PASSIVE HOUSE PRINCIPLES

1. SOLAR ORIENTATION
   - Detailed local weather & solar data used to evaluate orientation,
     shading & window placement to take advantage of solar gains in the
     winter & minimize them in the summer

2. CONTINUOUS HIGH R-VALUE INSULATION & ELIMINATE
   THERMAL BRIDGING
   - Min. R40 to R50 walls & ceilings (2015 IECC calls for R20, R30)
   - Reduce Heat Loss (winter)
   - Reduce Heat Gain (summer)
   - Comfortable interior surface temps
   - Avoid penetration of insulation with conductive materials to reduce
     heat loss & prevent damage from condensation/mold

3. AIRTIGHTNESS
   - Continuous air barrier via smart membranes
   - Max. 0.6 air changes per hour @ 50 pa (2015 IECC calls for 3ach)
   - Reduce possibility of moisture damage to structure
   - Reduce heat loss (winter) & reduce humidity (summer)
   - Enhanced performance of insulation layer
   - Eliminate drafts

4. HIGH PERFORMANCE WINDOWS
   - R7-R8 triple pane thermally broken window assemblies oriented
     properly add more energy to home than they lose
   - Triple gasketing prevents air leaks
   - Eliminate need for perimeter heat
   - Comfortable interior surface temps & no drafts

5. BALANCED VENTILATION W/ HEAT RECOVERY
   VENTILATION (HRV/ERV)
   - Clean, filtered air continuously supplied to sleeping and living
     areas, exhausted from kitchens & bathrooms
   - Heat and moisture (with ERV) is transferred between stale inside
     air and fresh outdoor air in winter and summer w/ minimum 75% efficiency

Diagram Source: http://www.passivehouseacademy.com/
Thermal Transmittance (U-value)

What does this mean?

**BTU/(hr*ft²·F)**

... in one **hour** ....

... for one **square foot** of surface area ....

... for every **degree** of temp. difference between faces.

The **U-Value** is also called the HEAT TRANSFER COEFFICIENT or CONDUCTANCE of the **whole assembly** (not an individual layer!)
Why < 4.75 kBtu/ft²·yr Heating & Cooling Demand?

- Passive House
- Low-Energy Home

- Reduce size and cost of heating system
- Total Project Cost
- Annual Energy Costs
- Construction Costs
SURFACE AREA TO VOLUME RATIO
PLATONIC SOLIDS
SURFACE AREA TO VOLUME RATIO
MORE COMPLEX FORMS
CLAUDE-NICOLAS LEDOUX
GARDENER HOUSE PROJECT FOR THE IDEAL CITY OF CHAUX, 1784
Favourable compactness ratio
$A / V \leq 0.7 \text{ m}^2/\text{m}^3$
ARTIST'S STUDIO
ORIENT, NY

R VALUES
Wall  49
Roof  76
Floor  56

A  =  1,080 ft²
(plan area)

V  =  15,175 ft³
(volume)

SA  =  4,320 ft²
(exterior surface area)

GUEST HOUSE
SHELTER ISLAND, NY

R VALUES
Wall  38
Roof  62
Floor  62

A  =  1,750 ft²
(plan area)

V  =  19,875 ft³
(volume)

SA  =  5,180 ft²
(exterior surface area)

WETLANDS HOUSE
ORIENT, NY

R VALUES
Wall  46
Roof  57
Floor  74/42

A  =  3,360 ft²
(plan area)

V  =  41,040 ft³
(volume)

SA  =  10,440 ft²
(exterior surface area)

ARTISTS RESIDENCE
GUILFORD, VT

R VALUES
Wall  52
Roof  145
Floor  40

A  =  4,000 ft²
(plan area)

V  =  64,660 ft³
(volume)

SA  =  14,350 ft²
(exterior surface area)
ARTIST’S RESIDENCE
GUILFORD, VT

R VALUES
Wall  52
Roof  145
Floor 40

A    = 4,000 ft²
(plan area)

V    = 64,660 ft³
(volume)

SA   = 14,350 ft²
(exterioir surface area)

SA/V = .22
(compactness ratio)

CUBE = .15
(comparable area)
VPL / GUILFORD SOUND ARTS CAMPUS // ENERGY SYSTEM SCHEMATIC

10.5 cords X +/- 20 trees = 1300 cubic feet

LEGEND

= ROVANCO RHINOFLEX 1.5” INSULATED PEX 4.45” SHELL
HX = HEAT EXCHANGER
MB = MUNCHKIN BOILER

HEAT PUMPS
AIR COOL

GEOTHERMAL BORE HOLES

PV PANELS

STUDIO

RADIANT FLOORING

HEATING PLANT

TARM SOLO 60 WOOD GASSIFICATION BOILER

MILK TANK THERMAL STORAGE

HX

MAIN RESIDENCE

PV PANELS

RADIANT FLOORING

SOLAR HOT WATER PREHEAT

L.P.

