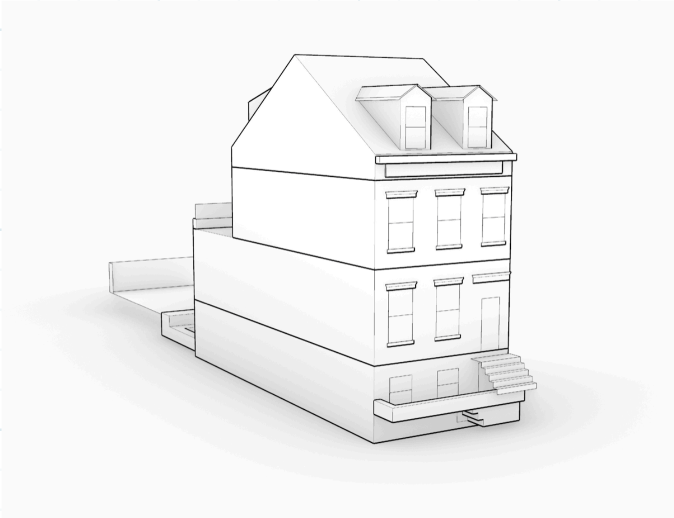
Whippoorwill

5 variants tested. PHI LEB is the current recommended path.

REPORT DATE 2026-06-29



DESIGN-PHASE BUILDING MODEL.

CONTENTS

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00

Executive summary

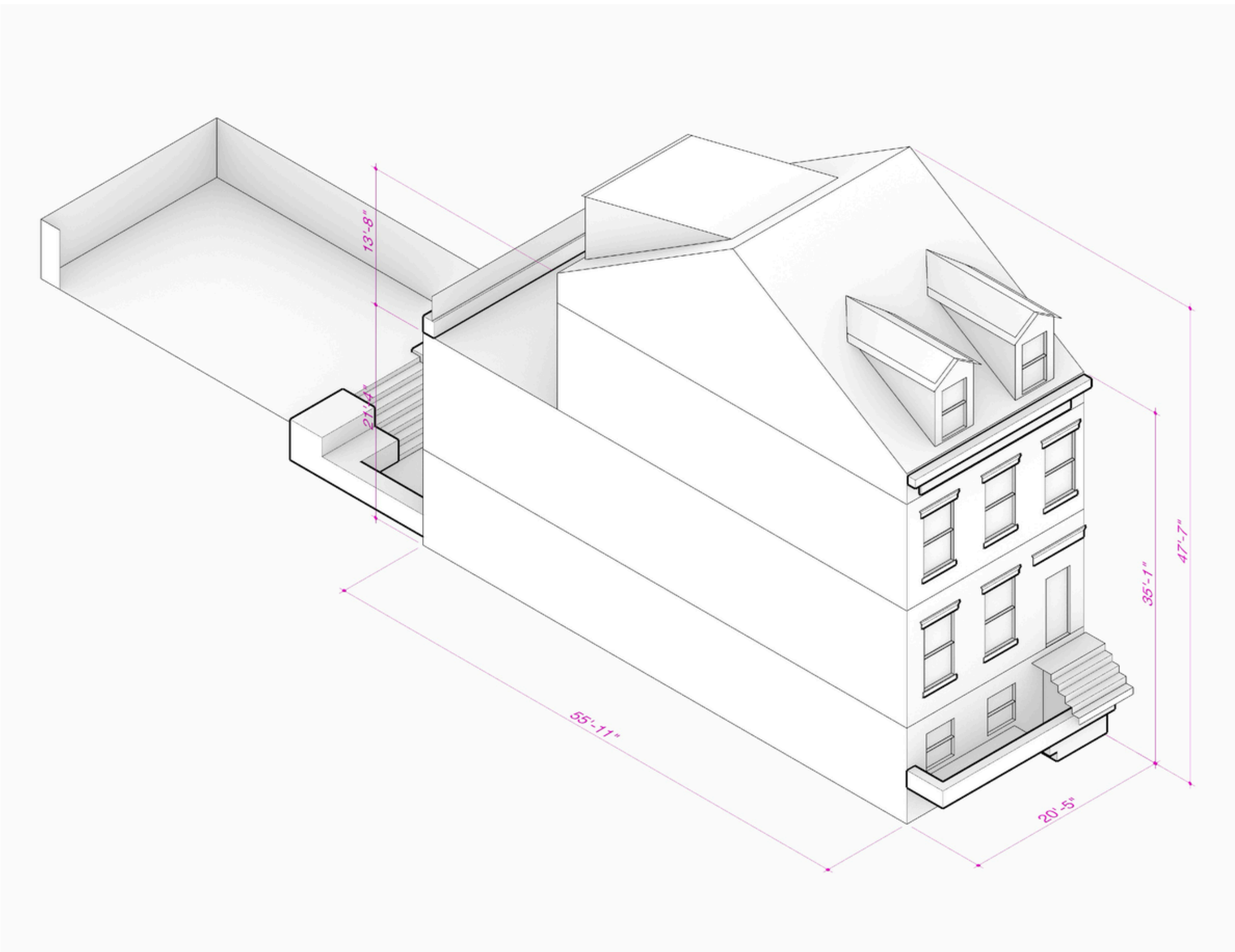
This report evaluates the energy performance, thermal comfort, and long-term durability of the proposed building under multiple distinct design variants. We have outlined the details of this assessment modeling, the key results, and our recommendations within the following pages.

> NOTE
>
> Keep high-stakes caveats here: overheating risk, airtightness assumptions, certification path uncertainty, or cost/constructability tradeoffs that could change the recommendation.

01

Model Geometry

For all model results shown here, the following building geometry was used. This geometry is based on the drawings/models received on . The model geometry used for this assessment includes both the building and the local shading context. For details on the context shading see the windows site shading section.



TFA

7,617 ft2

Treated floor area

	ENVELOPE AREA	TOTAL WINDOW AREA
	18,693 ft2	1,079 ft2
	Thermal envelope area	All orientations combined

02

Model Variants

As shown in the results below, in order to assess the building performance we have tested the building in five distinct configurations (variants):

1. **Code-Minimum:** A version which meets but does not exceed the / code minimums for assembly R-values, window U-values, airtightness and equipment efficiencies. This variant assumes a typical residential "extract-only" (bath fan) ventilation system, and that the building uses all-electric appliances and equipment for heating, cooling, hot-water and cooking.

2. **Improved Envelope:** This variant improves the window U-values, assembly R-values, and total airtightness of the building beyond the "code-minimum" levels, but not quite to full "Passive House" level.

3. **Improved HVAC:** This variant includes a dedicated fresh-air ventilation system with heat recovery (HRV). This system is assumed to be a "basic" HRV with 70% heat-recovery (unit). This variant shows a slight increase in the overall site-energy, due to the increased fan-energy needed.

4. **PHI EnerPHit 'By Component' [RECOMMENDED]:** A variant which meets the stringent Passive House Institute (PHI) EnerPHit (Energy Retrofit) standard's prescriptive targets for envelope U-values, airtightness, windows, and equipment efficiencies. This variant also includes a high performance ERV system for fresh-air ventilation.

5. **PHI EnerPHit 'By Demand':** A version which increases assembly R-values, window U-values, and mechanical system efficiencies to meet the PHI-EnerPHit 'by Demand' energy performance certification criteria. Due to the higher level of wall insulation required at the existing brick masonry, this variant is not recommended in this case.

Key results by variant

This table lists some of the key output results for each of the variants tested as part of this investigation. Values from the recommended variant, PHI LEB, are highlighted.

METRIC	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	• RECOMMENDED PHI LEB
Certification Compliant?	No	No	No	No	**Yes**
Total Primary Energy kWh/yr	293,711	242,962	182,550	63,642	**56,445**
Total Site Energy kWh/yr	112,966	93,447	70,212	24,478	**21,710**
Heat Demand kWh/yr	148,630	120,715	87,956	25,671	**21,344**
Heat Demand kWh/m2	210	171	124	36.3	**30.2**
Cooling Demand kWh/yr	2,710	2,637	1,961	1,856	**1,831**
Total Cooling Demand kWh/m2	4.13	3.96	2.94	2.69	**2.65**
Peak Heat Load Btuh	249,963	200,150	139,658	48,865	**43,494**

METRIC	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	• RECOMMENDED PHI LEB
Peak Sensible Cooling Load Btuh	30,147	28,178	21,366	13,805	**12,783**
Peak Latent Cooling Load Btuh	30,013	23,640	17,267	6,728	**6,728**

Geometry metrics by variant

This table lists model geometry metrics for each variant tested as part of this investigation. Values from the recommended variant are highlighted.

METRIC	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	• RECOMMENDED PHI LEB
TFA ft2	7,617	7,617	7,617	7,617	**7,617**
Building Envelope Area ft2	18,693	18,693	18,693	18,693	**18,693**
Vn50 ft3	94,547	94,547	94,547	94,547	**94,547**
Gross Volume ft3	122,911	122,911	122,911	122,911	**122,911**
Envelope Area To TFA ft2/ft2	2.45	2.45	2.45	2.45	**2.45**
Window Area (North) ft2	287	287	287	287	**287**
Window Area (East) ft2	105	105	105	105	**105**
Window Area (South)					

METRIC	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	• RECOMMENDED PHI LEB
ft2	549	549	549	549	**549**
Window Area (West) ft2	127	127	127	127	**127**
Window Area (Horiz) ft2	10.7	10.7	10.7	10.7	**10.7**

Envelope Inputs By Variant

This table lists the envelope, window, wall, etc. inputs for each variant tested as part of this investigation. Values from the recommended variant, PHI LEB, are highlighted.

DATATYPE	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	• RECOMMENDED PHI LEB
Exg BG Floor hr-ft2-F/Btu	R-3	R-3	R-3	R-22.2	**R-22.2**
Exg BG Wall hr-ft2-F/Btu	R-3	R-3	R-3	R-18.8	**R-18.8**
Exg AG Wall hr-ft2-F/Btu	R-5	R-5	R-5	R-24.9	**R-40**
Exg Roof hr-ft2-F/Btu	R-10	R-10	R-10	R-35.6	**R-50**
BG Floor hr-ft2-F/Btu	R-3	R-31.3	R-31.3	R-31.3	**R-31.3**
Thermal Bridge Allowance (% increase) % Increase	+20 %	+20 %	+10 %	+10 %	**+5 %**
Volumetric Air Leakage					

DATATYPE	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	● RECOMMENDED PHI LEB
Rate (n50) ACH@50	7	5	3	1	**1**
Envelope Air Leakage Rate (q50) cfm/ft2	0.59	0.42	0.25	0.08	**0.08**
Window U-value (Installed) Btu/hr-ft2-F	U-0.42	U-0.42	U-0.17	U-0.17	**U-0.17**
Window SHGC -	0.6	0.6	0.4	0.4	**0.4**

Mechanical System Inputs By Variant

This table lists the various mechanical system inputs for each variant tested as part of this investigation. Values from the recommended variant, PHI LEB, are highlighted.

