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On behalf of Eversource, a proud sponsor of Energize Connecticut, and in partnership with Connecticut Passive House, we are pleased to offer *Passive House Training* to support workforce development and help transform the energy efficiency and building construction industries in Connecticut.



For more information, please visit EnergizeCT.com/passive-house or email <u>PassiveHouseTrainingCT@icf.com</u> BROUGHT TO YOU BY



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Upcoming Webinar

June 9, 2021- Passive House Process: The Path to Certification presented by John Loercher

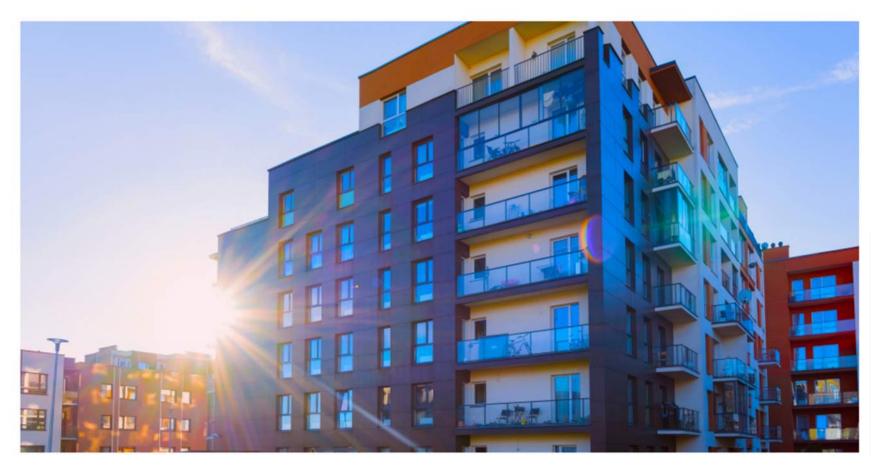


For more information, please visit EnergizeCT.com/passive-house or email <u>PassiveHouseTrainingCT@icf.com</u>

EVERSURCE

Take energy efficiency to a new level

Residential New Construction Passive House Multi-family buildings with five units or more



PASSIVE HOUSE INCENTIVE STRUCTURE FOR MULTI-FAMILY (5 UNITS OR MORE)										
Incentive Timing	Activity	Incentive Amount	Max Incentive (Per Unit)	Max Incentive (Per Project)						
	Feasibility Study ¹	Up to 100% of Feasibility Study Costs	N/A	\$5,000.00						
Pre-Construction	Energy	75% of Energy Modeling Costs (Before 90% Design Drawings)	\$500.00	\$30,000.00						
	Modeling ²	50% of Energy Modeling Costs (90% Design/50% Construction)	\$250.00	\$15,000.00						
Post Construction	Certification ³	Up to 100% of Certification Costs	\$1,500.00	\$60,000.00						

1. Feasibility Study will require documentation in the form of a Feasibility Study report and invoice from the Passive House Consultant

2. Incentives will only be awarded prior to 50% Construction Drawings for Passive House projects. No incentives will be granted after 50% Construction Drawing set.

3. Certification may be either through PHIUS, PHI, or EnerPHit certification offerings.

Next steps you can take... Contact your Energy Efficiency Representative or

Go to EnergizeCT.com or call 1-877-WISE USE for more details.



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Passive House 201 Technical Aspects of Passive House

For more information, please visit EnergizeCT.com/passive-house or email <u>PassiveHouseTrainingCT@icf.com</u>

Luke McKneally AIA, LEED AP, CPHC

Account Manager High Rise & Passive House projects



PH 201 Statement

- **Summary:** This is an introductory course to provide rudimentary knowledge of Passive House design considerations. It assumes familiarity with the PH101 presented by PHCT. It is not a formal training under PHIUS+ or PHI.
- **Audience:** Those interested in why Passive House works, but not yet engaged in a certification course through PHI or PHIUS+
- Topics:
 - Basic massing, shading and solar control
 - Air barrier, weather barrier and thermal control layers
 - Balanced ventilation, efficient heating, cooling and domestic hot water systems
 - Modeling used to guide the design

Learning Objectives

- 1. Learn more about what has been called the most energy efficient building standard in the world, Passive House.
- 2. Understand how Passive House provides an ideal path to achieving Net Zero Energy / Net Zero Carbon buildings.
- 3. Understand how the building enclosure design is critical to meeting the Passive House certification criteria.
- 4. Learn how mechanical systems design can work with envelope design to reduce energy loads.

Why Passive House?

Focus on fundamental principles of building physics to reduce energy loads at their source.

Net-Zero Energy via Passive House

- Total source energy demand is roughly equal to site energy production
- May offset large fossil fuel energy use • with renewable source electricity, resulting in high GHG emissions
- Rigorous standard for primary energy reduction (before renewable energy)
- Significant GHG emissions reductions
- Net-Zero energy or net-zero energy ready
- Source-Positive energy capable





Source Energy Limits

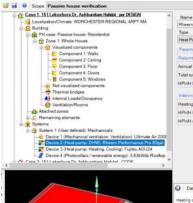
PHIUS+ 2021: Varies / person / yrPHIUS+ 2018: 3,840 kWh / person / yrPHIUS+ CORE: 5,500 kWh / person / yr

PHI Premium: PHI Plus: PHI Classic: 9.51 kBTU / sf / yr 14.26 kBTU / sf / yr 19.02 kBTU / sf / yr

Modeling



WUFI



Type							
He	at Pump water heater (HPWH) inside	÷					
Par	amelers						
Required data							
Ann	ual heating coefficient of performance (COP) [-]	2.5					
Total system performance ratio of heat generator [-] 0.4							
HPWH EF [-] 3.7							
bileven insults							
Heating months per year 7							
HP	AH DHW EF winter	1.78					
HP	vH de rated EF winter	2.58					



		Show warnings	> Cal	culate ¥	VUFI shi	ding					
demand	11.11	t kBtu/ft5yr	-		1	2	1	-	1	1	— ×
demand	3.79	€ kBtu/ft'yr	-	+			-	1	-	11	×
idad:	6.85	5 Btulle ft*	-	_	-	1	-	-	1		*
loat	2.75	5 Btulhr ft ^a	-		_	Ì	-		11		9
mergy.	2,055	9 kWh/Person y	-		2000	-	1				
120	6.6	5 kBtu/ft ⁴ yr	1	_	****	-				-	1



DesignPH/PHPP

Climate: Boston 51.2 kWh/m²a TFA 109 m² (User-defined) Heat Loss Form Factor 4.52



TEMPORARY DEMO LICENSE 1.5.03, registered to, demo user [Unregister] [Help & Support] [Language: EN]

Update window options Redraw windows

Heat

Overview	Heat balance	Areas	U-value editor	Assemblies	Components	Climate	
▼ Heat balan	ce		V Proi	ect overview			

				Render mode	Render by Area Group	
0.0	Losses	Gains		Thermal envelope checks The thermal envelope appears	to be completel	
12.5			13.4	Number of thermal bridges	None defined	details
25.0	55.8	-51.2	15.0	Number of windows Number of thermal surfaces	16 19	details details
37.5			Internal heat gains	Heat Loss Form Factor Projected building footprint	4.52 m ^e	200 000 200
50.0			(windows)	Treated Floor Area (TFA) Thermal envelope area	109 m² (User-defined) 494 m²	details details
	8.4	9.8	Ventilation heat losses Transmission heat loss	Annual heat demand (Qh)	51.2 kWh/m²a	details
62.5	14.7	12.9	(opeque surfaces and thermal bridges)	Climate	Boston	change
75.0	0.0	_	Transmission heat loss	TEMPORARY DEMO LICENSE		
ur De	siance			* Project overview		

