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

Intro to Passive House Trades

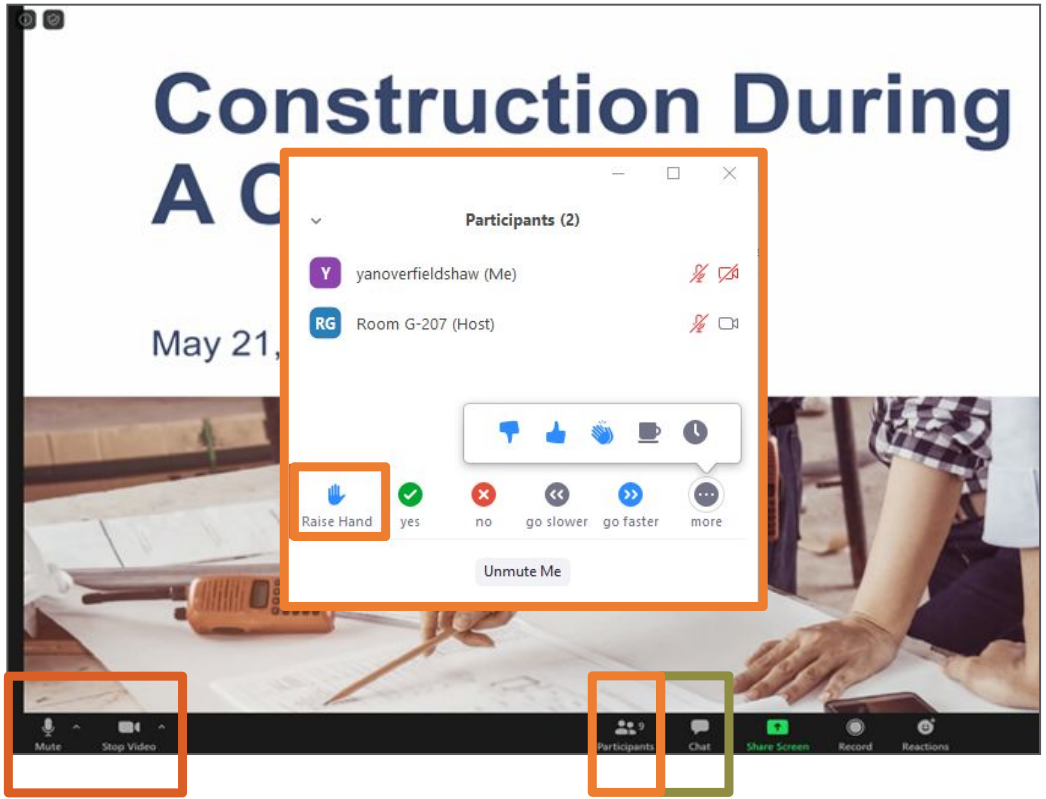
Ken Levenson – Passive House Network

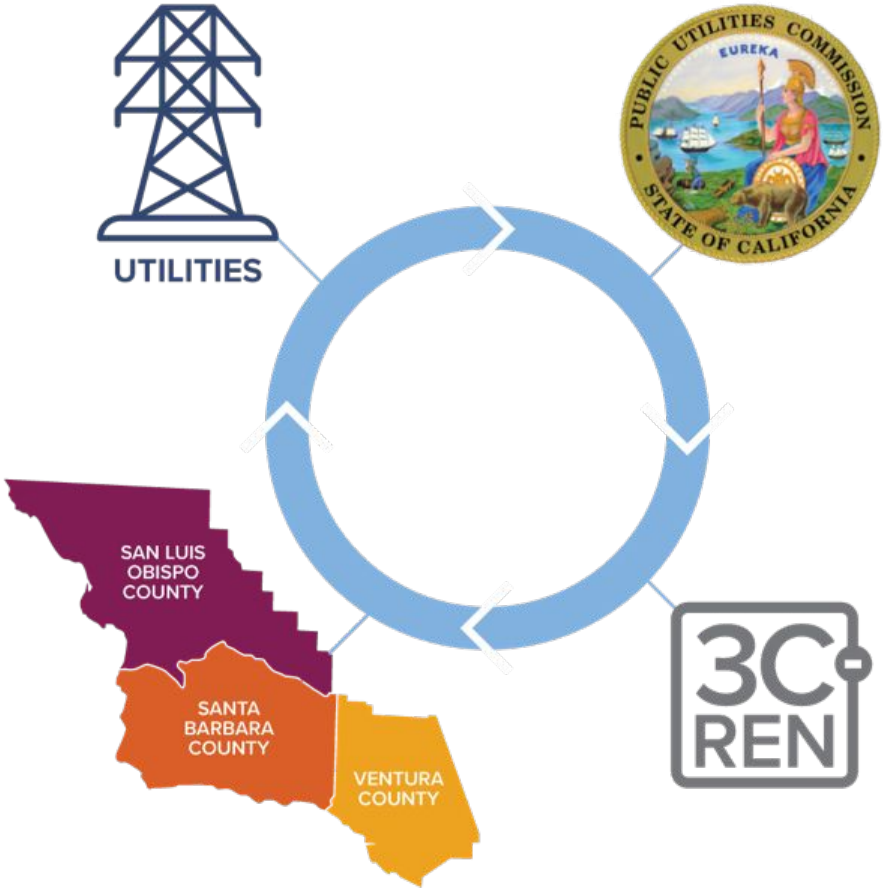
August 14, 2025

The Passive House Network

Zoom Orientation

- Add an **introduction** in the chat.
  Be sure **full name** is displayed.
- Did you call in? Please **share** first and last name with us.
- Please **mute** upon joining
- Use the "**Chat**“ to share questions or comments
- Under "**Participant**" select "**Raise Hand**" to share a question or comment verbally
- Session may be **recorded** and posted to 3C-REN's on-demand page
- Slides/recording are **shared** after most events
- 3C-REN does **not** allow **AI notetakers**, unless used to accommodate a disability.





Tri-County Regional Energy Network

3C-REN is a collaboration between the tri-counties

Our programs reduce energy use for a more sustainable, equitable and economically vibrant Central Coast

Our free services are funded via the CPUC, bringing ratepayer dollars back to the region

Our Services

Incentives

HOME ENERGY SAVINGS

3c-ren.org/for-residents
3c-ren.org/multifamily

COMMERCIAL ENERGY SAVINGS

3c-ren.org/commercial

Contractors can enroll at
3c-ren.org/contractors

Training

BUILDING PERFORMANCE TRAINING

3c-ren.org/events
3c-ren.org/building

ENERGY CODE CONNECT

3c-ren.org/code

View past trainings at
3c-ren.org/on-demand

Technical Assistance

AGRICULTURE ENERGY SOLUTIONS

3c-ren.org/agriculture

ENERGY ASSURANCE SERVICES

3c-ren.org/assurance

PASSIVE DESIGN/BUILD™ BOOTCAMP

REGISTER TODAY!

Ventura, CA

Sep 29 - Oct 3, 2025

PASSIVE DESIGN/BUILD™ BOOTCAMP

REGISTER TODAY!

Ventura, CA

Sep 29 - Oct 3, 2025

Typical Audience

- Builders, General Contractors
- Architects, Designers
- Construction Professionals

Registration

- Upon approval, tuition fees are covered by 3C-REN for professionals operating in the counties of Santa Barbara, San Luis Obispo, and Ventura (scan QR code for more info)
- Some spots available for purchase for participants from outside the 3C-REN territory ($2490/person)

Format: **In-person**

Typical Schedule:

- **Building Science Course -** Sep 29+30
- **Hands-on Workshop -** Oct 1+2
- **Passive House Certification Exam -** Oct 3

Application Deadline: **Sep 19**

In-person days are 8am-5pm

Lunches are provided (Mon-Thu)

Format: **Hybrid**

Typical Schedule:

- **Building Science Course –** 16hr self-paced on-demand, before coming in for the hands-on workshop
- **Hands-on Workshop -** Oct 1+2
- **Passive House Certification Exam -** Oct 3

Application Deadline: **Sep 1**

Introduction to Passive House Trades

Sendero Verde, Handel Architects

The Network

Global Knowledge. Regional Context. Local Applications





















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 1PHA

Passive House Institute

DESIGNER
CERTIFIED PASSIVE HOUSE DESIGNER

CERTIFIED PASSIVE HOUSE TRADESPERSON
TRADESPERSON

Certified Passive House
Passive House Institute

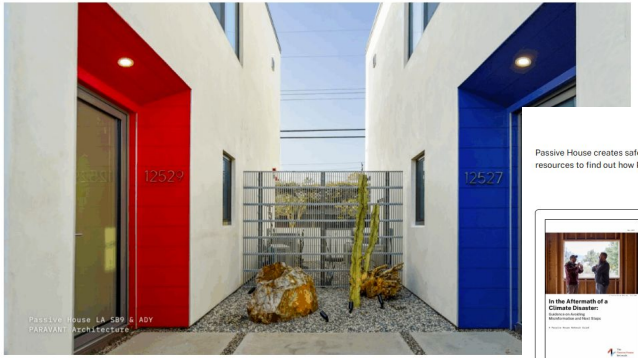
Climate Disaster Support

First Steps FAQs Become a Member Merch Donate

The Passive House Network Education Community Resources Events LOGOUT MY ACCOUNT

Climate Disaster Support

A resource page supporting homeowners rebuilding after a climate disaster.



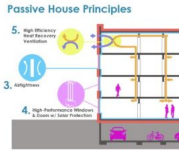
What is Passive House?

Passive House is a method of design and construction that prioritizes occupant comfort, health, and safety, while lowering monthly utility bills by up to 50%.

Based on over 30 years of scientific research, Passive House is an international standard used to create buildings all over the world. From single-family homes, to office buildings, to factories, and more, Passive Houses can be built anywhere, for any purpose.

In a world where the building sector produces almost 40% of greenhouse gas emissions, Passive House is the key to a greener, safer, and more efficient future.

Learn more about the Passive House Basics



Rebuilding with Passive House

Passive House creates safer communities, especially in areas prone to extreme weather. From winter storms to wildfires, explore these resources to find out how Passive House can keep you safer during Climate Disasters.

In the Aftermath of a Climate Disaster — Guidance on Avoiding Misinformation and Next Steps: It can be difficult to know what the next steps are after a Climate Disaster. This brief lays out 5 steps you can take to ensure a smooth rebuilding journey, and lists the reasons why rebuilding with Passive House can keep your community safer.

Download the Brief

Homeowner's Insurance & Wildfire Preparedness Guide: This two-page document offers an outline of your possible coverage options when it comes to wildfires, along with a guide on steps to take if you need to file a claim.

Download the Flyer

Blue Ribbon Commission on Climate Action and Fire-Safe Recovery: This report, released with UCLA, recommends high-performing building standards like Passive House for wildfire-vulnerable counties in California, especially Los Angeles.

Download the Report

5 Takeaways from the Blue Ribbon Commission Report: We highlight 5 takeaways from the report with action items and resources from PHN that you can take.

Download the Flyer

PHN Presents — Passive House & Fire Resilience: Our free online webinar explains how Passive House & Fire Resilient building techniques can be combined to create a better-protected building and surrounding landscape. Hear from experts in both the Passive House Community and the National Fire Protection Association.

Watch the Video

5 Ways Passive House Supports Fire Resilience: Learn the basics about the Passive House building standard, how Passive House supports a healthy planet, and how Passive House can support Fire Resilience. Then, explore education and community building resources from PHN.

Download the Flyer

Design Competition

Submission Deadline, September 30th

Tuesday, November 4th

AIA Los Angeles

PHCA PASSIVE HOUSE CALIFORNIA

...to develop a groundbreaking catalog of high-performance homes to inspire and inform the rebuilding efforts in the aftermath of the Eaton and Palisades Fires.

Certified Professionals

Financial incentives available.

Pacific Cohort Schedule

Fall 2025 - On-Demand / Live Online CPHD/C Training

October 2nd start

Depending on your learning preferences, **you can tackle this course in three ways:**

1. Focus on the **on-demand** content and view recordings of live online content. **(Most flexible)**
2. Stick to the cohort schedule of live online sessions. **(Best for clear pacing and making connections and community)**
3. Do a mix! Start before or after the cohort registration deadline, focus on the on-demand format at your pace, and attend the live online sessions as makes sense for you. **(Most popular)**

On-Demand		Live Online Activities		
Week Starts	**Content**	**Activity Date/Time**	**Activity**	**Led by**
9/29/25	Module 1: **Introduction** Module 2: **Insulation**	10/2/25 | 12-1 PM PT	Kick-Off	PHN
10/6/25	Module 3: **Airtightness** Module 4: **Thermal Bridging** Module 5: **Windows**	10/9/25 | 12-1 PM PT	Q&A Session 1	CPHD Practitioner
10/13/25	Webinar 1: **Building Envelope** Module 6: **Ventilation**	10/16/25 | 9-12 PM PT	Webinar 1: Building Envelope	PHN Trainer
10/20/25	Module 7: **Heating & DWH** Module 8: **Cooling** Module 9: **Certification**	10/23/25 | 9-11:30 AM PT	Open Review	Ken Levenson
10/27/25	Module 10: **Economics** Module 11: **QA/QC** Module 12: **Bidding**	10/30/25 | 12-1 PM PT	Q&A Session 2	CPHD Practitioner
11/3/25	Webinar 2: **Building Services & Economics** Review Exam Prep Modules	11/6/25 | 9-12 PM PT	Webinar 2: Building Services & Economics	PHN Trainer
11/10/25	Module 13: **designPH** Module 14: **PHPP** Review Exam Prep Modules	-	-	-
11/17/25	Module 15: **Exam Prep Course & Wrap-up** Review Exam Prep Modules	-	-	-
11/24/25	Review Exam Prep Modules	11/25/25 | 9-11 AM PT	**Exam Review**	PHN Trainer
12/1/25	Review Exam Prep Modules	12/4/25 | 9-10 AM PT	**Tech Setup (Required)**	PHN with PHA
12/8/25	**Exam**	12/11/25 | 9-12 PM PT	**PHI CPHD/C Exam**	PHN with PHA

All live online sessions - excluding the Tech Setup & Exam - will be recorded and made available for all cohort students for reference.

Agenda

1. Intro to Passive House
2. Passive House Criteria
3. Team & Process Overview
4. Enclosure
5. Mechanical Systems
6. QA/QC
7. Resources


Waring School, Massachusetts, Opal Architecture

Introduction to Passive House Trades

PHN's Introduction to Passive House Trades course is a comprehensive dive into constructing residential and commercial Passive House buildings, specifically at the enclosure and mechanical trades.

There will be a brief introduction to Passive House about the basic principles and the drivers of Passive House performance that most concern builders' work.

The enclosure section will look at typical construction types, windows and installation, air barriers and insulation, and new, innovative PH products. The mechanical will look at the ventilation heating, cooling systems, and domestic hot water.

The work of the trades will be clearly placed in the context of Passive House performance, the role of each aspect of construction, its sequencing - and the importance of the tradesperson's work in achieving the target goals.

2 AIA LUs Credit, #IntroTrades2hr

Learning Objectives:

1. Describe the five key principles of Passive House projects.
2. Summarize typical materials, methods, and components used in Passive House enclosures and mechanical systems.
3. Outline typical Passive House construction sequencing.
4. Describe the basic approach to quality control, verification and commissioning.

Introductions

Please answer questions in the comments:

1. Name? (if you'd like)
2. Location?
3. Typical project role/background?
4. Any previous Passive House knowledge or experience? If so, what?

Personal Start: A Townhouse Retrofit

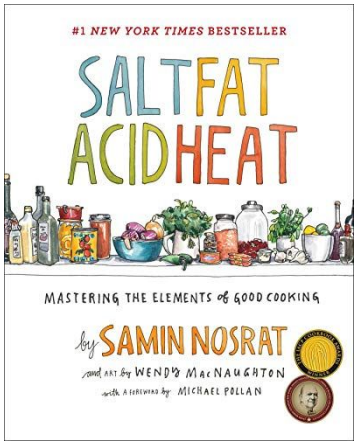
Brooklyn, NY

Intro to Passive House

How we use fundamental elements matters

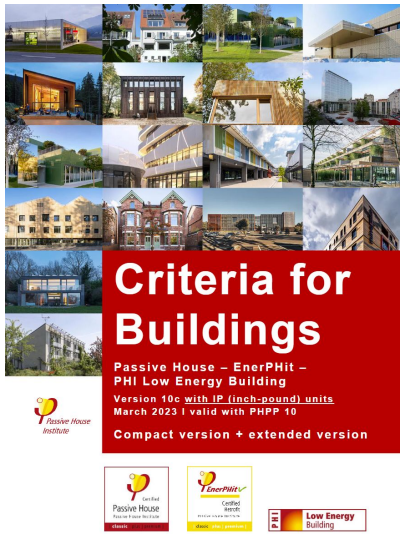
“I was working as a physicist. I read that the construction industry had experimented with adding insulation to new buildings and that energy consumption had failed to reduce. This offended me – it was counter to the basic laws of physics. I knew that they must be doing something wrong. So I made it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

- Wolfgang Feist



Passive House masters the elements of high-performance building.

What is Passive House?



- Passive House is a building standard
- Applies to new & existing buildings
- The most rigorous energy efficiency certification available
- Performance-based approach
- Focuses on mastering the drivers of building performance.

Project Types – Not Just Houses!

The House at Cornell Tech

Star Garment Factory

Betances V

Goals of Passive House

- Thermal Comfort
- Hygienic conditions
  - No mold
  - Healthy indoor air quality
- Energy Efficiency
- Durability

  +
- Affordability

Wildfire Resilience

5 Ways Passive House Supports Fire Resilience

Passive House delivers high-quality homes that are healthy, comfortable, efficient, and resilient. Passive house characteristics can also make your home more resistant to wildfire and smoke damage.

Sunflower Sanctuary, Shape Architecture

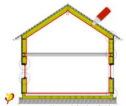
Here's how:

1. A Simpler Form

With fewer enclosure junctions, such as the ins and outs of dormers, eaves, overhangs, rooflines, and floorplans, a simpler form denies burning embers the opportunity to lodge in the building construction.

2. Continuous Insulation

Installed like a protective blanket around the entire structure, non-combustible insulation can shield the building from fire and deny the fire its fuel.



Wrapped in insulation & airtightness

3. Airtightness

The airtight enclosure keeps wind-driven burning embers and smoke out.

4. High-Performance Windows

Triple-pane windows, surrounded by robust frames, provide views, daylight, natural ventilation, and fire protection.

Robust glazing & frames

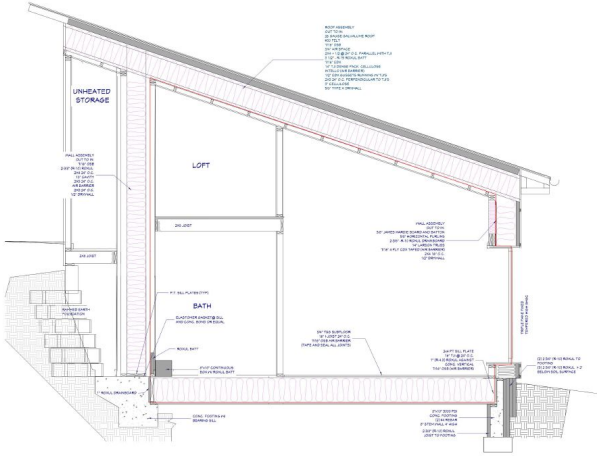
5. High-Performance Ventilation System

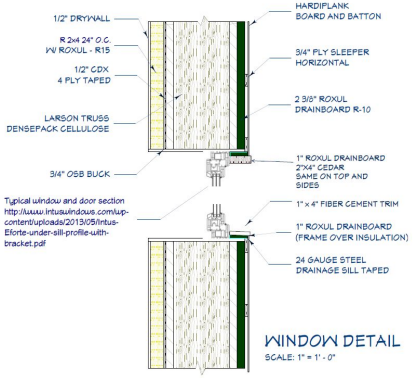
Filtered fresh air is continuously supplied while exhausting the stale air, providing healthy indoor air quality in polluted, smoky surroundings.

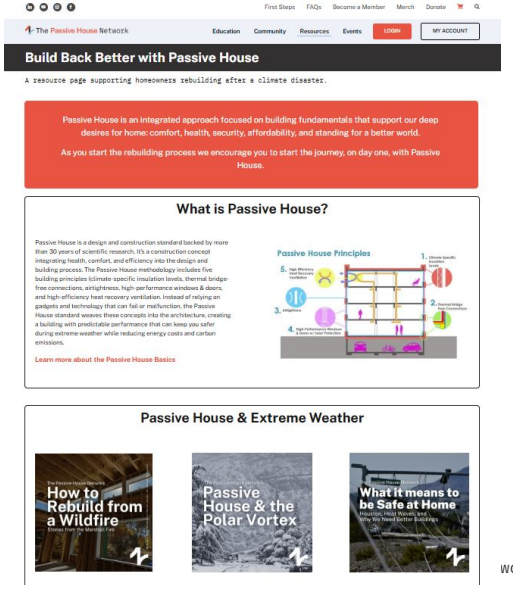
Be sure to take other common-sense measures like eliminating fossil fuels, using Class A fire-resistant materials at the exterior, and surrounding your home with fire-smart landscaping. Facing extreme conditions, let's design and build for a resilient future with Passive House.

@the_phnetwork The Passive House Network www.passivehousenetwork.org

Andrew Michler, Hyperlocal Workshop

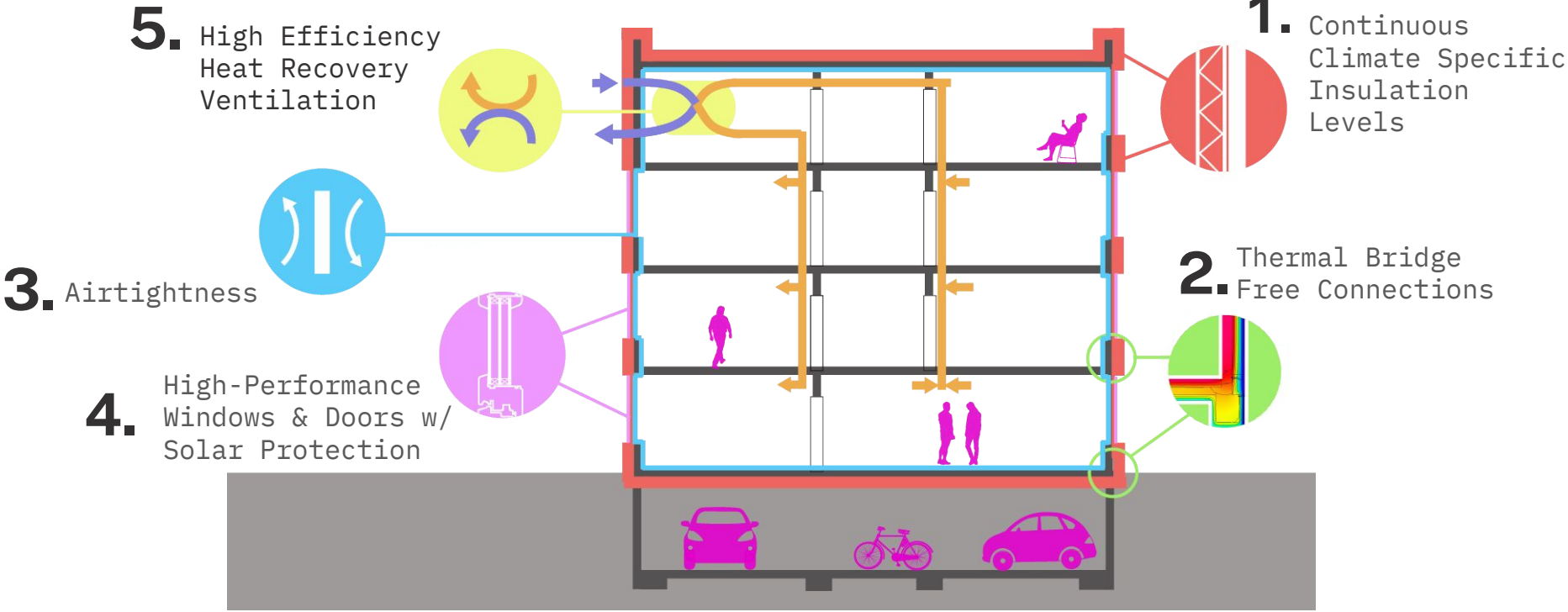






Plus:
Class A fire Spread rated materials
Vulcan Vents at eaves
Landscaping

5 Principles of Construction (the drivers)



These are the 5 things builders must focus on most intently.

Energy Modeling: Calculating Predictable Performance

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

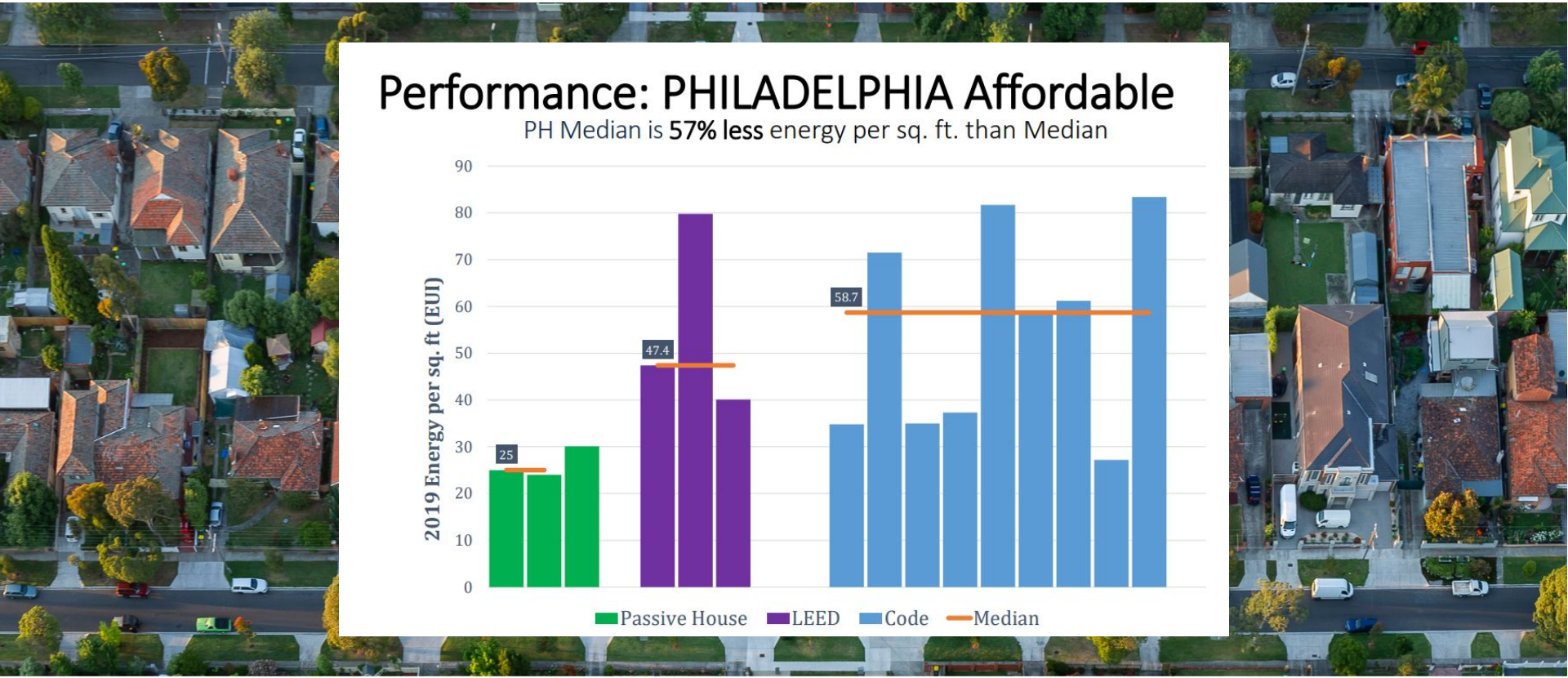
Window area orientation (main orientations)	Global radiation	Shading	Dirt	Non-vertical radiation incidence	Glazing fraction	SHGC	Solar irradiation reduction factor
Standard values →	kWh/(ft²yr)	0.75	0.95	0.85			
North	14	0.56	0.95	0.85	0.58	0.50	0.26
East	33	0.79	0.95	0.85	0.63	0.50	0.40
South	62	0.81	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

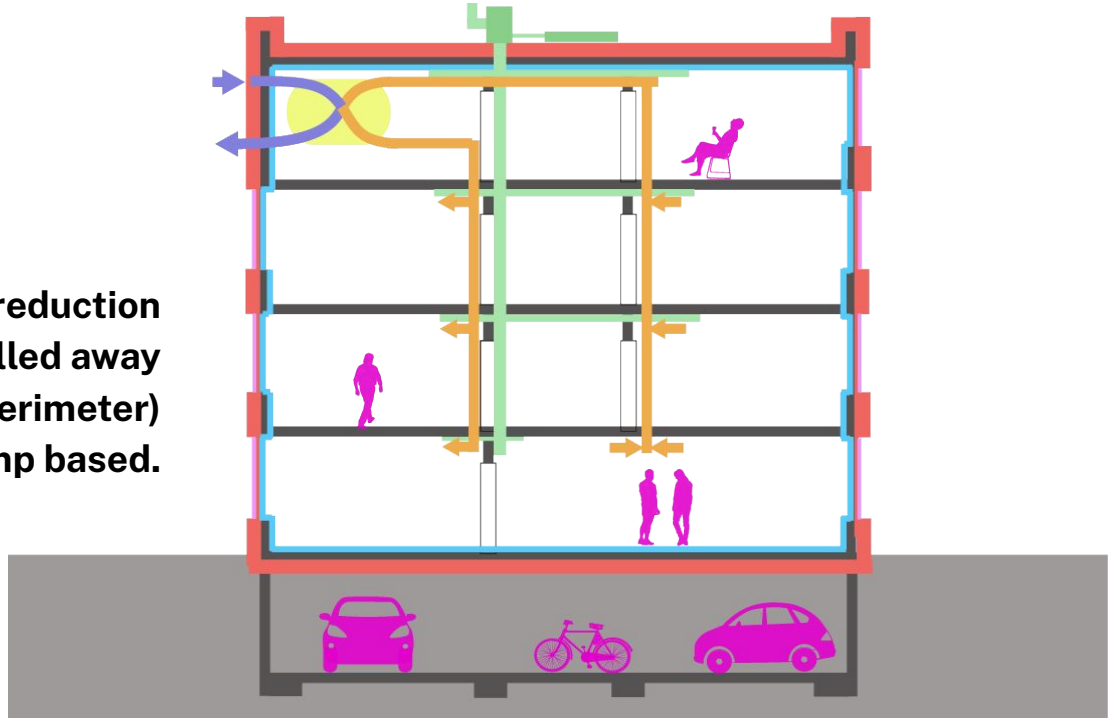
Qua n-tity	Description	Deviation from north	Angle of inclination from the horizontal	Orien- tation	Window rough ope Width	Height	Installed in Selection from 'Areas' worksheet	Glazing Selection from 'Components' worksheet	Frame Selection from 'Components' worksheet	g-Value Perpen-dicular radiation	U-Value Glazing	Frames (avg.)	Ψ Glazing edge 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			BTU/hr.ft².F or 1/0
1	W104	90	90	East	3.00	4.86	4-Wall_9351_E	01ud-Triple-insulated-Kr08	02ud Si82+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 Si82+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 Si82+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 Si82+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 AD575 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 Si82+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 Si82+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 Si82+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 Si82+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 Si82+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 Si82+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 Si82+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 Si82+Operable	0.50	0.11	0.19	0.018	1	1	1

Predictable Performance is THE thing.



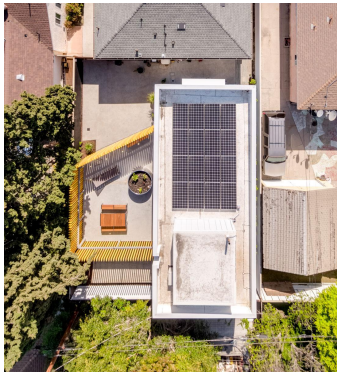
Right size Heating & Cooling Systems

75% equip sizing reduction
Efficient distribution (Pulled away from perimeter)
Often all-electric, heat pump based.



Single Family: Los Angeles

- 1791 SF
- Heating load – 1850 BTU/540 watts
- Cooling load – 5400 BTU/1580 watts
- **Net Zero with 9kW Solar PV**



Credit: Paravant Architects

Construction is complicated!

So many demands:

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

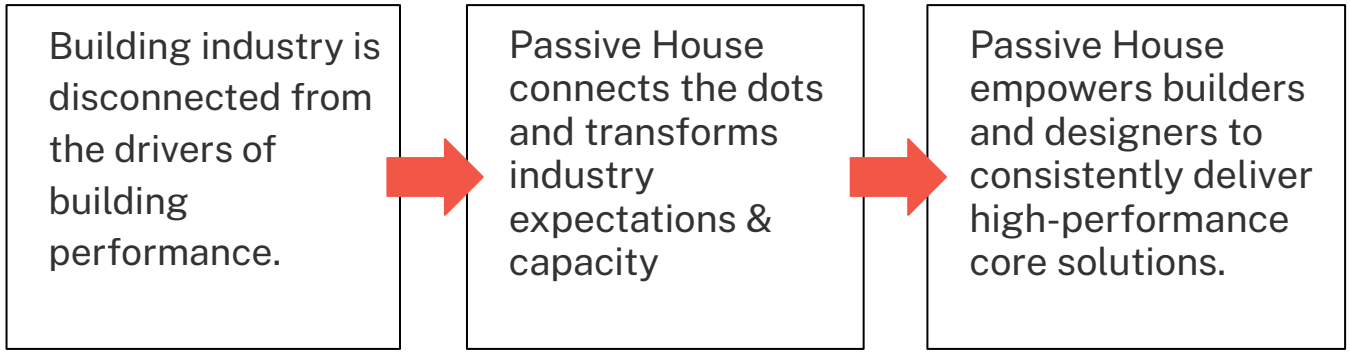
Passive House Focus: Hygiene, Comfort and Efficiency

What Trades to Focus on

- Carpentry
- Masonry
- Steel
- Foundation work
- Heating, Cooling & Ventilation
- Plumbing
- Electrical
- Verification, Testing & Commissioning

Each should have a general understanding of Passive House & specific knowledge of their works impact. Connect the work to final performance results.

