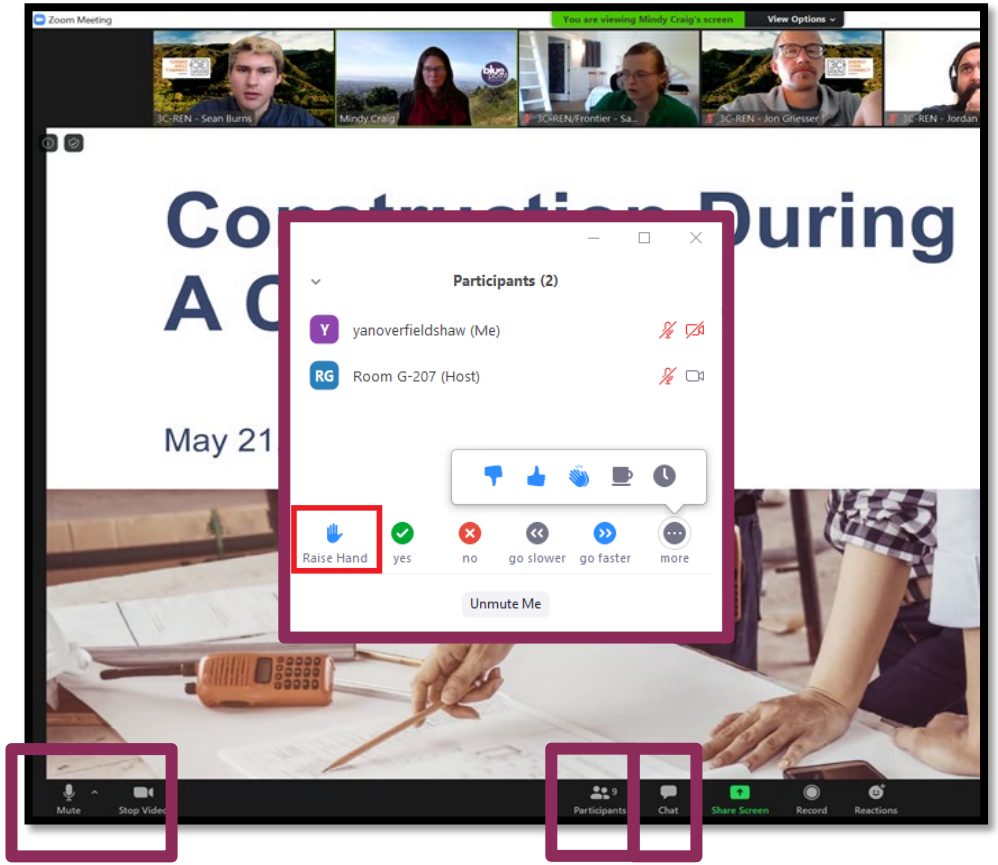
Zero Emissions Multifamily Passive House

Ken Levenson, Executive Director, The Passive House Network

October 22, 2024

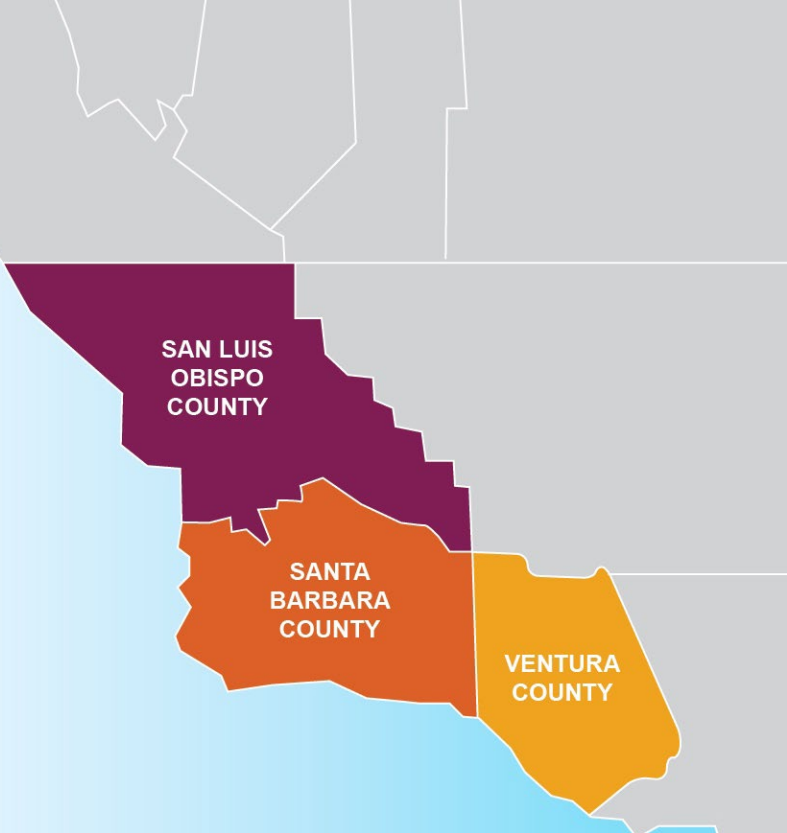
Zoom Orientation

- Please be sure your full name is displayed
- Please mute upon joining
- Use "Chat“ box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be recorded and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region



3C REN ENERGY CODE CONNECT

3C REN BUILDING PERFORMANCE TRAINING

3C REN HOME ENERGY SAVINGS

3C REN ENERGY CODE CONNECT

- Serves all building professionals
- Three services –
  - **Energy Code Coach**
  - **Training and Support**
  - **Regional Forums**
- Makes the Energy Code easy to follow

Energy Code Coach:
3c-ren.org/codes
805.781.1201

Event Registration:
3c-ren.org/events

BUILDING PERFORMANCE TRAINING

- Serves current and prospective building professionals
- Expert instruction:
  - **Technical skills**
  - **Soft skills**
- Helps workers to thrive in an evolving industry

Event Registration:
3c-ren.org/events

3C REN HOME ENERGY SAVINGS

Multifamily (5+ units)

- No cost technical assistance
- Rebates up to $750/apartment plus additional rebates for specialty measures like heat pumps

Single Family (up to 4 units)

- Sign up to participate!
- Get paid for the metered energy savings of your customers

Enrollment:
3C-REN.org/contractor-participation

Zero Emissions Multifamily
Passive House

Sendero Verde, Handel Architects

The Network

Global Knowledge. Regional Context. Local Applications

The Passive House Network





















Passive House Seattle
The Passive House Network

Passive House Rocky Mountains
The Passive House Network

Passive House Minnesota
The Passive House Network

Passive House Pennsylvania
The Passive House Network

Passive House Washington DC
The Passive House Network

New Jersey Passive House
The Passive House Network

Passive House Empire State
The Passive House Network

Passive House Northeast
The Passive House Network

PHCA Passive House California

North American Certifiers Circle
Passive House Certifier

International Passive House Association
iPHA

Passive House Institute

Designer
Certified Passive House Designer

Certified Passive House Tradesperson
Tradesperson

Certified Passive House
Passive House Institute

This course is an in-depth look at basic strategies for delivering successful all-electric decarbonized Passive House apartment buildings that teams want to build, and families want to live in. As we push to all-electric decarbonized multifamily buildings, designing to the Passive House Standard offers many benefits to building owners and occupants alike, from lower operating costs to greater durability, occupant comfort, indoor air quality, and storm resilience.

From theory to practice and completed projects, thiscourse will dive into all-electric multifamily design and construction as a Passive House process, producing affordable, high-quality results.

Areas covered will include: Planning Milestones, Efficient Multifamily Design, Ventilation, Glazing and Shading, Wall Assemblies, Thermal Bridges, Cooling, heating & hot water, Electrification, and Building Certification.

Special Recognition to Monte Paulsen and his Estate. Before Monte passed away in the summer of 2024, he provided the foundation for PHN's work on multifamily Passive House. He is greatly missed.

Learning Objectives:

1. Describe the 5 principles of Passive House.
2. Outline design and construction milestones for Passive House multifamily building.
3. Describe approaches to efficient multifamily design.
4. Outline key Passive House components in multifamily buildings and design integration and optimization examples.
5. Describe mechanical ventilation, heating/cooling, and hot water systems approaches used in Passive House multifamily.
6. Outline strategies for a smooth building certification process.

Instructor:
Ken Levenson, Executive Director, The Passive House Network.
Ken was a practicing architect for over three decades, completing early Passive House projects in New York City. Committed to accelerating Passive House growth and knowledge sharing, he co-founded 475 High Performance Building Supply, was a founding member of the Phius Passive House Alliance, a co-founder of New York Passive House and of NAPHN, which would become The Passive House Network (PHN). Today, as Executive Director of PHN, Ken continues to focus on driving building industry culture change with Passive House education.

Agenda

The Passive House Network

1. Context
2. Milestones
3. Efficient Multifamily Design
4. Ventilation
5. Exterior Shading & Sensible Glazing
6. “Thick” Walls
7. Thermal Bridges
8. Cooling, Heating & Hot Water
9. Electrification
10. Drama Free Certification


Waring School, Massachusetts, Opal Architecture

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Zero Emissions Buildings & Zero Net Energy

The Passive House Network

Title 24 is to move California to zero net energy (ZNE).

California Public Utilities Commission NZE building definition:

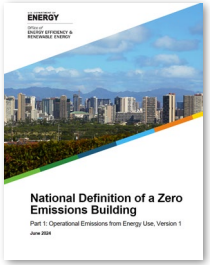
- An energy-efficient building where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy.

https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/zero-net-energy

In 2024 the US Department of Energy released a formal definition of what a zero emissions building is.

It's consists of three characteristics:

1. It must be very energy efficient.
2. It must not have any onsite emissions from energy use.
3. It must be powered only from renewables.



https://www.energy.gov/sites/default/files/2024-06/bto-national-definition-060524.pdf

Shift Focus: Analysis to fit our all renewable future

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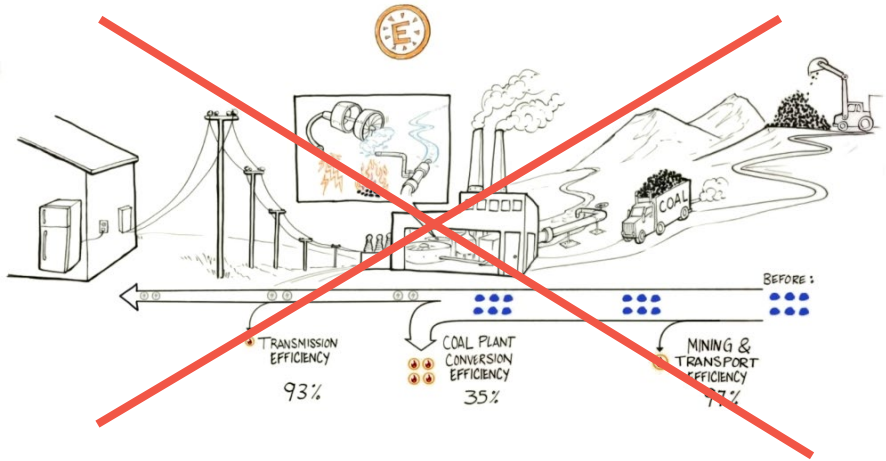
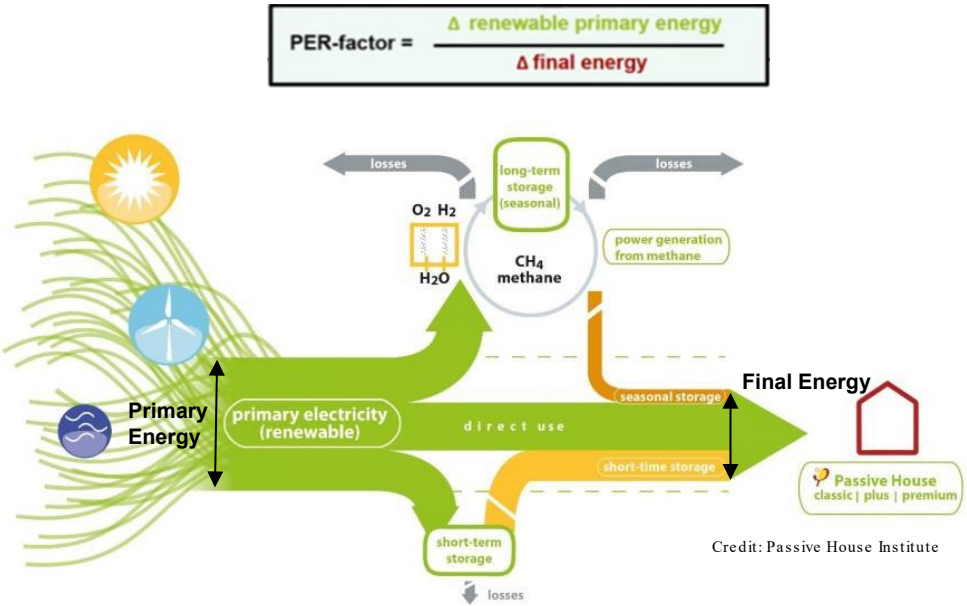
Passive House jettisons the anachronistic emissions analysis and looks at renewable production & utilization.



