Cold Climate 101

Thorsten Chlupp

ArcticSun LLC

Cold Climate Housing Research Center

CCHRC

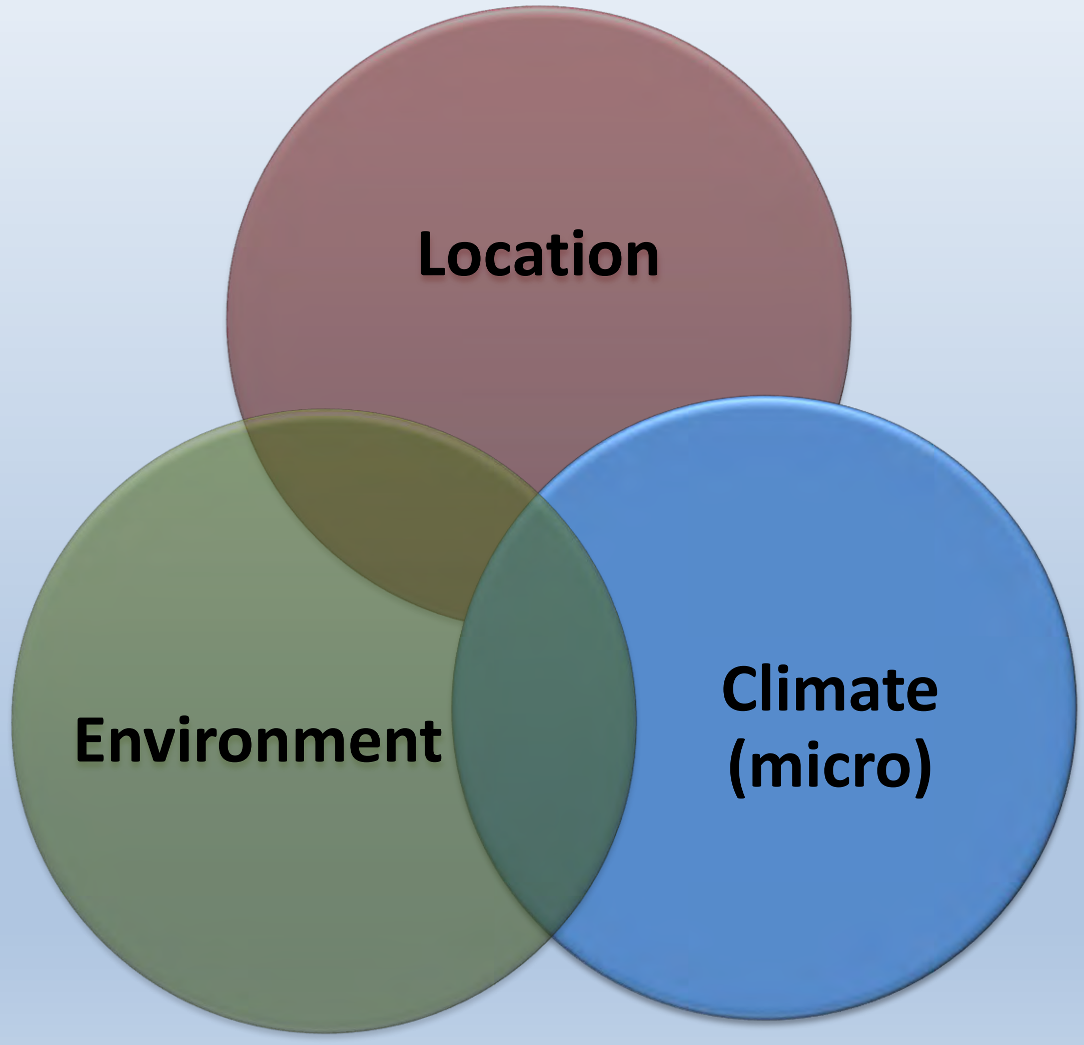
Efficiency Vermont

BBD

BETTER BUILDINGS BY DESIGN

Better Buildings by Design: Our first step to success...

3 Need to Knows:




Location Matters


Climate Matters

Environment Matters


Fred Meyer
-62°
Reality Check

3 Biggest Hurdles

Let's get help!

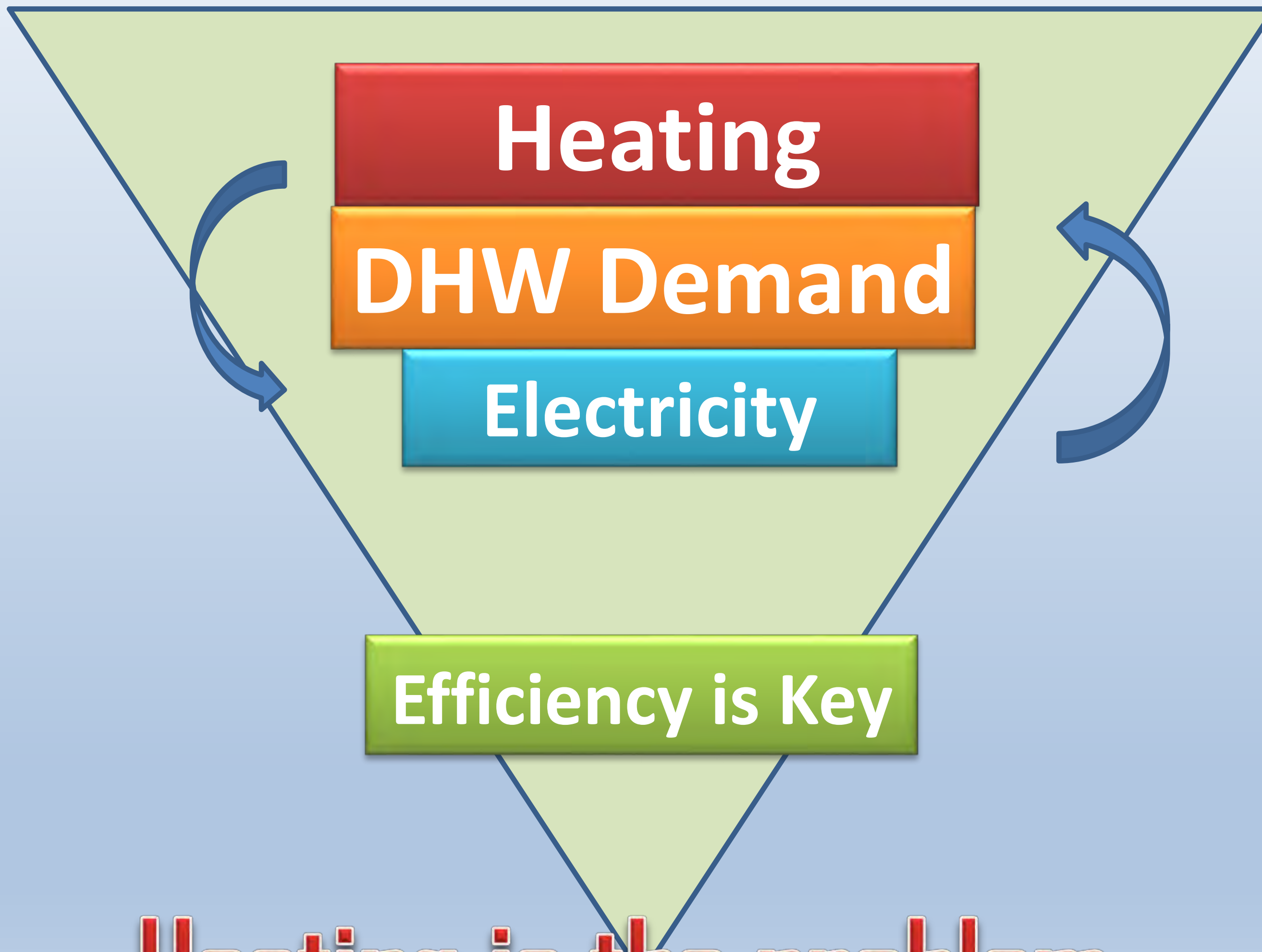

Back to the
Basics

The Keystones of an Energy efficient Building:

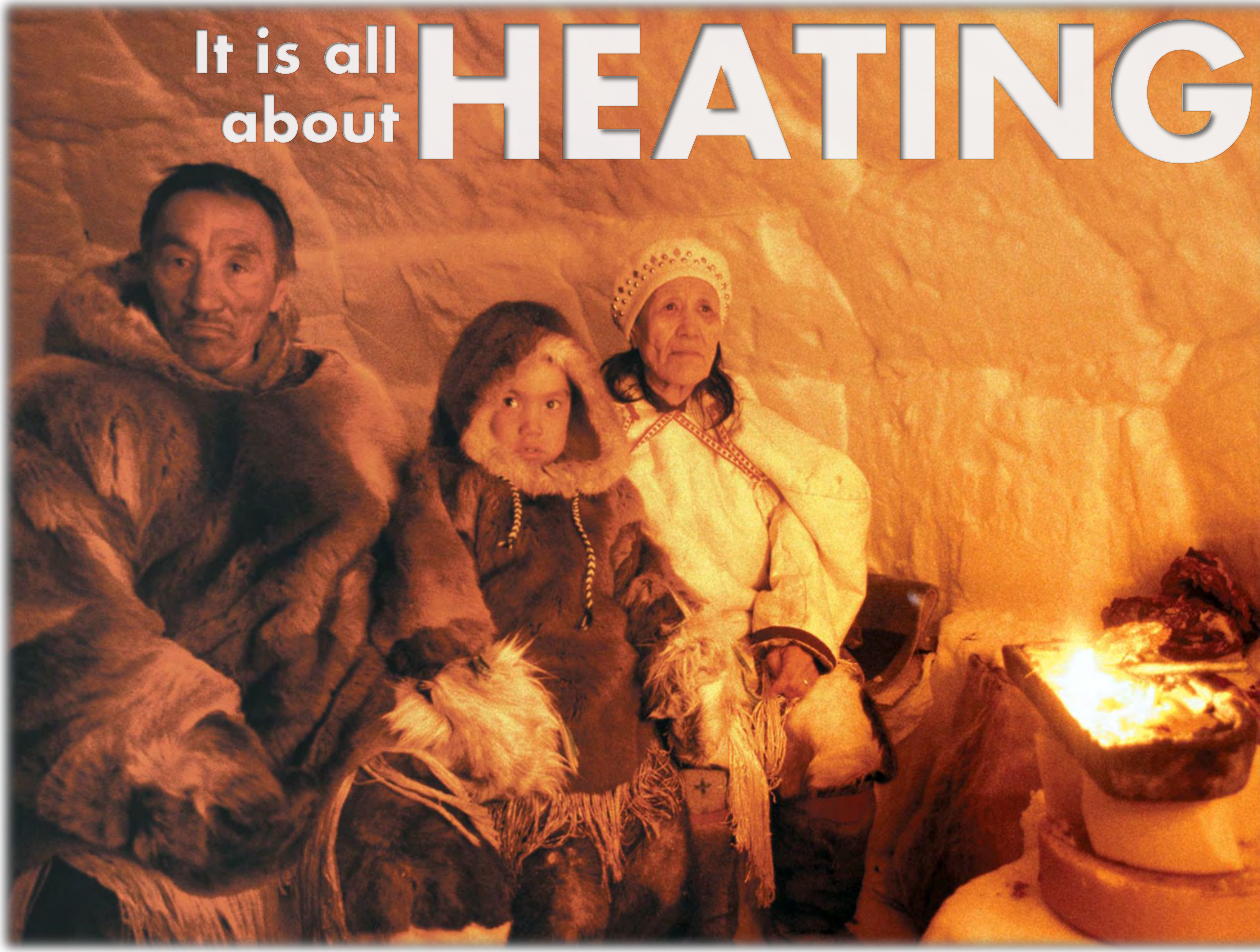
1. Moisture Control
2. Air-Tightness
3. Insulation

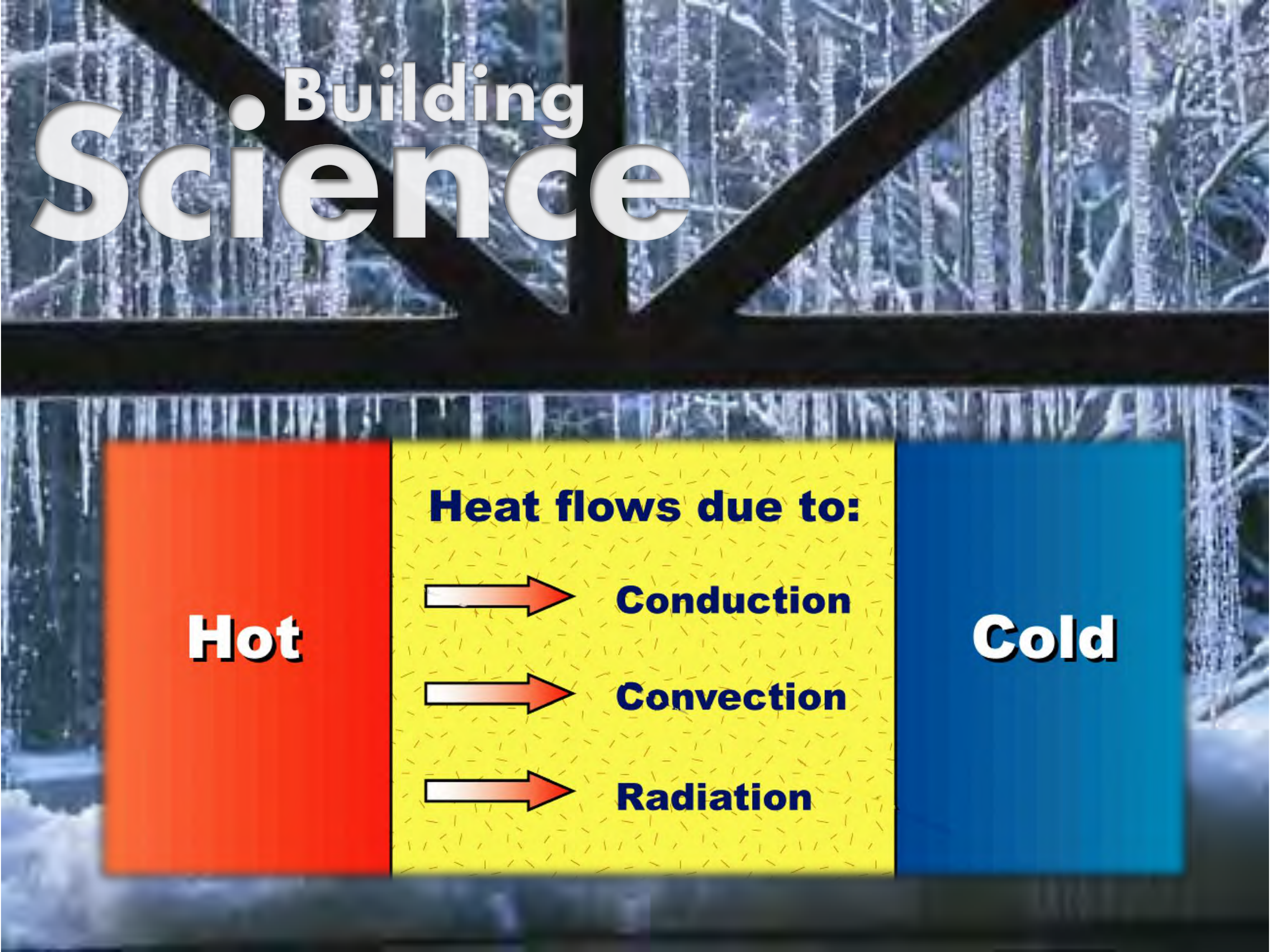
Insulation is Key.

Reducing the loads



Heating is the problem...


It is all about
HEATING

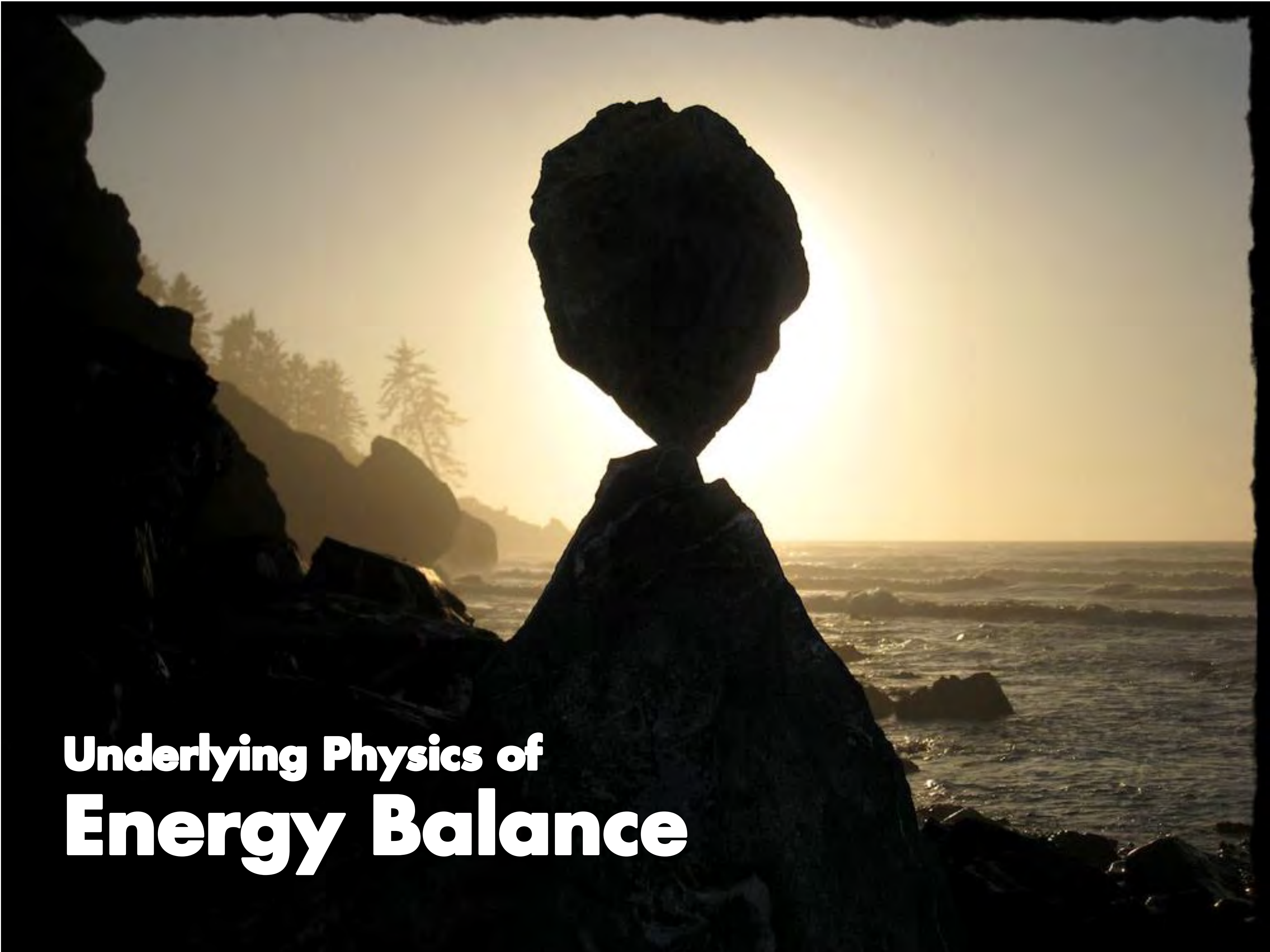

Building
Science
Heat flows due to:
Conduction
Convection
Radiation
Hot
Cold


GOOD DESIGN IS A TOUGH JOB.
VERLAG HERMANN SCHMIDT MAINZ

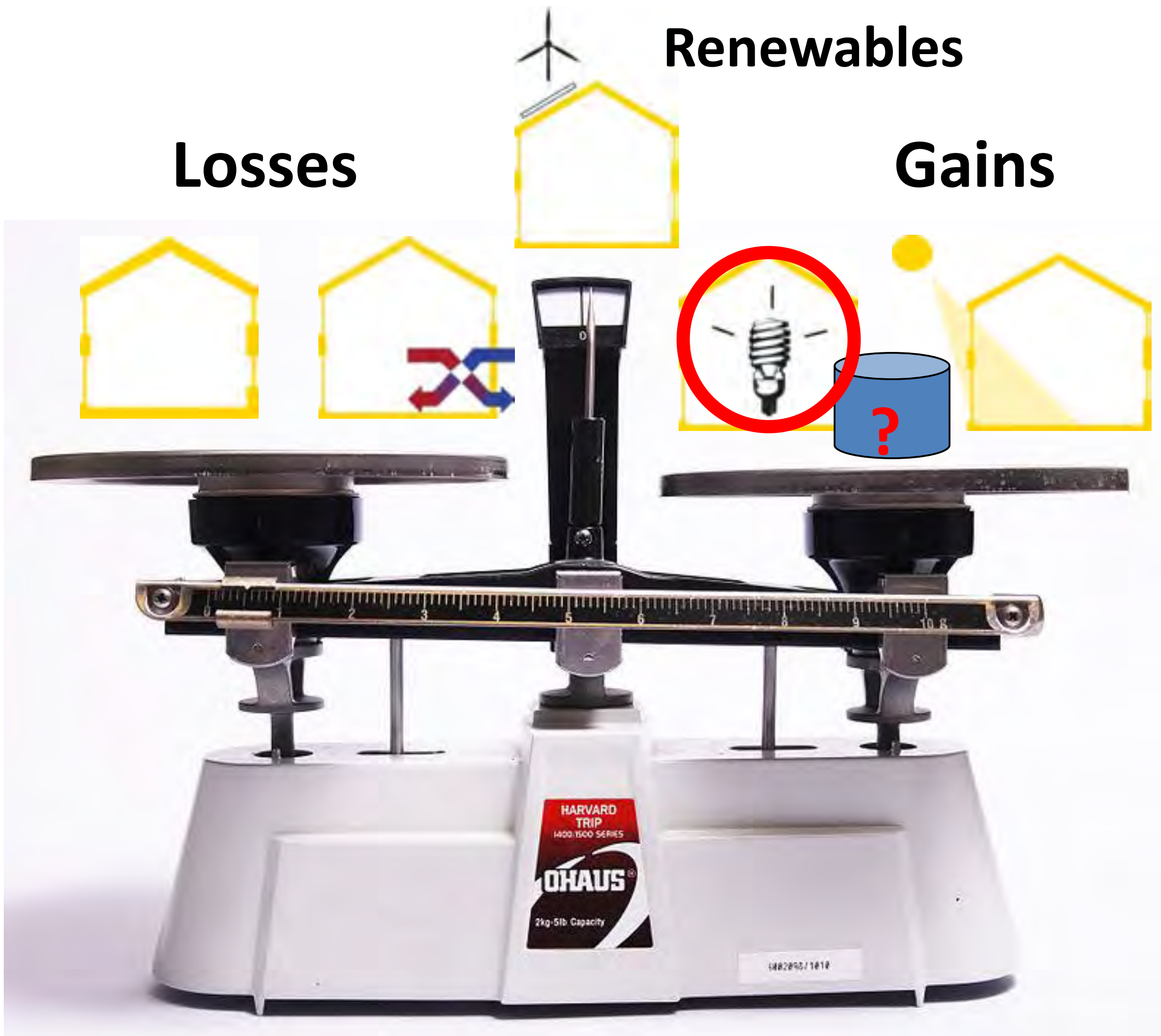

Design
Is not a linear
Process


Good Design is
Essential

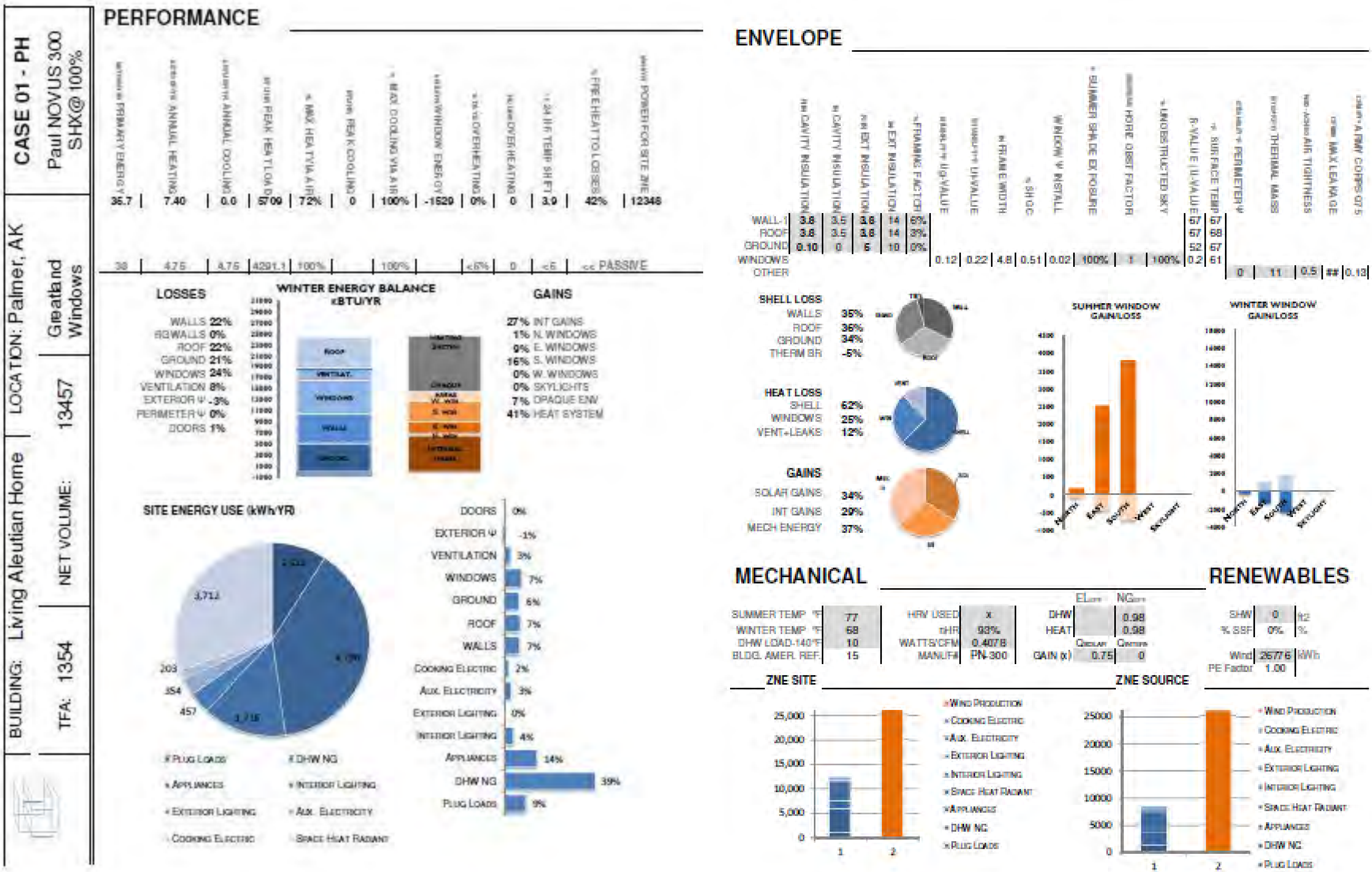

We can build
Good Buildings


Underlying Physics of
Energy Balance

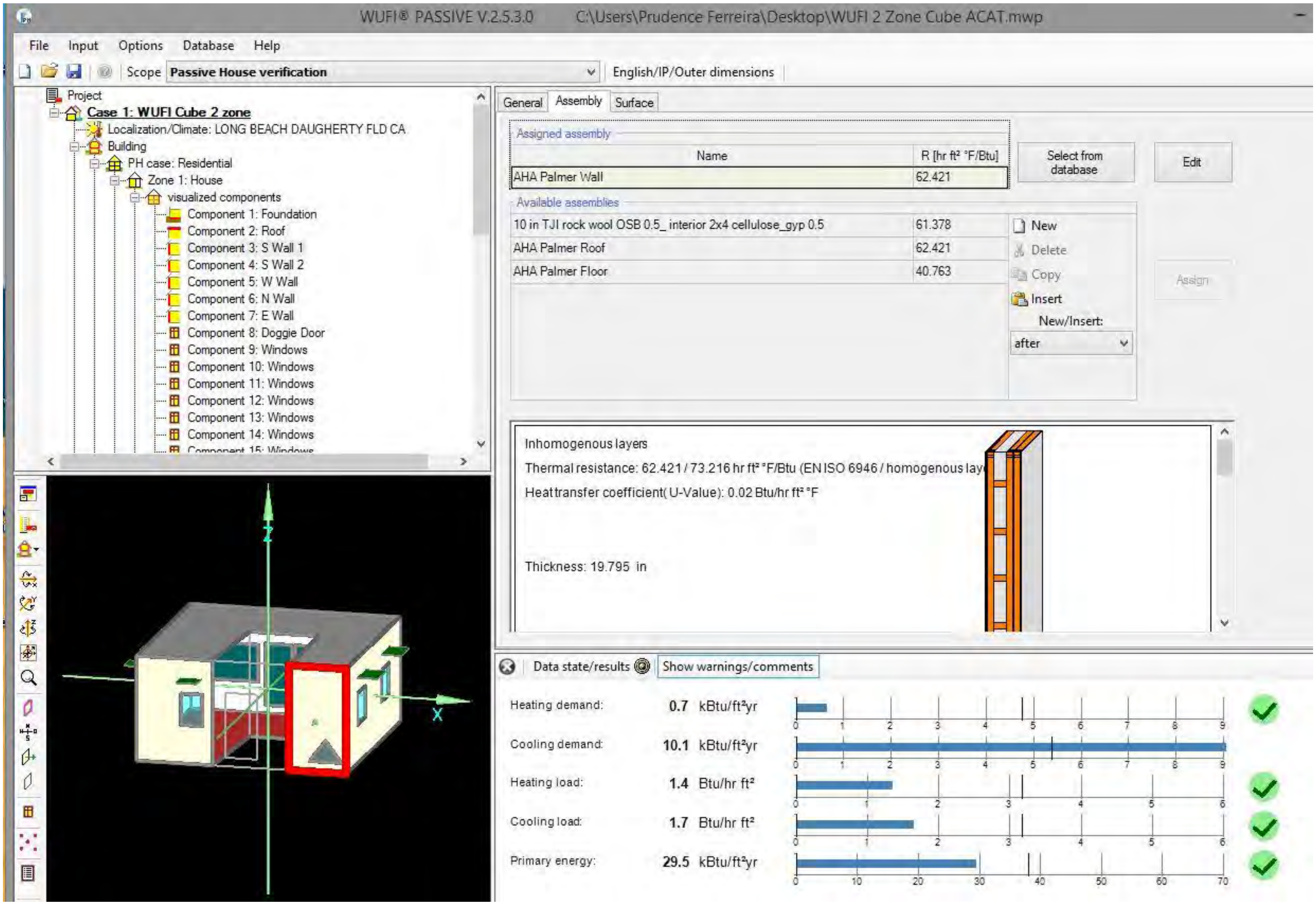
Balance Point



Essential Tools: PHPP



Essential Tools: WUFI Passive



Essential Tools

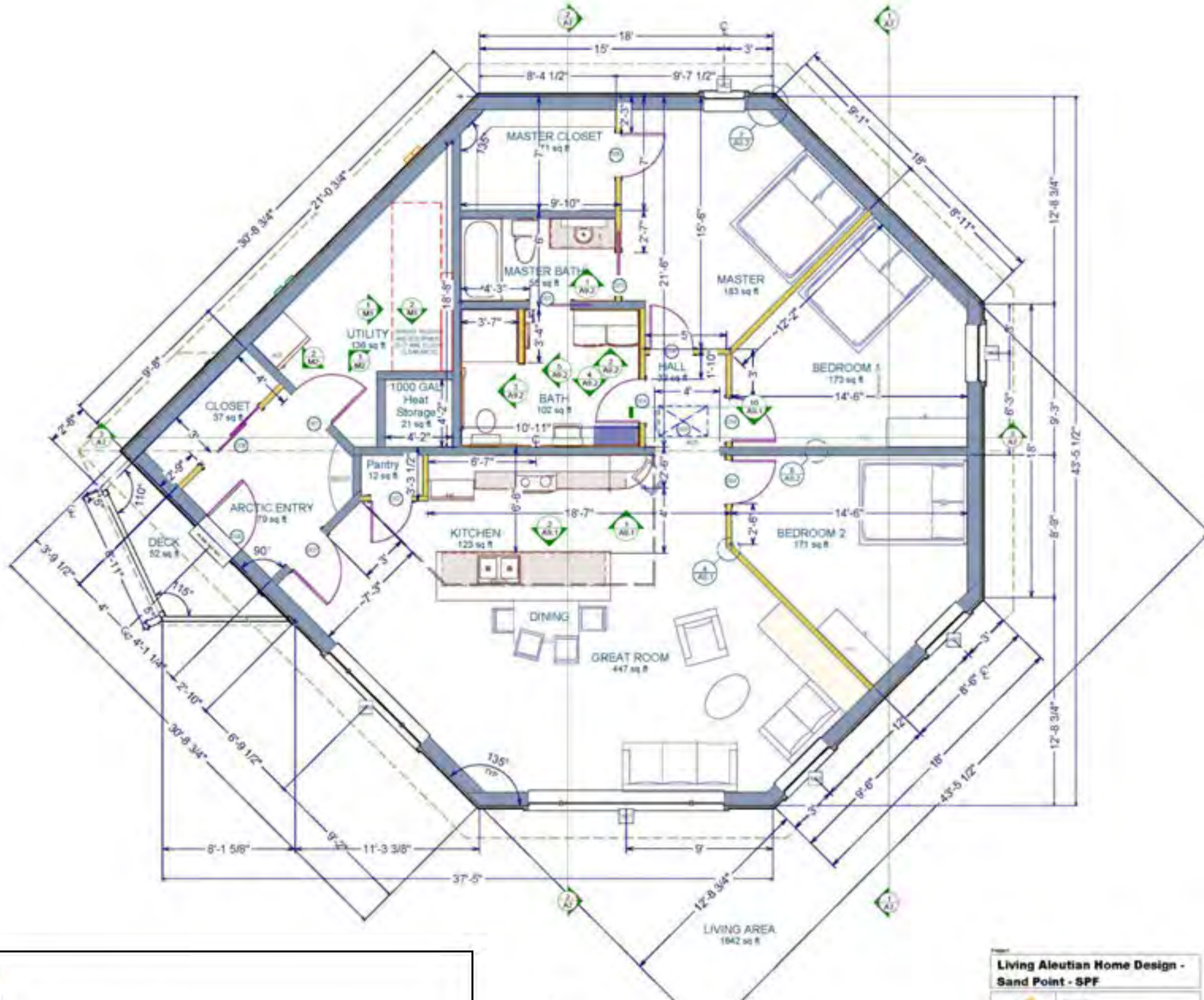
IR Camera

Moisture Meter

Indoor Air Quality Monitor

Anemometer


Sand Point – Exterior Rendition



FLOOR PLAN

TOTAL AREA OF PLAN

- Main Floor 1645 SQ.FT.
- PH Treated Floor Area 1453 SQ. FT.
- Total Conditioned Space 1680 SQ. FT.

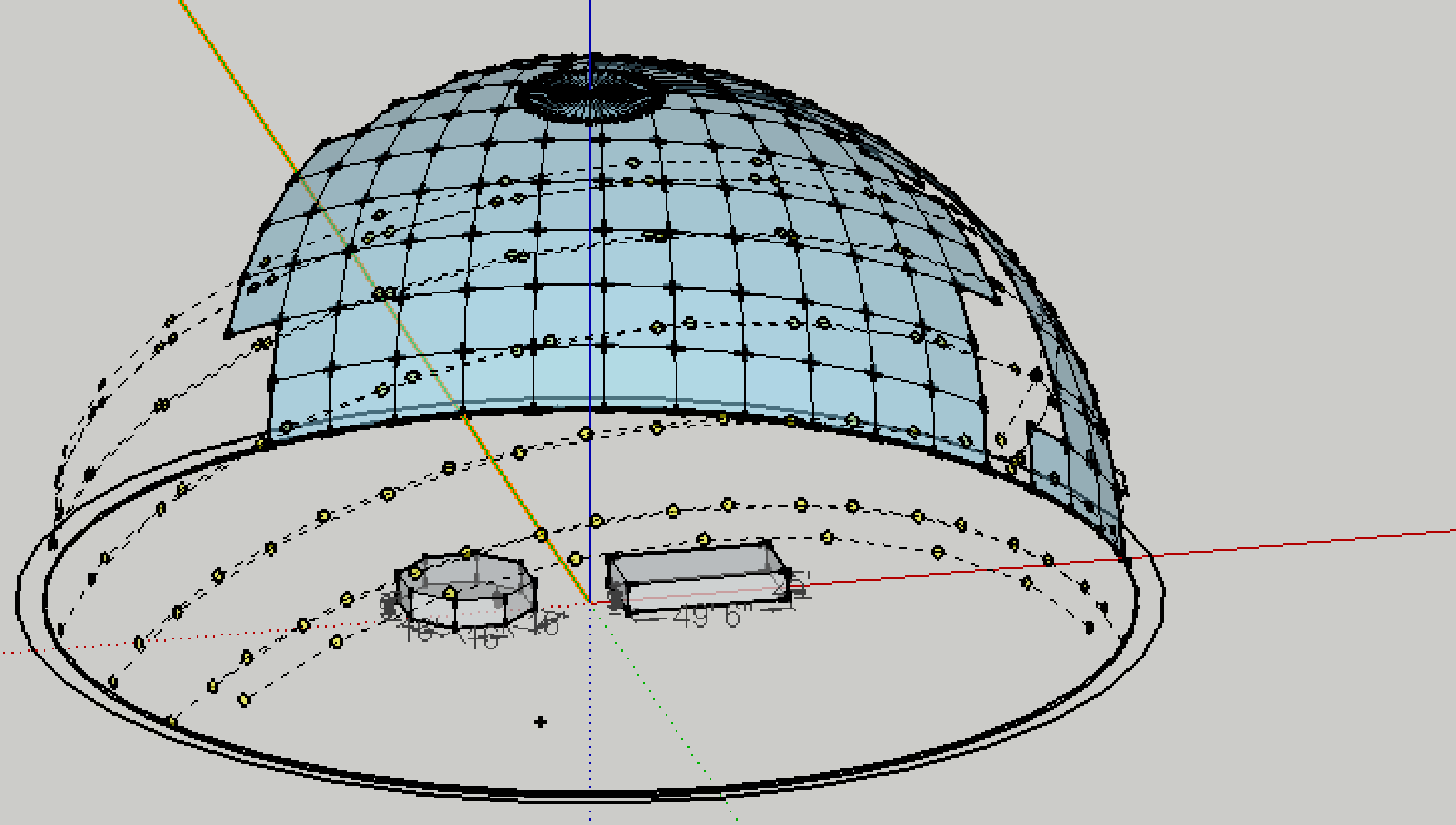
Living Aleutian Home Design - Sand Point - SPF

REINA

Scale: 1/4" = 1'-0"

Date: 07/14/2013

A1



Octagonal Structure: Approx. 1237 Sq. Ft.

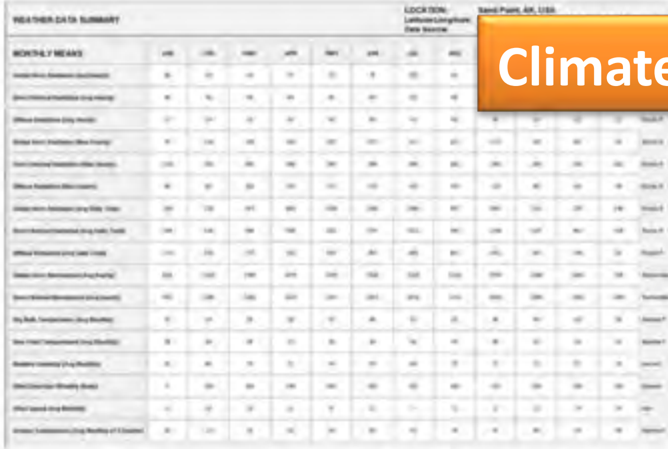
Perimeter Length: 128 Ft.
Exterior Wall Surface Area: 1152 Sq. Ft.

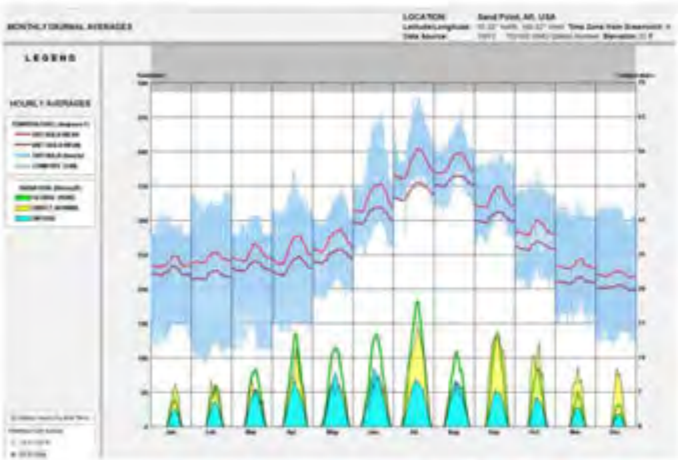
Rectangular Structure: Approx. 1237 Sq. Ft.

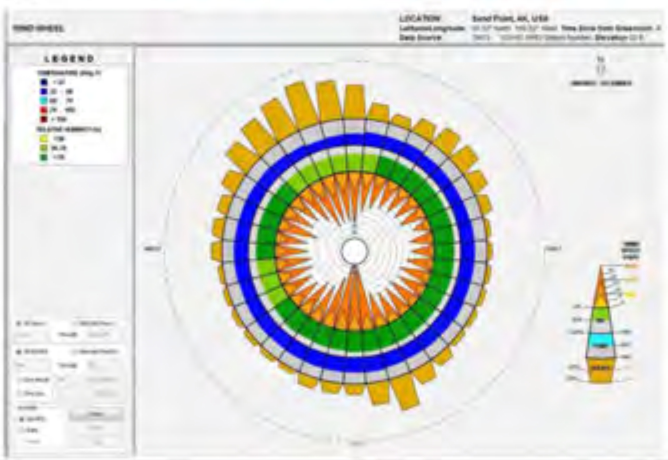
Perimeter Length: 149 Ft.
Exterior Wall Surface Area: 1341 Sq. Ft.

