Introduction to Passive House:

More than an Energy Standard

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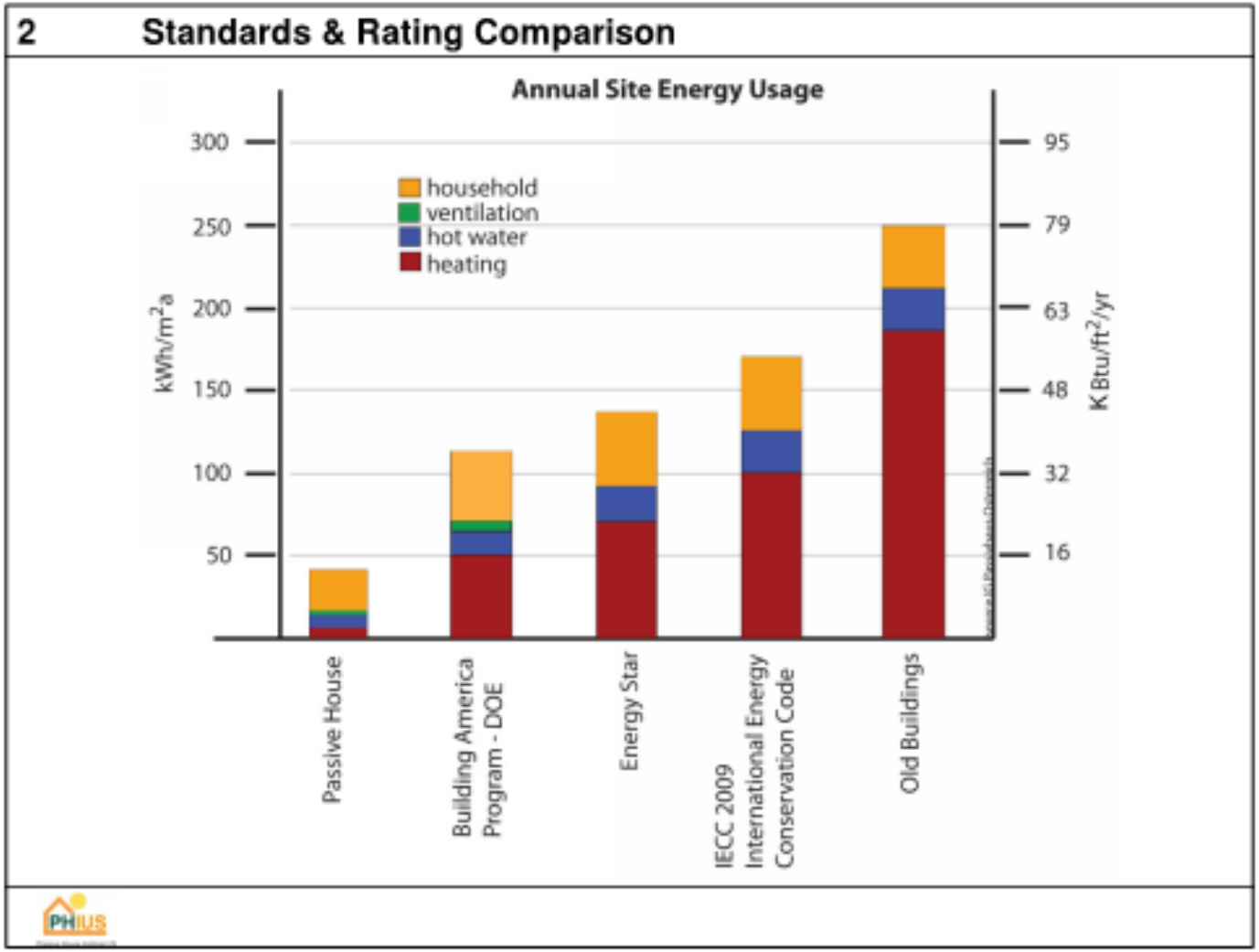
Design Coalition Architects, Madison, WI

Passive House is
a standard
AND
a methodology.

An energy standard that is the most ambitious in the world.



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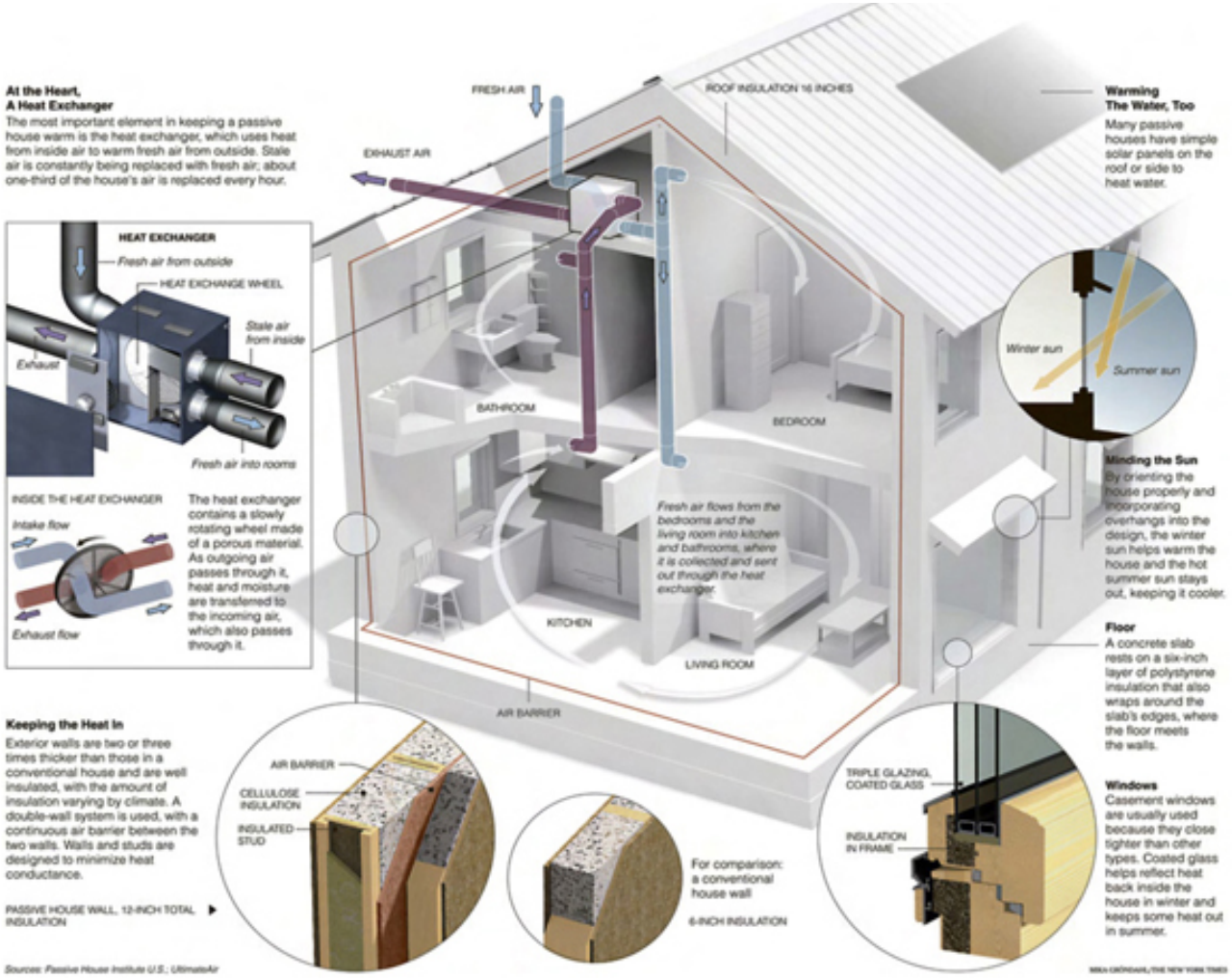
Passive House methodology = integrated envelope and systems design.



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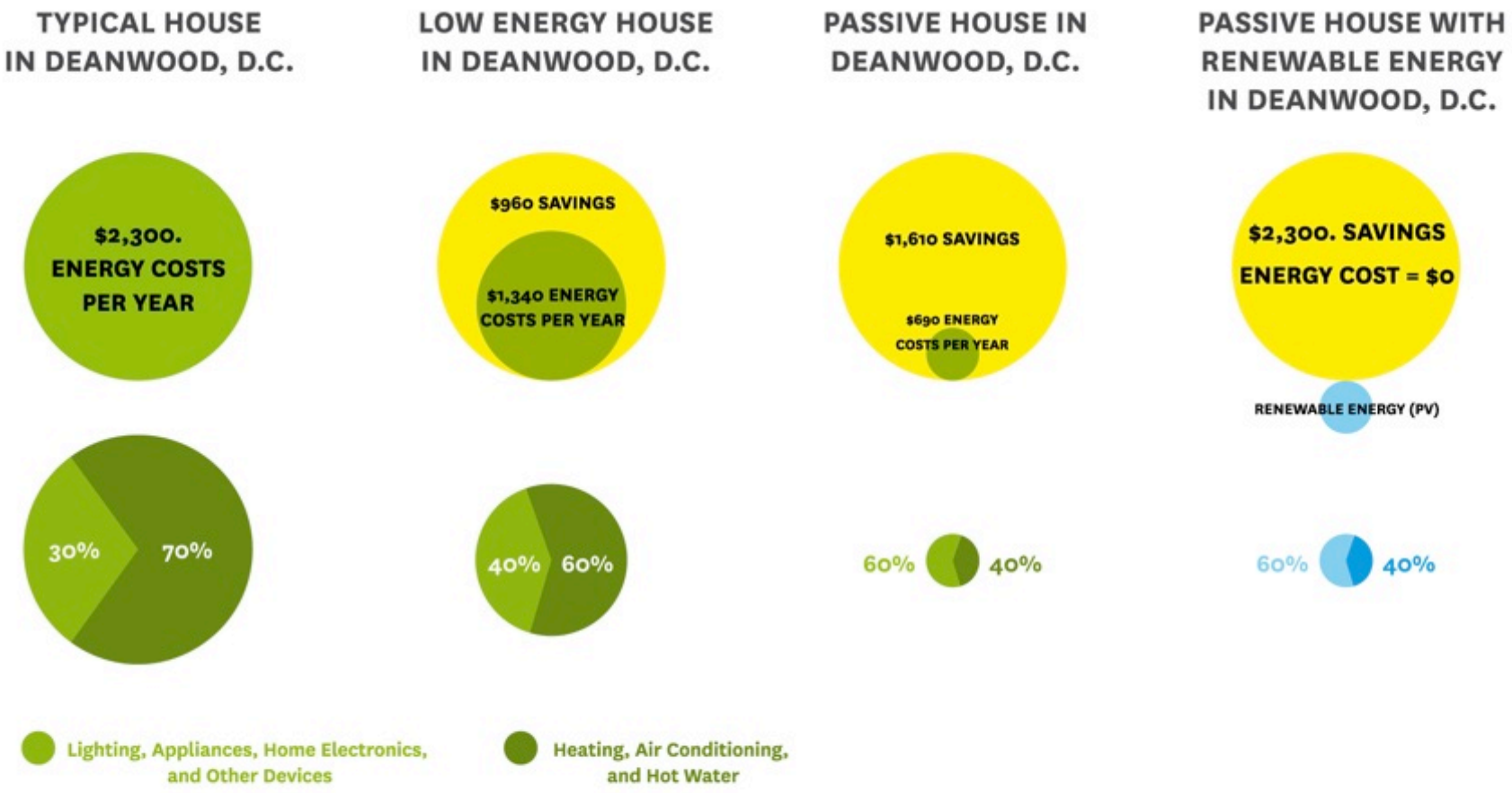
Vastly reduced utility bills!



Values calculated from information in PEPCO press release for service hike 2004 and Washington Gas, Historical Gas Comparison

Source: Empowerhouse

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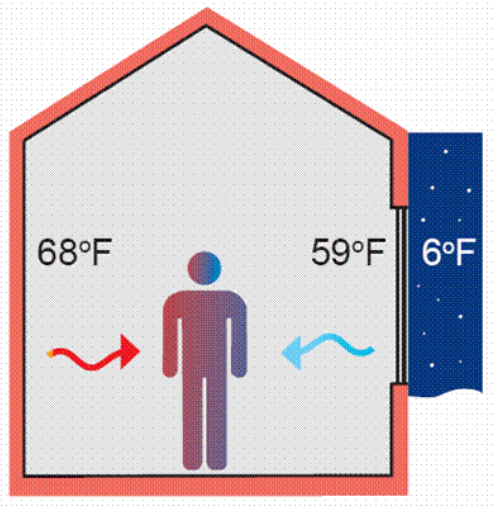
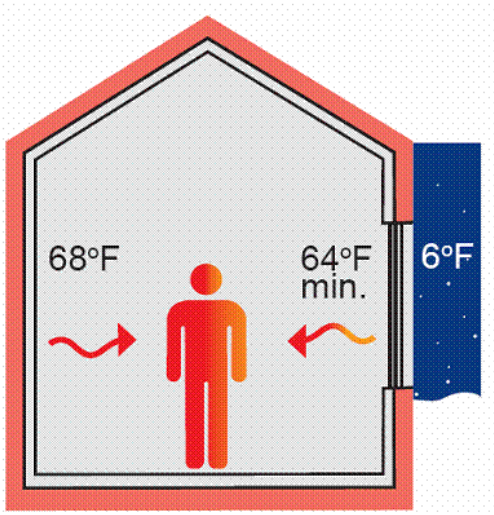
Superior comfort!

- No drafts, no condensation, no cold spots.
- Warm interior surfaces (no more than 4˚F colder than the interior air temperature).
- No drastic temperature swings.
- More “usable” square footage in the winter.



Conventional
Envelope & Windows

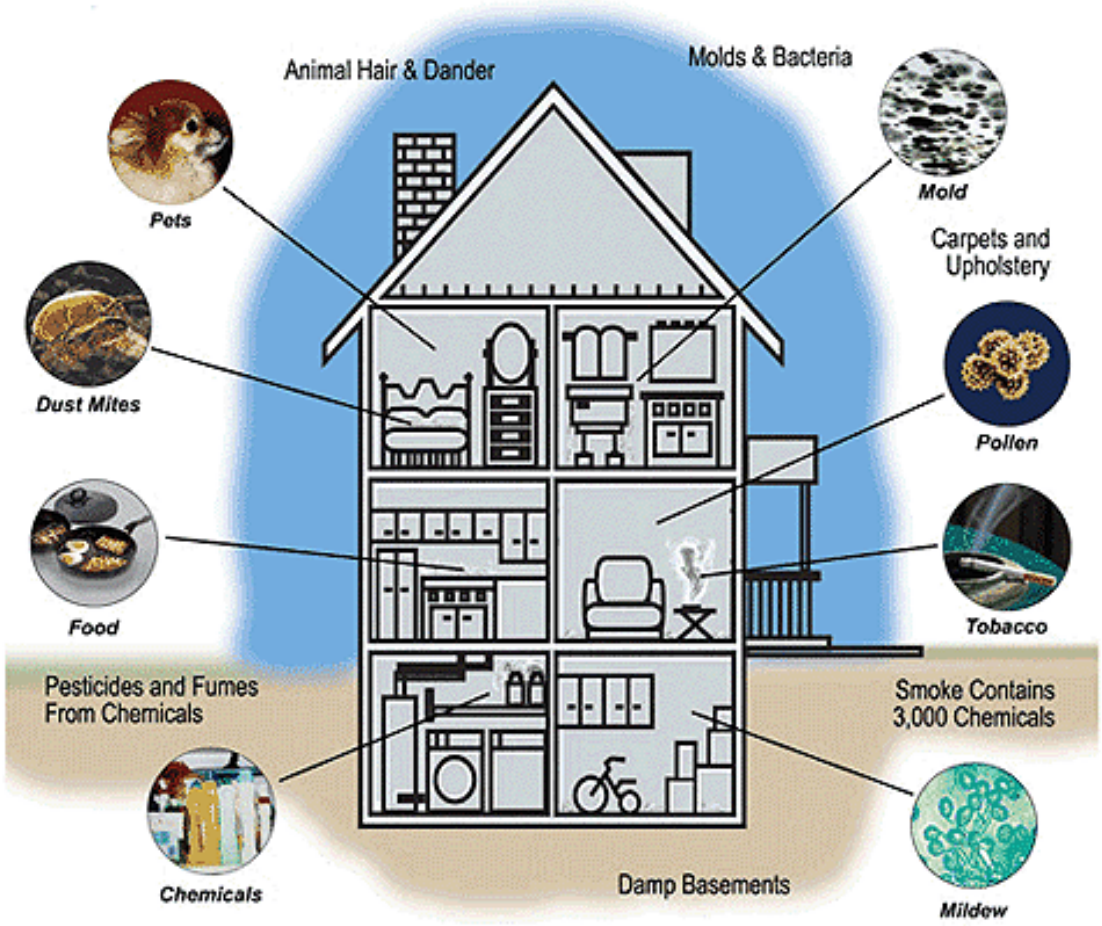


PH Envelope &
Windows

Source: Informationsgemeinschaft Passivhaus D,
Broschure “Aktiv fur mehr Behaglichkeit.”

Superior indoor air quality!

- Constant, low-velocity, filtered fresh air
- Reduced allergens, pollutants, etc.
- Lower CO_2 levels



Source: EPA

Energy-efficient homes have higher values.

- Market value of a home increases $20 for every $1 decrease in annual energy costs. - *The Appraisal Journal*
- Newly constructed homes with a HERS rating in Portland sold for 8% more, existing homes for 30% more. - *Earth Advantage Institute*

Energy-efficient homes sell faster.

- Earth Advantage Institute

Passive Houses come in any style…

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TWO DISTINCT APPROACHES TO CONSERVATION:

PASSIVE SOLAR

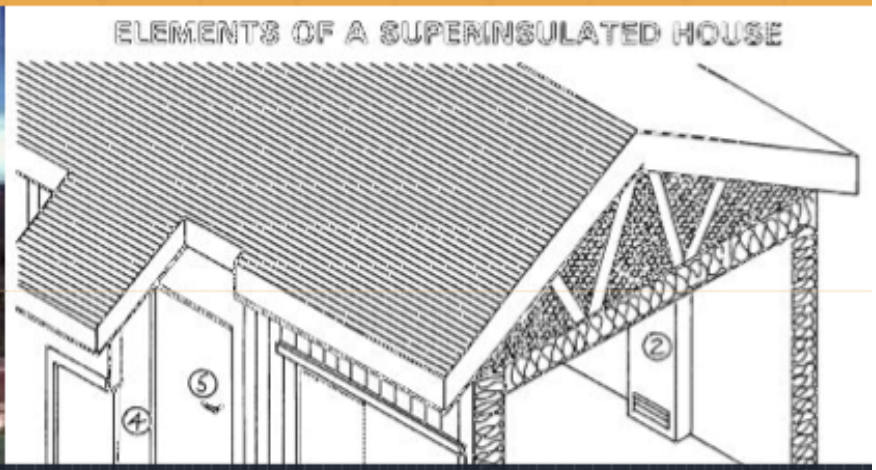
aka Mass & Glass

Big temperature swings

Net negative windows

Heavy focus on south glazing

Big temperature swings



PASSIVE HOUSING

aka Thick Walls & Tight

Slow temp movement

Net positive windows

Moderate south glazing

Balanced ventilation

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Not just for new construction…

O' Neill House Retrofit, Sonoma, California

Retrofit, Mamaroneck, New York

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Not just for houses... (Passive Buildings)

Office Tower in Austria

Primary School in the UK (image courtesy: Thomas Vale Construction)

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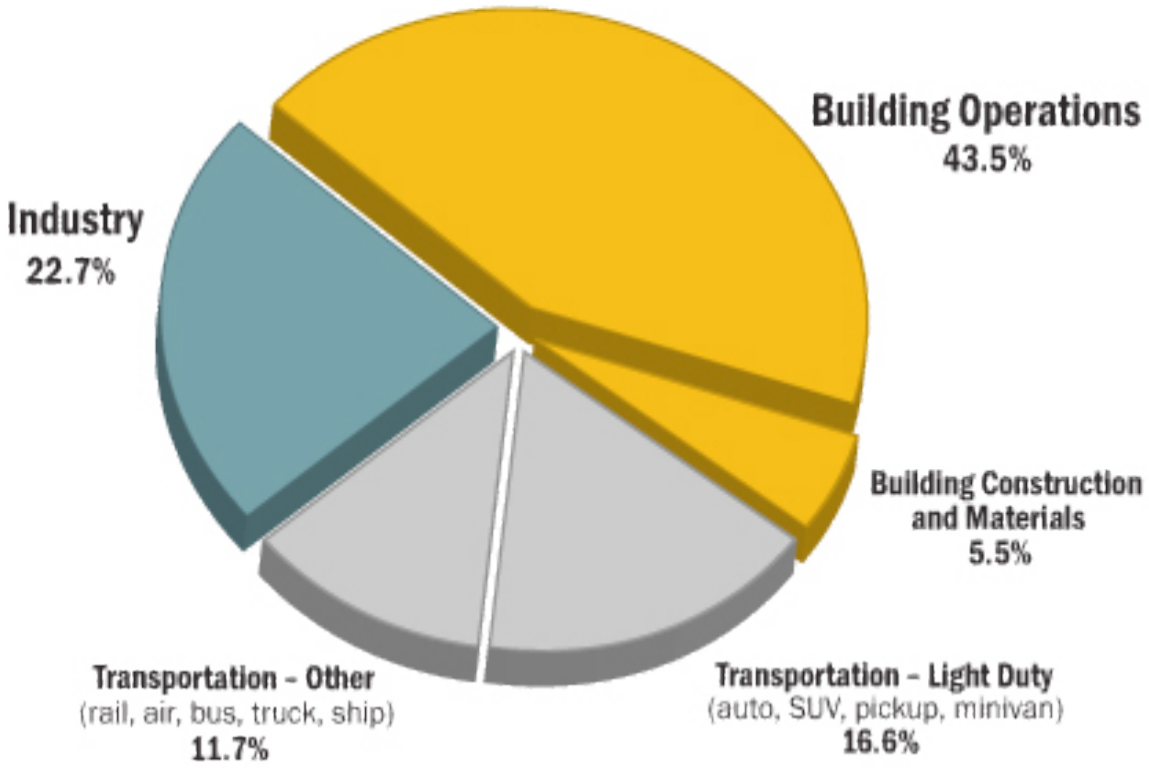
Passive House in our energy future…

Buildings are responsible for almost half of our energy use & CO2 emissions!



