Form Follows Energy:

Achieving the Passive House Standard for Habitat for Humanity

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International PASSIVE HOUSE Association iPHA

PH PASSIVE HOUSE ALLIANCE UNITED STATES

NYPH

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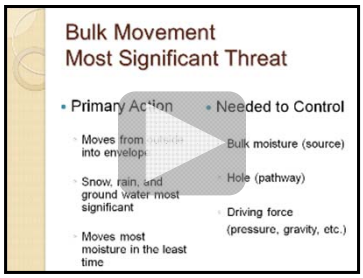
Researching Resiliency

Affordable Housing Research

Healthy Homes Research

ENERGY STAR v3



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Course Description

This webinar focuses the design and construction of a Passive House in northern Vermont. This house was the first Certified Passive House in the U.S. for Habitat for Humanity, the first Passive House in Vermont and the first to be built modular.

The webinar will discuss the principles of Passive House design: Envelope specifications; insulation, air sealing, and thermal bridge free details; mechanical systems; and modeling in the PHPP. The webinar will then walk you through the construction of the Passive House. The webinar will also review the monitored data on energy consumption, temperature and indoor air quality. Lastly we will review lessons learned and think about what is to come.

Learning Objectives

1. Participants will be able to identify the core principles and design techniques of the Passive House energy standard.
2. Participants will be able to evaluate the benefits of low load homes including: reduced operating costs; increased comfort, durability, and health; and as the best path to net zero.
3. Participants will review the design and construction of Vermont's first Passive House.
4. Participants will review measured data and reflect on the design and specification choices made.

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J.B. Clancy, AIA
Albert, Righter & Tittman Architects, Inc.

Submit a question to the moderator via the Chat box. They will be answered as time allows.

Stephen Schreiber FAIA
Professor and Architecture+Design Program Director
Department of Art, Architecture, and Art History
University of Massachusetts Amherst
Moderator

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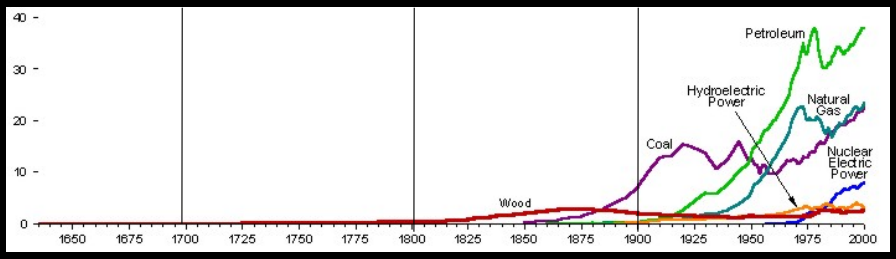
FORM FOLLOWS ENERGY

J.B. Clancy, AIA
CERTIFIED PASSIVE HOUSE CONSULTANT
ALBERT, RIGHTER & TITTMANN ARCHITECTS

AIA Webinar
June 4, 2012

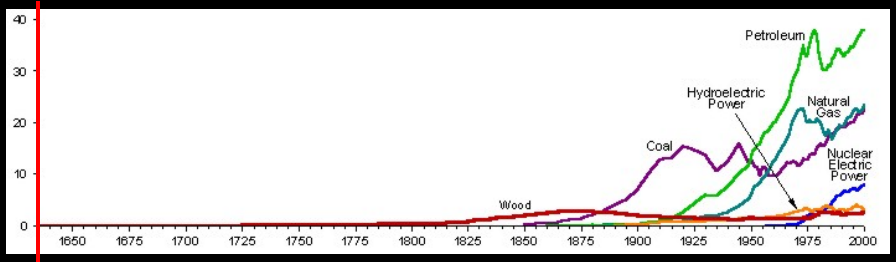
History of Energy Consumption by Source in USA 1630 to Present



E.I.A. Annual Energy Review 2003

FORM FOLLOWS ENERGY

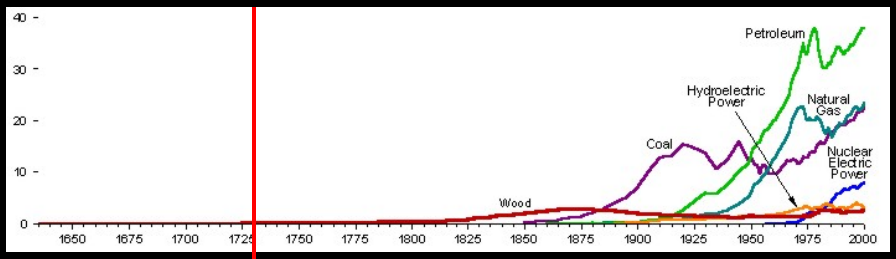
House 1630



E.I.A. Annual Energy Review 2003

George Soule House, Plymouth, MA 1630s

House 1732



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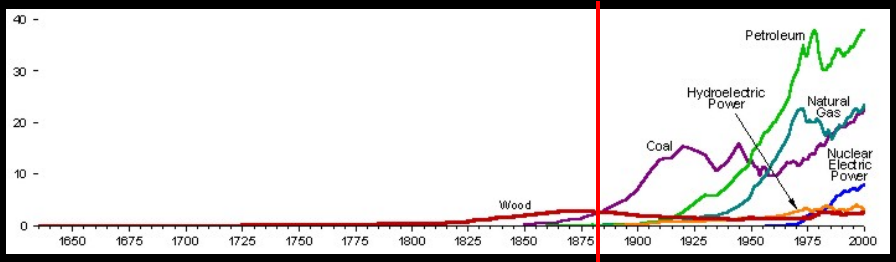
Hartwell Tavern, Concord, MA 1732

House1882



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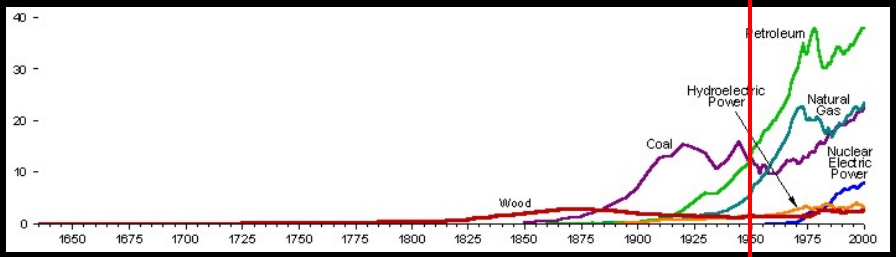
Drew House , Sandwich MA 1882

House 1951



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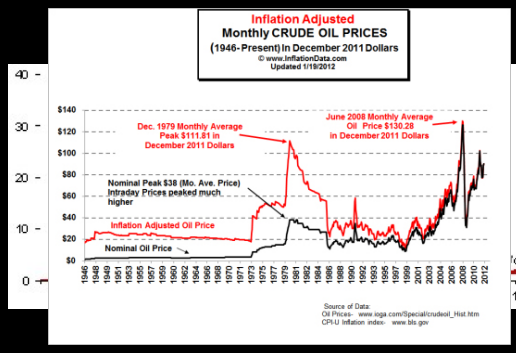
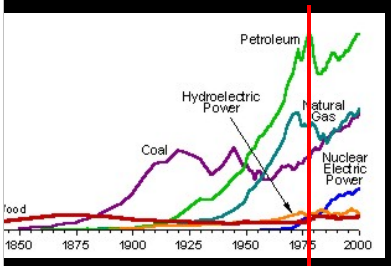
Farnsworth House, Mies van der Rohe , Plano, IL 1951

House 1976





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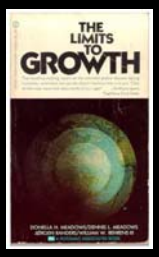
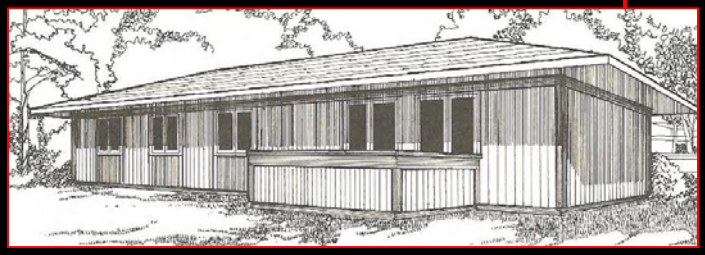
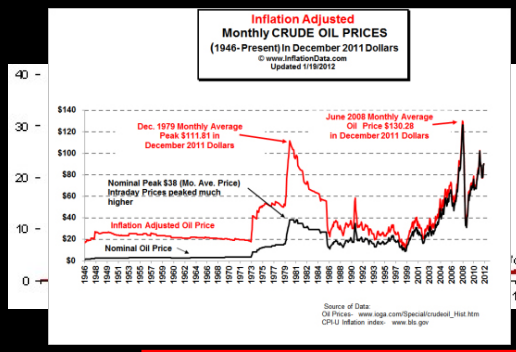
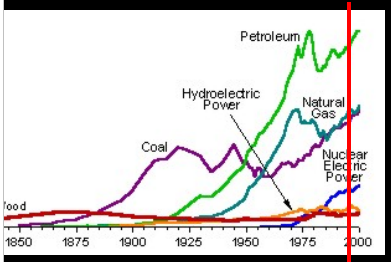




Lo-Cal House, University of Illinois at Urbana-Champaign 1976
Wayne Schick

House 1995

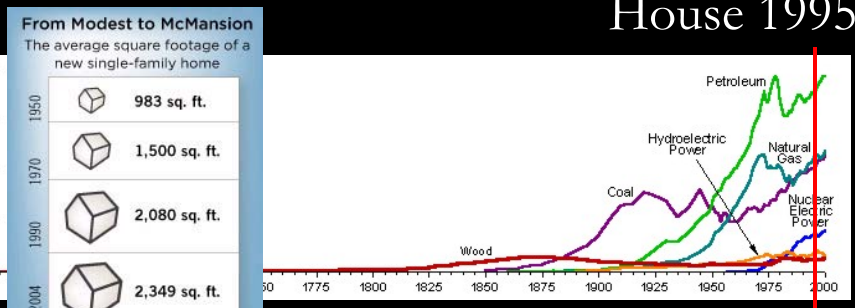




E.I.A. Annual Energy Review 2003

Anywhere USA

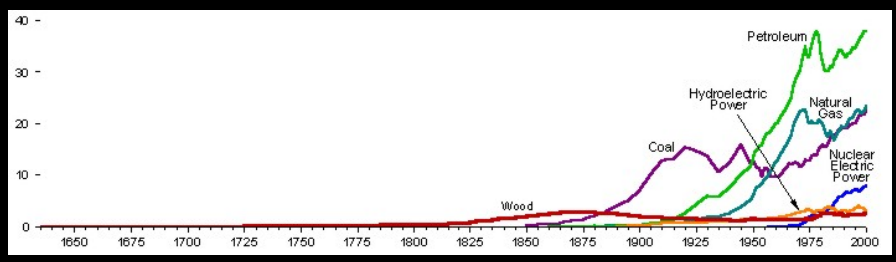
House 1995



E.I.A. Annual Energy Review 2003

Anywhere USA

House 21st Century



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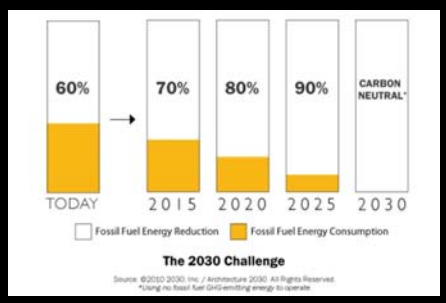