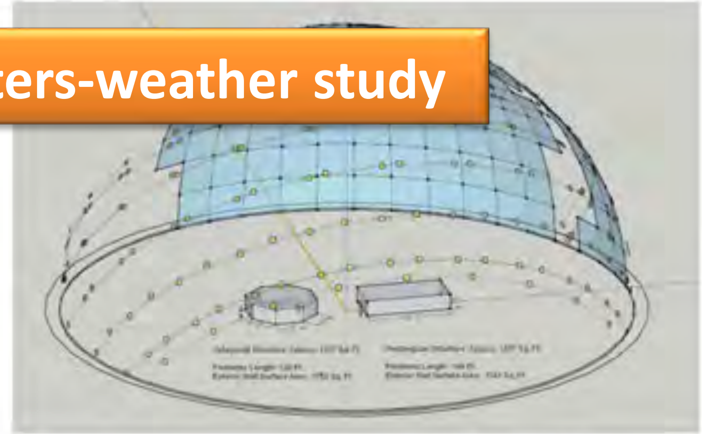
Efficiency by shape

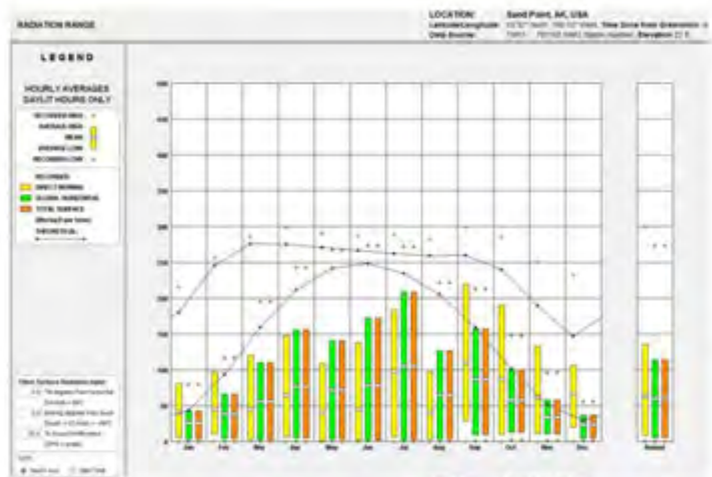
Climate Matters-weather study

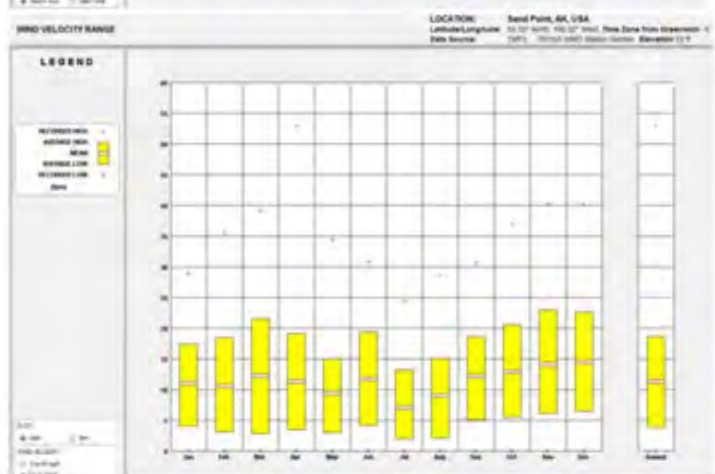












Living Aleutian Home Design
Sand Point - Option A

REINA

Scale: 1/4" = 1'-0"

Date: 08/13/12

A7

Heating Degree Days – don't be fooled…

Climate, location, Insolation and Precipitation

Sandpoint, AK 6946 HDD | 34.9 PE kBTU/SF/YR | 8.45 AH kBTU/SF/YR | 4103 Peak BTU/HR | 13483 ZNE kWH/YR

CASE 10 - CCSF | Wind Only - 1000 gal Storage+ Instant HW | INT AK

PERFORMANCE

kBTU/SF/YR PRIMARY ENERGY	kBTU/SF/YR ANNUAL HEATING	kBTU/SF/YR ANNUAL COOLING	BTU/HR PEAK HEAT LOAD	% MAX HEAT VIA AIR	BTU/HR/FT2 PEAK HEAT LOAD	BTU/HR /FT2 PEAK COOLING LOAD	kBTU/YR WINDOW ENERGY	% DAYS OVERHEATING	HOURS OVERHEATING	°F 24 HR TEMP SHIFT	% FREE HEAT TO LOSSES	kWH/YR POWER FOR SITE ZNE
34.9	8.45	0.0	4103	117%	2.67	0.00	-1378	0%	0	2.7	42%	13483

ENVELOPE

	R/IN CAVITY INSULATION	IN CAVITY INSULATION	R/IN EXT INSULATION	IN EXT INSULATION	% FRAMING FACTOR	BTU/HR.FT²°F Ug-VALUE	BTU/HR.FT²°F Uf-VALUE	IN FRAME WIDTH	% SHGC	WINDOW Ψ INSTALL	% SUMMER SHADE EXPOSURE	DEGREES HORIZ OBST FACTOR	% UNOBSTRUCTED SKY	R-VALUE | U-VALUE	°F SURFACE TEMP	BTU/HR.FT°F PERIMETER Ψ	BTU/°F.FT² THERMAL MASS	N50 - ACH50 AIR TIGHTNESS	CFM50 MAX LEAKAGE	CFM/FT² ARMY CORPS Q75
WALL-1	7.40	9	7.40	0	6%									55	67					
ROOF	7.40	9	7.40	0	6%									57	67					
GROUND	7.40	8			3%									56	67					
WINDOWS						0.12	0.22	4.8	0.51	0.02	100%	1	100%	0.2	61					
OTHER																0	11	0.5	63	0.05

Chicago, IL 6460 HDD | 28.8 PE kBTU/SF/YR | 5.05 AH kBTU/SF/YR | 5991 Peak BTU/HR | 11663 ZNE kWH/YR

CASE 10 - CCSF | Wind Only - 1000 gal Storage+ Instant HW | L*

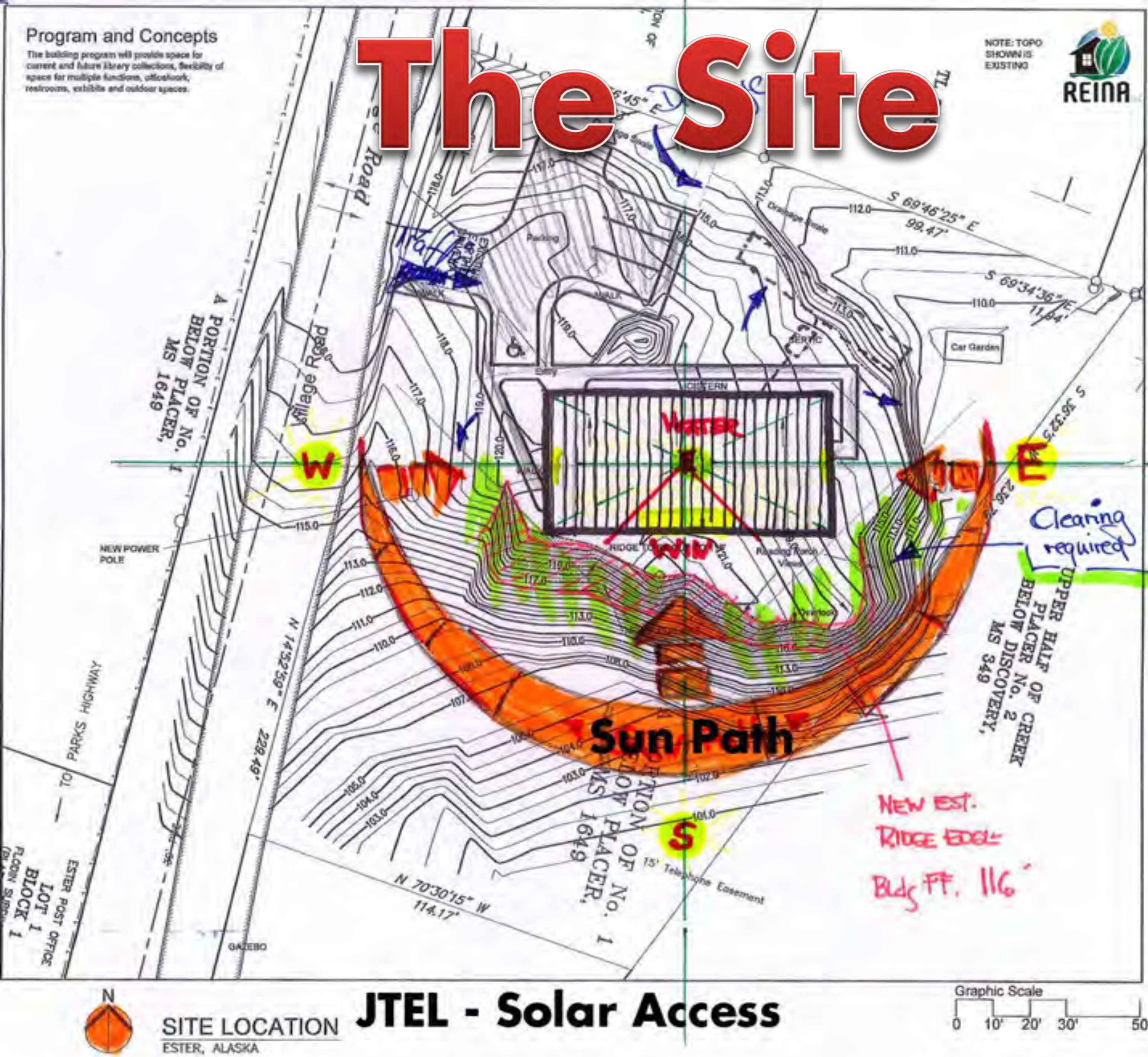
PERFORMANCE

kBTU/SF/YR PRIMARY ENERGY	kBTU/SF/YR ANNUAL HEATING	kBTU/SF/YR ANNUAL COOLING	BTU/HR PEAK HEAT LOAD	% MAX HEAT VIA AIR	BTU/HR/FT2 PEAK HEAT LOAD	BTU/HR /FT2 PEAK COOLING LOAD	kBTU/YR WINDOW ENERGY	% DAYS OVERHEATING	HOURS OVERHEATING	°F 24 HR TEMP SHIFT	% FREE HEAT TO LOSSES	kWH/YR POWER FOR SITE ZNE
28.8	5.05	1.5	5991	81%	3.90	3.43	899	15%	1306	3.4	56%	11663

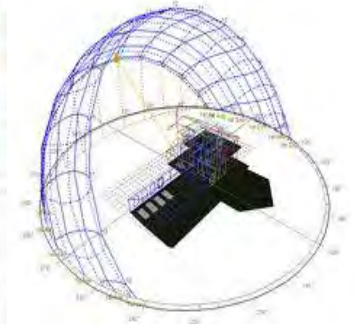
ENVELOPE

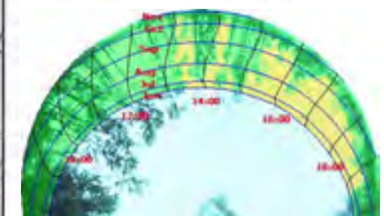
	R/IN CAVITY INSULATION	IN CAVITY INSULATION	R/IN EXT INSULATION	IN EXT INSULATION	% FRAMING FACTOR	BTU/HR.FT²°F Ug-VALUE	BTU/HR.FT²°F Uf-VALUE	IN FRAME WIDTH	% SHGC	WINDOW Ψ INSTALL	% SUMMER SHADE EXPOSURE	DEGREES HORIZ OBST FACTOR	% UNOBSTRUCTED SKY	R-VALUE | U-VALUE	°F SURFACE TEMP	BTU/HR.FT°F PERIMETER Ψ	BTU/°F.FT² THERMAL MASS	N50 - ACH50 AIR TIGHTNESS	CFM50 MAX LEAKAGE	CFM/FT² ARMY CORPS Q75
WALL-1	7.40	9	7.40	0	6%									55	67					
ROOF	7.40	9	7.40	0	6%									57	67					
GROUND	7.40	8			3%									56	67					
WINDOWS						0.12	0.22	4.8	0.51	0.02	100%	1	100%	0.2	61					
OTHER																0	11	0.5	63	0.05

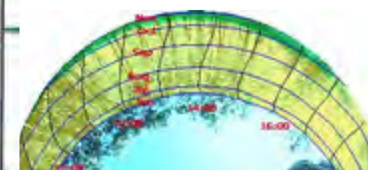
The Site



JTEL - Solar Access

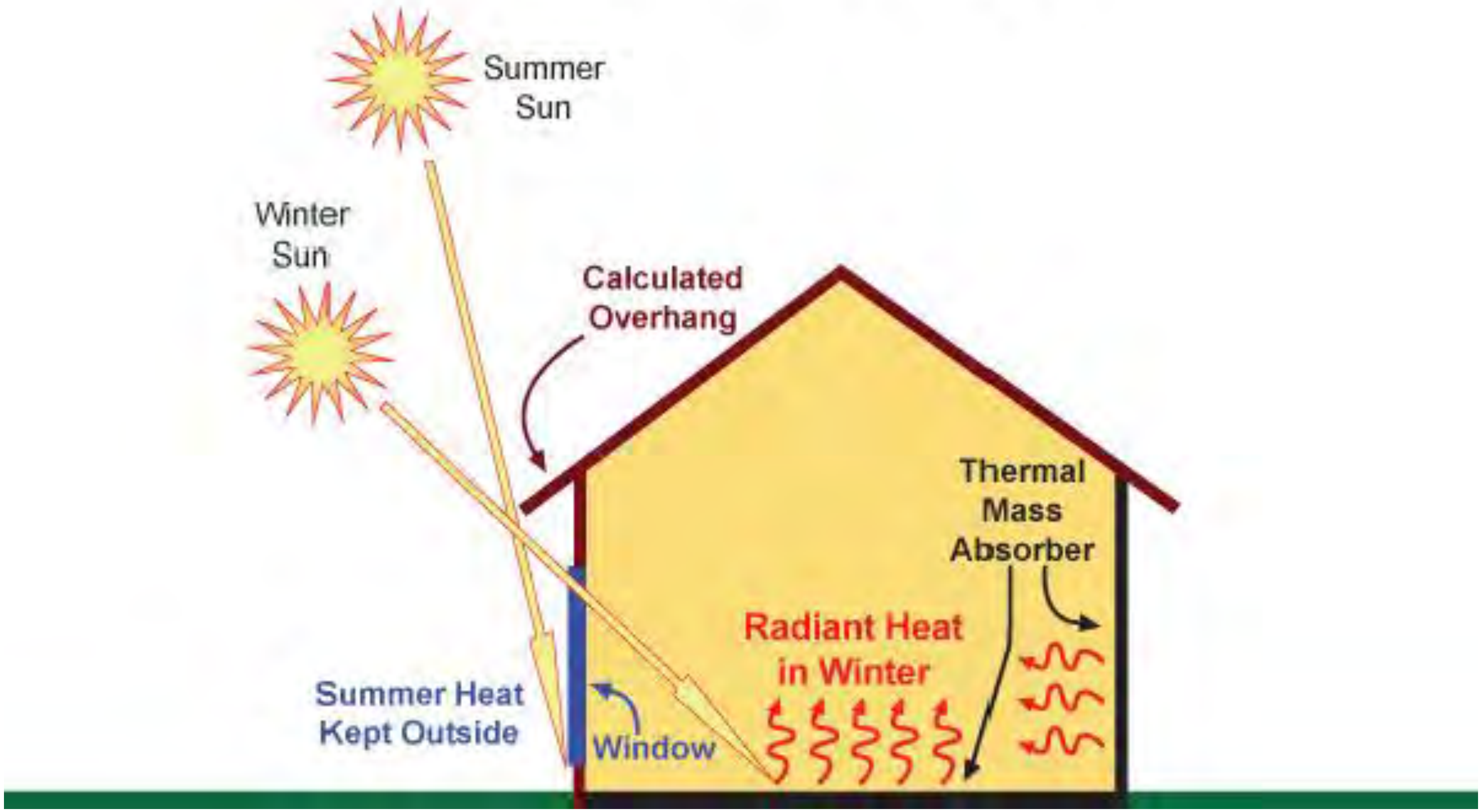




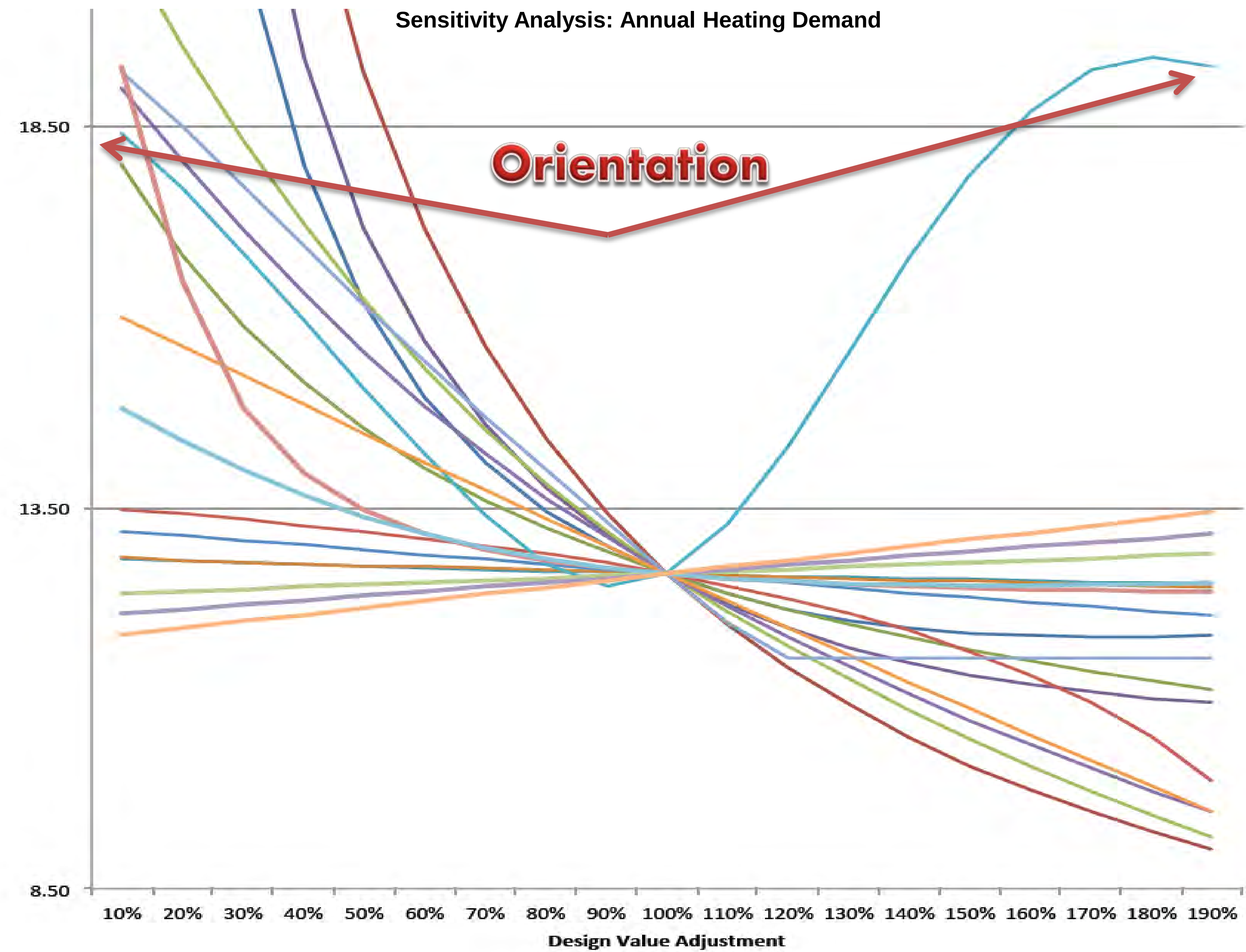



Orientation

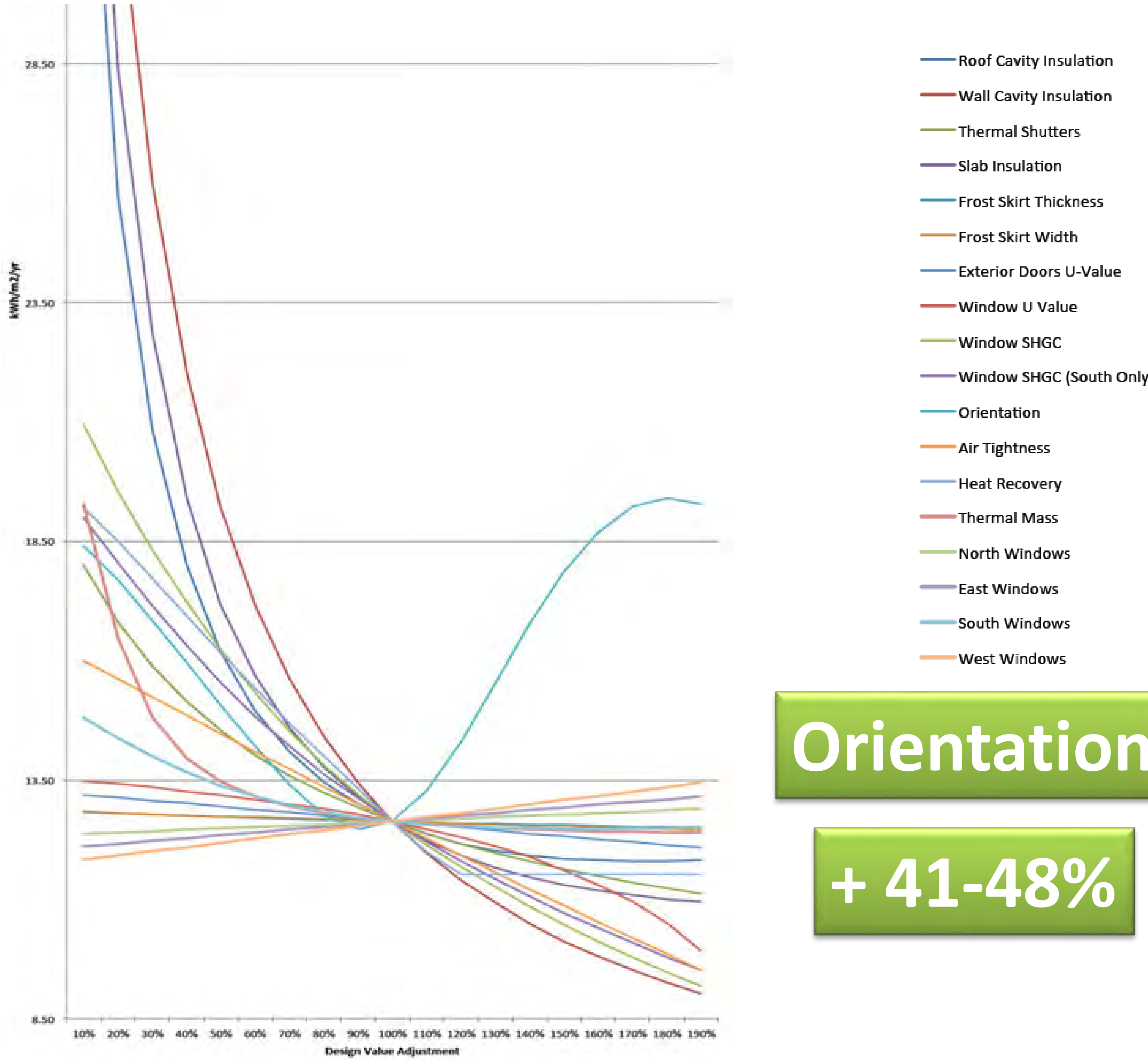
Passive Solar Design



No Moving Parts – No Maintenance – Free Fuel



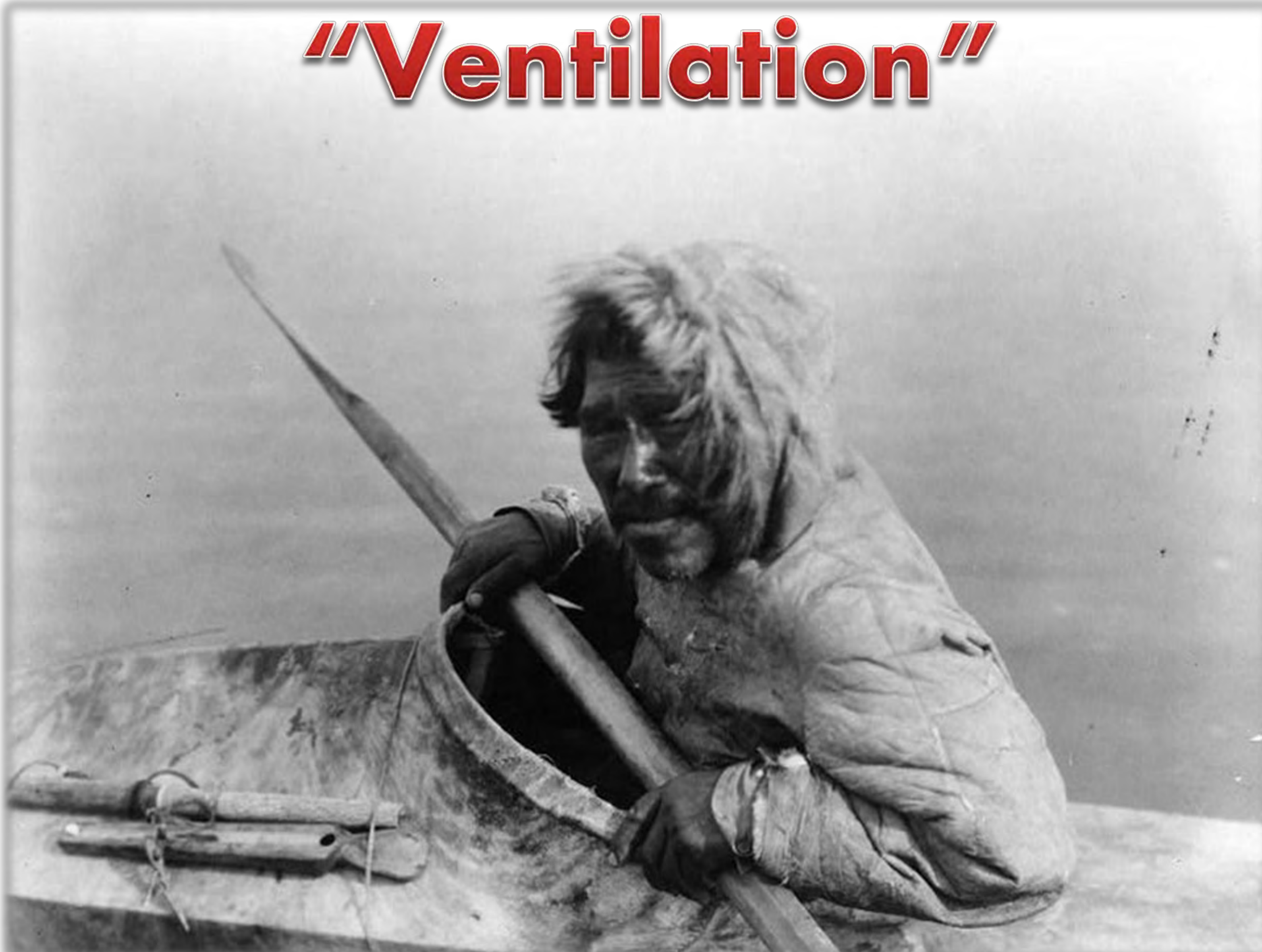
Sensitivity Analysis: Annual Heating Demand
Orientation
18.50
13.50
8.50
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
110%
120%
130%
140%
150%
160%
170%
180%
190%
Design Value Adjustment

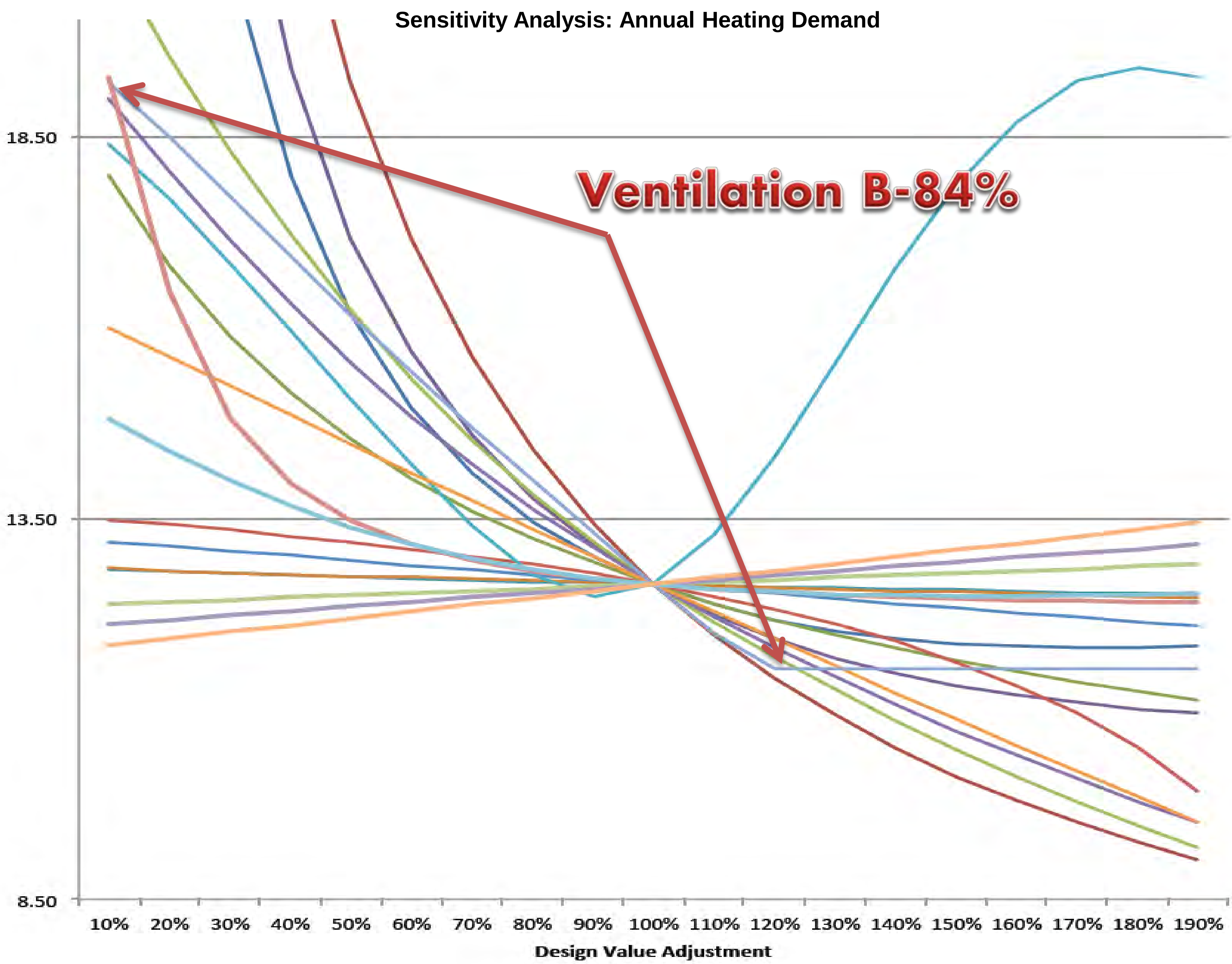


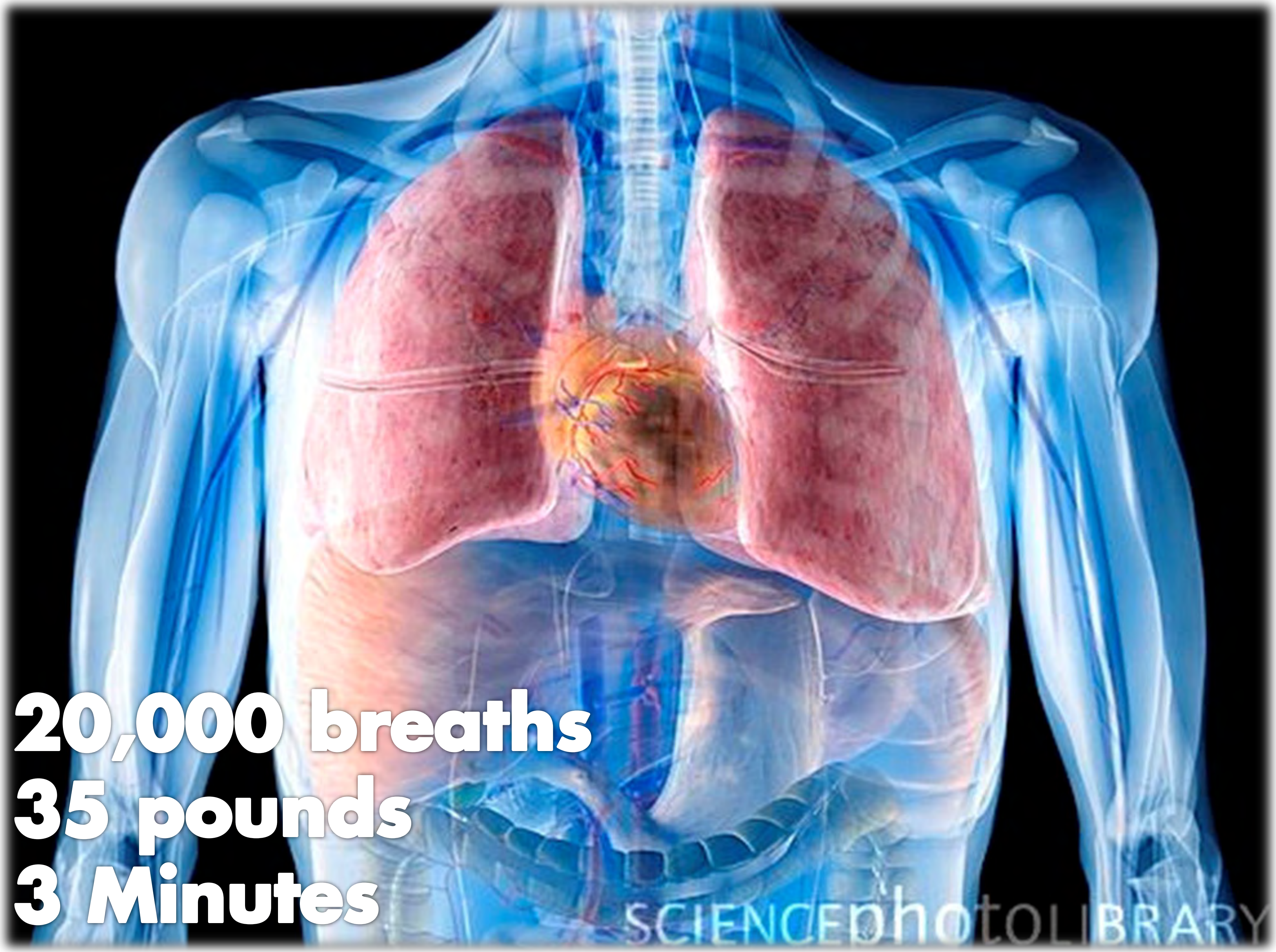
Orientation

+ 41-48%

"Ventilation"




Sensitivity Analysis: Annual Heating Demand
Ventilation B-84%
18.50
13.50
8.50
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
110%
120%
130%
140%
150%
160%
170%
180%
190%
Design Value Adjustment

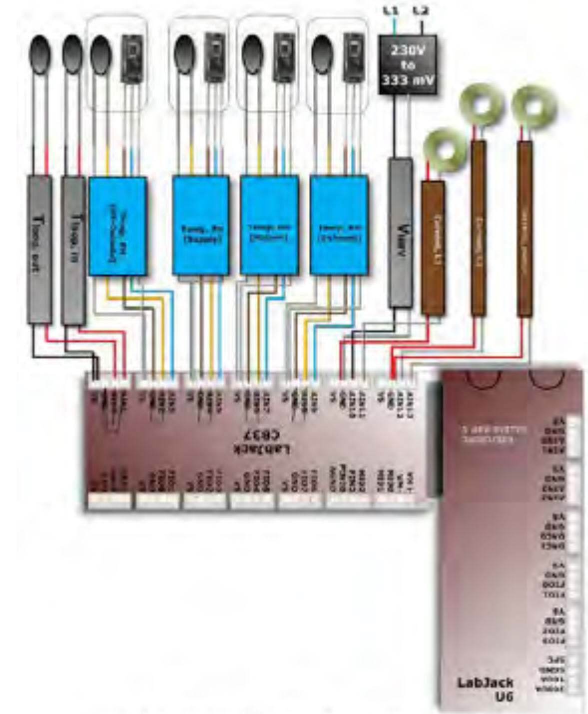

20,000 breaths
35 pounds
3 Minutes
SCIENCEPHOTOLIBRARY

Zehnder ComfoAir 350 @84% + ComfoFond

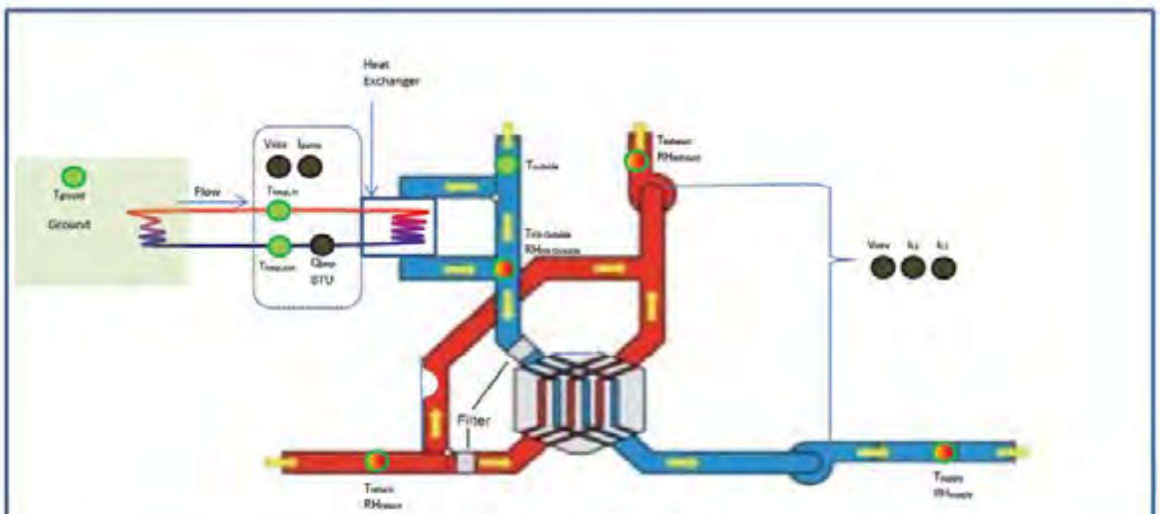
400 FT Ground loop

Heat exchanger @ 12 foot depth

HRV maintained 2-3°F differential Supply/Return @ -49°F



Labjack Wiring Configuration Diagram
BCG 9-21-11



HRV Sensor Locations

Highly efficient HRV

High efficient Heat Recovery is Expensive

Ventilation comparison Zehnder NOVUS 300 to Exhaust only

Method	Primary Energy	Peak Heat Load	Annual Heating	Annual Heating	Annual Heating	Heating costs	Heating costs
	KBTU/SF/YR	BTU/HR	KBTU/SF/YR	KBTU/YR	Fuel Oil 85%	No. 2 oil	Total
HRV Zehnder NOVUS 300	34.9	4103	8.45	12988	124	$ 5.10	$ 630.83
Exhaust Only	51.1	7264	19.07	29311	279	$ 5.10	$ 1,423.66
Difference	16.2	3161	10.62	16323	155		$ 792.83
	32%	44%	56%	56%	56%		56%

Cost Comparison and Payback period

Method	Material Costs	Labor Costs	TOTAL	Heating costs	Years to Pay at	Life Cycle	Life Cycle
					todays fuel costs	Net present Value	Net present Value
HRV Zehnder NOVUS 300	$ 8,447.00	$ 2,080.00	$ 10,527.00	$ 630.83	Simple Payback	Fixed utilities	w/utilities increase
Exhaust Only	$ 760.00	$ 325.00	$ 1,085.00	$ 1,423.66			
Difference	$ (7,687.00)	$ (1,755.00)	$ (9,442.00)	$ 792.83	**12**	**$ 2,832.85**	**$ 6,014.37**

Ventilation comparison VENMAR to Exhaust only

Method	Primary Energy	Peak Heat Load	Annual Heating	Annual Heating	Annual Heating	Heating costs	Heating costs
	KBTU/SF/YR	BTU/HR	KBTU/SF/YR	KBTU/YR	Fuel Oil 85%	No. 2 oil	Total
HRV Venmar Eko 1.5	38.6	5005	11.15	17138	163	$ 5.10	$ 832.40
Exhaust Only	51.1	7264	19.07	29311	279	$ 5.10	$ 1,423.66
Difference	12.5	2259	7.92	12173	116		$ 591.26
	24%	31%	42%	42%	42%		42%

Cost Comparison and Payback period

Method	Material Costs	Labor Costs	TOTAL	Heating costs	Years to Pay at	Life Cycle	Life Cycle
					todays fuel costs	Net present Value	Net present Value
HRV Venmar Eko 1.5	$ 3,000.00	$ 2,080.00	$ 5,080.00	$ 832.40	Simple Payback	Fixed utilities	w/utilities increase
Exhaust Only	$ 760.00	$ 325.00	$ 1,085.00	$ 1,423.66			
Difference	$ (2,240.00)	$ (1,755.00)	$ (3,995.00)	$ 591.26	**7**	**$ 5,153.41**	**$ 7,539.54**

