Happy Homes

Matt Oster

Red Edge Design

matt@rededgealaska.com

Objectives

- How do we Talk About What We Build or Live In
- Where is NZE Compared to what we Build Today
- Intro into Passive House as a Metric and Model
- Retro-fitting Existing Structures
- Wall Assemblies and Details for New Construction
- Air Tightness and Ventilation
- Heating and Over Heating

Happy Homes?

What is this all about?

How do we describe:

~ Durable – 20,50,100,200 years

~ Energy Efficient, metric?

~ Site Appropriate and Orientation

~ Moisture Management

~ No Pollution, Healthy Indoor Air

~ Highly Comfortable

~ Environmental Impact

~ Repairable

~ Affordable, over how long?

- Energy Star 5star+, 6star
- Super Insulated Home
- DEC Building America
- Passive House
- IEEC 2009
- A Builder's Reputation
- Net Zero Energy
- Living Building Challenge
- Natural Building
- Passive Solar Home

It's not just About Energy Efficiency!

We need to look at the human, environmental, aesthetic, durability, pollution, etc. issues as well as the monetary paybacks to describe what we want to live in.

What Are We Building?

Think and Listen.

What are words or descriptors we can use to encapsulate all of these characteristics of a home, besides Happy☺!

Path to NZE

What Are our options?

We have a couple:

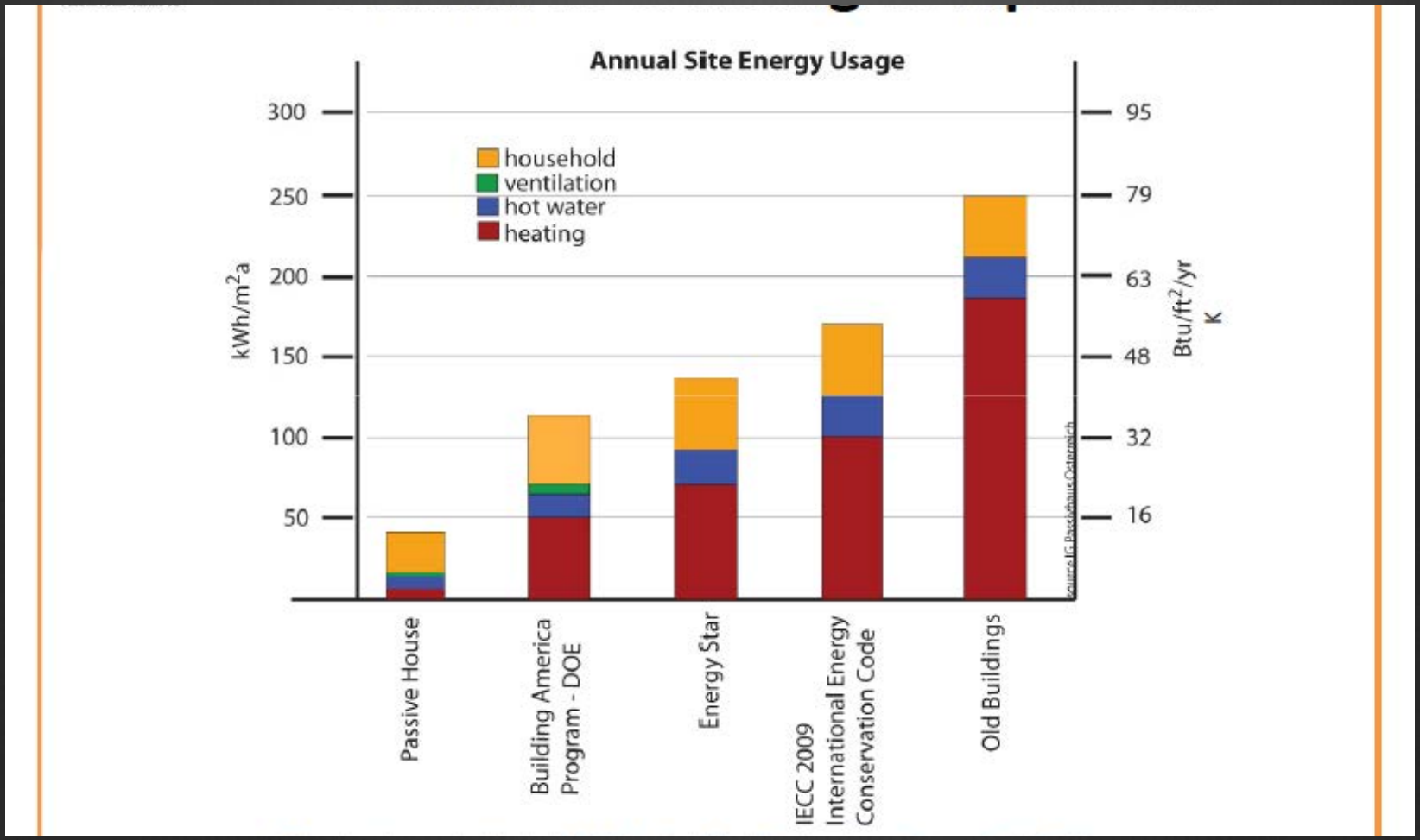
1 – Add a crap ton of Renewables to existing stock

2 – Build or Retro-fit our building shells to fit small Renewable systems

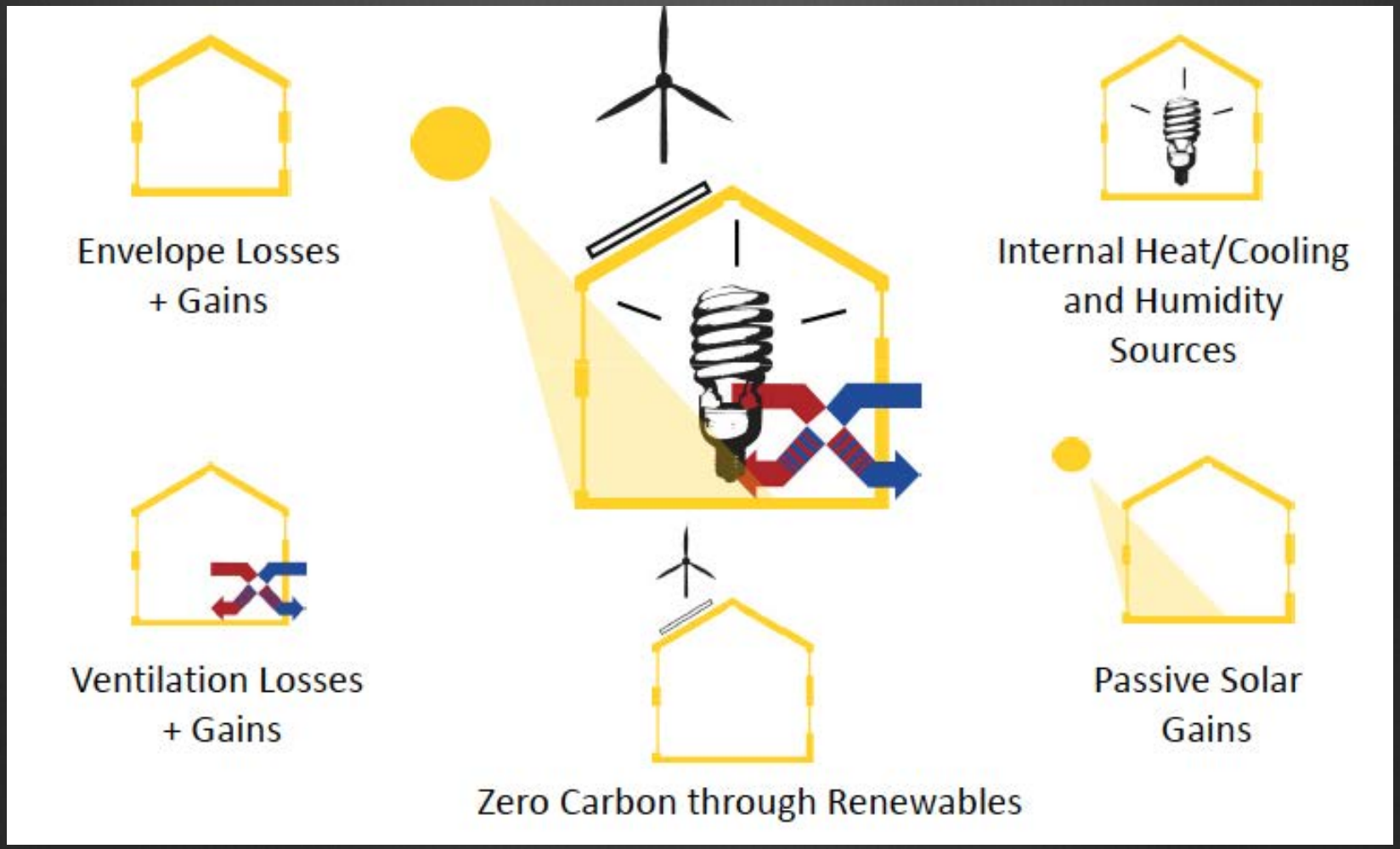
3 – Move to Iceland and build what ever you want

My 6star home NZE

Orders of Magnitude



Passive House as a Metric



This is the basis of PH

$$P_{H,\,Supply} = V * \Delta\vartheta * \rho c_p$$

$$P_{H,\,Supply} = 3.26\ ft^3/(hr.ft^2) * 54F * 0.018\ BTU/(hr.\ ft^3\ ^\circ\ F)$$

$$P_{H,\,Supply} = 3.17\ BTU/hr.ft^2$$

V	Ventilation Rate ($35ft^3/hr$ air per $10.8ft^2$ of living space= $3.26\ ft^3/(h.ft^2)$ $(.05cfm/ft^2)$
$\Delta\vartheta$	Difference between 68 F and 122 F (aka ΔT)
ρc_p	Heat capacity of air (aka c_{air})

PH Criteria

Energy Metrics

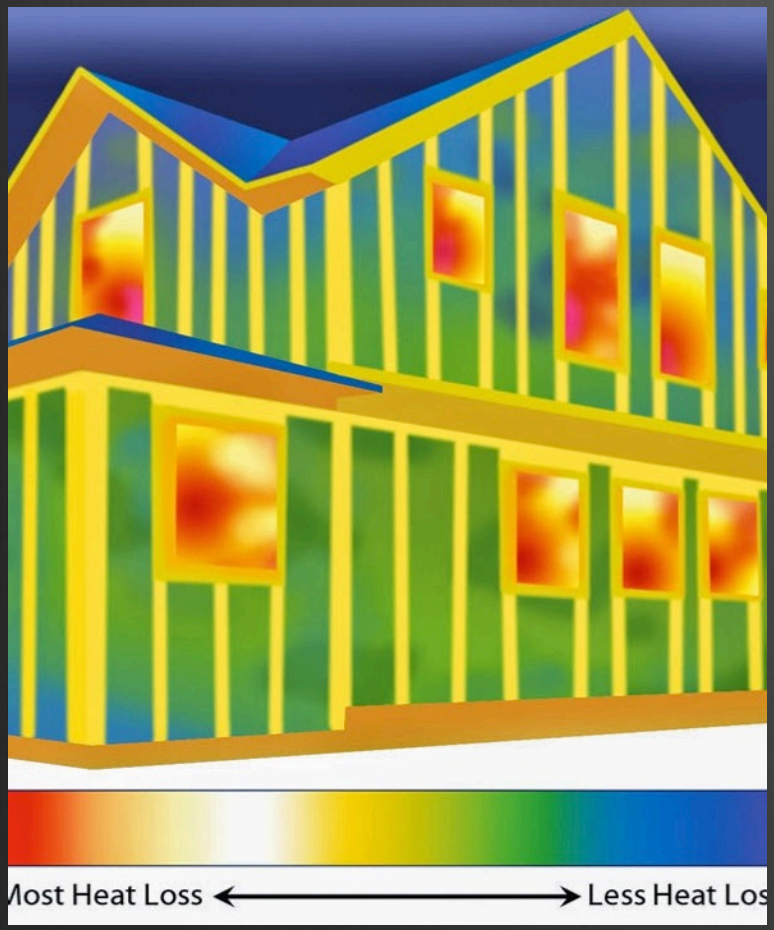
(discounted interior conditioned floor area - TFA)

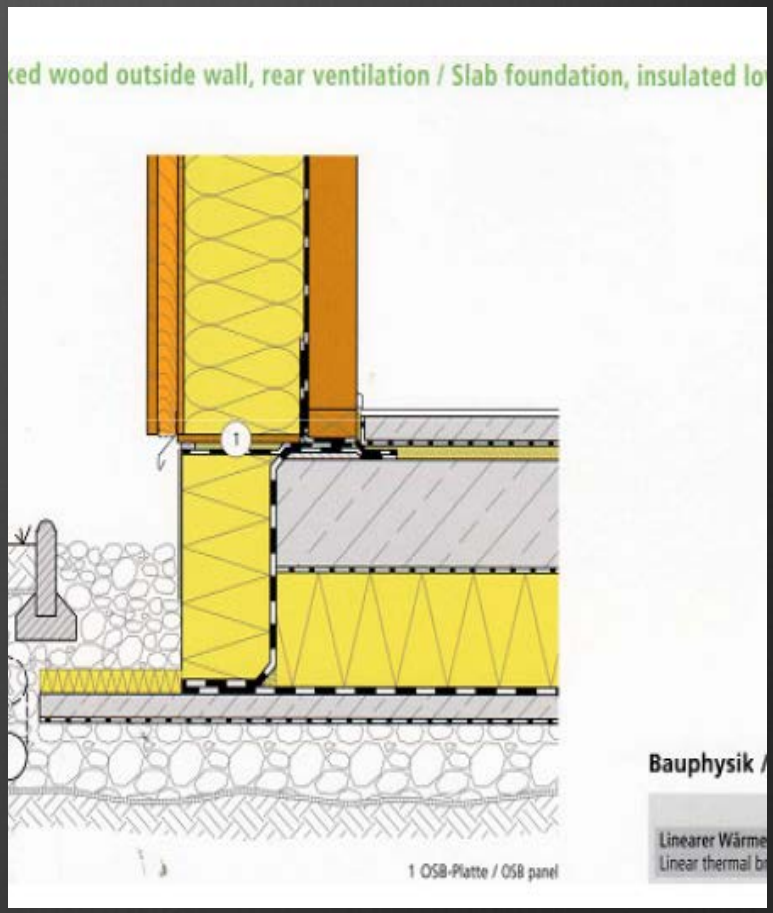
Annual Heating Energy Demand	≤4.75 kBTU/ft^2 yr or 1.4 kWh/ft^2 yr [15 kWh/m^{2}a]
Annual Cooling Energy Demand	≤4.75 kBTU/ft^2 yr or 1.4 kWh/ft^2 yr [15 kWh/m^{2}a]
	-OR-
Peak Heating Load	≤3.17 BTU/hr.ft^2 or approx. 1 W/ft^2 [10 W/m^2]
Peak Cooling Load	≤2.54 BTU/hr.ft^2 or approx. 0.75 W/ft^2 [8 W/m^2]
	-AND-
Annual Total Primary Energy Demand	≤38 kBTU/ft^2 yr or 11.1 kWh/ft^2 [120 kWh/m^{2}a]
Air Leakage @ 50 Pa	≤0.6 ACH$_{50}$