Logic of Passive House

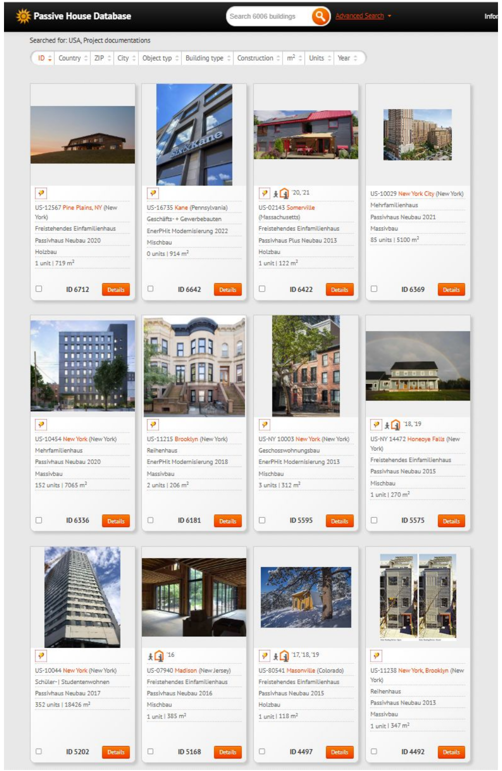


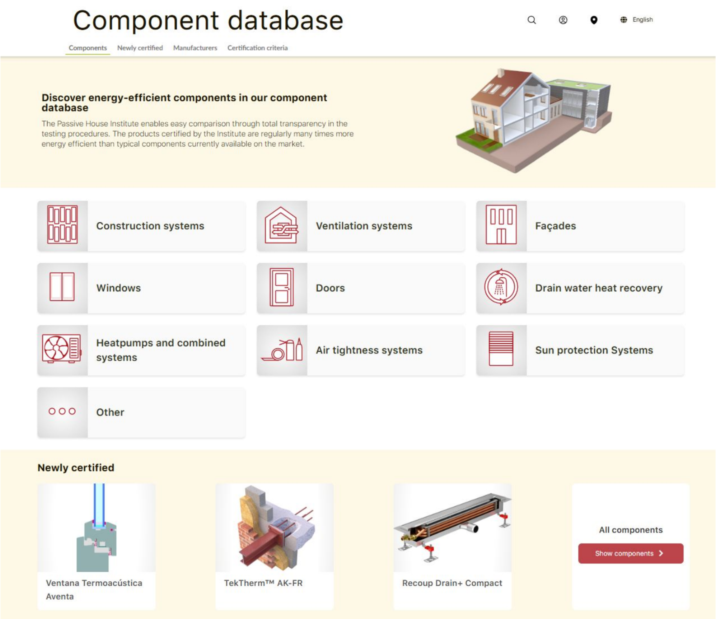
Focus makes high quality affordable

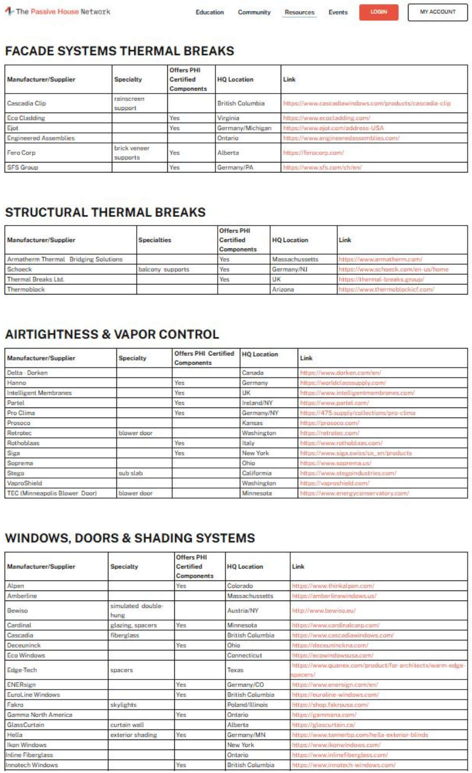
Anyone can build Passive House with modest but specific training.

It’s more about building intentionally and simply.

Access what's available: Project documentation, Certified Components, Manufacturer Directory







FACADE SYSTEMS THERMAL BREAKS

Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
Cascadia Clip	rainscreen support		British Columbia	https://www.cascadiawindows.com/products/cascadia-clip
Eco Cladding		Yes	Virginia	https://www.ecocladding.com/
Ejot		Yes	Germany/Michigan	https://www.ejot.com/address-USA
Engineered Assemblies			Ontario	https://www.engineeredassemblies.com/
Fero Corp	brick veneer supports	Yes	Alberta	https://ferocorp.com/
SFS Group		Yes	Germany/PA	https://www.sfs.com/ch/en/

STRUCTURAL THERMAL BREAKS

Manufacturer/Supplier	Specialties	Offers PHI Certified Components	HQ Location	Link
Armatherm Thermal Bridging Solutions		Yes	Massachussetts	https://www.armatherm.com/
Schoeck	balcony supports	Yes	Germany/NJ	https://www.schoeck.com/en-us/home
Thermal Breaks Ltd.		Yes	UK	https://thermal-breaks.group/
Thermoblock			Arizona	https://www.thermoblockicf.com/

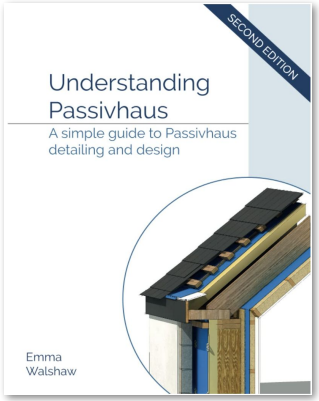
AIRTIGHTNESS & VAPOR CONTROL

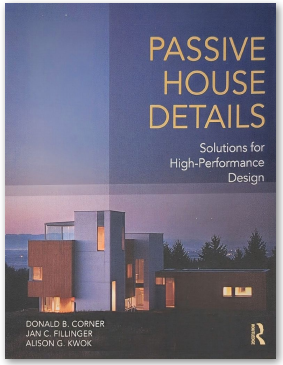
Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
Delta - Dorken			Canada	https://www.dorken.com/en/
Hanno		Yes	Germany	https://worldclasssupply.com/
Intelligent Membranes		Yes	UK	https://www.intelligentmembranes.com/
Partel		Yes	Ireland/NY	https://www.partel.com/
Pro Clima		Yes	Germany/NY	https://475.supply/collections/pro-clima
Prosoco			Kansas	https://prosoco.com/
Retrotec	blower door		Washington	https://retrotec.com/
Rothoblaas		Yes	Italy	https://www.rothoblaas.com/
Siga		Yes	New York	https://www.siga.swiss/us_en/products
Soprema			Ohio	https://www.soprema.us/
Stego	sub slab		California	https://www.stegoindustries.com/
VaproShield			Washington	https://vaproshield.com/
TEC (Minneapolis Blower Door)	blower door		Minnesota	https://www.energyconservatory.com/

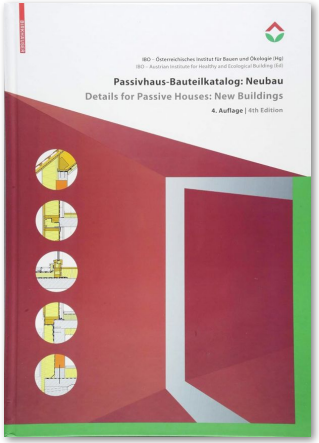
WINDOWS, DOORS & SHADING SYSTEMS

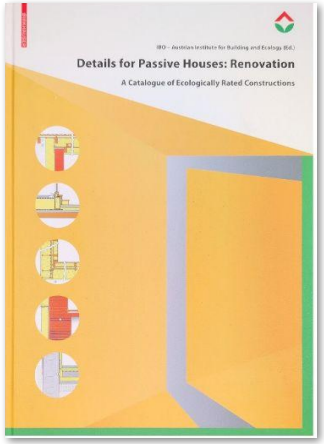
Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
Alpen		Yes	Colorado	https://www.thinkalpen.com/
Amberline			Massachussetts	https://amberlinewindows.us/
Bewiso	simulated double-hung		Austria/NY	http://www.bewiso.eu/
Cardinal	glazing, spacers	Yes	Minnesota	https://www.cardinalcorp.com/
Cascadia	fiberglass		British Columbia	https://www.cascadiawindows.com/
Deceuninck		Yes	Ohio	https://deceunincknа.com/
Eco Windows			Connecticut	https://ecowindowsusa.com/
Edge-Tech	spacers		Texas	https://www.quanex.com/product/for-architects/warm-edge-spacers/
ENERsign		Yes	Germany/CO	https://www.enersign.com/en/
EuroLine Windows		Yes	British Columbia	https://euroline-windows.com/
Fakro	skylights		Poland/Illinois	https://shop.fakrousa.com/
Gamma North America		Yes	Ontario	https://gammana.com/
GlassCurtain	curtain wall		Alberta	https://glascurtain.ca/
Hella	exterior shading	Yes	Germany/MN	https://www.tannerbp.com/hella-exterior-blinds
Ikon Windows			New York	https://www.ikonwindows.com/
Inline Fiberglass			Ontario	https://www.inlinefiberglass.com/
Innotech Windows		Yes	British Columbia	https://www.innotech-windows.com/

Books and more

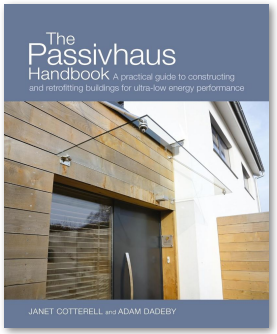


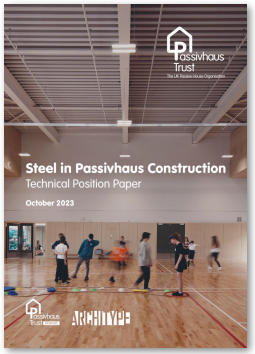


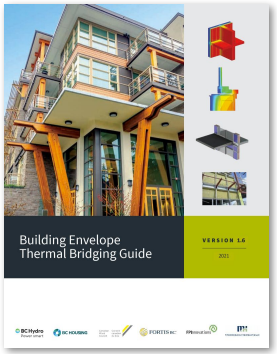


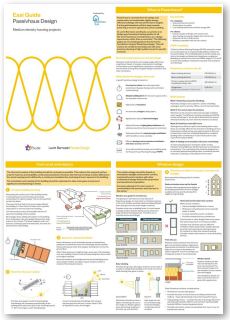


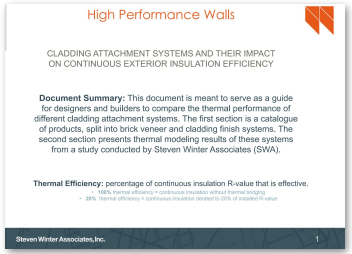
https://issuu.com/lafamillecarbonic/docs/passive_architecture_en



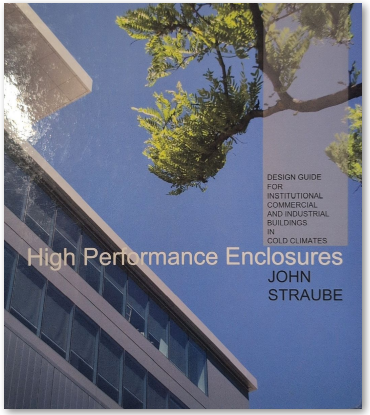


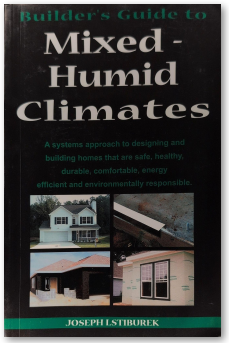


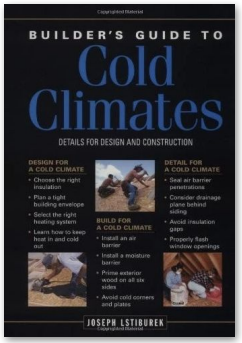


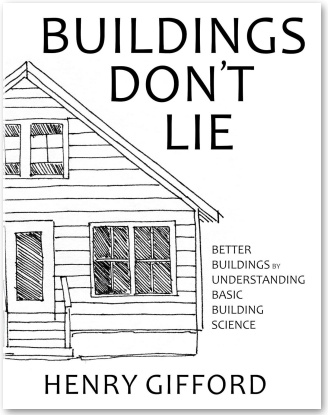


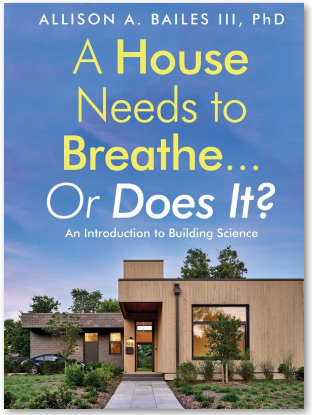
And more...

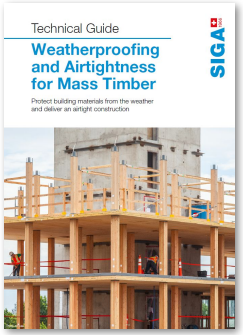

DESIGN GUIDE FOR INSTITUTIONAL COMMERCIAL AND INDUSTRIAL BUILDINGS IN COLD CLIMATES
High Performance Enclosures
JOHN STRAUBE

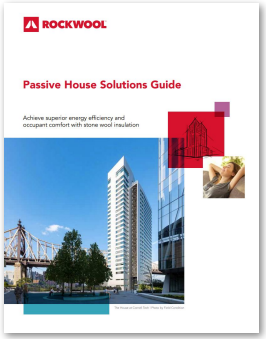

Builder's Guide to
Mixed - Humid Climates
JOSEPH LSTIBUREK

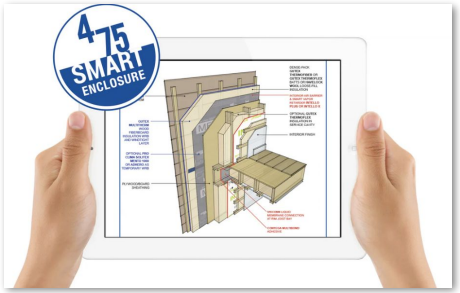

BUILDER'S GUIDE TO
Cold Climates
DETAILS FOR DESIGN AND CONSTRUCTION
JOSEPH LSTIBUREK


BUILDINGS DON'T LIE
BETTER BUILDINGS BY UNDERSTANDING BASIC BUILDING SCIENCE
HENRY GIFFORD


ALLISON A. BAILES III, PhD
A House Needs to Breathe... Or Does It?
An Introduction to Building Science

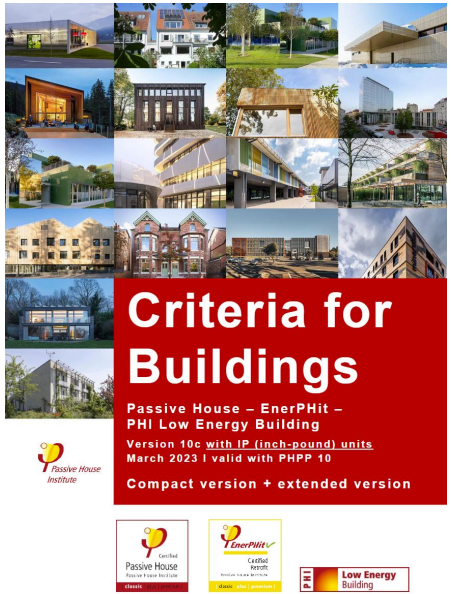

Technical Guide
Weatherproofing and Airtightness for Mass Timber
SIGA


ROCKWOOL
Passive House Solutions Guide


475 SMART ENCLOSURE

The Passive House Criteria

Criteria: Goals



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

\+ Affordable

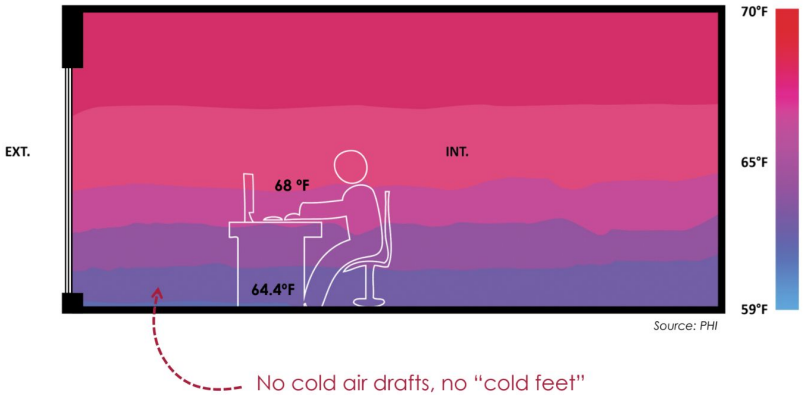
Criteria: Enclosure Quality

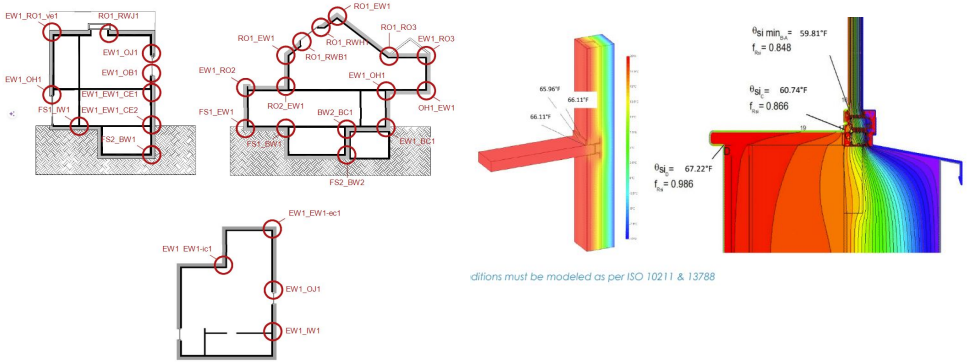
Thermal Protection (COMFORT)

- Interior Surface Temperatures: not more than 7.6 F below the operative indoor temperature.
- Floors: not below 66.2 F, Checked against 71.6 F in PHPP

Moisture Protection (HYGIENE/HEALTH)

fRsi defines the coldest point which can occur on the interior surface of a construction system. For example, if the temperature factor is 0.7, then 70% of the temperature difference between the inside and outside air is still present at the interior surface. If the temperature factor is achieved, then mould and condensation formation can be safely prevented at normal outdoor temperatures, indoor temperatures and indoor air humidity levels.



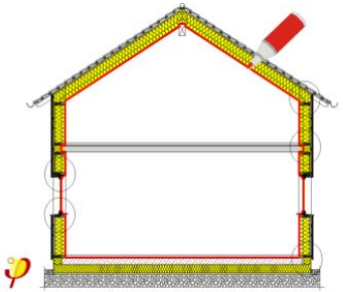


Even internal surface temperatures - Details matter a lot!

Criteria: Enclosure Quality

Airtightness (Health, Comfort & Durability)

- Whole building test result of equal or less than **0.60 ACH50**.
- Average of depressurization & pressurization.



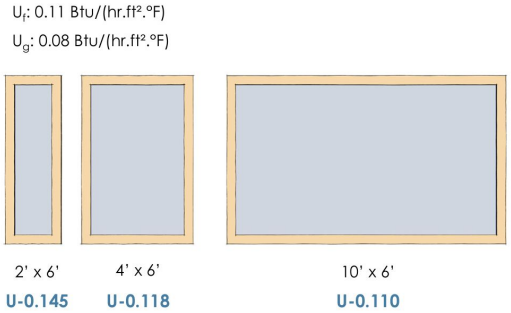
Airtight Building Envelope

Description of airtight cover
Air barrier spans the concrete slab on grade, transitions to the metal wall panel that has an interior air and vapor barrier which tranisitions to the concrete roof slab

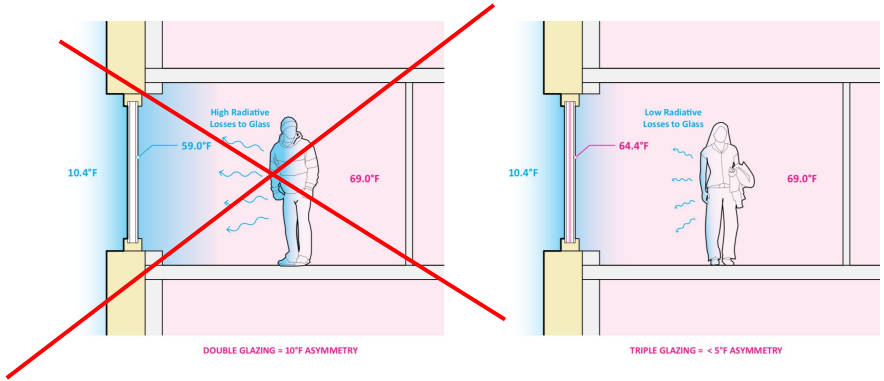
0.13 ACH50 final test = 0.15 CFM/SF

Criteria: High-Performance Windows & Doors

- Airtight
- Excellent thermal performance
- Interior Surface Temperatures: not more than 7.6 F below the operative indoor temperature.

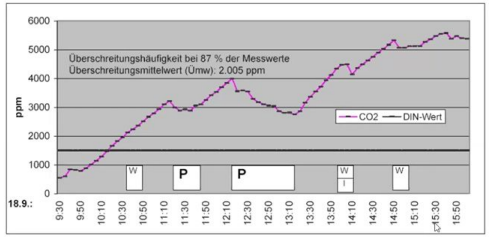


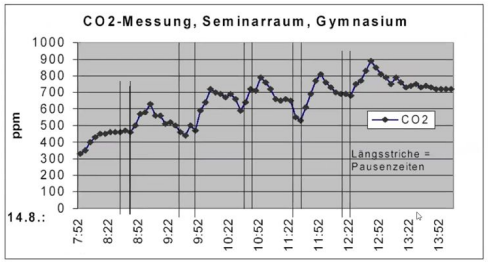
Less Frame = Better Performance

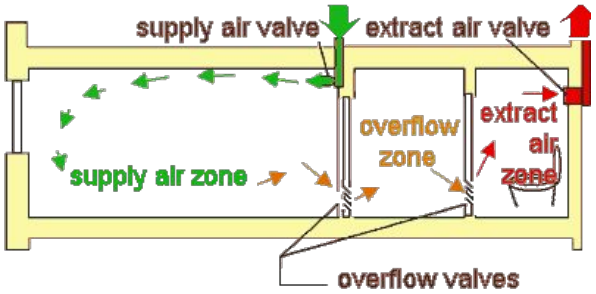


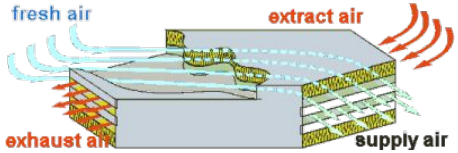
Criteria: Ventilation

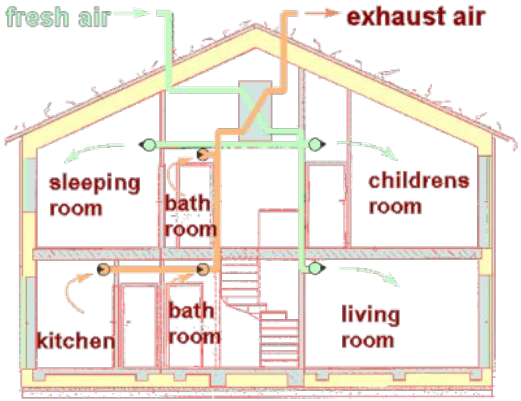
1. Sufficient filtered fresh air to all occupied spaces
2. User control and boost
3. 75% min system heat recovery efficiency
4. Fan power efficiency <0.765 W/CFM
5. Balanced Flow: <10% disbalance between fresh air supply and exhaust air.











Criteria: Other MEP

Heating & Cooling:

1. No hard rules but must be efficient.
2. While heat pumps are now common any type of system is possible.
3. Typical successful approaches.
    a. Keep it simple and small (right sized):
    b. Combined heat/cooling systems
    c. Minimize refrigerant lines.

Domestic Hot Water:

1. Efficient piping layout - minimizing circulation.
2. Well insulated hot water piping & accessories.
3. Efficient heater: Heat pump encouraged.
4. Efficient pumps.
5. Bath waste water heat recovery encouraged.

Appliances & Lighting:

1. Efficient appliances and lighting.
2. All-electric encouraged.

"Do no harm": **Minimize "accidental" heating & cooling.** *Only use what you need.*

Criteria: Energy (energy limits drive health & comfort)

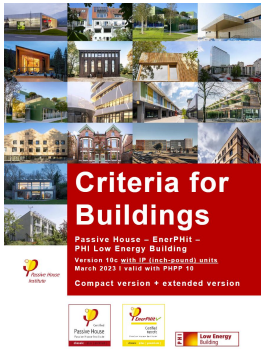


Table 1 Passive House criteria

			Criteria[1]			Alternative Criteria[2]
Heating						
Heating demand	[kBTU/(ft²yr)]	≤	4.75			-
Heating load[3]	[BTU/(hr.ft²)]	≤	-			3.17
Cooling						
Cooling + dehumidification demand	[kBTU/(ft²yr)]	≤	4.75 + variable allowance[4]			
Airtightness						
Pressurization test result n_{50}	[1/hr]	≤	0.6			
Renewable Primary Energy (PER)[5]			Classic	Plus	Premium	
PER demand[6]	[kBTU/(ft²yr)]	≤	19.02	14.26	9.51	±4.75 kBTU/(ft²yr) deviation from criteria…
Renewable energy generation[7] (with reference to projected building footprint)	[kBTU/(ft²yr)]	≥	-	19.02	38.04	…with compensation of the above deviation by different amount of generation[8]

Table 5 PHI Low Energy Building criteria

			Criteria[1]	Alternative Criteria[2]
Heating				
Heating demand	[kBTU/(ft²yr)]	≤	9.51	
Cooling				
Cooling + dehumidification demand	[kBTU/(ft²yr)]	≤	Passive House requirement[3] + 4.75	
Airtightness				
Pressurization test result n_{50}	[1/hr]	≤	1.0	
Renewable Primary Energy (PER)[4]				
PER demand[5]	[kBTU/(ft²yr)]	≤	23.77	Exceeding the criteria up to +4.75 kBTU/(ft²yr) is permitted…
Renewable energy generation[6] (with reference to projected building footprint)	[kBTU/(ft²yr)]	≥	-	…with compensation of the above deviation by additional generation

PHI Low Energy Building

Renovation Energy Criteria: EnerPHit

Table 3 EnerPHit energy demand criteria (as an alternative to Table 2)

Climate zone according to PHPP	Heating	Cooling
	Max. heating demand	Max. cooling + dehumidification demand
	[kBTU/(ft²yr)]	[kBTU/(ft²yr)]
Arctic	11.09	equal to Passive House requirement[1]
Cold	9.51	
Cool-temperate	7.92	
Warm-temperate	6.34	
Warm	4.75	
Hot	-	
Very hot	-	

or

Table 2 EnerPHit component criteria

Climate zone according to PHPP	Opaque envelope[1] against...				Windows (including exterior doors)					Ventilation	
	...ground	...ambient air			Overall[4]			Glazing[5]	Solar load[6]		
	Insu-lation	Exterior insulation	Interior in-sulation[2]	Exterior paint[3]	Max. heat transfer coefficient ($U_{D/W,installed}$)			Solar heat gain coefficient (SHGC)	Max. specific solar load during cooling period	Min. heat reco-very rate[7]	Min. hu-midity re-covery rate[8]
	Min. thermal resistance (R-value)			Cool colours							
	[hr.ft².°F/BTU]			-	[BTU/hr.ft².°F]			-	[kBTU/(ft²yr)]	%	
Arctic	Deter-mined in PHPP from project specific heating and cooling degree days against ground.	63.09	22.71	-	0.08	0.09	0.11	U_g - SHGC*0.7 ≤ 0	32	80%	-
Cold		47.32	18.93	-	0.11	0.12	0.14	U_g - SHGC*1.0 ≤ 0		80%	-
Cool-temperate		37.86	16.22	-	0.15	0.18	0.19	U_g - SHGC*1.6 ≤ 0		75%	-
Warm-temperate		18.93	11.36	-	0.18	0.19	0.21	U_g - SHGC*3.2 ≤ -0.6		75%	-
Warm		11.36	7.57	-	0.22	0.23	0.25	-		-	-
Hot		11.36	7.57	Yes	0.22	0.23	0.25	-		-	60 % (humid climate)
Very hot		22.71	12.62	Yes	0.18	0.19	0.21	-		-	60 % (humid climate)

plus

Table 4 General EnerPHit criteria (always applicable irrespective of the chosen method)

			Criteria[1]			Alternative Criteria[2]
Airtightness						
Pressurization test result n_{50}	[1/hr]	≤	1.0			
Renewable Primary Energy (PER)[3]			Classic	Plus	Premium	
PER demand[4]	[kBTU/(ft²yr)]	≤	19.02	14.26	9.51	±4.75 kBTU/(ft²yr) deviation from criteria...
			+ allowance for larger heating/cooling demand (compared to Passive House)			
Renewable energy generation[5] (with reference to projected building footprint)	[kBTU/(ft²yr)]	≥	-	19.02	38.04	...with compensation of the above deviation by different amount of generation

30+ Certifiers Working in the US

Active Certifiers in the US include:

1. CertiPHIers Cooperative
2. Emu Passive
3. Herz & Lang
4. Home Energy Services
5. Passive House Academy
6. Passive House Institute
7. Peel Passive House
8. RDH Building Science
9. Steven Winter Assoc

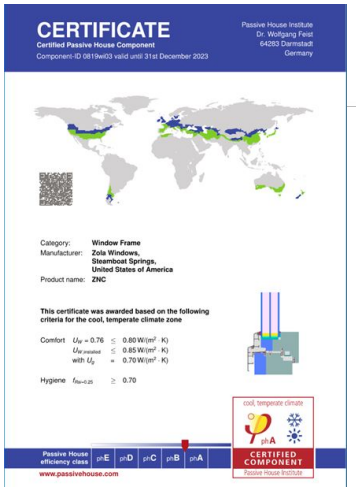
https://passivehousenetwork.org/certification/

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

Organisation	Country	Website	Building Certifier
CertiPHIers Cooperative, Inc.	United States of America	http://www.certiphiers.com	• Matthew Bowers, Languages: en • Tad Everhart, Languages: en • Rolf Jacobson, Languages: en • Chris Petit, 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

Certified Passive House Components



Climate icon legend

- Arctic
- Cold
- Cool, temperate
- Warm, temperate
- Warm
- Hot
- Very hot

Opaque building envelope

- Construction systems
- Floor slabs
- Wall and column connections
- Balcony connections
- Façade anchors
- ICF for roof parapets
- Attic staircases
- Flue systems
- Airtightness systems

Transparent building envelope

- Windows
- Roof windows
- Skylights
- Curtain wall systems
- Glass roofs
- Openable elements in glass roof
- Shutters
- Entry doors
- Sliding doors
- Glazing
- Glazing edge bonds
- Fall protections

Building services

- Heat pumps
- Ventilation systems (capacity < 600 m^3/h)
- Decentralised ventilation system (single room only / with second room connection)
- Decentralised ventilation system (school room)
- Ventilation systems (capacity > 600 m^3/h)
- Drain water heat recovery
- Exhaust air wall system

CERTIFIED COMPONENT
Passive House Institute

https://database.passivehouse.com/en/components/

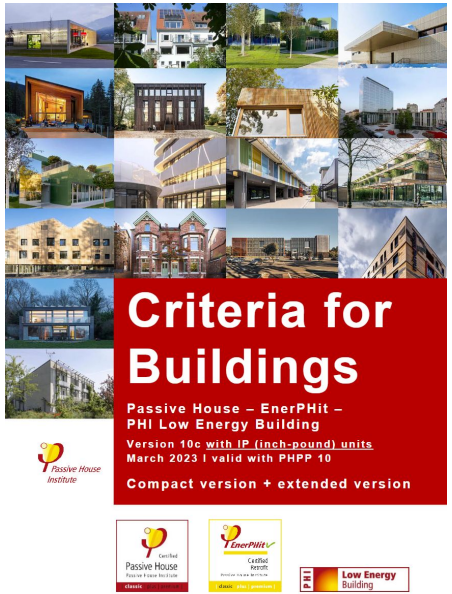
Certified Professionals

The on-demand and hybrid formats allow students to leverage the benefits of on-demand & live online training to best meet their learning preferences. 35 AIA LU/HSW credits

https://passivehousenetwork.org/designer-training/

https://passivehousenetwork.org/tradesperson-training/

Criteria Goals in Summary



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

\+ Affordable

1. Interior Surface Temperatures
2. Airtightness
3. Ventilation
4. Efficient MEP

Team & Process Overview

Assemble the team to deliver a Passive House

- Architects
- Engineers
- Consultants
- Passive House Consultant

- Builder & Trades

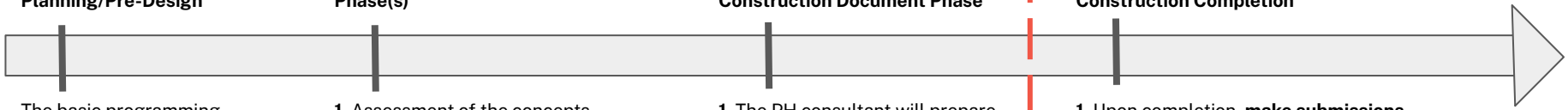
- Verifier/Verification
  - Inspectors
  - Ventilation Commissioning
  - Blower door testers

- Certifier

What a team needs:

1. common language
2. common goal: Passive House
3. good attitudes
4. enough training
5. willingness to work as a team and connect the dots

Certification Process Overview



Initial Check
Planning/Pre-Design

The basic programming complete, engage a Certifier, and have the Certifier conduct an **initial check** of programmatic assumptions and certification criteria - to **clarify how aspects will be assessed in the certification**.