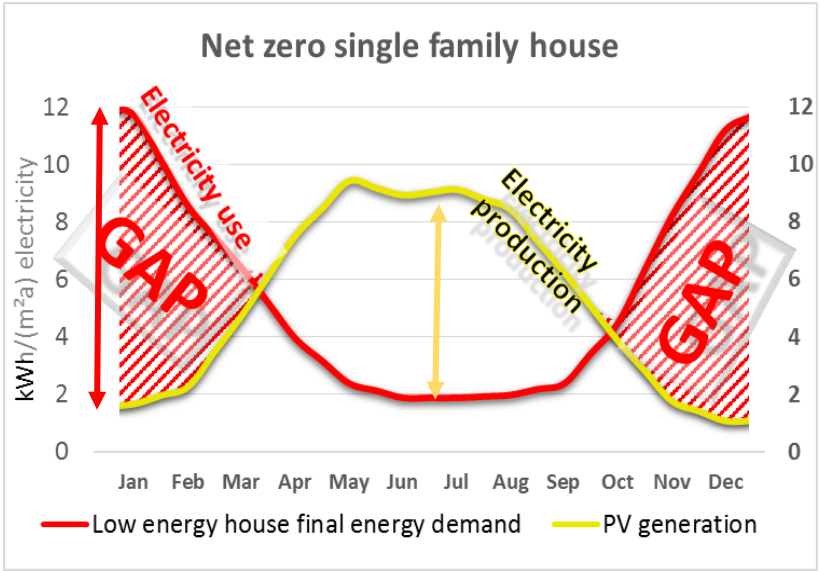


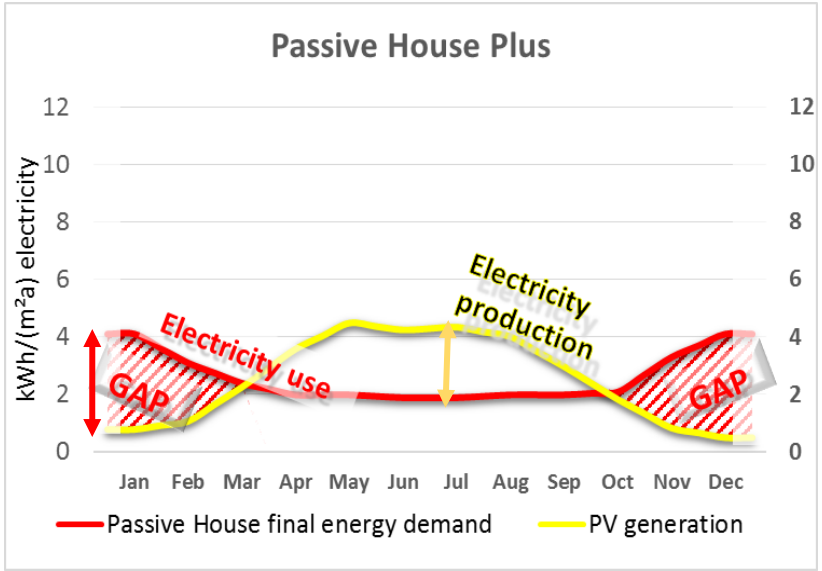
Credit: Passive House Institute

Credit: Bronwyn Barry/PassiveHouseBB

Mismatch in time of use: Reduce Energy Demand & Gap

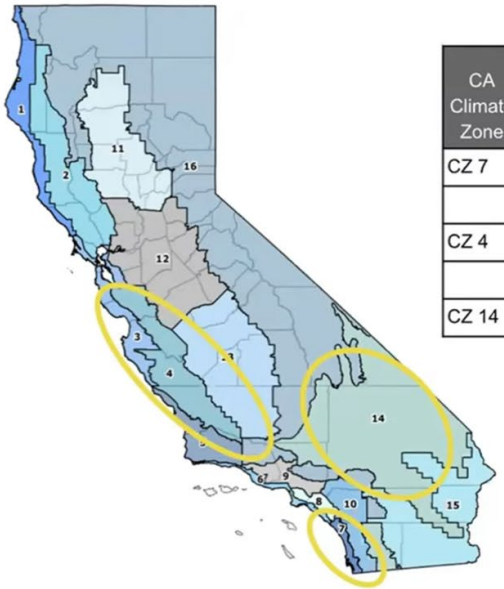
The Passive House Network





Credit: Passive House Institute

Reducing the demand in California



2020 CA Building Climate Zones Map
Source: https://gis.data.ca.gov/documents/CAEnergy::building-climate-zones/explore

CA Climate Zone	Energy use per kWh				HVAC Energy use (kWh)		
	T24	PHI	% Reduction		T24	PHI	% Reduction
CZ 7	5,364	4,864	9%		3,053	2,553	16%
CZ 4	8,210	6,201	24%		5,899	3,890	34%
CZ 14	9,882	5,125	48%		7,570	2,814	63%

Source: PHN study for CPUC - April 2023

Passive House 'Classic' *is*
CRUSHING heating & cooling loads in California in 2023!

Credit: Bronwyn Barry/PassiveHouseBB

Realization: efficiency underlies what we value most.

The Passive House Network

- Comfort
- Zero Emissions
- Healthy
- Cost Effective
- Resilience
- Safety
- Sustainable
- Lower Risk
- Beauty
  - Passive House

Vermont Artists Lodging, Ryall Sheridan Architects

Universal wants…Fundamental performance

Multifamily construction is complicated!

The Passive House Network

So many demands:

- Structural
- MEP
- Life safety
- Environmental
- Worker safety
- Framing
- Finishes
- Sequencing
- Budgets
- Other certifications!
- etc…

It’s easy to get lost. Passive House helps keep you focused.

Works with Other Standards but Stay Focused on Passive House

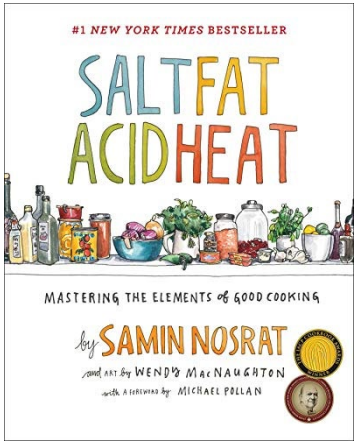
Winthrop Center, Boston

Certifications: Passive House, LEED Platinum, Well

How we use fundamental elements matters

The Passive House Network

"I was working as a physicist. I read that the construction industry had experimented with adding insulation to new buildings and that energy consumption had failed to reduce. This offended me – it was counter to the basic laws of physics. I knew that they must be doing something wrong. So I made it my mission to find out what, and to establish what was needed to do it right."
- Wolfgang Feist



Passive House uniquely masters the elements of high -performance building.

Criteria Goals: Hygiene, Comfort, Efficiency

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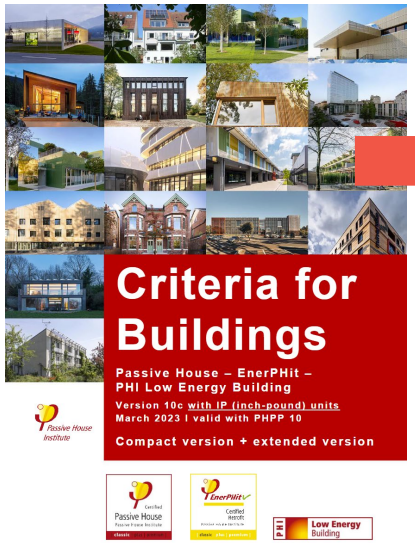
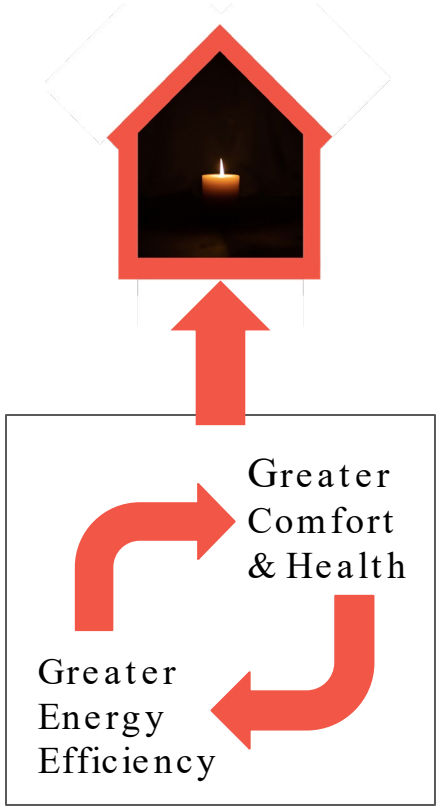


1. Occupant **Health**
2. Thermal **Comfort**
3. Energy **Efficient**
4. **Durable**
5. **Affordable**



5 Principles

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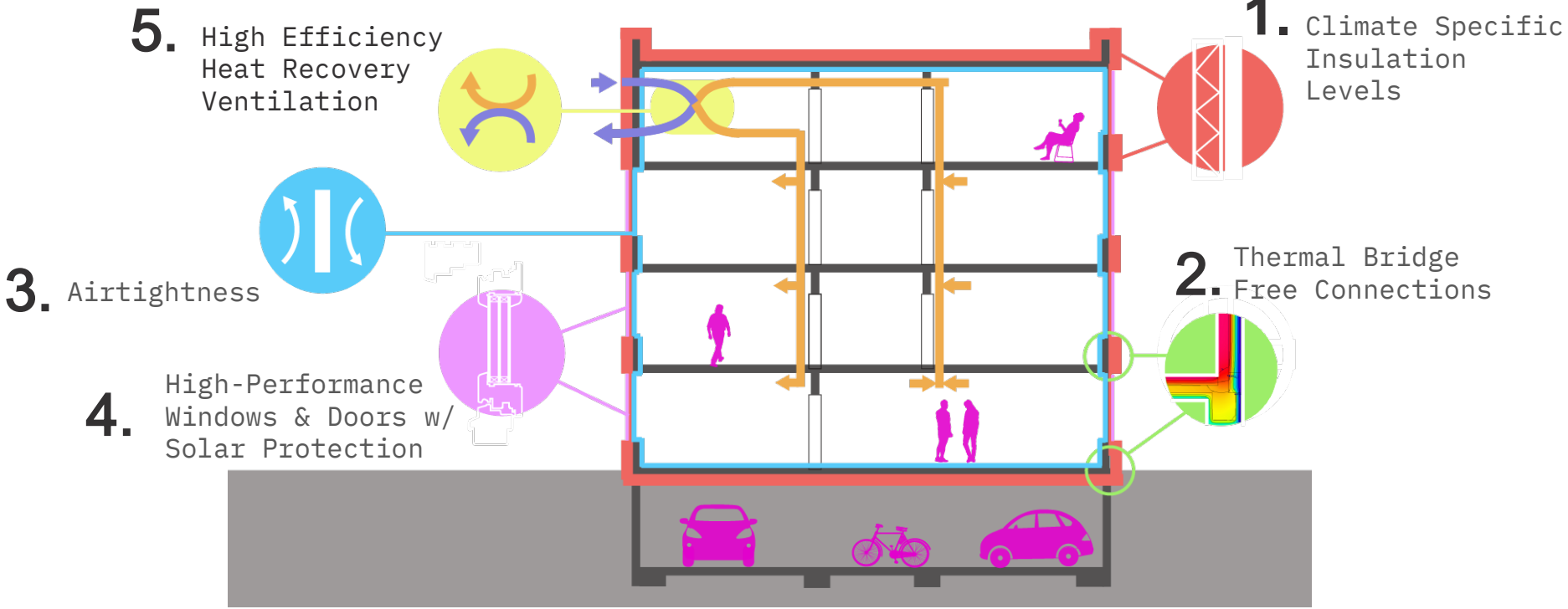


https://passipedia.org/basics/what_is_a_passive_house

Energy Modeling: Calculating Predictable Performance

The Passive House Network

https://passivehouse.com/04_phpp/04_phpp.htm

Window area orientation (main orientations)	Global radiation	Shading	Dirt	Non-vertical radiation incidence	Glazing fraction	SHGC	Solar irradiation reduction factor
Standard values →	kWh/(ft²yr)	0.75	0.95	0.85			
North	14	0.56	0.95	0.85	0.58	0.50	0.26
East	33	0.79	0.95	0.85	0.63	0.50	0.40
South	62	0.81	0.95	0.85	0.74	0.50	0.49
West	34	0.81	0.95	0.85	0.63	0.50	0.41
Horizontal	53	1.00	0.95	0.85	0.00	0.00	0.00
Total or average value for all windows.						0.50	0.43

Heating degree hours [°F.day/yr]: 7440

Go to glazing list | Go to window frames list

Qua n-tity	Description	Deviation from north	Angle of inclination from the horizontal	Orien- tation	Window rough ope Width	Height	Installed in	Glazing	Frame	g-Value	U-Value Glazing	Frames (avg.)	Ψ Glazing edge (Avg.)	Installation si left	right	bottom
		°	°		ft	ft		1-Sorting: LIKE LIST	Sort: AS LIST	-	BTU/hr.ft².F	BTU/hr.ft².F	BTU/hr.ft².F			
1	W104	90	90	East	3.00	4.86	4-Wall_9351_E	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W107	90	90	East	3.00	4.85	4-Wall_9351_E	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W106	90	90	East	3.00	4.85	4-Wall_9351_E	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W105	90	90	East	3.00	4.85	4-Wall_9351_E	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	D125	90	90	East	3.00	6.67	4-Wall_9351_E	01ud-Triple-insulated-Kr08	03ud ADS75 Door	0.50	0.11	0.32	0.029	1	1	1
1	W155	90	90	East	3.00	4.06	4-Wall_9351_E	01ud-Triple-insulated-Kr08	01ud Sil82+Fixed	0.50	0.11	0.19	0.018	1	1	1
1	W135	270	90	West	2.33	3.50	5-Wall_9544_W	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W134	270	90	West	3.00	4.85	5-Wall_9544_W	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W133	270	90	West	3.00	4.85	5-Wall_9544_W	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W132	270	90	West	3.00	4.85	5-Wall_9544_W	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W156	270	90	West	3.00	4.06	5-Wall_9544_W	01ud-Triple-insulated-Kr08	01ud Sil82+Fixed	0.50	0.11	0.19	0.018	1	1	1
1	W140	0	90	North	2.33	2.33	6-Wall_9368_N	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1
1	W139	0	90	North	2.33	3.50	6-Wall_9368_N	01ud-Triple-insulated-Kr08	02ud Sil82+Operable	0.50	0.11	0.19	0.018	1	1	1

Compelling Logic of Passive House

The Passive House Network

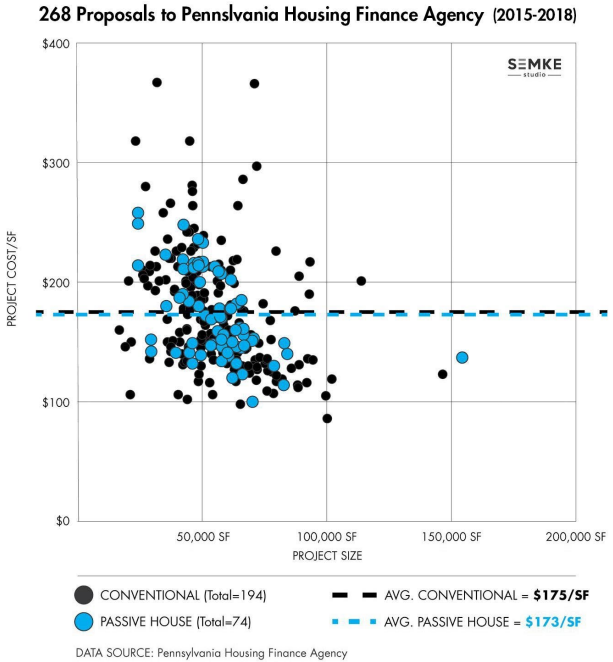
Building industry is disconnected from the drivers of building performance.

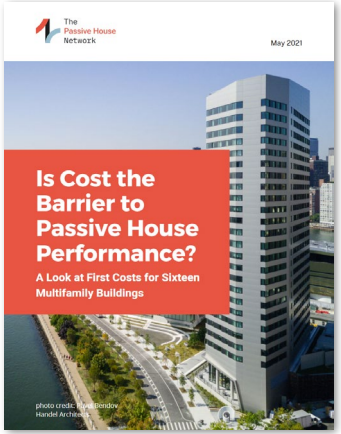
Passive House connects the dots and transforms industry expectations & capacity

Passive House empowers the builders and designers to deliver high-performance core solutions.

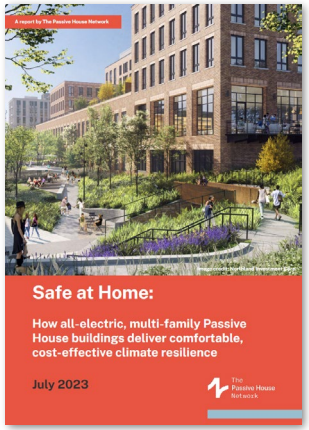
Budgets: Pushing Toward Parity

The Passive House Network





https://passivehousenetwork.org/wp-content/uploads/2022/10/Is-Cost-the-Barrier-to-Passive-House-Performance-May-2021-PHN.pdf



https://passivehousenetwork.org/safe-at-home/

https://passivehousenetwork.org/wp-content/uploads/2024/10/CONSTRUCTION-COST-ANALYSIS-OF-HIGH-PERFORMANCE-MULTI-UNIT-RESIDENTIAL-BUILDINGS-IN-BRITISH-COLUMBIA-V3.1.pdf

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Let's not just survive but thrive

The Passive House Network

Planning, constructing, and certifying a team's first multifamily Passive House building can feel like a Hero's Journey. More than a few projects have considered abandoning certification along the way.