Guidelines for PH

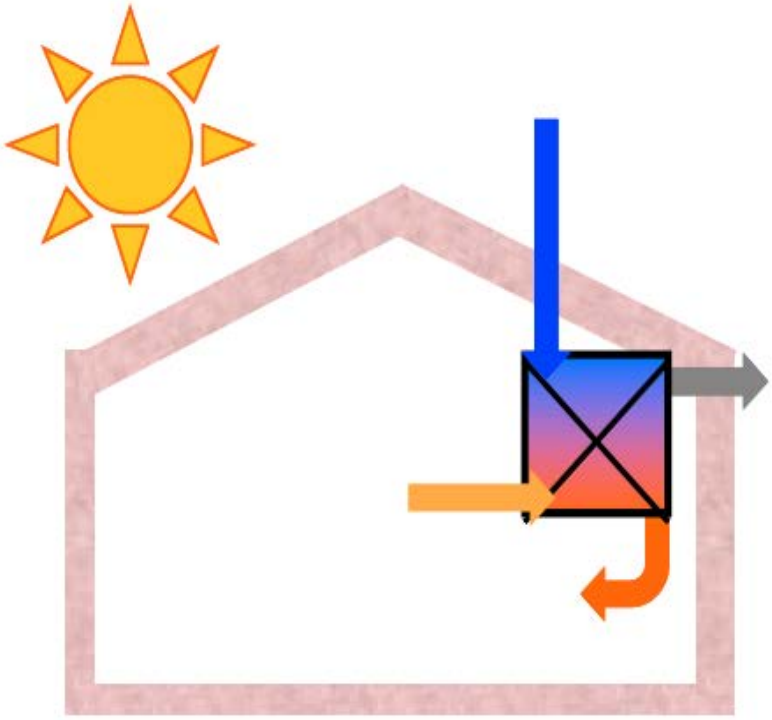
Heat Load:		≤10 W/m^2	≤ 1 W/ft^2
Cooling Load:		≤ 8 W/m^2	≤ 0.8 W/ft^2
Envelope Insulation:			
Very Cold/humid	Minneapolis, MN	U≤0.08 W/m^{2}K	R≥71 hr-ft^2-° F/Btu
Cold	Chicago, IL	U≤0.094 W/m^{2}K	R≥60 hr-ft^2-° F/Btu
Mixed/humid	Ashville, NC	U≤0.16 W/m^{2}K	R≥35 hr-ft^2-° F/Btu
Mixed/dry	Las Vegas, NV	U≤0.14 W/m^{2}K	R≥40 hr-ft^2-° F/Btu
Marine	Seattle, WA	U≤0.13 W/m^{2}K	R≥44 hr-ft^2-° F/Btu
Hot/humid	Houston, TX	U≤0.16 W/m^{2}K	R≥35 hr-ft^2-° F/Btu
Hot/dry	Phoenix, AZ	U≤0.16 W/m^{2}K	R≥35 hr-ft^2-° F/Btu
Thermal Bridge Free Construction:			
Linear Thermal Transmittance		Ψ≤0.01 W/mK	Ψ≤0.006 Btu/hr-ft-° F
High Performance Windows			
Overall Thermal Transmittance (Very Cold)		*U*≤0.6 W/m^{2}K	*U*≤0.11 Btu/hr-ft^2-° F
Solar Heat Gain Coefficient (Mixed/Cold)		g-value≥50%	SHGC≥50%
Solar Heat Gain Coefficient (Hot)		g-value ≤ 30%	SHGC ≤ 30%
Heat Recovery Ventilation			
Net Efficiency		h≥75%	h≥75%

Thermal Bridge Free Building





Max ΔT interior air vs interior surface temp:	≤ 7.2° F (≤ 4° C)
Minimum Ventilation Air Temp (winter)	≥ 62° F
Max Temperature of Heating Coil	125.6 ° F
24 hr DHW Design Flow Assumptions	6.6 gal/person @140° F

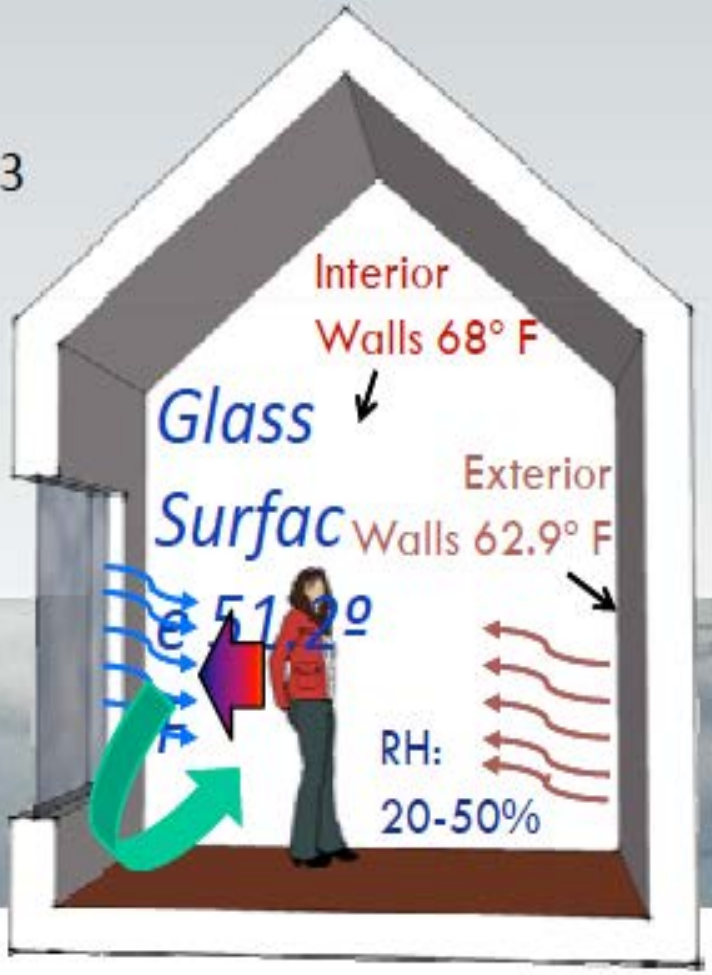


Feels chilly and drafty: uncomfortable!

Conventional Code House – Typ. 2x4 wall (actual R 10)

Double glazed window – R 3

Outside Temperature 0º F



Factors affecting Comfort:

- Air Temperature (dry bulb º F)
- Relative Humidity (%)
- Air Velocity (ft/min)
- Radiant Conditions (MRT º F or radiation value BTUh/ft²)

Feels: comfortable!

Temperate glass and wall surfaces and *no drafts*

Passive House R 60

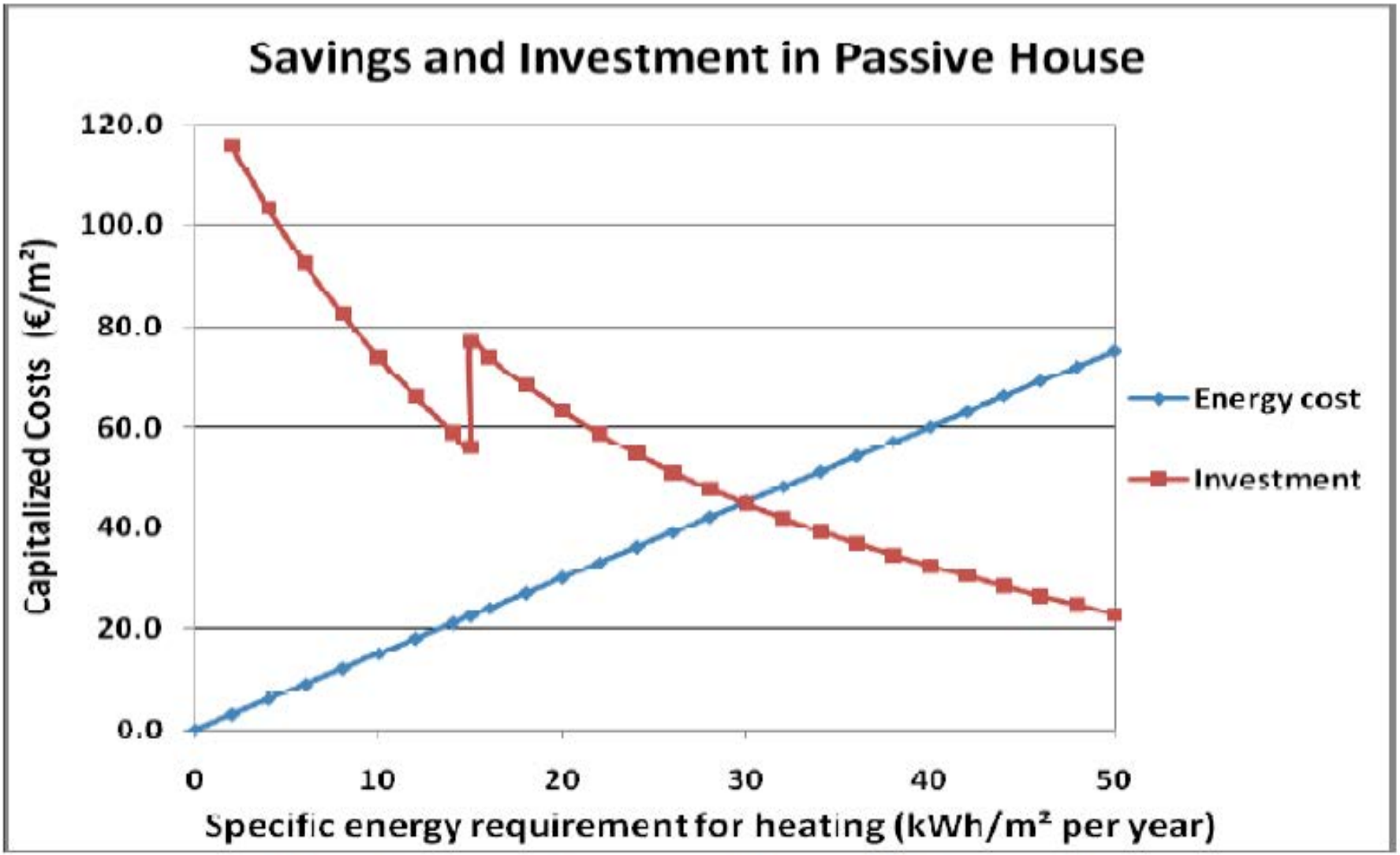
Triple glazed

Window R -9 (Climate specific)

Outside Temperature 0º F

PH Comfort criteria:

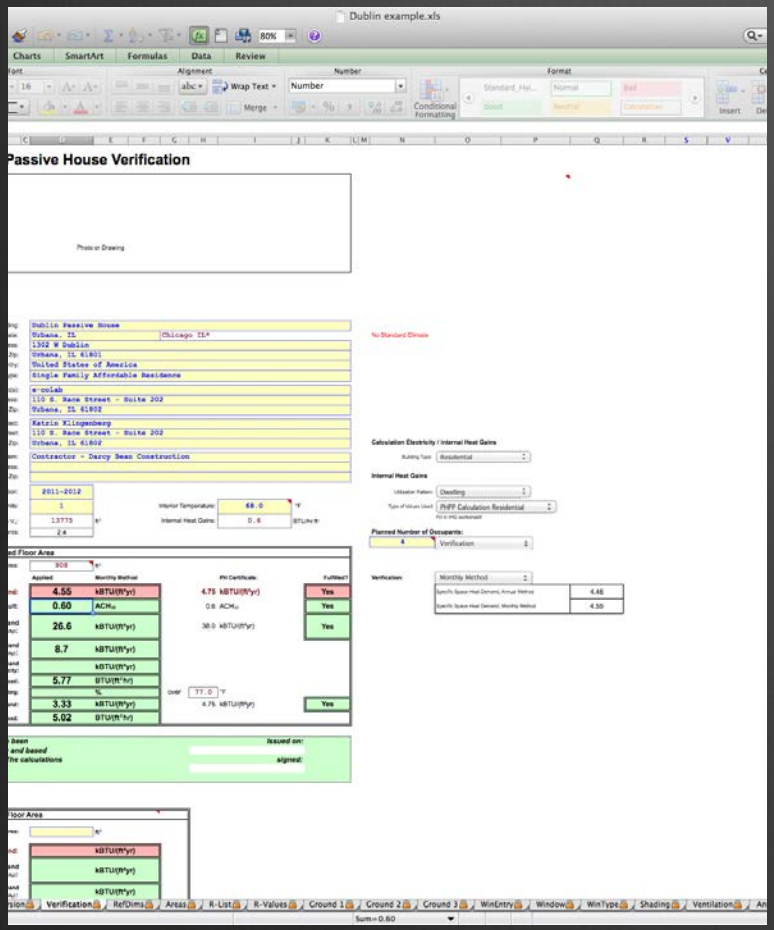
- Air Temperature (68 º F)
- Relative Humidity (40-60 % for PH)
- Air Velocity (<19.7 ft/min)
- Radiant Conditions (Difference between air temperature and coldest surface 68 -RT <7.2 º F)

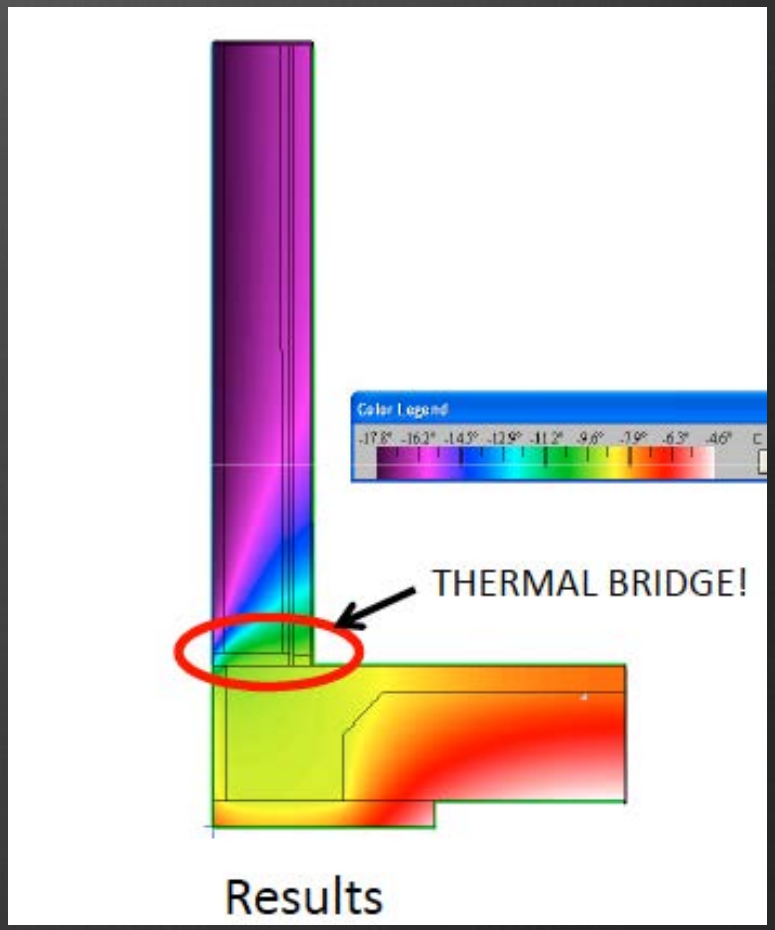


Note: Costs are for central Europe (Germany)

(Source: IEA Information Paper: Energy Efficiency requirements in Building Codes, Author Jens Laustsen)

Modeling


Dublin example.xls
Passive House Verification
Photo or Drawing
Dublin Passive House
Urbana, IL
Chicago IL*
1302 W Dublin
Urbana, IL 61801
United States of America
Single Family Affordable Residence
e-colab
110 S. Race Street - Suite 202
Urbana, IL 61802
Katrin Klingenberg
110 S. Race Street - Suite 202
Urbana, IL 61802
Contractor - Darcy Bean Construction
2011-2012
Interior Temperature:
68.0
Internal Heat Gains:
0.6
Calculation Electricity / Internal Heat Gains
Internal Heat Gains
Planned Number of Occupants:
4
Verification
Monthly Method
4.55 kBTU/(ft²yr)
0.60 ACH50
26.6 kBTU/(ft²yr)
8.7 kBTU/(ft²yr)
5.77 BTU/(ft²hr)
3.33 kBTU/(ft²yr)
5.02 BTU/(ft²hr)
Yes
Issued on:
Verification
RefDims
Areas
R-List
R-Values
Ground 1
Ground 2
Ground 3
WinEntry
Window
WinType
Shading
Ventilation


Color Legend
THERMAL BRIDGE!
Results

Retro-Fits

The elephant in the room for energy savings
My Experience, and where I see potential.