Preliminary Review SD/DD Phase(s)

1. Assessment of the concepts for the design, insulation and building services, and of the **preliminary version of the PHPP** calculation for **consistency with the certification criteria**.
2. The PH consultant **assembles key information**.
3. The Certifier will provide **feedback and suggestions** so you can optimize your design and specifications and update the PHPP energy model.

Design Stage Review
Construction Document Phase

1. The PH consultant will prepare the detailed **certification submittal package** (PHPP, plans, specifications, and required supporting documentation) **according to your Certifier's guidance**.
2. Make corrections to your Certifier requests and **re-submit until your Certifier can conditionally assure** certification when construction is completed.
3. Your Certifier will **issue a design stage assurance letter** that, as designed, the building can be certified.

Final Review
Construction Completion

1. Upon completion, **make submissions** for Certifier's final review.
- As-built PHPP energy model and plans per PHI certification protocols
- Photo documentation per PHI certification protocols.
- Blower door test results per PHI certification protocols.
- Ventilation system commissioning report per PHI certification protocols.
- Executed Builder Assurance Certificate that building has been constructed to the as-built plans and energy model per PHI certification protocols.

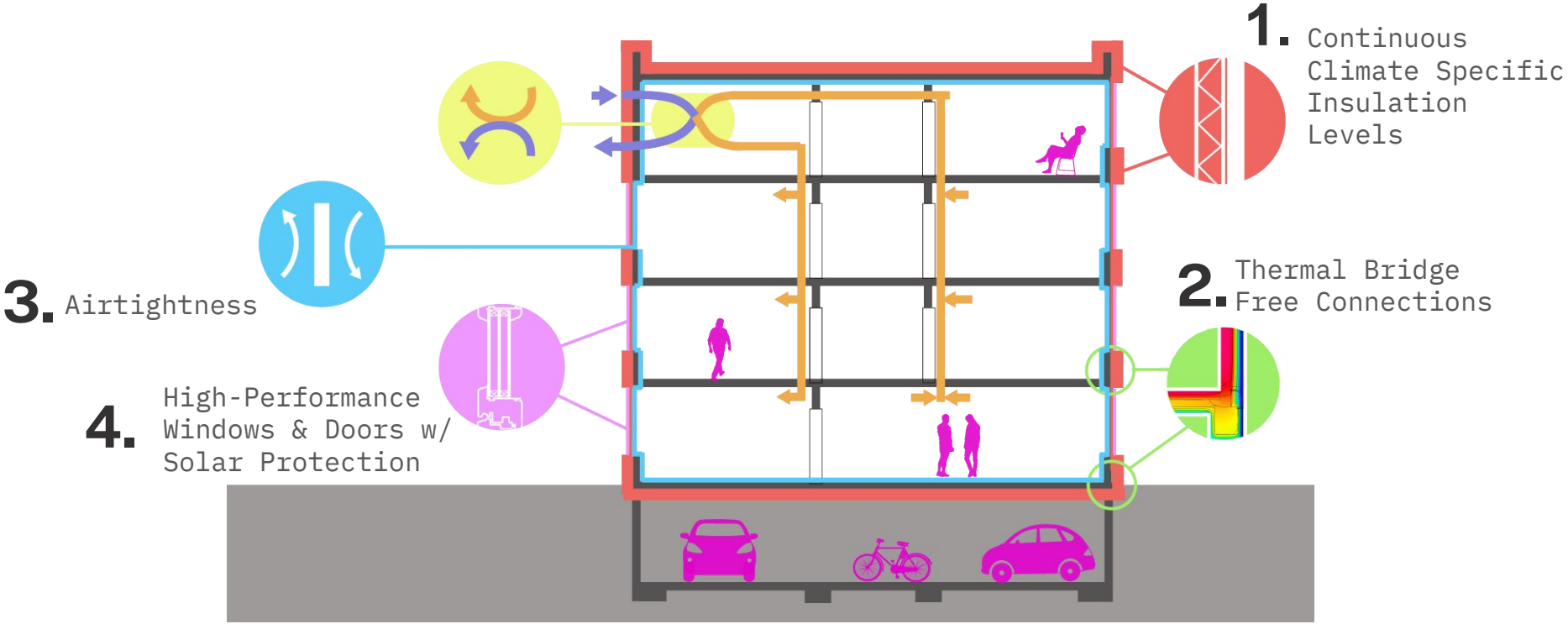
2. If your building meets all certification criteria, you will receive the building certificate.
3.Post the certificate on your website and attach the plaque to your new Passive House building.
4. List your newly certified building in PHI's online international project directory.

Think about what makes quality control easier or harder each step of the way.

Enclosure

Principles 1-4

First 4 Principles are about the enclosure



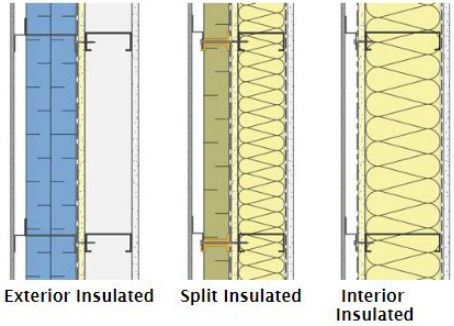
https://passipedia.org/basics/what_is_a_passive_house

Any Construction Type Can be Passive House

Passive House is enclosure system agnostic

- Wood
- Metal
- Concrete

Build with what your teams know.



Metal Framed Walls

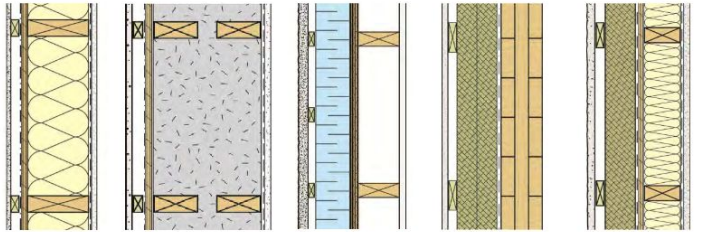


Fig. 3.2.1 Options for placement of insulation within thermally efficient above-grade wood-frame wall assemblies.

Wood Framed Walls

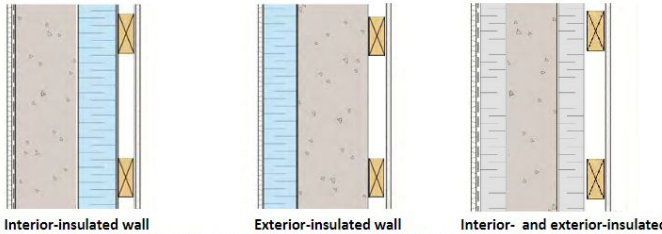
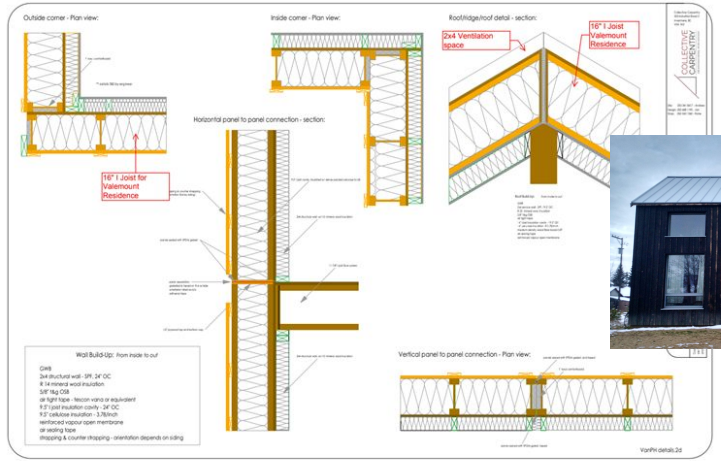


Fig. 3.2.2 Options for placement of insulation within thermally efficient below-grade wood-frame wall assemblies.

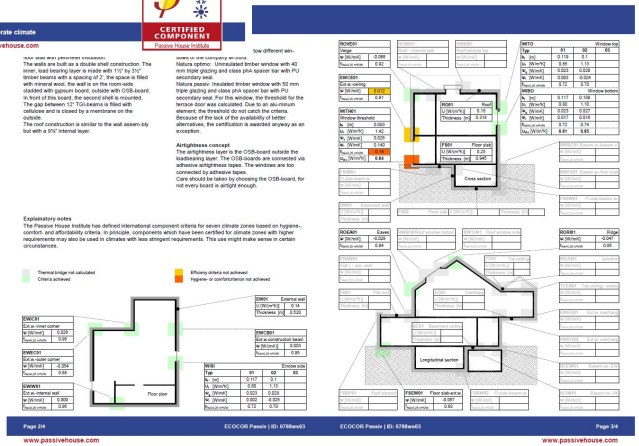
Concrete Walls

Enclosure systems

Ecocor



Collective Carpentry



ENCLOSURE SYSTEMS

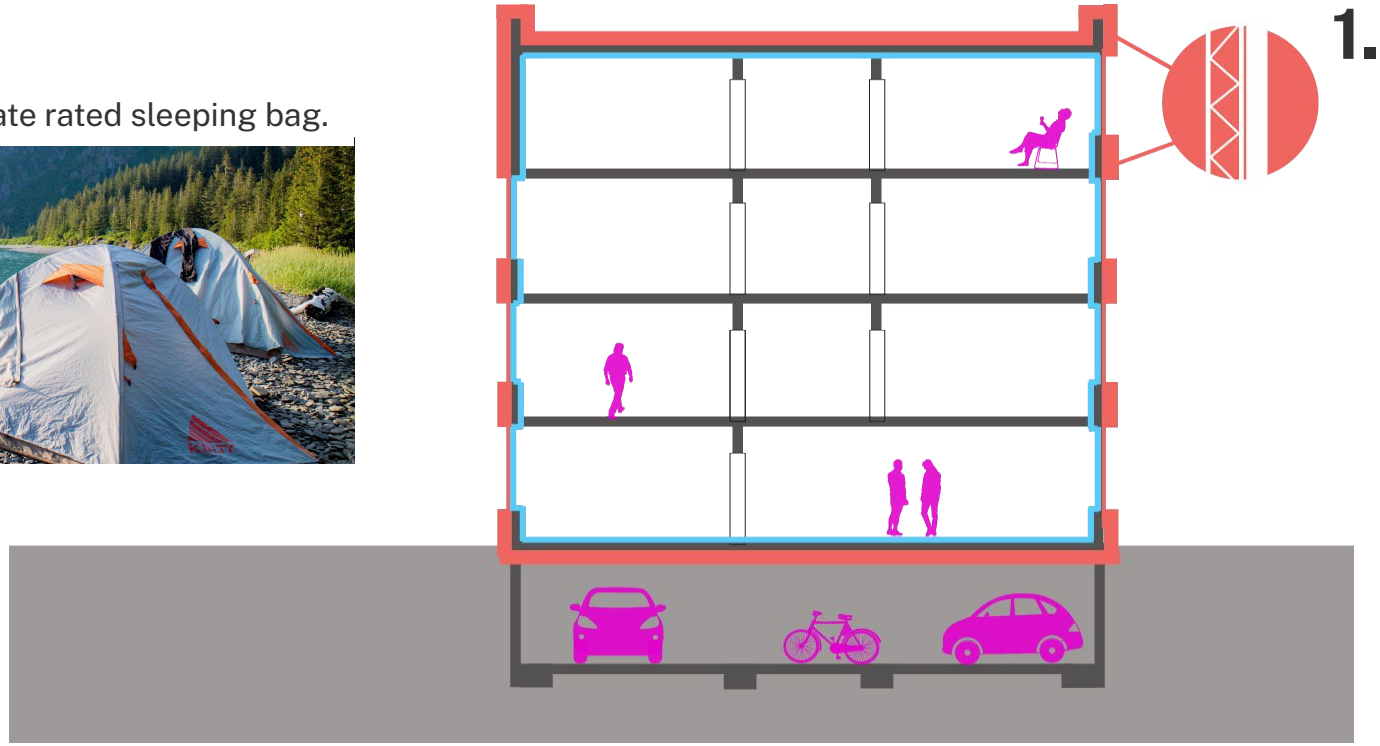
Manufacturer/Supplier	Specialty	Offers PHI Certified Components	HQ Location	Link
B.Public Prefab	panelized		New Mexico	https://www.bpublicprefab.com/
Blueprint Robotics	panelized		Maryland	https://www.blueprint-robotics.com/
BuildSmart	panelized	Yes	Kansas	https://buildsmartna.com/
Collective Carpentry	panelized		British Columbia	https://collectivecarpentry.com/
Ecococon	panelized / straw	Yes	Slovakia/NY	https://ecococon.eu/us/
Ecocor	panelized	Yes	Maine	https://ecocor.us/
EkoBuilt	panelized / kits		Ontario	https://ekobuilt.com/passive-house-kit/
GO Logic	panelized		Maine	https://www.gologic.us/thegohome
Holzraum System	panelized / mass timber		Pennsylvania	https://www.holzraumsystem.com/
Legalett	panelized	Yes	Quebec	https://legalett.ca/
NotchSB / Opal Shelter	mass timber		Maine	https://www.notchsb.com/ – https://opalshelter.us/
Pheonix Haus	panelized	Yes	Colorado	https://phoenixhaus.com/
Quantum Passivhaus	panelized	Yes	Ontario	https://www.quantumpassivhaus.com/

Continuous Climate Specific Insulation

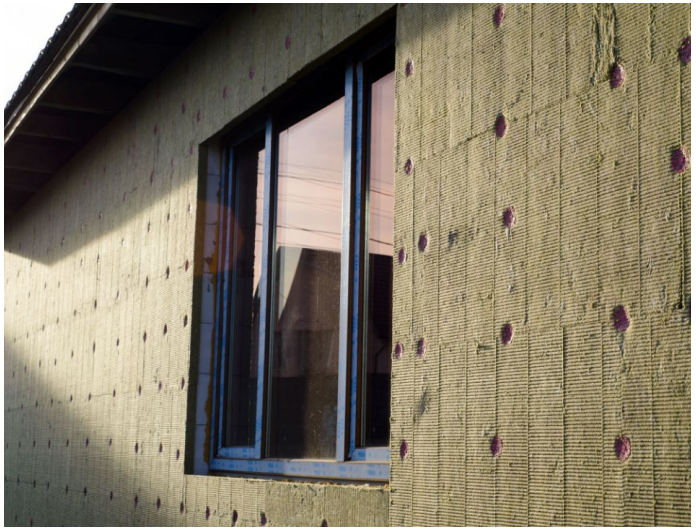
Principle #1

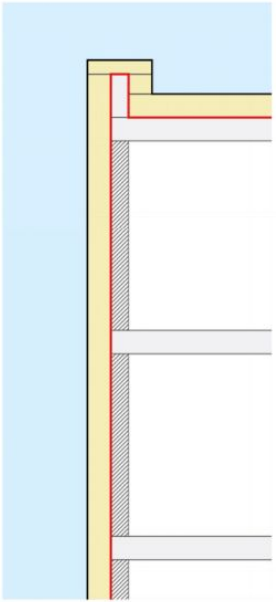
Element #1: Climate Specific Insulation

like a climate rated sleeping bag.



Any Insulation is possible too - just be continuous!





Boards: Mineral Wool, Foam, Wood Fiber

Spray Insulation: Dense Pack Cellulose is a Favorite

Dense-pack:
Pump to 3.5 lbs per ft^3 in walls to prevent settling

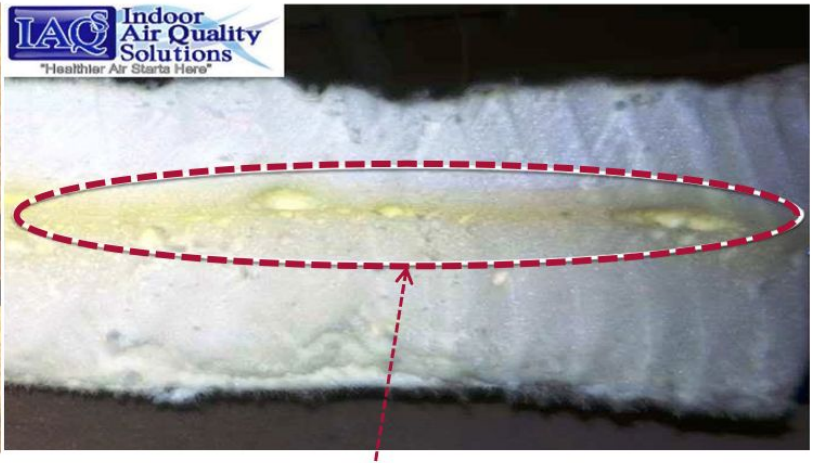
Batt Insulation (not continuous) Can play a part.

Quality Control of Batt Insulation is a Concern

Bad Installations Samples of Rigid Insulation

Problems with Spray Foam

Shrinking over time



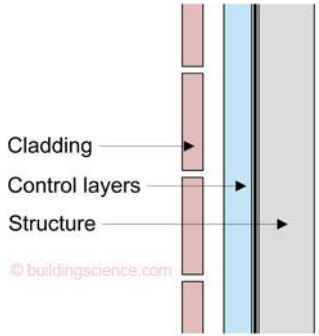
Incorrectly mixed

SOURCE: John Lapotaire

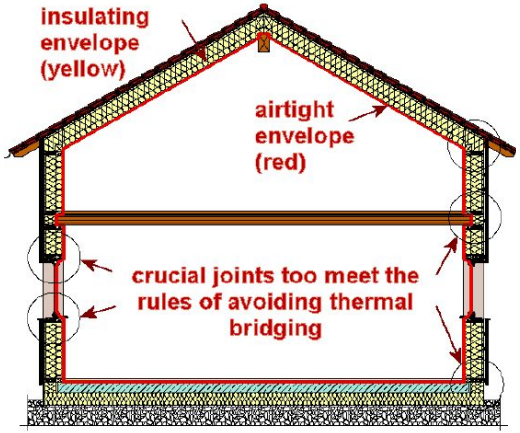
Fundamental Characteristics of Enclosures

Control Layers:

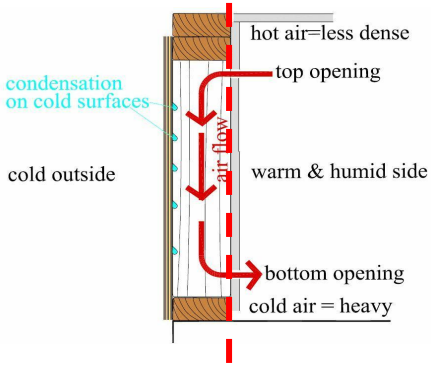
1. Shed Bulk Water (rain coat)
2. Vapor Control (prevent wetting and allow drying)
3. Air Control (airtightness)
4. Thermal Control (insulation)



"Perfect Wall" - The control layers wrap the structure and are protected by exterior cladding.



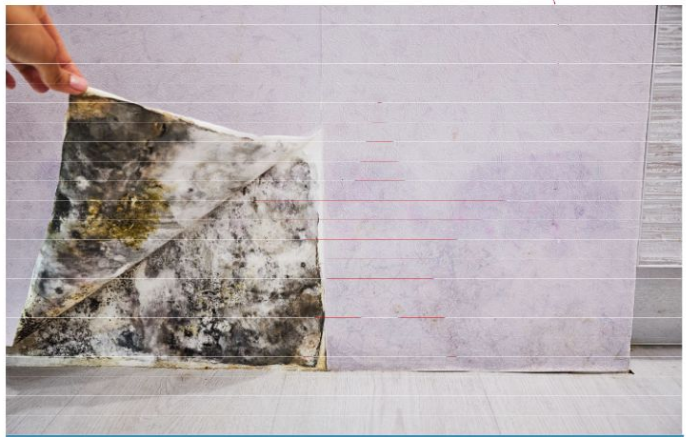
Ref http://passipedia.passiv.de/passipedia_en/



Primary air barrier at interior side of insulation - in a heating dominated climate this keeps warm moist air from condensing in the wall assembly.

Avoid Vapor Barriers in Walls & Roofs

Vinyl and plastic are vapor 'barriers' which will never let the moisture in these assemblies dry out



Vinyl Wallcovering – Mold due to inwardly driven moisture trapped by the vapor impermeability of the vinyl wallcovering

Interior Polyethylene Vapor Barrier – Condensation from inwardly driven moisture

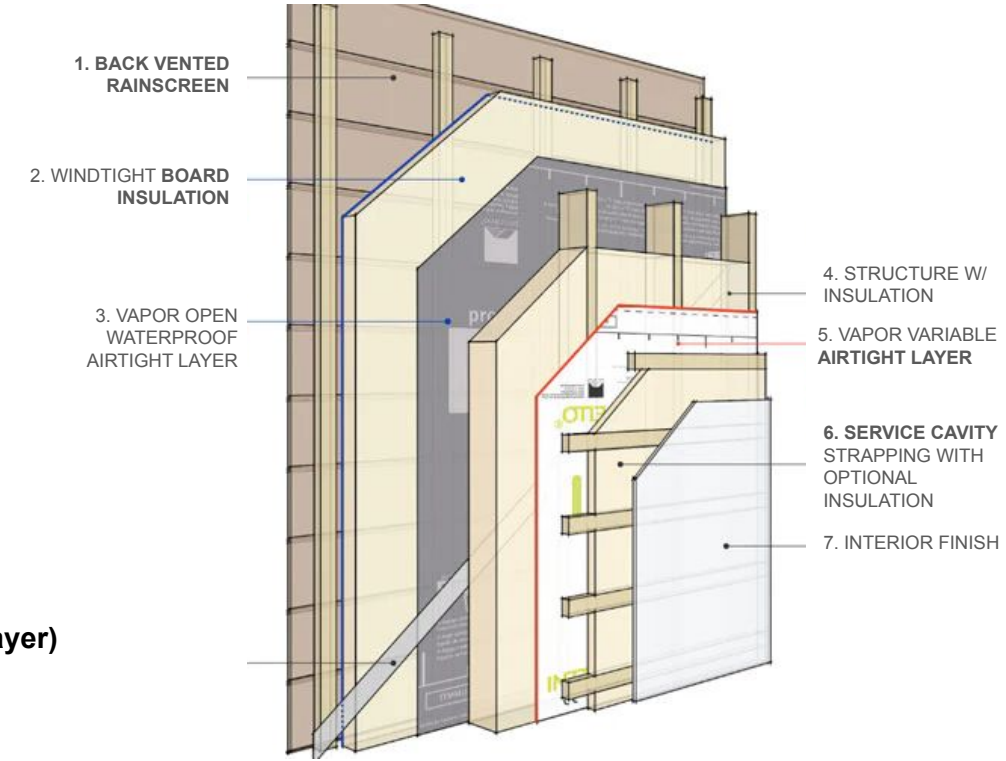
Building Science Corp.

#1: Try to keep water out, BUT…
#2: When* it gets in, let the water dry out.

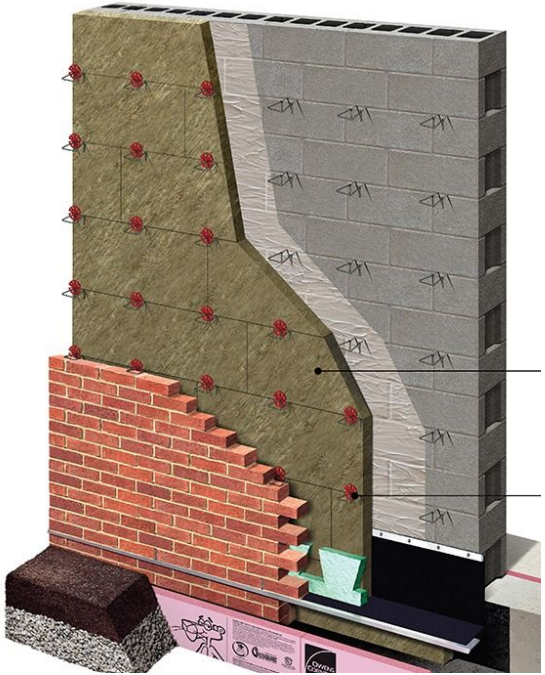
Variations on Layering below is typical

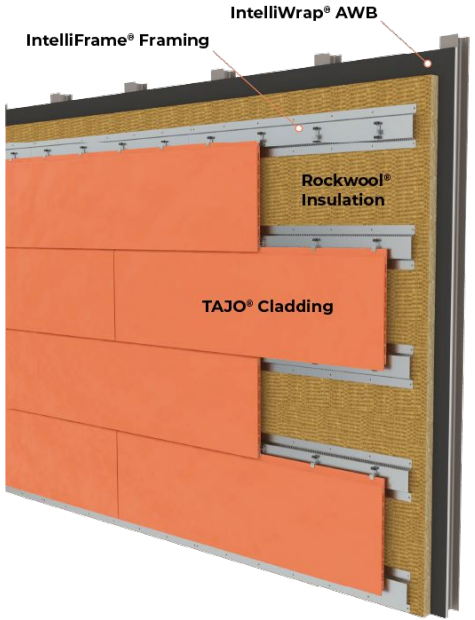
Shed Water
Vapor Control
Air Control
Thermal Control

1. **Back Vented Rainscreen**
2. **Continuous Insulation**
3. **Waterproofing**
4. **Structure (w/ insulation)**
5. **Airtightness**
6. **Service Cavity** **(to protect the airtight layer)**
7. **Interior Finish**

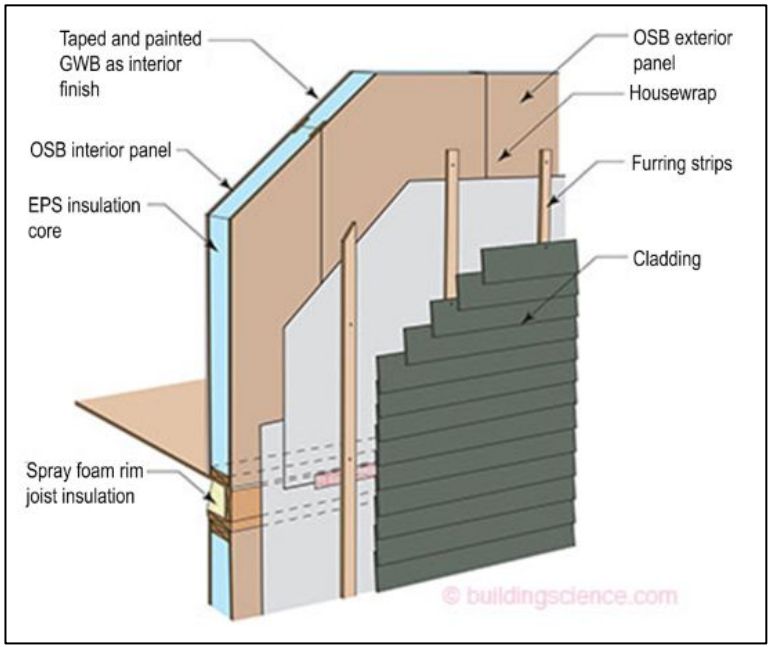


Brick, Panels & Siding on Masonry & Framing Walls

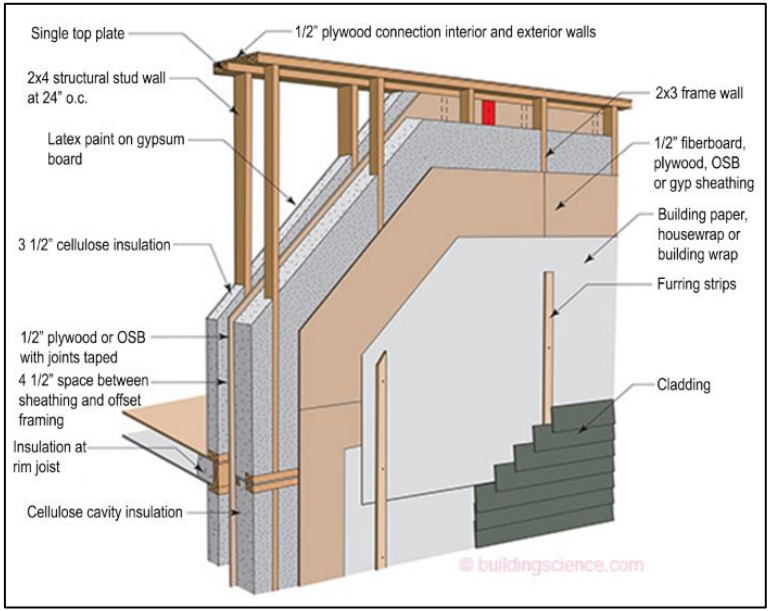




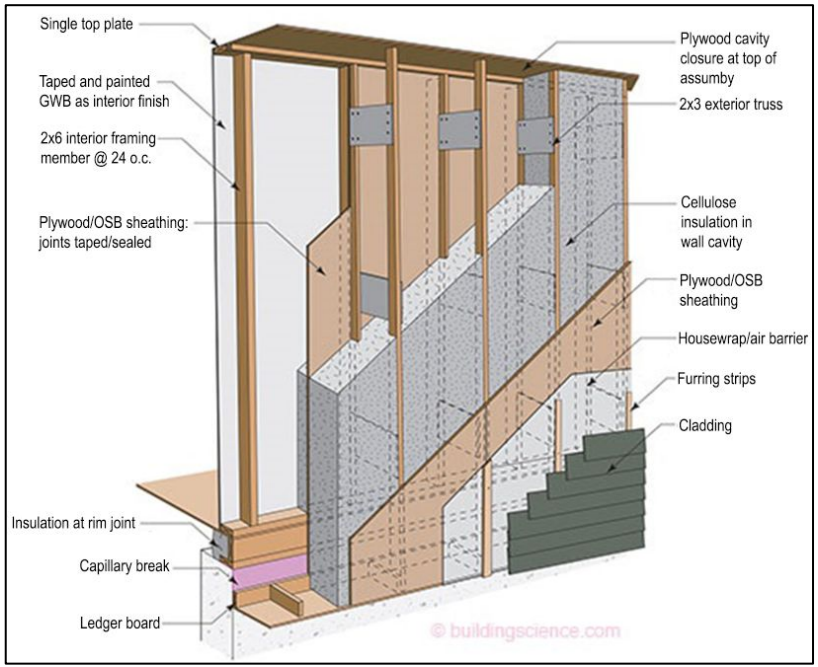
STRUCTURAL INSULATED PANELS (SIPS)



Double Stud Walls

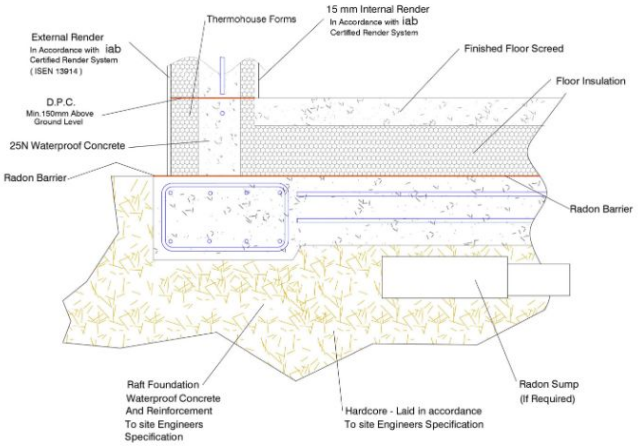


Larsen Truss or I-Joist Outrigger on Stud Wall



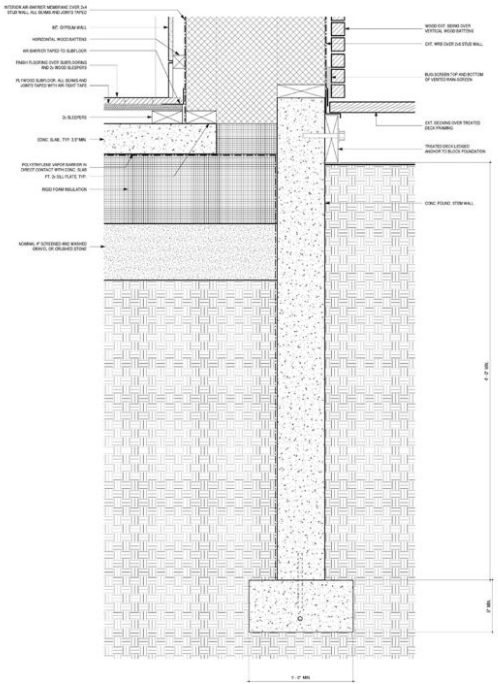
For a thick parka!

Insulated Concrete Form



SOURCE: Thermohouse ICF

Insulation under the entire slab on grade.

