

How I Built a Net-Zero Home

In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry assatisfying **1.5 code/energy hours** of credit toward **Building Officials and Residential Contractors** continuing education requirements."

For additional continuing education approvals, please see the continuing education credit section in the conference agenda booklet.



Amber Westerman poemhomes.org 608.935.9020 amberwesterman.com

How I Built a Net-Zero Home



POEM Homes.org



Goals

Amber Westerman, Spring Green, Wisconsin, 2018



-Small +/-1200 SF

-Simple Shape, South Roof

-Super Insulated

-Airtight

-All Electric: No Fossil Fuels

-Low Carbon & Non-Toxic

-No Job Site Dumpster

Small is Beautiful



2020 = 2333 sf



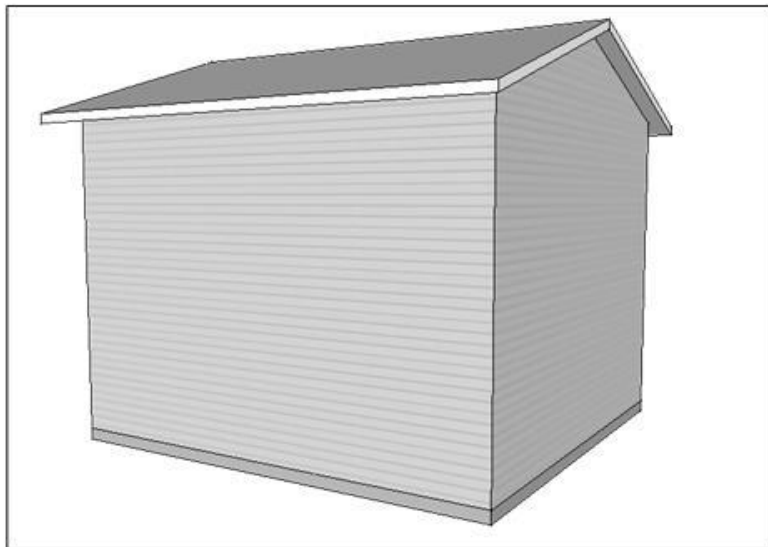
1955 = 1200 sf



2020 = 1208 sf

The Shape of Things

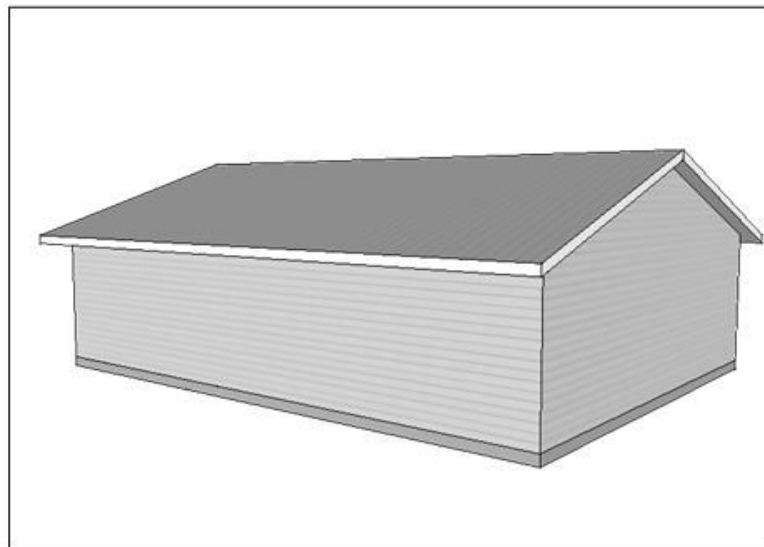
HEATING COSTS



Two Story = 1248 SF
= 11752 CF
= 3035 SF surface



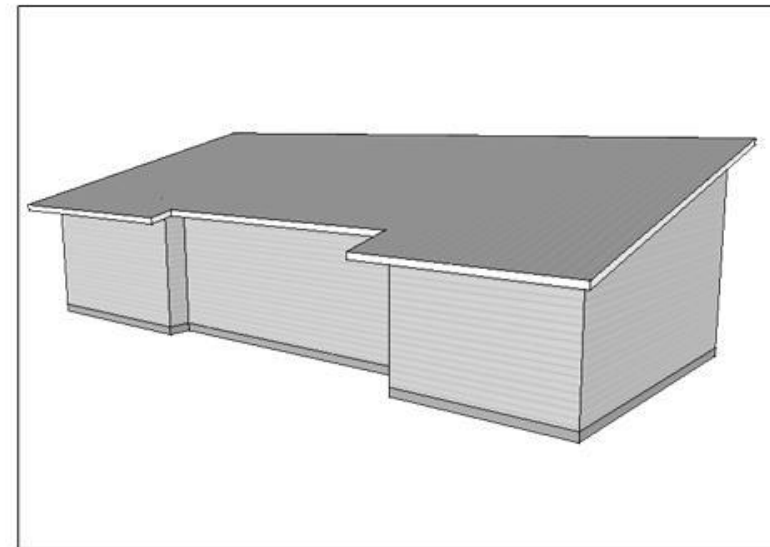
\$288/yr



One Story = 1200 SF
= 11800 CF
= 3640 SF surface



\$302/yr



As Built = 1208 SF
= 16052 CF
= 4449 SF surface

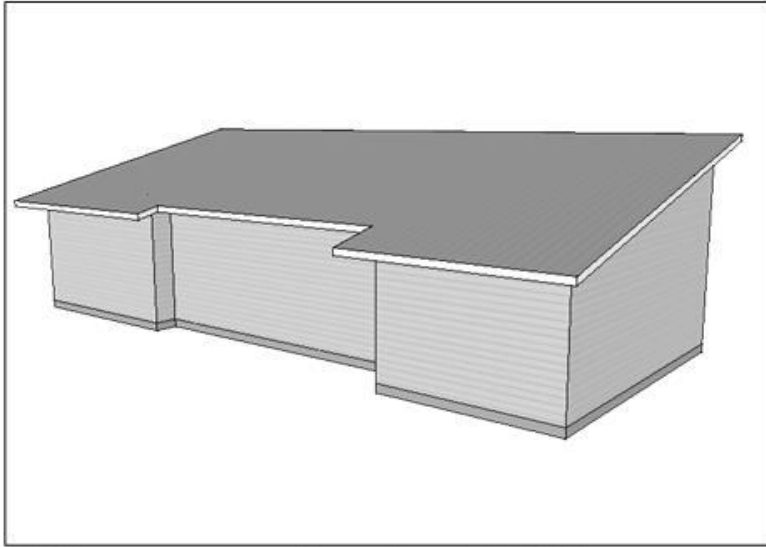


\$387/yr

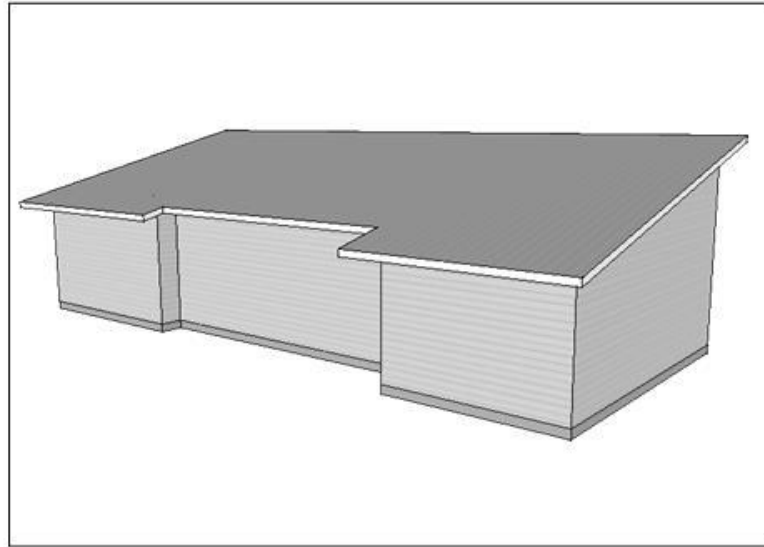
www.remrate.com

Code Min. *or* Super Insulation?

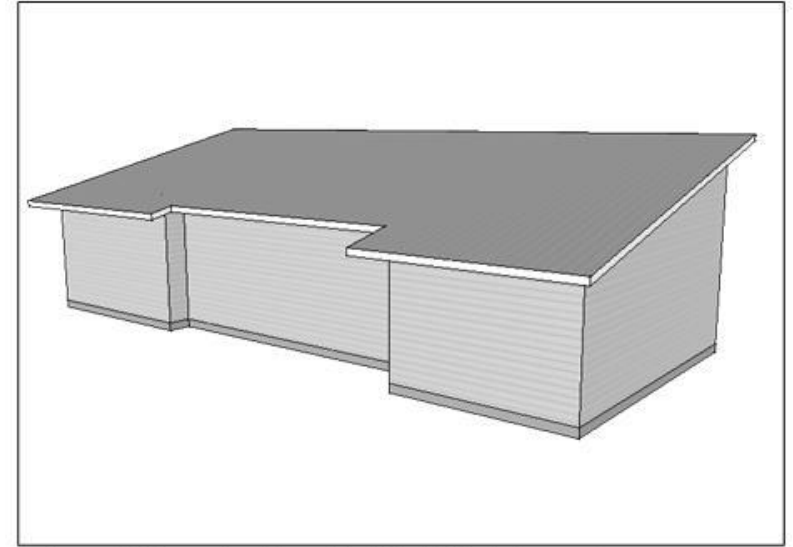
www.remrate.com



Wisconsin Code *2009



IECC 2021



As Modeled REM/Design



\$1160/yr (heat)



\$717/yr (heat)

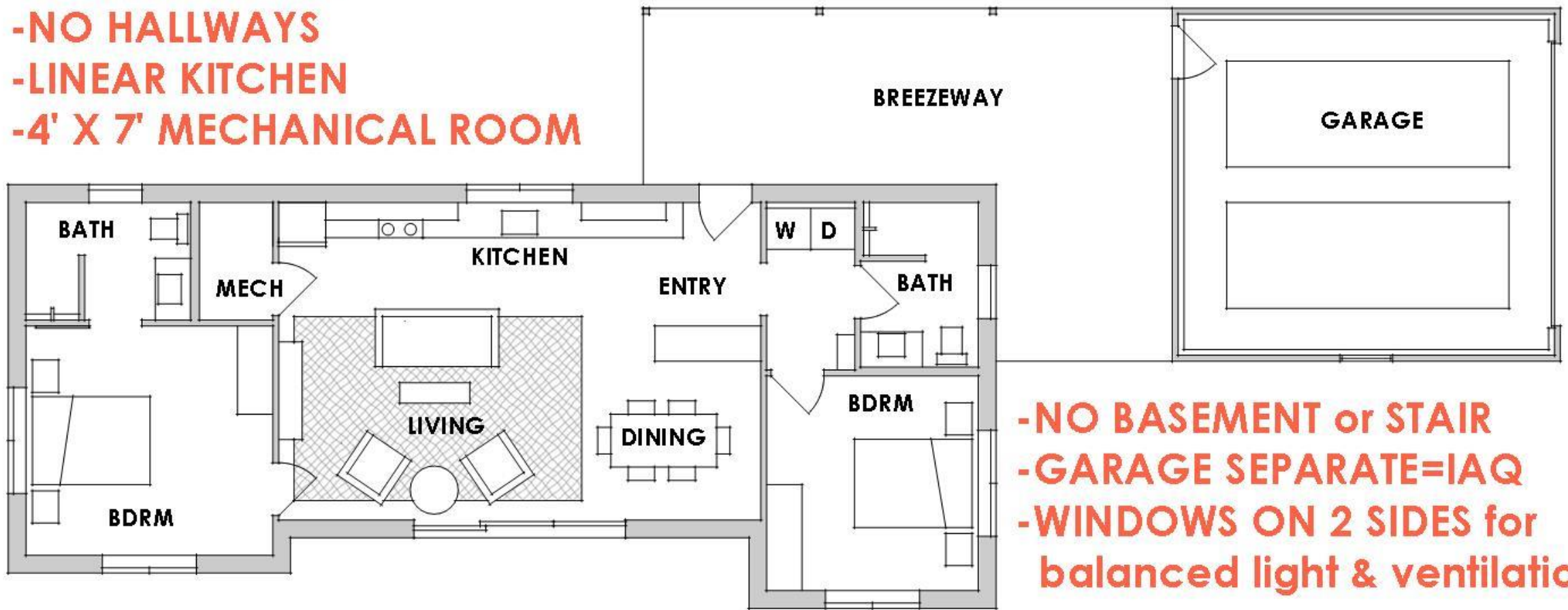


\$387/yr (heat)

MONEY ON THE TABLE ???

