Passive House Feasibility Study

for

366 Broadway Residences, Somerville, MA

Prepared for:

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LINNEAN Solutions

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Passive House Feasibility Study

366 Broadway, Somerville, MA

Overview:

Linnean Solutions examined the feasibility of 366 Broadway in Somerville, MA for earning Passive House certification through the PHIUS CORE 2021 program. This report documents the findings of the feasibility study. Drawings provided by Khalsa Design Inc. were used to create a baseline model. Default assumptions were used for modeling inputs where information was not currently available.

The initial baseline energy model was created to estimate the building energy performance with the design provided by Khalsa Design Inc. and several code compliance assumptions. A second energy model was then run with adjustments necessary to meet the PHIUS CORE 2021 requirements. These adjustments are the basis of the recommendations outlined in this report.

Scope:

The 366 Broadway multifamily project includes 1 building with 58 units and approximately 45,786ft^2 interior conditioned floor area. The energy model includes all interior spaces as part of the thermal Passive House envelope as well as the stair and elevator shafts which extend to the building foundation.

Current Design:

Modeled iCFA: 45,786ft^2
Envelope area of PH Envelope: 46,213ft^2
Occupants: 96
Bedrooms: 38 (studio units counts as 0-bedroom apartments per PHIUS)

PHIUS 2021 Targets:

The image below shows the PHIUS 2021 Space Conditioning Criteria Calculator, which calculates the building's targets for annual heating and cooling demands and peak heating and cooling loads. This calculation is based on project location as well as envelope-to-floor area ratio and occupant density. The climate data collected at the Boston Logan Int. Airport was used for both baseline and PHIUS 366 Broadway models.

PHIUS 2021 Targets for 366 Broadway

Phius 2021

Performance Criteria Calculator v3.1

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	MASSACHUSETTS
CITY	BOSTON LOGAN INT ARI
Envelope Area (ft²)	46,213.0
iCFA (ft²)	45,786.7
Dwelling Units (Count)	58
Total Bedrooms (Count)	38

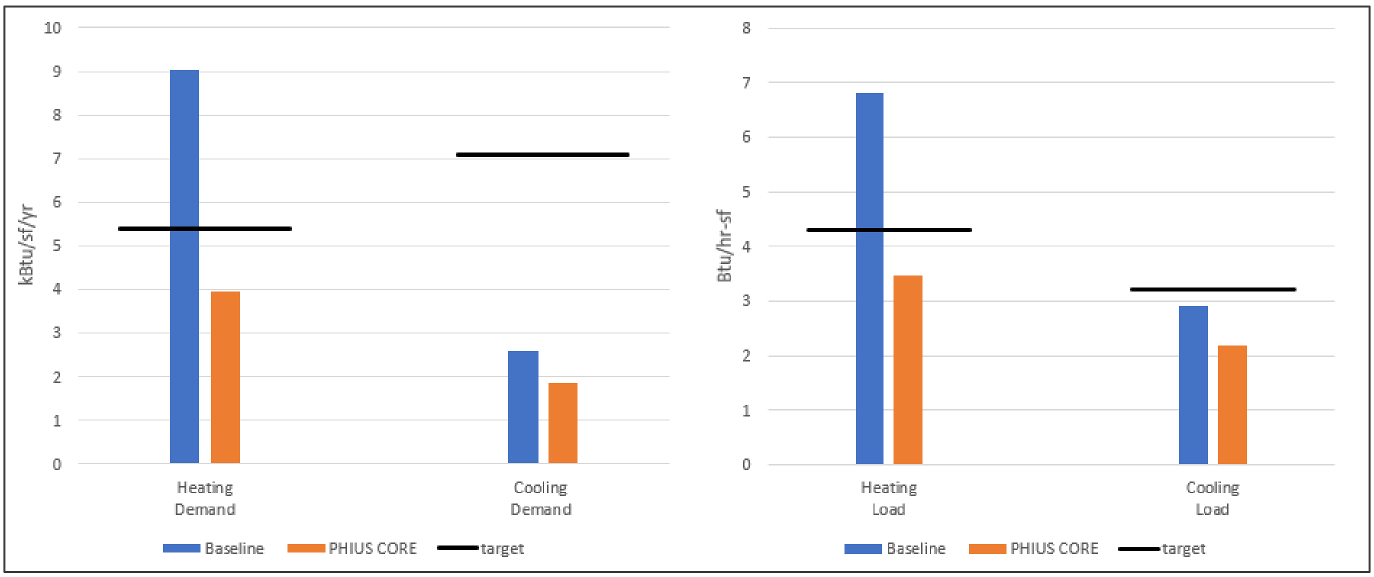
Space Conditioning Criteria		
Annual Heating Demand	5.4	kBtu/ft²yr
Annual Cooling Demand	7.1	kBtu/ft²yr
Peak Heating Load	4.3	Btu/ft²hr
Peak Cooling Load	3.2	Btu/ft²hr

Source Energy Criteria		
Phius CORE	6000	kWh/person.yr
Phius ZERO	0	kWh/person.yr

WUFI Energy Model Results:

The below graph shows the comparison between the results of the baseline energy model (blue) and the PHIUS CORE 2021 case (orange). The PHIUS targets (black lines) are based on the information from the Space Conditioning Criteria Calculator shown above. In order to earn certification, all criteria must fall below the PHIUS target levels. The adjustments made to the WUFI energy model from the baseline to the PHIUS model bring the building performance targets below each of the PHIUS target lines.

PHIUS 2021 Space Conditioning Criteria Results



The baseline model is based on the May 02, 2022, schematic plans of the 366 Broadway project, that were provided by Khalsa Design Inc., with assumed, typical envelope assemblies and systems common for this project type as well as code compliant assumptions. The baseline model did not meet the PHIUS CORE requirements. Significant contributors to the baseline model exceeding the PHIUS targets included the airtightness and lack of thermal insulation. Airtightness for baseline cases is modeled at code minimum 0.31 cfm/ft^2 whereas Passive House requires measured airtightness of 0.06 cfm/ft^2.

The 366 Broadway project could earn PHIUS CORE 2021 Certification by meeting the passive house airtightness requirements, improving thermal insulation for walls, roof, and floors, specifying high performance fenestrations, and HVAC systems.

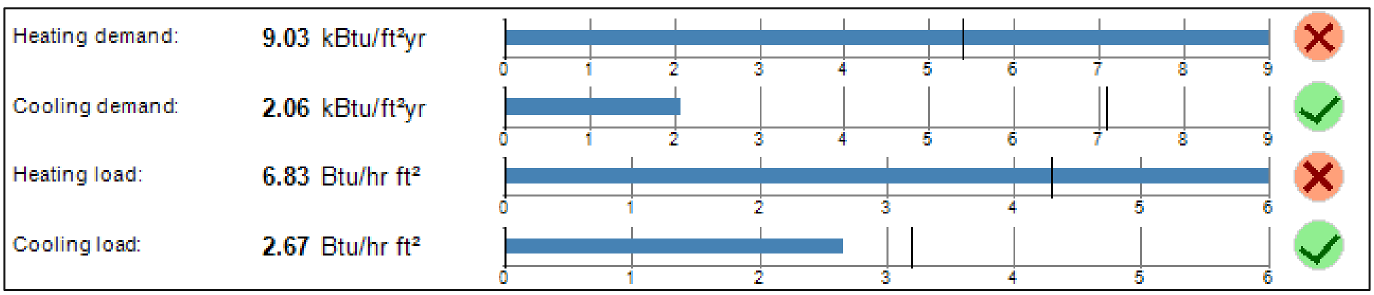
The images below show the building's WUFI Passive energy model results for each of the following cases.

1. Baseline model – based on the 02 May, 2022, drawings provided for the 366 Broadway project, envelope assemblies & systems based on typical equivalents of this project type, and realistic above standard code compliant air leakage (0.31 cfm/ft^2).

2. Baseline model with PHIUS required air tightness – the baseline model as described above with PHIUS air tightness requirement (0.06 cfm/ft^2).

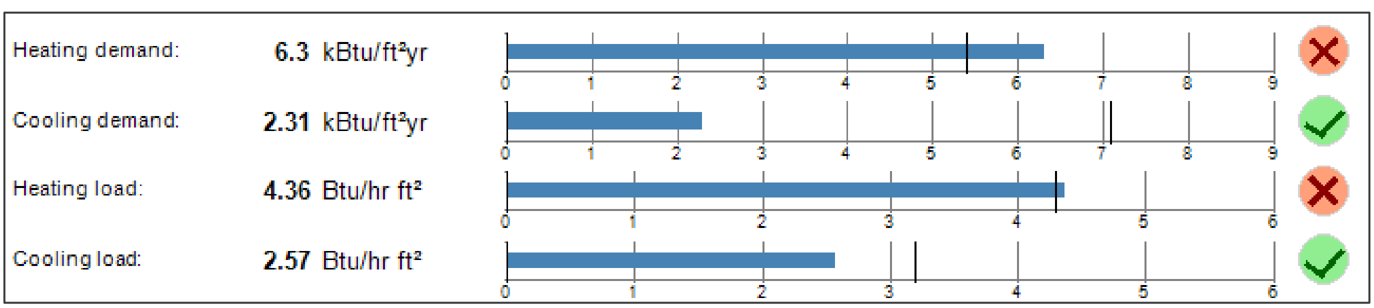
3. PHIUS 2021 model – includes air tightness requirement (0.06 cfm/ft^2), envelope & mechanical upgrades necessary to meet PHIUS CORE 2021 certification.

