BETTER BUILDINGS: BETTER BUSINESS®
POWERED BY slipstream
FEBRUARY 27-28, 2025 · KALAHARI RESORT, WISCONSIN DELLS

Net-Zero Home

What Worked and What Didn't After 4 Years

Amber Westerman, owner/designer/builder |
PoemHomes.org

Learning Objectives

- How to Balance Design, Costs, and Performance Goals
- How to use Energy Modeling and Other Tools to Make Decisions
- Problems and Solutions After 4 Years

POEM Homes.org

A Net-Zero Home: What Worked and What Didn't After 4 Years



Amber Westerman 608.935.9020

What We'll Talk About

1. Design Goals + Performance Details

2. Modeling + Monitoring Tools

3. Problems + Solutions

1. Design Goals & Performance Details

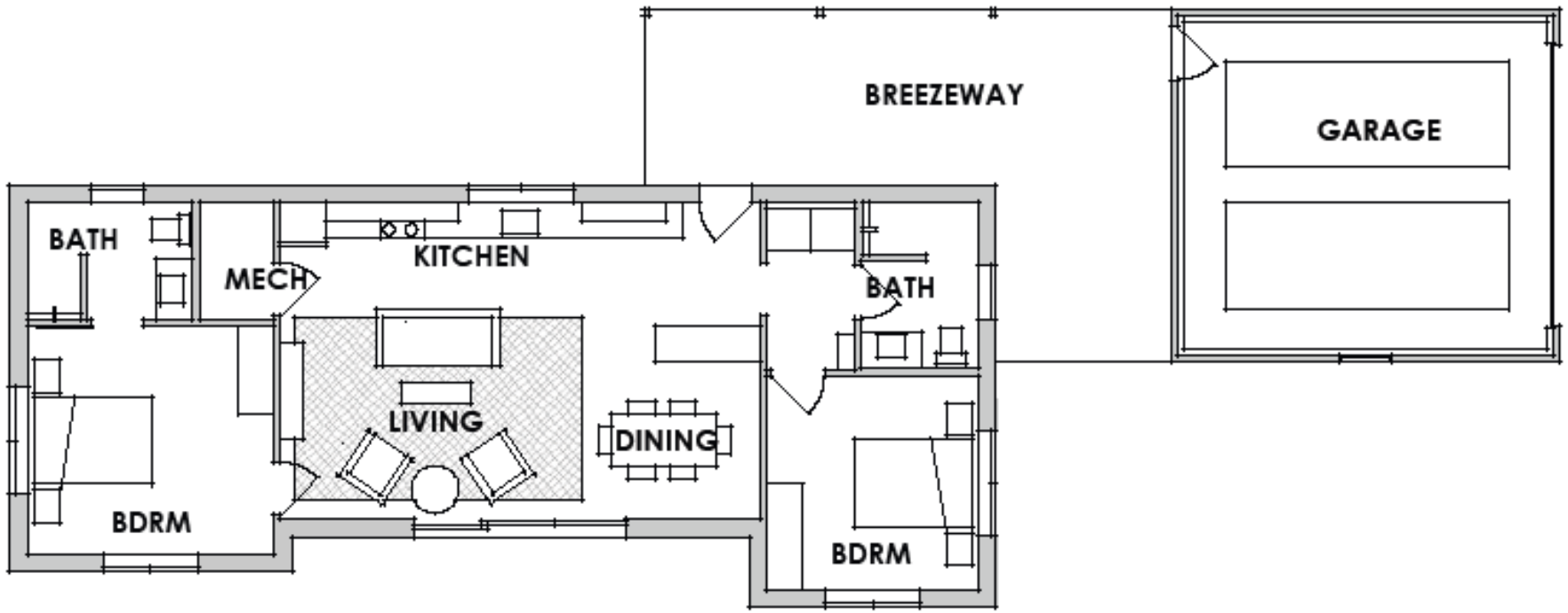
How Size & Shape Impact Heat Loss

Thermal- Water- Air- Vapor- Radon- Control

Off-the-Shelf, Builder-Friendly Methods & Materials

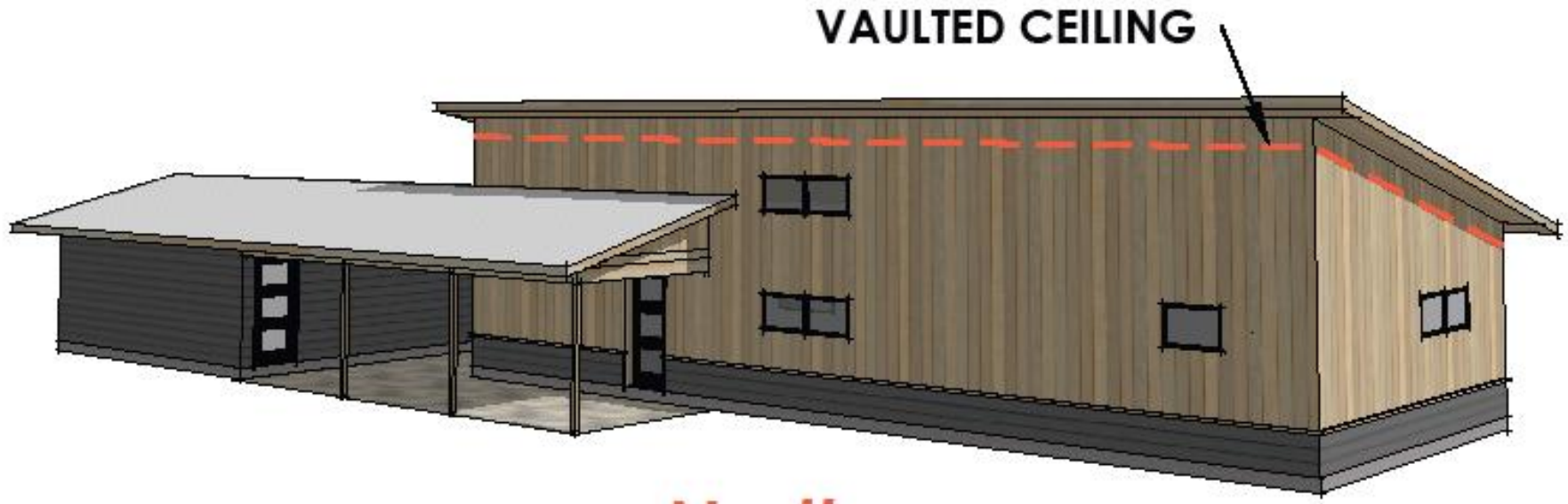
How Size & Shape Impact Heat Loss

1208 sf, detached garage



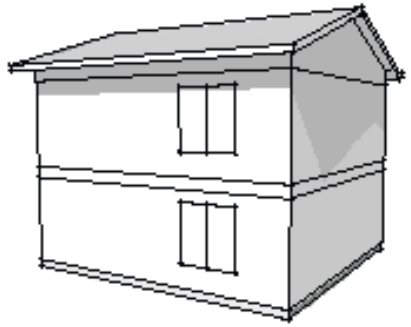
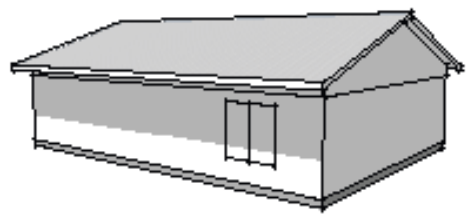
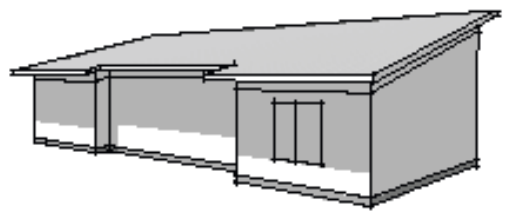


South



North

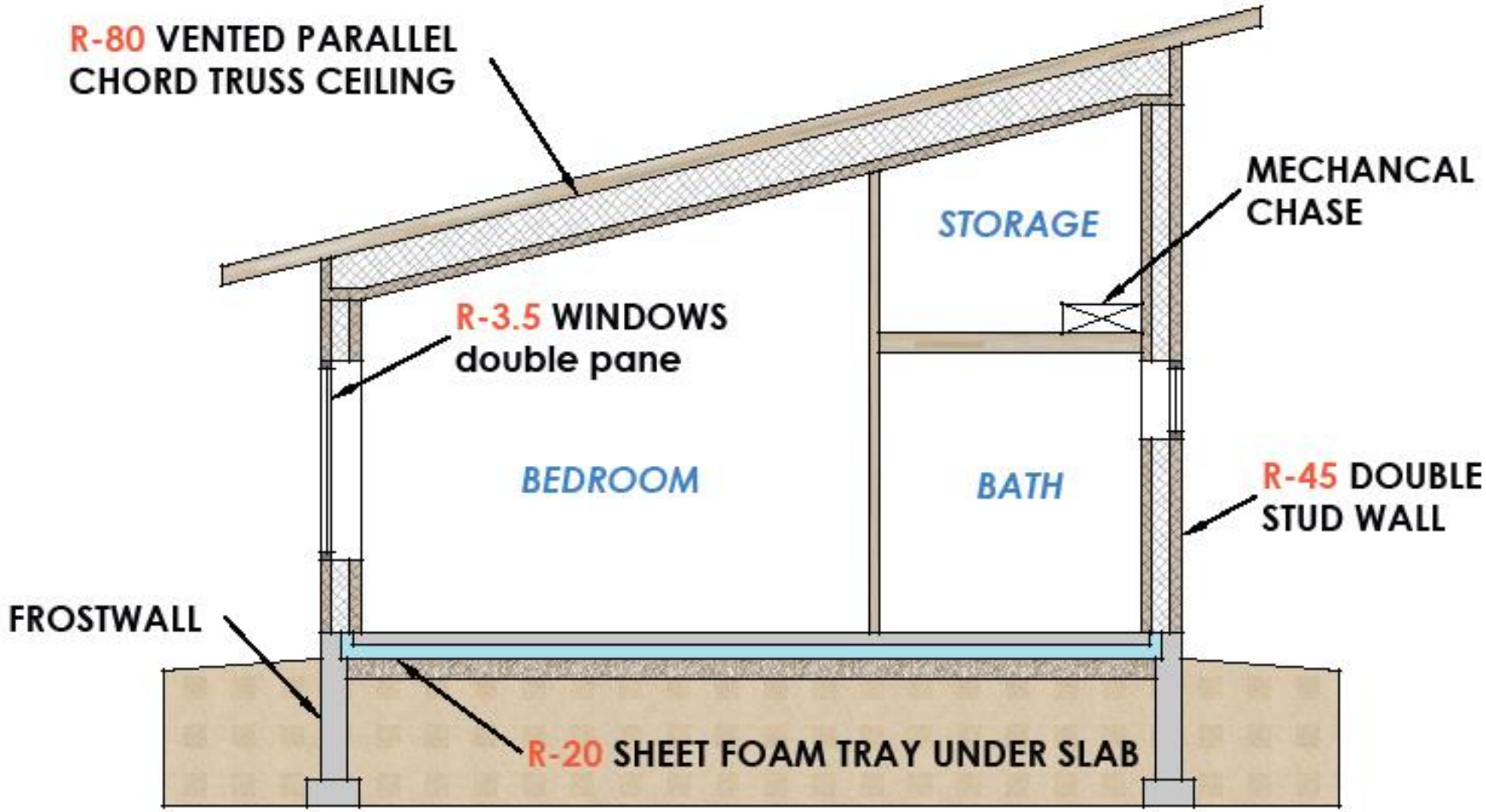
remrate.com

	FLOOR	CEILING	SURFACE	VOLUME	COST TO HEAT *1 ACH @50Pa*
2-STORY, FLAT CEILINGS 	1248	624	3148	11,856	$223/YEAR
1-STORY, FLAT CEILING 	1200	1200	3800	12,000	$239/YEAR
AS-DESIGNED 	1208	1245	4610	16,052	$339/YEAR

