PASSIVE HOUSE 101

An Introduction to Passive Buildings & Design

PASSIVEhouse
MASSACHUSETTS

AGENDA

What is Passive House

Passive House Standards & Metrics

Design Principles and Features

Case Studies and Lessons Learned

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Can You Find the Passive House?

Can You Find the Passive House?

Passive House

Passive House is a **performance-based** building certification that focuses on the dramatic **reduction of energy use for space heating and cooling**

Passive House achieves:

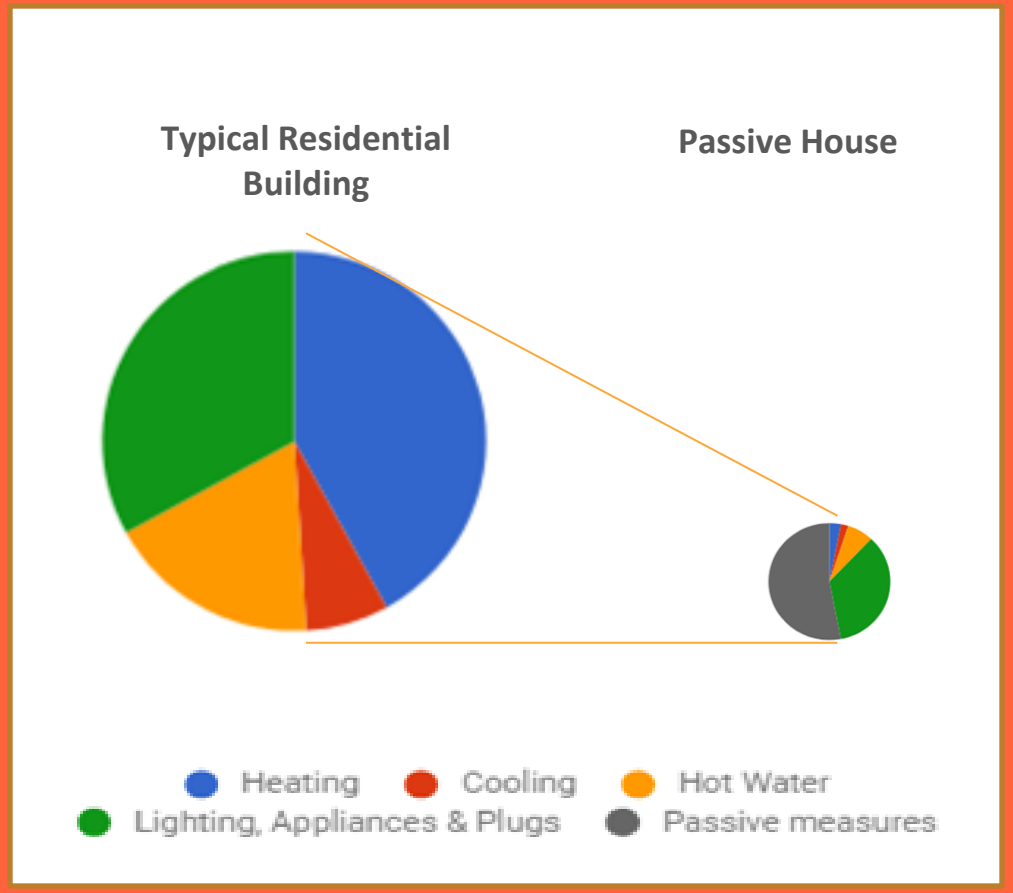
- Dramatic reduction in **overall energy use**
- Dramatic reduction in **carbon emissions**
- Proven improvement in **air quality**, **health**, and occupant **comfort**
- Greater building **durability**
- **Resilience** to major weather events
- Lower **operating costs**
- Pathway to **net-zero**

Goal:

90% reduction in heating and cooling loads comparted to a typical building

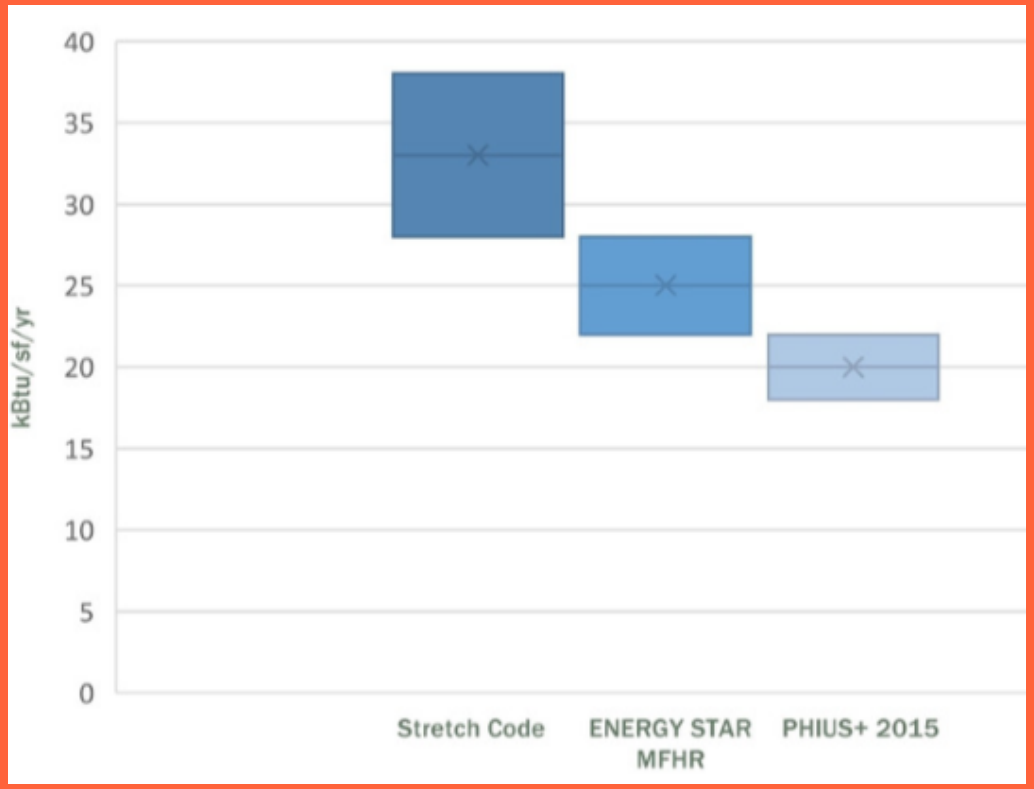
Goal:

60-70% reduction in overall energy use comparted to typical buildings



Measured Performance:

30-45% less carbon emissions than MA stretch code buildings



Source: New Ecology

Air Quality, Health, and Comfort

Continuous ventilation of filtered air

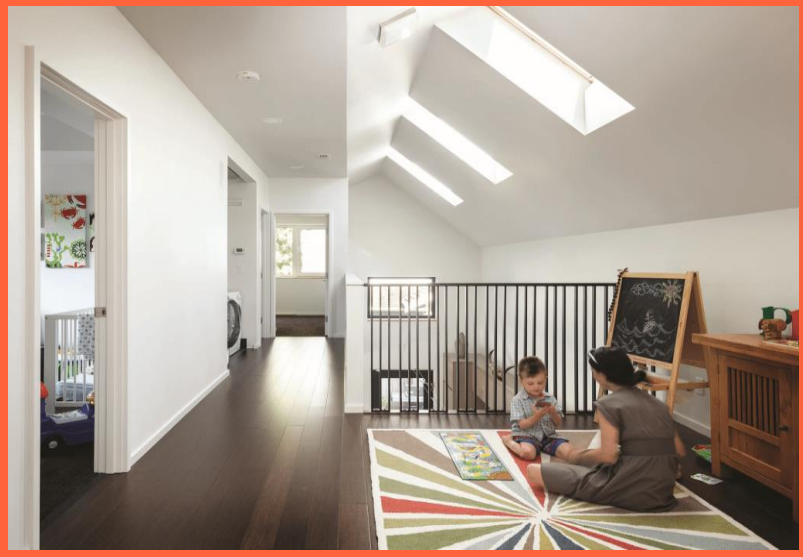
Increased use of non-toxic materials

Consistent comfortable room temps

Elimination of air drafts

Increased natural lighting

Quieter acoustic conditions



Durability & Resilience

Shelter in Place

Maintain consistent indoor temps during extreme weather and power outages

Durable & Long Lasting Construction

Resists mold, rot, pests & water intrusion

Passive Not Active

Lower reliance on mechanical systems

Passive House Examples

Rocksbury House
Placetailor Design/Build
33.2 EUI

Wayland House
Auburndale Builders
15.8 EUI

Passive House Examples

Distillery North
ICON Architecture
Commodore Builders
21.6 EUI

Orchards at Orneco
REACH CDC
William Wilson Architects
Walsh Construction
22 EUI

Passive House Oragnizations

Defines the Standard, Sets Metrics, and Certifies Projects & Professionals	PHIUS Passive House Institute US	Passive House Institute
Provides Local Training, Education, Outreach , and Advocacy	PASSIVEhouse MASSACHUSETTS	

Passive House Credentials

PHIUS	PHI
Certified Passive House Consultant (CPHC)	Certified Passive House Designer/Consultant (CPHD/C)
PHIUS Certified Builder	Certified Passive House Tradesperson (CPHT)
PHIUS+ Rater/Verifier	