However, **the project stands an excellent chance of achieving little to no construction cost premium if:**

- A comprehensive Passive House Charette is convened prior to design.
- A construction kickoff is held prior to construction.
- A building certifier is retained early.
- If milestones for Passive House are adhered to.
- If every item in this presentation is considered by the design team.

Mind Shift:

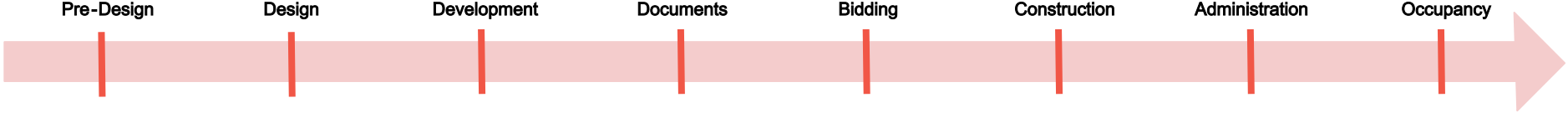
- You are designing with energy, like you already do with gravity.
- The PHPP model is an energy design tool.
- Every step each decision needs to be checked in the PHPP model.
- PHPP optimization is key to desired design, performance, and affordability outcomes.
- Embrace the PHPP in your design process. The PHPP is your friend.

Drivers of Energy Flow:

- Enclosure Design (principles 1-4)
- Ventilation System Design (principle 5)
- Internal Gains (multifamily)

Schedule With Focus on Passive House Pathway

The Passive House Network



Pre-Design

Owner's Project Requirements

Programming includes Passive House Certification requirements

Hire Experience / Interested team.

Schematic Design

Integrated Design Charrette

First energy model sets targets (include a 20% buffer)

Identify ventilation strategy

Identify shading & windows strategy

Identify assembly strategy

Design Development

Draw first the details that matter most

THERM/Flixo models of key junctions

Identify windows & ventilation systems

Second energy model includes all detail. (10% buffer)

Construction Documents

Details & model to building certifier

Review plans, details & specifications for inconsistencies

Third energy model with all documentation sent to certifier.

Certifier issues a **Design Stage Assurance letter**

Bidding

Iron out QA/QC procedures

Convene meeting to review all QA/QC responsibilities

Make a Verification Plan with Certifier sign-off

Pre-Construction

Passive House construction kickoff workshop

Led by PH consultant, enclosure engineer & builder air barrier super.

For key construction personnel + developer, architect team

Demonstrate with project specific mock-ups

Construction Administration

Site visits & testing

Enclosure reviews

Mechanical reviews

Ventilation commissioning

Air barrier testing

Final blower door test

As-built energy model & reports sent to building certifier.

Occupancy

Training for residents & managers

Certifier may issue letter for TCO

Final Certification issued

Provide operating manual for building managers and occupants

Pre-Design: Assemble Objectives & Team

The Passive House Network

- **Write a concise Owner's Project Requirements** (OPR) with specific sustainability targets and strategies to achieve this targets.
- **Hire a Passive House consultant** who has completed certification of a multifamily building.
- **Hire a PHI-accredited building certifier** with multifamily experience.
- **Hire an MEP engineer** with multifamily Passive House experience.
    - That's the trifecta. Bonus points if they've world together previously.*
- **Identify all incentives** available for a certified Passive House. (And make sure they're worth it!)
- **Identify other sustainability targets** .

* A note on experience. Data indicates that the most cost effective Passive House multifamily buildings are produced by experienced professionals. However, not everyone has experience, and so it's even more important to make sure key team members to, like the building certifier. For team members who don't have experience, mentors, coaches and an hourly consultant with special expertise, can grow your options for team composition.

Schematic Design: Chart a Strong Course

The Passive House Network

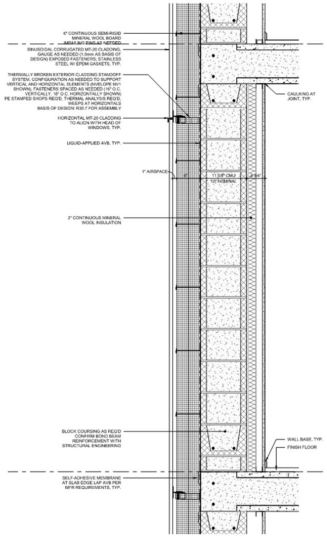
- **Kickoff with a Passive House Design Charette** . Agenda to include:
  - Preliminary PHPP based on likely form
  - …and a long list of assumptions.
  - Discuss each key assumption, item by item.
  - Choose ventilation strategy.
  - Choose a wall assembly strategy.*
- If the Charette is comprehensive, the team will feel relieved as they depart. Is that it?
- Front load *informed* decisions on critical aspects to inform initial PHPP:
  - Form factor
  - Circulation
  - Ventilation strategy
  - Shading and Window Strategy

* Passive House wall assemblies need not be exotic. Design with basic systems that are familiar to builders. Give first-time builders the space to focus on the tweaks that drive performance.

Design Development: Tackle Critical Details

The Passive House Network

- If the architect does not already have a library of high-performance details, begin developing thermal enclosure details during DD.
- Why? Because details that save money take time to design:
  - Conceive, draw detail, revise.
  - Review by enclosure engineer, revise.
  - Model in Flixo, revise.
  - Second round of feedback not uncommon.
- Identify basis-of-design windows and ventilation system. Pre-bid?
- PH consultant to prepare second PHPP model at the end of DD.
  - **PHPP based on actual details & components, not on assumptions.**



TYPICAL METAL PANEL WALL ASSEMBLY
NOT TO SCALE

Construction Documents: Design Assurance

The Passive House Network

Design Stage Assurance Review

- Passive House consultant sends plans specs, and PHPP to the building certifier.
  - Certifier responds with comments, questions, suggestions.
  - **If the team held a 10% buffer in PHPP, no problems! Hold a buffer!**
  - If PHPP is a the limit, certifier feedback could drag team back to DD.
  - Three rounds of review not uncommon.
- Once the plans, specs & PHPP meet the Passive House standard, the **building certifier issues a Design Stage Assurance letter** .*
  - Some jurisdictions require letter prior to issuing a building permit.
  - This helps drive accelerated deadlines.

CertiPHIers COOPERATIVE

via email care of aholden@oneseed.ca

October 28, 2020

To: Allison Holden-Pope
ONE Seed Architecture
Vancouver, BC Canada

CC: Kenneth Chan
JRG Building Engineering
Vancouver, BC Canada

Design Stage Conditional Assurance Letter for
[redacted] Duplex, [redacted] Ave, Vancouver, BC Canada

Dear Ms. Holden-Pope,

On behalf of CertiPHIers Cooperative, thank you for the opportunity to perform the pre-construction certification review of this exemplary Passive House project.

I am a Passive House Institute (PHI)-accredited Certifier performing building certification reviews through CertiPHIers Cooperative. I have completed my review of the PHPP, drawings, and specifications that your office and Kenneth Chan submitted on the CertiPHIers dropbox for this duplex. Upon submission of documents and photographs demonstrating construction according to the information submitted and air leakage and ventilation system commissioning within PHI requirements, I will be able to certify the project as meeting the Passive House Standard.

This assurance is conditional; and it is not certification. Only upon completion and meeting testing and PHI's documentation requirements, will CertiPHIers Cooperative certify the completed project. Please contact me for any questions or clarifications.

Sincerely,
CertiPHIers Cooperative, Inc.

By:

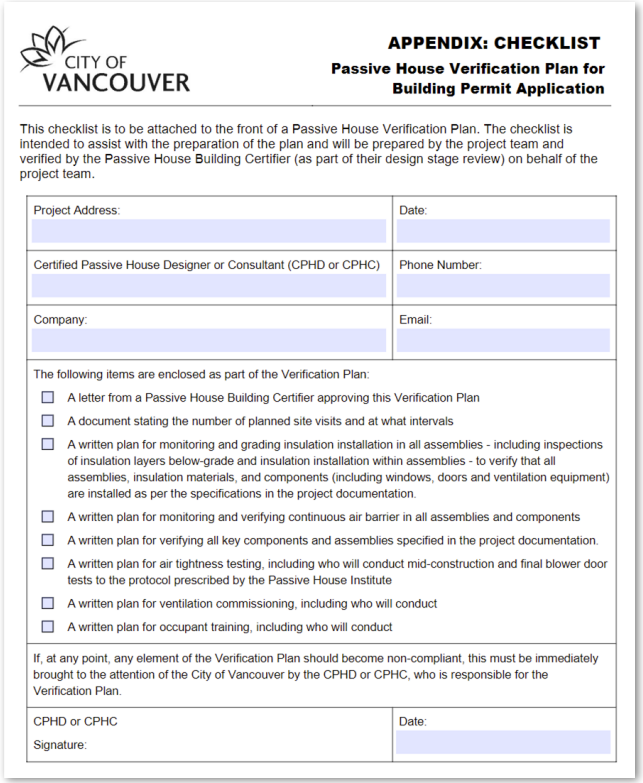
Tad Everhart
President
Certifier

Passive House Certifier

* You want a design assurance letter prior to bidding whether a permit requires it or not. It's critical that you are bidding a certifiable design.

Bid Phase: Lock Down QA/QC

- **Have explicit clarification of QA/QC procedures**
  - Who's responsible for what and when.
  - Identify ventilation commissioning agent and blower door tester.
  - Where will reports be compiled for the certifier?
  - What's the proposed substitution review procedure for Passive House relevant items? What are those items?
- **Consider pre -bidding critical items:**
  - Ventilation Units
  - Windows
- **Make a formal Verification Plan**
  - Vancouver requires one is in place prior to receiving a building permit.



CITY OF VANCOUVER

APPENDIX: CHECKLIST

Passive House Verification Plan for Building Permit Application

This checklist is to be attached to the front of a Passive House Verification Plan. The checklist is intended to assist with the preparation of the plan and will be prepared by the project team and verified by the Passive House Building Certifier (as part of their design stage review) on behalf of the project team.

Project Address:	Date:
Certified Passive House Designer or Consultant (CPHD or CPHC)	Phone Number:
Company:	Email:

The following items are enclosed as part of the Verification Plan:

- ☐ A letter from a Passive House Building Certifier approving this Verification Plan
- ☐ A document stating the number of planned site visits and at what intervals
- ☐ A written plan for monitoring and grading insulation installation in all assemblies - including inspections of insulation layers below-grade and insulation installation within assemblies - to verify that all assemblies, insulation materials, and components (including windows, doors and ventilation equipment) are installed as per the specifications in the project documentation.
- ☐ A written plan for monitoring and verifying continuous air barrier in all assemblies and components
- ☐ A written plan for verifying all key components and assemblies specified in the project documentation.
- ☐ A written plan for air tightness testing, including who will conduct mid-construction and final blower door tests to the protocol prescribed by the Passive House Institute
- ☐ A written plan for ventilation commissioning, including who will conduct
- ☐ A written plan for occupant training, including who will conduct

If, at any point, any element of the Verification Plan should become non-compliant, this must be immediately brought to the attention of the City of Vancouver by the CPHD or CPHC, who is responsible for the Verification Plan.

CPHD or CPHC Signature:	Date:

Construction Administration: Empower Team

The Passive House Network

- **Convene a Passive House construction kickoff workshop** .
  - Include design and construction teams with key personnel.
  - Demonstrate techniques specific to the project.
  - Use mockups to demonstrate and practice.
  - Don’t skimp! Full day workshop costs less than one change order.
- **Use the verification plan**
  - The verification plan should be the scaffold that keeps things in bounds and on track.
  - Regular inspections, reports, photos of corrected work.
  - Enclosure Airtightness testing: mock-up, mid-construction and final.
  - Ventilation duct airtightness testing.
  - Ventilation commissioning.
- Collect and organize site visit reports, photos, receipts for critical components, and relevant change orders as the work progresses. If this is done, final certification with be much simpler.
- Complete submission of required documentation to the certifier including as-built drawings and PHPP energy model.

Occupancy & Tuning: Complete Certification

The Passive House Network

- **Temporary Certificate of Occupancy** (when PH certification is a requirement)
  - Jurisdictions vary on specific requirements, but at minimum **may require a new declaration by the certifier** that all needed documentation has been submitted and the project is moving toward completing final certification.
- **Final Certificate of Occupancy** (when PH certification is a requirement)
  - Again, requirements vary but it likely requires the final certification be completed by the certifier.
- **Provide Building Operating Training and Manuals**
  - To building managers and occupants
- **Tune the Mechanical Systems***

* Mechanical systems may take time to tune, as motors, electronics components, programming, and user unfamiliarity, can all play a part in operations that initially fall short of expectations. ***Allow for proper commissioning.***

1. Context
2. Milestones
3. **Efficient Multifamily Design**
4. Ventilation
5. Exterior Shading & Sensible Glazing
6. “Thick” Walls
7. Thermal Bridges
8. Cooling, Heating & Hot Water
9. Electrification
10. Drama Free Certification

Keys to Efficient Design

The Passive House Network

1. Layout mechanical distribution space needs early.
2. Plan shading before glazing.
3. Minimize surface area.
4. Calculate the form factor.
5. Minimize circulation area.
6. Kill bad balconies.
7. Articulate the skin, not the thermal enclosure.
8. Have clear control over what's inside vs. outside the Passive House occupancy.
9. Slightly higher ceilings.
10. Repeat what works.

1. Layout Mechanical Systems' Needs Early

The Passive House Network

- Multifamily Passive House building require:
  - highly efficient energy recovery ventilation
  - well -insulated domestic hot water supply
  - appropriately sized cooling/heating systems.
- Too many multifamily design teams ignore the space these systems require until after the floor plan is set.
- The solution is to visualize the building from the inside out early in Schematic Design:
  - Choose centralized or localized ventilation system.
  - Locate hot water tanks and the heat pumps that feed them.
  - Choose the mechanical cooling strategy.

2. Plan Shading Before Glazing

The Passive House Network

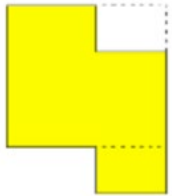
- Every multifamily building requires both exterior shading and mechanical cooling for its residents to survive heat waves that will grow hotter and more frequent.
- Multifamily Passive House buildings must defend against solar gains to minimize overheating.
- Two strategies:
  - Limit glazing to what's really needed.
  - Mount shading outside every directly solar exposed window.
- When visualizing the building from the outside, see the shading first.
- Leverage the extraordinary palette of shading materials to differentiate these areas from the cladding. Consider letting the shading, not the glazing define the lines of the building.

Unite d'habitation

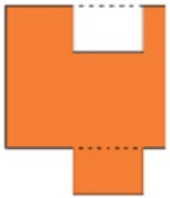
2. Minimize Surface Area

- Bays, step-backs, balcony insets, and other wrinkle-the-edge strategies raise housing costs in two ways:
  - Each corner or step-back raises the cost of construction materials and labor.
  - The additional thermal bridging and heat loss are created by these wrinkles must be compensated for through additional insulation.
- The solution is to iron out these wrinkles:
  - Count corners, then cut as many as feasible.
  - Eliminate step backs where possible.
  - Avoid structural cantilevers.
  - Be strategic about articulation to the building form.