DATATYPE	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	• RECOMMENDED PHI LEB
Ventilation System	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	1-Balanced PH ventilation with HR	**1-Balanced PH ventilation with HR**
Ventilation Unit HR Efficiency %	20.7 %	20.7 %	20.7 %	77.6 %	**77.6 %**
Ventilation Unit ER Efficiency %	18.1 %	18.1 %	18.1 %	68 %	**68 %**
System HR Efficiency %	20.7 %	20.7 %	20.7 %	77.6 %	**77.6 %**
Cold Air Duct Length (ea) ft	16.4	16.4	16.4	16.4	**16.4**
Cold Air Duct Insulation Thickness inches	2.05	2.05	2.05	2.05	**2.05**

DATATYPE	CODE MIN	(+) NEW ASSEMBLIES	(+) WINDOWS	(+) EXG ASSEMBLIES	● RECOMMENDED PHI LEB
Heating System	Heat pump(s)	Heat pump(s)	Heat pump(s)	Heat pump(s)	**Heat pump(s)**
Cooling System	Elec. Heat Pump	Elec. Heat Pump	Elec. Heat Pump	Elec. Heat Pump	**Elec. Heat Pump**
DHW System	Heat pump(s)	Heat pump(s)	Heat pump(s)	Heat pump(s)	**Heat pump(s)**

03

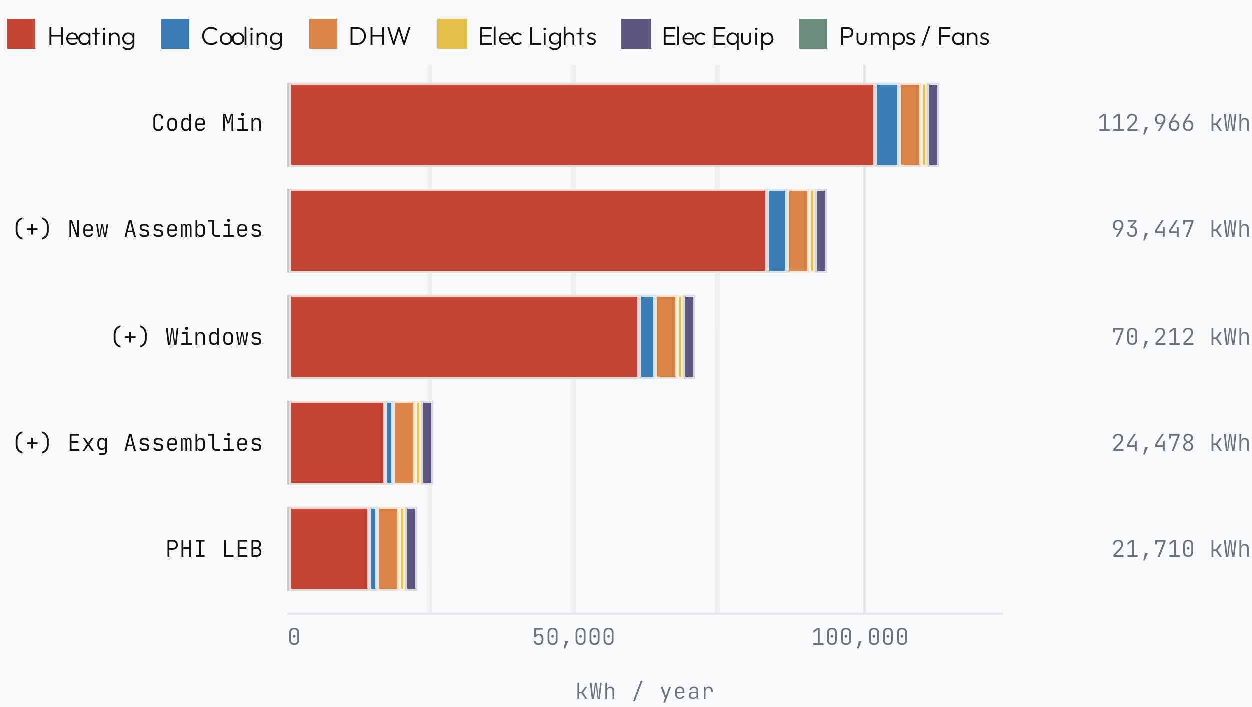
Site Energy

"Site Energy" represents the energy purchased by the building and delivered to the site by the utility. This is the most typical energy use figure assessed when considering a site "Net-Zero" building energy balance, or when considering the annual cost of energy for the building. This site-energy total is made up of 6 main groups: heating, cooling, hot-water, lighting, electric equipment (appliances, electric-vehicles, etc), and pumps / fans.

In order to assess the performance of the home across a range of options, we have simulated 5 distinct variants with different energy efficiency measures (see the Model Variants section for all the details on the specific variant inputs). In this case, compared to the "existing" home any of the variants assessed are likely to provide significant reductions in site energy consumption.

Annual site energy

Annual site energy end uses by modeled variant, in kWh / year.



04

CO2 Emissions

Carbon Dioxide and other types of pollution which results from energy consumption are mainly responsible for the increased warming of the earth's atmosphere and water. In order to reduce the risk of global climate change it is important to reduce all CO_{2e} (CO_2 Equivalent) emissions related to the buildings, industry and transportation across all sectors. While there is much debate about the specific targets these reductions should achieve, one useful method suggests that by 2030 each individual will need to meet an annual 'Carbon Budget' of roughly 2.3 tons-CO_{2e} per person for all activities. This would mean that an average individual's annual carbon emissions might include approximately 1 ton-CO_{2e} / year related to their housing and building inhabitation, 1 ton-CO_{2e} / year for their transportation, and another 0.3 tons-CO_{2e} / year for food. For reference, a single US-to-Europe round trip flight currently releases approximately 4 tons of warming gases into the atmosphere. This 1 ton/person target for building emissions gives us a useful benchmark for this building's annual CO_{2e} emissions. Given an average annual occupancy of approximately 0 people, this building should ideally see a total annual CO_{2e} emissions footprint of less than about tons-CO_{2e} / year.

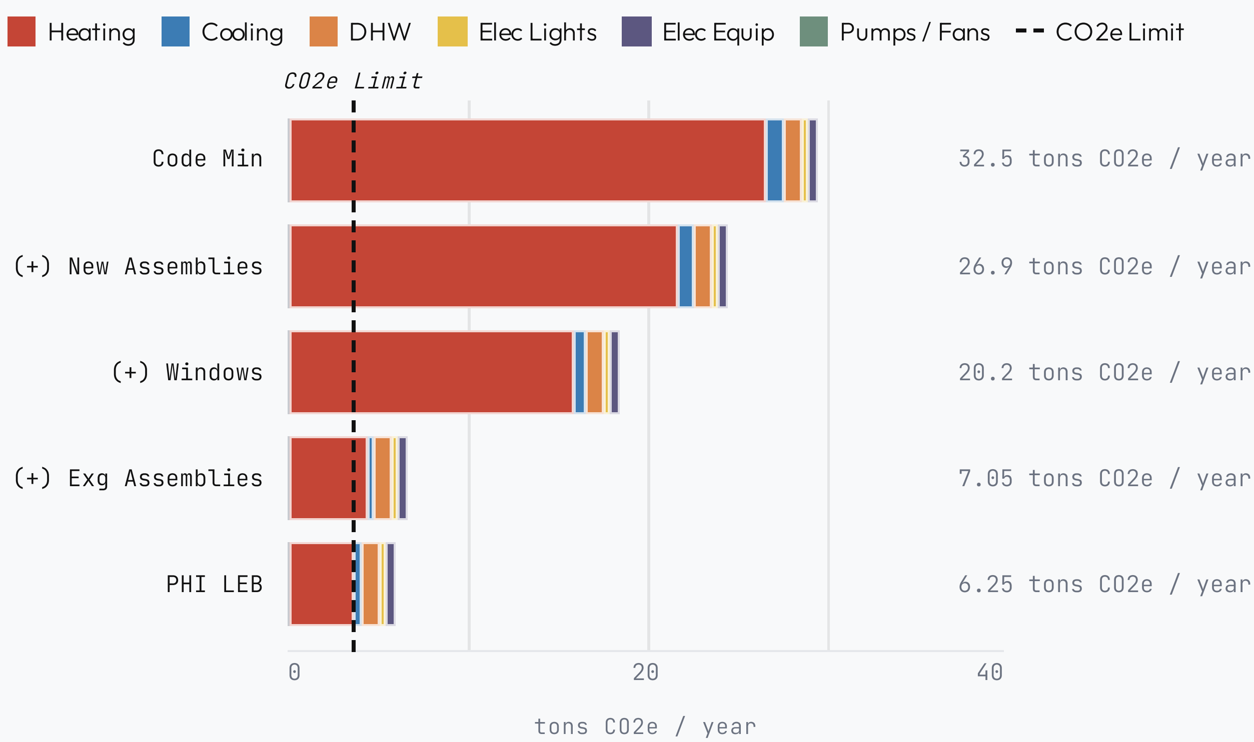
Based on the modeled source energy and fuel types for the various energy uses of the building we can approximate the average annual CO_{2e} emissions which will result. CO_{2e} emission totals shown below are those which result from fuel usage by the building for heating, cooling, hot-water and all other plug-loads. The total amount of CO_{2e} emitted as a result of each use-type depends on both the amount of fuel used as well as the type of fuel (gas, electricity, etc.). Although fuel-fired heating systems are permitted by Code, for this evaluation we have modeled all variants with electric-powered heat-pump systems only.

Output Emission Rates used are from the Subregion. For more information on these factors see the EPA eGRID Data Explorer. Source Energy Factors for all fuel types are taken from the EPA EnergyStar Portfolio Manager Technical Reference (2023).

While CO_{2e} emissions are calculated within the Passive House energy modeling software (PHPP), CO_{2e} is not one of the certification metrics for Passive House projects. The following is for informational purposes only.

Annual CO2e emissions due to operational energy consumption

Operational CO2e by modeled variant, in tons CO2e / year.



05

Passive House Thresholds

In order to evaluate a building's performance, total annual energy consumption is key, as shown above. However, in addition to this top line figure the 'Passive House' framework suggests that the building should also meet additional heating and cooling annual energy demand performance targets. It is also useful to compare the peak-heating and peak-cooling loads to the recommended limits for Passive House buildings. While these limits are not required for certification in all cases, it is still good practice to attempt to meet them where possible. Where the home fails to meet these targets is a clear indication that improvements are possible.

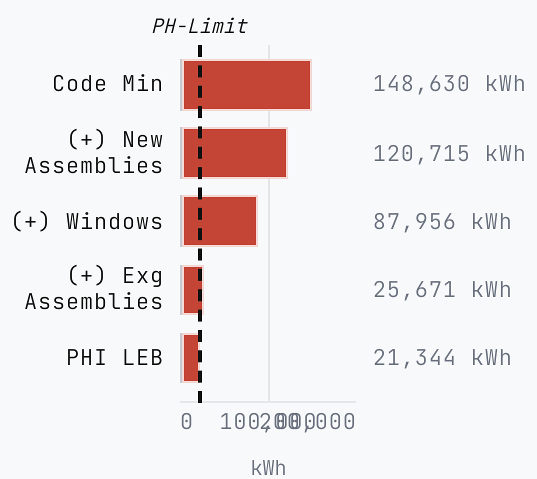
Shown below are results for these assessment metrics, for each of the tested variants.

Passive House thresholds

Modeled variants shown in PHPP order.

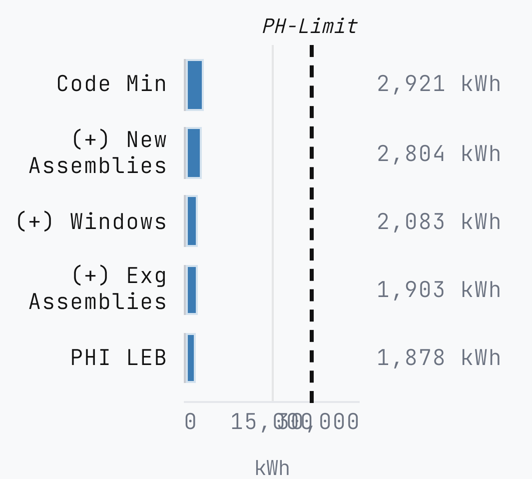
Annual Heating Energy Demand

Values in kWh.