Architecture 2030

Passive House Energy Standard

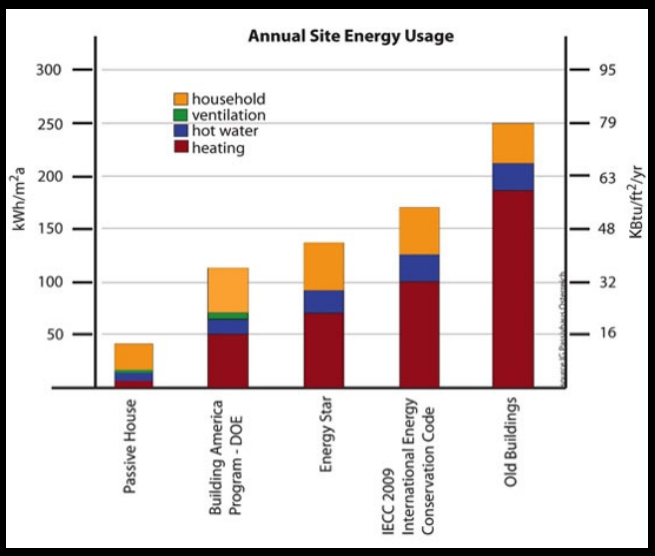
A Green Building Standard
built on an
Energy Budget
for the 21st Century

Passive House Energy Standard

Heating Demand (Site):	4.75 kBTU/SF/YR
Cooling Demand (Site):	4.75 kBTU/SF/YR
Total Energy Demand (Source):	38 kBTU/SF/YR
Air Tightness:	.6 ACH @ 50pa

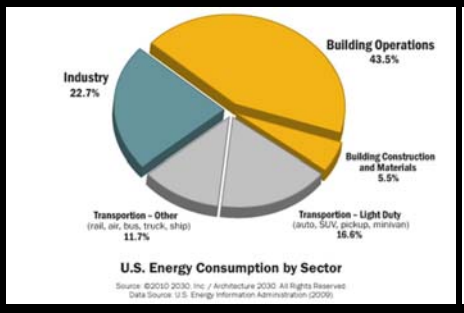
As modeled in the PHPP
(Passive House Planning Package)

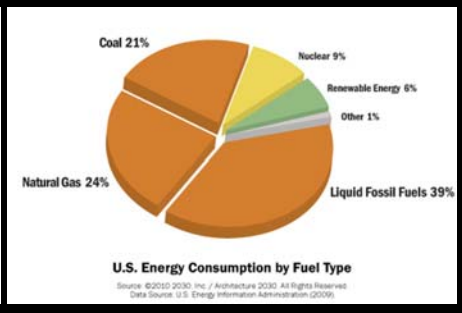
Standards Comparison



Passive House Energy Standard

Why an Energy Budget?





Architecture 2030

THE PASSIVE HOUSE CONCEPT

Passive House History

North American Roots

Leger House, Pepperell, MA

A whole series of North American developments ("super-insulated houses") in the 70s and 80s were very close to the Passive House. William A. Shurcliff (1981) authored many publications on this subject.

This work was an important basis for low-energy houses and Passive Houses in Europe.

Lovins House, Snowmass, CO

A. B. Lovins visited the Passive House in Darmstadt Kranichstein in 1995. It was he who suggested that the Passive House should be considered not just as a research project, but also as the energy standard of the future.

PASSIVE HOUSE INSTITUTE

Passive House Concept

Functional Definition

The Passive House: The Functional Definition

Although the designs of Passive Houses may appear quite different, the principle remains the same. The principle behind a Passive House is based on the concept by Amory Lovins of reducing investment through energy efficient design. By dramatically increasing the energy efficiency of a building, the HVAC systems can be radically simplified upon reaching a certain level of efficiency.

Consider the example of building a house for a cold climate. The heat demand for heating the house in the cold season is the major energy consuming service. If the heat demand is reduced by means of insulation, heat recovery, superwindows, passive solar gains and other measures, the heating system can be simplified step-by-step. But the most significant threshold appears when the peak heating load reaches

10 W/m².

When the peak heating load is less than 10 W/m², independent of climate, the ventilation system can easily be used for space heating, and a separate heating system is no longer required.

The primary function of the ventilation system is to maintain excellent indoor air quality.

If the maximum load is lower than 10 W/m², the ventilation system can distribute all heat needed throughout the building as well. The definition of a Passive House is therefore that the peak heating load should be projected to a lower level than 10 W/m². In warmer climates, this value may be easy to achieve, however in colder climates, careful planning is required.

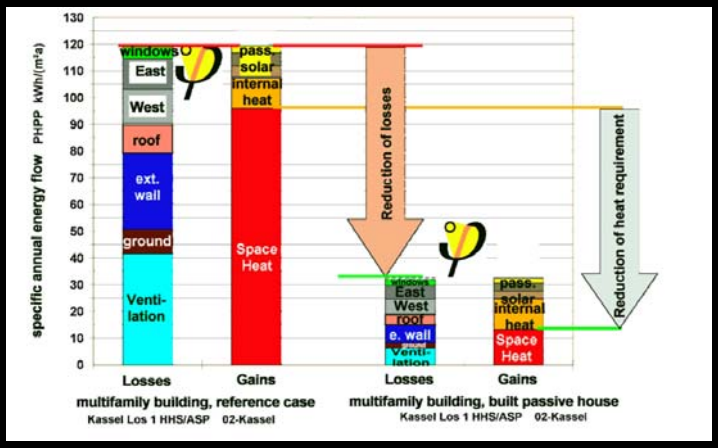
1. The Passive House: A Method Rather than a Building Style

First Steps: What Can be a Passive House in Your Region with Your Climate?
Dr. Wolfgang Feist

Passive House Concept

ENERGY BALANCE

Reduce Losses – Reduce Heat Requirement

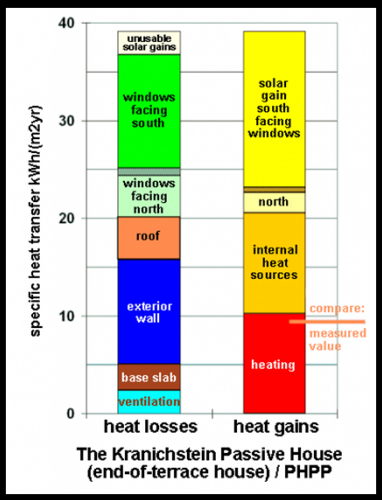


First Steps: What Can be a Passive House in Your Region with Your Climate?
Dr. Wolfgang Feist

Passive House Concept

ENERGY BALANCE

Minimize Losses and Maximize Gains



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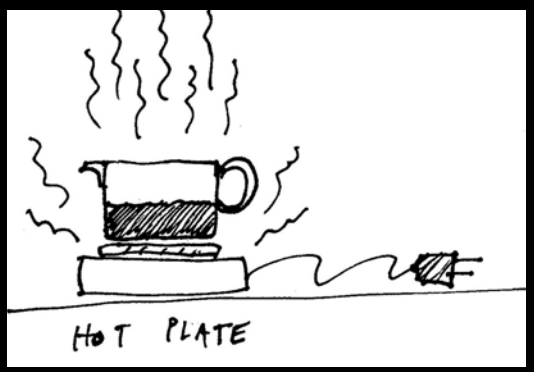
Passive House Concept

Maintain temperature using the envelope, rather than by using energy.



Passive House (Passivhaus)

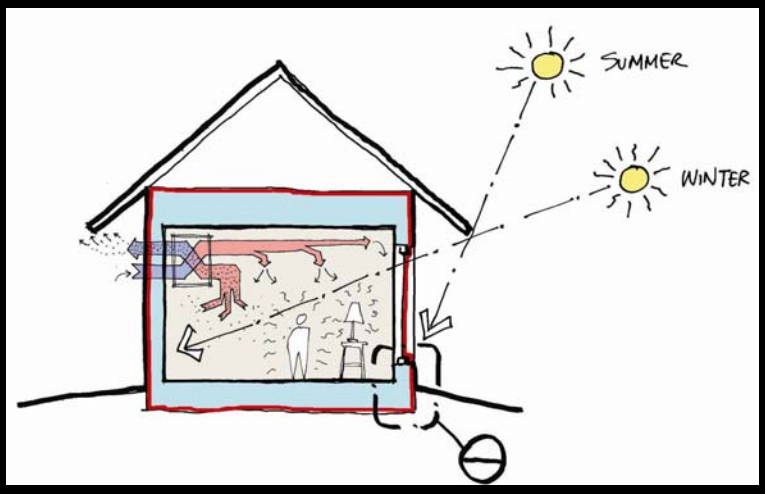
Passivhaus Institut
Darmstadt, Germany

Passive House Institute US
Urbana, Illinois

Passive House Concept

INTEGRATED

"Let the architecture do the work"



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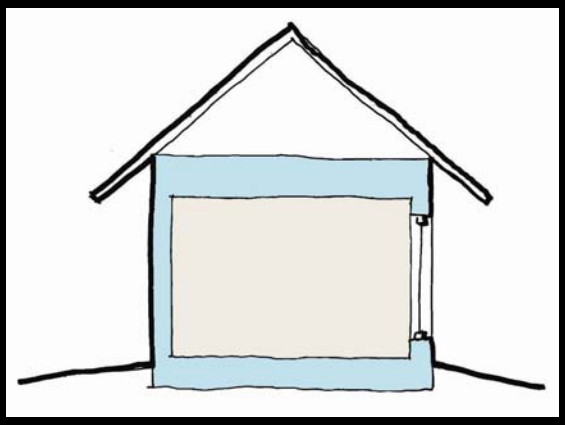
Passive House Concept

Controlling Heat Loss… INSULATION



R58 WALLS: R90 CEILING: R60 SLAB
High Performance WINDOWS U value 0.16

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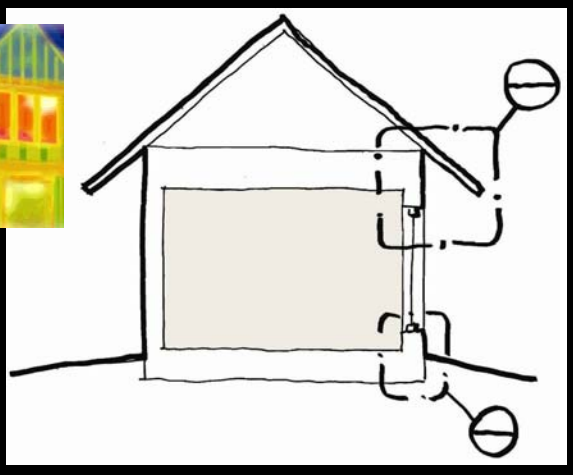
Controlling Heat Loss… ELIMINATE THERMAL BRIDGES