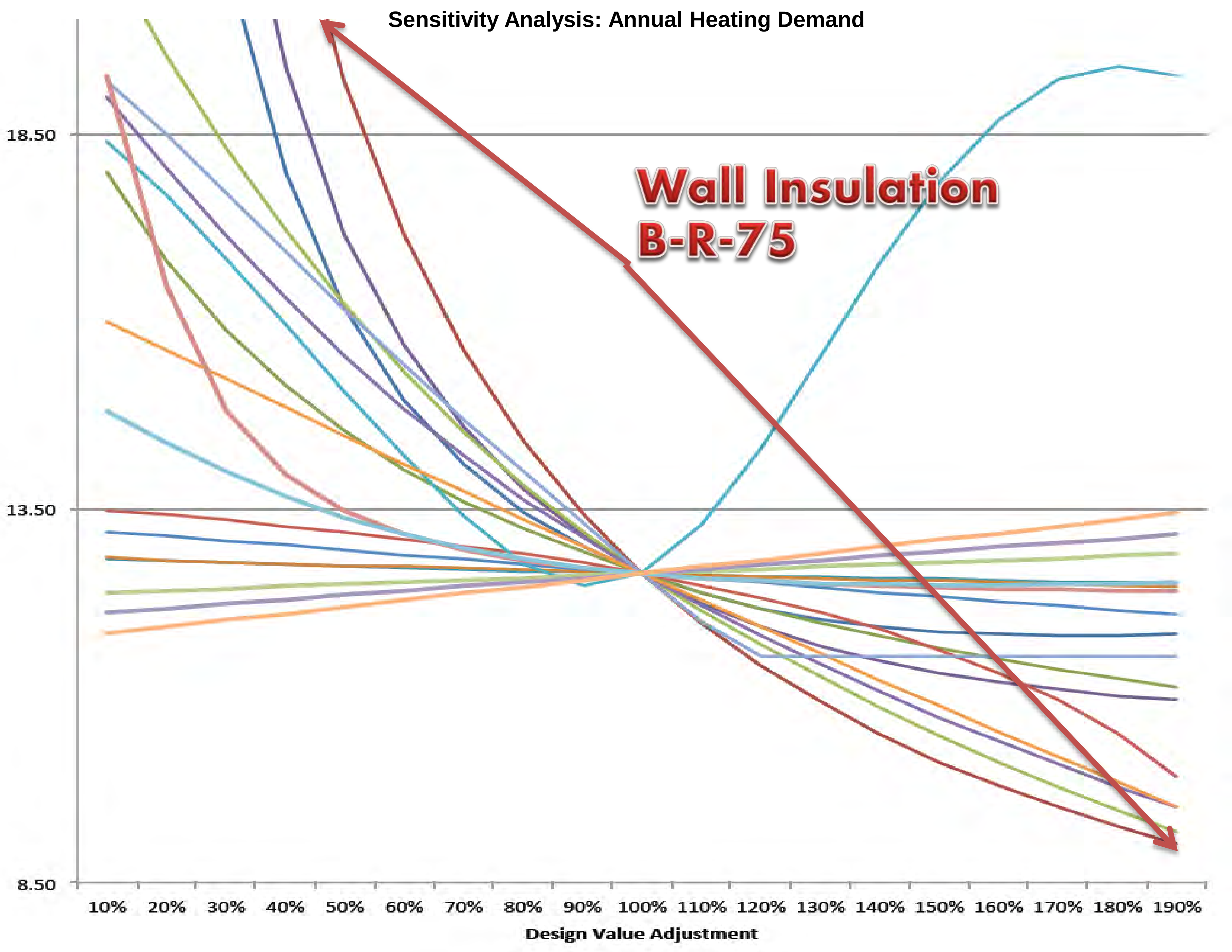
Ground Loop Heat Exchanger

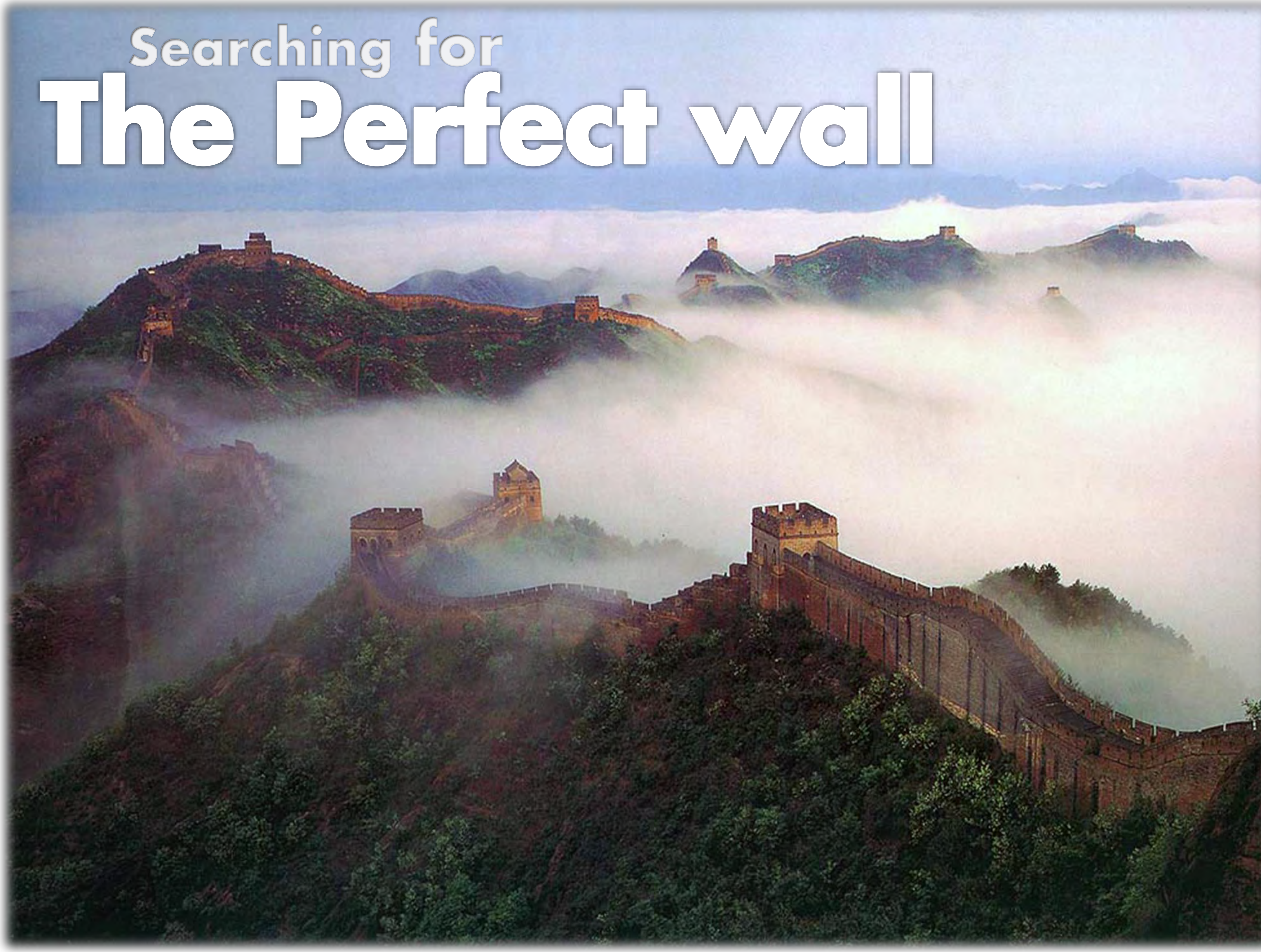
Ground Loop Heat Exchanger


Clinside

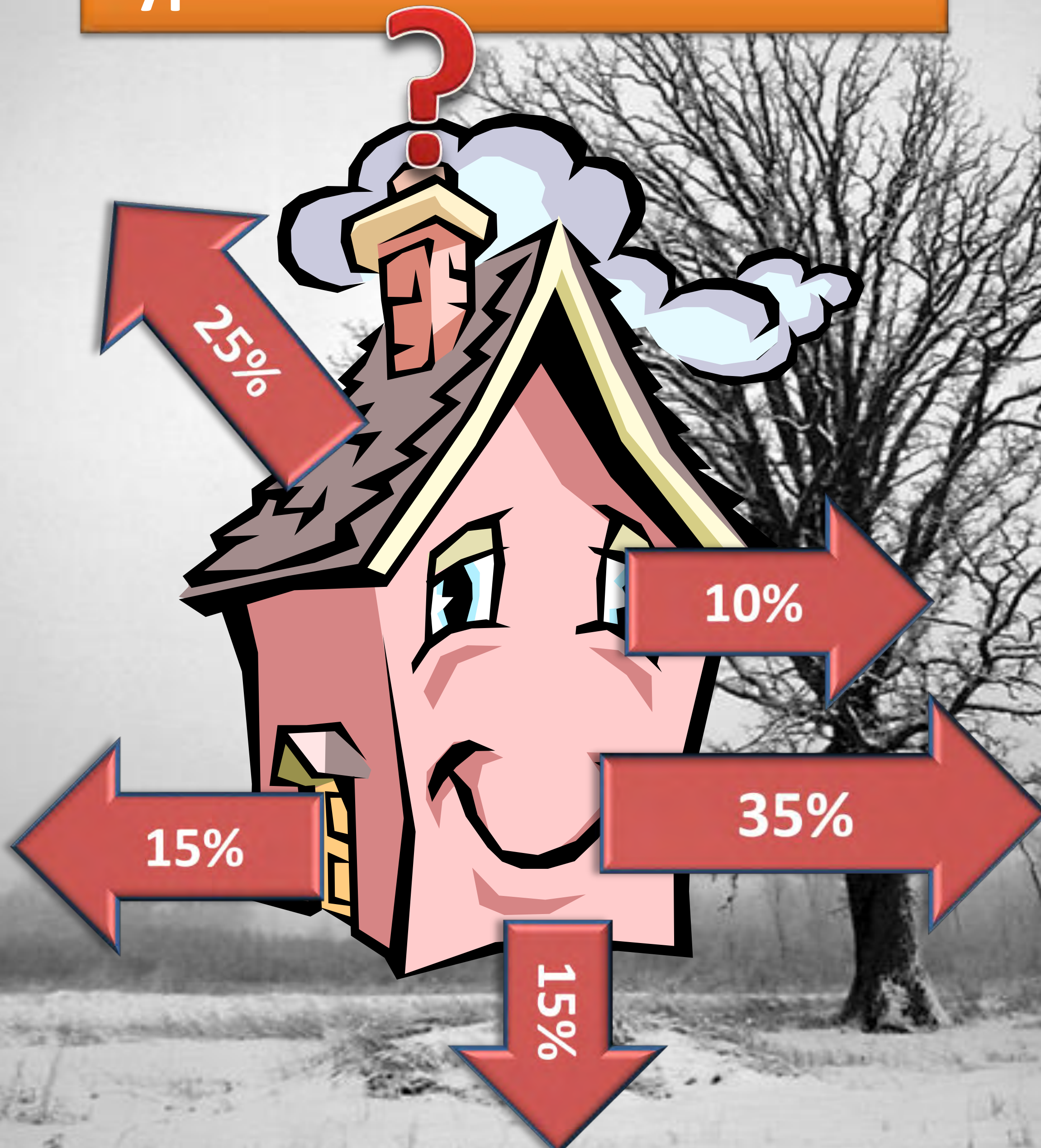
Living Walls

“Wall Insulation”


Sensitivity Analysis: Annual Heating Demand
Wall Insulation
B-R-75
18.50
13.50
8.50
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
110%
120%
130%
140%
150%
160%
170%
180%
190%
Design Value Adjustment


Searching for
The Perfect wall

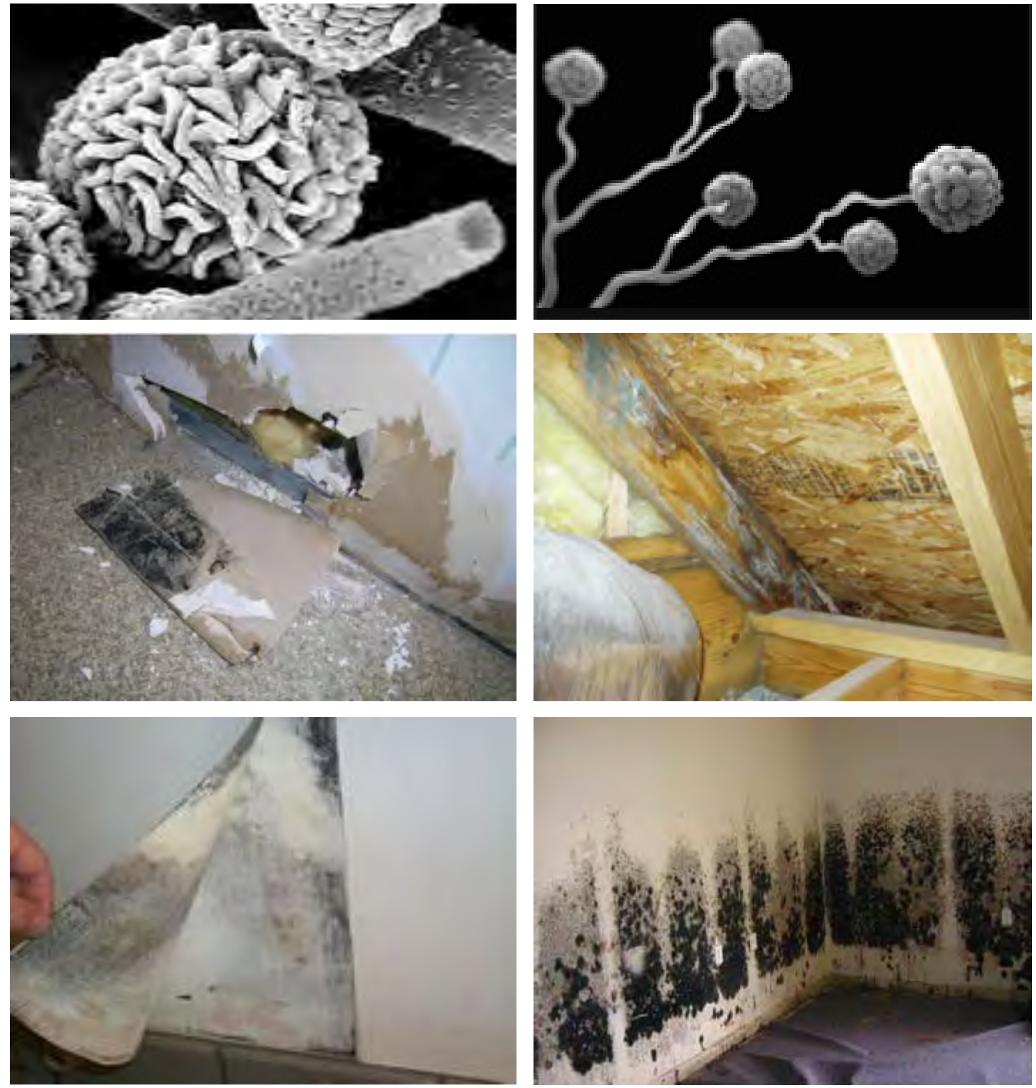
Typical heat loss of a Home



The Problem

Building Moisture and Mold Issues are a Big Deal

1. Condensation/Absorption
2. Moisture Accumulation
3. Toxic Mold + Fungus
4. Allergy + Immune Issues
5. Materials Deterioration
6. Building Failure

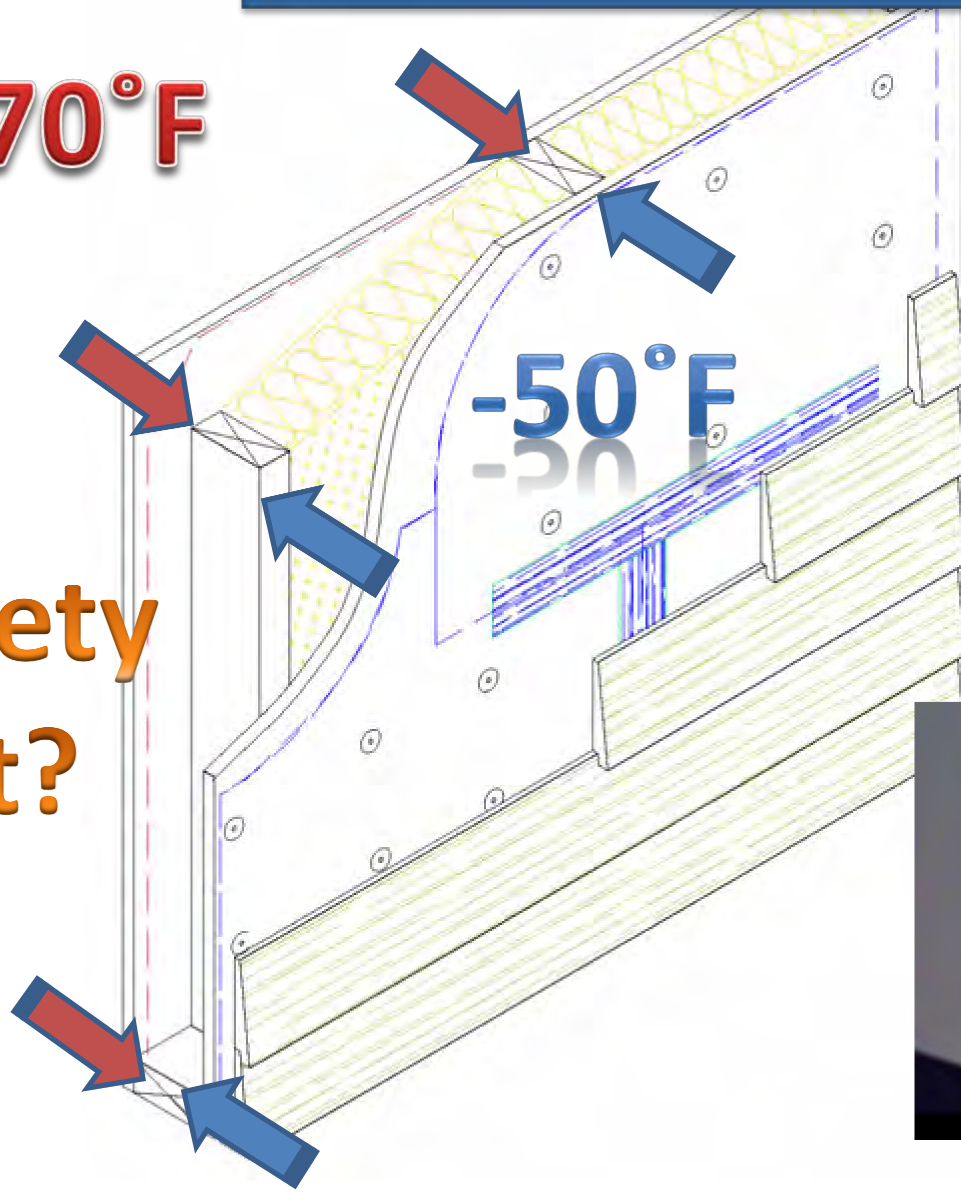


Conventional 2x6 wall w/batting insulation.

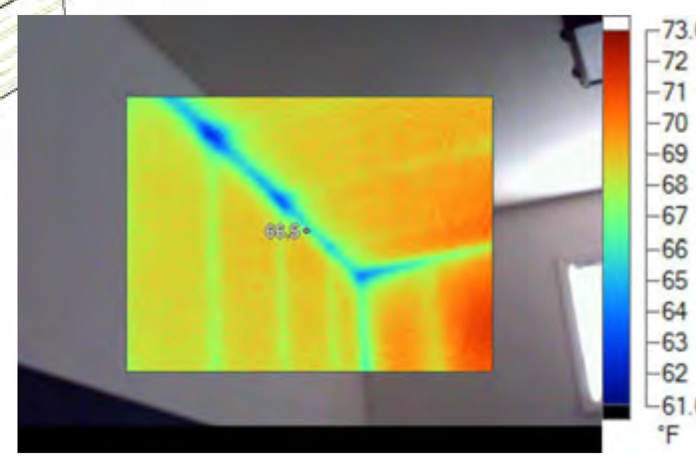
TYPICAL WALL
WOOD SIDING
WOOD FURRING
TYVEK â HOMEWRAP
7/16" PLYWOOD SHEATHING
2"x6" WOOD STUDS
w/ R21 BATT INSULATION
6 mil Vapor Barrier
1/2" GYPSUM BOARD

70˚F

-50˚F



Safety Net?



2x4 Test Wall 2 years, no VB on interior

Air Transport of Water Vapor

AIR LEAKAGE

4 X 8 sheet of gypsum board with a 1 inch square hole

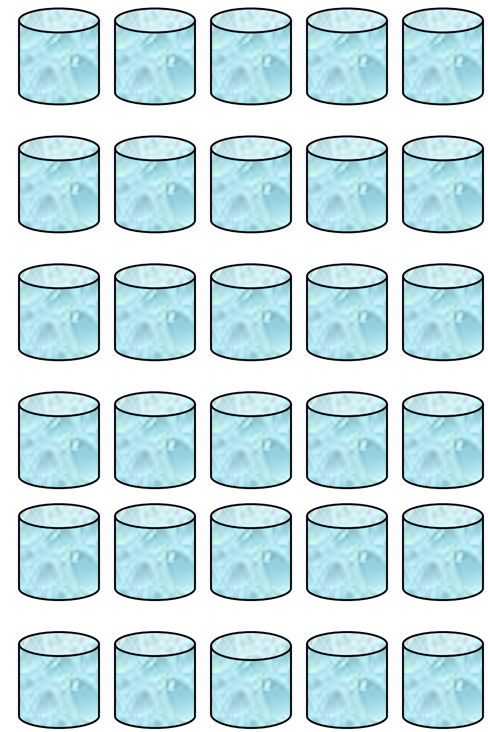
Interior at 70 F and 40 % RH one heating season

Air leakage

-Moisture flow
4 x 8 Drywall
70 F
40 % RH
1 square inch hole

Flow quantity

-30 Quarts of water



30 quarts of water

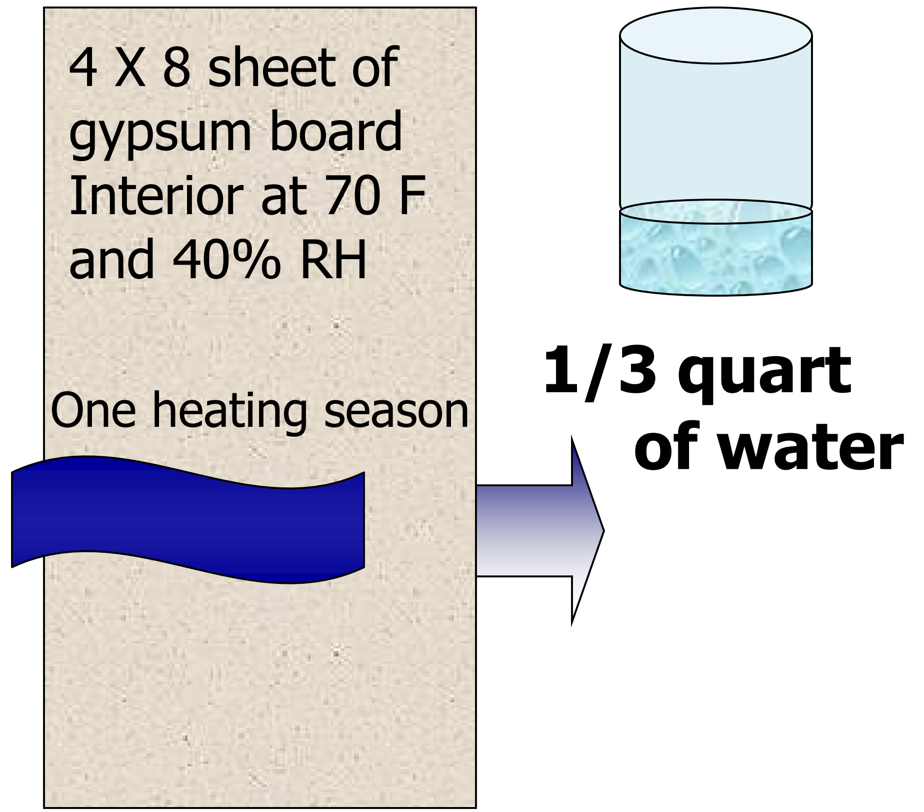
Diffusion Transport of Moisture

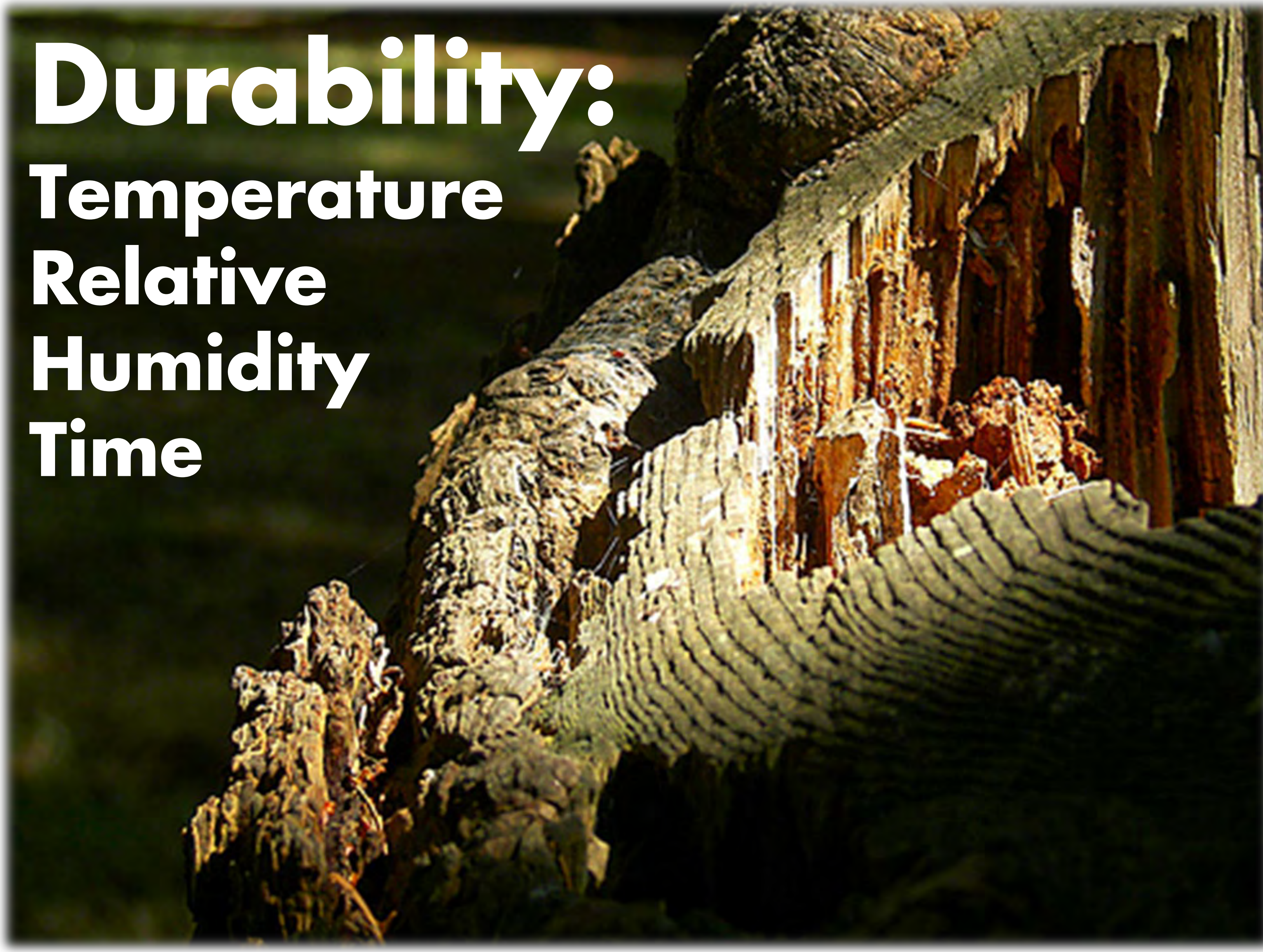
- **Diffusion**

  -Migration of moisture by means of vapor pressure differential.

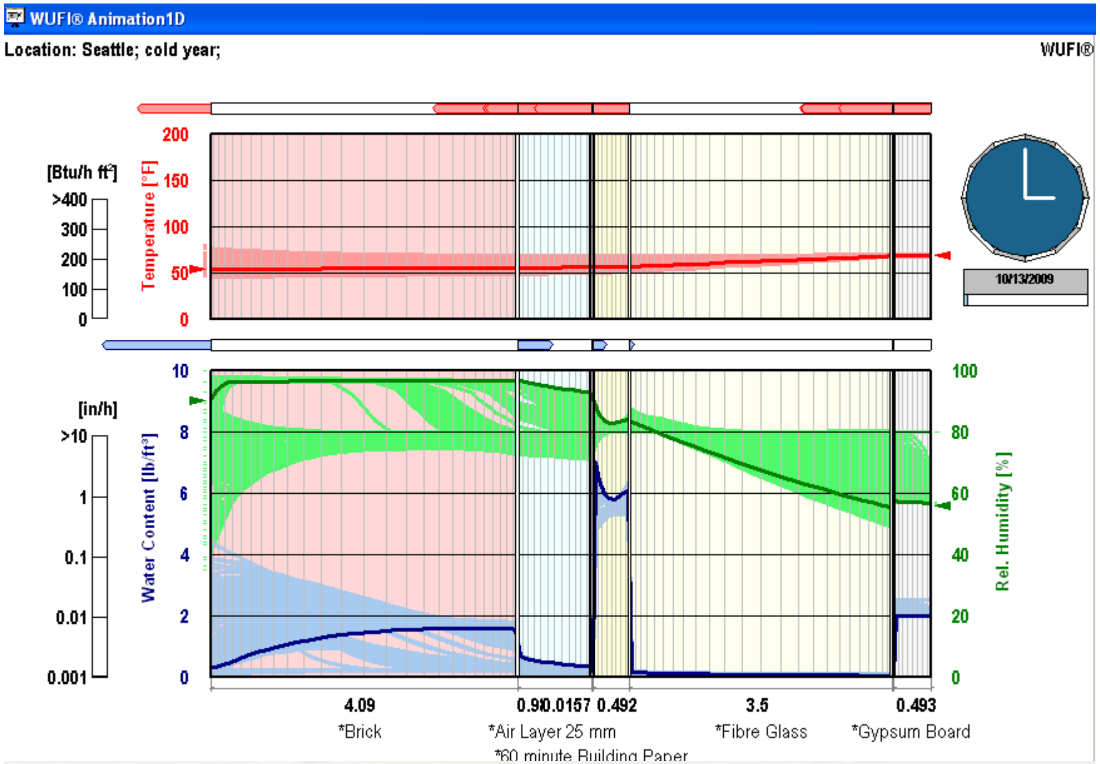
  -Occurs in either direction based on climate conditions and interior levels of humidity.

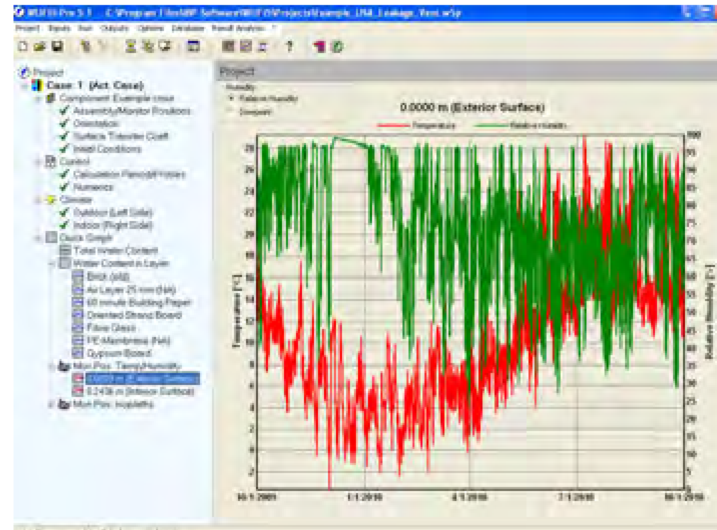
  -1/3 quart of water!!

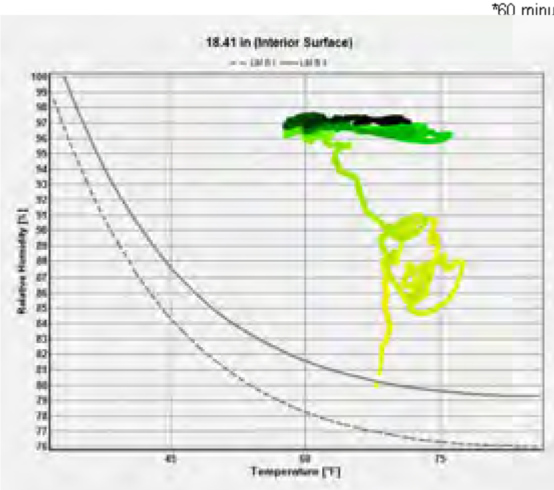


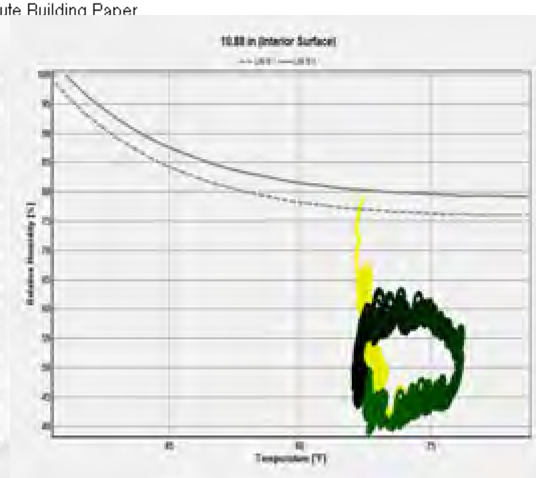

Durability:
Temperature
Relative
Humidity
Time

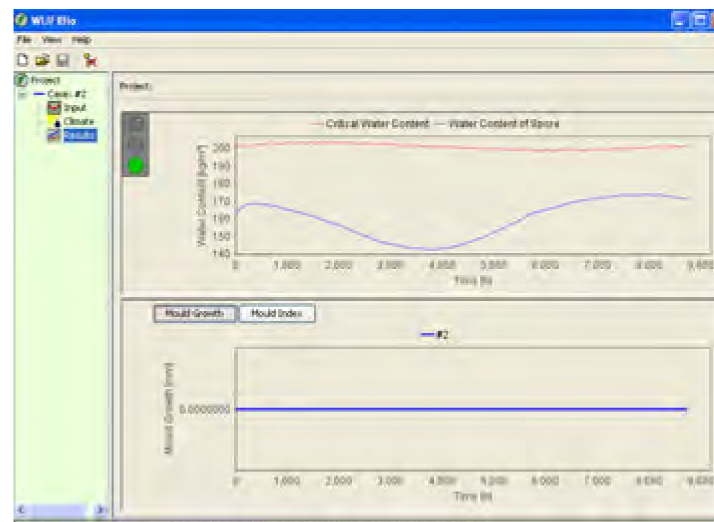
WUFI Hygrothermal Physics "Mold Prevention" Modeling



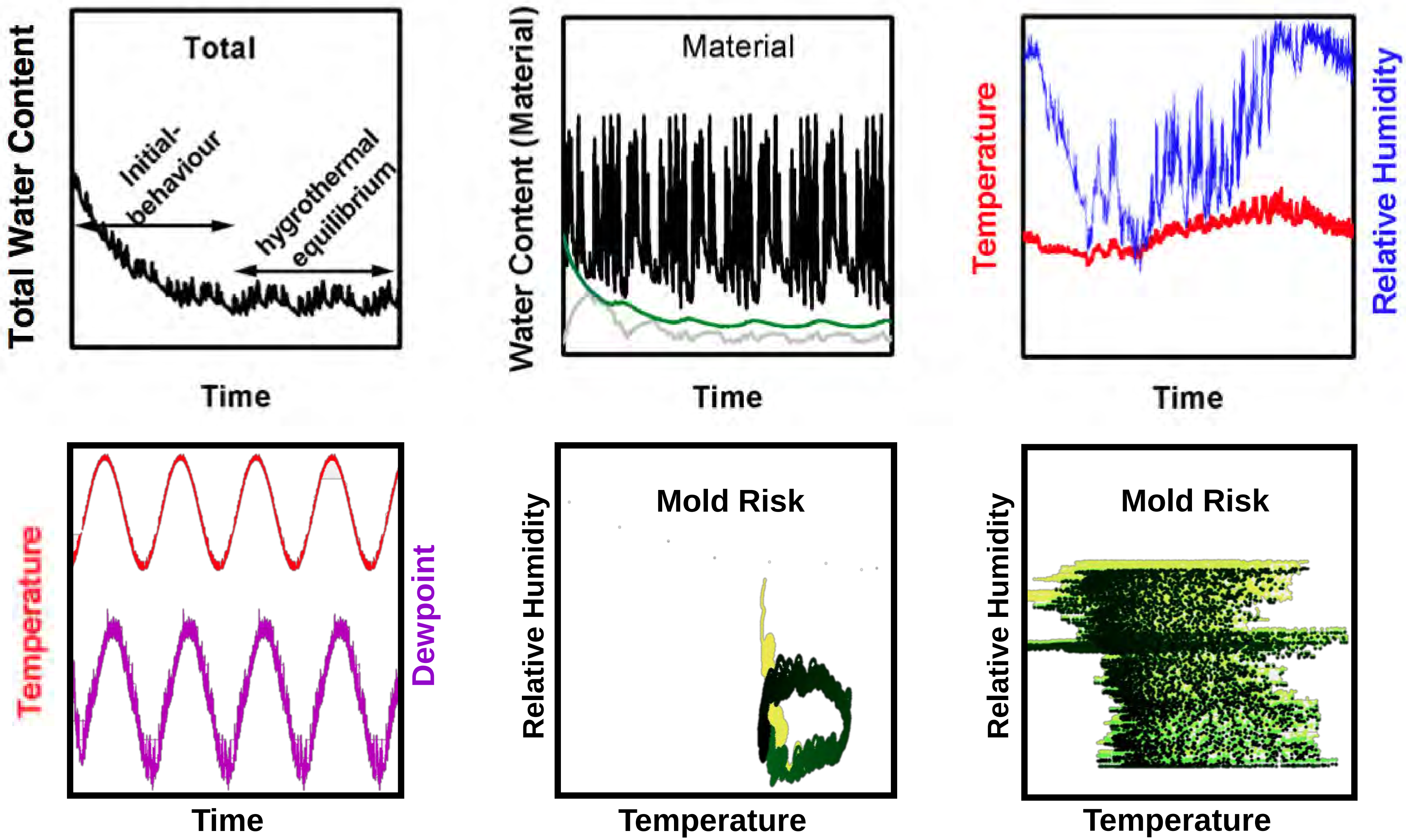




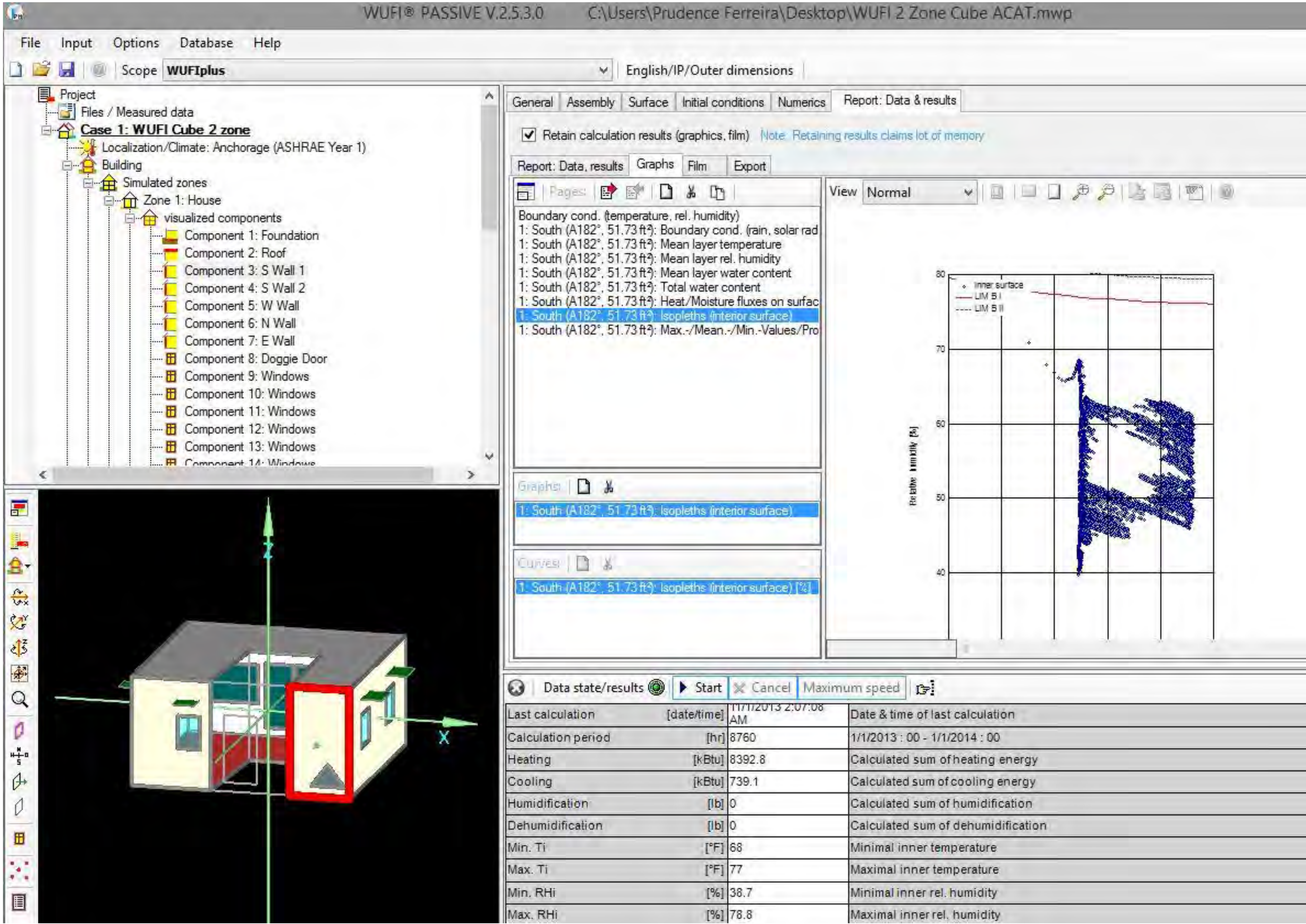




Reliable Results with Field and Lab Validation



WUFI Plus Energy AND Hygrothermal Modeling



The REMOTE Wall System

REMOTE:

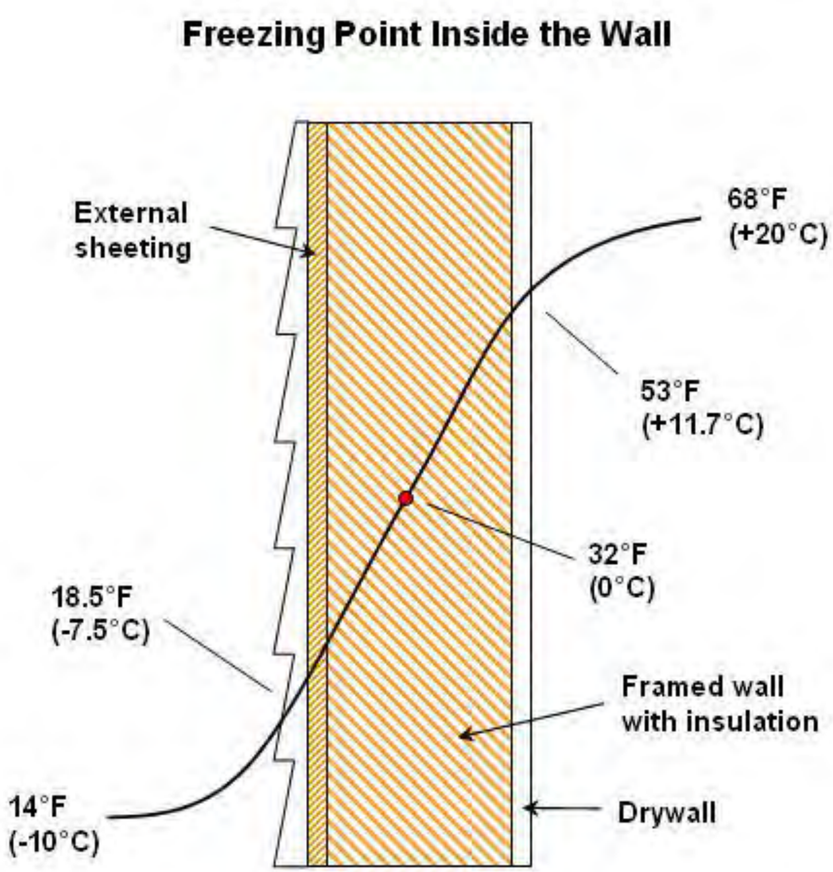
Residential Exterior Membrane Outside-insulation TEchnique

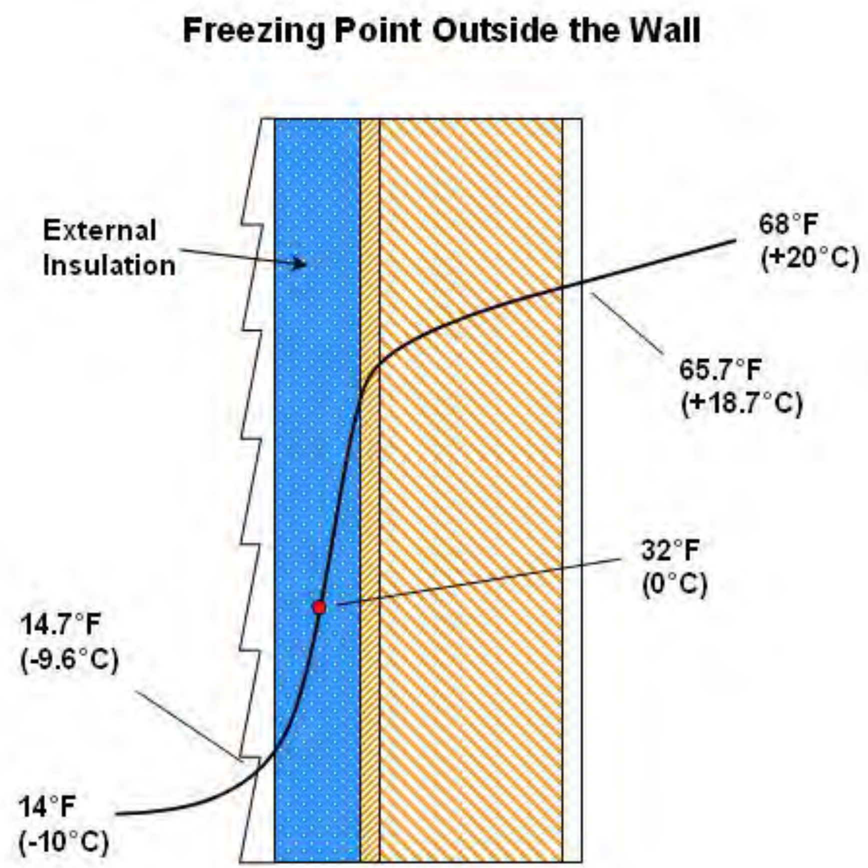
REMOTE = Modified PERSIST or an Alaskan Approach to a Canadian Concept

PERSIST:

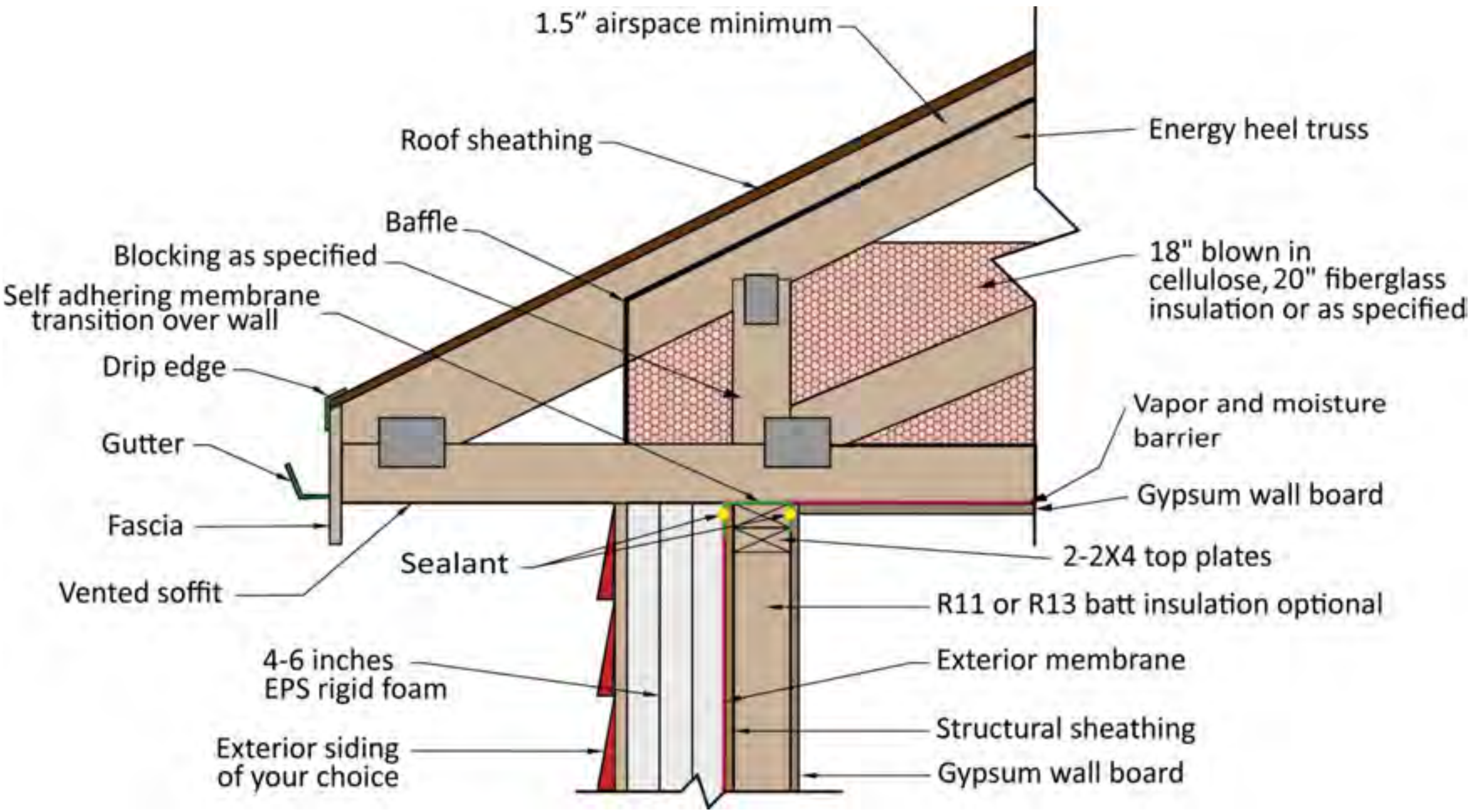
Pressure Equalized Rain Screen Insulated Structure Technique (1954)

REMOTE Wall System – Exterior Insulation

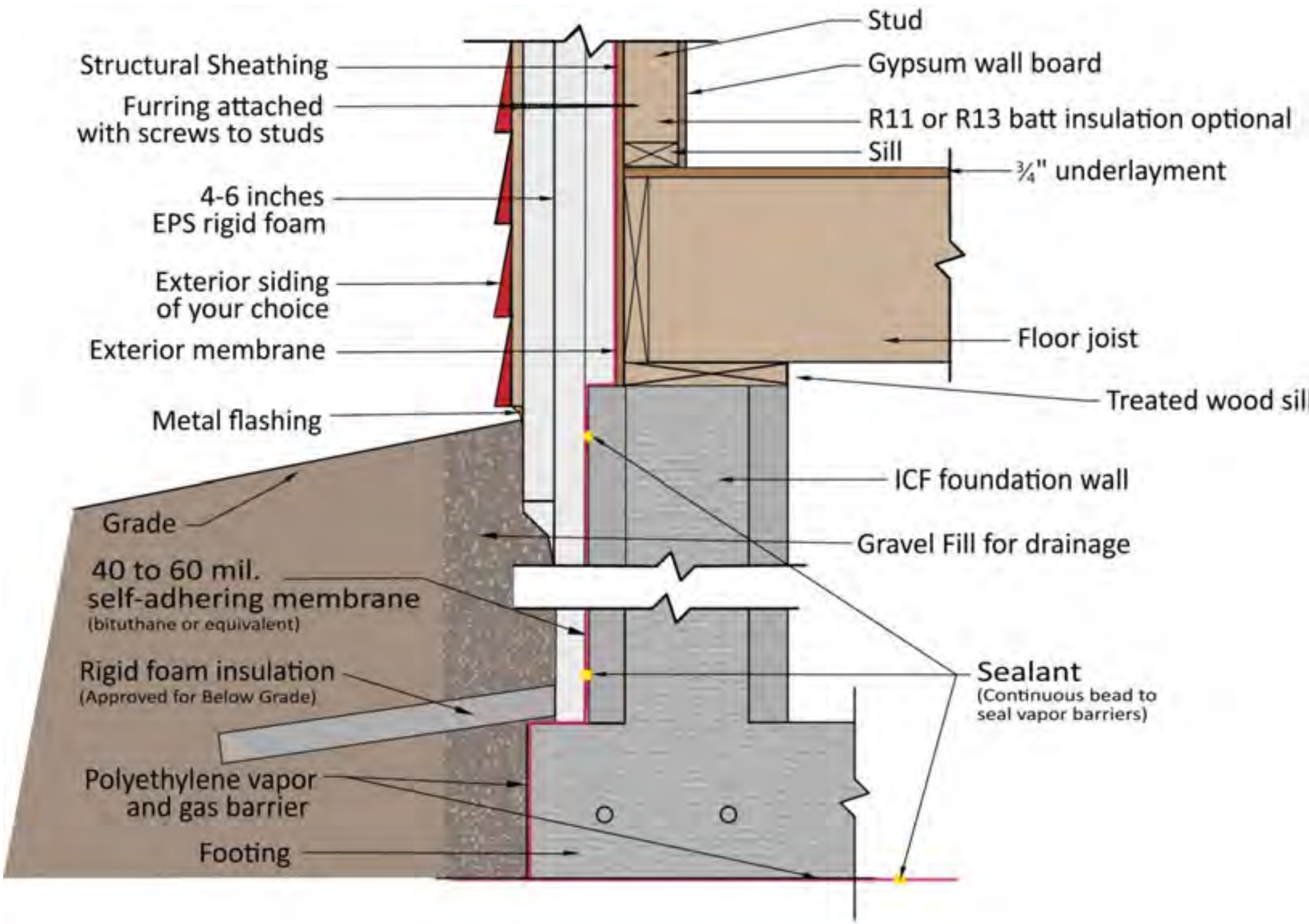




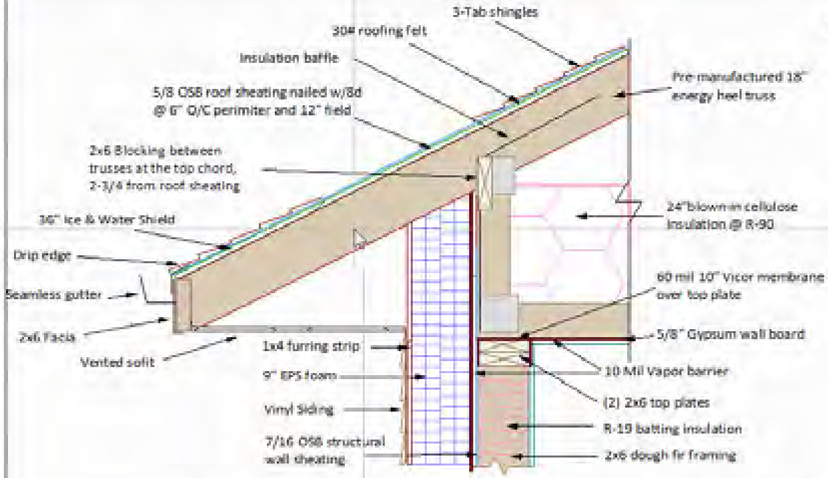
REMOTE Wall System – Wall & Roof detail



REMOTE Wall System – Wall & Foundation detail

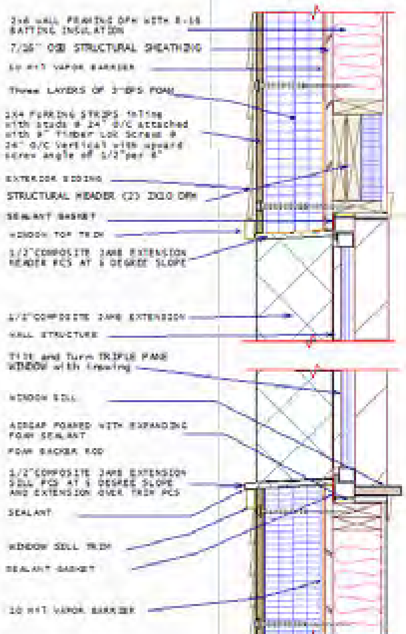


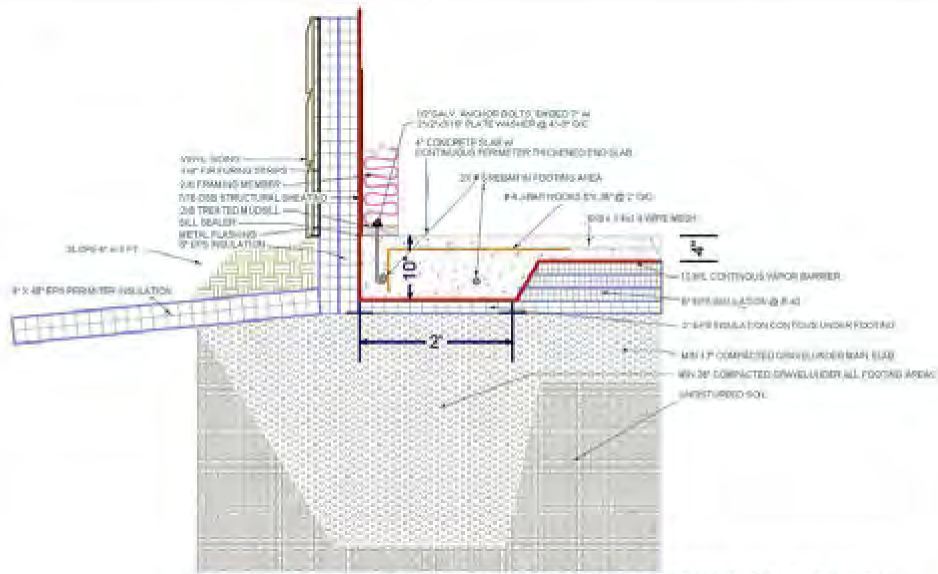
REMOTE Wall Details



Energy Heel Truss w/9 inch Remote Wall

(print at 1"=1')





SUPERINSULATED SHALLOW FROST PROTECTED FOUNDATION

(print at 1"=1')

CROSS-SECTION OF WINDOW SHOWING COMPOSITE JAMB EXTENSION WITH 6" REMOTE WALL & OVERINSULATED WINDOW

0907CH - The Kassel Home
4615 Old Murphy Dome Rd
Lot2A Perpect Perch 1st Addition

REINA

Scale: 1/4" = 1'-0"

Date: 09/02/2009

S4

REMOTE Wall System – The Manual 2nd Edition

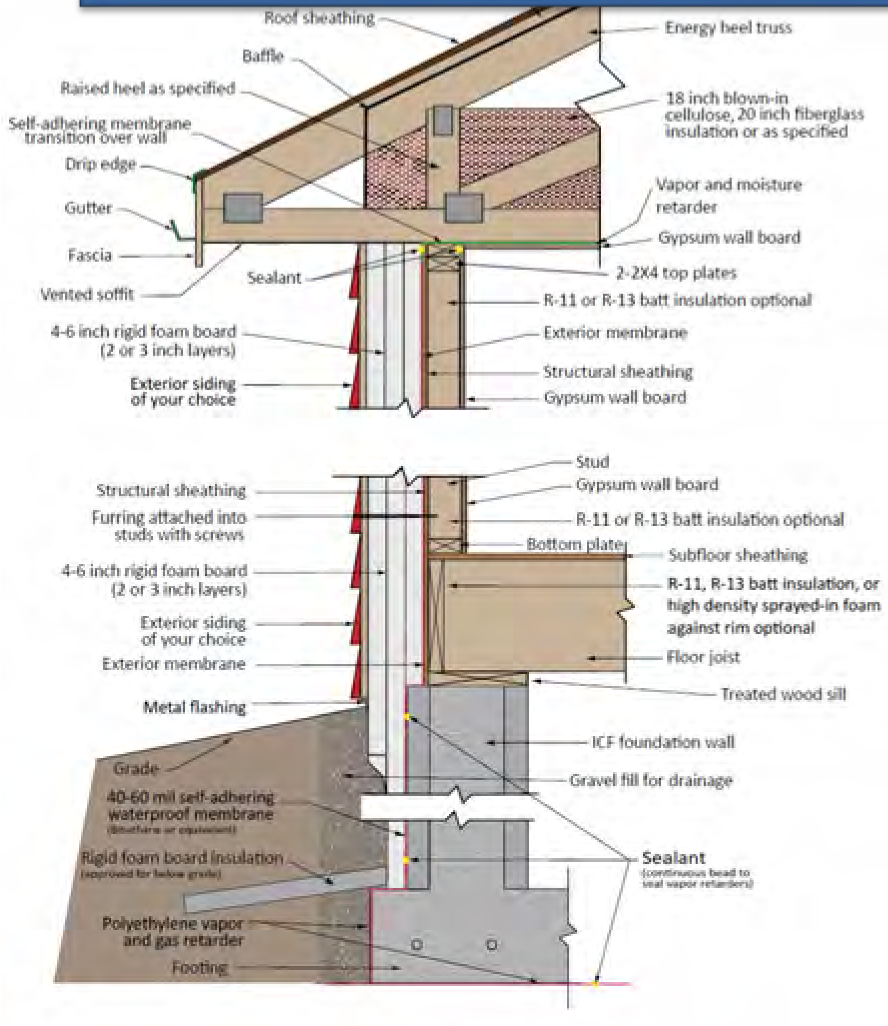
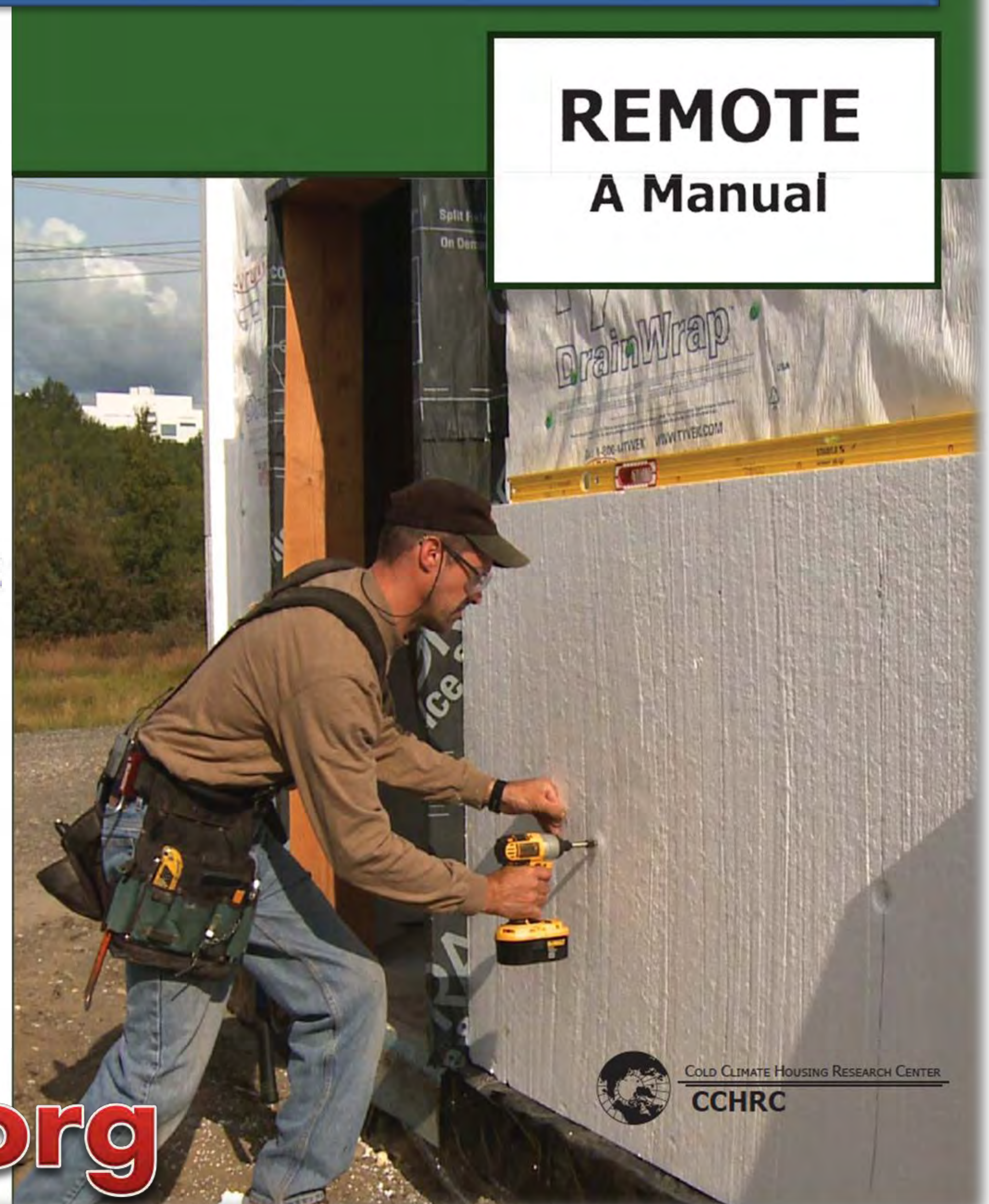


Figure 1. WALL CROSS SECTION



www.cchrc.org

Rubberized Adhesive Exterior Membrane

6 Mil Poly Exterior Membrane

Tyvek Drain Wrap Exterior Membrane

Exterior Membrane should transition to interior ceiling

Ceiling vapor barrier completes the envelope

Inset Windows

Azek

Stucco

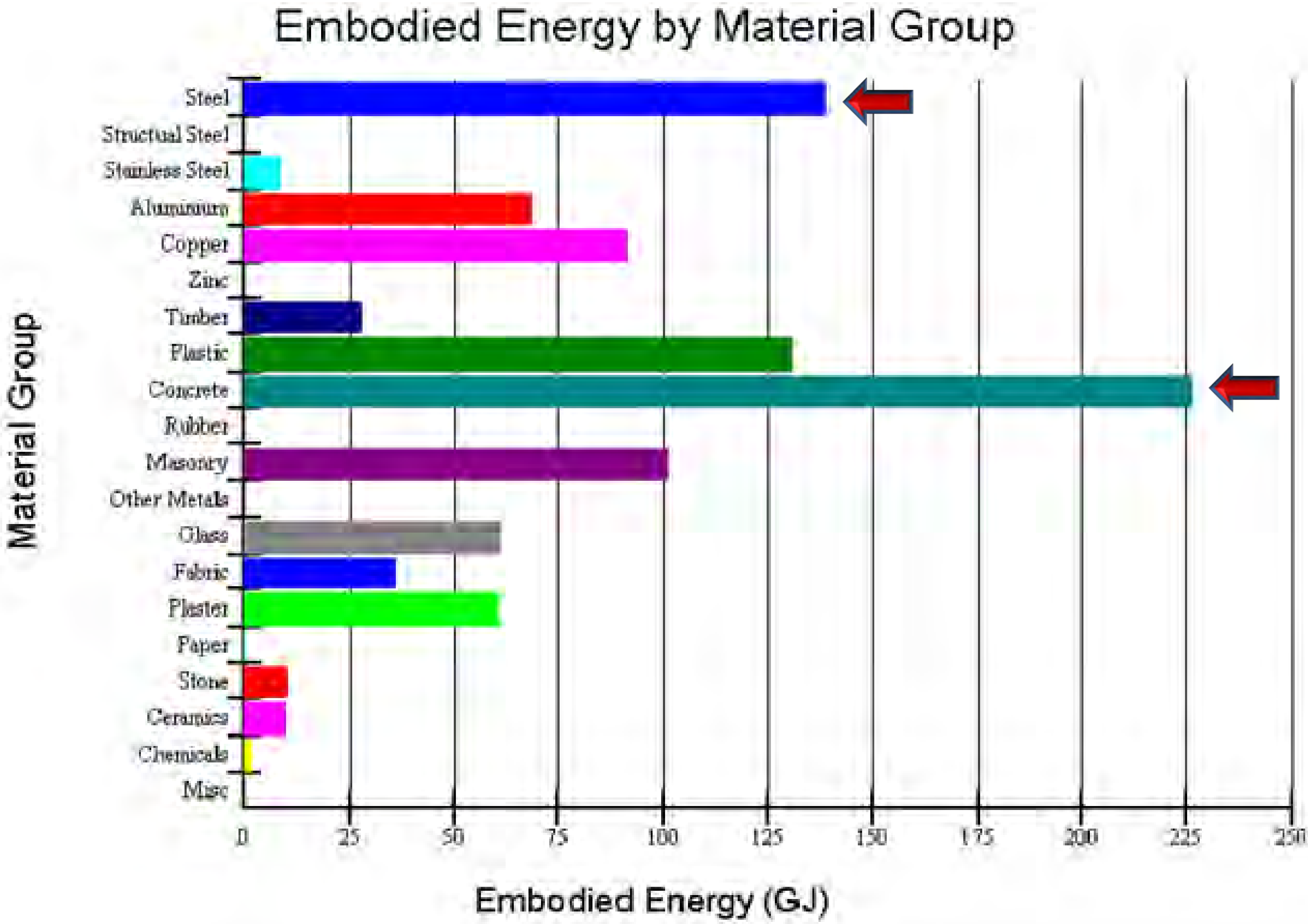
Steel

On deck REMOTE assembly can save time

REMOTE furring detail

Furring installed ready for siding

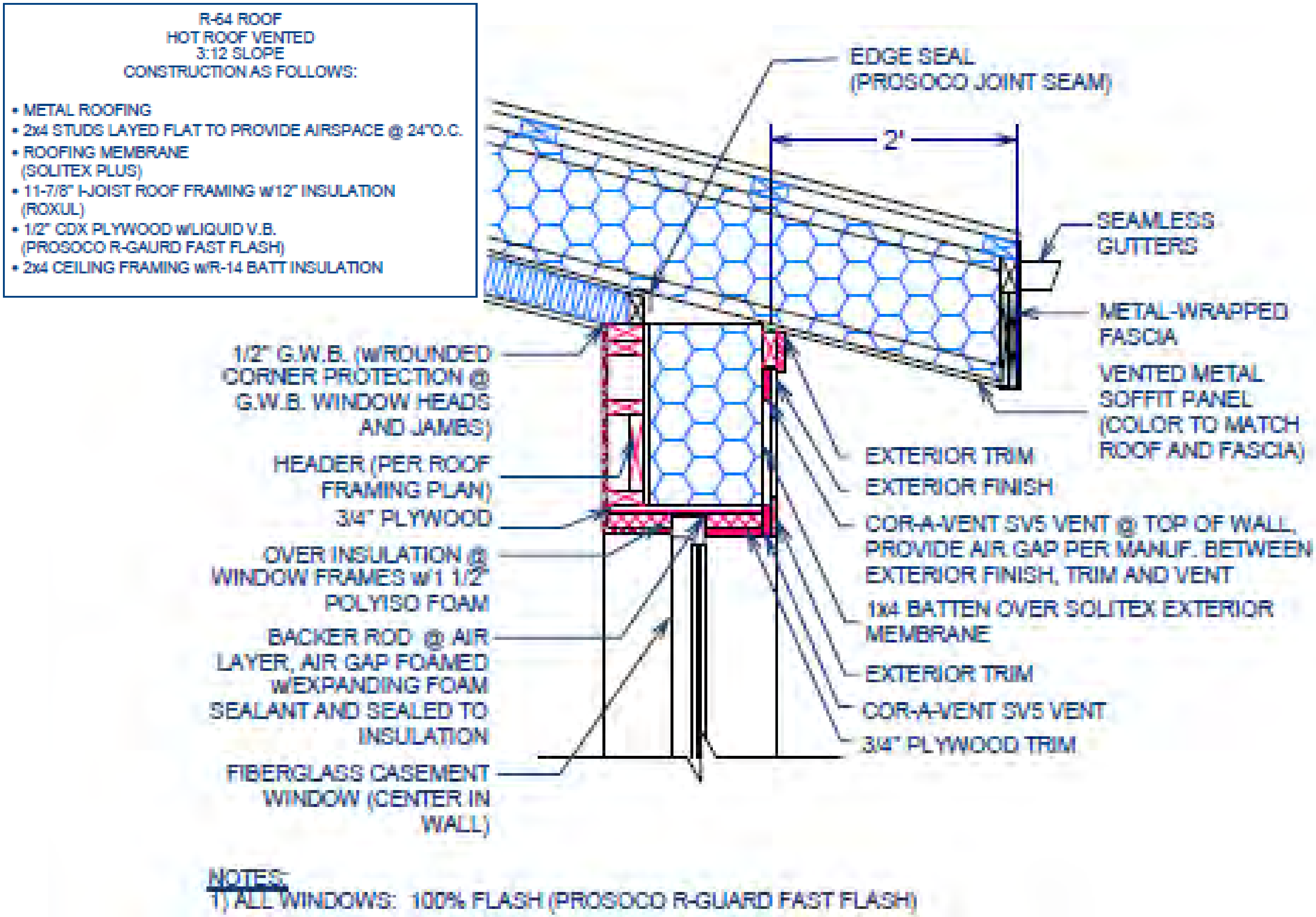

Embodied energy
Factor x64
Embodied Energy
Cellulose/ Cotton
Mineral Fiber
Foam Plastics
INSULFOAM
R-TECH



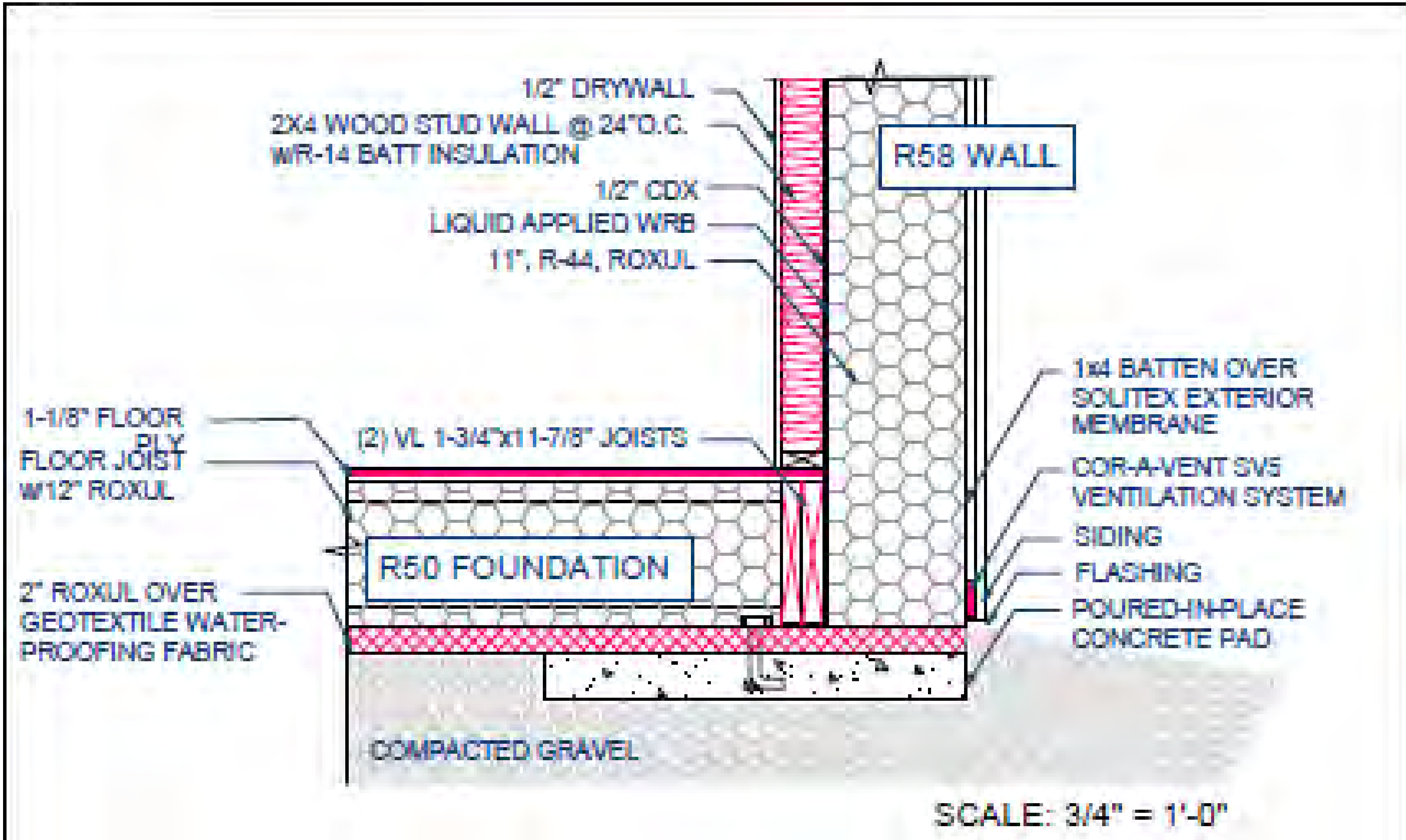
Embodied Energy by Material Group
Steel
Structual Steel
Stainless Steel
Aluminium
Copper
Zinc
Timber
Plastic
Concrete
Rubber
Masonry
Other Metals
Glass
Fabric
Plaster
Paper
Stone
Ceramics
Chemicals
Misc
0
25
50
75
100
125
150
175
200
225
250
Material Group
Embodied Energy (GJ)

