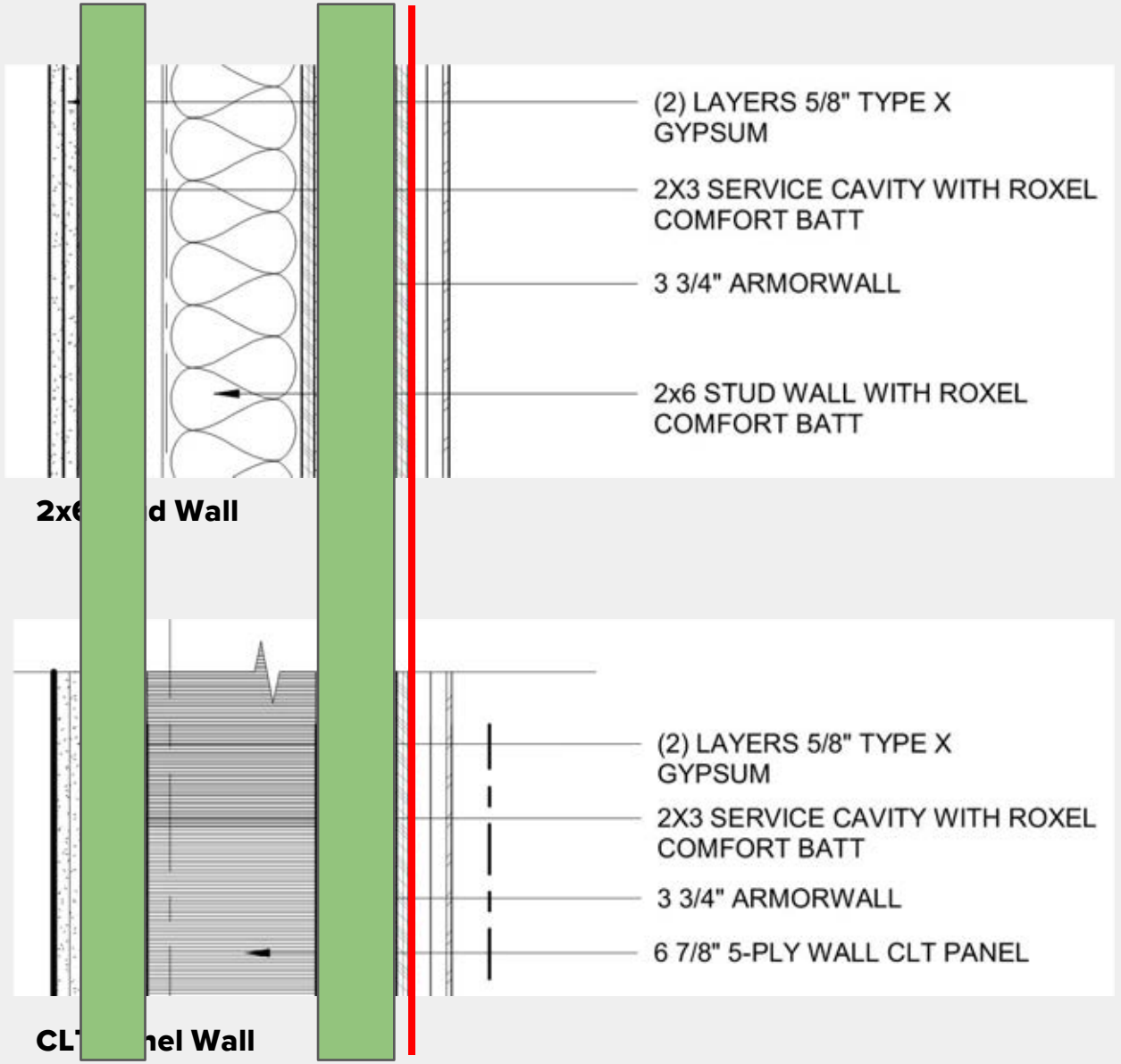


Passive House Assemblies

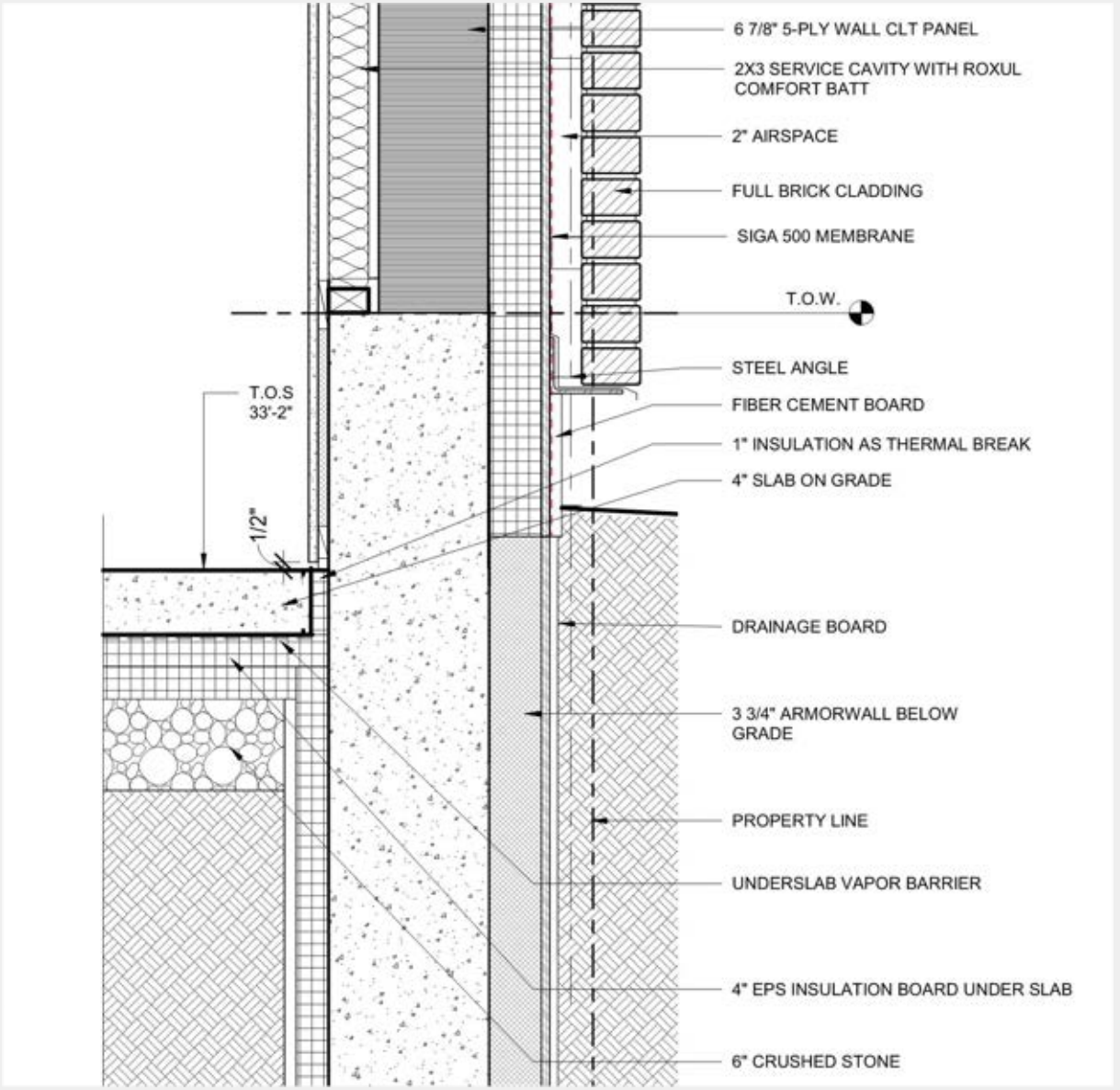
Exterior Wall to Foundation & Slab

Foundation Wall

- EPS rigid foam
- Water proofing
- Concrete
- Water proofing
- Below grade rated ZIP
- Drainage board