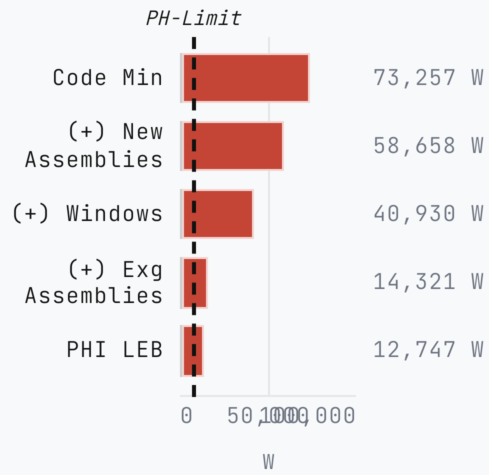
Annual Total Cooling Energy Demand

Values in kWh.



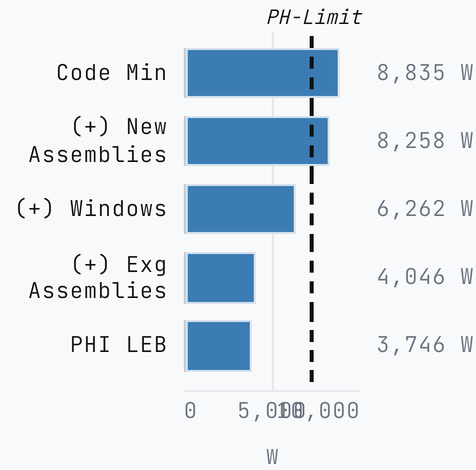
Peak Heating Load

Values in W.



Peak Sensible Cooling Load

Values in W.



06

Climate Data

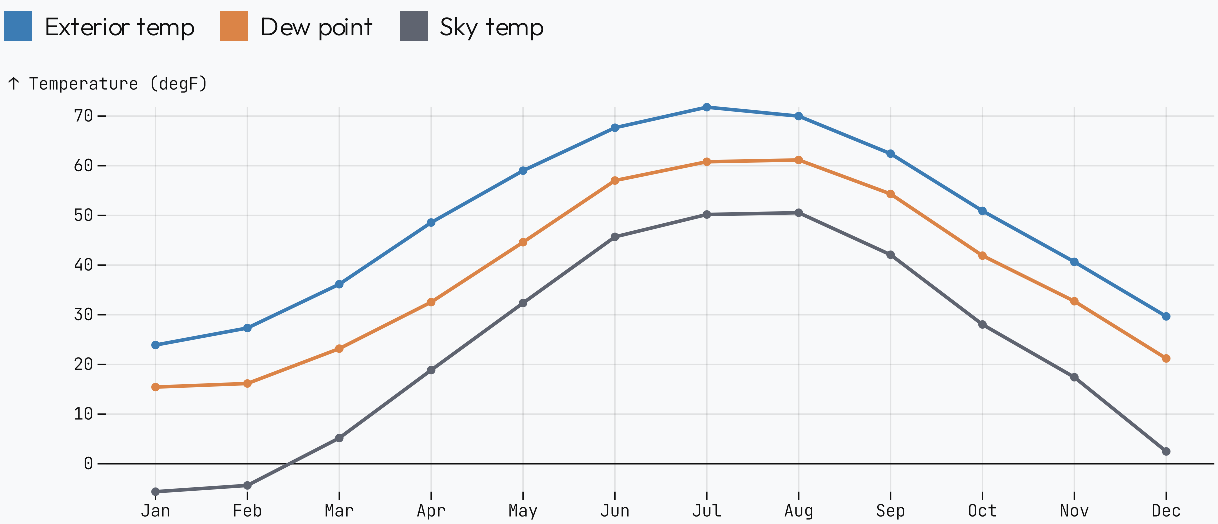
For all the modeled cases shown in the following sections, climate data from the nearest weather station was used.

-

The data from this climate set is illustrated here for reference purposes. It should be noted that for the Passive House energy models, monthly average climate data are used and therefore may appear different from the more typical ASHRAE hourly data shown in some other US Energy Modeling programs. The monthly data is all derived from the same sources (local weather stations) as the typical ASHRAE data however.

Monthly climate profile

Monthly PHPP climate temperatures, in degF.



07

Passive House Certifications

The following is for informational purposes only.

Passive House is a high-performance building standard focused on reducing heating, cooling, hot water, lighting, appliance, and source-energy use while improving comfort and enclosure durability.

PHI and Phius are separate certification systems. In this design-analysis report, these standards are used as reference targets for comparing model variants; actual certification requires the applicable certifier review, final documentation, construction QA, commissioning, and airtightness testing.

- PHI New Construction

- PHI Low Energy Building

- Phius CORE 2024

- Phius CORE Zero 2024

01

Recommended Assemblies

Below we have included recommendations for the building envelope assemblies based on the Energy model results shown in previous sections. These are recommendations only and should be reviewed by the design team to ensure they are appropriate for the project.

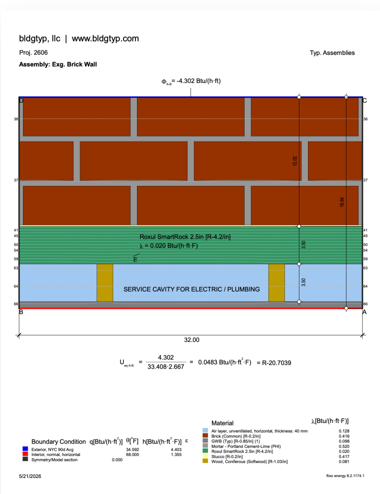
The following assembly U-values have been assessed using project-specific energy-model inputs and supporting thermal-bridge assumptions. Assembly diagrams should be treated as performance targets and coordination references, not final construction documents.

SmartRock Reference:

- How to Professionally Detail and Install ROCKWOOL Smartrock® Over Masonry Walls
- Attaching ROCKWOOL Smartrock insulation with TRUFAST® fasteners

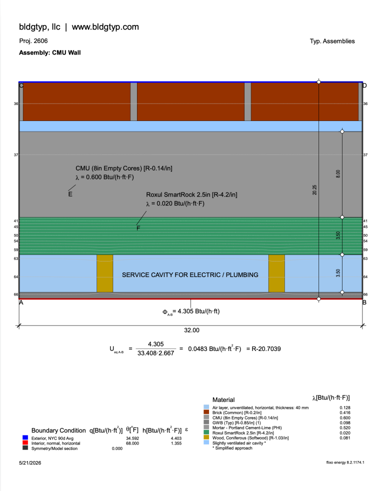
> STRUCTURAL COORDINATION
>
> All structural member sizing and spacing must be provided by the Structural Engineer and/or Architect. Sizing and spacing shown here is related to target insulation levels only.

Ext. Wall - Front



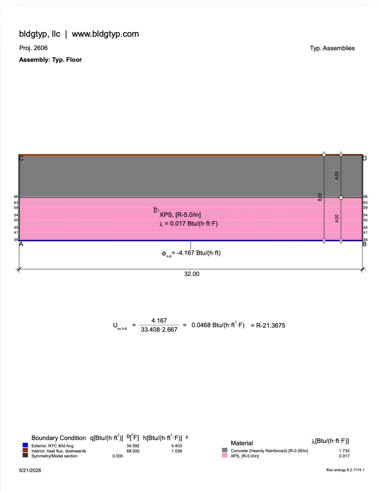
- Primary airtightness layer to be Pro-Clima Visconn or sim. liquid applied airseal applied to inside of face of existing masonry.
- 3-1/2" SmartRock mineral-fiber + Intello installed inside of existing masonry wall.
- 2x service cavity stud wall installed inside of SmartRock insulation layer.
- Use 'Service Cavity' on interior side for all plumbing and electrical. Reduce penetrations through the air-barrier to improve building airtightness.

Ext. Wall - Rear



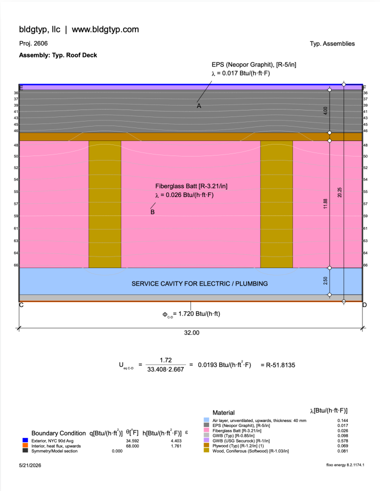
- Primary airtightness layer to be Pro-Clima Visconn or sim. liquid applied airseal applied to inside of face of new CMU wall.
- 3-1/2" SmartRock mineral-fiber + Intello installed inside of new CMU masonry wall.
- 2x service cavity stud wall installed inside of SmartRock insulation layer.
- Use 'Service Cavity' on interior side for all plumbing and electrical. Reduce penetrations through the air-barrier to improve building airtightness.

Floor



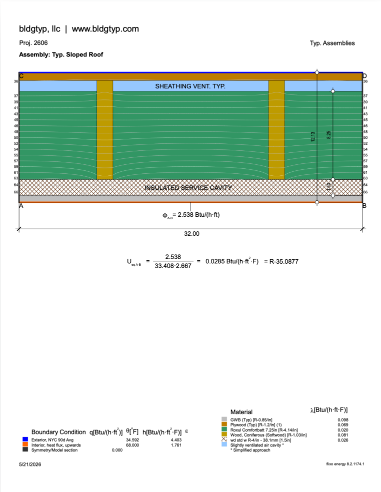
- Note: All concrete sizing as per Structural Engineer. Concrete is shown for illustration purposes only.
- Target. 6" sub-slab (Neopor Graphite EPS or sim.).
- Install foam insulation in 2 layers of 2", offset all board edges min 12", fill all voids with low-expansion spray foam.
- Sub-slab air and vapor barrier to be installed directly below concrete (above insulation). Use 15 Mil StegoHome or similar
- Tape / Seal all penetrations and seams of sub-slab air and vapor barrier with StegoTape / StegoMastic or similar.

Roof - Deck



- Install continuous insulation over wood-framed floor structure. Use min. 4” XPS foam insulation or sim.
- Use adhered insulation where possible (avoid metal fasteners)
- Primary air-barrier to be Intello Plus air and moisture vapor-retarder installed along underside of all roof joists. If preferred, substitute A/C plywood. Tape all seams to ensure air and moisture-vapor tight.
- Use service cavity / drop-ceiling below air/vapor retarder membrane for all plumbing, electrical, and / or lighting fixtures.
- Note: when constructing un-vented insulated rafter assemblies follow all code requirements as per Residential Code of NYS 2025 section 806.5
- If constructing the roof without venting, min R-20 insulation should be used above/outside the primary sheathing layer. R-20 can be achieved by:
- 5” EPS foam board
- 4” of GPS foam board
- 4” of XPS foam board
- 4” of Polyisocyanurate foam board.