Passive House Metrics

	PHIUS	PHI
Annual Heating	5.3 kBtu/ft2	15 kWh/m2 (4.8 kbtu/ft2)
Peak Heating	4.4 Btu/ft2	10 watts/m2 (3.2 btu/ft2)
Annual Cooling	2.9 kBtu/ft2-yr	15 kWh/m2-yr (4.8 kbtu/ft2)
Peak Cooling	4.2 Btu/ft2	10 watts/m2 (3.2 btu/ft2)
Source Energy	3840 kWh/person (Residential) 34.8 kBtu/ft2 (Commercial)	60 kWh/m2 (all projects)

Air Tightness Standard

MA Energy Code

3

ACH50

(air changes per hour at 50 Pascals)

Passive House*

0.6

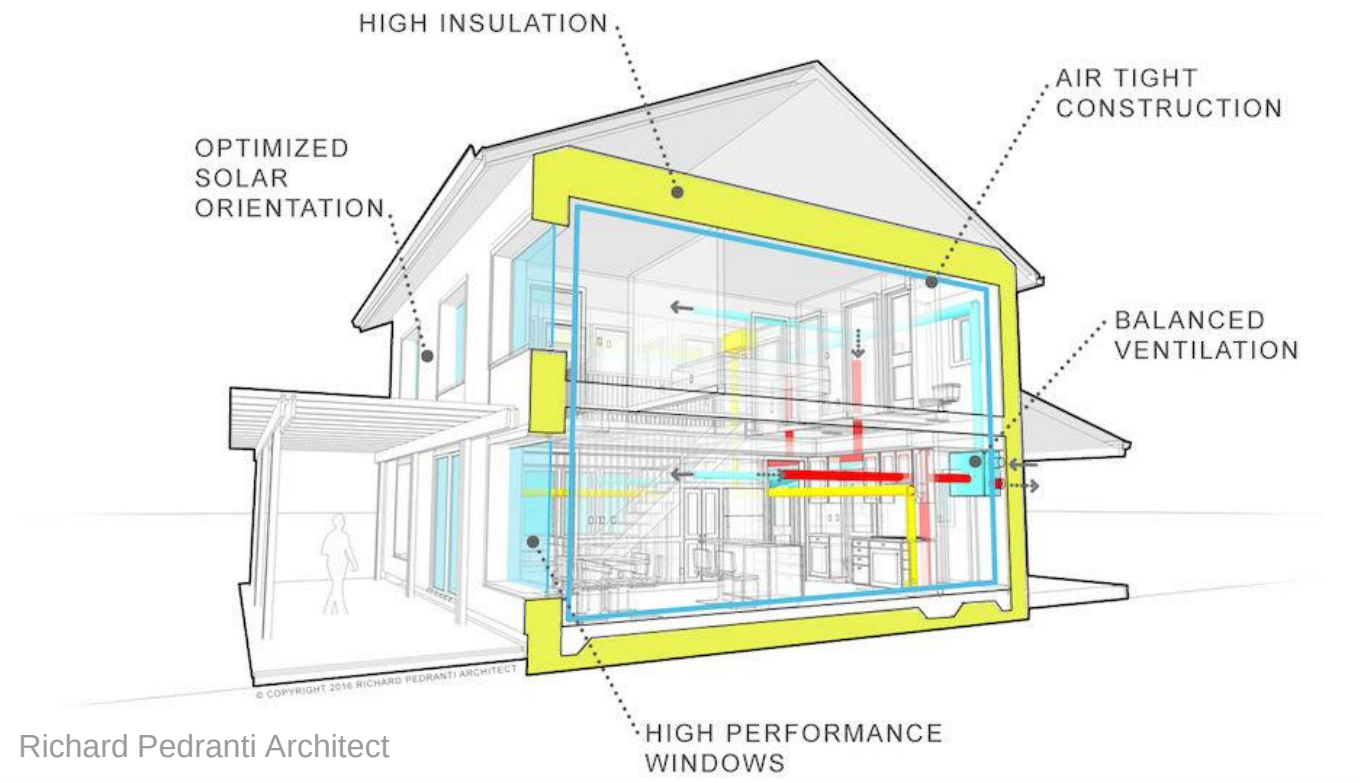
ACH50

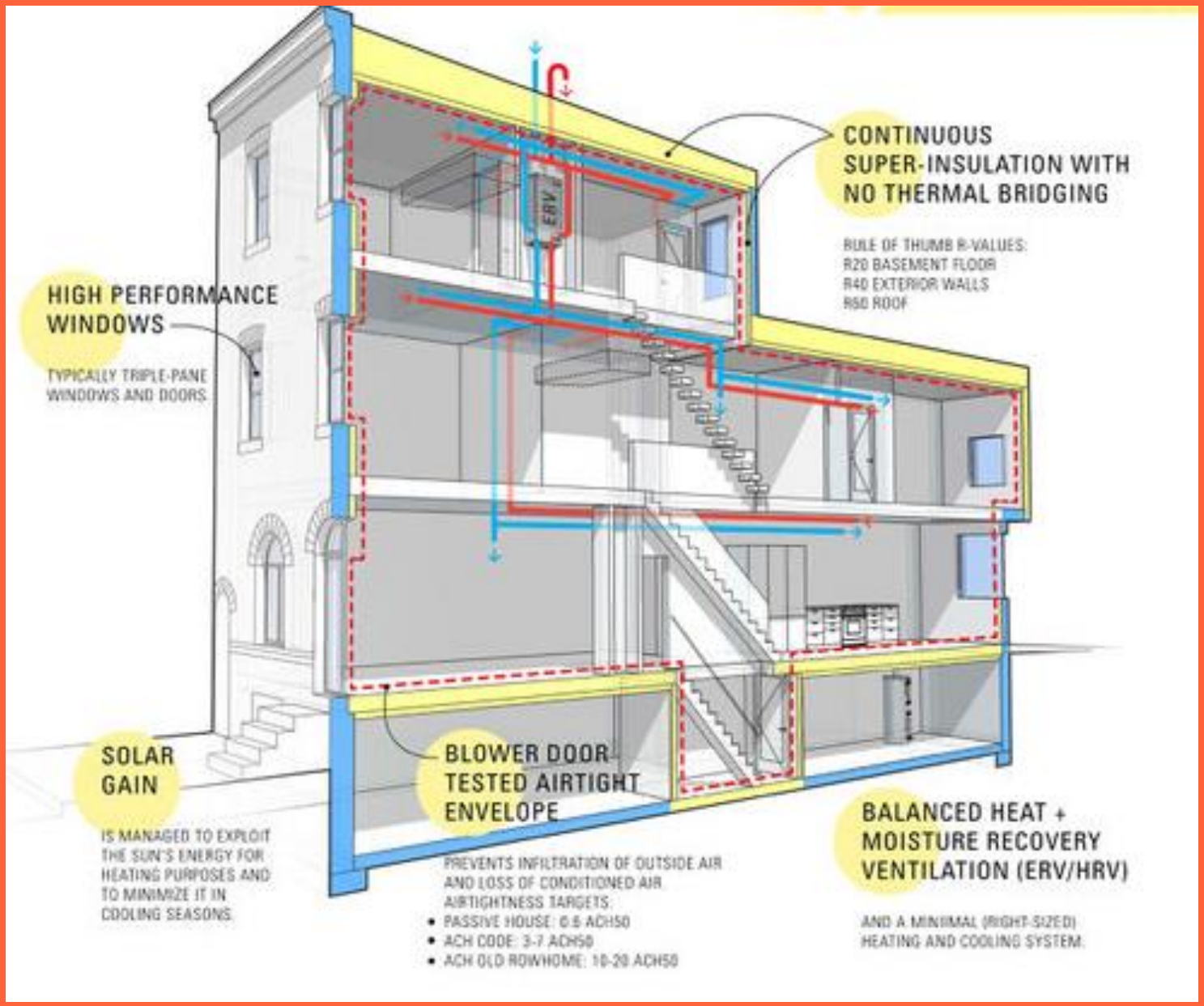
(air changes per hour at 50 Pascals)

*Passive House International (PHI)

Elements of Passive House Buildings

1. Super-Insulated and Airtight Building Envelope
2. Efficient Windows (and Doors) and Optimized Solar Heat Gain
3. Efficient and Minimized Mechanical Systems