U.S. Energy Consumption by Sector

Data Source: U.S. Energy Information Administration (2009).

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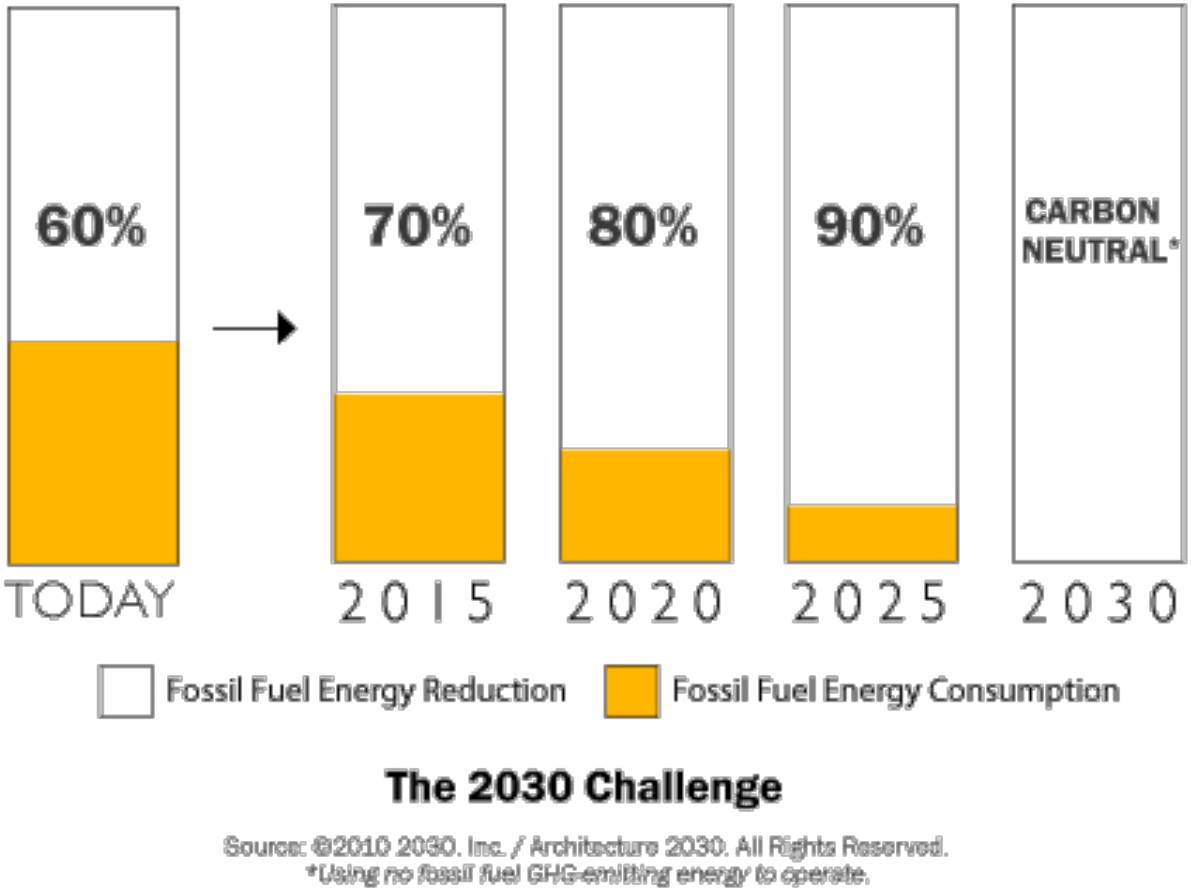
PH meets the goals of the 2030 Challenge.

Get to net-zero energy use by 2030!



Early adopters….
-State of MN, IL, CA, MA, NM, WA (not WI!)
-Energy Independence & Security Act
-U.S. Army Vision for Net Zero.

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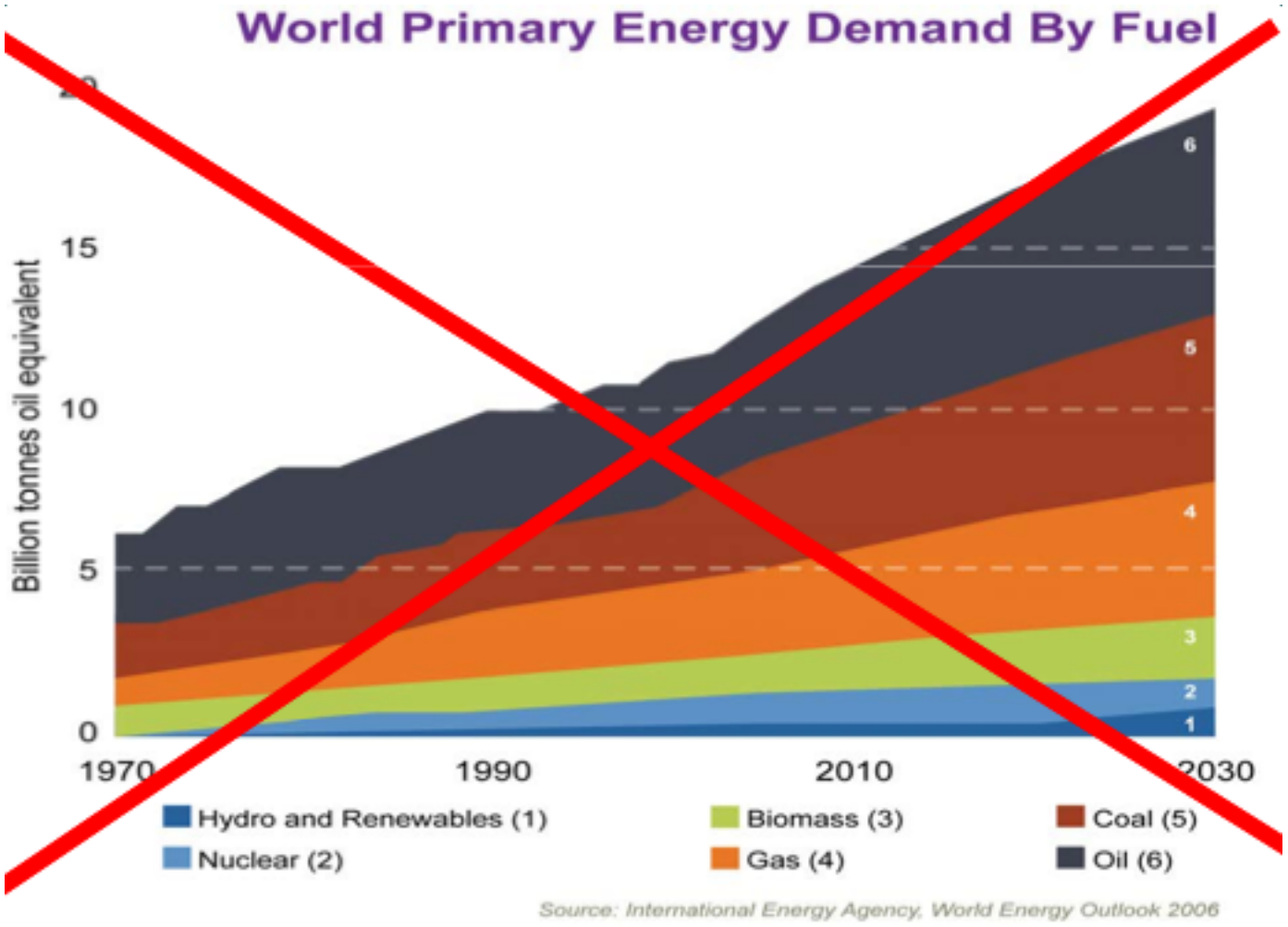
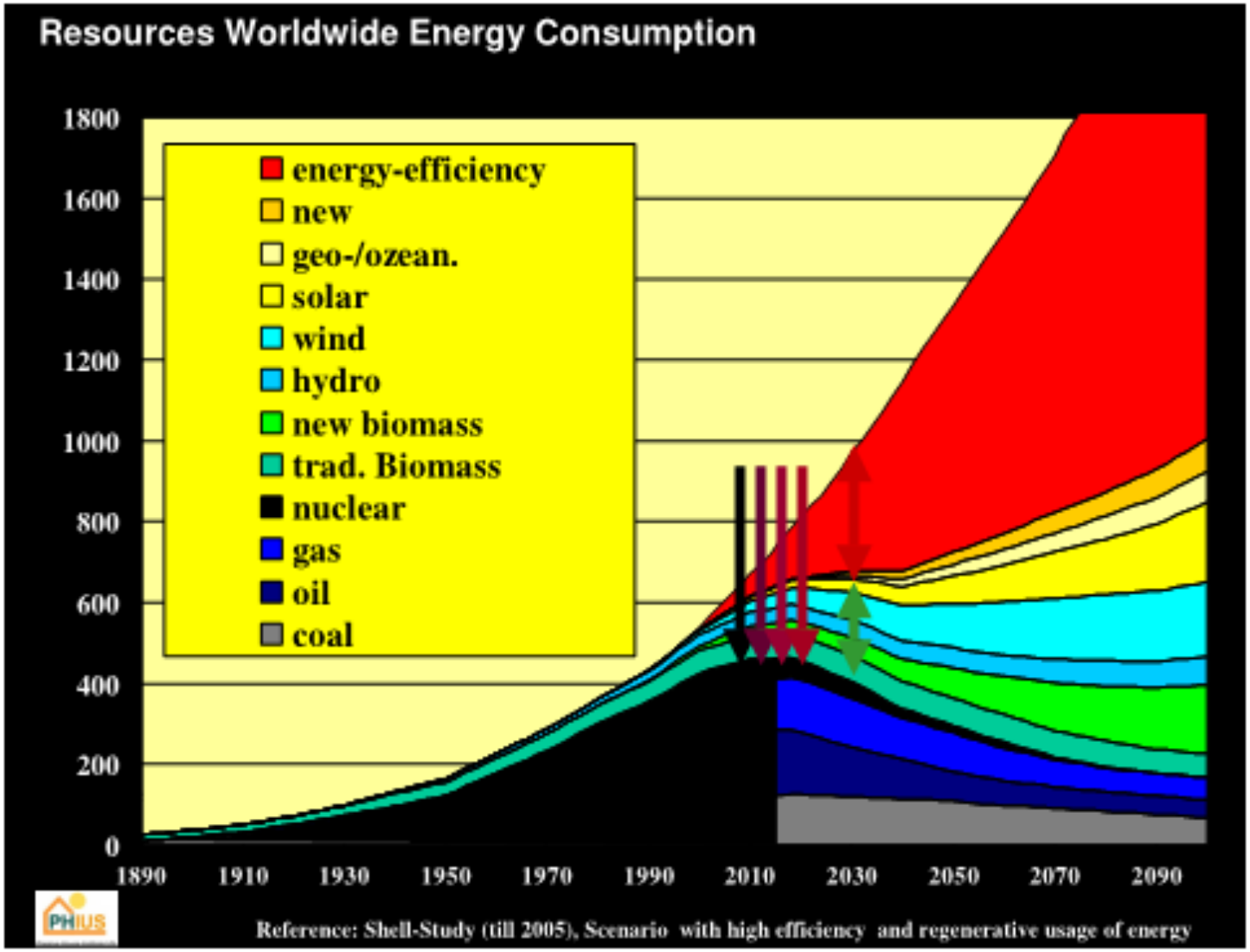
Future global energy use projections & related CO2 emissions are not sustainable



Future worldwide transition.

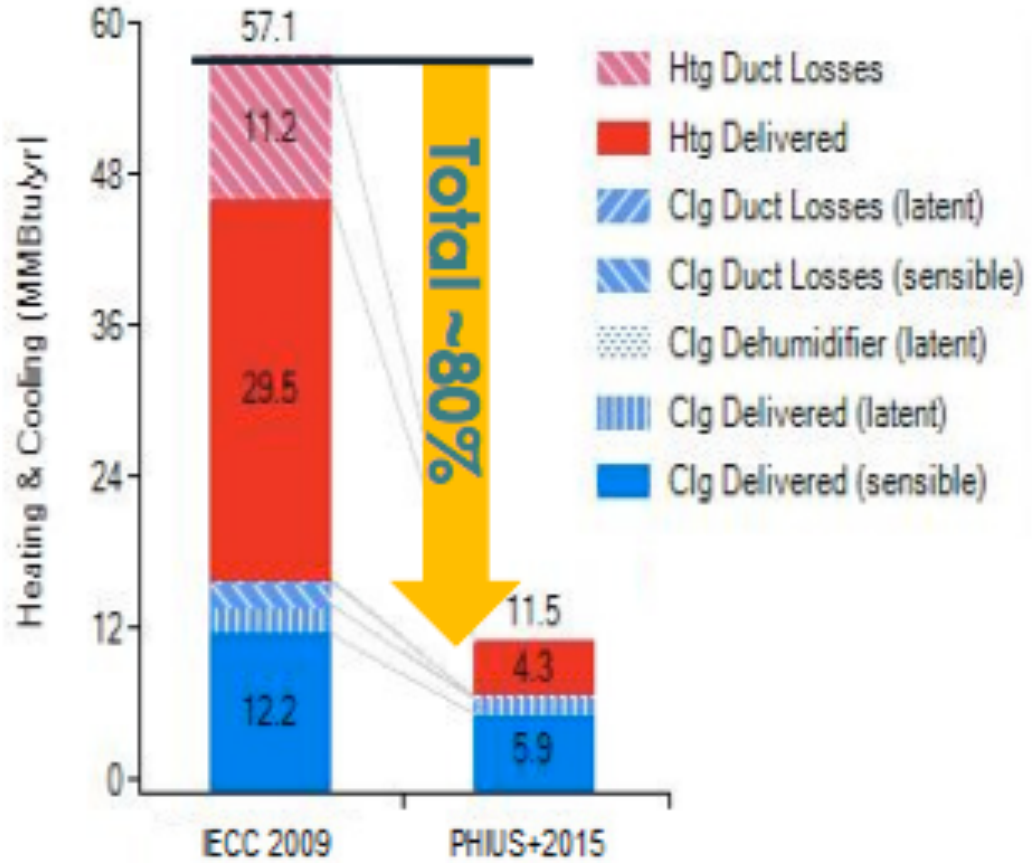


Energy-efficiency can close the gap.

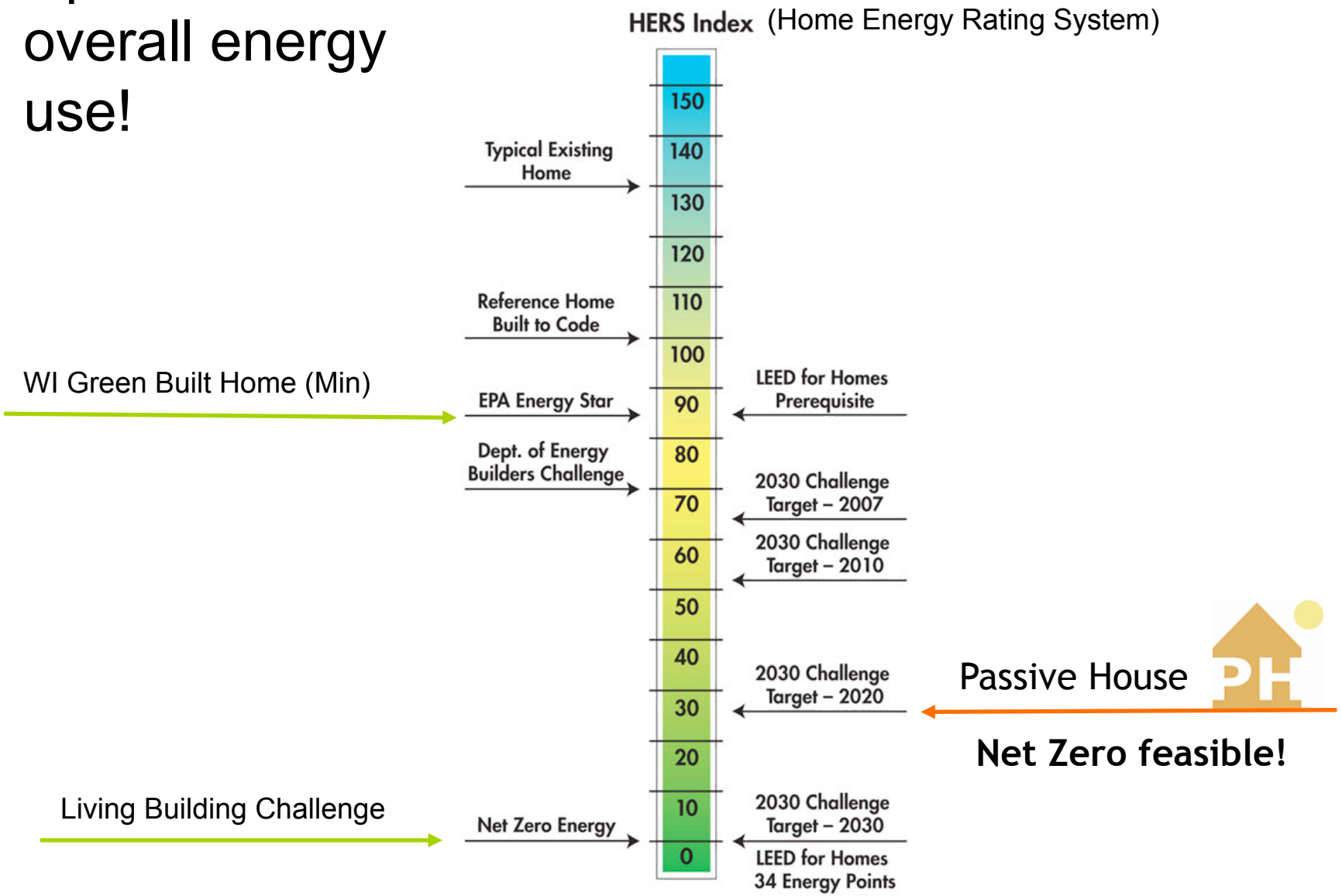
Renewables account for only a small portion of the rising increase in energy demand.

PH taps the ‘energy source’ of conservation.

Heating energy reduction in passive buildings: ~80-90%



Up to 90% less overall energy use!