Four corners



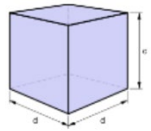
Eight corners
10% more surface area
One inch more insulation



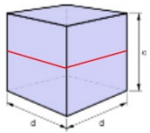
Twelve corners
20% more surface area
Two inches more insulation

3. Calculate the Form Factor

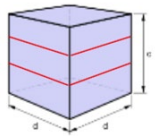
- You can’t manage what you don’t count.
- Calculate the building surface area, including all floors and roofs. Divide by the floor area. The resulting ratio is the building’s form factor. The lower the form factor, the less insulation the building requires to achieve Passive House.
- **A compact six -story building can achieve a form factor approaching 1:1, whereas even the most elegant single family homes struggle to achieve a form factor of 3:1.**
- In this way, multifamily buildings have a significant advantage over single -family homes, but only if the design takes advantage of the potential.



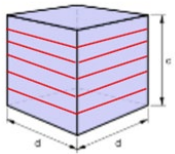
A cube has six surfaces through which heat may be transmitted. One of these is the floor.
The Form Factor is 6:1



Make the cube a two -story building and the form factor is reduced.
The Form Factor is 3:1



Make it a three -story building and the form factor drops again.
The Form Factor is 2:1

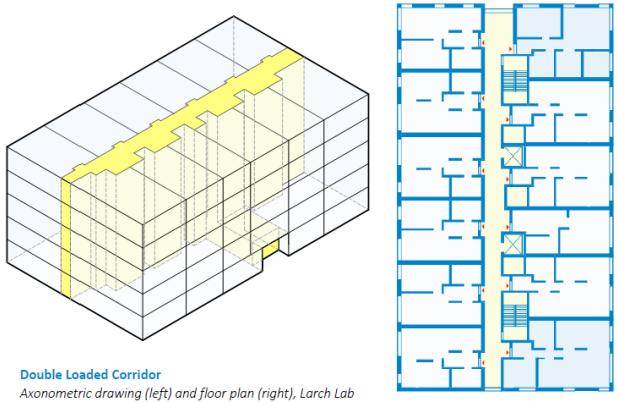


Make it a six -story building and the form factor drops significantly.
The Form Factor is 1:1
This form range typically results in the most affordable buildings.

4. Min. Circulation Area *& Max. Diversity of Units*

The Passive House Network

- Reduce circulation areas to make the floorplates more efficient. (Further incentive: The Passive House Standard assigns a lower Treated Floor Area value (typically 60%) to circulation areas.
- Typical American apartment buildings have a double -loaded corridor and give about 13% to circulation.
- They also eliminate cross -ventilation, restrict daylight and reinforce a uniformity of units.



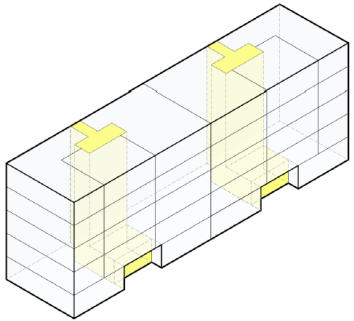
Double Loaded Corridor
Axonometric drawing (left) and floor plan (right), Larch Lab

- moderately efficient floor plate (13% of floor plate is circulation)
- primarily small units
- no cross ventilation
- no daylight on multiple sides
- little respite from urban noise

Point Access Blocks is an Alternative

- Point Access Blocks carry roughly half the circulation area of double -loaded corridor buildings.
- They also facilitate cross ventilation, daylight on two sides and a creator diversity uf unit sizes.

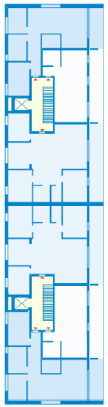
- California, Oregon and Washington State have recently revised codes to allow single -stair building, which make Point - Access Blocks possible.
- By taking advantage of this design, multifamily Passive House buildings can increase the Treated Floor Area, making it easier to achieve the target metrics.

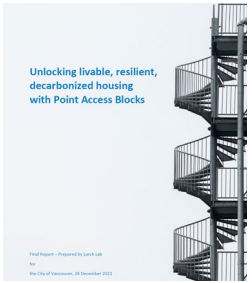


Point Access Block

Axonometric drawing (left) and floor plan (right) diagrams, Larch Lab

- compact layout (6,5% of floor plate is circulation)
- diversity of unit sizes (6 units, from 1- to 3-Bedrooms in this example)
- cross ventilation for most units
- daylight on multiple sides
- bedrooms on quiet side of building





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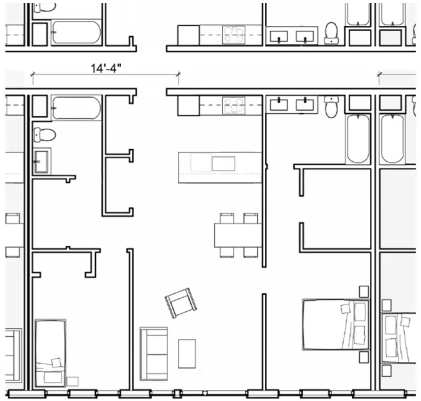
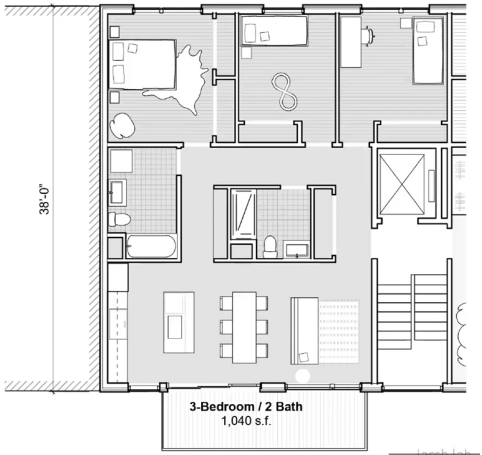
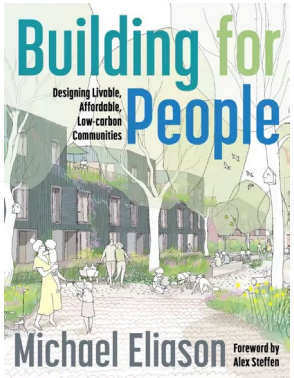


2-Bedroom/2 Bath
970 s.f.
60 s.f. (1/2 hall)

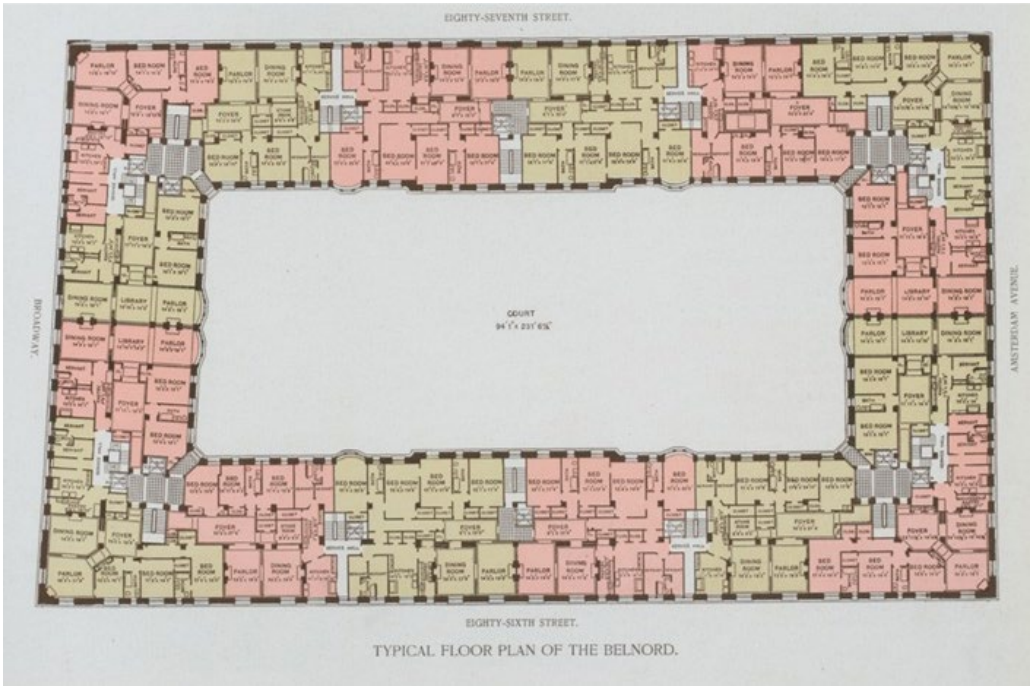




https://islandpress.org/books/building -people#desc

Form Factor, Surface Area & Circulation

The Passive House Network



Compact form, unit cross ventilation, daylit point access circulation, no murders(?)…

5. Kill Bad Balconies

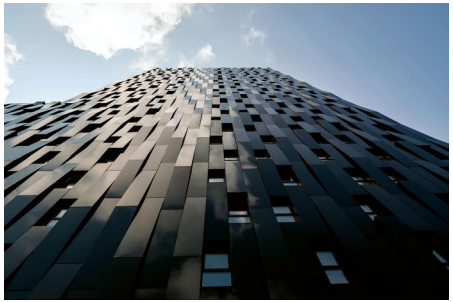
The Passive House Network

- A balcony is not likely to be used if:
  - It's less than six feet deep.
  - On a busy, loud and polluted street.
- And if it's not likely to be used kill it.
- However if it is six feet deep, and only a pleasant street then provide thermal bridge free design that minimizes enclosure complications.

6. Articulate the Skin, Not the Thermal Enclosure

The Passive House Network

- Articulation is essential to good design.
- Many municipalities require articulation of the facade that faces the street.
- But articulation of the thermal enclosure drives up heat loss and construction costs.
- Instead consider articulating the space between the outermost facade layer and the insulated enclosure.
- It can be achieved simply or in more complex ways.



7. What's Inside? What's Outside?

- What can be outside the thermal enclosure (and perhaps should be)?
  - Parking
  - Bicycle storage
  - Vestibules
  - Circulation Elements:
    - Stairs
    - Elevators
    - Hallways (perhaps not)
  - Storage Lockers
  - Trash Collection
  - Commercial Areas of mixed -use building. (see PHI criteria for options)

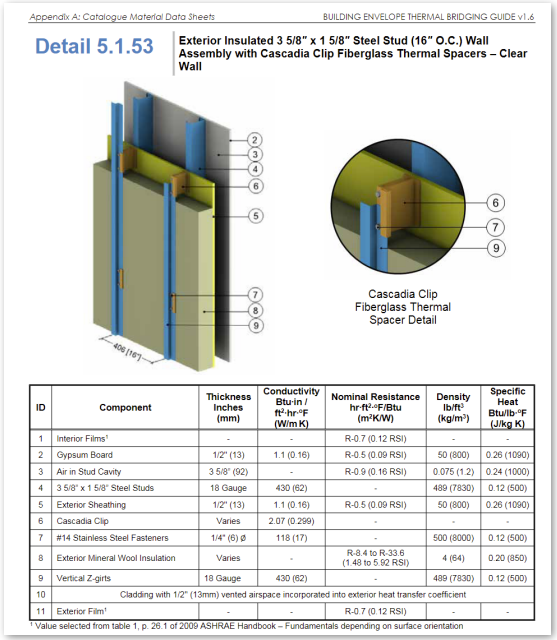
8. Slightly Higher Ceilings

The Passive House Network

- Hallway ceilings often serve as mechanical chases in multifamily buildings.
- It can be challenging to squeeze ventilation ducts, electrical conduits, insulated thermal water lines for cooling and heating, insulated piping for domestic hot water, piles for potable cold water, and sprinkler lines into an eight -foot ceiling.
- One elegant solution is to slightly raise the height of all ceilings to nine feet, providing appropriate chase space above the corridor.
- It also results in more spacious units without unreasonably raising the heat loss, given overall good form factor.

9. Repeat What Works

- Any multifamily project that is not leveraging repetition is not serious about affordability.
- Repeat details.
- Repeat components, like windows.
- Repeat wall panels.
- Repeat building modules.
- Repeat buildings.



Appendix A: Catalogue Material Data Sheets — BUILDING ENVELOPE THERMAL BRIDGING GUIDE v1.6

Detail 5.1.53 — **Exterior Insulated 3 5/8" x 1 5/8" Steel Stud (16" O.C.) Wall Assembly with Cascadia Clip Fiberglass Thermal Spacers – Clear Wall**

Cascadia Clip Fiberglass Thermal Spacer Detail

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Films[1]	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
3	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	3 5/8" x 1 5/8" Steel Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.09 RSI)	50 (800)	0.26 (1090)
6	Cascadia Clip	Varies	2.07 (0.299)	-	-	-
7	#14 Stainless Steel Fasteners	1/4" (6) ø	118 (17)	-	500 (8000)	0.12 (500)
8	Exterior Mineral Wool Insulation	Varies	-	R-8.4 to R-33.6 (1.48 to 5.92 RSI)	4 (64)	0.20 (850)
9	Vertical Z-girts	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
10	Cladding with 1/2" (13mm) vented airspace incorporated into exterior heat transfer coefficient					
11	Exterior Film[1]	-	-	R-0.7 (0.12 RSI)	-	-

[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

https://www.bchydro.com/content/dam/BCHydro/customer -portal/documents/power -smart/builders -developers/building -envelope -thermal -bridging -guide -v1-6.pdf

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Air Pollution

The Passive House Network

Indoor Air Pollution

Cooking, candles and cleaning products long accounted for most indoor pollutants in non -smoking homes. And now Covid.

And the remedy? Turn up the exhaust fan and open the windows.

Outdoor Air Pollution

- Exhaust smoke from transportation & industry.
- Tires release a trillion toxic particles per .6 miles driven.
- Wildfire smoke.
- Allergens

Multifamily Buildings

Most are built near highways and zoning laws are forcing apartment buildings to be adjacent to highways.

All combine to increase childhood asthma, and reduce life expectancy.

Multifamily buildings require robust ventilation. Passive House provides it.

Poorly planned ventilation systems lead to change orders and cost overruns on multifamily Passive House projects.

Plan a cost effective system.

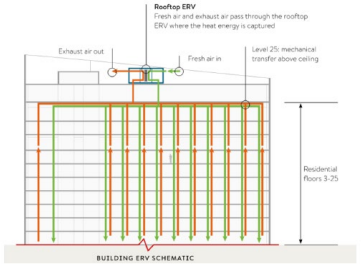
First Things First: Layout the Ventilation

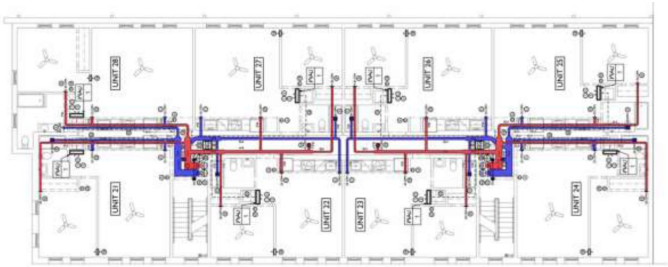
The Passive House Network

Architect are accustomed to installing bathroom fans and baseboards which require little to no floor space, so too many ignore the space these systems will require until after the floor plan is set. Consequently, these systems get “shoehorned” into inadequate space, costing more and lower performance.

The solution is to layout mechanical space early during schematic design.