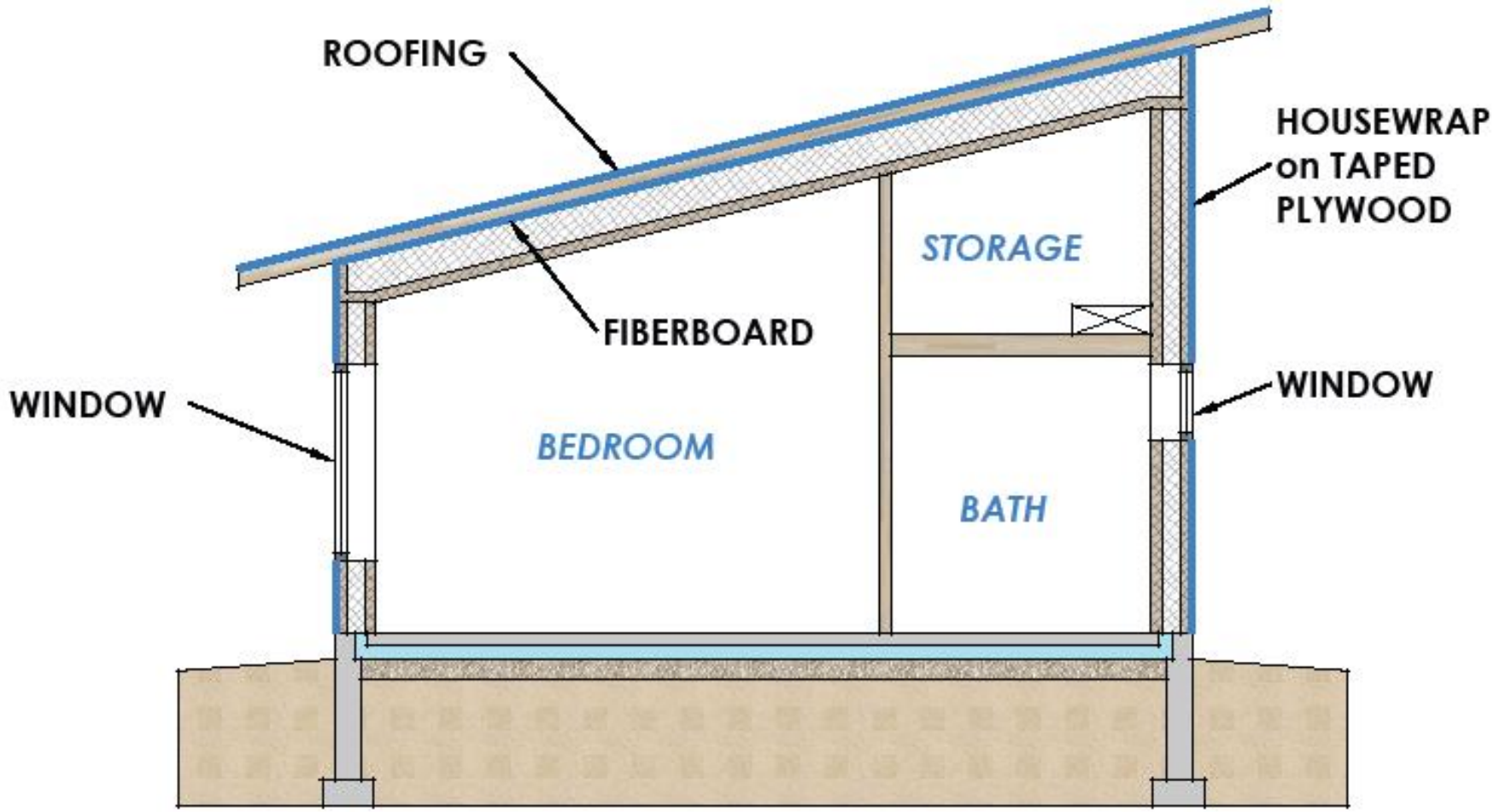
50% MORE!