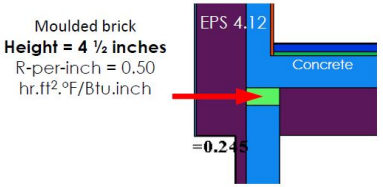


Foam

Mineral Wool

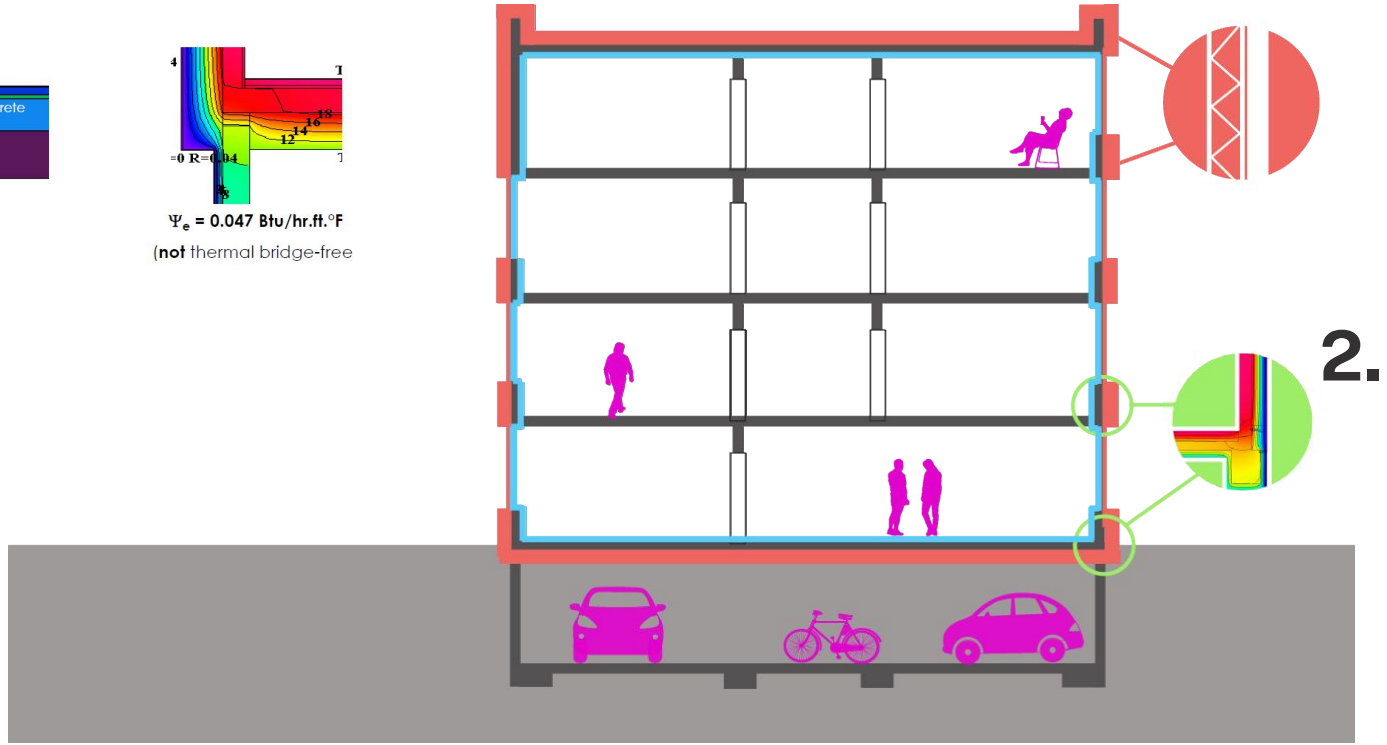
Thermal Bridge Free
Principle #2

Element #2: Thermal Bridge Free Construction

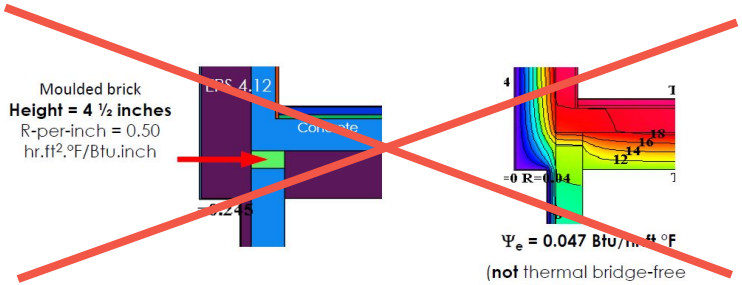


Ψ_e = 0.047 Btu/hr.ft.°F

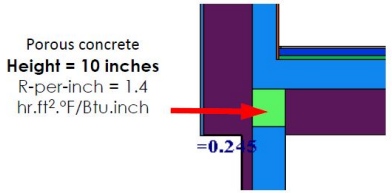
(**not** thermal bridge-free



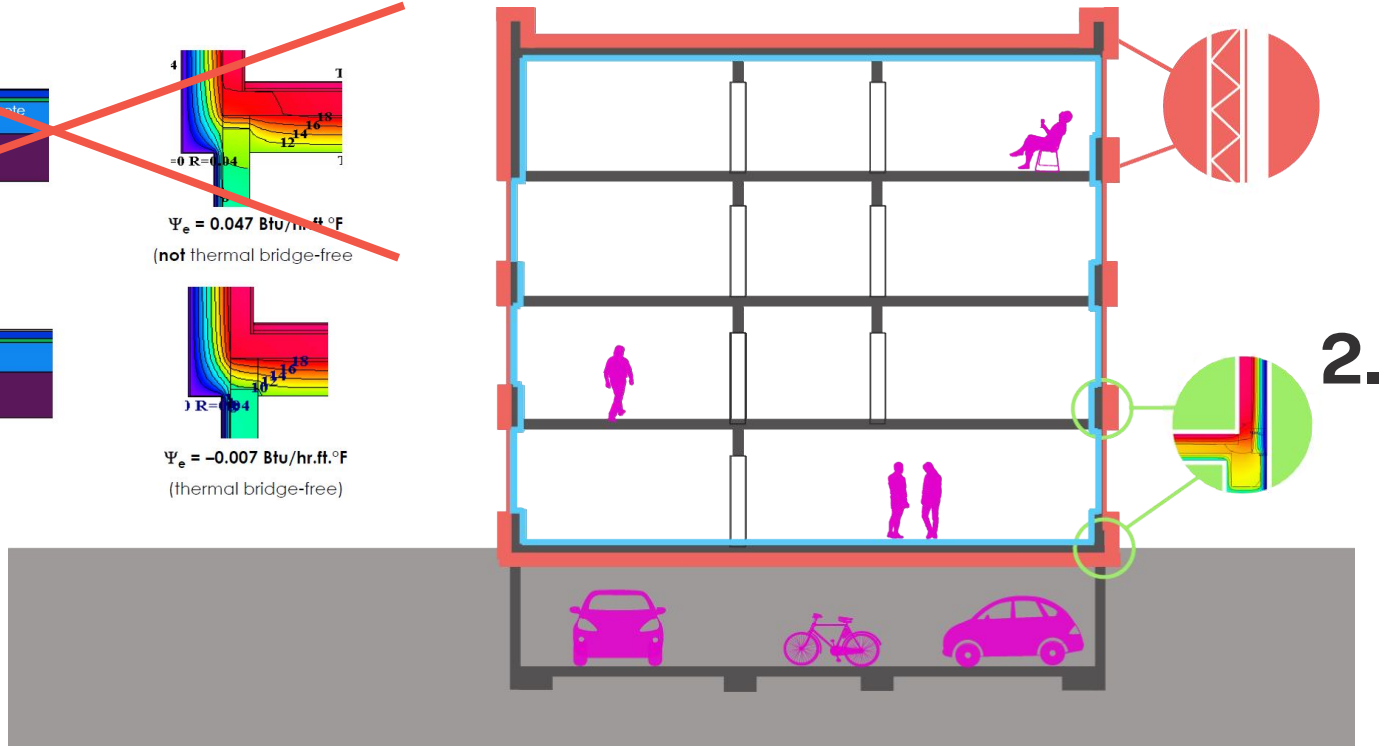
Element #2: Thermal Bridge Free Construction



Ψ_e = 0.047 Btu/hr.ft.°F
(**not** thermal bridge-free

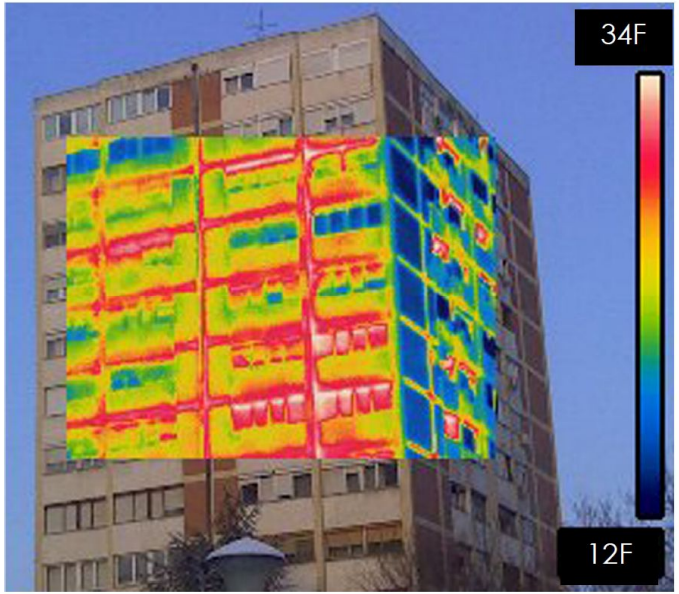


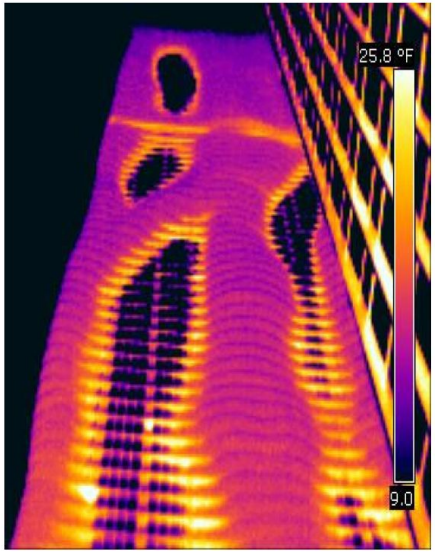
Ψ_e = –0.007 Btu/hr.ft.°F
(thermal bridge-free)



2.

Thermal ‘Shortcuts’ Through the Envelope Insulation

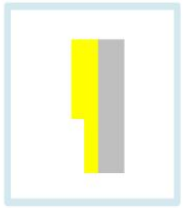




What's a Thermal Bridge?

Part of the building envelope where the otherwise uniform thermal resistance is significantly reduced by:

full or partial penetration of the insulating layers by materials with a different thermal conductivity



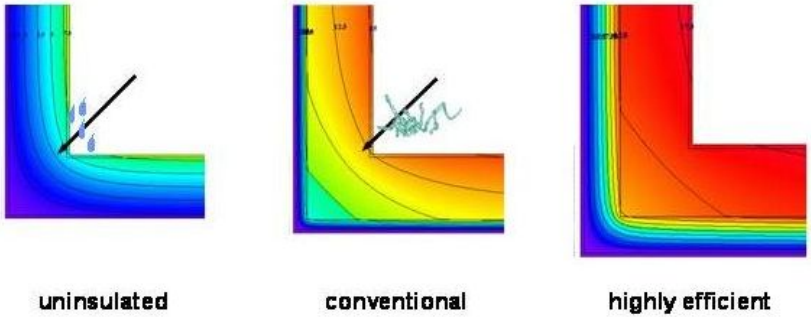
and/or

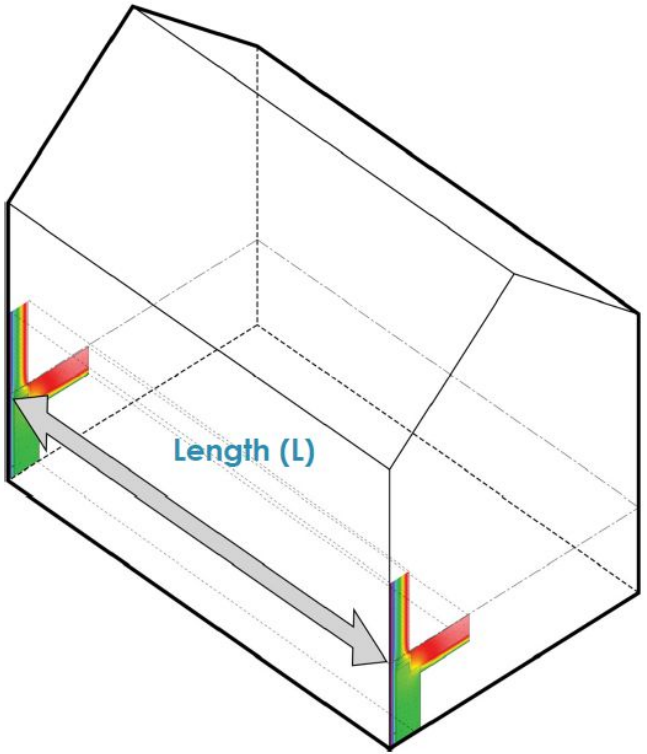
a change in thickness of the insulating layers

and/or

a difference between internal and external areas, such as occurs at wall/floor/ceiling junctions.

The Quality & Lengths of Joints Add Up!



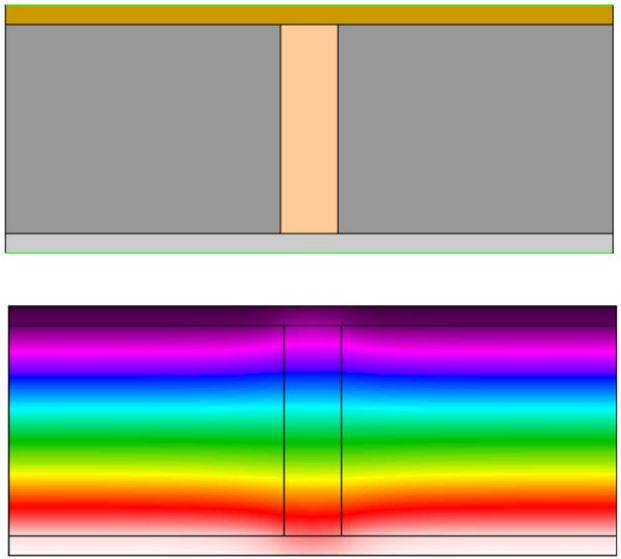


Repeating Thermal Bridges (clear field)

Wood stud wall, insulated cavity:

Nominal R-value (through cavity): 22.3

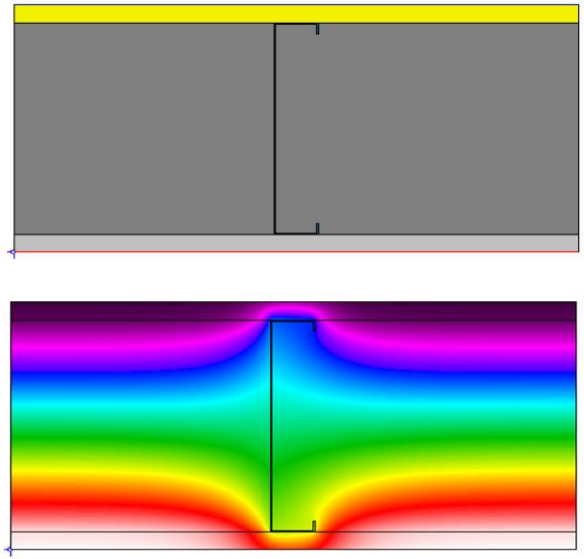
Actual R-value (incl. framing): 19.0



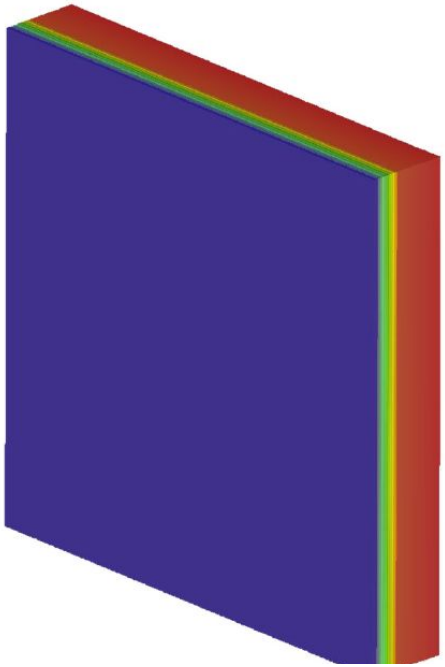
Steel stud wall, insulated cavity:

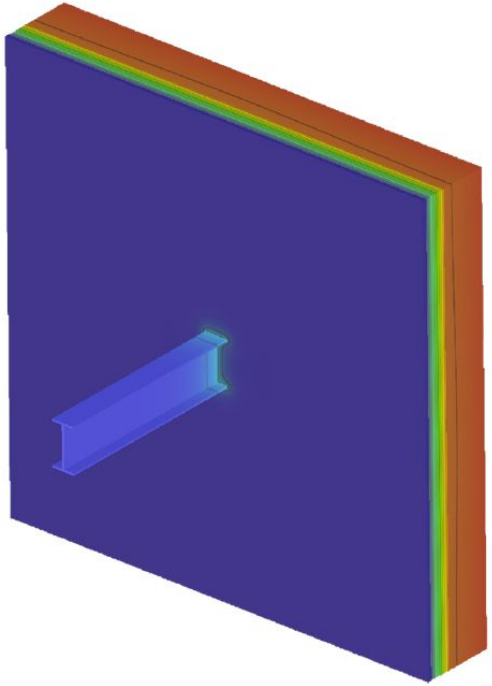
Nominal R-value (through cavity): 22.3

Actual R-value (incl. framing): 11.6

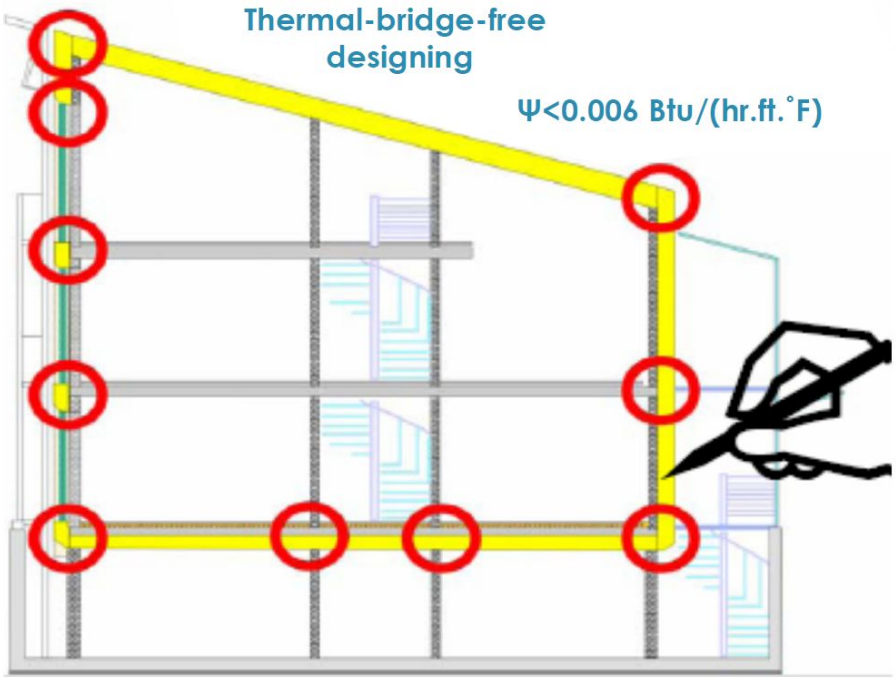


Point Thermal Bridges at Structure & Attachments





Identify all the locations of possible thermal bridges



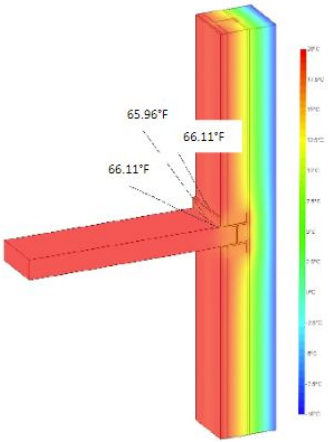
Source: PHI, Author: JS

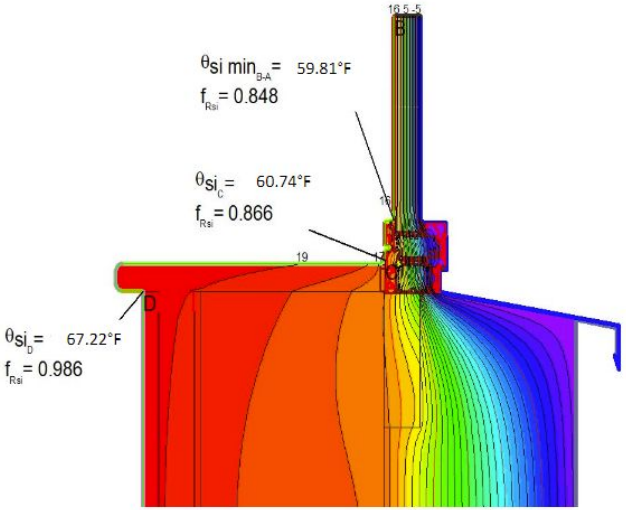
fRsi helps guide insulation levels at weak points.

$$f_{Rsi} = (t_{si} - t_e) \div (t_i - t_e)$$

With:

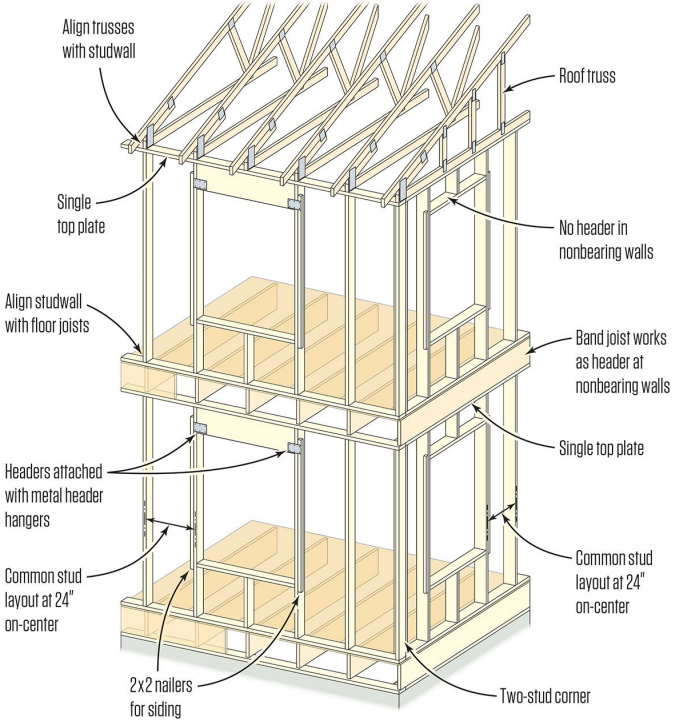
- f_{Rsi} Temperature factor at the internal surface
- t_{si} Interior Surface Temp
- t_e Exterior Design Temp
- t_i Interior Design Temp

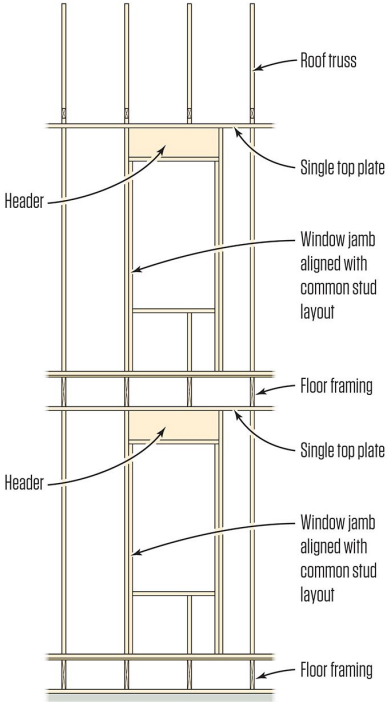


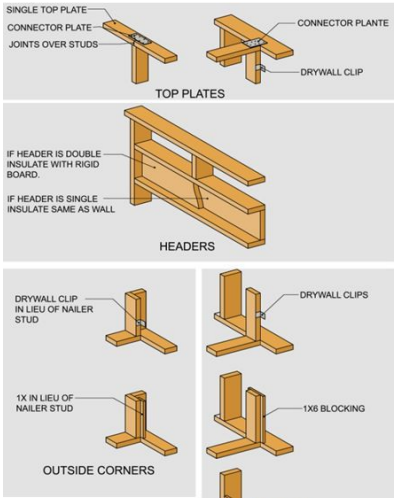


Note: For f_{Rsi} calculation, surface temps and exterior conditions must be modeled as per ISO 10211 & 13788

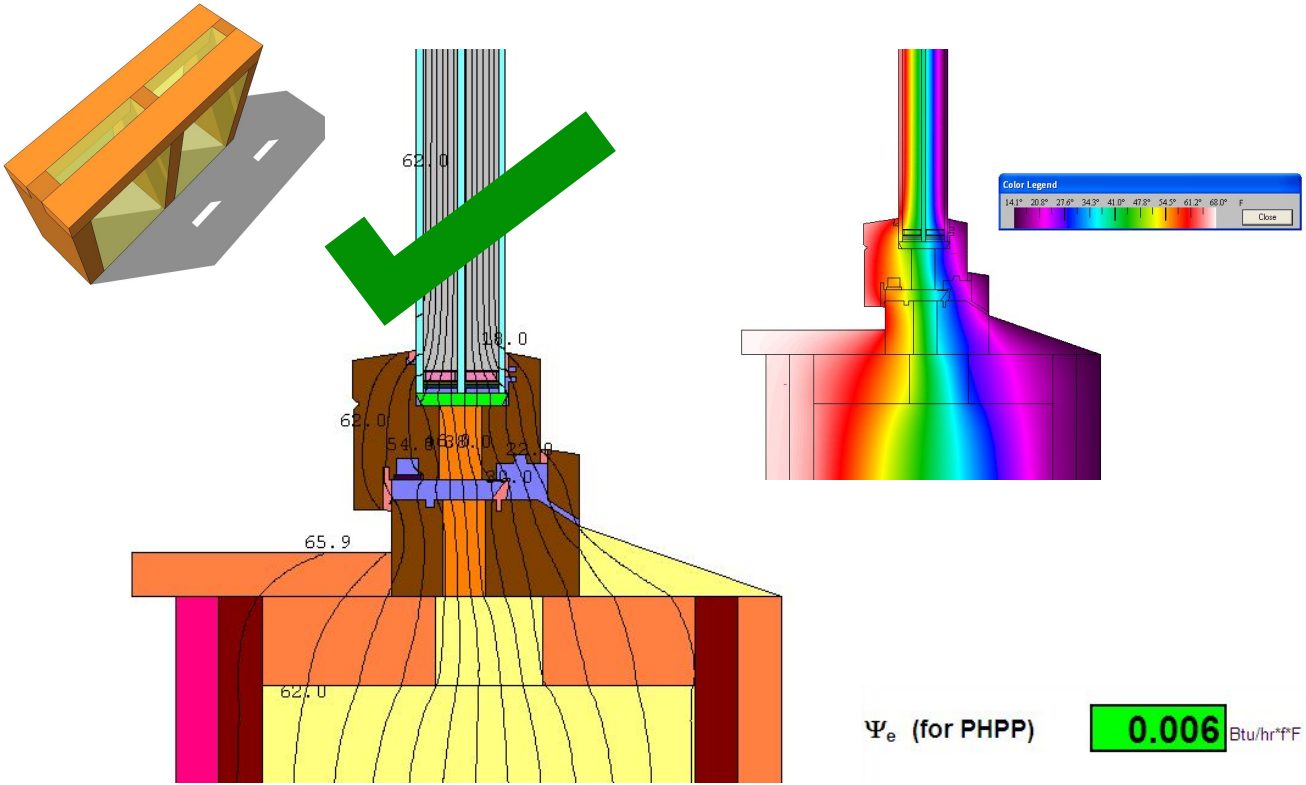
Advanced Framing





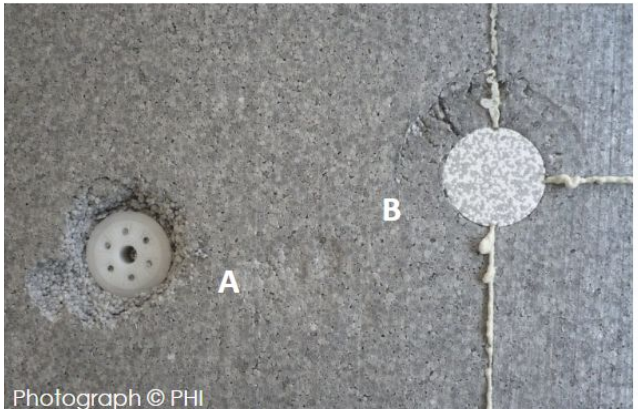


Double Stud Window Detail



Ψ_e (for PHPP) **0.006** Btu/hr*f*F

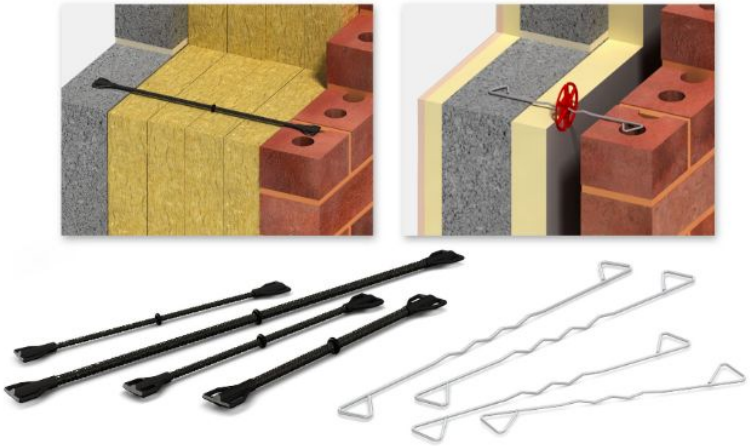
Thermal Bridge Free Attachments



Brick Ties

Basalt Wall Ties

Thermal Conductivity (k): 0.4 Btu/hr.ft.°F

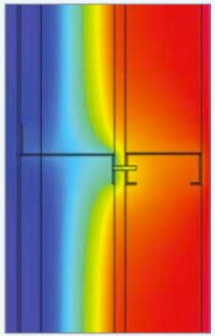


Stainless steel Wall Ties

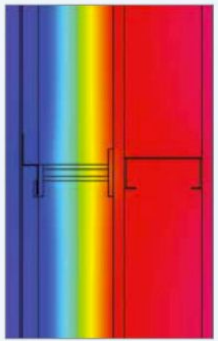
Thermal Conductivity (k): 9.8 Btu/hr.ft.°F

25 times more heat loss!