Complementary Programs









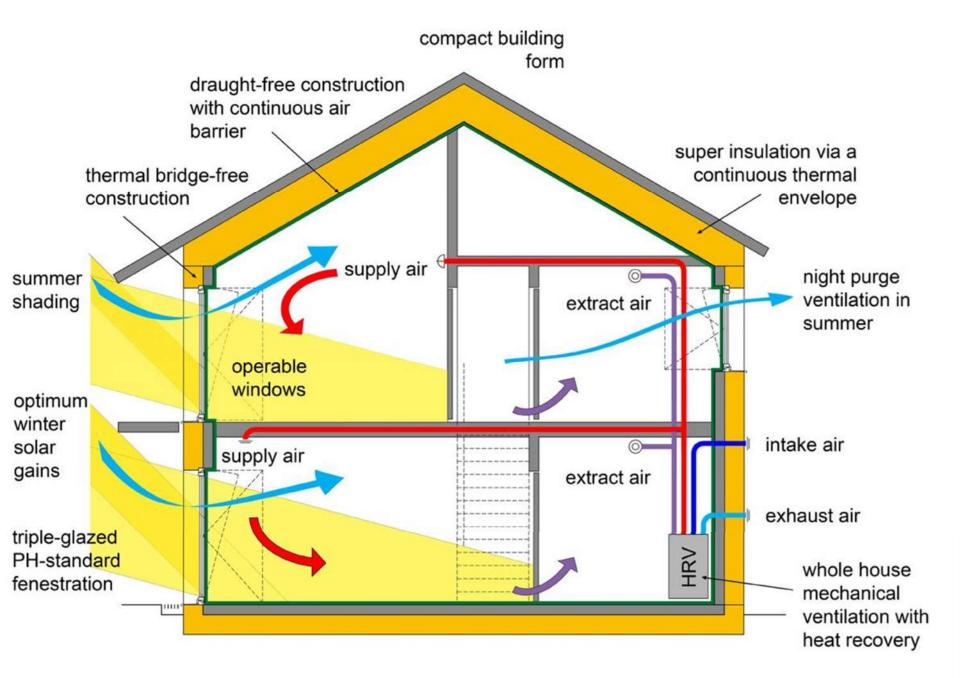
Passive House ≠ Products and Technologies



Passive House = Whole Building Systems Analysis

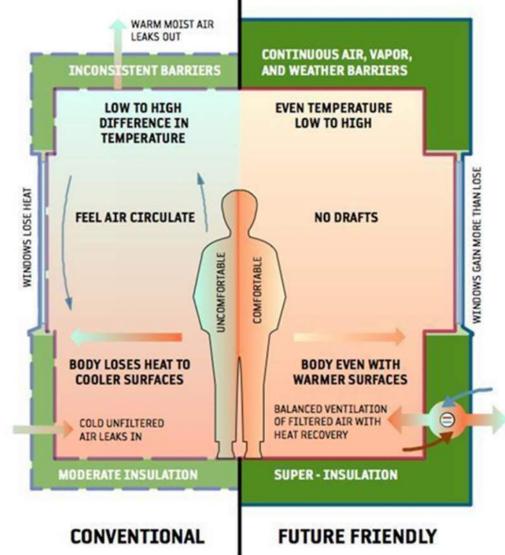
Energy Flow

Climate & Context Massing & Envelope Mechanical, Electrical, & Plumbing



Conventional vs. Passive House

BUILDINGS AND THERMAL COMFORT



Impacts on Users and Co-Benefits

- Healthy indoor environmental quality
 - Draft-free
 - Comfortable
 - Surface temperatures well above dew point
 - Reduced mold risk
 - Paired with low VOC, low toxin materials
 - Filtered fresh air
- Passive survivability
 - Minimal temperature drift during extreme weather conditions even with system shutdowns or power outages
 - Longer, slower heating and cooling loss times
- Minimized noise
 - Insulation

Passive House whole building energy flow

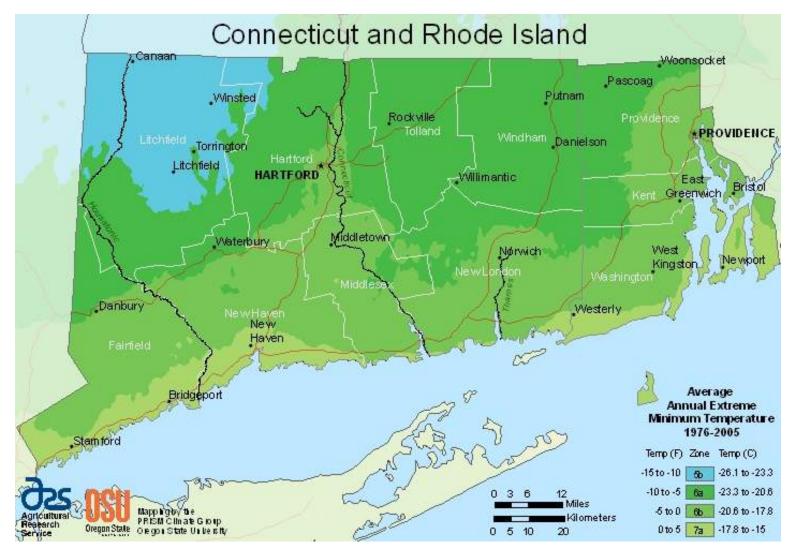
GAINS:

- Solar energy through windows, assemblies
- Occupant heat
- Equipment energy loss inside envelope (lights, computers, misc.)
- Equipment Outputs and Efficiencies
- Renewable energy system inputs if present (PV and Solar Thermal)

LOSSES:

- Thermal & Moisture transfer through:
 - Air Infiltration and Leakage
 - Assemblies and Components
 - Ventilation

Climate Data



USDA hardiness map

Climate Data

WUFI modelling

WUFI®Passive V.3.2.0.1 C:\Users\Luke McKneally\Documents_WORK-LM_local_Projects\210429_ICF WUFI multifam pres\EXAMPLE Residence.mwp

File Input Options Database Help

Project

Scope Passive house verification

English/IP/Outer dimensions/PHIUS+ 2018 Assign data ~

> March April

24.8

Data: CT - HARTFORD BRADLEY INTL AP (Monthly)

Feb

28.04 29.12 39.92

-7.42 -1.48 8.6

12.74 17.6

Solar radiation [kBtu/ft®Month]

Setting

Temperature ["F]

Ambient

Ground*

Sky*

North

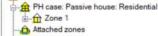
East

South

Dew point

- Cases Case 1: EXAMPLE Residence ASHP.noPV.noEVcharging Localization/Climate: CT - HARTFORD BRADLEY INTL AP (Monthly Building - 🔒 PH case: Passive house: Residential - T Zone 1: EXAMPLE Attached zones

- Systems System 1 (User defined): ASHP Mechanicals Device 1 (Mechanical ventilation: Ventilation): ERV 75%, 0.413 T Device 2 (Heat pump: DHW): Sanden ASHPWH with 119 gal ta - 🔁 Device 3 (Water storage: DHW): Sanden 119gal tank (confirm t Device 4 (Photovoltaic / renewable energy): 15.84kWh array =1 Tooling): Mitsubishi P SERIES - T Device 6 (Heat pump: Heating, Cooling): Fugitsu 12RGLXD-AF Case 2: with PV Localization/Climate: User defined - Building





14.8985 19.3365 24.4085 25.3595 28.5295 29.4805 33.9185 27.2615 23.4575 17.7515 12.3625 12.3625 18.3859 10.46094 51.35373 West Global 17.751922.506836.771843.428751.987755.474756.108749.451739.307727.895819.019914.581920.6048913.9479387.80853 * Optional input, Sky/Ground: if not defined, temperatures will be estimated) O Ambient O Dew poir O Sky Temperature ["F] Month

Data state/results @ Show warnings > Calculate WUFI shading

O North O East O South O West Radiation [kBtu/ft?Month] O Global -0 Month

Heating Cooling

W. 1

79.16

W.2

32.72

Solar radiation [Btu/hr ft²]

Cooling

W.2

Heating

W. 1

18.32

Credit: Fraunhofer IBP

σ ×

Localization Climate Source energy/CO2-Factor

50

31.82

19.4

May

60.44

44.06

34.34

June

67.28

57.02

48.02 53.96

July

74.12 70.7

62.78

Aug.

60.08

50.54

7.92496 10.1436 13.6305 13.3136 16.4836 17.4346 17.7516 14.5816 11.4116 8.5589 6.0229 6.65696 10.46094 7.60796 23.77487

14.581\$18.068\$25.676\$24.725\$28.212\$30.114\$28.846\$29.480\$23.140\$17.751\$12.996\$11.728\$16.16691 10.14395 45.33076

32 3335 32 6505 35 1865 27 5785 25 6765 24 0915 25 6765 28 8465 32 0165 32 0165 29 4805 27 5785 37 0888 17 43491 41 52678

Sept

63.14 51.8

52.52 41.72

41.72 28.58

Oct.

Nov.