Slab on grade

- Concrete slab
- Underslab vapor barrier
- EPS rigid foam
- Crushed stone



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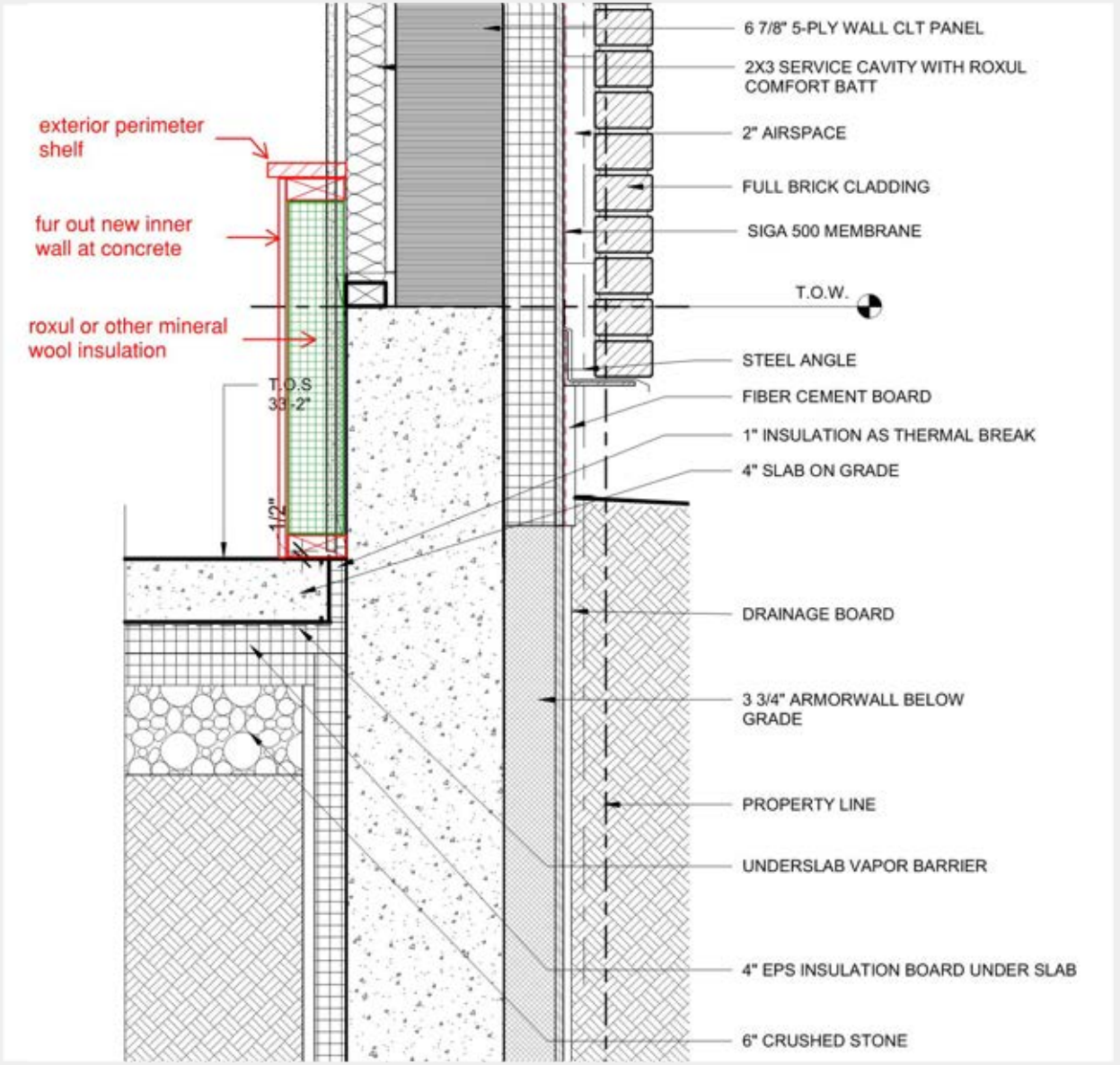
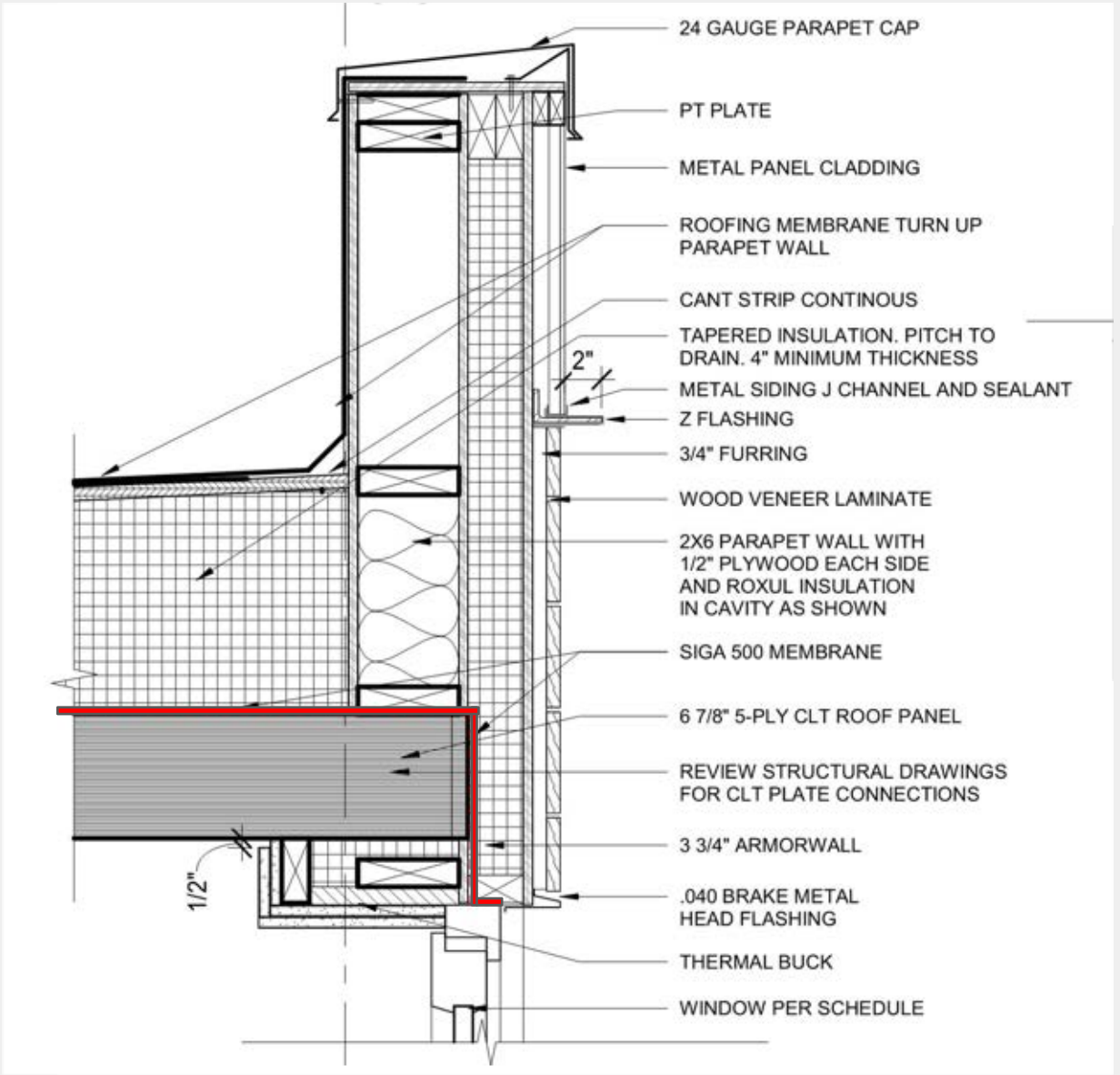