Facade Clips

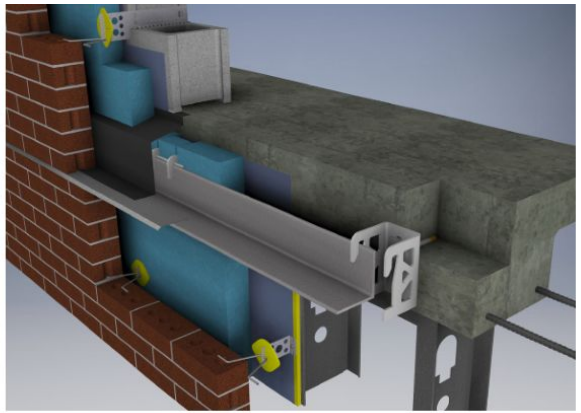


Typical Z-girt system

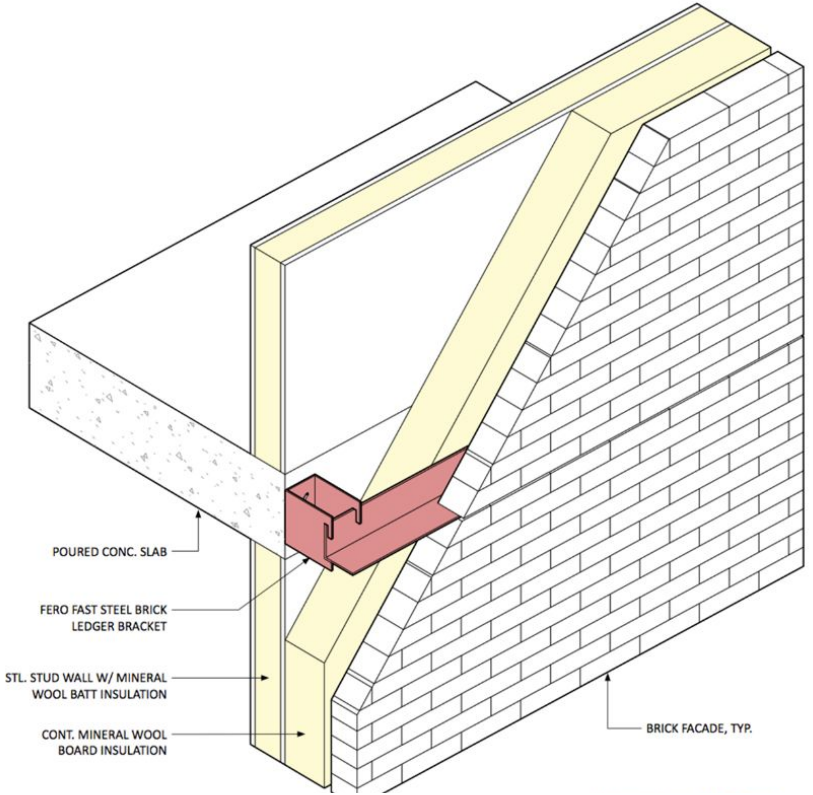


Cascadia Clip® system

Brick Shelf

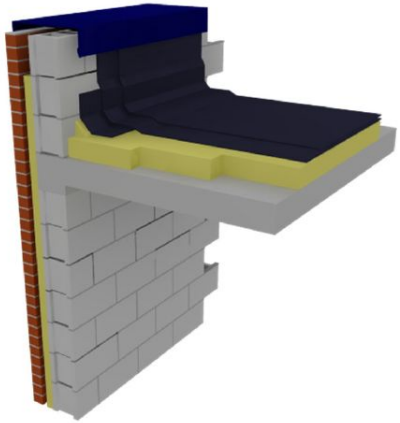


SOURCE: Ferro Fast



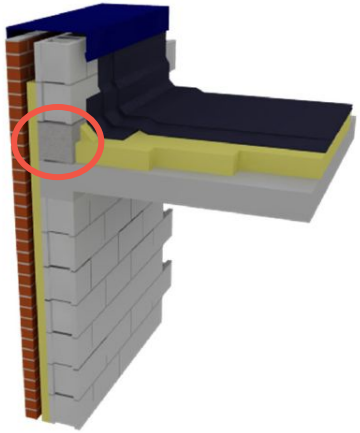
Parapet Improvement

Typical detail – poor thermal bridge



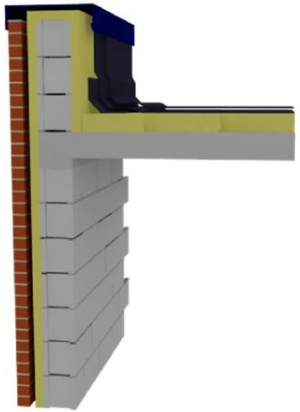
0.247 BTU/hr.ft.°F

Option 1: Insert thermal break



0.010 BTU/hr.ft.°F

Option 2: Wrap the parapet



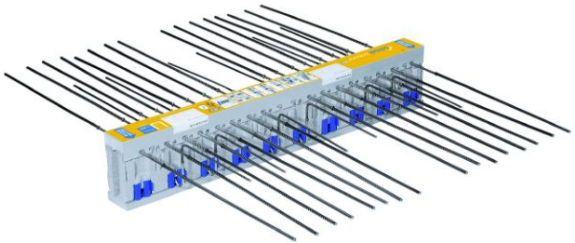
0.039 BTU/hr.ft.°F

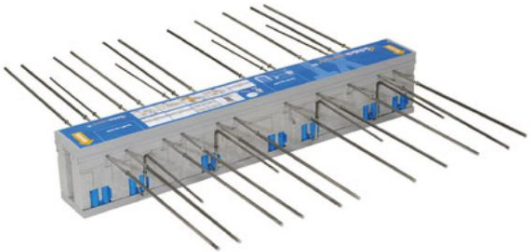
AAC Block

Autoclaved Aerated Concrete Block (AAC)

- Increased thermal insulation (roughly R-1)
- Structural thermal break material
- Lightweight, workable with hand tools
- Fireproof
- Less Portland cement
- Noise reduction
- Moisture regulation

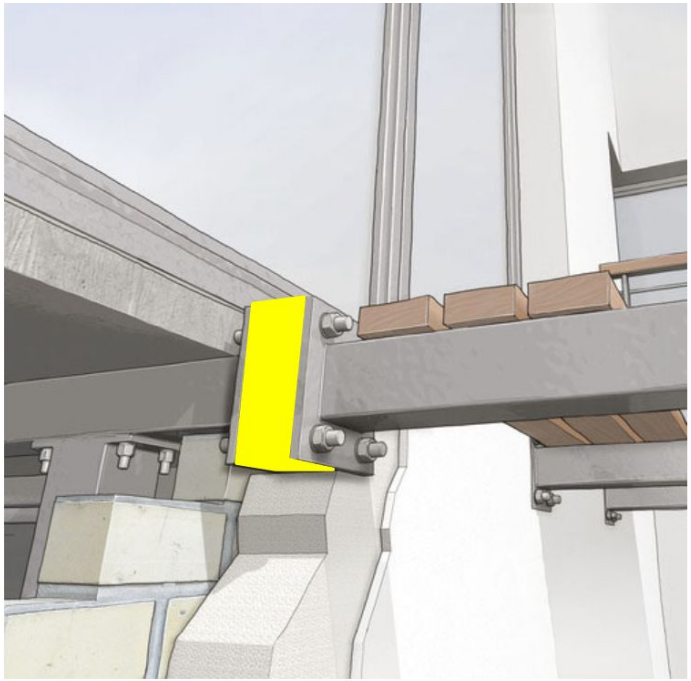
Balconies





Source: Contech Accessories and Schock

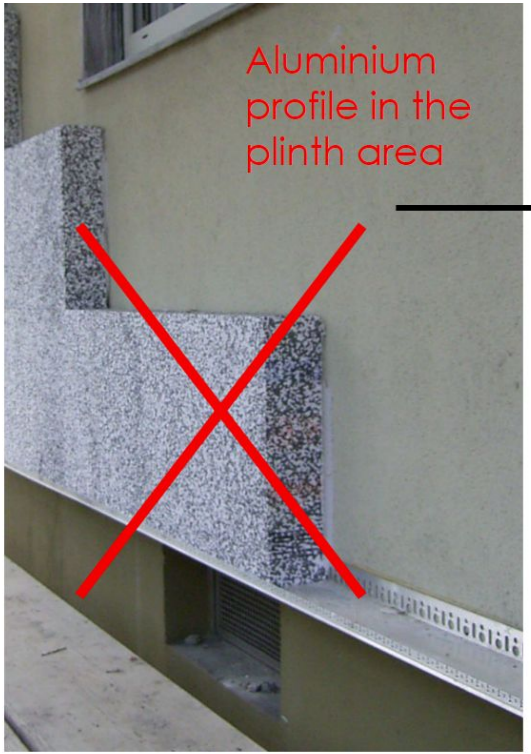
Structural Breaks



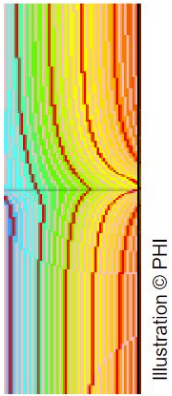
Steel to Steel Connections: Balcony Attachments (images courtesy of Contech Accessories and Shock)

Thermal Bridge Free Eaves

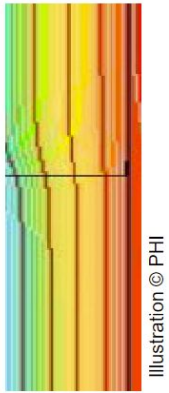
Don’t undermine insulation w/ metal parts



Higher heat losses



Plastic profile in the plinth area



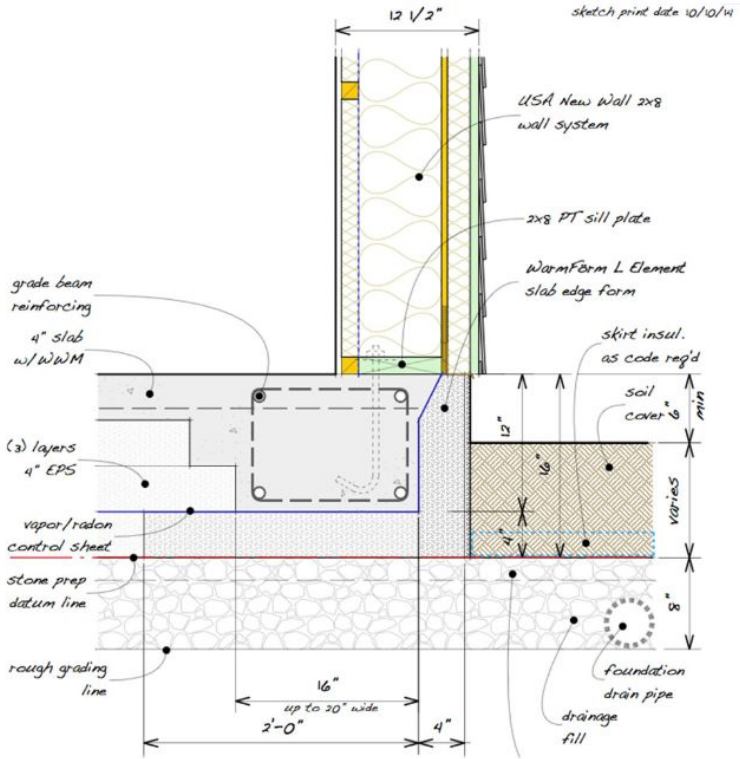
Hardly any heat losses

Aluminum starter track very commonly used

Creates a significant thermal bridge

Better to use a plastic version, or if using metal don’t run completely to the exterior.

Foundation Edge: Slab on Grade



Source: WarmForm

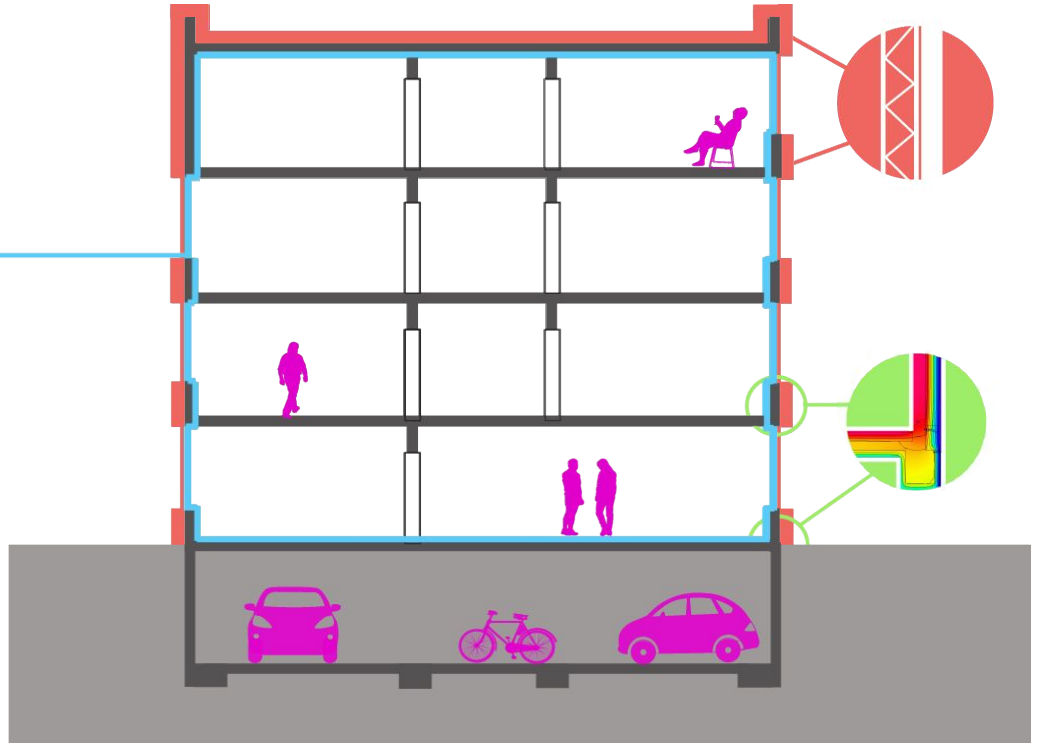
Thermal Break Materials: Armatherm

The Passive House Network

Airtightness
Principle #3

Element #3: Airtight/Smoke Tight Enclosure

3.



1. Reduces drafts
2. Reduce moisture damage
3. Reduce heat loss
4. Control humidity
5. Keep outdoor pollution out
6. Get control of interior air

0.60 ACH 50: There will be a test!

- **Care toward details and workmanship make the difference.**
- Experienced teams can rely on a good result with final test.
- **Teams new to passive house will want to plan for preliminary tests while air barrier remains exposed and repairable.**
- **Teams must recognize the air barrier, protect it, and report any damages.**
- The building can never be too airtight.

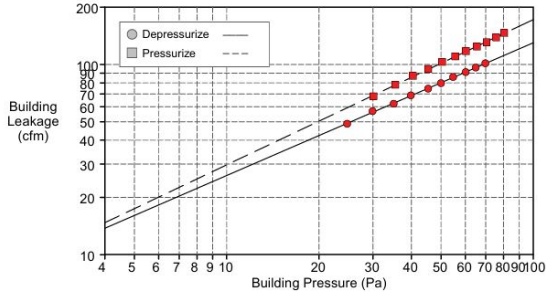
Date of Test: 1/11/2013 Test File: 15 Park Place Test
Technician: Nicholas Abreu Signature:
Project Number: 15 Park Place

Customer: Placetailor
67 Dudley Street
Roxbury, MA 02119
Phone: 617-639-0633
Fax:

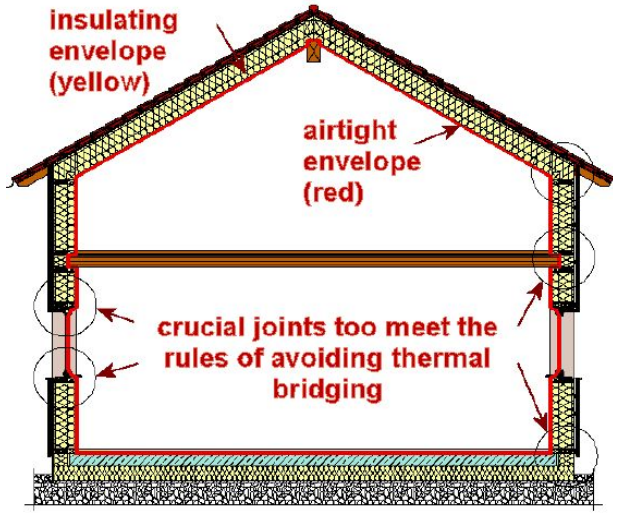
Building Address: 15 Park Place
Somerville, MA 02144

Test Results at 50 Pascals:	Depressurization	Pressurization	Average
cfm (Airflow)	80 (+/- 0.6 %)	101 (+/- 0.5 %)	91 (+/- 0.4 %)
ACH50	0.38	0.48	0.43
cfm/ft² (Floor Area)	0.0609	0.0770	0.0689
cfm/ft² (Surface Area)	0.0154	0.0194	0.0174
Leakage Areas:			
Canadian EqLA @ 10 Pa (in²)	7.7 (+/- 2.5 %)	8.7 (+/- 2.6 %)	8.2 (+/- 1.8 %)
in²/ft² Surface Area	0.0015	0.0017	0.0016
LBL ELA @ 4 Pa (in²)	3.9 (+/- 4.0 %)	4.2 (+/- 4.0 %)	4.0 (+/- 2.8 %)
in²/ft² Surface Area	0.0008	0.0008	0.0008
Building Leakage Curve:			
Flow Coefficient (C)	5.2 (+/- 6.2 %)	5.1 (+/- 6.1 %)	5.2 (+/- 4.3 %)
Exponent (n)	0.698 (+/- 0.016)	0.763 (+/- 0.015)	0.730 (+/- 0.011)
Correlation Coefficient	0.99959	0.99965	

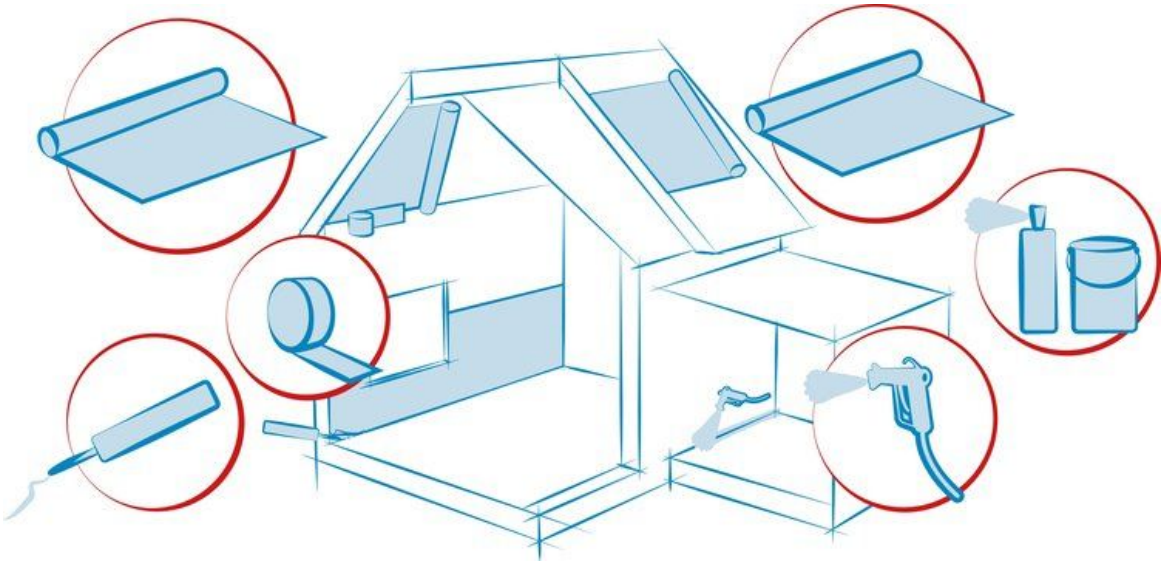
Test Standard: E779-10
Test Mode: Depressurization and Pressurization



Airtightness is a SYSTEM



Ref http://passipedia.passiv.de/passipedia_en/



Membranes, tapes, caulks and sprays.

Air Barrier: Fluid Applied

Air Barrier Materials: Membranes

Inboard, Outboard / Reinforced, Self-Adhered / Vapor Control

Airtightness: Sheathing, Plaster and Concrete

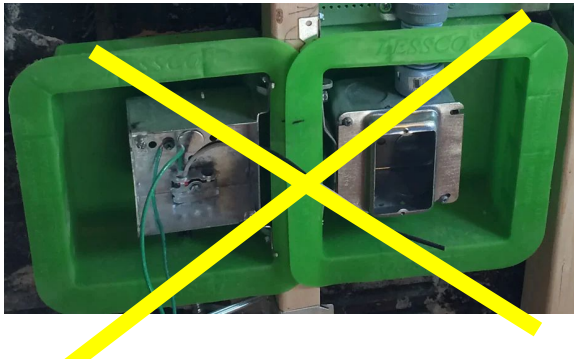
The Passive House Network

Air Barriers?

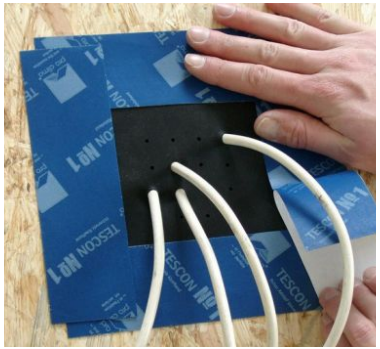
??????????????????

Don’t Use Sacrificial layers as air barrier.

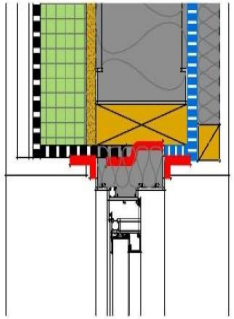
Protect Airtight Layer & Minimize Penetrations!

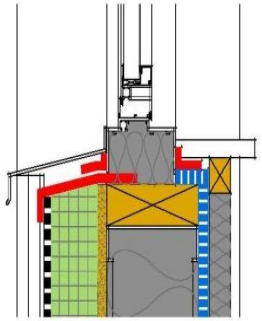


Ducts, Pipes, Wires: Flexible & Long Lasting



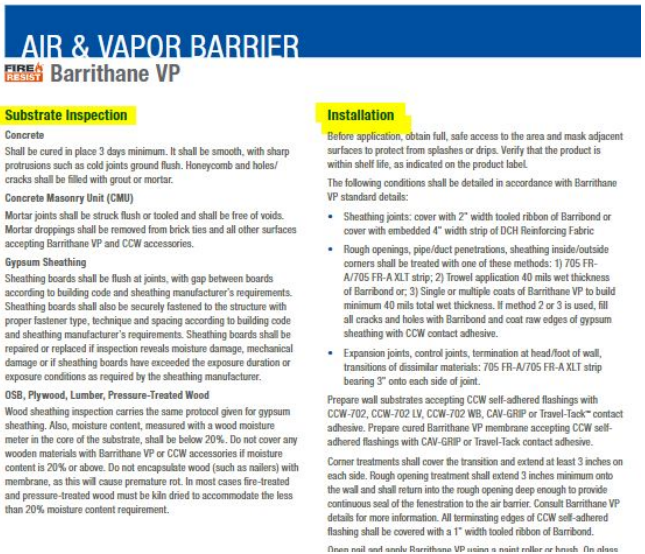
Connections: Use flexible materials/connections





Directions and Help

- Always consult and follow the manufacturer's data sheet and directions.
- Involve product reps as often as needed for assistance.



AIR & VAPOR BARRIER

FIRE RESIST Barrithane VP

Substrate Inspection

Concrete

Shall be cured in place 3 days minimum. It shall be smooth, with sharp protrusions such as cold joints ground flush. Honeycomb and holes/cracks shall be filled with grout or mortar.

Concrete Masonry Unit (CMU)

Mortar joints shall be struck flush or tooled and shall be free of voids. Mortar droppings shall be removed from brick ties and all other surfaces accepting Barrithane VP and CCW accessories.

Gypsum Sheathing

Sheathing boards shall be flush at joints, with gap between boards according to building code and sheathing manufacturer's requirements. Sheathing boards shall also be securely fastened to the structure with proper fastener type, technique and spacing according to building code and sheathing manufacturer's requirements. Sheathing boards shall be repaired or replaced if inspection reveals moisture damage, mechanical damage or if sheathing boards have exceeded the exposure duration or exposure conditions as required by the sheathing manufacturer.

OSB, Plywood, Lumber, Pressure-Treated Wood

Wood sheathing inspection carries the same protocol given for gypsum sheathing. Also, moisture content, measured with a wood moisture meter in the core of the substrate, shall be below 20%. Do not cover any wooden materials with Barrithane VP or CCW accessories if moisture content is 20% or above. Do not encapsulate wood (such as nailers) with membrane, as this will cause premature rot. In most cases fire-treated and pressure-treated wood must be kiln dried to accommodate the less than 20% moisture content requirement.

Installation

Before application, obtain full, safe access to the area and mask adjacent surfaces to protect from splashes or drips. Verify that the product is within shelf life, as indicated on the product label.

The following conditions shall be detailed in accordance with Barrithane VP standard details:

- Sheathing joints: cover with 2" width tooled ribbon of Barribond or cover with embedded 4" width strip of DCH Reinforcing Fabric
- Rough openings, pipe/duct penetrations, sheathing inside/outside corners shall be treated with one of these methods: 1) 705 FR-A/705 FR-A XLT strip; 2) Trowel application 40 mils wet thickness of Barribond or; 3) Single or multiple coats of Barrithane VP to build minimum 40 mils total wet thickness. If method 2 or 3 is used, fill all cracks and holes with Barribond and coat raw edges of gypsum sheathing with CCW contact adhesive.
- Expansion joints, control joints, termination at head/foot of wall, transitions of dissimilar materials: 705 FR-A/705 FR-A XLT strip bearing 3" onto each side of joint.

Prepare wall substrates accepting CCW self-adhered flashings with CCW-702, CCW-702 LV, CCW-702 WB, CAV-GRIP or Travel-Tack™ contact adhesive. Prepare cured Barrithane VP membrane accepting CCW self-adhered flashings with CAV-GRIP or Travel-Tack contact adhesive.

Corner treatments shall cover the transition and extend at least 3 inches on each side. Rough opening treatment shall extend 3 inches minimum onto the wall and shall return into the rough opening deep enough to provide continuous seal of the fenestration to the air barrier. Consult Barrithane VP details for more information. All terminating edges of CCW self-adhered flashing shall be covered with a 1" width tooled ribbon of Barribond.

Open pail and apply Barrithane VP using a paint roller or brush. Do glass

Not frozen over

Airsealed buck joints

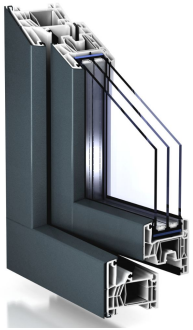
Grease/oil free

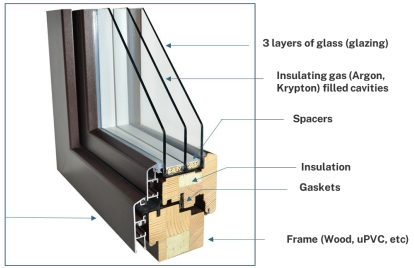
Swept clean

High Performance Windows & Doors

Principle #4

Element #4: High-Performance Windows w/ Solar Protection





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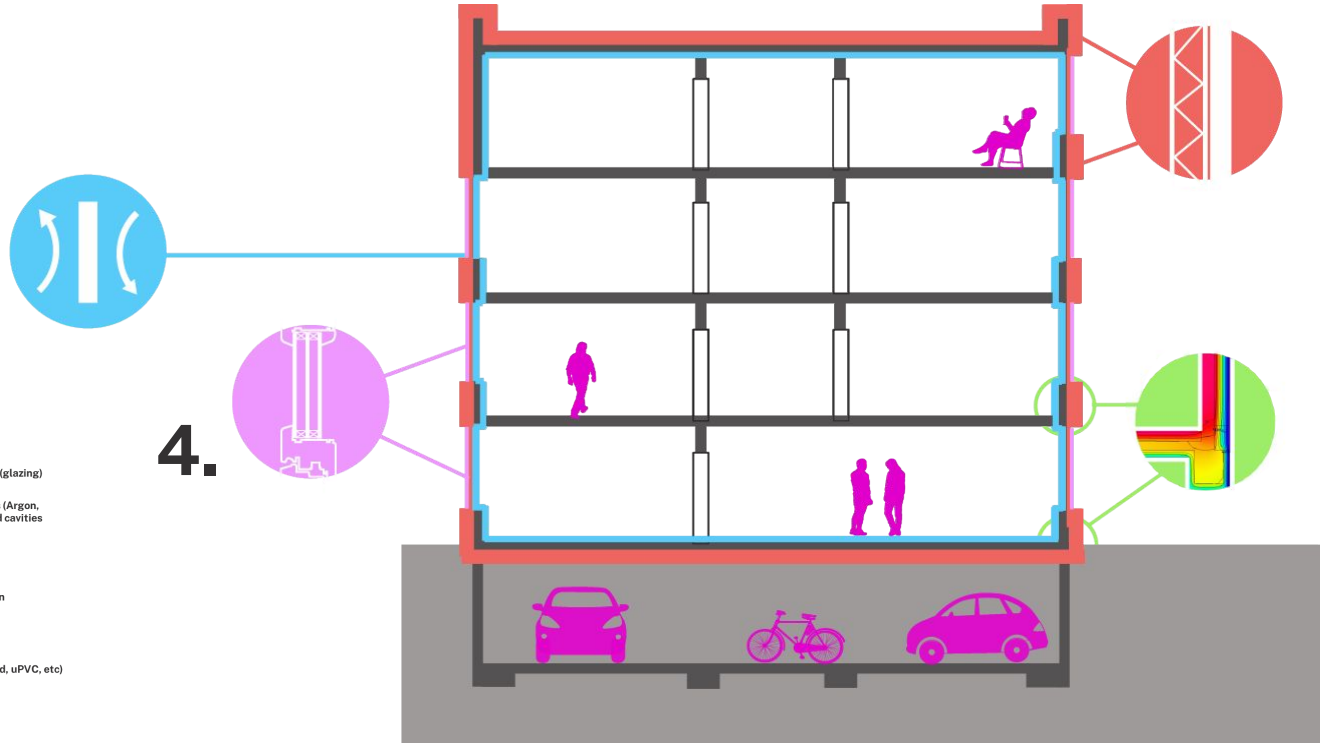
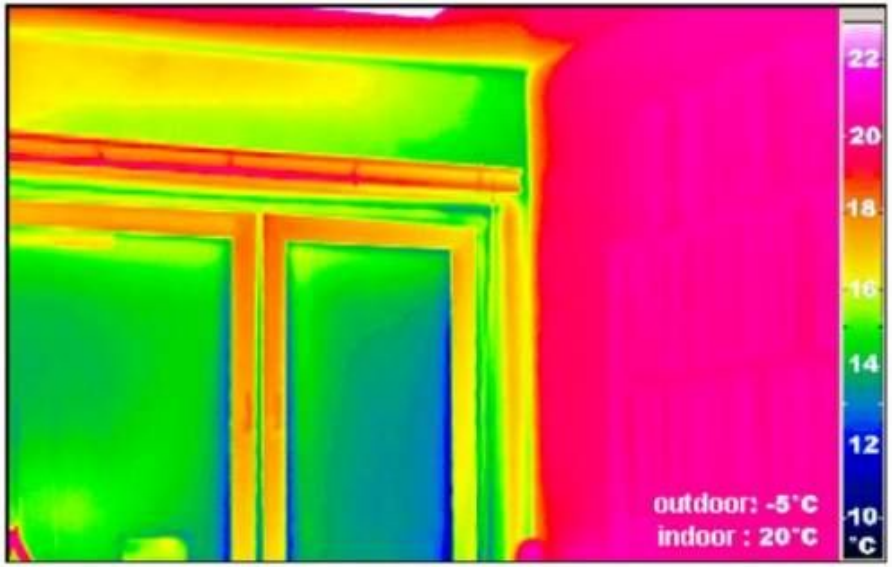


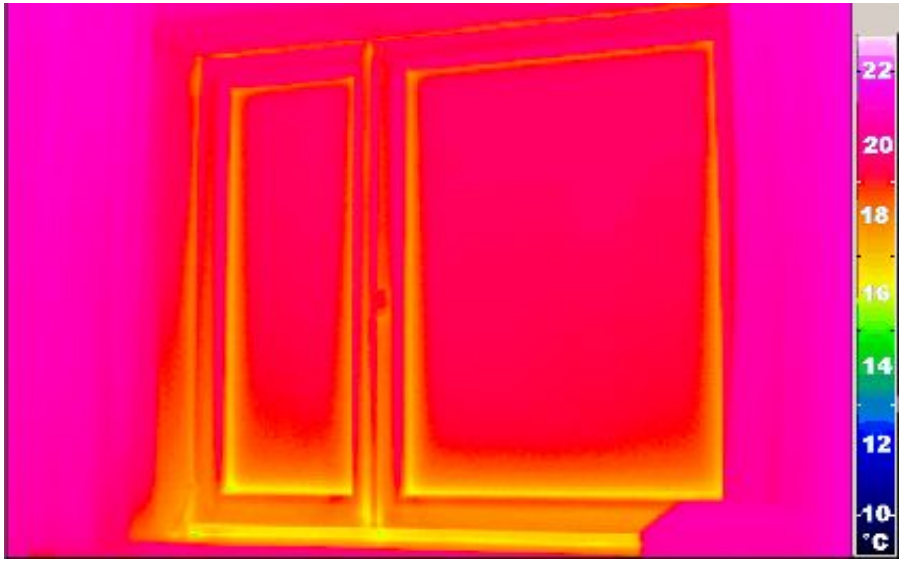
Extensions of Insulation & Airtightness

Typical Windows



°F
72
68
64
60
58
54
50

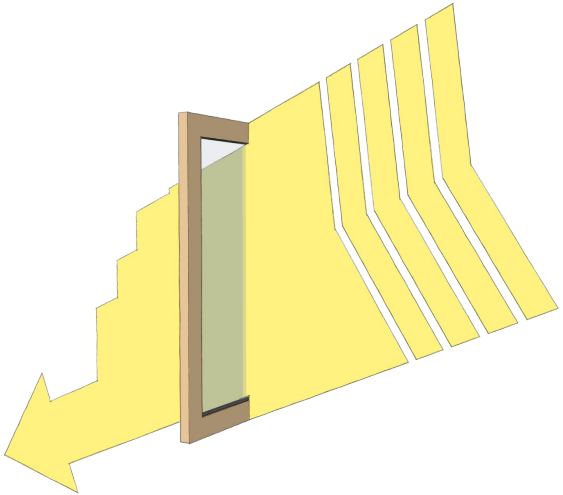
PH Windows



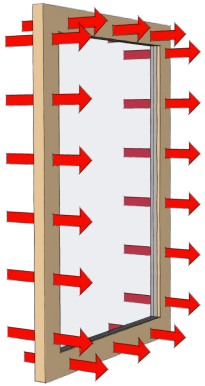
Interior 68°F Exterior 23°F

With high performance glass **frames are the weakest part** of the window assembly

PH Window Performance

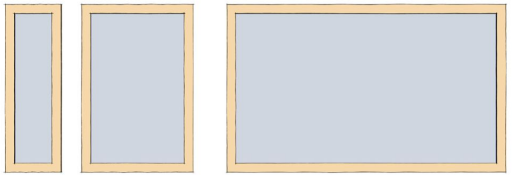


Solar Heat gain through the glass
SHGC



Heat Loss through the glass, frame, and spacer/installation thermal bridges **U-Value**

U_f: 0.11 Btu/(hr.ft².°F)
U_g: 0.08 Btu/(hr.ft².°F)



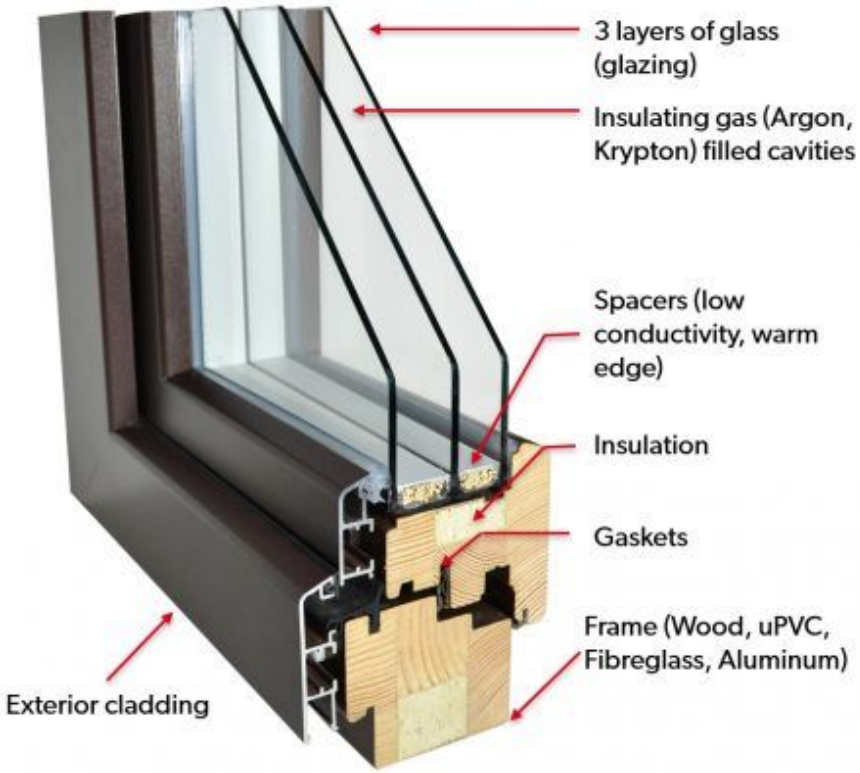
2' x 6' U-0.145

4' x 6' U-0.118

10' x 6' U-0.110

Less Frame = Better Performance

PH Windows



cool, temperate climate

phA

CERTIFIED COMPONENT

Passive House Institute

Certified Window Example Certificate

CERTIFICATE

Certified Passive House Component

Component-ID 1270ws03 valid until 31st December 2024

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
Germany

Category: Window system
Manufacturer: Wescon Cedar Products Ltd., Duncan, Canada
Product name: 106mm Wood-Alu Window

This certificate was awarded based on the following criteria for the cool, temperate climate zone

Comfort $U_W = 0.80$ W/(m² · K) ≤ 0.85 W/(m² · K) with U_f = 0.70 W/(m² · K)

Hygiene $f_{Rsi=0.25}$ ≥ 0.70
Airtightness $Q_{100} = 0.22$ ≤ 0.25 m³/(h · m)

cool, temperate climate

CERTIFIED COMPONENT
Passive House Institute

Passive House efficiency class: phE | phD | phC | phB | phA

www.passivehouse.com

Wescon Cedar Products Ltd.
5120 Polkey Road, V9L 6W3 Duncan, Canada
☎ +1-250-748-5234 | ✉ braden@fensturwindows.com | ⌂ http://www.fensturwindows.com |

Calculation model | Isothermal

Description

Timber-aluminium frame with cork insulation (0.045 W/(mK)). The required temperature factor is not met at the threshold. The airtightness testing was undertaken for a window with two sidelights and toplight (3600mmx 2900mm), as well as for a balcony door (1200mm x 2430mm); the required air tightness standard is not met for the balcony door. Glazing 4/18/4/18/4; glass intersection: 16mm; spacer: Superspacer Premium; secondary seal: butyl.