Thermal- Water- Air- Vapor- Radon- Control

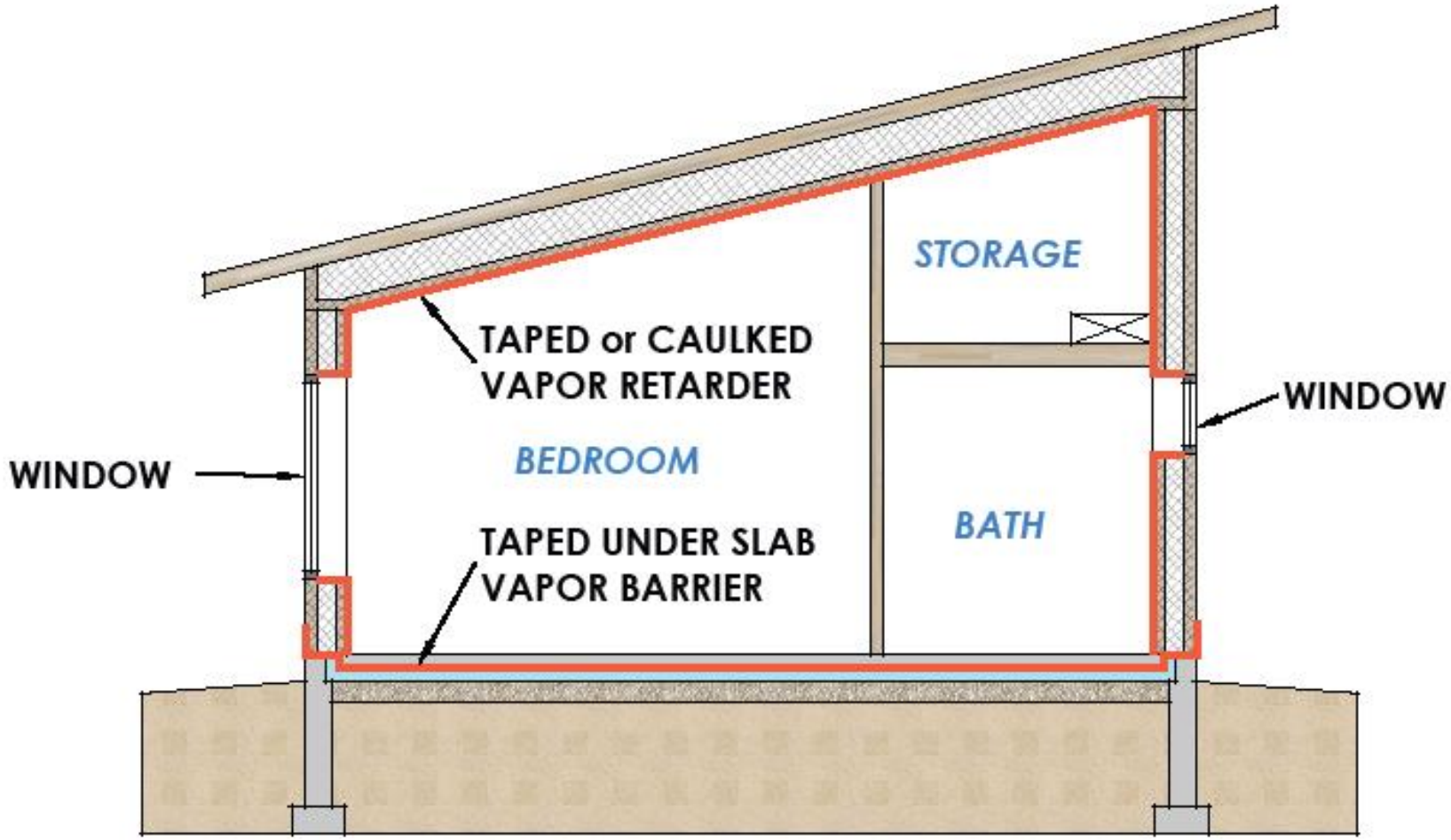
Thermal Control



EXTERIOR Air & Water Control

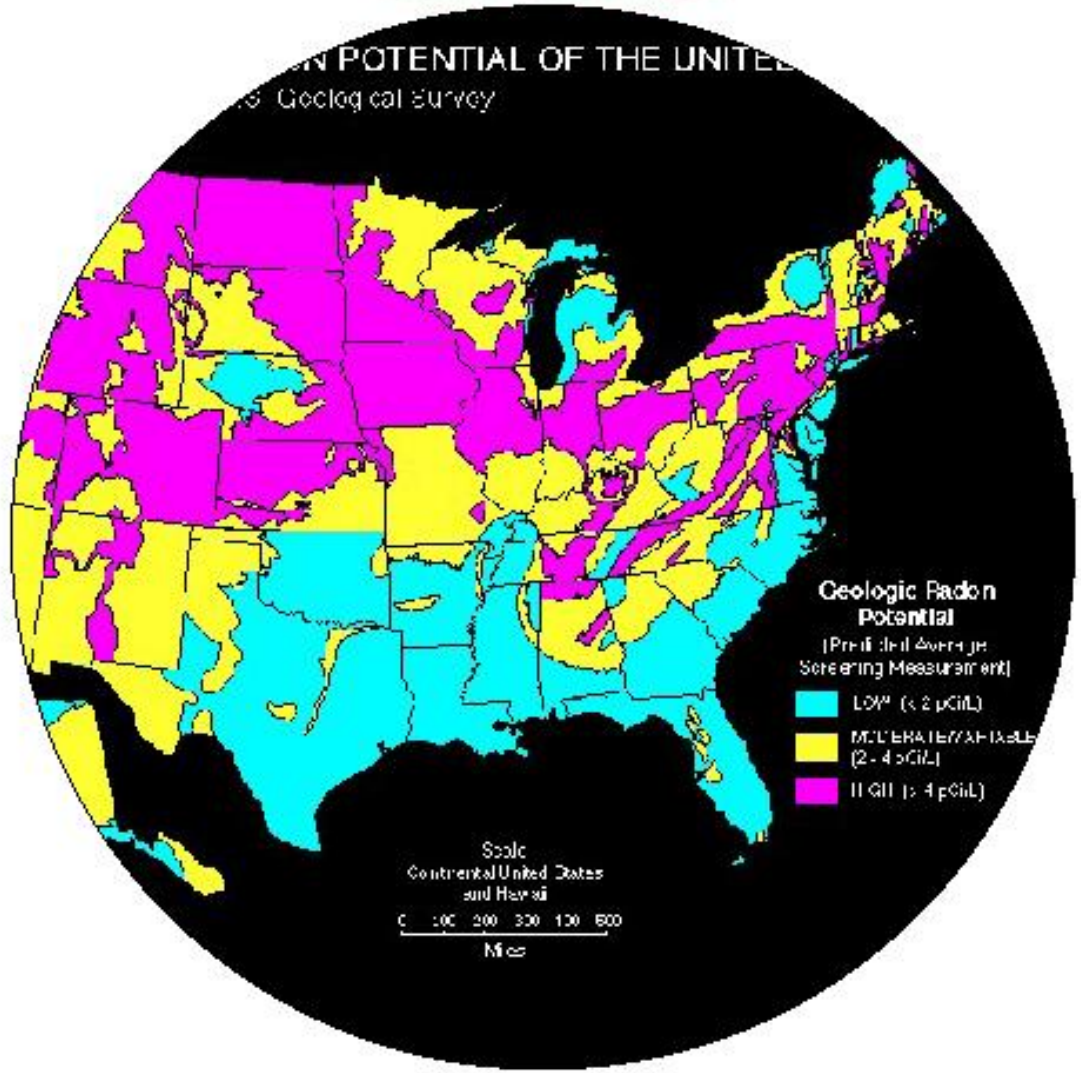


INTERIOR Air & Vapor Control



Radon Risk

PINK=HIGHEST



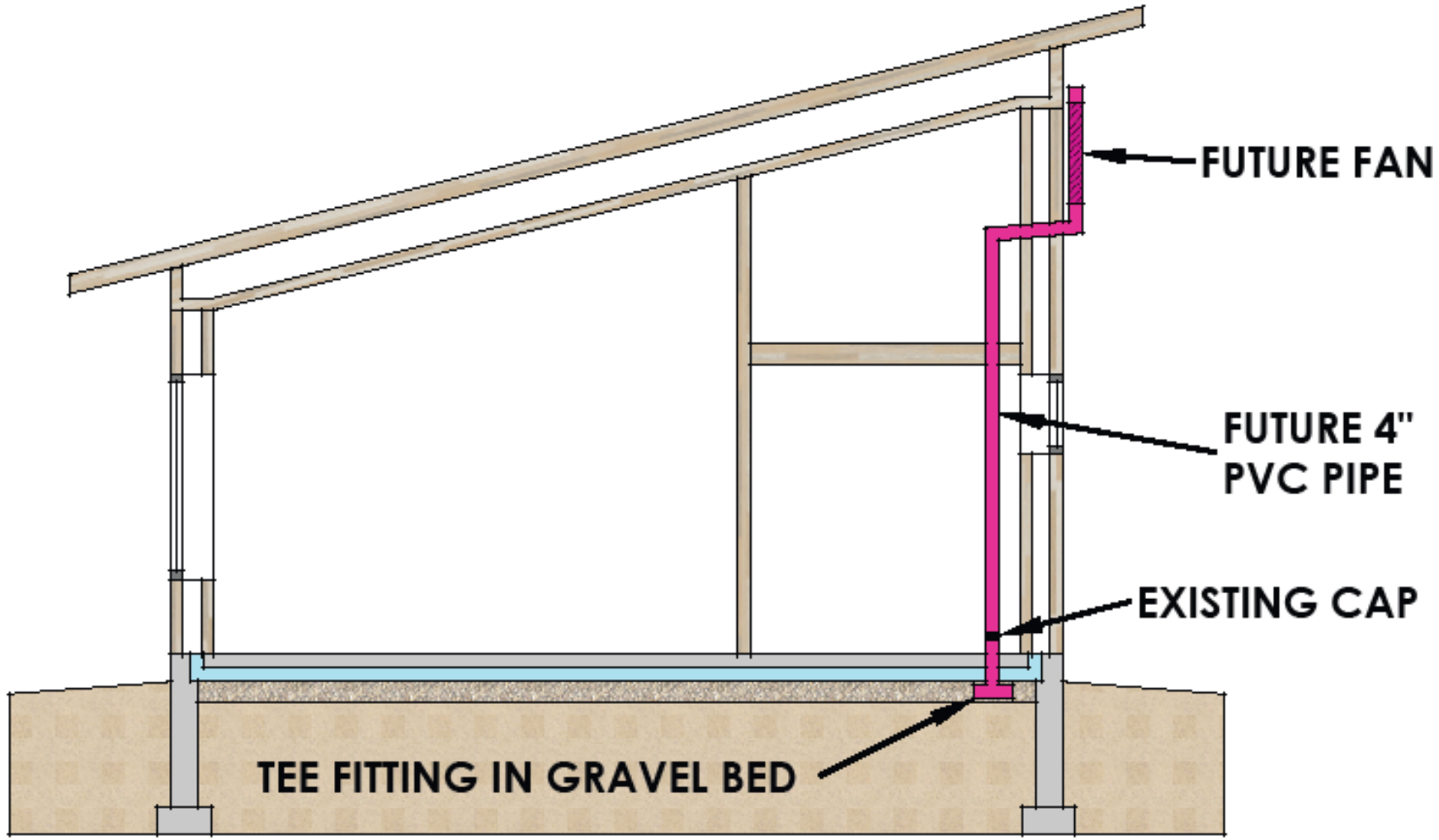
Radon Bed





1" Diameter Clear Gravel (NO FINES) 6" DEEP

Future Radon Mitigation System

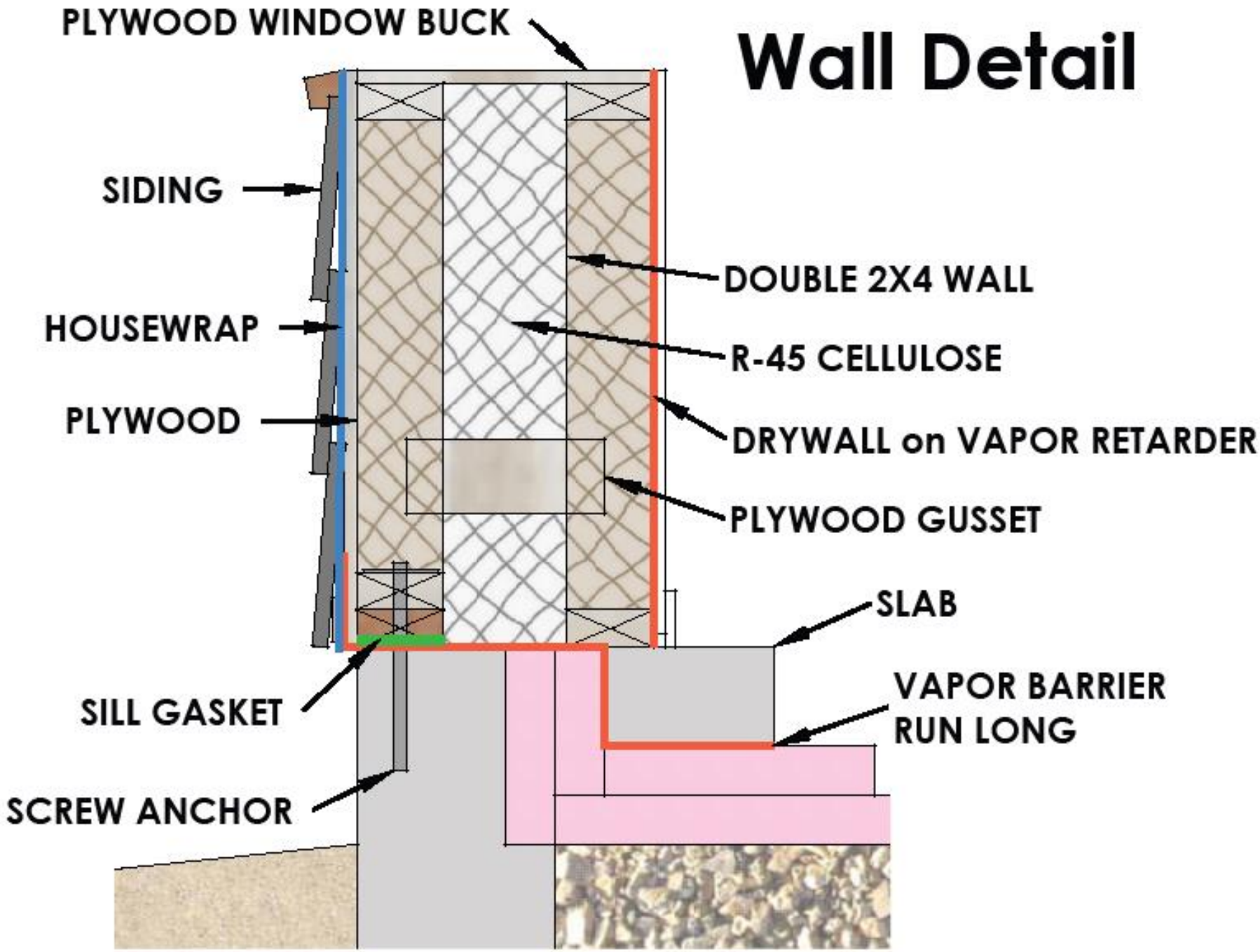


WISCONSIN Average Outdoor Level = 0.40 pCi/L
WISCONSIN Average Indoor Level = 1.30 pCi/L

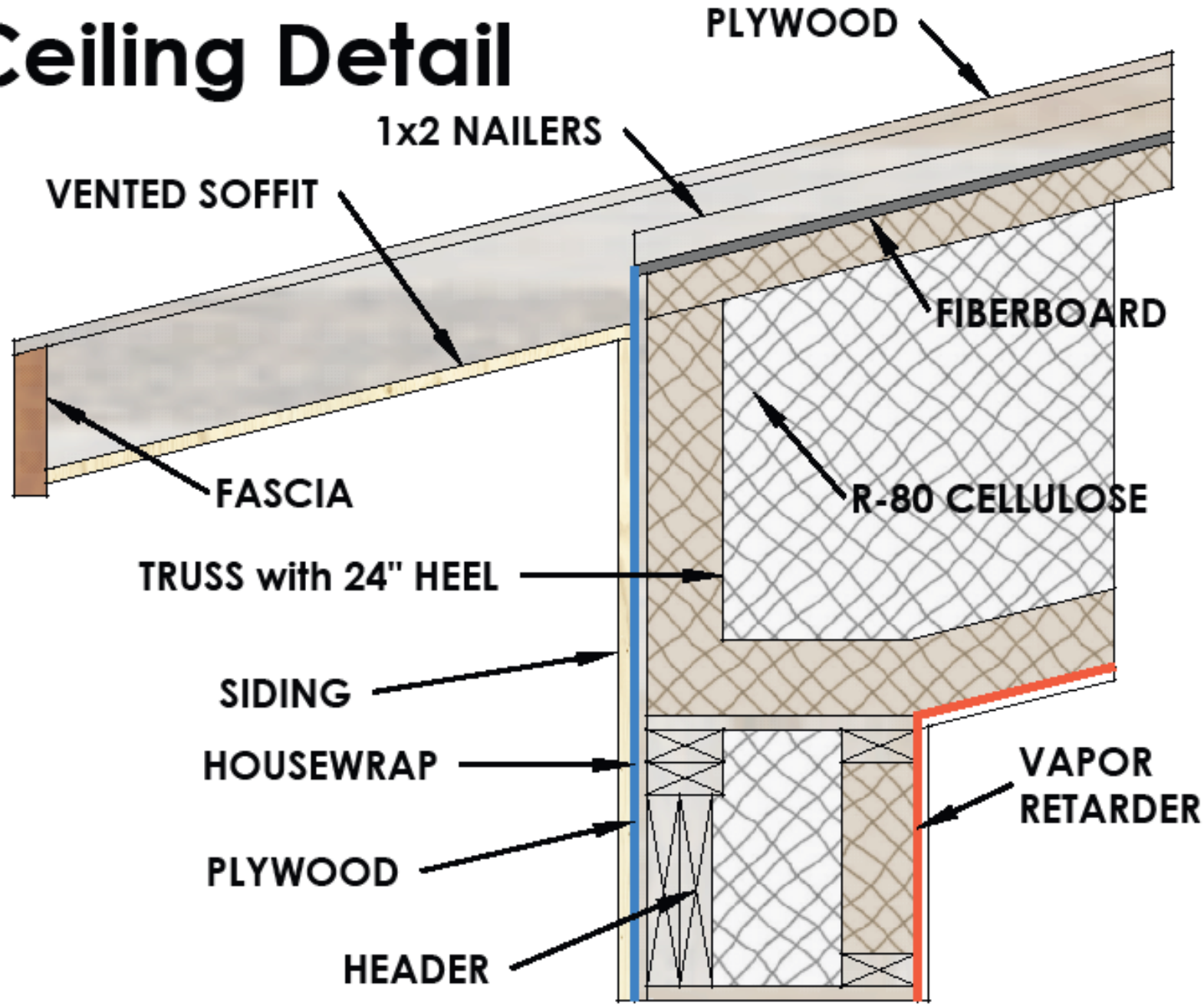
Level of Concern = 4.00 pCi/L
AMBER'S HOUSE = 2.40 pCi/L

Off-the-Shelf, Builder-Friendly Methods & Materials

Wall Detail


PLYWOOD WINDOW BUCK
SIDING
HOUSEWRAP
PLYWOOD
DOUBLE 2X4 WALL
R-45 CELLULOSE
DRYWALL on VAPOR RETARDER
PLYWOOD GUSSET
SLAB
VAPOR BARRIER
RUN LONG
SILL GASKET
SCREW ANCHOR

