Passive House Feasibility Study

for

1149-1151 Walnut Street, Newton Massachusetts

Prepared for:

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Table of Contents

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Overview:

Linnean Solutions examined the feasibility of 1149-1151 Walnut Street in Newton Massachusetts for earning Passive House certification through the PHIUS+ 2018 program and documented our findings in this report. The provided drawings and sketchup files were used to create a baseline WUFI Passive energy 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 current design and some code compliance assumptions. A second energy model was then run with the adjustments necessary to meet the PHIUS + 2018 requirements, these adjustments are the basis of the recommendations which are laid out in this report.

Scope:

For the purposes of this feasibility study, only floors 2-4 have been included in the energy model. The retail space on the first floor has been excluded. In order to exclude the first floor space, the thermal air barrier will need to separate the retail spaces from the residential .

Typically, retail spaces are excluded from the PH envelope in mixed use projects as storefront glass poses a problem in meeting PHIUS+ Window Comfort and Condensation requirements. If an acceptable system is found the entire building could be considered for certification.

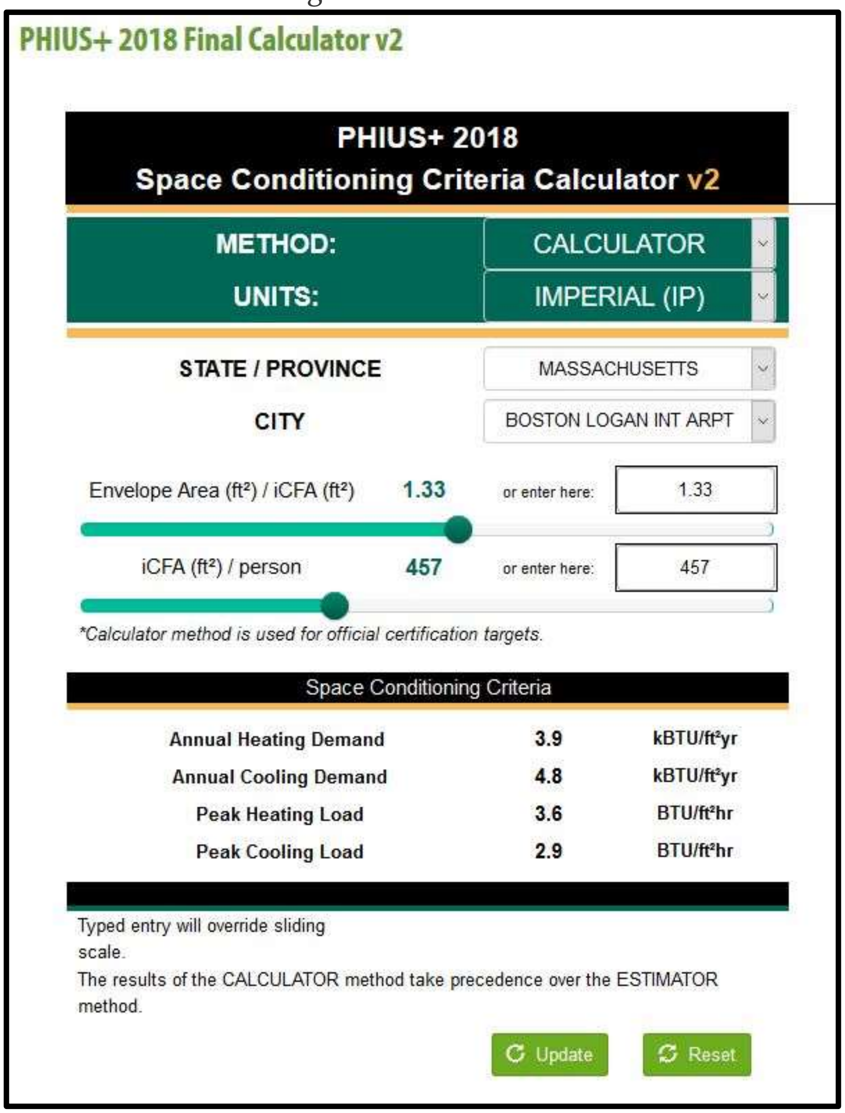
Current Design:

Total iCFA: 26,379
Modeled iCFA: 23,750ft^2 *(excluding first floor and basement)*
Envelope area of PH Envelope: 31,556 ft^2
Occupants: 52
Bedrooms: 44
Studios: 8
1 bed: 10
2 bed: 8

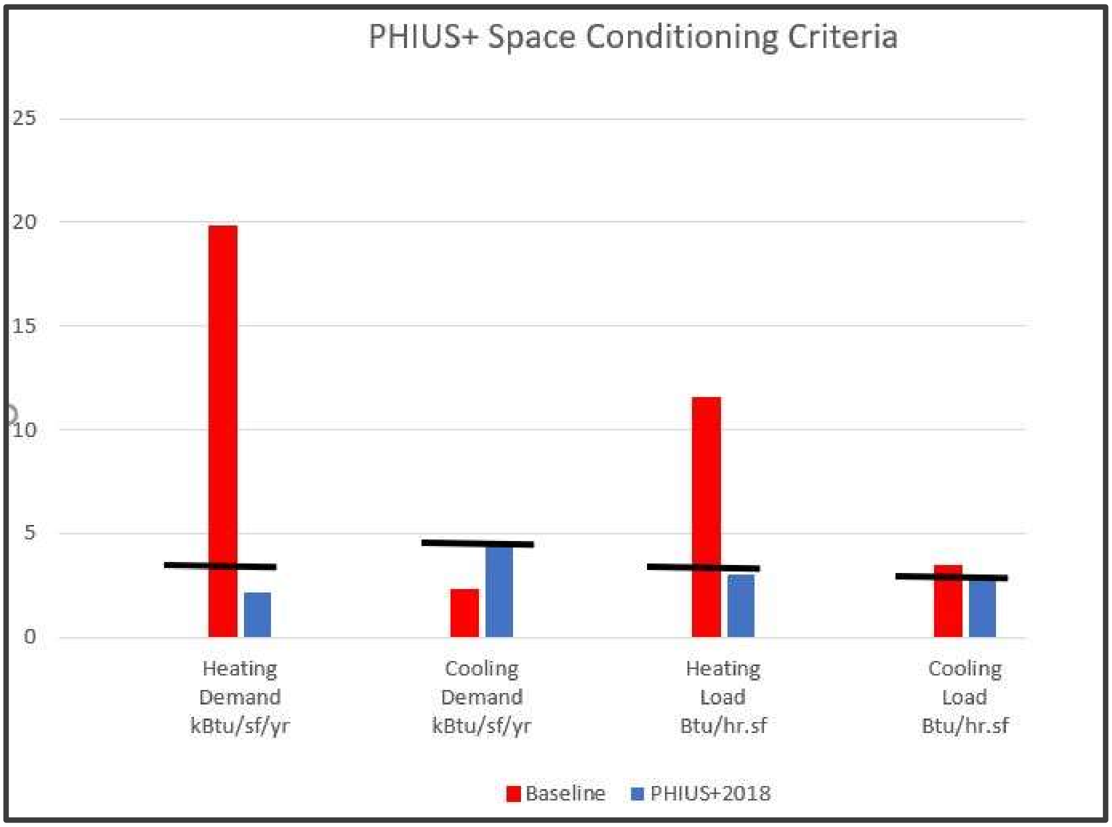
PHIUS+2018 Targets:

The image below shows the PHIUS+2018 Space Conditioning Criteria Calculator, which calculates the building's targets for Annual Heating and Cooling Demands and Peak Heating and Cooling Loads. As you can see this calculation is based on project location, but also on envelope to floor area ration and occupant density.

PHIUS+2018 Targets for 1149-1151 Walnut Street



The below graph shows the comparison between the baseline energy model (red) and the PHIUS+ 2018 case (blue). 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. You can see that the adjustments made to the WUFI energy model from the baseline to the PHIUS+ model brought the building performance targets below each of the PHIUS+2018 threshold lines.