Ψ ≤ 0.01 W/(mK)

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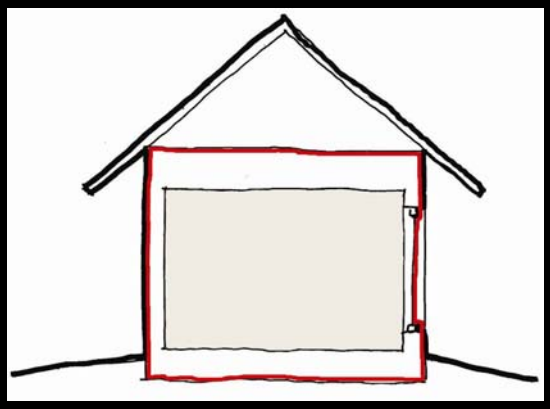
Passive House Concept

Controlling Heat Loss… REDUCE AIR INFILTRATION



.6 ACH @ 50 PA

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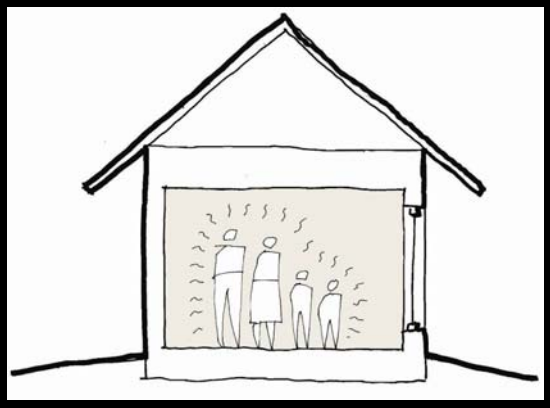
Passive House Concept

Capturing Heat Gains… PEOPLE



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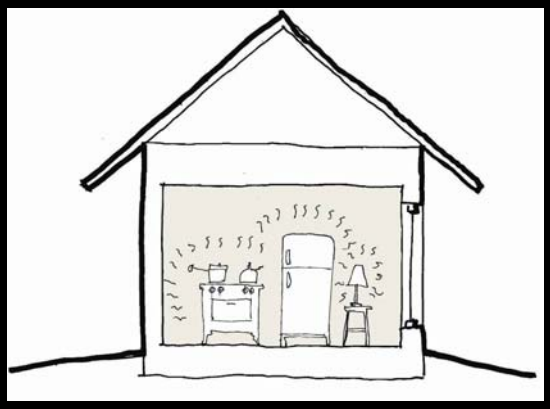
Passive House Concept

Capturing Heat Gains… EQUIPMENT



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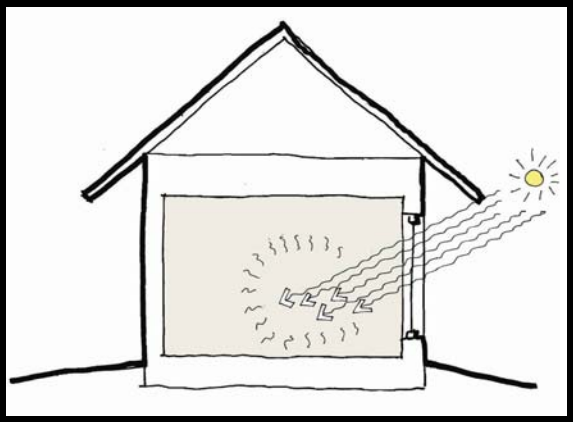
Passive House Concept

Capturing Heat Gains… SOLAR ENERGY



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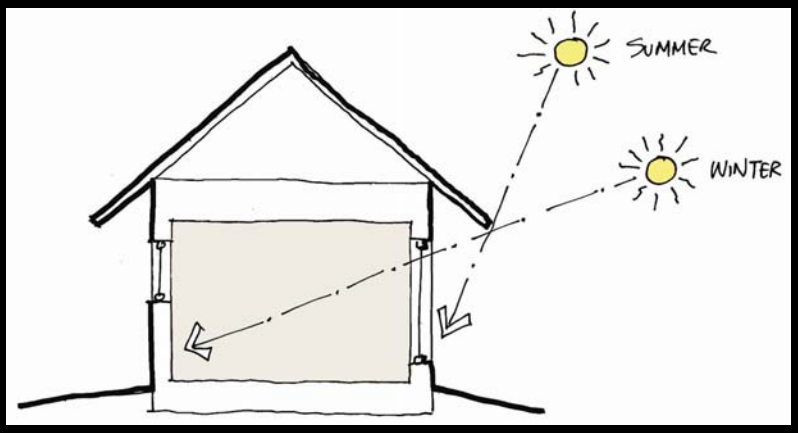
Passive House Concept

Controlling Gains Seasonally… WINDOWS & ORIENTATION



TRIPLE GLAZED: >.5 SHGC ON SOUTH WINDOWS

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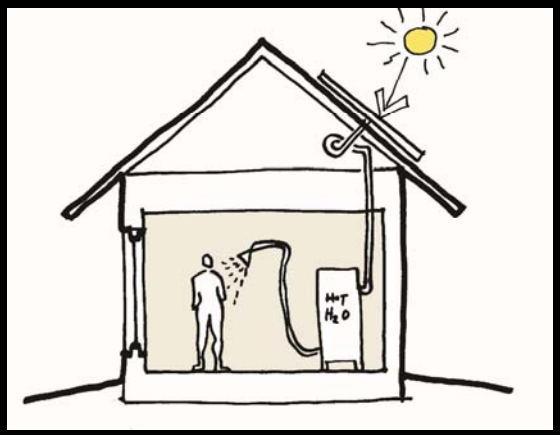
Passive House Concept

SOLAR THERMAL



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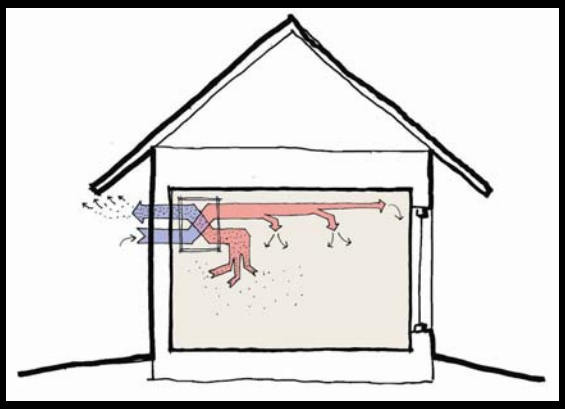
Passive House Concept

Providing Fresh Air… HEAT RECOVERY VENTILATION



MINIMUM .30 ACH

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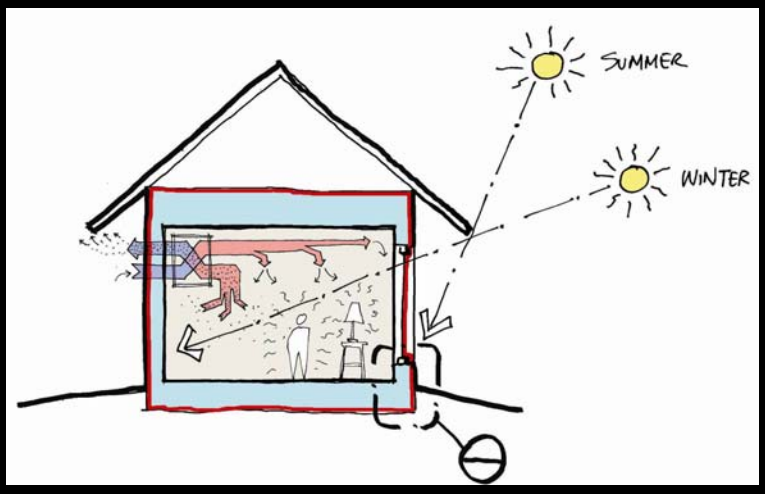
Passive House Concept

INTEGRATED

"Let the architecture do the work"



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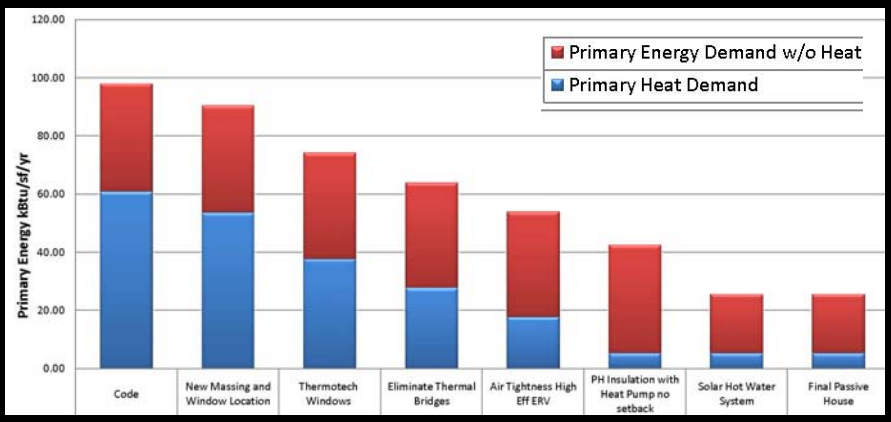
Passive House Concept

TO GET FROM CODE TO PASSIVE HOUSE



INTEGRATED

Passive House Concept

PHPP SOFTWARE

The PASSIVE HOUSE PLANNING PACKAGE (PHPP) is an important tool for designing Passive Houses consisting of a spreadsheet workbook and a manual.

The Passive House Planning Package (PHPP) provides everything needed to design a properly functioning Passive House including tools for:

- Calculating energy balances (including U-value calculation)
- Planning the windows
- Designing the comfort ventilation system
- Determining the heating load
- Estimating the summer comfort
- Design the heating and hot water supply

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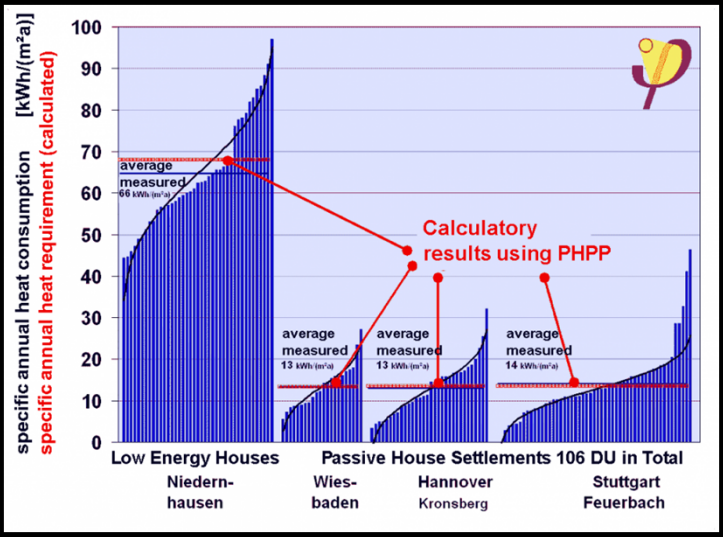
Passive House Concept

PHPP SOFTWARE



PASSIVE HOUSE INSTITUTE

Passive House Concept

RESULTS

- Dramatic reduction in energy consumption
- Superior indoor air quality
- Exceptional occupant comfort
- Lower annual energy costs
- Smaller carbon footprint
- More durable construction details

Passive House Concept
SUMMARY

- Envelope focused: super insulation, high performance windows, no thermal bridging, air tight
- Ventilation with heat recovery
- Optimized through integrated design using energy modeling

Passive House Concept
SUMMARY

- Focus on ENERGY conservation
- Do more with less ENERGY
- Minimize losses – Maximize gains
- Simple is better than complex
- Passive better than active
- Moving parts fail

THE FIRST CERTIFIED PASSIVE HOUSE IN VERMONT

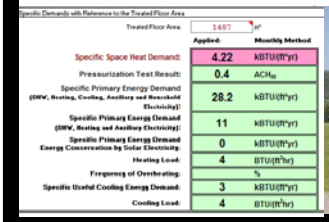
This building has been awarded the

Quality Approved Passive House Certificate

by the Passive House Institute issued by Passive House Institute US

This certification is based entirely on the design documentation and specifications provided by the client to the Passive House Institute US for the purpose of certification to the Passive House Standard. The Passive House Institute US has verified and approved the building's energy balances according to the provided building data.

