
- Part I -
50,000 new and renovated residential, commercial and institutional buildings have been built to the rigorous Passive House energy performance standard in the last twenty years worldwide. Super-insulation, high-performance windows, airtight construction, heat-recovery ventilation, and high-efficiency lighting, appliances, and equipment are key measures that combine to drastically reduce energy use and provide healthy, comfortable spaces. This presentation will provide an overview on the Passive House standard and its key principles.
Learning Objectives

- Participants will:
  - examine how conventional approaches to architectural design can contribute to excess energy use.
  - contrast standard code-level building assemblies with high-performance assemblies, and calculate their contributions to heating demands.
  - acquire a new understanding of heat flow dynamics in buildings and be challenged to apply this knowledge to optimize energy performance of new projects.
  - discuss the benefits of airtight envelope construction for structural systems durability and energy savings.
A very green home:

- “We installed a 2.5 KWh PV system, solar HW, tankless backup, radiant floor heating with 90% efficient boiler, evaporative cooler, top-quality low-E windows, recycled Douglas Fir trim, cabinets & doors, FSC Certified cherry for kitchen cabinets, SIP panels on the addition, Trex decking, Low VOC stains, radiant barrier, and low flow fixtures.”
“Sustainable in the Sierras”

- Yearly propane use:
  - 1500 gallons
  - = $4500

- Still green?

- “Efficiency must be first in the green building movement!”
  - - Ed Welch, homeowner

Why do buildings need energy?

- Space heating
- Cooling
- Ventilation
- Water heating
- Lighting
- Appliances
- Plug loads

Typical Building
- Passive Gains
- Total Heating Demand

Passive House Building
- Passive Gains
- Total Heating Demand

80-90% heat demand reduction
### Passive + House (Passivhaus) =

- **Passive**: passive heat gain from solar radiation, cooking, breathing, use of appliances etc. provides for majority of space heating demand (rather than large, active mechanical systems)

- **House**: Passive House (PH) standard was initially applied & tested on homes, but numerous schools, office buildings, & other non-residential buildings have now been built to standard
Passive House Building Standard

- A rigorous, voluntary building energy standard focusing on a high-performance envelope and minimized heating and cooling system
- Developed in Germany in early 1990’s by Drs. Wolfgang Feist & Bo Adamson—inspired by superinsulation & energy efficiency from the 1970’s
Passive House Concept

- First minimize losses:
  - Superinsulated* & airtight envelope with minimal thermal bridges
  - Optimized windows
  - Heat recovery ventilation**
- And optimize solar gain:
  - When possible!
- Finally, choose high-efficiency equipment, appliances, lighting, etc.

* what is “supersinsulated”?
** does this always make sense?
High Performance Logic

- **Step 1. Minimize energy demand**
  - Heating (ie super insulation, central core plumbing)
  - Cooling (ie shade trees, Cool Roof, radiant barrier)
  - Lighting (ie daylighting)

- **Step 2. Optimize energy use**
  - Tight ductwork
  - High SEER A/C & furnace AFUE
  - Energy-efficient lighting & appliances

- **Step 3. Incorporate renewable energy**
Greenhouse vs. Thermos

- Passive solar buildings:
  - Excessive glazing
    - Too hot during the day
    - Too cold at night
    - Lots of thermal mass needed
    - Limited to special sites

- Passive House buildings:
  - Optimized glazing + superinsulation
    - Consistent comfort
    - Architectural flexibility
    - Works anywhere!

renewablepowersolarenergy.com
passivhausprojekte.de
Habitat for Humanity – Dominick Tringali Architects
Passive House Requirements

- Envelope Efficiency (annual site energy)
  - Space heating demand: \( \leq 4.75 \text{ kBtu/sq.ft (15 kWh/m}^2) \)
    - Alternate: Peak heat load \( \leq 3.17 \text{ Btu/hr} \)
  - Space cooling demand: \( \leq 4.75 \text{ kBtu/sq.ft (15 kWh/m}^2) \)
  - Air tightness: \( \leq 0.60 \text{ ACH}_{50} \) *(verified by blower door)*