Our Retro-Fit

83.3 % reduction in heat load

AkWarm Heating Energy Flows Report

Client: Saskia Esslinger
Home at: 3842 Williams St.
Anchorage, AK 99508

Energy Flows below are in Btu/hour

Month	Hours	Gross Loss	Gross Internal	Useable Internal	Gross Solar	Useable Solar	Natural Infil cfm
Jan	744	38,402	7,350	7,350	803	794	162
Feb	678	34,803	7,175	7,175	1,923	1,916	159
Mar	744	30,431	6,937	6,937	3,761	3,673	151
Apr	720	21,935	6,699	6,699	4,171	3,942	138
May	744	14,446	6,524	6,524	3,879	3,399	131
Jun	720	9,121	6,460	6,052	4,119	2,517	118
Jul	744	6,660	6,524	5,282	3,844	1,375	102
Aug	744	7,804	6,699	5,809	3,263	1,766	102
Sep	720	12,870	6,937	6,892	2,645	2,359	114
Oct	744	22,398	7,175	7,175	1,863	1,854	136
Nov	720	31,795	7,350	7,350	1,069	1,060	151
Dec	744	37,731	7,413	7,413	491	485	160

Annual Energy Flows

Gross Loss: 195.6 MMBtu

Gross Internal: 60.8 MMBtu
Useable Internal: 58.9 MMBtu
Internal Utilization: 0.969

Gross Solar: 23.3 MMBtu
Useable Solar: 18.3 MMBtu
Solar Utilization: 0.788

Net Heat Load: 118.3 MMBtu

Design Heat Load

Main Home:	57,336	Btu/hour
Garage:	0	Btu/hour
Total:	57,336	Btu/hour

The above value is the required amount of heat to be supplied by the furnace/boiler. If the space heating system also heats domestic hot water, you need to add an allowance for this, typically 1,500 Btu/hour per person. If you need to determine the required Input Rating of the heating system, you must increase the output figure above to account for the inefficiency of the furnace/boiler and add a sizing safety margin.

AkWarmCalc ver. 2.3.1.0, Energy Library ver. 9/24/2013

AkWarm Heating Energy Flows Report

Client: Saskia Esslinger
Home at: 3842 Williams St.
Anchorage, AK 99508

Energy Flows below are in Btu/hour

Month	Hours	Gross Loss	Gross Internal	Useable Internal	Gross Solar	Useable Solar	Natural Infil cfm
Jan	744	13,617	5,639	5,639	715	712	83
Feb	678	12,294	5,464	5,464	1,700	1,676	81
Mar	744	10,676	5,226	5,224	3,304	2,765	78
Apr	720	7,756	4,987	4,804	3,638	2,330	71
May	744	5,195	4,813	4,017	3,361	1,178	67
Jun	720	3,377	4,749	3,019	3,557	358	61
Jul	744	2,559	4,813	2,416	3,324	143	52
Aug	744	2,985	4,987	2,766	2,838	219	52
Sep	720	4,775	5,226	3,959	2,322	789	58
Oct	744	7,955	5,464	5,168	1,644	1,514	70
Nov	720	11,165	5,639	5,630	949	948	77
Dec	744	13,359	5,702	5,702	438	435	82

Annual Energy Flows

Gross Loss: 69.7 MMBtu

Gross Internal: 45.8 MMBtu
Useable Internal: 39.3 MMBtu
Internal Utilization: 0.857

Gross Solar: 20.3 MMBtu
Useable Solar: 9.5 MMBtu
Solar Utilization: 0.468

Net Heat Load: 21.0 MMBtu

Design Heat Load

Main Home:	21,062	Btu/hour
Garage:	0	Btu/hour
Total:	21,062	Btu/hour

The above value is the required amount of heat to be supplied by the furnace/boiler. If the space heating system also heats domestic hot water, you need to add an allowance for this, typically 1,500 Btu/hour per person. If you need to determine the required Input Rating of the heating system, you must increase the output figure above to account for the inefficiency of the furnace/boiler and add a sizing safety margin.

AkWarmCalc ver. 2.3.1.0, Energy Library ver. 9/24/2013

Air Tight Layer

Reduce North Window Area

Buck Windows, add Foam

Create Rain Screan

Insulate Foundation and Slab


Abundant!

Chain Saw Example

Although a wonderful retro-fit, we would have done things a bit differently now.

- Air boundary in Attic and Roof Heel
- Window Detailing
- EPS insulation
- Bituthane air tight layer
- Window Area
- Door Quality and Placement
- Eves and Attic Ventilation
- Ventilation Ducts, and how heat is Expelled from House

What Went Right!

- Dramatic Energy Savings
- Noise Reduction
- Total Comfort
- Aesthetics
- Neighborhood Improvements
- Durability Increased
- Moisture Management
- Pollution Management

Retro-Fit Strategy

In the future, I would use an open diffusion wall retro-fit with blown cellulose.

This allows moisture to come, go, or be absorbed as needed.

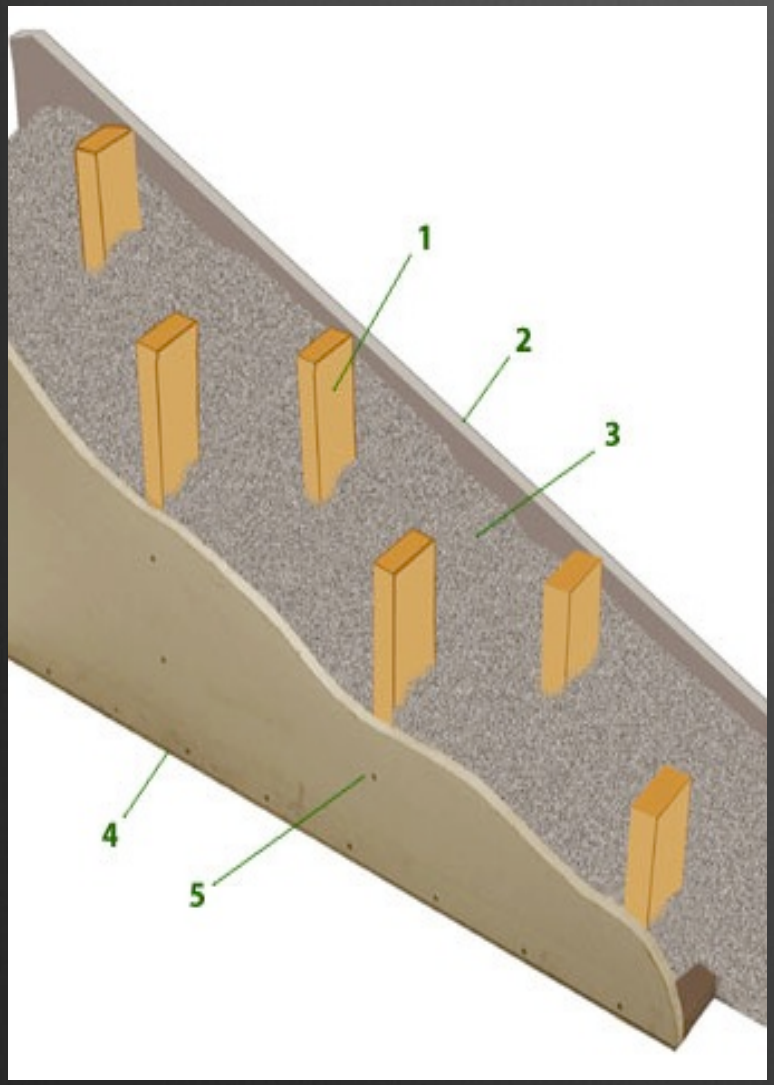
It also has a much lower embodied energy, and supports local manufacturing.