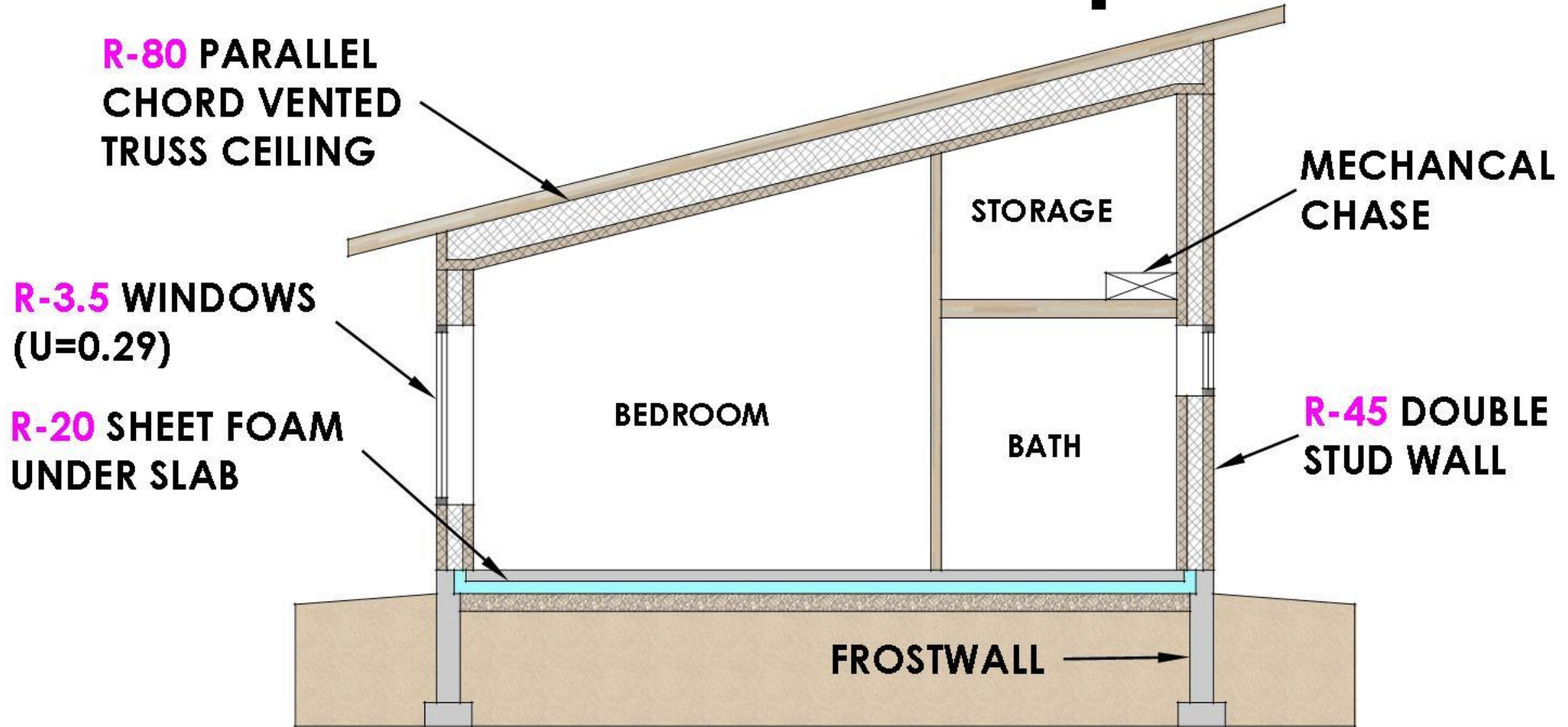
1208 sf Floor Plan

- NO MUDROOM
- NO HALLWAYS
- LINEAR KITCHEN
- 4' X 7' MECHANICAL ROOM

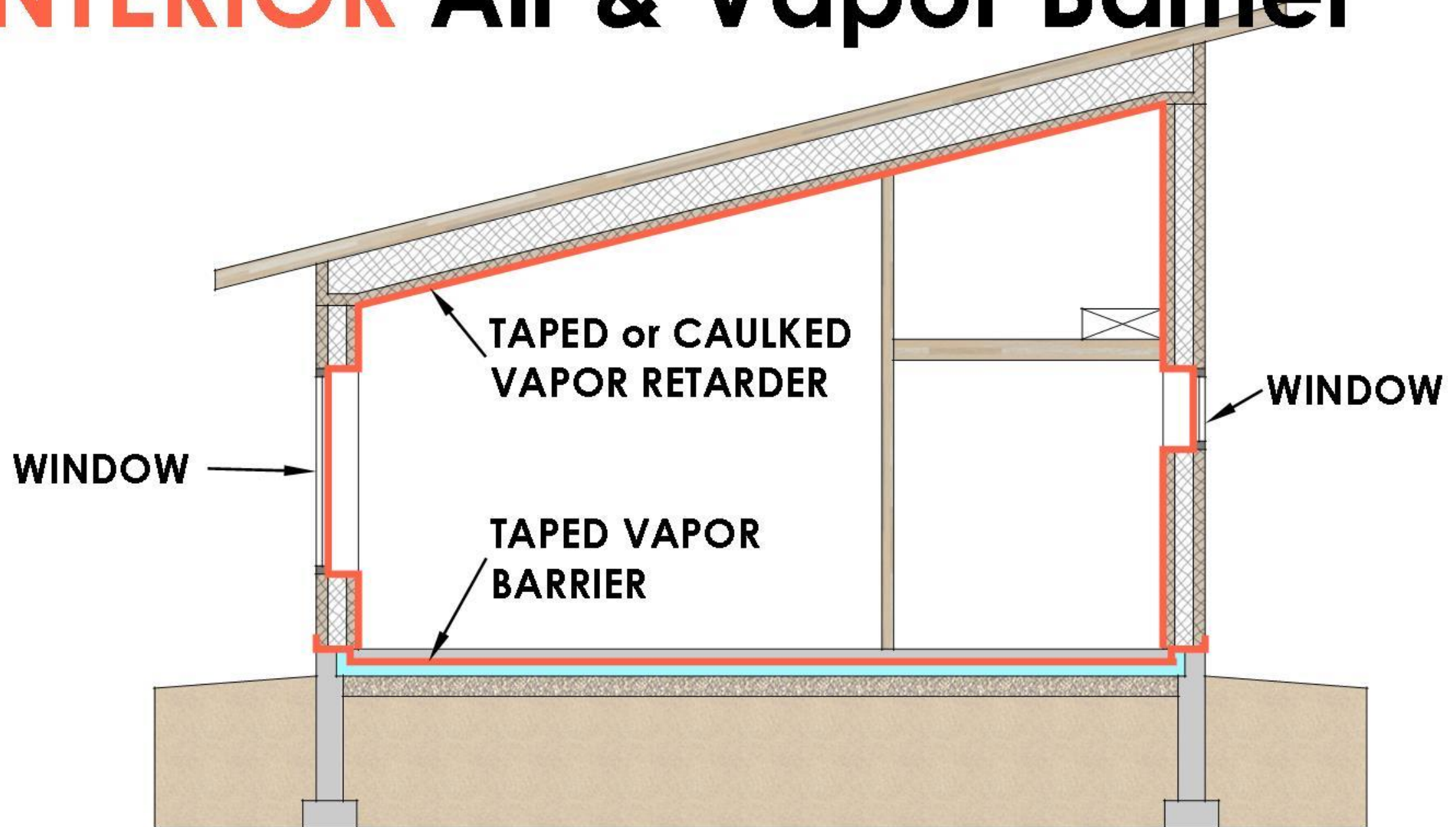


- NO BASEMENT or STAIR
- GARAGE SEPARATE=IAQ
- WINDOWS ON 2 SIDES for balanced light & ventilation

