A Geo-Solar Self-Heating Workshop / Garage

BBBD 2015
Burlington, Vermont

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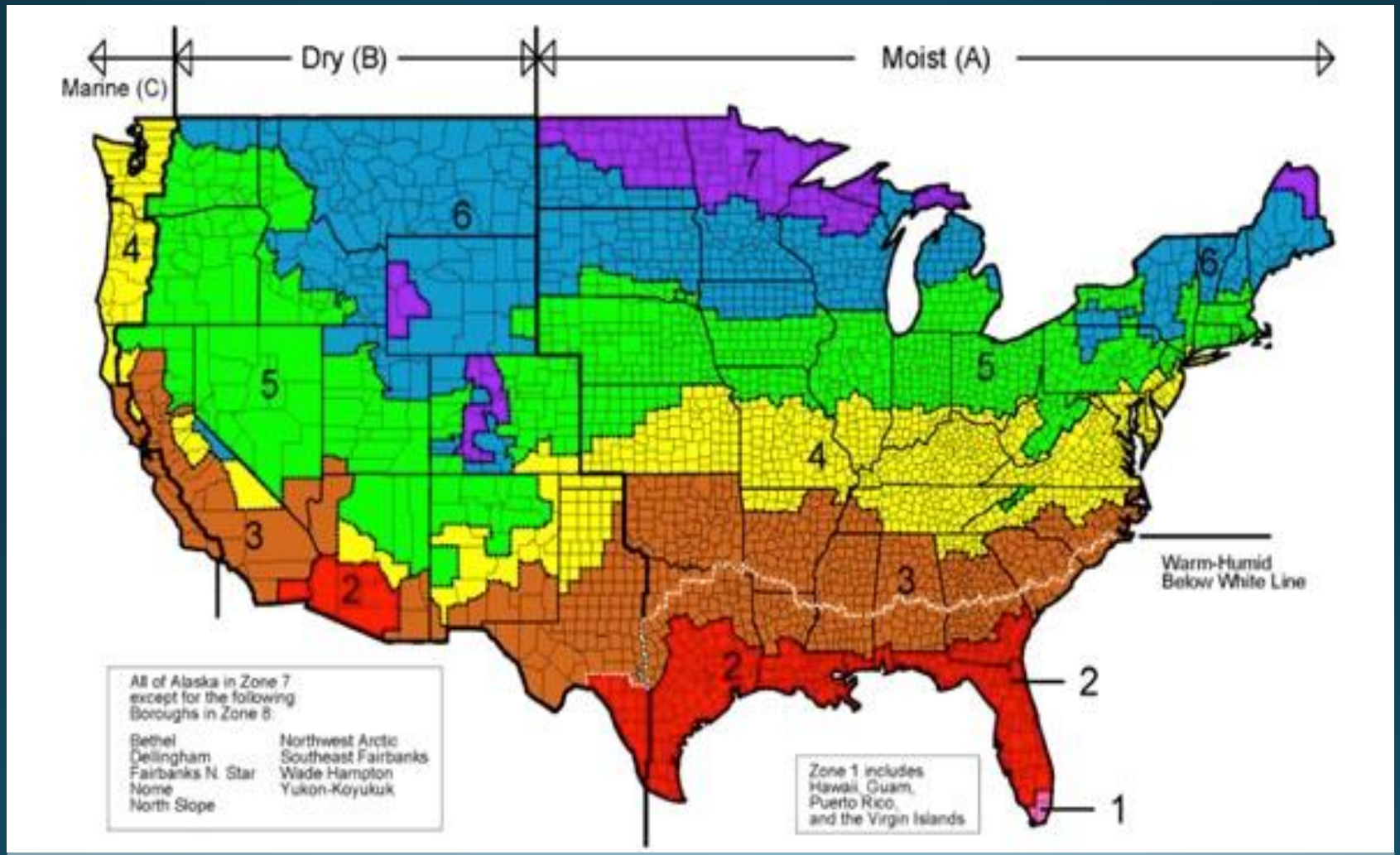
Who? From Where? Why?



Session Objectives

Recognize:

1. **the simplicity and economy of high performance construction methods**

2. **effective installation details of high performance air barriers and insulations**

3. **opportunities for simplifying wall and roof framing and insulation**

4. **importance of solar/hybrid role for heating and high performance**

Agenda (1.5 hr.)

1. Define client goals

2. What we considered and the economics.
   - Slab and geo exchange interface
   - Walls
   - Ceiling / Roofs
   - Garage doors

3. Results
   - Modeling
   - Data Logging: Geo, Floor, Room, Outside

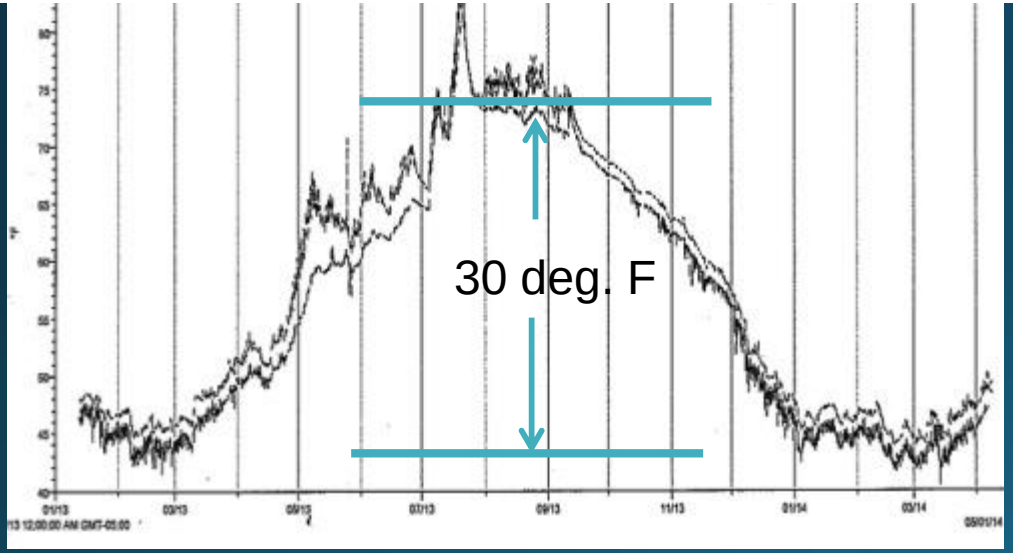
Goal:
Resilient and Futureproof

- *Durability, redundancy, resilience*
- *Flexibility, reduced obsolescence*
- *Long term life-cycle benefits*
- *Local materials and labor*
- *Maximum long-term ROI*

Goal: High Performance

?energy storage under the building ?

Ground Temperature Below Slab March to March



- Energy efficient
- Sustainable
- Environmentally Friendly
- Economical
- Zero Energy Ready

rcmzeroenergy.com ROSE construction

Key Goal: High Performance Enclosure Objectives

Easy, economical installation:

Thermal efficiency

Geo & solar efficiency

Minimal Cost

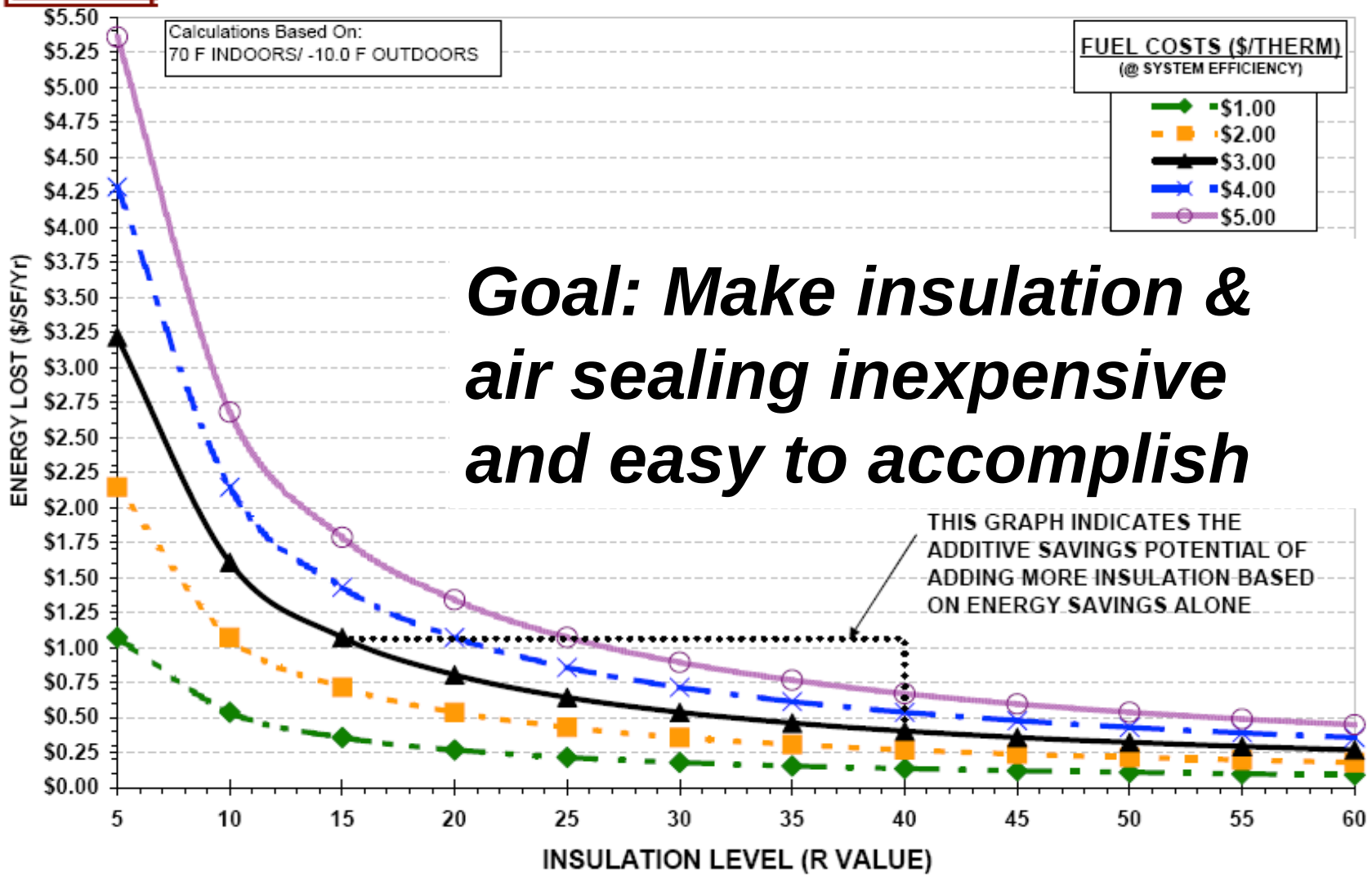
High Performance Enclosure Objective

Goal: Reduce heating load to less than 10,000 BTU/hr. at 0° F

TURNER GROUP

INSULATION COST EFFECTIVENESS

COST OF HEATING ENERGY LOST DUE TO INSULATION LEVELS



Goal: Make insulation & air sealing inexpensive and easy to accomplish

Consider Climate Impact of Insulation Materials

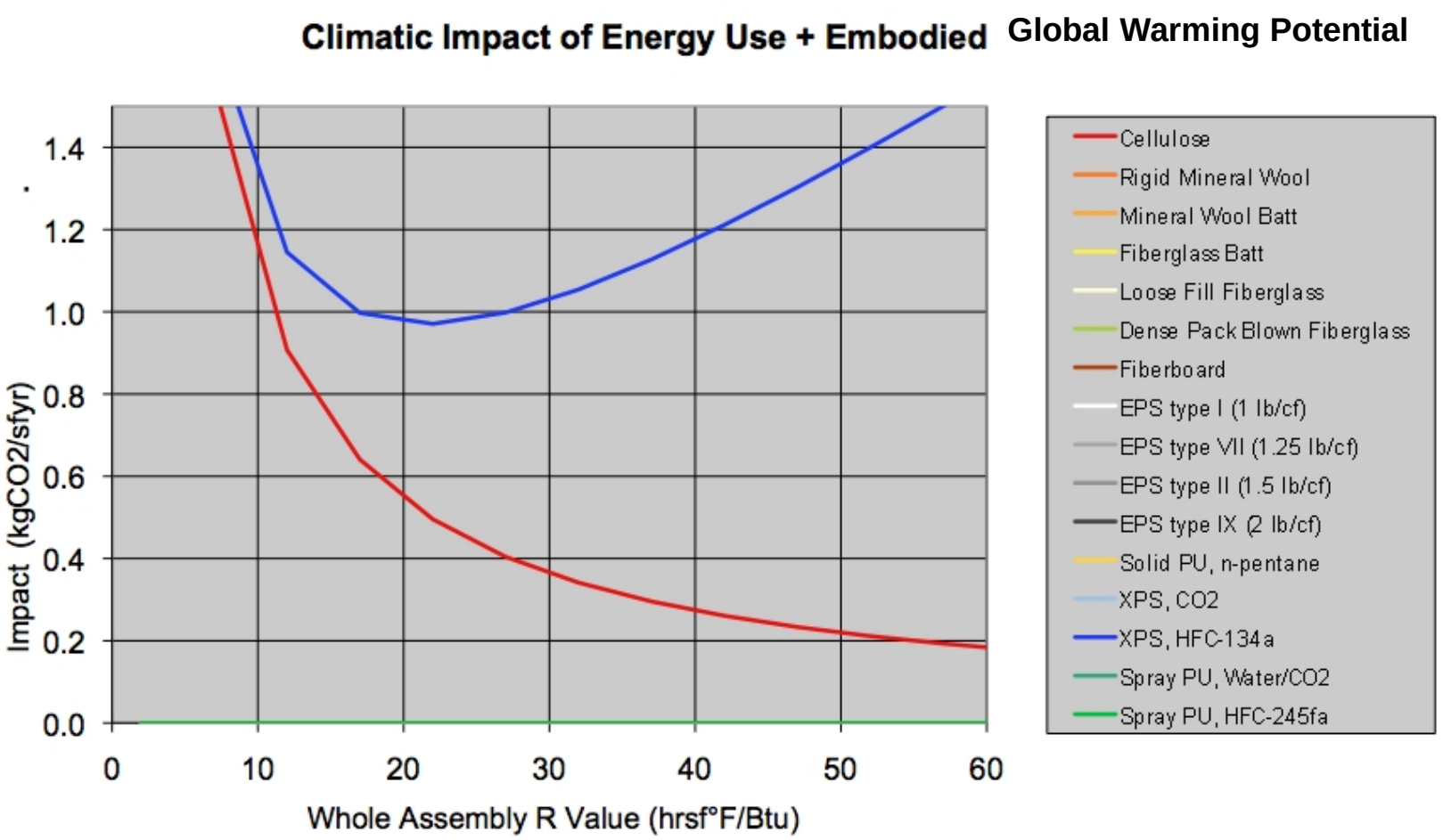


Chart Source: David White, Insulation GWP Tool v1.1

Simple, economical wall construction parameters:

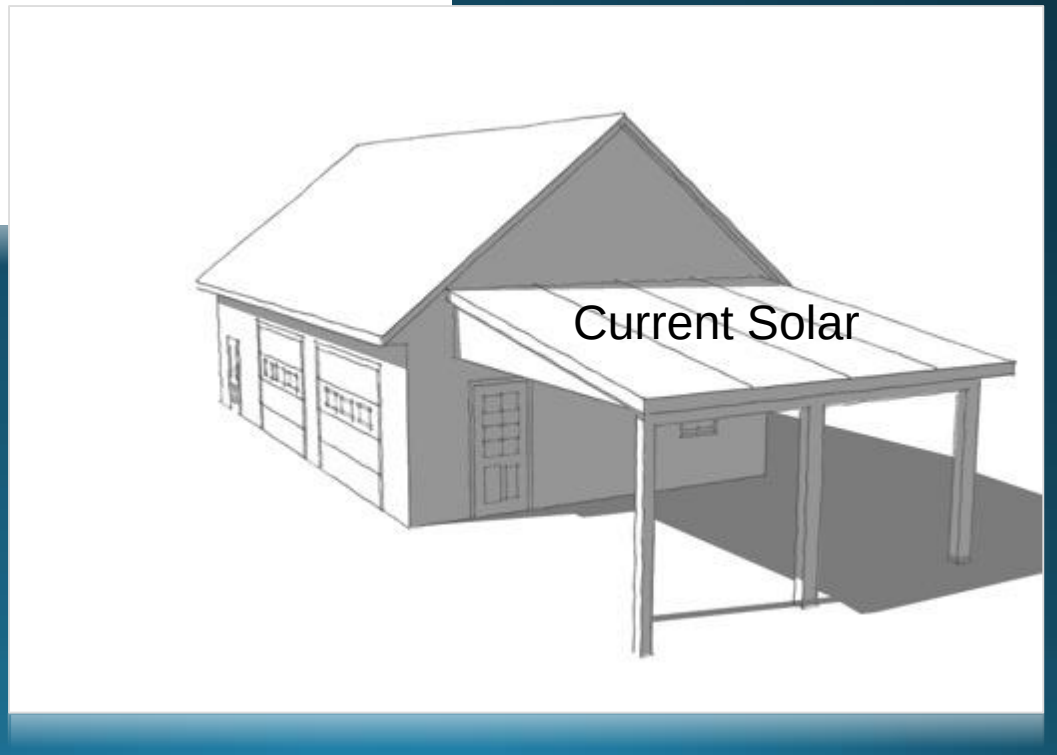
Minimal use of plastic foam products

Air and vapor barrier placed to accommodate heating and cooling

Standard carpentry practices

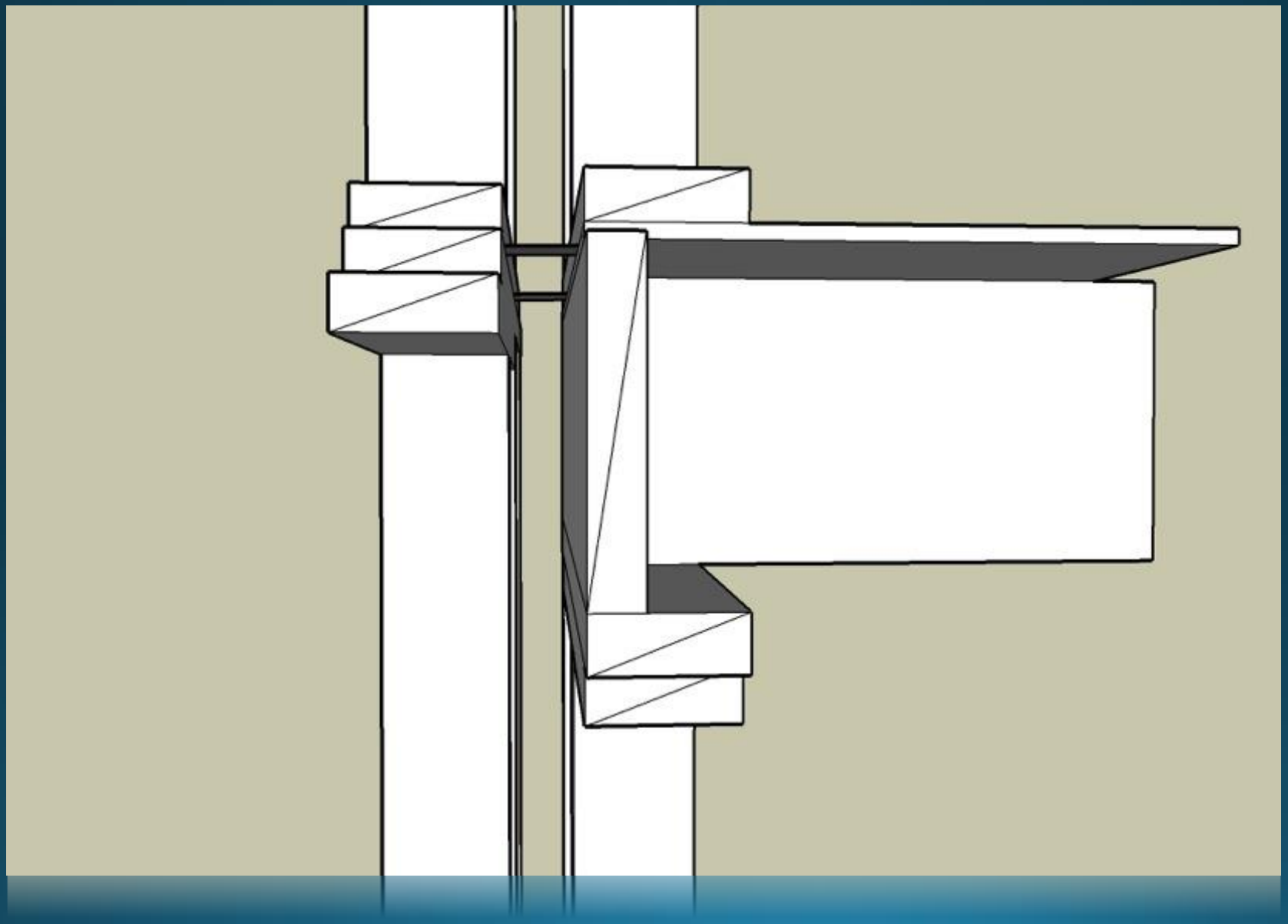
Standard electrical and plumbing practices

28’ x 48’ barn



32’ x 24’ lean to

Double Stud Wall?

