Pathways to Zero Energy In Alaska

Thorsten Chlupp

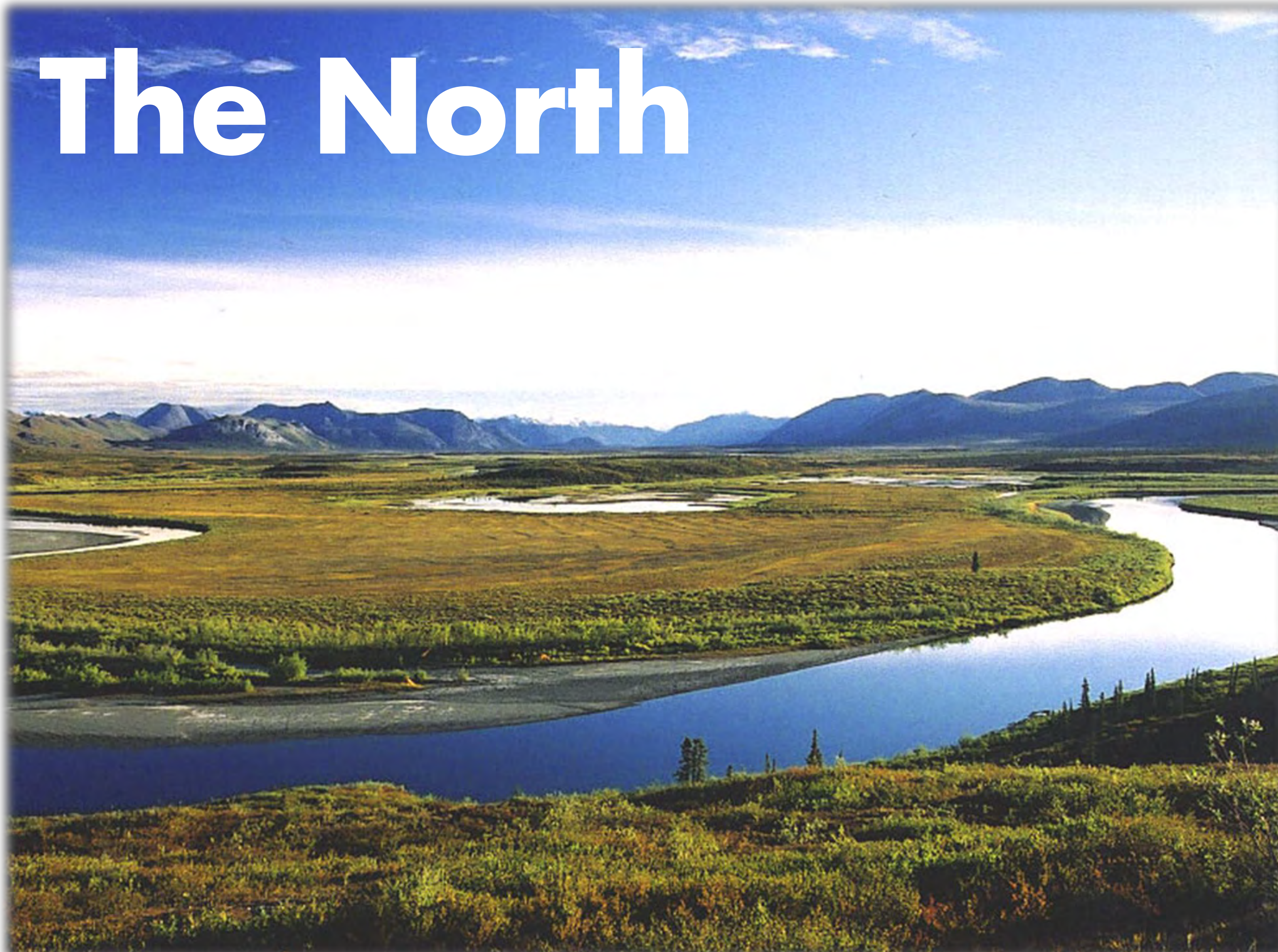
REINA LLC

ArcticSun LLC

Prudence Ferreira

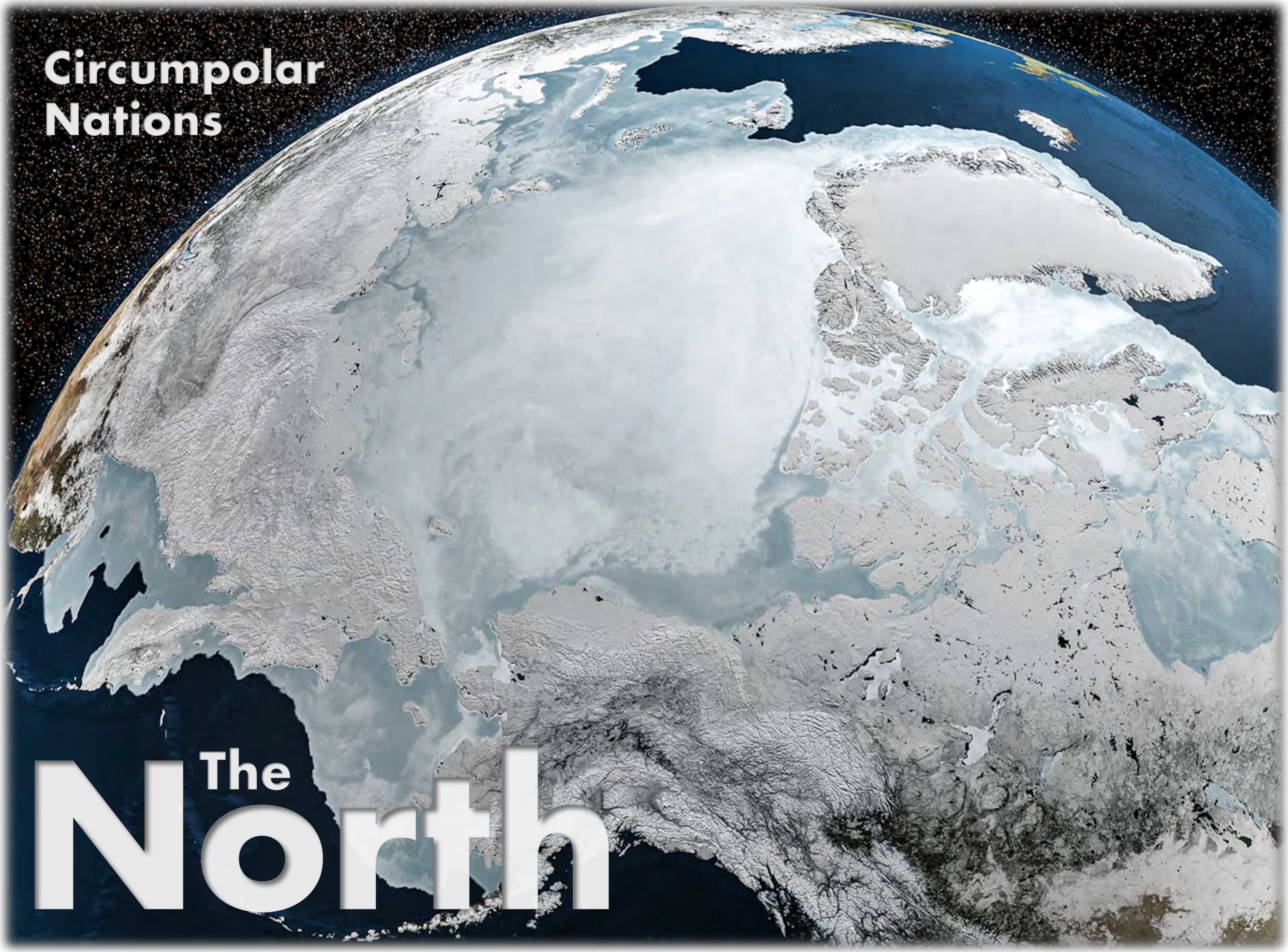
INTEGRAL IMPACT INC
THE PHYSICS OF BETTER BUILDINGS

Cold Climate Housing Research Center
CCHRC


The North

Circumpolar Nations

The North

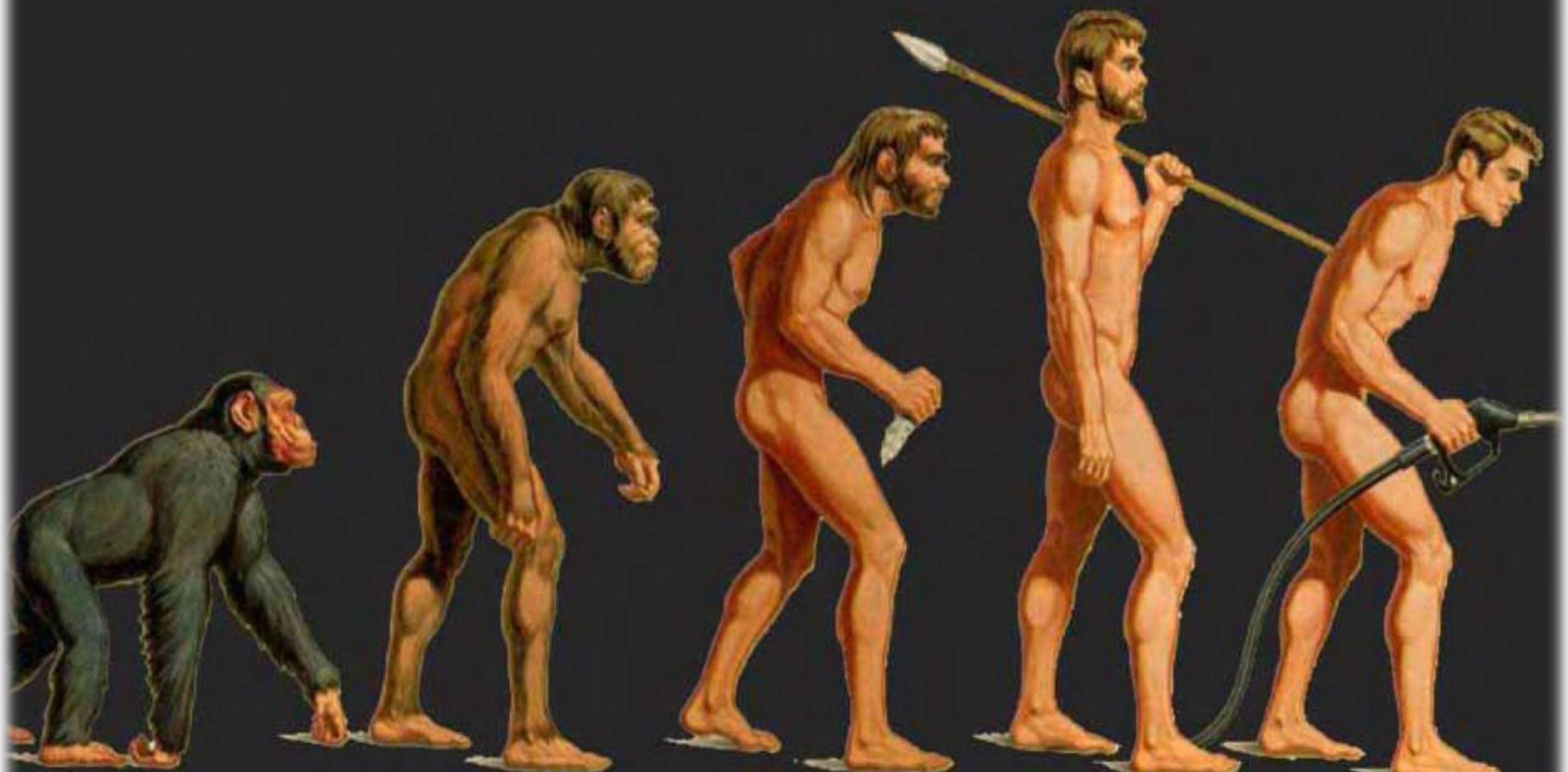


Good days

Bad Days


Turn up
the heat

“evolution”



The SunRise Home


Jump in
...or letting go!