- All Energy (annual source energy)
  - Total energy use: \( \leq 38.0 \text{ kBtu/sq.ft (120 kWh/m}^2) \)

**Definitions**
- demand: what’s left after accounting for passive gains & heat losses
- use: what it takes to meet the heating or cooling demand, factoring in equipment efficiencies & distribution losses

Blower door test for air tightness@ CLAM Blue2 – photo by Terry Nordbye
Site vs. Source Energy

- **Site**: energy used at the actual building (i.e. the meter)
- **Source (or primary)**: total energy used in delivering energy to building from power plant

100kWh at power plant

provides only 33kWh at home

Mining x Transportation x Refinement x **Generation** x **Transmission** x **Transform** x End Use
Pathway to Net Zero

- Now that energy requirements have been minimized by building to Passive House, achieving net zero is realistically—and practically—attainable.
Energy Use by Standard

<table>
<thead>
<tr>
<th>Standard</th>
<th>% New Buildings:</th>
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<td>Passive house</td>
<td>U.S.</td>
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<td>Energy Star</td>
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<td>75%</td>
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<td>IECC 2009 International Energy Conservation Code</td>
<td>17%</td>
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<td>8%</td>
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<td>Old buildings</td>
<td>80%</td>
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Average energy use (kWh/m²/yr)
WHY PASSIVE HOUSE?
Why: Energy Savings

- Reduces heating and cooling demand by 80-90%
- Reduces total energy demand by 60-80%

Hill Passive House, Carmel-by-the-Sea
Why: Energy Independence

- Now energy efficient = Always energy efficient
- Energy you don’t need has unlimited availability!
- Literally insulate buildings from rising & dramatically fluctuating energy costs
- Avoid political battles over limited resources
Why: Climate Independence

- Literally insulate buildings from climate, weather... and even political crises
- What if power goes down, fuel runs out?
  - Wind & ice storms
  - Hurricanes & tornadoes
  - Blizzards
  - Earthquakes
  - Wars...
Why: Comfort & Convenience

- Even temperatures
- Minimal air leakage & drafts
- No dust & insects
- Quiet (what street noise?)
- Durable assemblies
Why: Health

- Continuous fresh air
- Minimized condensation & mold
- Less dust & pollen
- Less asthma & allergies
Why: Smart Business

- Excellent PR
- Market edge
- Social equity
- Incentives
- Zero energy

- The “right thing to do”.

Last month, Serious Materials supported Habitat for Humanity, a non-profit organization that invites people of all backgrounds, races and religions to build houses together in partnership with families in need. Serious Materials extended support in two ways: with a sizable materials donation of Serious.Windows from our manufacturing facility in Longmont, Colorado, as well as with some hands-on activity from employees at Serious Materials’ corporate headquarters in Sunnyvale, California.
Fine Homebuilding Best New Home!

The Builder’s Journey

How I came to build FHB’s best new home of the year, and what it taught me

By Rob Beedle

Design requirements can sometimes seem like an obstacle to the trade. I have spent 25 years in construction thinking that building can be more...than a trade. Being an architect and organizational architect of projects in addition to the mechanical requirements of the building itself, we have to think about what we are trying to achieve in the building itself. I have always been fascinated by the sustainability and the idea of the house. I have always been fascinated by the idea of the house as a sustainable building. I have always been fascinated by the idea of the house as a sustainable building. I have always been fascinated by the idea of the house as a sustainable building. I have always been fascinated by the idea of the house as a sustainable building.
BUT, PASSIVE HOUSES ARE SO UGLY
Volksschule Montessori – Aufkirchen
WEISSENSEER Holzsystembau

Günter Lang, IG Passivhaus Österreich
St. Gerold communal centrum
MesseCenter exhibition hall + offices
Multifamily Tevesstraße - Frankfurt

Heating demand before renovation: 290 kWh/m²/yr
Heating demand after renovation: 17 kWh/m²/yr

94% reduction
Chemnitz Passivhouse - Saxony

Madreiter Architects
Passivhausscheibe Salzkammergut

Günter Lang, IG Passivhaus Österreich
Ridge Flats- Philadelphia
Ruby House- Salt Lake City
Balance Project- Santa Fe