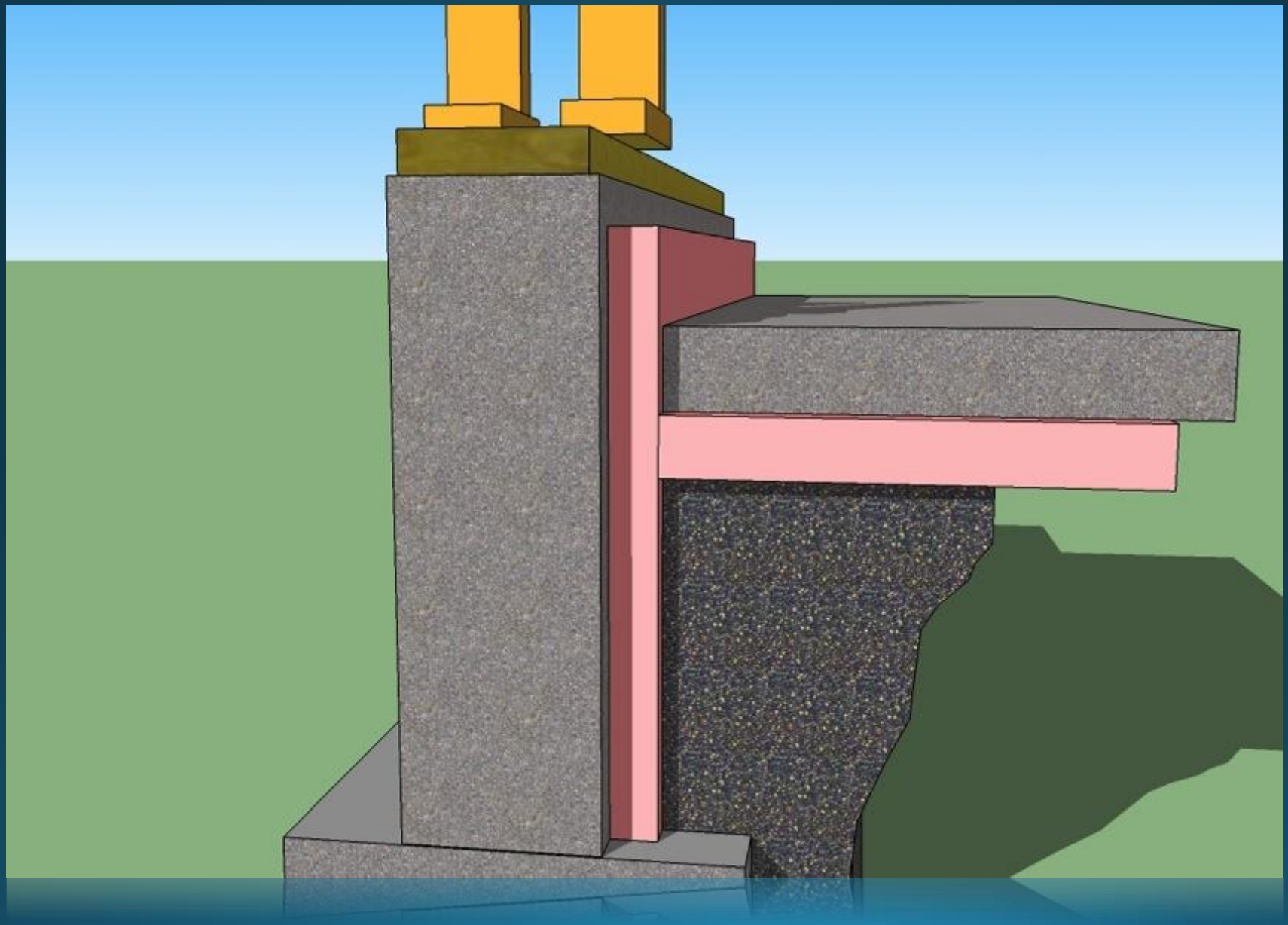


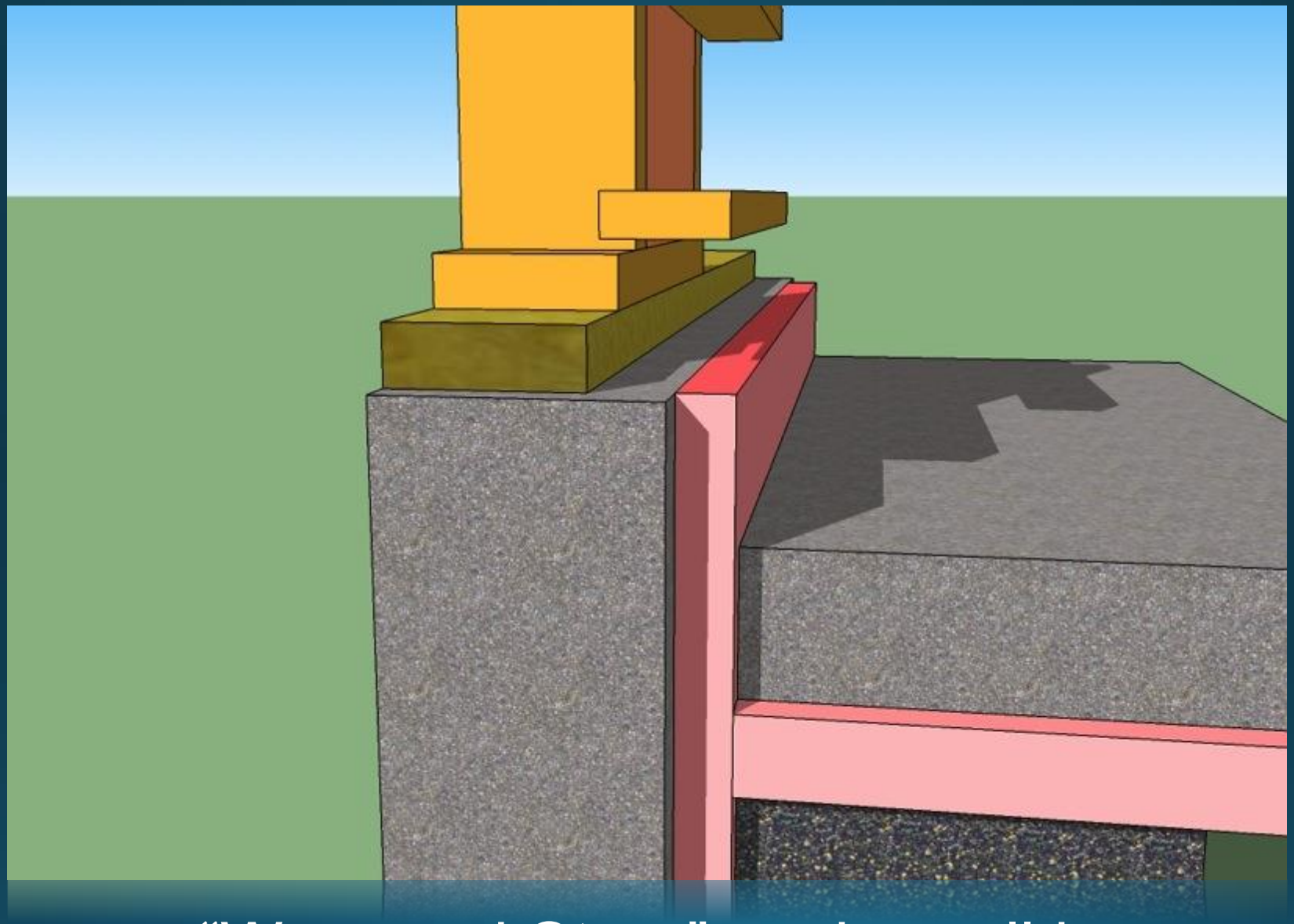
Double stud wall beginnings…

… just kidding!

Two story configuration

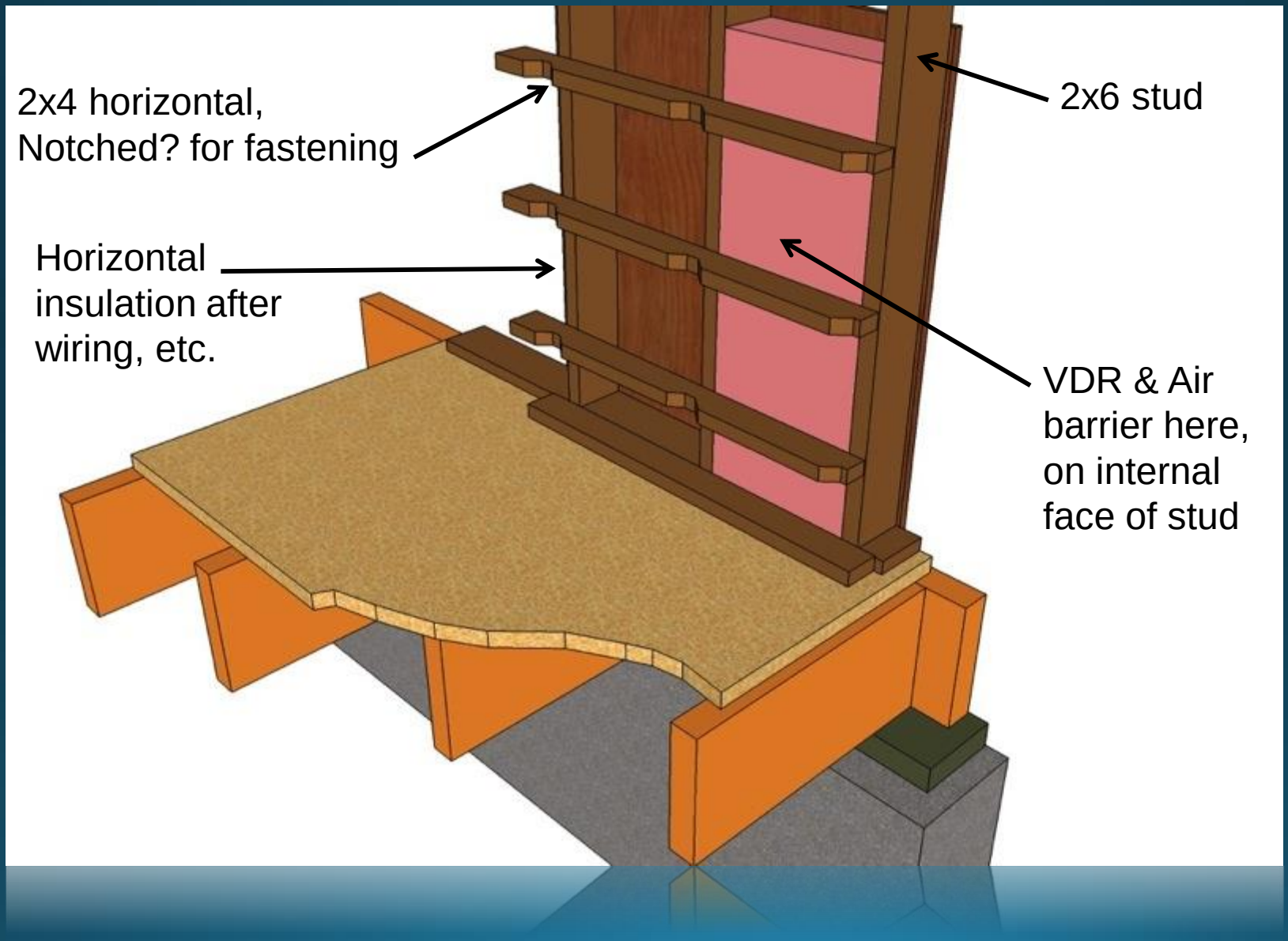
Double stud wall won’t work on an 8” frostwall