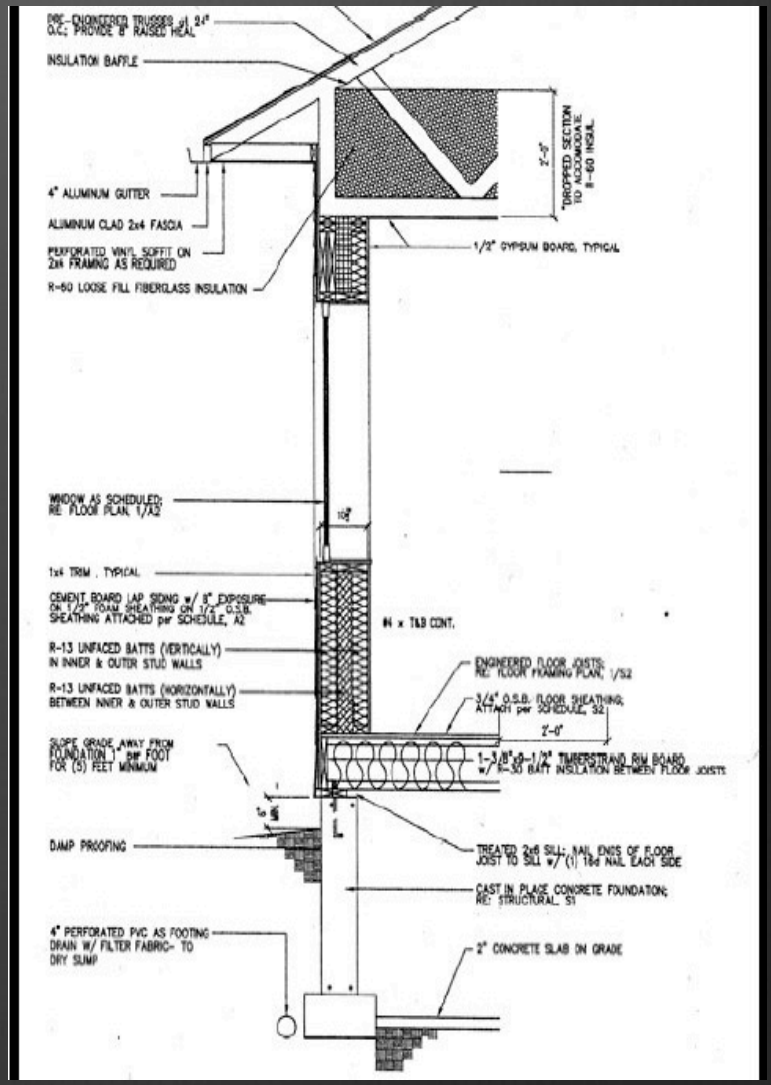
This Could be Difficult

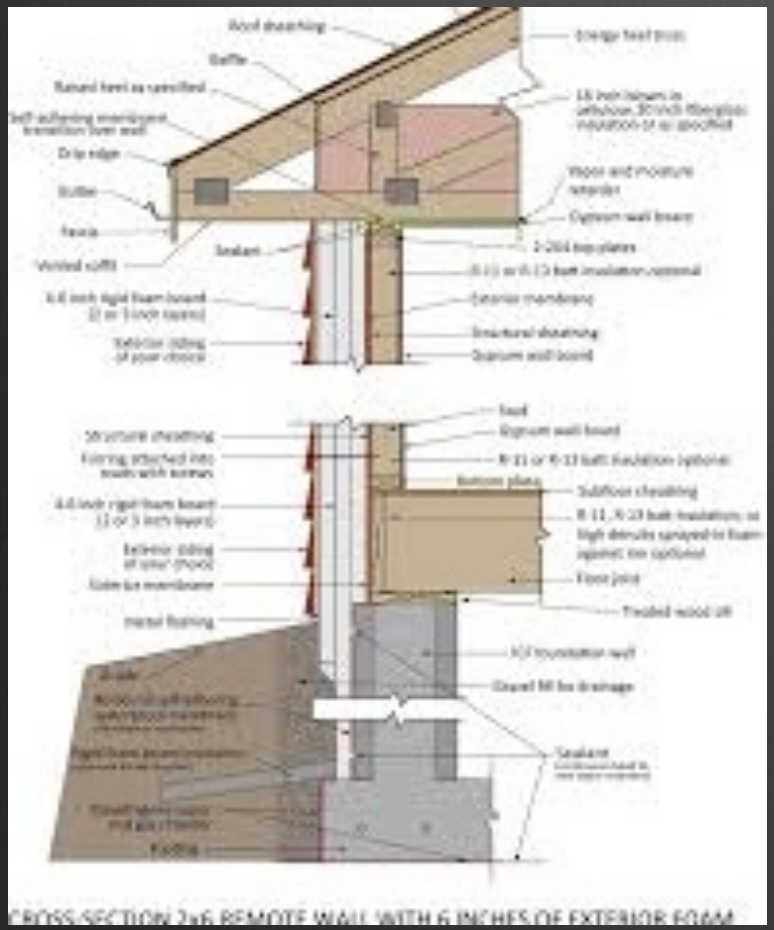
New Construction

Some possible Details

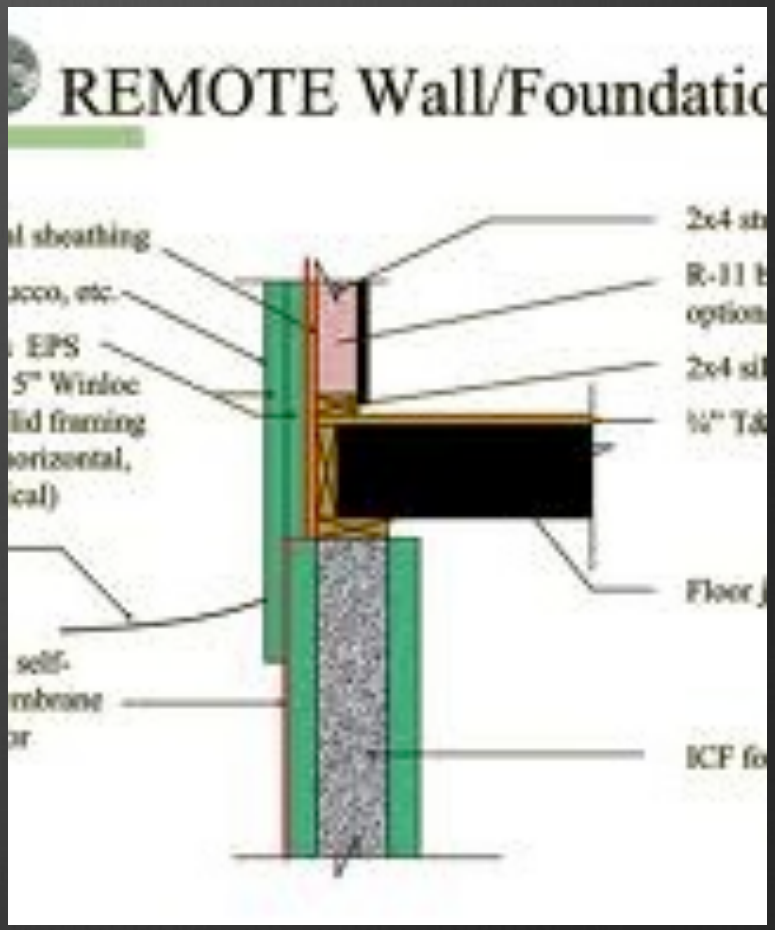
Double Stud Wall



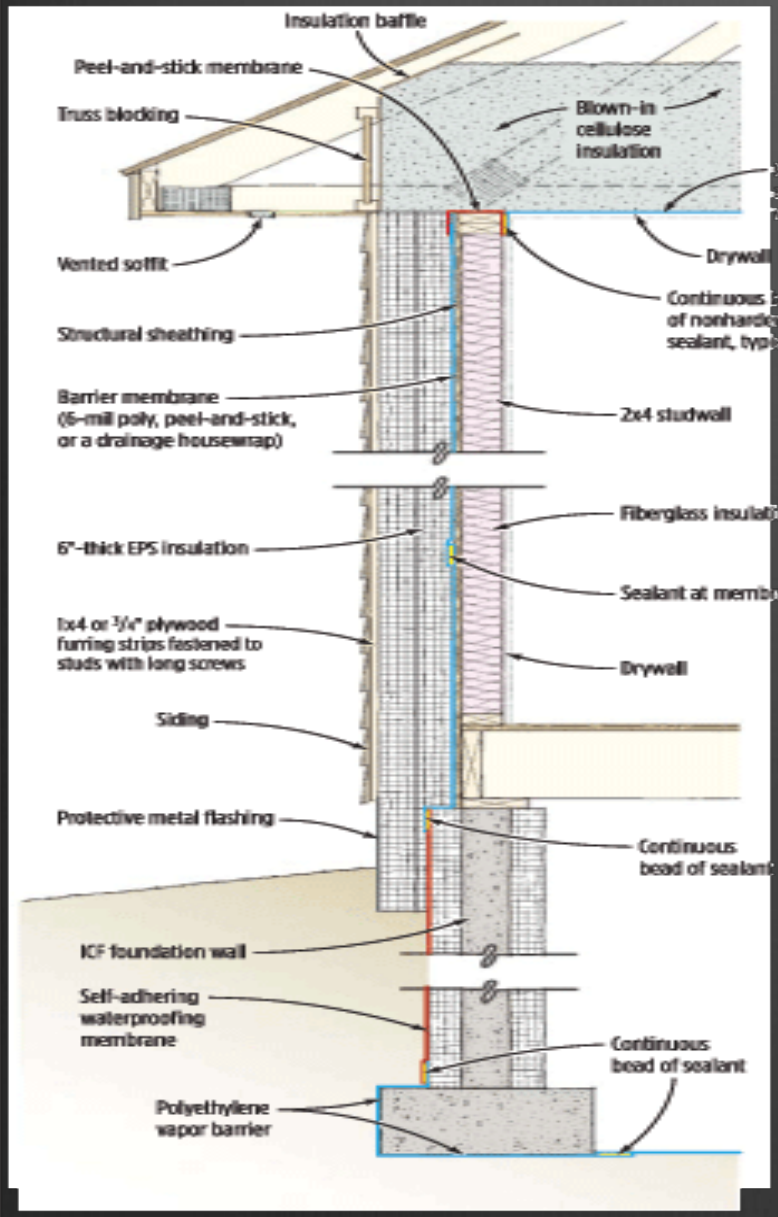


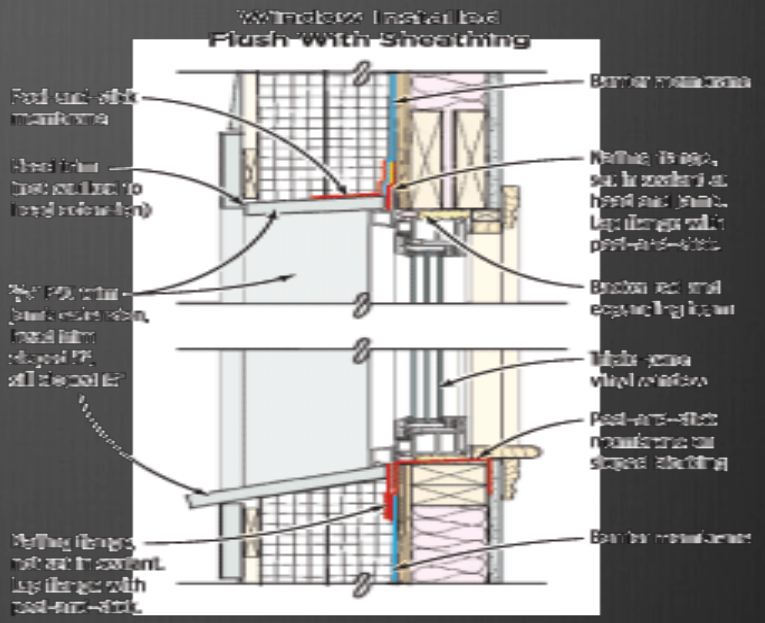


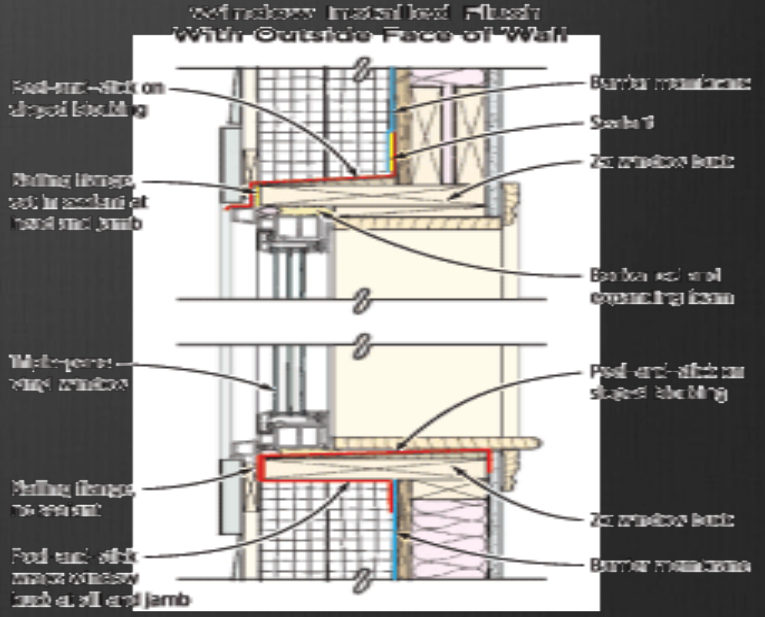
CROSS SECTION 2x6 REMOTE WALL WITH 6 INCHES OF EXTERIOR FOAM

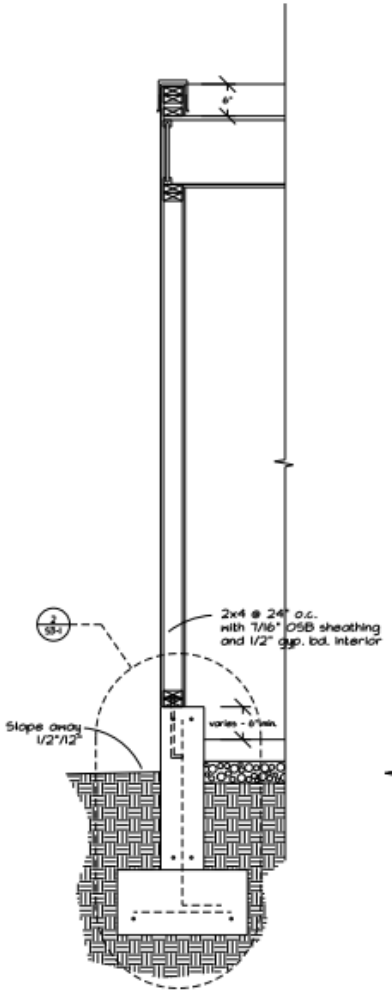


REMOTE Wall Details

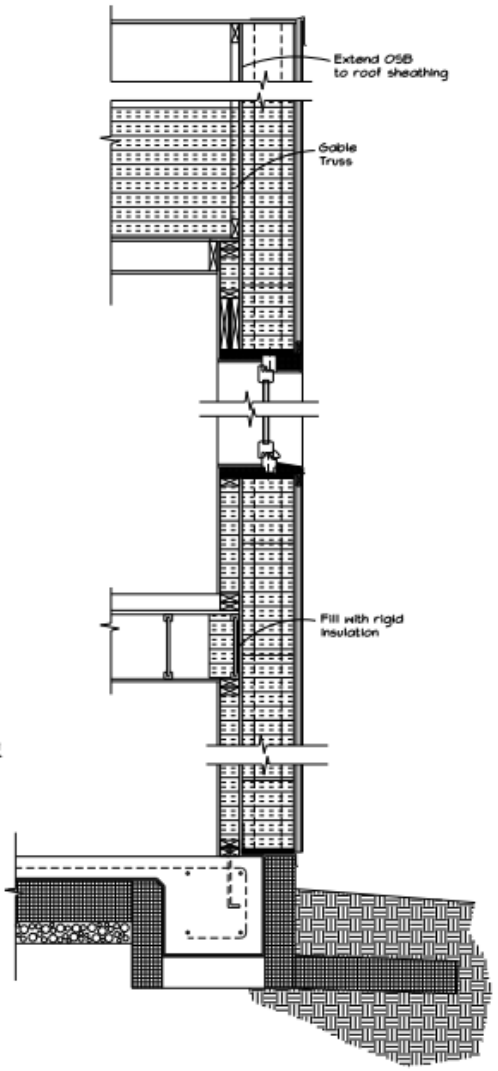








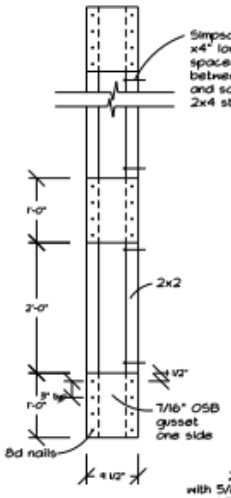
Garage
Wall Section
C / A5-1
D:1" = 1'-0"
B:1/2" = 1'-0"
Referenced on sheet(s) A4-1



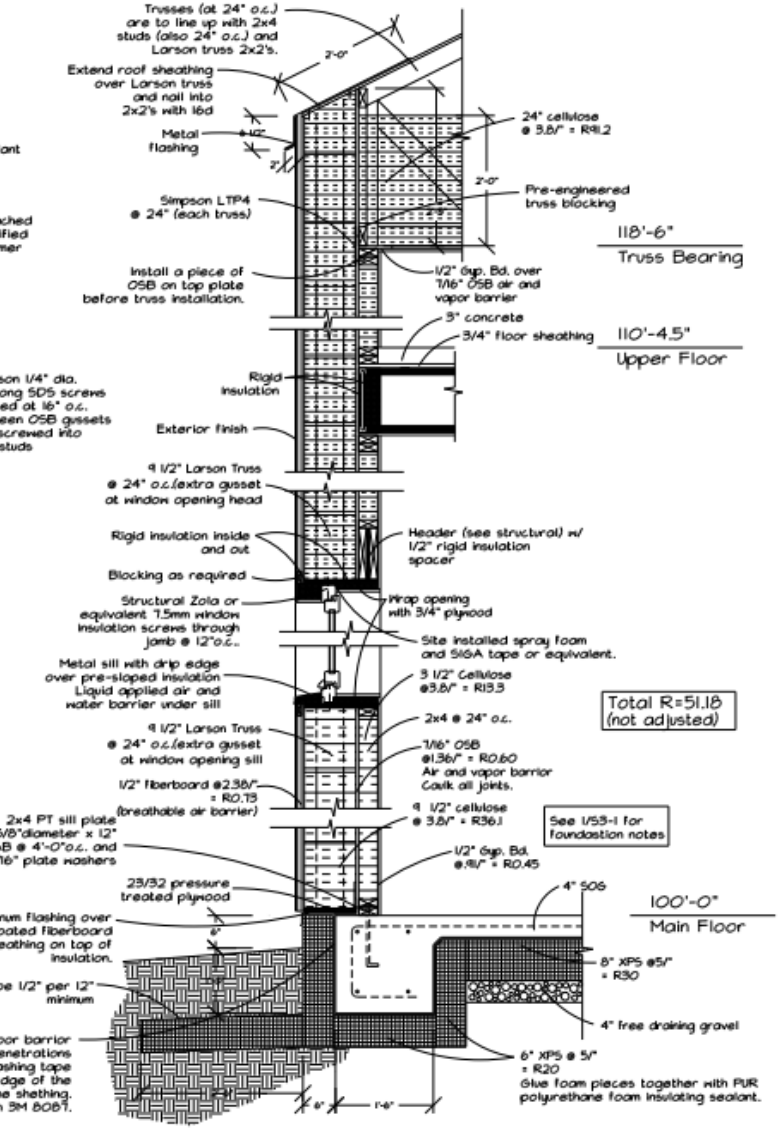
See A/A5-1 for
additional notes
Wall Section
B / A5-1
D:1" = 1'-0"
B:1/2" = 1'-0"
Referenced on sheet(s) A4-3

NOTES:

1. Glue OSB seams with PUR sealant
2. Seal all OSB seams with 3M 8067 flashing tape
3. Where larson trusses are attached to sheathing, apply Vycor modified bitumen flashing tape over primer before placing Larson truss.
4. XPS = Formular 40 or 60 (5760 and 8640 psi)