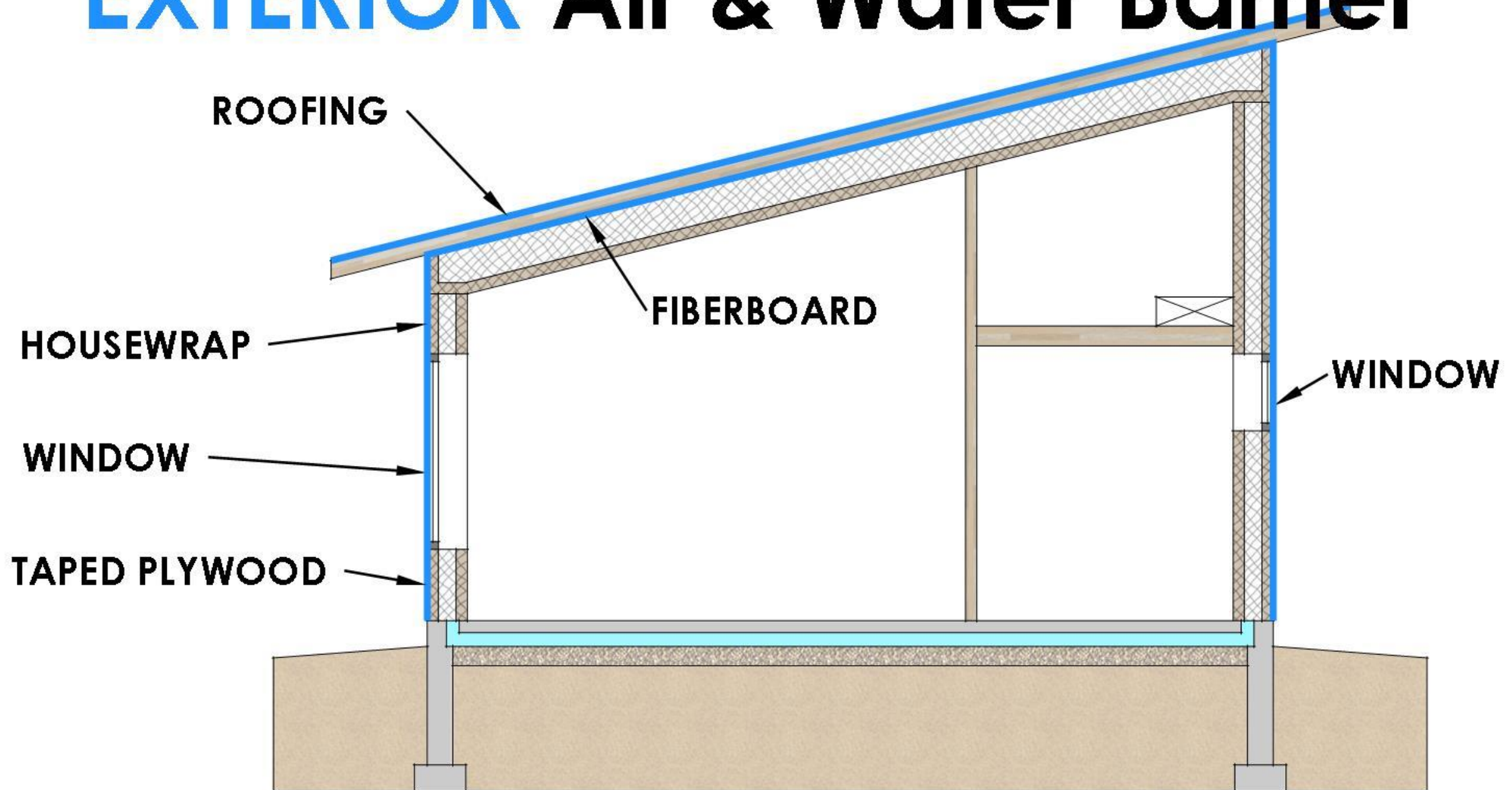
Thermal Envelope



INTERIOR Air & Vapor Barrier



EXTERIOR Air & Water Barrier



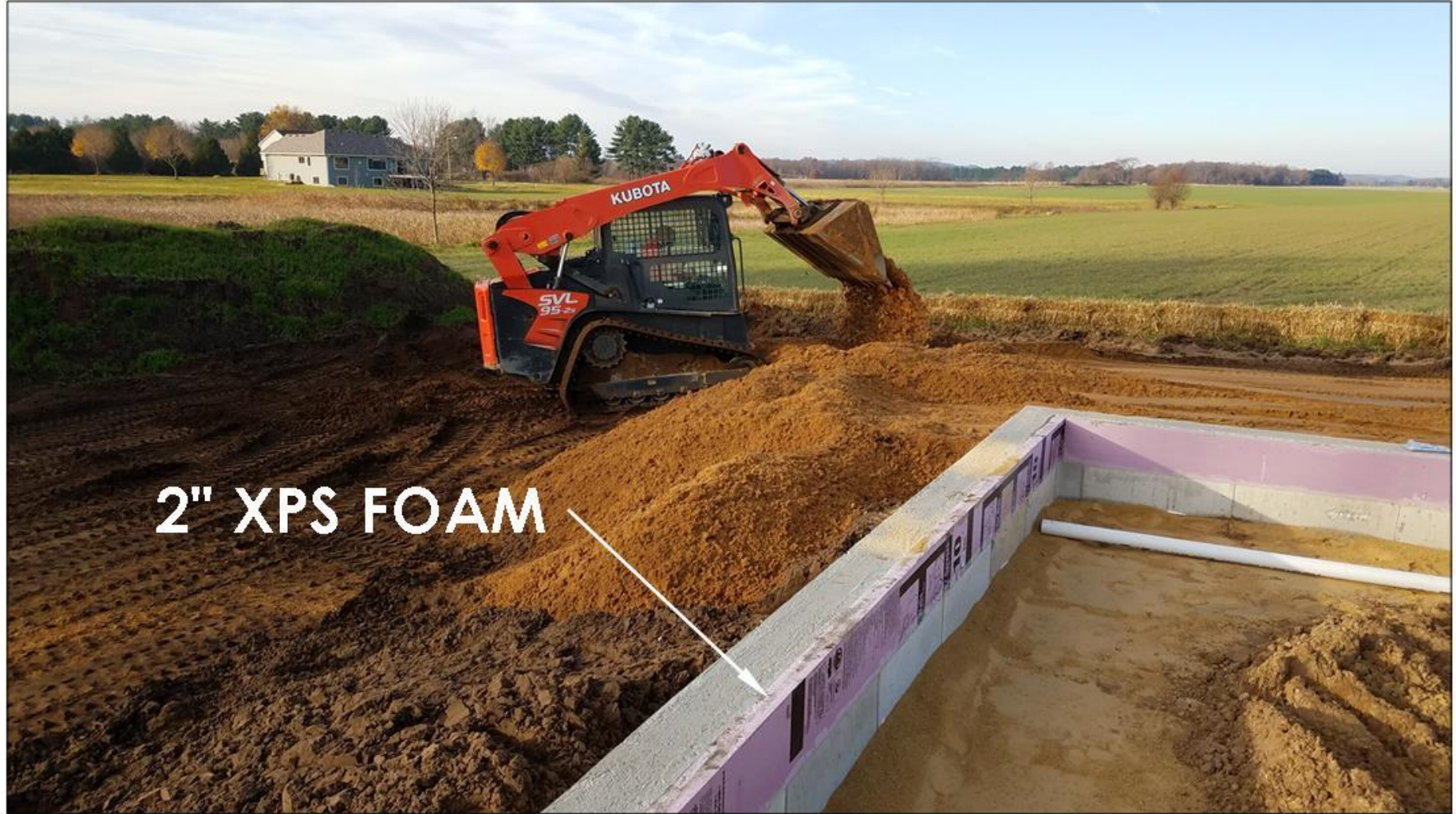
Footings



Frost Wall



Edge Foam

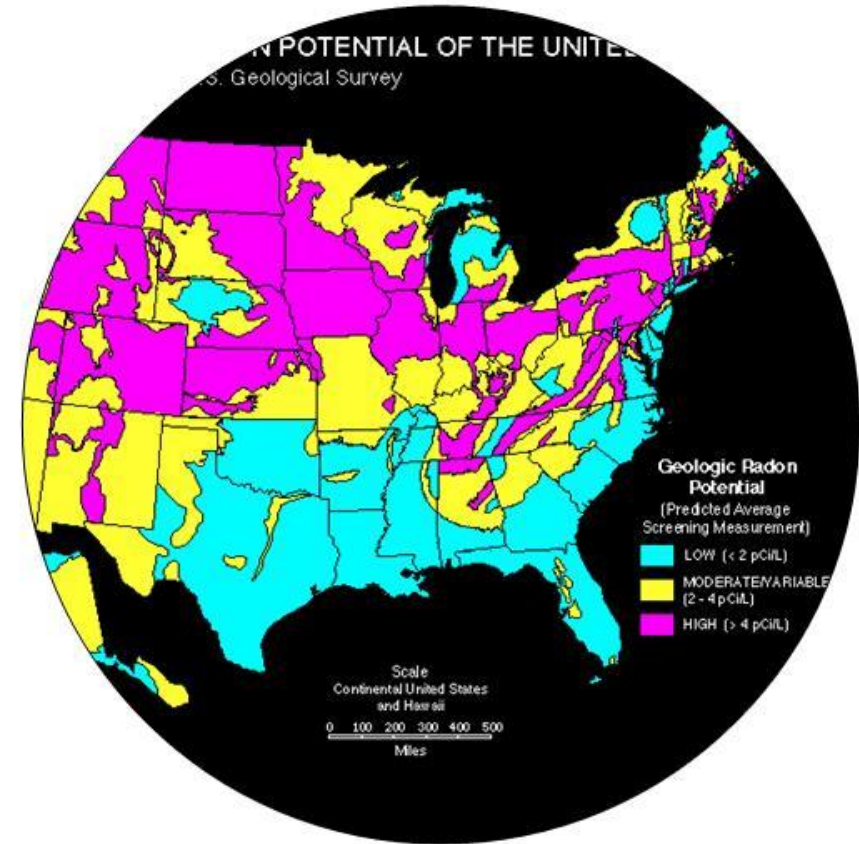


1" DIAMETER CLEAR
GRAVEL BED 6" DEEP
(no fines)

Radon Bed



PINK=HIGHEST RISK OF RADON GAS

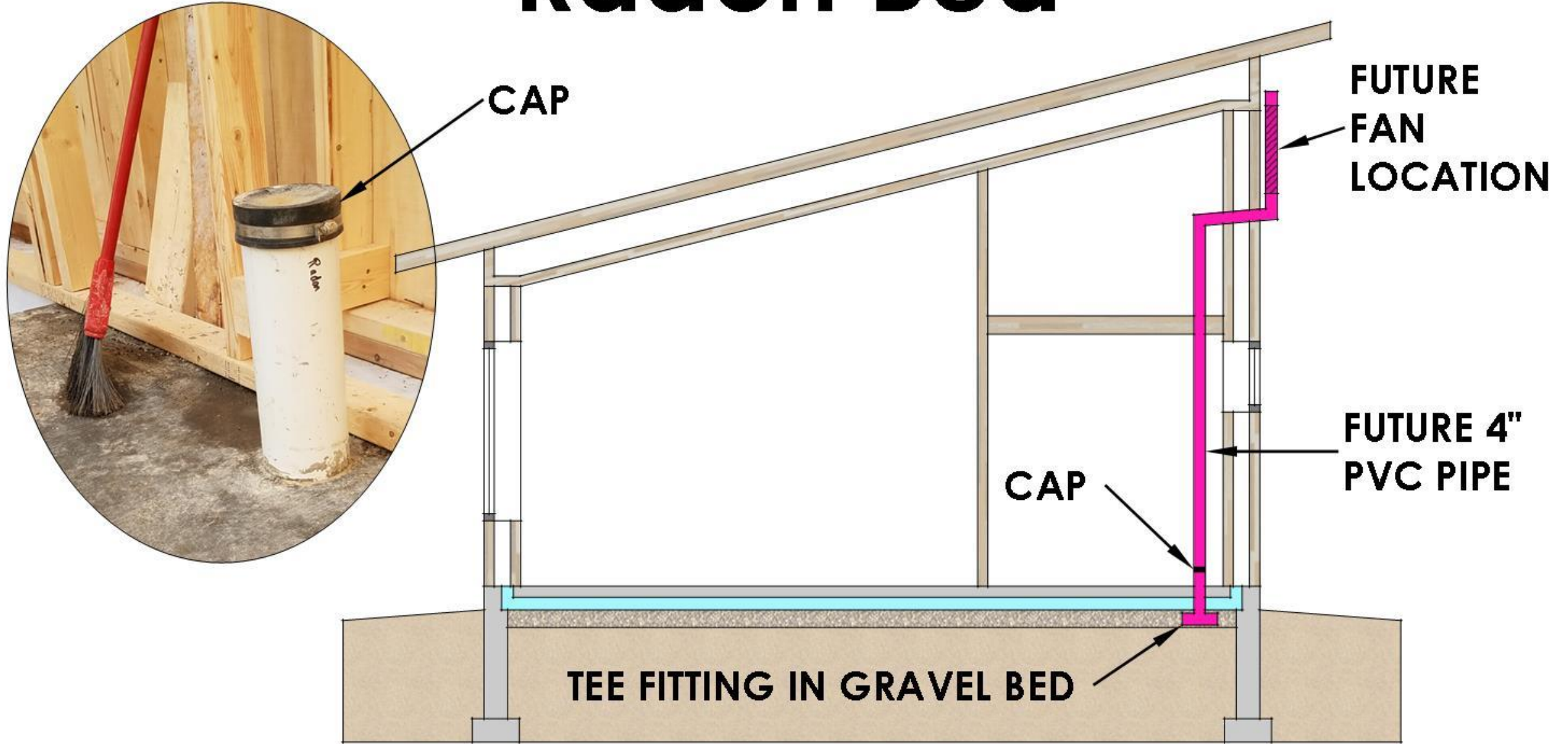


WISCONSIN Average Outdoor Level = 0.40 pCi/L
WISCONSIN Average Indoor Level = 1.30 pCi/L

Level of Concern
AMBER'S HOUSE

= 4.00 pCi/L
= **2.40 pCi/L**

Radon Bed



XPS Foam Tray



RADON

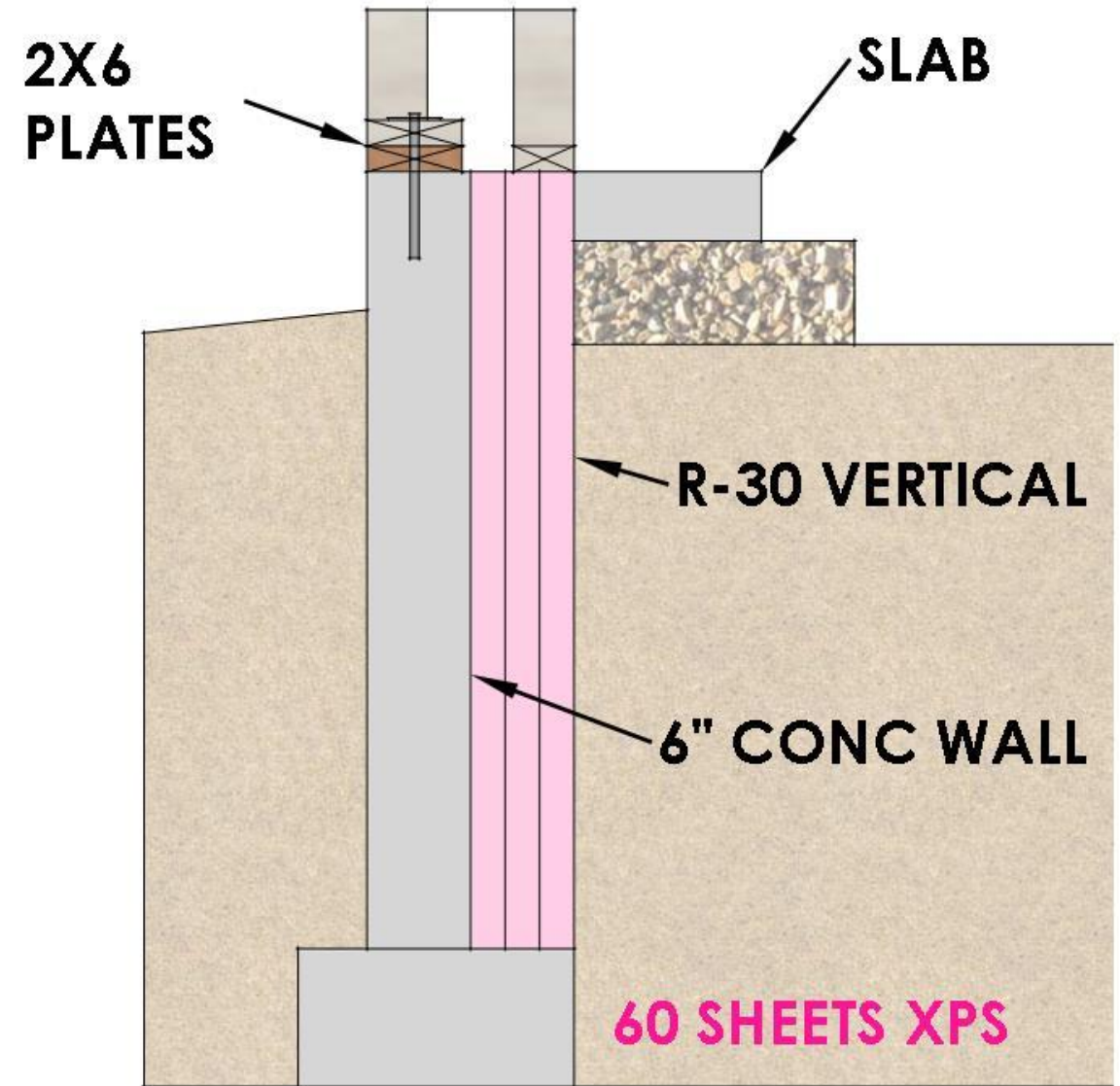
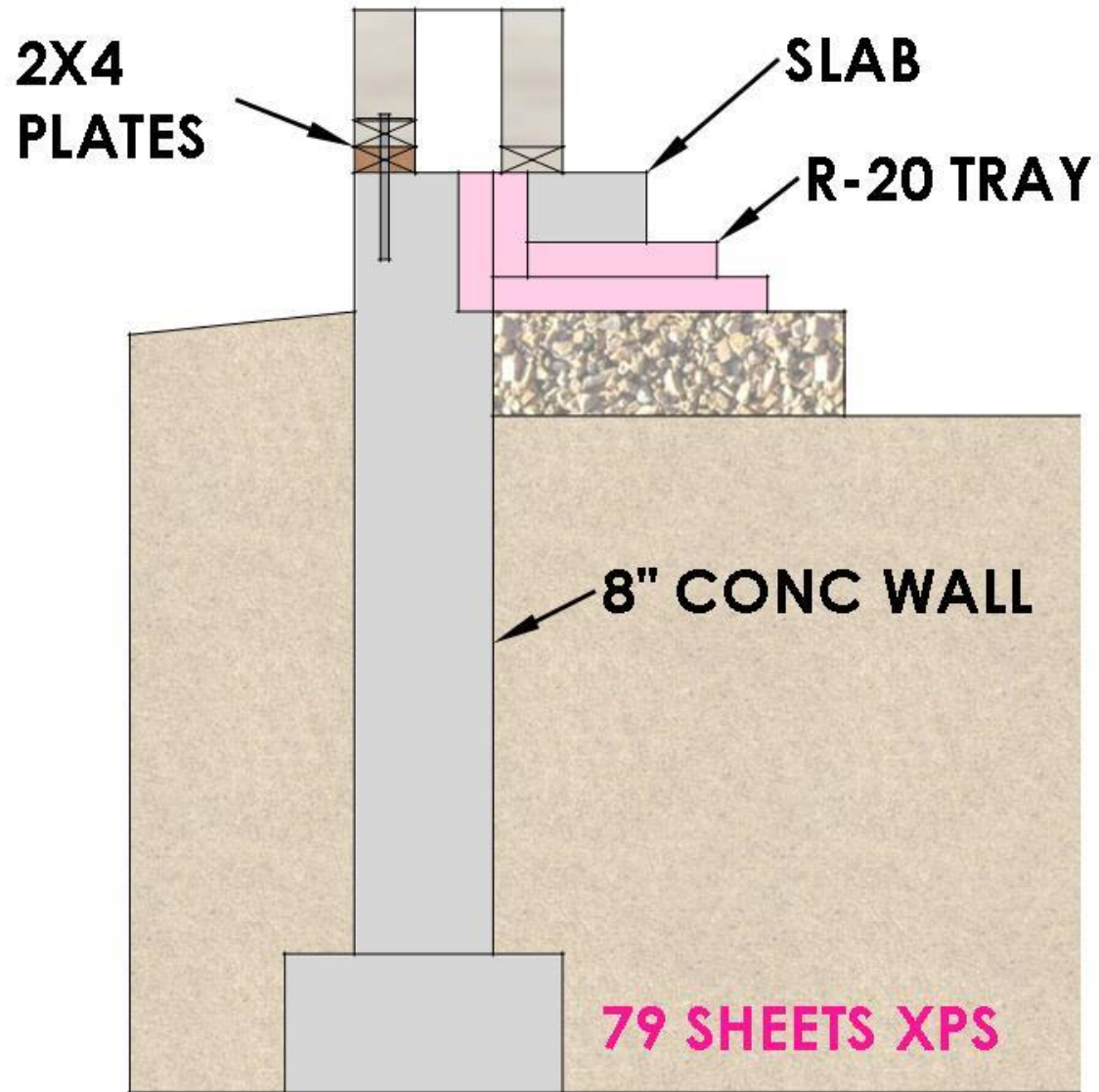
SPRAY FOAM GAPS