43.52

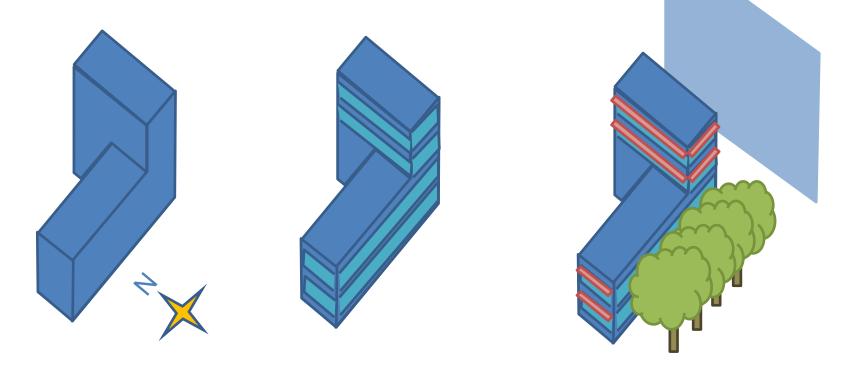
28.22 19.4

13.82 3.02

Dec

29.12

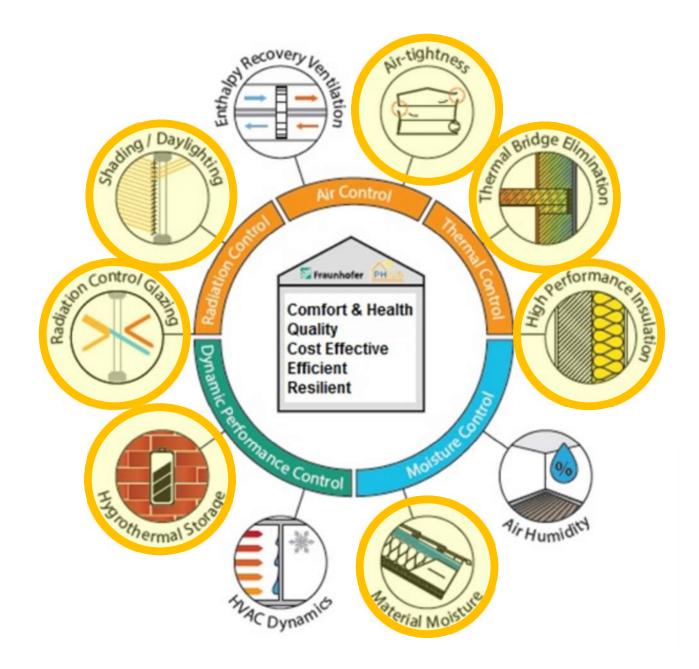
Massing, Orientation, Glazing, Shading



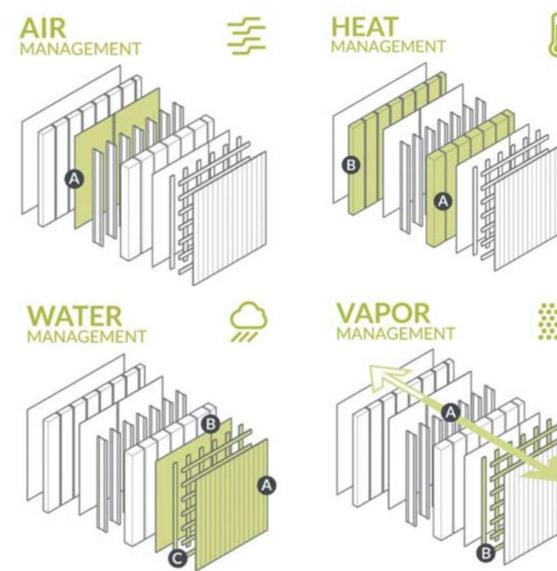
MASSING & ORIENTATION

WINDOW AREA & ORIENTATION

SOLAR EXPOSURE



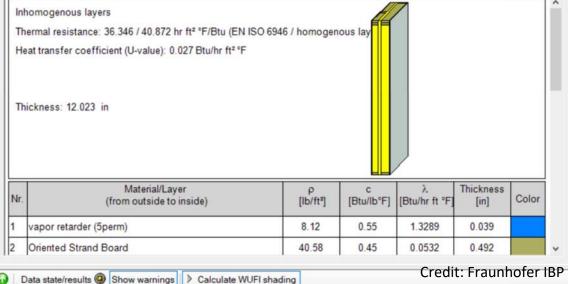
Enclosure

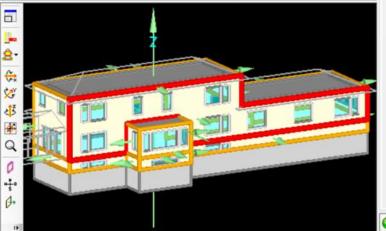


Assemblies

WUFI modelling

Scope Passive house verification English/IP/Outer dimensions/PHIUS+ 2018 Assign data Case 1: EXAMPLE Residence ASHP,noPV,noEVcharging General Assembly Surface Localization/Climate: CT - HARTFORD BRADLEY INTL AP (Monthly) Building Assigned assembly - PH case: Passive house: Residential Select from Name R [hr ft* *F/Btu] Edit - T Zone 1: EXAMPLE database Double Stud Wall-NewEngland, ZipSheathing, 3.5", 2"Gap, 5.5" Structural 36.346 Visualized components Component 1: Windows/Doors Available assemblies Component 2: Walls-BelowGrade ^ New IJoist Roof Framing 16"w/ 4" MineralWool Continuous Exterior Insul 66,197 Component 3: EntryFloor Component 4: Walls-AboveGrade A Delete IJoist Roof Framing 16" w/ 6" MineralWool Continuous Exterior Insul 73.024 Component 5: Roof-AtticSpace-CelluloseLF Copy 9.437 4" reinforced Slab on Grade w/ vapor barrier 2" MW Component 6: Cold Room Door A Insert ICF_Quad-Lock 12" block 27,478 Component 7: Walls-ColdRoom New/Insert Component 8: Slab 2" ZIP-R Wall, 5.5" MW 32.686 Component 9: Roof-OuterEdge-SPFcc Double-click to assign to current component. 4" Continuous MineralWool, 2x6 Stud w/ cavity MW Component 10: Roof-OuterEdge-SPFcc Double Stud Wall, 3.5 outside Continuous - 5.5" Structural cellulose 30.91 Component 11: Roof-OuterEdge-SPFcc Component 12: Roof-OuterEdge-SPFcc Double Stud Wall, 3.5 outside Continuous - 5.5" Structural MW 37.427 Component 13: Roof-InnerEdge-CelluloseLF Component 14: Roof-InnerEdge-CelluloseLF Component 15: Roof-InnerEdge-CelluloseLF





Component 17: Roof-Flat-SPFcc

Not viewalized componente

<

Component 16: Roof-InnerEdge-CelluloseLF

Assemblies

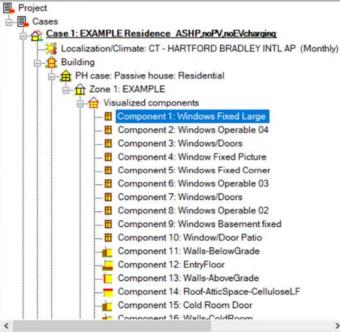
WUFI modelling

Scope Passive house verification

~

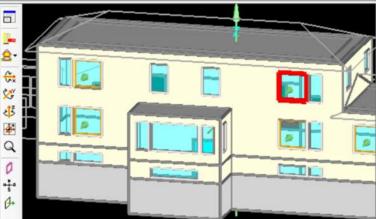
>





eneral	Window parameters	Solar protection				
Assign	ed window type			_		
		Name	Uw [Btu/hr ft ^e °F			
Shuco	AWS90 PHI certified Cl	imatop Argon	0.1544	database		
Availal	ble window types					
Alpen7	25		0.1407472672	New		
Alpen9	25		0.1520007086	👗 Delete		
KW Ec	oClad TT Triple 0.39SH	IGC, U-0.09, 52mm	0.1316247591	Сору		
Draft S	HUCO Living MD = 0.5	2SHGC, U-0.107, 90mm	0.1576	📇 Insert		
Glazing	g: Clear 3 Layers, Fram	e: Wood/Vinyl - Operable	0.5245	New/Insert		
Low -e	Double glazing on sur	face 2, e=0,2	0.3034	after ~		
Macro\	√in MW88_Climatop O	NE glass Krypton	Double click to a	assign to current window		
Macro\	Vin MW88 Climatop L	JX glass Krypton	0.1579	~		

Uw -mounted		[Btu/hr ft2 °F]	0.1544		
Frame factor			0.6815		
Glass U-value	1	[Btu/hr ft ² °F]	0.088		
SHGC/Solar energy transmittance (perp	endicular)		0.6		
rame data					
Setting	Left	Right	Тор	Bottom	
Frame width [i	in] 4.61	4.61	4.61	4.61	
Frame U-value [Btu/hr ft ² °	F] 0.176	0.176	0.176	0.176	
Glazing-to-frame psi-value [Btu/hr ft °	F] 0.016	0.016	0.016	0.016	
Frame-to-Wall psi-value [Btu/hr ft °	F] 0.029	0.029	0.029	0.029	
Solar radiation angle dependent data Angle Total Solar [°] trans.					