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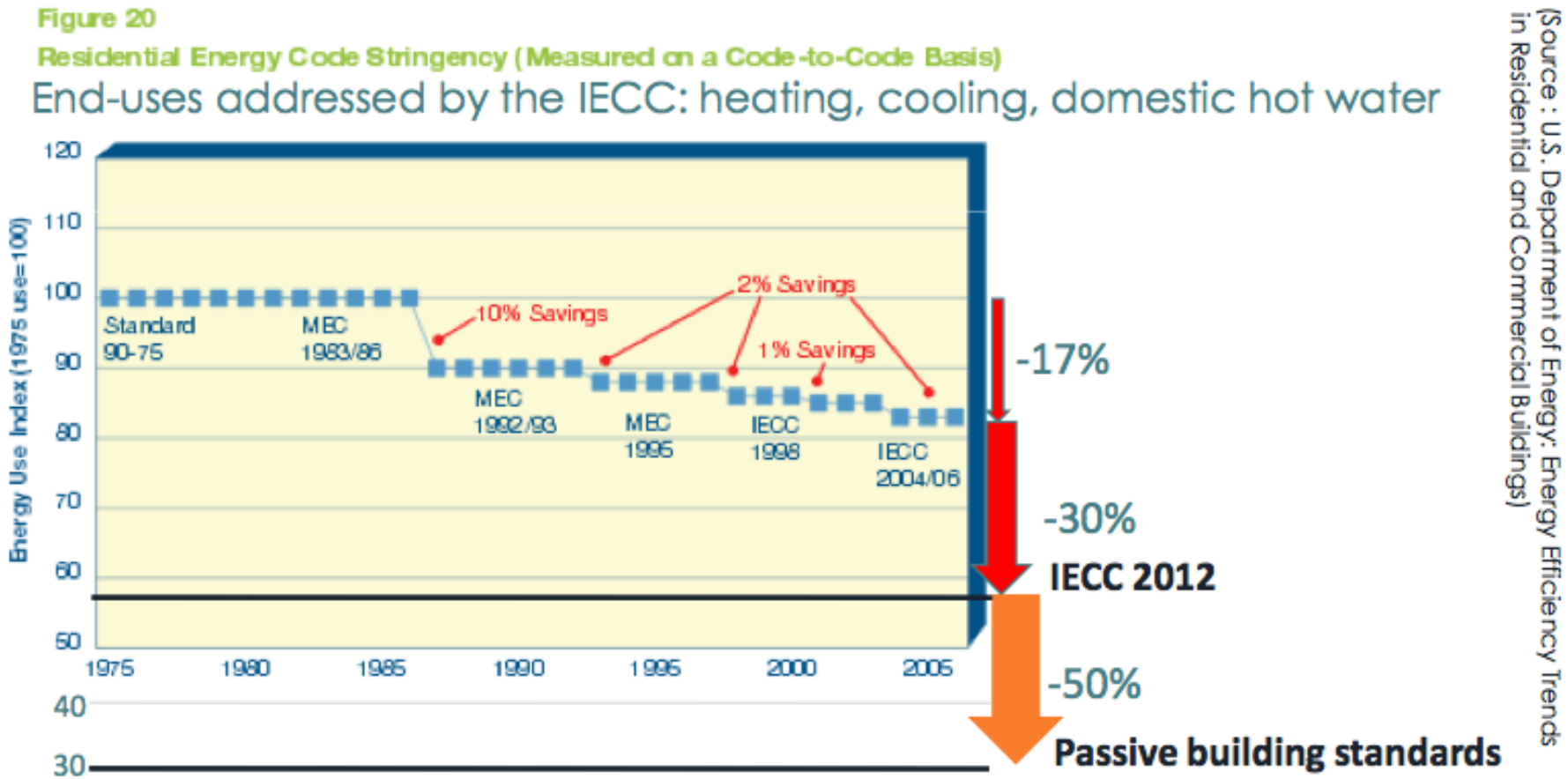
Since the energy crisis..

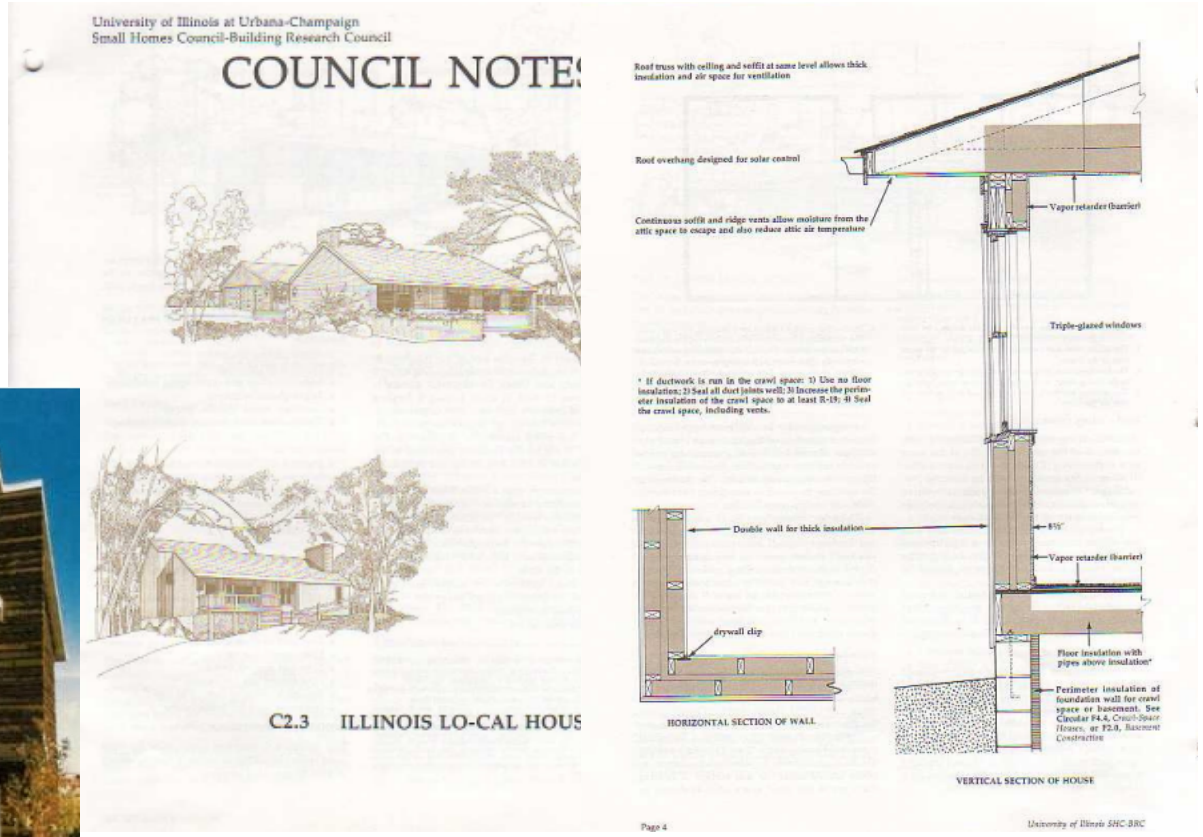


Brief History of Passive House

Passive House has roots in the U.S. and Canada

- Energy-efficiency in response to 1970's energy crisis.
- Concepts of super-insulation, air tightness, ERVs, etc. are not new.

Saskatchewan Conservation House, Canada, 1977



Super-insulated"Lo-Cal House", Wayne Schick, U of I Small Homes Council

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Formalized Passivhaus Standard

- Built upon the ideas pioneered in the US and Canada.
- Dr. Wolfgang Feist developed original Passive House performance criteria.
- Optimized for German climate.

Dr. Wolfgang Feist *(right)*, shown with Bo Adamson *(left)* and Robert Hastings, 1998 Passivhaus Conference

First Passivhaus, Darmstadt, Germany, 1991

Passive House concepts come back to the U.S. in 2003.

PHIUS
Passive House Institute US

- Founded by Katrin Klingenberg & Mike Kernagis
- Training & Education
- Research & Collaboration with other agencies
- Certification
- Developing markets for better doors, windows, ERVs, etc.
- Translating PH standard to North American climates

Smith House 2002

Biohaus 2006

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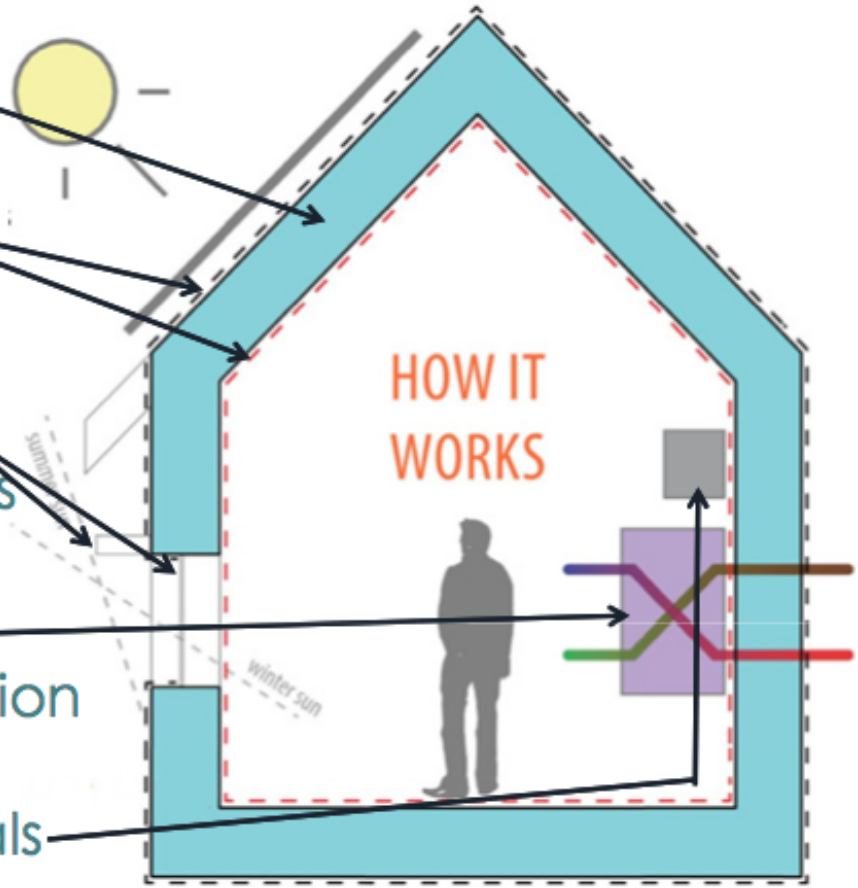
Passive House:

The Methodology

Passive House methodology is a **conservation** approach

- Minimize Losses, Maximize Gains
- Integrated Envelope & Systems design

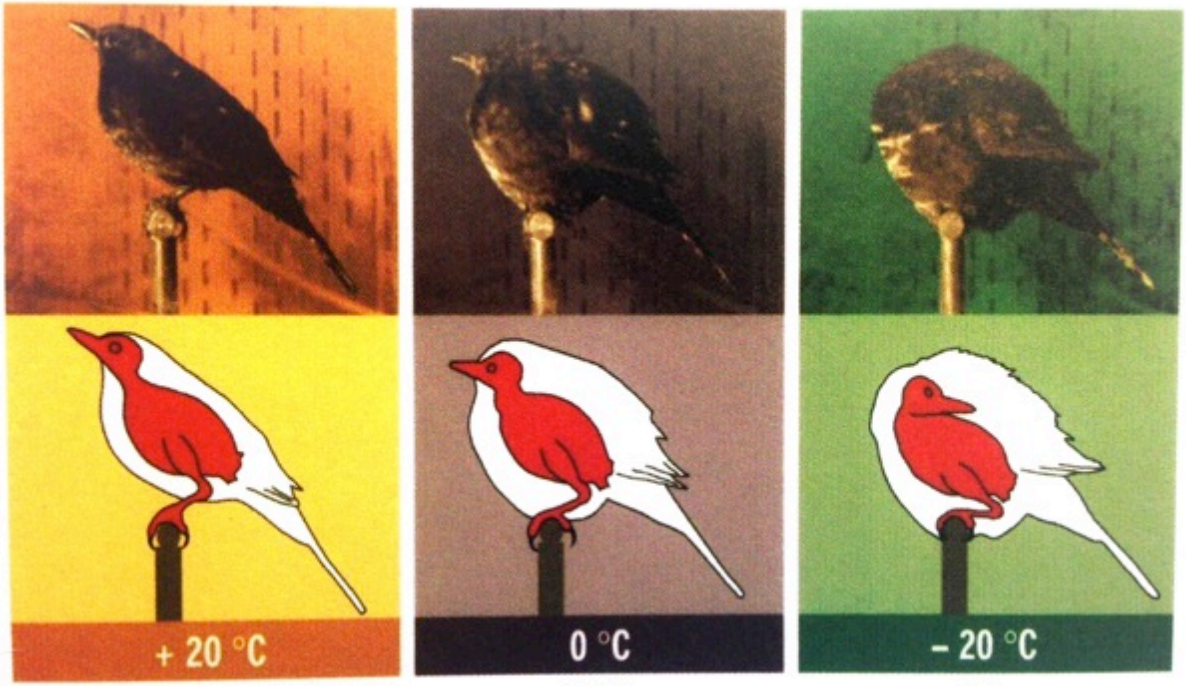
1. Continuous insulation
2. Air/wind-tightness - moisture performance
3. Optimizing solar gains – glazing and shading specs
4. Indoor air quality – heat/ moisture recovery ventilation
5. Miniminimized mechanicals



Continuous Insulation & the Thermal Envelope

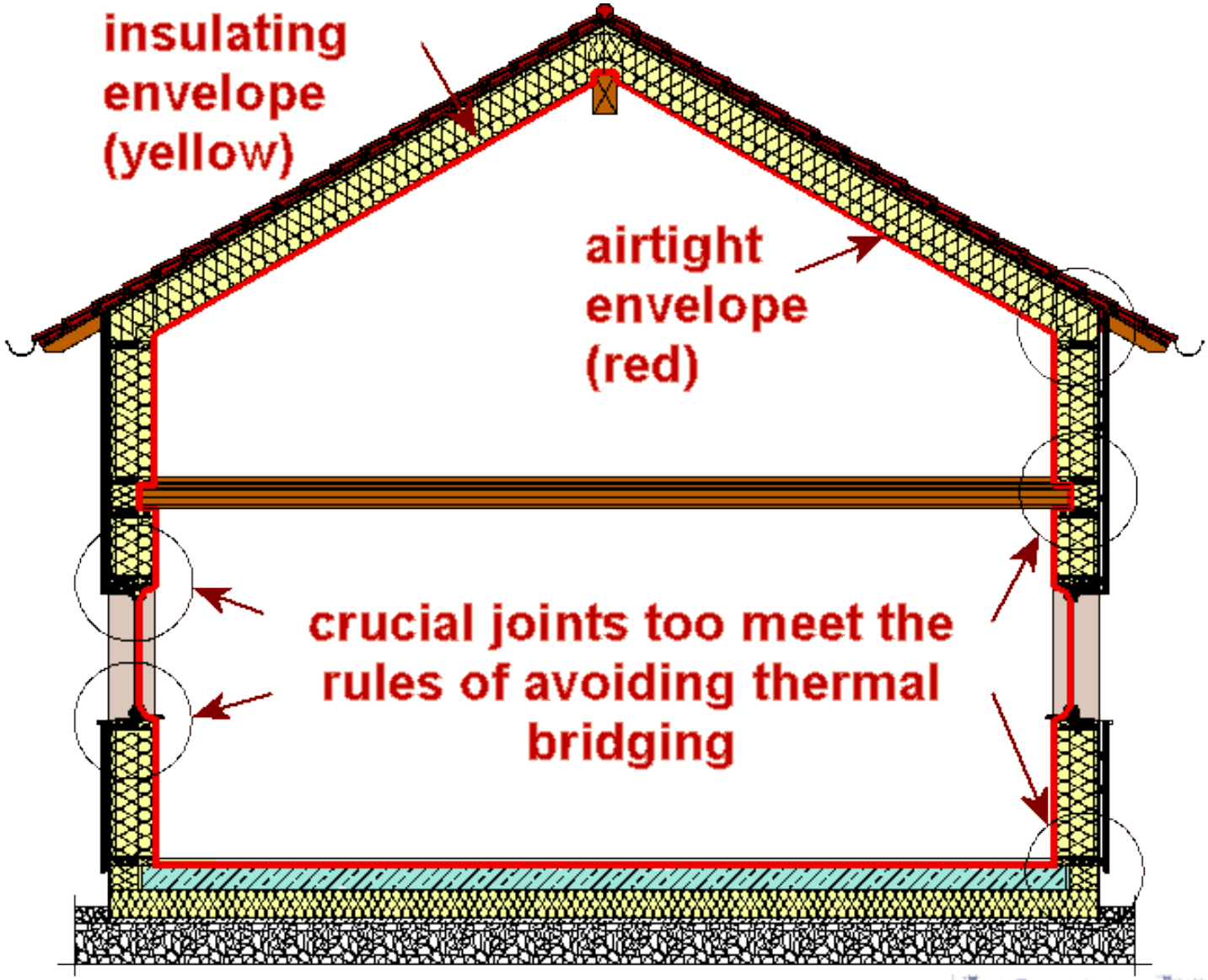
Continuous Insulation

Nature teaches us that continuous insulation decreases heat loss.



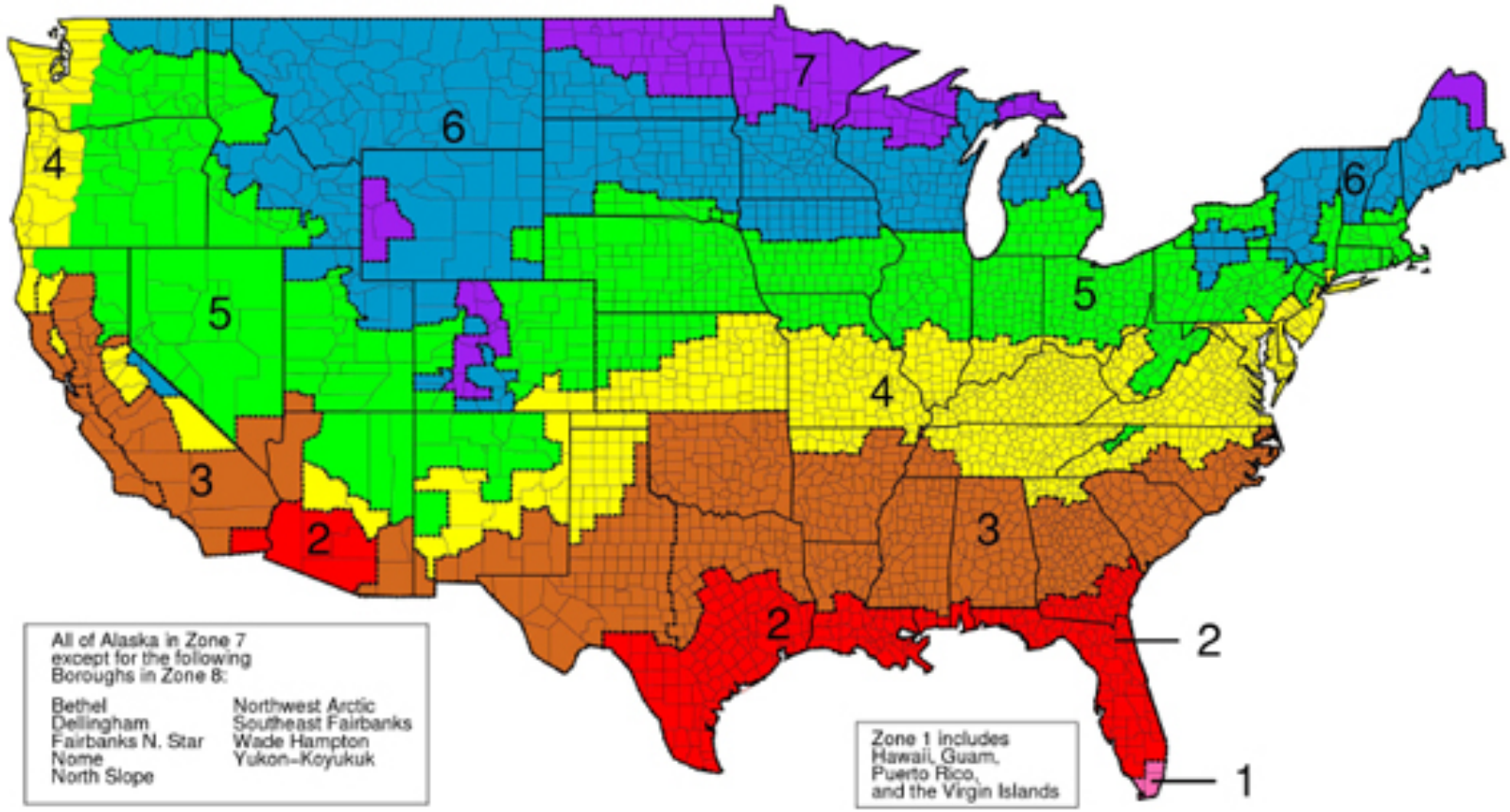
Source: Vogelwarte Radolfzell. Blackbird “feather envelope”

Continuous Insulation should be continuous – for real!