Disclaimer:

There is no going back.

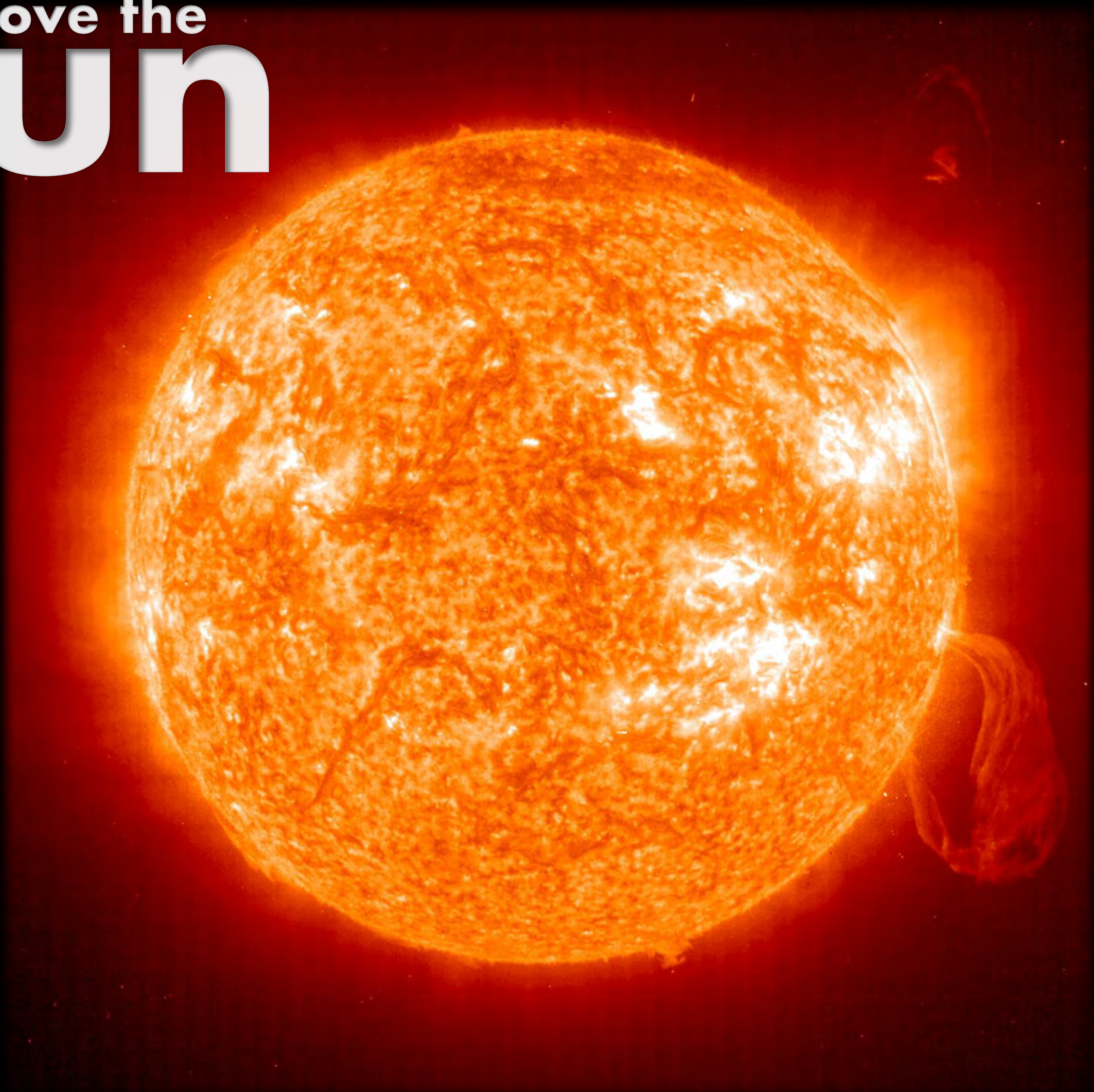

Cold Climate 101

3 Golden Rules

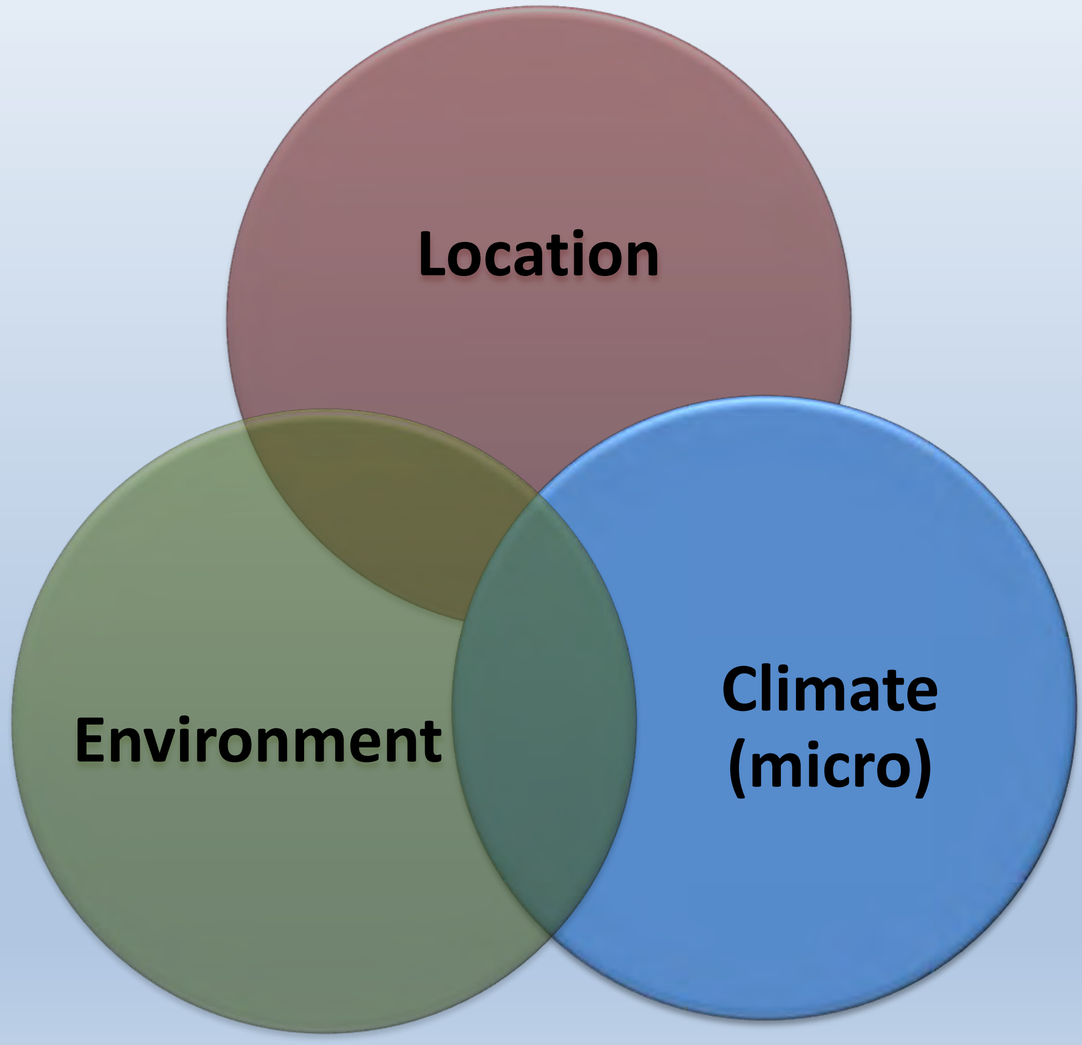

Learn to Adapt.
to Survive.