1. Baseline WUFI Model with (0.31 cfm/ft^2) Airtightness



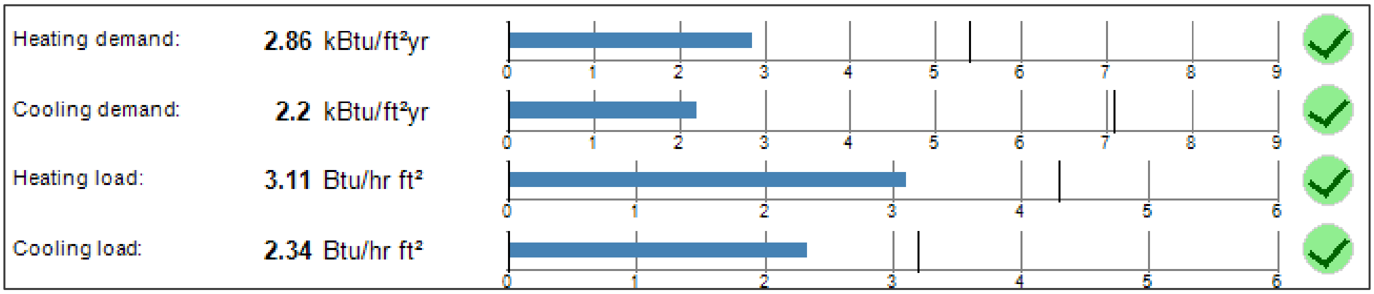
The initial baseline case shows the building fails to meet the heating demand and heating load thresholds due to the lower airtightness and lack of insulation. The reason cooling demand and load is easily met is due to higher air leakage and the northeastern climate.

2. Baseline WUFI Model with (0.06 cfm/ft^2) Airtightness



These results show improvements from the baseline design simply by increasing the building airtightness from 0.31 cfm/ft^2 to 0.06 cfm/ft^2. Heating demand and heating load results are reduced significantly but are still above PHIUS CORE 2021 targets.

3. PHIUS 2021 WUFI Model with (0.06 cfm/ft²):



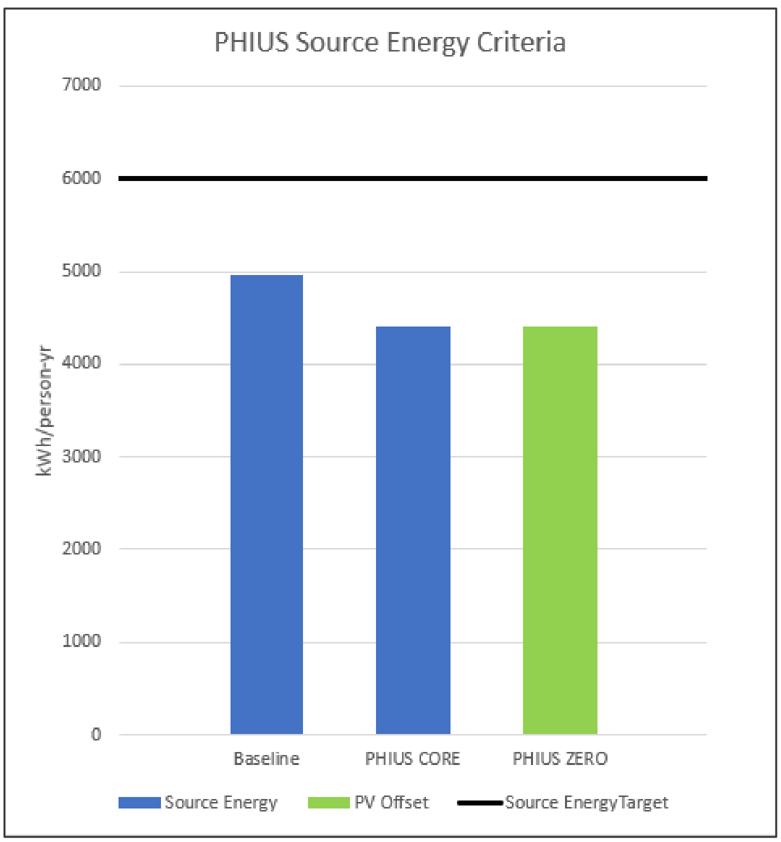
In order to meet the PHIUS requirements, the design would need to make adjustments to the building envelope and select high efficiency equipment for heating/cooling, ventilation and DHW.

Source Energy Criteria:

As shown in the PHIUS CORE 2021 WUFI Model results above, making adjustments to the current design will allow the project to meet all required performance targets for certification through PHIUS CORE 2021. For this project, based on building density and envelope area, the PHIUS CORE Source Energy requirement is 6000 kWh/person/yr.

The below graph indicates the building Source Energy for the baseline and PHIUS WUFI model cases. The baseline bar shows the source energy estimated per person per year for the baseline model. The PHIUS CORE bar shows the lower source energy achieved through the adjustments and upgrades included in the PHIUS model. Both the baseline and the PHIUS CORE models are currently meeting the source energy requirement.

If there is a desire for a net zero energy building instead (**PHIUS ZERO**), the green portion indicates the amount of source energy that will be required to be offset by renewable sources to meet the PHIUS ZERO Source Energy target of 0 kWh/person/yr. This source energy reduction would need to be met through the use of renewable energy systems on-site, off-site or a combination of the two. See the *Renewable Energy* section below for recommendations and pathways towards meeting the Source Energy target.



Renewable Energy:

To meet the PHIUS ZERO 2021 target for Source Energy, the building's PV system was estimated to need at least a 200kW system to produce approximately **240,000 kWh/yr**. Maximizing rooftop solar would be one option to mee the PHIUS ZERO 2021 Source Energy requirements.

There are several options for offsetting building source energy through both on-site and off-site energy systems. Alternative off-site options are shown below:

Type	kWh/yr	Onsite Utilization
Directly owned off-site renewable	Varies	1
Community renewable energy	Varies	1
Virtual power purchase agreement	Varies	1
Renewable energy certificates (RECs)	Varies	0.2

On-site and Off-site Renewable energy systems can be combined to meet source energy targets.

Passive House Design Recommendations:

Building Envelope:

Walls:
The baseline building envelope was based on information provided in the project drawing set dated 05/02/22 as well as assumptions common to similar standard buildings of this type. The thermal enclosure of the baseline exterior walls was modeled with 2" of mineral wool continuous insulation for an overall R-value of 25. The continuous insulation was modeled on 5/8" plywood and 2x6" wood studs with batt insulation filling the cavity.

For Passive House Certification it is typically recommended to target R-30 to R-50 for the exterior wall system. The PHIUS case for this feasibility study considered a total assembly value of R-33 modeled with 3" of Roxul CavityRock continuous exterior insulation and 5.5" of interior cellulose insulation for additional thermal resistance and improved moisture mitigation. This level of insulation should be maintained for all exterior walls. Note that WUFI considers the thermal properties of wood studs when calculating the R-value of cavity insulation.

To note, at least 30-50% of the R-value or more should be installed to the exterior to ensure the dew point is kept outside of the wall cavity. As currently modeled, the exterior mineral wool represents 40% of the R-value for the PHIUS case exterior walls.

Roof:
The baseline roof envelope was based on the minimum code-compliant assembly. It included 5" average of exterior continuous polyisocyanurate insulation over ¾" of plywood, yielding an R-value of R-31.
Typically, the roof assembly should be designed with a minimum total R-value of R-65 to R-80 to meet passive house standards. However, as a building's size and density increases, that requirement may be lowered. The PHIUS case for this feasibility study considered a total roof assembly of R-50 with 8" average of exterior polyisocyanurate insulation.

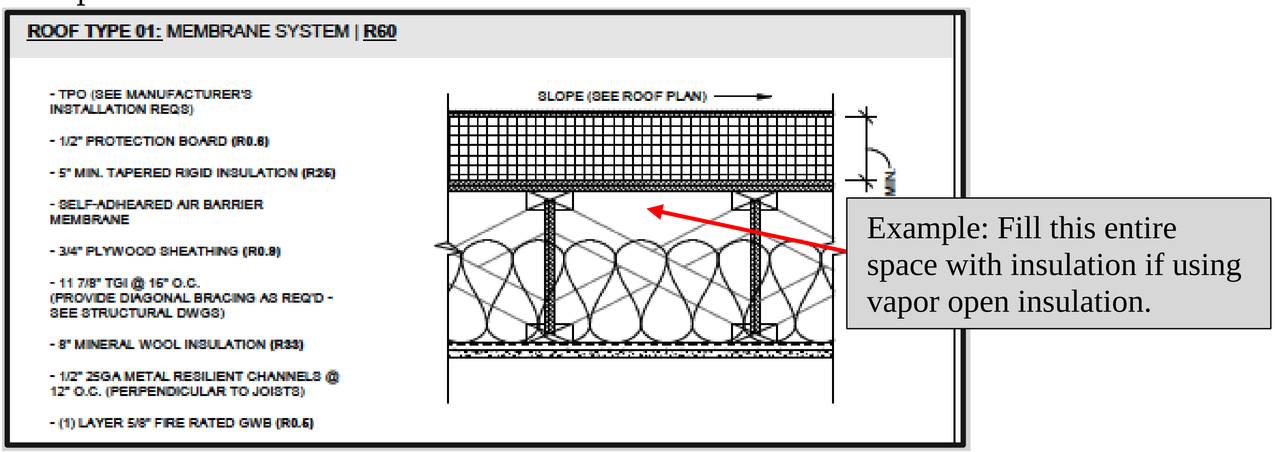
If vapor open insulation is used below the roof deck, there must be no open airspace between the roof deck and the interior insulation (see Example A image below), or a vapor closed insulation (closed cell foam) should be used.
In the case of insulation above and below the roof deck, our recommendation for reducing condensation potential is one of the following options:

1. Fill entire space below roof deck with blown-in insulation.

   OR

2. Use closed cell spray foam to fill the space below the roof deck equivalent to an R-40 or better (dependent on thickness of exterior foam).