Explanation

The window U-values were calculated for the test window size of 2.46 m × 1.48 m with U_f = 0.70 W/(m² · K). If a higher quality glazing is used, the window U-values will improve as follows:

Glazing	U_g =	0.70 ↓	0.64 ↓	0.58 ↓	0.52 ↓	W/(m² · K)
Window	U_W =	0.80	0.75	0.71	0.66	W/(m² · K)

Transparent building components are classified into efficiency classes depending on the heat losses through the opaque part. The frame U-Values, frame widths, thermal bridges at the glazing edge, and the glazing edge lengths are included in these heat losses. A more detailed report of the calculations performed in the context of certification is available from the manufacturer.
The Passive House Institute has defined international component criteria for seven climate zones. In principle, components which have been certified for climate zones with higher requirements may also be used in climates with less stringent requirements. In a particular climate zone it may make sense to use a component of a higher thermal quality which has been certified for a climate zone with more stringent requirements.

Further information relating to certification can be found on www.passivehouse.com and passipedia.org.

Component-ID: 1270ws03 2/8
www.passivehouse.com

Frame values		Frame width b_f mm	U-value frame U_f W/(m² · K)	Ψ-glazing edge Ψ_g W/(m · K)	Temp. Factor $f_{Rsi=0.25}$ [-]
Mullion fixed	(MH)	84	0.87	0.019	0.74
Transom fixed	(MT)	84	0.87	0.019	0.74
Mullion 1 casement	(MH)	135	0.89	0.020	0.71
Transom 1 casement	(TT)	135	0.89	0.020	0.71
Bottom fixed	(FB)	82	0.87	0.020	0.71
Top fixed	(FT)	82	0.85	0.020	0.71
Lateral fixed	(FJ)	82	0.85	0.020	0.71
Flying Mullion	(MH)	126	0.92	0.020	0.72
Bottom	(DB)	102	0.89	0.020	0.71
Top	(DT)	102	0.86	0.020	0.71
Lateral	(DJ)	102	0.86	0.020	0.71
Threshold	(TH)	158	1.30	0.021	0.55
Spacer: Super Spacer Premium			Secondary seal: Butyl		

Mullion fixed
b_f = 84 mm
U_f = 0.87 W/(m² · K)
Ψ_g = 0.019 W/(m · K)
f_{Rsi} = 0.74

Transom fixed
b_f = 84 mm
U_f = 0.87 W/(m² · K)
Ψ_g = 0.019 W/(m · K)
f_{Rsi} = 0.74

3/8 106mm Wood-Alu Window
www.passivehouse.com

Mullion 1 casement
b_f = 135 mm
U_f = 0.89 W/(m² · K)
Ψ_g = 0.020 W/(m · K)
f_{Rsi} = 0.71

Transom 1 casement
b_f = 135 mm
U_f = 0.89 W/(m² · K)
Ψ_g = 0.020 W/(m · K)
f_{Rsi} = 0.71

Bottom fixed
b_f = 82 mm
U_f = 0.87 W/(m² · K)
Ψ_g = 0.020 W/(m · K)
f_{Rsi} = 0.71

Top fixed
b_f = 82 mm
U_f = 0.85 W/(m² · K)
Ψ_g = 0.020 W/(m · K)
f_{Rsi} = 0.71

Lateral fixed
b_f = 82 mm
U_f = 0.85 W/(m² · K)
Ψ_g = 0.020 W/(m · K)
f_{Rsi} = 0.71

Component-ID: 1270ws03 4/8
www.passivehouse.com

Validated installations

Formwork blocks (fixed)
U_{frame} = 0.15 W/(m² · K)

$\Psi_{install}$	W/(m · K)
Top	0.002
Left	0.002
Flight	0.002
Bottom	0.016
$U_{W,installed}$ = 0.81 W/(m² · K)	

Formwork blocks (openable)
U_{frame} = 0.15 W/(m² · K)

$\Psi_{install}$	W/(m · K)
Top	0.003
Left	0.003
Flight	0.003
Bottom	0.016
$U_{W,installed}$ = 0.81 W/(m² · K)	

Lightweight timber (fixed glazed)
U_{frame} = 0.13 W/(m² · K)

$\Psi_{install}$	W/(m · K)
Top	0.014
Left	0.014
Flight	0.014
Bottom	0.029
$U_{W,installed}$ = 0.84 W/(m² · K)	

Lightweight timber (openable)
U_{frame} = 0.13 W/(m² · K)

$\Psi_{install}$	W/(m · K)
Top	0.015
Left	0.015
Flight	0.015
Bottom	0.029
$U_{W,installed}$ = 0.84 W/(m² · K)	

Exterior insulation and finishing system (EIFS) (fixed
U_{frame} = 0.13 W/(m² · K)

$\Psi_{install}$	W/(m · K)
Top	0.000
Left	0.000
Flight	0.000
Bottom	0.013
$U_{W,installed}$ = 0.81 W/(m² · K)	

Exterior insulation and finishing system (EIFS)
U_{frame} = 0.13 W/(m² · K)

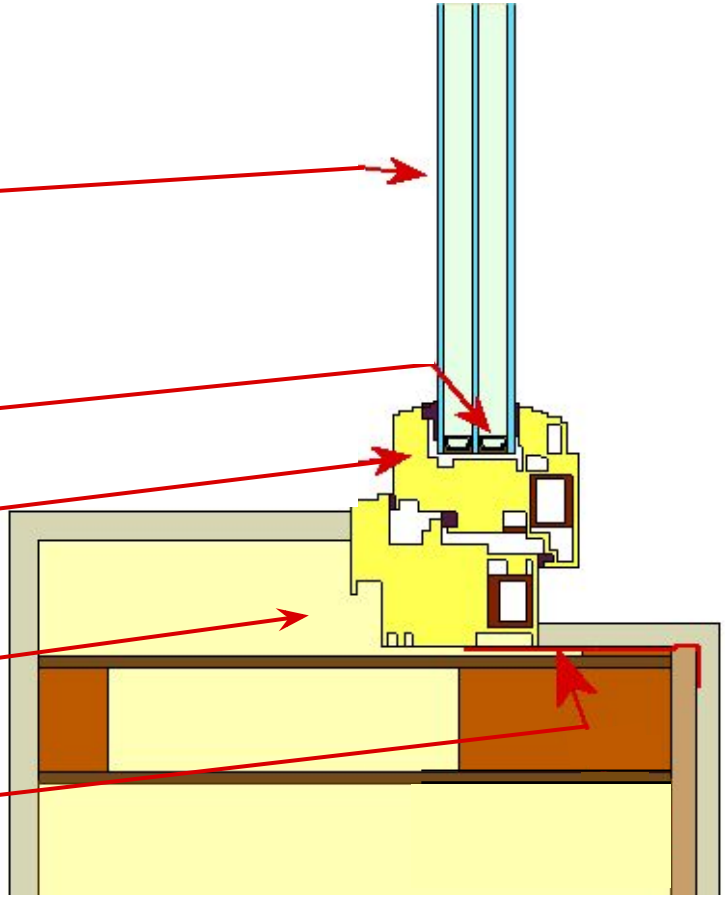
$\Psi_{install}$	W/(m · K)
Top	0.011
Left	0.011
Flight	0.011
Bottom	0.032
$U_{W,installed}$ = 0.83 W/(m² · K)	

Component-ID: 1270ws03 6/8
www.passivehouse.com

https://database.passivehouse.com/en/components/list/group_4?

Window Components

1. Glass
   a. U-value
   b. Glazing Coatings
2. Spacer
3. Frame
4. Installation
5. Airtightness



Traditional vs Passive Windows

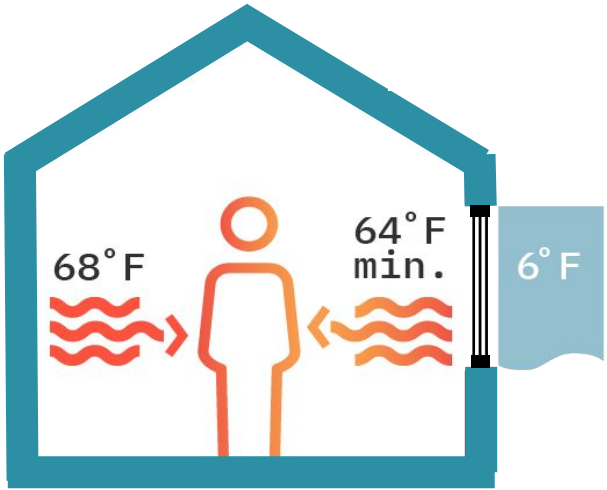
Traditional Double Hung

Tilt and Turn

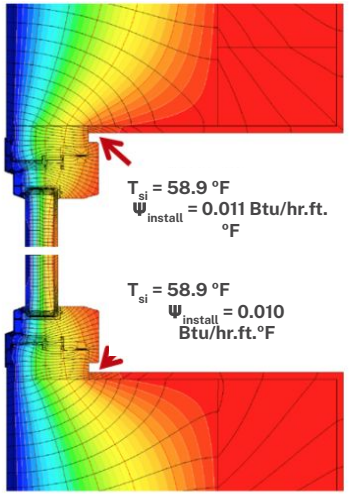
PH Comfort and Hygiene Criteria

1. **Comfort Criterion-** The minimum average window surface temperature can be no lower than 7.6°F than the average interior surface temperature. Based on the installed U value of a window.

2. **Hygiene Criterion-** sets limits that restrict the minimum interior surface temperature at the coldest point of the interior surface per climate zone, eliminating the potential for condensation avoiding mold growth. Measured by climate specific temperature factors (f_{Rsi}).

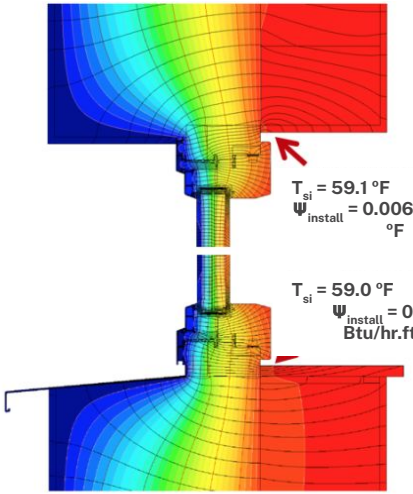


Install Conditions



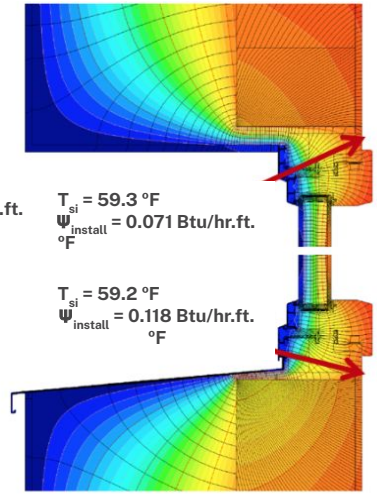
$U_{w\text{-}installed}$ = 0.151 Btu/hr.ft^2.°F
($R_{w\text{-}installed}$ = 6.62 hr.ft^2.°F/Btu)

Poor Installation



$U_{w\text{-}installed}$ = 0.148 Btu/hr.ft^2.°F
($R_{w\text{-}installed}$ = 6.76 hr.ft^2.°F/Btu)

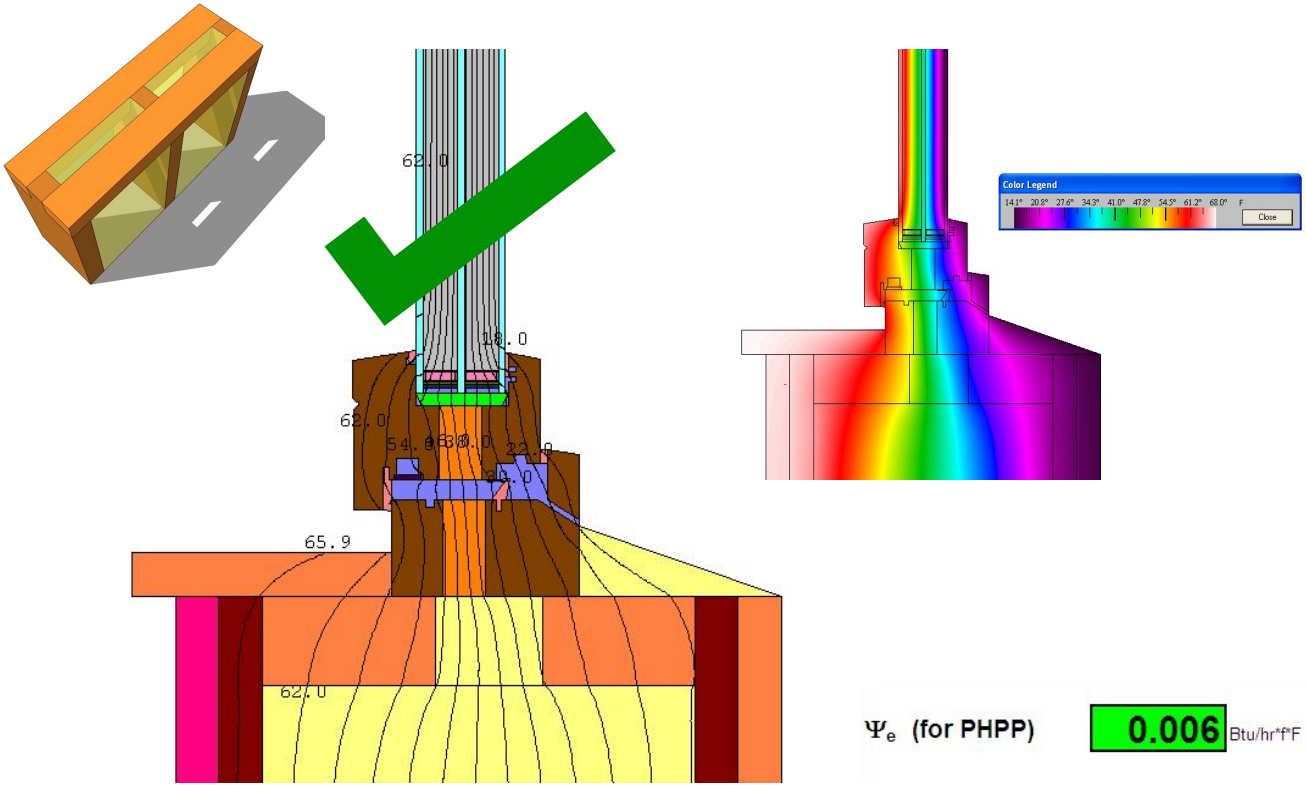
Recommended Installation



$U_{w\text{-}installed}$ = 0.215 Btu/hr.ft^2.°F
($R_{w\text{-}installed}$ = 4.65 hr.ft^2.°F/Btu)

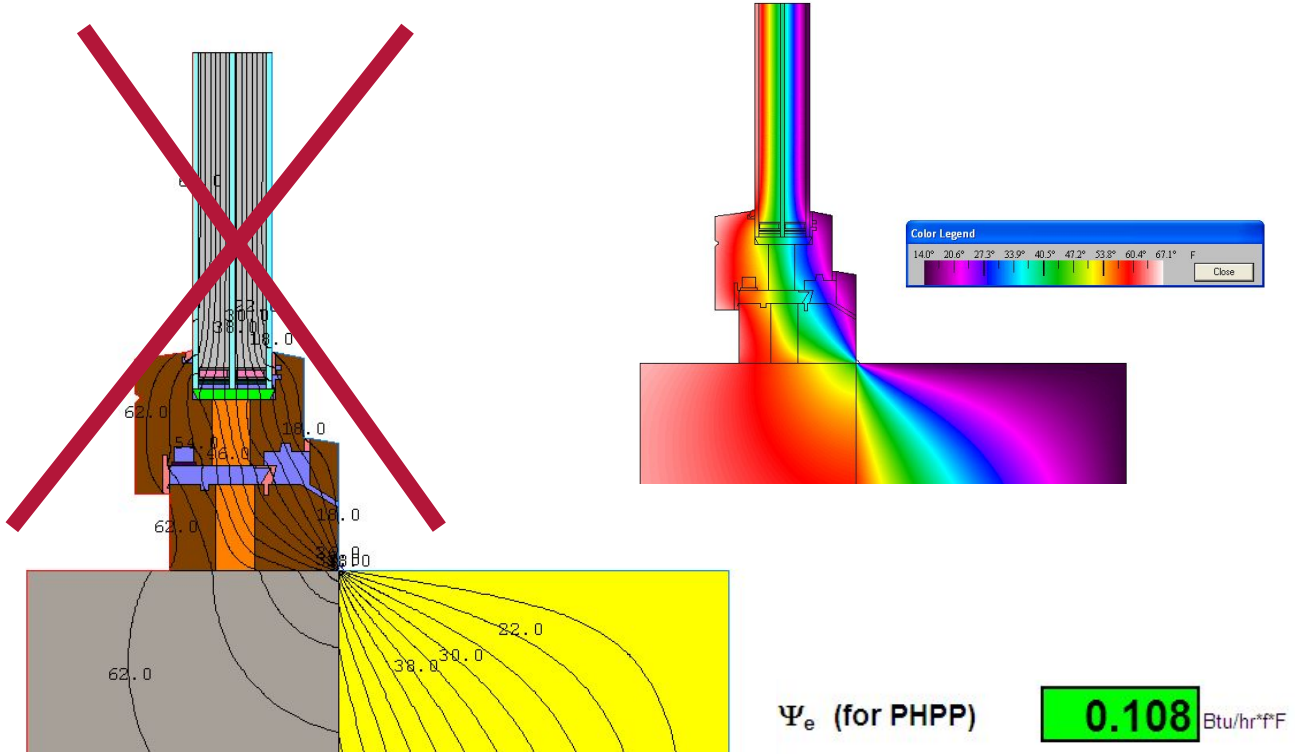
Poor Installation

Double Stud Window Detail

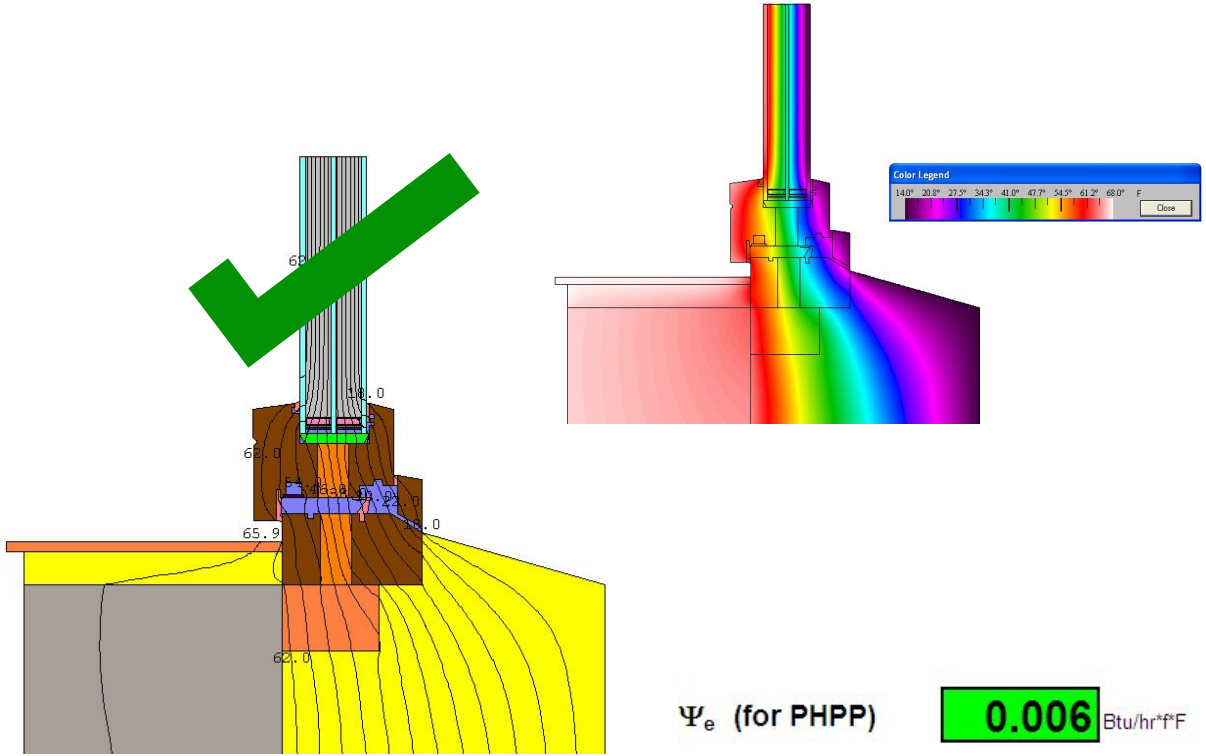


Ψ_e (for PHPP) **0.006** Btu/hr*f*F

Window in Masonry Layer



Window External to Masonry Layer



Ψ_e (for PHPP) **0.006** Btu/hr*f*F

Window Placed Outboard in Insulation Layer

Attachment with metal brackets (to be covered with insulation later)

Dense insulation blocking such as ‘Compact’ foam used to support the weight of the window whilst fixing into place

Retrofit example

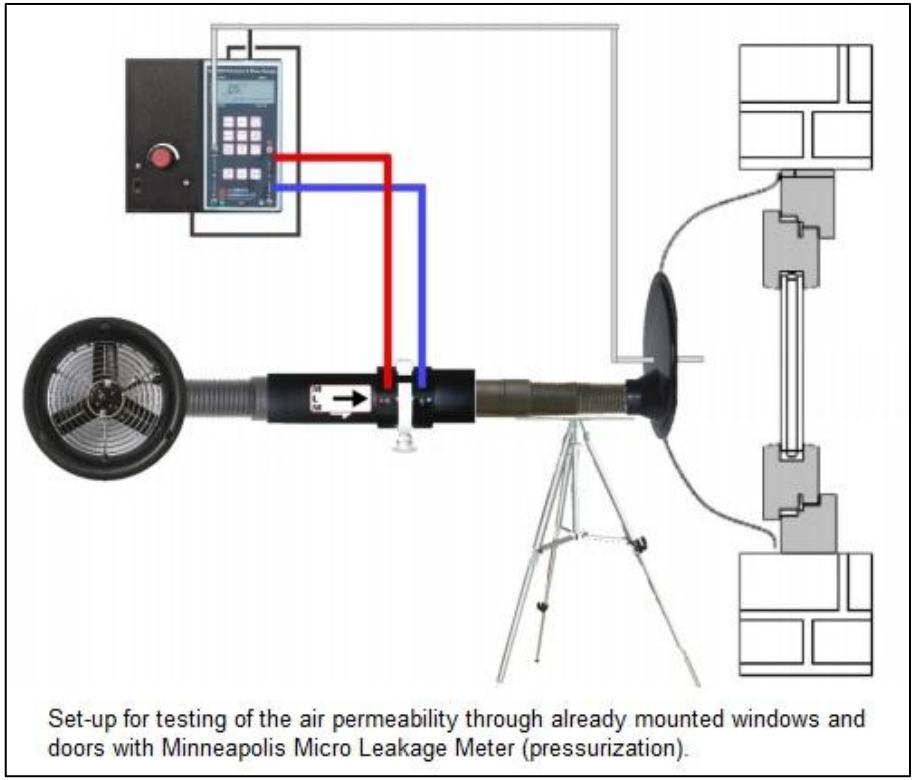
Pre taping for tight conditions.

Window Air Sealing Example

No Metal Sill Pans!

Window Install Testing: Sometimes Necessary

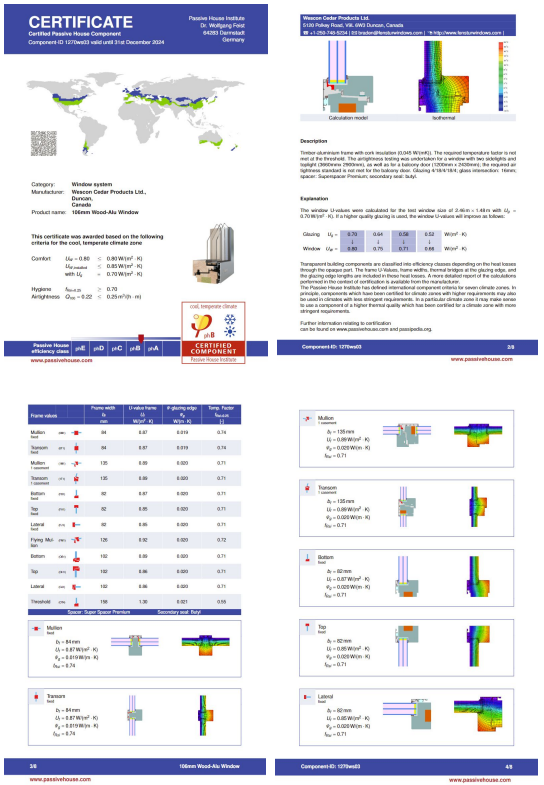
The Passive House Network



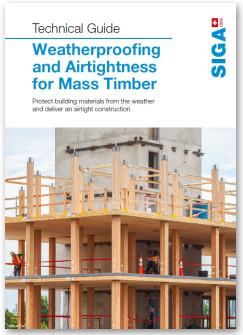
Set-up for testing of the air permeability through already mounted windows and doors with Minneapolis Micro Leakage Meter (pressurization).

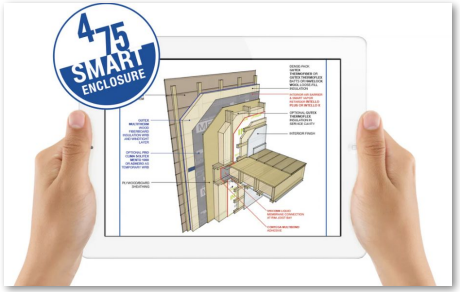
Many manufacturers to choose from

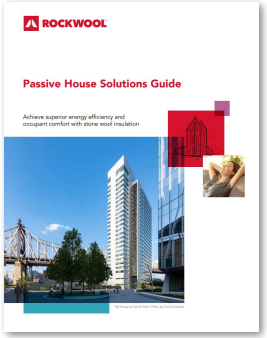
Manufacturer/Supplier	Speciality	Offers PHI Certified Components	HQ Location	Link
Alpen		Yes	Colorado	https://www.thinkalpen.com/
Amberline			Massachussetts	https://amberlinewindows.us/
Bewiso	simulated double-hung		Austria/NY	http://www.bewiso.eu/
Cardinal	glazing, spacers	Yes	Minnesota	https://www.cardinalcorp.com/
Cascadia	fiberglass		British Columbia	https://www.cascadiawindows.com/
Deceuninck		Yes	Ohio	https://deceuninckna.com/
Eco Windows			Connecticut	https://ecowindowsusa.com/
Edge-Tech	spacers		Texas	https://www.quanex.com/product/for-architects/warm-edge-spacers/
ENERsign		Yes	Germany/CO	https://www.enersign.com/en/
EuroLine Windows		Yes	British Columbia	https://euroline-windows.com/
Fakro	skylights		Poland/Illinois	https://shop.fakrousa.com/
Gamma North America		Yes	Ontario	https://gammana.com/
GlassCurtain	curtain wall		Alberta	https://glascurtain.ca/
Hella	exterior shading	Yes	Germany/MN	https://www.tannerbp.com/hella-exterior-blinds
Ikon Windows			New York	https://www.ikonwindows.com/
Inline Fiberglass			Ontario	https://www.inlinefiberglass.com/
Innotech Windows		Yes	British Columbia	https://www.innotech-windows.com/
Internorm		Yes	Germany/NY	https://www.sashandframe.com/
Intus Windwos		Yes	Virginia	https://www.intuswindows.com/
Lamilux	skylights/glass roofs	Yes	Germany/NY	https://475.supply/collections/lamilux
Makrowin		Yes	Slovakia/MA	https://www.eas-usa.com/
Morgan Advanced Materials – Vacupor			UK/MN	https://www.tannerbp.com/
Nord Windows & Doors		Yes	Alaska	https://aknordwindows.com/
NZP Fenestration		Yes	Quebec	https://nzpfenestration.com/en/
Optiwin		Yes	Germany/Wisconsin	https://www.heritagewindow.com/
PH Tech			Quebec	https://phtech.ca/en/
Raico	curtain wall	Yes	Germany/MN	https://www.tannerbp.com/
Rangate		Yes	British Columbia	https://rangate.com/
Rehau		Yes	Switzerland/NY	https://www.rehau.com/us-en/windows
Schueco		Yes	Germany/CT	https://www.schueco.com/ca/company/schueco-usa
Smartwin			Germany/KS	https://advantagewoodwork.com/
Swissspacer	spacers	Yes	Switzerland	https://www.swisspacer.com/en-us/
Tanner			Minnesota	https://www.tannerbp.com/
Technoform	spacers		Germany/OH	https://www.technoform.com/en
Viking		Yes	Estonia/CO	https://www.egresswindowtastic.com/
Westeck		Yes	British Columbia	https://www.westeckwindows.com/
Wythe Windows		Yes	New Jersey	https://www.wythewindows.com/
Yaro			Massachussetts	http://www.yarowindows.com/
Zola	simulated double-hung	Yes	Colorado	https://www.zolawindows.com/

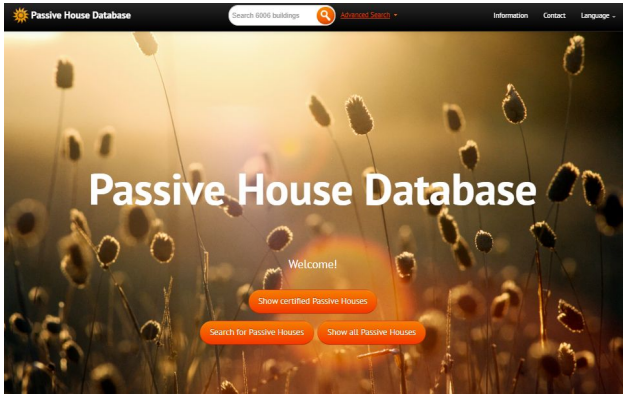


Examples from...

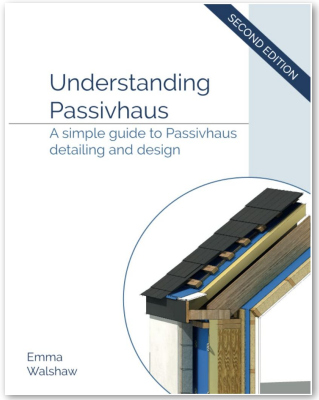


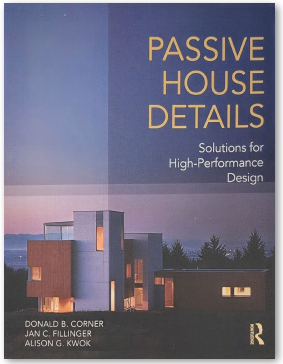


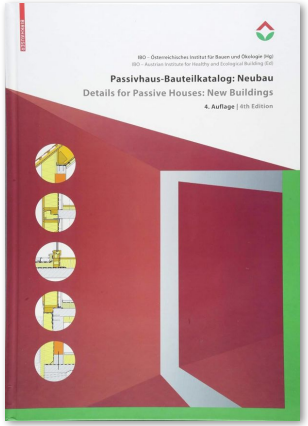


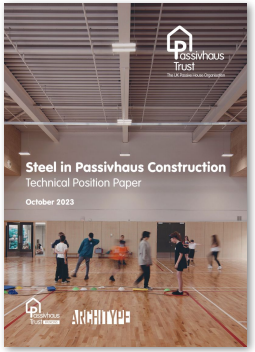


Secret: You can use the details and substitute the specs.

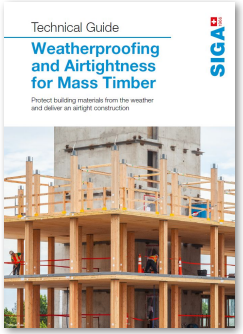


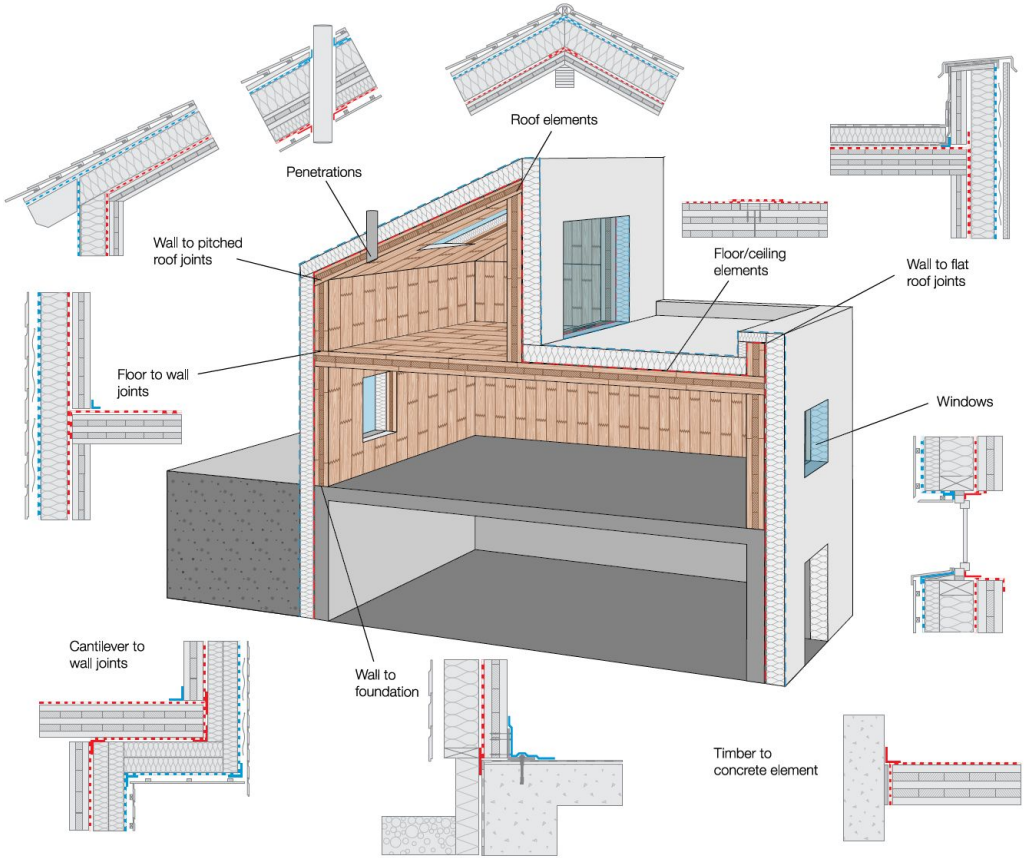




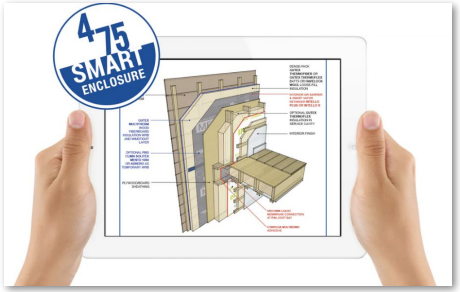


Mass Timber and Control Layers





Across Construction Types...