Passive House Assemblies

Air sealing detail

Parapet

- Simplify transitions
- Continuous insulation
- Continuous Air Barrier

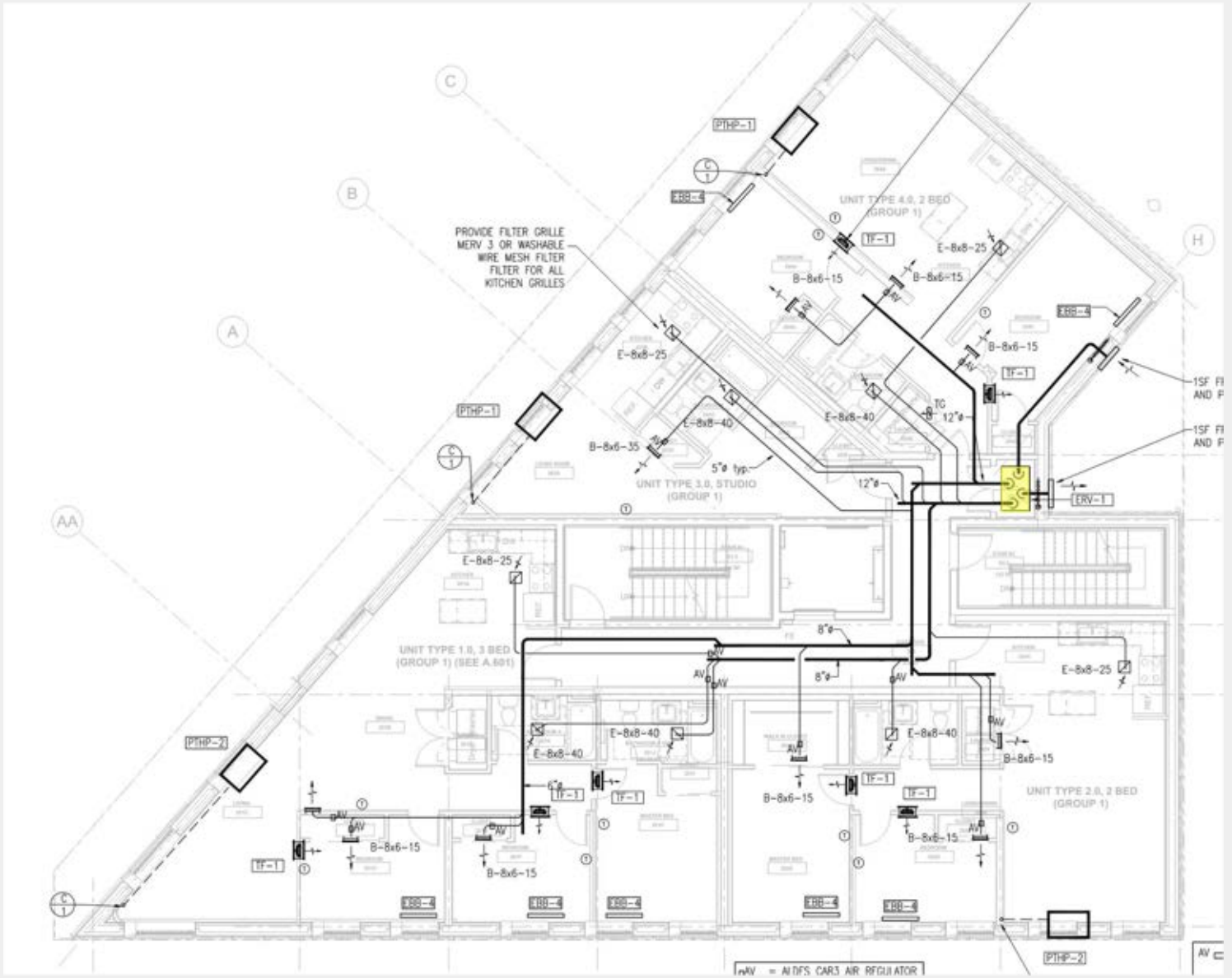


MEP Systems

Ventilation

ERV system

- Semi-centralized
- Reduces vertical chases and fire dampers
- More efficient distribution and runs
- Savings can be put into a higher performing ERV
- Topvex TR800
  - MERV 13 supply
  - MERV 9 exhaust
  - Rotating heat exchanger
  - AHRI + CAS certified