Example A:



Slab on Grade

Both the basement and the PHIUS cases modeled the slab on grade for the basement/first floor as a 6" concrete deck with 2" of rigid XPS underneath for an overall R-value of 11.

The connections between the foundation walls and the first floor have the potential to create a thermal bridge and should be carefully detailed to avoid thermal losses. Another potential area of thermal bridging is at the concrete footings where they may bridge from the ground through the concrete assembly to the interior residential space. For PHIUS 2021, these issues will need to be addressed using thermal breaks such as structural thermal break-pads (e.g., ARMATHERM) or other design elements.

Airtightness:

In order to meet Passive House requirements, the building's airtightness is critical. Reducing the building airtightness from code minimum (0.31 cfm/ft^2) to the PHIUS requirement (0.06 cfm.ft^2) has a significant impact on the building's overall performance and is directly indicated as such in the model outputs shown previously. As part of PHIUS documentation, it is required that building air layer drawings are provided showing the air barrier throughout the building and connection points. In addition to exterior airtightness, each unit must be compartmentalized and sealed off from the hallway and adjacent units, improving air quality for occupants. It should be assumed that contractor training will be necessary to ensure the building's assembly can meet PHIUS airtightness and compartmentalization requirements.

Thermal Bridging Potential:

Reducing thermal bridging is key to building a durable and energy efficient building. Thermal bridges transfer thermal energy from interior to exterior and exterior to interior, reducing building durability and energy efficiency while increasing potential for condensation points. Thermal bridges are often found in structural elements which pass from interior to exterior, without proper insulation or thermal break points.

There are several locations on the building which were identified as potential thermal bridges:

1. **Roof connections:** Where mechanical systems are secured to the roof should be designed to eliminate thermal bridging.

2. **Columns and foundation:** The connection of the columns and foundation walls to the conditioned space of the building will need to be thermally broken. For example, the column should terminate and include structural thermal break-pads between the exterior and interior portion of the column.

3. **Balcony connections:** Where unit balconies are secured to the exterior façade, along with any additional shading elements, will need to be designed to eliminate thermal bridging.

Mechanical Systems:

Heating & Cooling:

Both the baseline and the PHIUS models assumed individual heat pump systems within each unit and is an appropriate choice for efficient heating and cooling of a Passive House building.

Heating:

For the baseline energy model, a Rated COP (Coefficient of Performance) was estimated at 2.5-3, which is standard for many systems. Selecting units with a COP of 3.5 or 4 would be preferred to aid in meeting PHIUS targets.

Cooling:

The estimated COP for these systems was a COP of 4.5. We recommend increasing the COP efficiency if possible, which would lead to significant savings on cooling loads.

Ventilation:

The baseline model included one ERV per floor. These ERVs were modeled with an efficiency of 70%.

The PHIUS case was modeled with one central ERV at the roof. A similar efficiency of 75% was assumed, however it is recommended to increase the system's efficiency to further reduce heating demand.

To note, the shorter the duct length from the ERVs to the exterior walls the better the system will perform. By reducing duct lengths to exterior walls, the ERV systems will more easily maintain their rated efficiency and thus improve the building's performance.

The baseline model included both kitchen range exhaust and in-unit dryer exhaust that is vented directly to the outdoors. These auxiliary exhaust units were removed in the PHIUS model. Using recirculating vent hoods are a good approach for Passive House design as the ERV would handle the majority of exhaust. Note that PHIUS requires that all exhaust vents are located at least 6 feet of the kitchen range as part of Passive House requirements. Kitchen exhaust vents must be fitted with an appropriate grease filter. Condensation dryers are also recommended over exhaust dryers; this is not a requirement but may aid in reducing excess air changes associated with dryer exhaust.

Separate bathroom fans are not required, and bathroom exhaust should also be run through the HRV/ERV.

DHW:
The baseline model included in-unit electric water heaters and storage tanks. The PHIUS model upgraded the DHW to in-unit heat pump hot water systems. For Passive House it is recommended to use heat pump water heaters to further improve the efficiency of these systems, but it is not required.

Special attention should be given to ensure the EPA Watersense time-to-hot water requirements are met. Specifics of the requirements can be found here: https://basc.pnnl.gov/information/watersense-hot-water-delivery-requirements . Please ensure the mechanical engineer is given this information. If heat pump hot water heaters or other efficient DHW systems can be incorporated, it should aid in some additional energy savings.

Note for Energy Star, LEED and Passive House, all hot water piping should be insulated with a minimum R-4 insulation. It is recommended that all piping (hot and cold) is insulated to reduce potential for condensation. All pipes in exterior walls must be insulated.

Lighting:
High efficiency lighting and controls should be located throughout the building. Additional occupancy sensors are suggested for the entryway, corridors and stairwells (and any other appropriate common spaces) to reduce overall lighting loads.

Fenestrations:

In order to meet Passive House window requirements there are many combinations of adjustments that can be made. These can include reducing U-values & increasing/decreasing SHGC, reducing the window/wall area ratio and/or reducing the size of windows.

In reviewing the drawings and working with the energy model to get the building to a passing level, adjustments were made to the window performance specifications.

Adjustments are as follows:

Windows:

1. The window specs modeled for the baseline were based on the Andersen A-Series models:
    a. Operable: SHGC: 0.374, overall U-value: 0.23
    b. Fixed: SHGC: 0.374, overall U-value: 0.21

    The PHIUS case included windows based on the Intus Cascadia System:
    a. Operable: SHGC: 0.386, overall U-value: 0.17
    b. Fixed: SHGC: 0.386, overall U-value: 0.15

These window values noted above are not necessarily the required window performance specifications needed for Passive House, however the energy model results do indicate that a lower U-value will significantly improve overall building performance and comfort. The Intus Cascadia windows modeled in the PHIUS case have a significantly lower U-value than those utilized on the baseline model. Note that first floor storefront windows were modeled with the Kawneer 1600UT specifications in the PHIUS case.

1. In both cases, project windows were modeled as a single piece of glass. For example, the 6'x6' windows on the upper floors were all modeled as one 6'x6' window with simulated divided lites. More frame area will reduce the overall window U-value, therefore the model is indicating a conservative case, and this may represent an opportunity for additional reduction of heating demand and heating load.

2. The depth of the window reveal was modeled with an average of around 8" for both the baseline case and the PHIUS case based on preliminary information obtained from the floor plans. This value contributes a shading effect to each window and in this case may be playing a large role in reducing cooling demand and load due to the large number of windows on each façade. This value should be confirmed when possible as a reduction in the reveal depth may result in the need for additional exterior shading or a reduction in window sizes.

3. Reducing the window/wall area ratio is not indicated as necessary based on the results of this feasibility study, however it may still be required to meet the Passive House standard as the project design is further refined. There are a large number of windows on this project, and they play a big role in the building's heating demand and heating load.

   It is understood that windows are essential to creating spaces that feel comfortable, open, and bright, however fewer windows will reduce both heating and cooling demand. We recommend finding a balance that works best for this building. Reducing window sizes is also an effective alternative to eliminating windows, if necessary.

4. Reducing window height can also help meet Passive House window comfort requirements. This is also not indicated as necessary based on the results of this study but may be a useful strategy in the future. Wider single windows are preferred over several separate taller windows. See PHIUS Window Comfort and Condensation Risk Assessment below.

Doors:

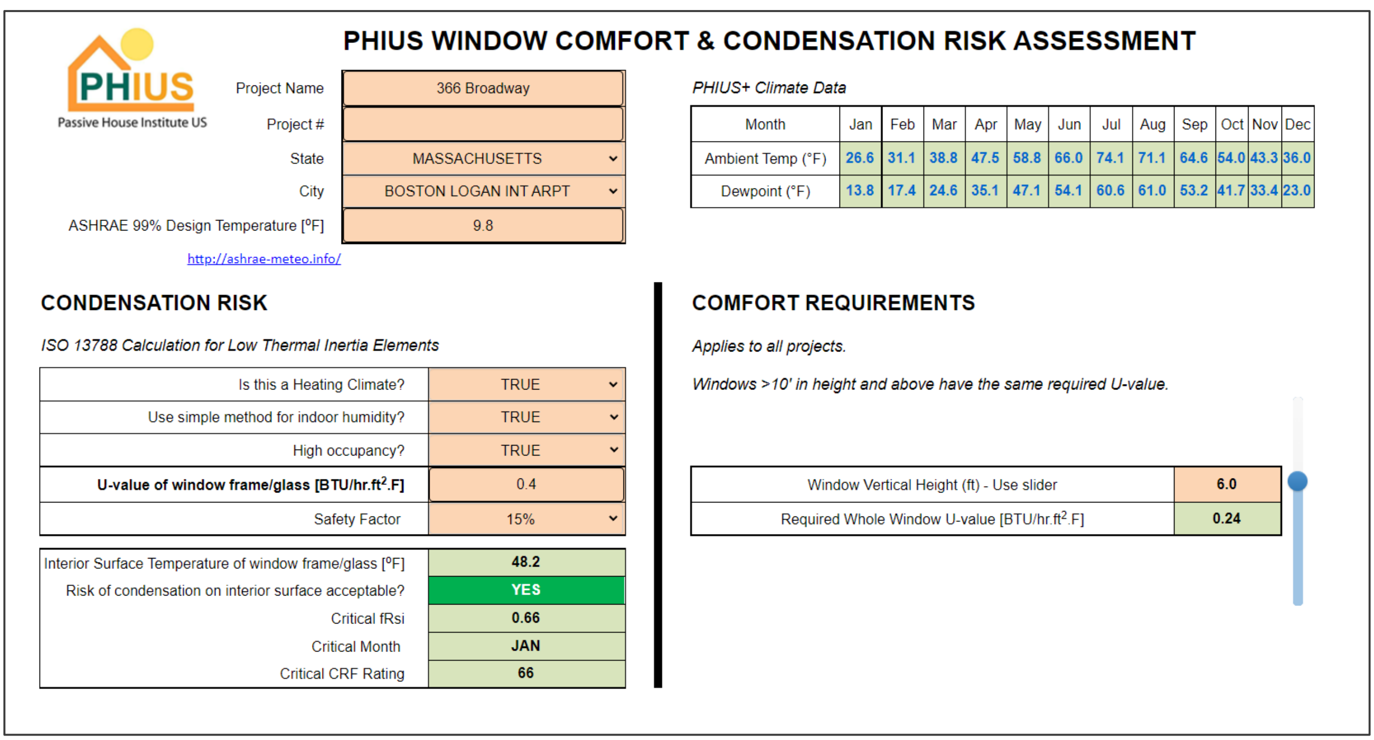
Balcony doors were based on the Andersen A-Series in-swing and gliding patio doors in the baseline models with an overall U-value of 0.26 while in PHIUS model, for simplicity, exterior glazed balcony doors were also modeled with the Intus Supera specifications with a U-value of 0.17.