Roof - Sloped



- Install mineral fiber batt insulation with sheathing-vent.
- Note: when constructing vented rafter assemblies follow all roof ventilation code requirements as per Residential Code of NYS 2025 section 806.1
- Primary air-barrier to be Intello Plus air and moisture vapor-retarder installed along underside of all roof joists. If preferred, substitute A/C plywood. Tape all seams to ensure air and moisture-vapor tight.
- Use service cavity / drop-ceiling below air/vapor retarder membrane for all plumbing, electrical, and / or lighting fixtures.
- In order to achieve sufficient assembly R-Value, insulate service cavity with mineral fiber batt insulation.

02

Building Airtightness

The primary role of airtightness in buildings is to avoid interstitial condensation and mold/moisture damage to the structure during the winter and shoulder-season months. Additionally, in hot climates, airtightness plays an important role in restricting warm outdoor air and moisture vapor ingress from the exterior. This helps reduce energy consumption needed for cooling and dehumidification while improving occupant comfort and building resiliency.

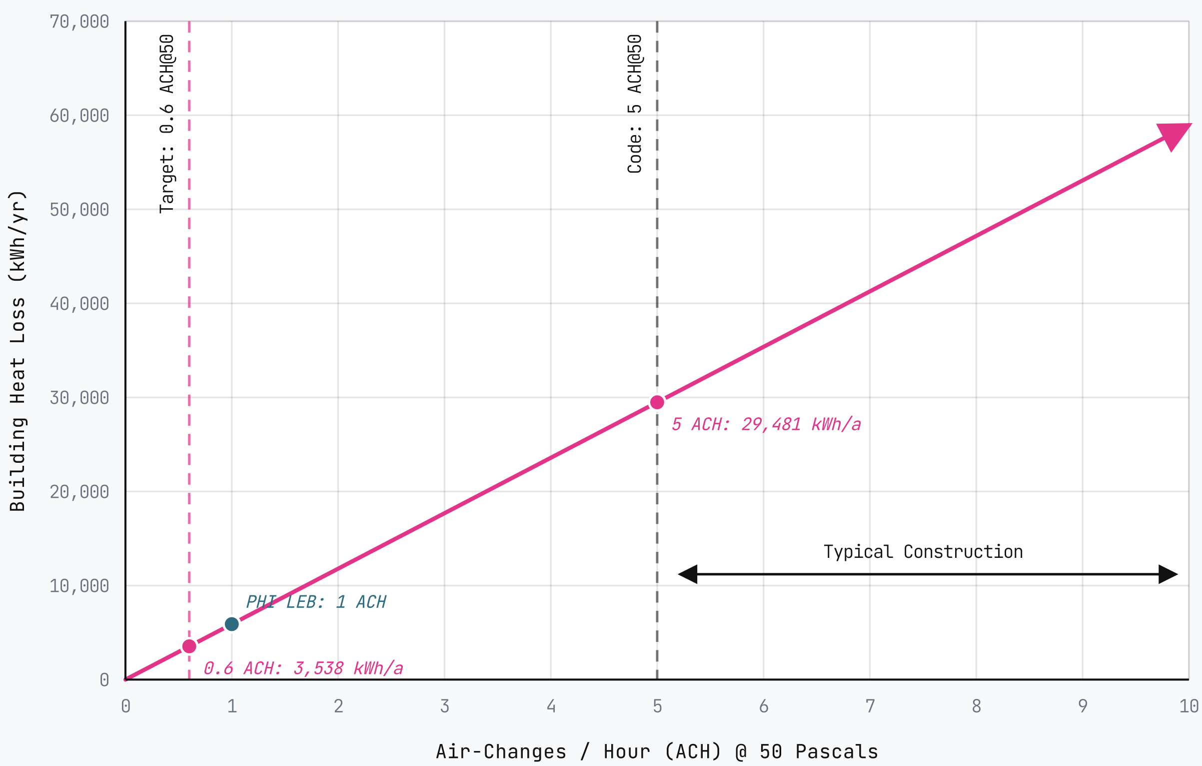
As well as its role in ensuring building durability, airtightness levels have a simple linear relationship to the building's heat loss: the more airtight the construction, the less heat is lost in winter and the better the energy performance. In addition, airtightness has a large effect on indoor relative humidity during the summer months with a corresponding reduction of cooling energy consumption and dehumidification need.

Code-minimum construction in most states requires an airtightness rate of somewhere between 3 to 7 air-changes per hour (ACH), and the / requires residential buildings in Climate Zones 3 to 8 to demonstrate an airtightness level of less than ACH@50Pa.

In order to meet the recommended building performance level, this project should target an airtightness level of better than **ACH@50Pa**. Improving airtightness to this low level is one of the best ways to improve performance, increase comfort and durability, and reduce the risk of uncontrolled wintertime air leakage.

Winter Heat Loss due to Envelope Air Leakage

PHI LEB shown across a range of blower-door results.

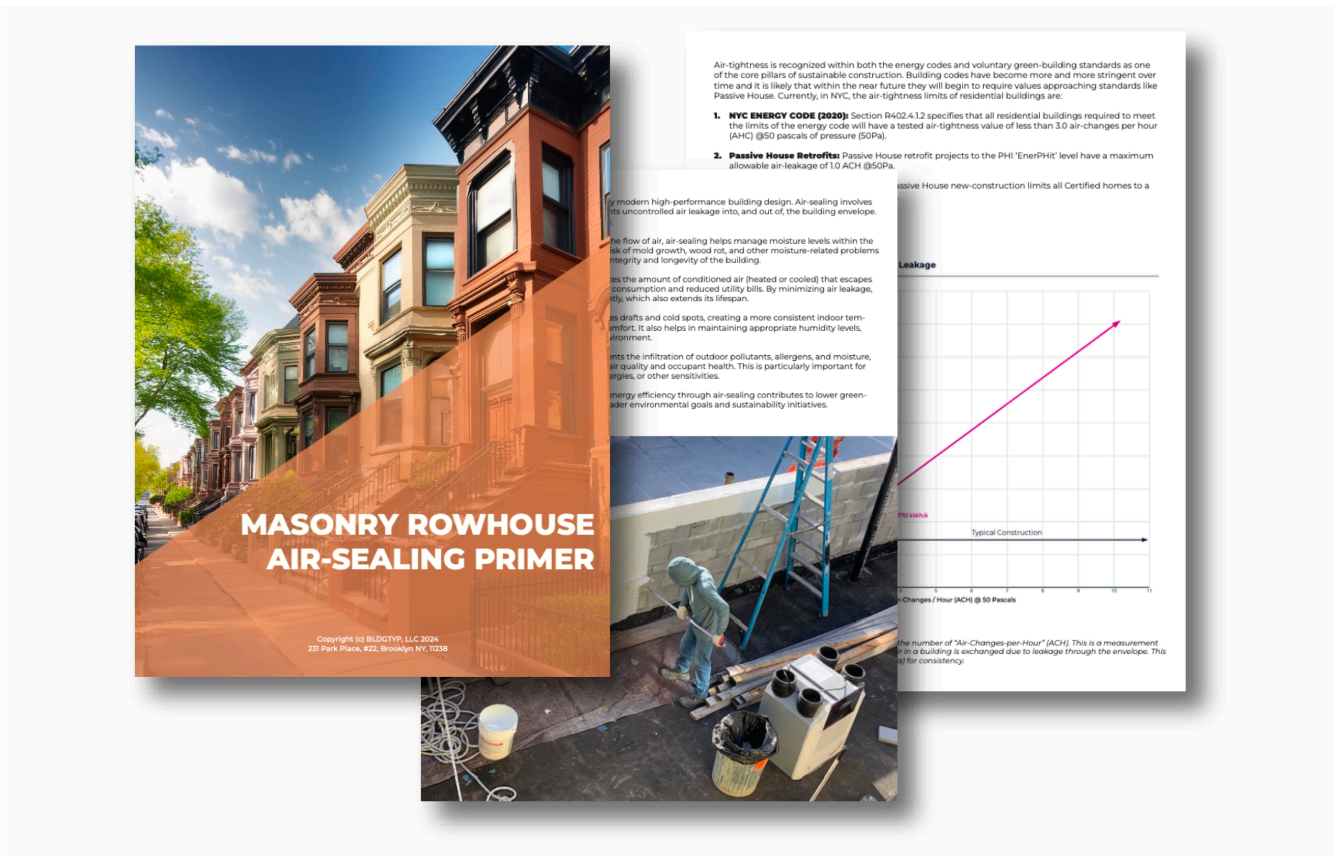


03

Masonry Rowhouse Air-Sealing Primer

BLDGTYP has prepared a comprehensive **Masonry Rowhouse Air-Sealing Primer** for masonry townhouse projects. The primer covers the value of air-sealing, common air-sealing methods for typical NYC masonry residential assemblies, recommended products, and testing strategies.

DOWNLOAD THE MASONRY ROWHOUSE AIR-SEALING PRIMER [12 MB]



04

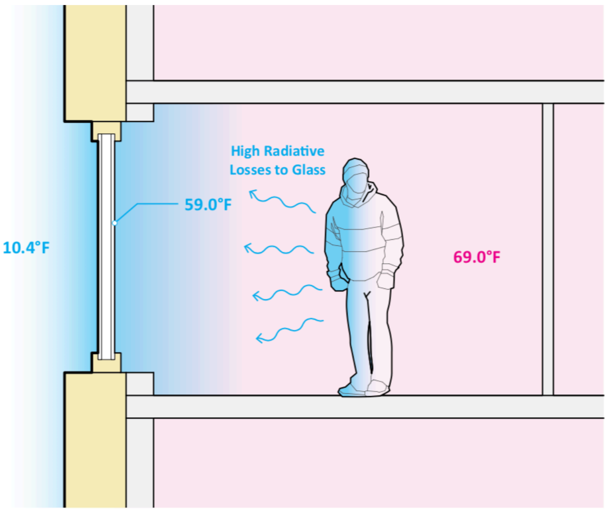
AeroBarrier

Achieving Passive House levels of airtightness in existing buildings can be challenging. The dedicated air barrier layers described above will provide excellent, durable airtightness. The goal should be to achieve Passive House airtightness levels with the dedicated air barrier systems described above. However, some areas may be inaccessible due to existing conditions or otherwise impractical to expose in order to accomplish perfect air sealing. In cases where air sealing results are uncertain, we recommend having a backup plan in place.

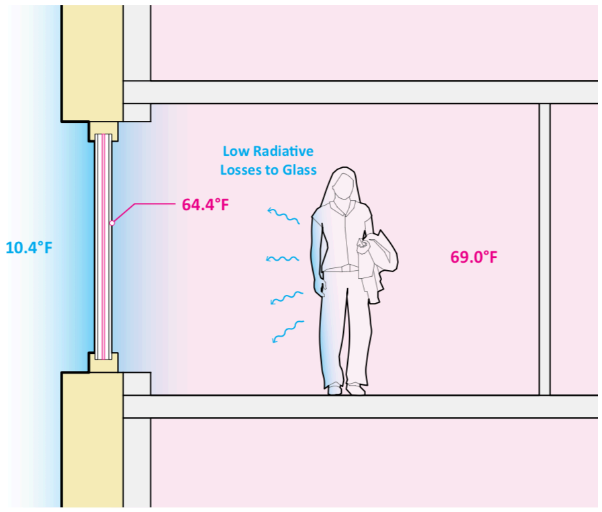
AeroBarrier provides whole-building air sealing using an aerosolized polymer that “finds” leaks and seals them. We recommend consulting early in the build with an AeroBarrier installer so that they can be included in the project schedule should their services be required.