WUFI Energy Model:

The initial Baseline WUFI model, based on the current design and code compliant assumptions, did not meet the PHIUS+2018 requirements. The biggest contributor to the baseline model not passing, was the airtightness and lack of thermal insulation. Airtightness for baseline cases is entered at code minimum 0.31 cfm/ft^2. By meeting the passive house airtightness requirements, improved thermal insulation for walls, roof and slab, high performance fenestrations and HVAC systems, and renewable energy, the building could be poised to earn PHIUS + 2018 Certification.

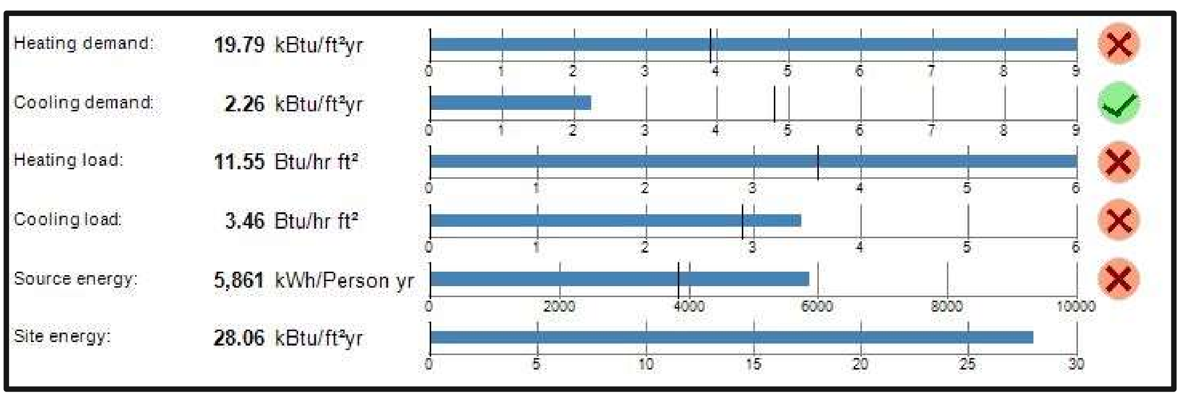
The images below show each of the building's WUFI Passive energy model results for each case.

1. Baseline model – based on current design and standard air leakage (0.31 cfm/ft^2) and code compliant insulation levels.

2. Baseline model with PHIUS required air tightness (0.05 cfm/ft^2) and code compliant insulation levels).

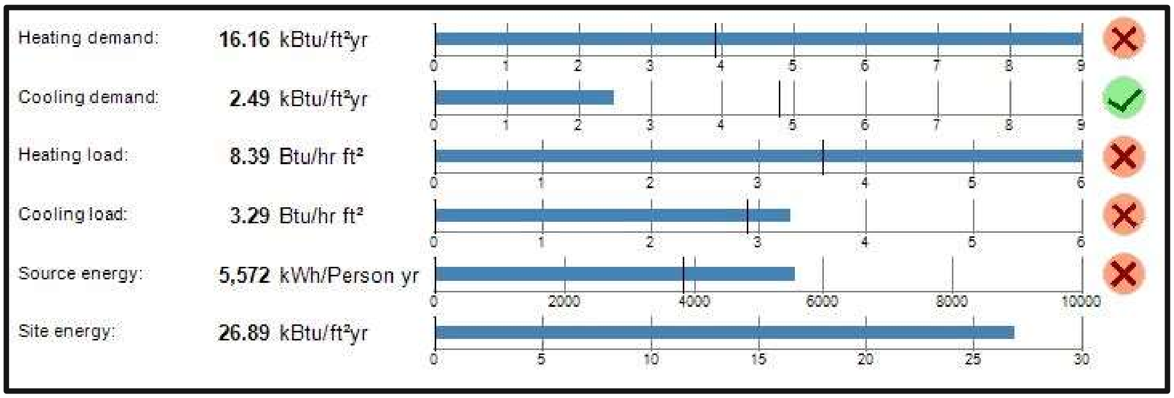
3. PHIUS+ 2018 model – Includes air tightness (0.05 cfm/ft^2) envelope & mechanical upgrades and additional solar PV necessary to meet PHIUS+2018 certification.