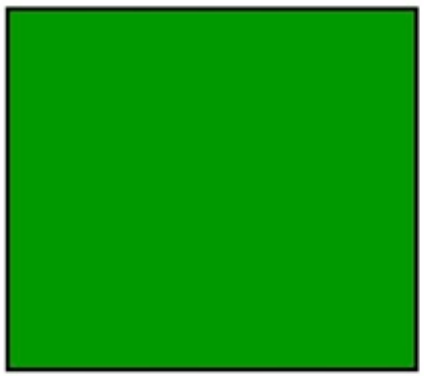
Continuous Insulation:

The right amount of depends on the climate.

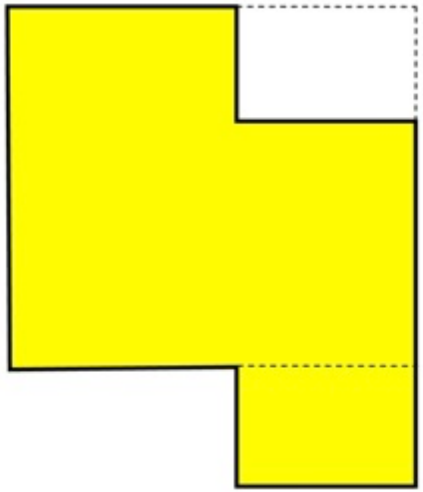


Continuous Insulation and a compact shape.

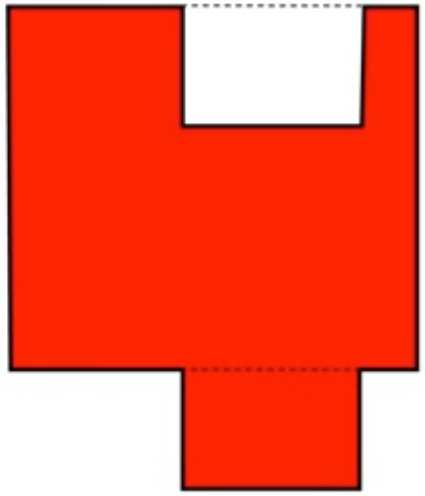
- Reduce heat loss through envelope
- Minimize ratio of Surface Area : Volume



Compact Shape



10% increase in wall area
(more heat loss)



20% increase in wall area
(even more heat loss)

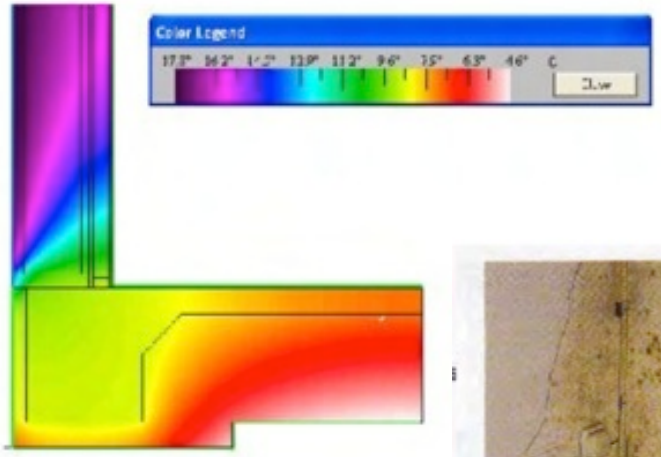
Source: Intelligent Energy, PHS 1.0

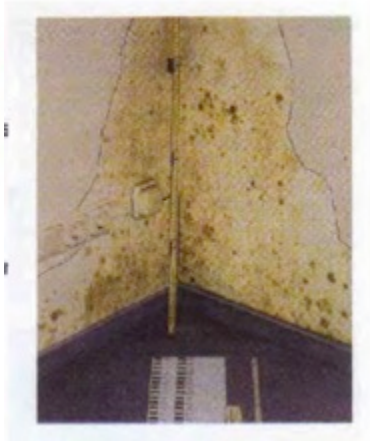
Continuous Insulation: Eliminate Thermal Bridges

Thermal Bridge = a building element or assembly that transmits heat through the envelope.

<u>Presence of thermal bridge:</u>

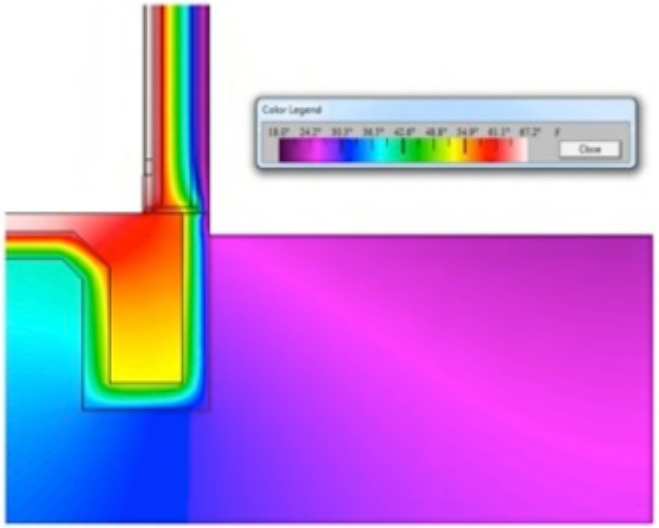
- Heat loss
- Risk of condensation & mold





<u>No thermal bridge:</u>

- Little to no heat loss
- Warm, comfortable interior
- No condensation or mold



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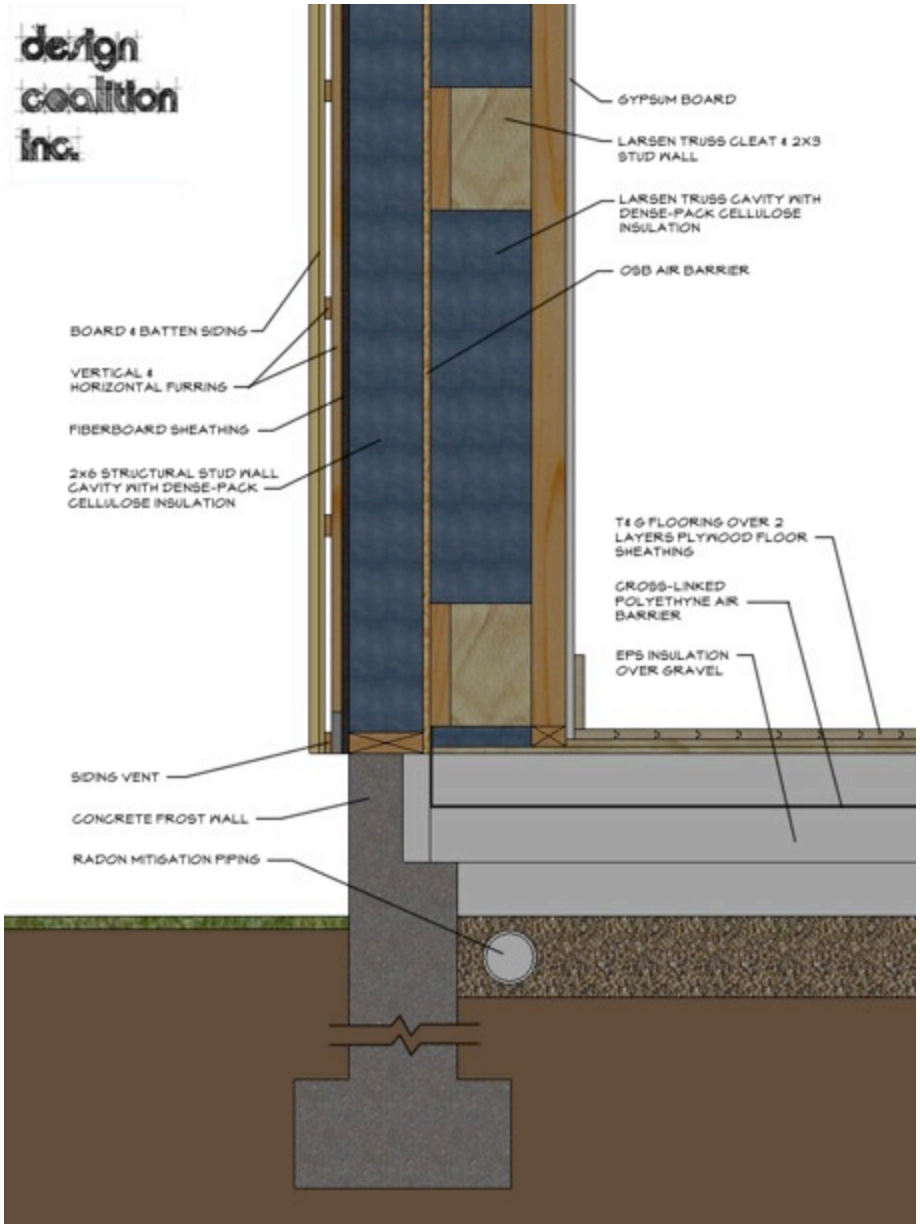
Continuous Insulation: Eliminate Thermal Bridges

See the studs!

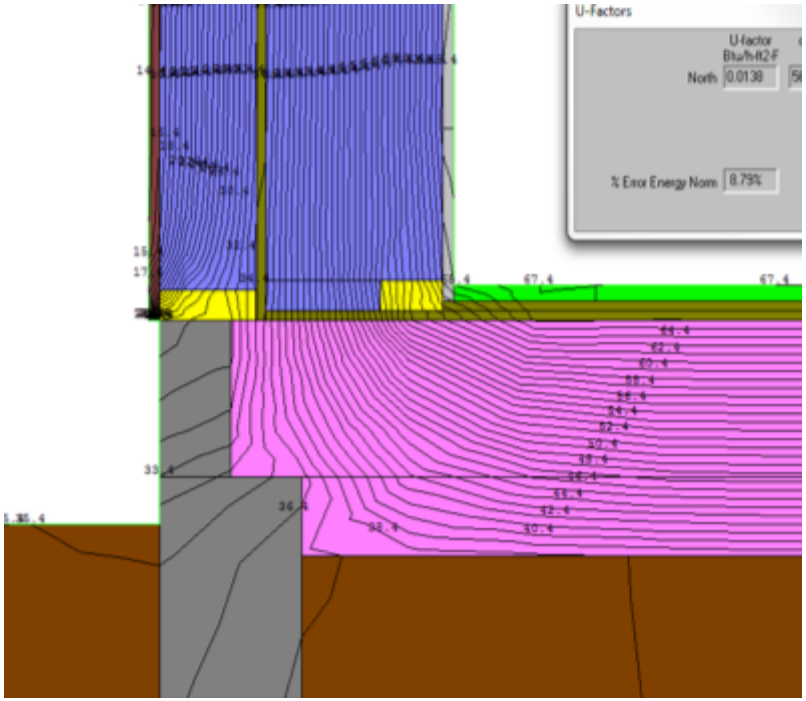
Not as much

Source: Dryvit Systems, Inc. and The Dow Chemical Company

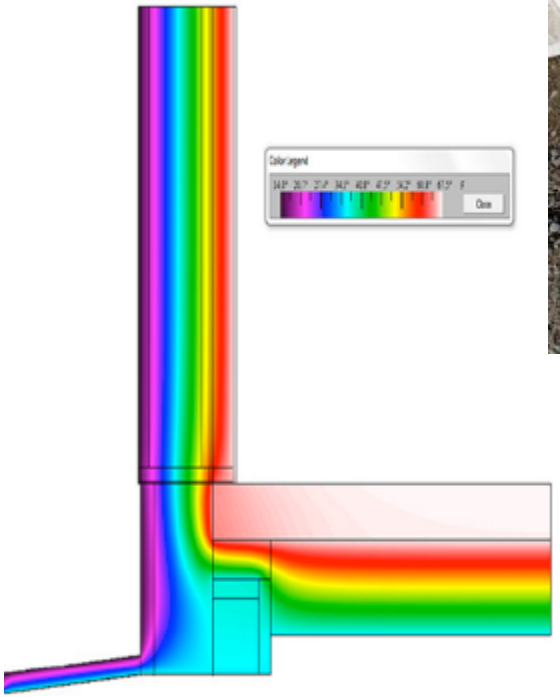
Example of Thermal Bridge Free Detail



The foundation to wall connection is one of the most challenging for thermal bridge free construction.



Example of Thermal Bridge Free Detail



Source: Tom Moore Builder

Source: Journal of Light Construction

Source: VOLKsHouse

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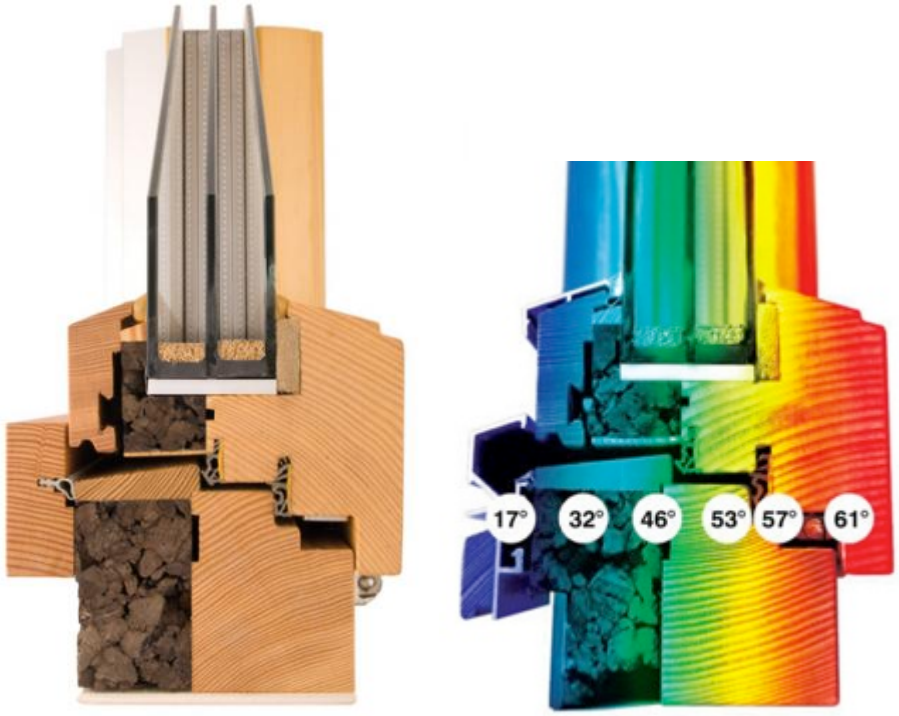
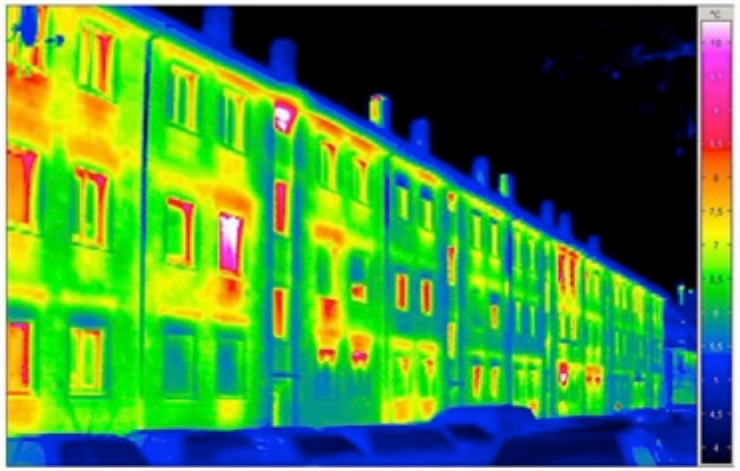
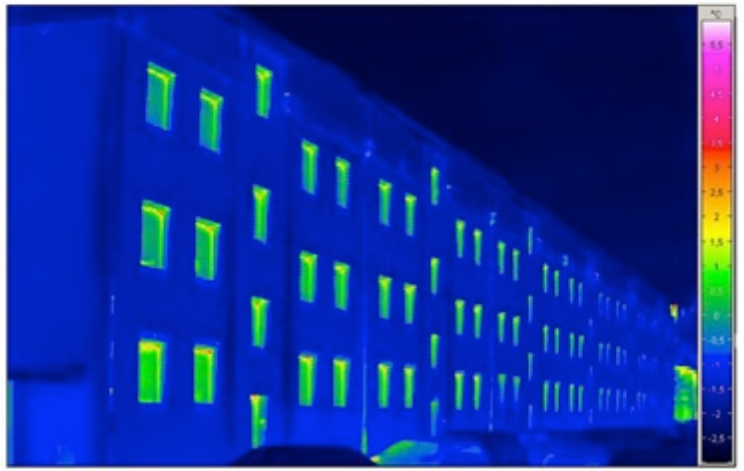
Thermally-broken, High-performance Windows and Doors:

Windows and doors present the other biggest challenge for thermal bridge free construction.







Passive House Certified Windows

Optiwin 3Wood R-8 (http://www.optiwin-usa.com)

Thermally-broken, High-performance Windows and Doors:
^
& air-tight!