01

Window Thermal Comfort



DOUBLE GLAZING = 10°F ASYMMETRY



TRIPLE GLAZING = < 5°F ASYMMETRY

In any high-performance building, both the energy and occupant comfort impacts of the glazing must be carefully assessed. For a building seeking any of the PHI or Phius certifications, a very stringent evaluation and quantification of this thermal comfort impact must be executed. This comfort evaluation looks at both the overall occupant comfort as a result of air-temperature and relative-humidity but also the localized thermal discomfort caused by cold-surfaces and drafts at the glazing surface.

In particular, the localized discomfort which results from a radiant temperature asymmetry (a difference in the temperature of the surfaces surrounding the body) must be assessed in order to evaluate the possibility of eliminating perimeter heating. If the radiant temperature asymmetry exceeds a certain level, a compensating heat source may be required in order to offset the potential discomfort. Typically, this would mean a radiator of some form, installed beneath the window.

Many engineering reference standards suggests that ideal thermal comfort is found when there are temperature differences of less than 7.6°F [4.2°K] between all the surfaces around a person's body. The windows are important in this respect, as this is where the coldest surface temperatures in the building will typically occur during the winter months.

For ’s winter comfort-design weather conditions [°F (°C)], Passive House certification guidelines for this climate would recommend that as long as windows with an Installed R-Value higher than hr-ft2-F/Btu [U-Value less than Btu/hr-ft2-F] are used this will lead to surface temperatures which PHI finds acceptable for thermal comfort. Note, for smaller windows with a lower ‘view-factor’ (less visible to the occupants) slightly lower R-Values may still achieve the desired thermal comfort targets.

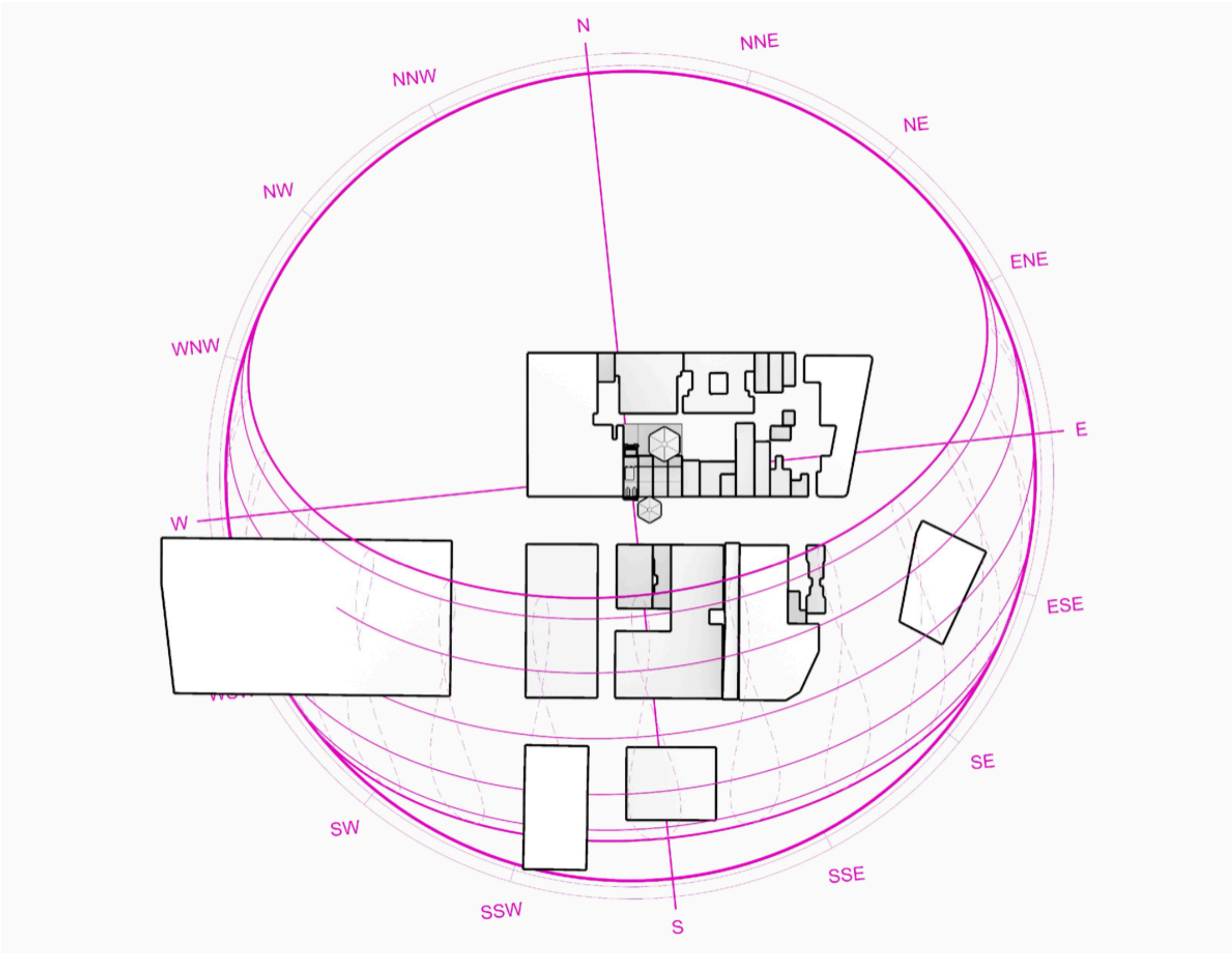
02

Site Shading

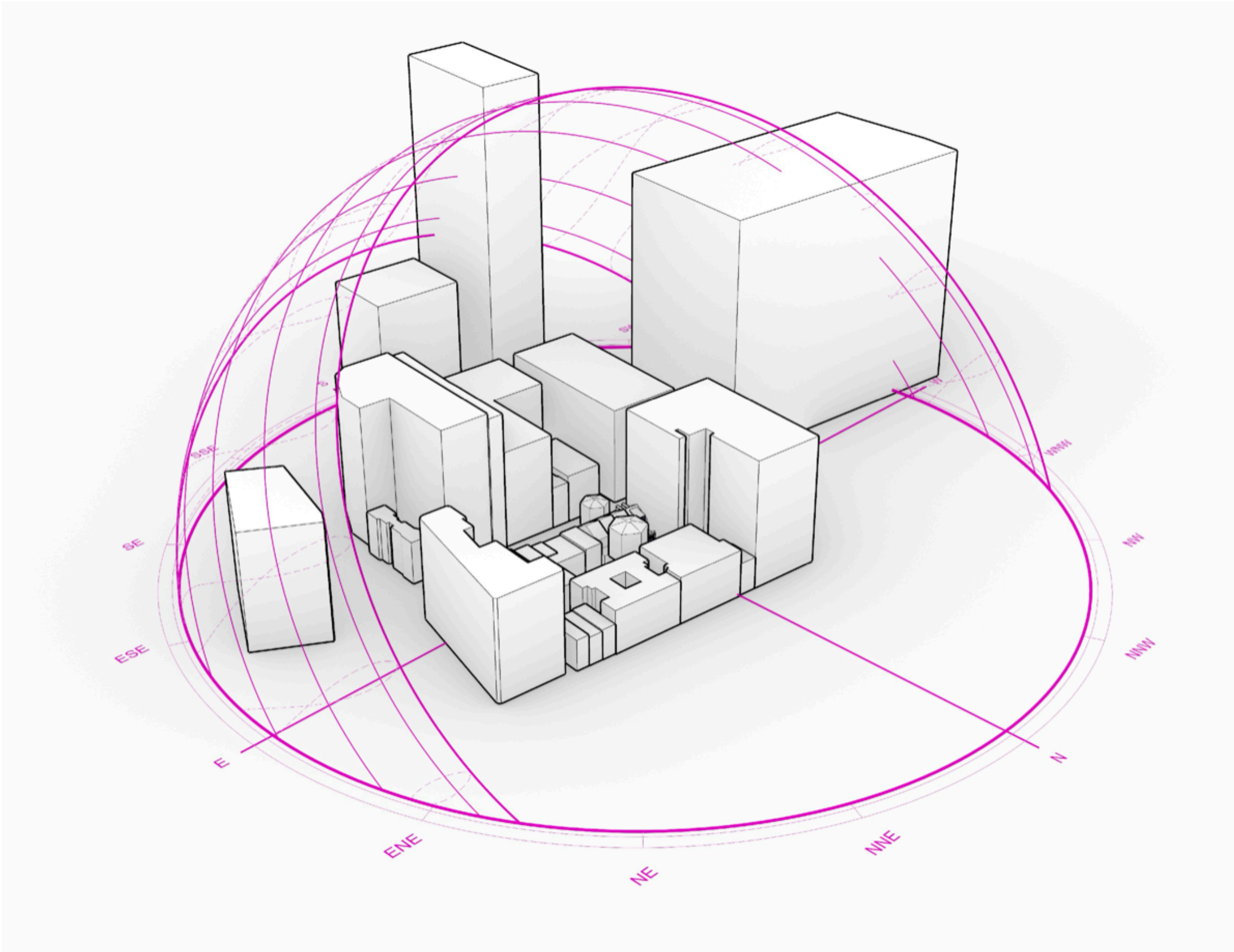
The energy balance of the windows is critical on any high-performance building project. The goal for this climate should be to take some advantage of wintertime solar gains in order to reduce overall heating energy need, while being extremely cautious about the potential for overheating and increasing cooling energy need. This can be particularly challenging with highly glazed rooms or space which feature large amounts of south or west facing glass.

All radiation values presented consider the local shading context. Where relevant, this context is created using satellite images from google maps and plot lines from OpenStreet Map and CadMapper. The site shading and orientation includes the following:

Orientation / Sun-Path Diagrams:



PLAN-VIEW SUN-PATH AND SITE-SHADING CONTEXT.