**(2) 2" LAYERS @ HOUSE
lapped joints**

(1) 2" LAYER @ GARAGE



Tray Foam = Vertical Foam

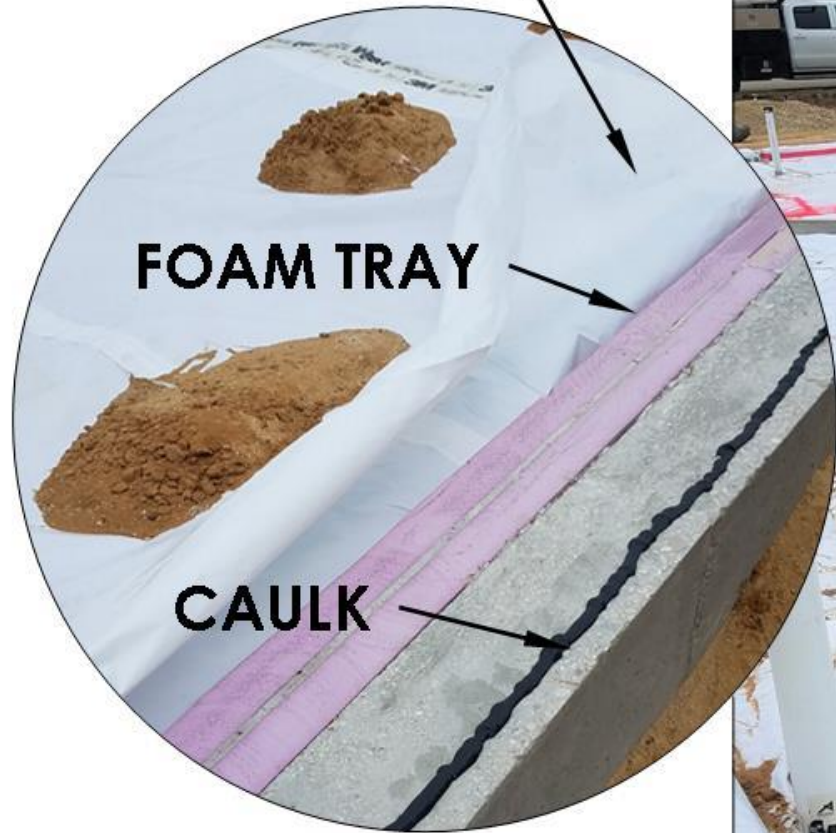


Sill Plate Prep



Vapor Barrier

VB RUN LONG



Slab Pour



VAPOR BARRIER RUN LONG

Sill Gasket



Pre-Fab Wall Panels & Trusses



Advanced Framing



**NO HEADERS @
NON-BEARING WALLS**

24" OC

**LADDER BLOCKING @ INTERIOR
PARTITION WALLS**



2-STUD CORNERS

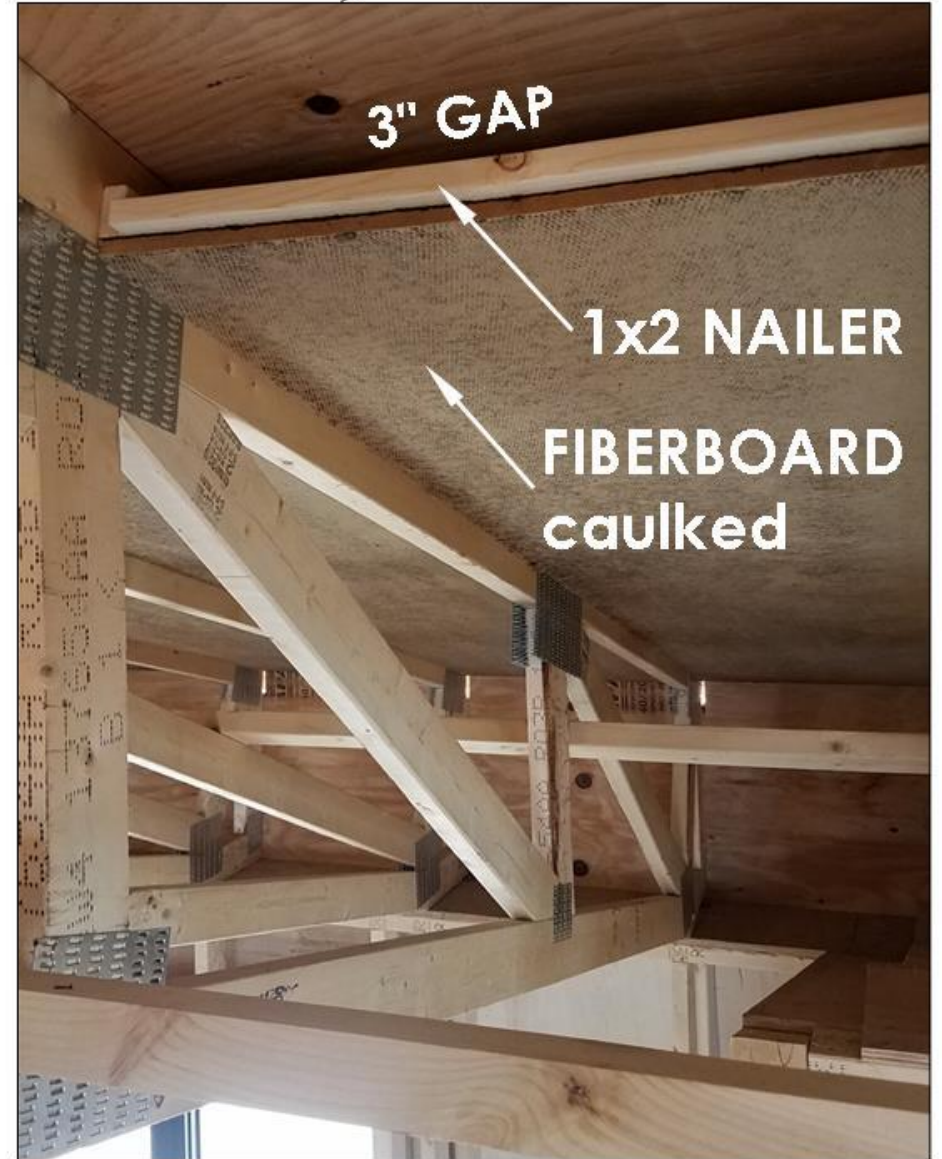
Vent Chute

ROOF SHEATHING



WALL
SHEATHING

PARALLEL
CHORD
TRUSSES



Taped Sheathing



**CEMENT
BOARD**

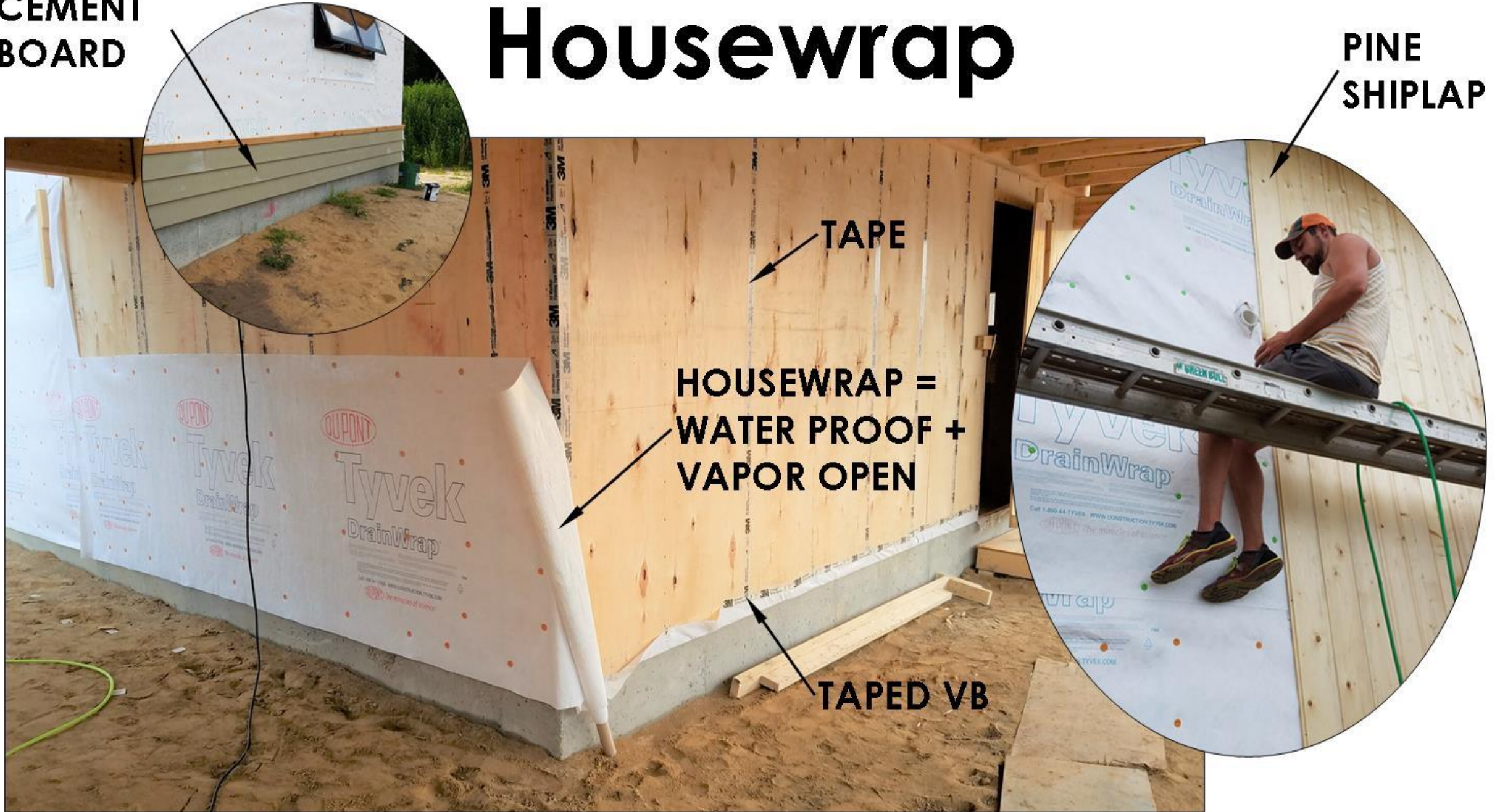
Housewrap

**PINE
SHIPLAP**

TAPE

**HOUSEWRAP =
WATER PROOF +
VAPOR OPEN**

TAPED VB



Roofing



**GALVALUME STANDING
SEAM STEEL ROOFING
concealed fastener**



Marvin Fiberglass Windows



DUAL PANE	
LOW E2 ARGON	
U	=0.29
SHGC	=0.29
VT	=0.49
CR	=59



STANDARD WINDOW INSTALL

Window Heat Cost /year

www.remrate.com

NORTH WINDOWS

\$165

AS MODELED

\$159

E1 @ SOUTH

\$159

TRIPLE PANE

\$111



Interior Air Seal #1