Mixed-use infill condominium- Jonah Stanford, NEEDBASED
Carmel-by-the-Sea Passive House
MAKING IT HAPPEN
Passive House Process: Design

- Assemble *motivated* team
- Set visions and goals!
- Develop schematic design
- Perform PHPP iterations
- Finalize design
- Submit to a Passive House Certifier for pre-certification (encouraged, not required, if certification being sought)
Passive House Planning Package (PHPP)

Heat Loss Components:
- Property line walls: 38%
- Windows: 15%
- Exterior walls: 5%
- Ground walls: 5%
- Roof: 5%
- Ventilation & air infiltration: 3%
- Slab: 3%
- Tempered walls: 2%
- Raised floors, tempered: 1%
- Raised floors, ambient: 1%

Custom PHPP Dashboard:
Kaplan Thompson Architects

VENTILATION
- EXHAUST ONLY
- HRV OR ERV
- 90% EFFICIENT ZEHNDER COMFORT 350 (EST $7,000 INSTALLED)

AIR TIGHTNESS
- 0.60 ACH50 PASSIVHAUS RENOVATION #

R-VALUES
- WALLS
- 40
- ROOF
- 80
- SUSPENDED FLOORS
- 50
- BASEMENT WALLS
- 30
- SLABS
- 30

R-VALUES
- TYPE: WALLS: FROM DASHBOARD
- TYPE: ROOF: FROM DASHBOARD
- TYPE: SUSPENDED FLOORS: FROM DASHBOARD
- TYPE: BASEMENT WALLS: FROM DASHBOARD
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- TYPE: SLABS: FROM DASHBOARD

WSNODG & DORS
- WINDOWS
- SHGC:
- GLASS 9.09 U-VALUE: 0.11
- FRAME 5.88 U-VALUE: 0.17
- TOTAL 6.69 U-VALUE: 0.15
- SOLID DOORS
- 9.00 U-VALUE: 0.11
- GLAZED DOORS
- GLASS SHGC:
- GLASS 9.09 U-VALUE: 0.11
- FRAME 5.88 U-VALUE: 0.17
- TOTAL 6.69 U-VALUE: 0.15

GLAZING % OF TFA
- SOUTH: 14%
- NORTH: 10%
- EAST: 5%
- WEST: 1%

PRIMARY ENERGY
- 35.21 MWH/ST/YEAR
- SITE ENERGY
- 5.73 MWH/ST/Year
- PV TO BE NET-ZERO
- 11.21 MWh

ANNUAL HEATING
- 4.40 MWH/ST/Year
- ANNUAL COOLING
- WINDOW ENERGY
- 9,174 MWh/Year

HEAT GAINS
- SOLAR GAINS: 59%
- PEOPLE, LIGHTS & APPLIANCES: 16%
- MECHANICAL HEATING: 24%

HEAT LOSS
- BUILDINGS SHELL: 50%
- WINDOWS: 45%
- VENTILATION & AIR LEAKS: 5%

SHELL LOSSES
- WALLS: 59%
- ROOF: 21%
- SUSPENDED FLOORS: 13%
- BASEMENT WALLS & SLAB: 8%

SCHEME A: Poly-Iso over Stud
- Sample Project
- TFA: 2,600 US SF
- BTU LOCATION:
- GRATLAND, ME
Successful Collaboration

- Identify project goals & incorporate into design docs.
- Assemble quality team—and educate them.
- Identify and assign “gray area” roles. WHO is accountable for WHAT?
- Who needs to be consulted when?
- How will success be measured or verified?
Passive House Process: Build

- Implement
  - Contractor education
  - Verification & quality control
  - Documentation
  - Air tightness testing
  - Systems commissioning
- Submit required documentation to Passive House Certifier for verification
Passive House Process: Enjoy!