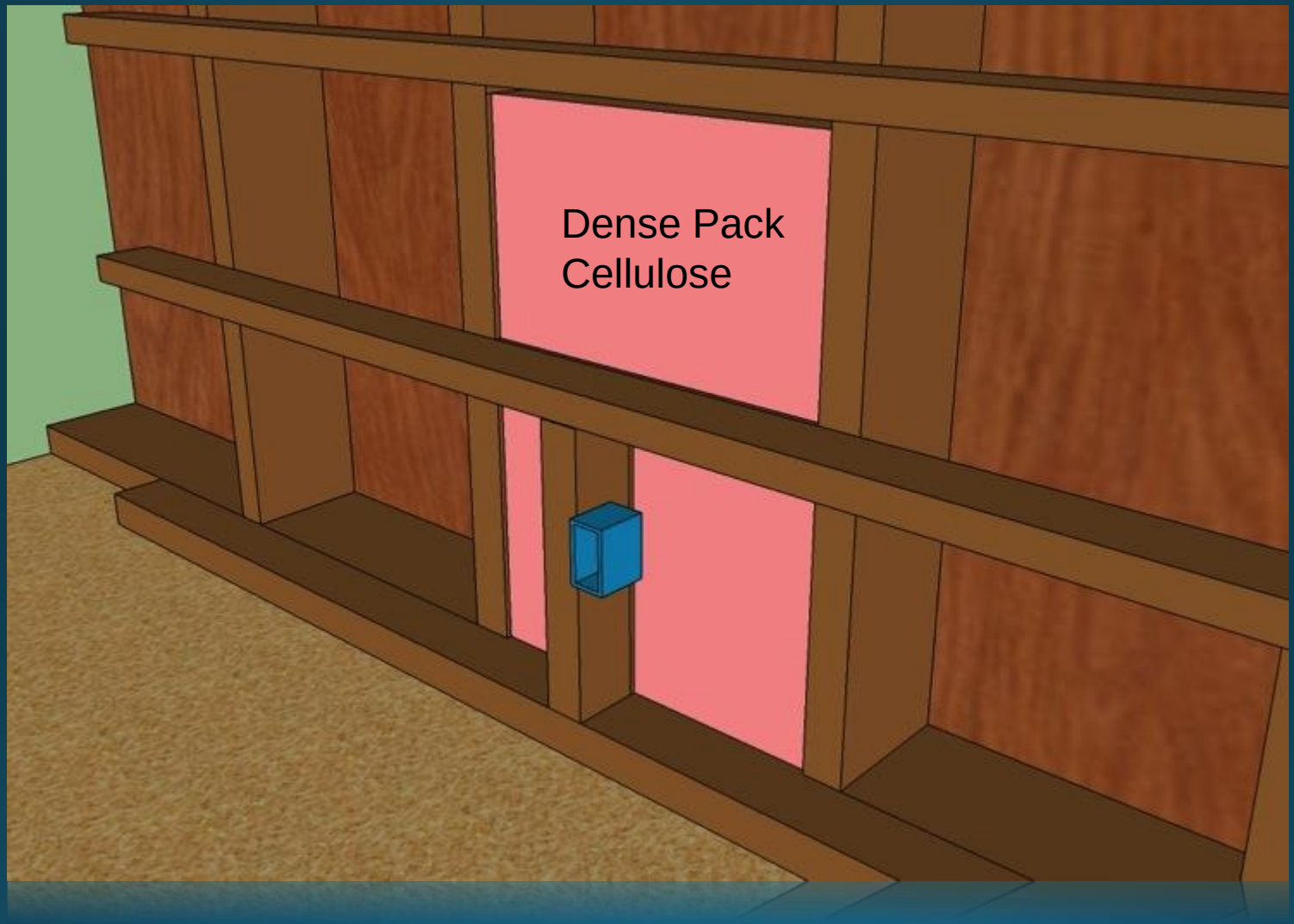




"Wrap and Strap" works well here

“Wrap and Strap”





Vertical framing for outlets, switches as needed

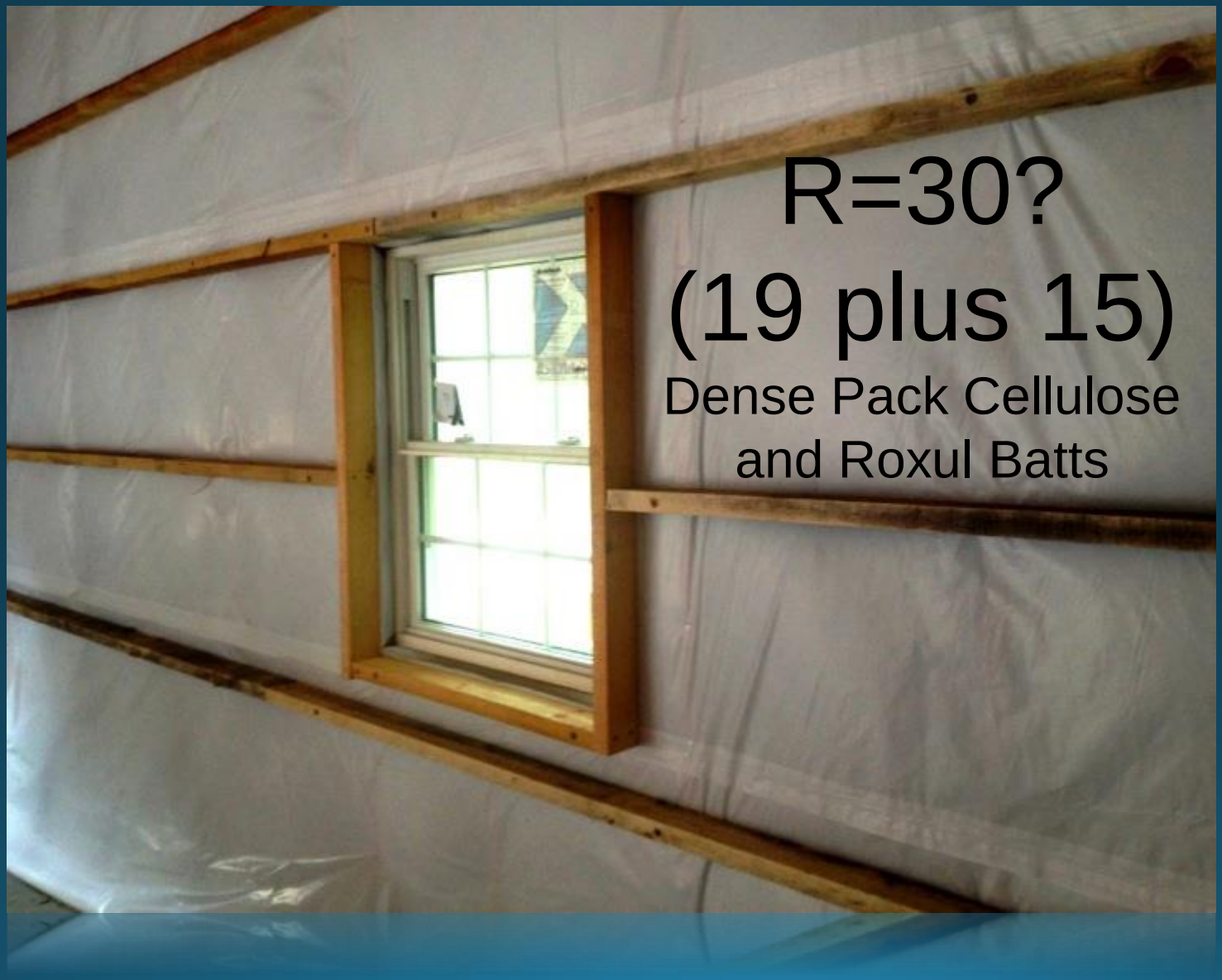
Ideal wiring arrangement

Valuable pine logs sold

Interior Finish: site harvested boards from culled pine and hemlock logs

Lean To: posts cut from hemlock timber

“Wrap and Strap”



Sealing techniques

tu-tuf®
THE CHILL SHIELD
VAPOR BARRIER

A good combination

Roxul™ mineral wool insulation

R-value 4.28/in

Dense packed cellulose

R-3.35/in

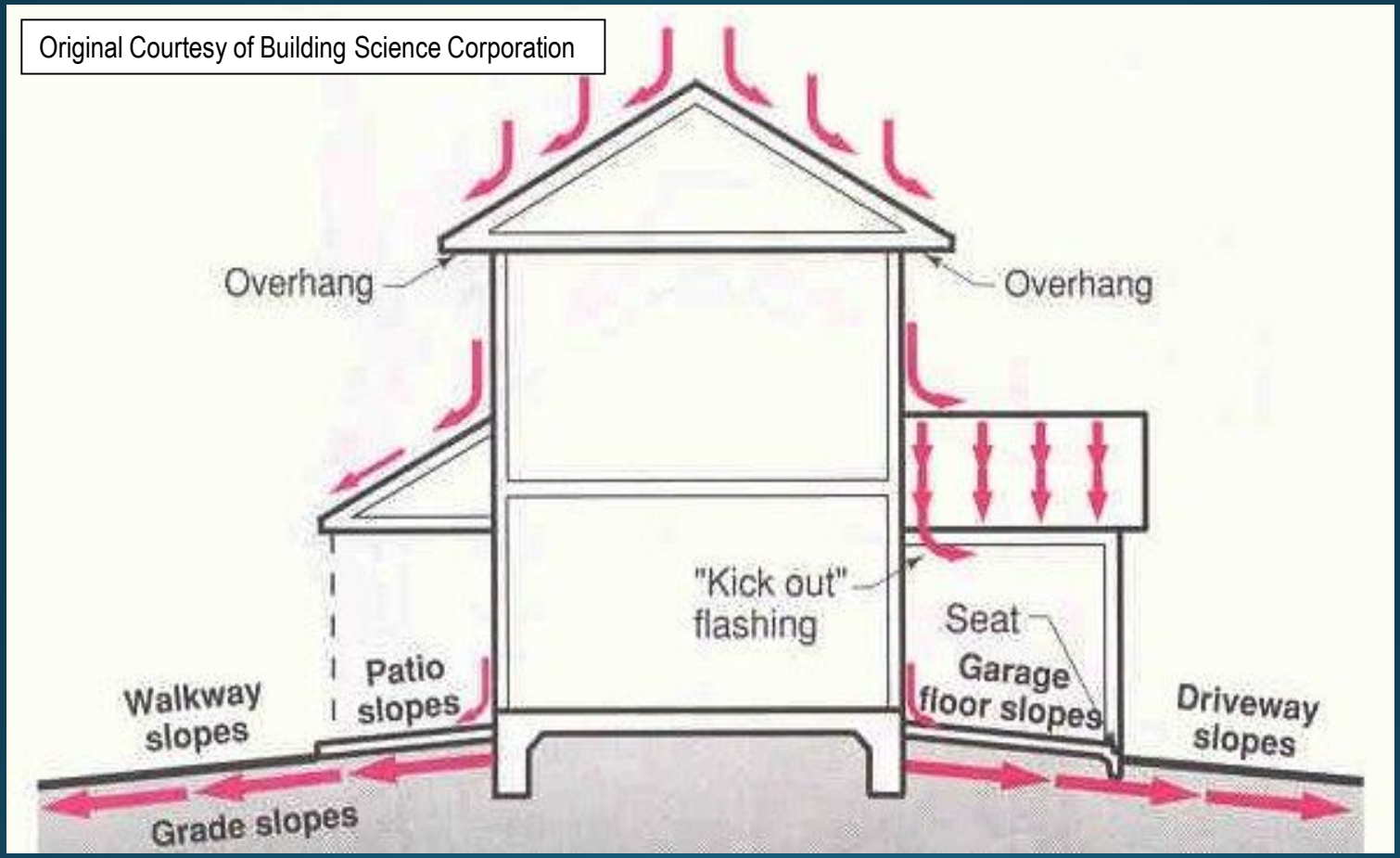
Sealed Floor Plate

Sealed Floor / Wall Air & VB Interface

Ceiling: 26”cellulose above Tu-Tuff, and OSB sheathing painted white

Cold Roof Design:
Blocking at Soffit, Vented, Cantilever Truss

Enclosure #1… Drain the Rain



Exterior: large overhangs (1.5 & 3 ft.), Inexpensive OSB, drain plane & 2nd air barrier, and vinyl siding

Garage Doors

Clopay Commercial Model 3730 , 3 inches thick

Two 12 feet by 10 feet, core= R 22.2

Manufacturer Test Data U= 0.15

Increase Potential for High Performance GEO / Solar Hybrid

Reduce the need for fossil or wood base fuel consumption

Potential for future net zero

Geo / Solar Hybrid

Exchange Possibilities:

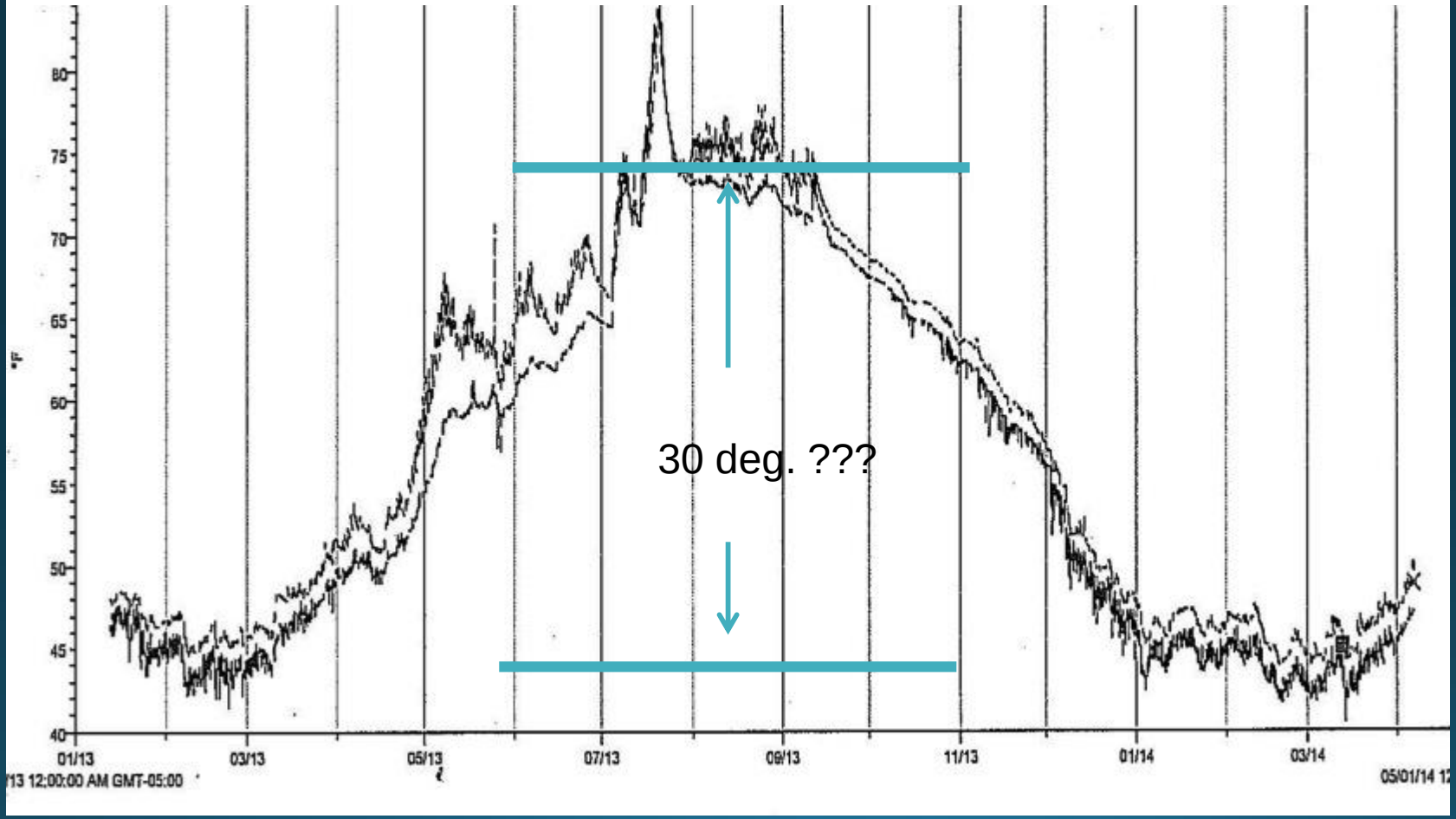
PEX ? (hot or cold)

GEOPERFORMX ®?

Pex: Affordable, solar compatible, easy to build off site & transport?

Goal: Economical Energy Storage Under The Building?

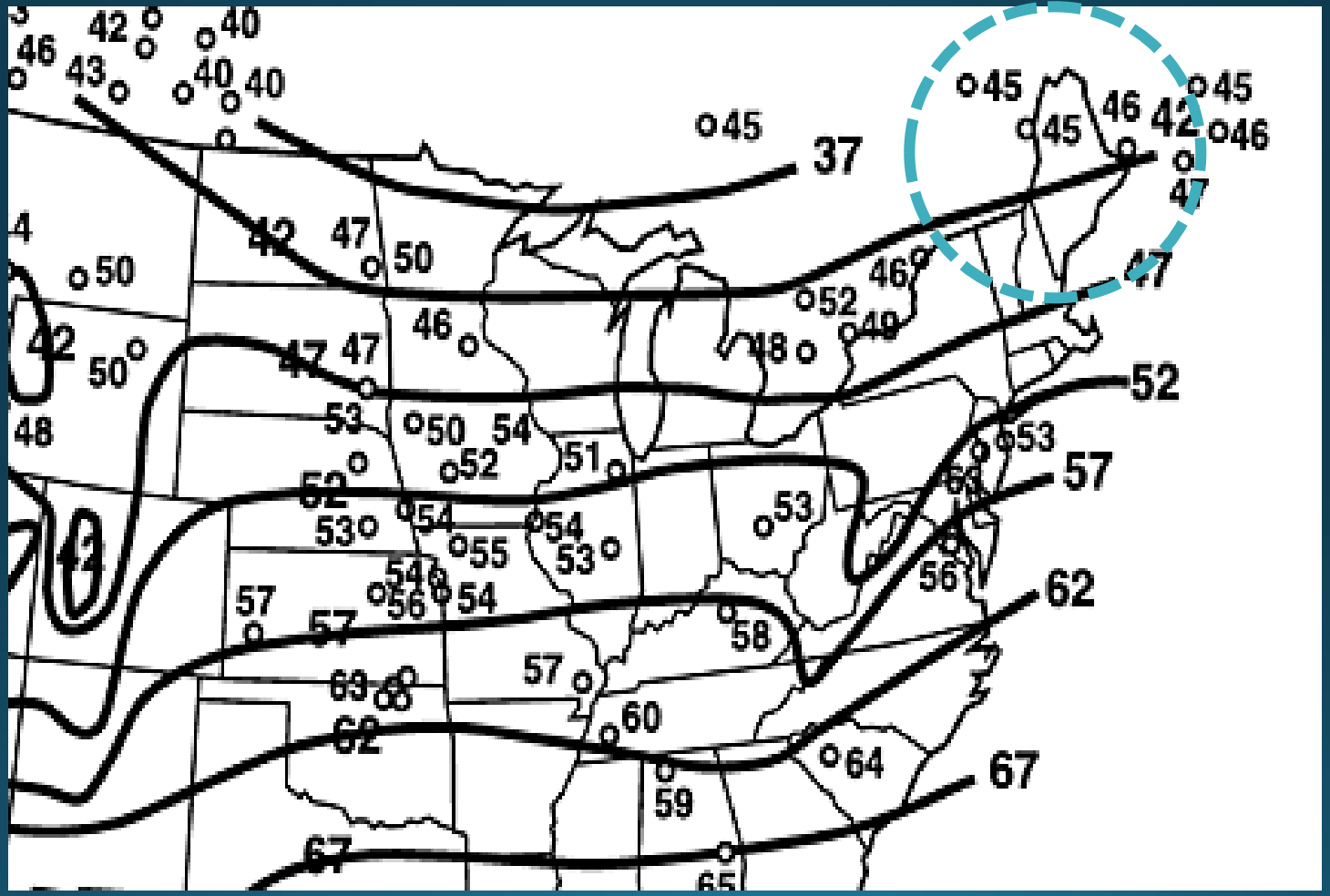
Rose Cottage Data: Measured Ground Temperature Under Slab March to March



Courtesy: rcmzeroenergy.com ROSE construction

Normal Mean Annual Earth Temperature

Source: Virginia Tech



Site Bedrock is close by

Pex Solar /Geo Slinkys

Three, 300 foot ¾ inch Slinkys
Goal: 9-12,000 BTU/hr heat transfer

Crete Heat™ R=15

Make Radiant Easy to Install

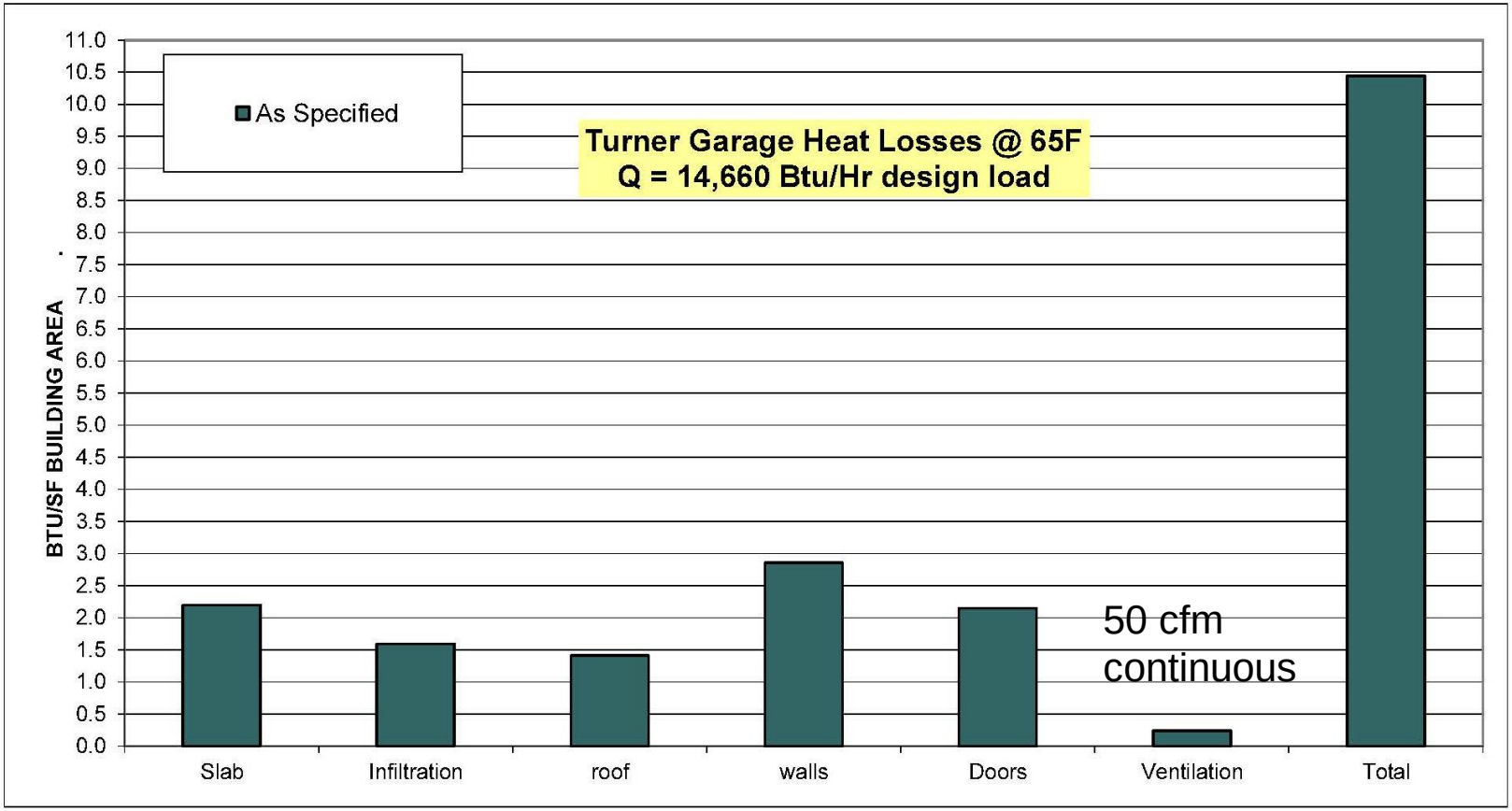
Radiant Floor

Four, 249 foot ½ inch Pex runs

Concrete Floor

Conservative Calculated Load @ -2 Deg. F Using TMY data

Radiant Floor Water needs to be at 75 Deg. F.
Solar Water Heating Fraction 70% to 85%?