← FLEX TAPE

SPRAY
FOAM



TAPE &
CAULK



CAULK

Blower Door #1

2.20 ACH @ 50Pa = 0.13 cfm50/sf shell



**FIBERBOARD
taped & caulked**

Ceiling Vapor Retarder + Drywall

CERTAINTED "MemBrain"
VAPOR VARIABLE
RETARDER caulked
= INTERIOR AIR BARRIER



Dense Pack Cellulose #1



**CELLULOSE = 84% RECYCLED NEWSPRINT
+ 14% BORIC ACID + 2% STARCH
manufactured in Fond Du Lac**



Partition Walls



2x4 WALLS INSTALLED **AFTER**
CEILING VR + DW

2x4 WALLS INSTALLED **AFTER**
STRIPS OF WALL VR + DW



Loft Frame

STRIP OF VR + DW



Blower Door #2

0.86 ACH @ 50Pa = 0.05 cfm50/sf shell



LINE SET
NOT SEALED

STATIONARY
PATIO DOOR
PANEL LEAKY

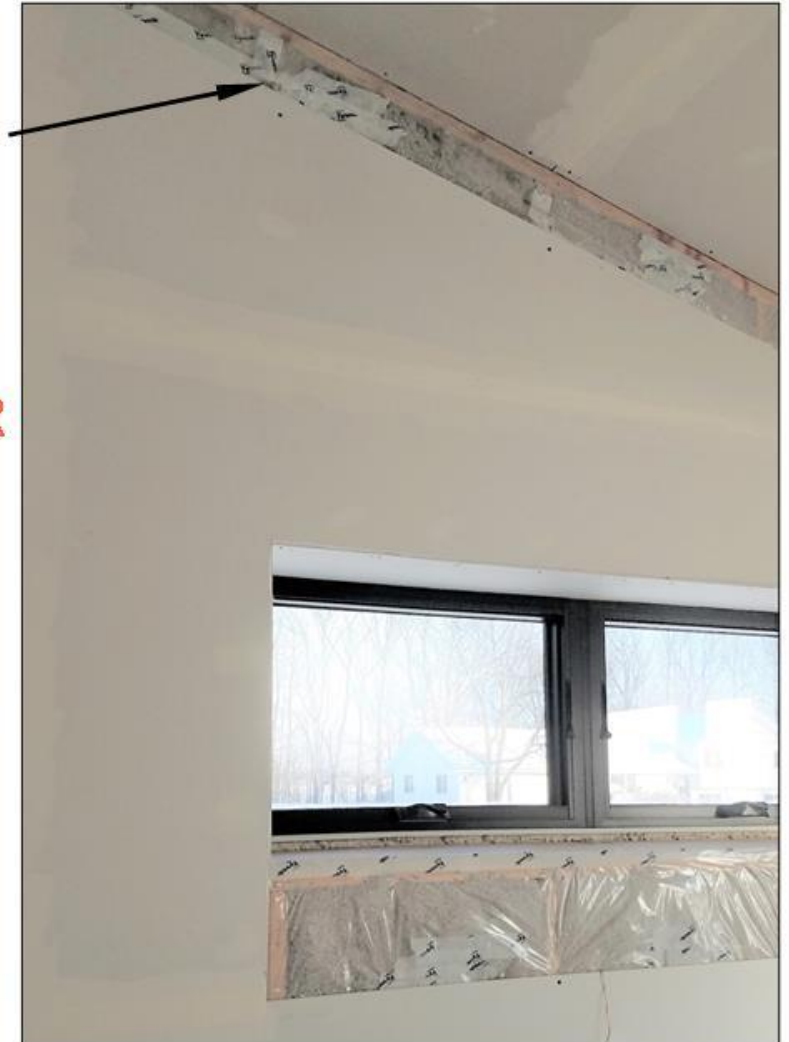


Wall Vapor Retarder + Drywall



GAP FOR INSULATION INSTALL

**CERTAINTED "MemBrain"
VAPOR VARIABLE RETARDER
caulked = INTERIOR AIR BARRIER**



Dense Pack Cellulose #2



DRYWALL HUNG *BEFORE* INSULATION

Cement Board Siding



Pine Siding



Pine Soffits



1/8" GAP

30" South Overhangs



Shade Trellis

SHADE @ NOON