Ceiling Detail



Slab Foam



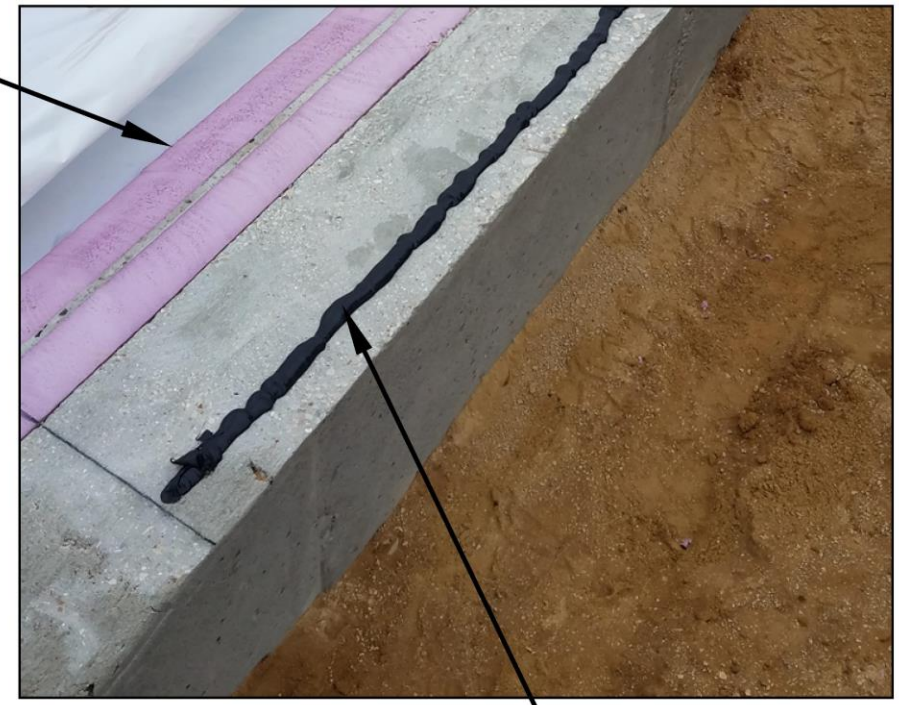
Air- Vapor- Radon Barrier



TAPED EDGES, SEAMS & PENETRATIONS

Vapor Barrier Run Long





Sill



Slab



ADVANCED FRAMING

Double Stud Wall @ 24" oc

NO HEADERS @
NON-BEARING WALLS

LADDER BLOCKING @
PARTITION WALLS

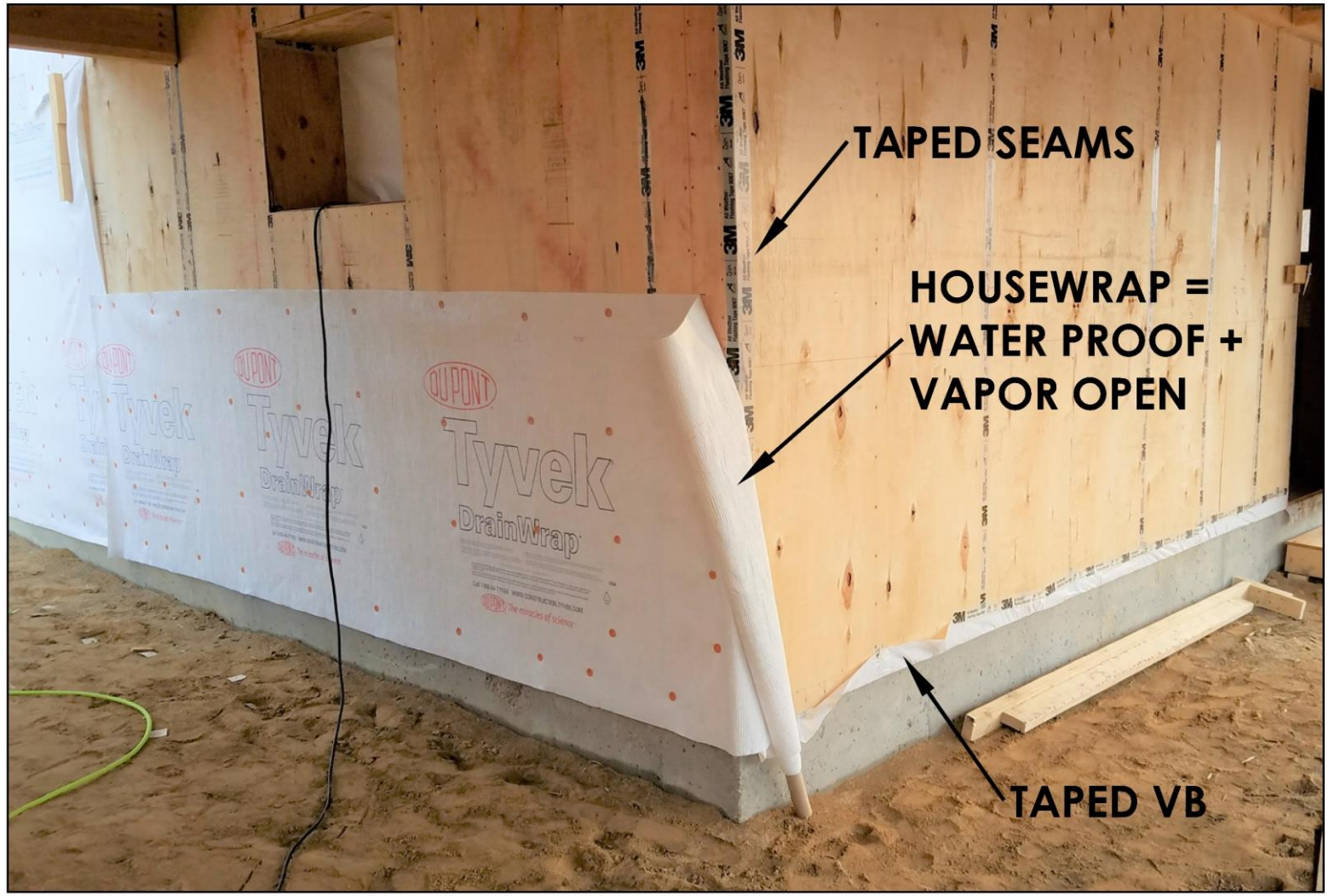


2-STUD CORNERS

Taped Sheathing



Housewrap


TAPED SEAMS
HOUSEWRAP =
WATER PROOF +
VAPOR OPEN
TAPED VB
DUPONT
Tyvek
DrainWrap

Standard Window Install



Marvin Fiberglass Windows

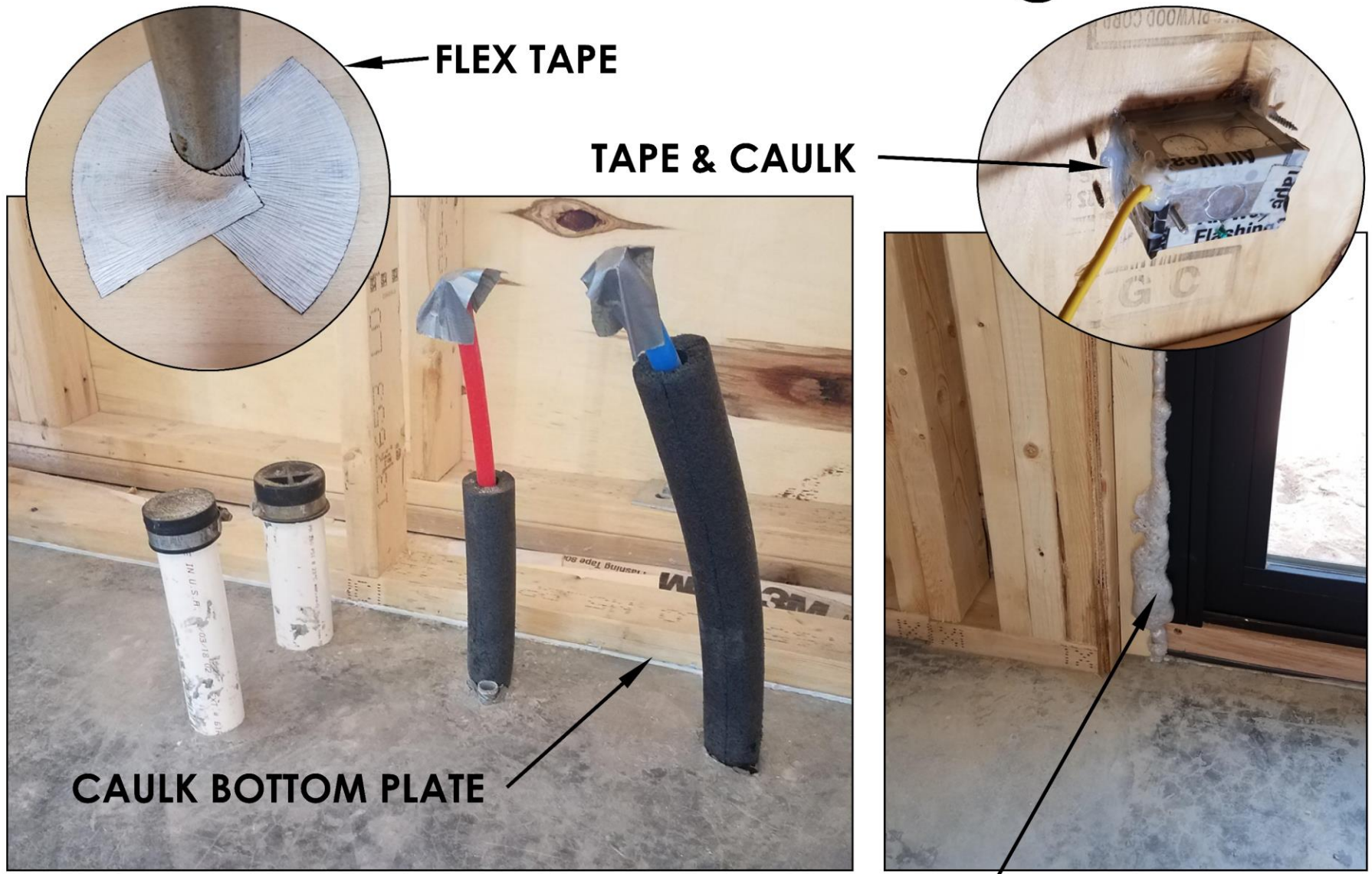


PLYWOOD
BUCK

dual pane
Low E2 Argon
U=0.29 R=3.5



Interior Air Sealing



Drywall & Vapor Retarder

CERTAINTEED "MemBrain" = VAPOR VARIABLE + INTERIOR AIR BARRIER



Dense Pack Cellulose CEILING



DRYWALL & VAPOR RETARDER INSTALLED
BEFORE **INSULATION**

Interior Walls



INSTALLED
AFTER CEILING VR + DW



INSTALLED
ON STRIPS OF VR + DW

Vapor Retarder WALLS





TAPED OR CAULKED

CERTAINTEED "MemBrain"
VAPOR VARIABLE RETARDER
+ INTERIOR AIR BARRIER

Dense Pack Cellulose WALLS

GAP FOR INSULATION



Standard Siding Install



Questions About Design?