Courtesy: Jeff Harrison, P. E.

Building Test Out Metrics

How did we do?

Measured Air Tightness

@ Negative Pressure…

1 ACH at 50 pascals

0.022 CFM/SF of surface area

@ Positive Pressure…

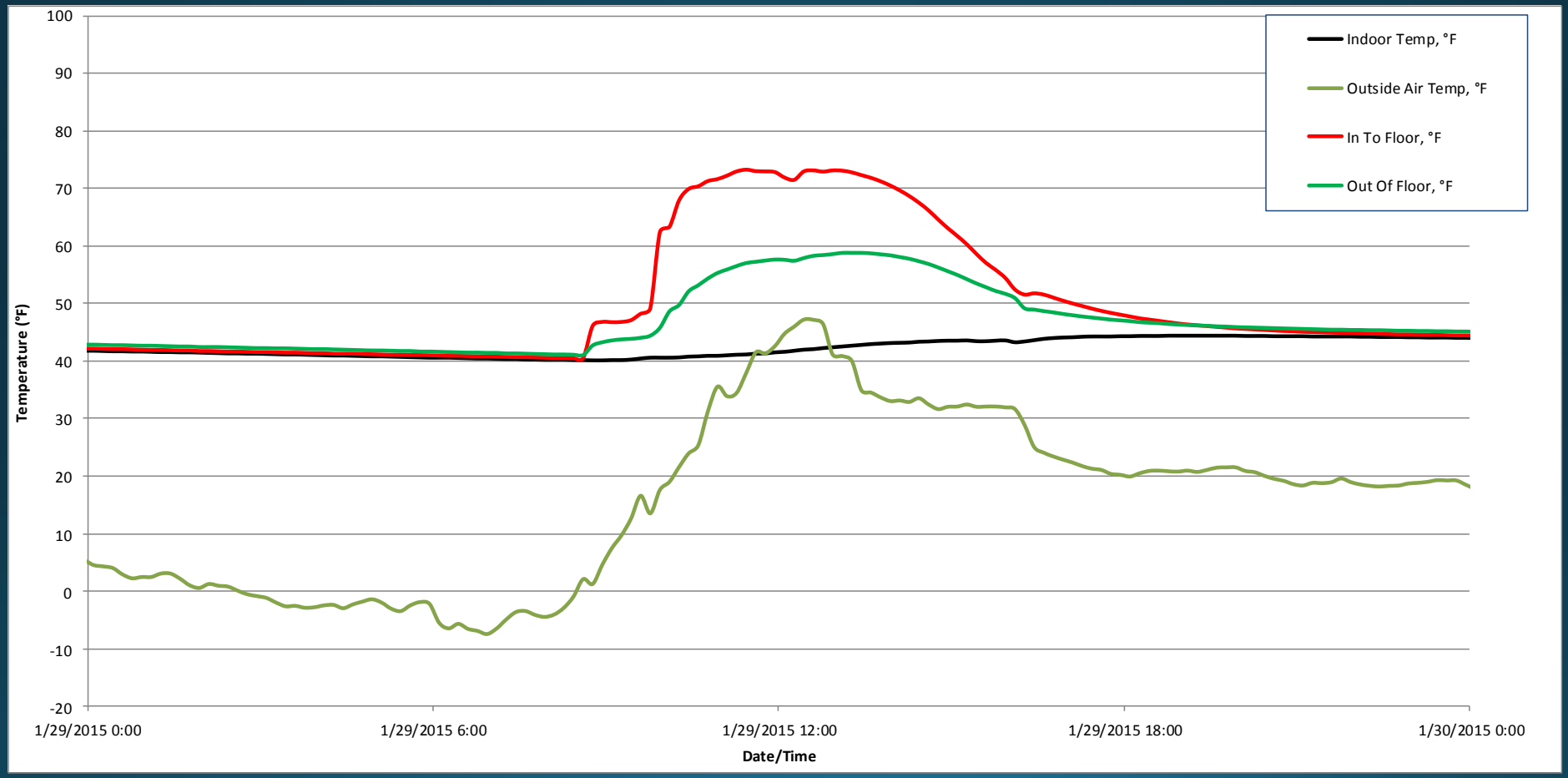
1.7 ACH at 50 pascals

Note:

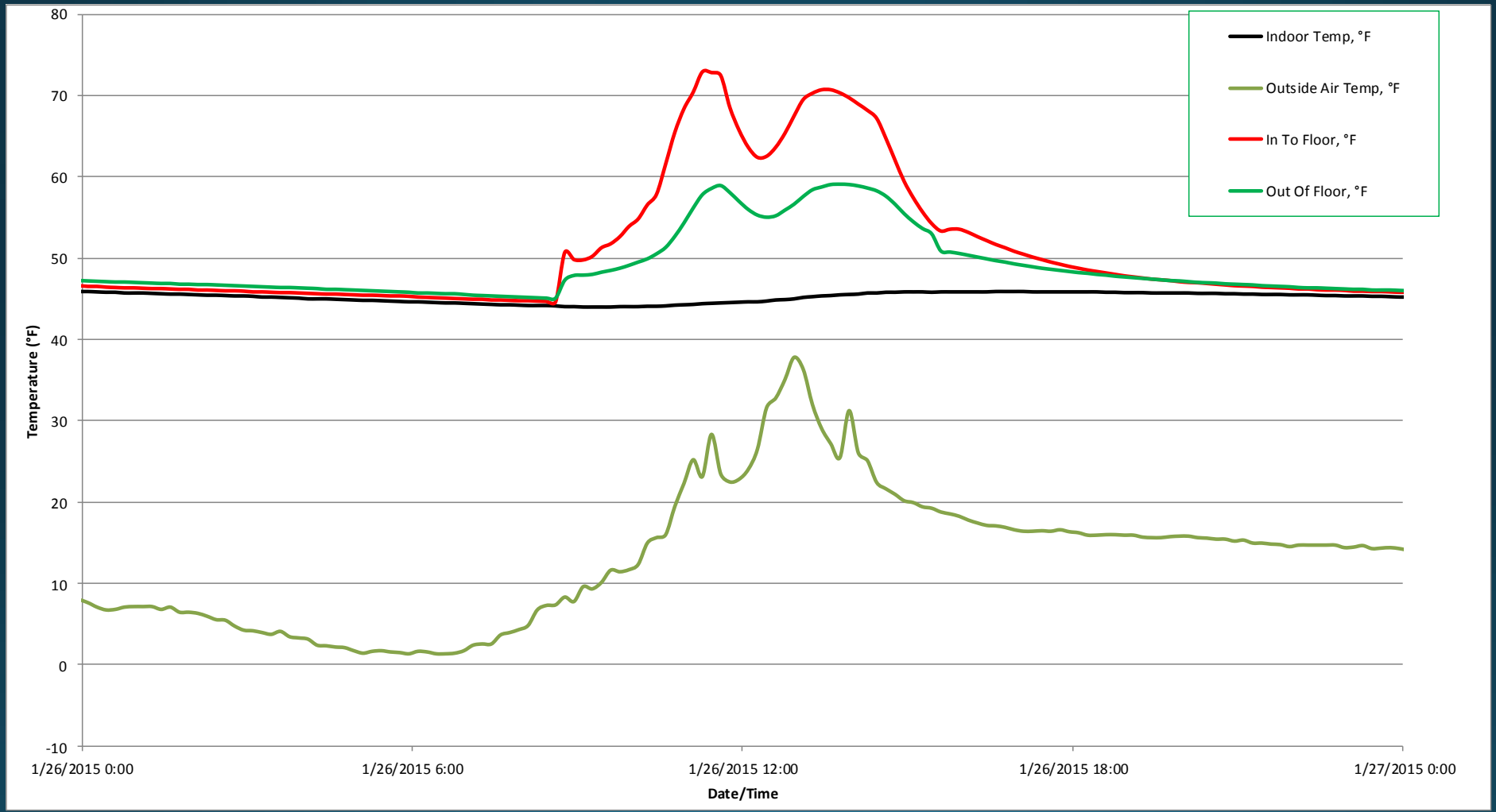
Construction schedule that evolved did not achieve solar thermal and PV installation until late December 2014, so seasonal heat storage has not been measured yet. Will log in 2015.

Heat pump is yet to be installed.