Letting Go!
Then, Now & Today

Love the Sun



3 Need to Knows:



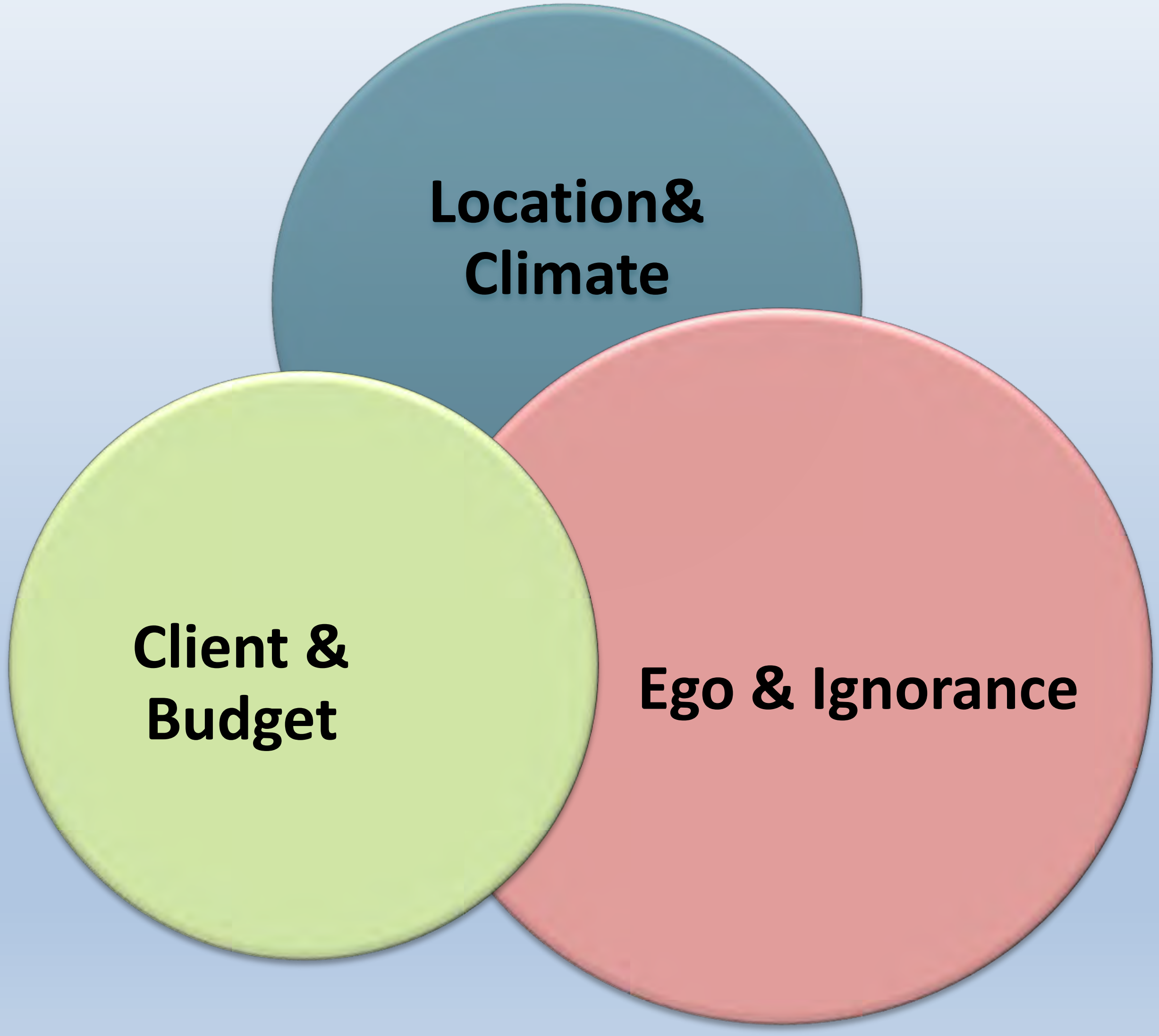

Location Matters

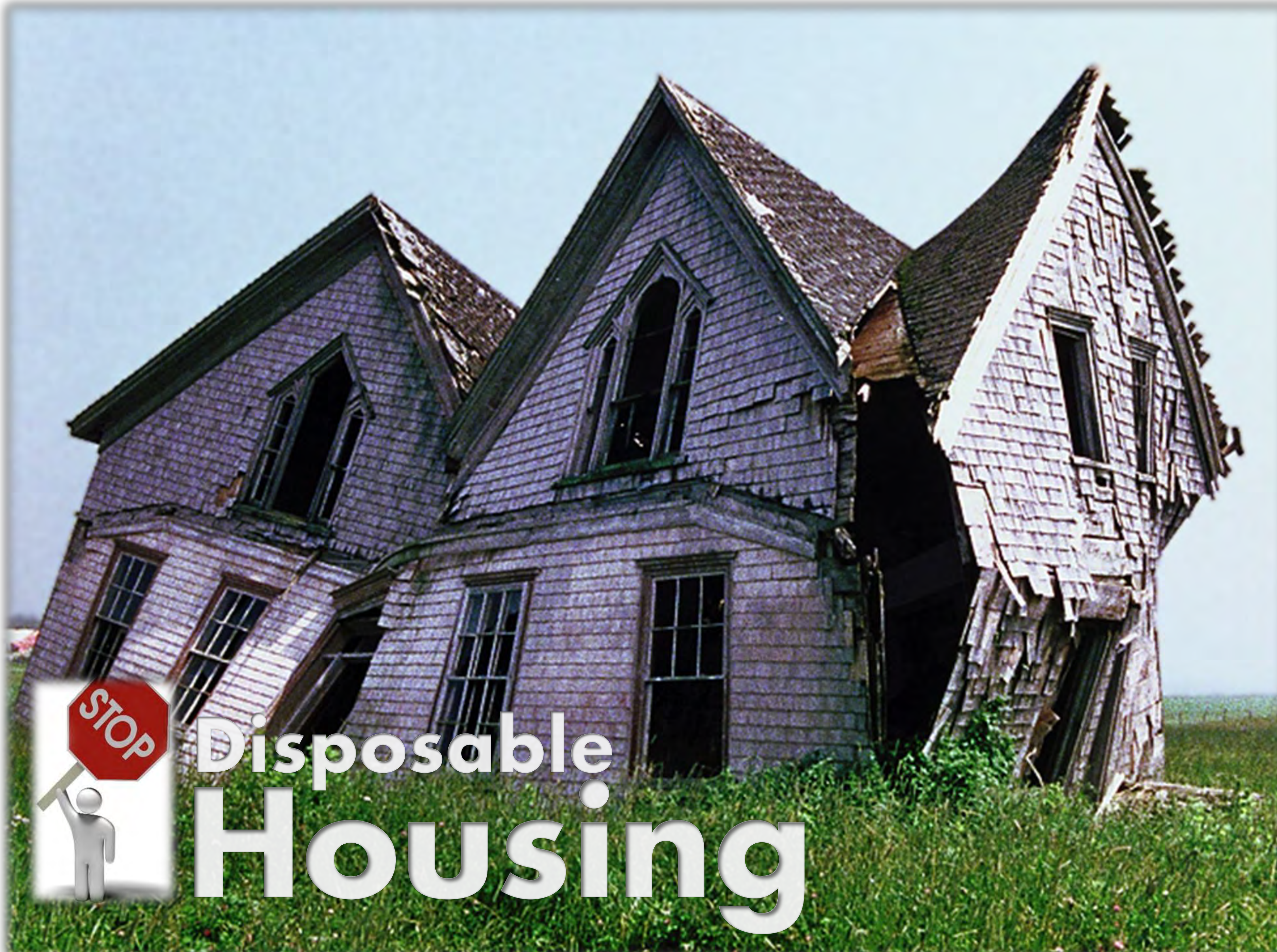

Climate Matters

Environment Matters


Fred
Meyer
-62°
Reality Check

3 Biggest Hurdles




STOP
Disposable
Housing

Value in our Homes?

Value in our Homes?

Insanity?

Resilience?

Code approved: 50 below, a few hours without heat

Sensible?

Code approved: **Just do NOT stop running!**

Climate Specific?

Code approved: Welcome to Paradise

Zone 7 Insulation Values

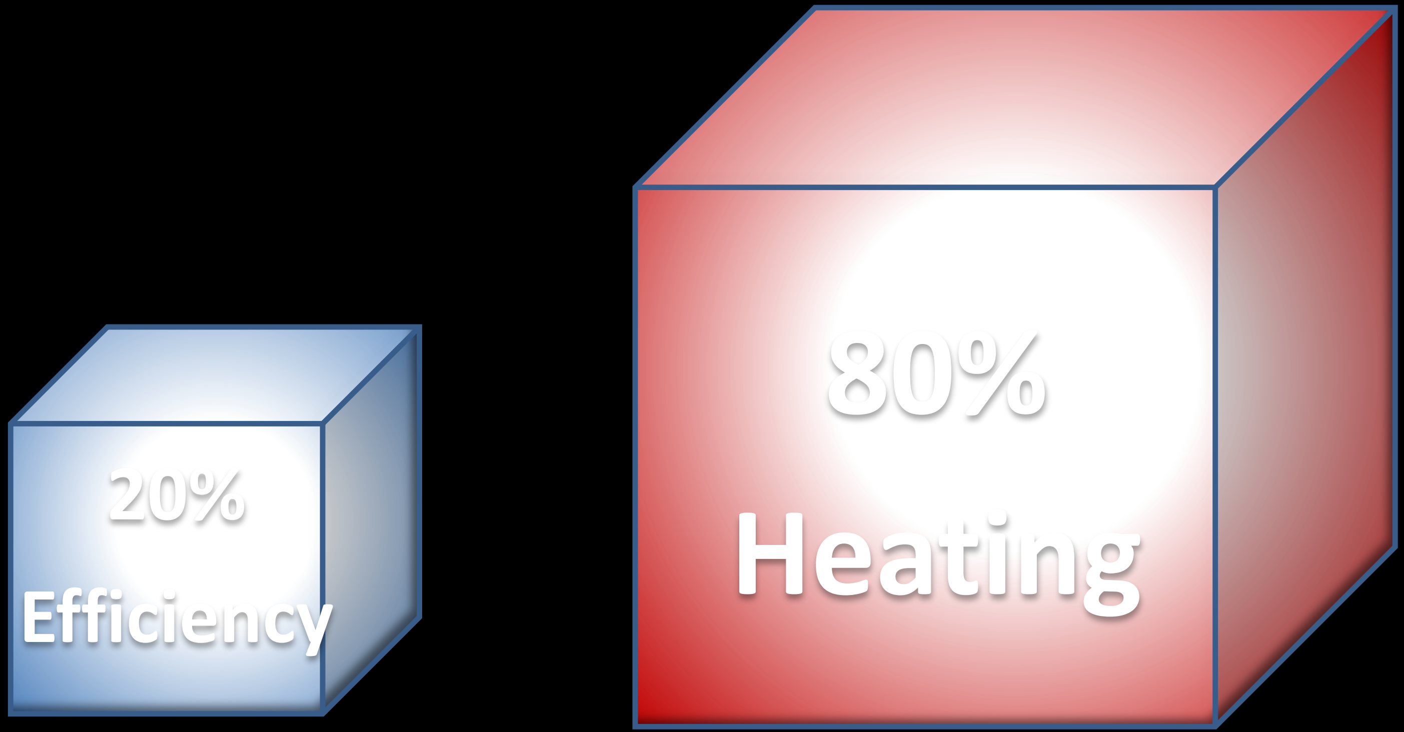
Passive House
- Roof R-110
- Walls R-80
- Slab R-60