- Identify the ventilation strategy (local vs. central) and cooling strategy (local vs. central) at the onset of of schematic design.
- Locate units and ducts in concert with the floorplan.
- Plan plumbing to minimize pipe lengths. (Short domestic hot water runs costs less to build, cuts heat loss, and reduces cooling expense. More on mechanical design later…



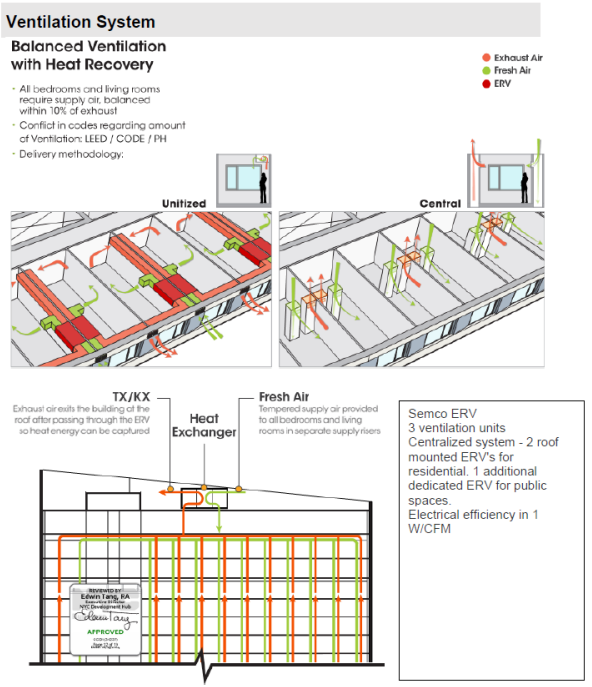


Key Decision: Local or Centralized Ventilation

The Passive House Network

Some multifamily Passive House buildings are designed around “local” Energy Recovery Ventilators (ERVs), which must be mounted inside each unit near an exterior wall. Others are designed around “central” ERVs which can be mounted on the roof and serve units through shafts.

Because each strategy requires floor space in different parts of the building, it is important to identify early which approach best fits the project so the plans can accommodate the strategy.



Key Decision: Local or Centralized Ventilation

The Passive House Network

Local ERVs: Pros

Local demand reduces aggregate flow rates.
No smoke fire dampers required.

Local ERVs: Cons

Locating effectively difficult.
Maintenance staff must enter unit to change filters.
Separation of intake and exhaust can be difficult to achieve.

Filters are critical : If they are not regularly changed, ventilation effectively ceases.

Central ERVs: Pros

Can be installed on rooftops or below ground.
Ducts can be routed in center of the building.
Maintenance doesn't require entering the apartment and few filters to change.
Units can provide dehumidification with addition of coils from heat pump.

Central ERVs: Cons

Smoke and fire dampers required.
Flow damper required for unit control.
Ducts need to (really) be airtight and duct leakage testing is recommended.

Kitchens & Laundry

The Passive House Network

Kitchen Ventilation in Apartments

Local codes for kitchen ventilation can vary significantly as have ASHRAE standards.

Typically we see a **hybrid approach** with **a recirculating range hood** to filter out grease combined with a nearby **exhaust vent going the the ERV**.

The range hood operates intermittently when needed, while the ERV exhaust is operating continuously, removing humidity and small particulate pollution.

Clothes Dryers

Traditional gas powered clothes dryers exhaust at a rate of 200 to 300 CFM, triple the rate of most apartments. Therefore if a dryer is to be in an apartment it should be a **condensing or heat pump dryer without exhaust.**

Laundry Rooms

In a central laundry room conventional dryers my be used if:

- It's has airtight separation from other spaces.
- Local makeup air provided.
- Local fan coil for needed additional heating & cooling of makeup air.

Seal Ducts “Perfectly”

The Passive House Network

Typical industry ductwork leaks significantly, in the order of 30% and will prevent buildings from being certified.

Communicate PHI commissioning requirements in the contract documents.

Specify AeroSeal in duct sealing specs and test leakage prior to drywall installation. (For tall buildings, it is often done several floors at a time.)

Involve mechanical contractors & commissioning agent in QA/QC efforts.

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Multifamily Buildings Need Shading & Cooling

The Passive House Network

Our world is getting hotter and so exterior shading and mechanical cooling are required to keep our buildings habitable in the coming years and decades.

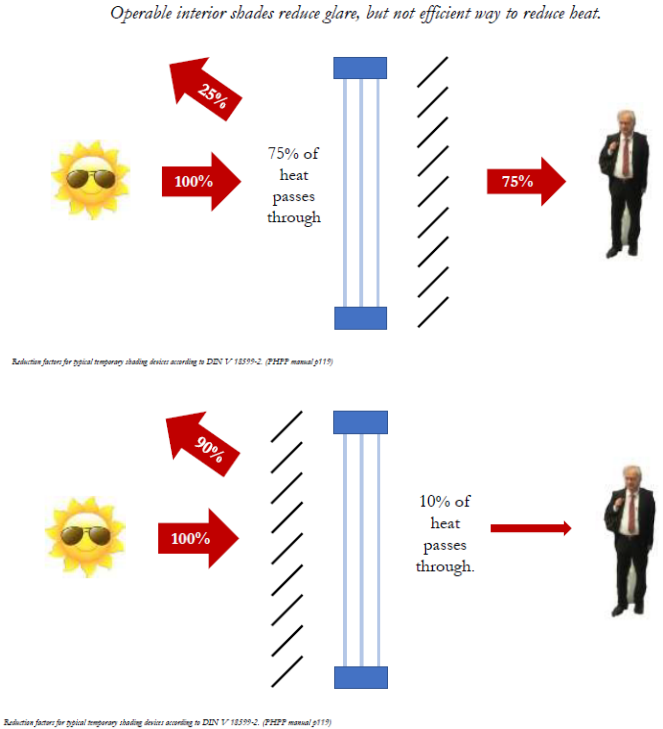
And because multifamily buildings have relatively high occupancy density, internal heat gains can exacerbate the problem and first must be minimized: Short, well insulated hot water piping; efficient lighting and appliances, etc…

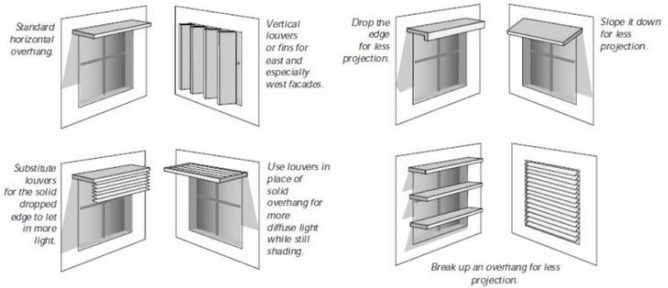
Well designed exterior shading improved comfort from spring through fall and lowers annual cooling demand. Durable exterior shading can also protect glazing from storm - driven debris.

By mitigating internal heat gains and unusable solar gains we minimize the cooling load, but we still need cooling, particularly as heat waves become more frequent and severe.

Mechanical cooling is a simple matter of life safety at this point, so that people can shelter in place, in a home that remains habitable.

Why We Mount Shading Outside the Window



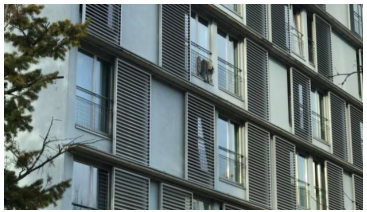


Visualize Shading Before Anything Else

The Passive House Network

Glazing in lieu of design, and glazing as design, have become common architectural practice. Do this instead:

- Close your eyes. Visualize the building. See only the shading.
- Design the shading before even thinking about windows.
- Utilize the rich palette of materials & textures.



Mix it Up!

The Passive House Network

1. Awnings
2. Brise Soleil
3. Balconies
4. Fixed Shades
5. Shutters & French Doors
6. Sliding Panels
7. Moving Louvers
8. Metal Roller Blinds
9. Integrated Blinds
10. Venetian Blinds
11. Rolled Screens
12. Curtains

If your design team can’t see exterior shading that works for your building… **Get a new team** .

Large Panes: Less Heat Loss, Less Cost

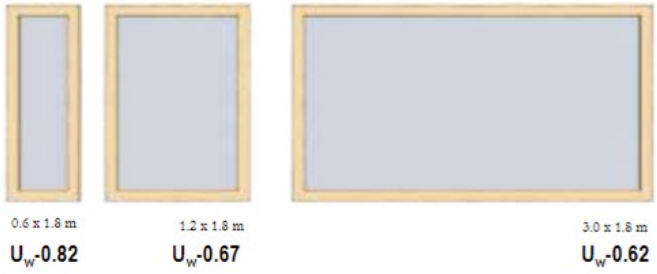
The Passive House Network

Window frames are the longest thermal bridges in a multifamily building. It is not uncommon for these thermal bridges to add up to a mile or more in length.

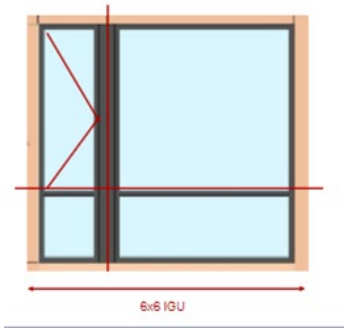
From a heat transfer perspective, the glazing unit (triple glazed) performs better than the frame it is in.

From a cost perspective window units made of small panels cost more that window units of large panes.

The solution is clear: Design windows units with larger panes and fewer frames.



Don't Do This.



- The window unit was relatively expensive.
- Most of the bottom panes were covered by a sofa.
- Nearly an inch of additional insulation was required to offset the thermal bridging.

Windows with Purpose

The Passive House Network

Windows bring light, views, and ventilation. Overglazing brings high heat loss, overheating, storm damage and greater costs.

Only place a window where it has a specific purpose, and where it's the best solution for that purpose. (daylight, view, ventilation)

Take the point of view of the resident and visualizing each proposed window ask: What is the purpose of this piece of glass and is this arrangement the most effective way to serve that purpose?

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High -Performance Walls

The Passive House Network

Stuff it, Wrap it, or Split it

There are basically three types of high -performance wall designs:

- Interior insulation (Stuff it)
- Exterior insulation (Wrap it)
- Hybrid assemblies (Split it)

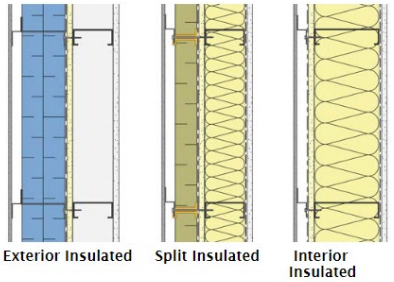


Figure 1: Standard approaches to insulating steel-framed wall assemblies

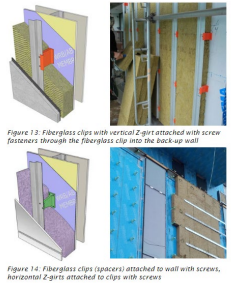


Figure 13: Fiberglass clips with vertical Z-girt attached with screw fasteners through the fiberglass clip into the back-up wall

Figure 14: Fiberglass clips (spacers) attached to wall with screws, horizontal Z-girts attached to clips with screws

Metal Framed Walls

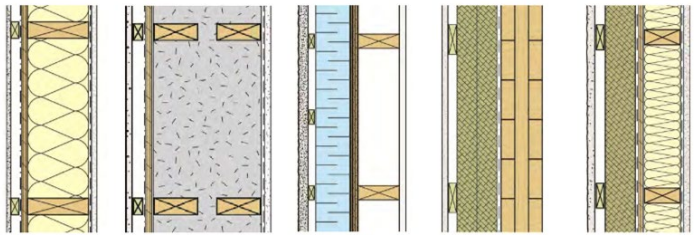


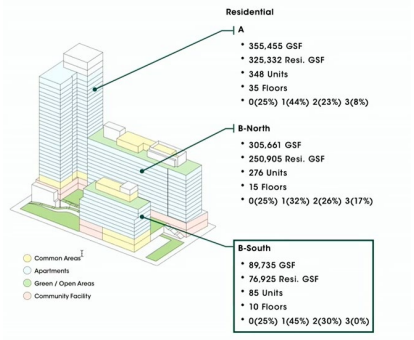
Fig. 3.2.1 Options for placement of insulation within thermally efficient above-grade wood-frame wall assemblies.

Wood Framed Walls

Fig. 3.2.2 Options for placement of insulation within thermally efficient below-grade wood-frame wall assemblies.

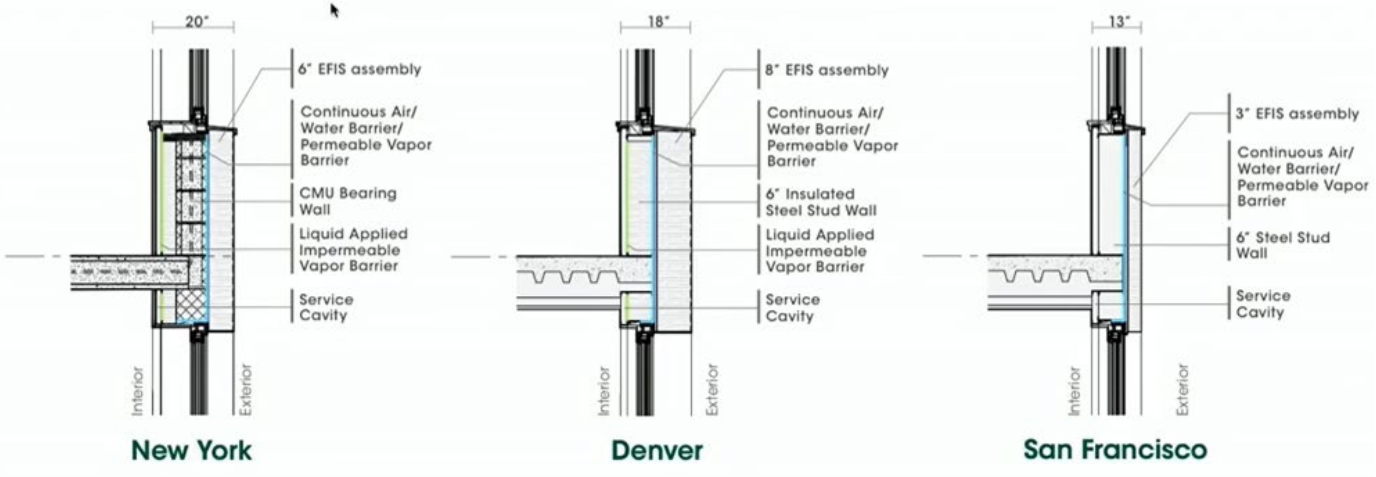
Concrete Walls

High -Performance Walls



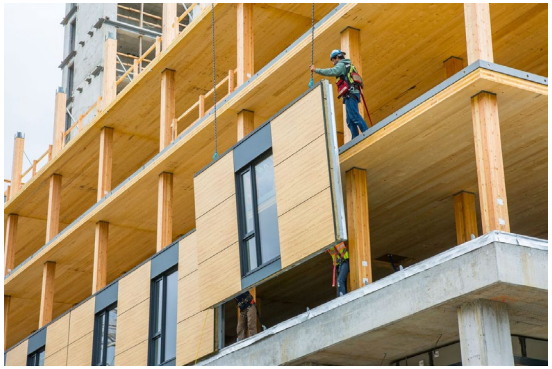
Design Mods	NYC	Denver	SF
EIFS Insul Thickness Interior Insulation *Avg. AG Wall R-Value*	6" / 4" Yes, 3.5" *R-34*	8" / 6" Yes, 3.5" *R-39*	3" / 1" No *R-14*
Elevator Pit Walls *Avg. AG Wall R-Value*	None *R-3*	2" Rigid *R-12*	None *R-3*
Roof R-Value (Bldg Avg)	R-36	R-47	R-31
Slab on Grade Insul *Avg. Slab OG R-Value*	None *R-2*	2" Rigid *R-12*	None *R-2*
Windows *Bldg Avg U-Value*	Good Triple *0.18*	Great Triple *0.17*	Avg. Double *0.31*
Center of Glass SHGC	0.38	0.47	0.27
ERV or HRV? *Air Sensible Recovery Eff of E/HRV*	ERV *86%*	ERV *86%*	ERV or HRV *75%*