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



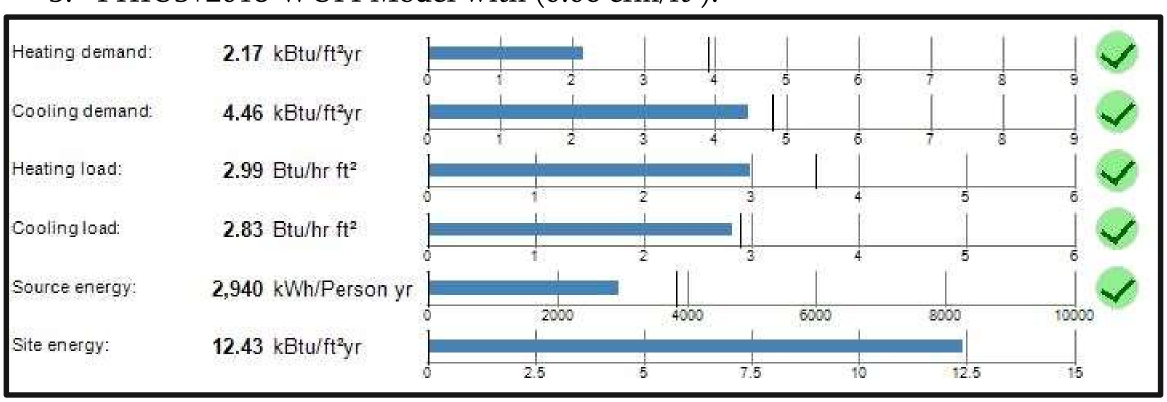
The initial baseline case shows the building fails to meet all Passive House thresholds but cooling demand. The reason cooling demand is easily met is due to higher air leakage and the northeastern climate.

2. Baseline WUFI Model with (0.05 cfm/ft²) Airtightness



These results show the improvements from the baseline design simply by increasing the building airtightness from 0.31 cfm/ft² to 0.05 cfm/ft².