SEPTEMBER 21

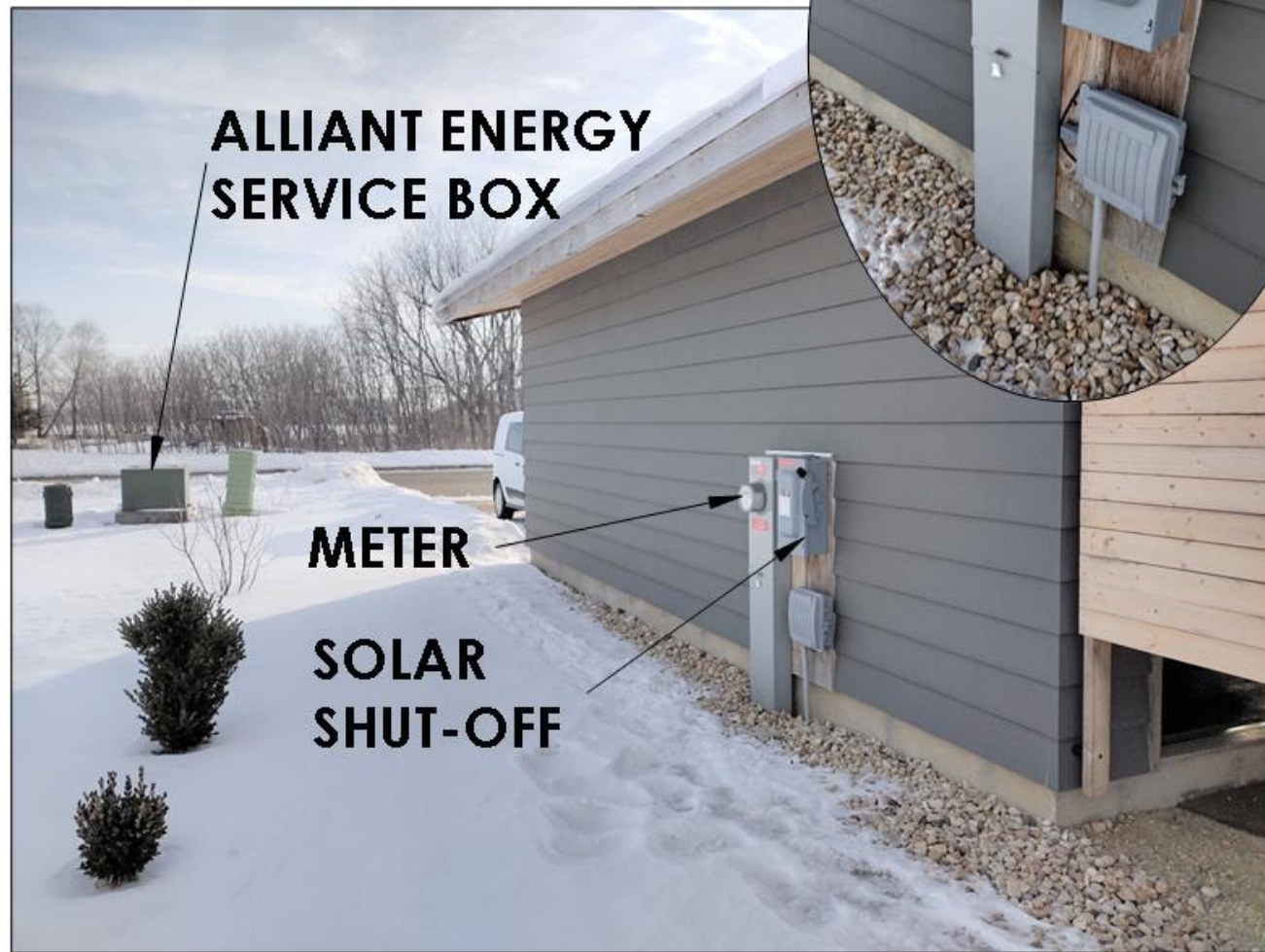


Electrical - Garage



ENVOY SOLAR MONITOR

MAIN
PANEL

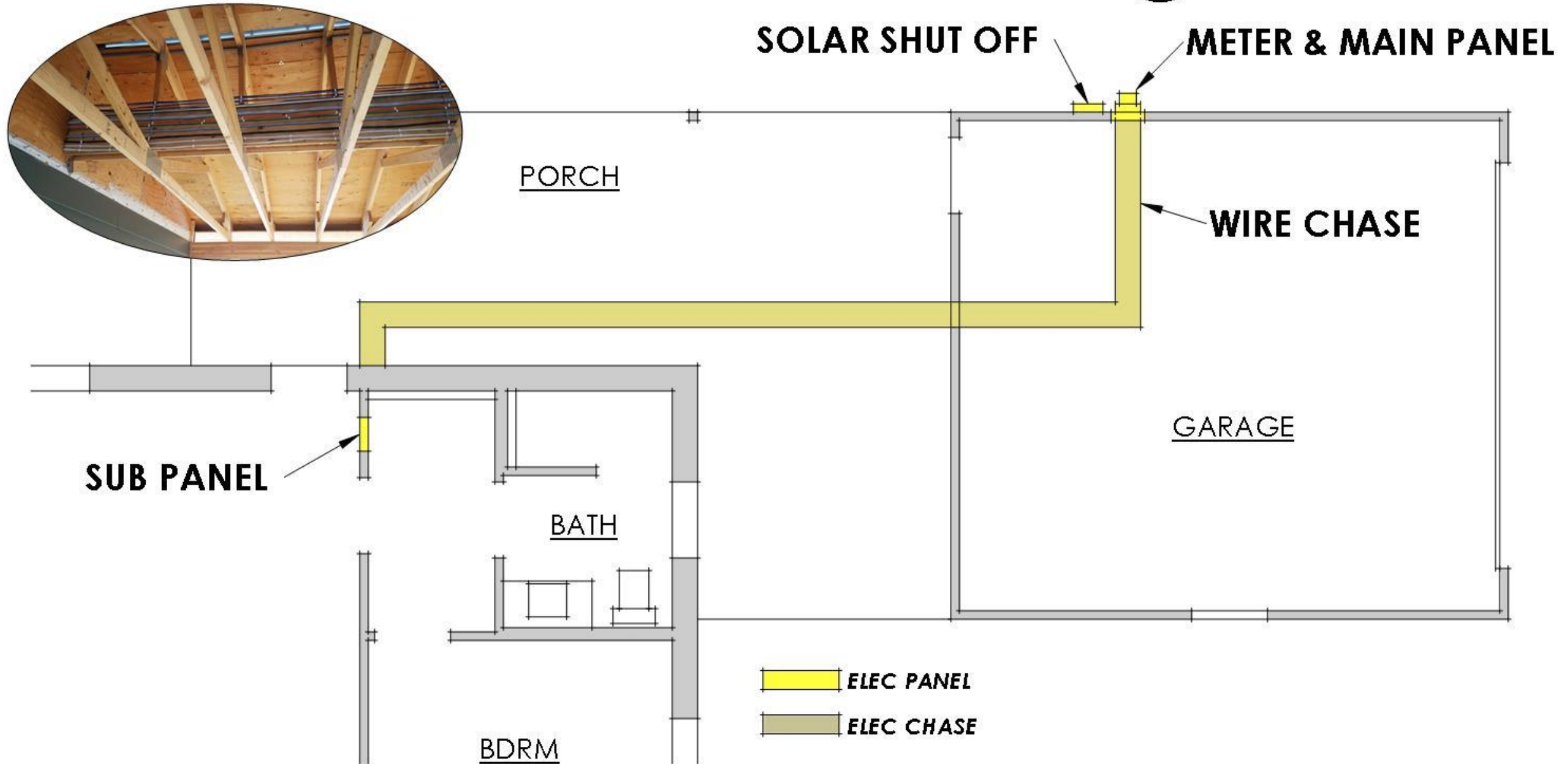


ALLIANT ENERGY
SERVICE BOX

METER

SOLAR
SHUT-OFF

Electrical - Garage



North Wall

Solar Electrical
Connection

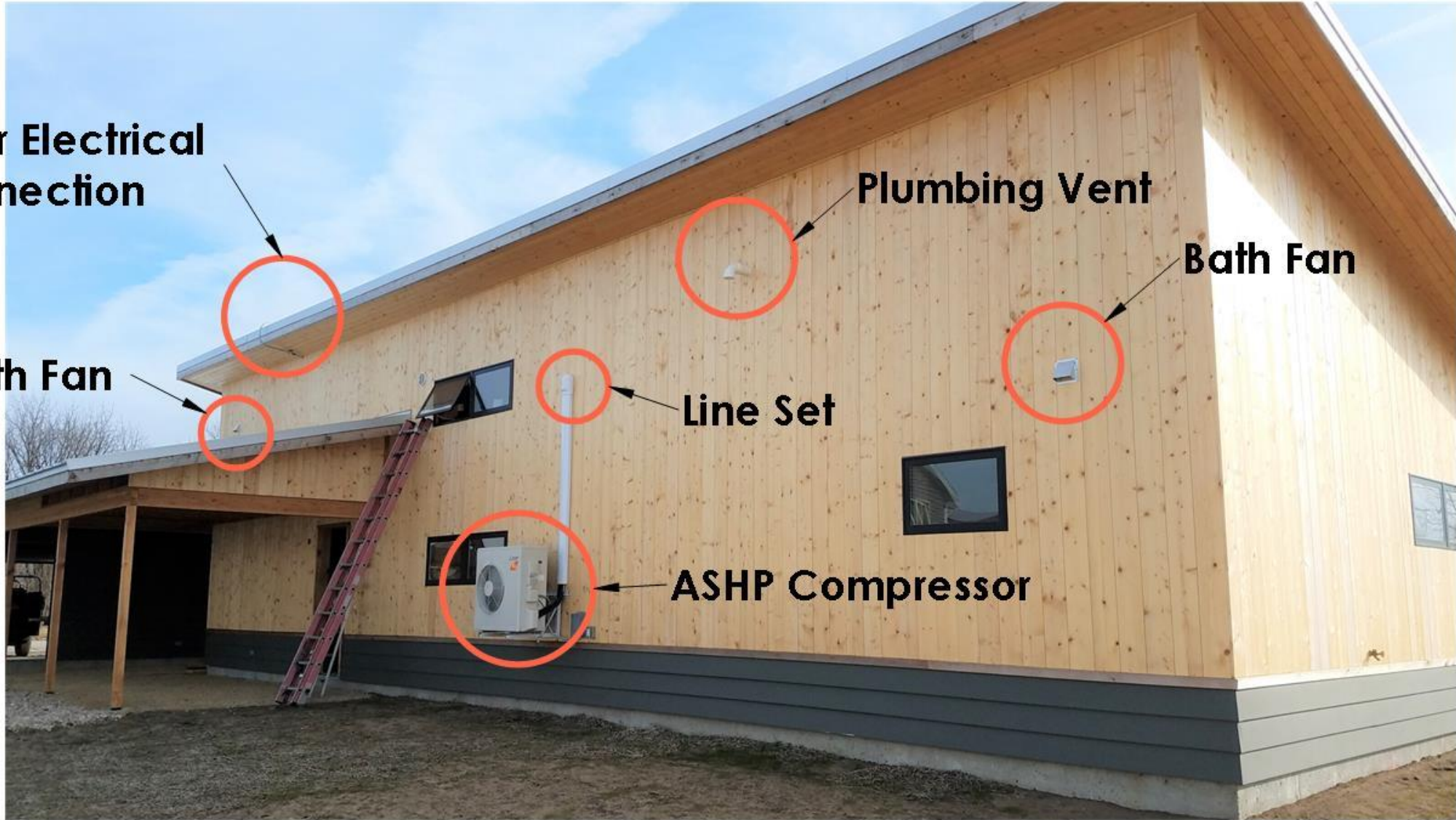
Plumbing Vent

Bath Fan

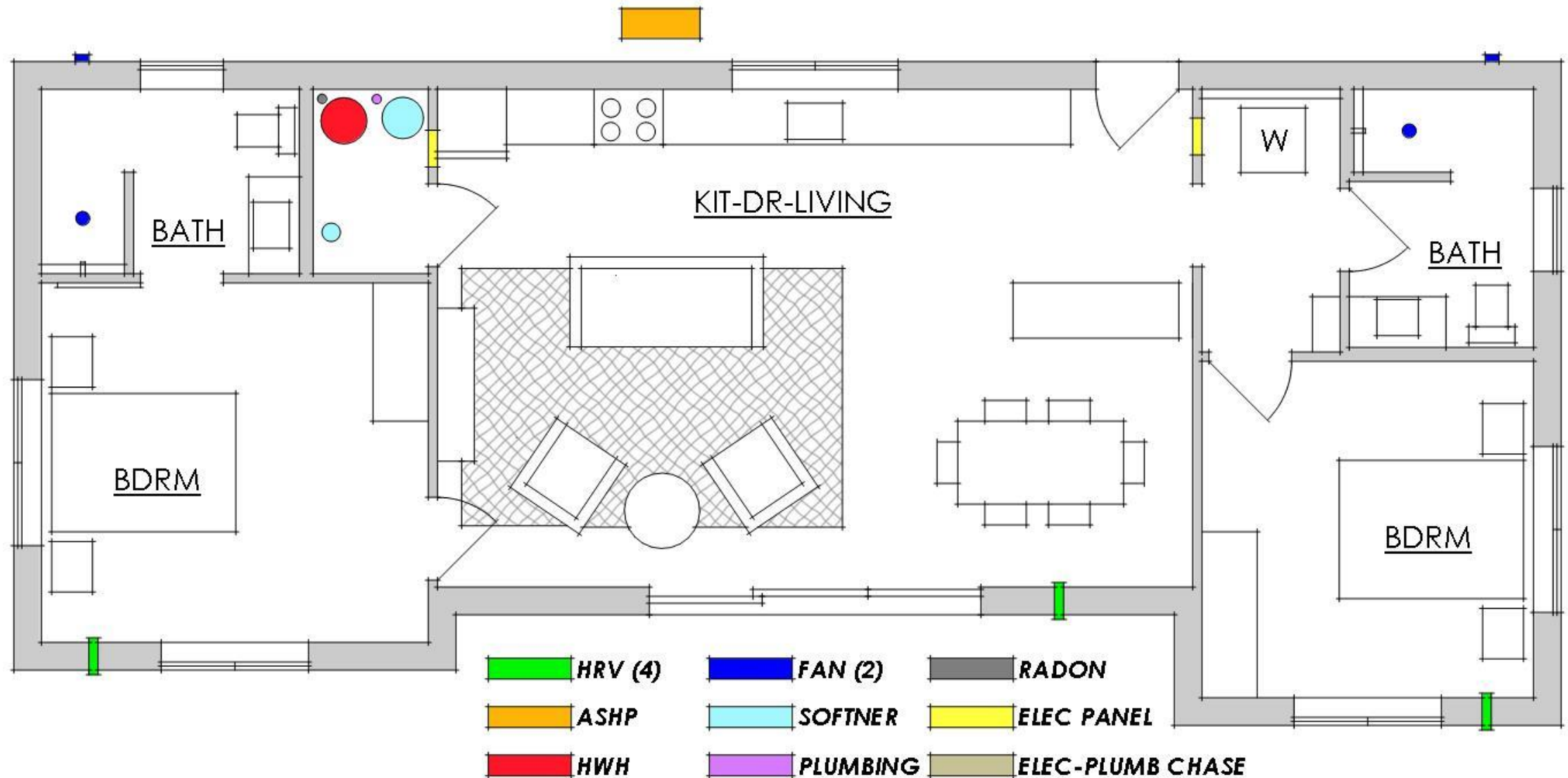
Bath Fan

Line Set

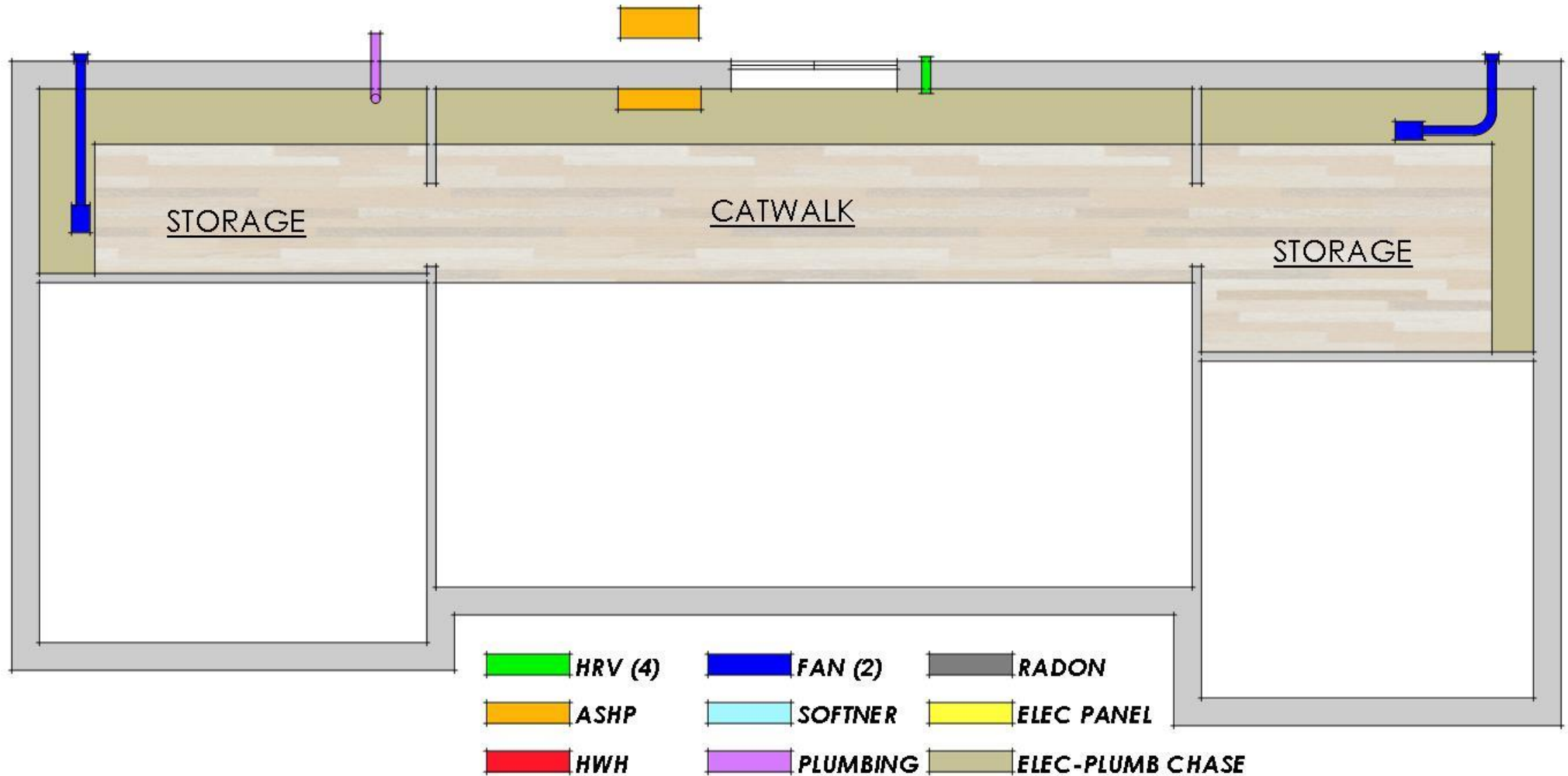
ASHP Compressor



Mechanical - Main Floor



Mechanical - Loft



Plumbing

Rheem Marathon
30 gallon HWH
R-20 insulation



Plumbing Stack



Plumbing + Wiring Chase



1.28 Gallons Per Flush



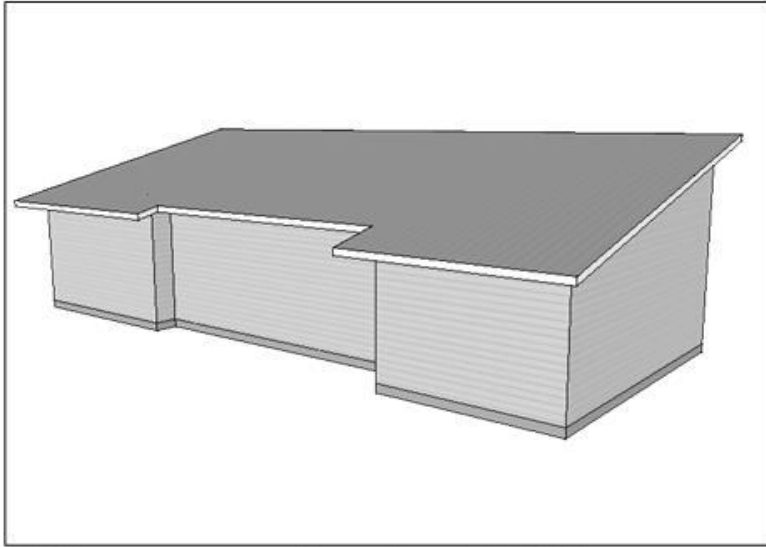
ASHP = Air Source Heat Pump



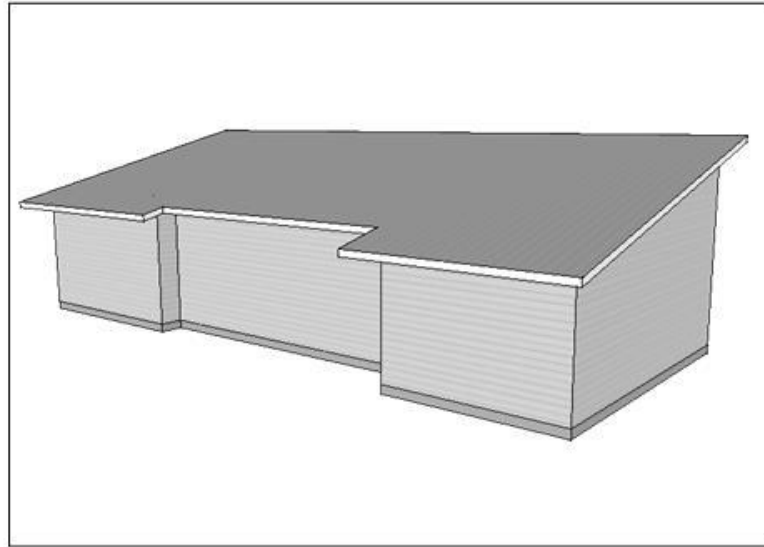
MITSUBISHI 18 kBtu/hour HEAT CAPACITY @ -13 = 12,580
PEAK LOAD = 12,300

ASHP Sizing

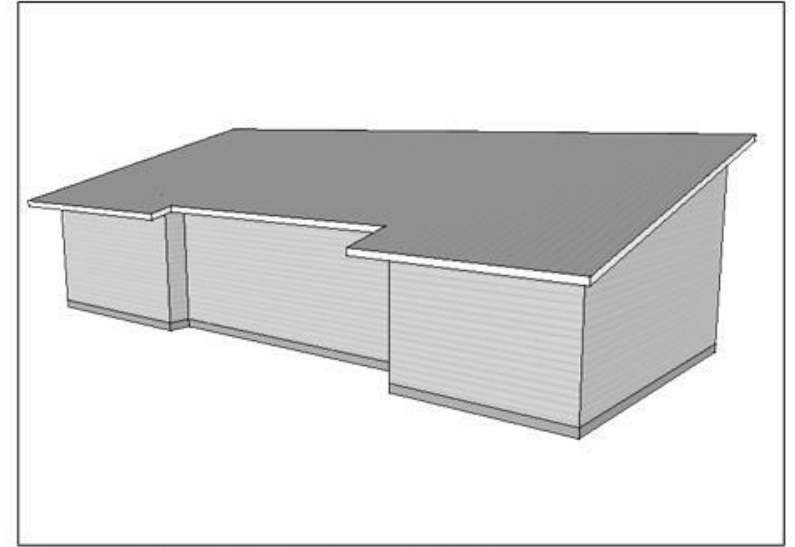
www.remrate.com



Wisconsin Code *2009



IECC 2021



As Modeled REM/Design



\$11,032



\$7602



\$4795

MONEY ON THE TABLE ???