Building Performance in Below 0˚ F Weather

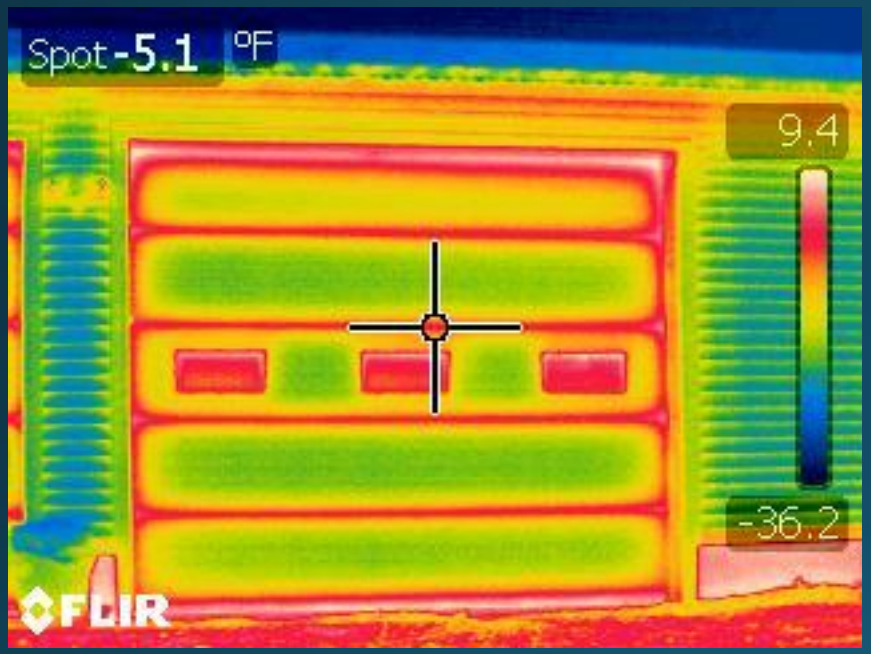


Building Performance only Solar Heated 0 Deg. F Weather



Door IR images when very cold

Outside looking in

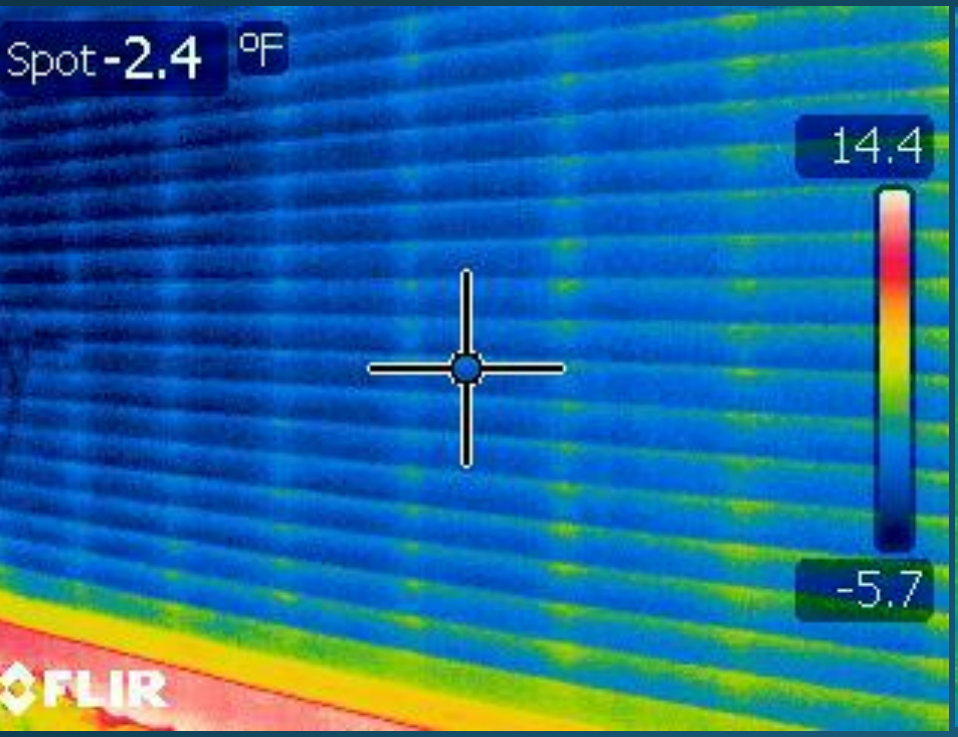


Inside looking out

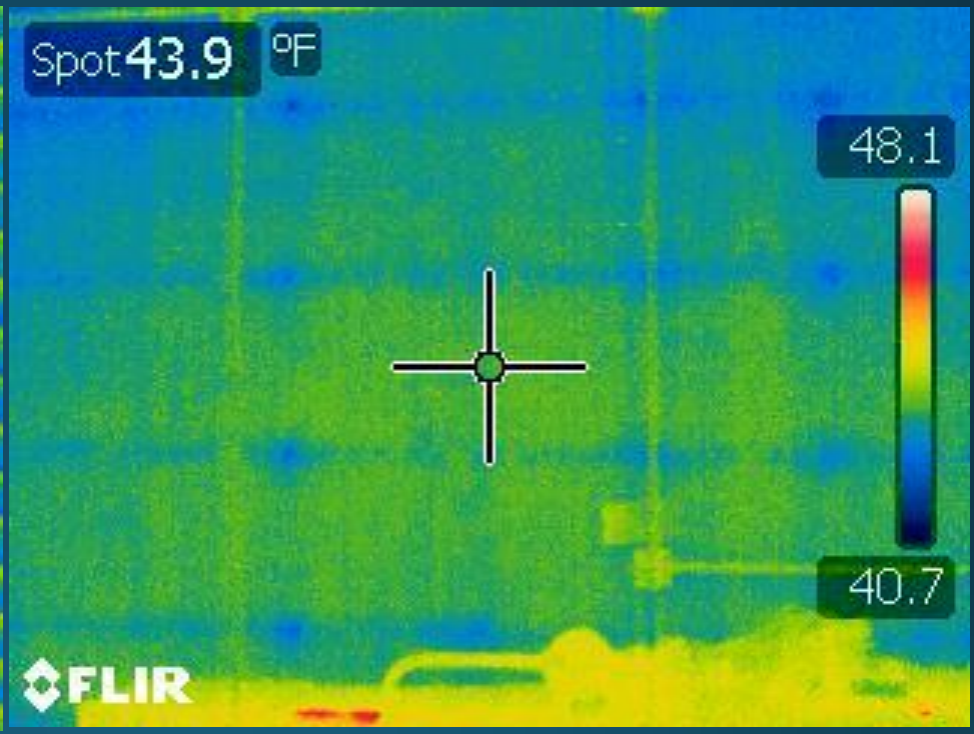
air leakage at top, conductive transfer at parting joints

North side IR images when very cold

Outside looking in



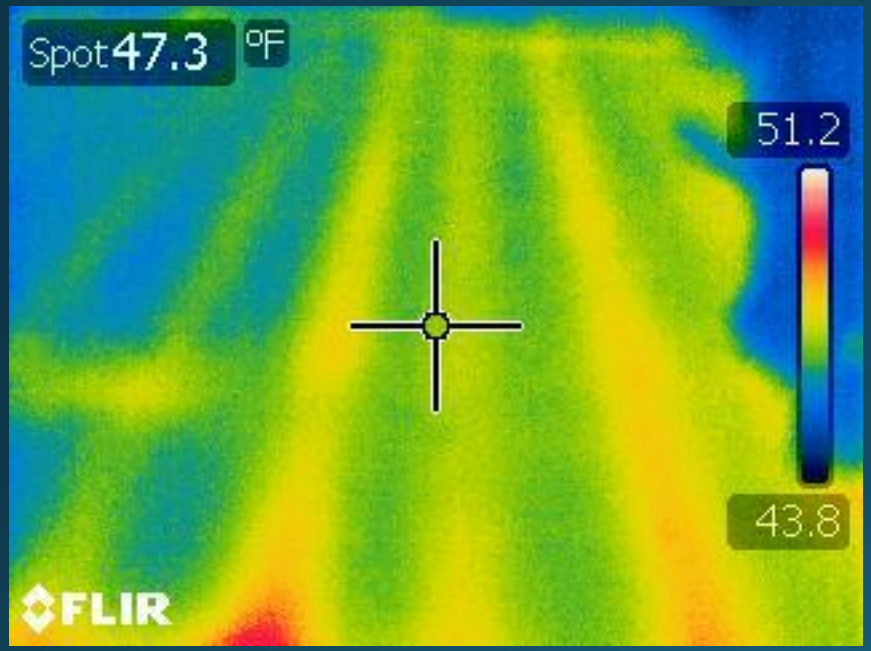
Inside looking out



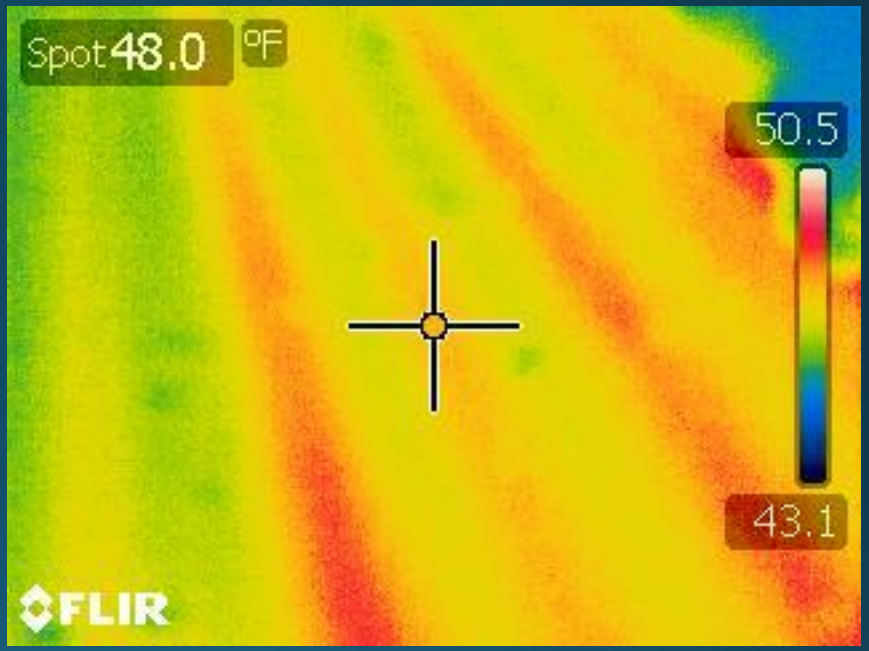
No air leakage, framing stud locations are observable

Floor IR images: 70 deg. supply water

Near garage doors



Near north wall



Mostly uniform floor heat distribution as planned

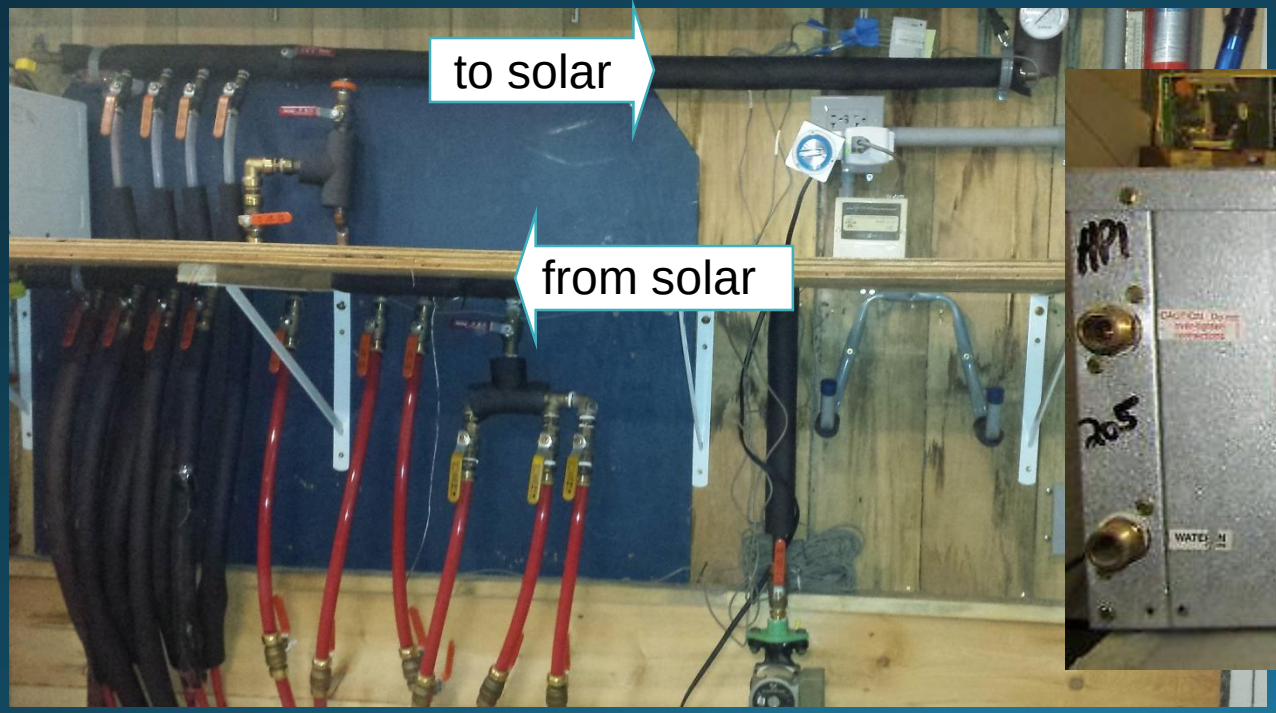
Current Systems

Solar:
124 sf ft. flat plate solar, 45 deg incline
Measured: (2 gpm, 10 deg. F rise @ 10 deg F ambient,15 deg. F rise at 30 deg. F ambient)