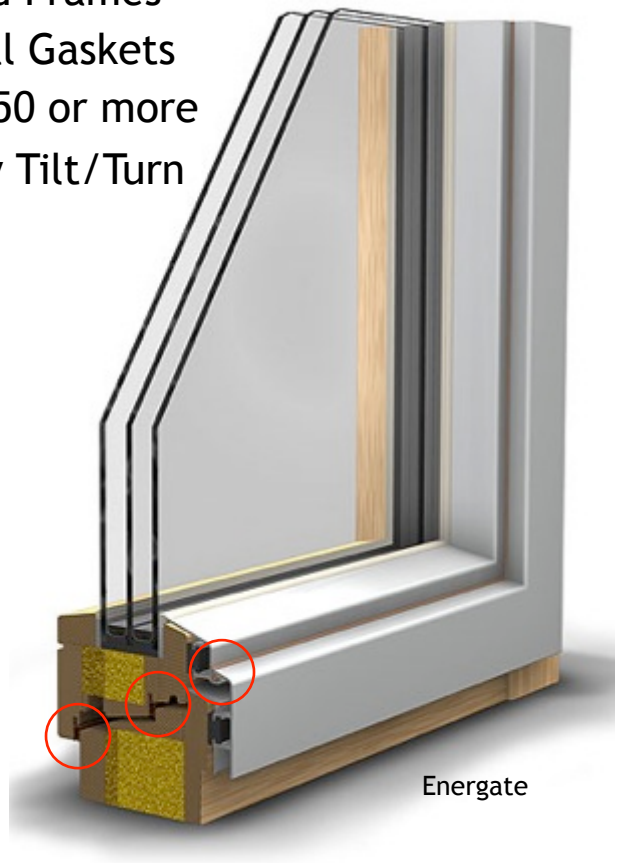
Marvin

Typical Passive House:

- Double Paned
- Metal Spacers
- Un-insulated Frames
- 1 Air Seal Gasket
- SHGC less than 0.50
- DH or Casement

Typical Passive House:

- Triple Paned
- Warm Edge Spacers
- Insulated Frames
- 3 Air Seal Gaskets
- SHGC 0.50 or more
- Typically Tilt/Turn



Energate

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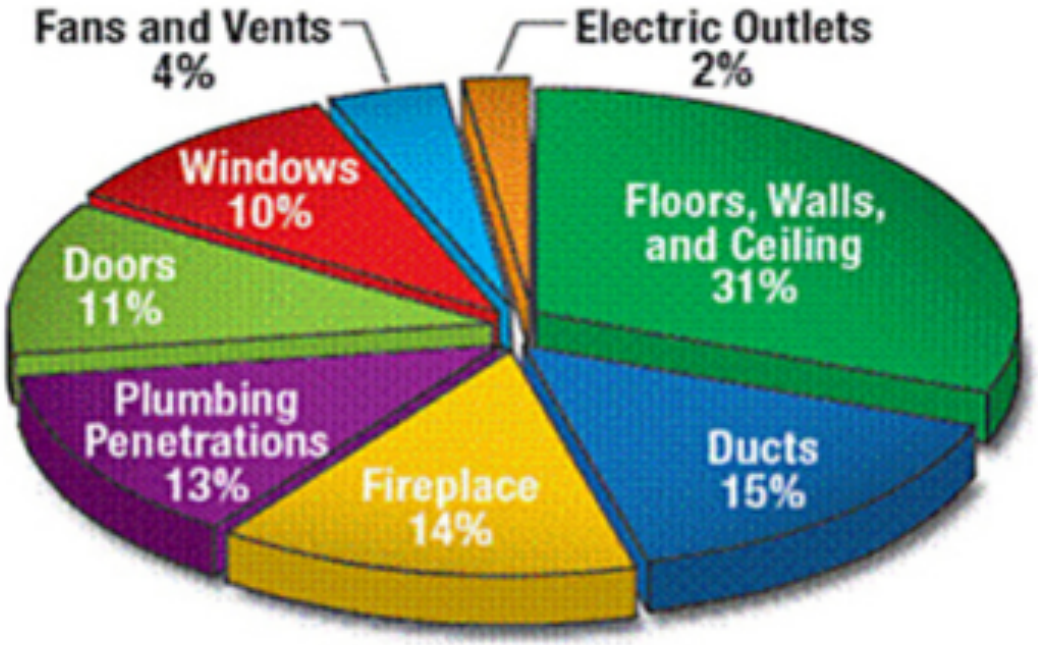
Air-Tightness

Air-Tightness

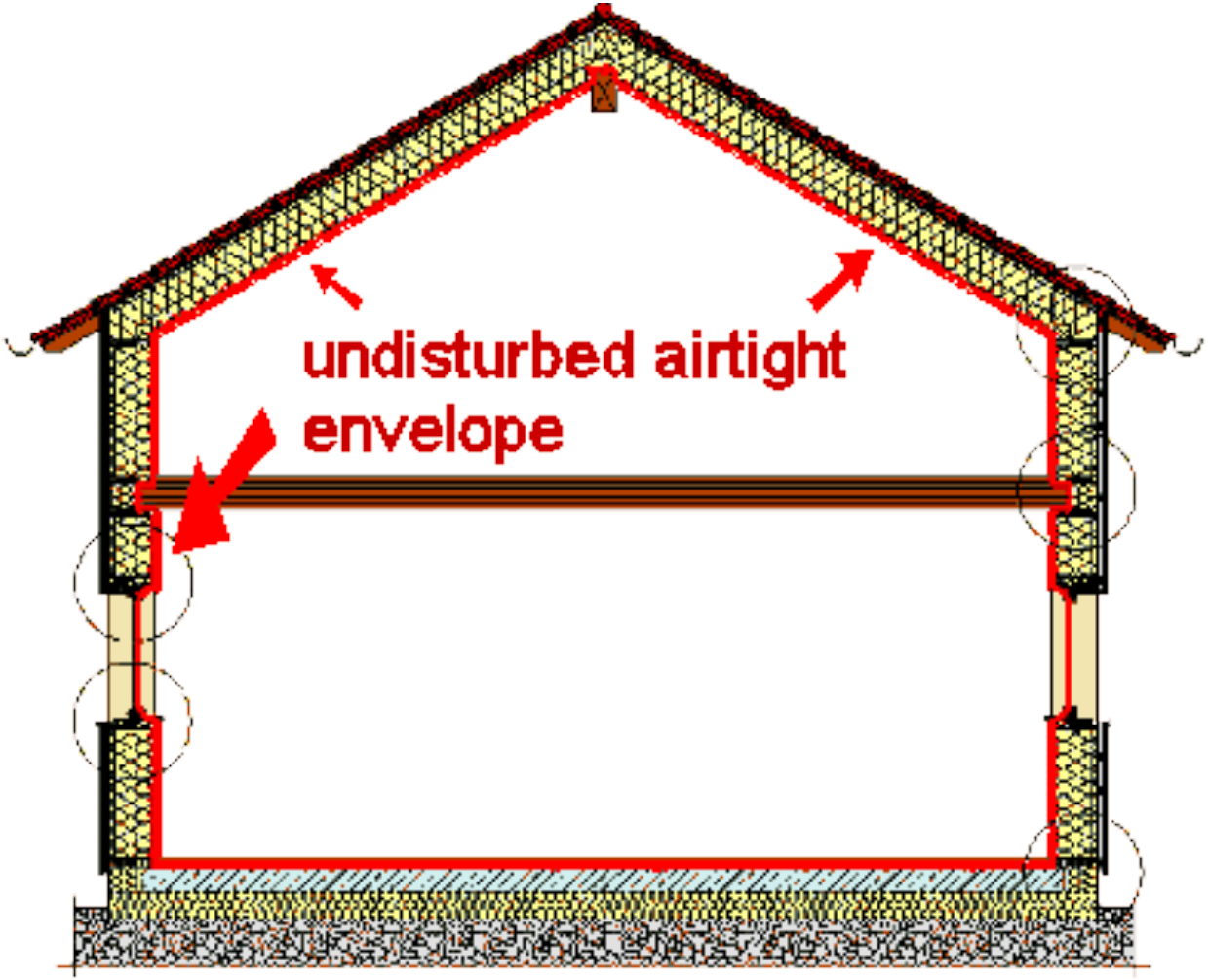
- Air infiltration & exfiltration account for a huge amount of heat loss.
- Continuous air barrier typically under-valued & overlooked.

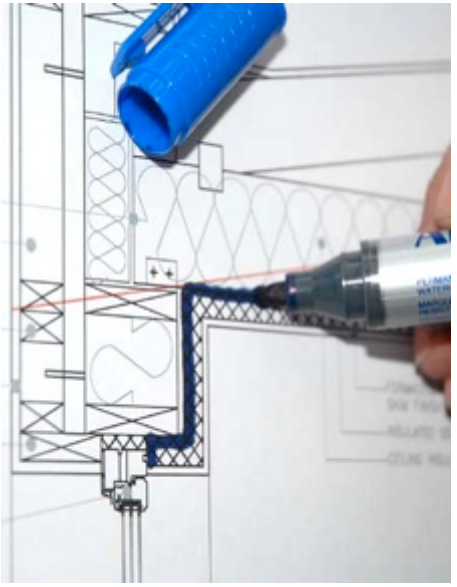
  - Average US house: 3 ft² of holes
  - Typical 2500 ft² home: ½ mile of cracks



Air-Tightness

Continuous air-tight layer is needed (just like insulation).





Air-Tightness

- Minimizes moisture diffusion into wall assembly.
- Protects structural longevity and indoor air quality.
- Mold prevention (Sick Building Syndrome).

Air-Tightness

- Many different strategies.
- Location in wall matters!

Source: Passive VOLKsHouse

Source: Journal of Light Construction

Source:Hayward Design Build

Air-Tightness

- Connect the pieces to maintain continuous air barrier!

Example of wall to window connection.

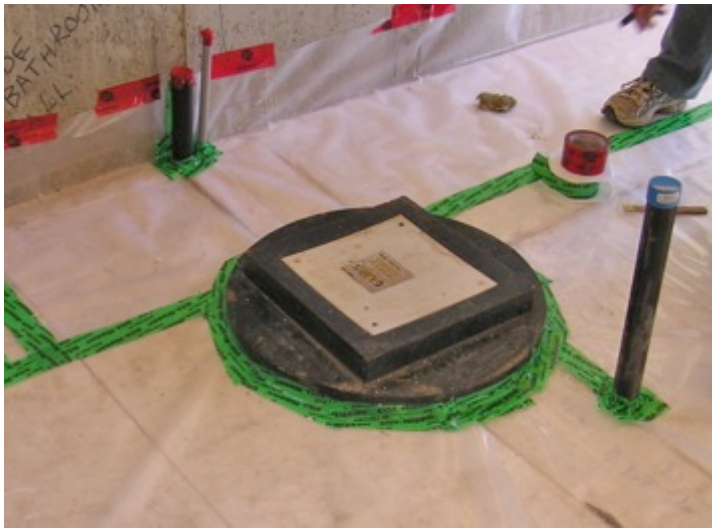
Example of floor to wall connection.

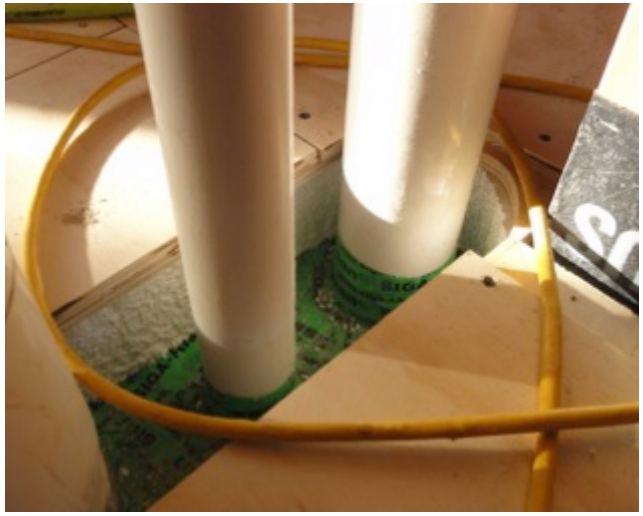
Source: BLDGtypblog

Air-Tightness

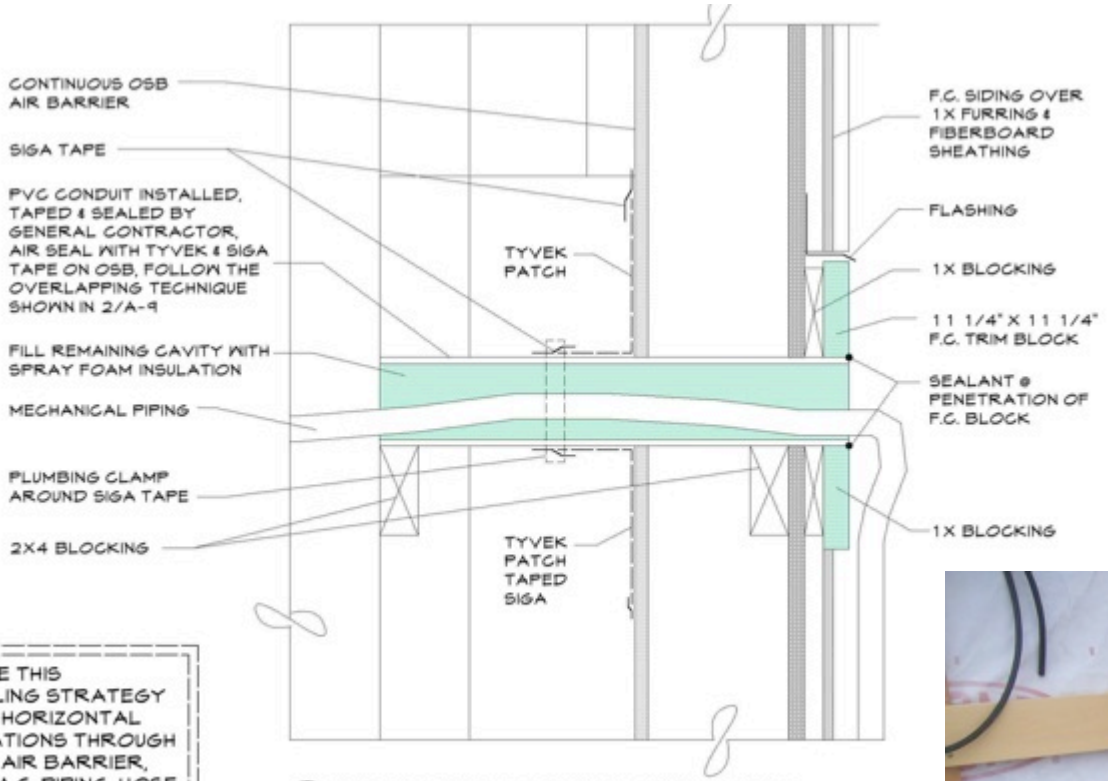
Seal all penetrations – even the smallest ones.

Helpful not to gang penetrations together.



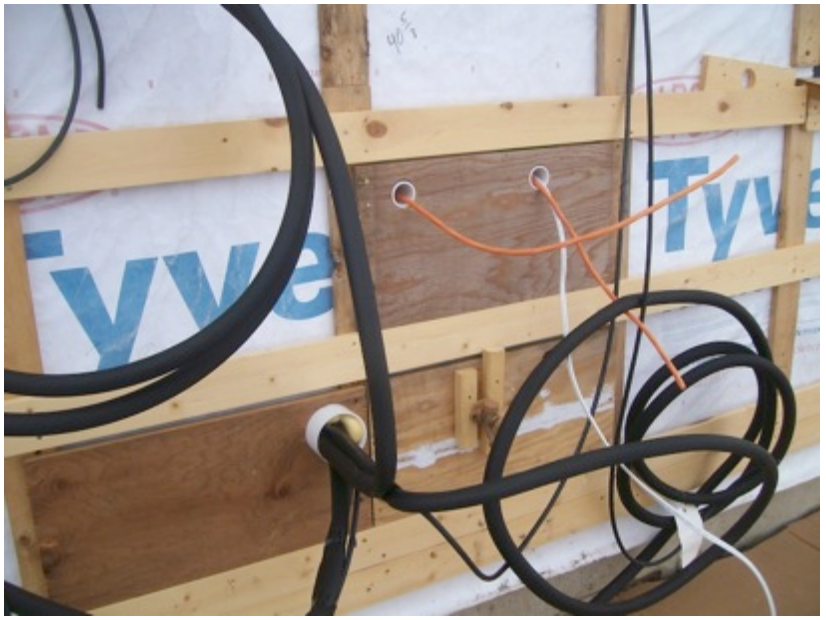


Air-Tightness



SE THIS
LING STRATEGY
HORIZONTAL
ATIONS THROUGH
AIR BARRIER,
A.C. PIPING, HOSE
TC.

4 A-9 AIR SEALING AT HORIZONTAL PENETRATIONS
Scale: 3" = 1'-0"



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Air-tightness: Quality Assurance

Educate the sub-contractors – they will all interact with the air barrier at some point.

Blower Door Test: Test air-tightness before insulation is installed. Seal up air leaks and repeat.

Optimized Solar Gains

Optimize Solar Gains

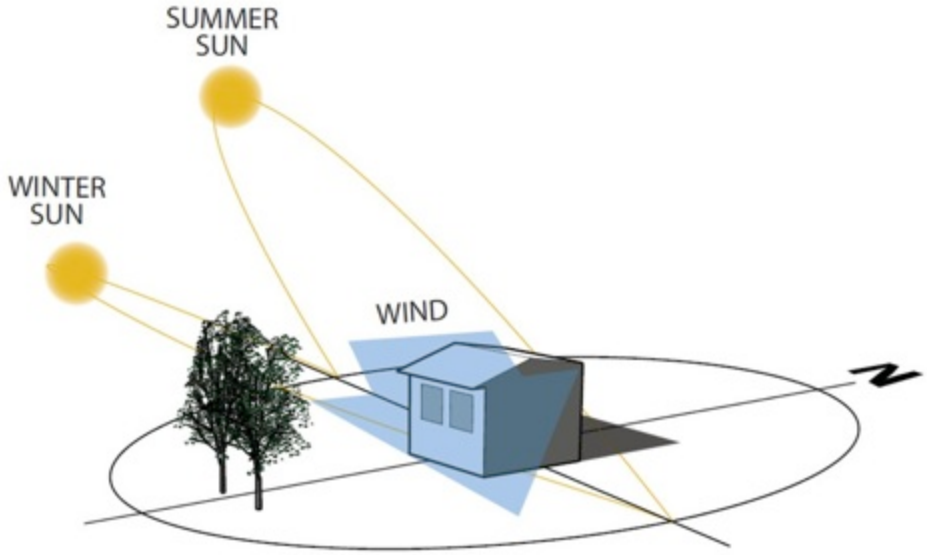
- Not too much, not too little – depends on climate.
- Generally most on south side, least on north side.