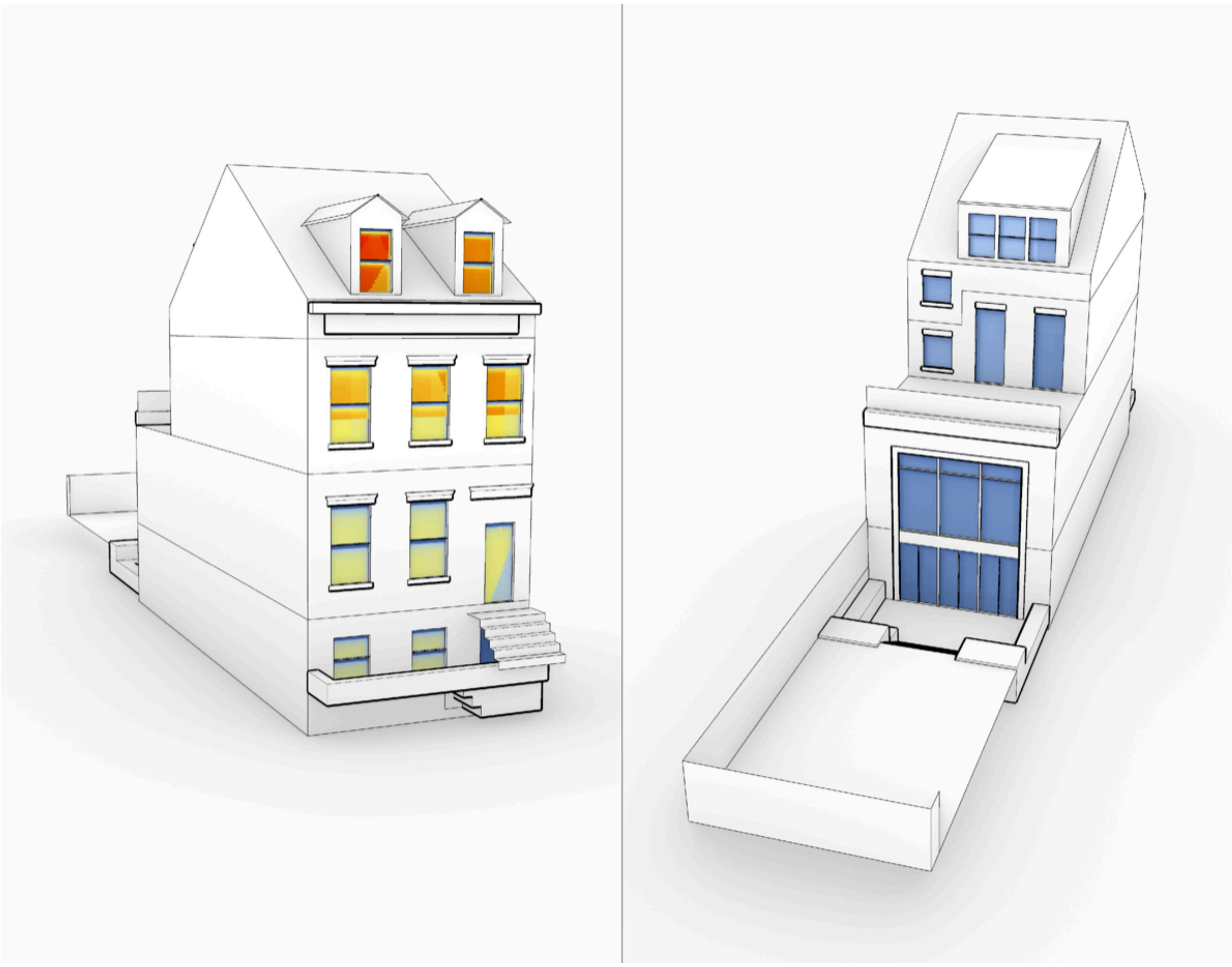
AXONOMETRIC SUN-PATH AND SITE-SHADING CONTEXT.

03

Winter Radiation

Taking into account the climate, orientation, and shading, in the results below we have assessed the average seasonal (winter / summer) solar radiation falling upon the windows in the project. The radiation levels will vary by orientation and as can be observed, shading obstructions also have a strong effect on the final level of solar radiation any individual window receives.

- Very good solar radiation is observed along the south facade which will help to reduce the wintertime heating energy need significantly.
- Very limited solar gain observed on all north side glazing. Given the large amount of glazing and the limited solar radiation, any small reduction in north-side glazing area (5% - 10%) would benefit the overall energy balance of the home.
- While the high levels of solar gain on the south do help reduce heating energy demand, it is possible that at some times this solar gain may be unwanted. It is recommended to ensure that all south-facing glazing, in particular the upper level windows in the dormers, are outfitted with robust user-operable blinds / shades to ensure against any thermal discomfort. While external shades are preferred, internal shades are a good option as well and can still help with glare and overheating issues.

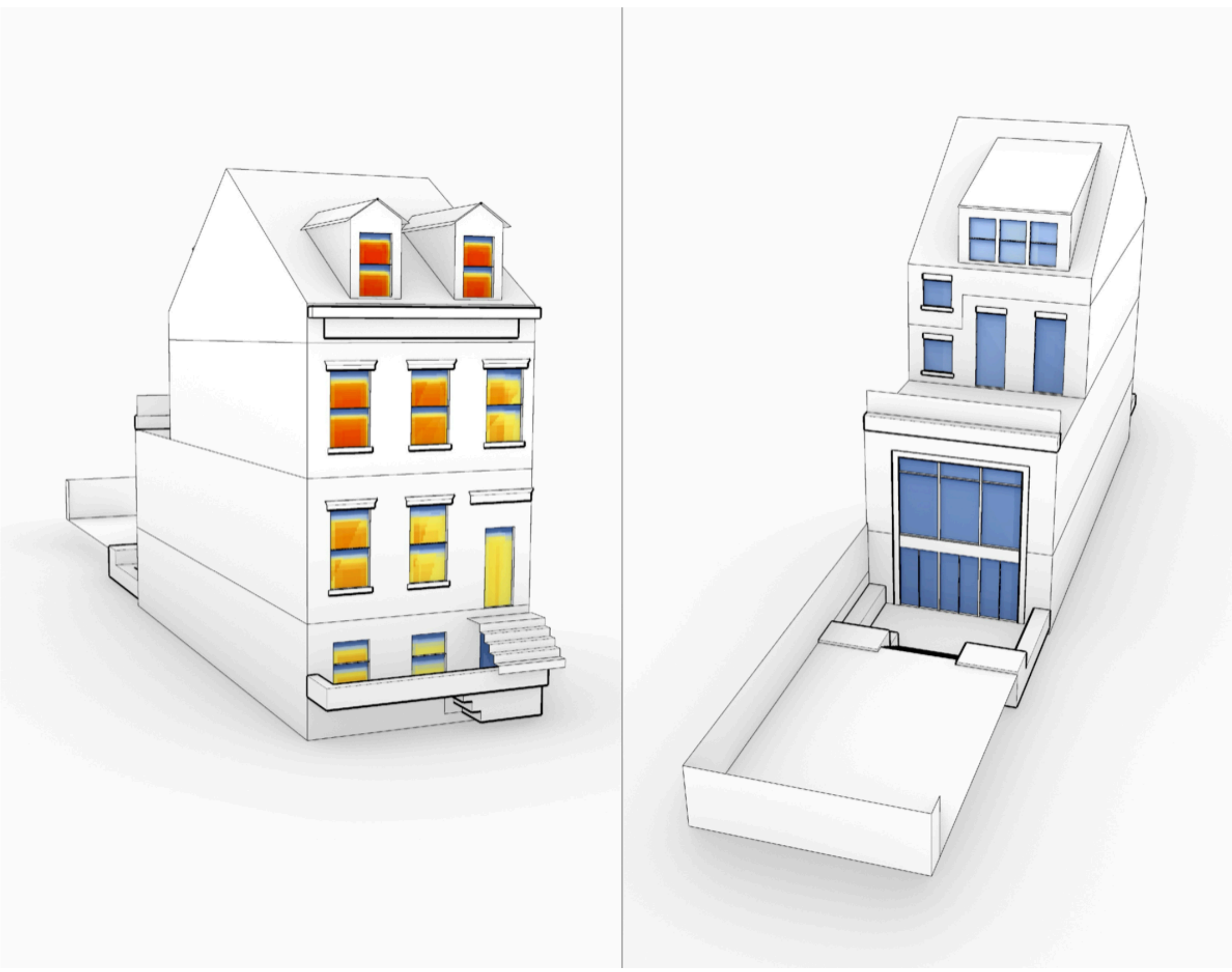


WINTER SOLAR RADIATION BY WINDOW ORIENTATION.

04

Summer Radiation

- Even taking into account the street trees, fairly high solar radiation is observed along the south facade's upper floors which will reduce thermal comfort.
- The most radiation is apparent on the upper floors, which receive the least amount of shading from the neighboring buildings or street trees.
- Coupled to the inevitable internal temperature stratification, this upper level solar radiation is the are most likely to see low thermal comfort in summer and early fall. It is recommended to prioritize shading for the dormer windows at minimum, and the top two floors if possible. Use robust user-operable interior blinds with high opacity and solar reflectance. Specify glazing with low SHGC (g-Value) for all south facing glazing.

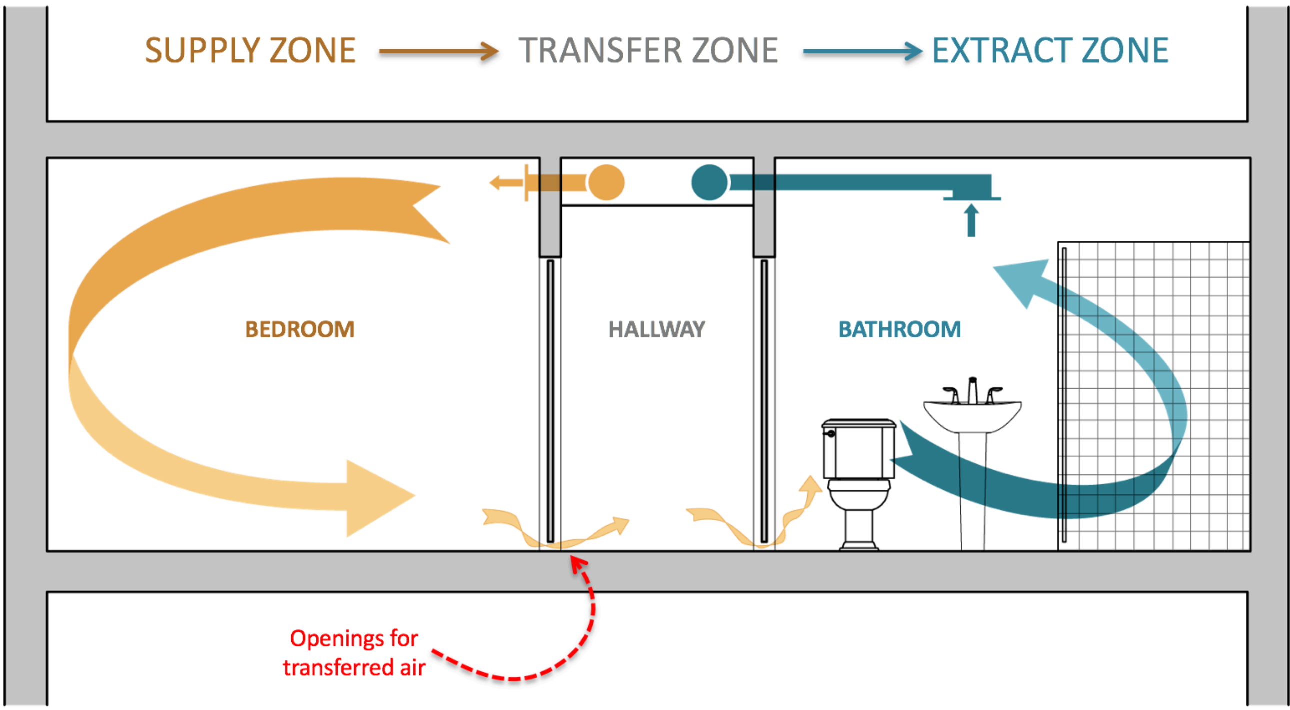


SUMMER SOLAR RADIATION BY WINDOW ORIENTATION.

01

Fresh-Air Ventilation

An airtight, low-energy building in this climate should include dedicated mechanical ventilation with heat recovery in order to deliver enough fresh air for good indoor air quality (IAQ) in all seasons.



It is important not to over-ventilate a building in winter. Otherwise, indoor air can become too dry, with associated health and comfort concerns. To reduce airflow rates while still maintaining good indoor air quality, we recommend a **Supply-Transfer-Extract** configuration rather than supplying and extracting from each individual room.

Supply air should be provided to bedrooms and living spaces, while extract air should be drawn from bathrooms, the kitchen, and any storage spaces. Transfer openings, such as door undercuts or transfer grilles, should be provided between supply and extract spaces.

This configuration reduces the potential for duct-borne sound transmission between spaces, ensures good mixing of fresh air, and reduces the size, complexity, and cost of the required ducting.

COORDINATION NOTE

It is critically important that the fresh-air ventilation system be installed so that it is completely independent of the heating and cooling system. There is no effective method of combining the fresh-air ducting with heating/cooling ducting, so planning should allocate sufficient space for both ducting systems.