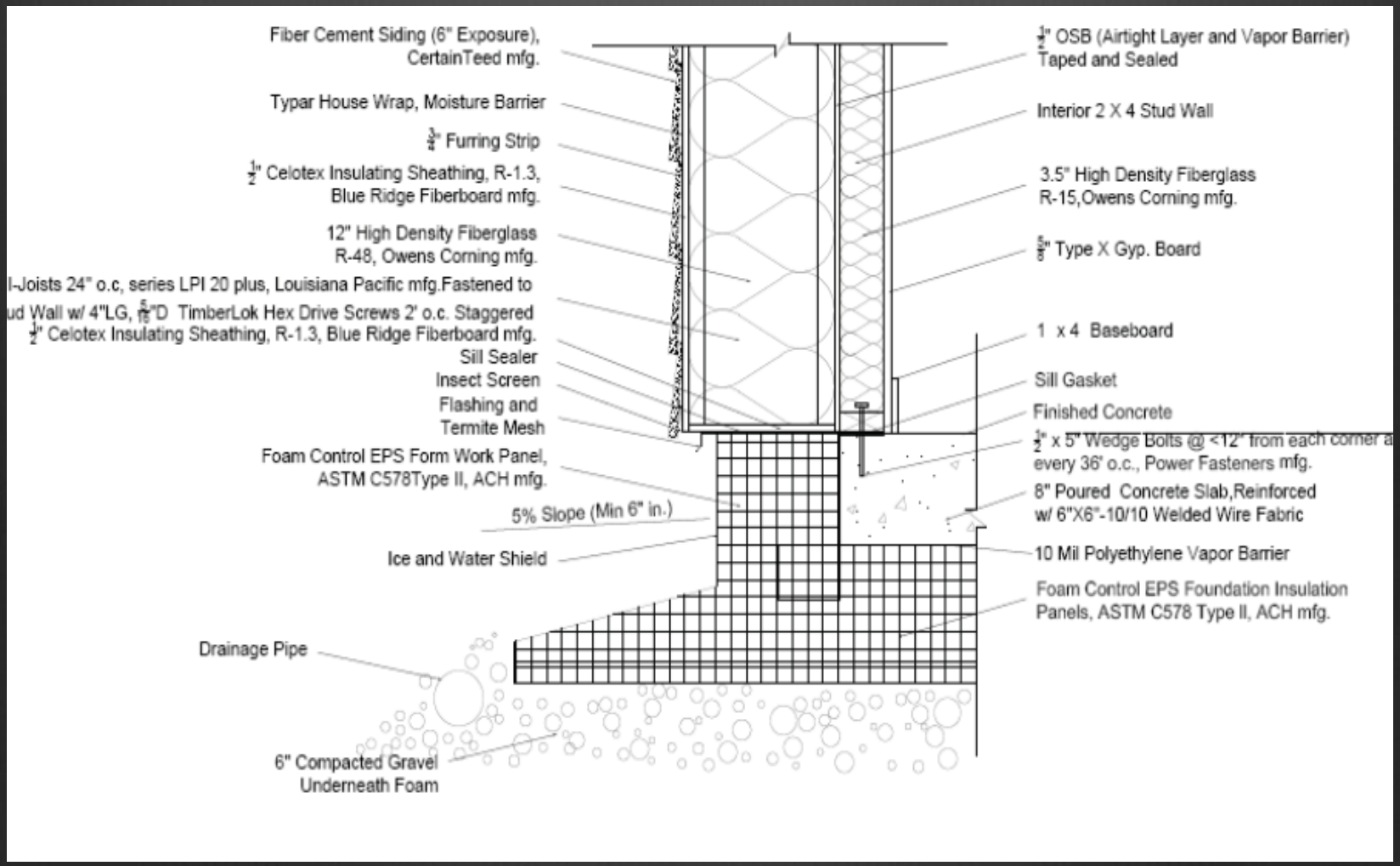
Larson Truss



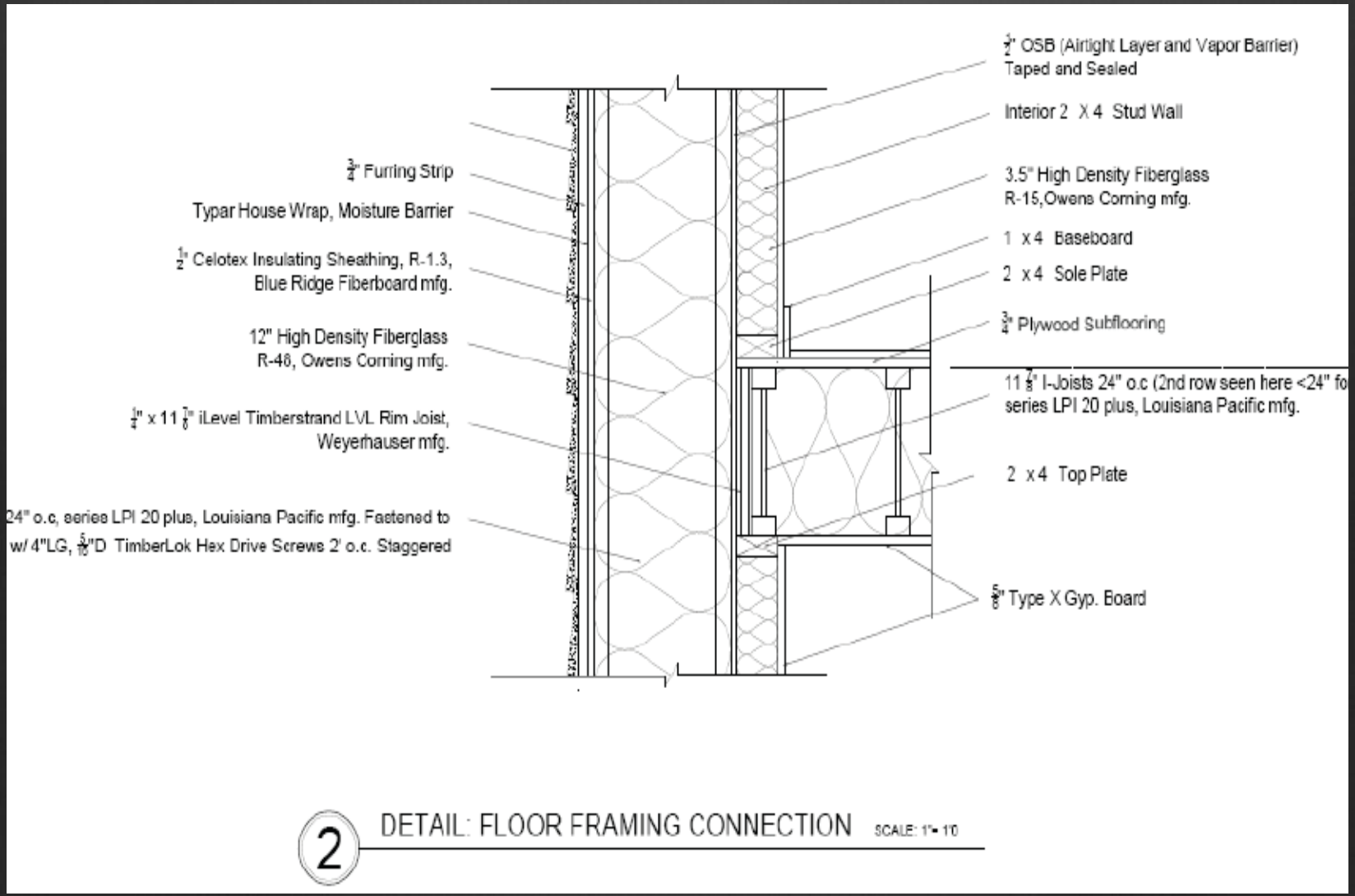
Wall Section
A / A5-1
D:1" = 1'-0"
B:1/2" = 1'-0"
Referenced on sheet(s) A4-1

SIPS

Foundation Detail

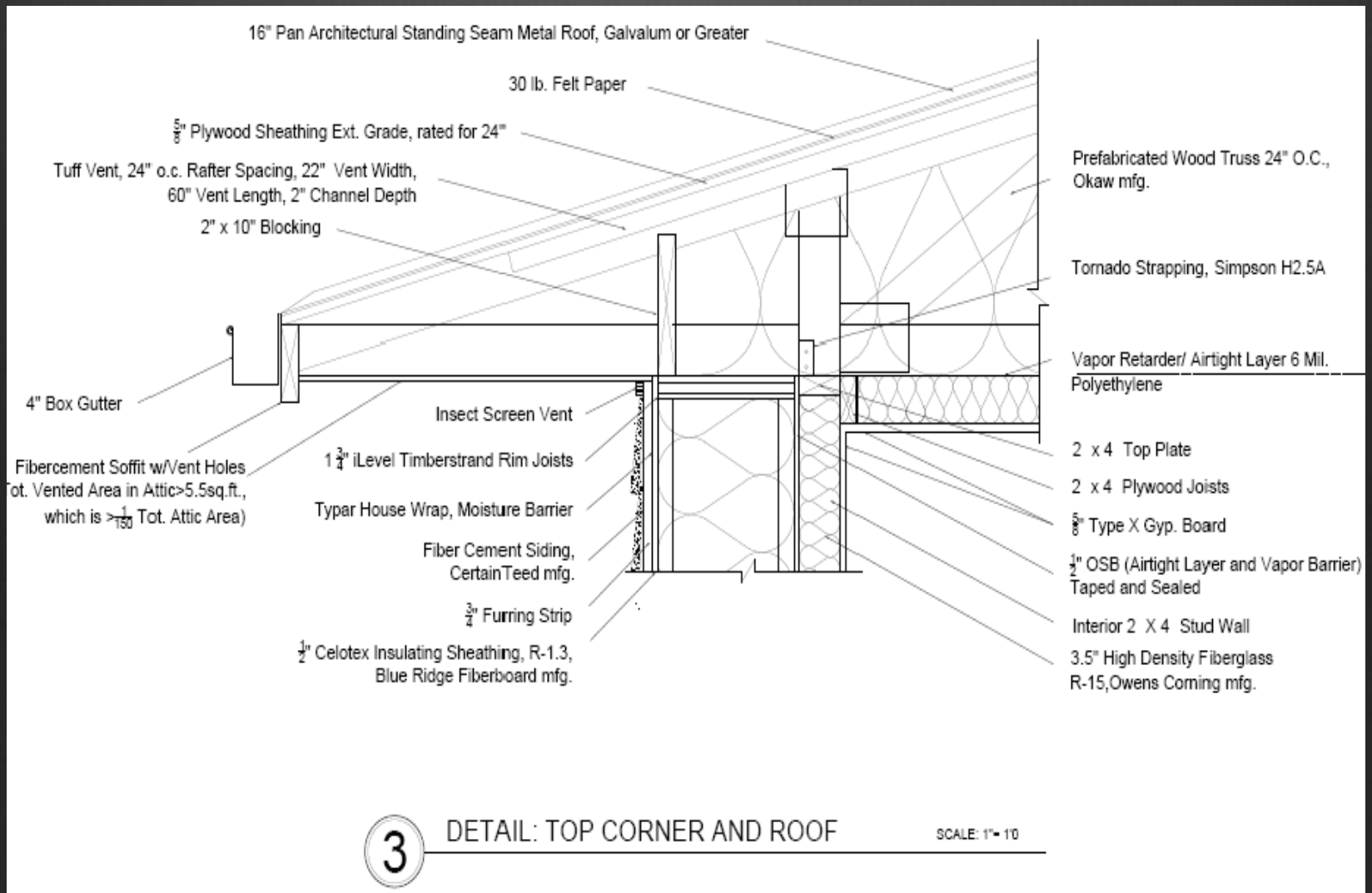


Floor Detail

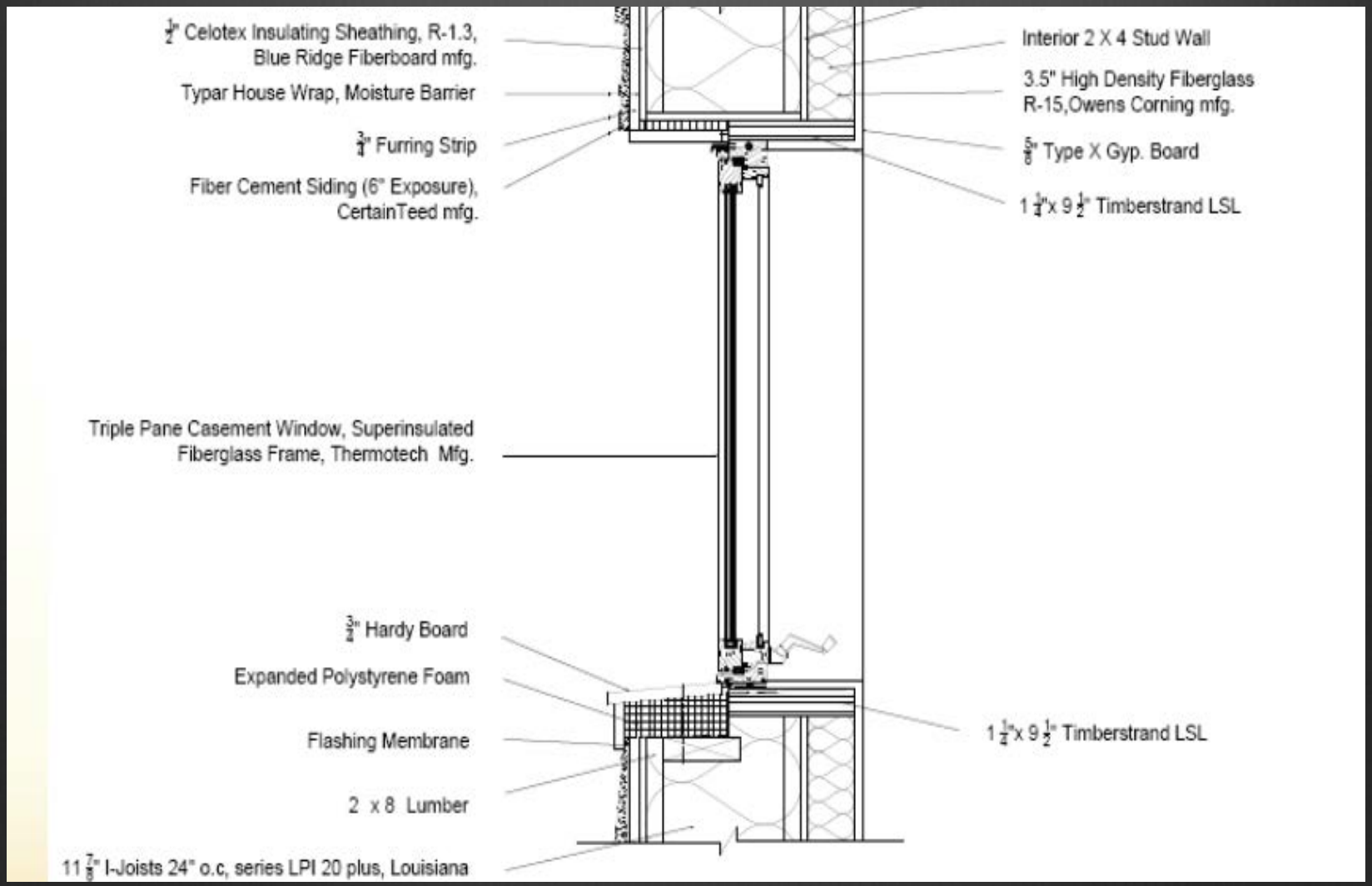


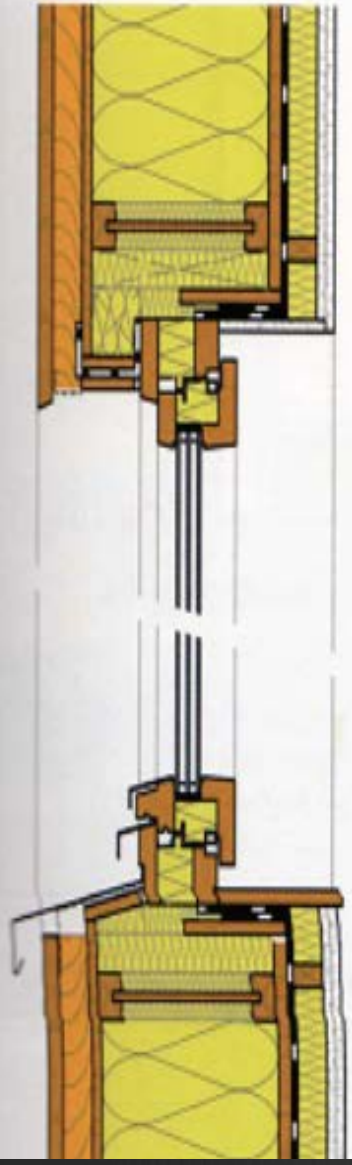
2 DETAIL: FLOOR FRAMING CONNECTION SCALE: 1"= 1'0

Roof Detail


16" Pan Architectural Standing Seam Metal Roof, Galvalum or Greater
30 lb. Felt Paper
5/8" Plywood Sheathing Ext. Grade, rated for 24"
Tuff Vent, 24" o.c. Rafter Spacing, 22" Vent Width, 60" Vent Length, 2" Channel Depth
2" x 10" Blocking
4" Box Gutter
Fibercement Soffit w/Vent Holes Tot. Vented Area in Attic>5.5sq.ft., which is >1/150 Tot. Attic Area)
Insect Screen Vent
1 3/4" iLevel Timberstrand Rim Joists
Typar House Wrap, Moisture Barrier
Fiber Cement Siding, CertainTeed mfg.
3/4" Furring Strip
1/2" Celotex Insulating Sheathing, R-1.3, Blue Ridge Fiberboard mfg.
Prefabricated Wood Truss 24" O.C., Okaw mfg.
Tornado Strapping, Simpson H2.5A
Vapor Retarder/ Airtight Layer 6 Mil. Polyethylene
2 x 4 Top Plate
2 x 4 Plywood Joists
5/8" Type X Gyp. Board
1/2" OSB (Airtight Layer and Vapor Barrier) Taped and Sealed
Interior 2 X 4 Stud Wall
3.5" High Density Fiberglass R-15,Owens Corning mfg.
3
DETAIL: TOP CORNER AND ROOF
SCALE: 1"= 1'0