This certification does not cover quality assurance of the construction or design implementations. The Passive House Institute US cannot be held responsible for faulty implementations. Means and methods and appropriate building science are the responsibility of the architect/builder.



Specific Demands with Reference to the Treated Floor Area	Applied	Monthly Method
Treated Floor Area:	149?	m²
Specific Space Heat Demand:	4.22	kBTU/(ft²yr)
Pressurization Test Result:	0.4	ACH_{50}
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	28.2	kBTU/(ft²yr)
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	11	kBTU/(ft²yr)
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	0	kBTU/(ft²yr)
Heating Load:	4	BTU/(ft²hr)
Frequency of Overheating:		%
Specific Useful Cooling Energy Demand:	3	kBTU/(ft²yr)
Cooling Load:	4	BTU/(ft²hr)

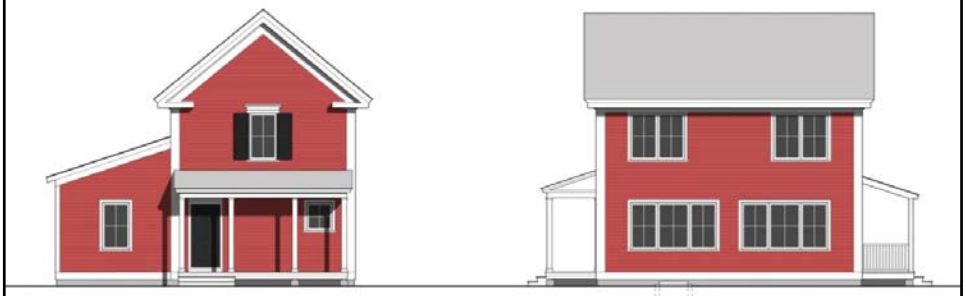
Philip Jensen-Carter

PROJECT TEAM
CLIENT: Green Mountain Habitat for Humanity, David Mullin
ARCHITECT: J.B. Clancy, Albert, Righter & Tittmann Architects
ENERGY CONSULTANT: Peter Schneider, VEIC
STRUCTURAL ENGINEER: John Higgins, Artisan Engineering

Habitat for Humanity Passive House

Albert, Righter & Tittmann Architects

Habitat for Humanity Passive House



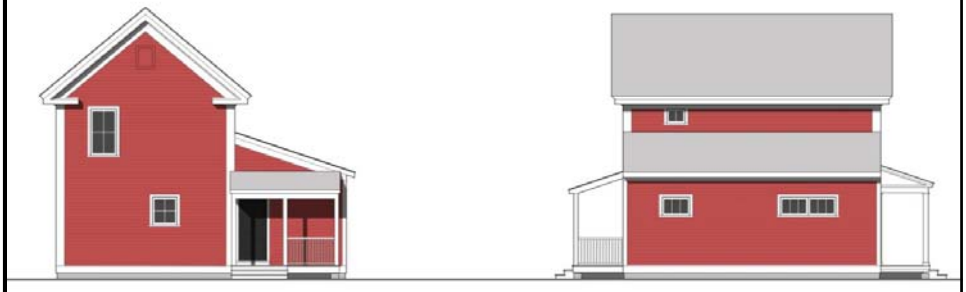
WEST ELEVATION

SOUTH ELEVATION

Glazing percentage % TFA: 1:1:8:2 (N:E:S:W)

Albert, Righter & Tittmann Architects

Habitat for Humanity Passive House



EAST ELEVATION

NORTH ELEVATION

Glazing percentage % TFA: 1:1:8:2 (N:E:S:W)

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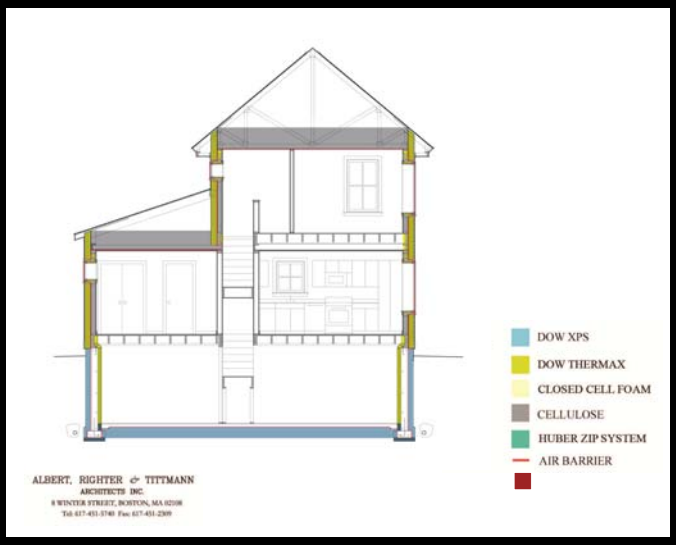
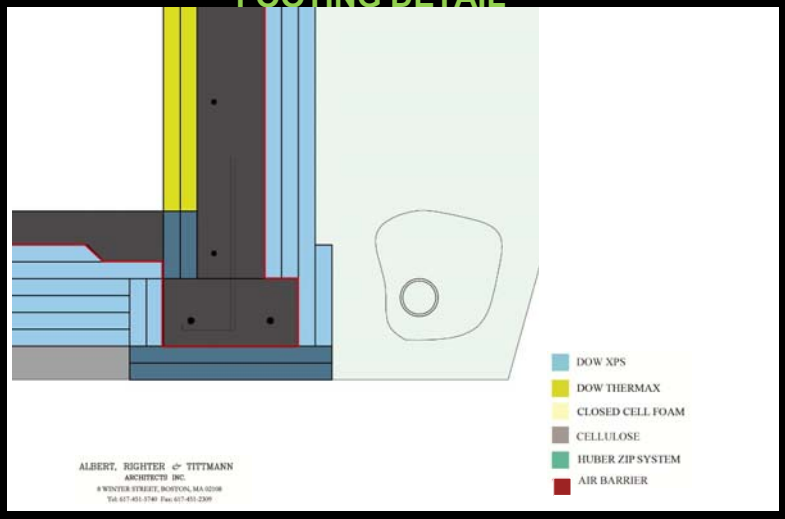
Habitat for Humanity Passive House



Albert, Righter & Tittmann Architects

Habitat for Humanity Passive House

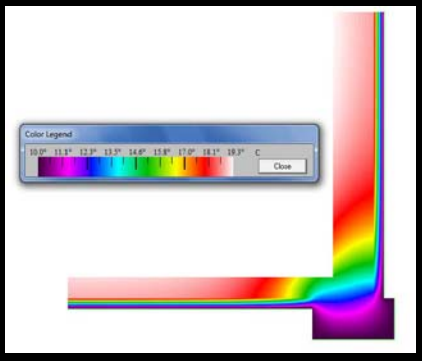
FOOTING DETAIL



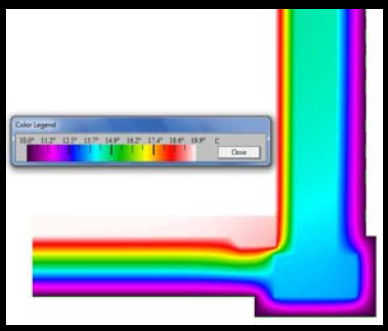
SLAB: R61 **FDN WALLS: R57**

Habitat for Humanity Passive House

FOOTING DETAIL



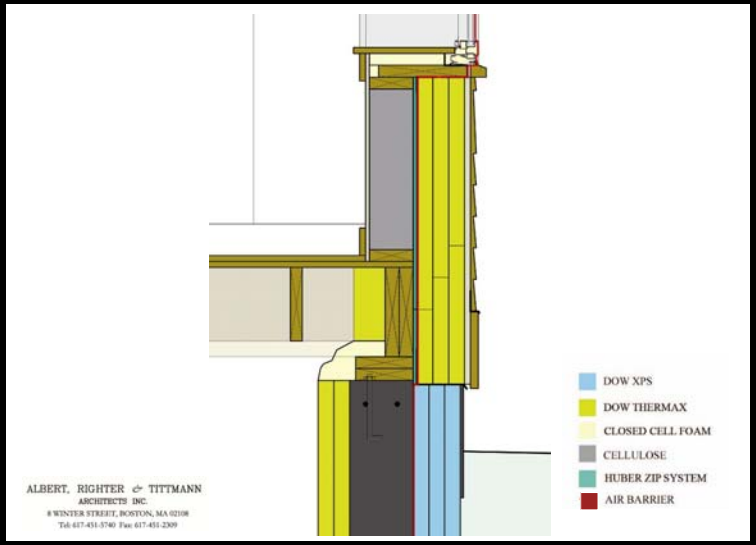
CODE INSULATION– 2” XPS Under Slab & on Wall



PASSIVE HOUSE INSULATION– 12” XPS Under Slab & 10” on Wall

THERM MODELS OF FOUNDATION DETAILS

Habitat for Humanity Passive House



EXTERIOR WALL: R59

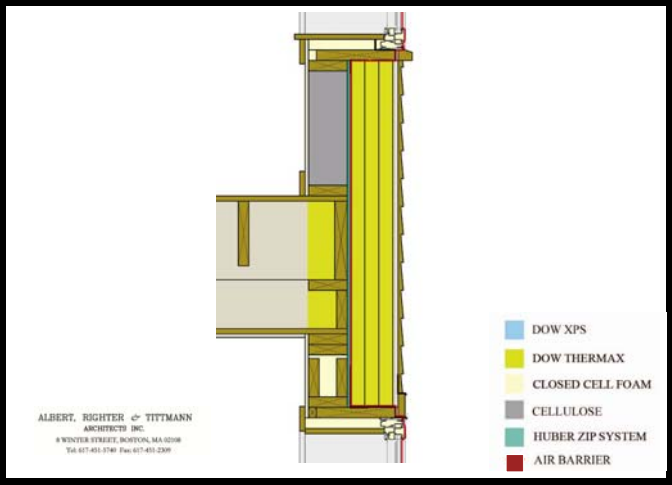
Habitat for Humanity Passive House

WALL SECTION

EXTERIOR WALL: R59

Habitat for Humanity Passive House

SECOND FLOOR PLATFORM DETAIL



EXTERIOR WALL: R59

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EAVE DETAIL

ROOF: R90

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WINDOWS

Thermotech
322 Gain+

.64 SHGC (solar heat gain coefficient)
COG U .16

NFRC whole window U .19 (R5.3)