Overheating

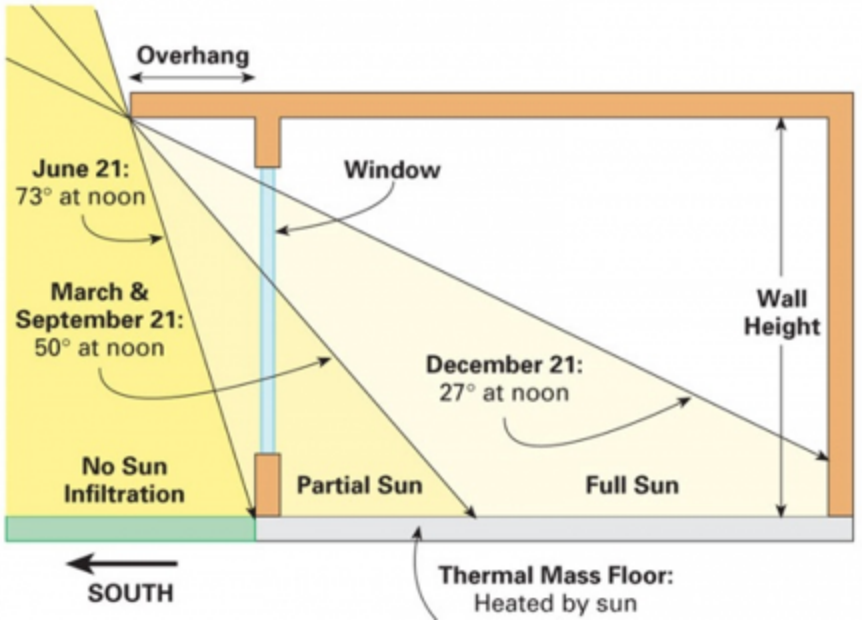
Missed opportunity

Optimize Solar Gains:
Building Orientation & Site Context

- Solar heat gain in winter
- Adjacent trees and buildings

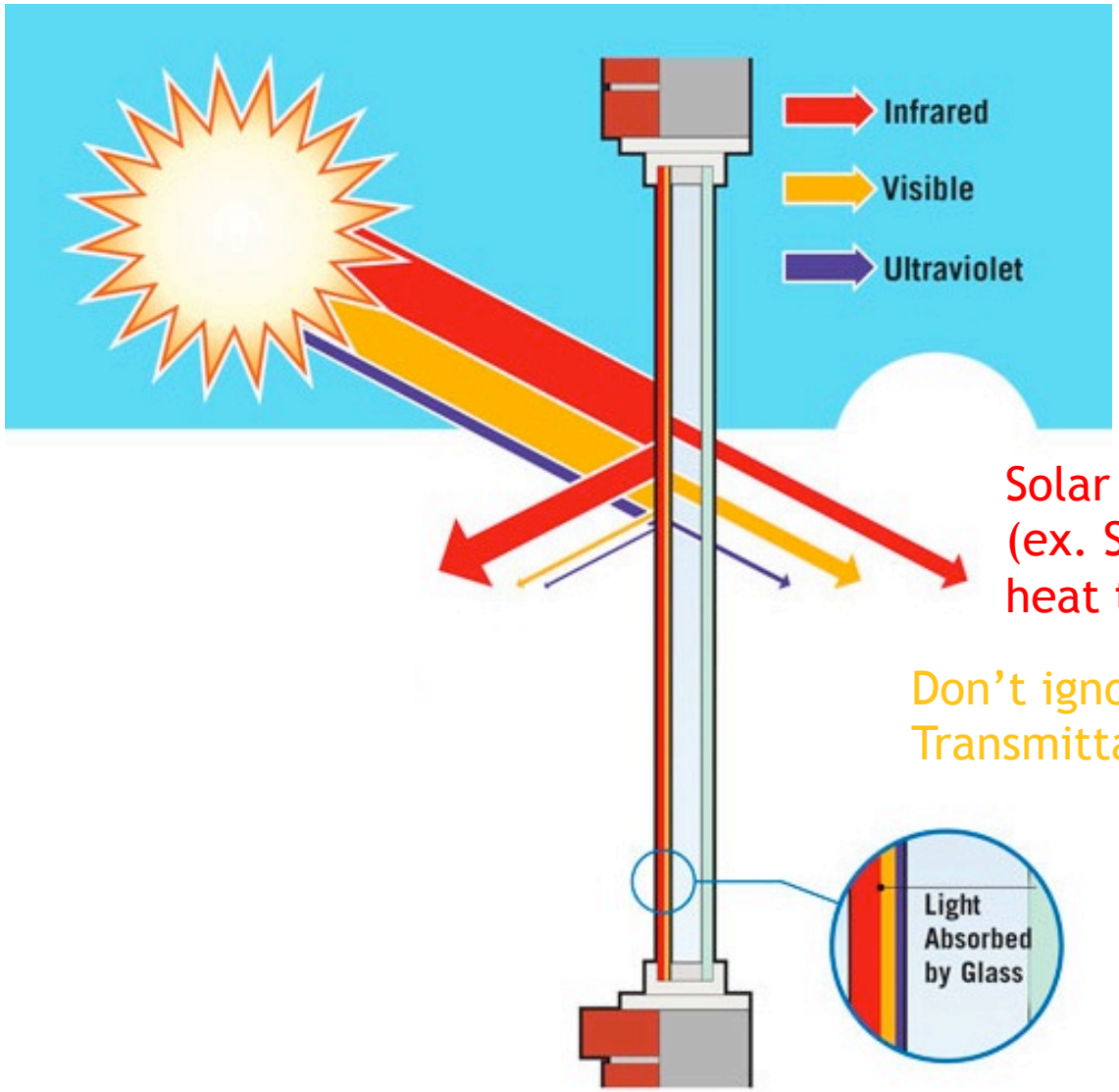


Graphic: Lighthouse Sustainable Center
Source: Passive Design Tool Kit



Source: Homepower.org

Optimize Solar Gains: Glazing Specs

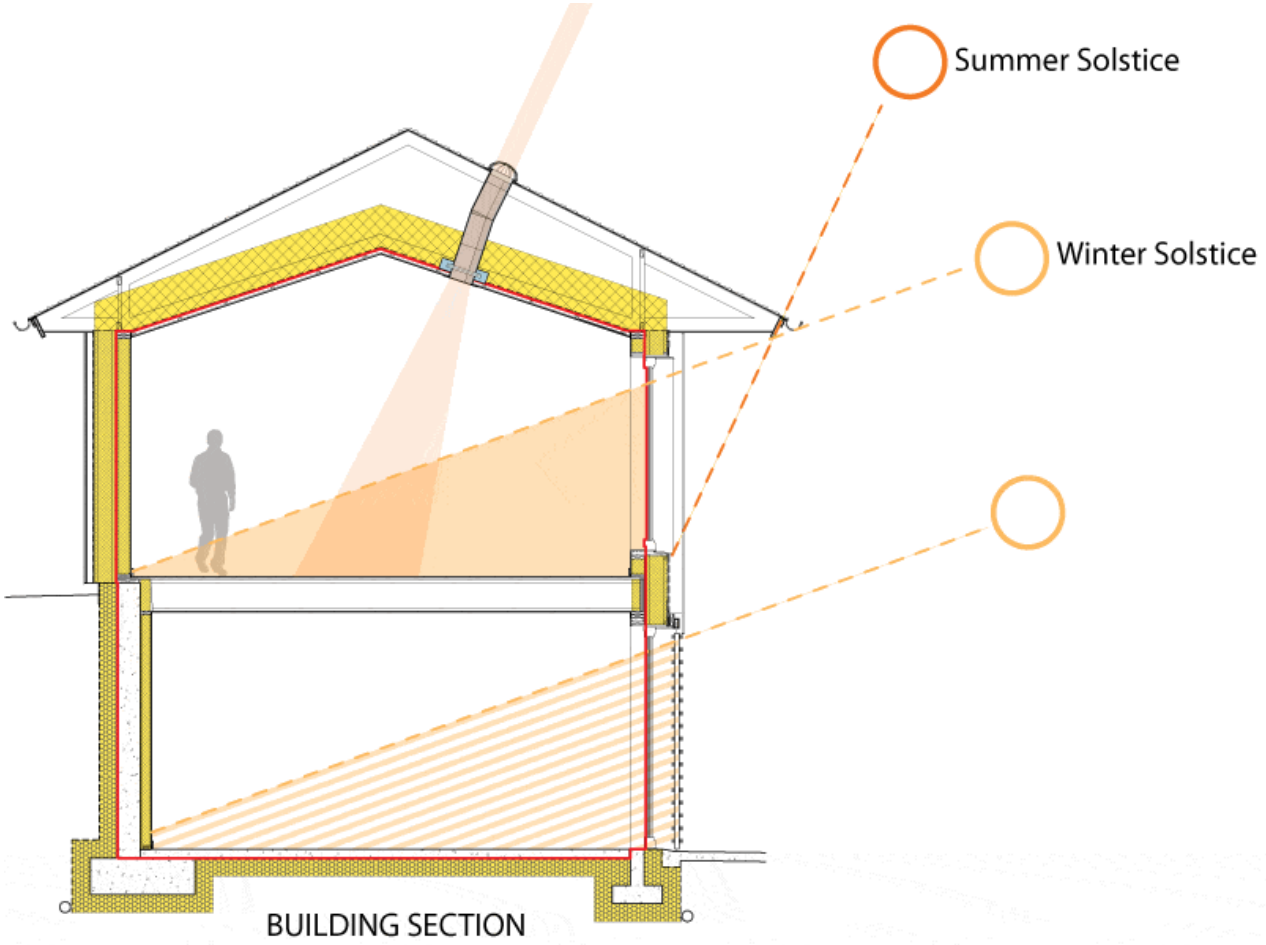


Solar Heat Gain Coefficient (ex. SHGC 0.52 = 52% solar heat transmitted)

Don’t ignore Visible Light Transmittance (VT)!

Optimize Solar Gains: Shade in Summer

- Correct size and placement is important!
- Avoid summer overheating.



Source: Hammer & Hand

Optimize Solar Gains: Shade in Summer

- Many shading strategies.
- Aesthetic opportunity.

Source: Hammer & Hand

Sliding shading panels

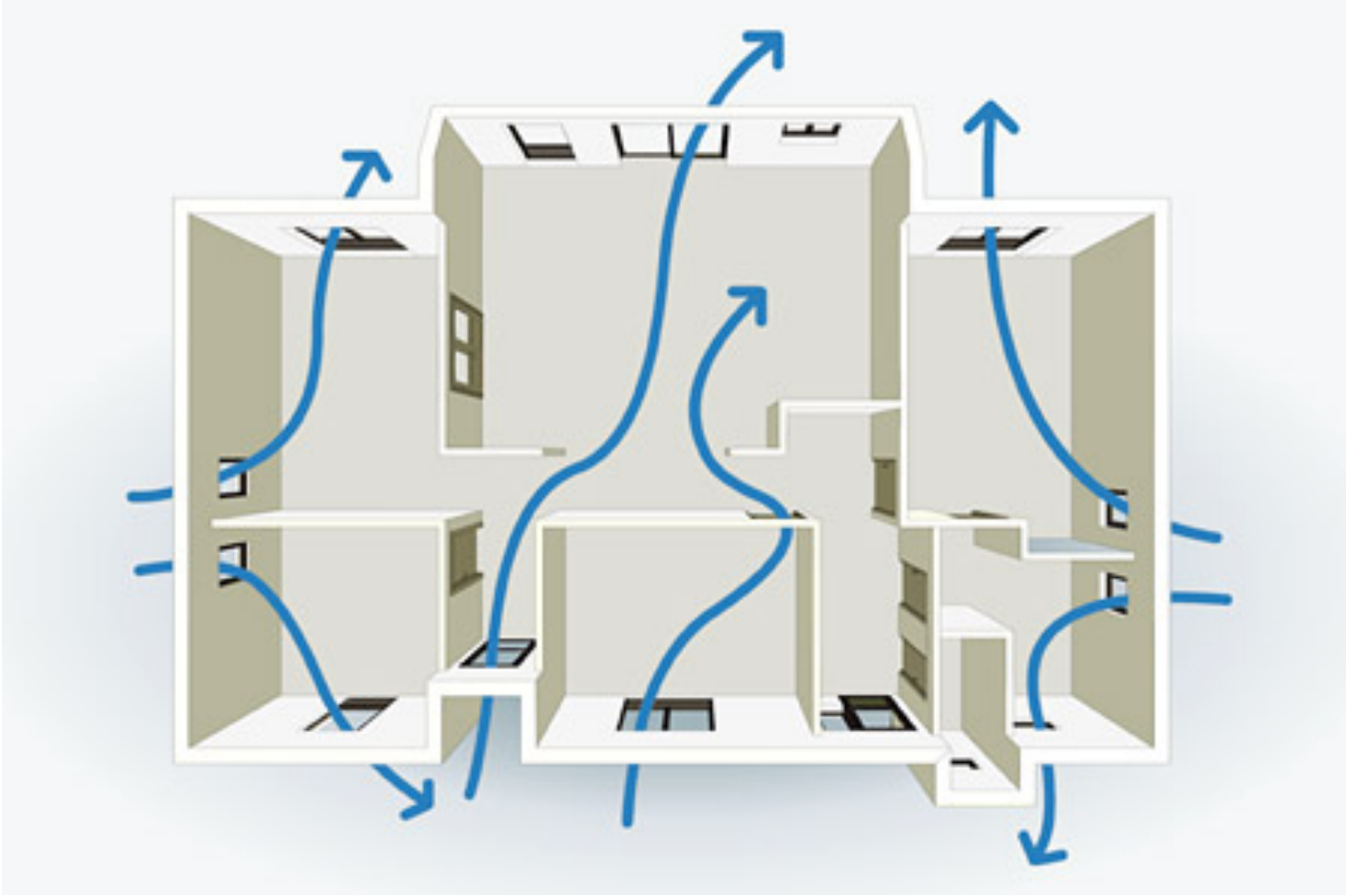
Curt Hofer & Associates

Porches

Canopies & Roof Overhangs

Windows should open!

- Natural ventilation conserves energy

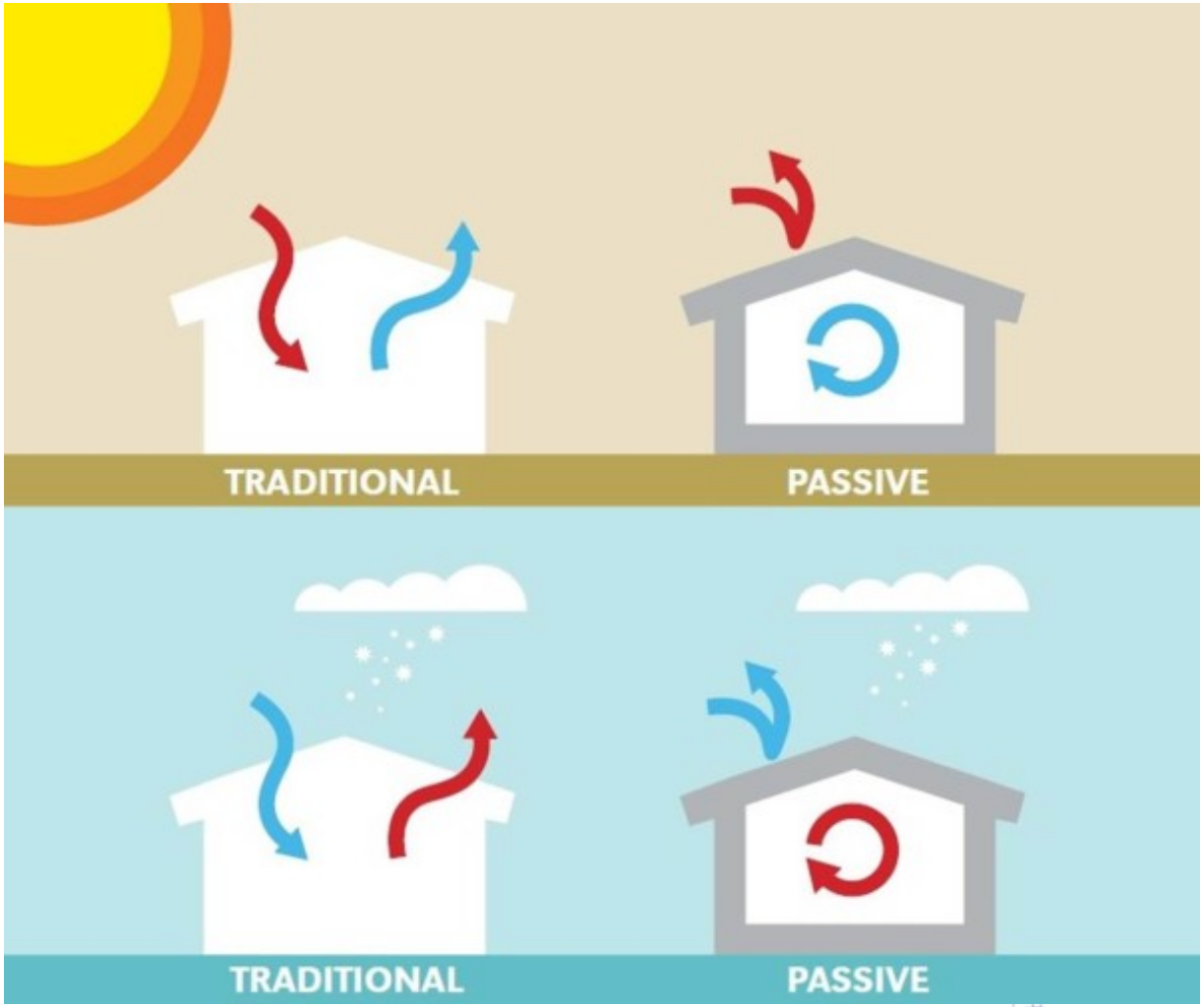


Source: Solartec

Indoor Air Quality & a Minimized Mechanical System

Indoor Air Quality

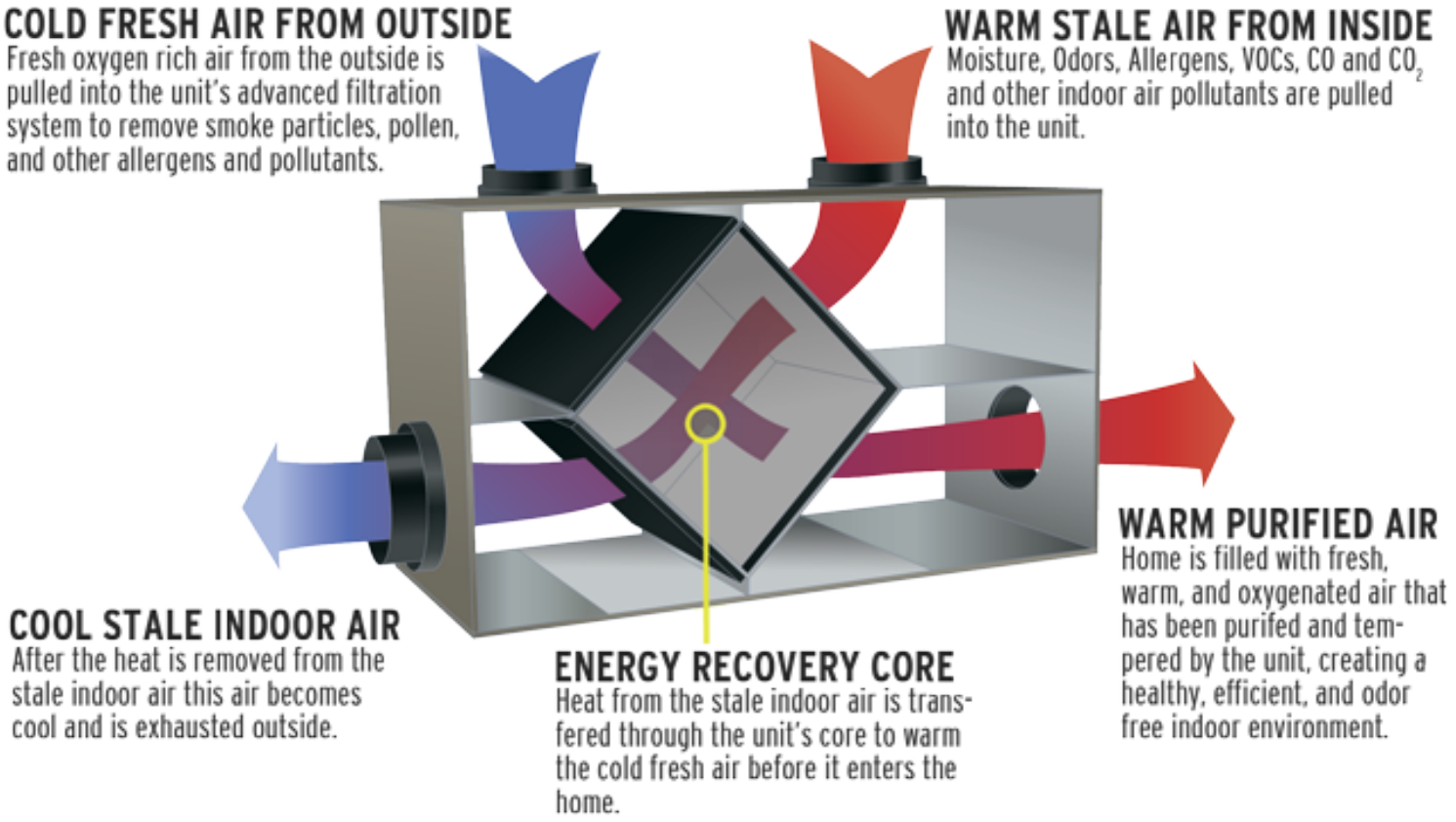
- Uncontrolled vs. controlled ventilation
- Controlled ventilation is healthier & more energy-efficient.



Source: Clarum Homes

Indoor Air Quality & Balanced Heat Recovery Ventilation:

- Constant, filtered fresh air (reduces allergens, pollutants, etc.)
- Heat from outgoing air transferred to incoming air.



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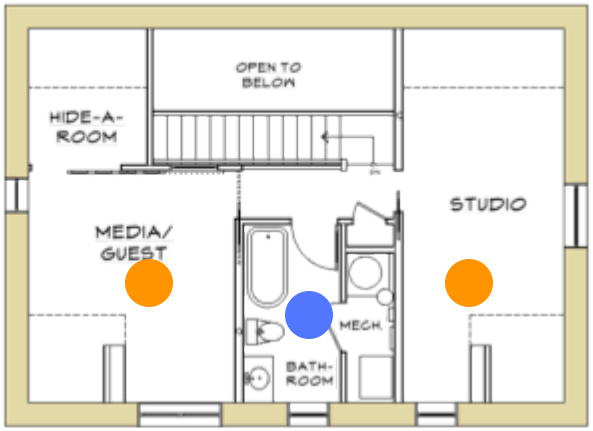
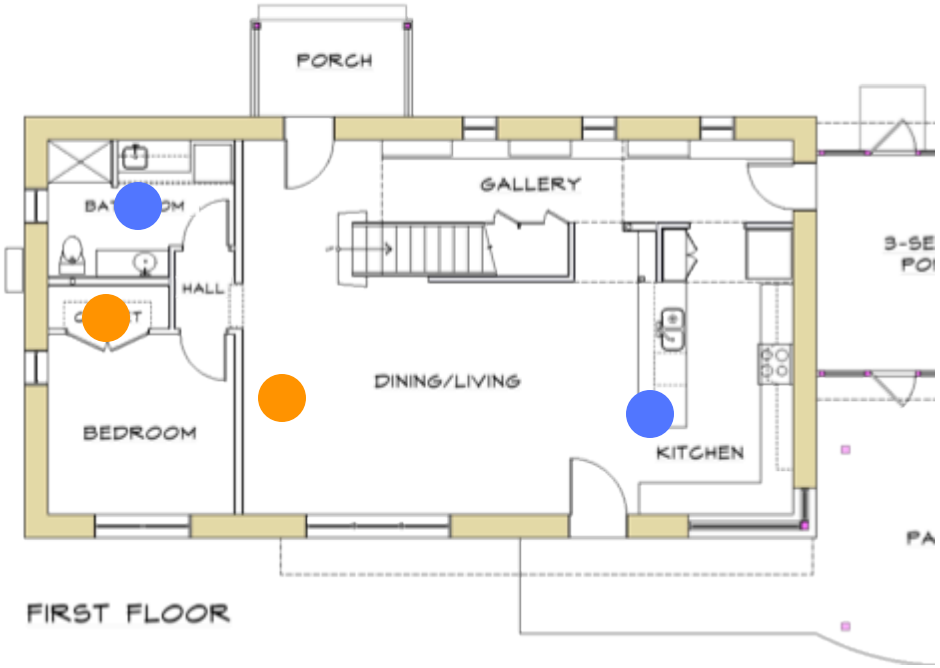
Supply

Exhaust



SECOND FLOOR



FIRST FLOOR

Fresh air is supplied to living spaces & exhausted from bathrooms, kitchens, laundry.