Window Detail



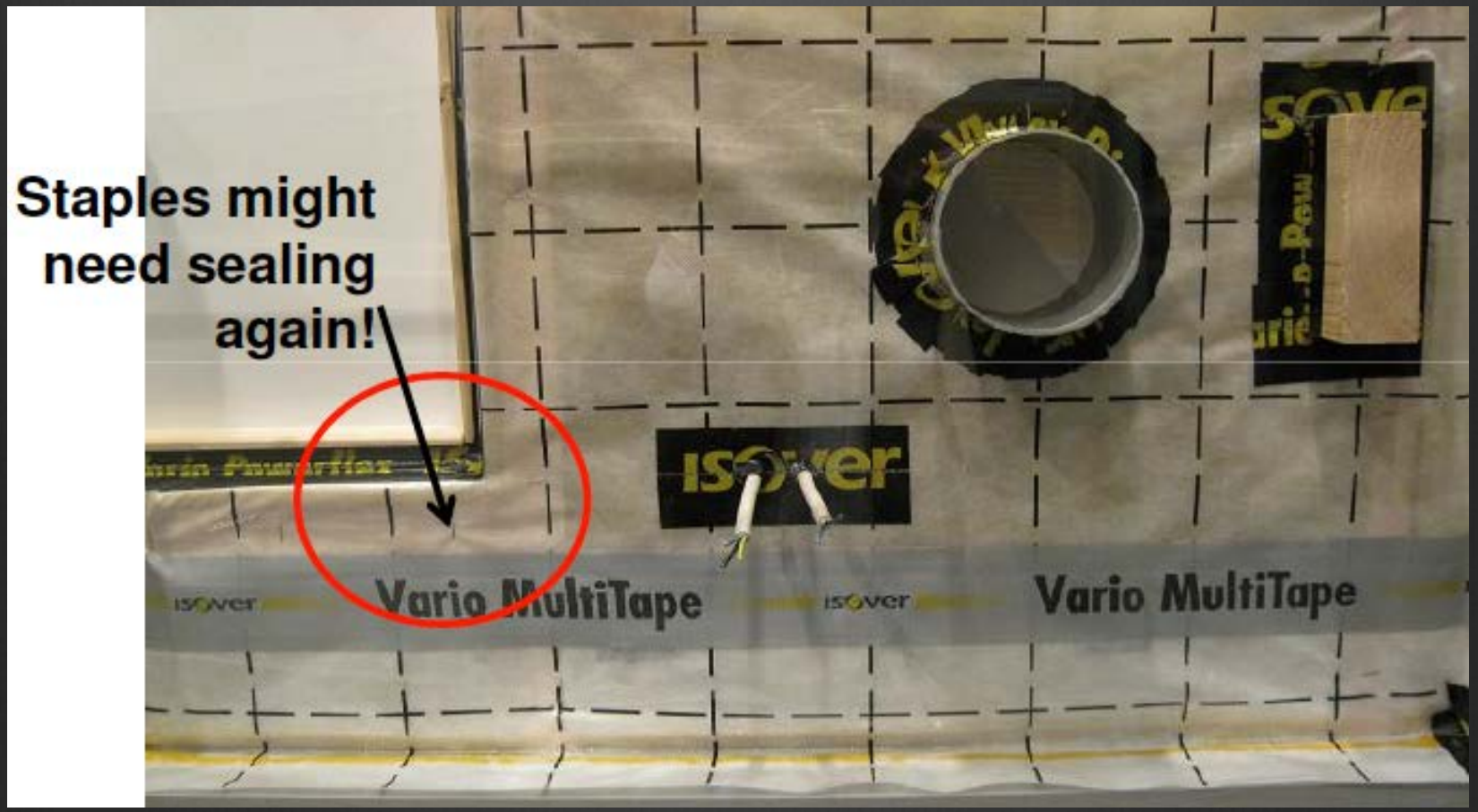


Box beam outside wall, rear ventilation/ wooden window

Bauphysik / Building physics

	Einheit / Unit	
Linearer Wärmebrückenkoeffizient Ψ • Linear thermal bridge coefficient Ψ	W/mK	
Sturz/Laibung • Header/reveal		0,007
Parapet ohne Überdämmung • Parapet w/o add. insulation		0,021
Parapet, 2 cm überdämmt • Parapet, 2 cm add. insulation		0,015
Parapet, 2 cm überdämmt, Doppel-T-Träger an durchgehender Spanplatte • Parapet, 2 cm add. insulation, double T-beams in contact with the continuous chipboard		0,019
Wie vor, 7 cm überdämmt • As above, 7 cm add. insulation		0,012
Wie vor, statt Doppel-T-Träger 6 cm Konstruktionsvollholz • As above, instead of double T beams 6 cm solid construction wood		0,016

Air Sealing


Staples might need sealing again!
Vario MultiTape
Vario MultiTape

Products for Airsealing

Majpell 5
Vapour control layer for roof renovations from the outside, above-rafter and between-rafter insulation for roof, wall and ceiling structures
▸ to detail page

Twinet
Double-sided high-performance adhesive tape for the pre-installation of membranes on hard substrates such as wood and metal
▸ to detail page

Sicrall 60
Yellow, single-sided high-performance adhesive tape for overlaps of vapour control layers
▸ to detail page

Rissan 60
Green, single-sided high-performance adhesive tape for circular penetrations in the interior
▸ to detail page

Primur Roll
High-performance adhesive compound on the roll for bonding the vapour control layer to various substrates
▸ to detail page

Primur tubular bag and cartridge
High-performance adhesive compound in tubular bag or cartridge for bonding to plastered masonry and massive structures
▸ to detail page

Corvum 30/30
Pre-folded single-sided high-performance adhesive tape for purlins, corners, skylights and joists
▸ to detail page

Corvum 12/48
Pre-folded single-sided high-performance adhesive tape for window and door frames
▸ to detail page

Rissan 100 and 150
Green, single-sided, slit high-performance adhesive tape for bonding wall elements to floor and ceiling
▸ to detail page

Dockskin
High-performance primer for strengthening sandy, fibrous substrates, such as woodfibre boards, wood-based panel materials, gypsum fibre boards, plaster and stone
▸ to detail page

Sicrall 170
Yellow, single-sided high-performance adhesive tape for injection holes and leakages
▸ to detail page

ACH < .6 @ 50Pa

The RecoupAerator® is the ONLY air filtration/ventilation system with All of these features:

- **Self-balancing** – Air flow between the fresh air intake and stale air exhaust are automatically balanced
- **EconoCool™** – Brings in cool filtered air in the summer – A/C required less often
- **Brushless Motor Technology** – EC Motors Perform quietly and efficiently
- **MERV 12 Filtration** – Filters particles as small as 1.8 microns
- **Filter Alert** – Automatically signals you when it's time for filter service
- **Adjustable Fan Speed** – Range of air flow to perfectly match fresh air requirements (30-200CFM)

Primary Benefits of the RecoupAerator®

- Delivers continuous, fresh, healthy air
- Saves money on ventilation by recovering 96% of building heat energy
- Automatically balances air flow and pressure
- Reduces cold air drafts by balancing building pressure
- Maintains consistent indoor humidity
- Lowest Cost-of-Ownership
- Exhausts pollutants to improve Indoor Air Quality
- Reduced wear and tear on HVAC system – extends service life
- Reduced usage of A/C system – saving energy
- Easiest whole-house ERV to install and maintain

c ETL us
Intertek

Passive House Approved

Certificate

Certified Passive House Component
For cool, temperate climates, valid until 31 December 2013

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
GERMANY

Category: **Heat recovery unit**

Manufacturer: **Zehnder Group Nederland B.V.**
8028 PM Zwolle, NETHERLANDS

Product name: **ComfoAir 350, ComfoD350, WHR930**

This certificate was awarded based on the following criteria:

Thermal comfort	$\theta_{supply\ air} \geq 16.5$ °C at $\theta_{outdoor\ air} = -10$ °C
Effective heat recovery rate	$\eta_{HR,eff} \geq 75$ %
Electric power consumption	$P_{el} \leq 0.45$ Wh/m³
Airtightness	Interior and exterior air leakage rates less than 3 % of nominal air flow rate
Balancing and adjustability	Air flow balancing possible: yes Automated air flow balancing: no
Sound insulation	Sound pressure level $L_p \leq 35$ dB(A) based on a 4 m² equivalent absorption area not met Here $L_p = 54.1$ dB(A) Unit should be installed so that it is acoustically separated from living areas
Indoor air quality	Outdoor air filter F7 Extract air filter G4
Frostprotection	Frost protection for the heat exchanger with continuous fresh air supply down to $\theta_{outdoor\ air} = -15$ °C

Certified for air flow rates of

71 – 293 m³/h

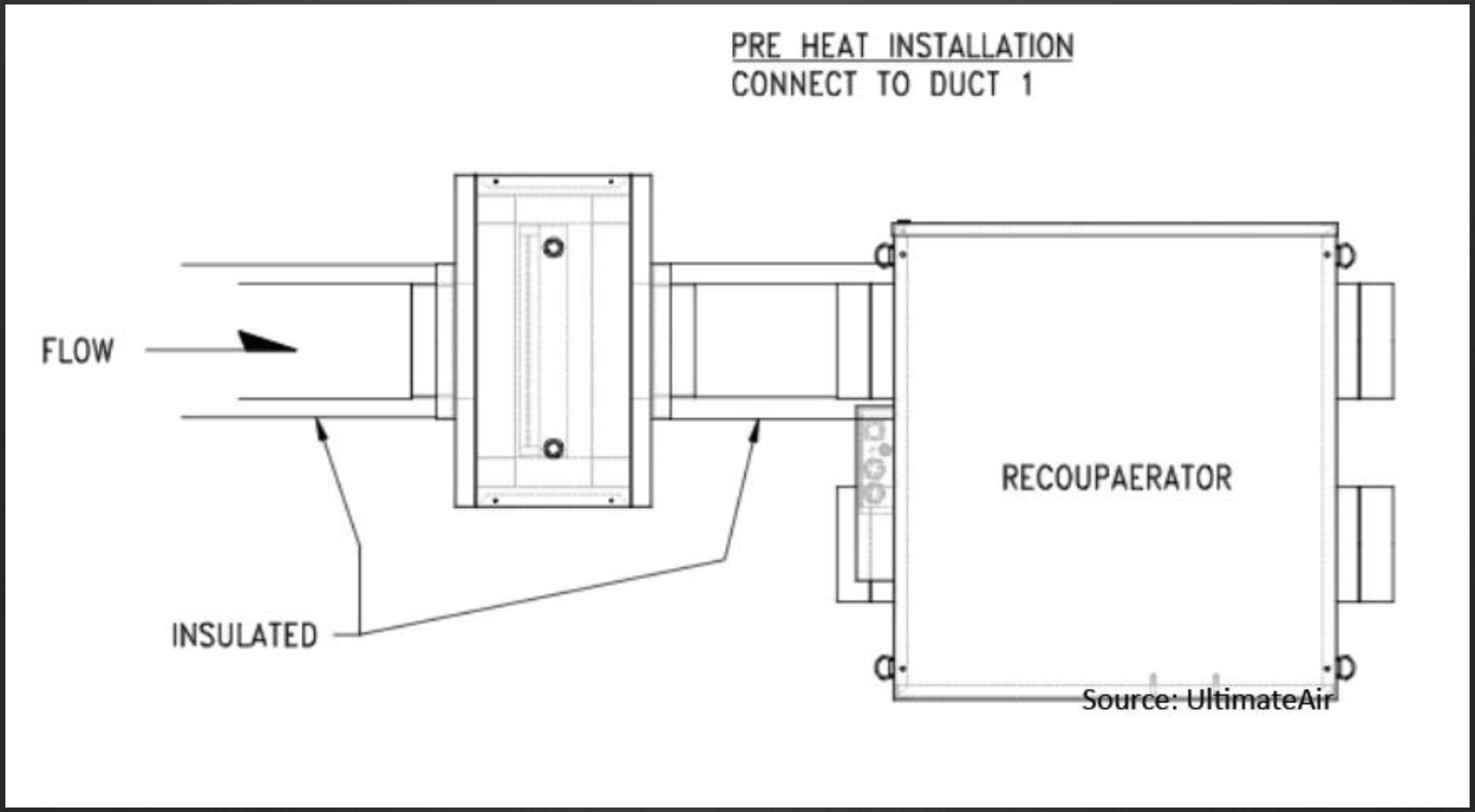
$\eta_{HR,eff}$

84%

Electric power consumption

0.29 Wh/m³

Pre-heating Fresh Air



Undercuts and Bypasses

Supply Air: Greater of

- 18cfm/person (DIN1946)
- OR 0.3AC/h
- Typ Home: 71cfm

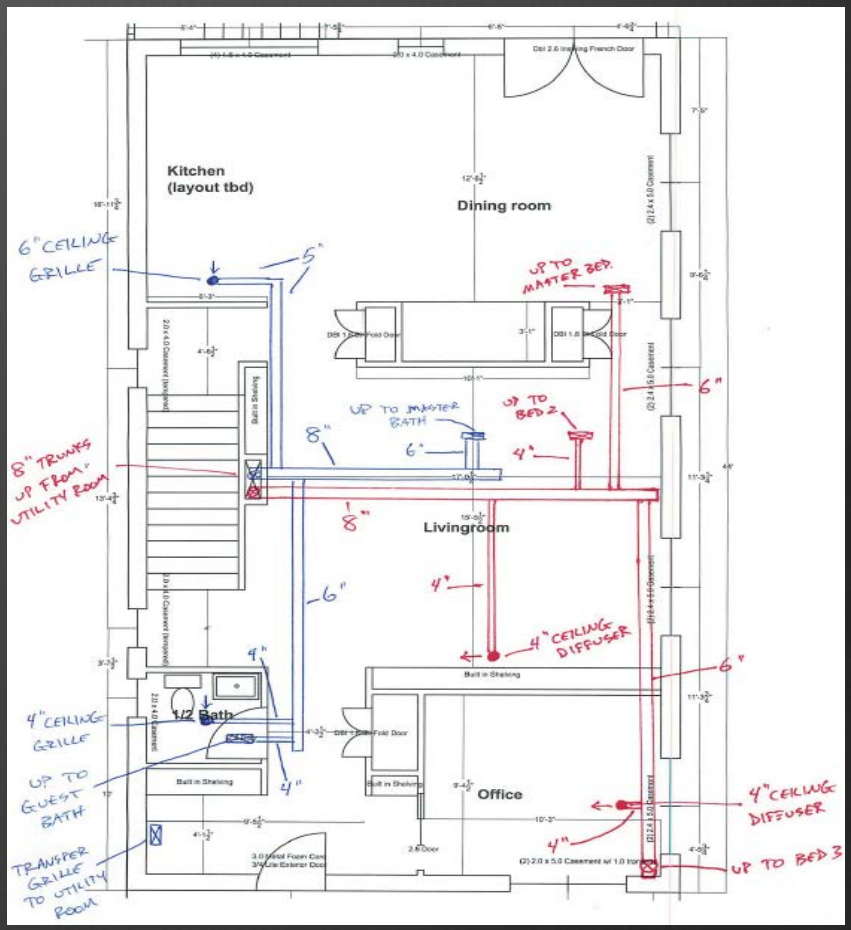
Max Design Airflow = Greater of Supply/ Extract

Extract Air:

- Kitchen – 35 cfm
- Bathrooms – 24 cfm
- ½ Bath – 12 cfm

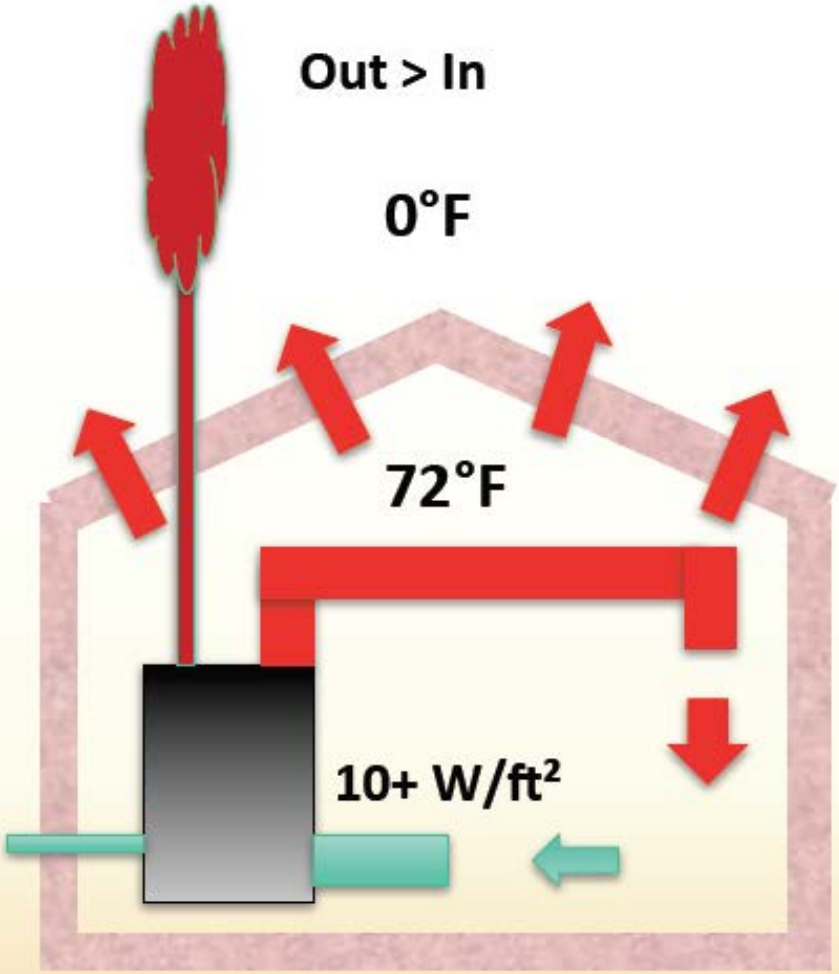
PH delivered ventilation exceeds ASHRAE 62.2, because PH sizes ventilation systems to meet loads, not assuming a leaky envelope will provide any fresh air