- Ongoing performance monitoring not req’d for Certified Passive House Projects
- Those that have been monitored show heating performance closely matches energy models
- Essential for optimizing operational efficiency:
  - Systems commissioning
  - Homeowner & tenant education
  - Facilities management education
  - Performance monitoring
We can help you push the envelope:

- Energy modeling & optimization studies
- High-performance envelope advising
- HVAC systems advising
- Green plan review & rating services
- Technical training & coaching
- Incentives program facilitation

Contact:

Katy Hollbacher, P.E., katy@beyondefficiency.us

WY: (307) 200-7236
CA: (415) 236-1333
Katy Hollbacher, P.E. | beyondefficiency.us

- Part II -
Course Description

- This presentation will discuss the fundamental science and energy modeling processes of the Passive House standard and provide steps for how to apply these principles to your projects.
AIA Learning Objectives

- Participants will:
  - discuss the "build tight, ventilate right" approach to assuring optimal air quality.
  - compare various window designs and product specifications and demonstrate the significant impacts these choices can have on a building's energy performance.
  - contrast a variety of energy-related metrics such as: average heating and cooling demands, peak heating and cooling loads, and total heating and cooling energy usage.
  - reexamine conventional approaches to providing mechanical heating and cooling for buildings.
HIGH-PERFORMANCE DESIGN
High Performance Logic

- **Step 1. Minimize energy demand**
  - Heating (ie super insulation, central core plumbing)
  - Cooling (ie shade trees, Cool Roof, radiant barrier)
  - Lighting (ie daylighting)

- **Step 2. Optimize energy use**
  - Tight ductwork
  - High SEER A/C & furnace AFUE
  - Energy-efficient lighting & appliances

- **Step 3. Incorporate renewable energy**
Step 1. Minimize heat losses

- Understand your “heat loss pie”, and then...
- Go for the biggest pieces!
  - walls
  - windows
  - air infiltration

QUIZ:) more heat loss through 2x6 walls or 2x10 roof?
Essential design techniques

- Compact, efficient shapes
- Lots of wall insulation
- Minimized thermal bridging
- Properly placed & shaded windows
- High-performance windows & doors
- Extreme\(^*\) air tightness detailing

\begin{itemize}
  \item Not really, but .60 sounds crazy!
  \item (just try it—you can do it)
\end{itemize}
R-value in real numbers

- What is a building assembly’s capacity to resist heat flow?
- **Newton’s Law of Cooling**: \( Q = u \cdot A \cdot \Delta T \)
  - Heat flow = heat transfer coefficient \((u)\) • surface area • difference in temperature between each side
  - Result: energy rate (Btu/hr)
  - Good calculation for uniform areas
- **Energy modeling demystified**
  - \( R = \frac{1}{u} \) (units: \( \text{hr} \cdot \text{ft}^2 \cdot ^\circ \text{F} / \text{Btu} \))
  - Simple, basic math!
  - Twice the R-value⇒ ________?
  - Half the area⇒ ________?

\[ \begin{array}{c}
30^\circ \\
70^\circ 
\end{array} \]
Conduction $\rightarrow$ Compactness

- Make building shape more “compact” to minimize amount of exterior wall for every square foot of living space provided
  - $\rightarrow$ save materials
  - $\rightarrow$ minimize construction costs
  - $\rightarrow$ minimize heat losses

- Typical energy code: shape of building irrelevant for determining compliance
Building Shape Compactness

- Minimize envelope surface area to floor area ratio
  - Design compact, efficient shapes
  - Minimize envelope articulations:
    - Foundation jogs
    - Cantilevered floors over ambient air
    - Bay windows

For Sale: $8,250,000
Heating bills = ???
Simplicity = efficiency

- Excerpt from NRDC’s Efficient Wood Use in Residential Construction handbook:
  - “Design simply and elegantly. A great deal of wood and money is wasted on excess, such as unnecessarily complex roofs and applique decoration, instead of being invested in the design of timeless structures whose appeal relies on beautiful proportions and fine craftsmanship.”
Simplicity = durability

- Where does the water go?
- Are you confident with flashing details & installation quality?
Conduction ➔ Thermal Bridging

Mountain View Cohousing: Thermal Analysis of Podium Slab Edge

Prepared for: __________________________
Prepared by: Katy Hollbacher, 4 March 2013

Background
Based on a detailed plan review to identify potential energy- or green-related improvements, I identified various “thermal bridges” of concern, one particular location being at the intersection of the concrete podium slab to the exterior wall of the wood-frame structure above. The podium slab is currently shown to be insulated with 2.5” continuous foil-faced polyiso insulation below the slab, ending in line with the outside plane of the exterior wall above (see A3.1).