BEES 2009
- Roof R-38
- Walls R-21
- Slab R-20

BEES 2012
- Roof R-43
- Walls R-20+5
- Slab R-20

FNSB 2012
- Roof R-70
- Walls R-50
- Slab R-20

Balancing
The Loads

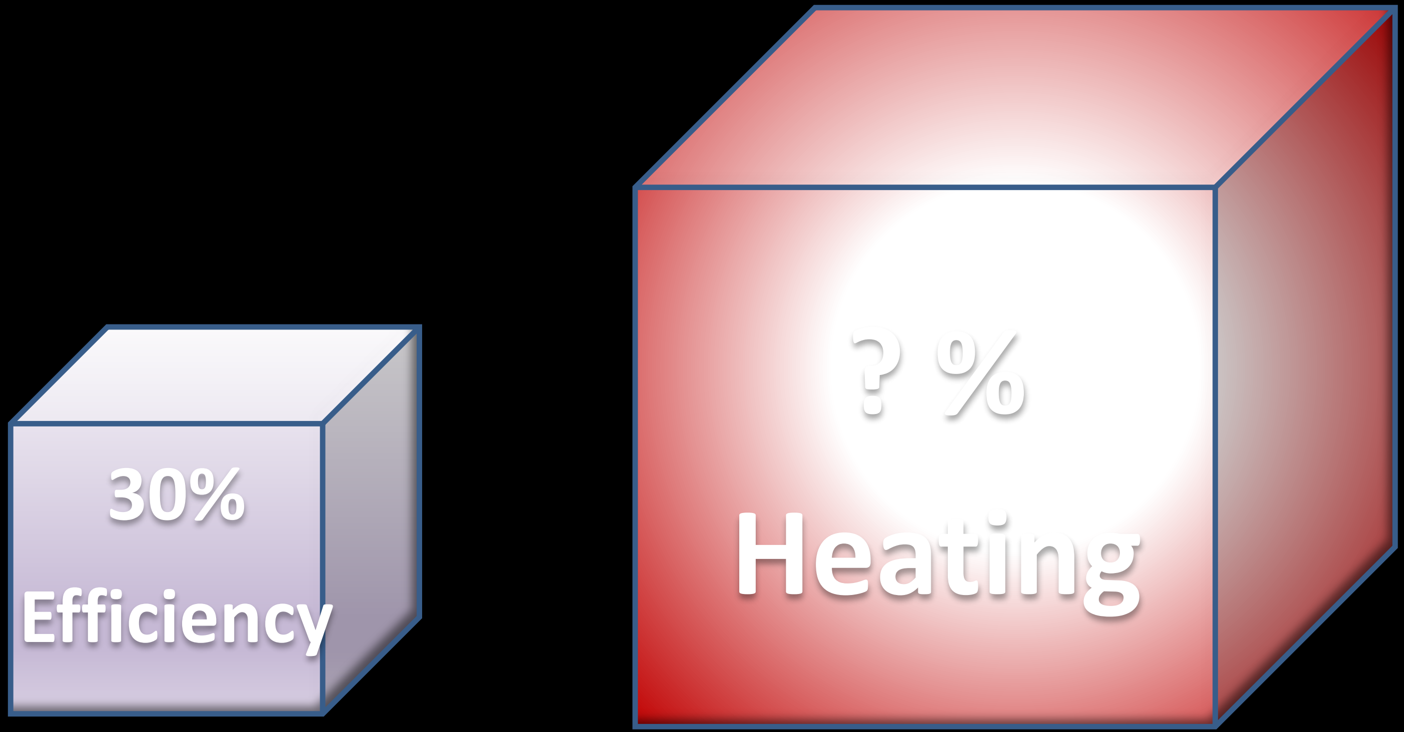


Balancing
The Loads

Heating

Balancing

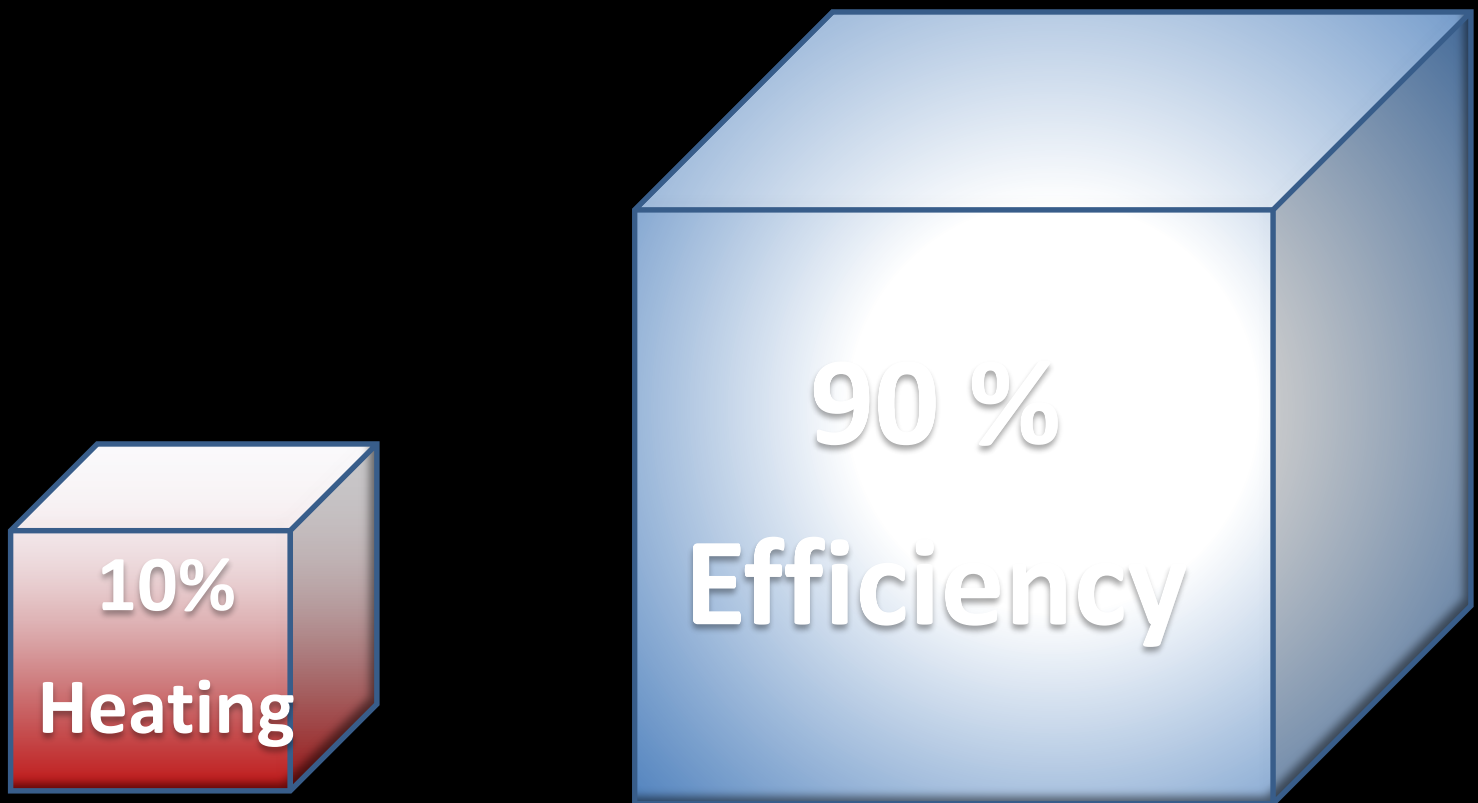
The Loads



Balancing
The Loads

Insulation

Balancing
The Loads




The 800 lb.
Gorilla

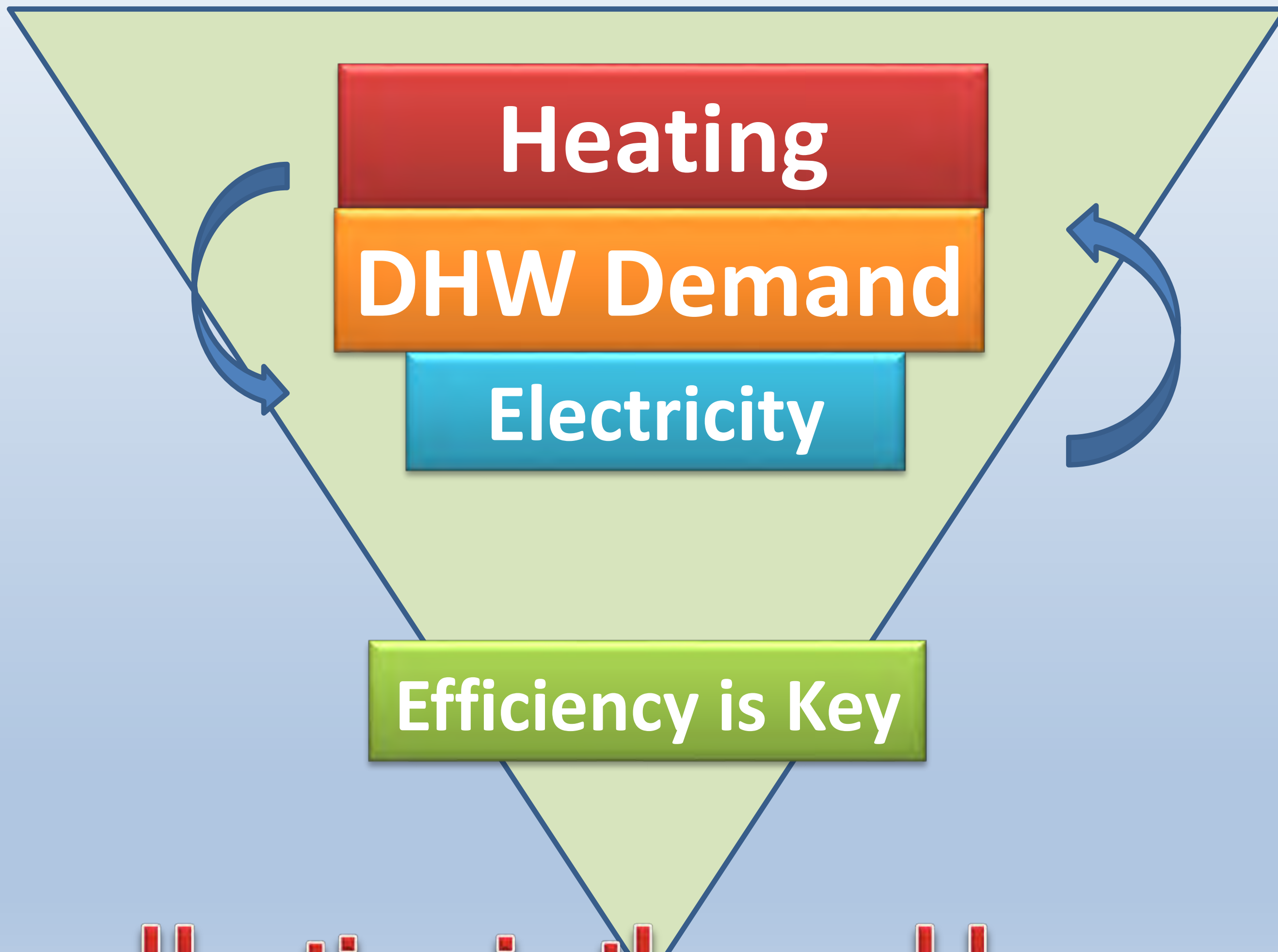
Let’s get help!