Storefront doors for both the baseline model and PHIUS model were based on the Kawneer 500T system with a U-value of 0.21.

Doors will also need to meet PHIUS Window comfort and condensation requirements. We highly recommend selecting PH Certified doors when possible. Selecting balcony doors that are opaque or partly opaque with lower U-values would help reduce thermal losses and aid in achieving Passive House Certification.

PHIUS Window Comfort and Condensation Risk Assessment:

The PHIUS Window Condensation requirements (see left side below) set a baseline U-Value for the entire fenestration assembly of 0.4 BTU/hr.ft^2.F. Required U-Values are further adjusted down based with the addition of the Comfort Requirements (see right side below). These targets are an additional mandatory requirement for all PHIUS 2021 projects. The comfort requirements ensure that occupants will be comfortable when they are near the windows throughout the year and that condensation will not collect on windows. Based on the window & door height, the comfort requirement adjusts the required U-Values. As the glazing height increases, the required U-Value is reduced.



PHIUS WINDOW COMFORT & CONDENSATION RISK ASSESSMENT

PHIUS Passive House Institute US

Project Name	366 Broadway
Project #	
State	MASSACHUSETTS
City	BOSTON LOGAN INT ARPT
ASHRAE 99% Design Temperature [ºF]	9.8

http://ashrae-meteo.info/

PHIUS+ Climate Data

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ambient Temp (°F)	26.6	31.1	38.8	47.5	58.8	66.0	74.1	71.1	64.6	54.0	43.3	36.0
Dewpoint (°F)	13.8	17.4	24.6	35.1	47.1	54.1	60.6	61.0	53.2	41.7	33.4	23.0

CONDENSATION RISK

ISO 13788 Calculation for Low Thermal Inertia Elements

Is this a Heating Climate?	TRUE
Use simple method for indoor humidity?	TRUE
High occupancy?	TRUE
U-value of window frame/glass [BTU/hr.ft^2.F]	0.4
Safety Factor	15%

Interior Surface Temperature of window frame/glass [ºF]	**48.2**
Risk of condensation on interior surface acceptable?	**YES**
Critical fRsi	**0.66**
Critical Month	**JAN**
Critical CRF Rating	**66**

COMFORT REQUIREMENTS

Applies to all projects.

Windows >10' in height and above have the same required U-value.

Window Vertical Height (ft) - Use slider	**6.0**
Required Whole Window U-value [BTU/hr.ft^2.F]	**0.24**

To meet comfort requirements, the baseline of a 0.23 (BTU/hr.ft^2.F) U-value becomes a 0.23 (BTU/hr.ft^2.F) based on a 6' window height. As the glazing height increases, the required Whole Window U-Value is reduced as shown in the table of estimated U-Values below:

Estimated Required U-Values:

Height of Fenestration	U-Value BTU/hr.ft^2.F
2 ft	0.31
4 ft	0.27
6 ft	0.24
8 ft	0.20
10+ ft	0.17

Electric-ready:

The PHIUS CORE 2021 program also requires that all projects comply with the electrification-readiness requirements for combustion equipment as outlines in the PHIUS Certification Guidebook v3.02. This applies to combustion water heating, space heating, clothes drying and cooking equipment. Combustion fuel devices may be used, however each device must be designed and constructed with the appropriate infrastructure for the future conversion of the combustible equipment to electric equipment serving the same purpose. Combustion fuel devices cannot be used for PHIUS ZERO 2021 projects.

Electric Vehicles:

Infrastructure for the current and future charging of electric vehicles (EVs) is required for all residential buildings where parking spaces are required.

EV Installed: A parking space with a minimum of a Level 2 EV charging station is *not* required.

EV Ready: A parking space that is provided with dedicated branch circuit that terminates at the junction box or receptacle, is located within 3 feet of the parking space, can support a 40-amp, 208/240-volt circuit and shall be labeled "for electrical vehicle charging" at the electrical panel and "for future electrical vehicle charging" at the junction box.

EV Capable: A parking space that is provided with continuous conduit infrastructure between the junction box which can accommodate a 40-amp, 208/240-volt branch circuit and shall be labeled "for future electrical vehicle charging".

Electric Vehicle ready and EV Capable Space requirements for multifamily dwelling

Total # of Parking Spaces	Minimum number of EV Ready Spaces	Minimum number of EV Capable Spaces
1	1	-
2-10	2	-
11-15	2	3
16-19	2	4
21-25	2	5
26+	2	20% of total

Summary:

Overall, the project is poised to be a high-performance building and will be able to meet the level of Passive House with some adjustments. As noted in this report, there are some additional design modifications that will be necessary for the project to meet the PHIUS 2021 Certification requirements. In summary, the following design adjustments are recommended:

1. Roof: Confirm roof assembly details and total R-value (R-50 or better). To discuss interior roof insulation.

2. Walls: Confirm wall assembly details and total R-value (R-30 or better). Add 3" of exterior continuous insulation, such as polyiso or mineral wool and fill cavity with interior insulation.

3. Slab on Grade: confirm insulation and air sealing details. (R-10 or better).

4. Detail exterior structural elements (roof connections, foundation walls and footings, balcony connections etc.) to eliminate potential for thermal bridges.

5. Use high efficiency HRV/ERVs and design to minimize duct lengths for supply and exhaust from unit to outdoors for higher performance operation.

6. Select high efficiency heat pumps or VRF systems for heating cooling.

7. DHW: Ensure piping is insulated with R-4 insulation or better and verify the project will meet EPA Watersense Requirements. Select heat pump hot water systems if possible.

8. Lighting: Ensure all lighting systems are high performance and all appropriate spaces utilize occupancy sensors, especially in common spaces.

9. Windows and Glass Doors Recommendations:
    a. Select windows with high performance specifications. **It is highly recommended to use Passive House Certified window systems.** This will save your team time in selecting a window that will meet the required performance targets. Intus Supera windows are Passive House Certified.
    b. Ensure fenestration systems that are selected meet both the comfort and condensation risk reduction U-Values. Request NFRC reports or PHIUS Window Data from potential window manufacturers as this is required for Passive House Certification. Please forward Linnean NFRC or Passive House window/door certifications ASAP.
    c. Storefront glass must meet all PHIUS requirements for certification.

Assumptions & Limitations:

1. Default assumptions were used for entries where specific information was not provided.
2. The study results provide one combination of performance upgrades that allow the building to meet PHIUS performance targets. As the PHIUS standard is performance based, there are countless combinations of upgrades that can be utilized to meet the performance targets.
3. Drawing sets and additional details provided by Khalsa Design Inc. and the SketchUp file created by Linnean were used to generate the baseline energy model.
4. Surrounding buildings and shading obstructions were modeled around the building to allow the WUFI Software to calculate shading assumptions created by these objects.
5. No Thermal bridge calculations were conducted for this study.
6. Ventilation Rates were set to minimum requirements for PHIUS modeling.
7. Note that certification is required through the following programs as part of PHIUS 2021 Certification:
    a. ENERGY STAR Multifamily
    b. ZERH – Zero Energy Ready Home:
    c. EPA Indoor Air Plus:
    d. EPA Watersense Homes
8. This report is not all inclusive of all requirements of the PHIUS certification program. For additional details on PHIUS 2021 Certification please review the Certification Guidebook v3.1 here
9. Current WUFI model is only an estimate, actual systems and design specifications will need to be input into the model Pre-Certification and Final Certification through PHIUS.

Passive House Feasibility Charrette

Prepared on August 30, 2022 for:

366 Broadway Somerville, LLC
Edward Doherty
200 Broadway, Suite 103
Lynnfield, MA 01940

LINNEAN Solutions

Presentation Roadmap

- Intro
- Passive House
- Mass Save
- Feasibility Study
- Summary & Conclusion

Project Details

Modeled iCFA: 45,786ft^2

PH envelope area: 46,213ft^2

Units: 58

Bedrooms: 38 (PHIUS counts studio units as 0 bedrooms)

Occupants: 96

Context - What is Passive House?