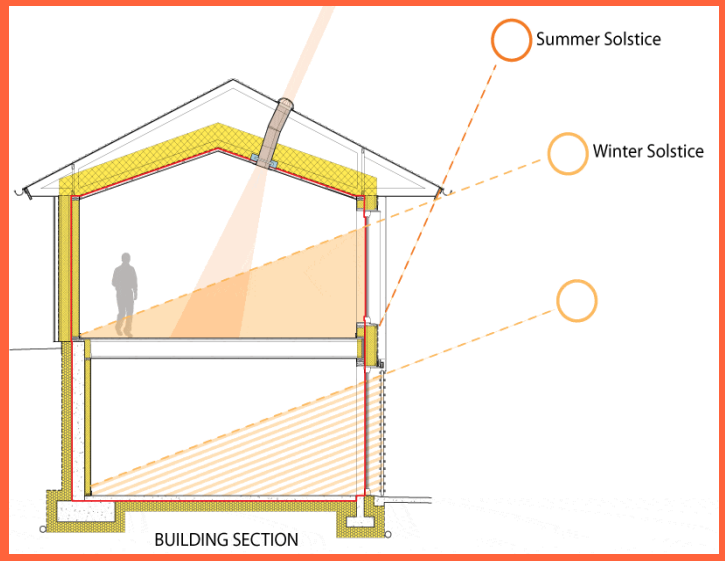

CONTINUOUS SUPER-INSULATION WITH NO THERMAL BRIDGING
RULE OF THUMB R-VALUES:
R20 BASEMENT FLOOR
R40 EXTERIOR WALLS
R60 ROOF
HIGH PERFORMANCE WINDOWS
TYPICALLY TRIPLE-PANE WINDOWS AND DOORS
ERV
SOLAR GAIN
IS MANAGED TO EXPLOIT THE SUN'S ENERGY FOR HEATING PURPOSES AND TO MINIMIZE IT IN COOLING SEASONS
BLOWER DOOR TESTED AIRTIGHT ENVELOPE
PREVENTS INFILTRATION OF OUTSIDE AIR AND LOSS OF CONDITIONED AIR
AIRTIGHTNESS TARGETS:
• PASSIVE HOUSE: 0.6 ACH50
• ACH CODE: 3-7 ACH50
• ACH OLD ROWHOME: 10-20 ACH50
BALANCED HEAT + MOISTURE RECOVERY VENTILATION (ERV/HRV)
AND A MINIMAL (RIGHT-SIZED) HEATING AND COOLING SYSTEM.

Super-Insulated and Airtight Envelope

a. High-Levels of Thermal Insulation
b. Continuous Insulation and Air Barrier
c. Elimination of Thermal Bridges
d. Airtight Construction

Efficient Windows (and Doors) and Optimized Solar Heat Gain

a. Efficient, low U-value windows
b. Properly installed and sealed windows and doors
c. Shading systems and overhangs for solar heat gain control
d. Optimal building orientation and window placement