The Keystones of an Energy efficient Building:

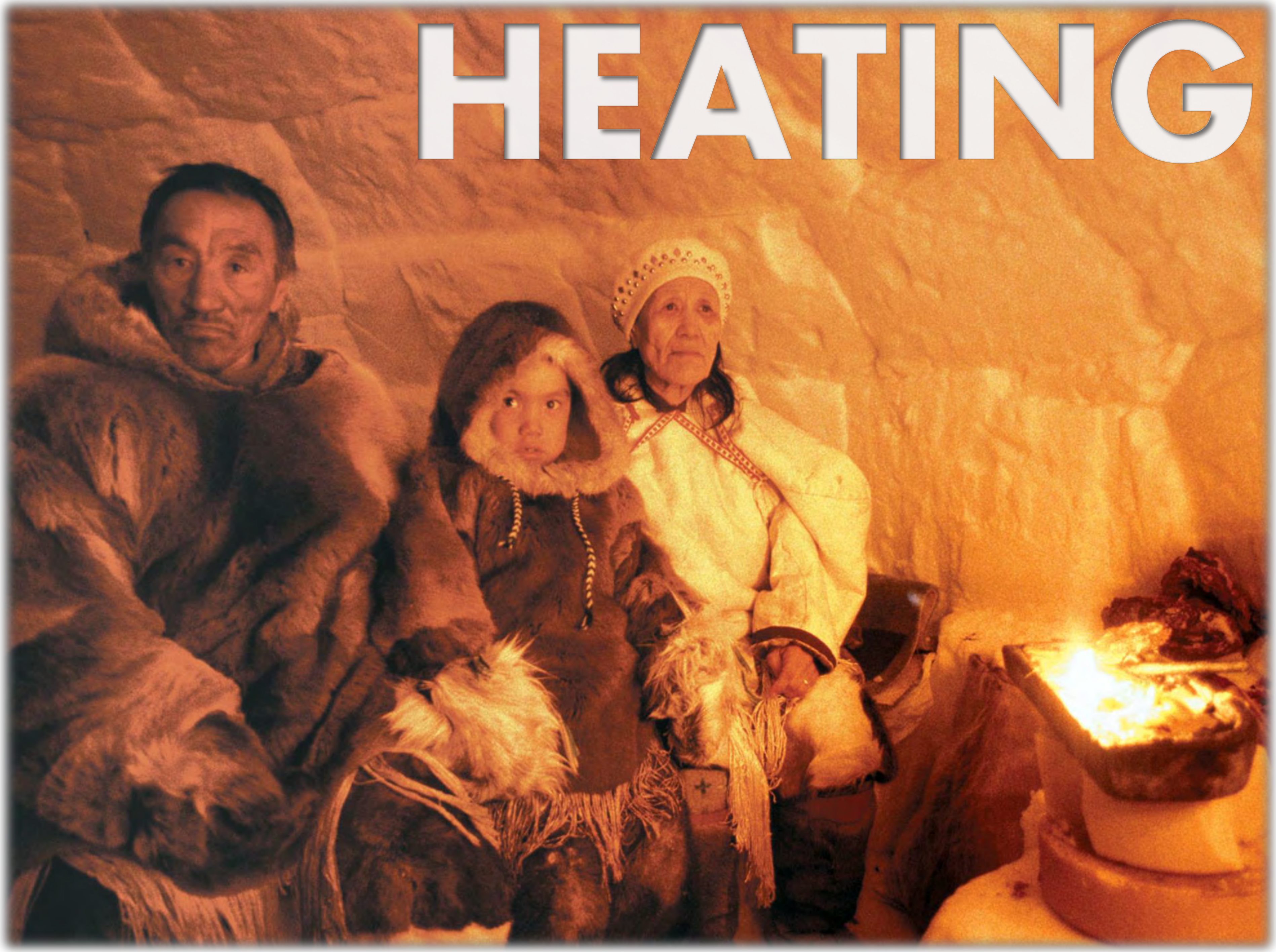
1. Moisture Control
2. Air-Tightness
3. Insulation

Insulation is Key.

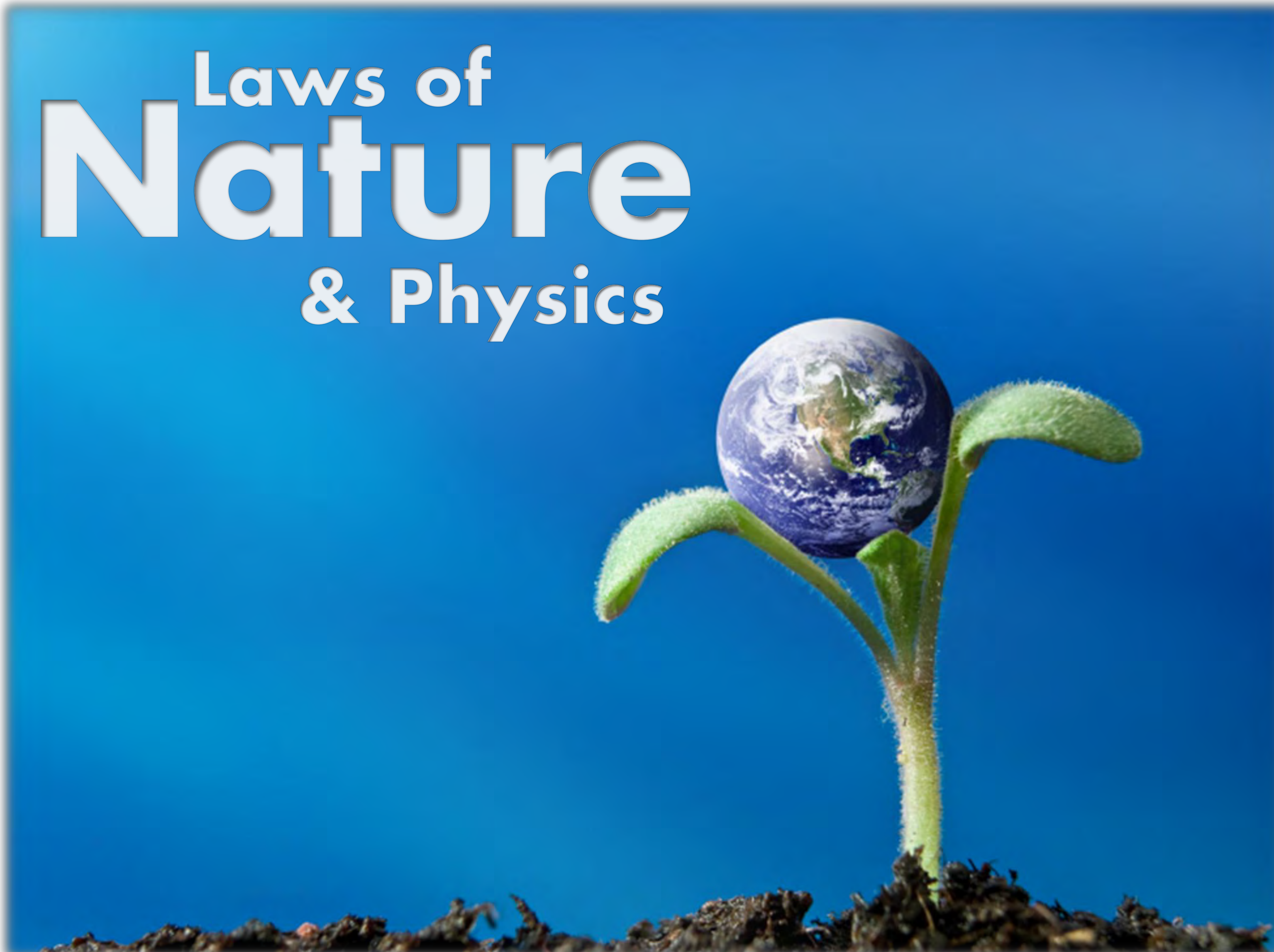
Reducing the loads

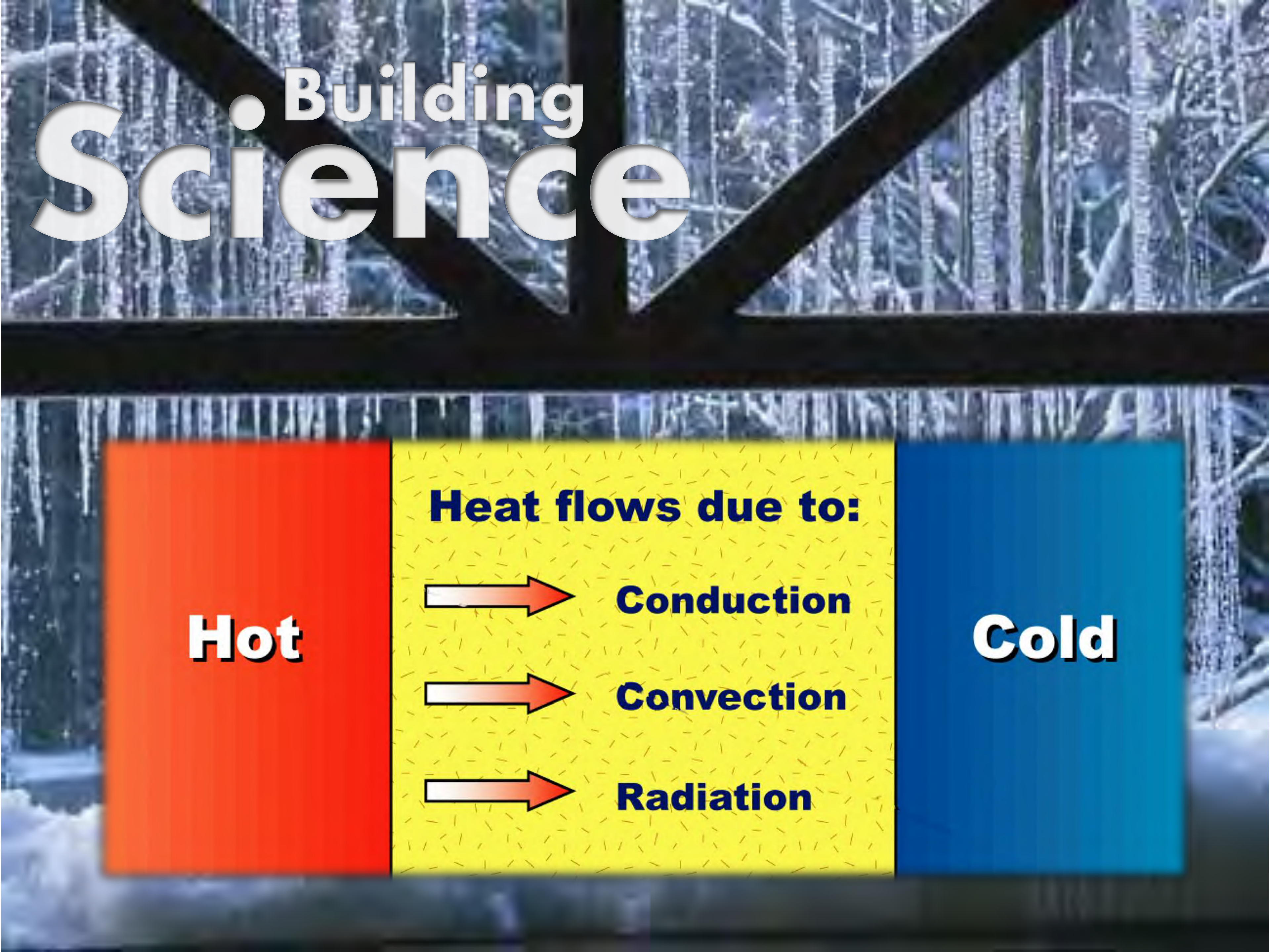


Heating is the problem...


HEATING

The Problem


Laws of
Nature
& Physics


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

Think
Outside the
Box(es)


Design
Appropriate
to Climate.


Insulate
Like you
Mean it.


R-80
pro clima SOLITEX
MENTO
PLUS
www.proclima.com


Airtight
Don't get your
blubber wet.