Courtesy of Handel Architects



Panelized Systems

The Passive House Network



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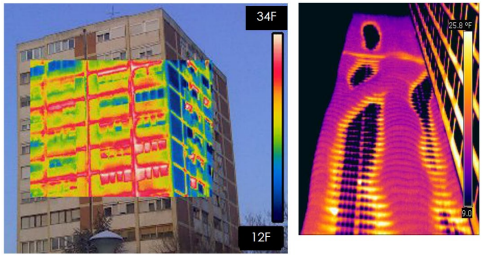
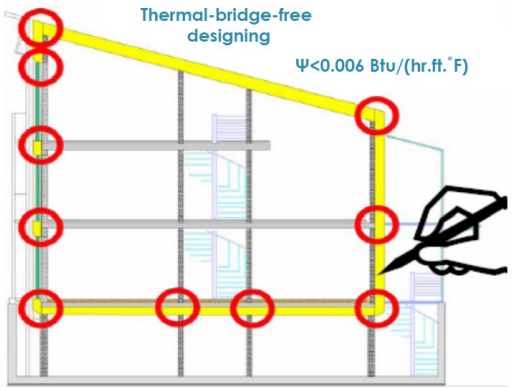
10. Drama Free Certification

Thermal Bridges in Multifamily Buildings

The Passive House Network

- **Plumbing and electrical penetrations, together with attachment -related thermal bridges, can account for 20 -30% of heat loss in a multifamily building.**
- Passive House practice requires every thermal bridge be assessed, and each be entered as a separate line item in the Passive House Planning Package (PHPP).
- Drawing so many details early can be challenging for small firms designing their first multifamily Passive House buildings.
- However, multifamily Passive House projects that proceed into Design Development without a realistic thermal bridging assessment risk discovering too late the project will require significant changes.

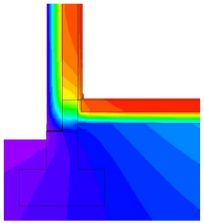


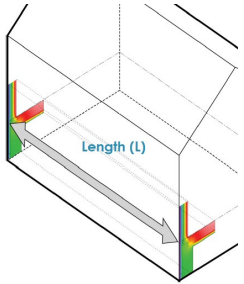


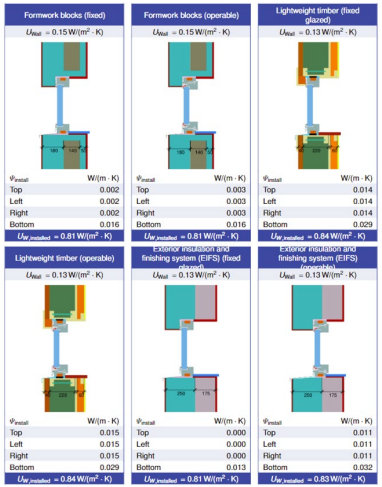
Use placeholder values in early design

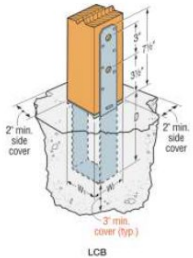
The Passive House Network

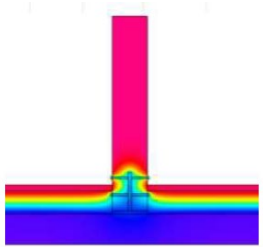
- The most responsible way to address this workflow conundrum is to systematically list every likely thermal bridge in the PHPP during Schematic Design, to estimate the length or count of each thermal bridge on the list, and to enter an acceptable Psi or Chi value as a placeholder. Replace these estimates with assessed values as they become available.
- Speak to your certifier about appropriate placeholder values!











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Cooling is About Survival

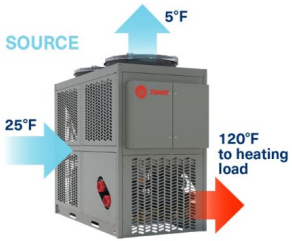
The Passive House Network

We cannot underestimate heat waves as people are dying in record numbers.

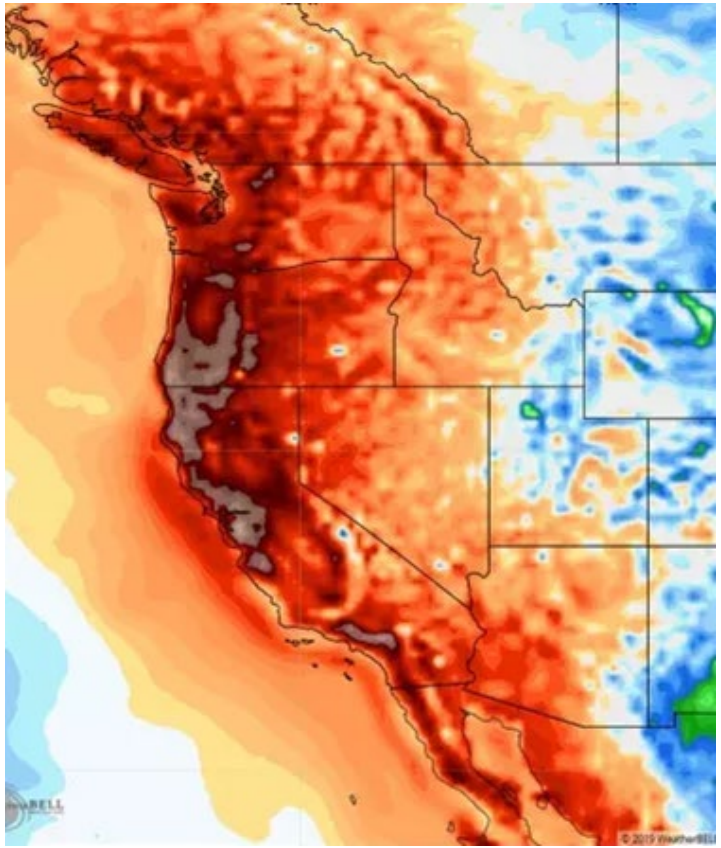
And while Passive House works to minimize the need for cooling through shading and other strategies, cooling will be needed.

Heat pumps provide cooling (& heating).

Cooing Mode



Heating Mode



Limit Air Conditioning Greenhouse Gasses

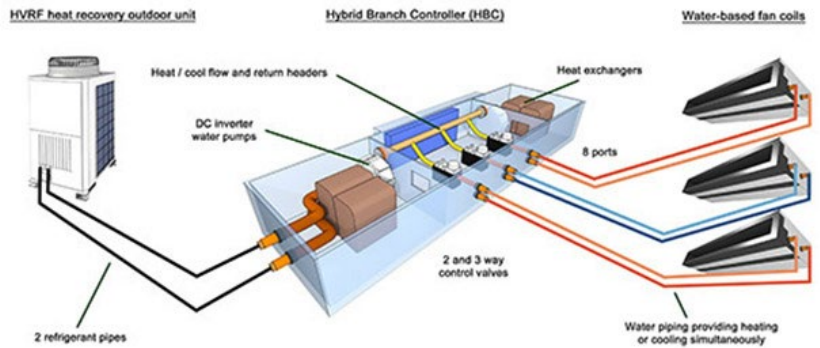
The Passive House Network

Buildings Emit Three Greenhouse Gasses

- Carbon dioxide from fossil fuel burning furnaces, boilers, water heaters, gas dryers, barbeques and fireplaces.
- Methane from gas pipe leaks. 86x CO2
- Refrigerant fluorinated gasses. 2088x CO2

Strategies to Reduce Refrigerant Leakage

- Reduce refrigerant need by reducing the cooling demand with passive measures.
- Specify Low -GWP Refrigerants: R32 or better.
- Use package unit/monobloc utilizing propane or CO2.
- Substitute hydronic distribution for refrigerants.



- When refrigerant pipes leak, the problem can go undetected. An HVAC technician must diagnose and recharge the system.
- When hydronic pipes leak, drips of water alert residents to the problem and plumber can fix it.

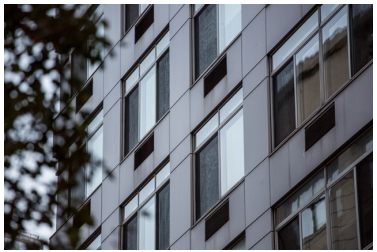
Multifamily Heating & Cooling & Dehumidification

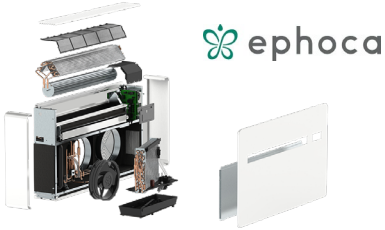
The Passive House Network

Systems can be centralized or decentralized.

To **limit refrigerant lines** , distribution may be through **hydronic piping to local distribution coils** , OR, by using Package Terminal Heat Pumps (PTHP).

Centralized Air -Source Heat Pumps With Distribution Zones





Decentralized Through -Wall Package Terminal Heat Pumps (PTHP)

Cooling, Dehumidification & Ventilation (+Heat)

The Passive House Network

Don’t Deliver Cooling Via Ventilation Air

- Cooling requires too much airflow and is therefore not feasible within the range of ventilation requirements.
- And because the cooling can’t the heating won’t be either. It stays separate.

Do Dehumidify via Central Ventilation Air

- Dehumidification is not the same as cooling, though it can feel similar.
- Dehumidification heats then cools air to “wring out” moisture.
- Almost all climates are becoming more humid as they become hotter.

With Cooling Planned, Heating is Too

- Heat pumps provide heating as well as cooling.
- It’s a practical certainty that the heat demand for a multifamily building will be lower than the cooling demand.
- Therefore, with the cooling demand sized, the heating capacity will be sufficient too.

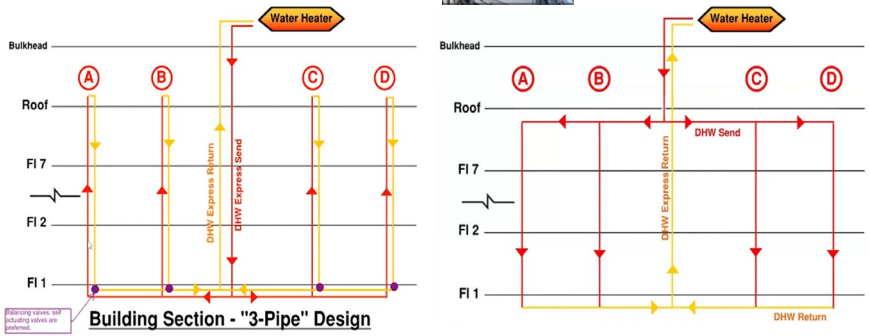
Centralized Units by Swegon and Ventacity

Domestic Hot Water

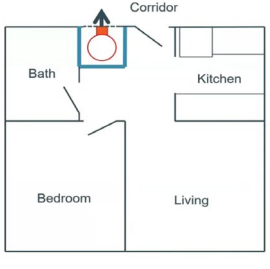
The Passive House Network

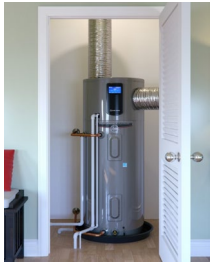
Distribution

- Utilize heat pumps.
- Monoblocs, or Splits with CO2 refrigerant.
- Systems can be centralized or decentralized
- Poorly designed systems loose ⅓ of energy = more hot water heating & more space cooling. $$$



Building Section - "3-Pipe" Design





Strategies for Efficient DHW Design

- Eliminate long runs, and minimize pipe runs in general.
- Use smallest pipe diameter practical.
- Insulate at least 2x pipe diameter.
- Locate hot water storage tanks to minimize circulation.
- Specify controls that slow recirculation when there is lower demand
- Consider wastewater heat recovery.

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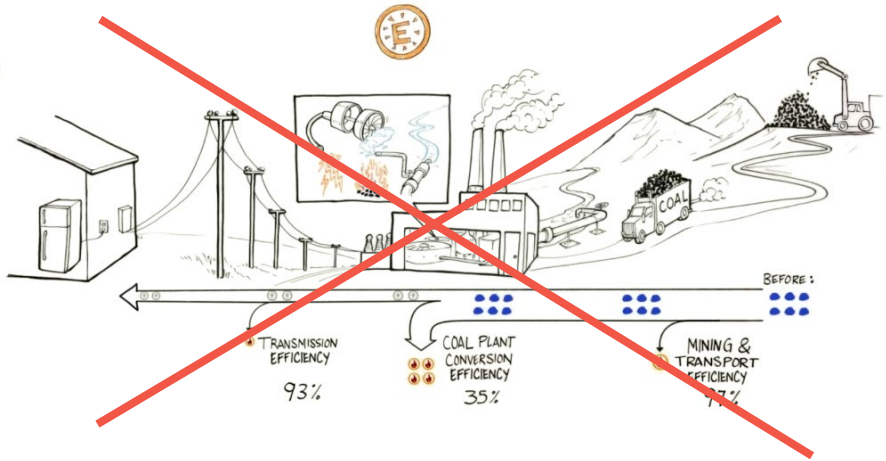
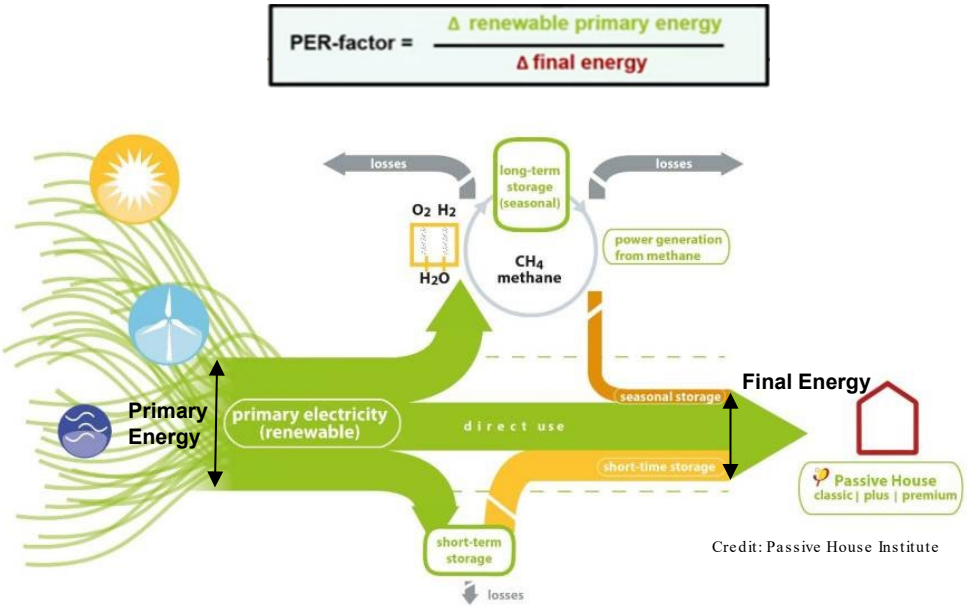
Shift Focus: Analysis to fit our all renewable future

The Passive House Network

Passive House jettisons the anachronistic emissions analysis and looks at renewable production & utilization.