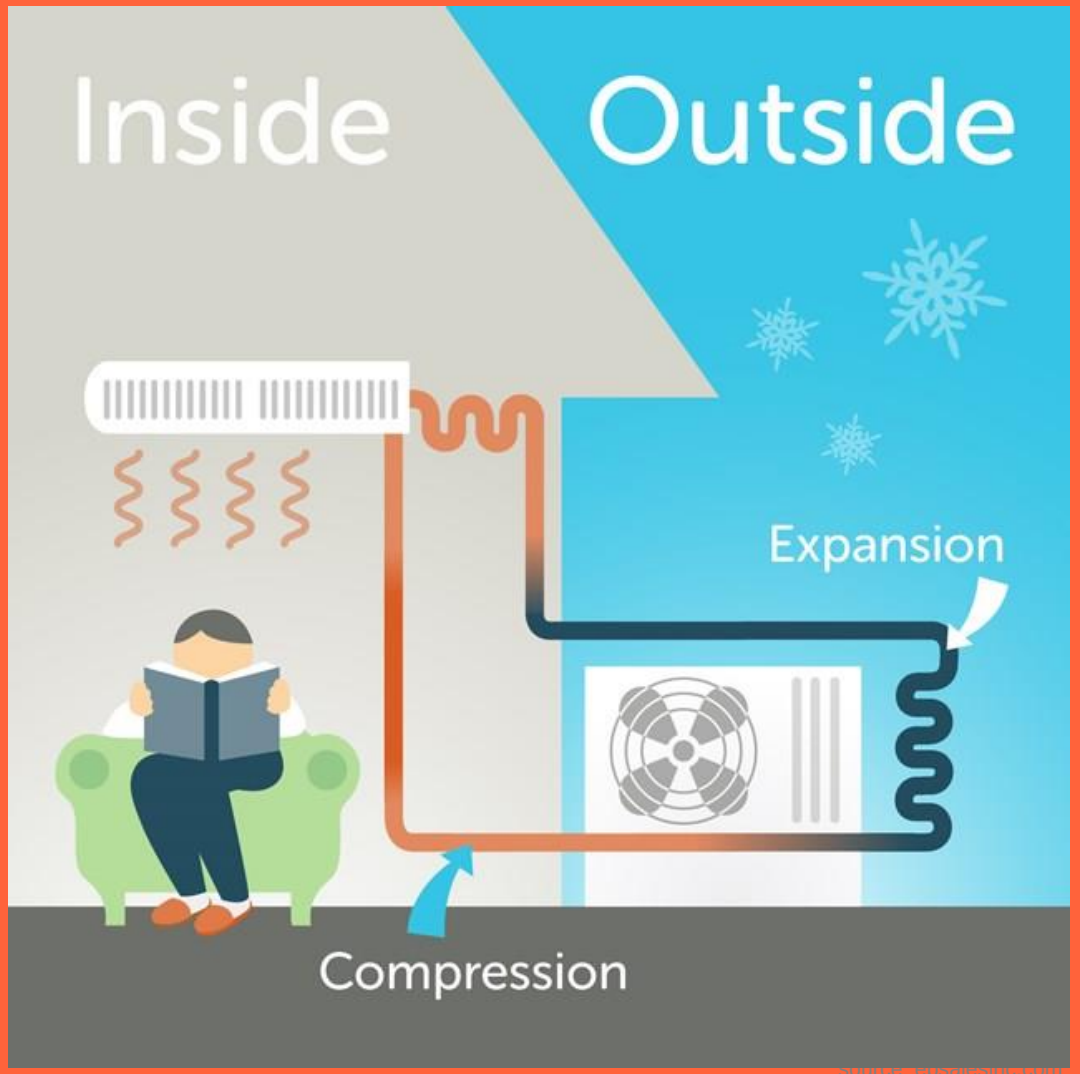


Efficient and Minimized Mechanical Systems

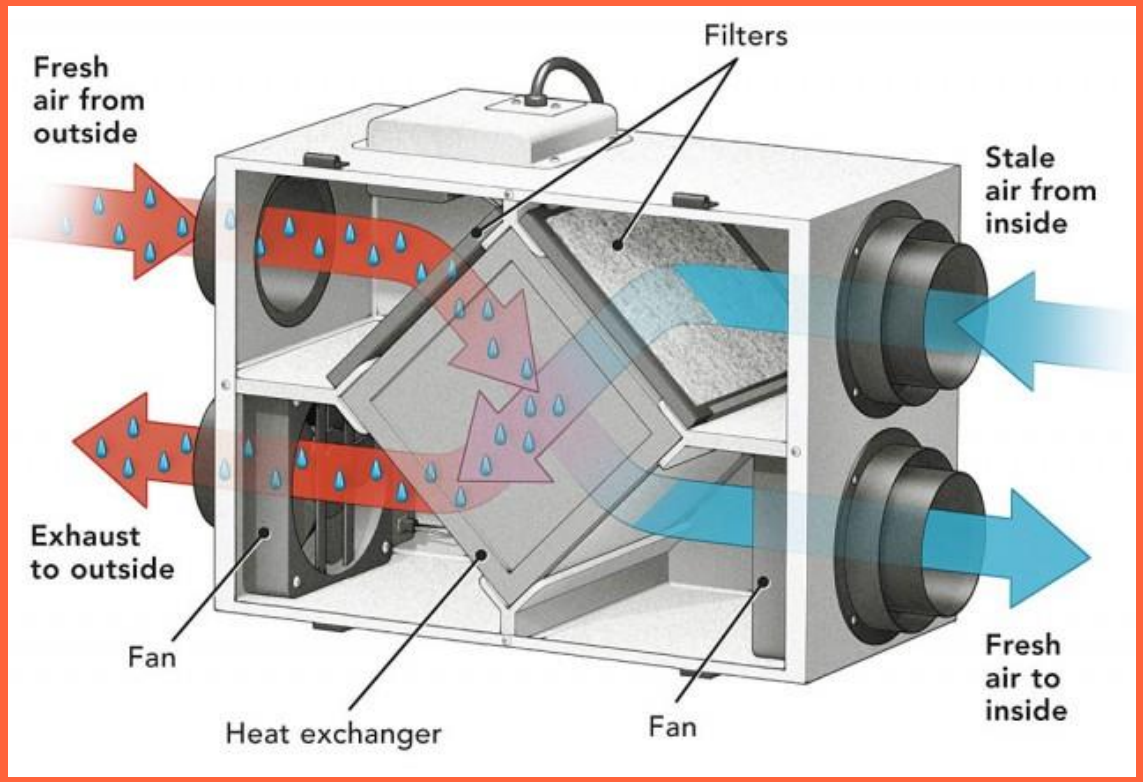
a. Heat Pumps, VRF system or similarly efficient systems
b. Properly engineered and sized system
c. Balanced heat recovery ventilation

source: epsalesinc.com

Heat Pumps



Heat (or Energy) Recovery Ventilators



DISTILLERY NORTH

South Boston, MA

Completed: 2017
# of Units: 28
Total Floor Area: 27,840 s.f.
Developer: Second Street Associates, LLC
Architect: ICON Architecture
General Contractor: Commodore Builders
CHPC: Mark Anstey

Building Type: Market-rate housing
Roof Insulation: Open web truss with cellulose + 2" EPS
Wall Insulation: 2x8" cellulose with 3" rockwool exterior insulation (R-37)
Floor/Slab Insulation:
Doors/Windows: R-7, triple paned, tilt turn
Heating/Cooling: Mitsubishi air source heat pumps in each unit; natural gas hot water
Ventilation: HRV 95% efficient
Renewable Energy: PV, near net zero
Special Features: LEED-H Midrise Platinum, Public café, a street-level commercial space, interior parking with EV charging stations

ELM PLACE

Milton, VT

Completed: 2017
# of Units: 30
Total Floor Area: 27,690 s.f.
Architect: Duncan Wisniewski Architects
General Contractor: ReArch
CHPC: Chris West

Building Type: Affordable senior housing
Roof Insulation: R70. Spray foam + fiberglass
Wall Insulation: 2x6 stud wall with fiberglass + 4" exterior polyiso
Floor/Slab Insulation: Concrete over R40 foam
Doors/Windows: U-.128, triple paned tilt/turn
Heating/Cooling: Mitsubishi Hyper Heat
Ventilation: Daikin ERU Renuwaire HE 1.5X
Renewable Energy: 15kW PV
EUI: 20.2 kBTU/sf/yr
Special Features: Parking under living spaces