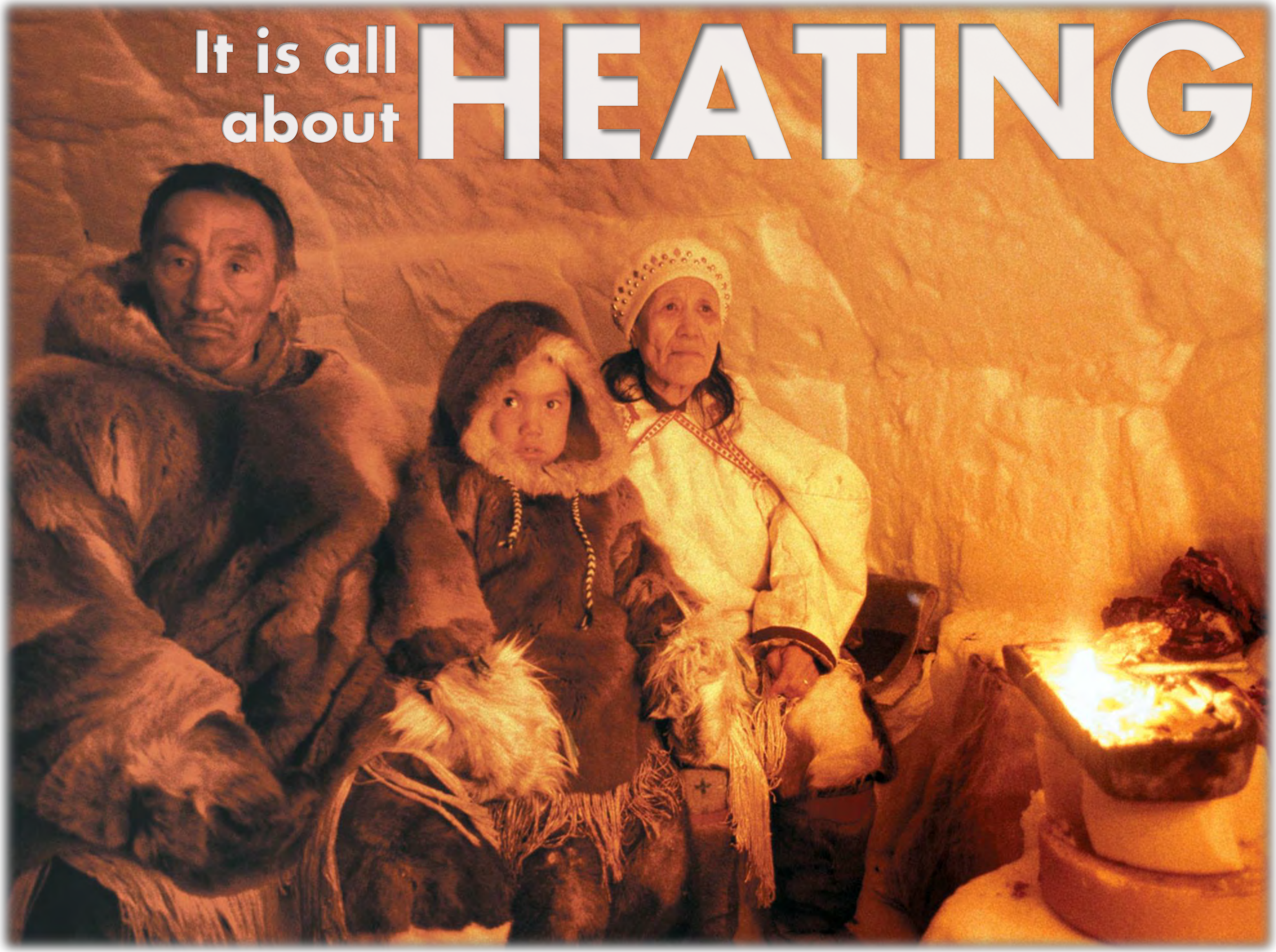
Insidious

Air Leakage

energystar.gov

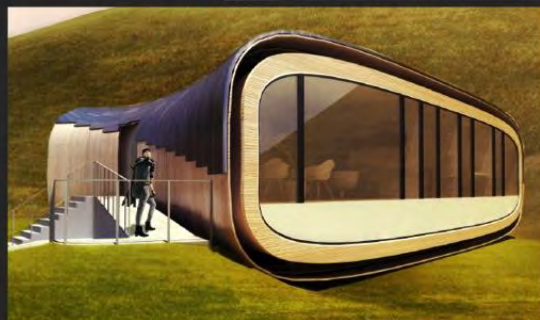

Insulation+
Airtightness=
Comfort

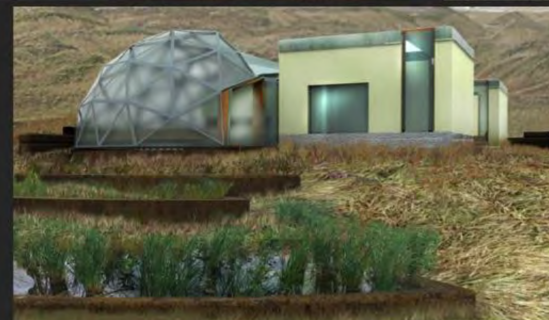

Buildings are for PEOPLE


It is all about
HEATING


We can build
Good Buildings

LIVING
ALEUTIAN
HOME
DESIGN
COMPETITION





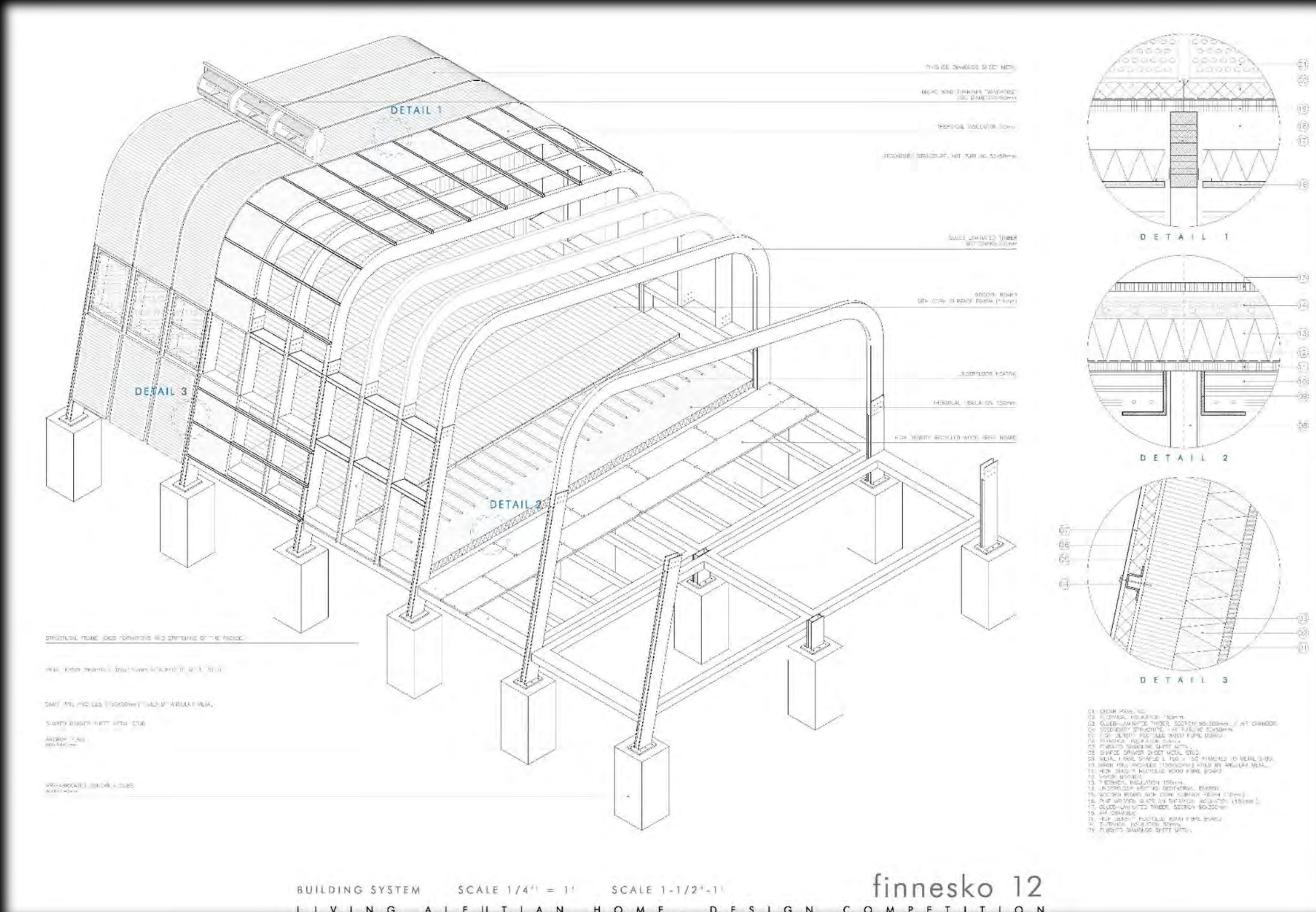
First Place
Team Spain

EXTERIOR VIEW

finnesko 13

LIVING ALEUTIAN HOME. DESIGN COMPETITION

Cold Climate Flaws?