2. Modeling + Monitoring Tools

SketchUp: calculate area, volume, shading

REMRate: compare code min to upgrades

NEEP: sizing heat pumps

Blower Door: test for air-tightness

PV Watts: predict PV

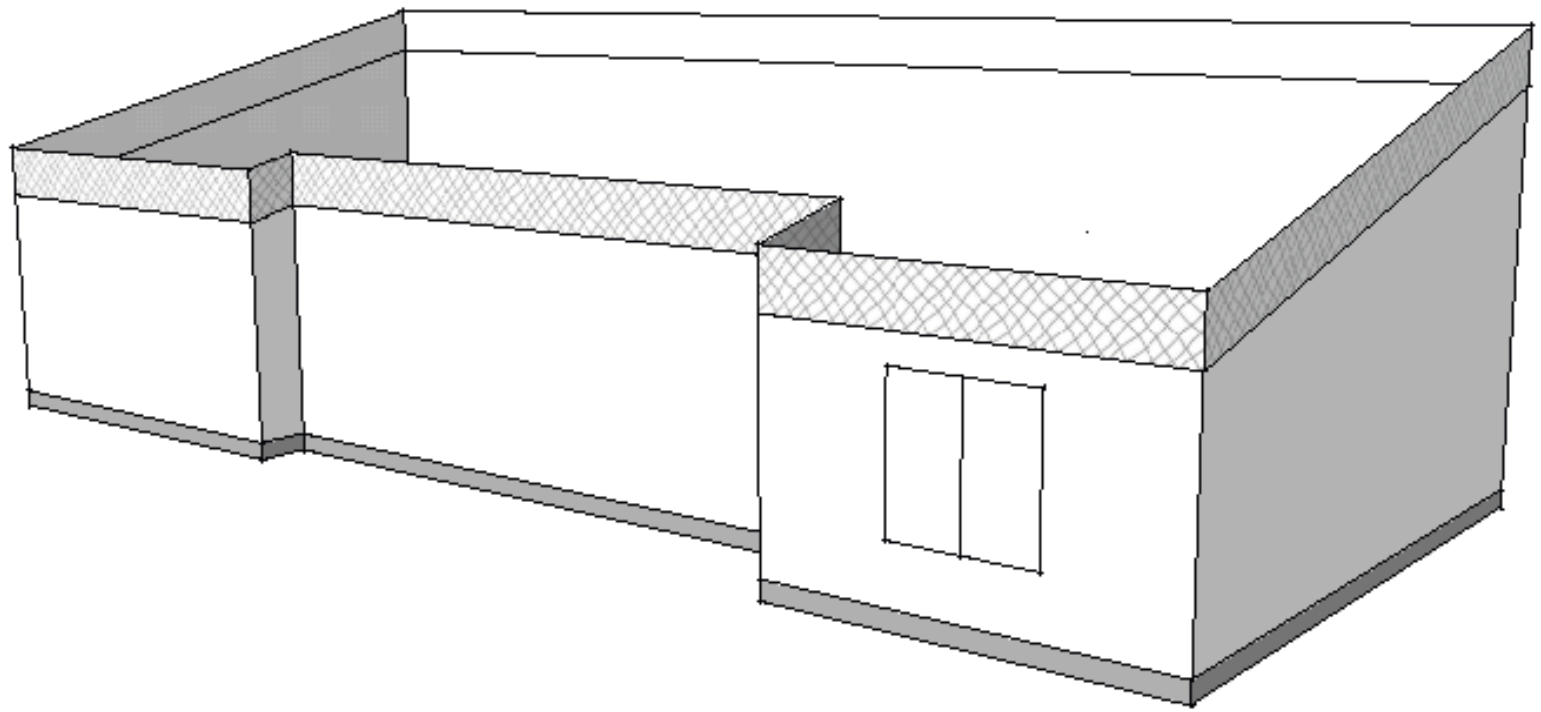
Enphase: monitor PV

Awair: monitor indoor air quality

SketchUp: calculate area, volume, shading

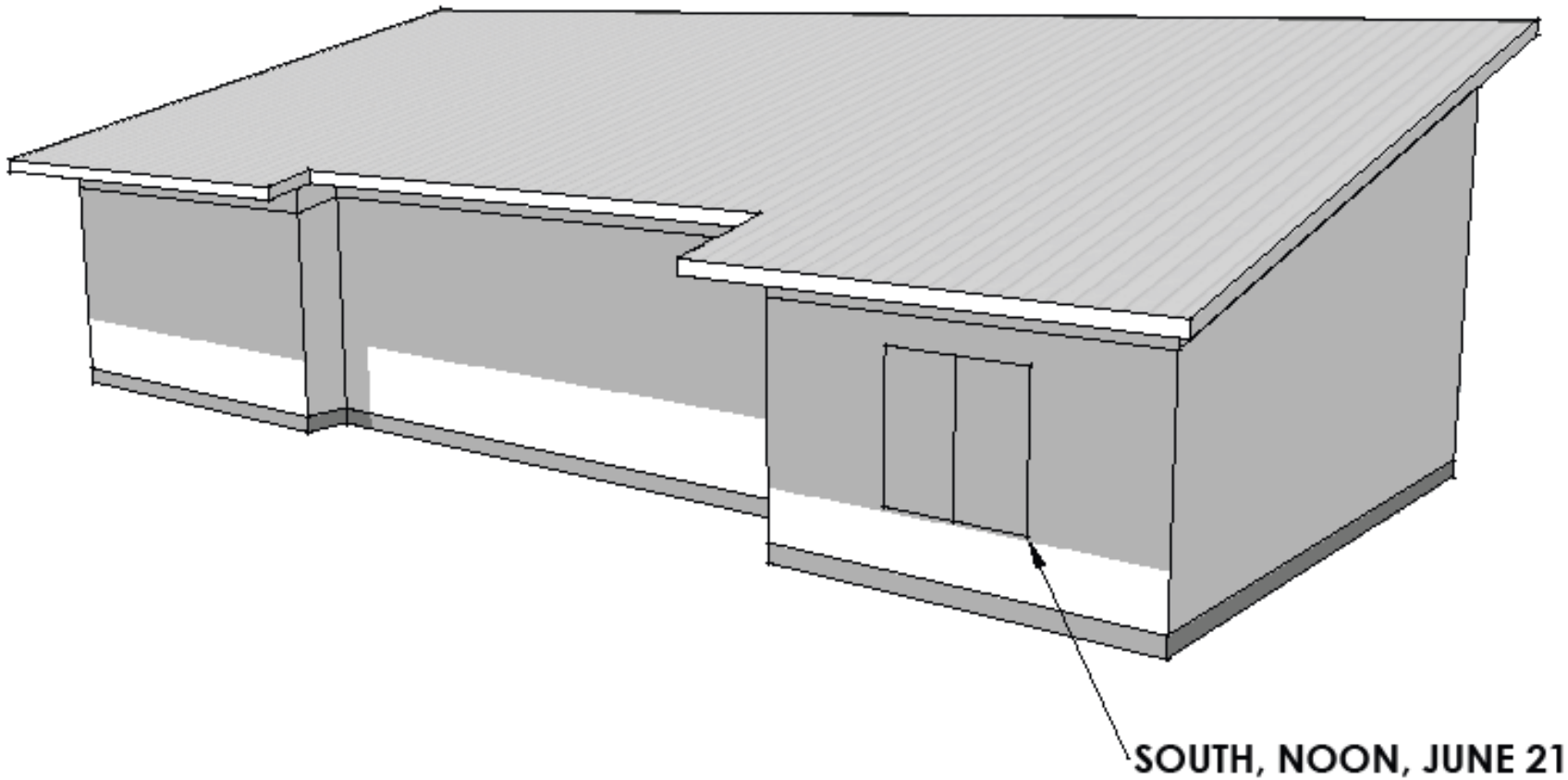
Area + Volume

sketchup.com



Shade Study

sketchup.com



REMRate: compare code min to upgrades

Energy Cost

remrate.com

Energy Cost and Features

Property

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Weather:Madison, WI
Amber's House Nov 22 2024 as built
Nov 22 Amber house.blg

Organization

Builder

Annual Energy Costs	$/yr
Heating	339
Cooling	43
Water Heating	369
Lights & Appliances	540
Photovoltaics	-0
Service Charges	183
Total	1474
Average Monthly($/Month)	123

Equipment Sizing

remrate.com

Equipment Sizing

Property

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Weather:Madison, WI
Amber's House Nov 22 2024 as built
Nov 22 Amber house.blg

Organization

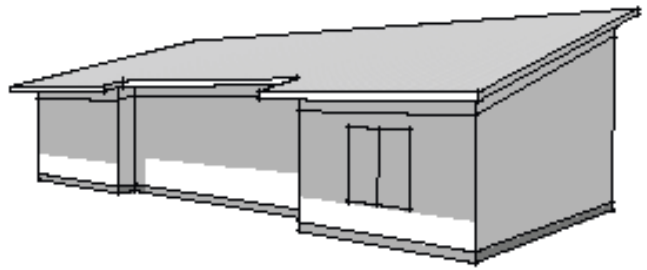
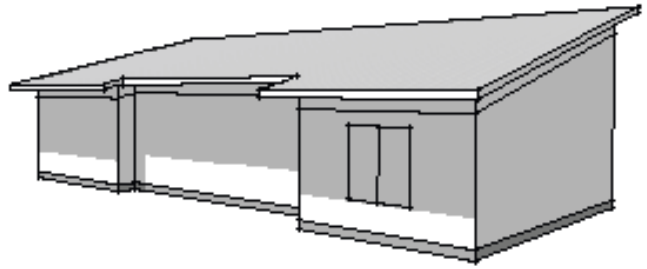
Builder

Heating

Calculated Peak Load (kBtu/hr)	12.8
Infiltration	1.2
Envelope	11.7
Sizing Factor (%)	100.0
Heating Equipment Capacity(kBtu/hr)	
Required	12.8
Specified	20.3

Insulation & Air-Sealing

remrate.com

	COST TO HEAT	HEATING PEAK LOAD *Heat Pump Sizing*
SUPER-INSULATED *1 ACH @ 50 Pa* 	$339/YEAR	12.8 kBtu/hr
WISCONSIN AVERAGE *2 ACH @ 50 Pa* 	$671/YEAR	21.0 kBtu/hr

NEEP: sizing heat pumps

Design Load

remrate.com

Equipment Sizing

Property

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Weather:Madison, WI
Amber's House Nov 22 2024 as built
Nov 22 Amber house.blg

Organization

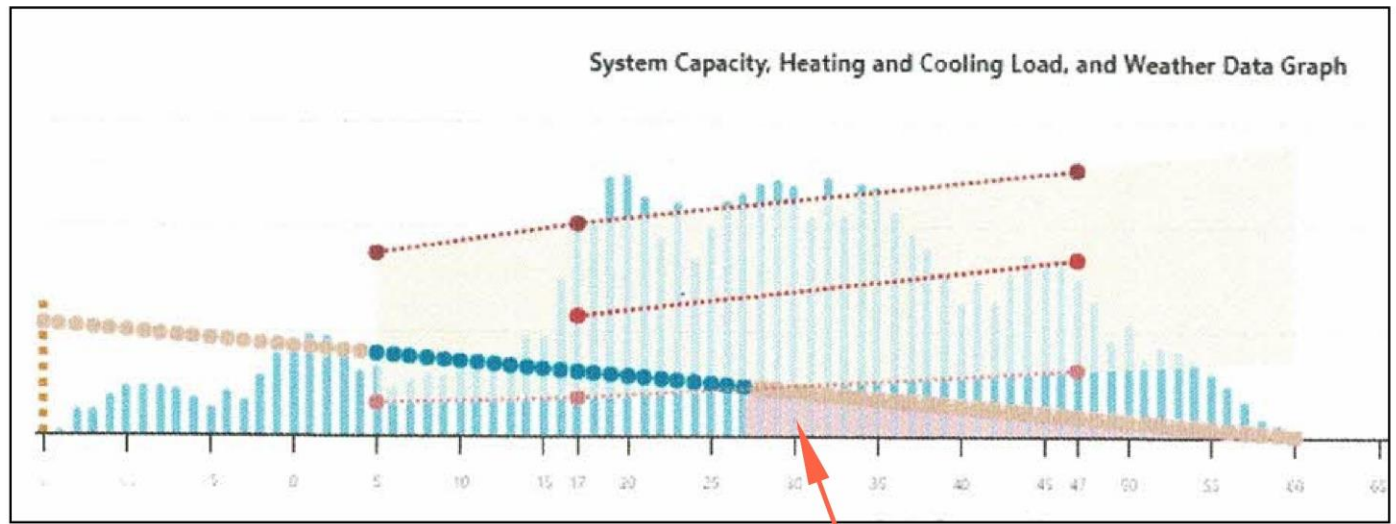
Builder

Heating

Calculated Peak Load (kBtu/hr)	12.8
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Envelope	11.7
Sizing Factor (%)	100.0
Heating Equipment Capacity(kBtu/hr)	
Required	12.8
Specified	20.3

NEEP Northeast Energy Efficiency Partners

ashp.neep.org



MITSUBISHI 18 kBtu/hour

HEAT CAPACITY @ -13 = 12,580

PEAK LOAD = 12,800

Air Source Heat Pump



OUTDOOR UNIT = COMPRESSOR

Air Source Heat Pump



INDOOR UNIT = FAN COIL

Blower Door: test for air-tightness

Blower Door SHELL



0.86 ACH @ 50 Pa = 0.05 cfm50/sf





Blower Door FINAL

AVERAGE WISCONSIN NEW HOME = 2 ACH @ 50 Pa



0.39 ACH @ 50 Pa = 0.02 cfm50/sf



PV Watts: predict PV

Predict PV Demand

remrate.com

Fuel Summary

Property
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Weather:Madison, WI
Amber's House Nov 22 2024 as built
Nov 22 Amber house.blg

Organization

Builder

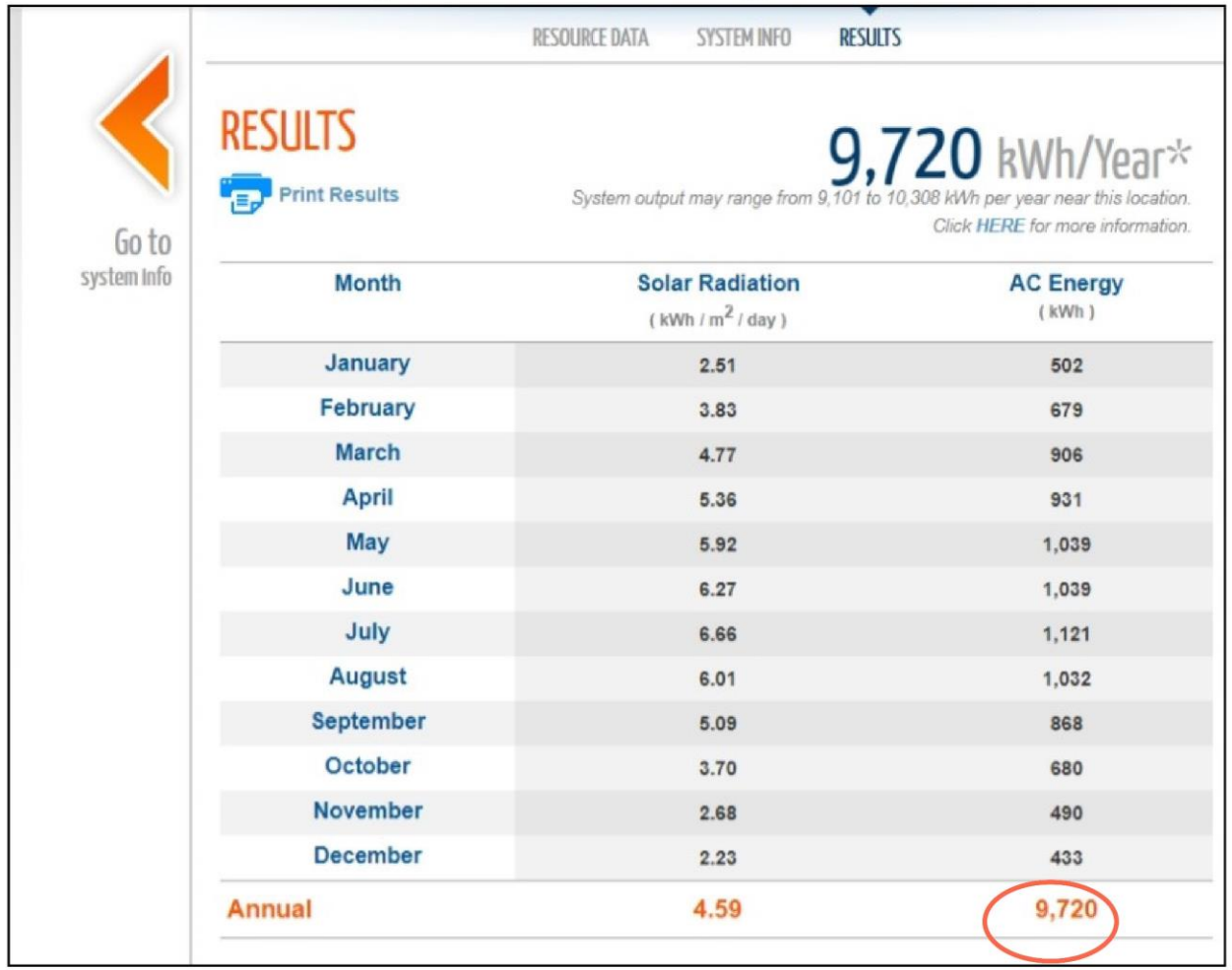
Annual Energy Cost	$/yr
Electric	1292

Annual End-Use Cost	$/yr
Heating	339
Cooling	43
Water Heating	369
Lights & Appliances	540
Photovoltaics	-0
Service Charge	183
Total	1474