REMOTE Wall System using Rockwool

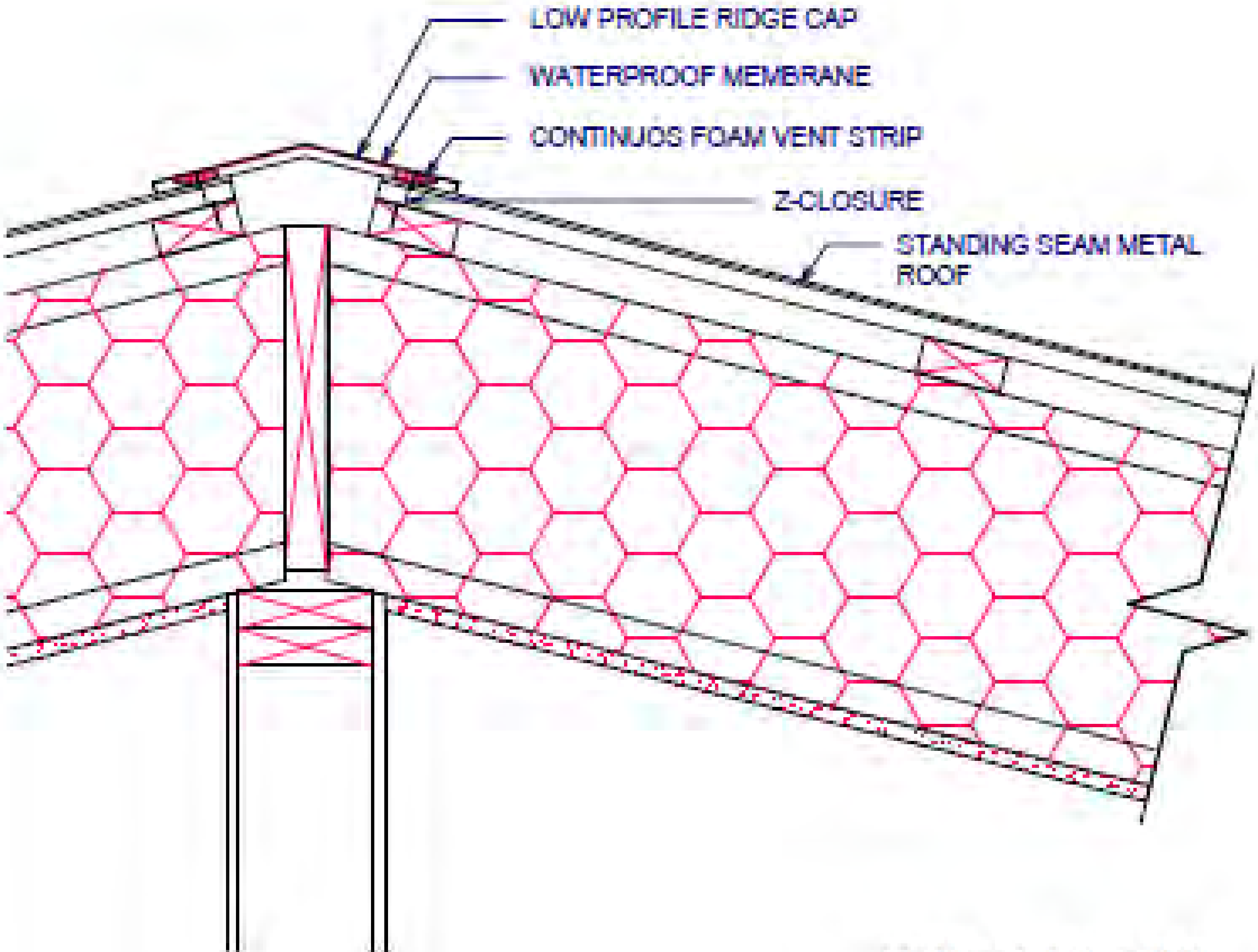
REMOTE Wall System using Rockwool



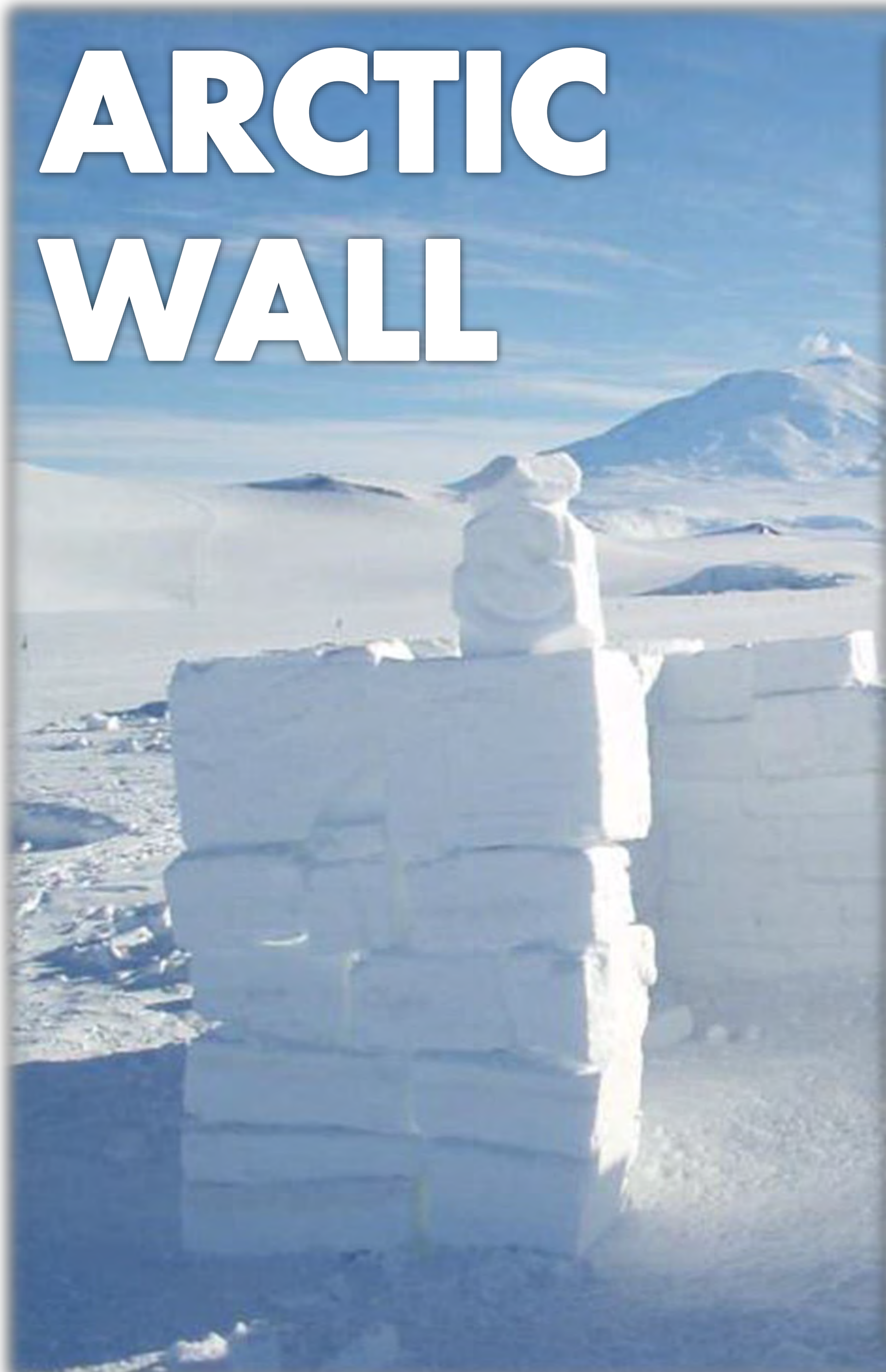
REMOTE Wall System using Rockwool

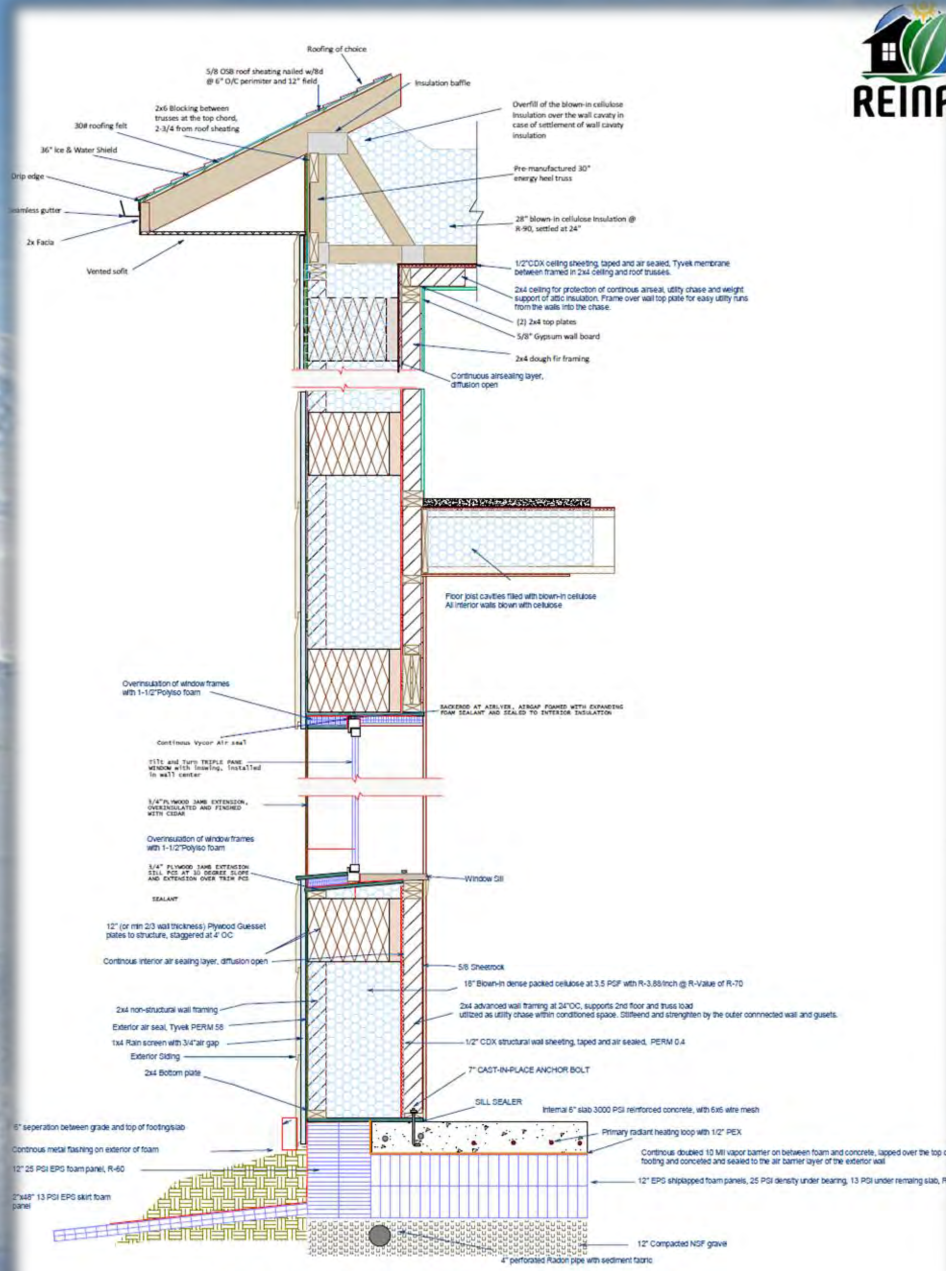


REMOTE Wall System using Rockwool



ARCTIC WALL

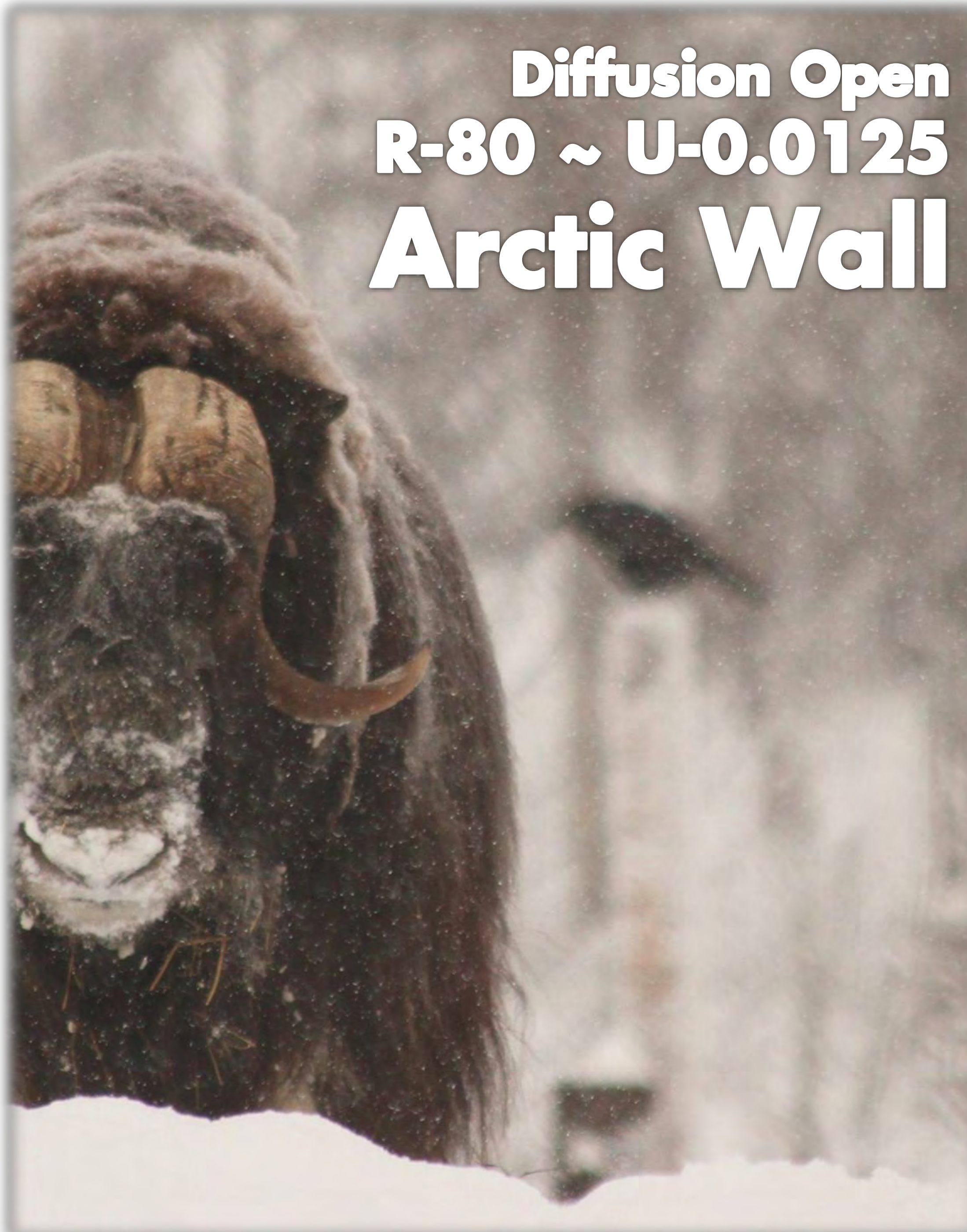




Superinsulated R-70 ARCTIC Wall and R-60 Slab detail

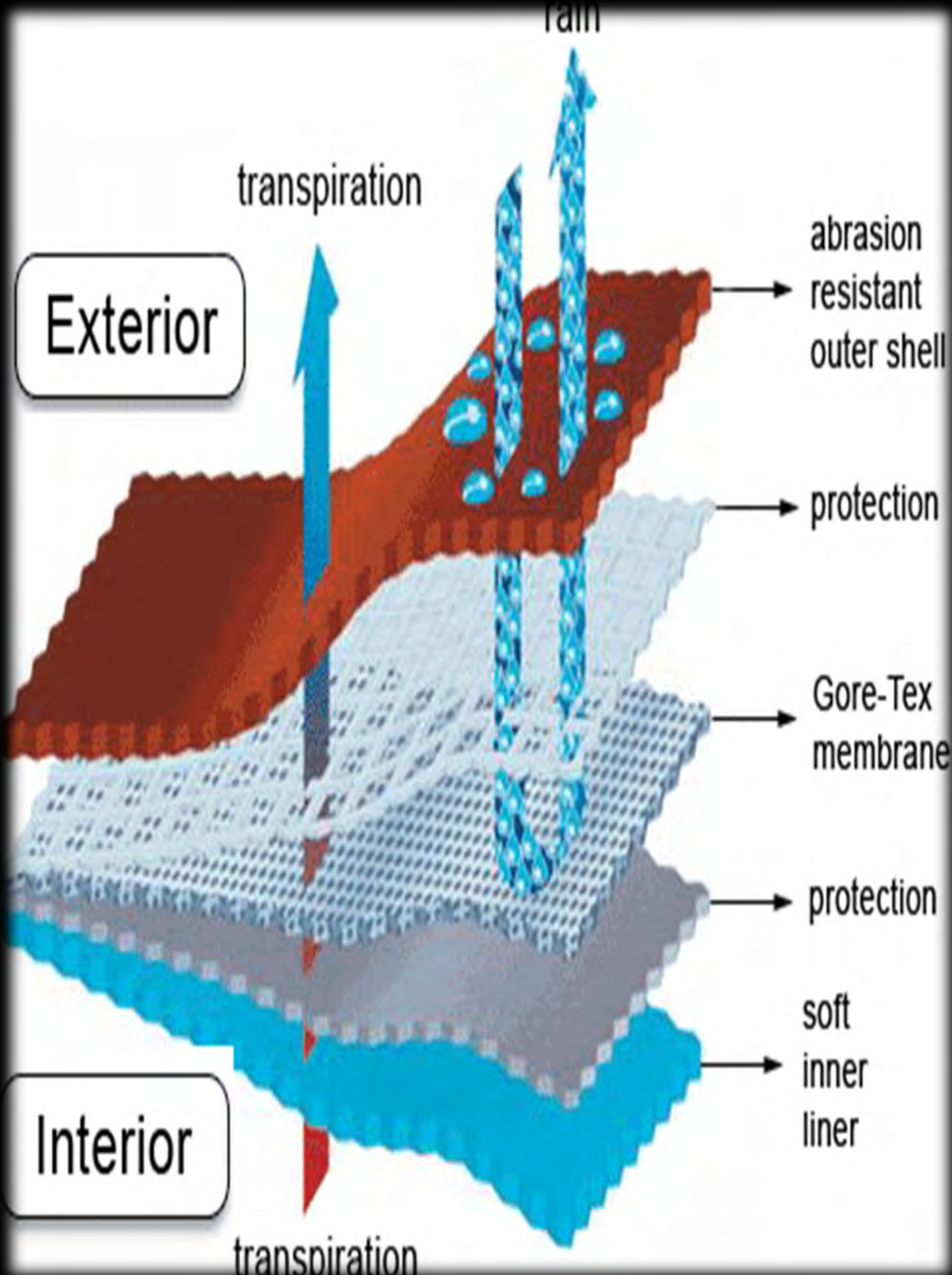
DESIGN by REINA, LLC - Thorsten Chlupp (print at 1"=1')


pro clima SOLITEX
MENTO
PLUS
26 inches
or 66 cm


Diffusion Open
R-80 ~ U-0.0125
Arctic Wall

Diffusion open wall

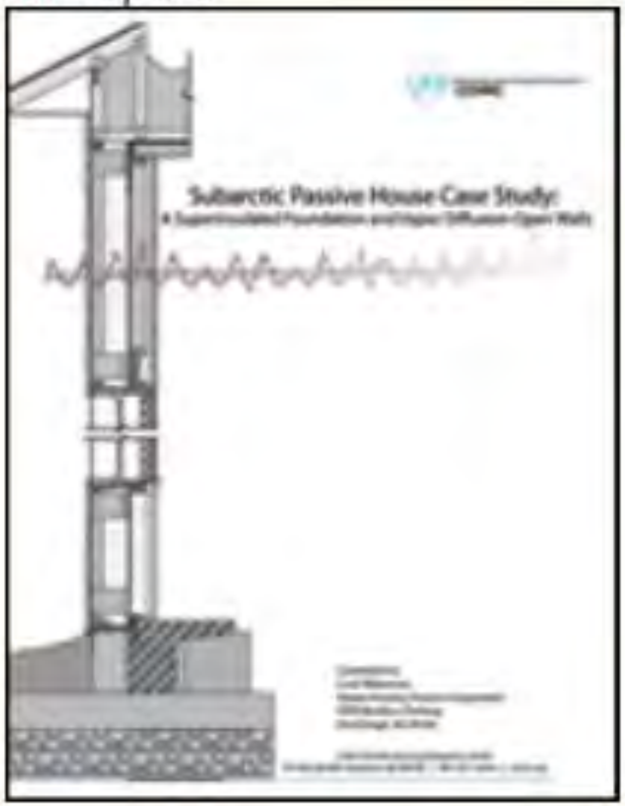
= Drying potential in any direction



Diffusion open = Think Gore Tex

ArcticWall System – The Research Report

Full report



Snapshot

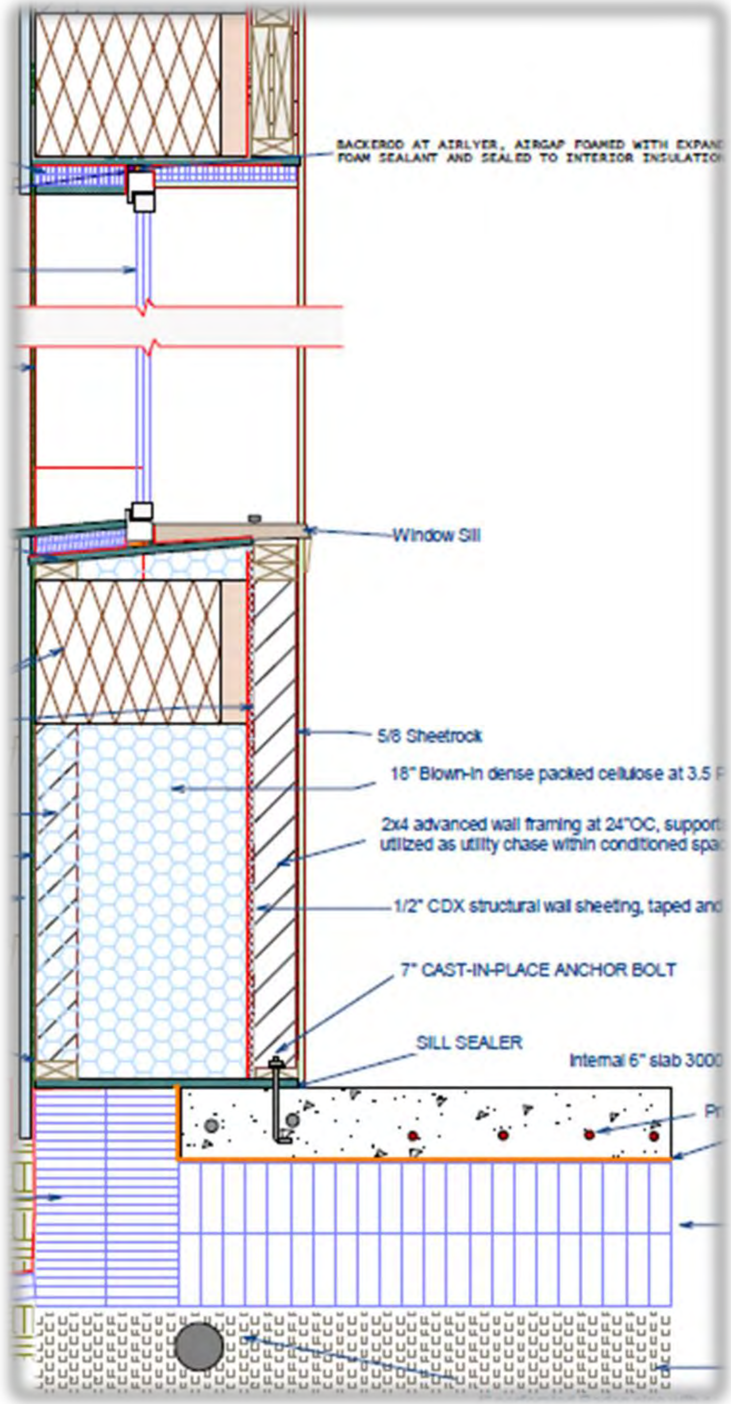
http://www.cchrc.org/arctic-wall


12 Tons
Cellulose
FORCE/3
4.0DP

Lambda value

High density, high heat capacity - phase displacement

Construction material	Bulk density ? kg/m^3	Thermal conductivity ? [W/(mK)]	Specific thermal capacity c J/(kg·K)	Temperature guide number a^2/m
Oriented Strand Board (OSB)	650	0,13	2100	3
Cement bound Particleboard	1200	0,23	2100	3
Spruce, pine, fir	600	0,13	2100	4
Particleboards	600	0,14	2100	4
Softboard	250	0,07	2100	4
Paroc	220	0,035	2100	4
Cellulose Insulation	70	0,04	2000	10
Woodwool	55	0,04	2000	13
Concrete	2000	1,35	1000	24
Polyurethane foam	30	0,035	1500	28
Flax	30	0,04	1300	37
Hemp	30	0,045	1300	4
Polystyrene foam	20	0,035	1500	42
Glass wool	20	0,035	1000	63
sheep wool	15	0,04	1300	74
Steel	7800	50,00	400	577


BACKEROD AT AIRLYER, AIRGAP FOAMED WITH EXPAN
FOAM SEALANT AND SEALED TO INTERIOR INSULATIO
Window Sill
5/8 Sheetrock
18" Blown-in dense packed cellulose at 3.5 P
2x4 advanced wall framing at 24"OC, support
utilized as utility chase within conditioned spa
1/2" CDX structural wall sheeting, taped and
7" CAST-IN-PLACE ANCHOR BOLT
SILL SEALER
Internal 6" slab 3000


R-80
Arctic Wall


Boise Cascade® VERSA-LAM® 2.0 2800/1950
se Cascade® VERSA-LAM® 2.0 2800/1950


Tyvek
HomeWrap
SIGA-Majcoat
www.siga.ch


Majcoat
siga.ch


siga.ch
Majcoat
siga.ch

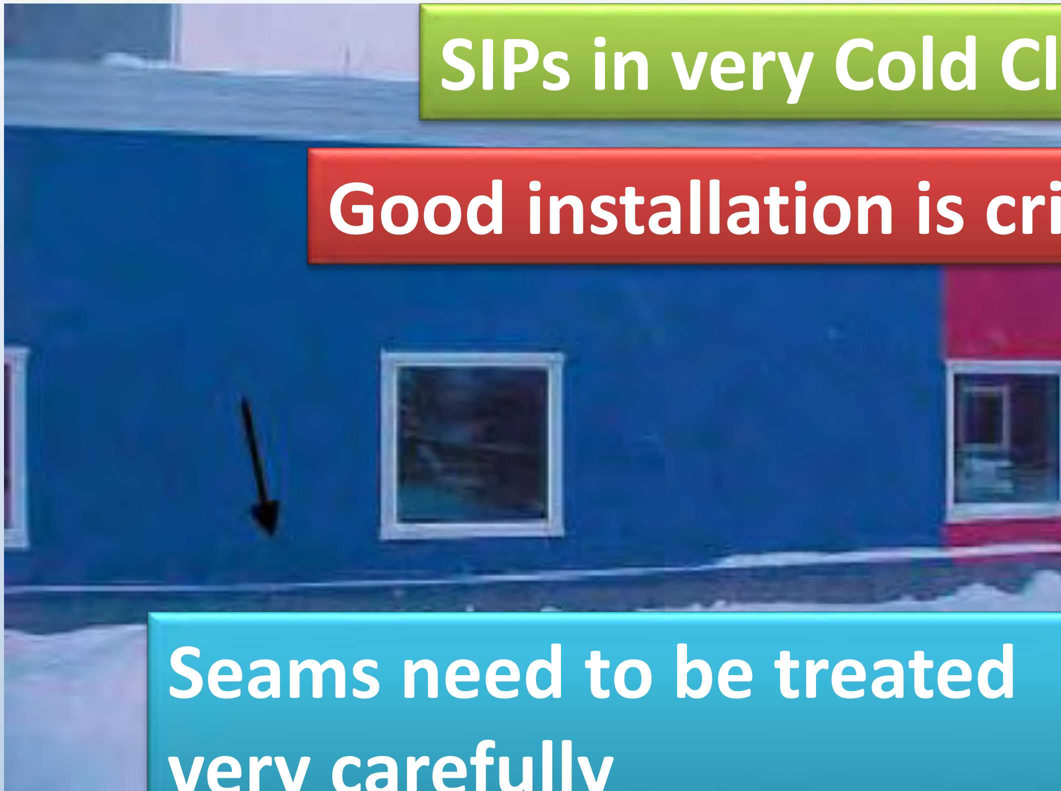

BOISE
VERSA LAM 2.0


va-Q-tec
R-60
Size Matters...

The SIPs Puzzle

SIPs in very Cold Climates

Good installation is critical

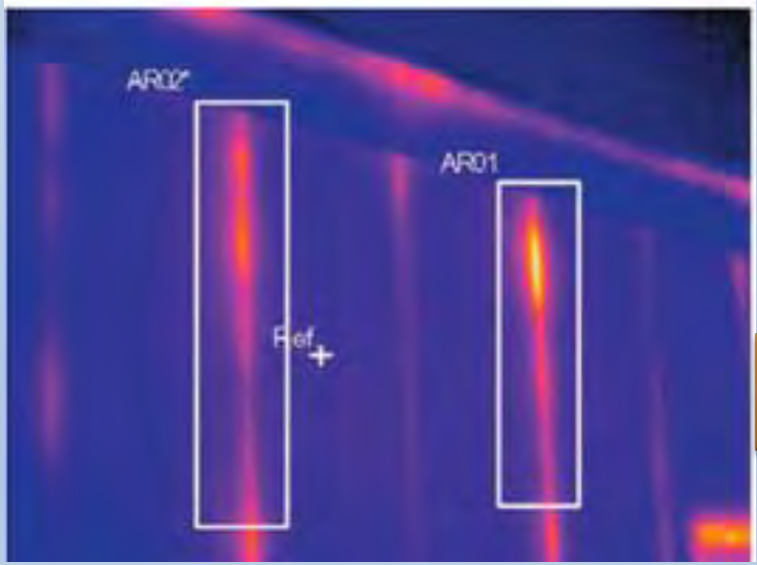


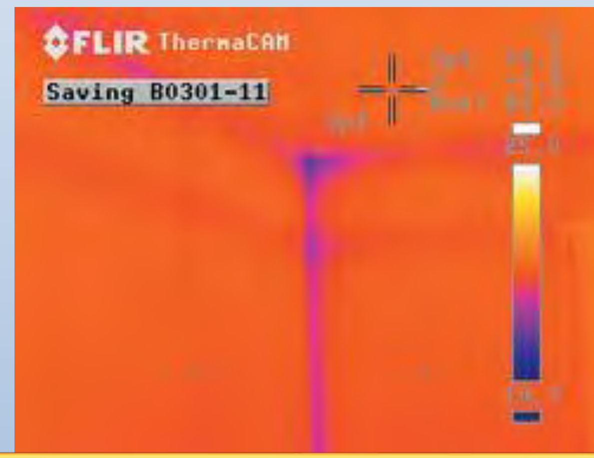
Seams need to be treated very carefully

Special attention on critical insulation points

SIPs in very Cold Climates

Extreme cold can penetrate seams over time





Thermal bridging at corners

ICFs –Insulated Concrete Forms

R-Value R-19 to 22

R-values of R-50 and more are NOT confirmed.

BUT - Thermal Mass Factor

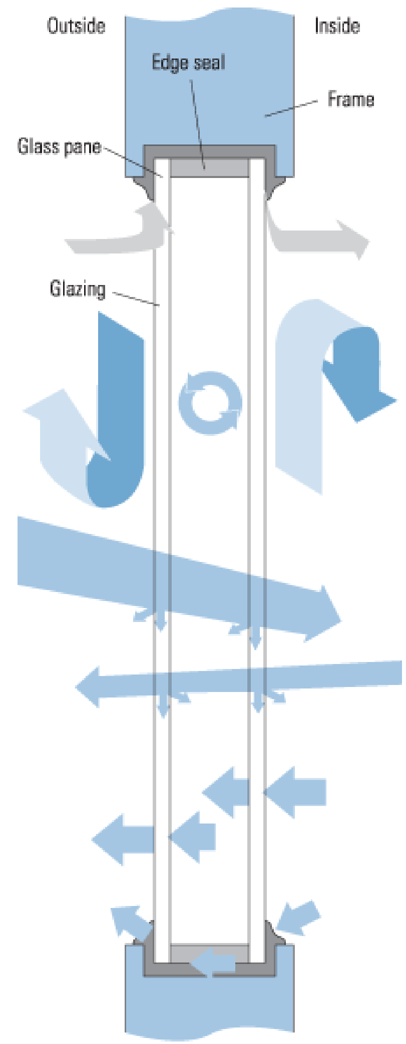
Very Air tight!


Put the insulation where it belongs – the OUTSIDE
GRACE Bituthene
WERNER

"Windows"

Window Considerations

U-value	• glazing and overall U-value, creating warm surface temperatures, avoiding convection, insulated, thermally broken frames
Quality of Spacers	• warm spacers or super spacers
Solar Heat Gain Coefficient	• 0.50 – 0.6 starting value, optimized per climate/project
Air Leakage	• multilock systems, no common sliding glass doors, double hung windows (lift and slide – sliding glass doors are the only sliding option available
Sun light Transmittance VT	• visible transmittance (number between 0 and 1) and light-to-solar gain ratio (ratio between light-to-solar gain and VT
Wind and Water Resistance	• Control air permeability and bulk water exposure



Infiltration
Air leaks around the frame, around the sash, and through gaps in movable window parts. Infiltration is foiled by careful design and installation (especially for operable windows), weather stripping, and caulking.

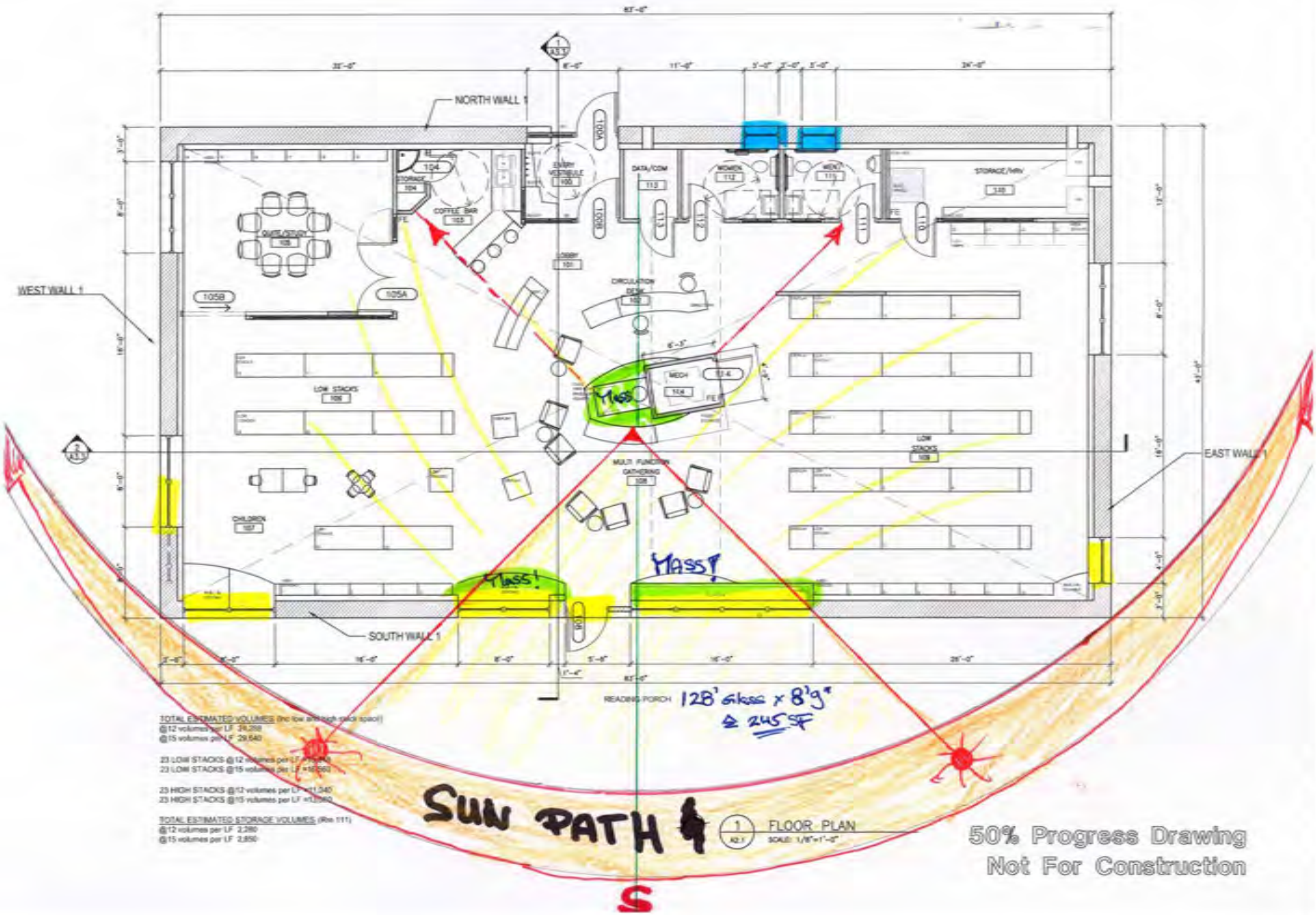
Convection
Convection takes place in gas. Pockets of high-temperature, low-density gas rise, setting up a circular movement pattern. Convection occurs within multiple-layer windows and on either side of the window. Optimally spacing gas-filled gaps minimizes combined conduction and convection.

Radiation
Radiation is energy that passes directly through air from a warmer surface to a cooler one. Radiation is controlled with low-emissivity films or coatings.

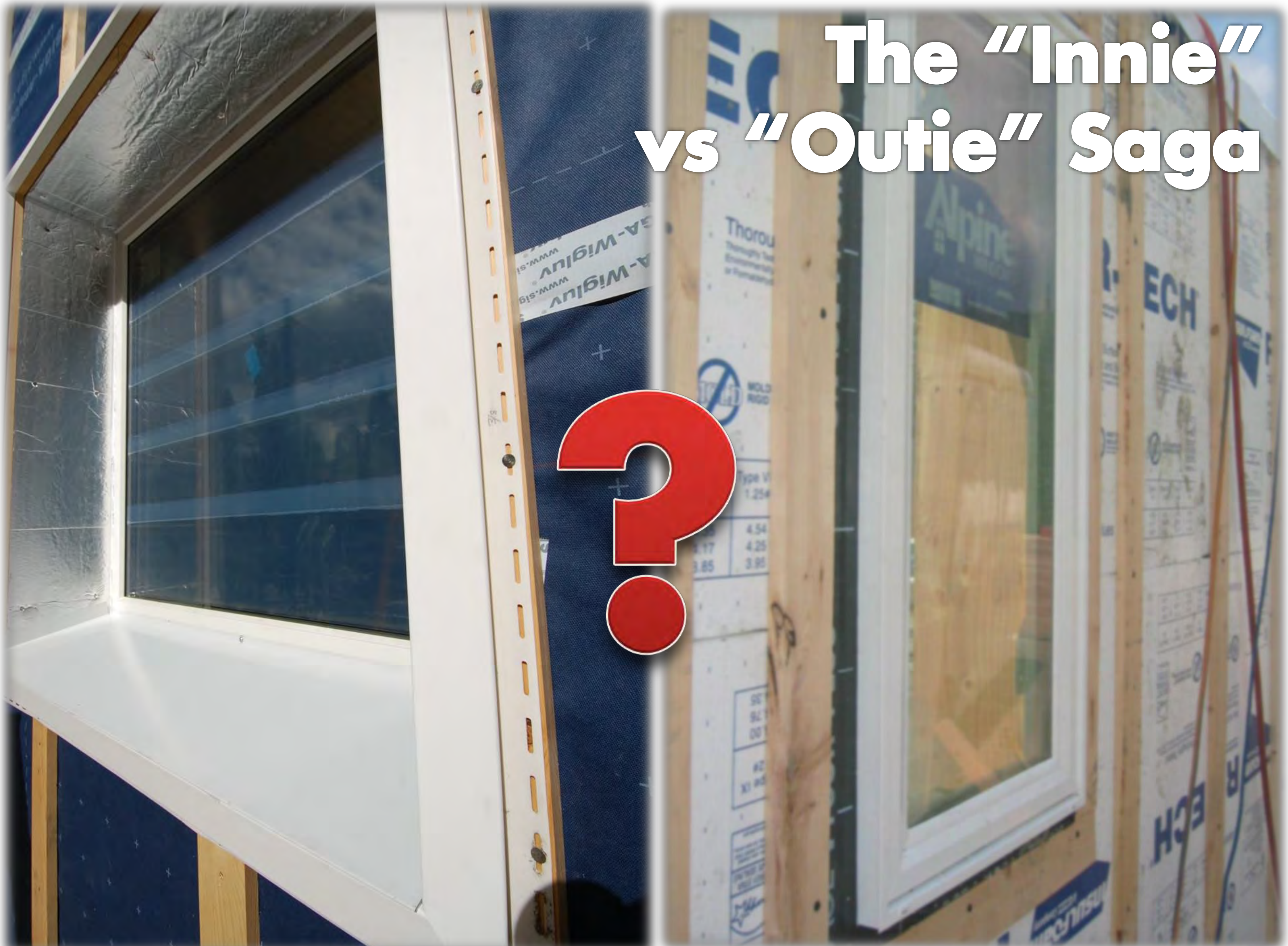
Conduction
Conduction occurs as adjacent molecules of gases or solids pass thermal energy between them. Conduction is minimized by adding layers to trap air spaces, and putting low-conductivity gases in those spaces. Frame conduction is reduced by using low-conductivity materials such as vinyl and fiberglass.

Courtesy: E source

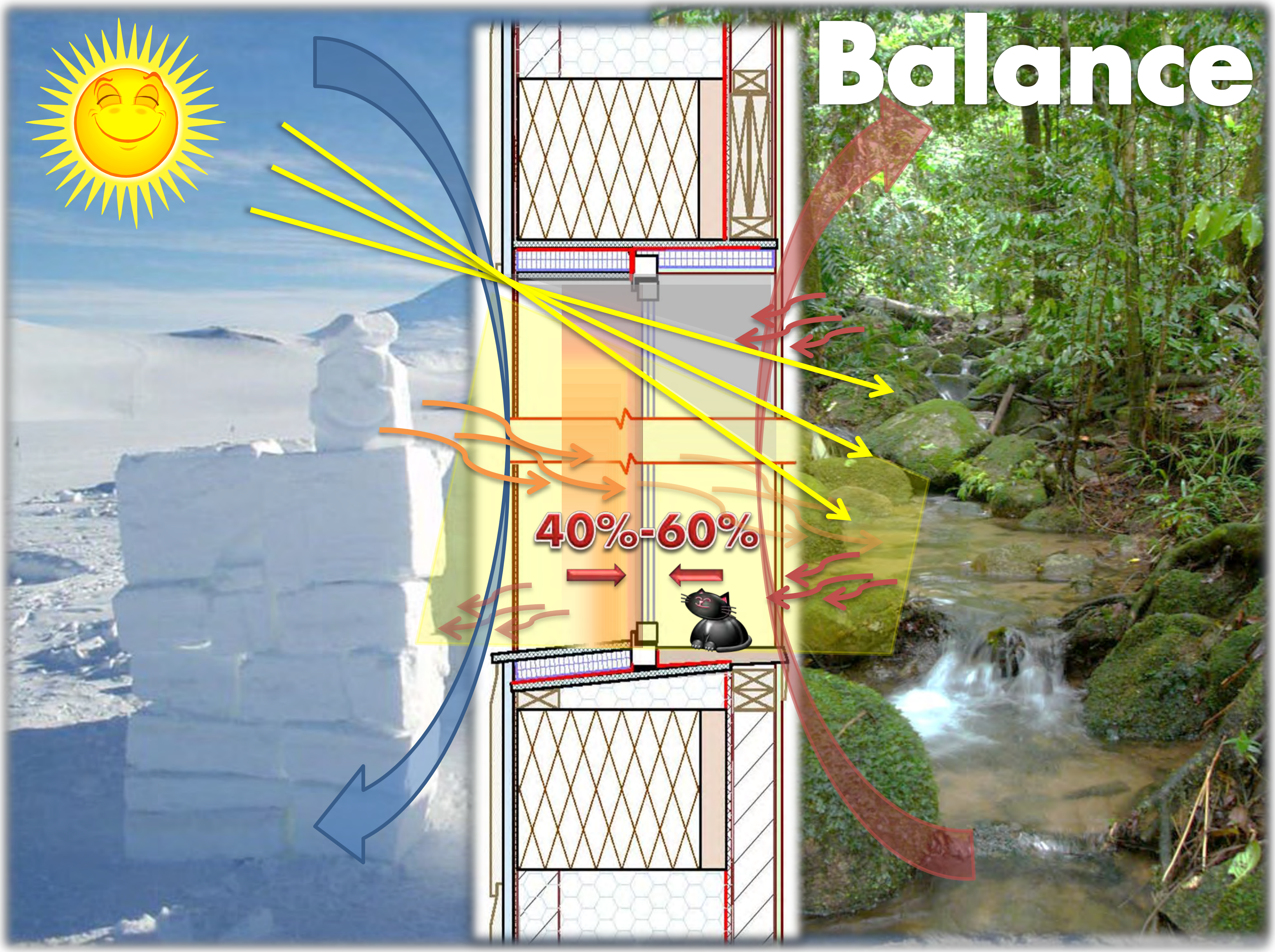
Maximize Passive Solar Gain

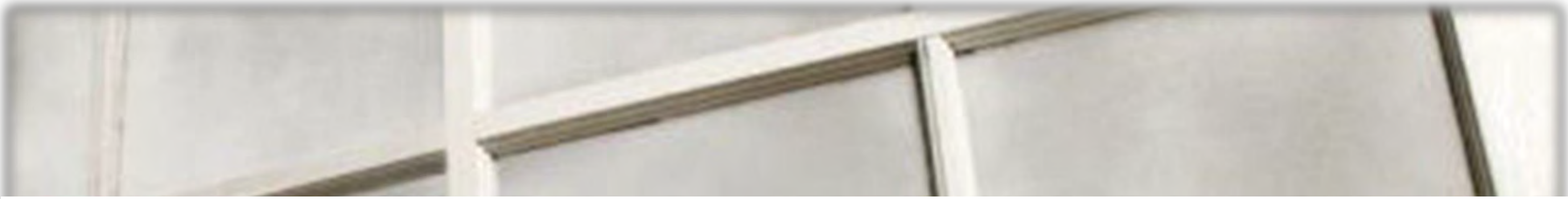



Clear Glass
Min 60% SHGC
NO North
windows


The "Innie"
vs "Outie" Saga
Alpine


Position
15 °C
12 °C
15 °C
20%
17,5 °C
12 °C
15 °C


Balance
40%-60%



Passive House Planning

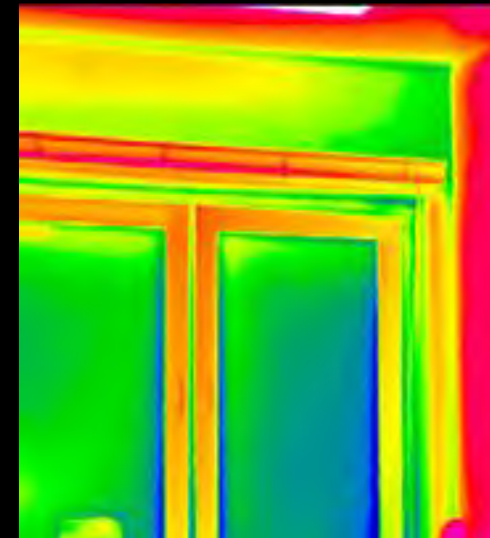
REDUCTION FACTOR SOLAR RADIATION, WINDOW U-VALUE

Annual Heat Demand: 4.33 kBTU/(ft²yr)

Heating Degree Days: 12056

raction	SHGC	Reduction Factor for Solar Radiation	Window Area	Window U-Value	Window R-Value	Glazing Area	Glazing Area as % of Gross	Average Global Radiation	Transmission Losses	Heat Gains Solar Radiation
			ft²	BTU/hr.ft².F	hr.ft².F/BTU	ft²		kBTU/ft²-yr	kBTU/yr	kBTU/yr
00	0.00	0.00	0.0	0.00	0.0	0.0	0.0%	17	0	0
28	0.63	0.43	48.3	0.18	5.7	35.2	2.7%	70	2470	921
50	0.63	0.66	242.1	0.12	8.4	205.8	15.9%	174	8301	17645
08	0.63	0.50	105.9	0.14	7.3	85.6	6.6%	87	4221	2878
00	0.00	0.00	0.0	0.00	0.0	0.0	0.0%	93	0	0
	0.63	0.59	396.3	0.13	7.6	326.6			14992	21443