475 HIGH PERFORMANCE BUILDING SUPPLY

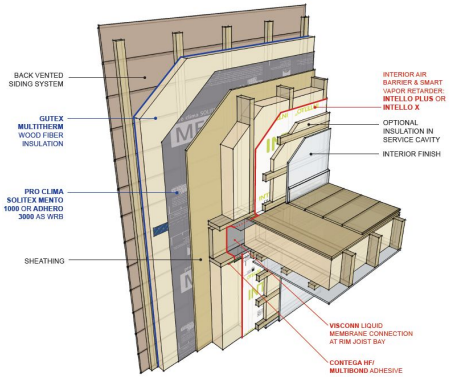
Smart Enclosure System Download

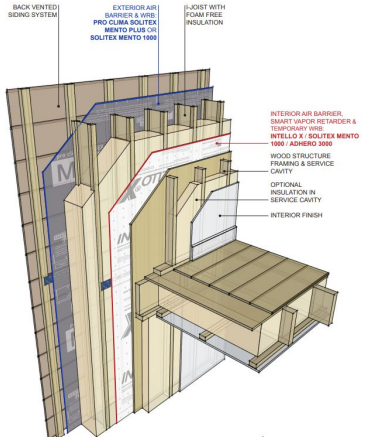
Assembly Type

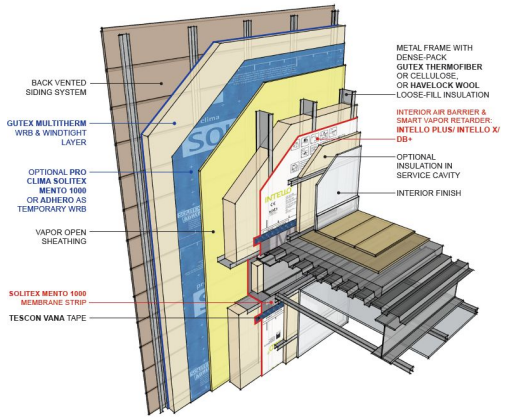
Masonry Retrofit | Wood Retrofit | 2X Framing | Double-Stud | I-Joist Outrigger | Metal Frame | Mass Timber

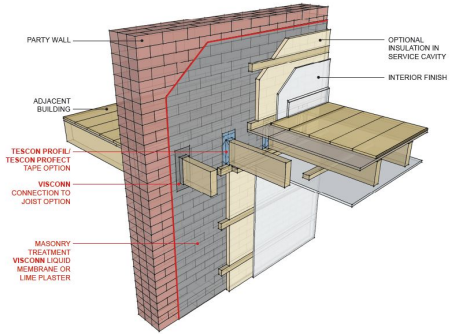
Download File

PDF - Page Layout | PDF - Spread Layout | DWG - CAD File

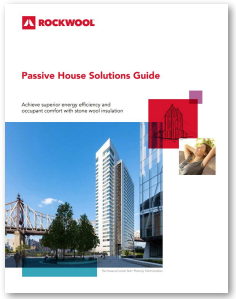


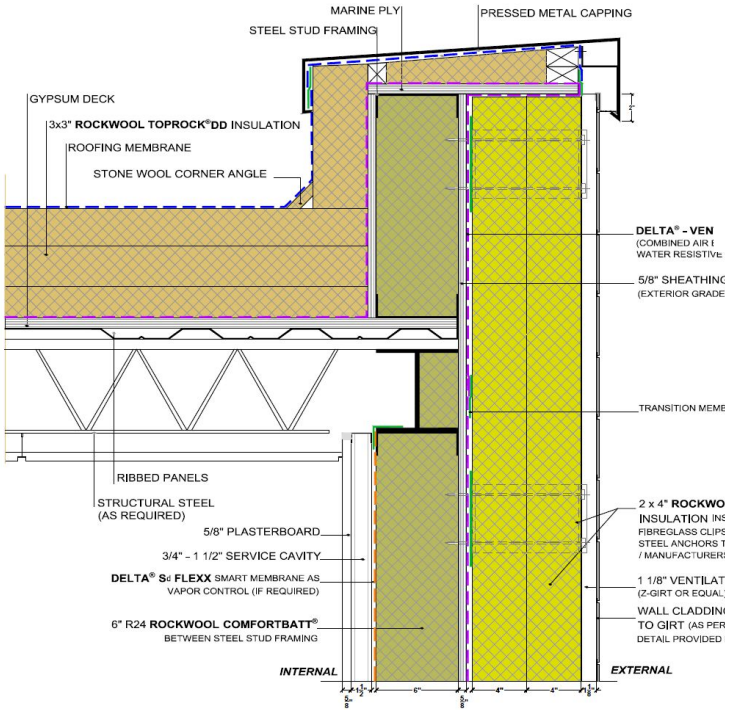


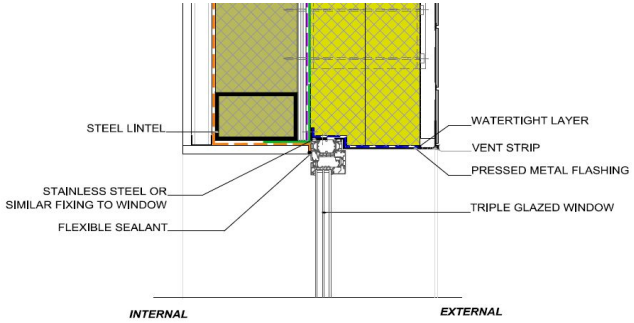


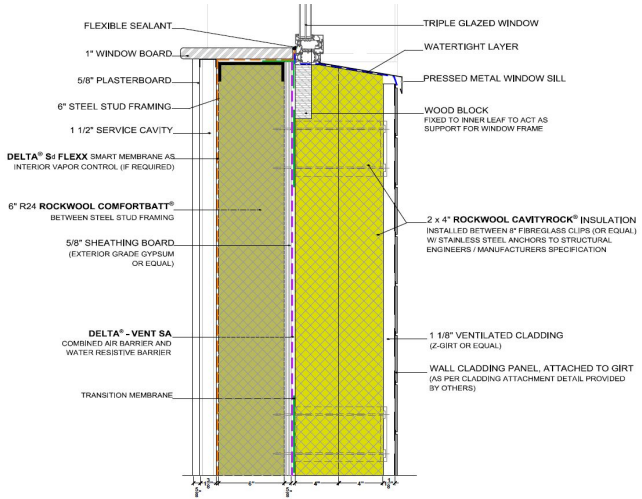


Steel


ROCKWOOL
Passive House Solutions Guide
Achieve superior energy efficiency and occupant comfort with stone wool insulation


MARINE PLY
PRESSED METAL CAPPING
STEEL STUD FRAMING
GYPSUM DECK
3x3" ROCKWOOL TOPROCK®DD INSULATION
ROOFING MEMBRANE
STONE WOOL CORNER ANGLE
DELTA® - VEN
(COMBINED AIR &
WATER RESISTIVE
5/8" SHEATHING
(EXTERIOR GRADE
TRANSITION MEME
RIBBED PANELS
STRUCTURAL STEEL
(AS REQUIRED)
5/8" PLASTERBOARD
3/4" - 1 1/2" SERVICE CAVITY
DELTA® Sd FLEXX SMART MEMBRANE AS
VAPOR CONTROL (IF REQUIRED)
6" R24 ROCKWOOL COMFORTBATT®
BETWEEN STEEL STUD FRAMING
2 x 4" ROCKWO
INSULATION INS
FIBREGLASS CLIPS
STEEL ANCHORS T
/ MANUFACTURERS
1 1/8" VENTILAT
(Z-GIRT OR EQUAL
WALL CLADDIN
TO GIRT (AS PER
DETAIL PROVIDED
INTERNAL
EXTERNAL


STEEL LINTEL
WATERTIGHT LAYER
VENT STRIP
PRESSED METAL FLASHING
STAINLESS STEEL OR
SIMILAR FIXING TO WINDOW
TRIPLE GLAZED WINDOW
FLEXIBLE SEALANT
INTERNAL
EXTERNAL

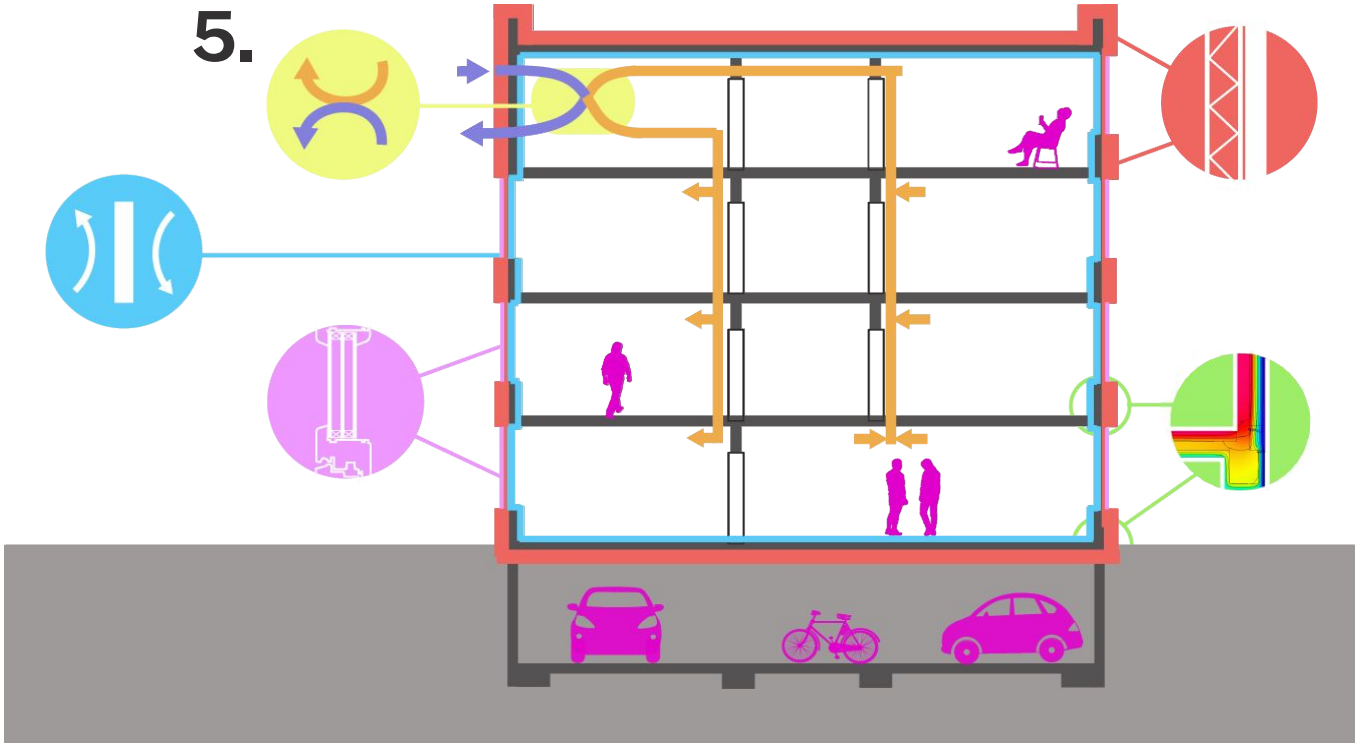

FLEXIBLE SEALANT
TRIPLE GLAZED WINDOW
1" WINDOW BOARD
WATERTIGHT LAYER
5/8" PLASTERBOARD
PRESSED METAL WINDOW SILL
6" STEEL STUD FRAMING
WOOD BLOCK
FIXED TO INNER LEAF TO ACT AS
SUPPORT FOR WINDOW FRAME
1 1/2" SERVICE CAVITY
DELTA® Sd FLEXX SMART MEMBRANE AS
INTERIOR VAPOR CONTROL (IF REQUIRED)
6" R24 ROCKWOOL COMFORTBATT®
BETWEEN STEEL STUD FRAMING
2 x 4" ROCKWOOL CAVITYROCK® INSULATION
INSTALLED BETWEEN 8" FIBREGLASS CLIPS (OR EQUAL)
W/ STAINLESS STEEL ANCHORS TO STRUCTURAL
ENGINEERS / MANUFACTURERS SPECIFICATION
5/8" SHEATHING BOARD
(EXTERIOR GRADE GYPSUM
OR EQUAL)
DELTA® - VENT SA
COMBINED AIR BARRIER AND
WATER RESISTIVE BARRIER
1 1/8" VENTILATED CLADDING
(Z-GIRT OR EQUAL)
WALL CLADDING PANEL, ATTACHED TO GIRT
(AS PER CLADDING ATTACHMENT DETAIL PROVIDED
BY OTHERS)
TRANSITION MEMBRANE

Mechanical Systems

Principle 5 + Other Systems

Ventilation
Principle #5

Element #5: Hygienic Ventilation w/ Heat Recovery



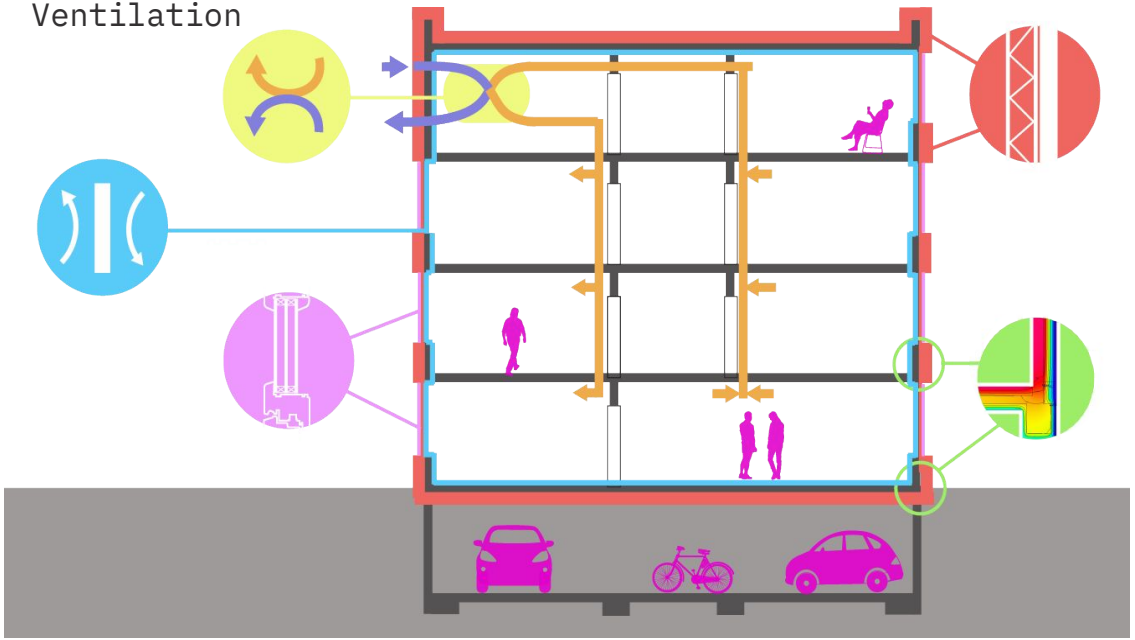
Passive House Ventilation

- Good air quality
- Continuous Operation
- Balanced ventilation
- Heat/Energy recovery

Heating, cooling & domestic hot water systems are important but come after addressing the enclosure and ventilation performance.

5.

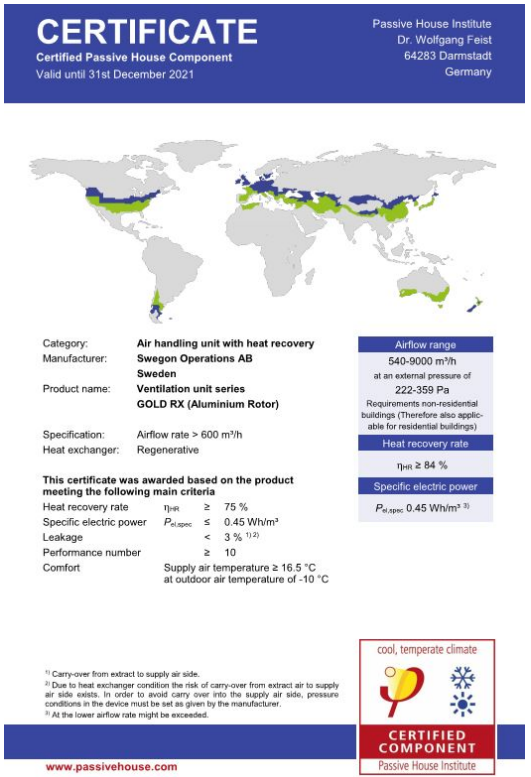
High Efficiency
Heat Recovery
Ventilation



PH Ventilation Design Criteria

The Passive House Network

- Energy recovery > 75%
- Fan power efficiency < 0.765 W/CFM.
- Supply > 62°F on winter design day.
- Supply air to all served spaces: living rooms, bedrooms, offices, classrooms etc…
- Exhaust from all services spaces: kitchens, bathrooms, utility rooms etc…
- Overall supply and exhaust must be balanced to be with within 10% of each other.



CERTIFICATE

Certified Passive House Component

Valid until 31st December 2021

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
Germany

Category: Air handling unit with heat recovery
Manufacturer: Swegon Operations AB, Sweden
Product name: Ventilation unit series GOLD RX (Aluminium Rotor)

Specification: Airflow rate > 600 m³/h
Heat exchanger: Regenerative

This certificate was awarded based on the product meeting the following main criteria

Heat recovery rate	η_{HR}	≥	75 %
Specific electric power	$P_{el,spec}$	≤	0.45 Wh/m³
Leakage		<	3 % [1) 2)]
Performance number		≥	10
Comfort	Supply air temperature ≥ 16.5 °C at outdoor air temperature of -10 °C		

Airflow range
540-9000 m³/h
at an external pressure of
222-359 Pa
Requirements non-residential buildings (Therefore also applicable for residential buildings)

Heat recovery rate
η_{HR} ≥ 84 %

Specific electric power
$P_{el,spec}$ 0.45 Wh/m³ [3)]

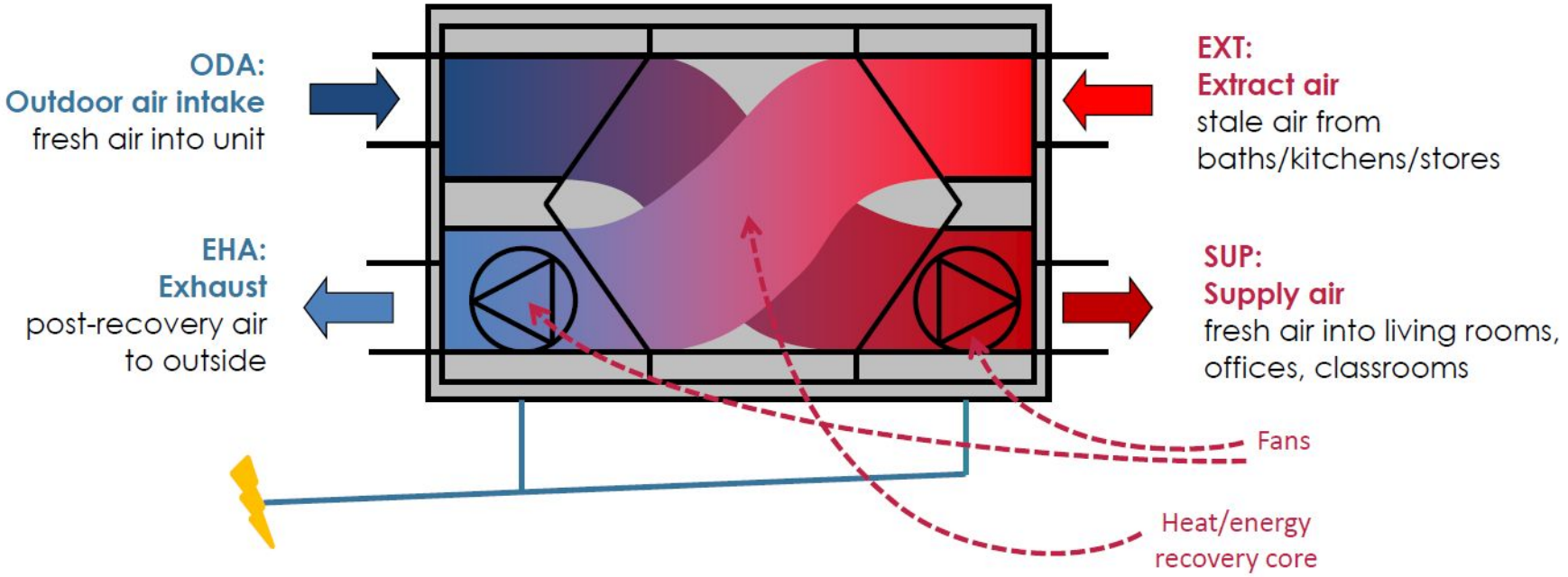
1) Carry-over from extract to supply air side.
2) Due to heat exchanger condition the risk of carry-over from extract air to supply air side exists. In order to avoid carry over into the supply air side, pressure conditions in the device must be set as given by the manufacturer.
3) At the lower airflow rate might be exceeded.

cool, temperate climate

CERTIFIED COMPONENT
Passive House Institute

www.passivehouse.com

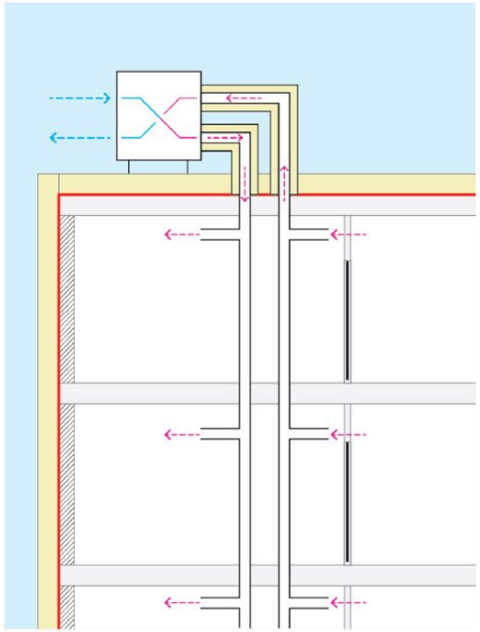
Heat Recovery Ventilation Unit



Balanced Ventilation

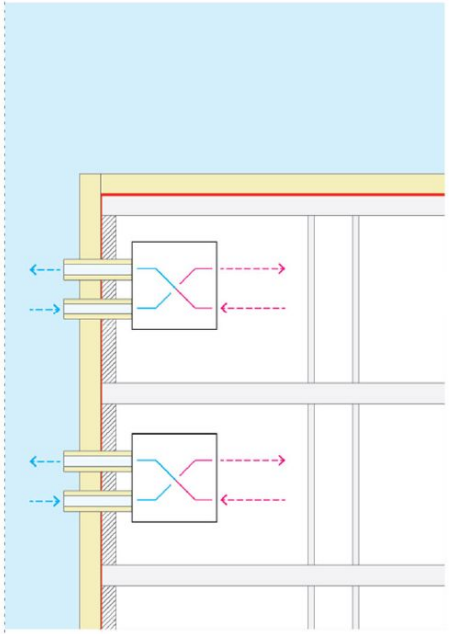
Centralized:

One main ventilator unit for the entire building



Decentralized:

Multiple ventilators distributed throughout the building

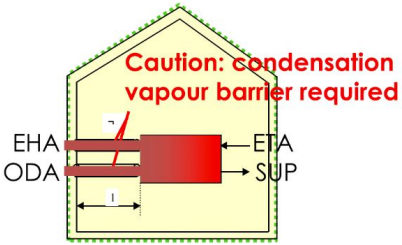


ERV/HRV – Single Unit

Source: Zehnder, Lunos, Renewaire

PH Ventilation Systems Considerations

- Duct insulation for intake and exhaust ducts with vapor-tight seal.
- Sound level – ventilation system must not be noisy.
  - ≤ 25 db(A): supply air to rooms
  - ≤ 30 db(A): rooms in non-residential buildings and exhaust air rooms in residential buildings
- Filtration for both supply and exhaust air.
  - MERV 13-14 to filter incoming air pollutants
  - MERV 6 to filter Extract return (only needed to protect heat exchange core)



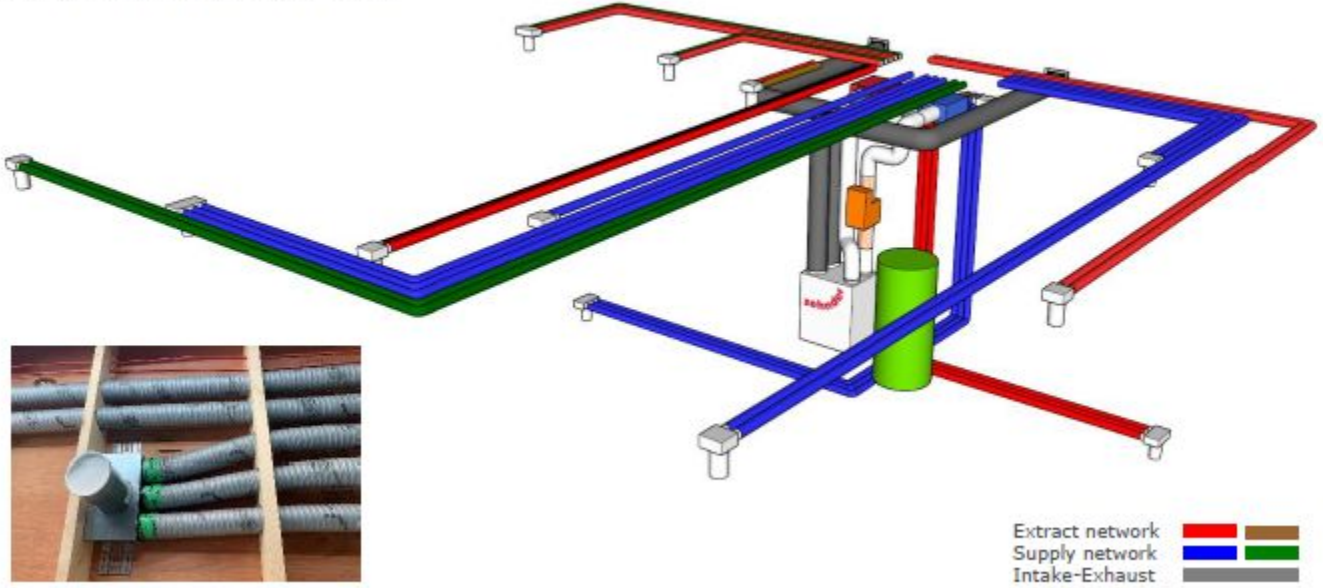
Intake and exhaust duct insulation

Merv 13 filter sample

Source: Zehnder

Single Family Ventilation Layout

This 3-dimensional model of the ventilation system helped the design team avoid structural and other building services conflicts, balance duct lengths for system efficiency and easy provisioning, and ensure that the mechanical room was adequately dimensioned and laid out.



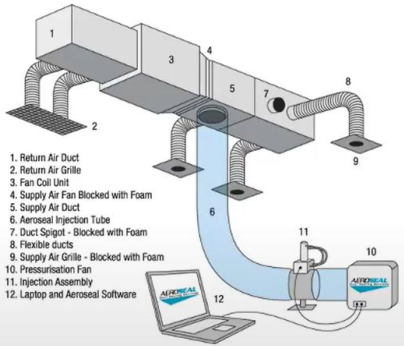
Recirculating Kitchen Venting

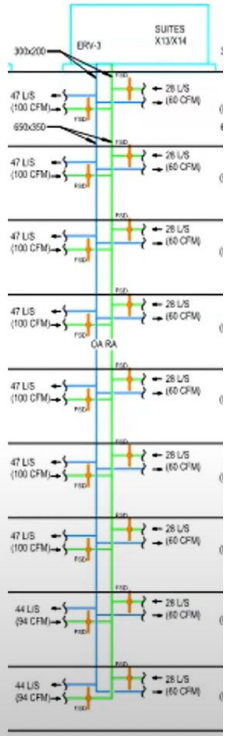
- Extract grille in ceiling connected to ERV and working 24/7
- Recirculating hood with charcoal filter directly above the stove
- Operable window for purge ventilation if needed

Duct Sealing & Testing for Large Buildings

- Ductwork needs to be airtight!
  - mastic duct sealant
  - mastic tape
  - preformed and insulated duct layouts
- Recommend to perform duct leakage testing to ensure system is well sealed.
- Balanced air flows is critical.
  - One strategy is to use Constant Airflow Regulators (CARs)

- Long ductwork requires careful planning
- Ensure CxA knows what the protocol is for measuring outlets – all outlets must be turned on, not just the suite being measured





- Proper duct sealing will only get you so far, a good design is always important!

Ventilation Balancing & Report

© Acin

Zero pressure compensating flow measuring instruments are the most accurate

Vane anemometers typically allow measurement of volumetric flow rate, air flow speed and temperature

Training for commissioning agents is vital for accurate results

VENTILATION

Manufacturer/Supplier	Speciality	Offers PHI Certified Components	HQ Location	Link
Acin	air flow meter		Netherlands	https://acin.nl/en/
Aeroseal	duct sealing (central systems)		Ohio	https://aeroseal.com/
Aldes	constant airflow regulator	Yes	Quebec/FL	https://www.aldes-na.com/
Brink		Yes	Netherlands/NY	https://475.supply/collections/brink
Ephoca	through wall		Italy	https://ephoca.com/
Lunos			Germany/NY	https://475.supply/collections/lunos
Minotair Ventilation Inc.			Quebec	https://www.minotair.com/home_us/
Oxygen 8		Yes	British Columbia	https://oxygen8.ca/
Swegon		Yes	Sweden/Ontario	https://www.swegon.com/na/
Ventacity		Yes	Oregon	https://www.ventacity.com/
Zehnder		Yes	Netherlands/ME	https://zehnderamerica.com/

FINAL PROTOCOL WORKSHEET for Ventilation Systems: Initial Start-up
Supply- / Extract-Air Ventilation System with Heat Recovery

Project		Initial Start-up		Ventilation System	
Object:	End-terrace house	Company:	Passive House Ventilation	Manufacturer:	Passive House Ventilation
Location Street, No.:	Passive street 123	Person in Charge:	John Smith	Product Name:	Passive House unit
Location Postcode, Town	12345 Passive City	Street, No.:	Passive street 12	Unit No.:	00000
Building Owner Name:	John Doe	Postcode, City:	12345 Passive City	Control No.:	00000
Building Owner Phone No.:	0	Phone No.:	00000		
Year of Construction	2017	Date:	07 / 01 / 2017		

1. Record of the air flow volumes, supply and extract air

Nr.	Room	Design			Measurement 1		Measurement 2		Measurement 3		Type of Valve	Adjustment	Flow-Through	Noise	Filter Grade	Filter Clean?
		V_{SU}	V_{EX}	$V_{THROUGH}$	V_{SU}	V_{EX}	V_{SU}	V_{EX}	V_{SU}	V_{EX}			$V_{THROUGH}$			
		m³/h	m³/h	m³/h	m³/h	m³/h	m³/h	m³/h	m³/h	m³/h			m/s	dB(A)		
1	Hobby room	35			45.1		30		37		Jet nozzle		0.6	20	F7	yes
2	Storage room		20			36		26		21	Poppet Exhaust Air		0.8	22	G4	yes
3	Technical space		20			41.2		18		20.3	Poppet Exhaust Air		0.7	22	G4	yes
4	Office	20			31.6		19.6		19.6		Jet nozzle		0.6	20	F7	yes
5	Living / kitchen	60	60		62.4	45.2	57.4	65.3	59.5	61.2	Jet nozzle/poppet exhaust air		1.0	20	F7/G4	yes
6	Master bathroom		40			12.7		34.2		41	Poppet Exhaust Air		0.6	22	G4	yes
7	Bedroom 2	20			21.9		26		20.7		Jet nozzle		0.6	20	F7	yes
8	Bedroom 3	20			28		26.9		19.1		Jet nozzle		0.6	20	F7	yes
9	Master bedroom	25			20.6		26.1		26.1		Jet nozzle		0.7	20	F7	yes
10	Bathroom		20			40.1		22.1		19.9	Poppet Exhaust Air		0.6	22	G4	yes
11	WC		20			43.6		23		19.6	Poppet Exhaust Air		0.7	22	G4	yes
12																yes / no
13																yes / no
14																yes / no
15																yes / no
	sum:	180.00	180.00	---	209.60	218.80	186.00	188.60	182.00	183.00			---	---	---	---

2. Balance of airflow volume

		Measurement 1			Measurement 2		Measurement 3		Disbalance	Type of Control	Adjustment	Noise	Filter Grade	Filter Clean?
		V_{AUL}	V_{FOL}		V_{AUL}	V_{FOL}	V_{AUL}	V_{FOL}				Measurement		
		m³/h	m³/h		m³/h	m³/h	m³/h	m³/h				dB(A)		
1	fresh air inlet				210	---	186	---	182	---	1%	BUS		30	F7	yes
2	exhaust air outlet				---	219	---	189	---	183		BUS		30	G4	yes

3. Initial start-up accomplished according to manufacturer's specifications: yes

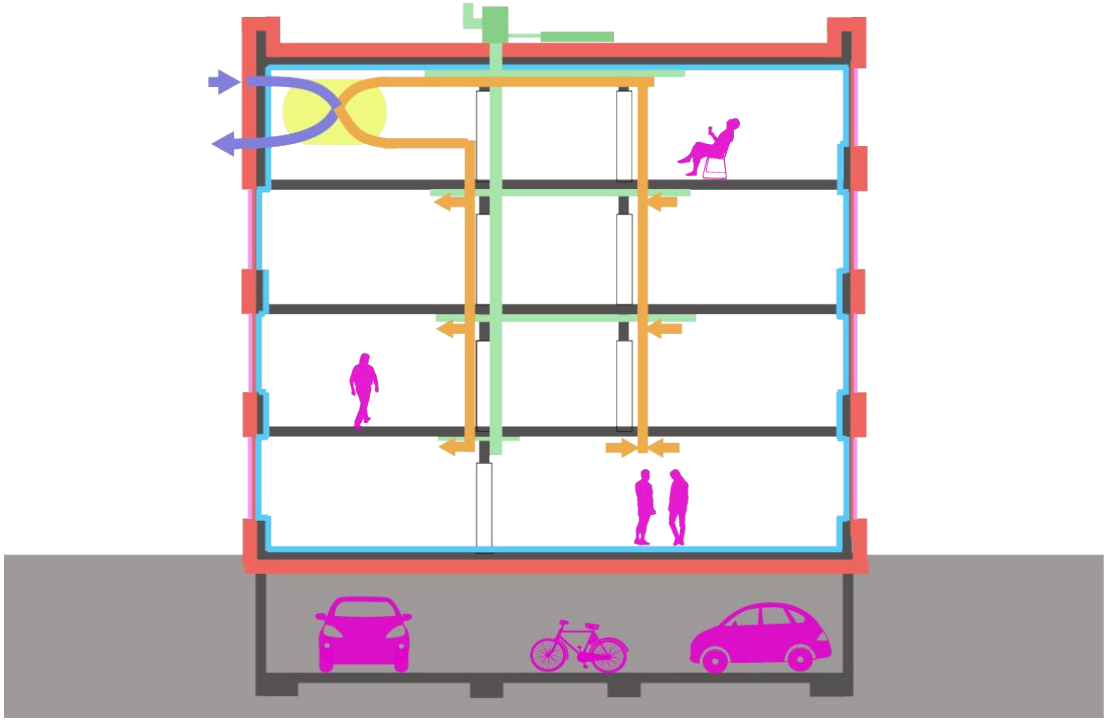
Signature: Signature

Sample documents for building certification © Passive House Institute 2023
Find out more at: www.passipedia.org/certification/certified_passive_houses/example_documents

Heating & Cooling Systems

Right Size Heating & Cooling Systems

- Often up to 75% reduction in equip sizing.
- Practically any kind of heating and cooling system can be used in a Passive House.
- Critical is efficient design with relatively compact distribution and right sizing of equipment.
- Typically heat pump technology capable of providing heating and cooling.
- Typically runs separately from, and independently of, ventilation air.