Edit

Air Leakage

 PHI:
 0.6 ACH50

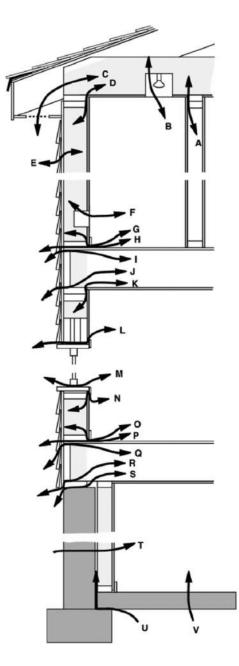
 0.033 cfm50 / ft2 for ≥10,000sf

 PHIUS:
 0.08 cfm75 / ft2 for 1-4 stories

 0.11 cfm75 / ft2 for ≥5 stories
 0.30 cfm50 / ft2 dwelling units

<u>US Army Corp of Engineers (v3, 2012)</u>: 0.25 cfm75 / ft2

Mass Save UDRH 2019 Baseline: 0.4 cfm75 / ft2



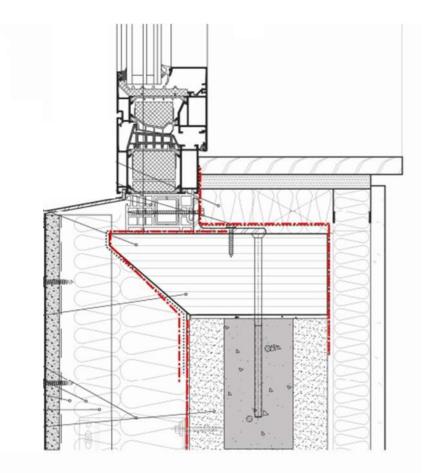
Air Barrier Details

Air barrier continuity

High attention to all exterior details

Insulation continuity

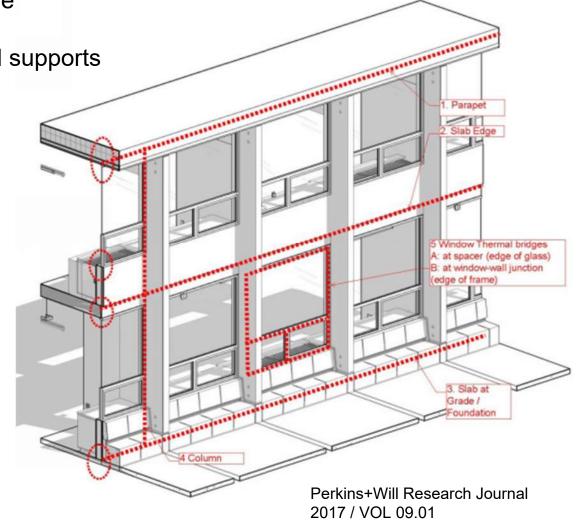
 Thermal bridge mitigation wherever possible



Thermal Bridging

Thermal Bridges are common at structural interfaces:

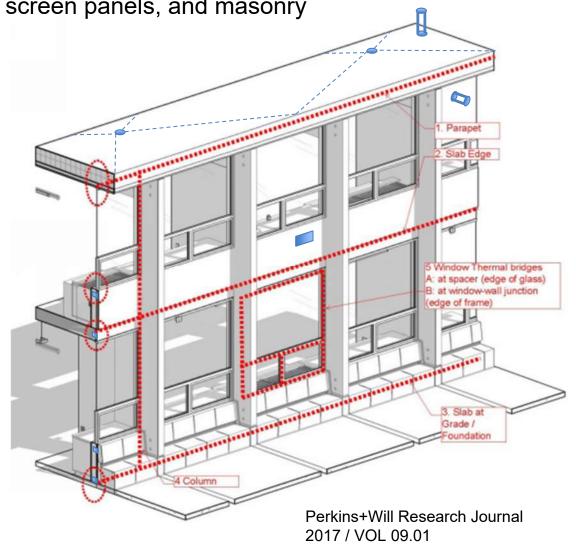
- Columns and beams at facade
- Slab & floor edges at facade
- Window and door frames and supports
- Cantilevers
- Penetrations



Thermal Bridging

AND

- Anchors for curtain walls, rain screen panels, and masonry
- Rainwater drains
- Waste pipes
- Electrical
- Ventilation
 - Intakes and exhausts
 - Kitchen extraction hoods
 - Dryer exhaust



Thermal Bridge Modeling

15

15

15

15

15

15

15

Thermal bridges Ambient

Nr.

6 7

8

9

10

11

12 13

14

15

16 17

18

19

20

Roof Bridges

TB1

TB2

TB3

TB4

TB6

TB7

TB8

PHPP	Passive House pla	nning: SPEC	IFI	C	ANNU	AL HE	EA	TING	DI	EMAN	N D	(monthly	method)
	Clin Buil Spec. Capa	nate: NY, New York ling: city: 19 BTU/(ft2*F)			******	s of the monthly			Int Treate	Building Building ad floor area	type:		per ft²	
		Temperature	e zone		rea	R-Value	1	Month. red. fac	2.	G,			treated	
	Building assemb				R'	hr.R ² .'F/BTU		r	1	'F.daylyr	1 1	kBTU/yr	floor area	
		all - Ambient	A		719 * 1/	23.6	*	1.00	*	5673	=	528826	2.80	
		ng - Ambient	A		972 * 1/	34.2		1.00	. * .	5673	=	43631	0.23	4
	Floor slak	/ Basement ceiling	B	10	788 * 1/	3.6	*	1.00	*	708	=	51051	0.27	
	Windows		A	30	231 * 1/	4.2	*	1.00	*	5673	=	977446	5.17	
	Exterior d	oor	A	6	00 * 1/	28.0	*	1.00	*	5673	=	2917	0.02	
	Exterior T	B (length/ft)	A	18	904 *	0.041	*	1.00	*	5673	=	106418	0.56	
	Transmission	heat losses Q_T				= 6 % of	the	total h	eat	t loss t	Total hro	1710290 Pugh the er	квт04(н [.] уг) 9.05 1 velope	٦
		Thermal	bridg	ge i	nputs									
Thermal bridge description	Group Nr.	Assigned to group	(Qty		-mined length [ft]	۱ -	Length ([ft]	!			bridge heat loss BTU/hr.ft.F	Ψ BTU/hr.ft.	.F
Wall Panel Bridges							-		_	Vall Pane	l Br:	idges		
Panel to panel (H1)	15	Thermal bridges Ambient		1	2.65.4	31.80	-	8131.80	_	Panel to		1 (H1)	0.072	_
Panel corner	15	Thermal bridges Ambient		2		3.00	-	506.00	_	Panel cor			-0.038	_
Shallow over Deep (SO	15	Thermal bridges Ambient		1		49.50	-	3949.50		shallow o			0.012	
Deep over shallow (S)	15	Thermal bridges Ambient		1	7227-85	49.50	-	3949.50		eep over			0.015	
Vertical Joint (V1)	15	Thermal bridges Ambient		1	18:	28.78	-	1828.78	3 V	Vertical	Join	t (V1)	0.029	