Alpine

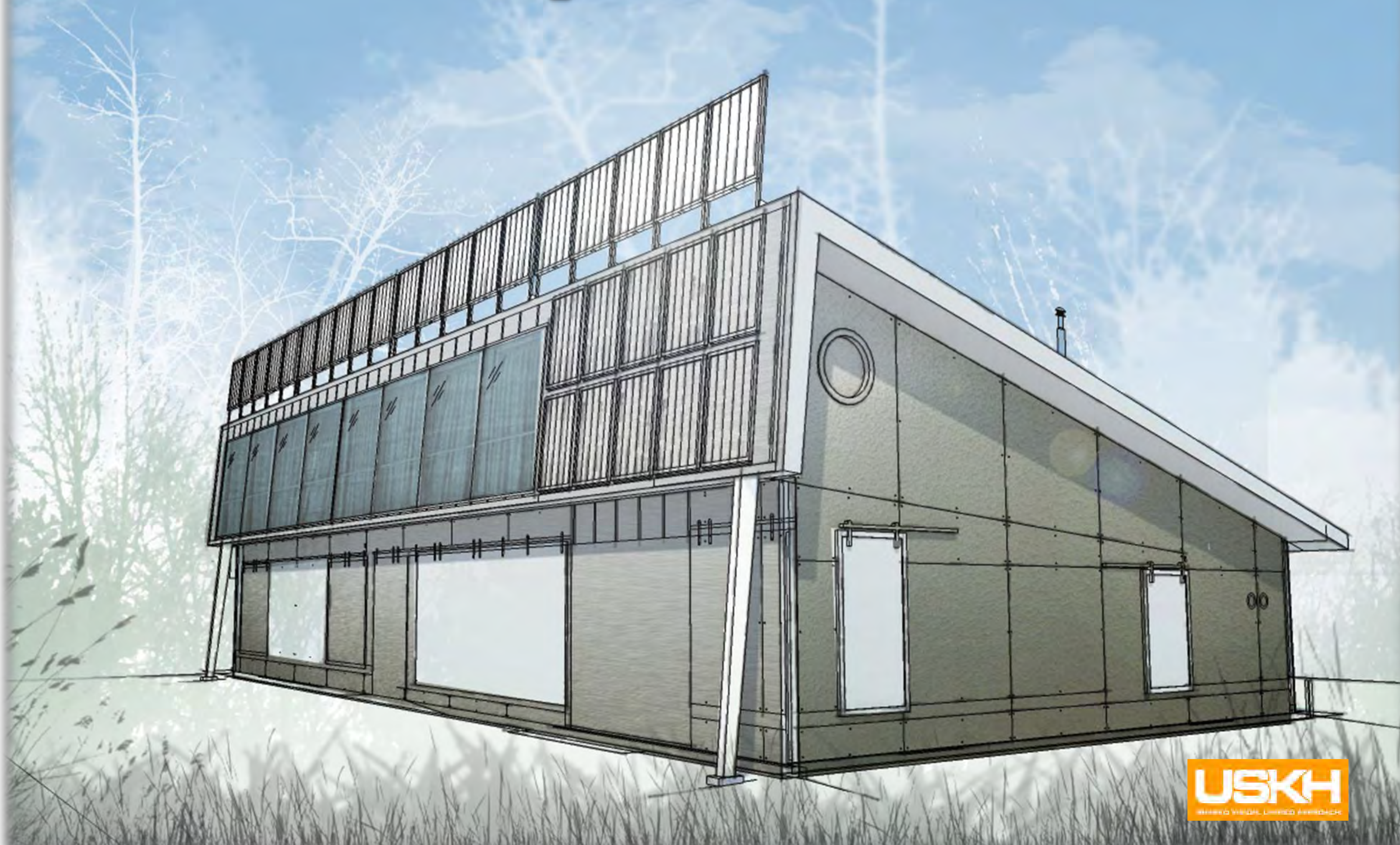


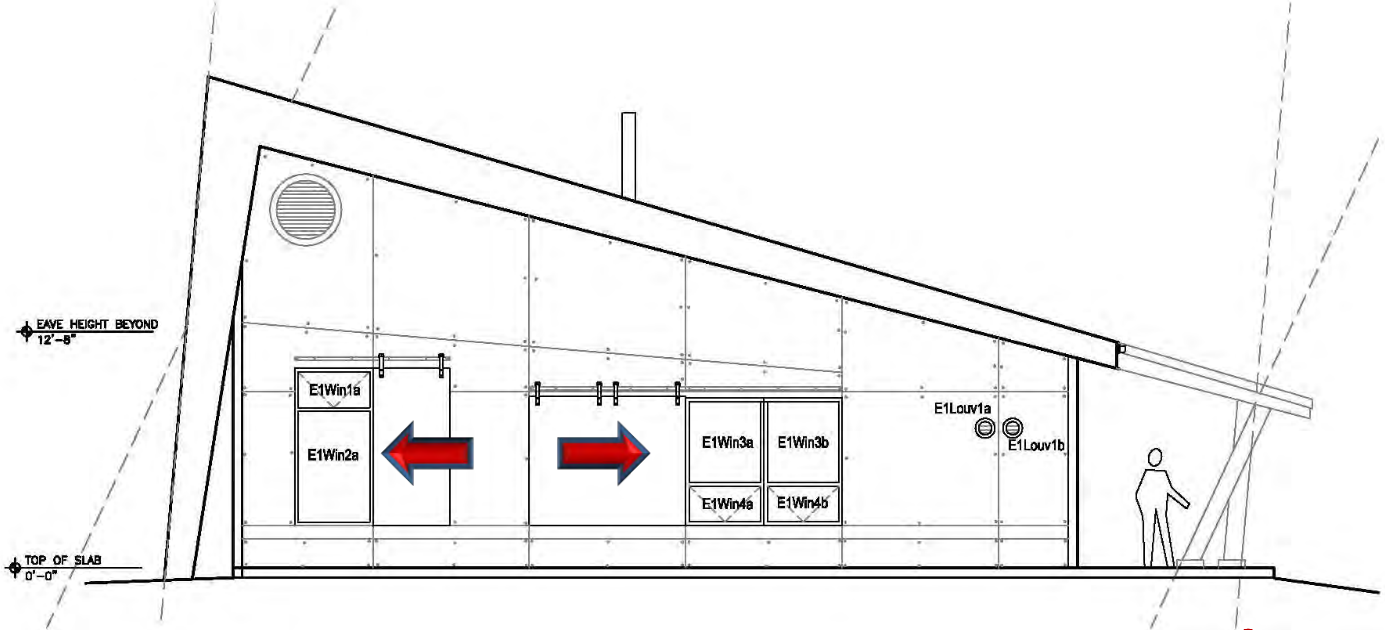
Please! **Inset &**

Over-insulate

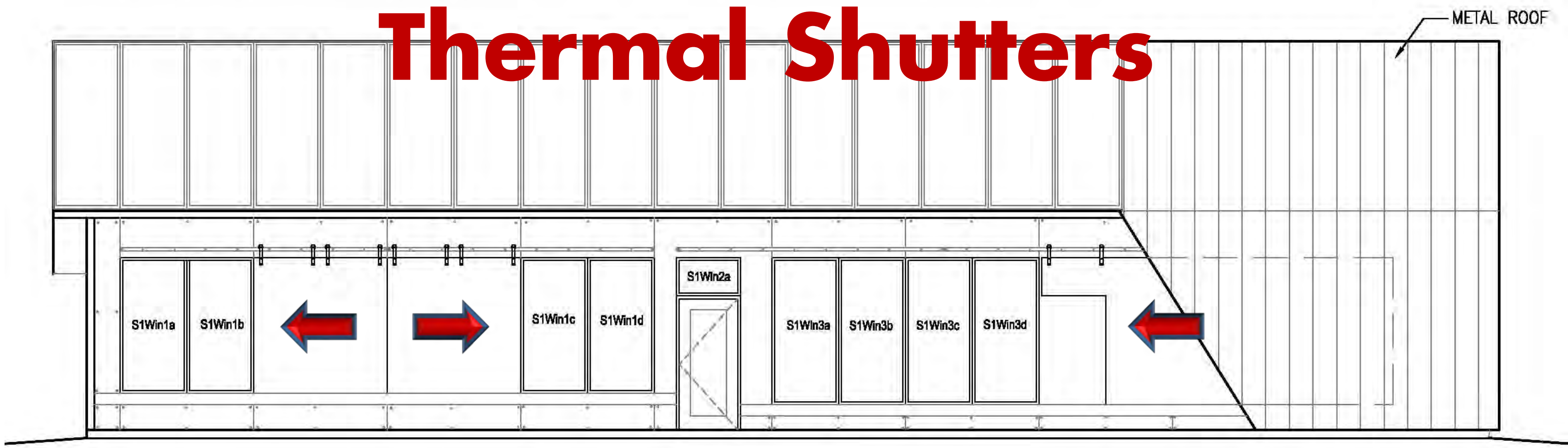
Thank you.

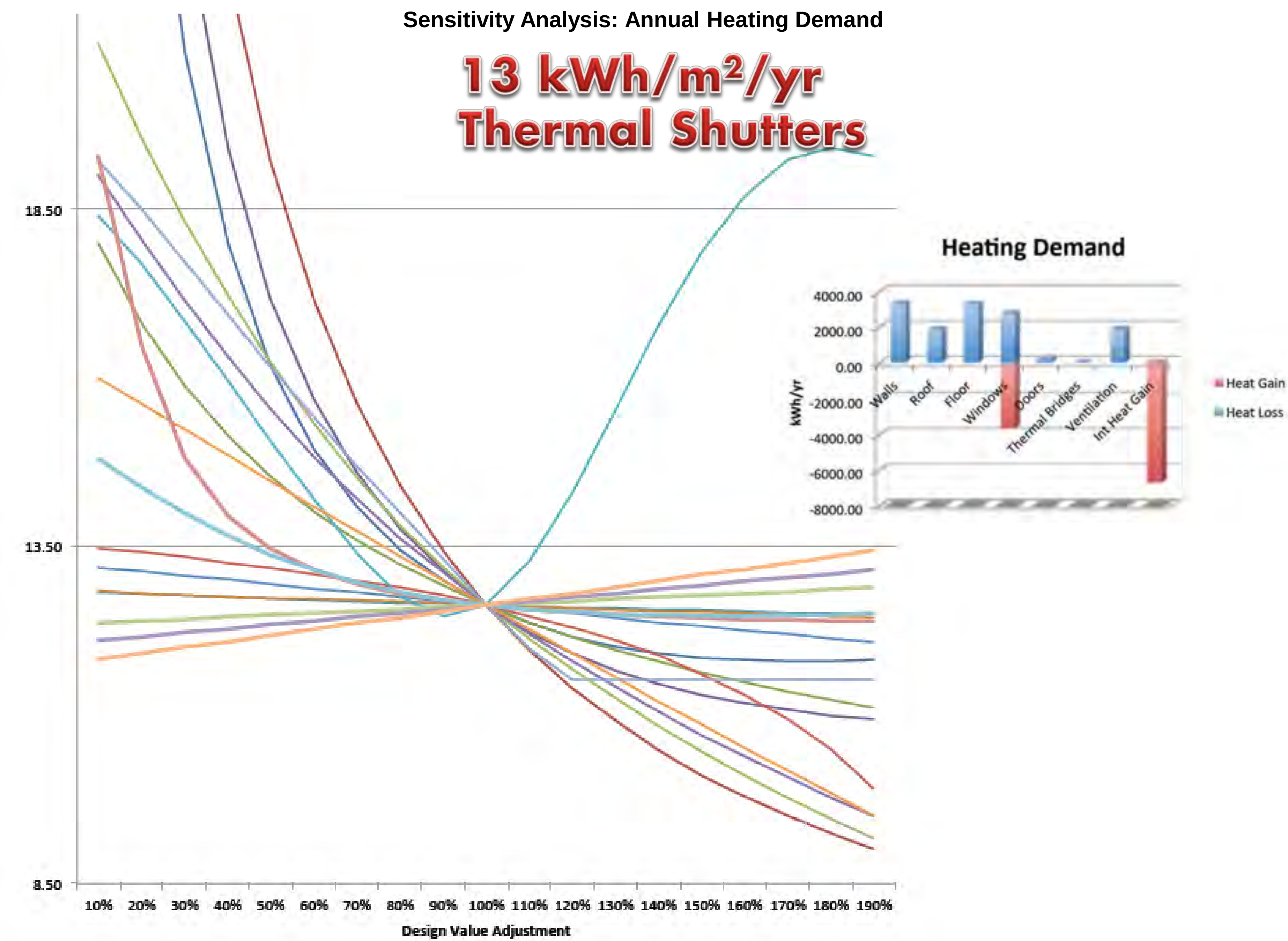
The John Trigg
Ester Library

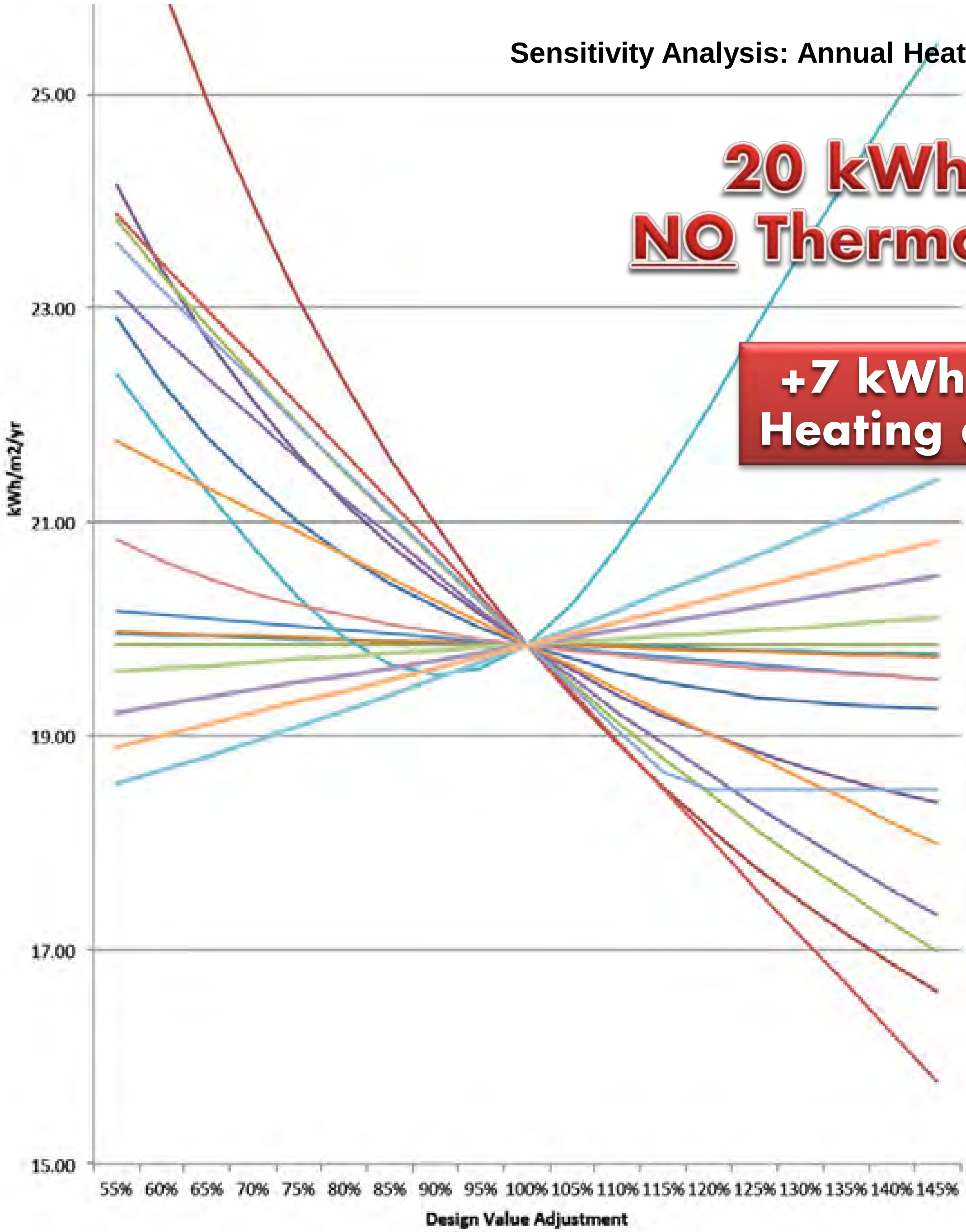


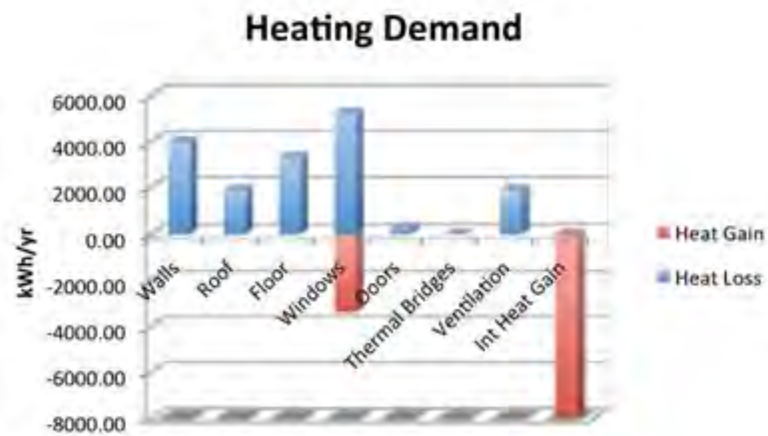


R-20 or U-0.05 Exterior Thermal Shutters




Sensitivity Analysis: Annual Heating Demand
13 kWh/m²/yr
Thermal Shutters
18.50
13.50
8.50
10% 20% 30% 40% 50% 60% 70% 80% 90% 100% 110% 120% 130% 140% 150% 160% 170% 180% 190%
Design Value Adjustment
Heating Demand
4000.00
2000.00
0.00
-2000.00
-4000.00
-6000.00
-8000.00
kWh/yr
Walls
Roof
Floor
Windows
Doors
Thermal Bridges
Ventilation
Int Heat Gain
Heat Gain
Heat Loss


Sensitivity Analysis: Annual Heating Demand
20 kWh/m²/yr
NO Thermal Shutters
+7 kWh/m²/yr
Heating demand
kWh/m2/yr
25.00
23.00
21.00
19.00
17.00
15.00
55% 60% 65% 70% 75% 80% 85% 90% 95% 100% 105% 110% 115% 120% 125% 130% 135% 140% 145%
Design Value Adjustment


Heating Demand
kWh/yr
6000.00
4000.00
2000.00
0.00
-2000.00
-4000.00
-6000.00
-8000.00
Walls
Roof
Floor
Windows
Doors
Thermal Bridges
Ventilation
Int Heat Gain
Heat Gain
Heat Loss

Thermal Shutters and PHPP

Thermal Shutter Calc for PHPP07

						Baseline 100%		Annual Average			Heating Season			Add Window		Assembly at 58%		
Shutter values	R/inch	inch	R-value	U-value	R-Airspace	%	Total R	Total U	%	Annual R	Annual U	%	Heating R	Heating U	Win-R	Win-U	S-Win-R	S-Win-U
Polyiso	6.5	2	13	0.0769	1.596	100%	14.596	0.0685	44%	6.4222	0.1557	58%	8.4657	0.1181	6.6600	0.1502	15.1257	0.0661
Polyiso	6.5	3	19.5	0.0513	1.596	100%	21.096	0.0474	44%	9.2822	0.1077	58%	12.2357	0.0817	8.3300	0.1200	20.5657	0.0486
Polyiso	6.5	3.5	22.75	0.0440	1.596	100%	24.346	0.0411	44%	10.7122	0.0934	58%	14.1207	0.0708	6.6600	0.1502	20.7807	0.0481
Polyiso	6.5	4	26	0.0385	1.596	100%	27.596	0.0362	44%	12.1422	0.0824	58%	16.0057	0.0625	6.2500	0.1600	22.2557	0.0449
Polyiso	6.5	6	39	0.0256	1.596	100%	40.596	0.0246	44%	17.8622	0.0560	58%	23.5457	0.0425	6.2500	0.1600	29.7957	0.0336
Air space	0.266	6	1.596	0.6266														

CITY	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Fairbanks	4:00	6:55	10:07	13:35	17:01	20:33	21:25	18:11	14:39	11:19	7:51	4:43
Daylight	4.00	6.55	10.07	13.35	17.01	20.33	21.25	18.11	14.39	11.19	7.51	4.43
Night	20.00	17.45	13.93	10.65	6.99	3.67	2.75	5.89	9.61	12.81	16.49	19.57
% darkness	83%	73%	58%	44%	29%	15%	11%	25%	40%	53%	69%	82%

% darkness	Annual Average	12 month	49%	44%
% darkness	Heating Season	8 month	63%	58%
% human factor	shutters not closed		5%	

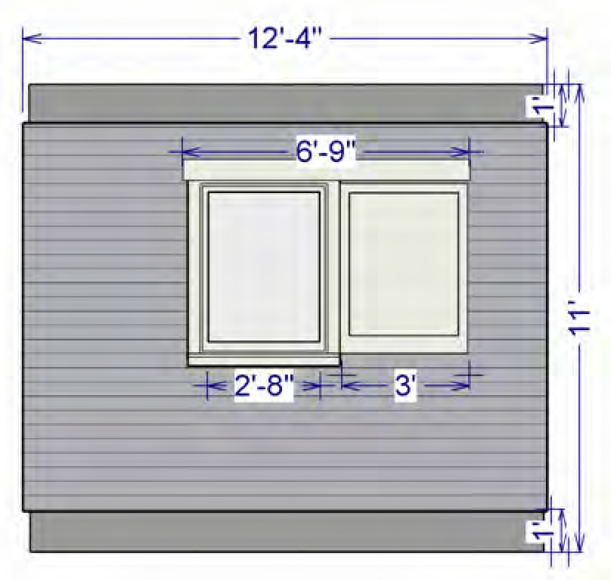
Figure:

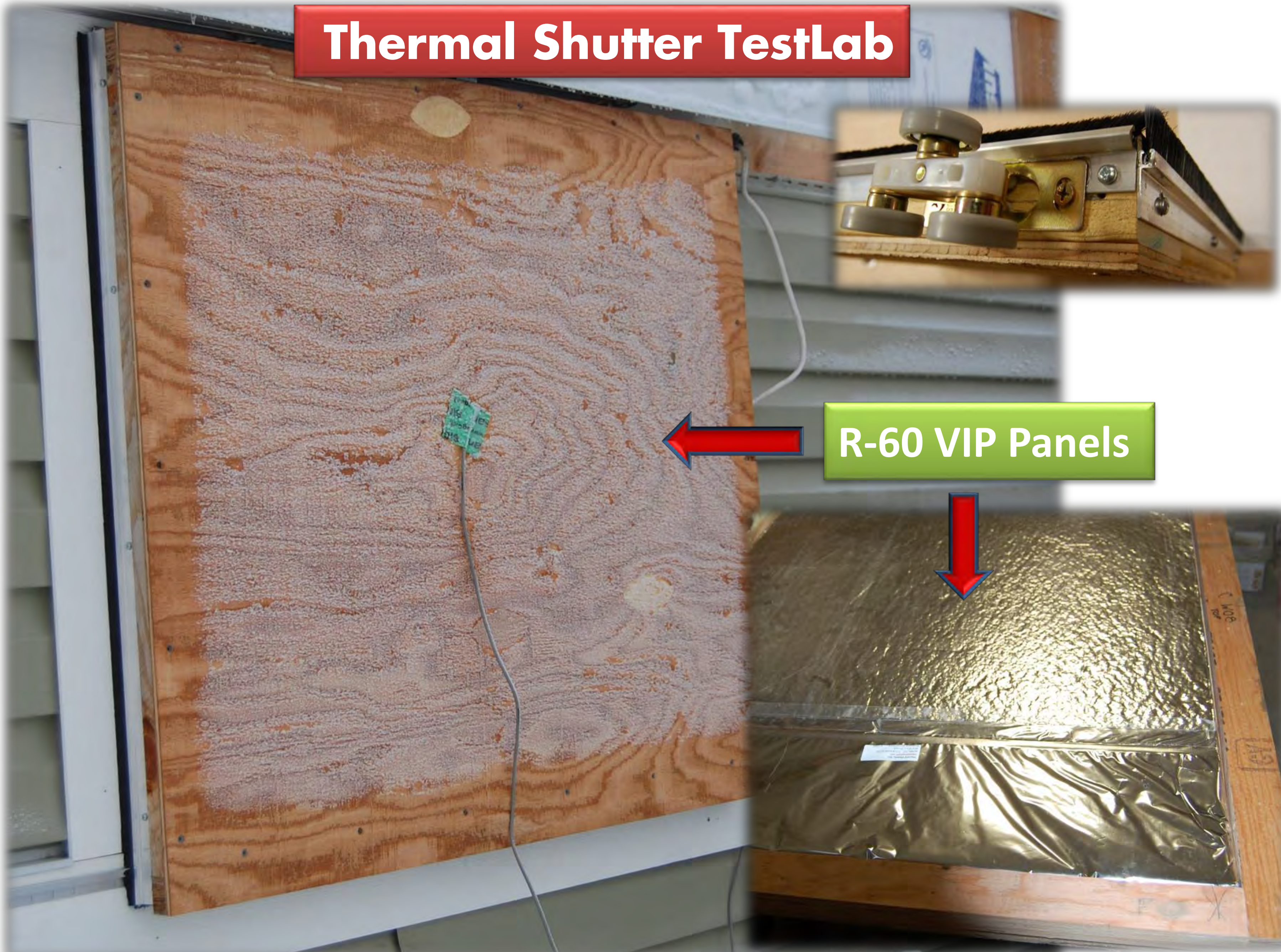
- U-Value of Thermal Shutter
- % darkness heating season
- % human factor
- Establish adjusted window u-value
- Use in PHPP window sheet

Thermal Shutter TestLab

<u>Thermal Shutter test LabBox</u>

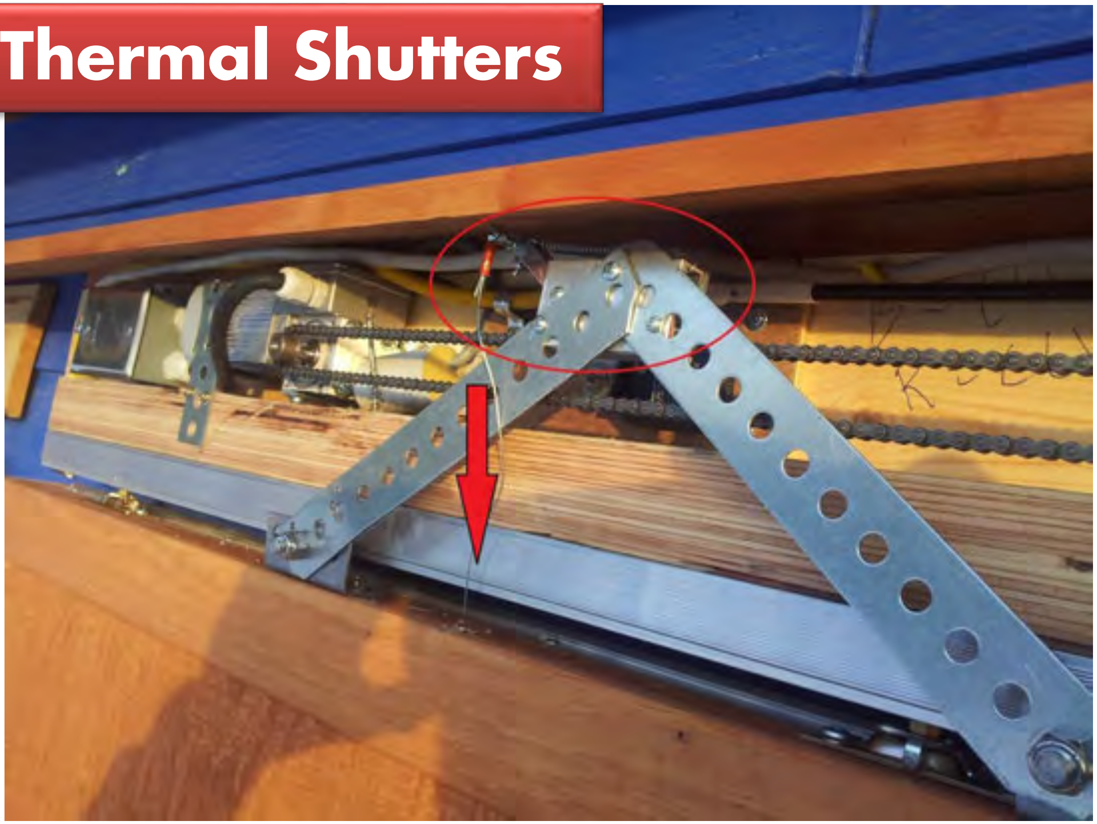
1) Framed Cube with 12" EPS Exterior Insulation at R-60 Floor, Walls and Roof
2) ALPINE Triple Pane casement window
3) Thermal Shutter on top and bottom tracks 3" Polyiso foam at R-20
4) Belt driven actuator with micro motor




Thermal Shutter TestLab
R-60 VIP Panels

Thermal Shutter R-60 VIPS

Exterior Thermal Shutters



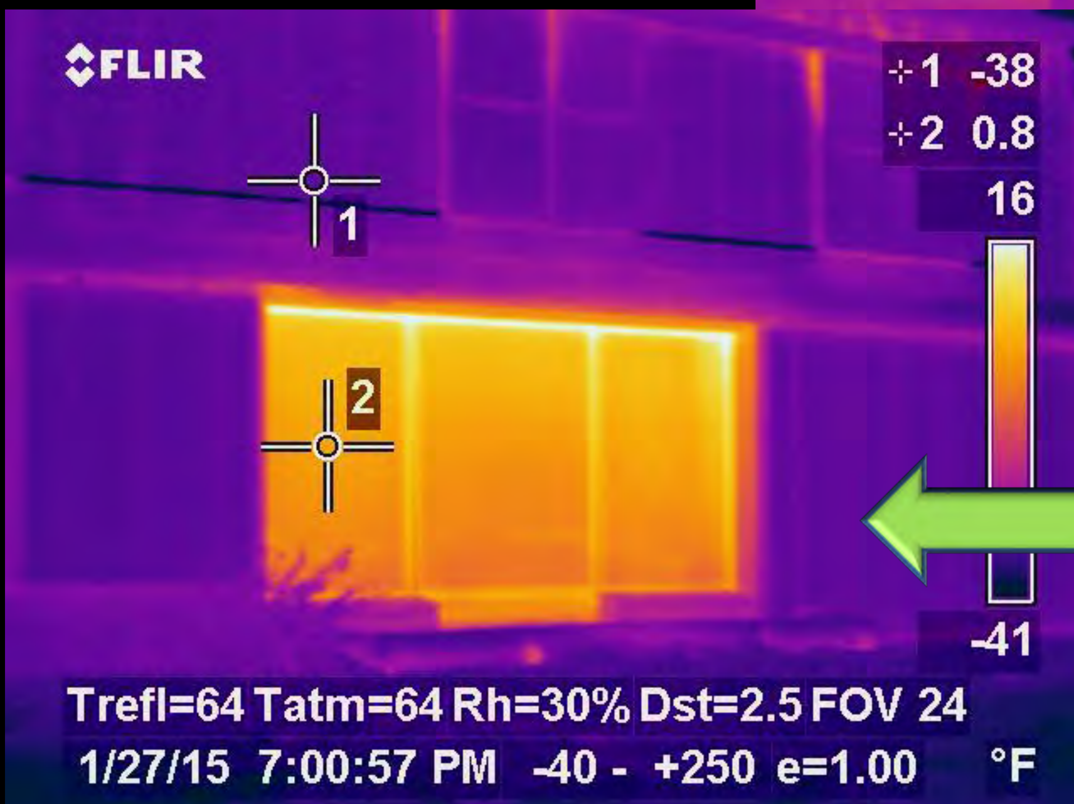
Thermal Blown-In Shutter – Installed

Thermal Blown-In Shutter – Installed

Thermal Blown-In Shutter – Installed

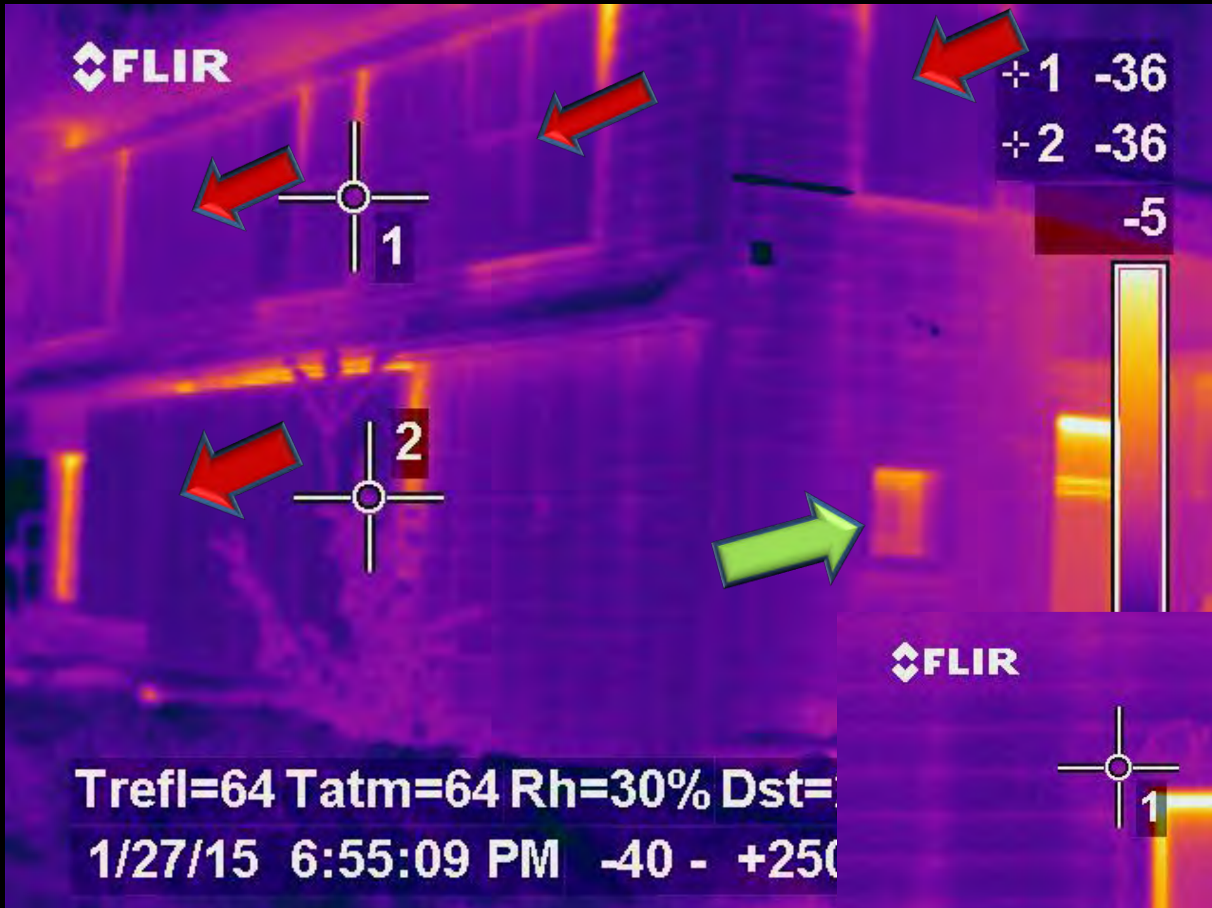
Thermal Shutters

Thermal Shutters @-40F



R-40 Shutter

Exterior Thermal Shutters



Interior Thermal Shutters

Interior Thermal Shutters function BUT:

Sealing/Icing issues

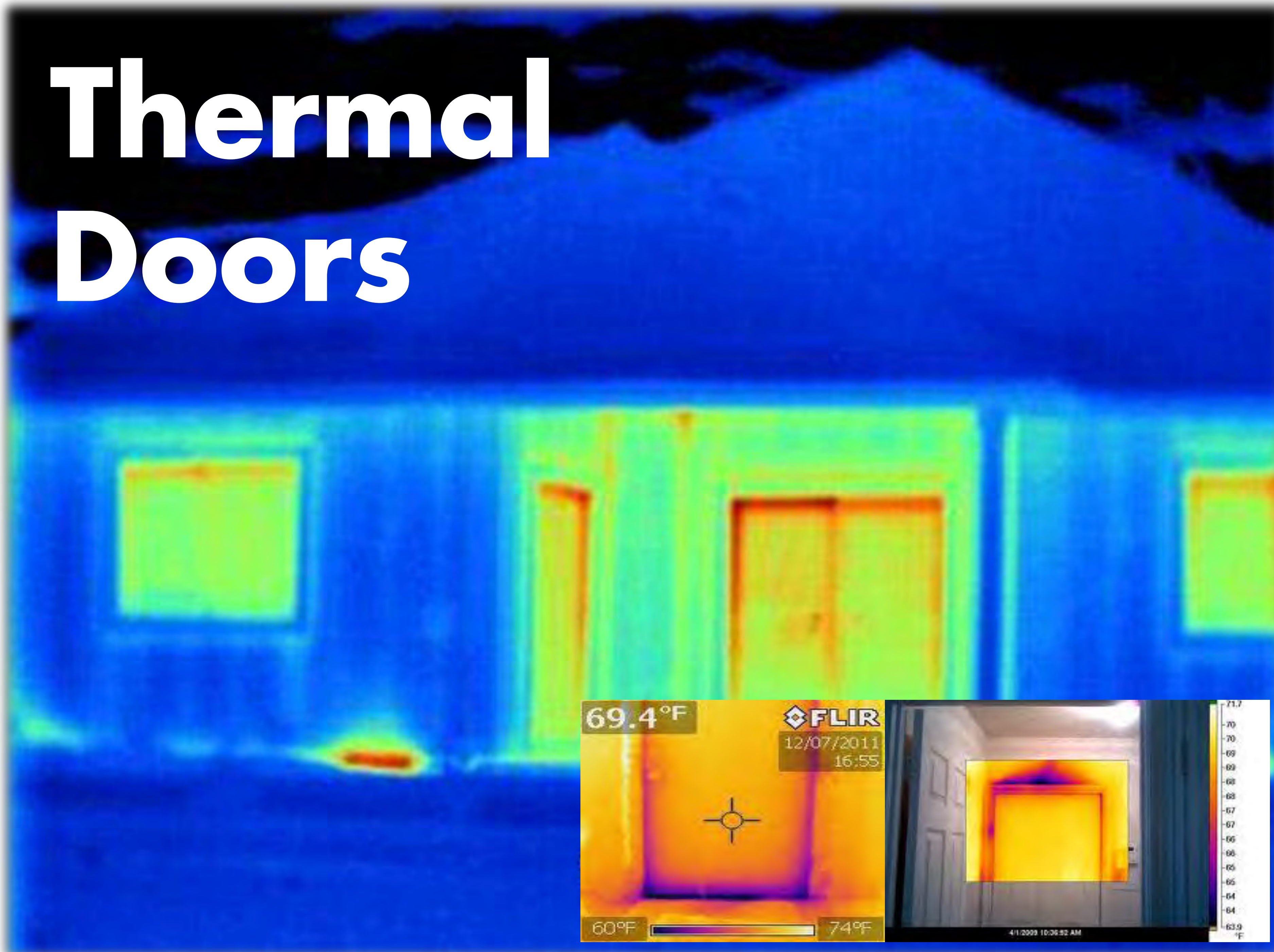
Proved difficult

Under-perform

Key Lesson: Shutters are the Key – but they need to be on the outside!