HRV = Heat Recovery Ventilators

2 PAIR "LUNOS" DUCTLESS FANS 10, 15, 20 CFM



CERAMIC CORE + FILTERS
+ DUAL DIRECTION FAN

Bath Fans

2 "PANASONIC" EXHAUST ONLY FANS @ 80 CFM

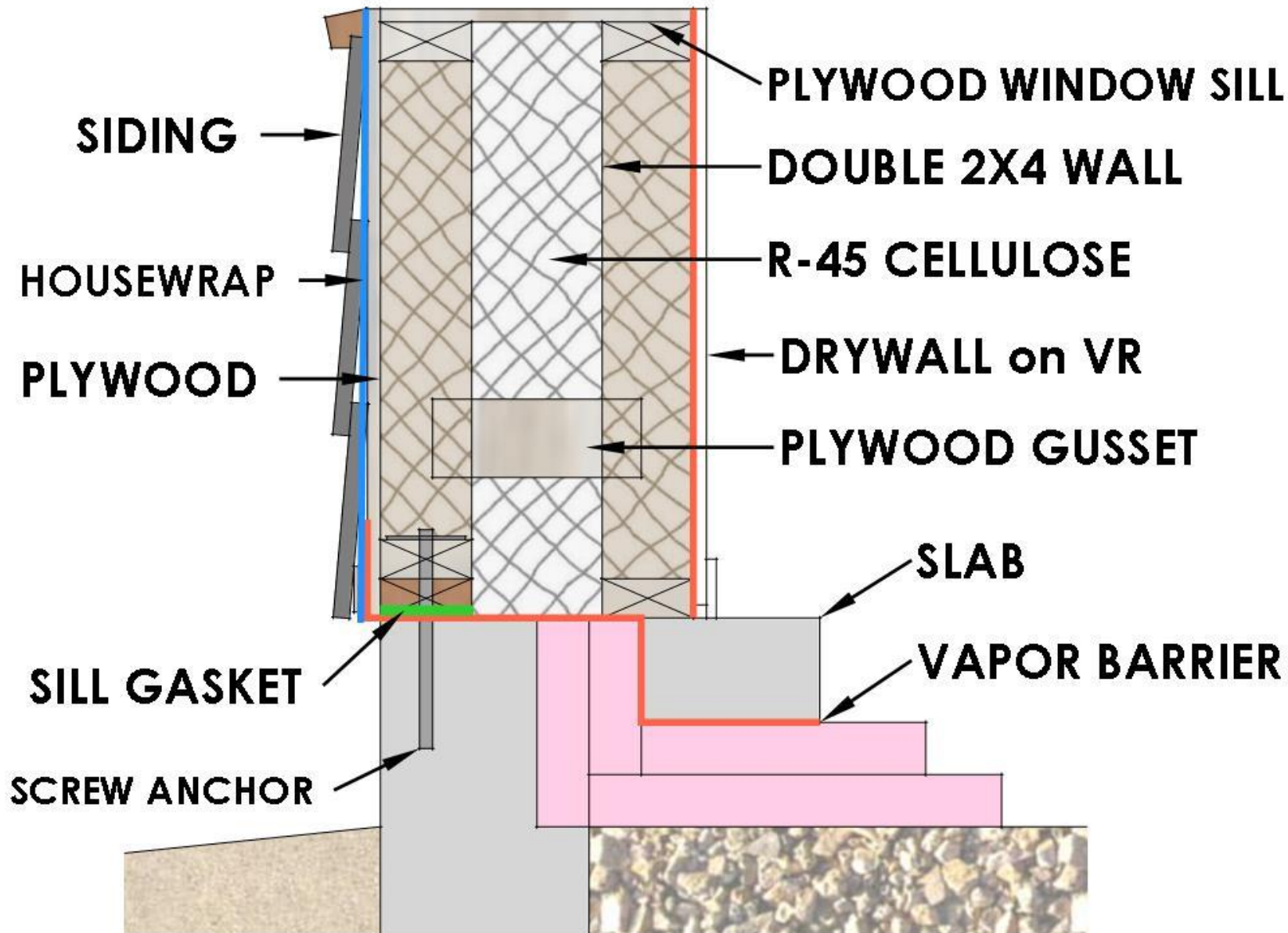


LIGHT-FAN COMBO

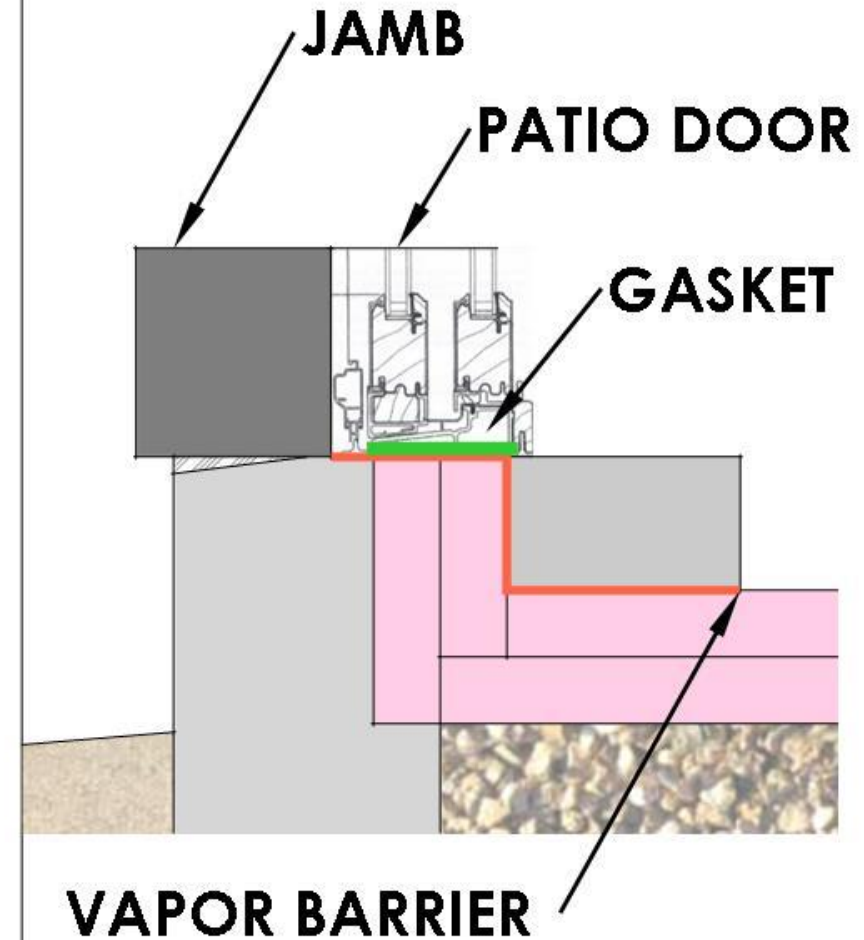
FAN HOUSING
on attic floor



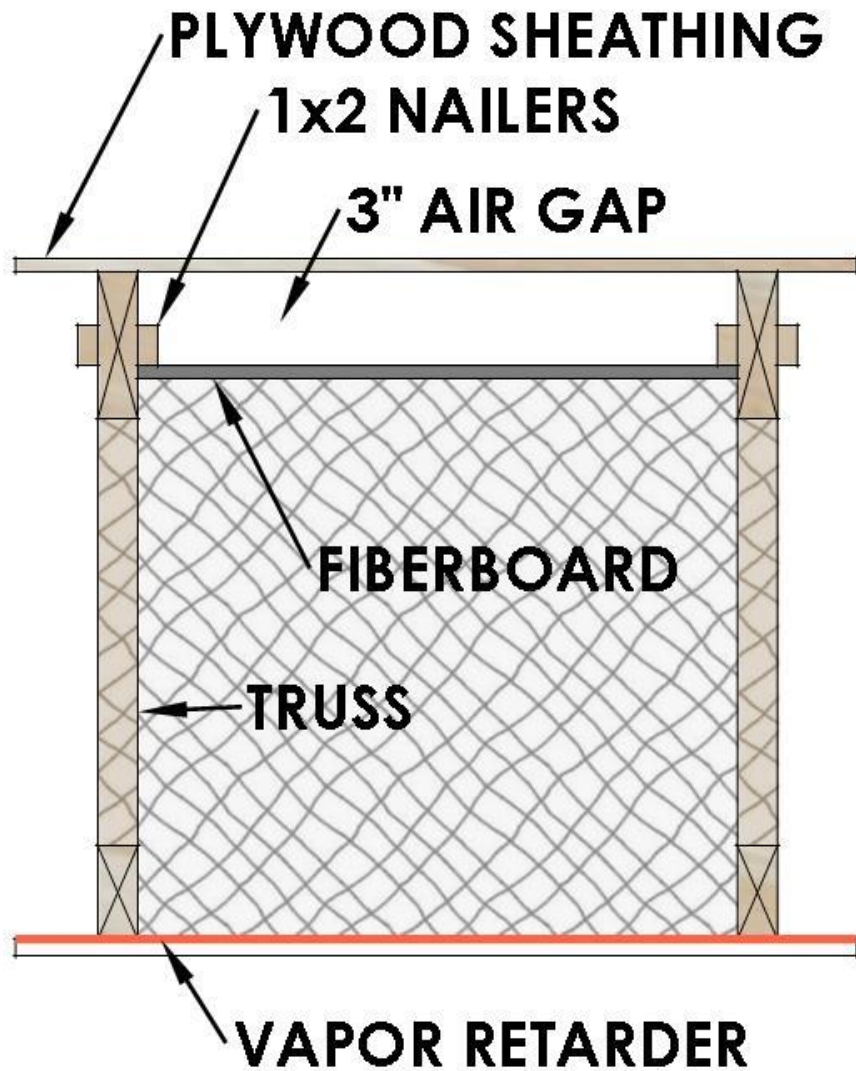
Wall @ Sill Plate



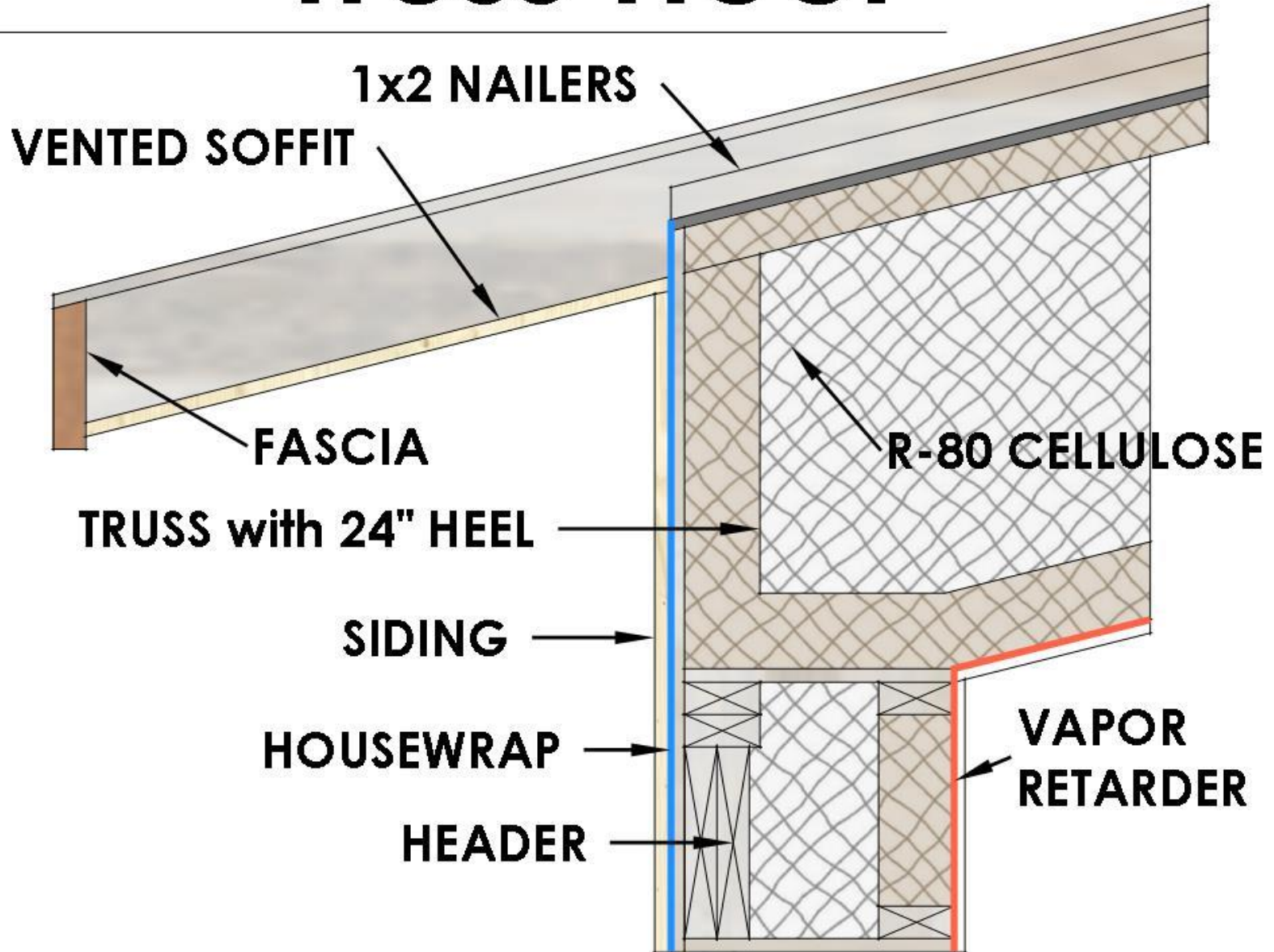
Door Sill



Chute



Truss Heel



Blower Door #3

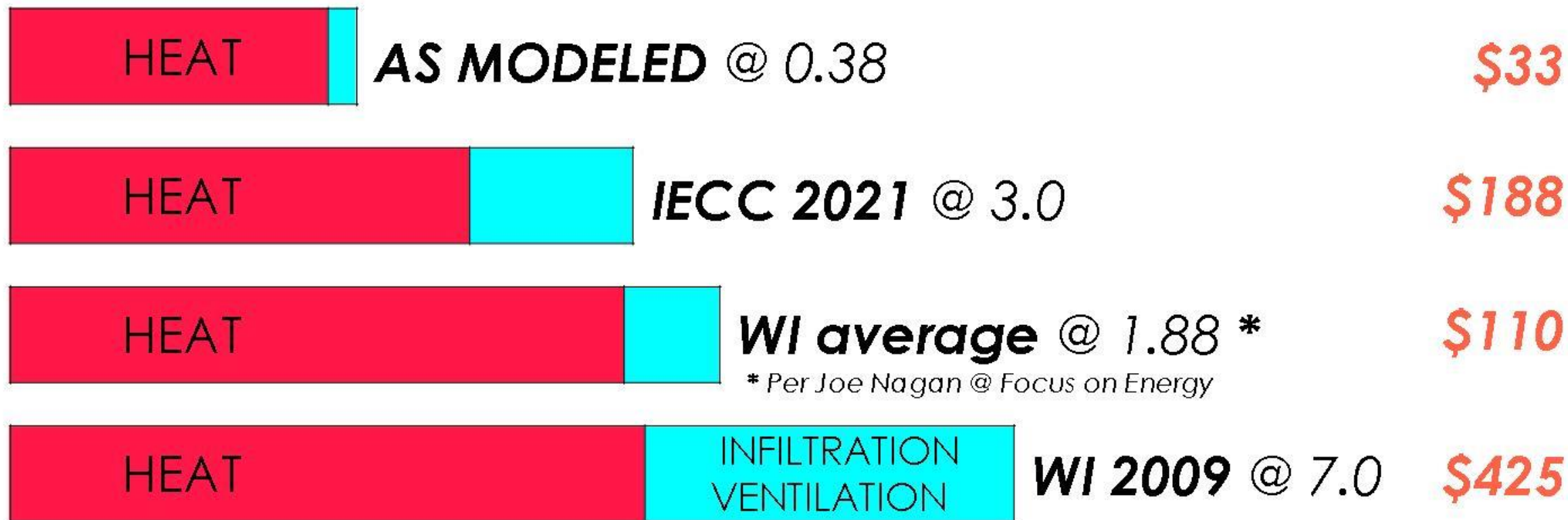
0.38 ACH @ 50Pa = 0.02 cfm50/sf shell



Cost of INFILTRATION

www.remrate.com

BLOWER DOOR TESTED ACH @ 50Pa



MONEY ON THE TABLE ???