7.58

207.22

24.27

24.27

23.84

23.84

70.24

Total: 18,904

1

1

1

1

1

1

1

0.099

0.136

0.072

0.087

0.021

0.130

0.143

Roof Bridges

TB1

TB2

TB3

TB4

TB6

TB7

TB8

-

-

-

-

-

7.58

207.22

24.27

24.27

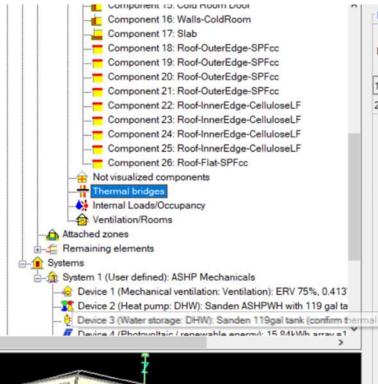
23.84

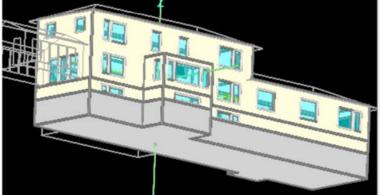
23.84

70.24

Thermal Bridge Modeling

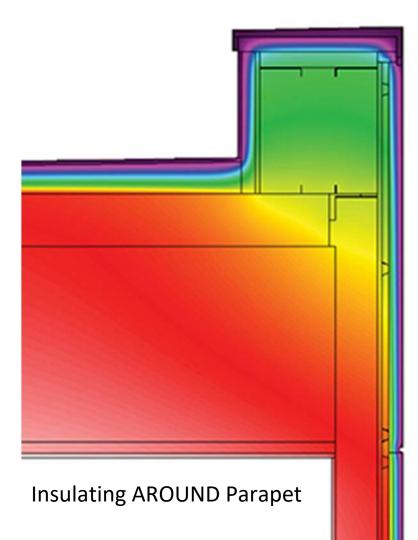
WUFI

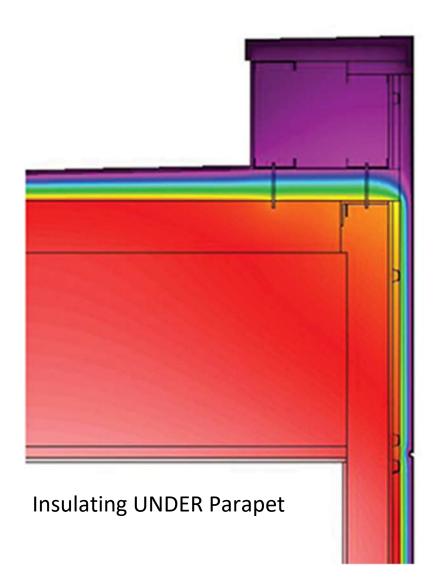




Nr	Name	Linear thermal transmittance [Btu/hr ft *F]	Length [ft]	Attachment	
1	Slab edge	.047	276	Perimeter) New
2	Porch Roof	0.1	2.5	Ambient	b Delete → Copy Copy Insert New/Insert: after ~
					after V
Ó6	ses)				

Thermal Bridging

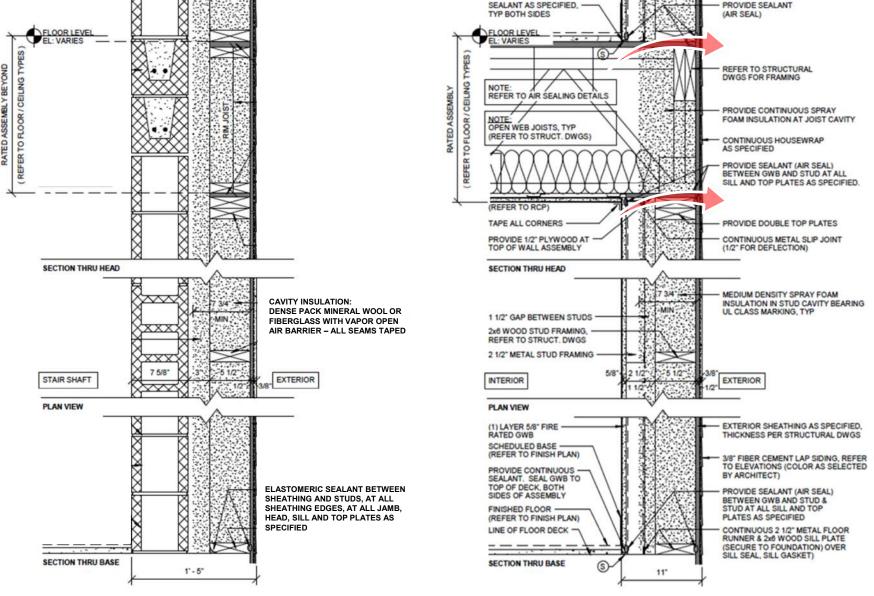




Thermal Bridging

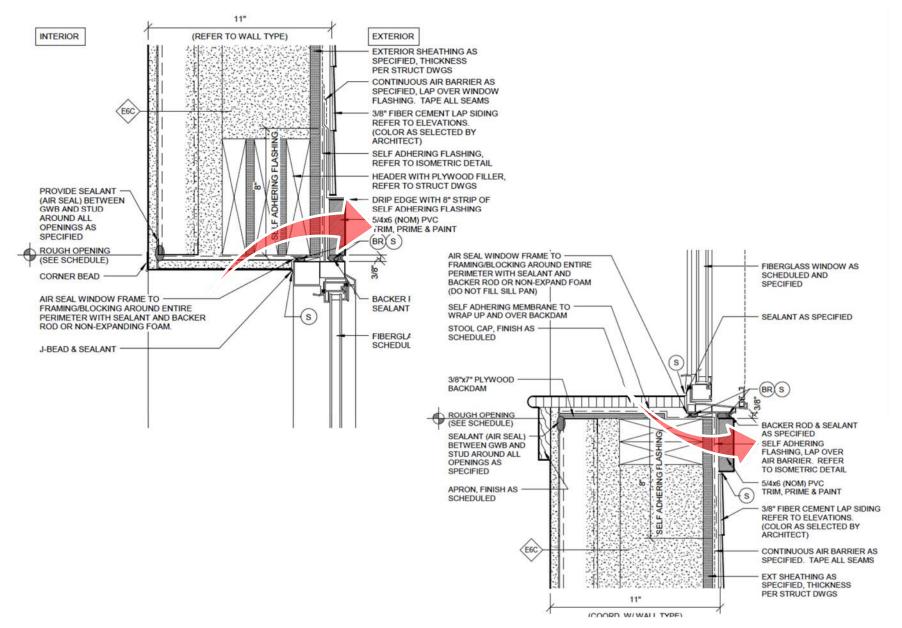
	Knife Plate	Fero FAST System	HSS Section	Large Angle
Effective Assembly R-Value	R-16.4 (RSI 2.89)	R-16.3 (RSI 2.87)	R-16.1 (RSI 2.84)	R-10.6 (RSI 1.87)
Effective Reduction	14.0%	14.6%	15.7%	43.0%