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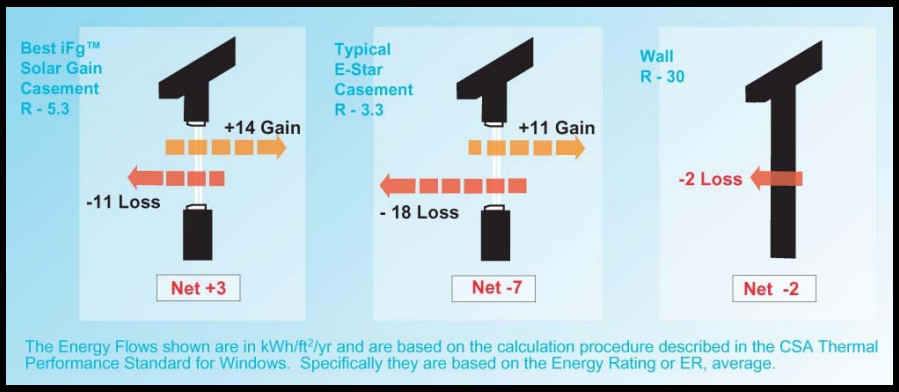
THERMOTECH WINDOWS



Thermotech Windows

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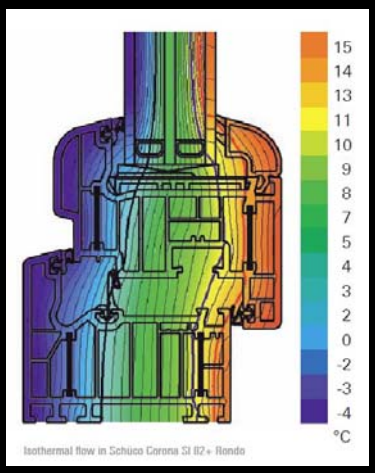
WINDOWS – NORTH AMERICAN CASEMENT

Habitat for Humanity Passive House

WINDOWS – EUROPEAN TILT-TURN



Habitat for Humanity Passive House

HVAC SYSTEM

Air Source Heat Pump
Mitsubishi Hyper-heat MSZ-MUZ FE 12

HRV
Zender ComfoAir 350 HRV

Soil heat exchange system
Two 125' loops of 1" pex around the base of the footings filled with water/glycol mix & tied to Zehnder ComfoFond (~30F Temp Rise and 80% efficiency)

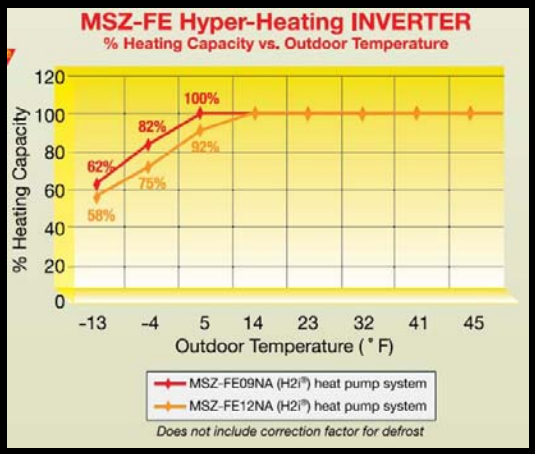
Solar Hot Water
Sunward Solar water heating system mounted on roof with 40g electric hot water heater as back-up

Habitat for Humanity Passive House

HVAC SYSTEM

Air Source Heat Pump

Mitsubishi Hyper-heat MSZ-MUZ FE 12

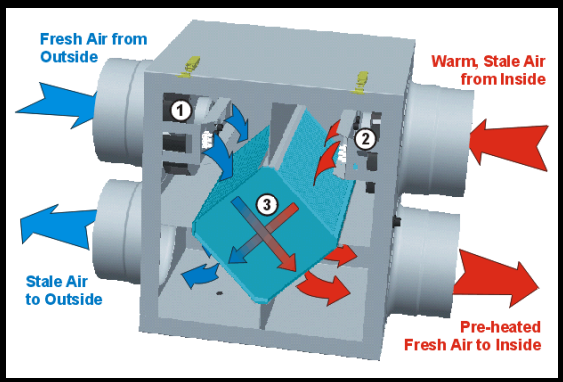


Habitat for Humanity Passive House

HVAC SYSTEM

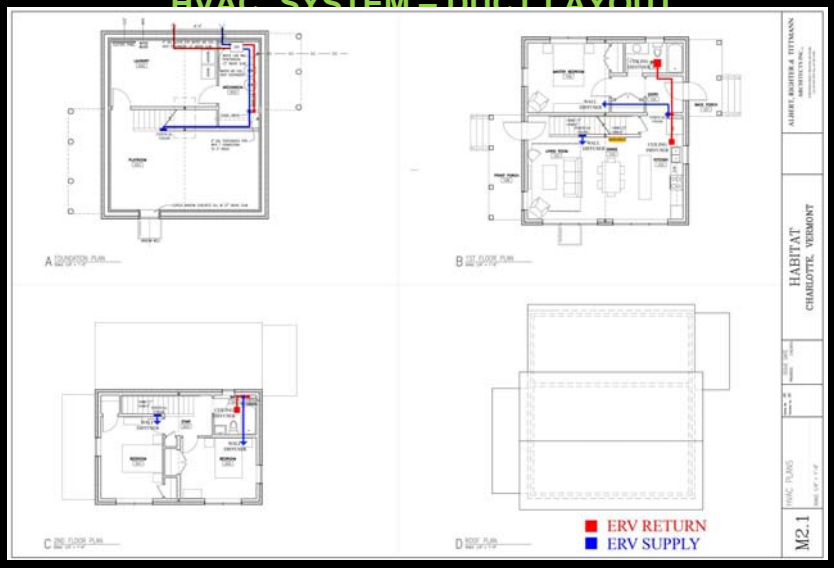
HRV

Zender ComfoAir 350 HRV



Habitat for Humanity Passive House

HVAC SYSTEM – DUCT LAYOUT



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Habitat for Humanity Passive House

ENERGY STAR - TIER III APPLIANCES

Refrigerator

Brand	Model	KWH/ Year	% Less Energy
Whirlpool	W9RXXMF2*0	343	30%

Dishwasher

Brand	Model	KWH/ Year	Energy Factor
Whirlpool	GU3100XTV*	270	0.82

Washer
Dryer

Brand	Model	KWH/ Year	MEF Energy
Bosch	WFVC844*UC	130	2.55

PHPP Energy Model

VERIFICATION PAGE

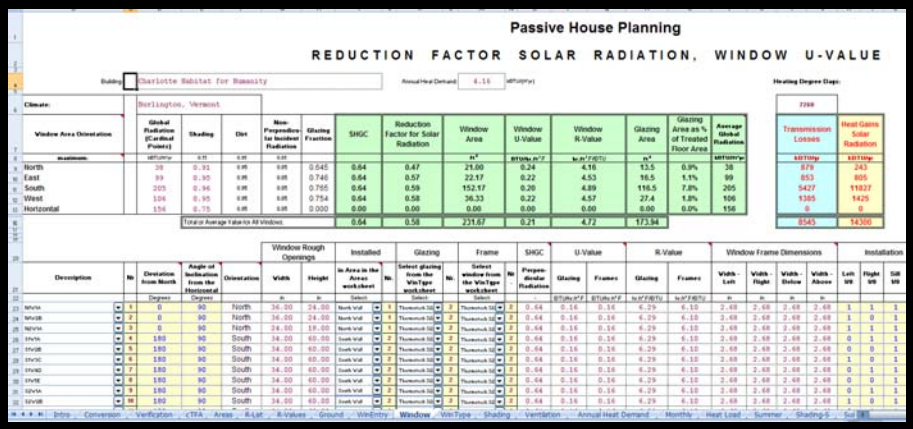
Specific Demands with Reference to the Treated Floor Area

Treated Floor Area: 1487 ft²

	Applied:	Monthly Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	4.22	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	Yes
Pressurization Test Result:	0.4	ACH_{50}	0.6 ACH_{50}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	28.2	kBTU/(ft²yr)	38.0 kBTU/(ft²yr)	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	11	kBTU/(ft²yr)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	0	kBTU/(ft²yr)		
Heating Load:	4	BTU/(ft²hr)		
Frequency of Overheating:		%	over 77.0 F	
Specific Useful Cooling Energy Demand:	3	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	Yes
Cooling Load:	4	BTU/(ft²hr)		

PHPP Energy Model

WINDOW ENTRY



Post-Construction Performance Testing

Airflow at 50 Pascals — 50 Pa

102 cfm50 (+/- 3.4 %)
0.41 ACH50
0.0685 cfm50/ft² Floor Area
0.0257 cfm50/ft² Surface Area

Leakage Areas

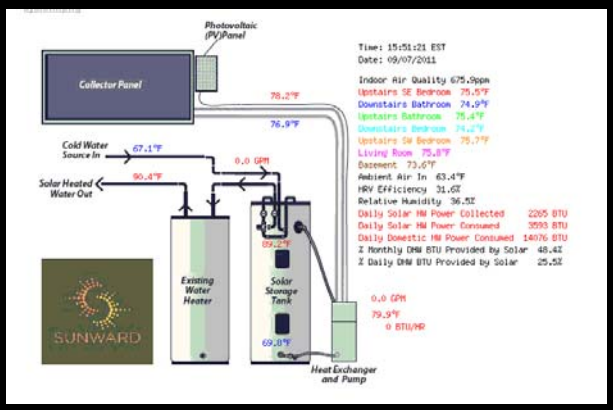
7.6 in² (+/- 12.5 %) Canadian EqLA @ 10 Pa or 0.0019 in²/ft² Surface Area
3.4 in² (+/- 19.7 %) LBL ELA @ 4 Pa or 0.0009 in²/ft² Surface Area

Building Leakage Curve

Flow Coefficient (C) = 3.7 (+/- 30.7 %)
Exponent (n) = 0.849 (+/- 0.080)
Correlation Coefficient = 0.99107