DHW

400 ft

50 ft

400 ft

50 ft

10.5 cords X +/- 20 trees = 1300 cubic feet
PASSIVE HOUSE - BEYOND SINGLE FAMILY: Meeting the 2030 Challenge

Vermont ACX, Champlain College, Burlington
ARTIST RESIDENCE 2
LONGITUDINAL SECTION // ENTRY, KITCHEN + PORCH
CROSS SECTION // CLERESTORY + BEDROOM
DETAIL SECTION // CLERESTORY N-S

BOTTOM OF LVL
708'-4"

TOP OF 2X6 SERVICE WALL FRAMING
703'-0" 1/2"
HIGH POINT OF PLANTING MEDIUM
702'-7" 1/2"

CURVED PLASTER FINISH
4'-11 1/2"

TAPERED MEMBRANE DECK
ELEVATION VARIES

TOP OF STRUCTURAL DECK
599'-6"

WOOD TOP TRIM

WOOD SILL

FINISH SILL TO TOP OF ARC
Z-10 1/2"
Z-10 1/2"

TOP OF TJI WALL FRAMING
703'-0" 1/2"

WOOD BLOCKING
RIGID XPS INSULATION

6" EXPANDED SHALE PLANTING MEDIUM
DRAINAGE MAT

RIGID INSULATION (6) X 3" SHEETS XPS

J-DRAIN DRAINAGE MAT

COLD FLUID APPLIED FLEECE REINFORCED WATERPROOF MEMBRANE (SOPREMA ALSAN)
ADVANTECH SHEATHING (2x)
TAPERED SLEEPER SPACE
TAPPED SEAM AIR BARRIER
(2) LAYERS 3/4" PLYWOOD
9 1/4" CELLULOSE INSULATION

R-VALUE TOTAL

1/4" BENT STEEL PLATE FASIA
SLOPE 1/4" PER FOOT
TOP OF ROUGH OPENING
706'-5" 1/2"
B.O. LVL
706'-4"

CLEATED BRAKE-FORMED METAL CAP
T.O. PARAPET
706'-6" 1/2"

UNIT SIZE 3'-2 1/2"
R.O. 39 1/2" = 3'-3 1/2"

T.O. BLOCKING R.O. FOR WINDOW
706'-2"

FLOOR ASSEMBLY R-VALUE CALCULATIONS

25 PER INCH
1 PER

5 PER INCH
1 PER

1 PER

N/A

N/A

N/A

N/A

R VALUE TOTAL

13.47
R-18.42
PASSIVE HOUSE - BEYOND SINGLE FAMILY:
Meeting the 2030 Challenge

Vermont ACX, Champlain College, Burlington
PASSIVE HOUSE - BEYOND SINGLE FAMILY: Meeting the 2030 Challenge

Vermont ACX, Champlain College, Burlington
PASSIVE HOUSE - BEYOND SINGLE FAMILY:
Meeting the 2030 Challenge

Vermont ACX, Champlain College, Burlington
VPL / GUILFORD SOUND ARTS CAMPUS // PROPORTIONAL ENERGY USE

- **HOT WATER**
- **HEATING/COOKING**
- **AIR CONDITIONING**
- **EQUIPMENT, PLUG AND LIGHTING LOADS**

### ARTISTS RESIDENCE 1
- **2,542 SF**
- **65%**
- **17%**
- **18%**

### ARTISTS RESIDENCE 2
- **4,280 SF**
- **38%**
- **33%**
- **21%**

### RECORDING STUDIO
- **5,065 SF**
- **34%**
- **23%**
- **41%**

### MAIN RESIDENCE
- **6,104 SF**
- **45%**
- **23%**
- **32%**

### AVERAGE RESIDENTIAL, VT
- **US ENERGY INFORMATION ADMINISTRATION**
- **6,828 kwh**
- **31%**
- **20%**
- **8%**
- **41% +/- 650 gallons oil**

### Energy Breakdowns
- **65%**
  - **38,160 kwh**
  - **41%**
  - **23%**
  - **2%**

- **41% +/- 650 gallons oil**

- **0%**
  - **7,440 kwh**
  - **32%**
  - **45%**

- **0%**
  - **3,458 kwh**
  - **9%**
  - **38%**

- **0%**
  - **5,065 kwh**
  - **23%**
  - **34%**

- **0%**
  - **6,104 kwh**
  - **23%**
  - **45%**

**Legend:**
- **= EQUIPMENT, PLUG AND LIGHTING LOADS**
- **= AIR CONDITIONING**
- **= HEATING/COOKING**
- **= HOT WATER**
VPL / GUILFORD SOUND ARTS CAMPUS // ABSOLUTE ENERGY USE