3. PHIUS+2018 WUFI Model with (0.06 cfm/ft²):

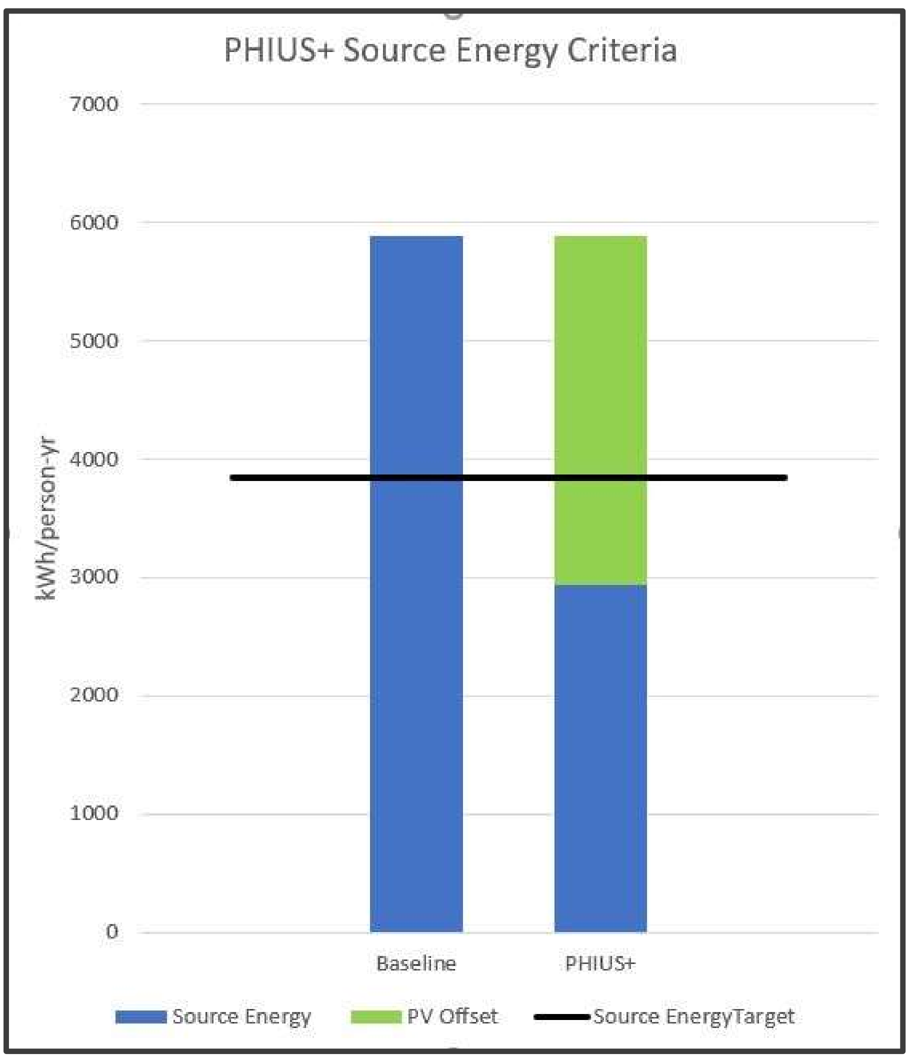


In order to meet the PHIUS requirements, the design would need to make adjustments to the building envelope and select high efficiency equipment for heating/cooling, ventilation and DHW. This also includes adding a 44 kW photovoltaic (60,000 kWh/year) system to the rooftop.

Source Energy Criteria:

As shown in the PHIUS+2018 WUFI Model results above, through making some adjustments to the current design, the project can meet all required performance targets for certification through PHIUS+2018. The biggest challenge for the project will most likely be meeting the PHIUS+ Source Energy requirement of 3,480 kWh/person/yr.

The below graph indicates the building Source Energy for the baseline and PHIUS+ WUFI model cases. The graph illustrates in green, the reduction necessary to meet the PHIUS+ Source Energy target of 3,840 kWh/person/yr from where it currently is for the building at around 5,887 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 below under "Renewable Energy" for recommendations and pathways towards meeting the Source Energy target.



Passive House Design Recommendations:

Building Envelope:

Walls:

For the current building envelope, TAT provided wall details in an email dated June 19th 2020 to be used as a baseline.

The wall from outside to inside was shown as follows:

1. Brick or Fiber cement board siding
2. Air gap (1.5")
3. Zip R Sheathing (2") R-9.6
4. 2x6 wood stud wall, with 3.5" Fiberglass Batt
5. Air gap (2")
6. Gypsum Board (5/8")_

Accounting for thermal losses, the above wall comes in at an R-26. For Passive House Certification it is recommended to target around R-30 to R-40 wall system. In this case, filling the 2x6 wall completely with insulation, (5.5") for the additional thermal resistance and improved moisture mitigation is recommended. We also recommend using mineral wool batts over fiberglass for the higher R-value per inch. In moving to mineral wool and filling the 2x6 cavity completely, the wall is then at a comfortable level of R-36. This level of insulation should be maintained for all exterior walls.