VILLAGE CENTRE

Brewer, ME

Completed: 2016
# of Units: 48
Total Floor Area: 51,778 s.f.
Architect: CWS Architects
General Contractor: Wright-Ryan Construction
CHPC: Colin Schless
PH Consultant: Thornton Tomasetti

Building Type: Affordable housing
Roof Insulation: Polyisocyanurate foam (R-57)
Wall Insulation: 2x6 wood stud wall + 2x4 metal stud wall with spray cellulose (R-40)
Floor/Slab Insulation: 4" XPS under slab (R-20)
Doors/Windows: U-0.18, triple paned
Heating/Cooling: Electric baseboard (6 ft per unit), Natural gas boiler
Ventilation: Renewaire ERV (3:1)
Renewable Energy: Rooftop PV

GILFORD VILLAGE KNOLLS III

Gilford, NH

Completed: 2018
# of Units: 24
Total Floor Area: 20,571 s.f.
Developer: Laconia Area Community Land Trust
Architect: Stewart Associates Architects LLC
General Contractor: Martini Northern
CHPC: Michael Hindle, Mike Duclos
PH Consultant: GDS Associates

Building Type: Affordable senior housing
Roof Insulation: R-75
Wall Insulation: 2x8 with blown in fiberglass
Floor/Slab Insulation: 6" EPS
Doors/Windows: Yaro Economy
Heating/Cooling: Mitsubishi Mr. Slim 8:1
Ventilation:
Renewable Energy: 104.92-kilowatt rooftop solar array

BAYSIDE ANCHOR

Portland, ME

Completed: 2017
# of Units: 45
Total Floor Area: 38,500 s.f.
Developer: Portland Housing Authority/Avesta Housing
Architect: Kaplan Thompson Architects
General Contractor: Wright-Ryan Construction
CHPC: Jesse Thompson

Building Type: Affordable + Market-Rate Housing
Roof Insulation: Polyiso (R-50)
Wall Insulation: Double stud wall with dense pack cellulose (R-34)
Floor/Slab Insulation: 3" EPS (R-16)
Doors/Windows: R-5, triple paned
Heating/Cooling: Electric resistance baseboard
Ventilation: Renewaire 450 ERV ECM
Renewable Energy: 50 kW PV array
Special Features: Storm water collection, Community garden

BEACH GREEN NORTH

Far Rockaway, NY

Completed: 2017
# of Units: 101
Total Floor Area: 93,894 s.f.
Architect: Curtis + Ginsberg Architects LLP
General Contractor: The Bluestone Organization
CHPC: Lisa White
PH Consultants: De Nardis Engineering, LLC, Tectonic, GDSNY

Building Type: Affordable housing
Roof Insulation: Concrete + polyiso (R-40)
Wall Insulation: ICF construction (R-24)
Floor/Slab Insulation: Mineralwool + concrete (R-28)
Doors/Windows: Rehau 4500
Heating/Cooling: LG VRF
Ventilation: RenewAire EV90
Renewable Energy: 129.5 kW PV, 10 kW microturbine

LESSONS LEARNED: DESIGN PHASE

- Bring together your **integrated team** early and often! All the aspects of the project need to be coordinated together from the beginning. Know your PH Rater/Certifier and take advantage of their expertise.
- **Continuity of critical barriers** - air barrier, WRB, thermal barrier, vapor barrier- and show those lines in the design drawings.
- Work with a **mechanical engineer** with experience in low energy buildings. Most engineers will oversize equipment.
- Consult your trades during the design process to identify any issues related to **constructability**.
- In cold climates using heat pumps, pay attention to **location of compressors** and keeping them out of snow.
- Pay attention to shading - south- and west-facing apartments can have **excessive solar heat gain**.
- Design for **energy monitoring** from the beginning. This may mean designing how circuits are installed/organized.
- Plan for **apartment compartmentalization** (unit to unit air tightness). This is required for EnergyStar (with PHIUS+).
- Design for **easy maintenance** - changing filters in minisplit heads, ERVs, etc. Consider how to educate tenants on building operations.


Source: Ballston Mourningkill Associates

LESSONS LEARNED: CONSTRUCTION PHASE

Kickoff Meetings

At each stage in the construction process, convene a **kickoff meeting** on site with all the associated trades. Make sure everyone knows what they are responsible for, especially in the area of air sealing.

Build mock-ups showing installation techniques.

Invite **manufacturer reps** to answer questions about specific products.