No place for Mistakes

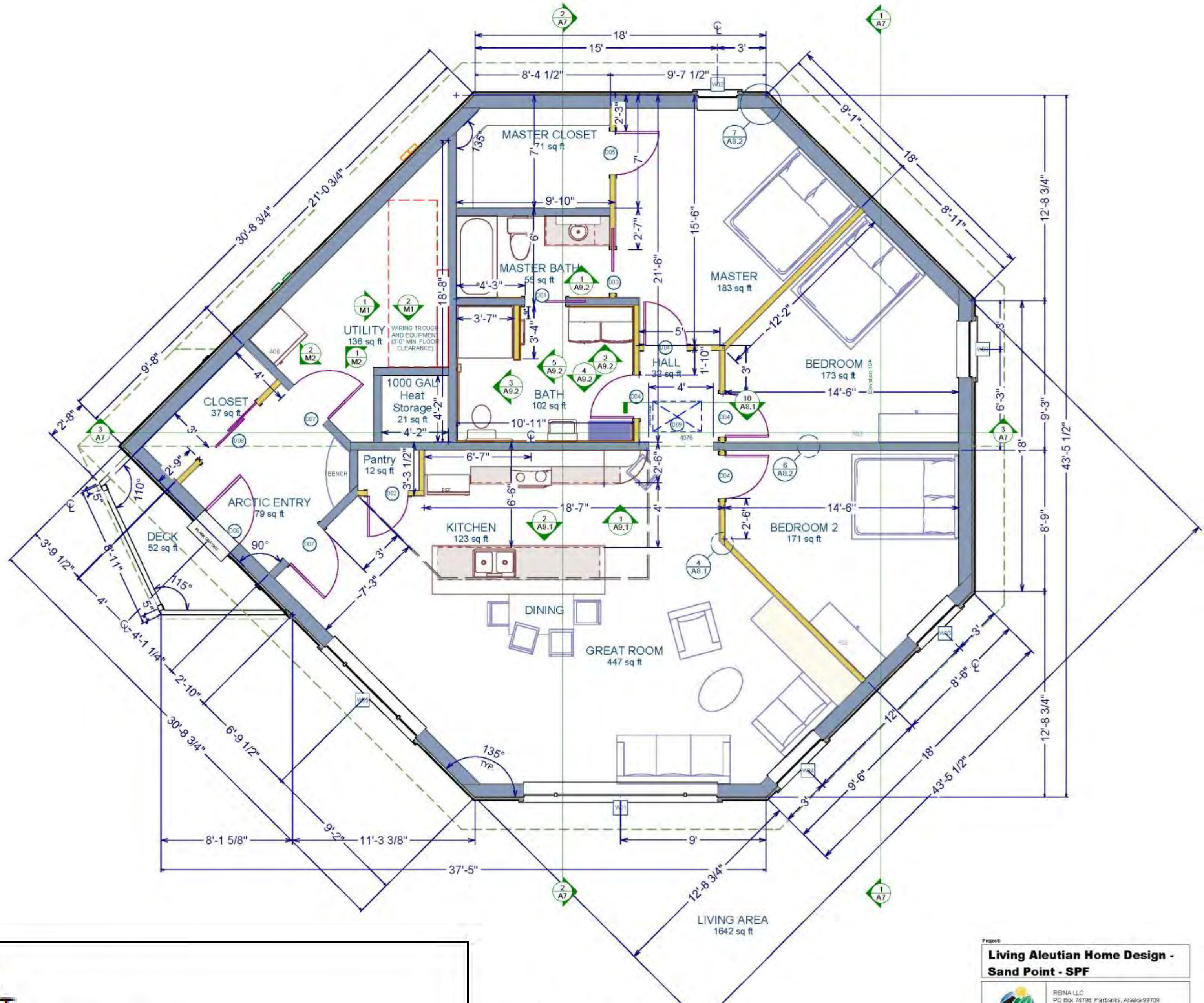

Back to the
Basics


GOOD DESIGN IS A TOUGH JOB.
VERLAG HERMANN SCHMIDT MAINZ


Design
Is not a linear Process


Good Design is
Essential

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.

Project:
Living Aleutian Home Design - Sand Point - SPF

REINA LLC
PO Box 74798 Fairbanks, Alaska 99709
Phone 907-457-1297
Fax 907-457-3397
Email info@reina-properties.com

Design by: Thorsten Chlupp

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

Date: 07/14/2013

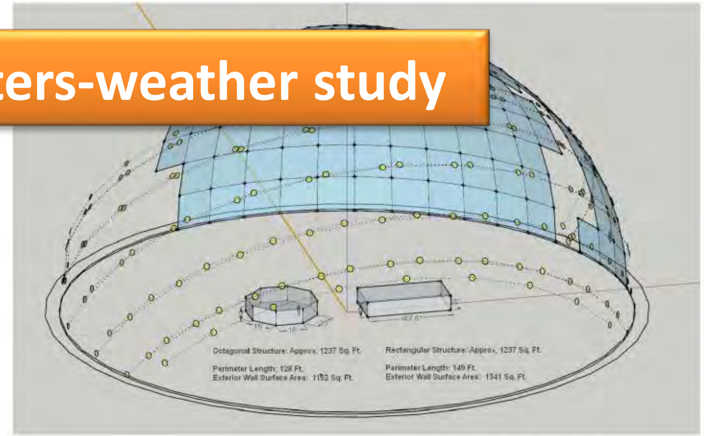
A1

Climate Matters-weather study

WEATHER DATA SUMMARY

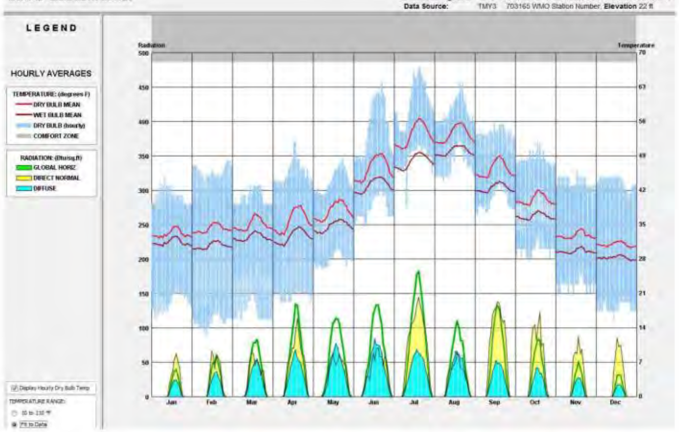
LOCATION: Sand Point, AK, USA
Latitude/Longitude:
Data Source:

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG					
Global Horiz Radiation (Avg Hourly)	26	38	55	77	71	78	105	65					
Direct Normal Radiation (Avg Hourly)	40	45	45	64	40	44	57	40					
Diffuse Radiation (Avg Hourly)	17	24	35	41	45	49	43	42	36	29	20	13	Btu/sq.ft
Global Horiz Radiation (Max Hourly)	79	116	185	242	267	273	271	221	213	147	98	55	Btu/sq.ft
Direct Normal Radiation (Max Hourly)	215	255	285	298	290	286	289	282	298	285	250	232	Btu/sq.ft
Diffuse Radiation (Max Hourly)	66	82	102	147	177	175	141	143	118	90	64	45	Btu/sq.ft
Global Horiz Radiation (Avg Daily Total)	184	332	587	969	1039	1206	1586	857	983	511	220	146	Btu/sq.ft
Direct Normal Radiation (Avg Daily Total)	308	418	468	856	622	724	1521	548	1298	817	481	428	Btu/sq.ft
Diffuse Radiation (Avg Daily Total)	123	210	377	522	667	762	666	587	403	262	144	82	Btu/sq.ft
Global Horiz Illumination (Avg Hourly)	826	1225	1789	2474	2340	2556	2329	2135	2743	1838	1069	738	footcandles
Direct Normal Illumination (Avg Hourly)	942	1180	1262	1857	1191	1303	2816	1141	3065	2285	1425	1385	footcandles
Dry Bulb Temperature (Avg Monthly)	33	34	35	36	37	46	51	53	46	40	32	30	degrees F
Dew Point Temperature (Avg Monthly)	28	29	28	27	30	39	42	47	38	32	23	23	degrees F
Relative Humidity (Avg Monthly)	82	86	75	71	74	76	68	70	73	72	67	70	percent
Wind Direction (Monthly Mode)	0	160	160	340	340	160	320	160	320	330	340	340	degrees
Wind Speed (Avg Monthly)	11	10	12	11	9	11	7	9	12	13	14	14	mph
Ground Temperature (Avg Monthly of 3 Depths)	36	33	32	32	34	38	42	45	47	46	44	40	degrees F



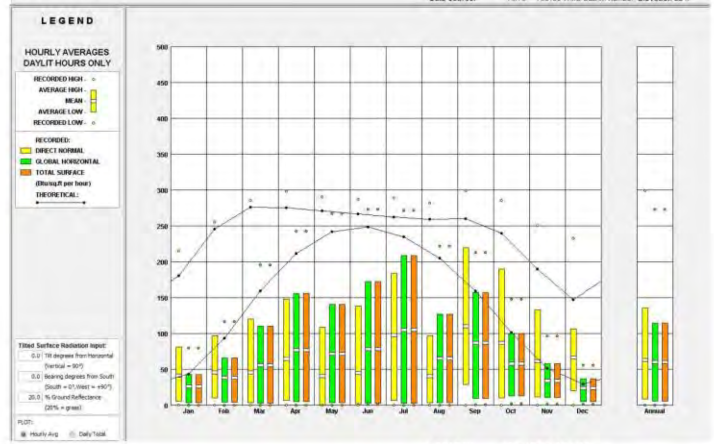
MONTHLY DIURNAL AVERAGES

LOCATION: Sand Point, AK, USA
Latitude/Longitude: 55.32° North, 160.52° West, Time Zone from Greenwich -9
Data Source: TMY3 703165 WMO Station Number, Elevation 22 ft



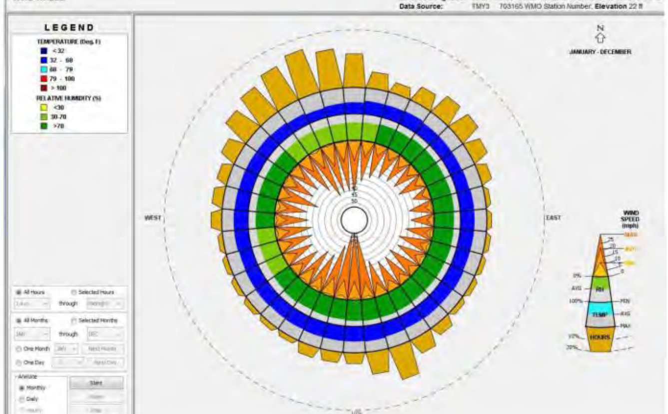
RADIATION RANGE

LOCATION: Sand Point, AK, USA
Latitude/Longitude: 55.32° North, 160.52° West, Time Zone from Greenwich -9
Data Source: TMY3 703165 WMO Station Number, Elevation 22 ft



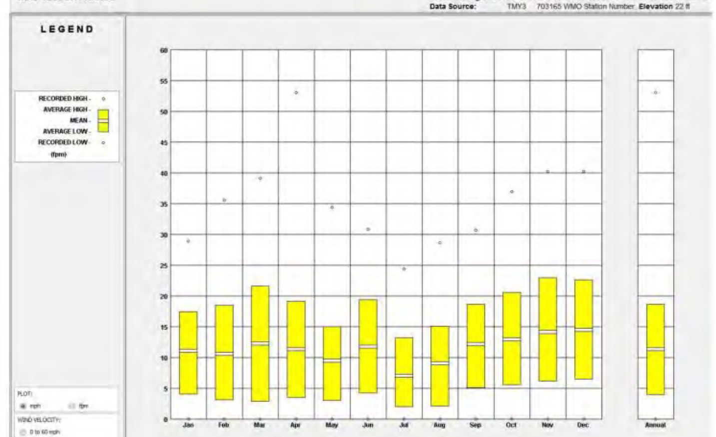
WIND WHEEL

LOCATION: Sand Point, AK, USA
Latitude/Longitude: 55.32° North, 160.52° West, Time Zone from Greenwich -9
Data Source: TMY3 703165 WMO Station Number, Elevation 22 ft



WIND VELOCITY RANGE

LOCATION: Sand Point, AK, USA
Latitude/Longitude: 55.32° North, 160.52° West, Time Zone from Greenwich -9
Data Source: TMY3 703165 WMO Station Number, Elevation 22 ft



Project:
Living Aleutian Home Design
Sand Point - Option A

REINA Properties Corporation
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Phone 907-457-1297
Fax 907-457-3397
Email info@reina-properties.com