- HOT WATER
- HEATING/COOKING
- AIR CONDITIONING
- EQUIPMENT, PLUG AND LIGHTING LOADS

(HISTORICAL)
ARTISTS RESIDENCE 1
10,236,000 BTU / yr

(RECORDING STUDIO)
282,201,920 BTU / yr

(NEW)
ARTISTS RESIDENCE 2
35,078,000 BTU / yr

MAIN RESIDENCE
177,385,280 BTU / yr

AVERAGE RESIDENTIAL, VT
113,322,136 BTU / yr

U.S. Average
127,243,096 btu / yr

41%
34%
23%

32%
45%
23%
0%

41%
**VPL / GUILFORD SOUND ARTS CAMPUS // PROPORTIONAL ENERGY/ SITE SOURCED ENERGY USE**

- **ARTISTS RESIDENCE 1**
  - 2,542 SF
  - 65% HOT WATER
  - 18% AIR CONDITIONING
  - 17% HEATING/COOKING
  - 0% EQUIPMENT, PLUG AND LIGHTING LOADS

- **ARTISTS RESIDENCE 2**
  - 4,280 SF
  - 38% HOT WATER
  - 33% AIR CONDITIONING
  - 21% HEATING/COOKING
  - 9% EQUIPMENT, PLUG AND LIGHTING LOADS

- **RECORDING STUDIO**
  - 5,065 SF
  - 41% HOT WATER
  - 23% AIR CONDITIONING
  - 34% HEATING/COOKING
  - 2% EQUIPMENT, PLUG AND LIGHTING LOADS

- **MAIN RESIDENCE**
  - 6,104 SF
  - 23% HOT WATER
  - 45% AIR CONDITIONING
  - 32% HEATING/COOKING
  - 0% EQUIPMENT, PLUG AND LIGHTING LOADS

**Average Residential, VT**
- US ENERGY INFORMATION ADMINISTRATION
  - 31% HOT WATER
  - 41% AIR CONDITIONING
  - 8% HEATING/COOKING
  - 20% EQUIPMENT, PLUG AND LIGHTING LOADS

**Energy Use Breakdown**
- **18%, 17%, 0%**
- **23%, 34%, 2%**
- **41%, 38,160 kwh, 16,200 kwh PV panels**
- **22,750,000 btu/wood, 10,950 kwh PV Panels**
- **7,440 kwh, 5.5 cords black, locust, oak, maple**
- **129,250,000 btu/wood, 5.5 cords black, locust, oak, maple**
- **31%, 6,828 kwh, +/- 650 gallons oil**
- **41%, 38,160 kwh, ground source heat pump**
- **32%, 7,440 kwh, solar hot water preheat**
- **31%, 6,828 kwh, +/- 650 gallons oil**
- **31%, 6,828 kwh, +/- 650 gallons oil**

**GUILFORD SOUND ARTS CAMPUS**

- **5.5 cords black, locust, oak, maple**
- **129,250,000 btu/wood**
- **16,200 kwh PV panels**
- **22,750,000 btu/wood**
- **7,440 kwh**
- **10,950 kwh PV Panels**
- **5.5 cords black, locust, oak, maple**
- **129,250,000 btu/wood**
- **7,440 kwh**
- **10,950 kwh PV Panels**
- **5.5 cords black, locust, oak, maple**

**Energy Sources**
- **PV panels**
- **solar hot water preheat**
- **5.5 cords black, locust, oak, maple**
- **129,250,000 btu/wood**
- **16,200 kwh PV panels**
- **22,750,000 btu/wood**
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**Proportional Energy Use**

- **VPL / GUILFORD SOUND ARTS CAMPUS // PROPORTIONAL ENERGY/ SITE SOURCED ENERGY USE**

- **5.5 cords black, locust, oak, maple**
- **129,250,000 btu/wood**
- **16,200 kwh PV panels**
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**Site Sourced Energy Use**

- **VPL / GUILFORD SOUND ARTS CAMPUS // PROPORTIONAL ENERGY/ SITE SOURCED ENERGY USE**

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**Energy Sources**

- **PV panels**
- **solar hot water preheat**
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**Proportional Energy Use**

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WETLANDS HOUSE
ORIENT, NY

R VALUES
Wall  46
Roof  57
Floor 74/42

\[ A = 3,360 \text{ ft}^2 \]
(plan area)

\[ V = 41,040 \text{ ft}^3 \]
(volume)

\[ SA = 10,440 \text{ ft}^2 \]
(exterior surface area)

\[ \frac{SA}{V} = 0.25 \]
(compactness ratio)

\[ CUBE = 0.17 \]
(comparable area)
DETAIL @ LIVING ROOM WINDOW

1 1/2" = 1'0"

GALV. PTD. W-BEAM, SEE S-103

RIGID INSULATION

314"

912"

PTD. STL POST BEYOND 1/2" PLYWD SHEATHING

ROOFING MEMBRANE

WRB RUNS CONTINUOUSLY BEHIND STEEL, INSTALL PRIOR TO ROOF FRAMING

CEMENT BOARD

METAL FLASHING

AIR BARRIER

WINDOW FRAME

4" AIR BARRIER

BLOCKING FOR ROLLER BLINDS

J-BOX

LIGHT FIXTURE TRANSFORMER

4"X12" DUCT

LIGHT FIXTURE STEM

10"
TESCON VANA TAPE TO CREATE AIR BARRIER @ SHEATHING