Zehnder ComfoAir 350 ERV

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Balanced Heat Recovery Ventilation:

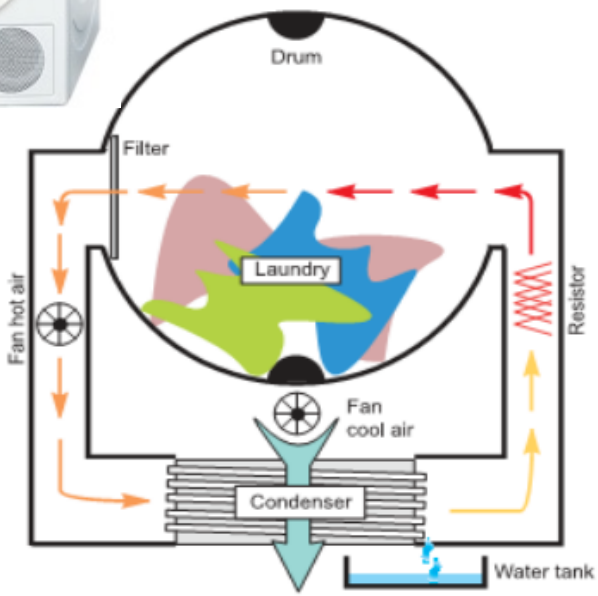
- Low velocity
- Ventilation Ductwork fits within 2x4 wall and is flexible.

Balanced Ventilation & Direct-Vent Appliances

- Air is exhausted without recovering the heat.
- Can throw off the balance of the ventilation system.
- Compromise the air tightness of the building – lack of good dampers.
- Examples of direct vent appliances: clothes dryer, range hood, fireplace.

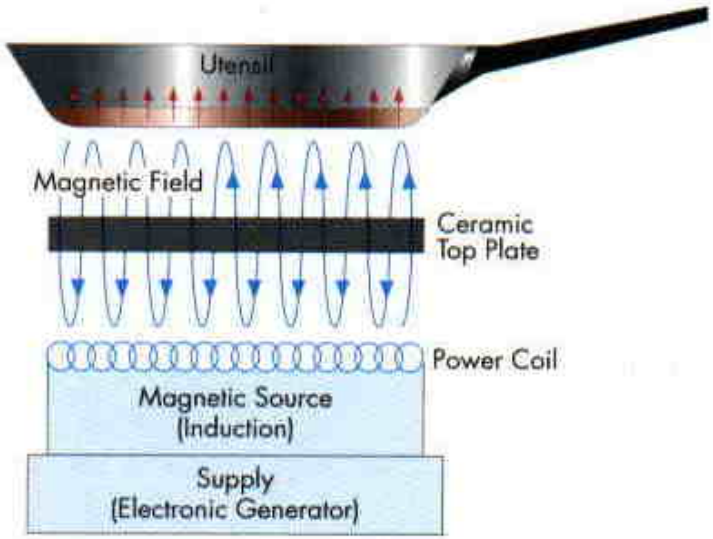
Clothes Dryer Options:

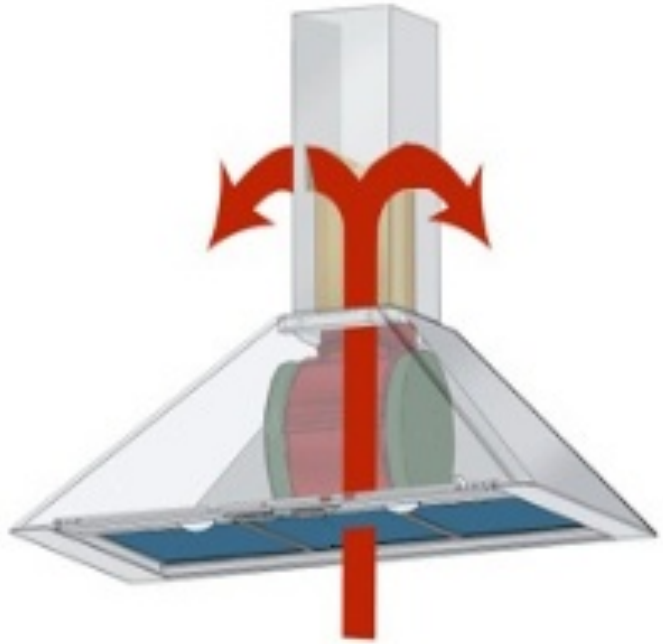
- Remove the laundry from the air tight envelope.
- Condensing dryer instead of traditional dryer.
- Opt for no dryer – use racks & lines – lifestyle choice.



Range & Hood Options:

- Select an electric, halogen or induction cooking appliances that can use recirculating range hoods (gas stoves need to exhaust due to combustion).
- Select the lowest possible CFM range hood and work with the ERV supplier to address system balance concerns.





Fireplace options:

- Traditional fireplaces kick out way too much heat for a PH.
- Move fireplace out of thermal envelope (ex. Screened porch)
- Choose a closed combustion, low-BTU wood stove.

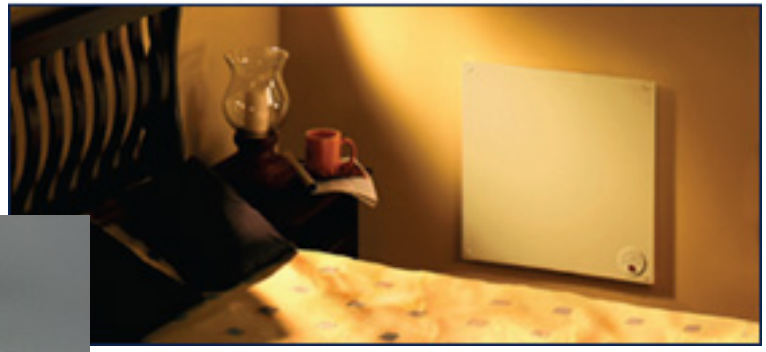
Source: Rika

Newenhouse Passive House, Source: Inhabitat

Minimized Mechanical System

- Passive Houses have tiny loads.
- Ex: Root River House Peak Heat Load: 6,503 BTU/hr
- Smallest available furnace = 35,000 - 40,000 BTU/hr

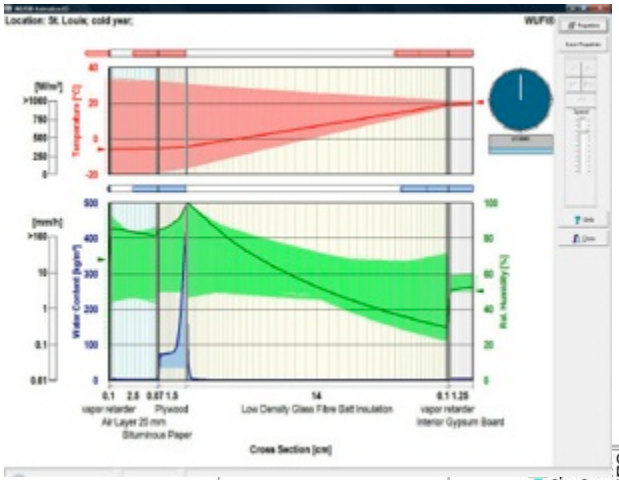
ecoheater®
warm never felt so good™

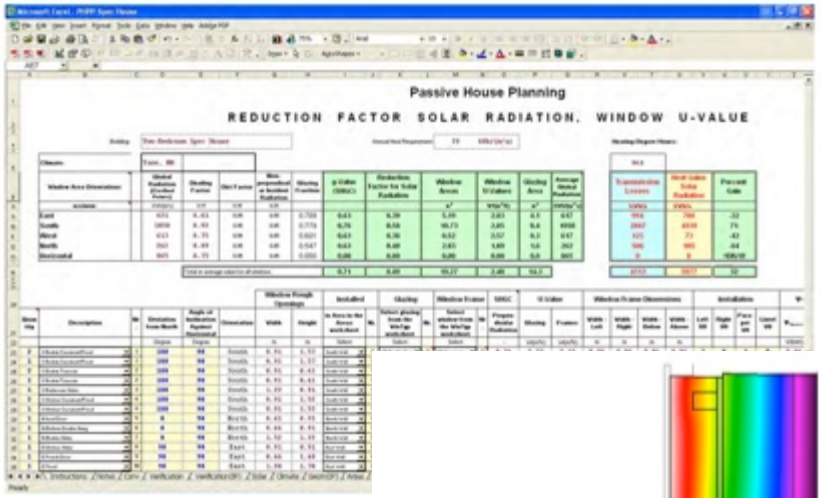


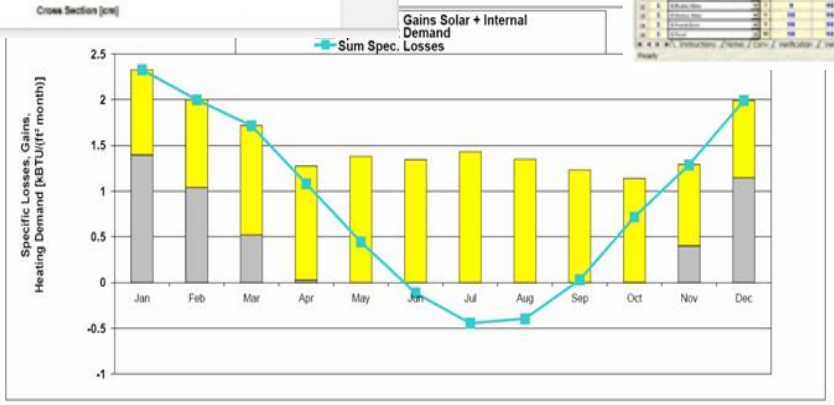
Computer Modeling

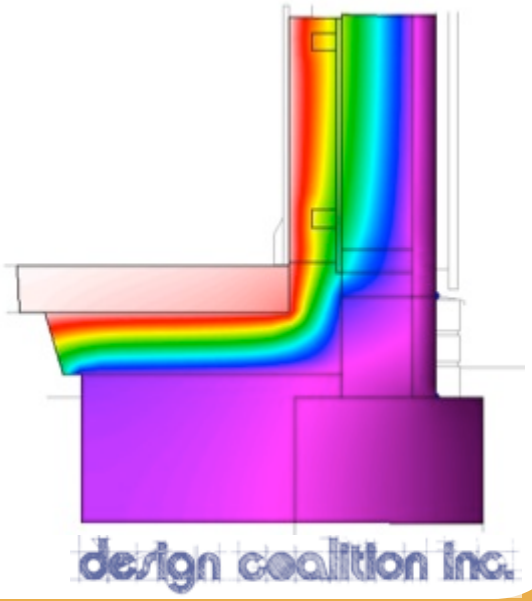
Energy, Moisture, & Thermal Modeling:

- Passive House Planning Package (PHPP) – energy modeling
- Optimize the envelope, window sizes, shading, insulation levels, etc.
- WUFI Passive – energy and hygro-thermal (moisture/condensation risks)
- THERM – thermal bridges analysis









The main take-aways:

- Conserve first through good design -- then renewables.
- Integration is key.
- Educate the entire construction team on the Passive House goals – especially on air-tightness.
- Details are everything!!

Passive House:

The Standard & Certification

PHIUS

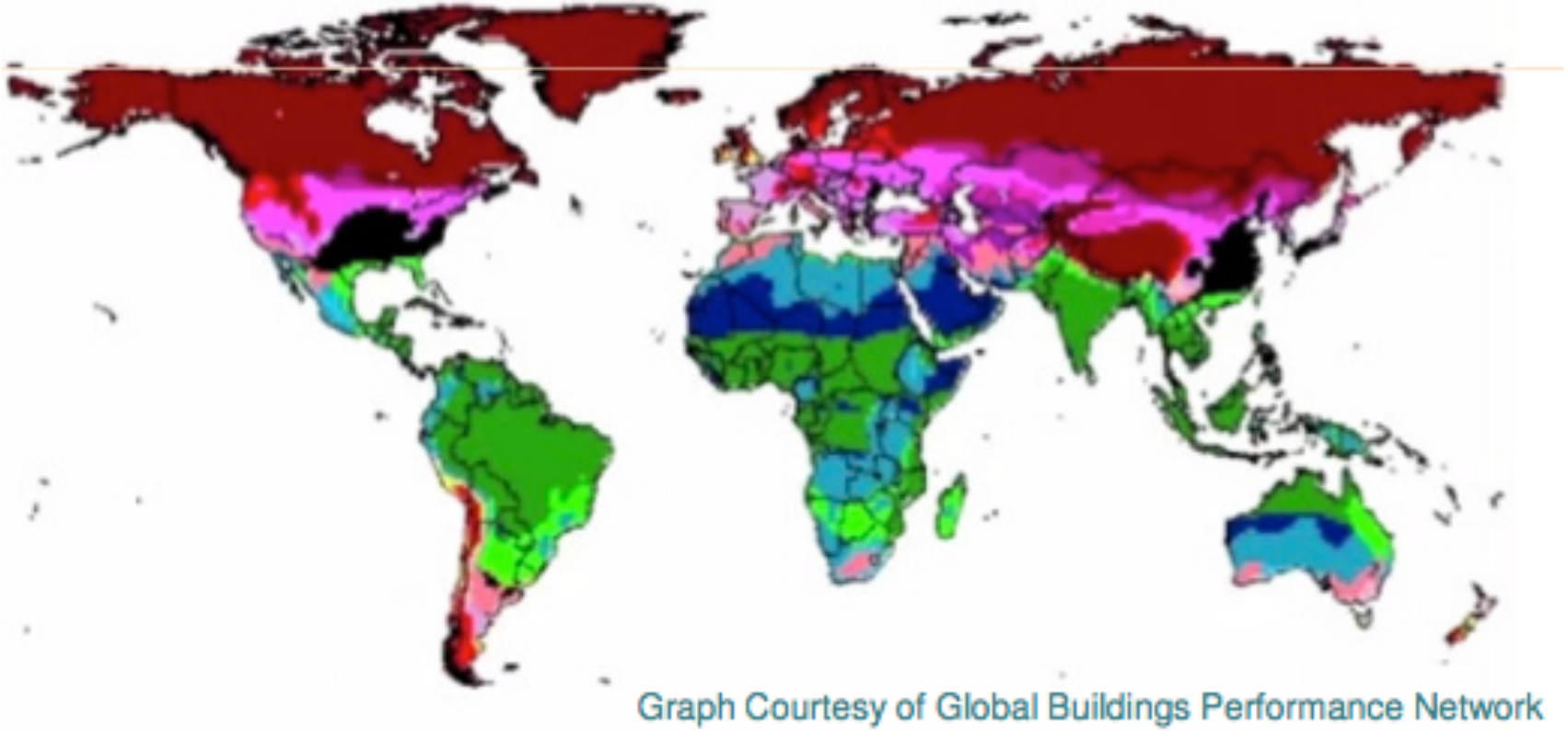
Passive House Institute US

design coalition inc.

Passive House certification criteria
have changed…
but the methodology has NOT!

Passivehaus criteria optimized for German climate:

One size fits all approach does not work in North America…



Graph Courtesy of Global Buildings Performance Network

THE CONCEPT CONTINUES TO DEVELOP

CLIMATE SPECIFIC METRICS

VARYING CLIMATES – DIFFERENT METRICS?

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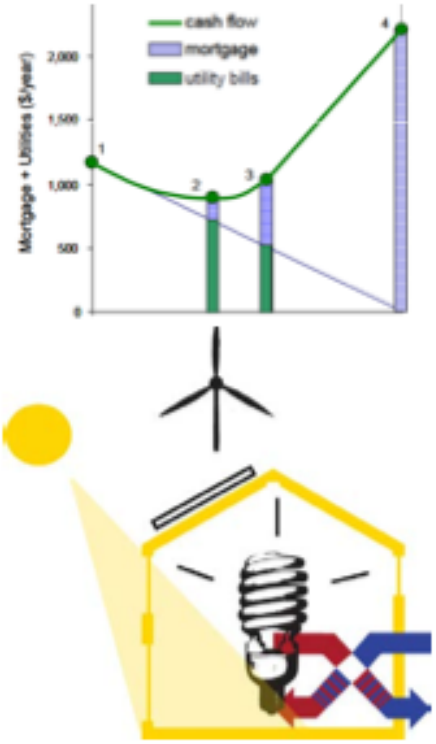
Main issues:

- In colder climates, old criteria are not cost-optimal.
- In warmer climates, cost-feasible energy savings left on the table.
- Air-tightness requirement was based on SF of floor area rather than SF of building envelope (allowing large buildings to be leaky than small buildings).
- Primary Energy was based on SF, rather than a “fair-share” per/person requirement.
- Tendency towards overheating.
- Assumed energy-use defaults for lighting and plug loads were too low compared to actual use by the average North American.
- Certification did not allow for the use of solar-electric.

Climate Specific & Cost Optimal Standards

Developed by US Industry



- Used NREL BEopt program to determine cost-optimized performance targets by climate that represent the "sweet spot" where aggressive carbon & energy reduction overlap with cost-effectiveness.

- Goal of pushing forward on the path to net-zero.