Building Standards

Reduce Load
and
Power with Renewables

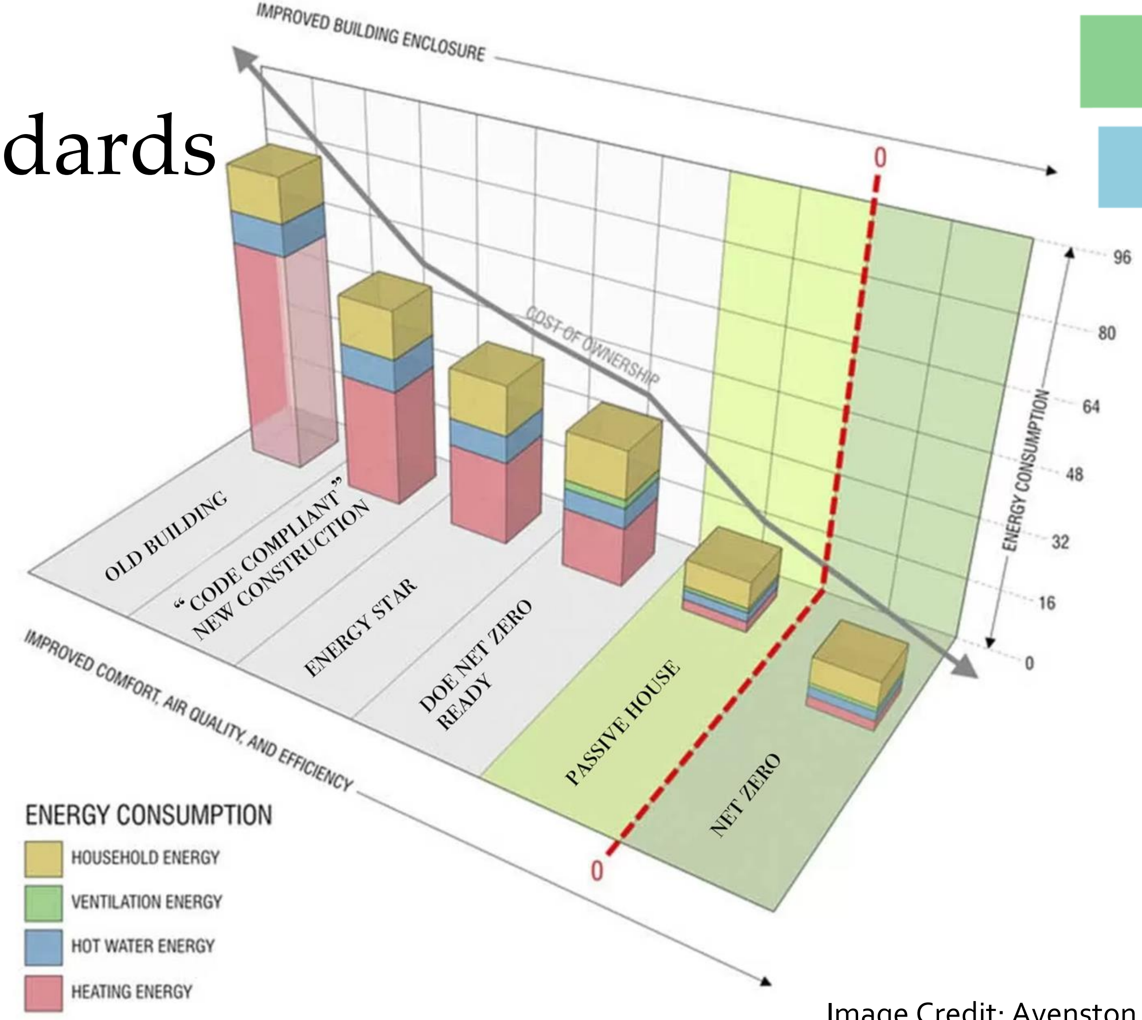
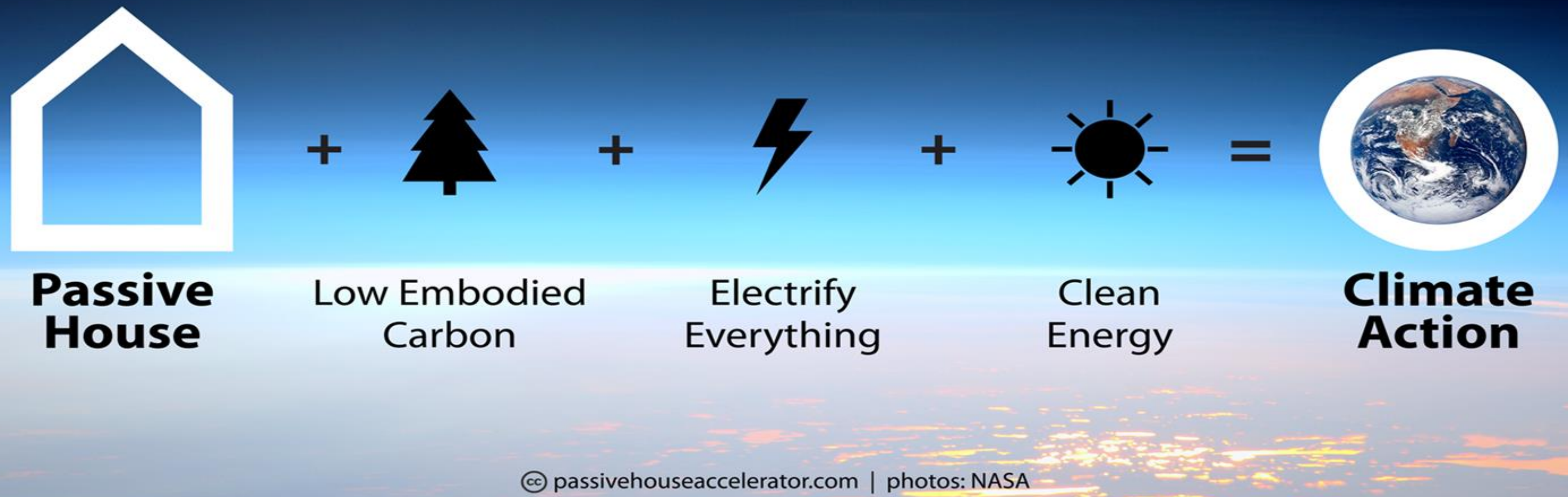


Fig. 1: Energy consumption buildings categories

Image Credit: Avenston Architecture

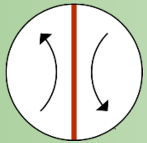
Climate Change Mitigation

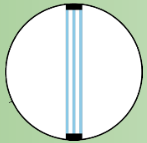


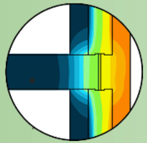
Why Passive House? Many Benefits!

- Health
- Comfort
- Quiet
- No dust
- Keeps critters out
- Moisture/odor elimination
- Durability
- Predictable performance
- Affordable
- Energy efficient
- Resilient
- Complementary