Enclosure - Walls



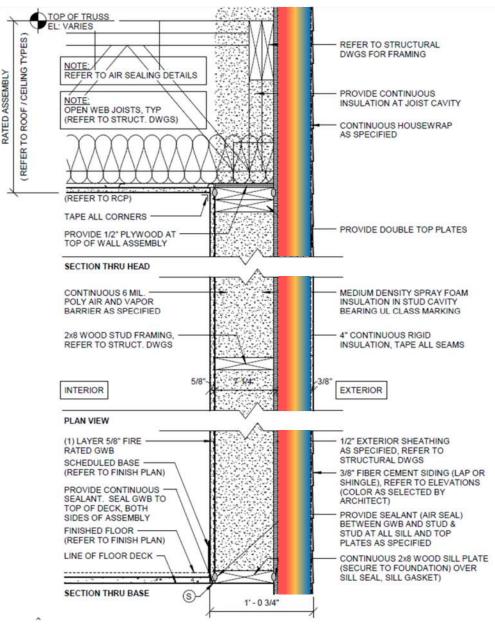
Credit: The Architectural Team

Enclosure – Windows & Doors

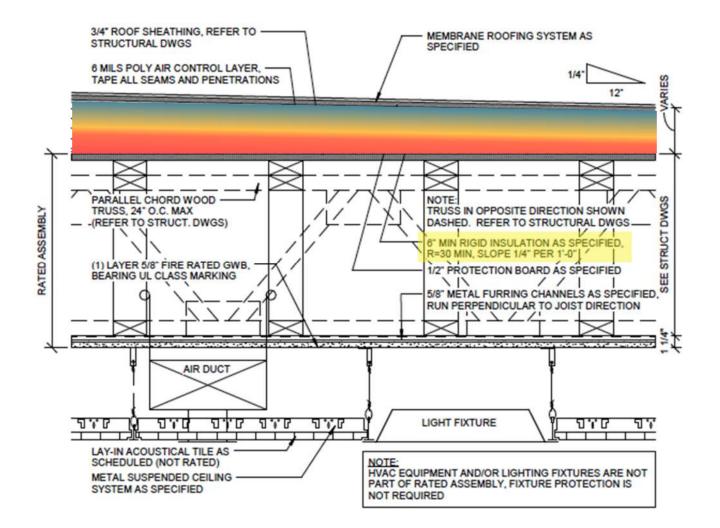


Credit: The Architectural Team

Enclosure - Walls

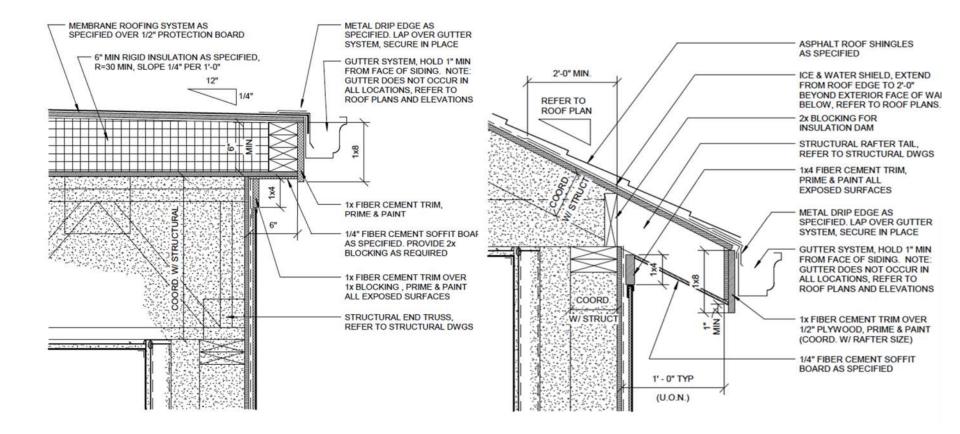


Enclosure - Roof



Credit: The Architectural Team

Enclosure – Wall to Roof



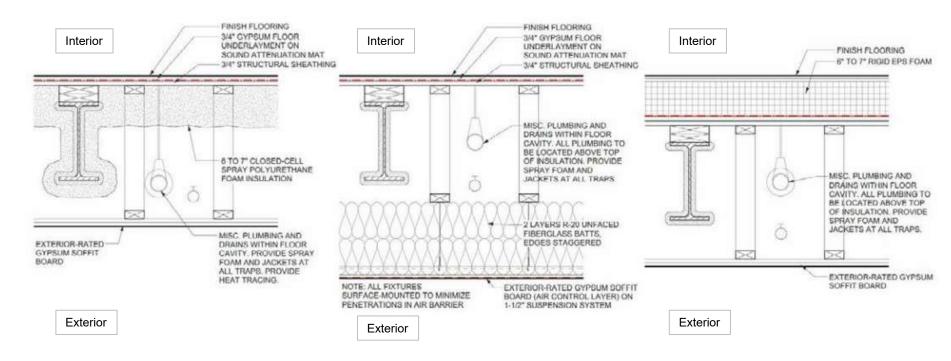
Credit: The Architectural Team

Enclosure – Interior over Exterior

Insulation Under Deck

Insulation At Ceiling

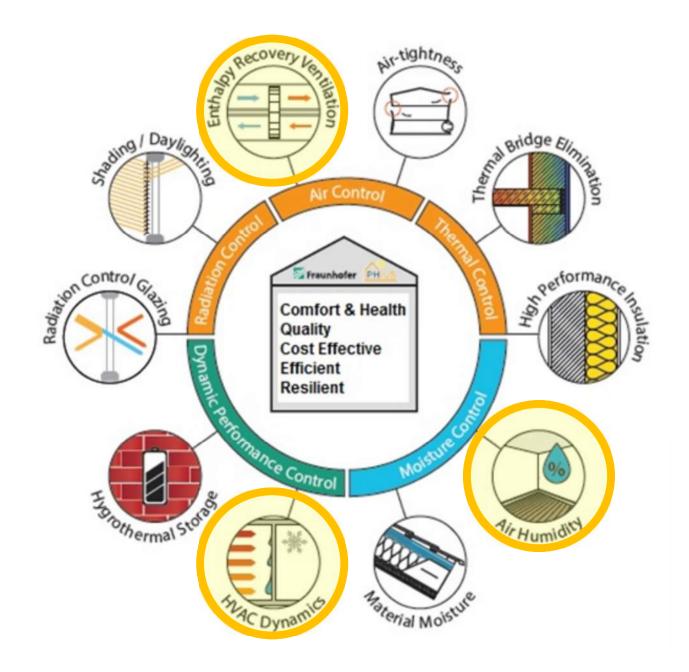
Insulation Above Deck



Challenges

- Heat Tape for plumbing
- Access to plumbing traps
- Inspection of insulation for effectiveness, codes, and PH compliance
- Managing moisture risks at interior spaces
- Location / control of Air Barrier

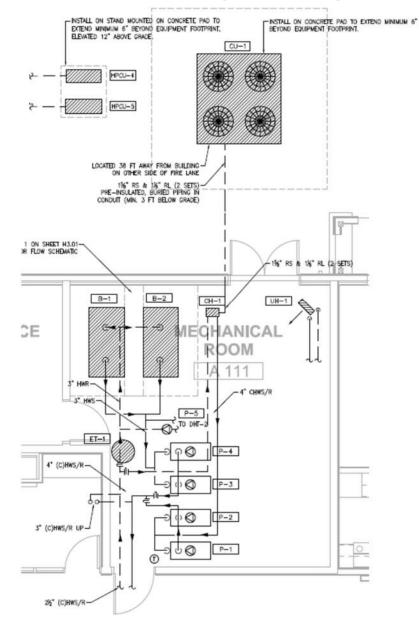
Credit: Utile Inc.



Mechanical Systems

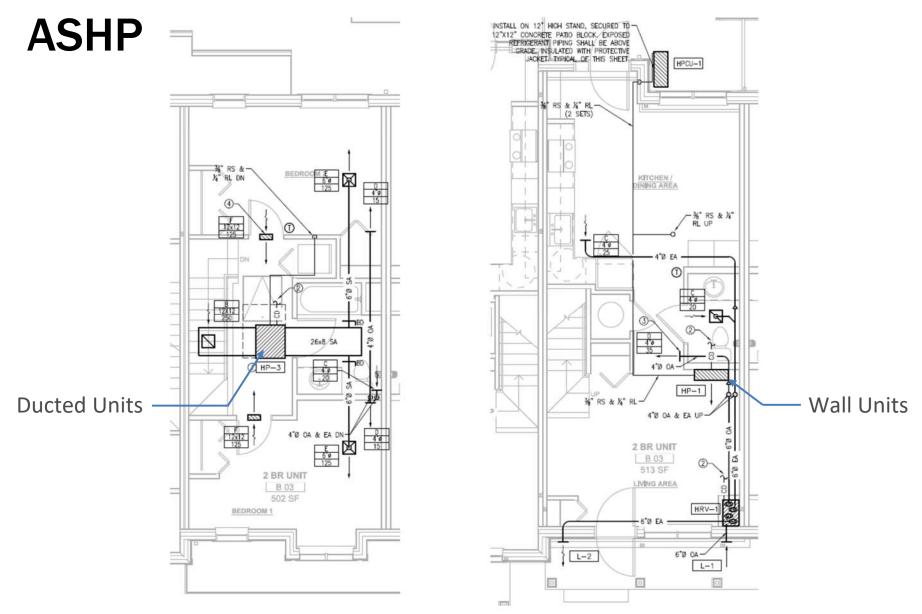
	Central	Semi-Central	Unit-Based
Ventilation (ERV/HRV)		X	
Heating			Х
Cooling			Х
Domestic Hot Water	Х		

Mechanical Systems – Central Heating/Cooling



Credit: Petersen Engineering Inc.

Mechanical Systems – Individual HVAC



Credit: Petersen Engineering Inc.

Mechanical Systems – Central / Semi-Central HVAC

VRF



Wall unit



Ducted Ceiling Units

Performance

- + Ventilation ductwork minimized
- + Heat recovery option allows for simultaneous heating and cooling

Design

- Extra piping required

Wall Units

- + No additional ceiling space required
- Additional power for each unit per room
- No units on market for very small loads

Ducted Units

- + Hidden equipment
- Requires additional ceiling space
- Requires sealing of ducts

Ventilation

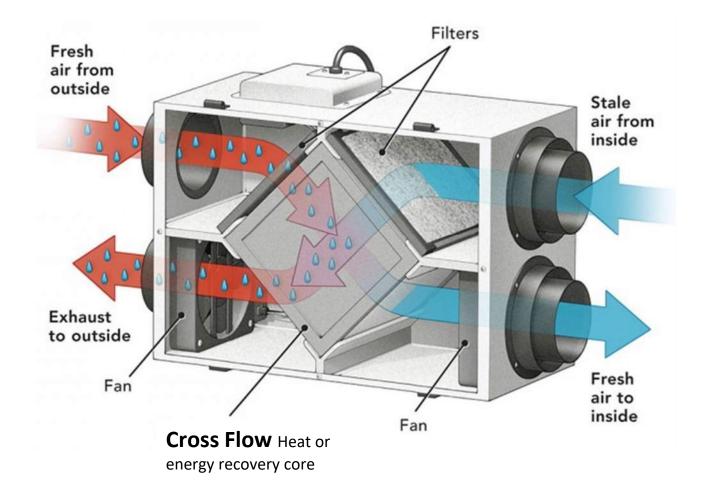
Continuous Balanced Ventilation:

- Exhausting Stale Air
 from point sources (kitchen, bathroom ...)
- + Intake and Filtering of Fresh Air to living areas (bedrooms, living room ...)