VERMONT ENERGY INVESTMENT CORPORATION

Post-Construction Performance Monitoring

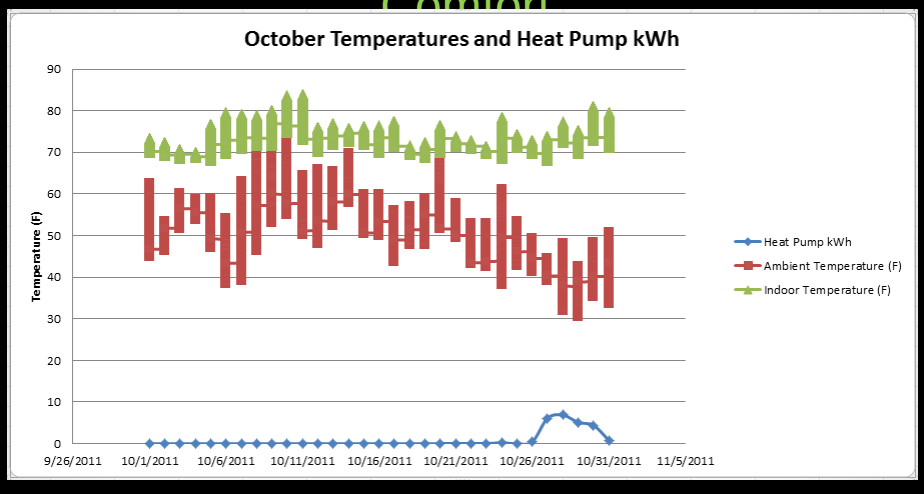


VERMONT ENERGY INVESTMENT CORPORATION

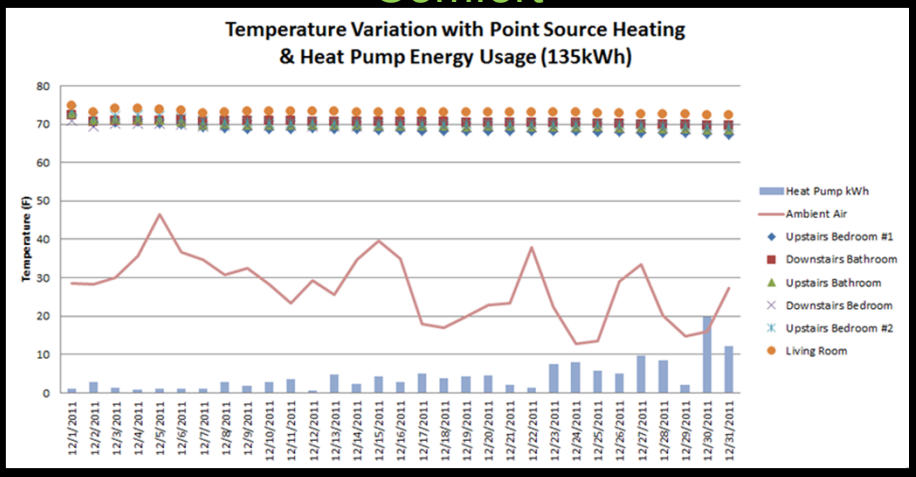
Post-Construction Performance Monitoring

VERMONT ENERGY INVESTMENT CORPORATION

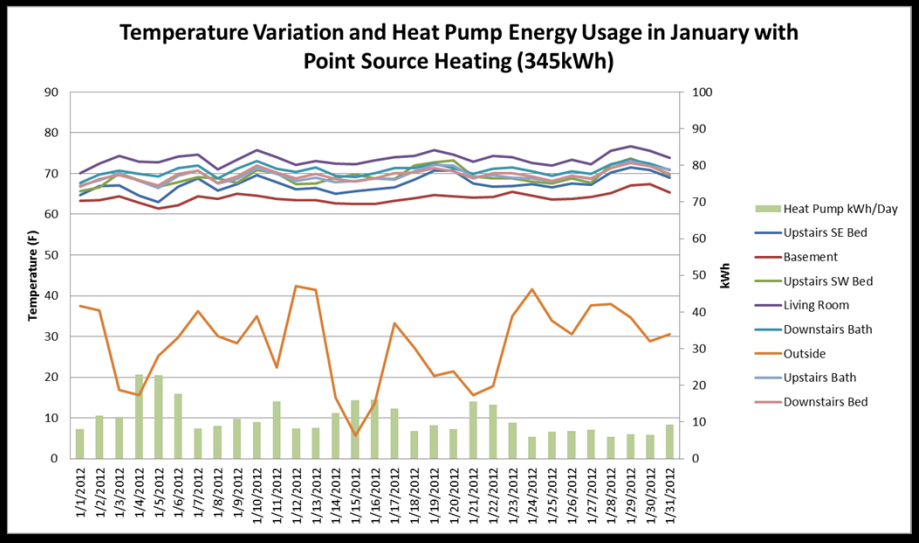
Heating Energy Needed to Meet Comfort



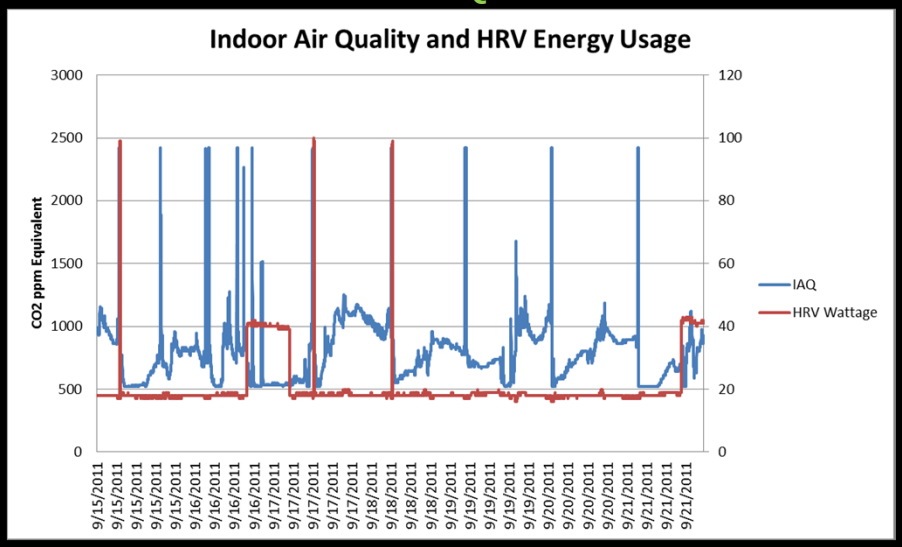
Heating Energy Needed to Meet Comfort



Heating Energy Needed to Meet



IAQ



HRV Energy to Meet IAQ Needs

IAQ

The levels of CO2 in the air and potential health problems are:

250 - 350 ppm – background (normal) outdoor air level

350- 1,000 ppm - typical level found in occupied spaces with good air exchange.

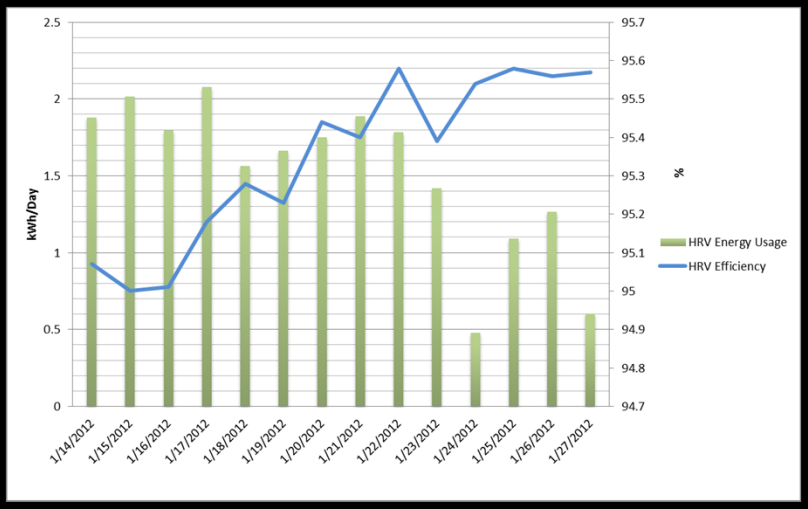
1,000 – 2,000 ppm - level associated with complaints of drowsiness and poor air.

2,000 – 5,000 ppm – level associated with headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.

>5,000 ppm – Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma and even death.