02

Fresh-Air Flow Rates

The fresh-air system should be sized around the room-by-room supply, transfer, and extract strategy rather than around a single whole-building ventilation rate. The table below keeps the modeled airflow assumptions visible for design coordination and commissioning.

Room airflow schedule

This table lists room-level ventilation airflow values from the PHPP ventilation schedule.

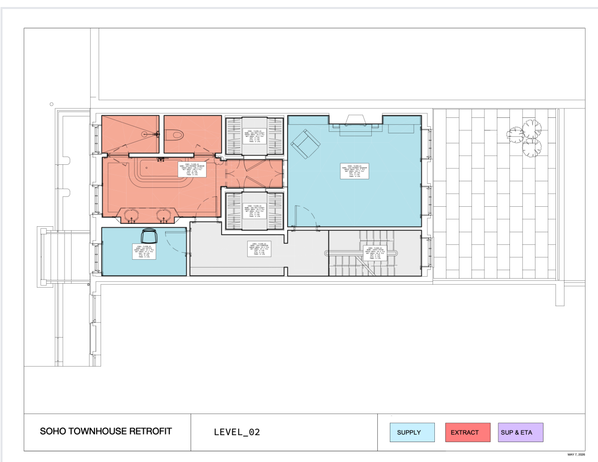
ROOM	AREA FT2	VOLUME FT3	SUPPLY HIGH CFM	EXTRACT HIGH CFM	SUPPLY MED CFM	EXTRACT MED CFM
001-EXISTING BASEMENT	1,352 ft2	11,091 ft3	0 cfm	24 cfm	0 cfm	18.5 cfm
002-CRAWLSPACE	438 ft2	1,723 ft3	0 cfm	0 cfm	0 cfm	0 cfm
003-CRAWLSPACE	1,441 ft2	5,675 ft3	24 cfm	0 cfm	18.5 cfm	0 cfm
100-STAIR	30.8 ft2	273 ft3	0 cfm	0 cfm	0 cfm	0 cfm
101-STAIR	8.35 ft2	74 ft3	0 cfm	0 cfm	0 cfm	0 cfm
102-HALL	24 ft2	213 ft3	0 cfm	0 cfm	0 cfm	0 cfm
103-LIBRARY	369 ft2	3,268 ft3	24 cfm	0 cfm	18.5 cfm	0 cfm
104-FOYER	136 ft2	1,206 ft3	12 cfm	0 cfm	9.24 cfm	0 cfm
105-GREAT ROOM	566 ft2	6,311 ft3	24 cfm	0 cfm	18.5 cfm	0 cfm
106-BATH 6	50 ft2	443 ft3	0 cfm	26 cfm	0 cfm	20 cfm

ROOM	AREA FT2	VOLUME FT3	SUPPLY HIGH CFM	EXTRACT HIGH CFM	SUPPLY MED CFM	EXTRACT MED CFM
107-KITCHEN	213 ft2	1,889 ft3	0 cfm	36 cfm	0 cfm	27.7 cfm
108-DINING/LOUNGE	442 ft2	3,919 ft3	20 cfm	0 cfm	15.4 cfm	0 cfm
109-LOWER GALLERY	307 ft2	2,719 ft3	24 cfm	0 cfm	18.5 cfm	0 cfm
110-SQUASH COURT	788 ft2	21,988 ft3	52 cfm	0 cfm	40 cfm	0 cfm
111-EQUIP STOR	46.6 ft2	413 ft3	0 cfm	12 cfm	0 cfm	9.24 cfm
112-LOCKERS	60.6 ft2	537 ft3	0 cfm	24 cfm	0 cfm	18.5 cfm
113-PWDR RM	35 ft2	310 ft3	0 cfm	26 cfm	0 cfm	20 cfm
114-LAUNDRY	50 ft2	443 ft3	0 cfm	24 cfm	0 cfm	18.5 cfm
Total	9,855 ft2	94,547 ft3	396 cfm	396 cfm	305 cfm	305 cfm

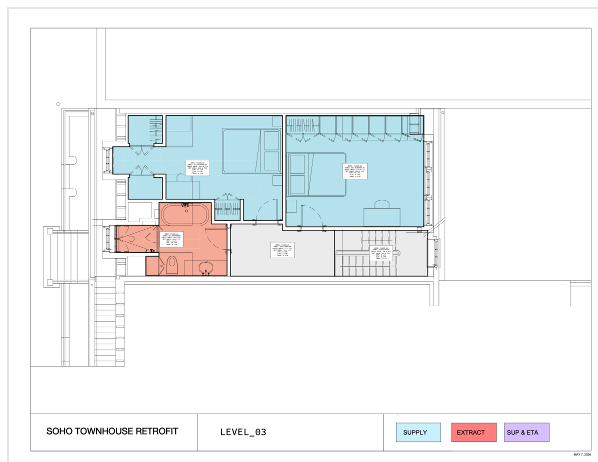
Level 00

Level 01

Level 02



Level 03



03

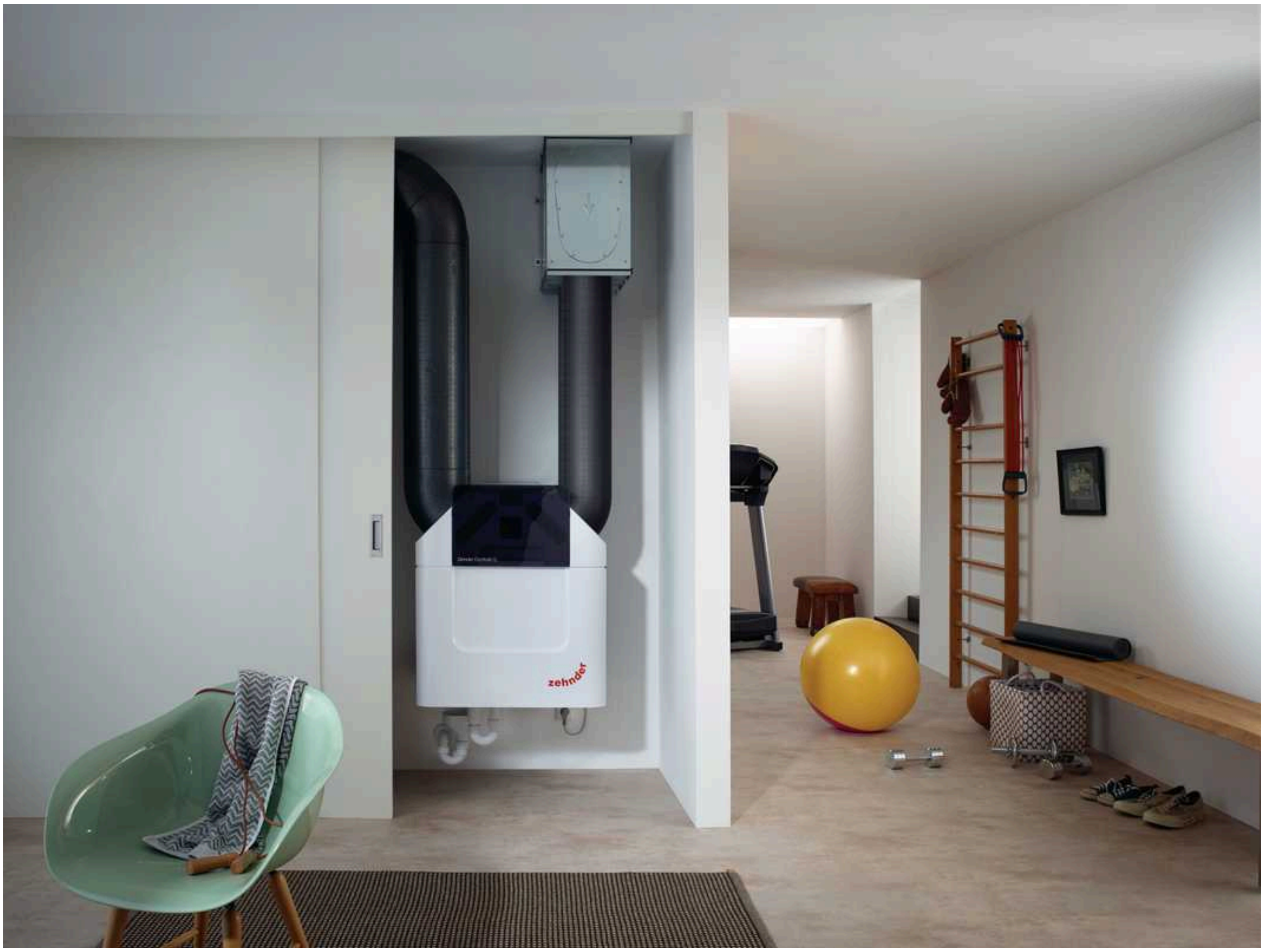
Ventilation System Balancing

For this building, we recommend that each unit have its own high-performance H/ERV with better than 75% heat recovery. The Zehnder America ComfoAir Q600 ERV would be a good selection and provide excellent indoor air quality while minimizing energy consumption and occupant comfort issues. These units are outfitted with excellent air filtration, MERV 13 by default, which will be critical to ensuring clean and healthy indoor air.

The values used in this analysis are assumed only. Zehnder America should be retained to fully design, specify, and balance the system after installation. This is critical for proper operation and required for all high-performance buildings. The balancing service will normally come standard with Zehnder America packages, but this should be verified in this case.

System balancing

Prior to occupancy, the fresh-air system should be tested and balanced to ensure good air mixing and adequate supply to all living spaces. The HRV vendor should provide this balancing as part of their services.


zehnder

04

Ventilation System Passive House Requirements

In addition to the modeled performance thresholds, in order to certify a building as a Passive House building, projects would have to comply with the following design requirements. Whether the project achieves full Passive House certification or not, the following design guidelines are recommended for all projects:

- Total measured fresh-air ventilation supply and exhaust airflows are within 10% of each other. Use the higher number as the basis of the percentage difference.
- All ventilation air inlets are located at least 10 ft. stretched-string distance from known contamination sources.
- All ventilation air inlets are located at least 5 ft. from ventilation exhaust outlets; 10 ft. is recommended.
- Ventilation air comes directly from outdoors, not from adjacent dwelling units, common spaces, garages, crawlspaces, or attics.
- Outside air passes through a minimum MERV 13 filter prior to distribution, the filter is changed at the end of construction, and the building is ventilated prior to occupancy.
- The outside-air filter is located to facilitate regular service by the occupant and/or building superintendent.
- An air-sealed Class 1 vapor retarder shall be installed over all air-permeable insulation, such as fiberglass duct wrap, on ventilation ducts connected to outside.
- Fresh-air outside-air supply to bedrooms is required in all dwelling units.
- Measured bathroom exhaust rates meet one of the following: at least 20 cfm continuous or 50 cfm intermittent.
- Measured kitchen exhaust rates meet one of the following: at least 25 cfm continuous, 100 cfm intermittent for range hoods, or 5 ACH based on kitchen volume.
- If kitchen exhaust is connected to an ERV/HRV, the register is at least 6 ft. from the cooktop, a MERV 3 or washable mesh filter is provided for trapping grease, and a recirculation hood is provided over the range.
- Total supply and exhaust are within 10% of each other.
- Net pressure across the envelope is no greater than +/-5 Pa.