Weakest link
Windows
of the Assembly

Thermal Doors



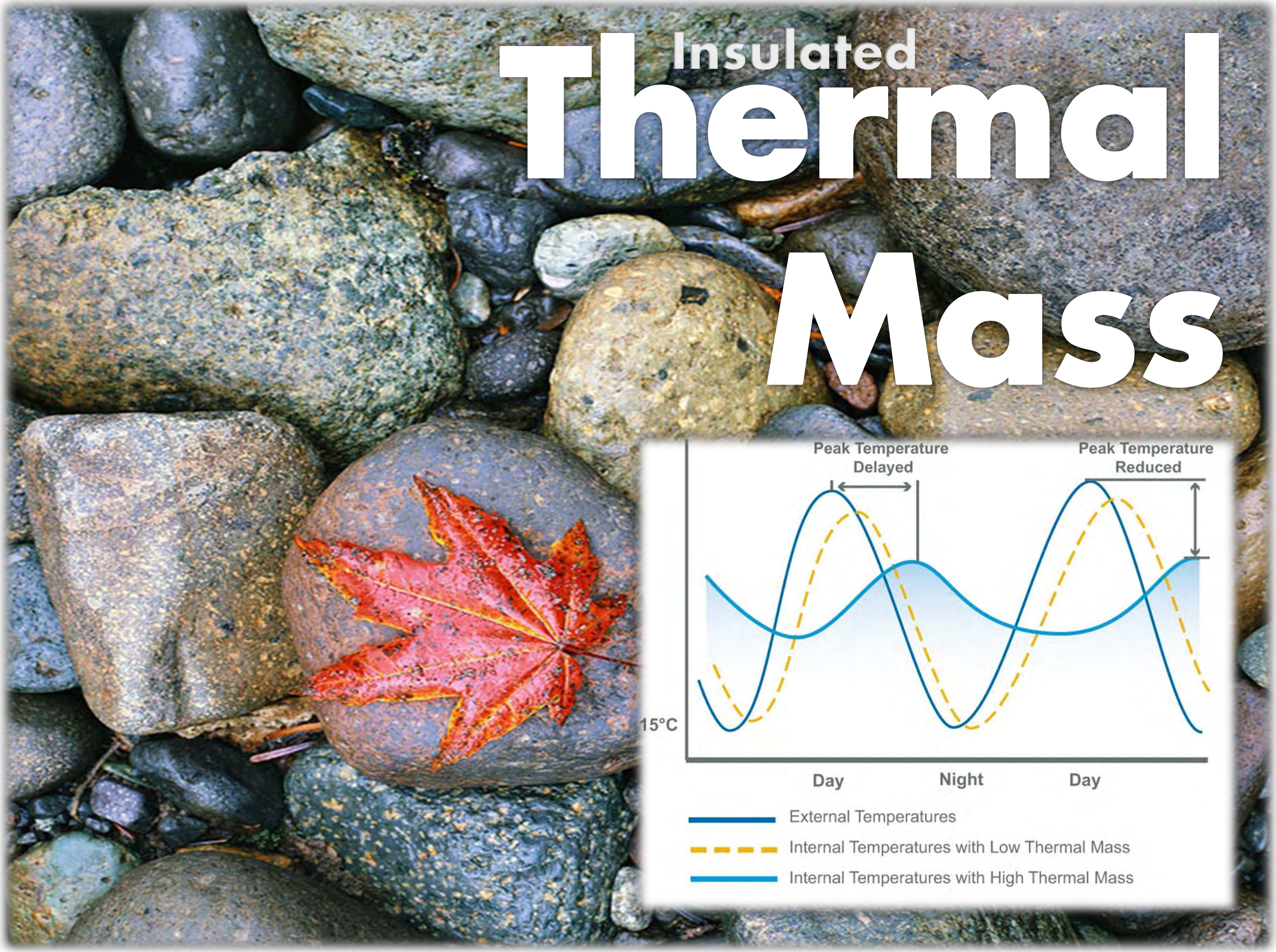
ARCTIC DOOR

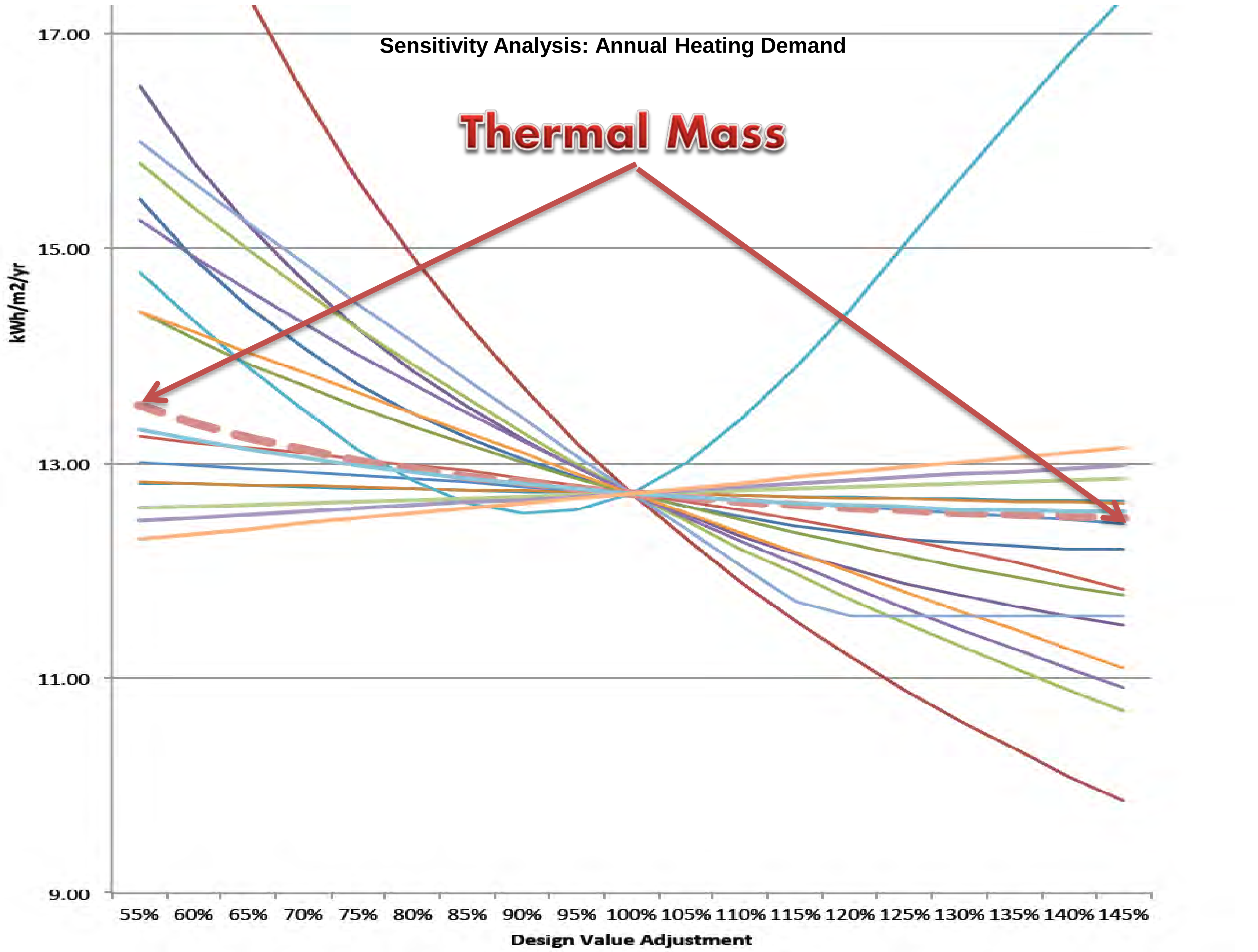
- All Fiberglass construction
- Airtight, 7 point lock system
- Double air sealing gasket
- R-60 Vacuum insulation core

- Mounted hinges on warm side of the door


R-60
Thermal Breaks

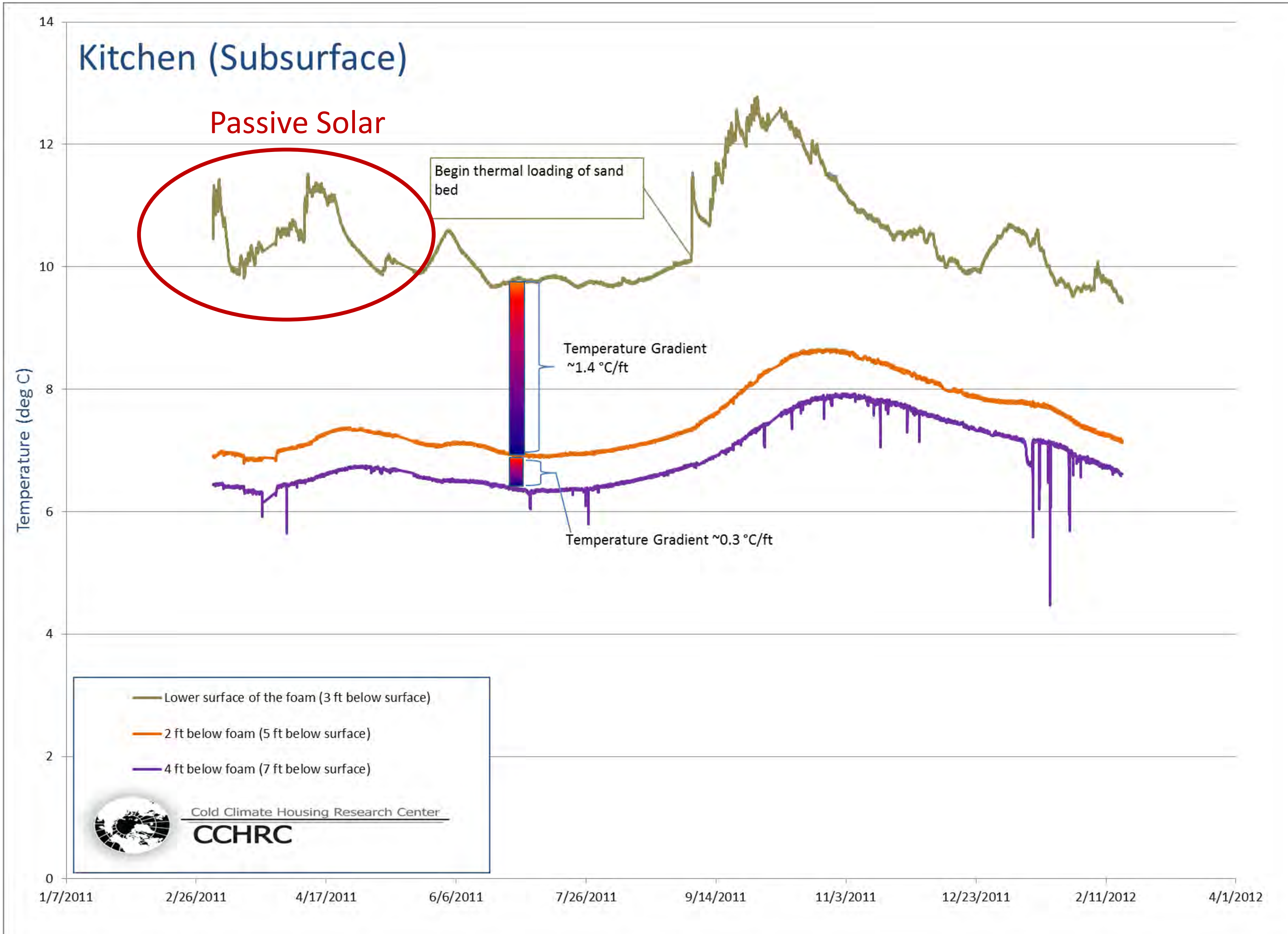

R-60
Thermal Breaks


Insulated
Thermal
Mass
Peak Temperature
Delayed
Peak Temperature
Reduced
15°C
Day
Night
Day
External Temperatures
Internal Temperatures with Low Thermal Mass
Internal Temperatures with High Thermal Mass


Sensitivity Analysis: Annual Heating Demand
Thermal Mass
kWh/m2/yr
17.00
15.00
13.00
11.00
9.00
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
105%
110%
115%
120%
125%
130%
135%
140%
145%
Design Value Adjustment

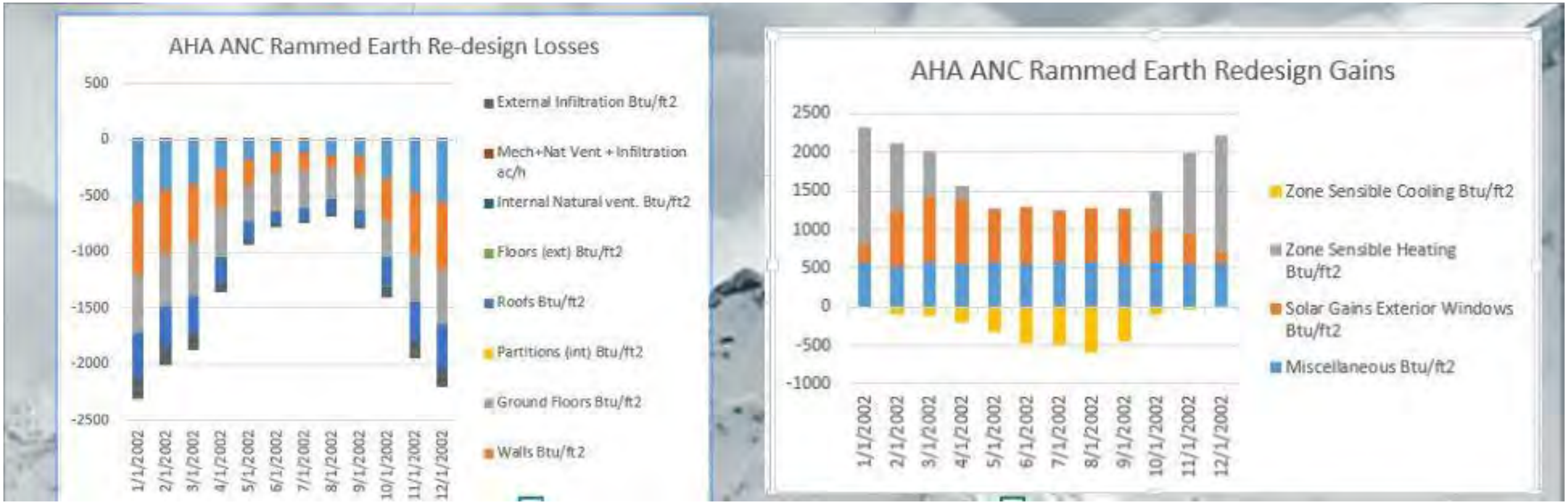

Solar Slab


Clear Glass
High Mass


Kitchen (Subsurface)
Passive Solar
Begin thermal loading of sand bed
Temperature Gradient ~1.4 °C/ft
Temperature Gradient ~0.3 °C/ft
Temperature (deg C)
14
12
10
8
6
4
2
0
1/7/2011
2/26/2011
4/17/2011
6/6/2011
7/26/2011
9/14/2011
11/3/2011
12/23/2011
2/11/2012
4/1/2012
Lower surface of the foam (3 ft below surface)
2 ft below foam (5 ft below surface)
4 ft below foam (7 ft below surface)
Cold Climate Housing Research Center
CCHRC

Modeling Thermal Mass

AHA Rammed Earth Case Study



PHPP = One BTU/lb-ft and static w/24hr avg temps

EPlus+WUFI = BTU/lb-ft per layer and dynamic w/hourly temps

Use the right tool for the job!

Modeling Thermal Mass

PHPP = wrong tool for the job!

ANNUAL HEAT DEMAND (AHD) BALANCE kBtu/ft2	10" EPS Redesign
E-PLUS LOSSES	-17.02
E-PLUS GAINS	13.79
E-PLUS AHD	-3.24
PHPP 2007 AHD	-6.85
PHPP 2012 AHD	-4.90
INCREASE HEAT LOSS vs E-PLUS	211.66%
INCREASE HEAT LOSS vs E-PLUS	71.53%

NOTES:

Per all modeling tools comfort criteria are met with SRE + 10" EPS

EPlus will show higher loads then the other 2 depending on "Design Day",

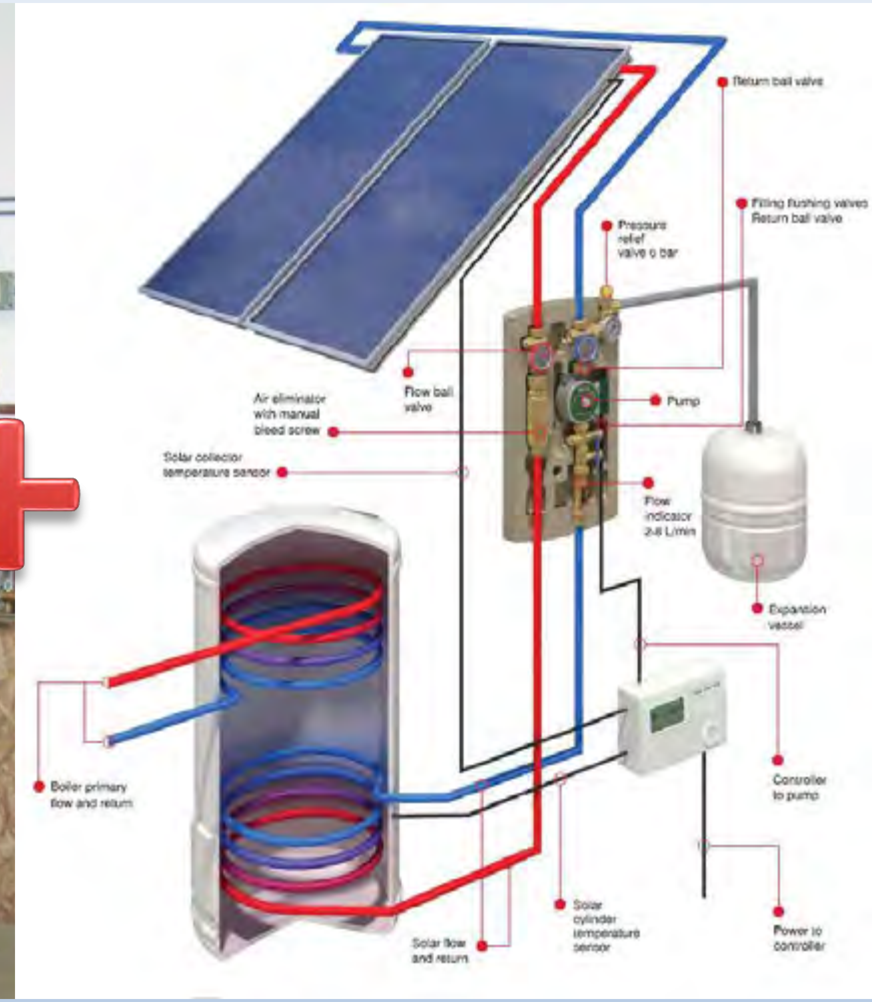
Project Meets PH under PHPP 2012 but not under PHPP 2007, even with plug loads and lighting completely itemized

WUFI Passive provides most granular results and does everything other 2 programs do

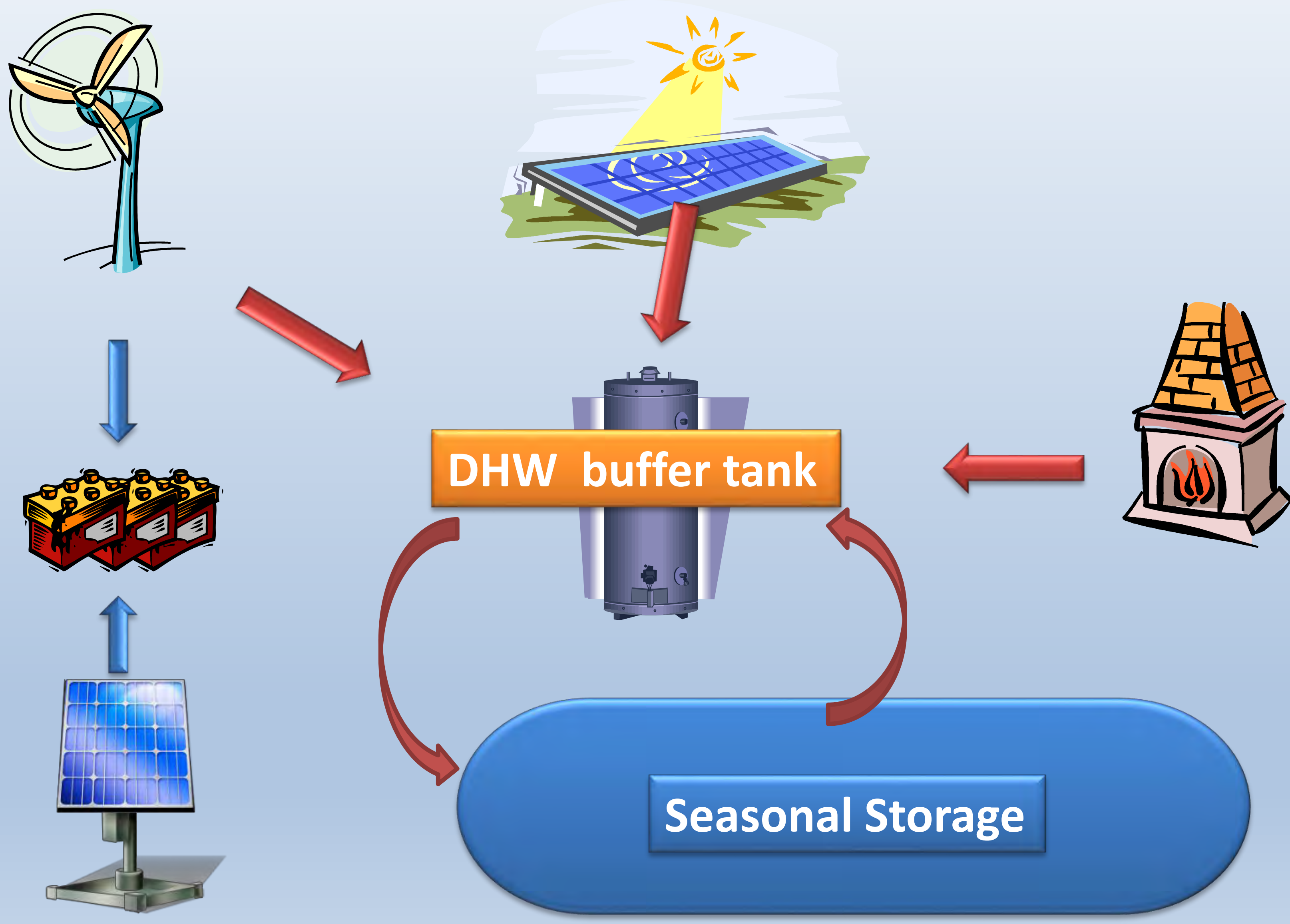
"Annual Heat Storage"

3 months without Sun

Solar Hot Water



Micro Hybrid Energy System for the Arctic



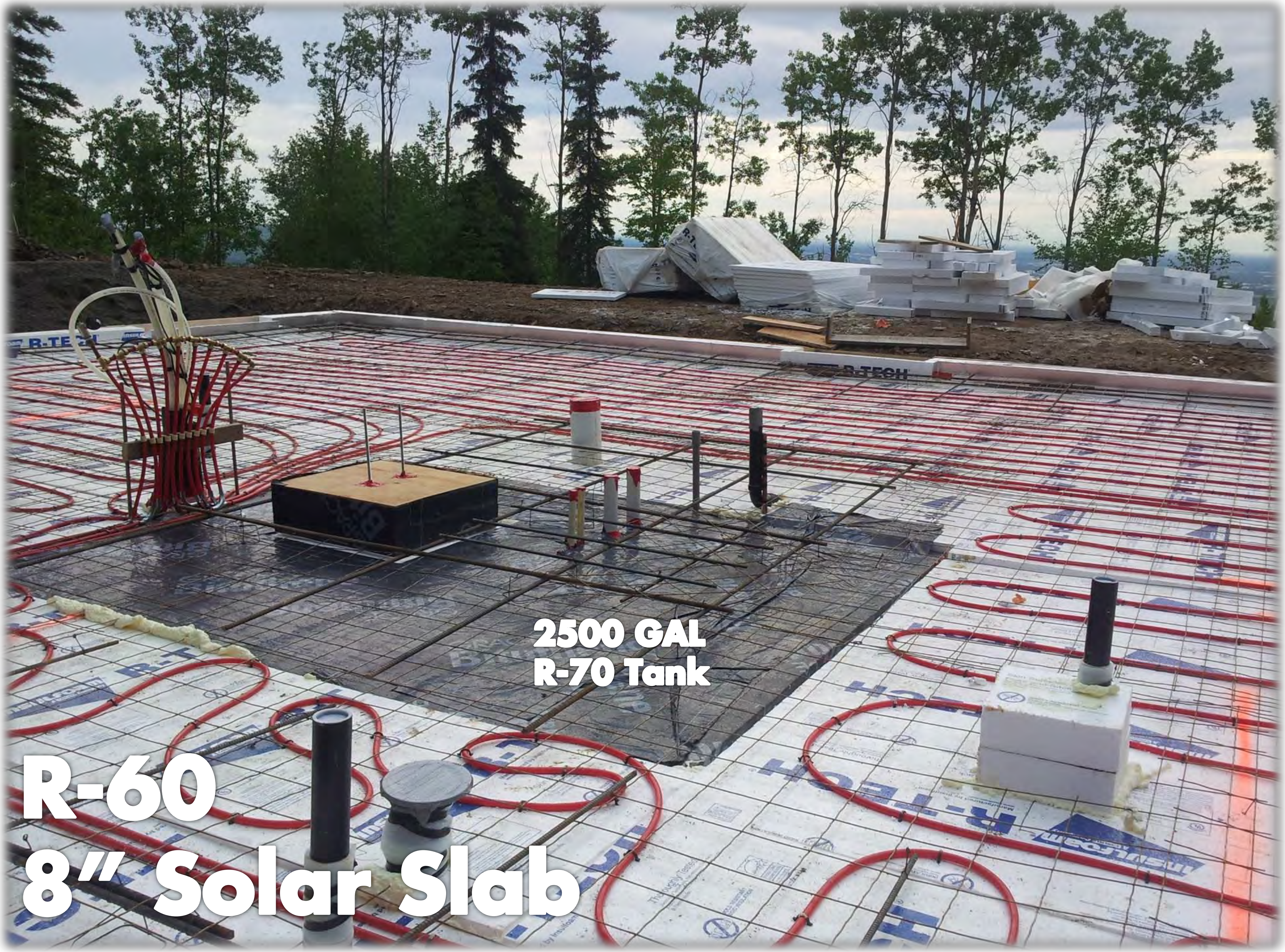

480 SF Thermal Collectors
Drainback System only!
Shoulder season is critical


Seasonal
Storage

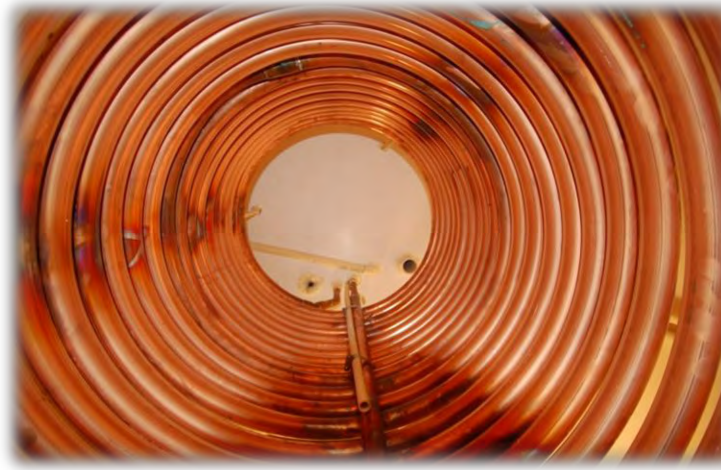

5000 GAL
~ 19.000 L
No PEX!
No physical connection in tank
Maybe coil over DHW tank
Virtual unlimited
Hot water
Excellent stratification

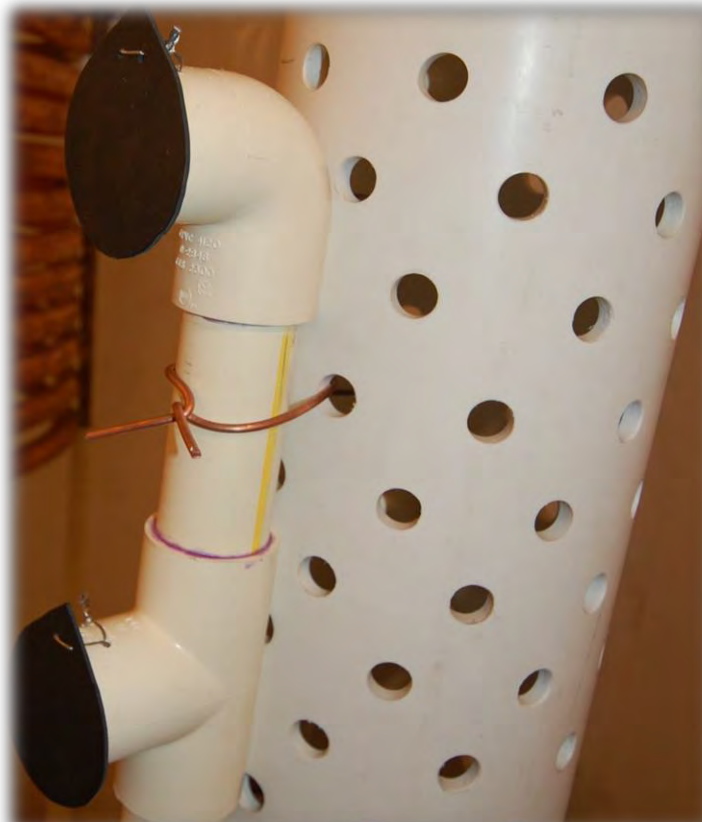
Thermal Energy
@ 48W

DHW Heating


2500 GAL
R-70 Tank
R-60
8" Solar Slab
R-TECH


12inch EPS
R-70 Tank
2500 GAL
Solar Storage Tank
EXIT



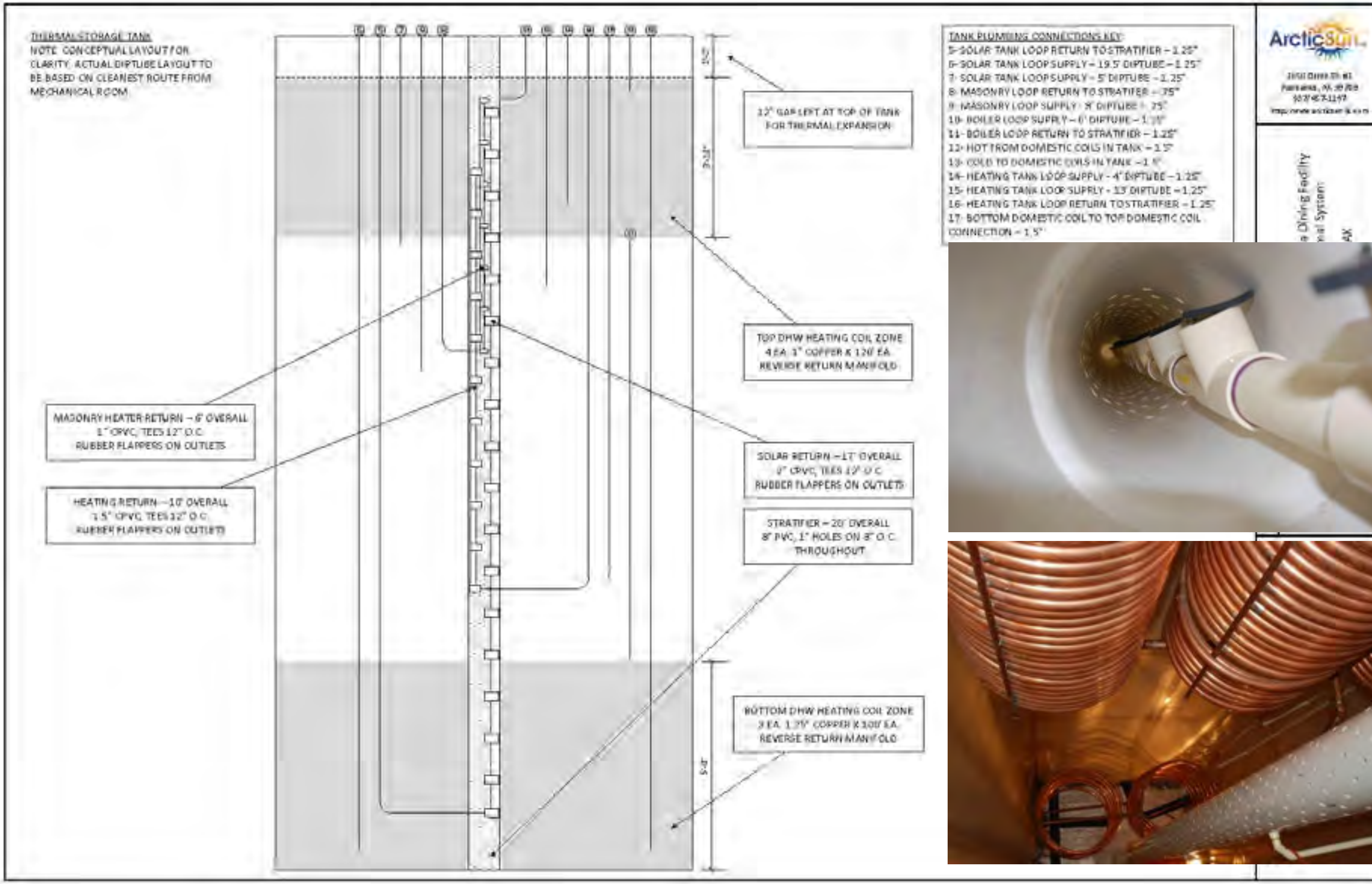



eco
SMART


Integral Solar
Heating System
10,000 GAL Storage

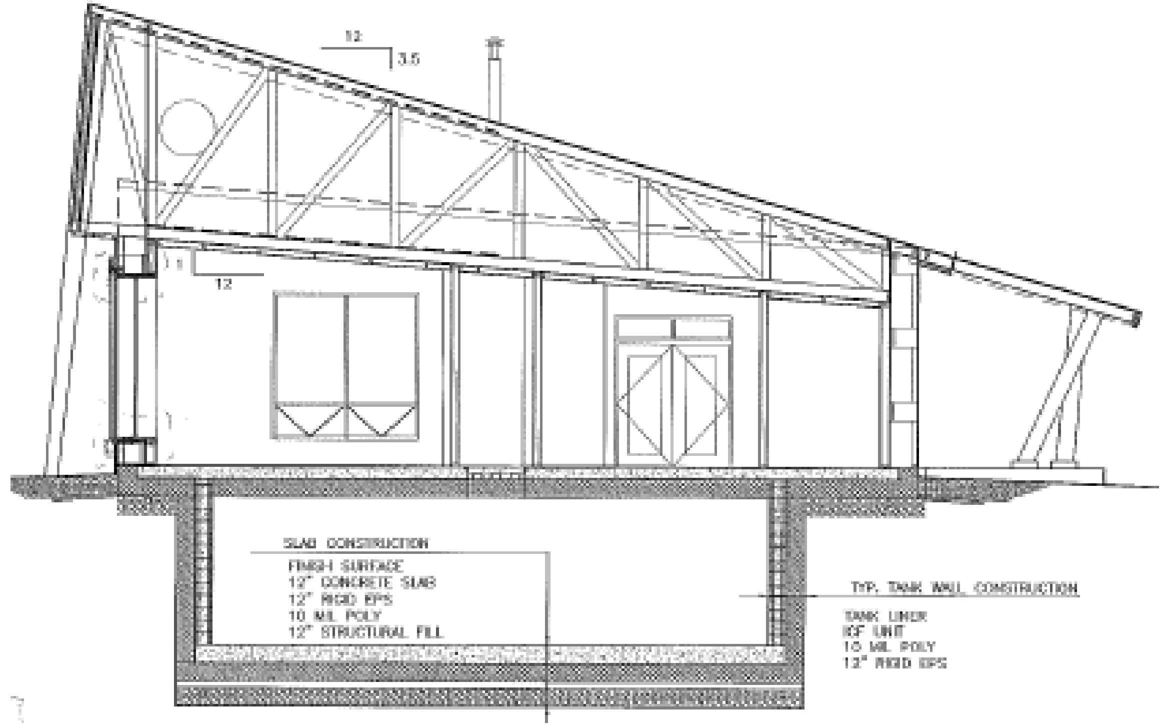


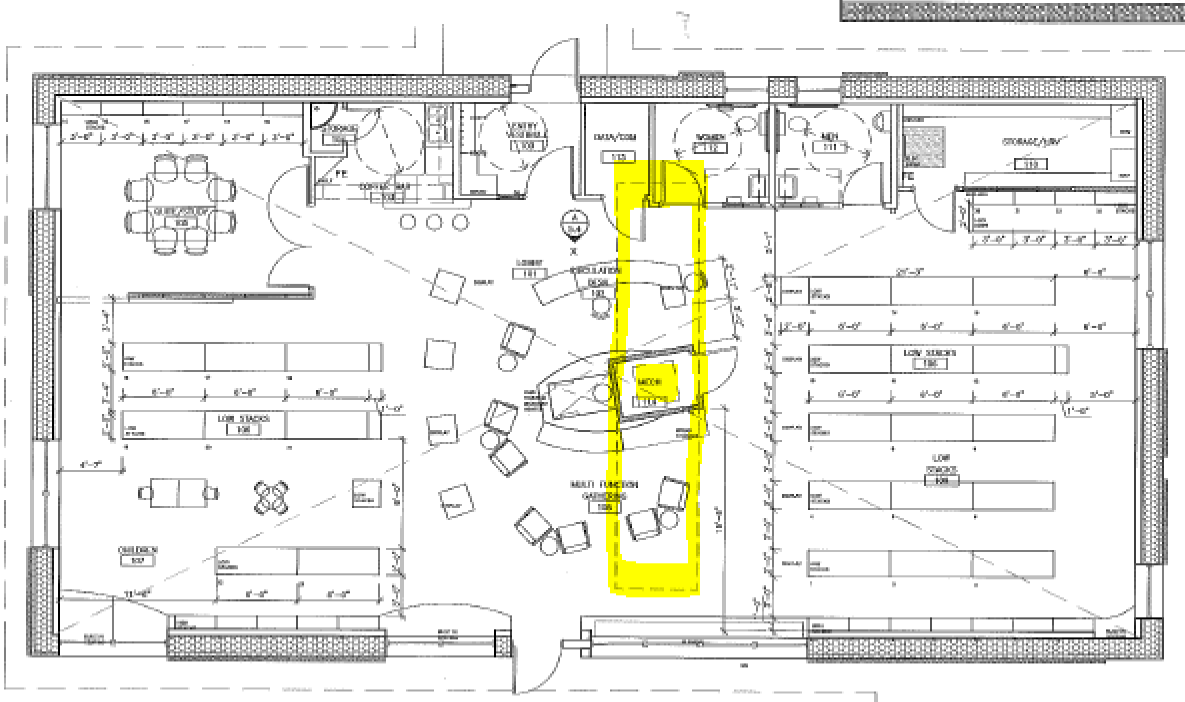

Integral Solar Heating System



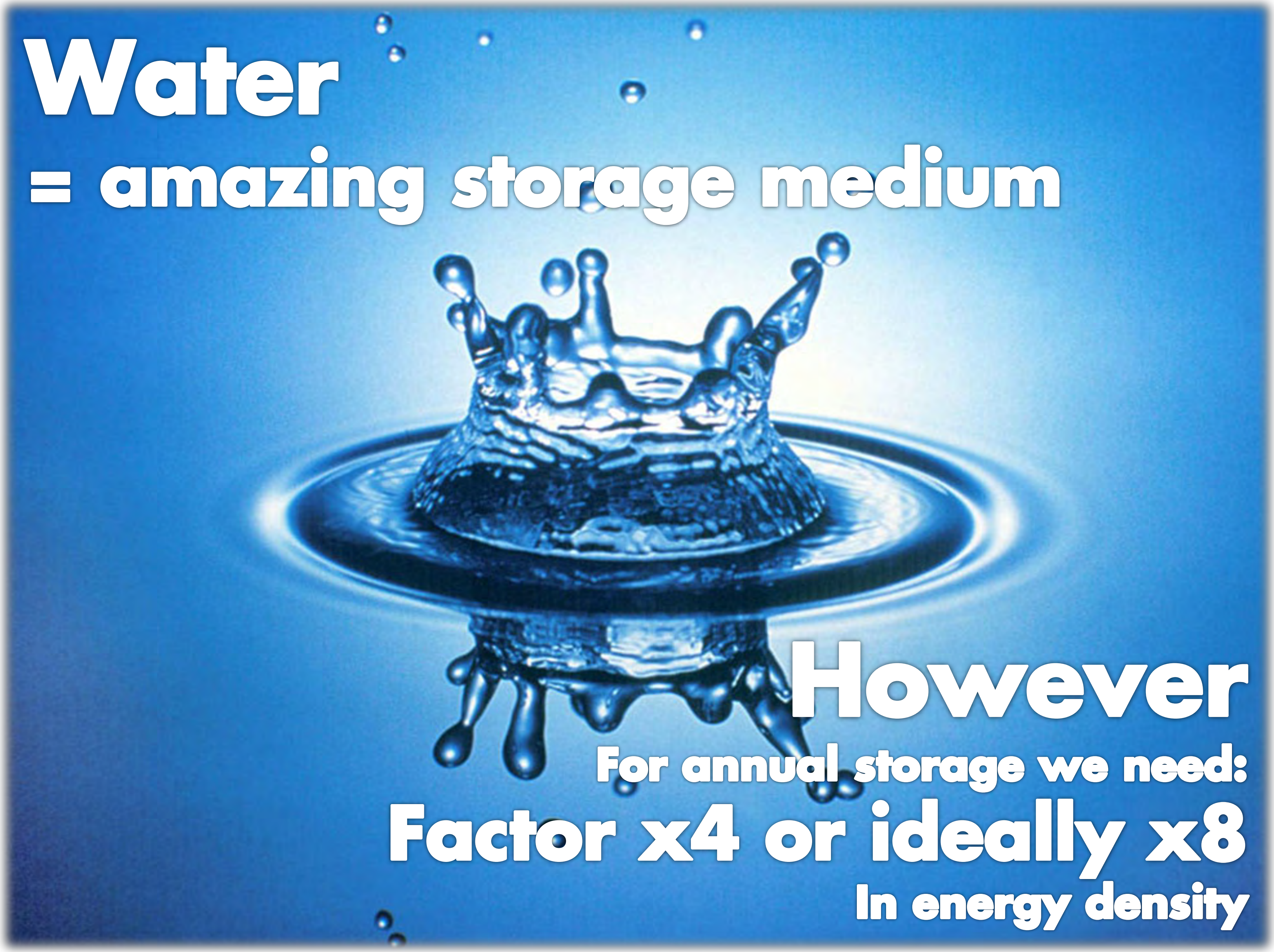

engaging the sun
RESOL

Heating dominated minimal DHW needs





14,000 Gal seasonal storage


Water
= amazing storage medium
However
For annual storage we need:
Factor x4 or ideally x8
In energy density

Water vs. Concrete as Thermal Storage Medium

Heat Capacity

- Water = 1.0 Btu/(° F * lb.)
- Concrete = 0.18 – 0.23 Btu/(° F * lb.)
- Dry Sand/Soil = 0.19 Btu/(° F * lb.)
- Wet Sand/Soil = 0.35 Btu/(° F * lb.)

Useful Absolute Temperature (for Space Heating)

- Water = approx. 100 ° F (180 ° F Max. / 80 ° F Min.)
- Concrete = approx. 10 ° F (80 ° F Max. / 70 ° F Min.)