Super-insulated envelopes

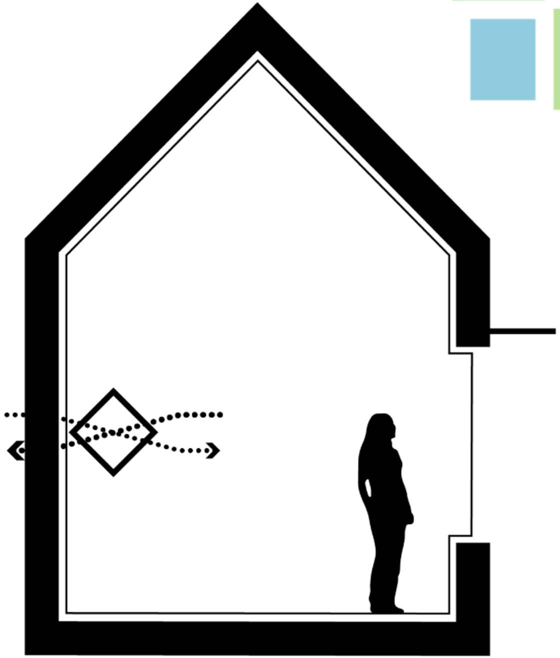

Airtight construction


High-performance glazing


Thermal-bridge free construction


Heat recovery ventilation

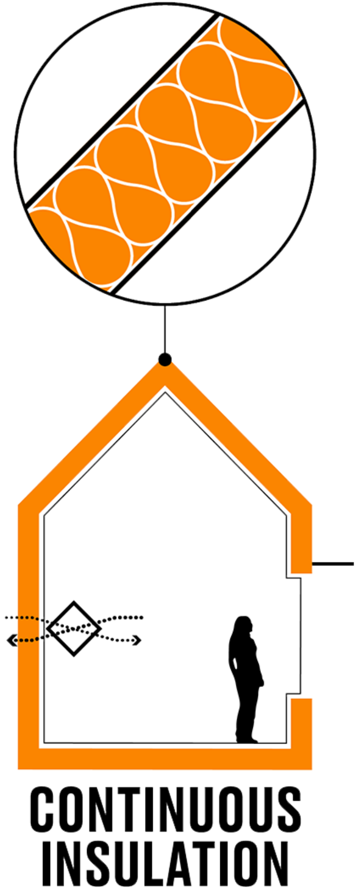

Moisture management



PASSIVE HOUSE DESIGN PRINCIPLES

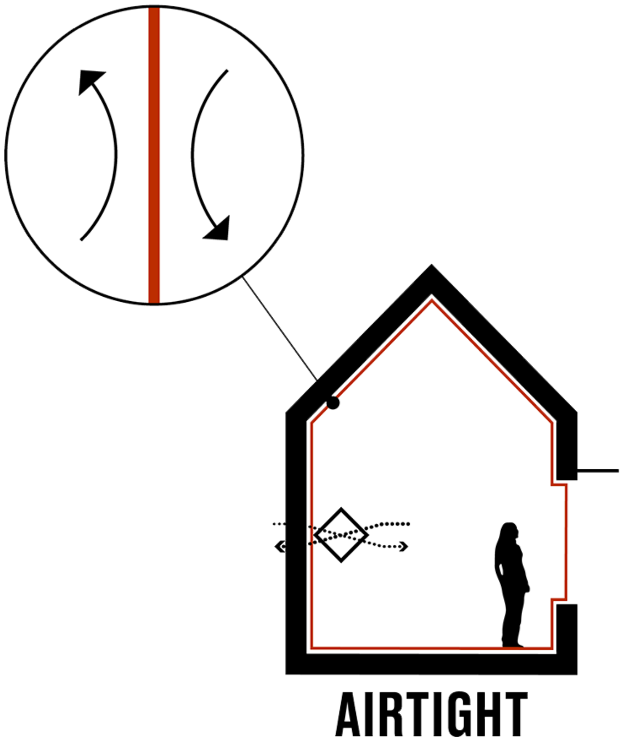
Passive House - Principles

- 2x or 3x of code compliant assembly R-value
- Better soundproofing
- Better resiliency
- No thermal bridging
- Easier moisture control



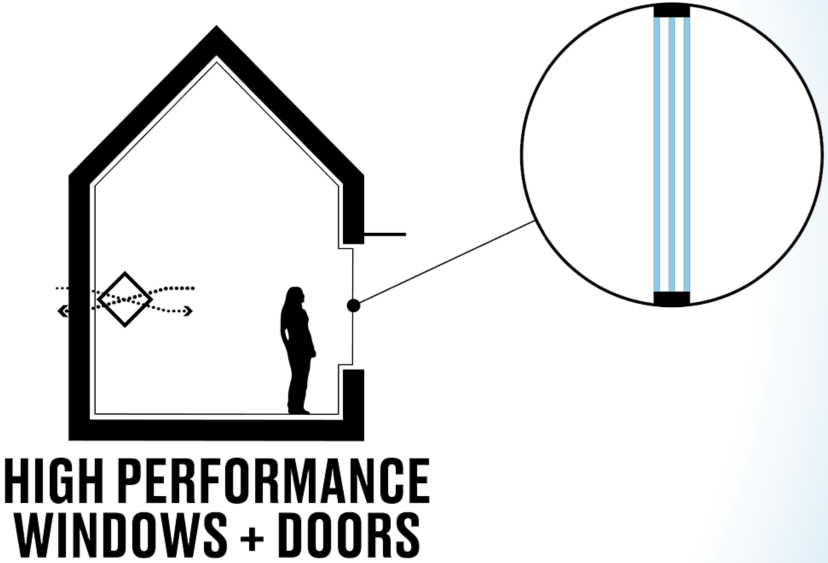
Passive House - Principles

- Minimize heating
- Better durability
- No condensation
- No mold
- No air drafts



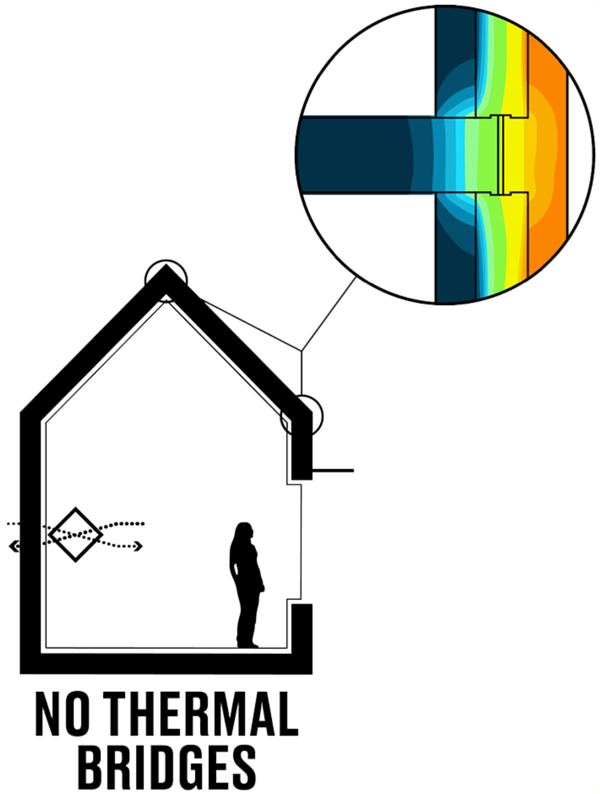
Passive House - Principles

- Triple glazing windows/doors
- Optimal SHGC and orientation
- Lower U-value
- More airtight



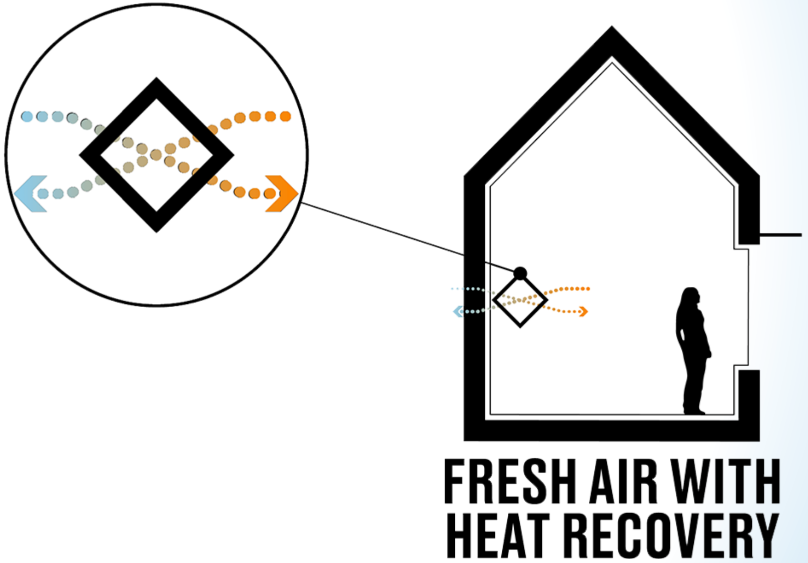
Passive House - Principles

- Eliminate “cold corners” and cold indoor surfaces
- Minimize mold risk
- Improves comfort



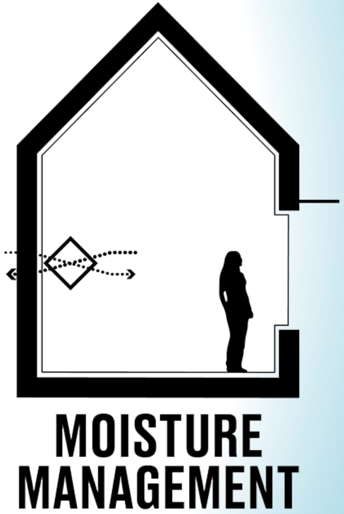
Passive House - Principles

- Critical to maintain the indoor air quality
- Unconditioned supply air can increase energy usage
- ERV/HRV necessary
- At least 75% efficiency



Passive House - Principles

- Necessary for building durability
- No moisture trapped within assemblies
- Indoor humidity controlled by ERV



Why are YOU working in Passive House?

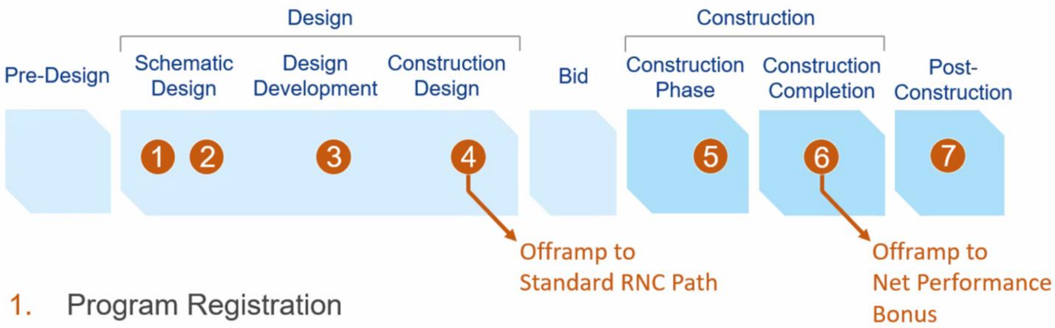
- Health
- Comfort
- Quiet
- No dust
- Pest reduction
- Moisture/odor management
- Durability
- Performance
- Affordable
- Efficient

Questions? or Clarifications?

Mass Save Portion / Handoff

PH Incentive Timeline

mass save
Savings through energy efficiency



1. Program Registration
2. PH Feasibility and Energy Charrette
3. PH Energy modeling
4. PHIUS / PHI Pre-Certification
5. Verification of ECMs
6. PHIUS / PHI Certification
7. Closeout — incentive payment

Feasibility Study - Overview

What's Included in the Study?