Credit: Passive House Institute

Credit: Bronwyn Barry/PassiveHouseBB

No Fossil Fuels & PER Limits

The Passive House Network

Once both heat and hot water systems are electric, there is no need to connect the building to the fossil gas network. The cost savings of avoiding a gas connection would be considered in any cost comparison.

Also, achieving the **Primary Primary Energy Renewable (PER)** is simpler for an all -electric building. PER starts with Energy Use Intensity (EUI) and adjusts based on how renewable the energy source may be. The key is simultinaity.

The Passive House standard sets a maximum PER limit of 5.5 kWh per square foot of TFA per year.

However, **PHI allows higher PER limits for multifamily buildings** . The revised PER limit is prepared by a Building Certifier using a calculation that considers elevators, hallway lighting, and other factors. Talk to your certifier about a PER limit.

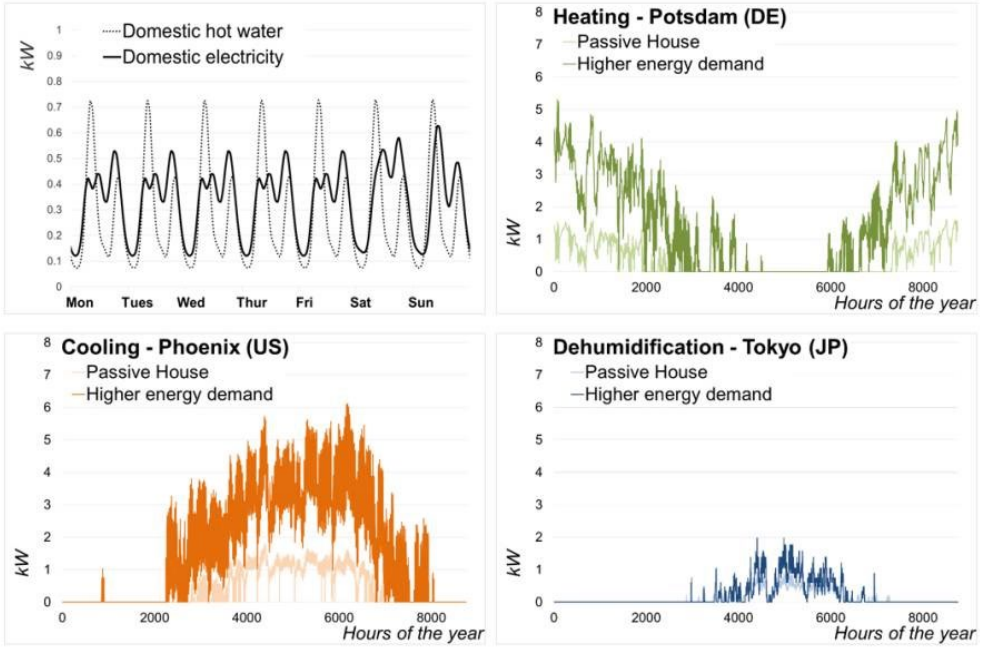
In general, it is not difficult for multifamily buildings served by heat pumps and efficient electrical components to achieve the revised PER targets.

Specific Use Demands & Different Climates:

The Passive House Network

Use Categories

1. Heating
2. Cooling
3. Dehumidification
4. Hot Water
5. Other Elec Uses



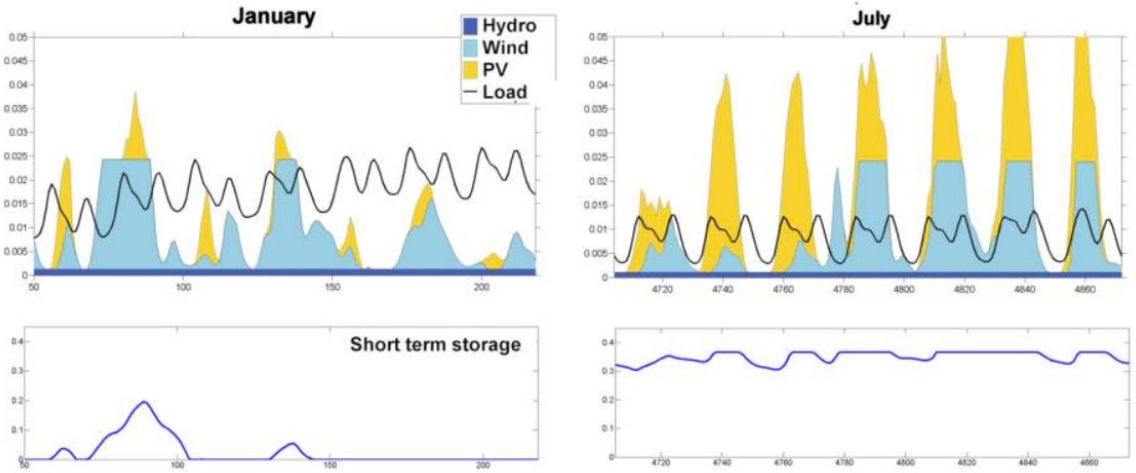
Top left: Load profile for one week of the household electricity and domestic hot water (cold water temperature for Mannheim, Germany, Winter). Top right and below: Exemplary useful energy profiles from different climates for heating, cooling and dehumidification.

Credit: Passive House Institute

Match of Supply to Use Determines Storage Need

The Passive House Network

No storage. Need long term storage.



No shortage of short term storage.

Example of hourly load profiles of RE electricity (cumulative) and electricity demand for a Passive House in Stuttgart. The left represents a week during winter with little RE availability, compared to a week during summer on the right, with much higher RE supply. The two graphs below show the simultaneous storage level of the short-term storage.

Credit: Passive House Institute

Efficient Elevators, Better Stairs & Daylit Corridors

The Passive House Network

There is an elevator tool (“Energy Demand Assessment of Lifts”) by which elevator energy demand may be estimated. The tool estimates usage (number of trips) as well as elevator efficiency.

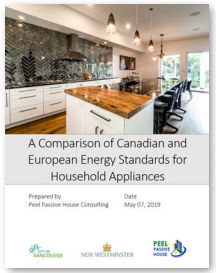
Strategy One: Lower the number of elevator trips by designing irresistible stairs.
Strategy Two: Specify high -efficiency elevators.

Daylight the Corridors, stairways and common areas wherever possible. (The loads are small but the annual demand adds up.) It is simpler to achieve with a point access block than a double loaded corridor.

Appliances, Monitoring & Metering

The Passive House Network

Because the refrigerator runs 24 -7, it is often the appliance that consumes the most electricity. Typical refrigerators are large and not very efficient. The solution is to specify the smallest and most efficient refrigerator possible. Specify the high -end of the Energy Star range as a minimum.



https://passivehousenetwork.org/featured/appliance -modeling -guide/

Energy Monitoring is not required for Passive House certification. However, when real -time monitoring can support resident -engagement strategies when installed in a lobby or public areas.

Metering: Because the loads are so low, individual unit loads are below the minimum billing threshold, and only provide the utility with monthly service charges.

Renewables

The Passive House Network

On-site renewable power is not required for Passive House certification.

Bear in mind that the roof is not the only place to mount PV panels. Installing PV panels above at - grade parking may cost less and reduce local heat island effect.

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Building Certification

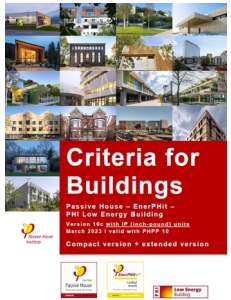
The Passive House Network

Building Certification benefits everyone involved in a multifamily project.

- The architect & design team receive third-party assurance prior to construction that the plans will achieve the standard.
- The construction team receives verification of build quality and performance.
- The funders receive proof they got what they paid for: A Passive House Building.
- The residents receive a home that is quieter, more comfortable, healthy and resilient than others.

Passive House Criteria for Buildings

The Passive House Network



The Criteria for Buildings includes guidance on the certification process, requirements, and best practices. Refer to this document for all questions involving building certification.

https://passivehouse.com/03_certification/02_certification_buildings/08_energy_standards/08_energy_standards.html

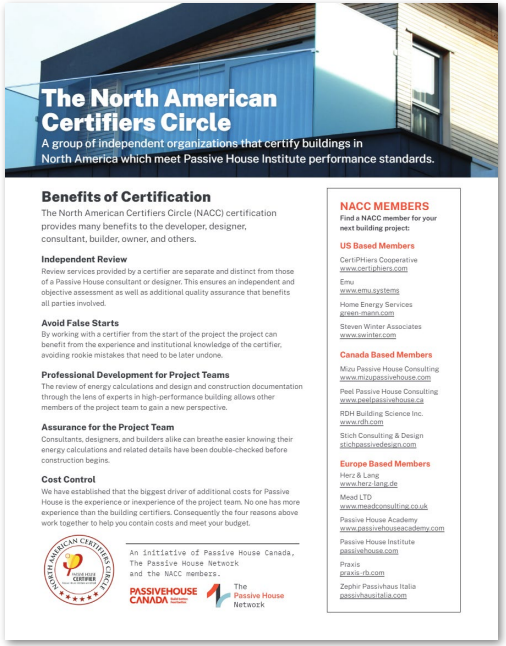
30+ Certifiers Working in the US

The Passive House Network

It is advantageous to hire a Passive house consultant and a Building Certifier who have completed certification of several multifamily buildings together. They will bring a mutual understanding of issues facing multifamily buildings in the US, as well as proven strategies to address those issues.

Hire a certifier early.

https://passivehousenetwork.org/certification/



The North American Certifiers Circle

A group of independent organizations that certify buildings in North America which meet Passive House Institute performance standards.

Benefits of Certification

The North American Certifiers Circle (NACC) certification provides many benefits to the developer, designer, consultant, builder, owner, and others.

Independent Review

Review services provided by a certifier are separate and distinct from those of a Passive House consultant or designer. This ensures an independent and objective assessment as well as additional quality assurance that benefits all parties involved.

Avoid False Starts

By working with a certifier from the start of the project the project can benefit from the experience and institutional knowledge of the certifier, avoiding rookie mistakes that need to be later undone.

Professional Development for Project Teams

The review of energy calculations and design and construction documentation through the lens of experts in high-performance building allows other members of the project team to gain a new perspective.

Assurance for the Project Team

Consultants, designers, and builders alike can breathe easier knowing their energy calculations and related details have been double-checked before construction begins.

Cost Control

We have established that the biggest driver of additional costs for Passive House is the experience or inexperience of the project team. No one has more experience than the building certifiers. Consequently the four reasons above work together to help you contain costs and meet your budget.

An initiative of Passive House Canada, The Passive House Network and the NACC members.

PASSIVEHOUSE CANADA

The Passive House Network

NACC MEMBERS

Find a NACC member for your next building project:

US Based Members

CertiPHiers Cooperative
www.certiphiers.com

Emu
www.emu.systems

Home Energy Services
green-mann.com

Steven Winter Associates
www.swinter.com

Canada Based Members

Mizu Passive House Consulting
www.mizupassivehouse.com

Peel Passive House Consulting
www.peelpassivehouse.ca

RDH Building Science Inc.
www.rdh.com

Stich Consulting & Design
stichpassivedesign.com

Europe Based Members

Herz & Lang
www.herz-lang.de

Mead LTD
www.meadconsulting.co.uk

Passive House Academy
www.passivehouseacademy.com

Passive House Institute
passivehouse.com

Praxis
praxis-rb.com

Zephir Passivhaus Italia
passivhausitalia.com

https://passivehousenetwork.org/wp-content/uploads/2023/01/NACC-Brochure-Jan-2023.pdf

Other accredited Passive House certifiers

PASSIVE HOUSE CERTIFIER

Passive House Institute accredited

The following experts* have been internationally accredited by the Passive House Institute to certify Passive House buildings, EnerPHit retrofits and Low Energy Buildings anywhere in the world on behalf of the Passive House Institute and in accordance with their criteria

How to become a Passive House certifier

* Unless otherwise stated, building certification contracts are always concluded between the Passive House Institute and an individual person and not with their companies/organisations.

Organisation	Country	Website	Building Certifier
CertiPHiers Cooperative, Inc.	United States of America	http://www.certiphiers.com	• Matthew Bowers, Languages: en • Ted Everhart, Languages: en • Rolf Jacobson, Languages: en • Chris Pytlik, Languages: en • Christina Snyder, Languages: en
Emu Building Science LLC	United States of America	https://emu.systems/	• Enrico Bonilauri, Languages: en | it
Home Energy Services	United States of America	http://www.green-mann.com	• Steve Mann, Languages: en
Steven Winter Associates, Inc	United States of America	http://www.swinter.com	• Lois Arena, Languages: en
Etude Consulting Ltd.	United Kingdom/ Britain	http://passivhaus.etude.uk | passivhaus.certification@etude.uk	• Naomi Grint, Languages: en • Will South, Languages: en • Chris Worboys, Languages: en
Mead Energy & Architectural Design LTD	United Kingdom/ Britain	http://www.meadconsulting.co.uk	• Kym Mead, Languages: en
WARM - Low Energy Building Practice	United Kingdom/ Britain	http://www.peterwarm.co.uk	• Sally Godber, Languages: en • Liam McDonagh-Greaves, Languages: en • Mike Roe, Languages: en • Peter Warm, Languages: en
ZE Passivhaus Services Ltd	United Kingdom/ Britain	https://www.passiv.org	• Jesus Menendez Amigo, Languages: es | en
Passivhusbyrån Ingo Theoboldt	Sweden	http://www.passivhusbyran.se	• Ingo Theoboldt, Languages: de | en | sv

https://passivehouse.com/03_certification/02_certification_buildings/03_certifiers/01_accredited/01_accredited.html

Scope of Certification Services

The Passive House Network

TABLE 1 Core Scope of Services

Project Stage	Item	Activity
1 PRELIMINARY REVIEW (SD/DD Phases)	1.1 Certification Process	1.1.1 Confirm certification approach with cons Passive House Institute (PHI) if required) inc climate data set, number of PHPPs and gene conditions.
		1.1.2 Establish a list of planned meetings.
		1.1.3 Issue initial list of submittals required f Design Stage Review.
		1.1.4 Issue file structure for collating design construction submittals.
		1.1.5 Set up the project on the PHI portal (https://certification.passivehouse.com/) or a methods to store information and ensure the how to use it.
	1.2 Initial Review	1.2.1 Review early-stage design information, and supporting calculations to verify against certification criteria.*
		1.2.2 Identify recommended specific design review design submittals provided.
		1.2.3 Review assumptions made in the absen submittals.
2 DESIGN STAGE REVIEW (CD Phase)	2.1 Design Review	2.1.1 Compliance review of pre-construction i the Passive House criteria.
		2.1.2 Review the agreed-upon number of the calculations.
		2.1.3 Review of the airtightness testing plan ventilation commissioning plan.
		2.1.3 Review the energy balance calculation in PHPP.
		2.1.4 Review of dynamic modeling for summer comfort for
	2.4 Verification Plan Review	2.4.1 Review the proposed Verification Plan.
3 CONSTRUCTION REVIEW & QUALITY ASSURANCE (CA Phase)	3.1 Construction Submittals	3.1.1 Provide project-specific construction submittal register
	3.2 Quality Assurance	3.2.1 Review certification submittals provided by Passive House Designer/Consultant.
		3.2.2 Review of duct leakage testing and ventilation pre-commissioning results.
		3.2.3 Provide feedback, including highlighting key risks to obtaining certification
4 AS-BUILT ASSESSMENT (CA Phase)	4.1 Complete PHPP Verification	4.1.1 Review final PHPP. Passivhaus designers should provide a final PHPP to the Passive House Certifier, updated to reflect construction information: - final airtightness test result - ventilation commissioning - space heating & cooling - domestic hot water system commissioning - changes during construction
5 CERTIFICATION (CA Phase)	5.1 Completion & Processing	5.1.1 Passive House certifiable projects: Coordinate with PHI to obtain certificate-ID
		5.1.2 Non-certifiable projects: In some instances the project may not be certifiable to any of the Passive House standards. In this case, the client will be informed, and no further action will be taken by the Certifier.*
		5.1.3 Upload project information to the Passive House Database.
	5.2 Certification Documents	5.2.1 Provide Passive House certificate and documentation.
		5.2.2 Provide Passive House plaque.
	8 Site visits	8.1 Site inspection visits. The number and timing of visits are to be agreed upon with the site team.
	9 Thermal Bridge Calculation Review	9.1 Review of 3D thermal bridges.
	10 Dynamic hygrothermal moisture calculation review	10.1 Review of WUFI modeling.
	11 Blower Door Testing	11.1 Carry out blower door testing.
	12 User guidance	12.1 Support in preparing User Guidance documentation.
	13 Other Certifications	13.1 When certifications such as LEED, Zero Energy Ready Home, Energy Star, Indoor airPLUS, RESET Air, Living Building, and WELL are being sought, further support may be provided in regard to information sharing and feedback.