I suggested that this condition might result in excessive heat loss along with cold surface temperatures at the perimeter of the slab in the first level conditioned spaces, which could cause moisture condensation as well as thermal discomfort for inhabitants from radiative heat loss.
This thermal bridge: 17% more heat loss than through the 8’ section of insulated wall above.
High R-Value Wall Assemblies

- Single stud wall with cont. exterior insulation
- Double stud wall
- Larsen truss
- I-joist studs
- SIPS panels
- SIPS + interior stud wall
- Curtain walls?

Modified Larsen truss – Robert Riversong
Thorsten Chlupp
Double Stud Wall for Wyoming

1x Reclaimed wood siding (milled tongue and groove)
1/4" Drainage mat
Spray applied weather barrier
1/2" plywood sheathing
2x6 Wood structural stud, Re: Struct.
Provide closed cell spray foam insulation, R-40 Min.
Air space
Blown fiberglass insulation
2x4 Non-structural wood stud, (LSL or Sim.) wall
5/8" GWS

Carney Logan Burke Architects:
typical wall assembly for Jackson Passive House-inspired residence
Staggered vs. In-Line Double Studs

- Consortium for Advanced Residential Buildings study: staggered studs have negligible impact on overall R-values
  - Tip: provide min 1” gap between studs

![Diagram showing effective R-values for walls from THERM analysis.](carb-swa.com)
Typical Curtain Walls

- John Straube, Building Science Corporation:
  - “Sleek appearance but dismal performance by any normal standard. The R-value of the combined spandrel and glazing is less than R-4, and the solar gain is high enough to require air-conditioning on cold sunny winter days.”

Irresponsible design
8 Octavia’s beauty only skin deep

Energy waste = UGLY
WINDOWS
Solar Insolation Worldwide

Hours of sun per day on an optimally tilted surface during the worst month of the year - NREL
Solar Insolation U.S.

Western Mountain Region: SUN! Yours for free!

Hours of sun per day on an optimally tilted surface during the worst month of the year - NREL
Solar Radiation Data

- Insolation = INcoming SOLar radiATION
- Measurements, kBtu/ft²:
  - Horizontal (flat)
  - Vertical (N,S,E,W elev.)

San Francisco climate data from PHPP
Solar Radiation Data

- Insolation = \textbf{INcoming SOLar radiATION}
- Measurements, kBtu/ft²:
  - Horizontal (flat)
  - Vertical (N,S,E,W elev.)
Window Configuration

- Optimize shape & orientation for passive solar gain if appropriate for site
  - Orient longer side along east-west axis
- Look up solar radiation data
  - Majority of glazing on south
  - Less glazing on north
  - *Thoughtful* glazing on east & west
  - Thermal mass or phase change?
The Problem with Passive Solar in JH:
What to do:

- **Frame north- and west-facing views**
  - reduce thermal discomfort from massive areas of cold glass surfaces. add *art!*
  - reduce space heating: north windows lose 4-5x more heat* than they gain over a year
    → prioritize low U-factor glazing

- **Optimize south windows for solar gain**
  - reduce space heating: south windows gain 2-3x more heat* than they lose over a year
    → prioritize high SHGC glazing

* Based on wood-frame, triple-pane, low-E w/ higher south SHGC
Key Window Ratings

- **SHGC**: Solar Heat Gain Coefficient
- **VT**: Visible Light Transmission
- **U-factor**: Heat loss measurement of entire assembly

*the Germans do it differently!*
Window Choices:

Low U-value not always best.

Gas fill vs. Mountains

Loewen Windows
Passive Solar Is Not Dead...

Especially in sunny climates of the western U.S.!
Old Thermal Mass Is Dead...