- WUFI® Passive energy model with completed cases for the proposed design and Phius-complaint (when proposed design is not compliant)
- WUFI® Passive report estimating preliminary annual energy use for base design and Phius-compliant design
- Target building-envelope thermal performance values to meet Phius standards
- One solution for mechanical system equipment selection and corresponding performance ratings
- Comparison report between the proposed and Phius-compliant projects, outlining variances in enclosure, system selection, and more.
- Energy use comparison vs. code (optional)
- A 1-hour conference call between the Phius team and project team running through results, generally about 1-2 weeks after the completed study is sent back to the project team.

Feasibility Study Process

1. Linnean receives drawings
2. WUFI proposed/baseline design energy model
3. Modify WUFI model to meet ph requirements
4. Analyze & compare models
5. Detail and report out (including suggestions to reach compliance)

PHIUS Targets

1. Location
2. Building envelope/iCFA
3. Density: # bedrooms & units

The factors above are entered into the calculator to determine the target criteria for the project

PHIUS 2021 Targets for 366 Broadway

Phius 2021

Performance Criteria Calculator v3.1

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	MASSACHUSETTS
CITY	BOSTON LOGAN INT ARI
Envelope Area (ft²)	46,213.0
iCFA (ft²)	45,786.7
Dwelling Units (Count)	58
Total Bedrooms (Count)	38

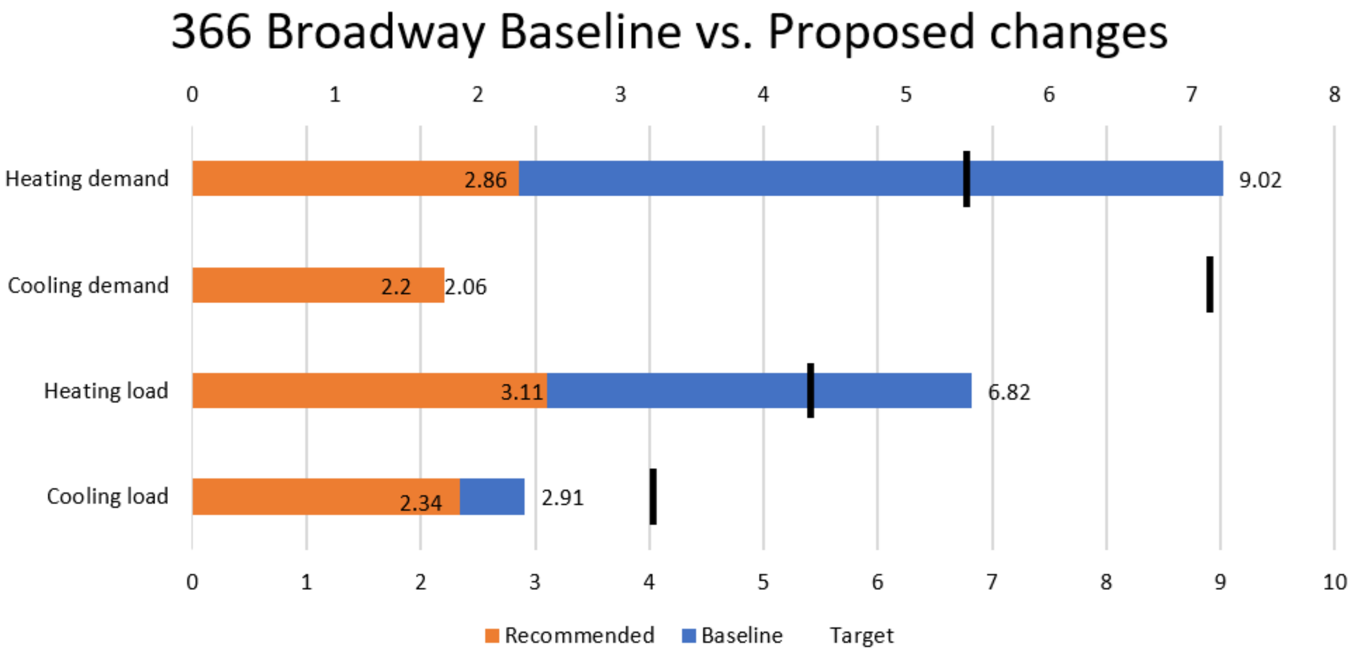
Space Conditioning Criteria

Annual Heating Demand	5.4	kBtu/ft²yr
Annual Cooling Demand	7.1	kBtu/ft²yr
Peak Heating Load	4.3	Btu/ft²hr
Peak Cooling Load	3.2	Btu/ft²hr

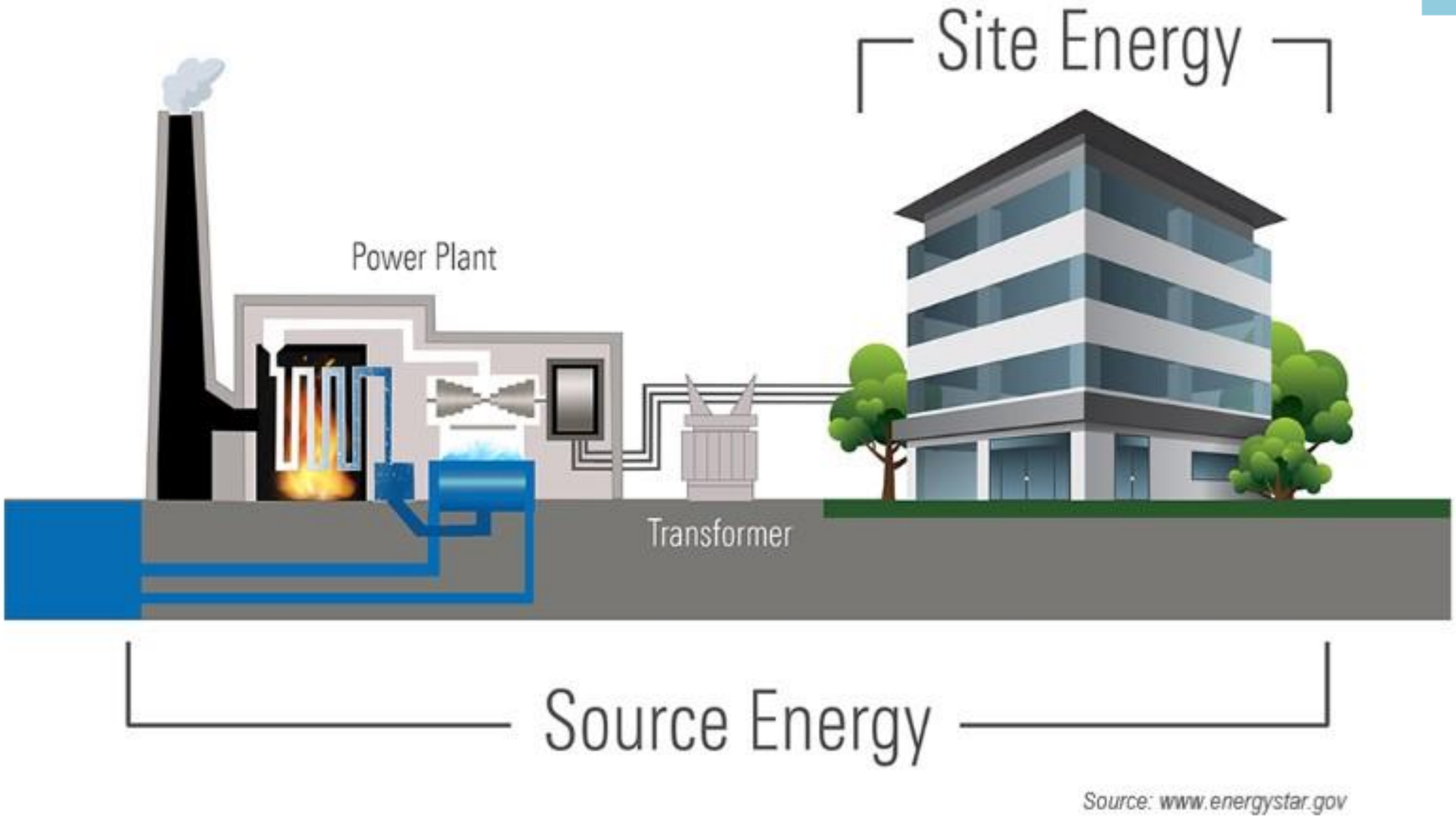
Source Energy Criteria

Phius CORE	6000	kWh/person.yr
Phius ZERO	0	kWh/person.yr

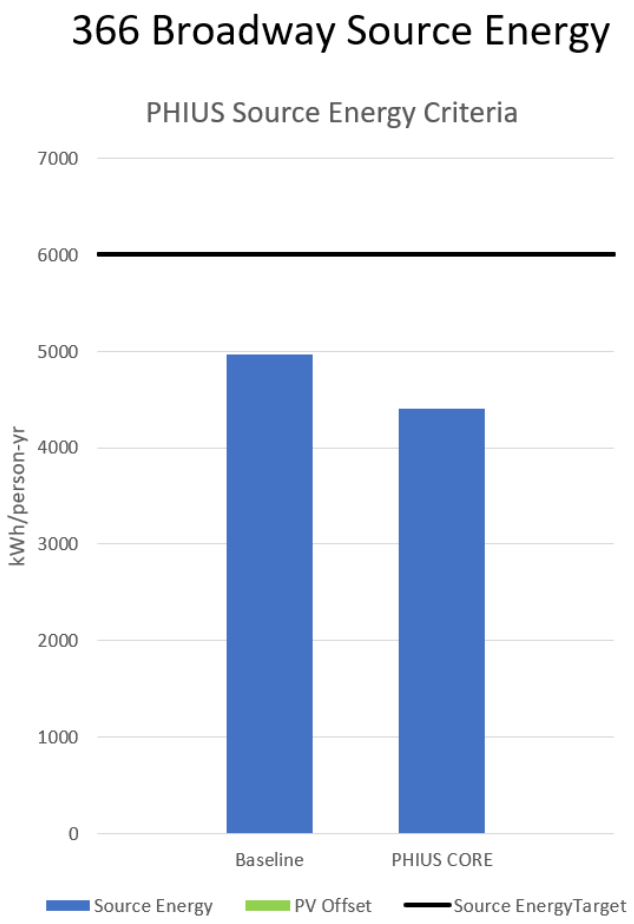
WUFI Modeling: Load vs. Demand



Source Energy



Source Energy - Renewables



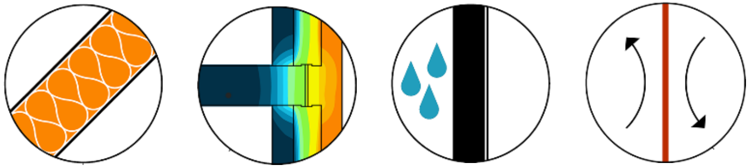
Design changes…

…From code compliance to Passive House Certified

Exterior Walls

- Thermally broken cladding
- Continuous exterior insulation
- Vapor barrier
- 30-50% R-Value to exterior of sheathing