Source: Blue Quality Services

LESSONS LEARNED: CONSTRUCTION PHASE

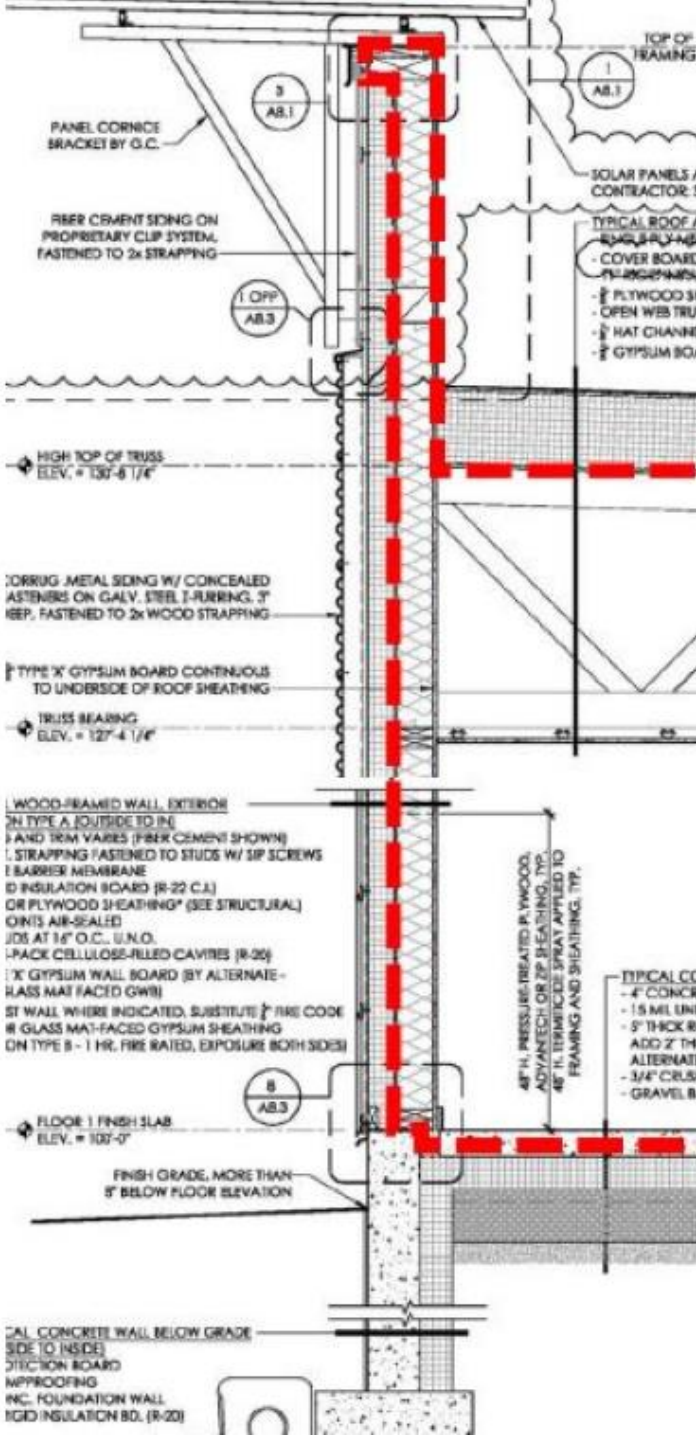
Know Your Air Barrier

Everyone on your team should know exactly where the air barrier lies in your assemblies.

Clearly label the air barrier on plan sets.

Identify who is responsible for maintaining the air barrier.

Signage can help remind your trade partners of their responsibility to inform the site supervisor to any unanticipated penetrations in the air barrier.



Source: Maclay Architects

LESSONS LEARNED: CONSTRUCTION PHASE

Blower Door Testing

Test early and often.

At minimum:
1. Full envelope test once windows and doors are installed (ideally after mechanicals are installed and sealed off)

2. After sheetrock, test individual apartments for compartmentalization

3. Pre-occupancy for final numbers

Smoke testing can be useful at preliminary stages to identify leaks in the envelope.

Source: Black Mountain Architecture

INCREMENTAL COST OF PASSIVE HOUSE

Multifamily: Lower Comparative Incremental Cost than Single-family

PA has 23 Affordable Multifamily: 0-2% Cost Comparison

Consultant experience: 2-5% Incremental Cost

MassCEC Design Challenge: 3% Incremental Cost Goal

Incentives Available from Mass Save

Alterative Energy Credits

Upcoming Events

Passive House Multifamily Workshop: Lessons Learned from the First Generation of Projects
Featuring Dan Whitmore,& Monte Paulson
February 11th | 5:00pm to 8:00pm

PHIUS Certified Builders Training
February 12th – 14th

PHI Certified Designer Training
February 24th – 28th

Video Library

Cost-Estimating for Passive House Projects

A Builder's Approach to Residential Passive House

Innovations in Low-Carbon Materials

Affordable Design Workshop

Bringing Passive House Development to Scale

THANK YOU!

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