			Passive House quality control is managed by the contractor & Passive House Designer/Consultant (not the Certifier). Certifier site visits are not required for certification.
			*Certifier may provide a letter confirming performance achieved upon request.

iterations are not included.

To allow time to make any

TABLE 2 Optional Additional Scope of Services

Project Stage	Item	Activity	Notes
Additional Services may occur across project stages	6 Additional Technical Support	6.1 Support on the general process. 6.2 Design feedback. 6.3 Design/construction workshops. 6.4 Verify design/specification changes. 6.5 Collation of information. 6.6 Work related to unique design challenges such as commercial kitchens, pools, hospitals etc... 6.7 Coaching of team members*	* Targeted coaching of team members on thermal bridge calculations, PHPP, or other optimization aspects can help rapidly increase team experience and expertise.
	7 Additional Design Stage Reviews	7.1 Further review of corrections submitted addressing deficiencies identified in previous Design Stage Review.	

https://passivehousenetwork.org/wp-content/uploads/2024/07/Building-Certifier-Scope-of-Services-JULY-2024-UPDATE.pdf

Roles of Consultant vs. Certifier

The Passive House Network

The Passive House consultant is a member of the development team. The consultant helps the team craft plans and specifications that will meet the Passive House criteria and helps the construction team complete a building that will achieve certification. The consultant will attend meetings and make site visits. **The consultant acts as an envoy between the Building Certifier and the development team.**

The Building Certifier is a third-party reviewer and may not perform any other services for the development team. The certifier represents the Passive House Institute. The certifier will communicate primarily with the consultant. If unique situations arise, t **he building certifier acts as an envoy between the consultant and the Passive House Institute.**

How to hire a PHI Building Certifier

The Passive House Network

Prepare a package at pre -design that includes the Owner's Project Requirements and basic information about the intended design, along with relevant information about the team's experience.

Hire a building certifier with multifamily experience. A less -expensive certifier may cost the project more by suggesting desired but not mandatory improvements.

Consider the relationship between the consultant and the certifier. Look for a duo that have worked together on numerous multifamily buildings.

Don't skimp on SD & DD guidance. A certifier may attend the Passive House Planning Charette, and may discuss various issues with the consultant before the and after the preparation of the Schematic Design PHPP. Ten hours of early -stage advice can often save hundreds of hours of design remedication later.

DON'T DO THIS

First -time projects too often delay consulting a building certifier until the building design is well underway and deprives the design team of some of the best early stage advice available.

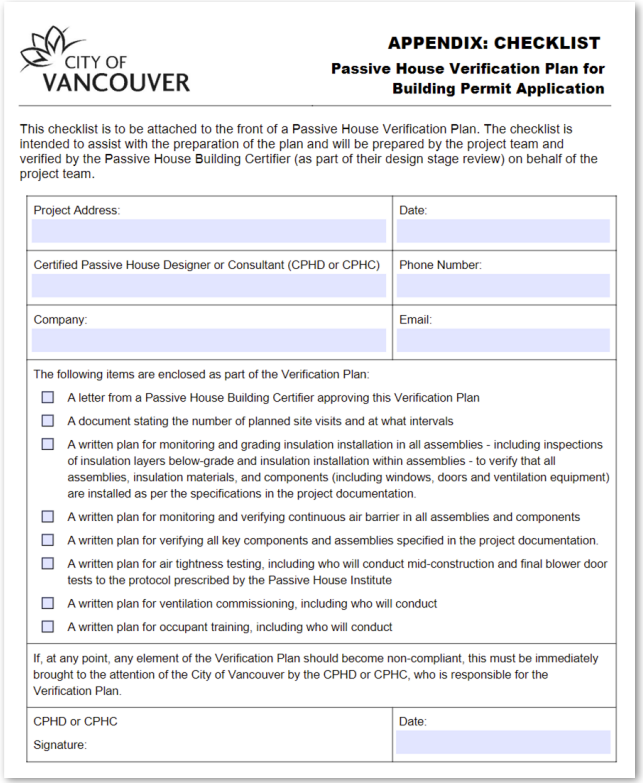
Veteran consultants call the certifier the day the contract is signed.

Address the Typical Difficulties: Verification Plan

The Passive House Network

Four Main Areas of Difficulties:

- Airtightness System
  - Window Installations
  - Inaccessible
- Ventilation System
  - Duct Leakage and Balancing
- Unvetted Component Substitutions
  - Windows
  - Ventilation
  - Airtightness
  - Insulation/Thermal Breaks
- Unorganized Information
  - Gathering & Submissions



CITY OF VANCOUVER

APPENDIX: CHECKLIST

Passive House Verification Plan for Building Permit Application

This checklist is to be attached to the front of a Passive House Verification Plan. The checklist is intended to assist with the preparation of the plan and will be prepared by the project team and verified by the Passive House Building Certifier (as part of their design stage review) on behalf of the project team.

Project Address:	Date:
Certified Passive House Designer or Consultant (CPHD or CPHC)	Phone Number:
Company:	Email:

The following items are enclosed as part of the Verification Plan:

- ☐ A letter from a Passive House Building Certifier approving this Verification Plan
- ☐ A document stating the number of planned site visits and at what intervals
- ☐ A written plan for monitoring and grading insulation installation in all assemblies - including inspections of insulation layers below-grade and insulation installation within assemblies - to verify that all assemblies, insulation materials, and components (including windows, doors and ventilation equipment) are installed as per the specifications in the project documentation.
- ☐ A written plan for monitoring and verifying continuous air barrier in all assemblies and components
- ☐ A written plan for verifying all key components and assemblies specified in the project documentation.
- ☐ A written plan for air tightness testing, including who will conduct mid-construction and final blower door tests to the protocol prescribed by the Passive House Institute
- ☐ A written plan for ventilation commissioning, including who will conduct
- ☐ A written plan for occupant training, including who will conduct

If, at any point, any element of the Verification Plan should become non-compliant, this must be immediately brought to the attention of the City of Vancouver by the CPHD or CPHC, who is responsible for the Verification Plan.

CPHD or CPHC Signature:	Date:

https://passivehousenetwork.org/wp-content/uploads/2024/07/Vancouver-Passive-House-Verification-Plan-Checklist-2023.pdf

Construction Submission to Certification Platform

The Passive House Network

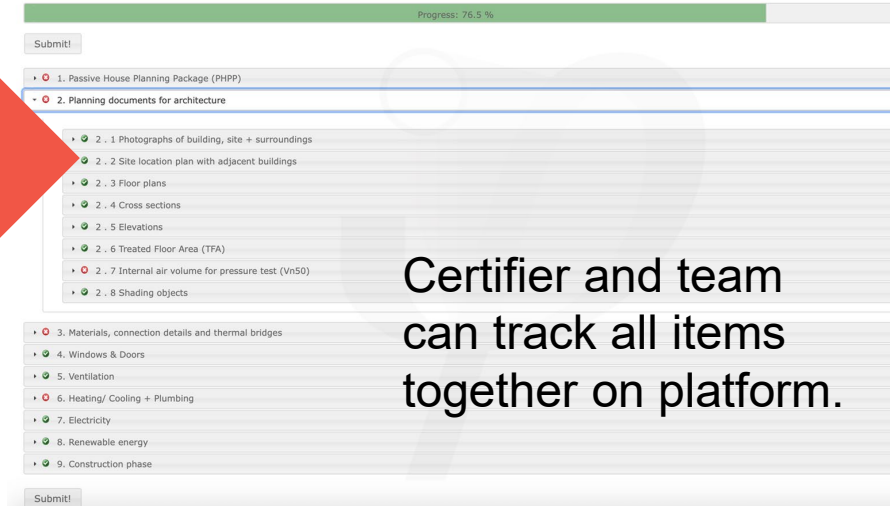
A/E/C

Builder*

On-site Verification
- General Inspections
- Ventilation Commissioning Agent
- Blower Door Technician

Passive House Consultant
(only the consultant can submit to the platform)

Owner Builder Regulator Other Team Members



Certifier and team can track all items together on platform.

Organized in 9 Folders

*Builder needs in-house inspectors, but they don't report out for Certification. Verifier A/EC and Certifier are hired independent of builder by owner.

Conclusion

The Passive House Network

Your project stands an excellent chance of hitting all the targets while avoiding cost premium:

1. A comprehensive Passive House Charette is convened prior to design
2. A construction kickoff is held prior to construction
3. A building certifier is retained early.
4. If milestones for Passive House are adhered to.
5. If every item in the guide is considered by the design team.

General Recommendations:

- Meet early with the Certifier and identify all critical items and develop a Verification Plan.
- Include all necessary verification work in construction schedule.
- Insist on training for the design & construction staff.
- Hire experience (on team/coaching)
- Develop a culture that connects construction work to high-performance outcomes, including specialized training.
- Empower the team.

Next Steps:

1. Become a Certified Passive House Designer/Consultant.
2. Attend Building Verification Course & More

Resources

Resources

The Passive House Network

1. A Comparison of Canadian and European Energy Standards for Household Appliances - https://passivehousenetwork.org/featured/appliance -modeling -guide/
2. BC Hydro Building Envelope Thermal Bridging - https://www.bchydro.com/content/dam/BCHydro/customer -portal/documents/power -smart/builders -developers/building -envelope -thermal -bridging -guide -v1-6.pdf
3. Building Certifier Scope of Services - https://passivehousenetwork.org/wp-content/uploads/2024/07/Building-Certifier-Scope-of-Services-JULY-2024-UPDATE.pdf
4. Building Database - https://passivehouse-database.org/index.php?lang=en
5. Buildings for People - https://islandpress.org/books/building -people#desc
6. Certification Criteria - https://passivehouse.com/03_certification/02_certification_buildings/08_energy_standards/08_energy_standards.html
7. Certification Guide - https://passivehouse.com/03_certification/02_certification_buildings/09_guide/09_guide.html
8. Certified Components - https://database.passivehouse.com/en/components/
9. Certifiers Globally - https://passivehouse.com/03_certification/02_certification_buildings/03_certifiers/01_accredited/01_accredited.html
10. Certified Passive House Designer Training - https://passivehousenetwork.org/designer-training/
11. Certified Passive House Tradesperson Training - https://passivehousenetwork.org/tradesperson-training/
12. Construction Cost Analysis of High -Performance Multi -Unit Residential Buildings in British Columbia - https://passivehousenetwork.org/wp-content/uploads/2024/10/CONSTRUCTION-COST-ANALYSIS-OF-HIGH-PERFORMANCE-MULTI-UNIT-RESIDENTIAL-BUILDINGS-IN-BRITISH-COLUMBIA-V3.1.pdf
13. Is Cost the Barrier to Passive House Performance? - https://passivehousenetwork.org/wp-content/uploads/2022/10/Is-Cost-the-Barrier-to-Passive-House-Performance-May-2021-PHN.pdf
14. ISO 9972 - https://www.iso.org/standard/55718.html
15. Manager Declaration Sample - https://passipedia.org/_media/picopen/construction_manager_declaration.pdf
16. National Definition of Zero Emissions Building: https://www.energy.gov/sites/default/files/2024 -06/bto -national -definition -060524.pdf
17. North American Certifiers Circle - https://passivehousenetwork.org/wp-content/uploads/2023/01/NACC-Brochure-Jan-2023.pdf
18. Passipedia - https://passipedia.org/start
19. Passive House Certification - https://passivehousenetwork.org/certification/
20. Passive House Criteria for Buildings - https://passivehouse.com/03_certification/02_certification_buildings/08_energy_standards/08_energy_standards.html
21. Passive House Definition - https://passipedia.org/basics/the_passive_house_-_definition
22. Passive House - Historical Review - https://passipedia.org/basics/the_passive_house_-_historical_review
23. Passive House Planning Package (PHPP) - https://passivehouse.com/04_phpp/04_phpp.htm
24. Safe at Home PHN Report - https://passivehousenetwork.org/safe-at-home/
25. Sample Submission Documents - https://passipedia.org/certification/certified_passive_houses/example_documents
26. Summer Comfort - https://passipedia.org/planning/summer_comfort
27. Thermal Comfort - https://passipedia.org/basics/building_physics_-_basics/thermal_comfort
28. Vancouver Passive House Verification Plan Checklist - https://passivehousenetwork.org/wp-content/uploads/2024/07/Vancouver-Passive-House-Verification-Plan-Checklist-2023.pdf
29. Ventilation Duct Leakage Testing - https://passivehousenetwork.org/product/multifamily-ventilation-duct-leakage-targets-strategies-and-lessons-learned/

Thank you.

www.passivehousenetwork.org

Questions about Title 24?

3C-REN offers a *free* Code Coach Service

Online:
3c-ren.org/codes

Call:
805.781.1201

Energy Code Coaches are local experts who can help answer your Title 24 questions. Coaches have decades of experience in green building and energy efficiency improvements. They can provide citations and offer advice for your project to help your plans and forms earn approval the first time.

Closing

- Continuing Education Units Available
  - Contact shuskey@co.slo.ca.us for AIA LUs
- Coming to Your Inbox Soon!
  - Slides, Recording, & Survey – Please Take It and Help Us Out!
- Upcoming Courses:
  - October 25th - Regional Forum: SMVCA's Inaugural Cornhole Tournament
  - October 30th - Carbon-Free Homes: Features, Benefits, Valuation
  - November 13th - Health and Resilience of Clean Energy Homes
  - November 14th - Modeling All-Electric Homes in the 2022 Energy Code
  - November 19th - Residential Compliance Forms for Permitting
  - November 21st - HRV and ERV Basics
- Visit www.3c-ren.org/events for our full catalog of trainings.

Thank you!

For more info:
3c-ren.org

For questions:
info@3c-ren.org

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TRI-COUNTY REGIONAL ENERGY NETWORK
SAN LUIS OBISPO • SANTA BARBARA • VENTURA