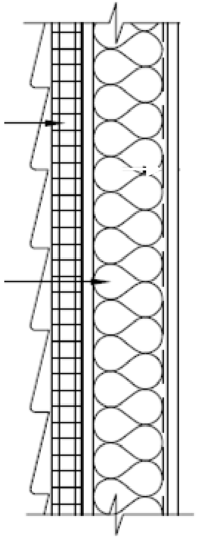
Key Passive House Principles:



Baseline: R-25 PHIUS: R-37

3″ Roxul Cavity Rock continuous insulation

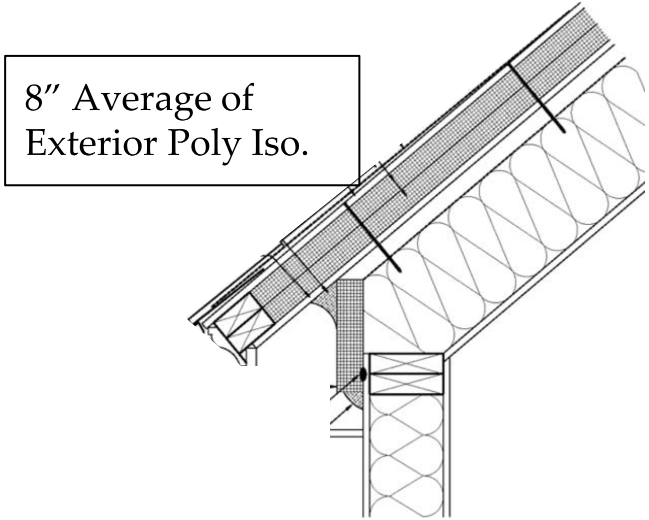
5.5″ of cellulose cavity insulation



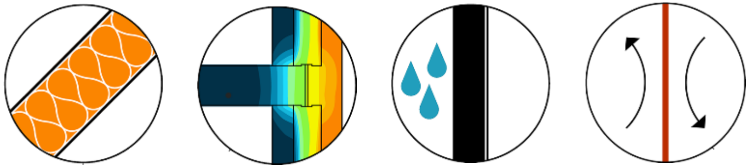
Roof Assembly

Baseline: R-31 PHIUS: R-50

- Continuous exterior insulation
- Vapor barrier
- 35% of insulation exterior of decking
- Manage cavity moisture carefully



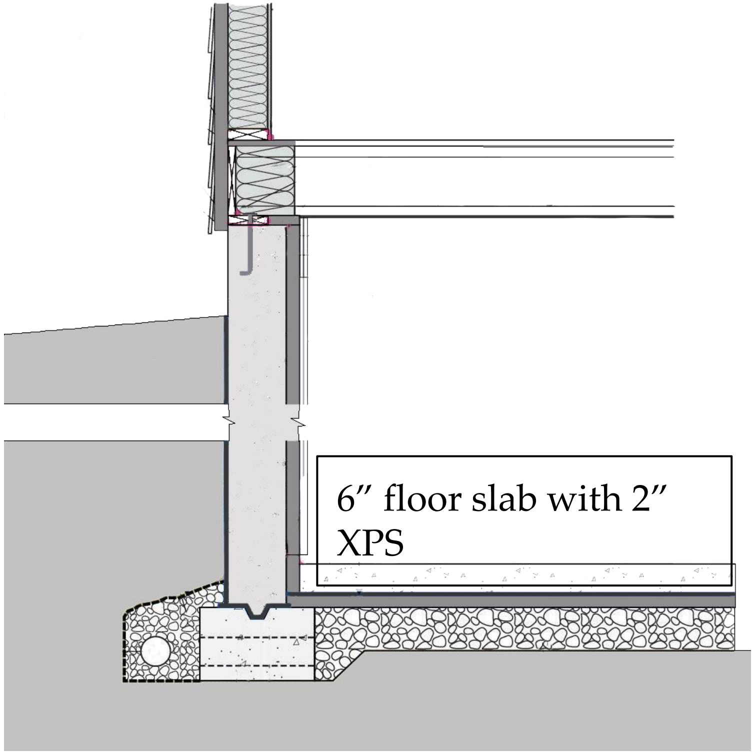
<u>Key Passive House Principles:</u>



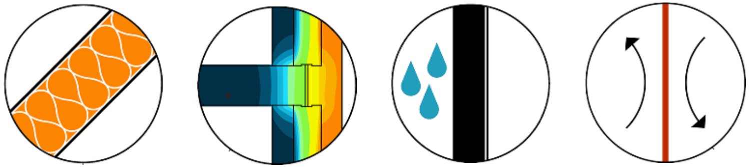
Foundation

Baseline: R- 10   PHIUS: R- 11

- Continuous insulation
- Vapor barrier
- Mitigate thermal bridging at footing and wall connection



Key Passive House Principles:



Windows

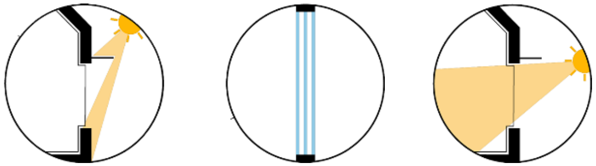
- Manufacturer/model that has PHI/ PHIUS certification to avoid delays
- SHGC helps control heating/cooling demands and load
- More frame area will increase overall window U value

Baseline	PHIUS
Uw: .21 - .23	Uw: .15 - .17
SHGC: .374	SHGC: .386

Recommendations:

- Select windows with lowest u-value
- Consider reduction of window/wall area

Key Passive House Principles:



Storefront Glazing

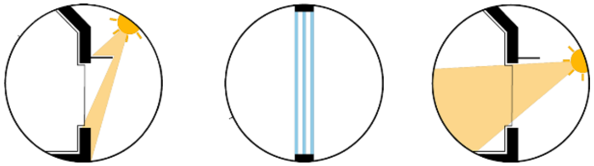
- Thermally broken frames
- Code exceptions for egress/ ADA doors
- Meets PHIUS condensation requirement
- Kawneer 1600UT fixed storefront system

Baseline	PHIUS
Uw: .26	Uw: .17
SHGC: .374	SHGC: .386

Recommendations:

- Select PH doors – Kawneer 250/350/500T
- Consider slightly opaque balcony doors

Key Passive House Principles:



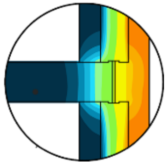
HVAC - Heating & Cooling

- COP as high as possible
- VRF/VRV are also OK
- Minimize envelope penetrations and thermal bridging

Recommendations:

- Heating: select units with COP of 3.5 or 4
- Cooling: increase COP from 4.5 if possible

Key Passive House Principles:



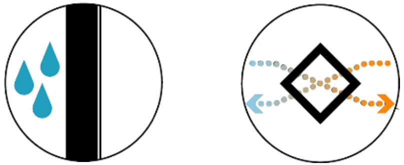
HVAC- Ventilation

- 75% or better ERV efficiency
- PHIUS compliance with 3rd party documentation needed (AHRI)

Recommendations:

- Centralized ERV on roof
- Minimize duct runs
- Consider recirculating vent hoods
- Consider condensation dryers vs exhaust dryers

Key Passive House Principles:



Domestic Hot Water

- Electric ready requirement
- Insulated pipes (r-4 min.)
- EPA time-to-tap requirements –reduce lengths

Recommendations:

- Upgrade to in-unit heat pump HW heater or central HPWH system
- Ensure compliance with EPA Watersense requirements me

Getting to PHIUS 2021

ZERO
ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

EPA Indoor airPLUS
QUALIFIED HOME

WaterSense
Meets EPA Criteria

ENERGY STAR

Summary

- Improve roof R-value of R-50 or better
- Increase continuous wall insulation to 3”
- Confirm slab design for insulation and air sealing details
- Carefully manage thermal breaks at assembly connections
- Upgrade HRV/ERV and design system for minimal duct lengths
- Select high efficiency heat pumps for heating/cooling
- Insulate DHW piping with min R-4, and review for EPA Watersense compliance
- Select fenestrations approved by PHIUS to save time—target .017 U-w or better

THANK YOU!

LINNEAN Solutions