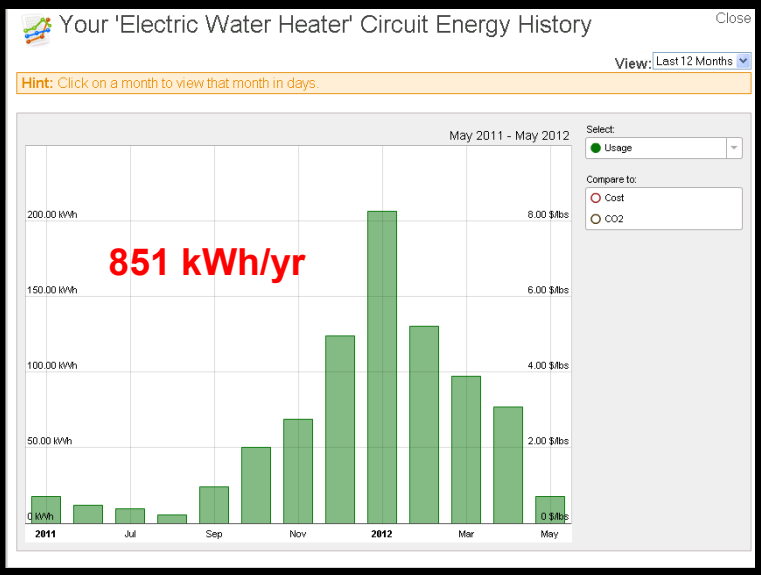
Wisconsin's Department of Health

IAQ



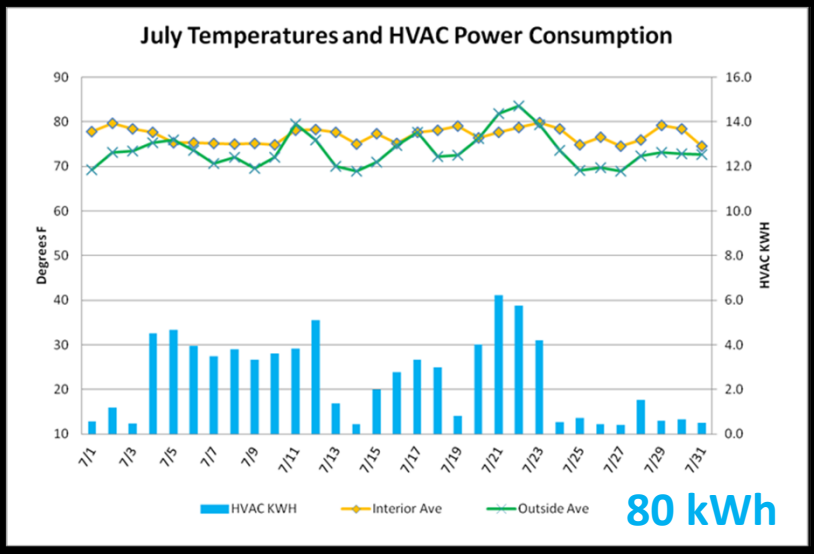
HRV Efficiency & Energy Use

DHW



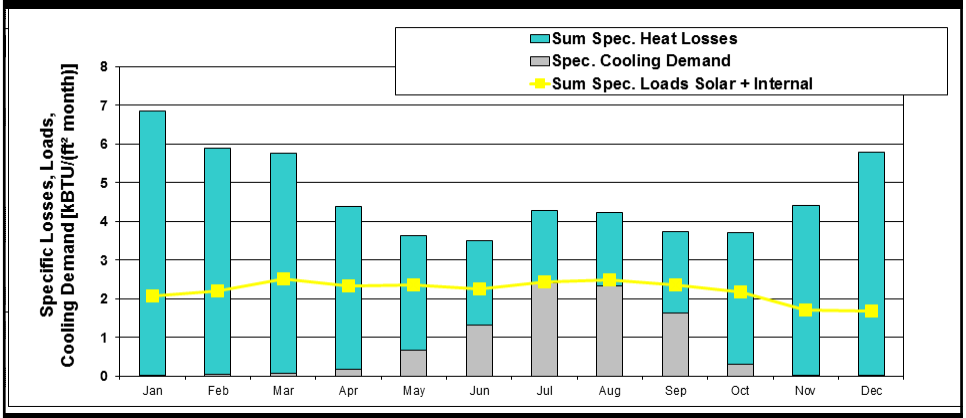
Sunward Solar Thermal System

Cooling Season



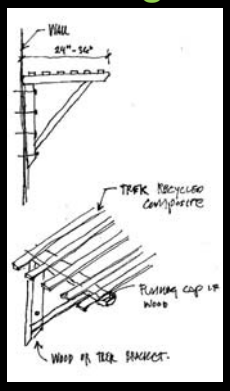
Cooling Energy Needed to Meet

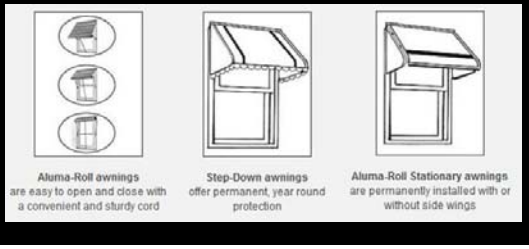
Cooling Season



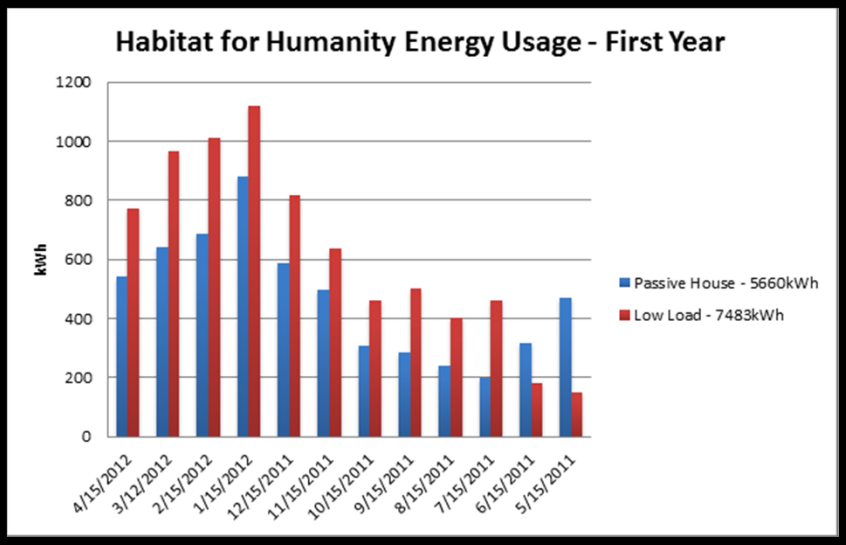
PHPP Predicted Cooling Demand

Passive Houses need Shading

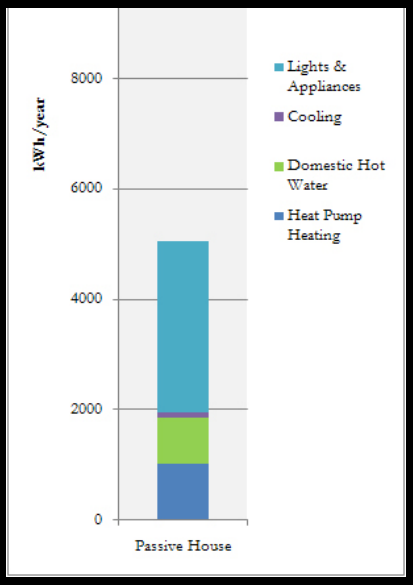




Total Energy

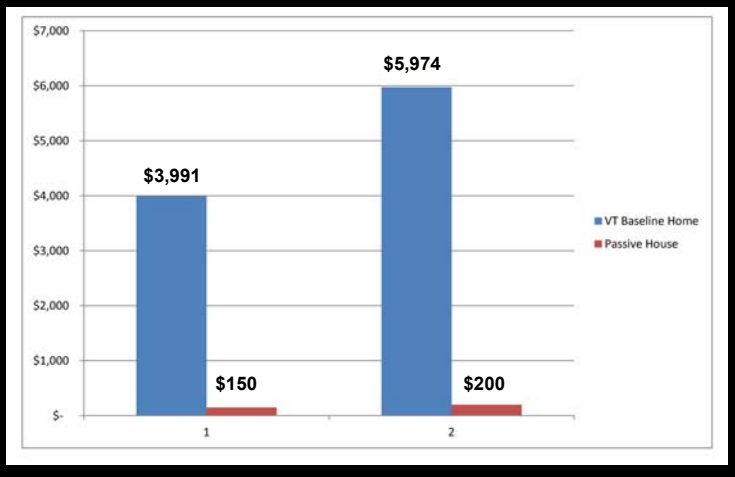


Total Energy



Comparison of Annual Heating Costs

VT Baseline* : Passive House



Estimated monthly energy costs
$3.34/gal; elec $.15/kWh

Estimated monthly energy costs
$5/gal; elec $.20/kWh

*VT Baseline: VEIC Study of 300 new construction houses – Estimated heating costs based on REMRate models

Comparison of **Total Costs**

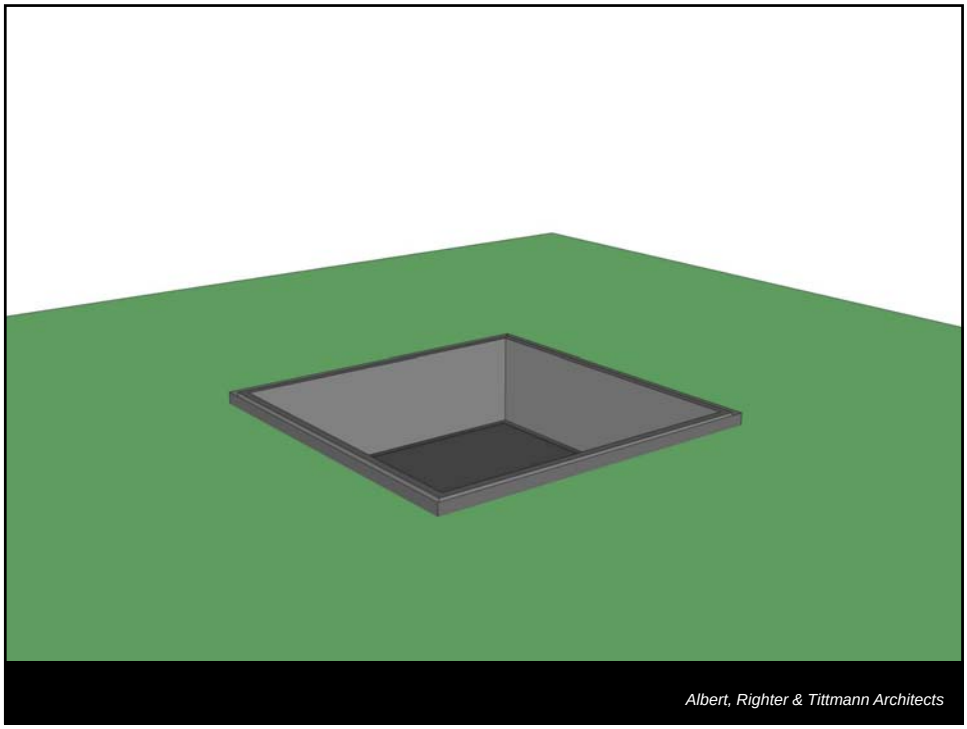
VT Baseline* : Passive House

	VT Baseline Home	Passive House
Total Cost of Home (Includes $200k for Land and Site Work)	**$375,000**	**$390,000**
Mortgage/month 30 year fixed @ 5%	$2,013	$2,093
Insurance	$50	$50
Property Taxes	$500	$500
Estimated monthly energy costs @ $3.34/gal; elec $.15/kWh	$438	$42
Total Costs/month @ $3/gal; elec $.14/kWh	**$3,001**	**$2,685**
Estimated monthly energy costs @ $5/gal; elec $.20/kWh	$638	$56
Total Costs/month @ $5/gal; elec $.20/kWh	**$3,201**	**$2,699**

Passive House yearly savings @ $3.24/gal; elec $.15/kWh over energy code home =	$3,792
Passive House yearly savings @ $5/gal; elec $.20/kWh over energy code home =	$6,024

*VT Baseline: VEIC Study of 300 new construction houses – Estimated heating costs based on REMRate Models. Models assume 4400 kWh for DHW and 4000 kWh for plugs

MODULAR CONSTRUCTION



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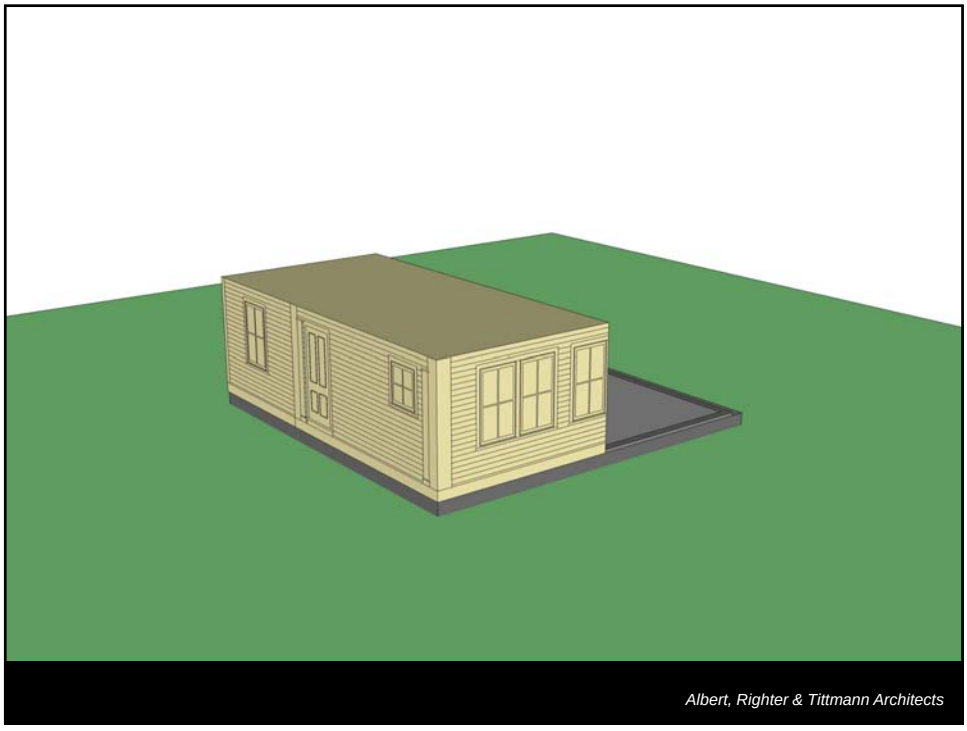