With Heat / Energy Recovery

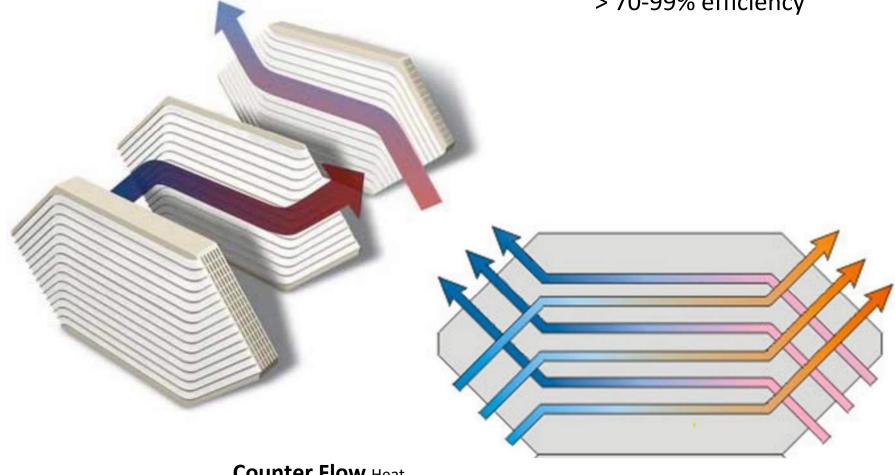
Sensible and Latent Energy Transfer

> 50-70% efficiency



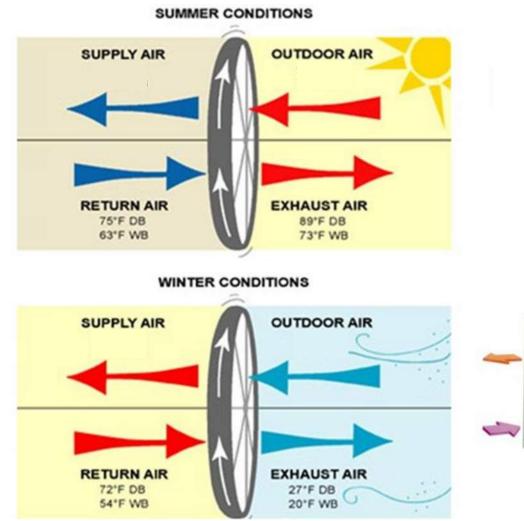
Sensible and Latent Energy Transfer

> 70-99% efficiency



Counter Flow Heat or energy recovery core

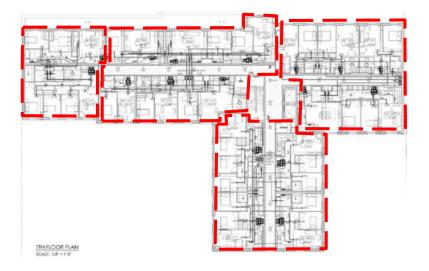
Sensible and Latent Energy Transfer

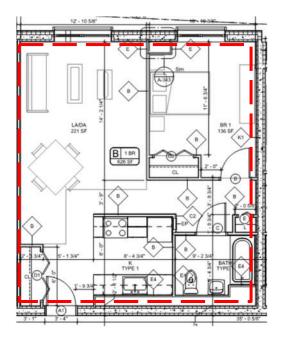


> 60-80% efficiency

Credit: doas-radiant.psu.edu

Mechanical Systems – Balanced Ventilation Heat/Energy Recovery Ventilator





Centralized

One ERV ventilates several apartments

Decentralized

Each unit has their own ERV

Mechanical Systems – Balanced Ventilation Heat/Energy Recovery Ventilator

Design / Constructability

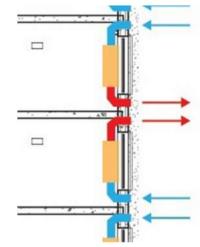




Benefits

- Less horizontal duct > Less ceiling depth
- No exterior through wall penetration **Challenges**
- Loss of floor space for vertical shafts
- Large floor and roof penetrations
- Fire rated shafts & dampers needed
- Critical to seal duct
- Higher floor to floor at horizontal distribution floor requires coordination





Decentralized

Benefits

- No floor and roof penetrations
- Better apartment compartmentalization **Challenges**
- Sealing 2 penetrations per apartment
- Horizontal duct at every apartment requires detailed coordination and increases ceiling depth

Mechanical Systems – Central vs Distributed Heat/Energy Recovery Ventilator

Maintenance and Operation



Centralized

Benefits

- Fewer units to maintain
- ERV more accessible to maintenance **Challenges**
- Cost of ventilation on owner



Decentralized

Benefits

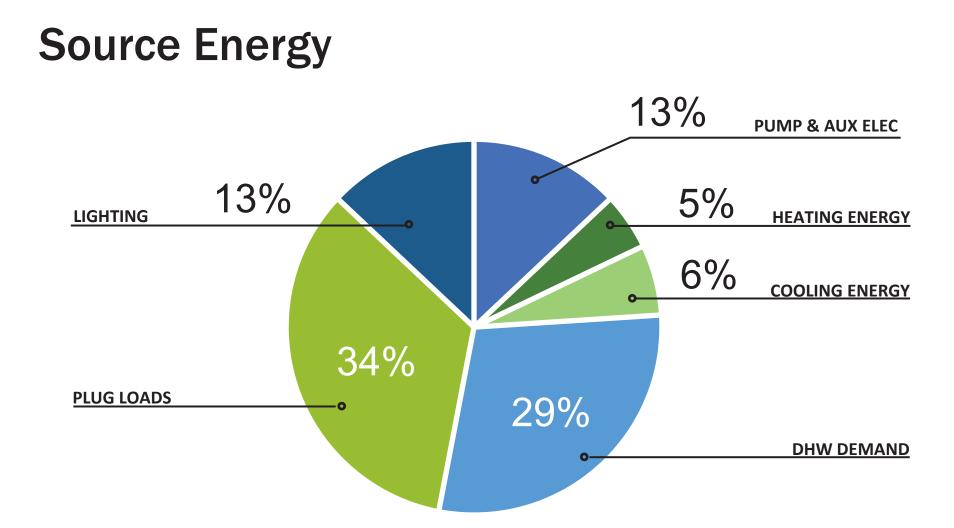
• Power for ERV on tenant panel

- Filters need to be replaced in every apartment every 3 months
- Requires access to exterior louvers for cleaning

Mechanical Systems - DHW Domestic Hot Water

- Hot water used for drinking, food prep, sanitation, and personal hygiene
- NOT for heating, swimming pools, commercial cooking, etc.





PASSIVE HOUSE HIGH RISE: NYC

Credit: Steven Winter Associates

Mechanical Systems - DHW Domestic Hot Water – Central



Benefits

- Reduced pumping power
- Can use gas boilers
- Potential to switch to HP in future
- Could utilize demand controlled to reduce recirc loop losses

- Loss of floor space
- On owner's meter

Mechanical Systems - DHW

Domestic Hot Water – Semi-Central Per Floor



Benefits

- Heat Pump-ready now
- Reduced pumping power
- Beneficial electrification
- Could utilize demand control to reduce recirculation loop losses

- Loss of roof area
- On owner's meter

Mechanical Systems - DHW

Domestic Hot Water – De-centralized Per Unit



Benefits

- Heat Pump-ready now
- Can easily meet PH criteria
- Beneficial electrification
- Could utilize demand control to reduce recirculation loop losses
- On tenant meter

- Requires maintenance closet
- Hybrid units require venting
- Split units require outdoor area

Mechanical Systems

WUFI modelling

Scope Passive house verification			~	English/IP/Out	ter dimension	ns/PHIUS+ 2018	Assign data
Component 21: Roof-OuterEdge-SPFcc Component 22: Roof-InnerEdge-CelluloseLF Component 23: Roof-InnerEdge-CelluloseLF Component 24: Roof-InnerEdge-CelluloseLF Component 25: Roof-InnerEdge-CelluloseLF Component 26: Roof-Flat-SPFcc Not visualized components Thermal bridges Ventilation/Rooms Attached zones Components Comp		Cooling v Cooling v Cooling v Dehumid Panel cool Additiona Supply ai Recircula Minimum	istribution eating DH distribution via ventilati via air recir lification oling al data ir cooling is ation air cooling is ation air cooling is	W Cooling	Ventilation	Supportive device /	auxiliary energy
Device 4 (Photovoltaic / renewable energy): 15.84kWh array =1 Device 5 (Heat pump: Heating, Cooling): Mitsubishi P SERIES Device 6 (Heat pump: Heating, Cooling): Fugitsu 12RGLXD-AF Case 2: with PV		Supply air cooling COP [-] Minimum temperature of cooling coil (for recirculation air) [°F]					2.5
						ulation air) [°F]	45
		Recirculation air flow rate [cfm]				20	
Localization/Climate: User defined		Recirculation air flow is variable					
A PH race Paceive house Residential	*	Recircula	ation air co	oling capacity	[kBtu/hr]		4
>		Recircula	ation coolin	g COP [-]			2.5
		Useful de	ehumidifica	tion heat loss			
		Dehumid	ification C	OP [-]			1.25