Usable, Recoverable Storage (for Space Heating)

- 1 lb. Water ≈ 50 lb. Concrete
- 1 ft^3 Water ≈ 20-30 ft^3 Concrete

New Controller - RESOL MX

- 18 independent relays (w/ EM module)
- Variable speed control of all pumps
- Manual adjustment of setpoints
- Visual readout of all realtime values
- Integrated energy monitoring
- Add-on datalogger
- Web based access from anywhere in world
- Literally unlimited expansion capability with extension modules

Data

Data

Download

Erase

Customize

State

General

Network

Remote Access

Device Config

General

Network

Remote Access

Users

About

General

Powered by

History

Links

Kassel System Live

VBus 0: DeltaSol MX [Regler]

Garage Collector Temperature	93.2 °F
Seasonal Tank Bottom Temperature	151.7 °F
Seasonal Tank Top Temperature	153.0 °F
Garage Array Supply Temperature	106.7 °F
Garage Array Return Temperature	89.1 °F
Seasonal Tank Supply Temperature	142.0 °F
Garage Array Heat Exchanger Temperature	143.6 °F
Roof Collector Temperature	119.8 °F
Preheat Tank Bottom Temperature	113.7 °F
Preheat Tank Top Temperature	121.5 °F
Roof Array Supply Temperature	112.5 °F
Roof Array Return Temperature	109.2 °F
Outdoor Ambient Temperature	63.3 °F
Irradiance Meter	124 W/m²
Seasonal Tank Return Temperature	151.7 °F
Garage Array Flowrate	0.00 gal/min
Roof Array Flowrate	0.29 gal/min
Seasonal Tank Flowrate	0.00 gal/min
Garage Array Pump	0%
Seasonal Tank Pump	0%
Roof Array Pump	0%
Preheat Tank Pump	0%
'C' Pump	0%
'Bosch' Pump	0%
'B' Pump	0%
Bosch 3 Port Valve	0%
'A' Pump	0%
System date	2013-07-16 15:16:42

VBus 0: DeltaSol MX [Module]

Domestic Tank Top Temperature	149.4 °F
Domestic Tank Bottom Temperature	133.5 °F

VBus 0: DeltaSol MX [WMZ #1]

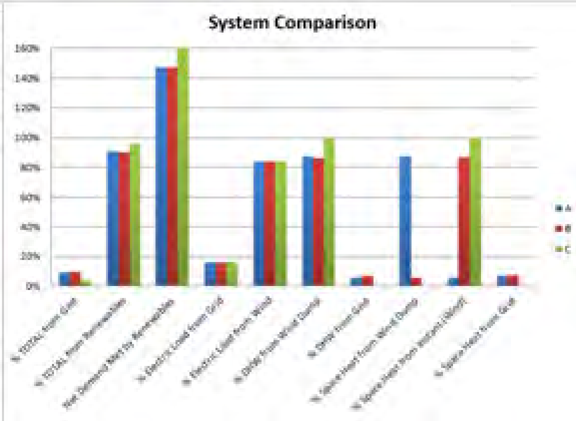
Heat quantity	245045.38 BTU
Heat quantity today	0.00 BTU
Heat quantity week	2456.73 BTU

VBus 0: DeltaSol MX [WMZ #2]

Heat quantity	54843.13 BTU
Heat quantity today	0.00 BTU
Heat quantity week	0.00 BTU

System Design and Sensitivity Analyses

NO payback from the utility in Rural Alaska. Grid Tied Zero Energy approach results still in high cost for occupants…



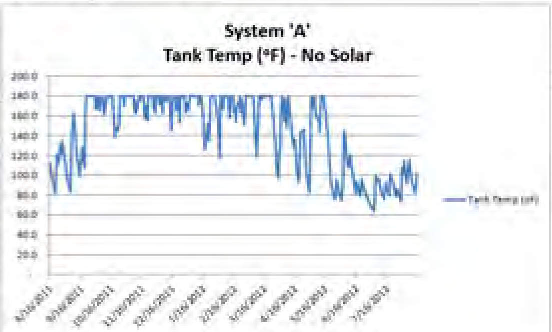
SYSTEM COMP	A	B	C
% TOTAL from Grid	9.02%	9.51%	4.24%
% TOTAL from Renewables	90.98%	90.49%	95.76%
Net Demand Met by Renewab	147.06%	147.06%	160.60%
% Electric Load from Grid	16.01%	16.01%	16.01%
% Electric Load from Wind	83.99%	83.99%	83.99%
% DHW from Wind Dump	87.60%	86.41%	99.77%
% DHW from Grid	5.97%	6.74%	0.04%
% Space Heat from Wind Dun	87.56%	5.86%	0.10%
% Space Heat from Instant (W	5.49%	86.62%	99.89%
% Space Heat from Grid	6.95%	7.52%	0.02%
PE Factor Electric	1.27	1.27	1.27
PE Factor DHW-Electric	1.10	1.11	1.00
PE Factor Heat Electric	1.12	1.13	1.00
0	0.00	0.00	31.20

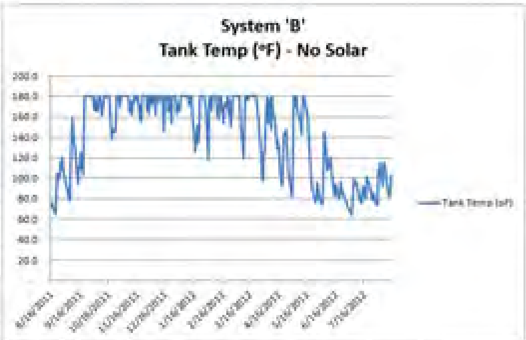
SYSTEM

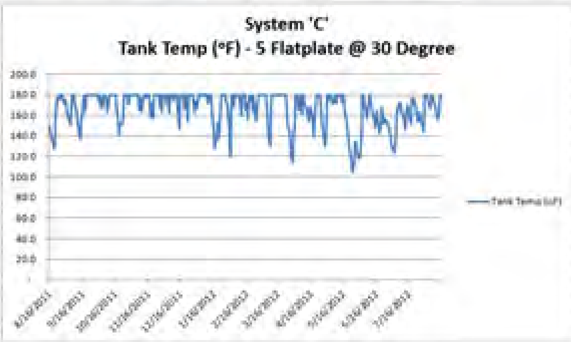
Electric Rate	$	0.87
Seasonal Tank Size		1000 (Gallons)
System 'A' Tanks Size		1000 (Gallons)
stem 'A' Average COP Derate:		1
Standby Loss Factor Sys 'A'		2

WIND

Tower Height	50 (ft)		
Wind Shear	0.28	(AEA Wind Shear)	0.298024



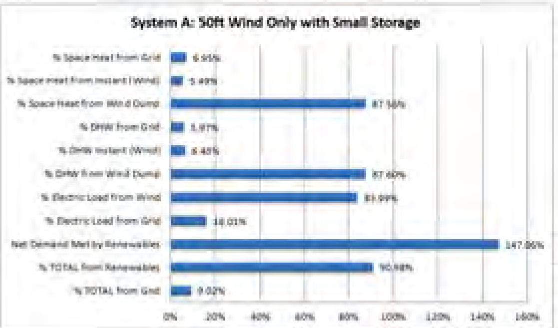


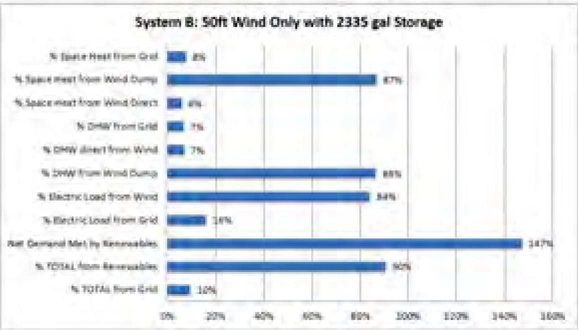


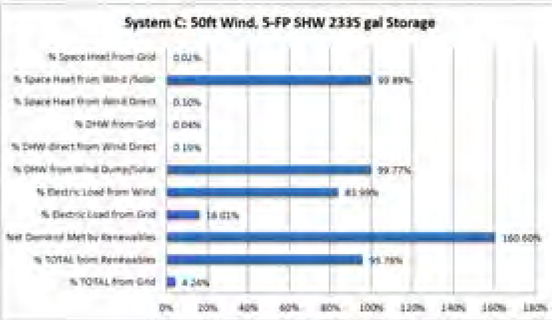
Heat: $ (699.12)
Electric: $ (613.23)
Total: $ (1,312.35)

Heat: $ (770.02)
Electric: $ (613.23)
Total: $ (1,383.25)

Heat: $ (2.92)
Electric: $ (613.23)
Total: $ (616.15)





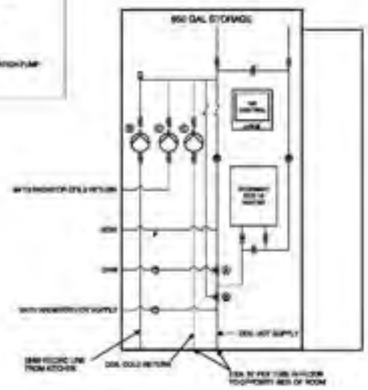


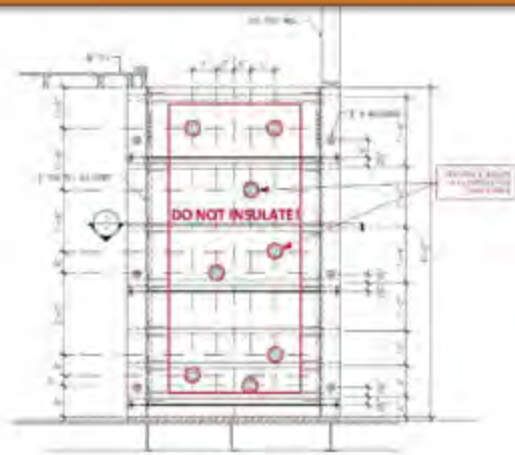
System Design and Sensitivity Analyses

Date	M	Reference (7m) Wind Speed MPH	Turbine Wind Speed MPH	kWh Produced	Electric Load (kWh)	Balance after electric load met	Domestic Load (kWh)	Wind % of DHW Load	Wind % of DHW Load	Balance after DHW (Includes DHW from tank)	Heating Load (kWh)	Heat Load x Coil Supply COP(kWh)	Balance (kWh) (includes space heat from tank)	Remaining Wind kWh % of Space Heat Load	Remaining Wind kWh % of Space Heat Load	Solar Energy Added (kWh)	Domestic from Tank (kWh)	Heat from Tank to subtract from Heat Load	Tank Temp (oF)	Standby Tank Loss (kWh)	Bought for Electric	Bought for DHW	Bought for Space Heat	Donated to TDX
																		95.9	**113.0**	(0.8)				
8/16/2011	8	3	4	1.0	(12.0)	(11.0)	(14.5)	0.00%	0%	(12.7)	(8.8)	(8.8)	(13.0)	0%	0%	0.0	(12.8)	(8.5)	**103.9**	(0.7)	(11.0)	(1.7)	(0.3)	0.0
8/17/2011	8	5	7	7.0	(12.0)	(5.0)	(14.5)	0.00%	0%	(8.6)	(8.8)	(8.8)	(11.3)	0%	0%	0.0	(10.9)	(6.0)	**96.7**	(0.6)	(5.0)	(3.5)	(2.8)	0.0
8/18/2011	8	3	4	1.0	(12.0)	(11.0)	(14.5)	0.00%	0%	(15.9)	(8.8)	(8.8)	(20.4)	0%	0%	0.0	(9.6)	(4.3)	**90.7**	(0.5)	(11.0)	(4.8)	(4.5)	0.0
8/19/2011	8	6	8	10.0	(12.0)	(2.0)	(14.5)	0.00%	0%	(8.0)	(8.8)	(8.8)	(14.0)	0%	0%	0.0	(8.5)	(2.8)	**85.8**	(0.5)	(2.0)	(5.9)	(6.0)	0.0
8/20/2011	8	7	9	15.0	(12.0)	3.0	(14.5)	20.51%	21%	(3.9)	(8.8)	(8.8)	(11.2)	0%	0%	0.0	(7.6)	(1.5)	**81.9**	(0.4)	0.0	(6.9)	(7.3)	0.0
8/21/2011	8	14	18	87.4	(12.0)	75.4	(14.5)	520.78%	100%	67.8	(8.8)	(8.8)	59.5	676%	100%	0.0	(6.9)	(0.5)	**103.1**	(0.7)	0.0	0.0	0.0	0.0
8/22/2011	8	13	17	79.0	(12.0)	67.0	(14.5)	462.74%	100%	63.4	(8.8)	(8.8)	60.7	690%	100%	0.0	(10.9)	(6.0)	**120.8**	(0.8)	0.0	0.0	0.0	0.0
8/23/2011	8	7	9	15.0	(12.0)	3.0	(14.5)	20.51%	21%	2.6	(8.8)	(8.8)	2.6	30%	30%	0.0	(14.1)	(8.8)	**112.1**	(0.8)	0.0	0.0	0.0	0.0
8/24/2011	8	11	14	51.7	(12.0)	39.7	(14.5)	274.10%	100%	37.8	(8.8)	(8.8)	37.3	424%	100%	0.0	(12.6)	(8.3)	**118.5**	(0.8)	0.0	0.0	0.0	0.0
8/25/2011	8	12	16	68.6	(12.0)	56.6	(14.5)	390.88%	100%	55.8	(8.8)	(8.8)	55.8	635%	100%	0.0	(13.7)	(8.8)	**131.9**	(1.0)	0.0	0.0	0.0	0.0
8/26/2011	8	6	8	10.0	(12.0)	(2.0)	(14.5)	0.00%	0%	(2.0)	(8.8)	(8.8)	(2.0)	0%	0%	0.0	(14.5)	(8.8)	**121.9**	(0.9)	(2.0)	0.0	0.0	0.0
8/27/2011	8	12	16	68.6	(12.0)	56.6	(14.5)	390.88%	100%	56.4	(8.8)	(8.8)	56.4	641%	100%	0.0	(14.3)	(8.8)	**135.3**	(1.0)	0.0	0.0	0.0	0.0
8/28/2011	8	5	7	7.0	(12.0)	(5.0)	(14.5)	0.00%	0%	(5.0)	(8.8)	(8.8)	(5.0)	0%	0%	0.0	(14.5)	(8.8)	**125.3**	(0.9)	(5.0)	0.0	0.0	0.0
8/29/2011	8	4	5	3.0	(12.0)	(9.0)	(14.5)	0.00%	0%	(9.0)	(8.8)	(8.8)	(9.0)	0%	0%	0.0	(14.5)	(8.8)	**115.4**	(0.8)	(9.0)	0.0	0.0	0.0
8/30/2011	8	9	12	33.8	(12.0)	21.8	(14.5)	150.42%	100%	20.5	(8.8)	(8.8)	20.5	233%	100%	0.0	(13.2)	(8.8)	**114.4**	(0.8)	0.0	0.0	0.0	0.0
8/31/2011	8	6	8	10.0	(12.0)	(2.0)	(14.5)	0.00%	0%	(3.5)	(8.8)	(8.8)	(3.5)	0%	0%	0.0	(13.0)	(8.8)	**105.2**	(0.7)	(2.0)	(1.5)	0.0	0.0
9/1/2011	9	3	4	1.0	(12.0)	(11.0)	(14.5)	0.00%	0%	(14.2)	(12.0)	(12.0)	(17.3)	0%	0%	0.0	(11.3)	(8.9)	**96.6**	(0.6)	(11.0)	(3.2)	(3.1)	0.0
9/2/2011	9	7	9	15.0	(12.0)	3.0	(14.5)	20.51%	21%	(1.9)	(12.0)	(12.0)	(8.0)	0%	0%	0.0	(9.6)	(5.8)	**90.0**	(0.5)	0.0	(4.8)	(6.1)	0.0
9/3/2011	9	9	12	33.8	(12.0)	21.8	(14.5)	150.42%	100%	15.6	(12.0)	(12.0)	7.1	59%	59%	0.0	(8.3)	(3.4)	**87.8**	(0.5)	0.0	0.0	0.0	0.0
9/4/2011	9	4	5	3.0	(12.0)	(9.0)	(14.5)	0.00%	0%	(15.5)	(12.0)	(12.0)	(24.7)	0%	0%	0.0	(8.0)	(2.7)	**83.2**	(0.5)	(9.0)	(6.5)	(9.2)	0.0
9/5/2011	9	16	21	120.0	(12.0)	108.0	(14.5)	746.05%	100%	100.7	(12.0)	(12.0)	90.1	754%	100%	0.0	(7.2)	(1.4)	**116.6**	(0.8)	0.0	0.0	0.0	0.0
9/6/2011	9	15	20	104.3	(12.0)	92.3	(14.5)	637.56%	100%	91.2	(12.0)	(12.0)	91.2	762%	100%	0.0	(13.4)	(12.0)	**143.3**	(1.1)	0.0	0.0	0.0	0.0
9/7/2011	9	14	18	87.4	(12.0)	75.4	(14.5)	520.78%	100%	75.4	(12.0)	(12.0)	75.4	630%	100%	0.0	(14.5)	(12.0)	**163.0**	(1.3)	0.0	0.0	0.0	0.0
9/8/2011	9	5	7	7.0	(12.0)	(5.0)	(14.5)	0.00%	0%	(5.0)	(12.0)	(12.0)	(5.0)	0%	0%	0.0	(14.5)	(12.0)	**151.6**	(1.2)	(5.0)	0.0	0.0	0.0
9/9/2011	9	1	1	0.0	(12.0)	(12.0)	(14.5)	0.00%	0%	(12.0)	(12.0)	(12.0)	(12.0)	0%	0%	0.0	(14.5)	(12.0)	**140.2**	(1.1)	(12.0)	0.0	0.0	0.0
9/10/2011	9	3	4	1.0	(12.0)	(11.0)	(14.5)	0.00%	0%	(11.0)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(12.0)	**128.9**	(0.9)	(11.0)	0.0	0.0	0.0
9/11/2011	9	3	4	1.0	(12.0)	(11.0)	(14.5)	0.00%	0%	(11.0)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(12.0)	**117.7**	(0.8)	(11.0)	0.0	0.0	0.0
9/12/2011	9	3	4	1.0	(12.0)	(11.0)	(14.5)	0.00%	0%	(12.0)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(12.0)	**106.9**	(0.7)	(11.0)	(0.9)	0.0	0.0
9/13/2011	9	6	8	10.0	(12.0)	(2.0)	(14.5)	0.00%	0%	(5.0)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(9.2)	**98.1**	(0.6)	(2.0)	(3.0)	(2.7)	0.0
9/14/2011	9	13	17	79.0	(12.0)	67.0	(14.5)	462.74%	100%	62.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(6.5)	**114.5**	(0.8)	0.0	0.0	0.0	0.0
9/15/2011	9	9	12	33.8	(12.0)	21.8	(14.5)	150.42%	100%	20.3	(12.0)	(12.0)	20.3	170%	100%	0.0	(13.0)	(12.0)	**112.2**	(0.8)	0.0	0.0	0.0	0.0
9/16/2011	9	13	17	79.0	(12.0)	67.0	(14.5)	462.74%	100%	65.1	(12.0)	(12.0)	64.4	539%	100%	0.0	(12.6)	(11.3)	**128.6**	(0.9)	0.0	0.0	0.0	0.0
9/17/2011	9	4	5	3.0	(12.0)	(9.0)	(14.5)	0.00%	0%	(9.0)	(12.0)	(12.0)	(9.0)	0%	0%	0.0	(14.5)	(12.0)	**117.3**	(0.8)	(9.0)	0.0	0.0	0.0
9/18/2011	9	6	8	10.0	(12.0)	(2.0)	(14.5)	0.00%	0%	(3.0)	(12.0)	(12.0)	(3.0)	0%	0%	0.0	(13.5)	(12.0)	**106.5**	(0.7)	(2.0)	(0.9)	0.0	0.0
9/19/2011	9	20	26	180.0	(12.0)	168.0	(14.5)	1160.64%	100%	165.0	(12.0)	(12.0)	162.3	1357%	100%	0.0	(11.5)	(9.2)	**164.4**	(1.3)	0.0	0.0	0.0	0.0
9/20/2011	9	21	27	185.0	(12.0)	173.0	(14.5)	1195.18%	100%	173.0	(12.0)	(12.0)	173.0	1447%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	146.5
9/21/2011	9	18	23	164.5	(12.0)	152.5	(14.5)	1053.53%	100%	152.5	(12.0)	(12.0)	152.5	1275%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	126.0
9/22/2011	9	15	20	104.3	(12.0)	92.3	(14.5)	637.56%	100%	92.3	(12.0)	(12.0)	92.3	772%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	65.8
9/23/2011	9	21	27	185.0	(12.0)	173.0	(14.5)	1195.18%	100%	173.0	(12.0)	(12.0)	173.0	1447%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	146.5
9/24/2011	9	12	16	68.6	(12.0)	56.6	(14.5)	390.88%	100%	56.6	(12.0)	(12.0)	56.6	473%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	30.1
9/25/2011	9	14	18	87.4	(12.0)	75.4	(14.5)	520.78%	100%	75.4	(12.0)	(12.0)	75.4	630%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	48.9
9/26/2011	9	10	13	42.3	(12.0)	30.3	(14.5)	209.15%	100%	30.3	(12.0)	(12.0)	30.3	253%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	3.8
9/27/2011	9	12	16	68.6	(12.0)	56.6	(14.5)	390.88%	100%	56.6	(12.0)	(12.0)	56.6	473%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	30.1
9/28/2011	9	17	22	140.0	(12.0)	128.0	(14.5)	884.24%	100%	128.0	(12.0)	(12.0)	128.0	1070%	100%	0.0	(14.5)	(12.0)	**180.0**	(1.5)	0.0	0.0	0.0	101.5
9/29/2011	9	9	12	33.8	(12.0)	21.8	(14.5)	150.42%	100%	21.8	(12.0)	(12.0)	21.8	182%	100%	0.0	(14.5)	(12.0)	**177.5**	(1.4)	0.0	0.0	0.0	0.0
9/30/2011	9	7	9	15.0	(12.0)	3.0	(14.5)	20.51%	21%	3.0	(12.0)	(12.0)	3.0	25%	25%	0.0	(14.5)	(12.0)	**167.2**	(1.3)	0.0	0.0	0.0	0.0
10/1/2011	10	18	23	164.5	(12.0)	152.5	(14.5)	1053.53%	100%	152.5	(17.8)	(17.8)	152.5	855%	100%	0.0	(14.5)	(17.8)	**180.0**	(1.5)	0.0	0.0	0.0	120.2
10/2/2011	10	4	5	3.0	(12.0)	(9.0)	(14.5)	0.00%	0%	(9.0)	(17.8)	(17.8)	(9.0)	0%	0%	0.0	(14.5)	(17.8)	**166.1**	(1.3)	(9.0)	0.0	0.0	0.0
10/3/2011	10	12	16	68.6	(12.0)	56.6	(14.5)	390.88%	100%	56.6	(17.8)	(17.8)	56.6	317%	100%	0.0	(14.5)	(17.8)	**175.6**	(1.4)	0.0	0.0	0.0	24.3
10/4/2011	10	8	10	20.7	(12.0)	8.7	(14.5)	59.90%	60%	8.7	(17.8)	(17.8)	8.7	49%	49%	0.0	(14.5)	(17.8)	**165.3**	(1.3)	0.0	0.0	0.0	0.0
10/5/2011	10	13	17	79.0	(12.0)	67.0	(14.5)	462.74%	100%	67.0	(17.8)	(17.8)	67.0	376%	100%	0.0	(14.5)	(17.8)	**179.0**	(1.4)	0.0	0.0	0.0	34.7
10/6/2011	10	11	14	51.7	(12.0)	39.7	(14.5)	274.10%	100%	39.7	(17.8)	(17.8)	39.7	223%	100%	0.0	(14.5)	(17.8)	**180.0**	(1.5)	0.0	0.0	0.0	7.4
10/7/2011	10	9	12	33.8	(12.0)	21.8	(14.5)	150.42%	100%	21.8	(17.8)	(17.8)	21.8	122%	100%	0.0	(14.5)	(17.8)	**175.1**	(1.4)	0.0	0.0	0.0	0.0
10/8/2011	10	2	3	0.0	(12.0)	(12.0)	(14.5)	0.00%	0%	(12.0)	(17.8)	(17.8)	(12.0)	0%	0%	0.0	(14.5)	(17.8)	**161.2**	(1.3)	(12.0)	0.0	0.0	0.0
10/9/2011	10	11	14	51.7	(12.0)	39.7	(14.5)	274.10%	100%	39.7	(17.8)	(17.8)	39.7	223%	100%	0.0	(14.5)	(17.8)	**163.7**	(1.3)	0.0	0.0	0.0	0.0
10/10/2011	10	12	16	68.6	(12.0)	56.6	(14.5)	390.88%	100%	56.6	(17.8)	(17.8)	56.6	317%	100%	0.0	(14.5)	(17.8)	**173.2**	(1.4)	0.0	0.0	0.0	24.3
10/11/2011	10	19	25	175.0	(12.0)	163.0	(14.5)	1126.09%	100%	163.0	(17.8)	(17.8)	163.0	914%	100%	0.0	(14.5)	(17.8)	**180.0**	(1.5)	0.0	0.0	0.0	130.7
10/12/2011	10	10	13	42.3	(12.0)	30.3	(14.5)	209.15%	100%	30.3	(17.8)	(17.8)	30.3	170%	100%	0.0	(14.5)	(17.8)	**178.6**	(1.4)	0.0	0.0	0.0	0.0
10/13/2011	10	17	22	140.0	(12.0)	128.0	(14.5)	884.24%	100%	128.0	(17.8)	(17.8)	128.0	718%	100%	0.0	(14.5)	(17.8)	**180.0**	(1.5)	0.0	0.0	0.0	95.7
10/14/2011	10	27	35	200.0	(12.0)	188.0	(14.5)	1298.83%	100%	188.0	(17.8)	(17.8)	188.0	1055%	100%	0.0	(14.5)	(17.8)	**180.0**	(1.5)	0.0	0.0	0.0	155.7
10/15/2011	10	12	16	68.6	(12.0)	56.6	(14.5)	390.88%	100%	56.6	(17.8)	(17.8)	56.6	317%	100%	0.0	(14.5)	(17.8)	**180.0**	(1.5)	0.0	0.0	0.0	24.3
10/16/2011	10	11	14	51.7	(12.0)	39.7	(14.5)	274.10%	100%	39.7	(17.8)	(17.8)	39.7	223%	100%	0.0	(14.5)	(17.8)	**180.0**	(1.5)	0.0	0.0	0.0	7.4
10/17/2011	10	1	1	0.0	(12.0)	(12.0)	(14.5)	0.00%	0%	(12.0)	(17.8)	(17.8)	(12.0)	0%	0%	0.0	(14.5)	(17.8)	**166.1**	(1.3)	(12.0)	0.0	0.0	0.0

There is no easy answer

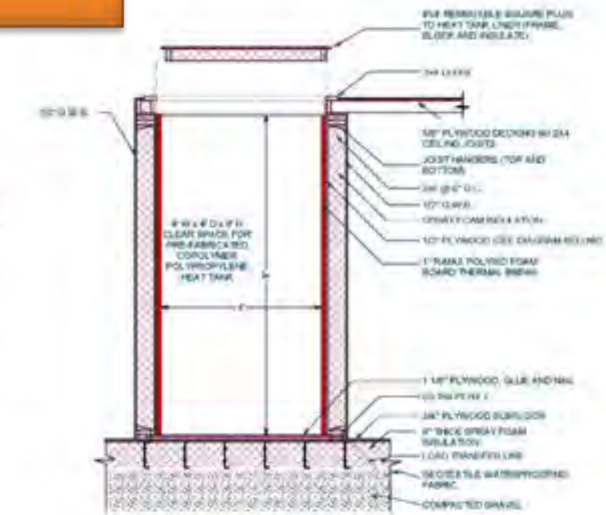
1000 GAL Energy storage Tank

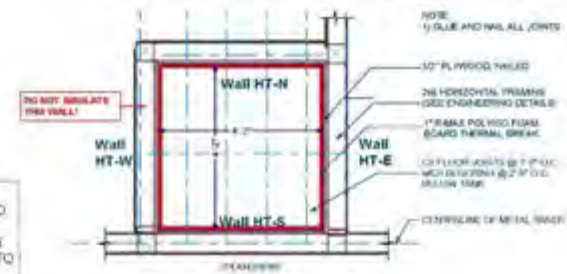


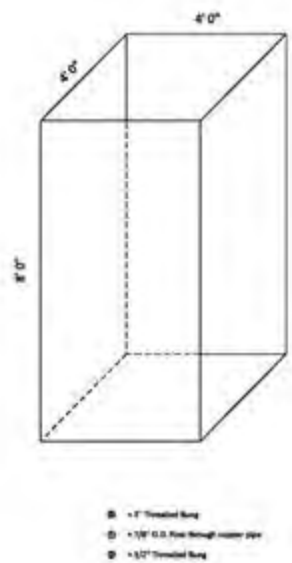


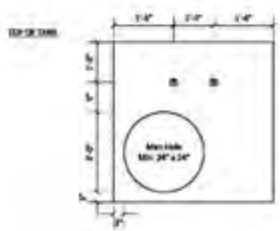
TANK LINER CONSTRUCTION (SUPPLIED BY OTHERS)

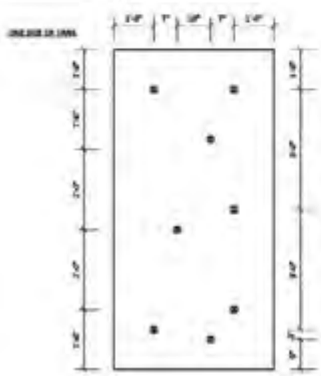
SCALE: 1/2" = 1'-0"











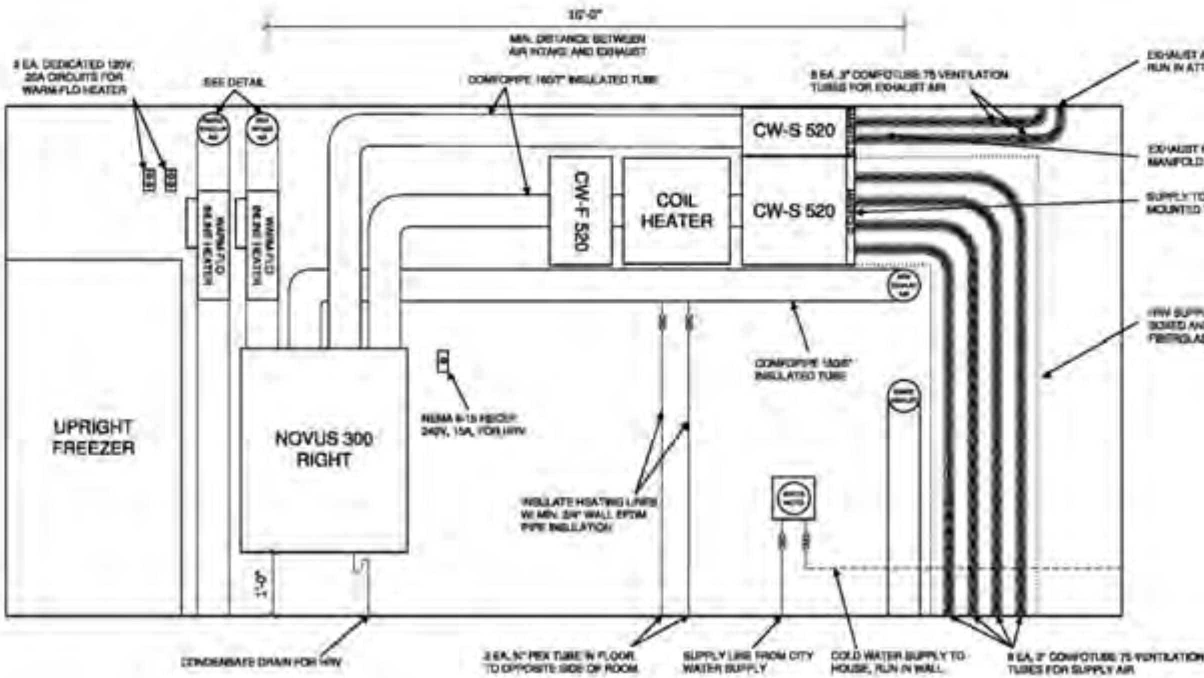
TANK WALL FRAMING NOTES:
FRAME WALLS HT-S AND HT-E. INSTALL SHEETING AND FOAM BOARD. PLACE THE RIDGED HEAT STORAGE TANK IN ITS PLACE AND THEN INSTALL WALL FRAMING HT-N AND HT-W. ENSURE TIGHT FIT ON THE FRAMING TO THE TANK. ONCE ALL FRAMING CONNECTIONS ARE DONE AND INSPECTION IS COMPLETED THE TANK WALLS CAN BE SPRAY FOAMED.
NOTE: WALL SECTION HT-W HAS ALL MECHANNICAL CONNECTIN TO THE TANK AND WILL REQUIRE DRILLING 4" HOLES FOR ALL PORTS IN THE PLYWOOD. THIS WALL WILL NOT BE SPRAYFOAMED AND INSULATED WITH ROXUL AFTER ALL CONECTIONS HAVE BEEN COMPLETED.

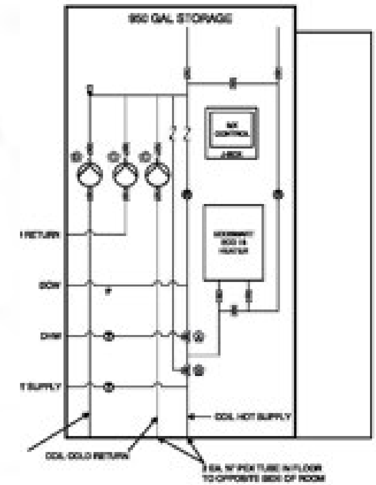
1 / M3 **TANK WALL SECTION AND PLAN**

SCALE: 1/2" = 1'-0"

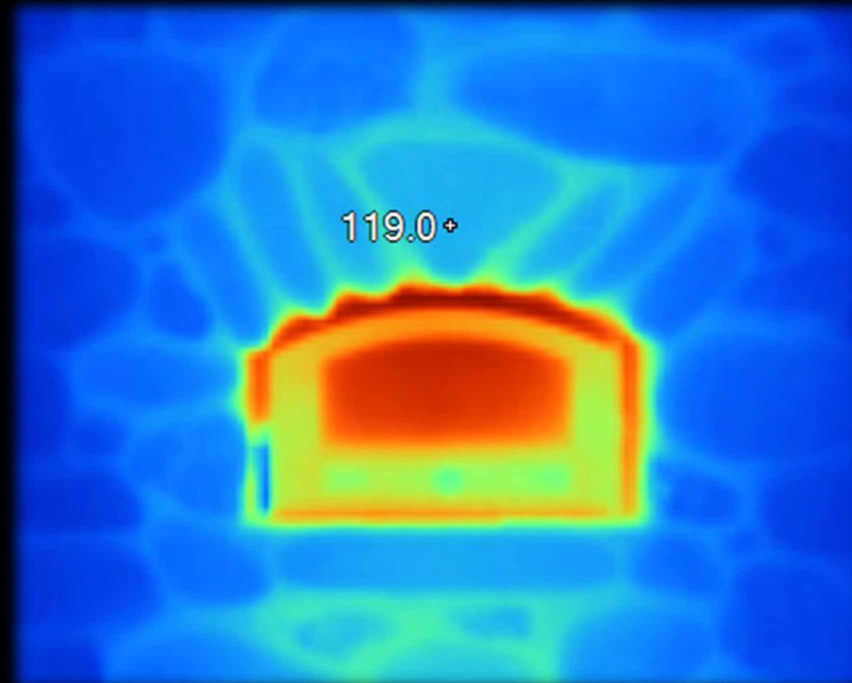
Living Aleutian Home Design - Sand Point - SPF	
REINA	
Scale: 1/4" = 1'-0" Date: 07/14/2013	M3

Integrated heating system






Masonry
Heater


119.0


Masonry
Heater
61.5

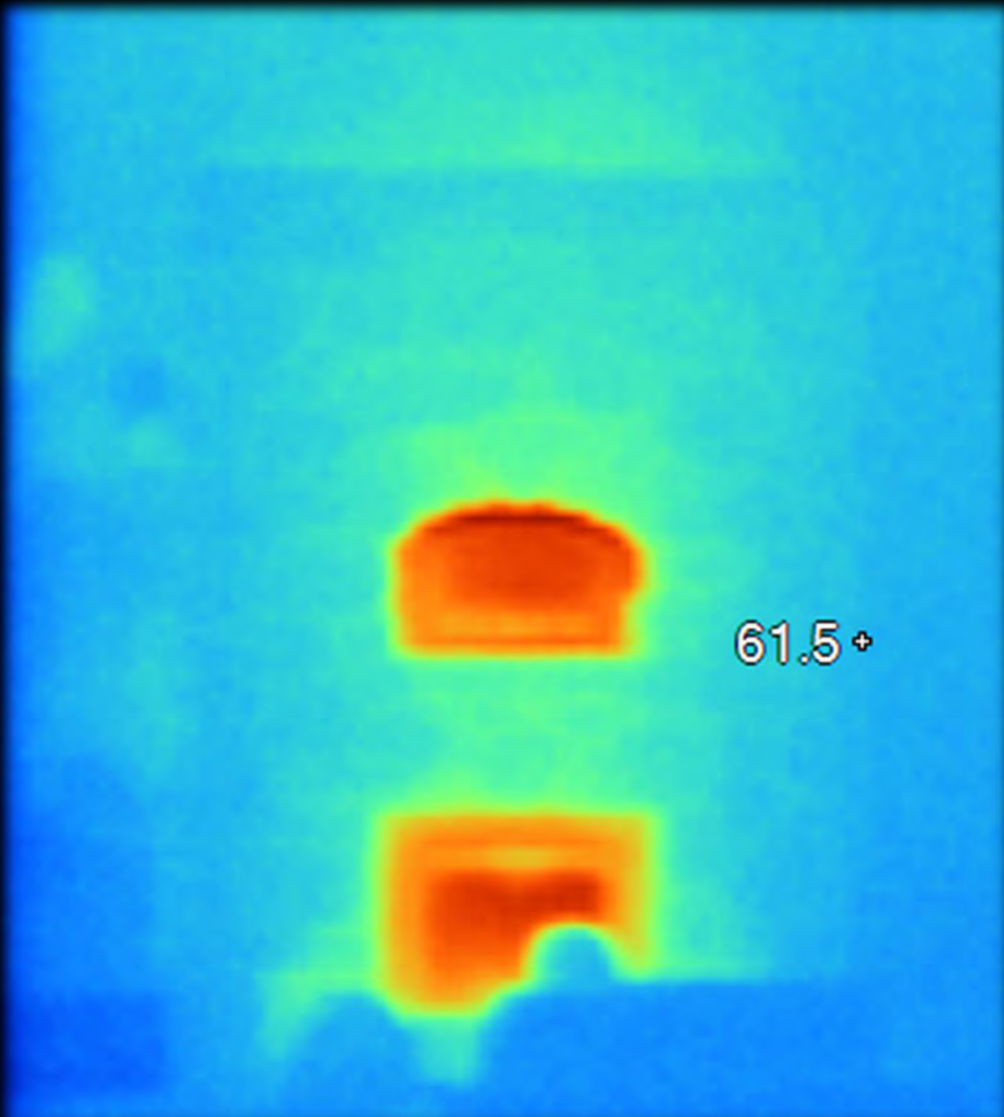
1-1/2 cords of wood

=22.5 MBTU

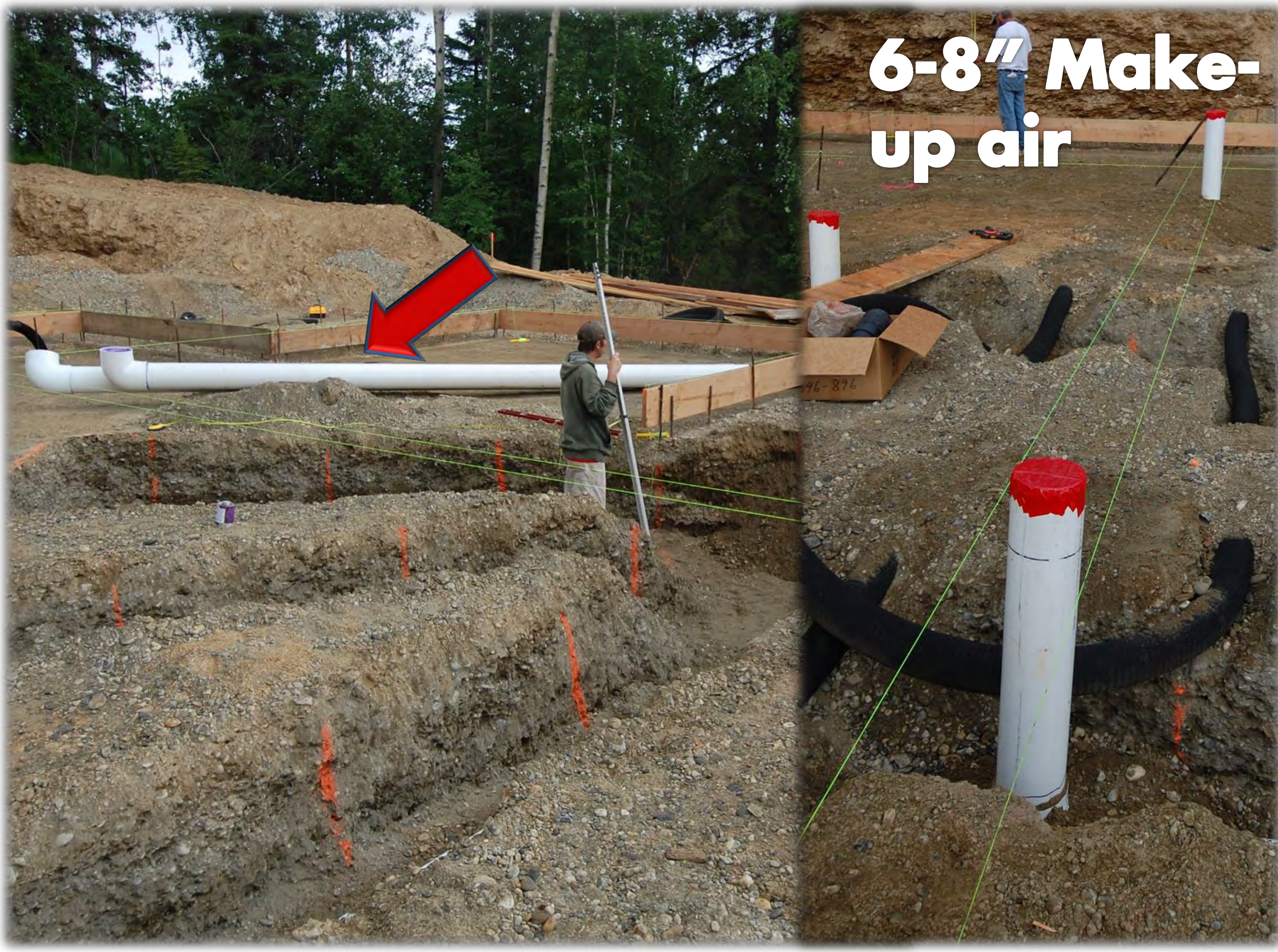
= $ 340

180 Gallons or 680 L oil

= $ 720




6" Make-up air


6-8" Make-up air


Learn to
Love the Sun
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CCHRC
ArcticSun LLC