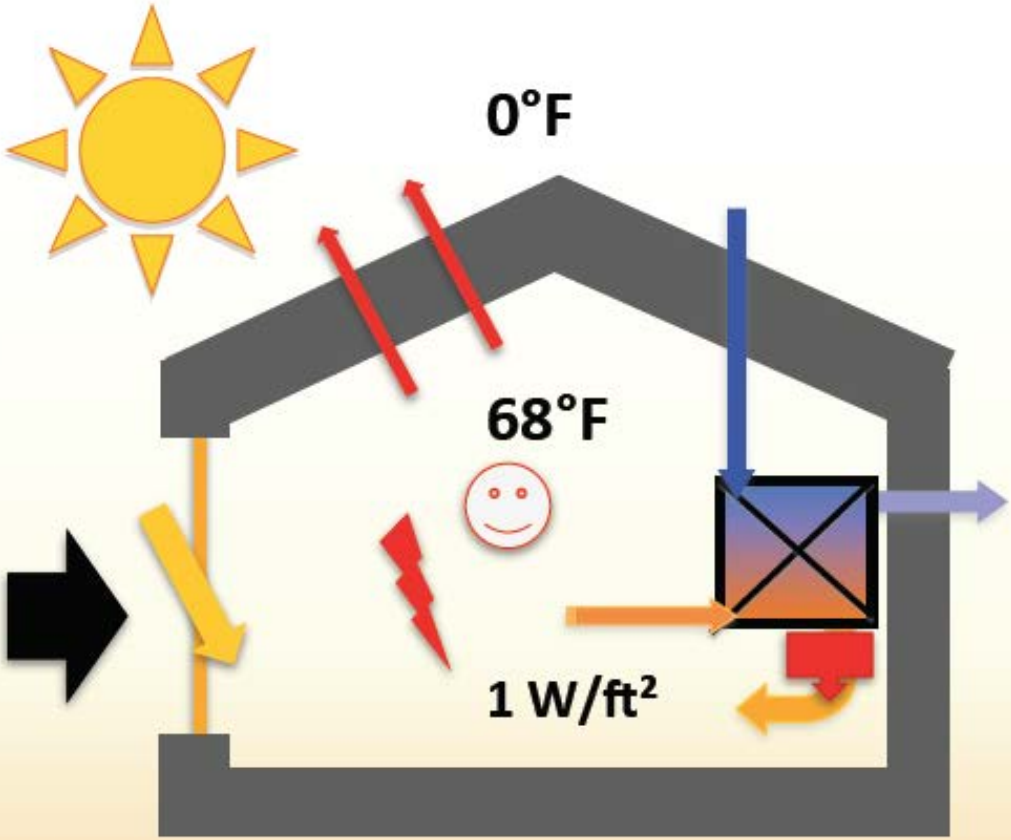
Coanda Effect and Efficient Duct Layout

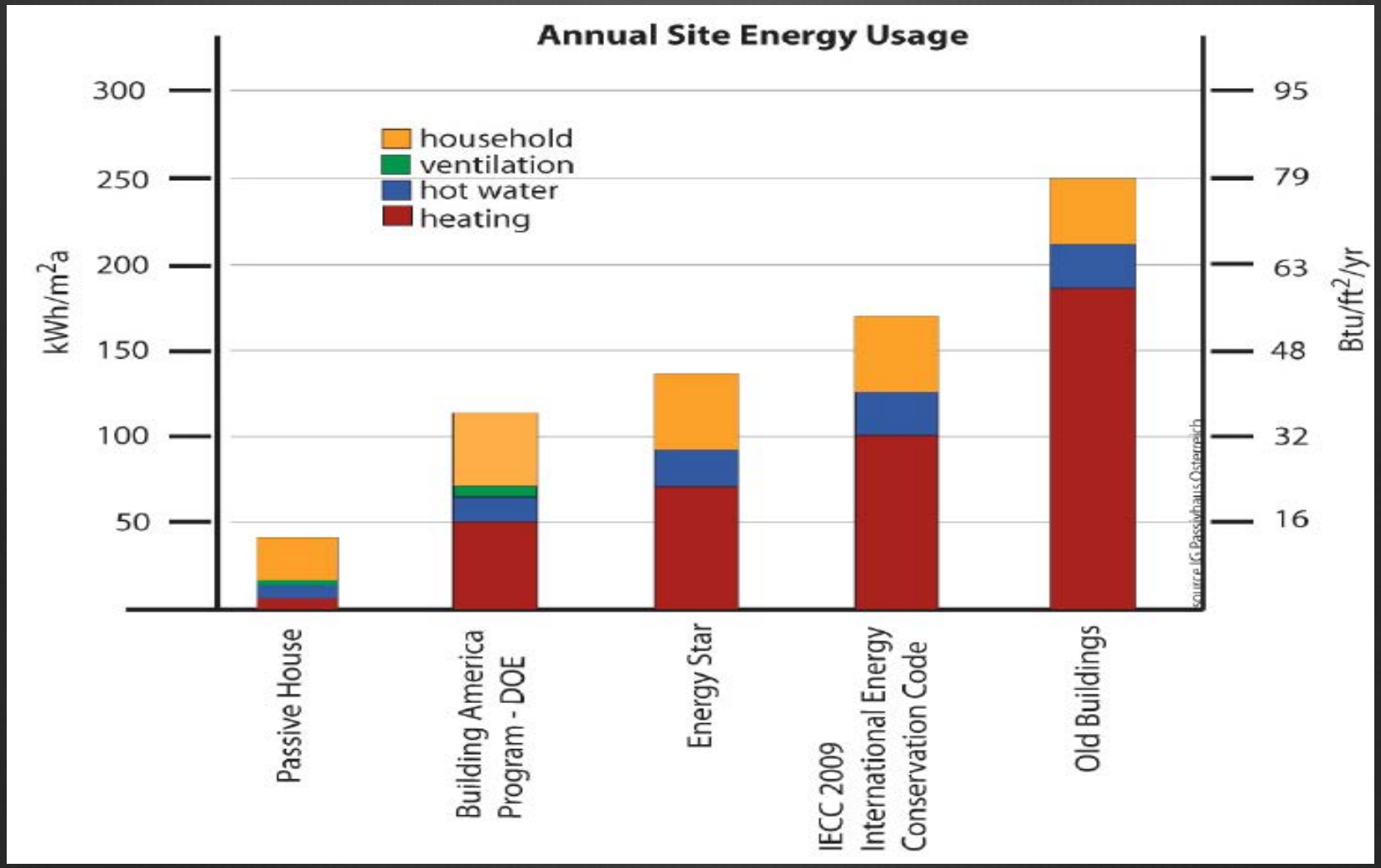


Educate and Maintain

- Provide simple, understandable and obvious maintenance features
- Educate end-user or facilities staff on maintenance needs, process and schedule
- Automatic maintenance reminders can be very effective


Out > In
0°F
72°F
10+ W/ft²

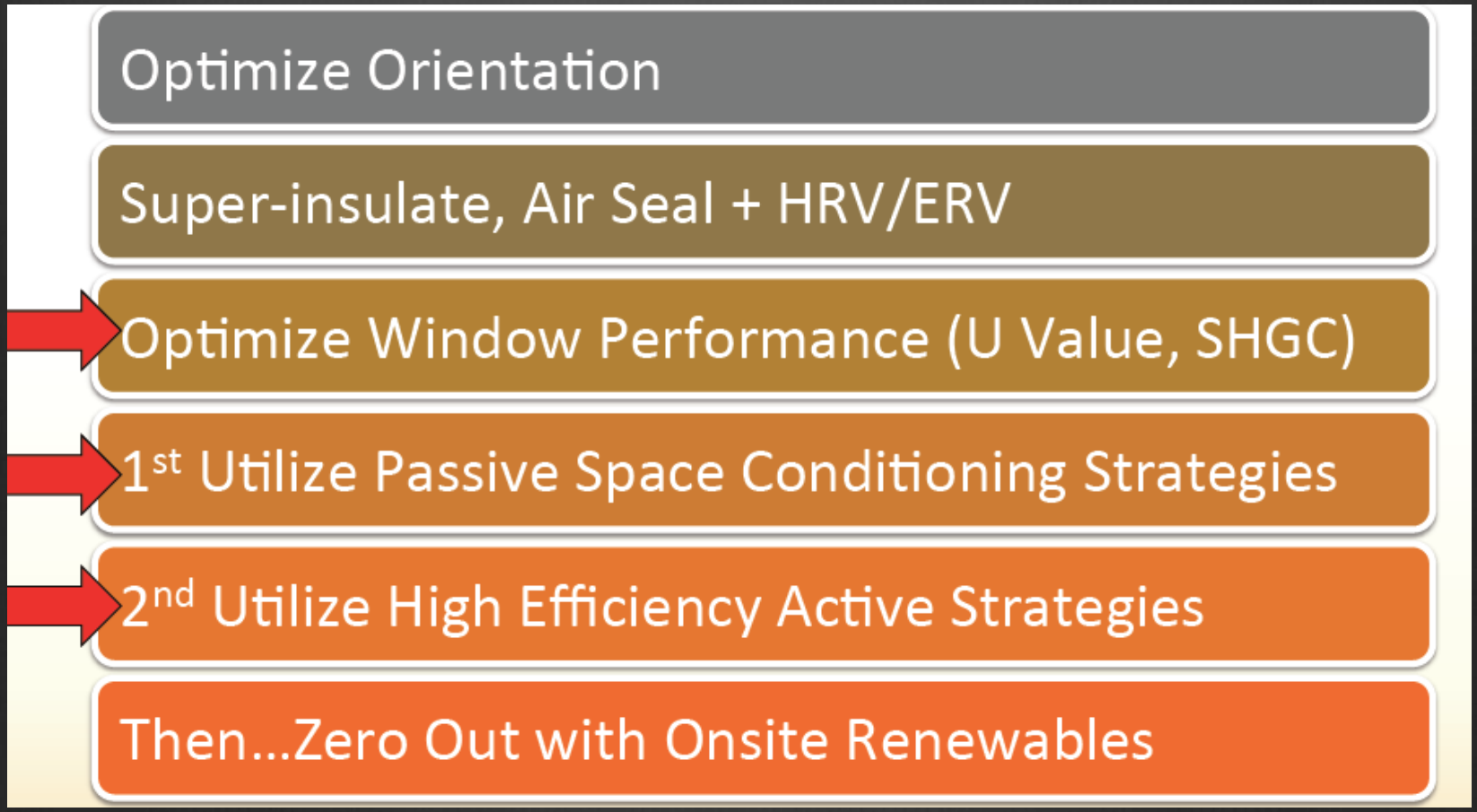

Out = In
0°F
68°F
1 W/ft²


Annual Site Energy Usage
household
ventilation
hot water
heating
kWh/m²a
Btu/ft²/yr
300
250
200
150
100
50
95
79
63
48
32
16
Passive House
Building America Program - DOE
Energy Star
IECC 2009 International Energy Conservation Code
Old Buildings
Source: IG Passivhaus Österreich

Passive House Approach:

Size the Shell to the Heating System

Order of Mechanical Design



Advantages

- Smaller Heating & Cooling Demand
- Smaller Peak Loads: Solar & Heat Pumps Have Low Peak Output
- Passive House Is "Sluggish":Heating & Cooling "Averaged" over 24 HR Period

Challenges

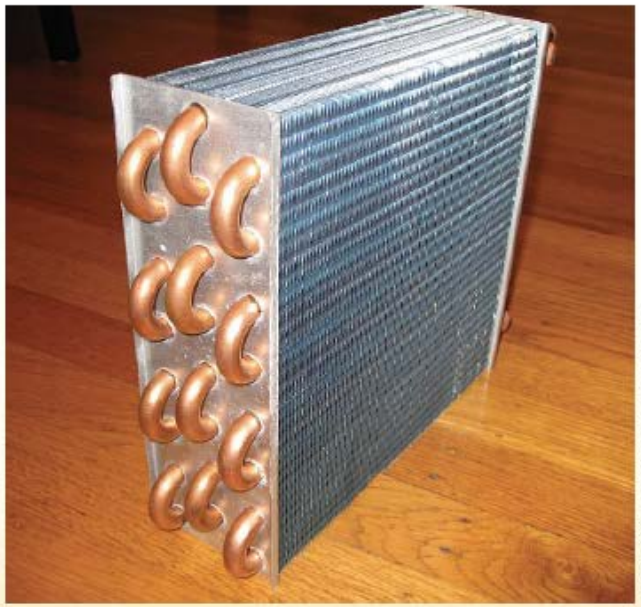
- Small Energy Budget (38 kBTU/ft^2| 11 kWh/ft^2yr)
- Sourcing Appropriate Equipment in N America