For those who don’t want concrete floors.
Thermal mass 2.0:

- Phase change materials (PCM)
- Specify product’s temperature setpoint to act as “thermostat” at that temp
- Carmel Passive House product: BioPCmat
  - One square foot equals heat storage capacity of 1 cu.ft of concrete (27 BTUs)
Window Choices

- Strategic SHGC selections
- Very low U-values
  - Thermal comfort goals
  - Total energy balance
- Very airtight
- Recommendations:
  - Fixed best.
  - Casements & awnings good
  - Sliders: minimize (can be leaky)
  - Hung: never (always leaky)
  - Metal frame: NEVER! (clad or TRULY thermally broken OK)
Window Comfort Recommendation

- 5°F maximum temperature diff. throughout space
Window Comfort Recommendation

- 5°F maximum temperature diff. throughout space
The Window “Comfort Index”

<table>
<thead>
<tr>
<th>US Climate Zone</th>
<th>Low Outdoor Temp. (°F)</th>
<th>Max. $U_W$ (BTU/hr.ft².°F)</th>
<th>Min. $R_W$ (hr.ft².°F/BTU)</th>
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</table>

Data source: Dariush Arasteh – LBNL, email to Bronwyn Barry, 2009

Only triple-pane in Mountain West!
Window Placement

- Install within insulation layer

  **POOR:** $U_w^{(installed)} = 1.05 \text{ W/m}^2\text{K}$  
  $\Psi_{\text{install}} = 0.039 \text{ W/m}^2\text{K}$

  **BETTER:** $U_w^{(installed)} = 1.00 \text{ W/m}^2\text{K}$  
  $\Psi_{\text{install}} = 0.023 \text{ W/m}^2\text{K}$

  **BEST:** $U_w^{(installed)} = 0.99 \text{ W/m}^2\text{K}$  
  $\Psi_{\text{install}} = 0.02 \text{ W/m}^2\text{K}$

  $\rightarrow$ **49% less heat loss due to installation**
  $\rightarrow$ **6% less total heat loss via window**

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008
### Shading Studies w/ Solar Pathfinder

**Notes:** South facade, 2/2

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Shading Studies w/ Sketchup
Have Your Sun & Shade It, Too!

- Exterior shading can be beautiful
Have Your Sun & Shade It, Too!

- LBL Tips for Daylighting with Windows – Shading Strategy

Exterior Devices

- Use exterior shading. Either a device attached to the building skin or an extension of the skin itself, to keep out unwanted solar heat. Exterior systems are typically more effective than interior systems in blocking solar heat gain.

- Design the building to shade itself. If shading attachments are not aesthetically acceptable, use the building form itself for exterior shading. Set the window back in a deeper wall section or extend elements of the skin to visually blend with envelope structural features.

- Use a horizontal form for south windows. For example, awnings, overhangs, recessed windows. Also somewhat useful on the east and west. Serves no function on the north.

- Use a vertical form on east and west windows. For example, vertical fins or recessed windows. Also useful on north to block early morning and late afternoon low sun.

- Give west and south windows shading priority. Morning sun is usually not a serious heat gain problem. If your budget is tight, invest in west and south shading only.

- Design shading for glare relief as well. Use exterior shading to reduce glare by partially blocking occupants’ view of the too-bright sky. Exterior surfaces also help smooth out interior daylight distribution.
AIR TIGHTNESS
Convection ➔ Air Leakage

- “Air leaks can be responsible for a third or more of the energy loss in typical houses”
  - John Straube, Building Science Corporation

Air infiltration through window frame from behind trim:
homeefficiencysolutionsllc.com

Air infiltration and lack of insulation:
energyexams.com
Why Air Tightness?

- Energy
- Health
  - “Naturally” leaky = “Randomly” leaky
  - Build Tight, Ventilate Right
- Sound
- Safety (fire & smoke)
- Durability
  - What besides heat does air contain?
  - Water vapor

“Carpet filter effect”
Why Air Tightness?