Annual End-Use Consumption	
Heating (kWh)	2835
Cooling (kWh)	361
Water Heating (kWh)	3071
Lights & Appliances (kWh)	4502
Total (kWh)	10769

Predict PV Production

pvwatts.nrel.gov



RESOURCE DATA SYSTEM INFO RESULTS

Go to system Info

RESULTS

Print Results

9,720 kWh/Year*

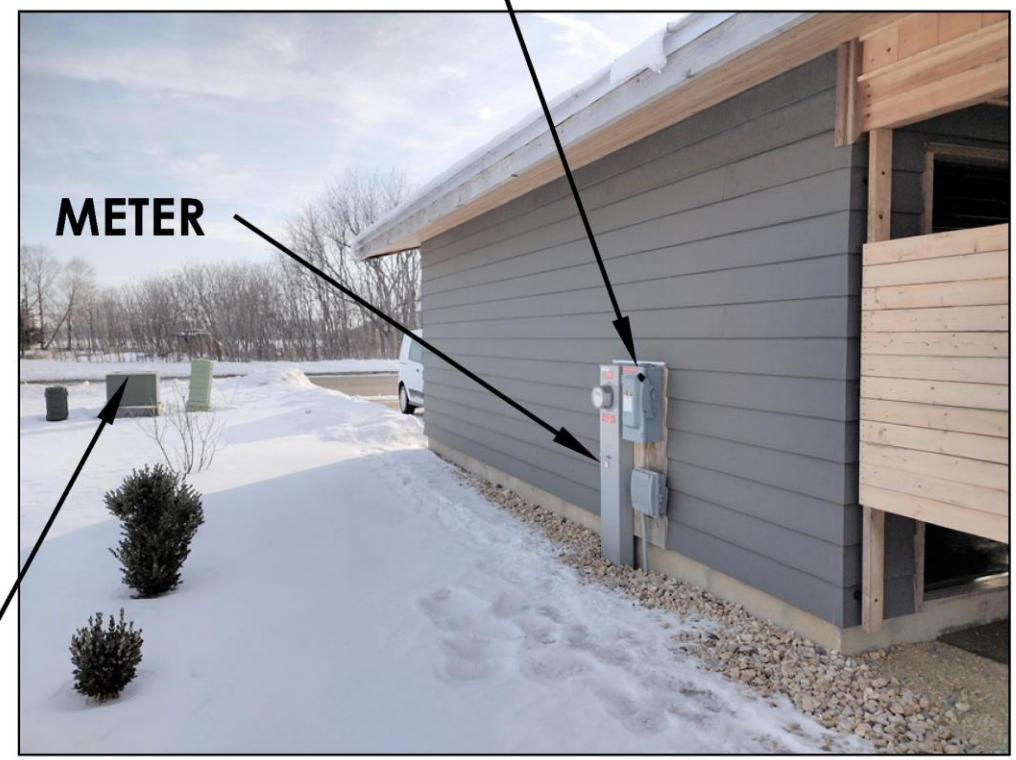
System output may range from 9,101 to 10,308 kWh per year near this location.
Click HERE for more information.

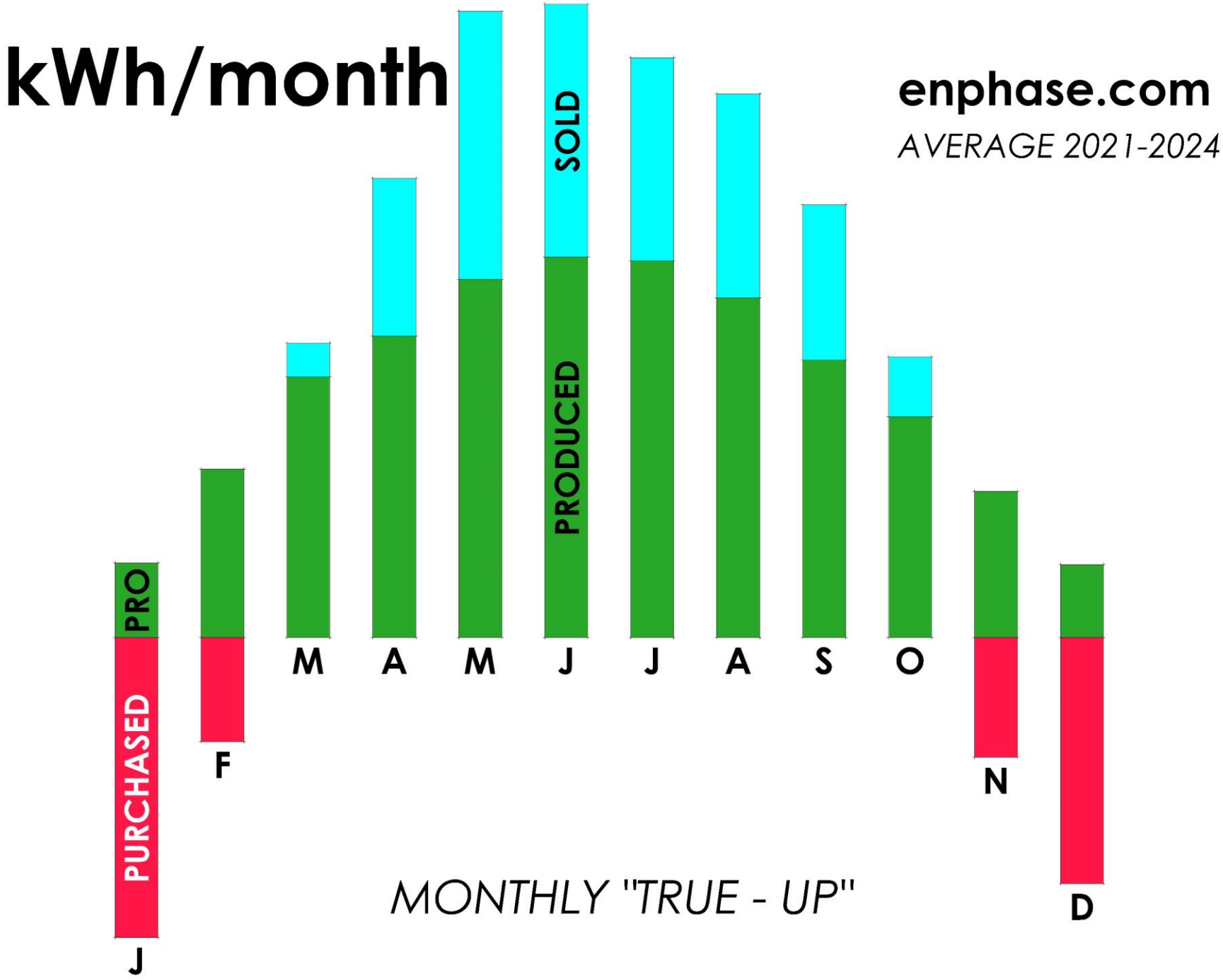
Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.51	502
February	3.83	679
March	4.77	906
April	5.36	931
May	5.92	1,039
June	6.27	1,039
July	6.66	1,121
August	6.01	1,032
September	5.09	868
October	3.70	680
November	2.68	490
December	2.23	433
Annual	4.59	9,720

Enphase: monitor PV

Electrical Service






kWh/month
enphase.com
AVERAGE 2021-2024
SOLD
PRODUCED
PRO
PURCHASED
J
F
M
A
M
J
J
A
S
O
N
D
MONTHLY "TRUE - UP"

kWh/year enphase.com

AVERAGE 2021-2024

PRODUCED 8311 Kwh
(PV Watts predicted 9720)….snow days?

USED 3296 Kwh
MARCH-OCT

SOLD 3726 Kwh
MARCH-OCT

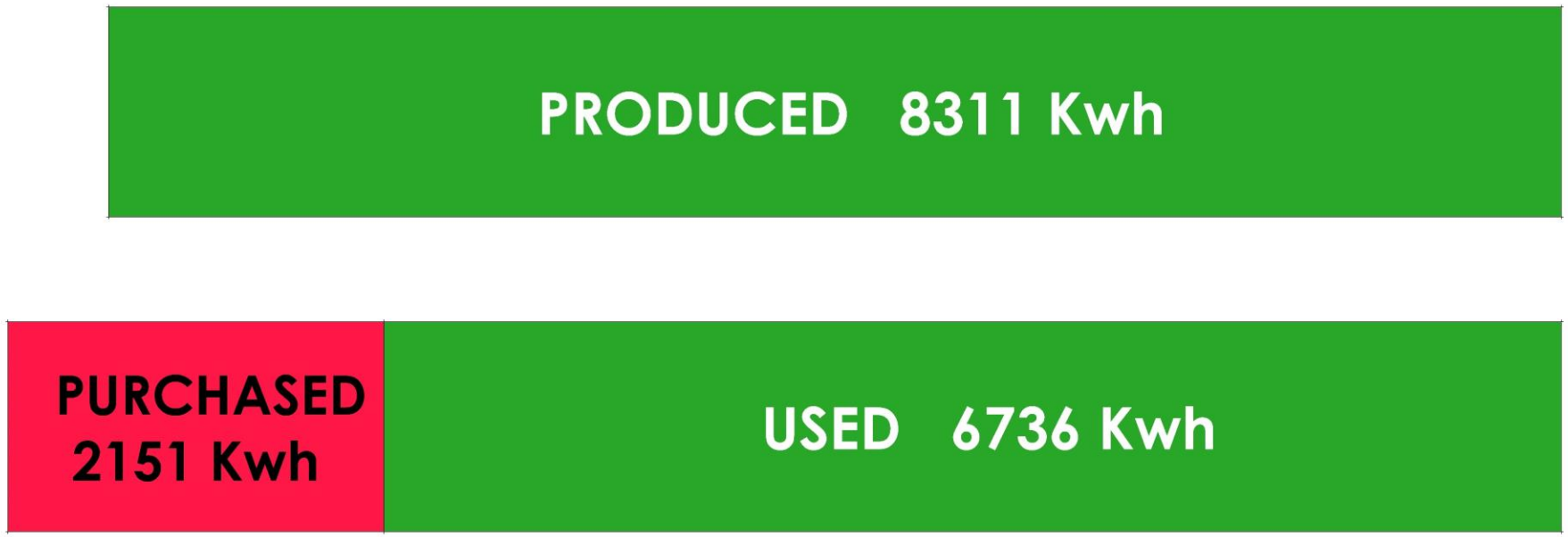
PURCHASED
2151 Kwh

USED 3440 Kwh
JAN FEB NOV DEC

Almost Net Zero

AVERAGE 2021-2024

8311 / (6736) + (2151) = 93%



Awair: monitor indoor air quality

Indoor Air Quality

getawair.com



AWAIR

Awair Score and Awair Indexes



Know what's in the air you breathe with Awair.
Awair Omni monitors the five key factors that influence your indoor air quality as well as light and noise so that you can take action to make the indoor environment healthier.

WHAT WE MEASURE

TEMPERATURE °F

Temperature has an obvious impact on comfort, but it can also impact health. Being either hot or cold can cause difficulty concentrating and a loss of productivity.

Healthy	Fair	Moderate	Unhealthy	Poor
64 ~ 77	63 ~ 64 77 ~ 79	52 ~ 63 79 ~ 90	48 ~ 52 90 ~ 93	‹ 48 › 93

AWAIR SCORE

A real-time score determined by the data acquired by the Awair Omni and proprietary algorithms that lets you know **your air quality** at a glance.

Good	Fair	Poor
80 - 100	60 - 80	0-60

HUMIDITY %

A dry environment can cause dry and irritated skin, while high humidity combined with with high temperature breeds bacteria and mold.

Healthy	Fair	Moderate	Unhealthy	Poor
40 ~ 50	35 ~ 40 50 ~ 60	20 ~ 35 60 ~ 65	15 ~ 20 65 ~ 80	‹ 15 › 80

CHEMICALS (TVOCs) PPB

VOCs, volatile organic compounds, are found in common building materials and cleaning products that can cause skin and respiratory irritation. Protect health by maintaining a toxic compound-free environment.