New Climate-Specific Metrics

Passive House Institute US

Annual Heat & Cooling Demand	• Varies by climate	Sliding scale by climate, cold climate example
and		
Peak Loads	• Varies by climate	Sliding scale by climate, cold climate example
Primary Energy Demand	• ≤ 4200 (6200 TEMP) kWh/person	Change to a per person metric for residential and some PV counts
Airtightness	• ≤ 0.05 cfm^{50}/ft^2 envelope	ACH50 does not scale for larger buildings

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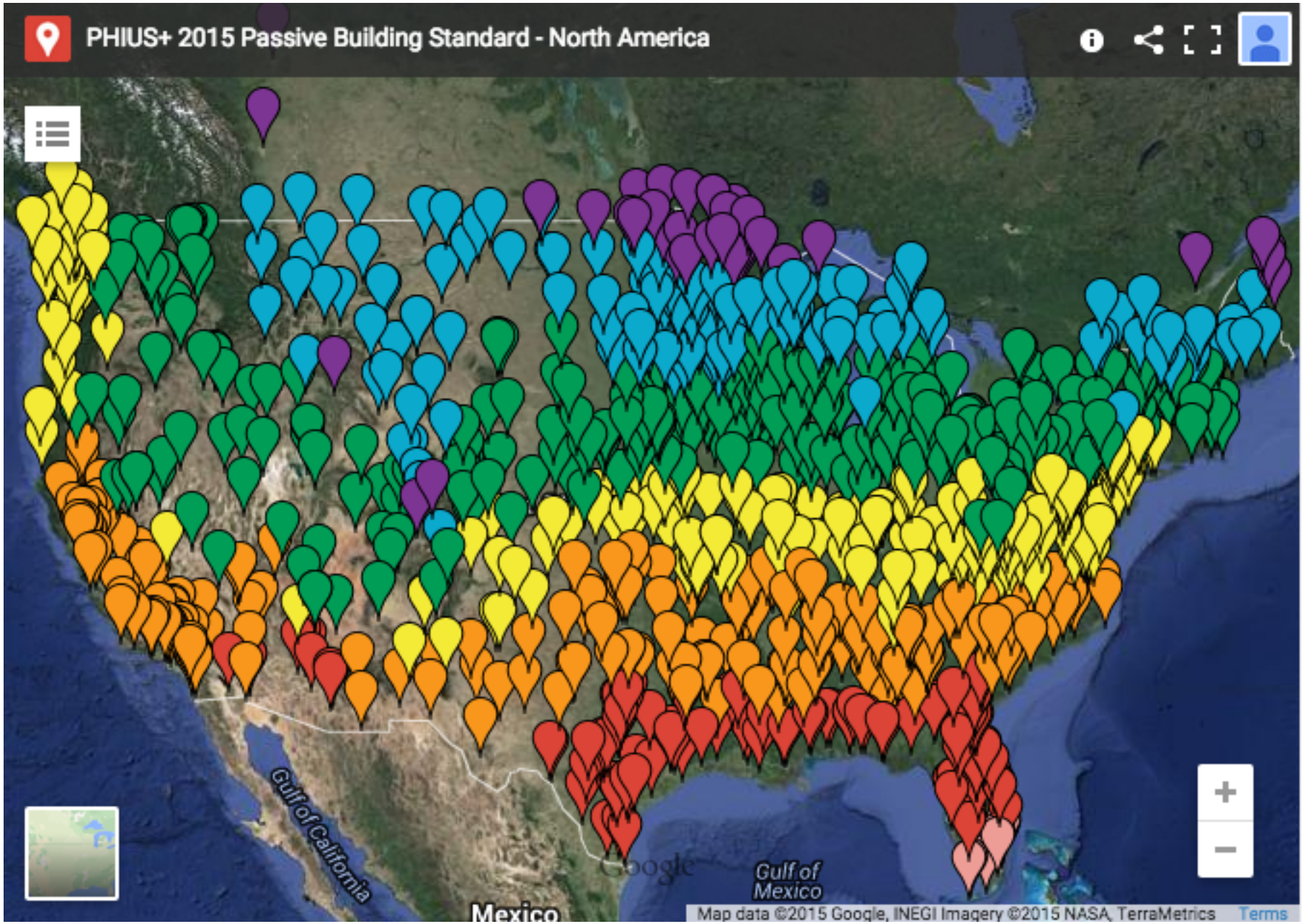

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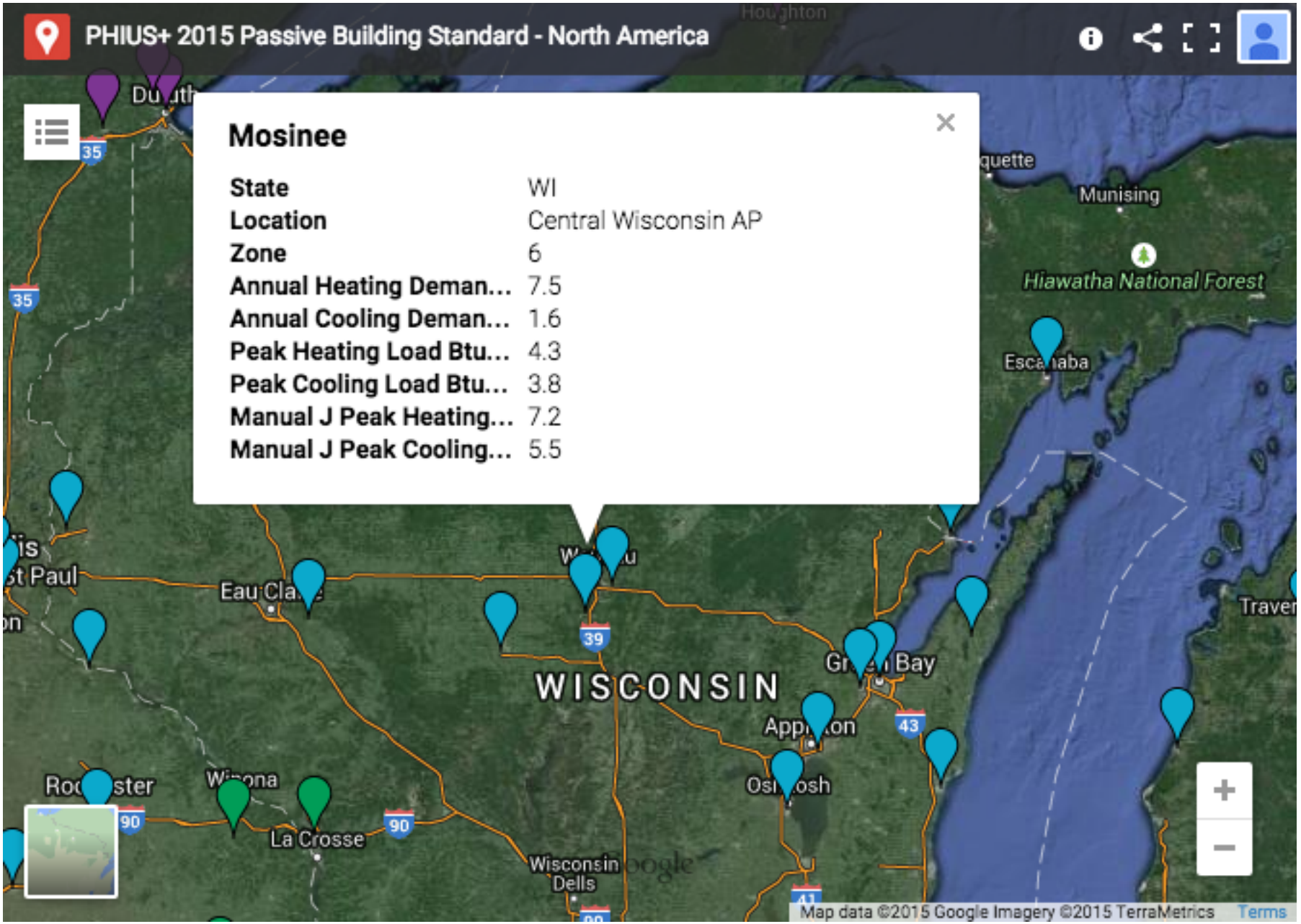

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PHIUS+ Certification combines both program characteristics (2012 onward):

- New Construction Residential
- New Construction Commercial
- Retrofit

PHIUS
Passive House Institute US

www.PHIUS.org

PHIUS+2015 Certification

- Full review of project plans, details, & energy model.
- Blower door test required.
- Cost of Certification is $1,000-$2,000 depending on SF and involvement of CPHC.
- PHIUS-approved RESNET Rater evaluation, site inspections, and QA/QC report. (additional cost to hire)
- Includes the assignment of a HERS Index (eligibility for LEED for Homes and Energy Star).
- Earn DOE Zero Energy Ready Home status.

Cost & Affordability

How much?

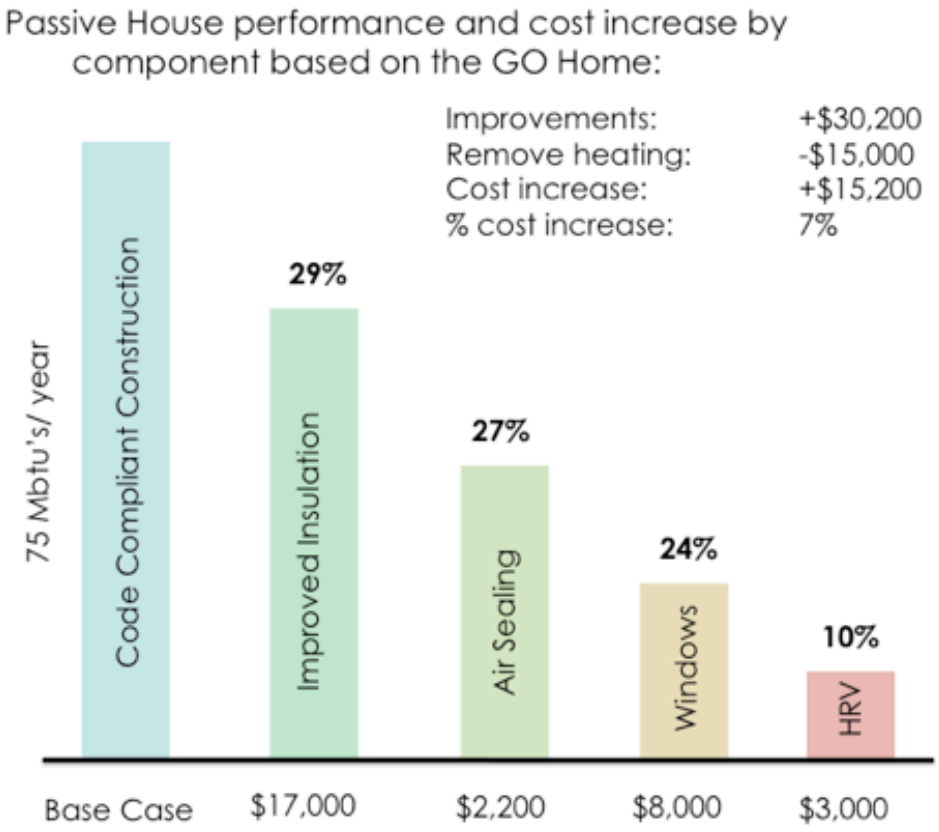
U.S. PH projects:

- More research needed.
- 2%-15% cost increase over standard construction.
- Need to start integrating PH strategies from the beginning of project!
- Depends on how “fancy” you get.
- Increased up-front cost offset by massive energy use reductions.
- Elimination of conventional HVAC system *(also less maintenance cost)*.
- More money available for better insulation and windows.
- Tiny loads make alternative energy sources more affordable.

GO Home

Does not take into account:

- increased market value
- rising energy costs
- long-term operational cost savings



Source: GO Logic

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Root River House – Cost Analysis

Monthly expense comparison

	Base Case House	Root River House
Total Construction Cost	$338,610	$383,570
20% Downpayment	$67,722	$76,714
80% Financed (30 yr. Mortgage @ 4.25% interest)	$270,888	$306,856
Monthly Mortgage Payment (P&I)	$1,332	$1,409
Approx. Monthly Energy Bill*	$220	$45
Total Monthly Cost	$1,552	$1,454

*Grid connection charge from power co-op is $32/mo.

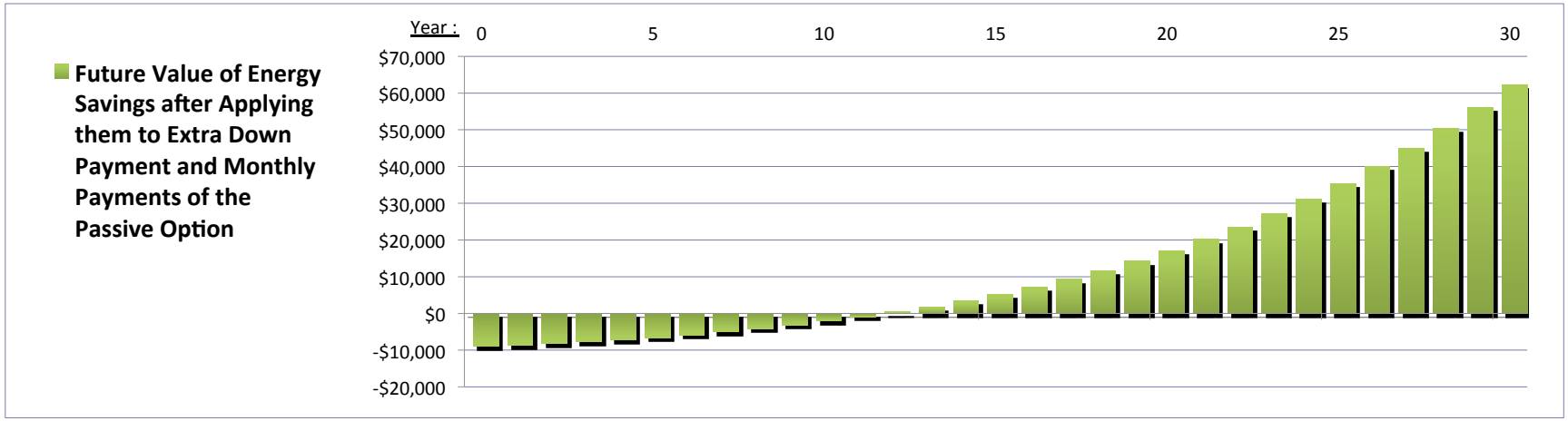
$98 savings/month for the first year of mortgage

Root River House – Cost Analysis

Future Value & Rising Energy Costs

Cost of Home Options	Cost of Baseline Home	Cost to Upgrade to Passive House	Cost of Passive House
	338,610	13.28%	383,577

Energy Cost, Baseline Home ($ per month)	220
Annual Rate of increase in Energy Costs Projected	3%
Energy Reduction from Passive House Approach (%)	93%



Areas below zero indicate that the extra down and monthly payments exceed the value of the energy savings to date.

When the value reaches zero, it's all gravy - and the energy savings each month will add up to a substantial sum!

INFORMATION PRESENTED BY: Christi Weber, Design Coalition, Inc.

Beyond the financial - the **REAL** Return on Investment

-No drafts, cold spots, or large temperature swings - surfaces are warm

-Healthy air

-Daylight and views to outside

-Acoustical benefits

-No fear (or less fear) of the unknown
(weather, energy prices, power grid)

-Reduction of personal ecological footprint

Energy-efficient homes have higher values.

- Market value of a home increases $20 for every $1 decrease in annual energy costs. - *The Appraisal Journal*
- Newly constructed homes with a HERS rating in Portland sold for 8% more, existing homes for 30% more. - *Earth Advantage Institute*

Energy-efficient homes sell faster.

- Earth Advantage Institute

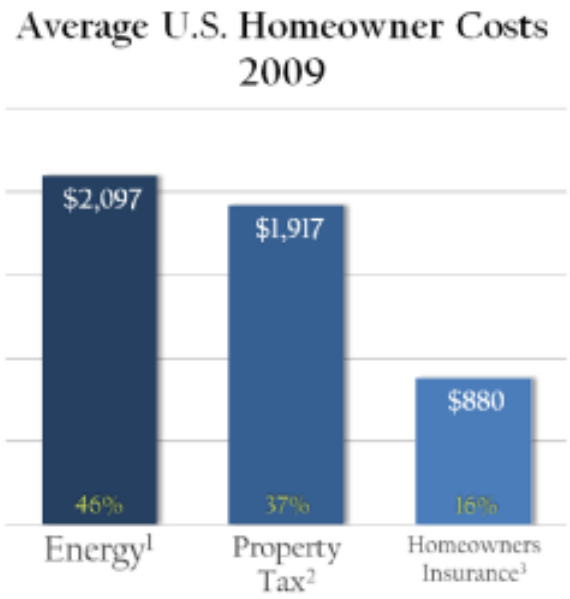
The SAVE Act: Sensible Accounting to Value Energy [S.1106]

- Proposed legislation to improve accuracy of mortgage underwriting
- Would ensure energy costs are included in the underwriting process
- Borrower capacity adjusted for energy costs
- Home values reflect energy cost savings

Energy costs now exceed property taxes and insurance, which are accounted for in mortgage underwriting.

A homeowner who spends less on utilities will have more money to make mortgage payments.

Contact your Senators and Representatives – especially if he/she site on Banking, Housing & Urban Affairs Committee.



IMT

More information: www.imt.org/save-act

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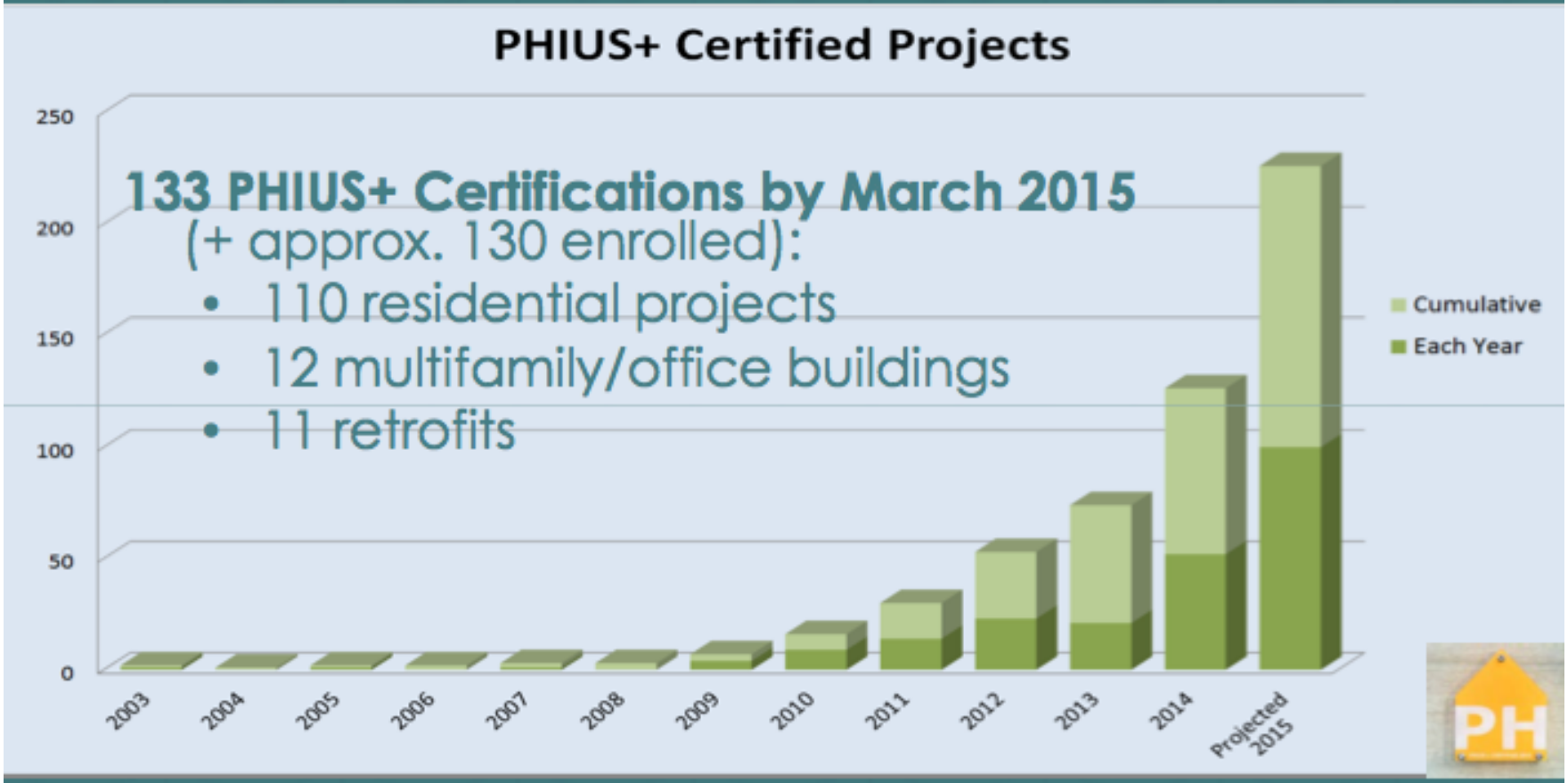
Passive House Case Studies abound!

PASSIVE HOUSE US DATABASE



Source: www.phius.org

PHIUS/ZERH CERTIFIED PROJECTS

Wisconsin Examples

SWIPHT House, by Western Technical College, LaCrosse, WI

Newenhouse Home, Viroqua, WI

“Passive House in the Woods”, Hudson, WI

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Other U.S. Residential Examples

Lema House, River Forest, IL

Hudson Passive Project, Hudson, NY

G.O. Home

Oregon Passive House, Portland, OR

Breezeway House, Salt Lake City

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Multifamily U.S. Examples

TrekHaus, Portland, OR

02Haus, Portland, OR

Stellar Passive House Apartment Building
Eugene, OR

Commercial U.S. Examples

Glasswood Passive House Retrofit,
Portland, OR

Center of Energy Efficient Design,
Rocky Mount, VA

Waldsee Biohaus School, Bemidji, MN
First Certified Passive House in the US

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Schools and Commercial Examples in Europe

Retrofit: The Drexel & Weiss factory

Primary School in the UK

Office Tower in Austria

Montessori School, Germany

design coalition inc.

Case Study @ Noon on Saturday!!!

The Root River House

A Net-Zero Project

www.rootriverhouse.2030home.org

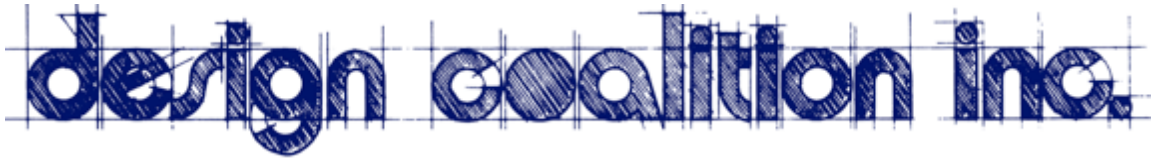
design coalition inc.

Thank you!

Christi Weber

Building Designer & Certified Passive House Consultant

Design Coalition Architects, Madison, WI



www.designcoalition.org

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