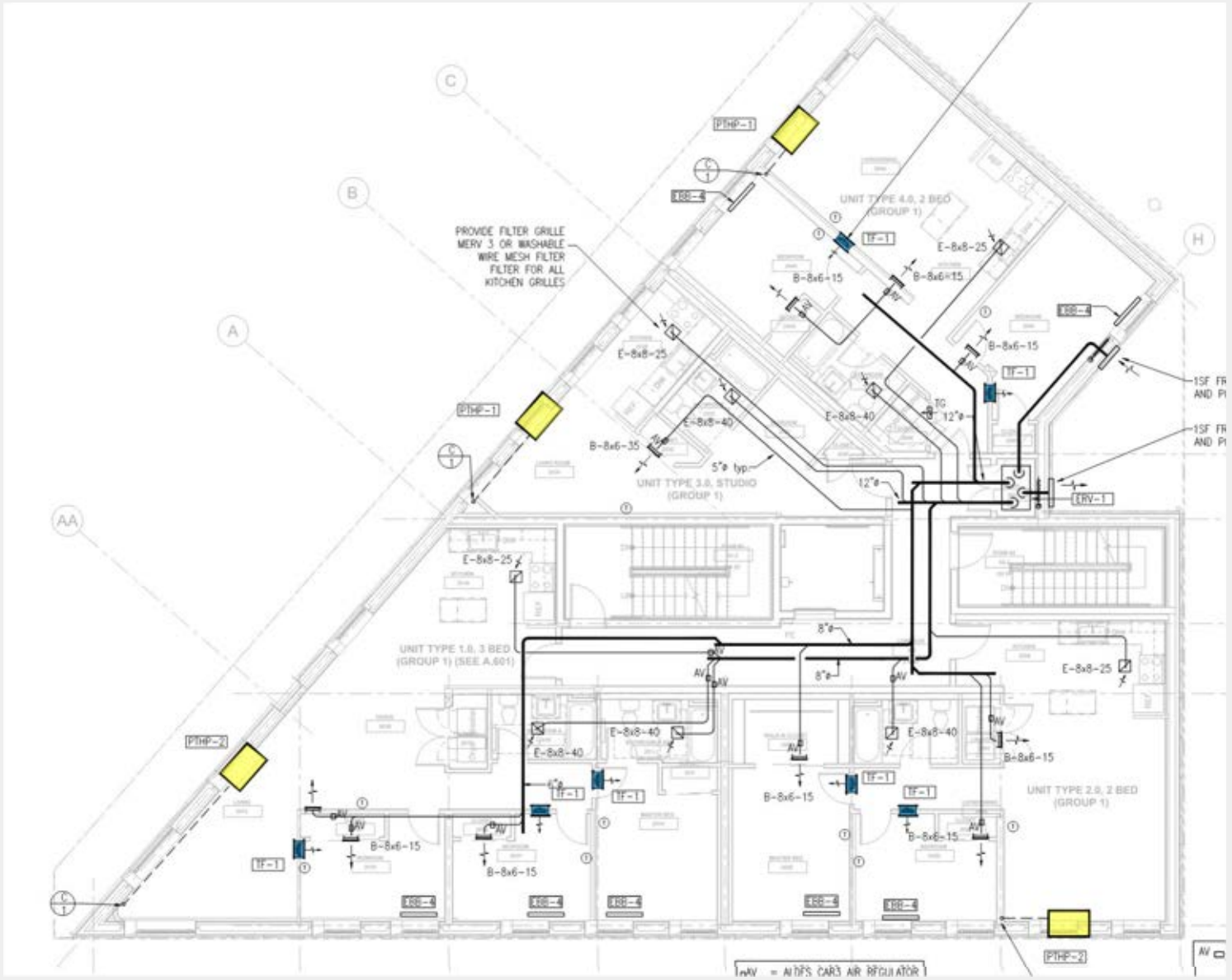


MEP Systems

Heating + Cooling

Heat Pumps

- Decentralized, one (1) per unit
- Direct tennant control over indoor temp
- Transfer fan per bedroom
- Ephoca HPAC
    - Heating: COP 2.94
    - Cooling: EER 11.25