Roof:

No Roof example was given so we estimated the baseline roof at R-35. For meeting Passive House, The roof assembly should be designed with a minimum total R-value of R-60. Roof deck recommendation would be several layers of poly-iso OR XPS insulation followed by additional insulation below the deck. 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)

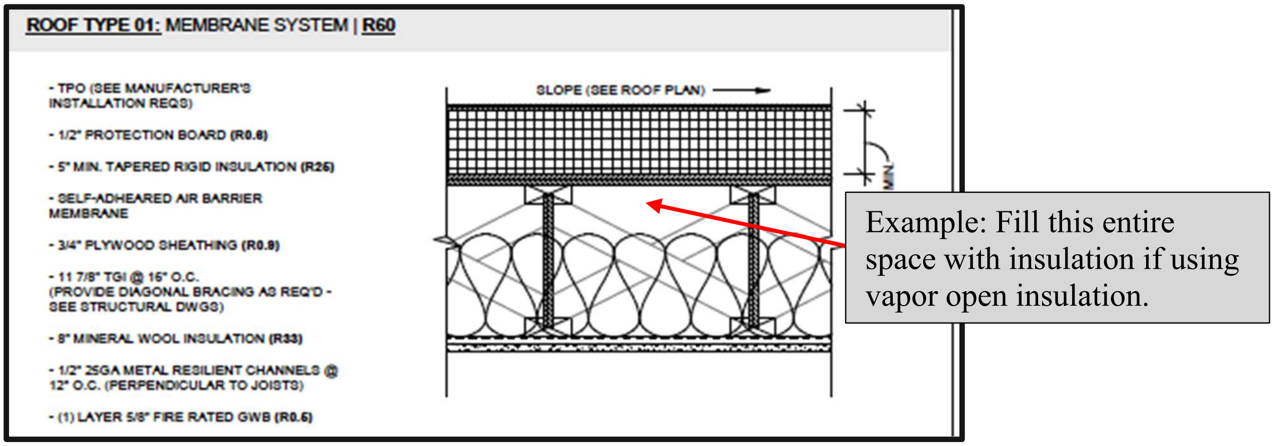
Our recommendation for reducing condensation potential is one of the following options:

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:



<u>Slab:</u>
For slab on grade and the elevator pit walls and floor, a minimum R-10 is recommended using EPS or XPS insulation.

<u>Air-tightness:</u>
In order to meet Passive House requirements, the building's airtightness cannot be stressed enough. Reducing the building airtightness from code minimum (0.31 cfm/ft^2) to PHIUS required (0.05 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 (this is also a LEED requirement), improving air quality for occupants. It should be assumed that contractor training will be necessary to ensure the building's assembly can to meet PHIUS airtightness and compartmentalization requirements.

<u>Thermal Bridging Potential:</u>

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. Balcony connections:
    a. Where balconies connect to the building, a thermally broken design is recommended. One option, is using structural thermal break pads between the balcony and building connection points.

2. Lower roof decks:
    a. Where structural components pass from the interior to the exterior, it is recommended that beams include thermal breaks at all transition points.

3. Columns at parking level:
    a. Where each column comes up to the floor of the building, the column should terminate and include structural thermal break pads between the exterior and interior portion of column.

4. Roof extensions.
    a. Where the angled roof caries above the flat roof on the northern façade, should be designed to eliminate thermal bridging.

Mechanical Systems:

Heating & Cooling:

The baseline provided, included heat pump systems for HVAC and is an appropriate choice for efficient heating and cooling for Passive House.

Heating:

For the baseline energy model a Rated COP (Coefficient of Performance) was estimated at 3, which is standard for many systems. Selecting units with a COP of 4 or 4.5 would be preferred to aid in meeting PHIUS targets.

Cooling:

The estimated COP for these systems was a COP of 4. We recommend increasing the COP efficiency if possible, which would lead to significant savings on cooling loads.

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Ventilation:
For the baseline, it was assumed that two roof-top gas-fired Greenheck ERVs would be used. These units have an minimum 70% effective energy recovery.

If the building pursues 100% electric, and eliminates natural gas, it would be recommended to use smaller HRV/ERVs. Using smaller higher efficiency ERVs on each floor could be a good approach for Passive House. 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.

From the current drawings, how kitchen range exhaust will be handled is unclear. Using recirculating vent hoods, can be a good approach for passive house design as the HRV/ERV would handle the majority of kitchen exhaust. PHIUS requires that each unit have an exhaust vent within 6 feet of the kitchen range as part of Passive House requirements. Kitchen exhaust vents must be fitted with an appropriate grease filter.