Credit: Fraunhofer IBP

PH Pre-certification

Reviewing Reports

BUILDING INFORMATION

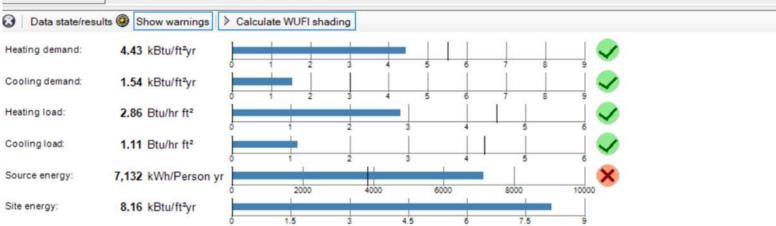
Category:	Residential		
Status:	Under construction		
Building type:	New construction		
Year of construction:	2021		
Units:	1		
Number of occupants:	6 (Design)		
Occupant density:	1,065.4 ft²/Person		



Boundary conditions

Building geometry

Climate:	CT - HARTFORD BRAI	DLEY INTL AP (Monthly)	Enclosed volume:	65,539.2	ft ³	
			Net-volume:	49,809.8	ft ³	
Internal heat gains:	0.5	Btu/hr ft ²	Total area envelope:	12,840.2	ft²	
Interior temperature:	68	°F	Area/Volume Ratio:	0.2	1/ft	
			Floor area:	6,392.4	ft ²	



Credit: Fraunhofer IBP

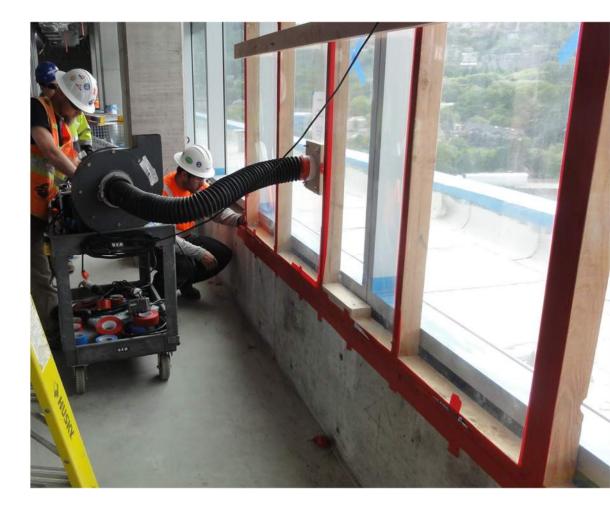
Construction Phase Support

3rd Party Verification

- Engaged during Design
- Verification Team should understand & comment on the design prior to start of construction
- Responsible for enforcing implementation of Design during Construction
- Must have authority through Owner / Architect
- Critical to Passive House performance and certification

Commissioning & Verification

- Testing Assemblies
- Checking critical connections
- Verifying specs
- Documenting issues
- Suggesting resolutions



Quality Control



REPORT ALL PENETRATIONS TO SUPERVISOR

Credit: 475 Building Supply

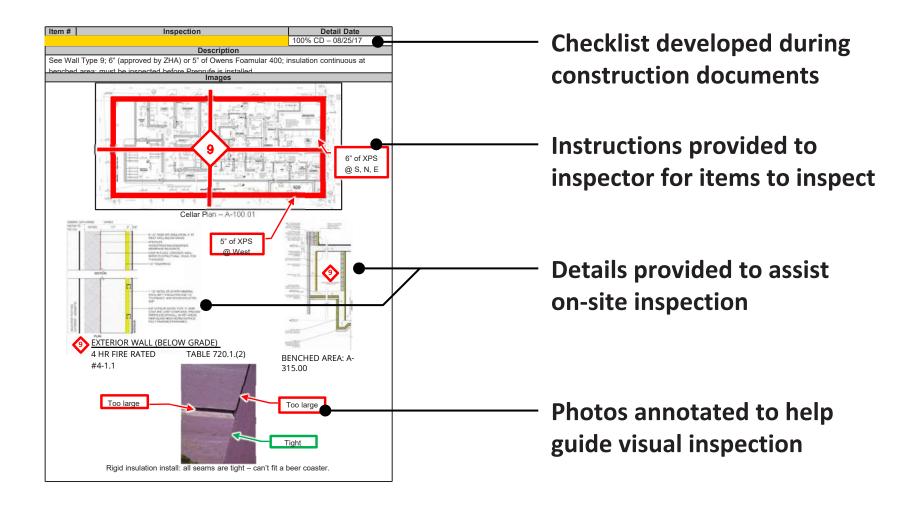
Site Inspection Checklist

The following items must be inspected and/or tested before being made inaccessible:

Phase	Description			
	Sub-Slab Insulation			
ш	Sub-Slab Air/Vapor Barrier			
AD	Below Grade Wall Insulation			
B	Below Grade Air/Vapor Barrier			
Ž	Gas Meter Room - penetrations			
BELOW GRADE	Trash Room			
B	Laundry Room			
	Waste / Misc. penetrations			
	Perimeter conditions at Grade			
ш	Building Corners, Expansion Joints			
ABOVE GRADE	Canopies - 1st inspection			
BR 1	Above Grade Wall Insulation			
ŽE V	Above Grade Air/Vapor Barrier Transitions			
BO	Trash Chute Doors			
⋖	Roof Surfaces - Insulation			
	Roof Surfaces - Air/Vapor Barrier Transitions			
	Mechanical Bulkhead - Insulation			
F	Mechanical Bulkhead - Air/Vapor Barrier			
TOP OUT	Elevator Shaft - Smoke Dampers			
PP	Storefront - Air Sealing			
Ĕ	Canopy - Final Inspection			
	Mezzanine - Final Inspection			

Credit: Steven Winter Associates

Site Inspection Checklist: Unique Conditions



Mid-Point Testing

- Whole Building / Guarded blower door test
 - focus on one floor
- Individual apartment blower door tests
- Individual components & Unique Conditions



Final Blower Door Test

PHIUS - Pressurize whole building / zones 0.11 cfm75 / ft2 ≥ 5 stories 0.08 cfm75 / ft2 all others

PHIUS - Pressurizing dwelling 0.3 cfm50 / ft2

PHI - Pressurize whole building 0.033 cfm50 / ft2

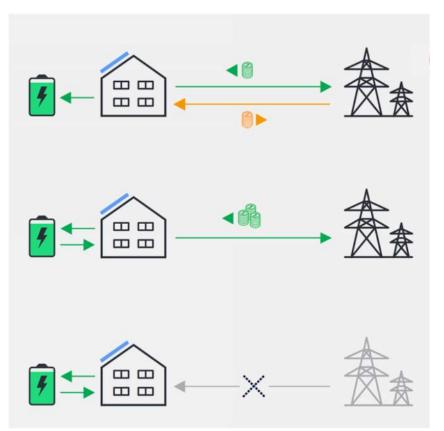






Passive House + Renewables = "Net Zero"





Renewable Energy Systems plus storage

- Reduce source energy
- May contribute heat (reduce heating loads, increase cooling loads)

It CAN be done



Zero Energy Design Tighthouse Passive House, Brooklyn



Kaplan Thompson Bayside Anchor, Portland Portland Housing Authority (PHA) and Avesta Housing

1.0

Christine Benedict Knickerbocker Commons RiseBoro Community Partnership

Icon Architecture Finch Cambridge HomeOwner's Rehab, Inc.



It IS BEING done!

Handel Architects Cornell Tech Residences Roosevelt Island Cornell University BROUGHT TO YOU BY

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Questions & Further Discussion

Luke McKneally AIA, LEED AP, CPHC ICF Account Manager <u>luke.mckneally@icf.com</u>

For more information, please visit EnergizeCT.com/passive-house or email <u>PassiveHouseTrainingCT@icf.com</u>