Healthy	Fair	Moderate	Unhealthy	Poor
0 ~ 333	333 ~1000	1000 ~ 3333	3333 ~ 8333	› 8333

CARBON DIOXIDE (CO_2) PPM

As more people occupy a space, CO_2 levels spike increasing the likelihood of drowsiness and lethargy as well as impacting productivity, concentration, and decision making.

Healthy	Fair	Moderate	Unhealthy	Poor
400 ~ 600	600 ~ 1000	1000 ~ 1500	1500 ~ 2500	› 2500

PARTICULATE MATTER (PM2.5) (µg/m3)

Dust, fungi, pollen, and smoke are common examples of particulate matter. These small particles can travel deeply into your lungs and trigger health problems like asthma and allergies.

Healthy	Fair	Moderate	Unhealthy	Poor
0 ~ 15	15 ~ 35	35 ~ 55	56 ~ 75	› 75

Breathe confidently. Know what's in the air you breathe so that you can take action to make the indoor environment healthier.

getawair.com

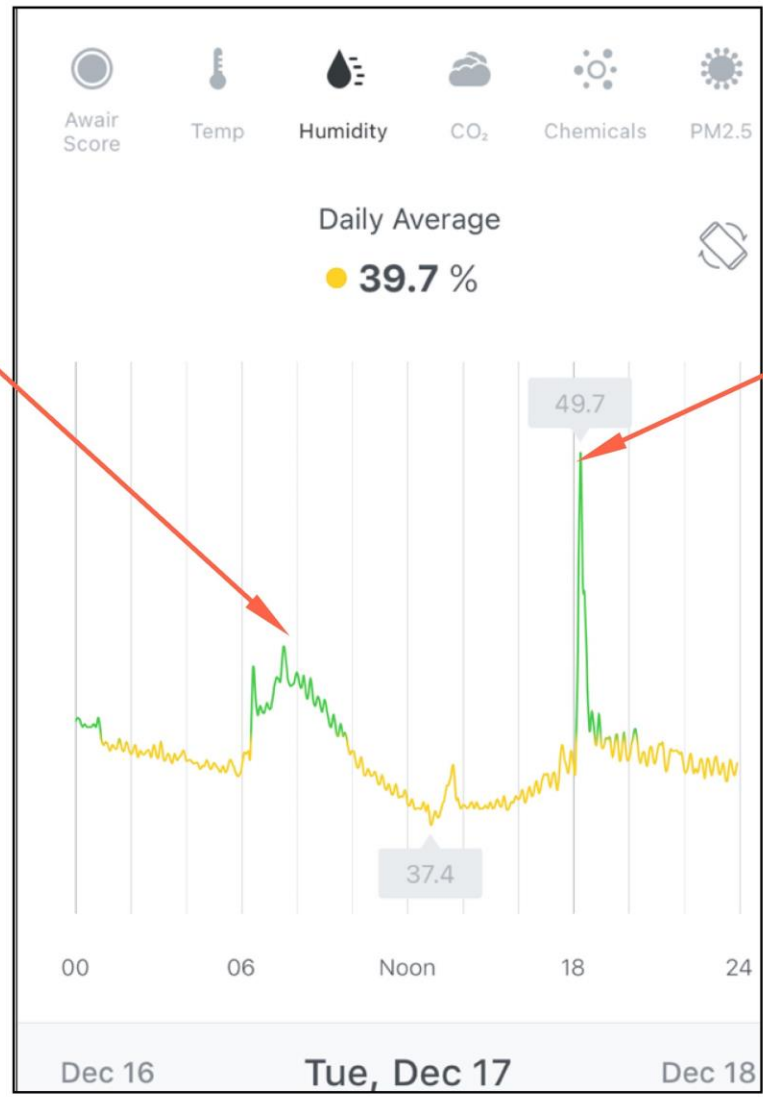
The Awair Index and Awair Scores reflect guidance from the EPA, WHO, ASHRAE, OSHA and others current at the time of publication.