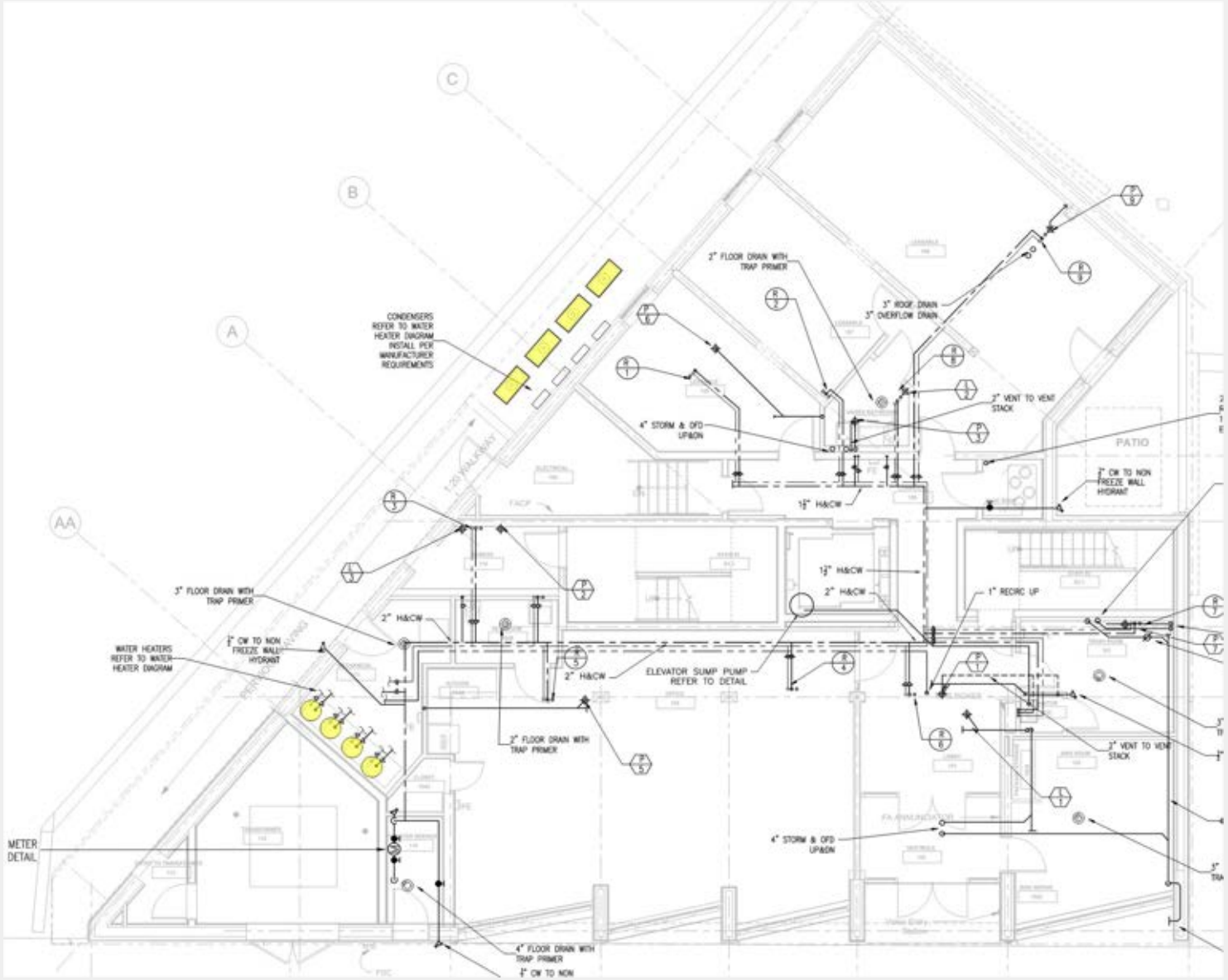


MEP Systems

DHW

Centralized DHW Heat Pump & Storage Tank

- Four (4) 119-gallon tanks
- High efficiency system
  - 14% EUI savings
- CO2 Refrigerant lines reduce system heat loss and has low GWP.
- No fossil fuels, all electric.
- SanCo2 Heat Pump
  - EF 3.40
  - Heating COP 5.5/4.2/2.8
  - Energy Star rated



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Thank you.

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