Heating through Ventilation

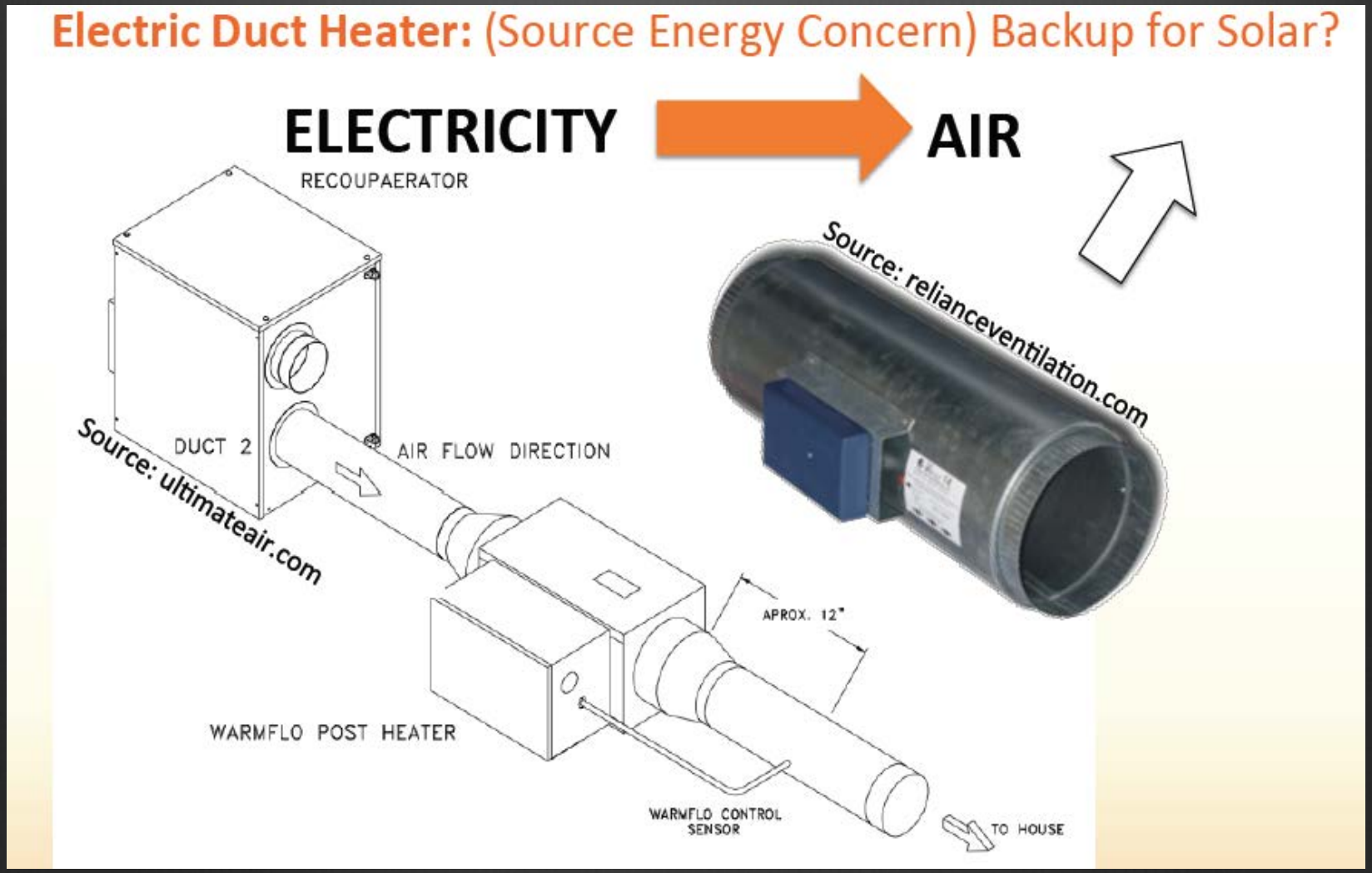
WATER → **AIR**

Hydronic Duct Coil:
Heating with DHW

- Feed with Solar Thermal
- Feed with High Eff Boiler



Electric Heat inline with HRV

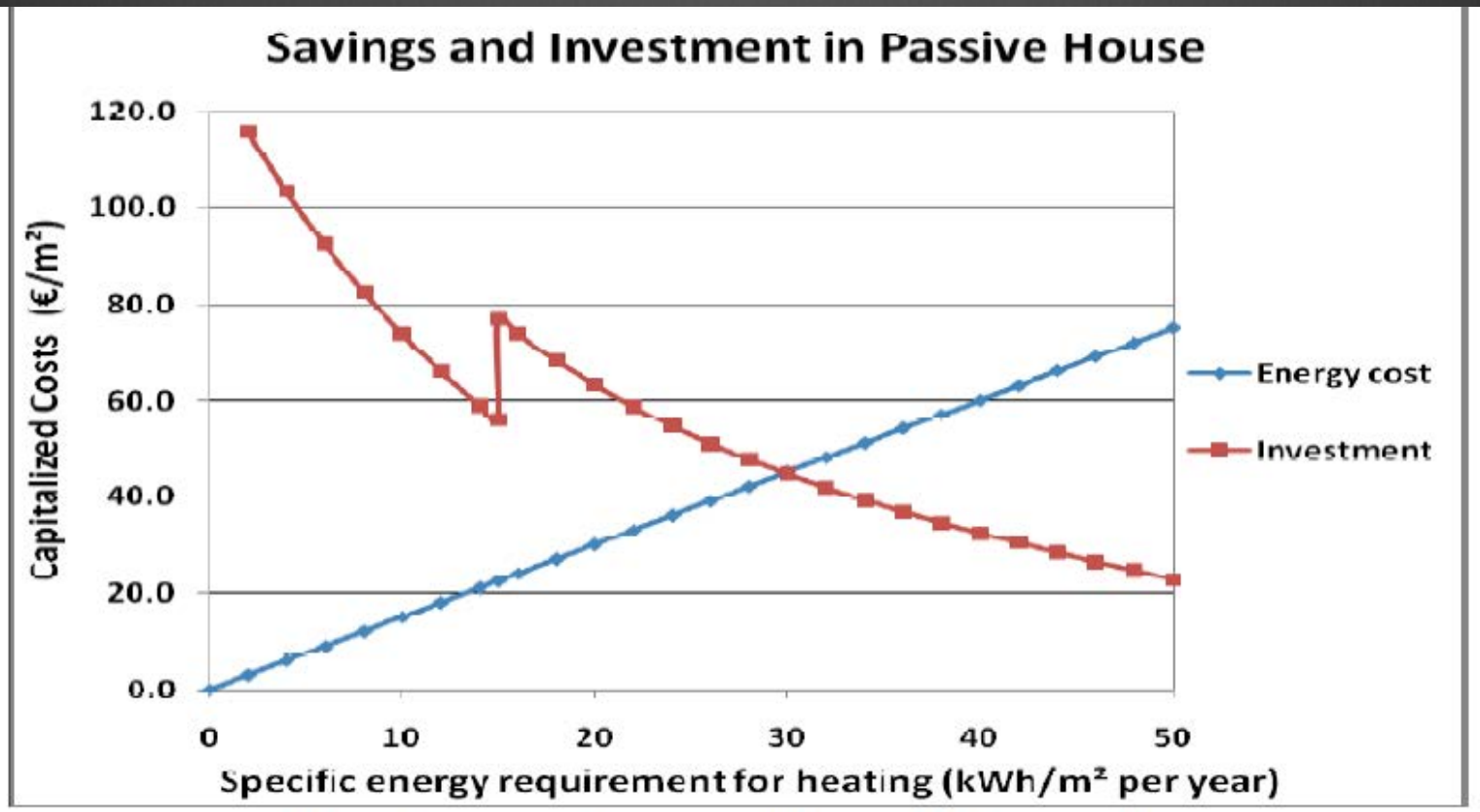


Point Source Heat

Source: Rinnai

Through-the-wall sealed combustion furnace

Sweet Spot

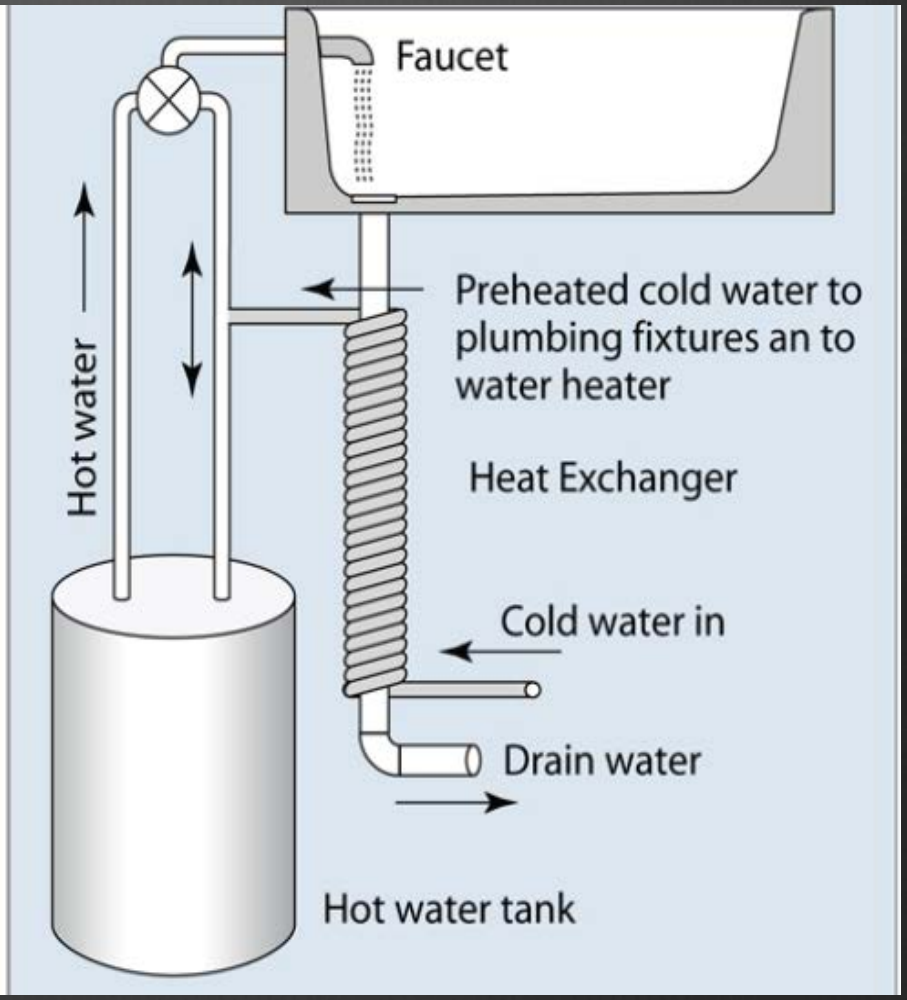


Note: Costs are for central Europe (Germany)

DHW will likely be the largest energy draw in a PH

DHW considerations

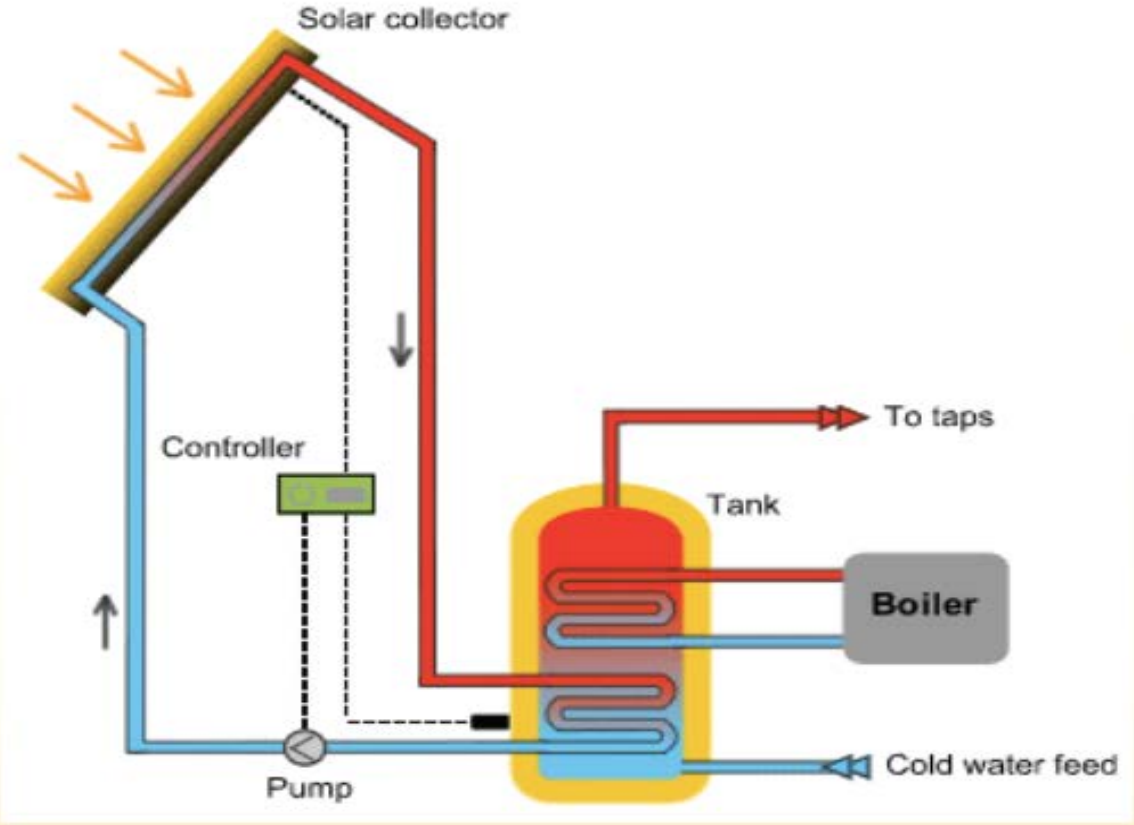
- Low flow fixtures
- Insulated tanks
- Insulated pipe
- Waste heat recovery



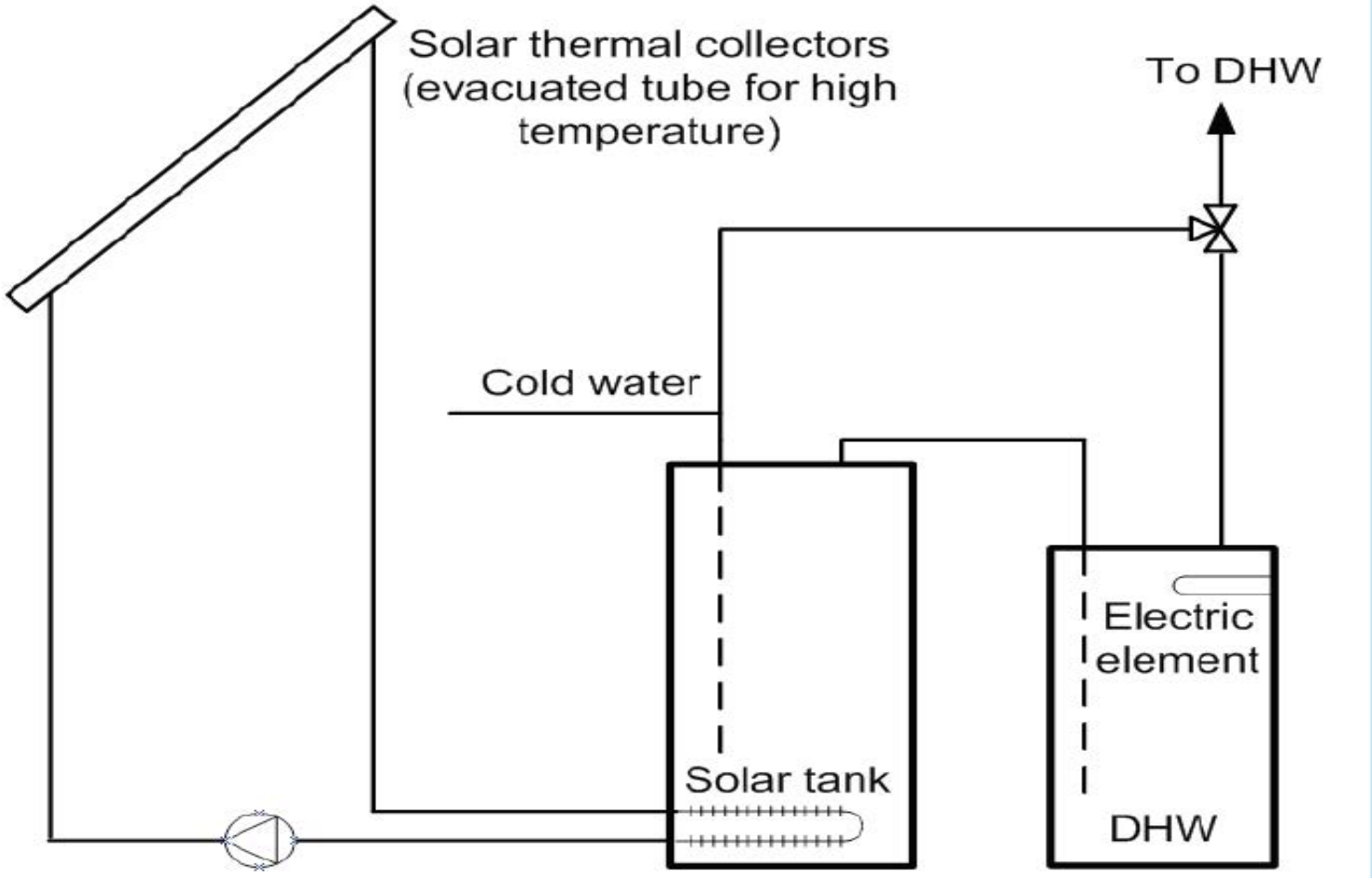
Boilers as DHW Heaters

- Sealed Combustion
- Modulating Burners
- Low Water Content
- Condensing
- Low Temp Operation

Solar Hot Water



Solar with E- back up



Review

Goal is towards NZE, to increase healthy living spaces, comfort, durability, reduce energy use, minimize costs, reduce environmental impact, and to enjoy.

- Thermal Shell >R-60
- Thermal Bridge Free
- Window placement and Detailing
- <.6ACH @ 50Pa
- HRV/ERV well designed
- No Open Combustion in Home
- Stable Surface Temperatures
- ACAT membership