MAR 2022

Humidity

AWAIR Recommends = 40-50%

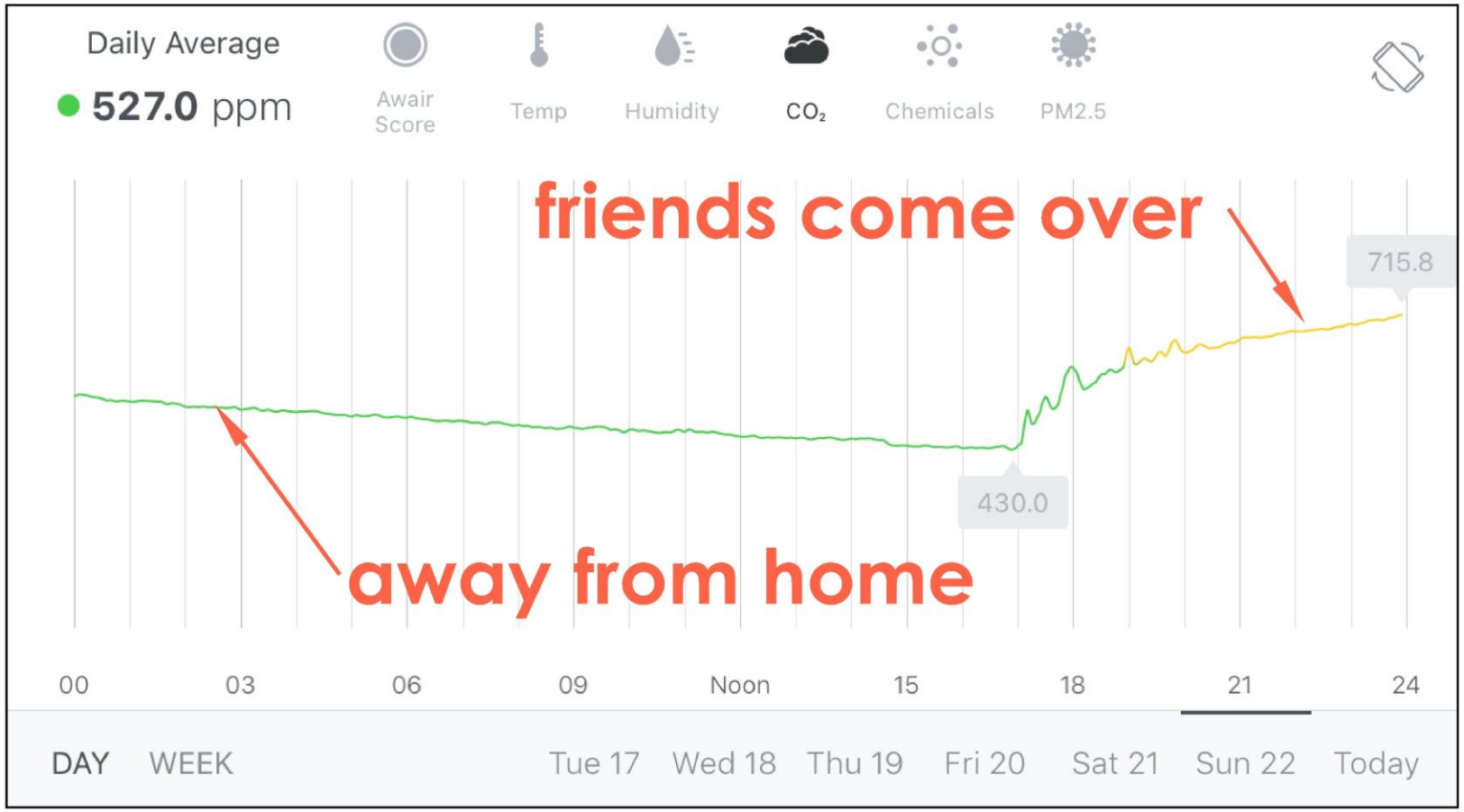
shower



dinner

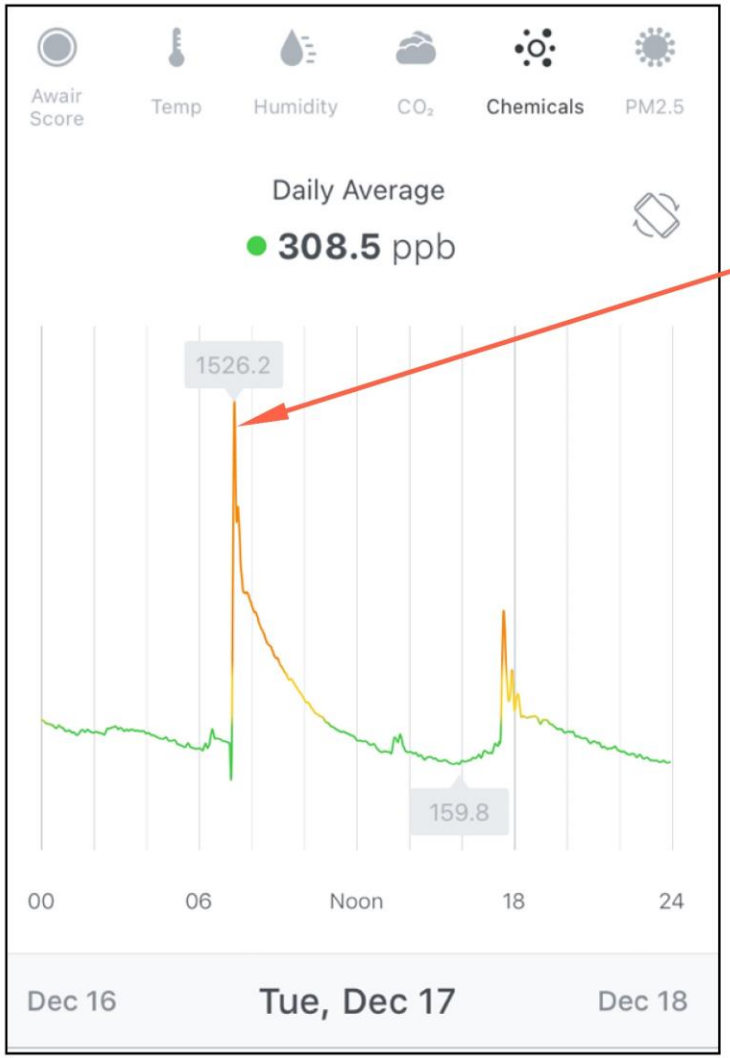
CO_2

AWAIR Recommends = under 600 ppm



Chemicals

AWAIR Recommends = under 333 ppb

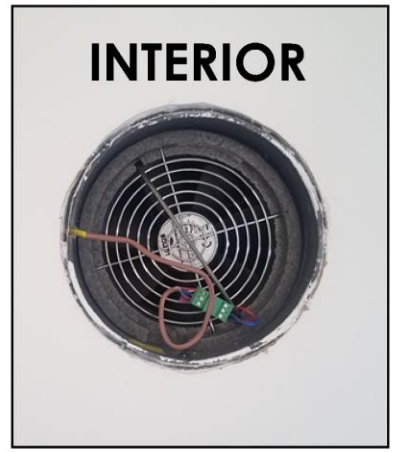


toast

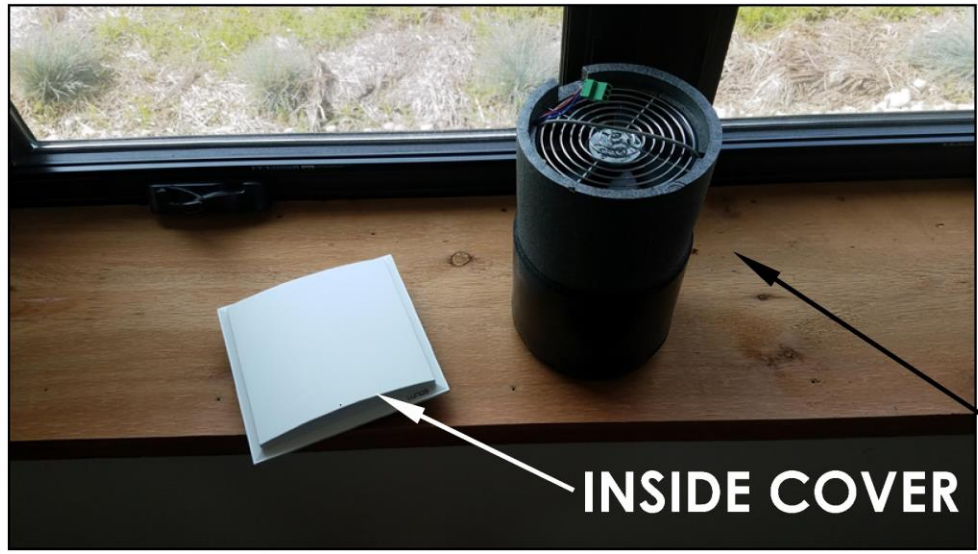
Heat Recovery Ventilators *475.supply*

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





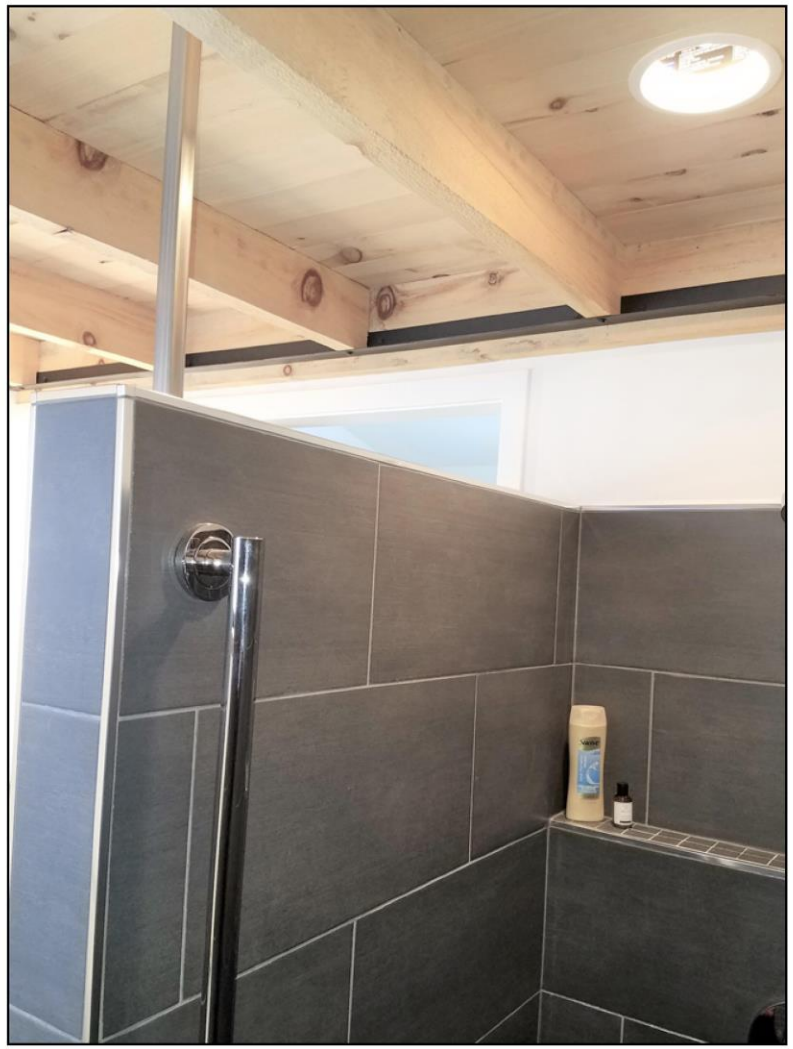




CERAMIC CORE + FILTERS
+ DUAL DIRECTION FAN

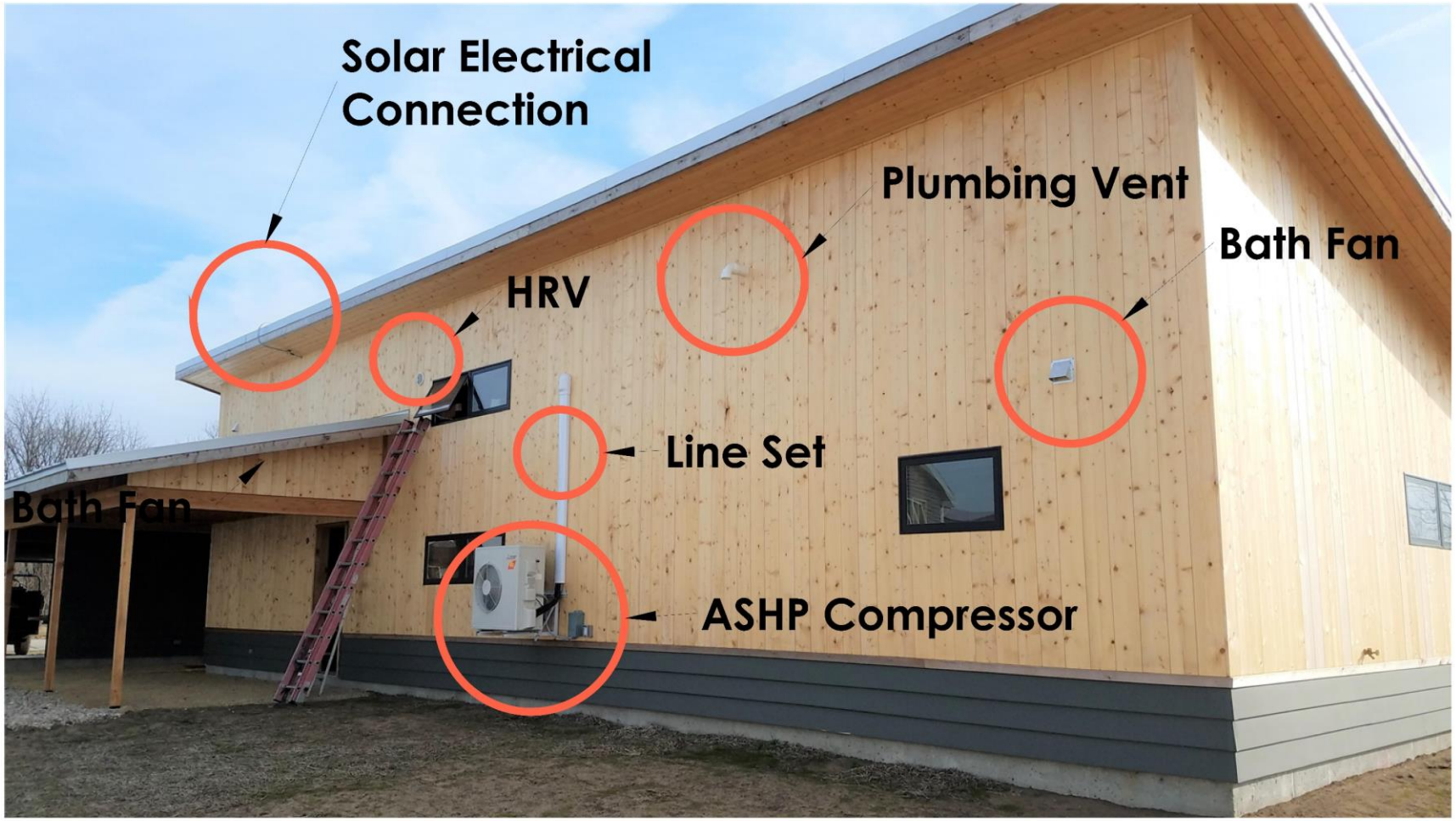
Bath Fans

2 "PANASONIC" EXHAUST ONLY FANS @ 80 CFM on humidistat





Mechanical Wall



Questions About Modeling or Monitoring?



3. Problems + Solutions

Noise

Comfort

Condensation

Indoor Air Quality

Noise

VIBRATION EVEN WITH GASKETED BRACKETS

FOUNDATION MOUNT or GROUND MOUNT ?



Noise



HRV FAN @ 40 CFM

DUCTED SYSTEM QUIETER ?

Comfort, Heat Distribution

LOFT = 5 to 10 DEGREES WARMER THAN GROUND FLOOR

ASHP NEEDS COOL RETURN AIR TO RUN EFFICIENTLY



Heat Distribution, Comfort

SLAB FEELS COLD, EVEN WHEN AIR TEMP IS GOOD

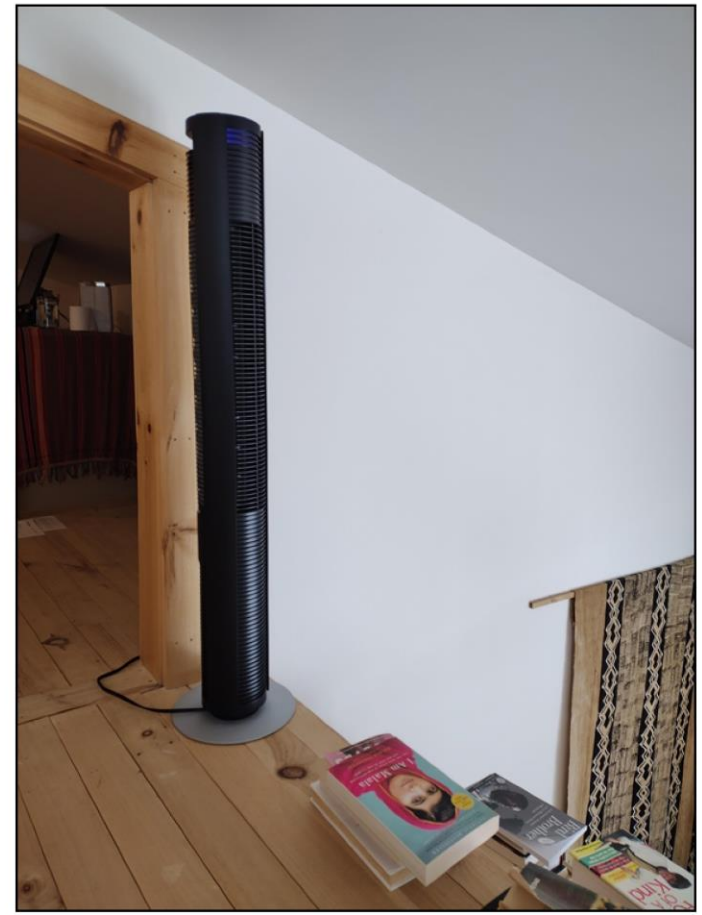


Heat Distribution, Comfort

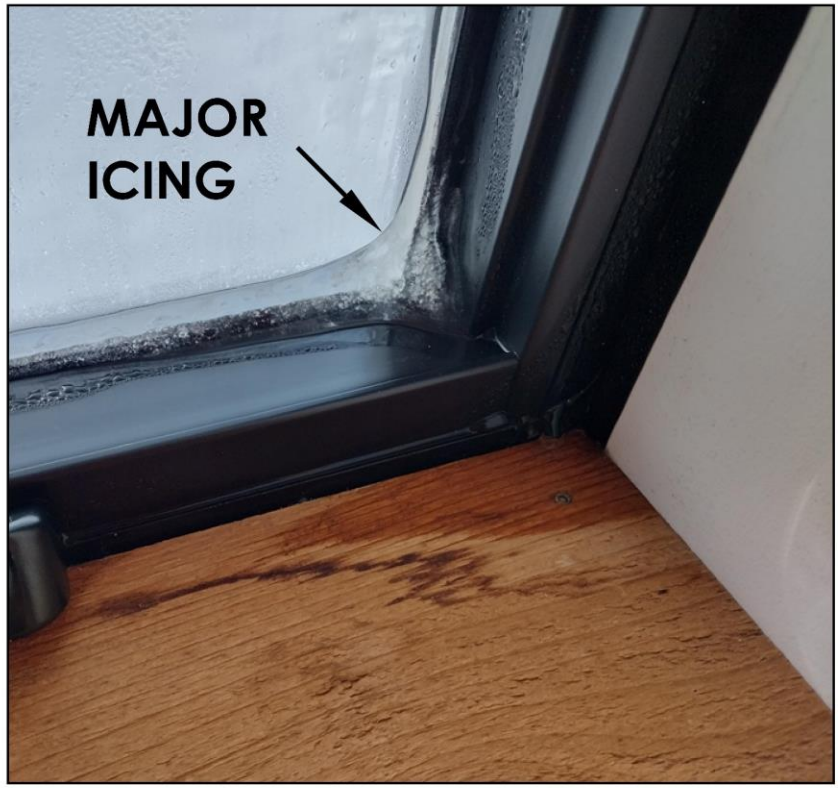


PORTABLE HEATER

PORTABLE FAN



Condensation, Icing



OUTSIDE - 7 F

INSIDE 62 F
42 RH



OUTSIDE - 4 F

INSIDE 61 F
26 RH

Condensation, Icing



-REDUCE HUMIDITY WITH LARGER HRV ?

-ADD INSIDE STORM WINDOW ?

-INCREASE AIR CIRCULATION ?

-UPGRADE R-VALUE WINDOW FRAME ?

-INSTALL WINDOW MID-WALL ?

Indoor Air Quality

NO RANGE HOOD !!



LUNOS HRV CAPACITY
= 40 CFM = 0.2 ACH =
5 HOURS TO FLUSH HOUSE



Questions About Problems or Solutions?



















POEM Homes.org



I welcome your visit to Spring Green!

Amber Westerman 608.935.9020

Thank you for being here!

Net-Zero Home: What Worked and What Didn't After 4 Years

Please contact:

Amber Westerman,
owner/designer/builder

PoemHomes.org

amber@amberwesterman.com |
608.935.9020