05

Appliances and Venting

Kitchen venting

Kitchen venting should be provided at the lowest rate that satisfies regulations. For gas cooking, this flow rate will be specified by code. For electric cooking, limit exhaust hood airflow to 200-400 cfm maximum through the selection of an appropriately sized hood. The Home Ventilation Institute (HVI) specifies a minimum of 40 cfm and recommends 100 cfm per linear foot of range. For effective kitchen venting, sizing and placement of the hood can be more important than the air flow rate, as sizing and placement effect the capture efficiency of the hood. Hoods should be as low as practical, extend beyond the range by approximately six inches at the sides and be as deep as possible without interfering with use of the range.

Makeup air systems

In order to properly vent any exhaust air appliances (clothes dryers, kitchen hoods, etc..) in an air-tight home, a dedicated makeup air system may be necessary. This is especially true of homes with combustion appliances (e.g. wood stoves/fireplaces) located indoors. In this scenario, makeup air from an automatic makeup air fan is used to balance out the exhausted air.

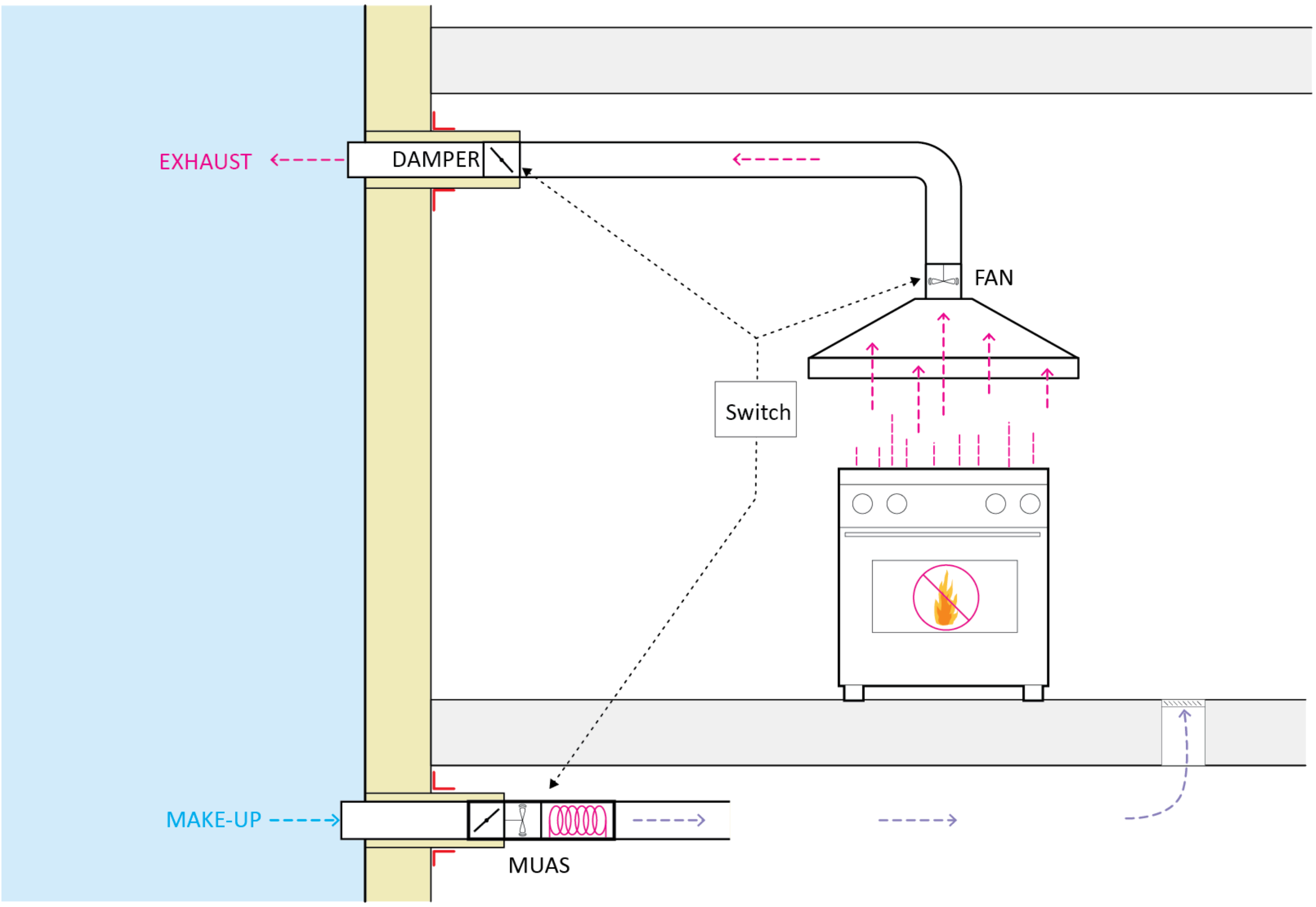
Note that for most cases we do NOT recommend this strategy as it is costly, complicated, and adds considerable complexity to the envelope construction (insulation, air-sealing) and represents a significant energy penalty to heat/cool the makeup air.

> Wherever possible, the use of all-electric systems should be considered, and combustion appliances should be installed only in outdoor locations (porches, decks, etc.).

Heating / Cooling of any outdoor makeup air may be needed once it enters the habitable space. Self-closing (magnetic) dampers should be included on all ducting to prevent air infiltration / exfiltration when the appliances are not in use. In order not to compromise occupant comfort when makeup air is being supplied to the home, a high output heating element will need to be sized and installed to heat the incoming volume of air to a comfortable temperature.

There are several good, self-modulating makeup air system (MUAS) and corresponding makeup air heater (MUAH) which could be a good fit for this project:

- Electro Industries
- Neptronic



Makeup air system commissioning

> Proper commissioning and continued maintenance of the makeup air system is critical to the safe operation of the home, particularly when combustion appliances are present.

Several things should be kept in mind when configuring such a system:

1. Ensure airtightness at all envelope penetrations. 2. All ducting insulated with vapor-closed insulation (min 2”) and vapor-closed tape all joints. 3. Provide no more than 60% of the make-up air at base of range/oven. 4. For Gas cooking, follow all local code requirements and manufacturer’s instructions.

06

Building Monitoring

Environmental monitoring

There are several systems available for monitoring temperature, RH, CO2, and other environmental conditions. We strongly recommend installing a system of some form in order to successfully commission the home and correct any issues with indoor comfort over the first year. Environmental monitoring systems are relatively low cost, and we recommend two possible systems: the **Wireless Sensor Tag** by Cao Gadgets LLC, and the **Netatmo** weather station. Both systems upload data to the internet over a wireless network and data can be accessed online. Note that this requires a wireless network to be in operation at the home at all times. Other monitoring systems are available from newer platforms such as **Ecobee**.

The Wireless Tag system is less costly, but cannot monitor CO2. For this reason, we would prefer the Netatmo system.

More information can be found at:

- Ecobee
- WirelessTag
- Netatmo

Energy monitoring

To really understand a home's energy use, a branch-circuit monitoring system is the way to go. Monitoring each electrical circuit, especially in the first months of a project's operation, can help identify systems that are working incorrectly and using more energy than they should. For projects with new electrical services, it makes sense to install a load center designed to do just that. A number of manufacturers offer load centers with integrated branch-circuit monitoring that can integrate with other smart controls, such as switching and dimming. Real-time and historical energy-use data are available through the product app.

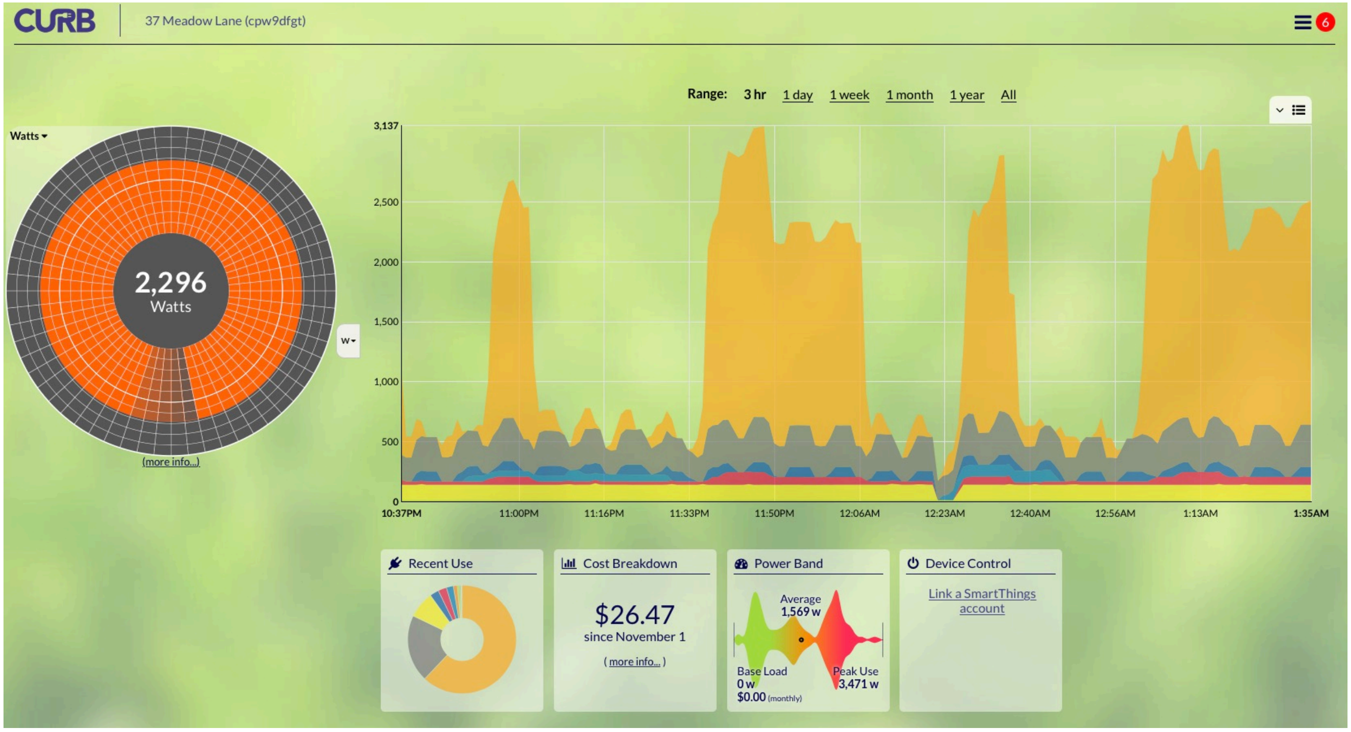
More information can be found at:

- Leviton
- Span

Other options are available for integration with more typical circuit breaker panels. Systems such as the Curb energy monitor, the Emporia Vue, and the eGauge provide customizable, real-time monitoring of electrical usage. The web/app-based interface displays detailed information about the home's energy usage and can help to fine-tune energy conservation measures.

More information can be found at:

- EnergyCurb
- Emporia Energy
- eGauge


CURB
37 Meadow Lane (cpw9dfgt)
Range: 3 hr 1 day 1 week 1 month 1 year All
Watts
2,296
Watts
(more info...)
3,137
2,500
2,000
1,500
1,000
500
0
10:37PM
11:00PM
11:16PM
11:33PM
11:50PM
12:06AM
12:23AM
12:40AM
12:56AM
1:13AM
1:35AM
Recent Use
Cost Breakdown
$26.47
since November 1
(more info...)
Power Band
Average
1,569 w
Base Load
0 w
$0.00 (monthly)
Peak Use
3,471 w
Device Control
Link a SmartThings account