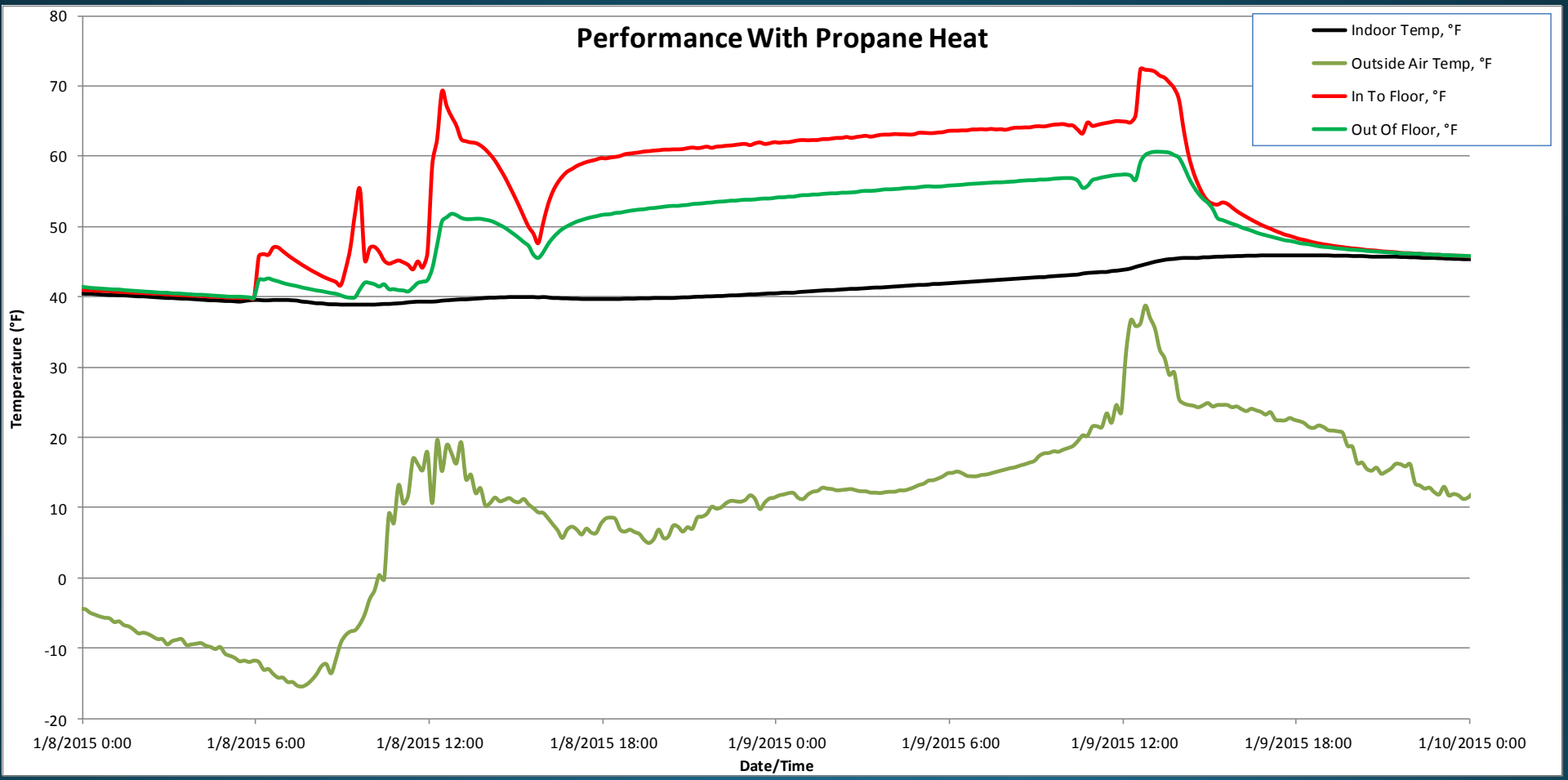
Solar tank and backup heat for radiant floor:
Recycled power vented hot water heating unit

Future System?:
Add 2 ton heat pump to geo/solar slinky manifold, or a 1.5 ton ductless mini-split?

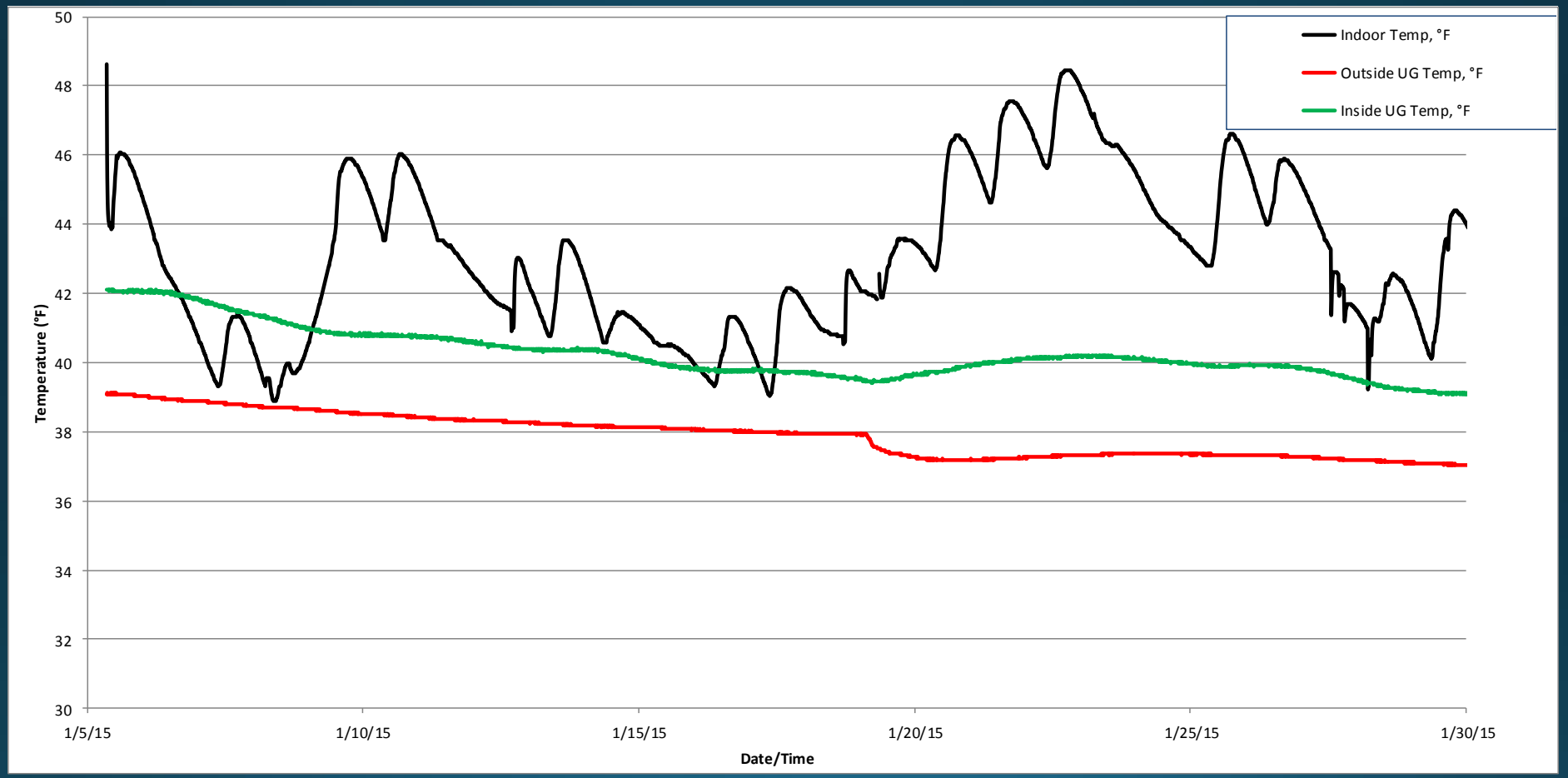
Current Plan: Data Log a year on solar only.



Adding Propane Heat to Floor

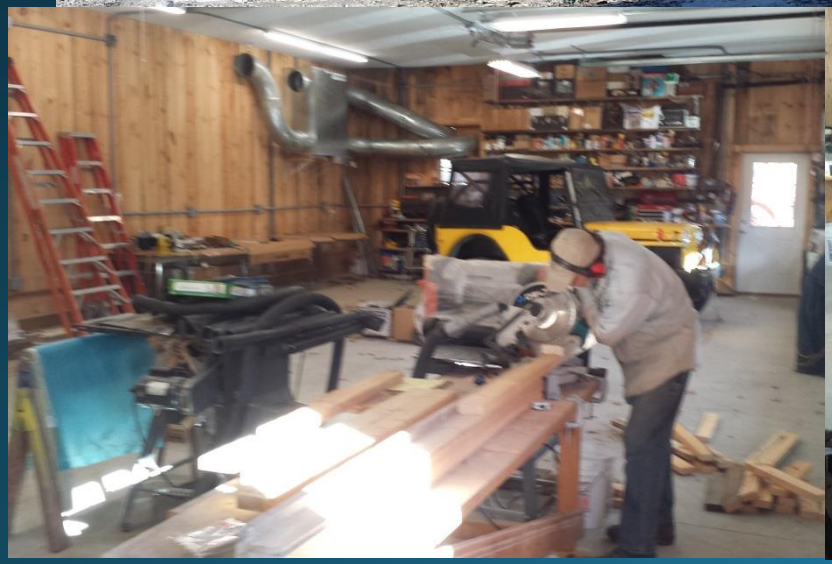


Underground Temperatures



Current Use: Workshop & Repairs,
Could be divided to Office and Garage Space

Cost: $87K
$71/SF
(Including site)



Summary

Building Thermal Envelope 7500DD

Frost wall R-value… *10+*
Floor Slab R-value… *15+*
Wood frame wall… *30+*
Ceiling… *60+*
Windows… *2 avg.*
Garage Doors Panels *22*
Garage Door Assembly *7*
1232 Ft^2 FFA

Total Energy Use:
?TBD kWhr/YR
(Net Zero Ready)

Solar Thermal 124 Ft^2
Solar PV 1.4 kW

Cost: $87K
$71/SF
(Including site work)

Ventilation Rate Capacities

ACH 50 = 1 ACH (250cfm 50)
Natural Predicted Annual < 0.1 ACH
Whole Building ERV max. 800 CFM, min. 50 CFM

Overall Design: Intended to meet or surpass typical Energy Star & Indoor Air Plus Specification and 0.025 CFM/SF surface air leakage criteria
Light Power Density = 0.40 watts/sf via High eff. T-8

High Performance Guideline

1000HomeChallenge.org “10 steps”

1. **Assess Needs, Site, Goals, *and Use of Space***
2. **Optimize Enclosure** (reduce heat and cooling load)
3. **Minimize Internal Loads** (lights, appliances…)
4. **Provide Fresh Air Ventilation / Manage Combustion**
5. **Control Humidity**
6. **Determine Cooling Needs**
7. **Integrate Hot Water with Other Loads**
8. **Determine Heating Needs**
9. **Integrate Renewables to Address Remaining Loads**
10. **Incorporate: Verification, Feedback, and Evaluation**

Getting to Net Positive an Approach

- ✓ Very High Performance Enclosure
- ✓ On Site Solar PV and Thermal
- ✓ Energy Recovery Ventilation
- ✓ LED Lighting ? (not yet)
- ✓ Minimize All Water Pumping Energy Use
  - Low Head Solar and HP Geo-exchange
- ✓ Planned ERV and Air Filtration
- ✓ Low Odor Finishes
- ✓ Carport mounting for Solar Thermal and Small PV (rake-able)
  - ✓ Roof reserved for large PV @ optimum year round angle

- ✓ Motivated Owner, Builder, and Occupants?

Will Post 2015 Temperatures

Questions?

Thank You:

- **Efficiency Vermont**
- **Crete Heat™**
- **Jeff Harrison, PE**

Future Data will be posted at:
rcmzeroenergy.com
ROSE construction

Thank You