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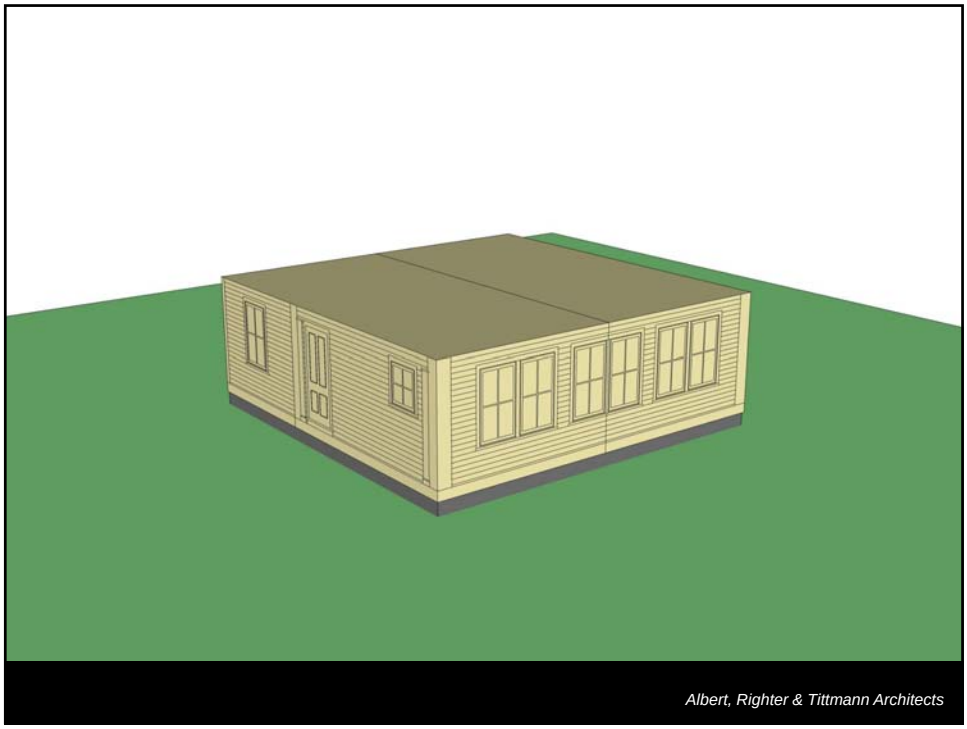

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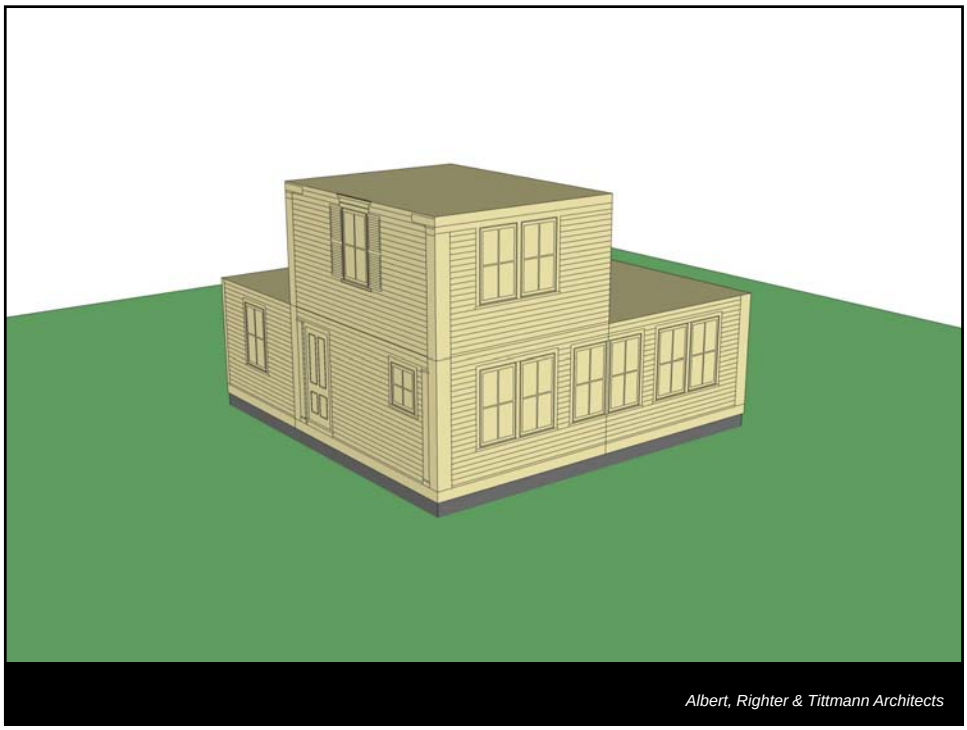

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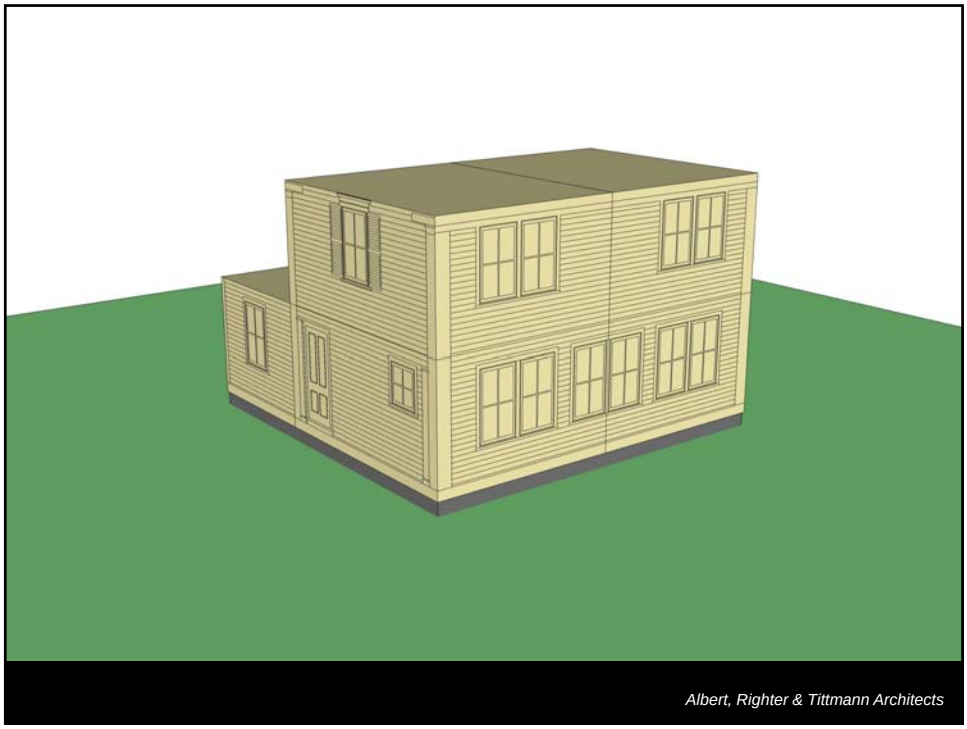

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Beginning of floor system-open web joists, LVL to reduce columns in basement

4”Foam blocking on outside perimeter of floors – open web joists – urethane adhesive on floors

EPDM gasket on floors.

EPDM gasket at floor and wall intersections

Spraying the foam seal - attaches the sheetrock to framing and makes air-tight assembly

Sheetrock air-sealed to framing

Lifting wall section off framing table

Assembled walls on floor for ½ of 1st floor

Insulated headers – built load specific

Full sheetrock air-seal behind tub

Foam sprayed on sheetrock joints at tub to complete air-seal

OVE framing

(partial double plate is temporary for lifting)

20” raised Heel folding truss w/ EPDM gasket between walls and ceiling

13 3/8” window buck
clapboard drainage under window

Installed dense pack cellulose

Air seal around plumbing vents

Radon vent and ERV ducts

Silicone sealing of wires penetrating exterior insulation

Exterior insulation details

Air sealing of wall sheathing

Wide strapping on corners

Folded shed roof

Eave framing on shed roof

Front door area

8.17.2010

10 working days

On the launch pad Claremont, NH
6:30 AM 9.10.2010

Section

Foundation and wall insulation detail

Coming in for landing

Charlotte, VT
1:30 PM 9.10.2010

Habitat for Humanity Passive House

“Heating System”
$30 for January, average temp 72

Habitat for Humanity Passive House

Habitat for Humanity Passive House

Habitat for Humanity Passive House

Habitat for Humanity Passive House

Philip Jensen-Carter

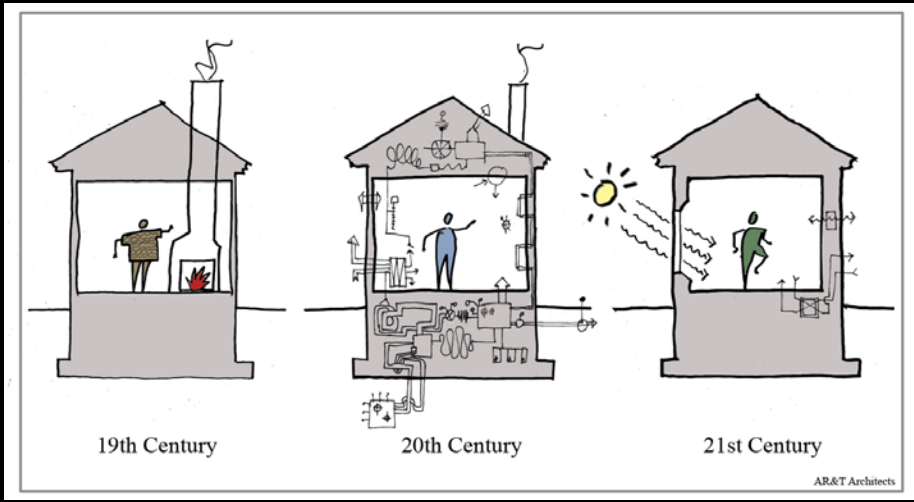
Habitat for Humanity Passive House

Philip Jensen-Carter

Habitat for Humanity Passive House

Philip Jensen-Carter

Moving Towards Simplicity



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Resources

Philip Jensen-Carter

- Passipedia: www.passipedia.passiv.de
- Passivhaus Institute Germany: www.passiv.de
- PHIUS: www.passivehouse.us

J.B. Clancy, AIA
Albert, Righter & Tittman Architects, Inc.

Submit a question to the moderator via the Chat box. They will be answered as time allows.

Stephen Schreiber FAIA
Professor and Architecture+Design Program Director
Department of Art, Architecture, and Art History
University of Massachusetts Amherst
Moderator

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Thank you for joining us!

This concludes the AIA/CES Course #H12005.

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