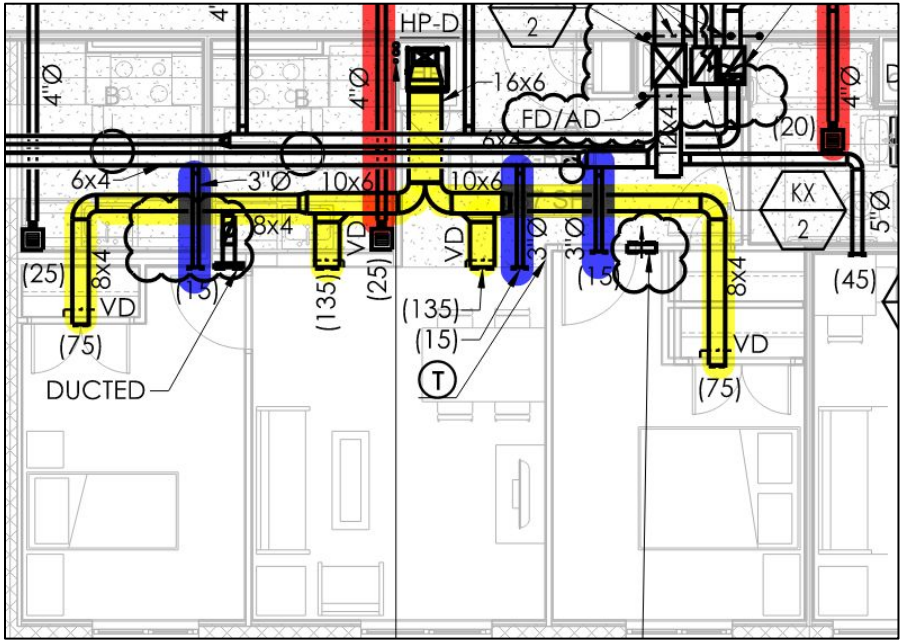
Single Family: Heating, Cooling & Dehumidification

Much smaller load and great flexibility in locating distribution outlets: surface mounted, recessed, ducted.

Commissioning is critical.

Keep Ventilation Separate from Cooling

- If ducted, must keep ventilation duct work completely separate from heating / cooling system ductwork.
    - Very difficult to properly balance air flows.
    - Increased fan energy penalty from air handler running 24/7
    - More wear and tear on equipment

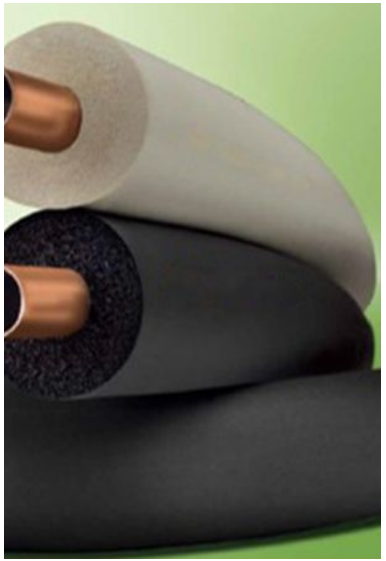


Exhaust air: kitchens and baths (red)
Supply air: living room and bedrooms (blue)
Heating/cooling (yellow)

Duct and Refrigerant Piping & Insulation

- Insulate all air conditioning ducts.
- Insulate all refrigerant lines.

Source: Armaflex



DHW

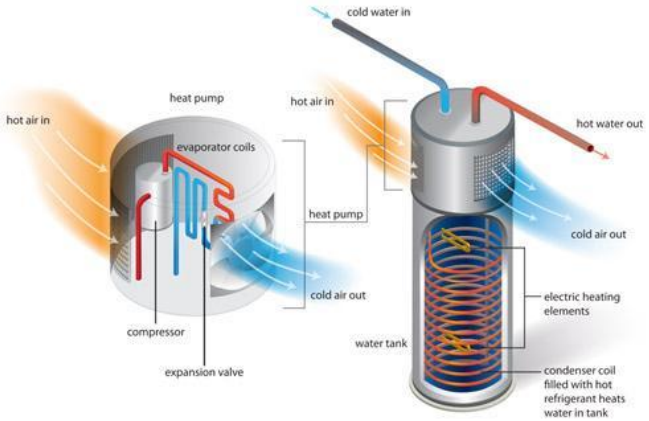
DHW and Energy Use

- **Reducing the use of hot water** is largely dependent on occupants, but an efficient water heater and distribution system can still make a big difference on the total energy used by **reducing unnecessary losses**.

- **Overall strategy:**
  - Minimize demand using low-flow devices
  - Use small-diameter pipes
  - Use the shortest possible pipe lengths
  - Minimize losses through insulation
  - Optional - use heat recovery from wastewater
  - Optional - generate hot water on-site from solar collector

Decentralized Hot Water

- Common options include
  - Conventional storage water heaters (gas, electric)
  - Tankless or on-demand water heaters (gas, electric)
  - Solar water heaters
  - Tankless coil / indirect water heaters
  - Heat pump water heaters

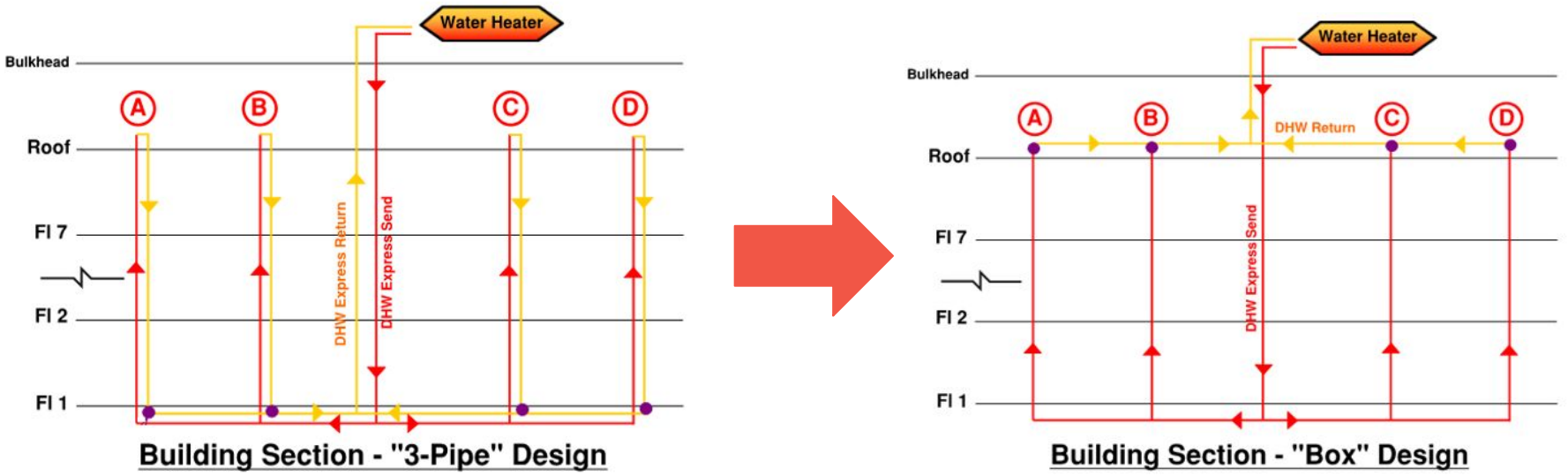


Combined Heat Pump System

Source: Energy Star, SANCO2

Split Heat Pump System

Minimize Pipe Runs in Design & Installation



DHW Pipe Insulation

- Insulation thicknesses to align with PHPP assumptions and local energy code requirements.
- Insulation to be continuous at all hanger locations.
- Runout piping to be fully insulated to the greatest extent possible.

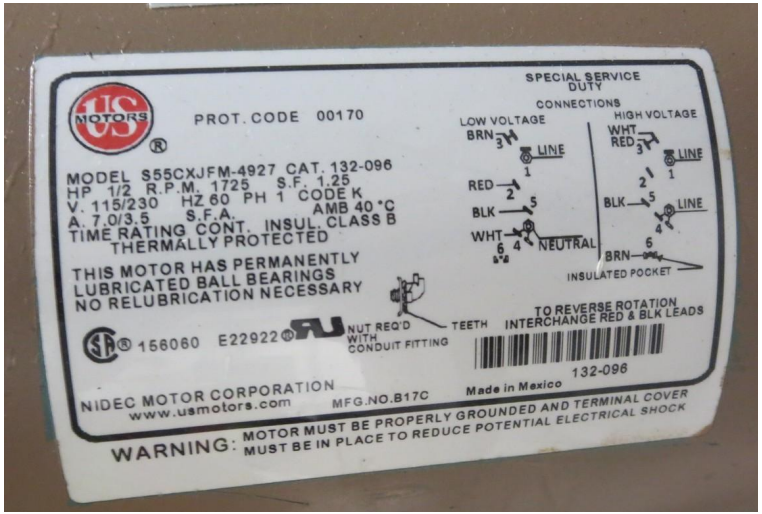
Pipe Insulation

- Pipes to be insulated include:
  - **Domestic hot water:** typically 1” insulation for smaller pipes, 1.5” insulation for larger pipes.
  - **Domestic cold water (best practice):** typically 1” all locations.
  - **Refrigerant lines:** typically 1” insulation for smaller pipes, 1.5” insulation for larger pipes.

Source: Johns Manville

DHW – Recirculation Pumps

- Ensure DHW pump sizes align with PHPP assumptions.
- Some systems may utilize a demand recirculation system that turns off the recirc pump during periods of low DHW use.



QA/QC

Assemble the team to deliver a Passive House

- Architects
- Engineers
- Consultants
- Passive House Consultant

- Builder & Trades

- Verifier/Verification
  - Inspectors
  - Ventilation Commissioning
  - Blower door testers

- Certifier

What a team needs:

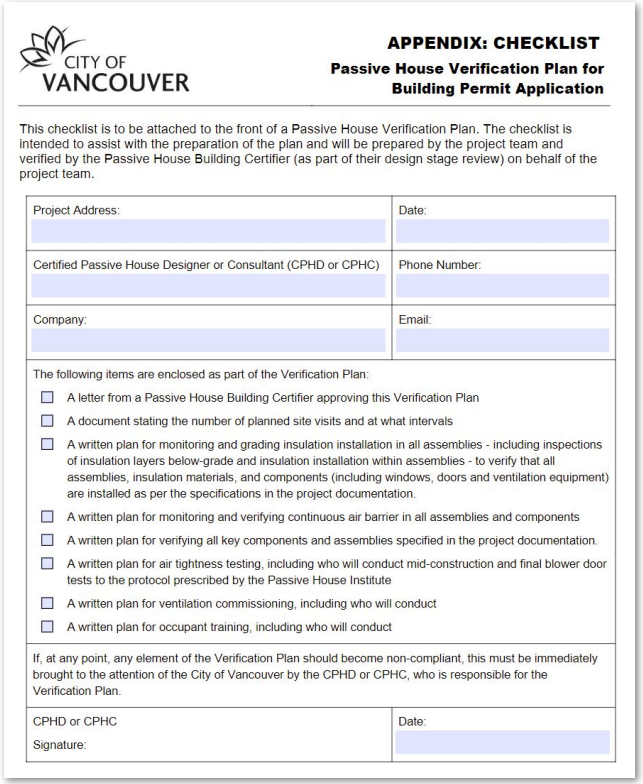
1. common language
2. common goal: Passive House
3. good attitudes
4. enough training
5. willingness to work as a team and connect the dots

Construction Schedule: Passive House line items...

Design Stage Open Items												
Close out unresolved items												
Submittals												
Verification Plan												
Product Specs												
Training & Mockups												
Envelope Connections												
Window Installation												
Inspections												
Representative Photos												
Ventilation												
Duct Leakage Testing												
Ventilation Commissioning												
Airtighness Testing												
Connections Mockup												
FInal Whole Building Blower door test												
As-Built Updates												
PHPP, Construction Drawings, Details, schedules and descriptions												
Photo "catalog"												
Builder Assurance Certificate												

Passive House Specific Verification Plan

- **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?
  - Make a formal Verification Plan



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

Checklists for Use During Construction

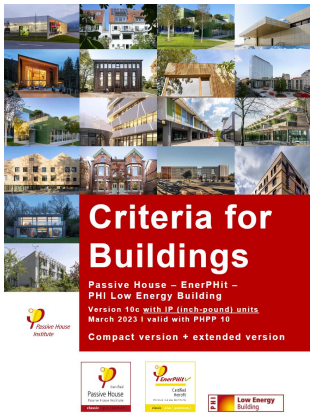
- **Helpful for the field verifier and the contractor to understand what is expected for the project**

- Below-grade insulation
- Above-grade wall insulation
- Roof insulation
- Air barrier
- Fenestration performance values
- Duct Sealing
- Pipe insulation
- HVAC and DHW equipment
- Lighting and lighting controls

Common Difficulties & Frustrations

1. Design review open items remain open.
2. Proposed changes during construction are not vetted in the PHPP. (And maybe the PHPP was never really completed. See #1)
3. Construction changes are not brought to the Certifiers attention delivering unintended consequences.
4. Not certified components substituted in – not vetted – more unintended consequences.
5. Thermal bridge calculations are not completed.
6. Work is out of sequence and air barrier is covered before testing.
7. Photographs are not organized, for expeditious review.
8. Approved submittals and as-built documentation are not submitted to the Certifier in a timely fashion.
9. Special conditions are not resolved early.
10. Team loses focus on whole building airtightness and ventilation.
11. **Team doesn’t appreciate their impact on performance results.**

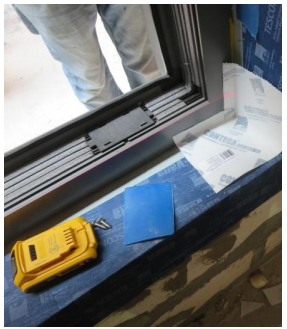
Submittals for Certification



Mock-Ups: Visual & Testing

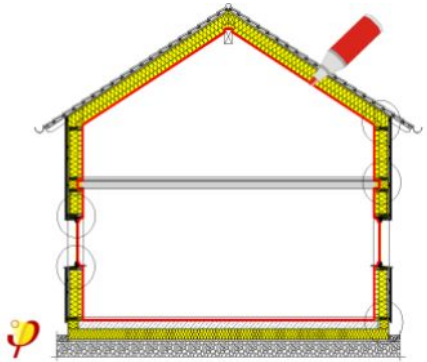
- Mock-ups can vary in terms of extensiveness.

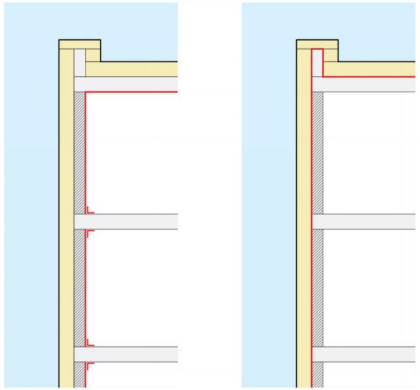
A simple mock-up could be the first window installed on the project.

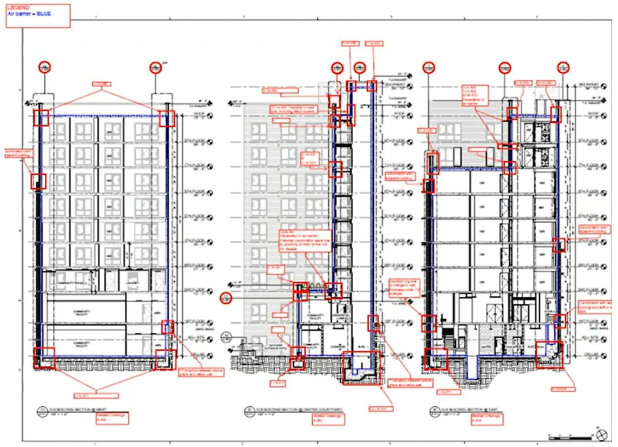


An extensive mock-up could be a full six-sided box with various details reflected.

Airtightness Plan & Culture





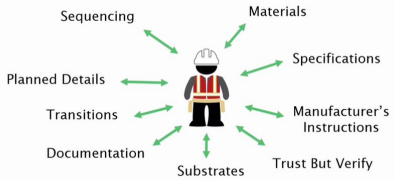


- Combination of hands-on practice and theoretical principles
- Focus on continuity of insulation and airtightness
- Change of mindset and attitude – 'thinking' fingers

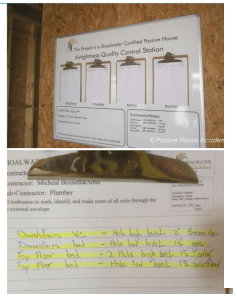
CERTIFIED PASSIVE HOUSE TRADESPERSON

TRADESPERSON

The "Air Boss"



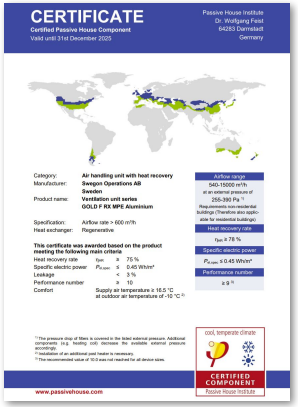
- Airtightness 'control station' strategically located at project
- All penetrations must be noted in writing
- Airtightness coordinator checks the log of penetrations daily and repairs holes



Protect Ventilation Performance

a. Accommodate adequate space early in design
b. Use high-quality units & size sufficiently
c. Aim for PHI recommendation of <2% leakage
d. Aeroseal ducts.

Industry standard specs for sealing can result in 30%+ leakage.



Photographs

3.2.11 Photographs

Back to compact version: ►3.2.11

Criteria

Evidence of the progress of construction must be supported with photographs, but it is not necessary to provide complete photographic documentation of all measures.

Additional requirements

The construction progress must be documented with illustrative photographs. However, full photo-graphic documentation of all measures is not necessary. Photos should be taken preferably at a time when the installation situation is not yet covered by cladding etc. Typically, photographs of the following areas should be taken:

- Thermal insulation of the building envelope (preferably with a measuring ruler in the picture to show the insulation thickness)
  - floor slab or basement ceiling
  - perimeter area
  - wall insulation
  - roof insulation
- Product data labels of
  - windows frames and glazing
  - heating and cooling units
  - ventilation unit
- Insulation and attachments of the air ducts
- Insulation and attachment of heating, hot water and cooling pipes and fittings
- Other energy-relevant construction details, e.g. thermal bridges

Sample photographs

A checklist of the pictures of the building site to be submitted for certification can be downloaded at: www.passipedia.org → Passive House Certification → Building Certification → Examples of documents that need to be submitted for certification

Building Site Photos for the Passive House Certification

Please make sure that the photos can be assigned correctly.

		Comment
Foundation		
Photos of delivered insulation packages	Product name, thermal conductivity, thickness	
Photos of the installation	Insulation of the foundation area / basement (e.g. under the floor slab, perimeter insulation)	
	Joint between floor slab / basement ceiling to walls and pillars (e.g. thermal break, flank insulation)	
External walls		
Photos of delivered insulation packages	Product name, thermal conductivity, thickness	
Photos of the installation		
Thermal bridges		
Photos of thermal bridges	Balcony railings, canopies, fixed ladders, fall protection etc.	
	All places where the insulation is penetrated or weakened	
Windows		
Photos of delivered windows + doors	Technical data on glazing (glass thickness, spacers, filling gas)	
	Technical data on frame (description), photo of frame	
Photos of the installation: windows	lateral, top, bottom, different installation types	
	Fixing sun protection, fall protection	
Photos of the installation: doors	lateral, top, bottom, different installation types	
Roofs		
Photos of delivered insulation packages	Product name, thermal conductivity, thickness	
Photos of the installation		
Building Service		
Photos of specification plate	all devices (e.g. pumps, ventilation unit, heater, cooling system, elevator)	
Photos ventilation unit	Location, silencer, duct insulation (thickness)	
Photos of sanitary pipes	Insulation of hot water / solar / heating pipes, storage and insulation of down waste water pipes (thickness)	
Project Specific Details depending on the project additional photos may be necessary		

Photographs of the construction process demonstrating that:
a) the specified products have been installed
b) correct installation practices have been followed

1. Photos must show the make model of the equipment
2. A description of what the photo captures must accompany each photo
3. All construction photos should be taken prior to interior finishes
4. Photos of all product types / variants of the following must be submitted:

Assemblies	Each insulation product for each wall, roof, floor, and foundation type
Junctions	Each junction in the building, as per Junctions worksheet
Windows	Each window and door type
	Each operable window type in fully open and tilted positions to demonstrate how far they open
	Compensatory window heater
Ventilation Systems	Each type of HRV / ERV unit
	Outdoor and extract air filters for each HRV / ERV type
	Ductwork & insulation for the supply, extract, outdoor and exhaust air ducts for each HRV / ERV type
	Duct attachements (hangers, etc)
	Volume Flow Dampers
	Internal and external vents / grilles, showing sufficient space between intake and exhaust
	Air transfer grilles AND / OR door under/overcut height
	Frost protection system
	Acoustic Attenuators
	Supply air heater
	In-unit occupant control devices for each HRV / ERV type
Heating and Cooling Systems	Each type of heat and cooling generator
	Each type of humidification / dehumidification system
	Distribution pipe insulation product and thickness, including valves & T junctions
	Distribution pumps
DHW Systems	Each type of heat generator
	Each type of storage tank
	Insulation product and thickness of primary pipes and recirculation pipes
	Pipe attachments (hangers, clips, etc)
	Circulation pumps
	Sanitary system - AAVs, backwater valves, pipe insulation, alternative approach
	Rainwater pipes - Ptraps, alternative approach
	Solar thermal panels
Electrical Equipment	Each type of light fixture and lamp
	Each appliance type
	Elevators
	Solar PV panels
	Any other relevant equipment
Airtightness Testing	During search for areas of additional air leakage - showing method of detection.
Shading	Include photographs of:
	a. Each elevation of the building
	b. Window and door overhangs and reveals (from exterior)

Organize daily/weekly throughout…don't wait!

Note: Typically conducted as part of inspection regime by independent verifier.

Contractor may submit photographs to document fixes.

Construction Managers Declaration

Signed Declaration	Include a completed and signed copy of the Declaration of Conformance form from the construction supervisor.

Project name:	
Location:	
Project name on Certification platform:	
Construction manager (First name, Surname):	
Project manager (First name, Surname):	

Construction manager declaration

In order for the quality inspection to award the "Certified Passive House" seal for the above mentioned construction project, we hereby assure that the on-site execution is in accordance with the planning documents, technical documents and textual descriptions that have been uploaded to the Passive House Institute's certification platform up to and including / / (and not marked as "obsolete").

This has been checked through regular site visits.

https://passipedia.org/_media/picopen/construction_manager_declaration.pdf

Construction management Date, Signature	Project management Date, Signature

Recommendations

1. **Meet early with the Certifier and identify all critical items and develop a Verification Plan.**
2. Include all necessary verification work in construction schedule.
3. Insist on training for the construction staff.
4. All subs should be aware of the project goals even if not directly related to Passive House.
5. Do mockups and preliminary blower door testing.
6. Do ventilation duct leakage testing and Aeroseal the ventilation ducts. (MF)
7. **Maintain a dedicated inspection log for all on-site Passive House items for Contractor to address and close out.**
8. Stay aware of what's outstanding and keep on schedule with the work.
9. Make submissions to Certifier in a timely manner.
10. **Organize the photos as you go address all items outlined by the Certifier.**
11. If you're not sure about something, ask the Certifier.
12. Hire a Certifier to coach team as needed.
13. Develop a culture that connects construction work to high-performance outcomes, including specialized training.
14. **Empower the team.**

Build a Culture of Quality!

Focus on the 5 principle drivers, and the comfort, hygiene & efficiency goals.

With focus and a little training, **anyone can build a Passive House**.

Resources

Resources

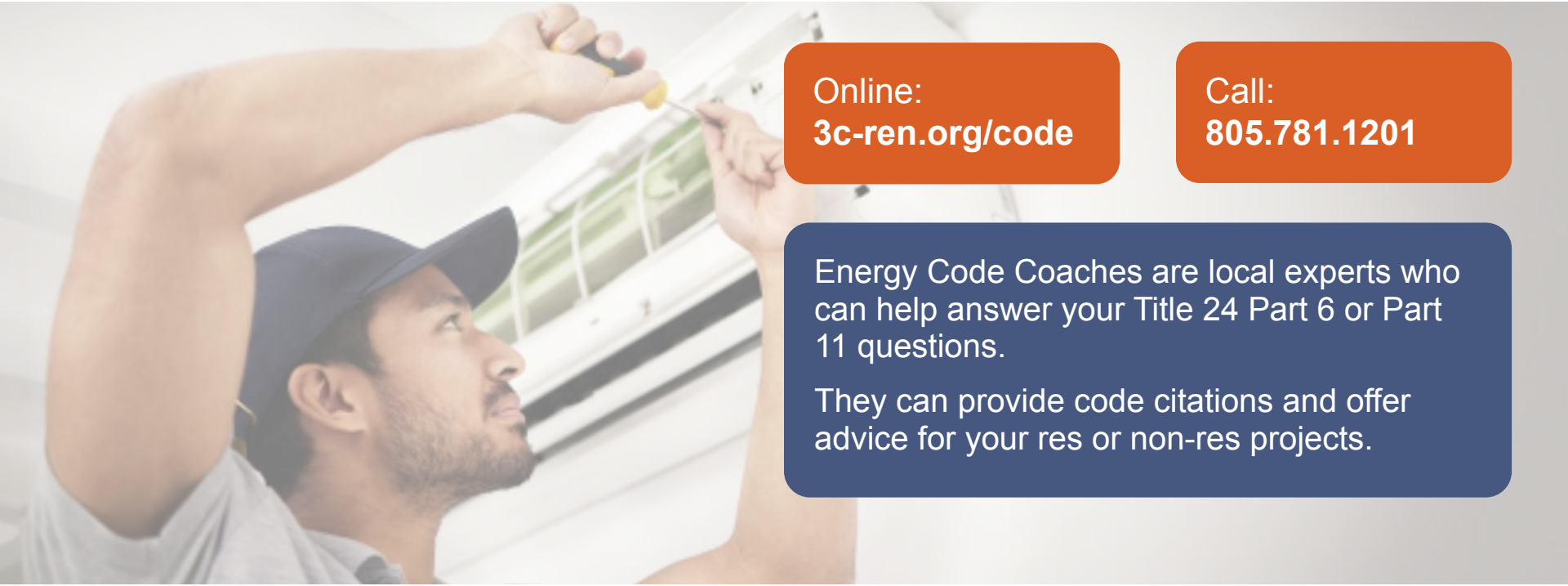
1. A Comparison of Canadian and European Energy Standards for Household Appliances - https://passivehousenetwork.org/featured/appliance-modeling-guide/
2. BC Hydro Building Envelope Thermal Bridging - https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/builders-developers/building-envelope-thermal-bridging-guide-v1-6.pdf
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. Building 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. Details for Passive Housees: New Buildings - https://www.thriftbooks.com/w/passivhaus-bauteilkatalog-neubau--details-for-passive-houses-new-buildings-kologisch-bewertete-konstruktionen--a-catalogue-of-ecologically-rated-constructions-german-edition/54431586/item/83148133/
14. Details for Passive Houses: Renovation - https://birkhauser.com/en/book/9783035607543
15. Easi Guide to Passivhaus Design - https://www.levittbernstein.co.uk/site/assets/files/3553/passivhaus-easi-guide_screen_portrait.pdf
16. High Performance Walls Study by Steven Winter Associates - http://swinter.com/wp-content/uploads/High-Performance-Walls-2019-reformatted.pdf
17. 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
18. ISO 9972 - https://www.iso.org/standard/55718.html
19. Legalizing Mid-Rise Single-Stair Housing in Massachusetts - https://www.jchs.harvard.edu/sites/default/files/research/files/harvard_jchs_utile_boston_indicators_single-stair_housing_october_10_2024.pdf
20. Manager Declaration Sample - https://passipedia.org/_media/picopen/construction_manager_declaration.pdf
21. Manufacturers Directory - https://passivehousenetwork.org/manufacturers-directory/
22. National Definition of Zero Emissions Building: https://www.energy.gov/sites/default/files/2024-06/bto-national-definition-060524.pdf
23. North American Certifiers Circle - https://passivehousenetwork.org/wp-content/uploads/2023/01/NACC-Brochure-Jan-2023.pdf
24. Passipedia - https://passipedia.org/start
25. Passive Architecture - https://issuu.com/lafamillecarbonic/docs/passive_architecture_en
26. Passive House Certification - https://passivehousenetwork.org/certification/
27. Passive House Criteria for Buildings - https://passivehouse.com/03_certification/02_certification_buildings/08_energy_standards/08_energy_standards.html
28. Passive House Definition - https://passipedia.org/basics/the_passive_house_-_definition
29. Passive House Details - https://www.amazon.com/Passive-House-Details-Solutions-High-Performance/dp/1138958263
30. Passive House - Historical Review - https://passipedia.org/basics/the_passive_house_-_historical_review
31. Passive House Planning Package (PHPP) - https://passivehouse.com/04_phpp/04_phpp.htm
32. Safe at Home PHN Report - https://passivehousenetwork.org/safe-at-home/
33. Sample Submission Documents - https://passipedia.org/certification/certified_passive_houses/example_documents
34. Summer Comfort - https://passipedia.org/planning/summer_comfort
35. The Greenest Home - https://www.amazon.com/Greenest-Home-Superinsulated-Passive-Design/dp/1616891246
36. Thermal Comfort - https://passipedia.org/basics/building_physics_-_basics/thermal_comfort
37. Understanding Passivhaus - https://www.firstinarchitecture.co.uk/understanding-passivhaus/
38. Unlocking livable, resilient, decarbonized housing with Point Access Blocks - https://www.larchlab.com/wp-content/uploads/2022/01/Eliason_CoV-Point-Access-Blocks-report_v1.2.pdf
39. Vancouver Passive House Verification Plan Checklist - https://passivehousenetwork.org/wp-content/uploads/2024/07/Vancouver-Passive-House-Verification-Plan-Checklist-2023.pdf
40. 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/code

Call:
805.781.1201

Energy Code Coaches are local experts who can help answer your Title 24 Part 6 or Part 11 questions.

They can provide code citations and offer advice for your res or non-res projects.

Closing

Continuing Education Units Available

- Contact dresurreccion@co.slo.ca.us for AIA LUs

Coming to Your Inbox Soon!

- Slides & Recording

Get Passive House Certified!

(FREE for Ventura, Santa Barbara, & San Luis Obispo County)

- Certified Passive House Designer/Consultant Pacific Fall 2025 Cohort
- 5-Day Passive Design/Build Bootcamp in Ventura (Sept 29 – Oct 3)

Upcoming Courses:

- Aug 20 – Best Practices for Hot Water Distribution
- Aug 26 – Ask The Experts : Enclosures
- Sept 9 – Energy Basics | Building The Future: Passive Performance Construction in California

Any phone numbers who joined? Please share your name!

Thank you!

More info: **3c-ren.org**

Questions: **info@3c-ren.org**

Email updates: **3c-ren.org/newsletter**

3C REN

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