Solar PV

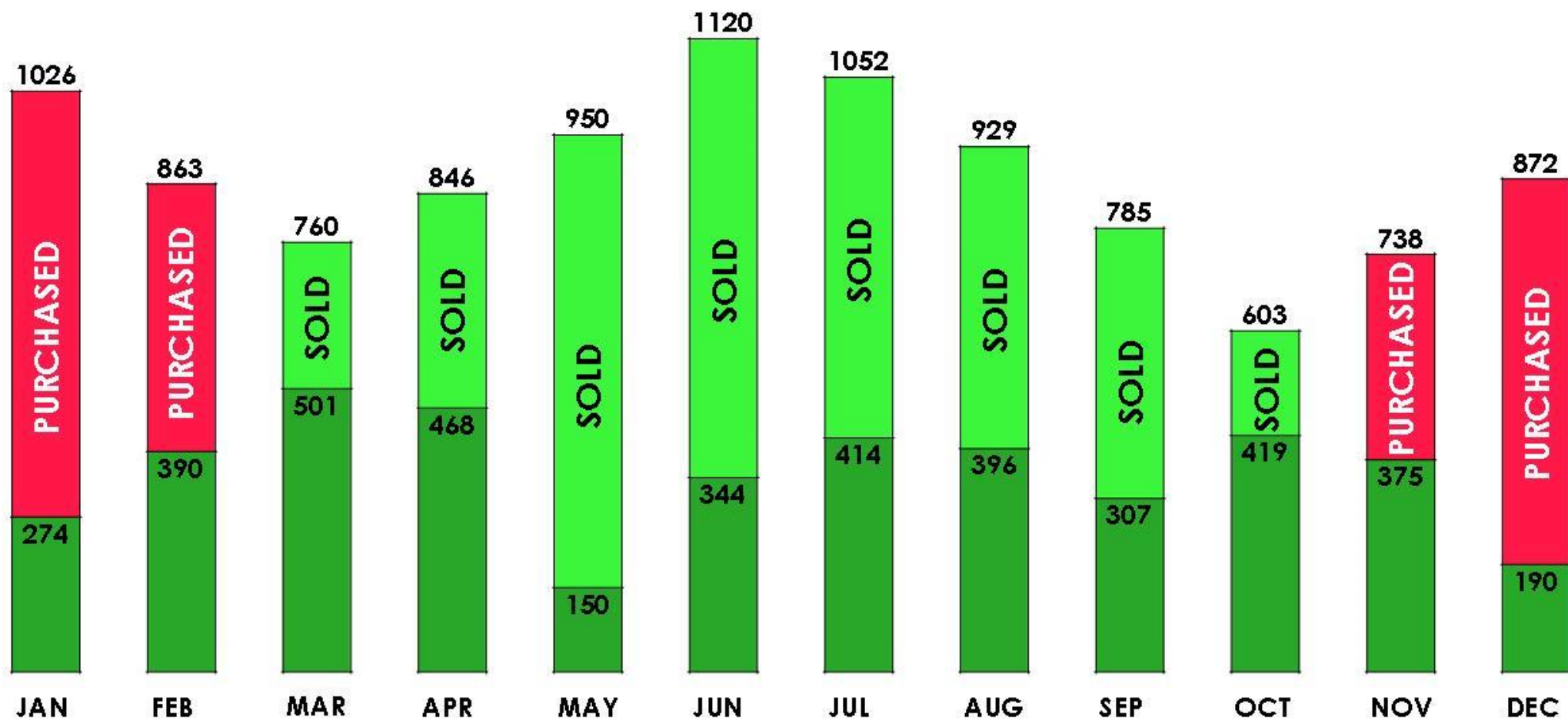
-7.32 kW ARRAY
-24 PANELS 39" X 66"

-3:12 ROOF PITCH
-7 DEGREES EAST OF DUE SOUTH



kWh/month

AVERAGE 2021 + 2022



kWh/year

AVERAGE 2021 + 2022

PRODUCED

= 8274 kWh

USED = 4224

SOLD = 4050
March-Oct

= 8274 kWh

USED = 4224

PURCHASED = 2274
Jan/Feb/Nov/Dec

= 6498 kWh

Net Zero + 27%

$$8274 / 6498 = 1.27$$

PRODUCED

= 8274 kWh

USED

PURCHASED

= 6498 kWh

38 Snow Days

AVERAGE 2021 + 2022



**LOST PRODUCTION =
approx 13 SUNNY
DAYS IN JUNE**

REM PREDICTION

= 8616 kWh

PRODUCED

= 8274 kWh

Optimal Roof Pitch

pvwatts.nrel.gov



MY ROOF PITCH = 3:12

**OPTIMAL ROOF PITCH
@ 43 DEGREE LATITUDE = 8:12**

**COST OF LOST PRODUCTION = \$510
(one solar panel)**

Electricity Costs = \$28/mo.

Alliant Energy "Monthly True-Up"

SOLD

$4050 \text{ kWh} @ 0.03 = (\$122)/\text{year}$

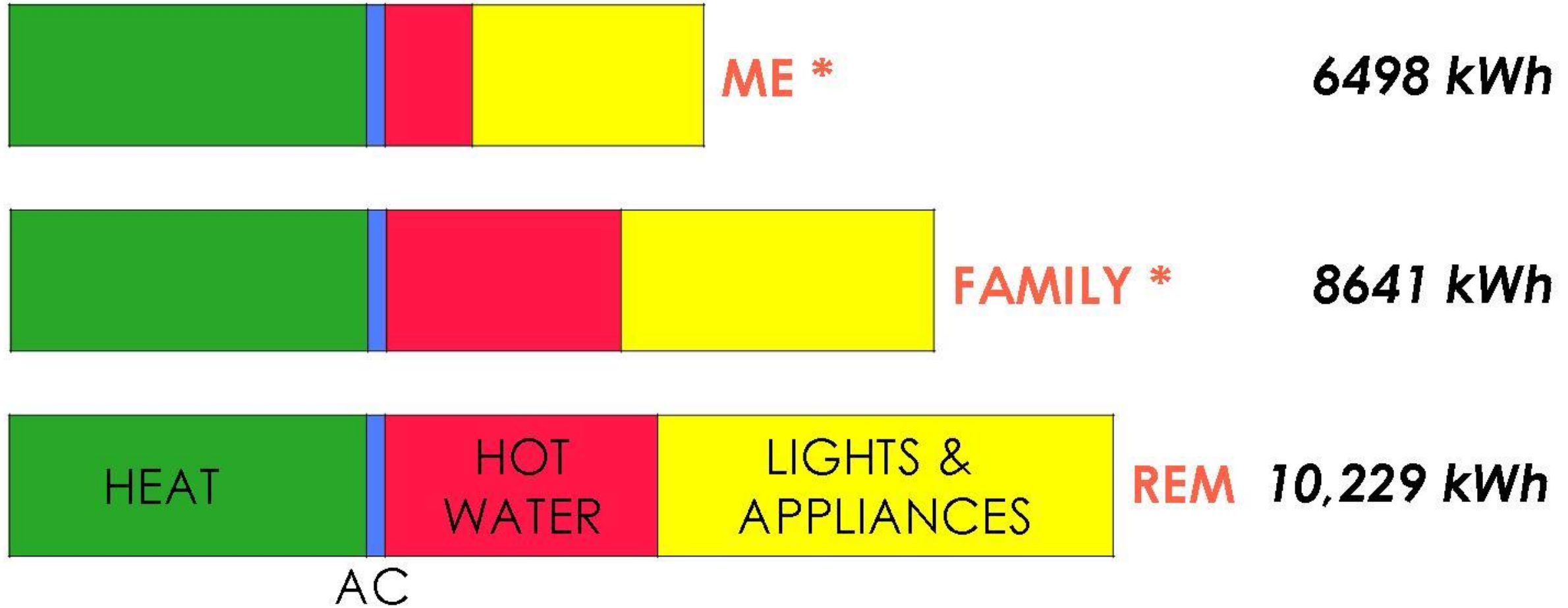
PURCHASED

$2274 \text{ kWh} @ 0.12 = \$273/\text{year}$

**METER
CHARGE**

$\$15/\text{month} = \$180/\text{year}$

Compared to REM/Design



** no TV, dishwasher, clothes dryer*

Compared to Code *per year*

6498 kWh	my use avg. 2021-2022	\$780
10,229 kWh	REM	\$1227
12,933 kWh	IECC 2021	\$1552
13,742 kWh	WI 2009 average*	\$1649
16,483 kWh	WI 2009	\$1978

* Per Joe Nagan @ Focus on Energy













Problem - ASHP Vibration

BRACKETS



SOLUTION.....GROUND MOUNT ???

Problem - Heat Distribution



LOFT = 3 to 5 DEGREES WARMER
than Living Room

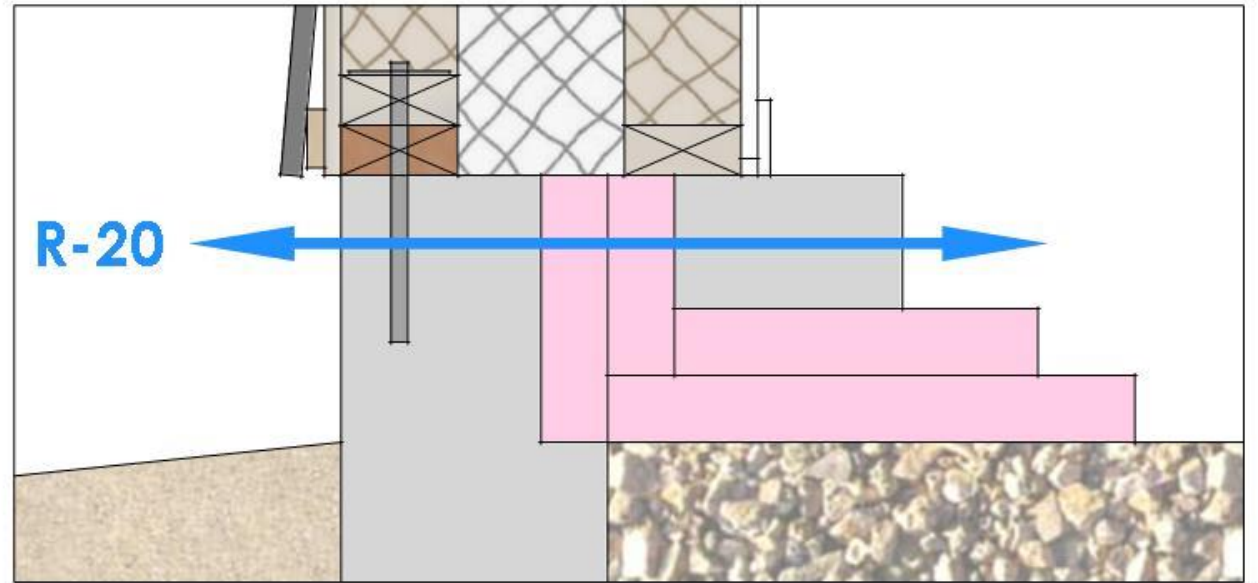
BDRMS = 0 to 3 DEGREES COOLER
than Living Room

* varies with outdoor
temperature & sunshine

SOLUTION.....RUN A FAN ???.... FLOOR MOUNT ASHP ???

Problem - Cold Slab

SLAB = 3 to 5 DEGREES COLDER
than air temperature



* varies with outdoor
temperature & sunshine

SOLUTION.....IN-FLOOR RADIANT HEAT (PEX) ???

Problem - Condensation



OUTSIDE:	-14 DEGREES
INSIDE:	+62 DEGREES
RH:	38-45%

Problem - Condensation



Problem - Condensation

RELATIVE HUMIDITY = 20-25%



RELATIVE HUMIDITY = 38-45%



SOLUTION.....NO HOUSE PLANTS ???

Problem - Condensation



-THERMAL BRIDGING OF FRAME?

-WINDOW SET TO EXTERIOR?

**-NEW HOME TAKES 1-3 YEARS
TO DRY OUT?**

SOLUTION.....INCREASE AIR FLOW ???

Quick & Dirty Testing

TEST #1 HRV on low (20 cfm) **RH = 38-45%**
HRV on high (40 cfm) **RH = 33-36%**
for 3 days continuous

TEST #2 WATERING PLANTS
& SHOWERING ADDS **RH = 2-4%**

TEST #3 HRV on high EXHAUST **RH = 32%**
HRV on high INTAKE **RH = 27%**

TEST #4 HRV on high EXHAUST **69 DEGREES**
HRV on high INTAKE **66 DEGREES**
@ outside temp=29, RH=69



LUNOS FAN
70 second
cycle

**WEATHER
STATION**

Marvin Windows Chart

HEALTHY LEVEL OF HUMIDITY = 30 to 35%

Outside Air Temperature		Inside relative humidity for 70°F (21°C) indoor air temperature
-20°F	-29°C	15 to 20 percent humidity
-10°F	-23°C	20 to 25 percent humidity
0°F	-18°C	25 to 30 percent humidity
+10°F	-12°C	30 to 35 percent humidity
+20°F	-7°C	35 to 40 percent humidity

SOLUTION.....RUN A DEHUMIDIFIER ???

Triple Pane Windows

DUAL PANE LOW E2 ARGON	
U	=0.29
SHGC	=0.29
VT	=0.49
CR	=59

TRI PANE E2/E1 ARGON	
U	=0.19
SHGC	=0.27
VT	?
CR	?

SOLUTION.....WINDOW UPGRADE ???

POEM Homes.org



I welcome your visit to Spring Green!
text Amber 608.935.9020

Comments? Questions?



Huckleberry's Fur Makes a Cozy Home



Amber Westerman poemhomes.org 608.935.9020 amberwesterman.com