- “It is well established that convection, not diffusion, is the major vehicle of moisture transport out of homes.”
  - Daniel Friedman, Building Forensics Investigation & Analysis Expert, InspectAPedia
Defining the Thermal Boundary

- Draw a continuous line:
- Then, detail it:
  - Thermal
  - Air
Air Sealing Planning

- Develop “Air Sealing Matrix” & Narrative

<table>
<thead>
<tr>
<th>Area / Location</th>
<th>SIPS Tape</th>
<th>Other Tape</th>
<th>Energy Complete</th>
<th>Foam</th>
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<td>Backer Rod &amp; Caulk w/ drywall mud &amp; tape</td>
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This is a description of the various air sealing methods that will be incorporated into the 1206 N. Lemon Avenue project, located in Menlo Park, CA. Please refer to the Air Sealing Matrix dated 3/3/11 and the approved plans for further clarification.

1. **Vertical Panel Connection**: The exterior walls shall be constructed using a Structurally Insulated Panel (SIP) approximately 6” thick. The panels shall be joined using a spline (either foam, lumber or i-joist) and a 3/16” bead of mastic (mastic acts as both a glue and caulk) placed approximately ¼” from each spline edge and along the foam-to-foam edges (please refer to Exhibit ‘A’, Sheets 8 - 11, 19 & 20). Once the panels are in place, the exterior seams of the panels shall be taped using a SIP tape, 10 mil self-adhesive membrane that is made with a...
HVAC
HVAC

- Heat recovery (HRV) or energy recovery (ERV) ventilation
  - Deliver continuous fresh air without wasting all the building’s precious heat
  - ERVs recover moisture as well as heat
  - HRVs generally recommended except in extremely humid or dry climates (in the dry West, I often recommend ERVs)
Heat Recovery Ventilation Design

- Heat recovery vs. fan efficiency
- Summer override
- Supply air to living & sleeping areas
- Extract air from bathrooms, kitchen & laundry
- Recirculating range hood...?
Duct Layout Best Practices

- Minimize duct runs from outside to the unit
- Keep conditioned ducts within conditioned space
- Minimize duct losses & fan energy:
  - Design for short runs (& select proper diffusers)
  - Minimize hard turns
  - Use proper diameter to minimize velocities
  - Seal tightly!
Popular heating systems for very low-load buildings:
- Hydronic or electric resistance coils in line w/HRV (i.e., heat the ventilation air)

If more heat needed:
- Hydronic or electric (!) baseboards, in-floor elements, or towel warmers
- Mini-split heat pumps (as cold as -13°F/-25°C)
- Is it really cold? Pellet stoves etc...
Iconic PH: Post Heat Ventilation Air

First Co. HWC series duct coil paired with Zehnder ComfoAir 350 HRV

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New PH: Mini-Split Heat Pump

Flexible and Quiet
Mini splits offer flexibility because they can be suspended from a ceiling, mounted flush behind a drop ceiling, hung on a wall or floor-standing. Ductless heat pumps allow for a peaceful inside environment by enabling the contractor to install components like compressors and motors outdoors.

Individual temperature control.
74° 72° 70°

Halcyon HFI
Hybrid Flex Inverter
Mini-Splits Go Creative!
Mini-Splits Go Creative!
Mini-Splits Go Creative!
Radiant Towel Warmers
Pellet Stoves

- Pellet stoves
  - Biomass = renewable
  - 80% and better efficiency
  - High Btu output

Harman XXV pellet stove
50000 Btu’s

Ecoteck Veronica ductable pellet stove
91% efficiency, 8500-44000 Btu’s
HVAC

- Best: design so minimal cooling needed (where feasible)
  - Modest E & W window areas with very low SHGC
  - Thoughtful shading
  - Thermal mass or PCM
  - Night flushing
  - Natural ventilation
- Mini-split heat pumps
- Radiant cooled ceilings
- Chilled beams

Image courtesy of Environmental Building News
Your responsibility & challenge:

Commit to making your next project high-performance!
Questions?
We can help you push the envelope:

- Energy modeling & optimization studies
- High-performance envelope advising
- HVAC systems advising
- Green plan review & rating services
- Technical training & coaching
- Incentives program facilitation

Contact:
Katy Hollbacher, P.E., katy@beyondefficiency.us
WY: (307) 200-7236
CA: (415) 236-1333
This Concludes the American Institute of Architects Continuing Education System Program.