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

Condensation dryers should be used if possible over exhaust dryers, however this is not a requirement.

DHW:
As noted in the email from TAT, we assumed two Lochinvar water heaters. 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 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, window quantity.

Adjustments are as follows:

Windows:

1. The window specs provided for the baseline were:
   a. Double Hung: SHGC: 0.19, U-value: 0.27
   b. Casement: SHGC: 0.18, U-value: 0.27

   In order to get the building to a passing level for Passive House, we needed to adjust the window performance to the following:
   a. All Windows: SHGC: 0.25, U-value: 0.20

   These window values noted above are not necessarily the required window performance specifications needed for Passive House, however the energy model results do indicates that a higher SHGC and lower U-value will improve overall building performance and comfort.

2. The large east facing window, should be either broken into several smaller windows, or removed entirely. Tall windows in Passive House projects are difficult as there are rigorous comfort and condensations requirements. For the purpose of this feasibility study, this window was removed.

3. Reducing the window/wall area ratio will also aid in meeting the Passive House standard. Recommendation: Reduce quantity of windows.

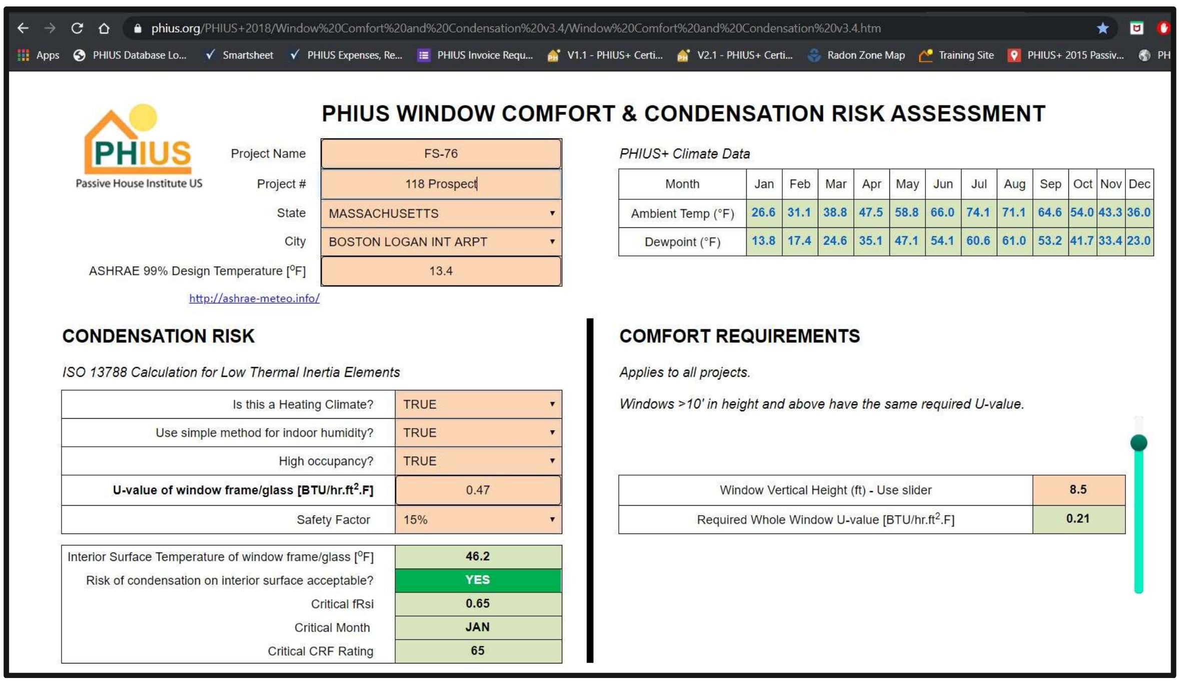
Doors:

1. The patio door specs provided for the baseline are:
   a. Patio doors: SHGC 0.18, U-value: 0.28

   Selecting patio doors that are opaque or have a lower U-value would help reduce thermal losses and aid in achieving Passive House Certification.

All windows and doors need to meet the PHIUS Window Comfort and Condensation Risk Assessment requirements as shown below:

The PHIUS Window Condensation requirements (see left side below) set a baseline U-Value for the entire fenestration assembly of 0.47 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+2018 projects. The comfort requirements ensure that occupants will be comfortable when they are near the windows throughout the year. 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	FS-76
Project #	118 Prospect
State	MASSACHUSETTS
City	BOSTON LOGAN INT ARPT
ASHRAE 99% Design Temperature [ºF]	13.4

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]	0.47
Safety Factor	15%
Interior Surface Temperature of window frame/glass [ºF]	46.2
Risk of condensation on interior surface acceptable?	YES
Critical fRsi	0.65
Critical Month	JAN
Critical CRF Rating	65

COMFORT REQUIREMENTS

Applies to all projects.

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

Window Vertical Height (ft) - Use slider	8.5
Required Whole Window U-value [BTU/hr.ft^2.F]	0.21

https://www.phius.org/PHIUS+2018/Window%20Comort%20and%20Condensation%20v3.1/Window%20Comort%20and%20Condensation%20v3.1.htm

So the baseline of a 0.47(BTU/hr.ft^2.F) U-value becomes a 0.21(BTU/hr.ft^2.F) based on an 8' 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	0.33
3 ft	0.31
4 ft	0.29
5 ft	0.27
6 ft	0.25

Renewable Energy:

To meet the PHIUS+ 2018 target for Source Energy, the building's PV system was estimated to need to be appropriately 44 - 55 kW and approximately 57 - 71 kWh/yr using PV Watts. Maximizing rooftop solar would be one option to mee the PHIUS+2018 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.

Summary:

Overall, the project is poised to be a high-performance building with some minor adjustments. As noted in this report, there are some additional design modifications that will be necessary for the project to meet the PHIUS+2018 Certification requirements, as several assumptions were made at this early stage in design. In summary, the following design adjustments are recommended:

1. Confirm renewable energy systems to reduce total source energy below 3,480 kWh/person/yr through both on-site and/or off-site options.

2. Roof: Confirm roof assembly details and total R-value(R-60 to R70). Fill all cavities.

3. Walls: Confirm wall assembly details. (R-30 or greater wood framing / R-40 steel framing or better). Fill all cavities.

4. Slab and Elevator pit: confirm insulation and air sealing details. (R-10 or better).

5. Provide Air sealing and Compartmentalization details. Elevators and stairwells should be sealed off if connecting PH to non-PH areas.

6. Detail exterior structural elements (balconies, roof decks etc.) to eliminate potential for thermal bridges.

7. Use smaller higher efficiency HRV/ERVs, and design to minimize duct lengths for supply and exhaust from unit to outdoors for higher performance operation.
8. Select high efficiency Heat Pumps for heating cooling.

9. 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.

10. Lighting – ensure all lighting systems are high performance and all appropriate spaces utilize occupancy sensors, especially in common spaces.

11. Windows and Glass Doors Recommendations:
    a. Reduce window/wall ratio.
    b. Consider opaque patio doors.
    c. 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.
    d. Remove entirely or break up the large window on the East façade.

12. Although not included in this study for lack of information, the first floor retail space should also be designed to the Passive House standard as much as possible. Although storefront windows would not need to meet the comfort/condensation requirements if they were deemed outside of the PH envelope, HVAC systems and envelope design should still be high performance as total building energy is incorporated into the final energy model's source energy. PH doors will need to be used between transition areas -lobby, elevators, entryway doors etc.

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. The 04 29, 2020 1149-1151 Walnut Street and the updated sketchup file documents from TAT 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+ 2018 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+2018 Certification please review the Certification Guidebook v2.1: https://www.phius.org/PHIUS+2018/PHIUS+%20Certification%20Guidebook%20v2.1.pdf
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+.
10. Total energy for retail spaces was not included as no baseline was provided.