Design by: Thorsten Chlupp

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

Date: 08/13/12

Sheet No.: 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

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

ENVELOPE

	CAVITY INSULATION R/IN	CAVITY INSULATION IN	EXT INSULATION R/IN	EXT INSULATION IN	FRAMING FACTOR %	Ug-VALUE BTU/HR.FT²°F	Uf-VALUE BTU/HR.FT²°F	FRAME WIDTH IN	SHGC %	WINDOW Ψ INSTALL	SUMMER SHADE EXPOSURE %	HORIZ OBST FACTOR DEGREES	UNOBSTRUCTED SKY %	R-VALUE | U-VALUE	SURFACE TEMP °F	PERIMETER Ψ BTU/HR.FT°F	THERMAL MASS BTU/°F.FT²	AIR TIGHTNESS N50 - ACH50	MAX LEAKAGE CFM50	ARMY CORPS Q75 CFM/FT²
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*

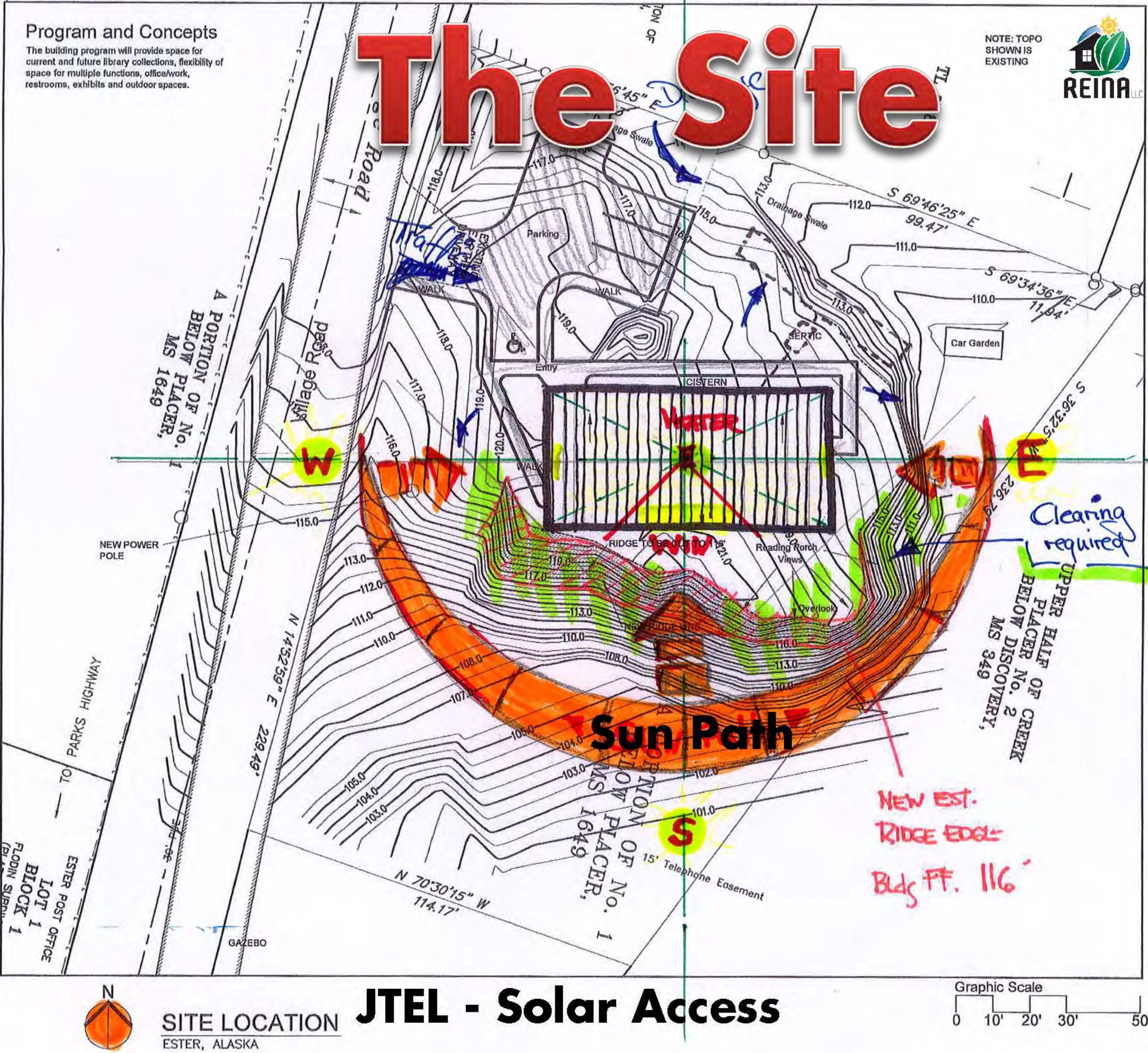
PERFORMANCE

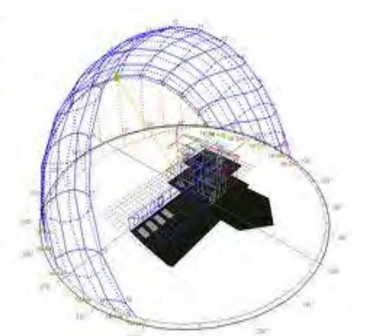
PRIMARY ENERGY kBTU/SF/YR	ANNUAL HEATING kBTU/SF/YR	ANNUAL COOLING kBTU/SF/YR	PEAK HEAT LOAD BTU/HR	MAX HEAT VIA AIR %	PEAK HEAT LOAD BTU/HR/FT2	PEAK COOLING LOAD BTU/HR /FT2	WINDOW ENERGY kBTU/YR	OVERHEATING % DAYS	OVERHEATING HOURS	24 HR TEMP SHIFT °F	FREE HEAT TO LOSSES %	POWER FOR SITE ZNE kWH/YR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

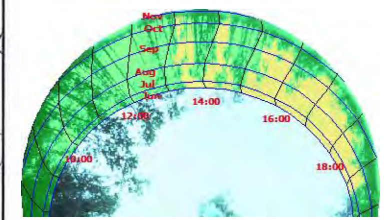
ENVELOPE

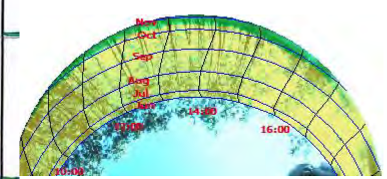
	CAVITY INSULATION R/IN	CAVITY INSULATION IN	EXT INSULATION R/IN	EXT INSULATION IN	FRAMING FACTOR %	Ug-VALUE BTU/HR.FT²°F	Uf-VALUE BTU/HR.FT²°F	FRAME WIDTH IN	SHGC %	WINDOW Ψ INSTALL	SUMMER SHADE EXPOSURE %	HORIZ OBST FACTOR DEGREES	UNOBSTRUCTED SKY %	R-VALUE | U-VALUE	SURFACE TEMP °F	PERIMETER Ψ BTU/HR.FT°F	THERMAL MASS BTU/°F.FT²	AIR TIGHTNESS N50 - ACH50	MAX LEAKAGE CFM50	ARMY CORPS Q75 CFM/FT²
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



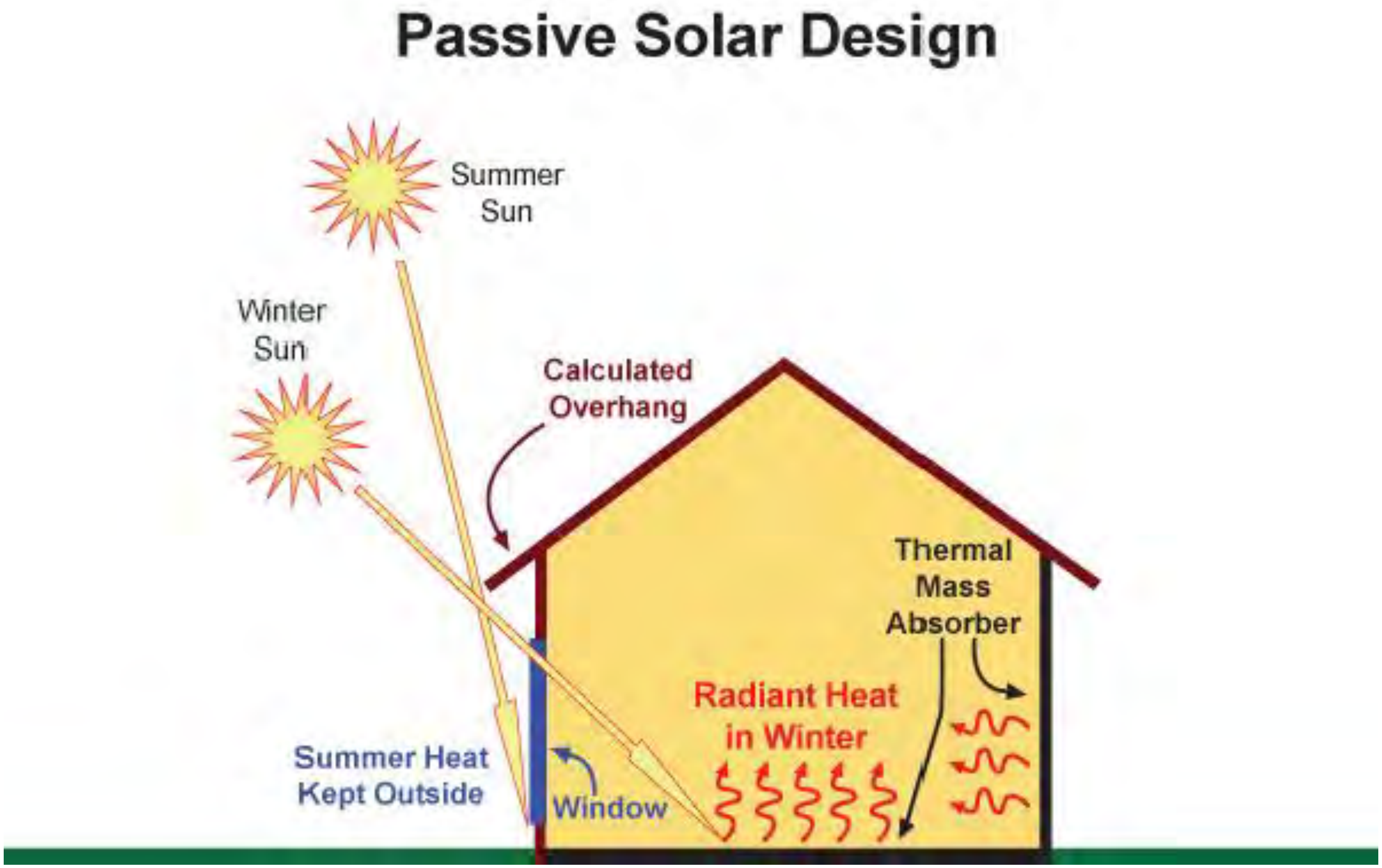




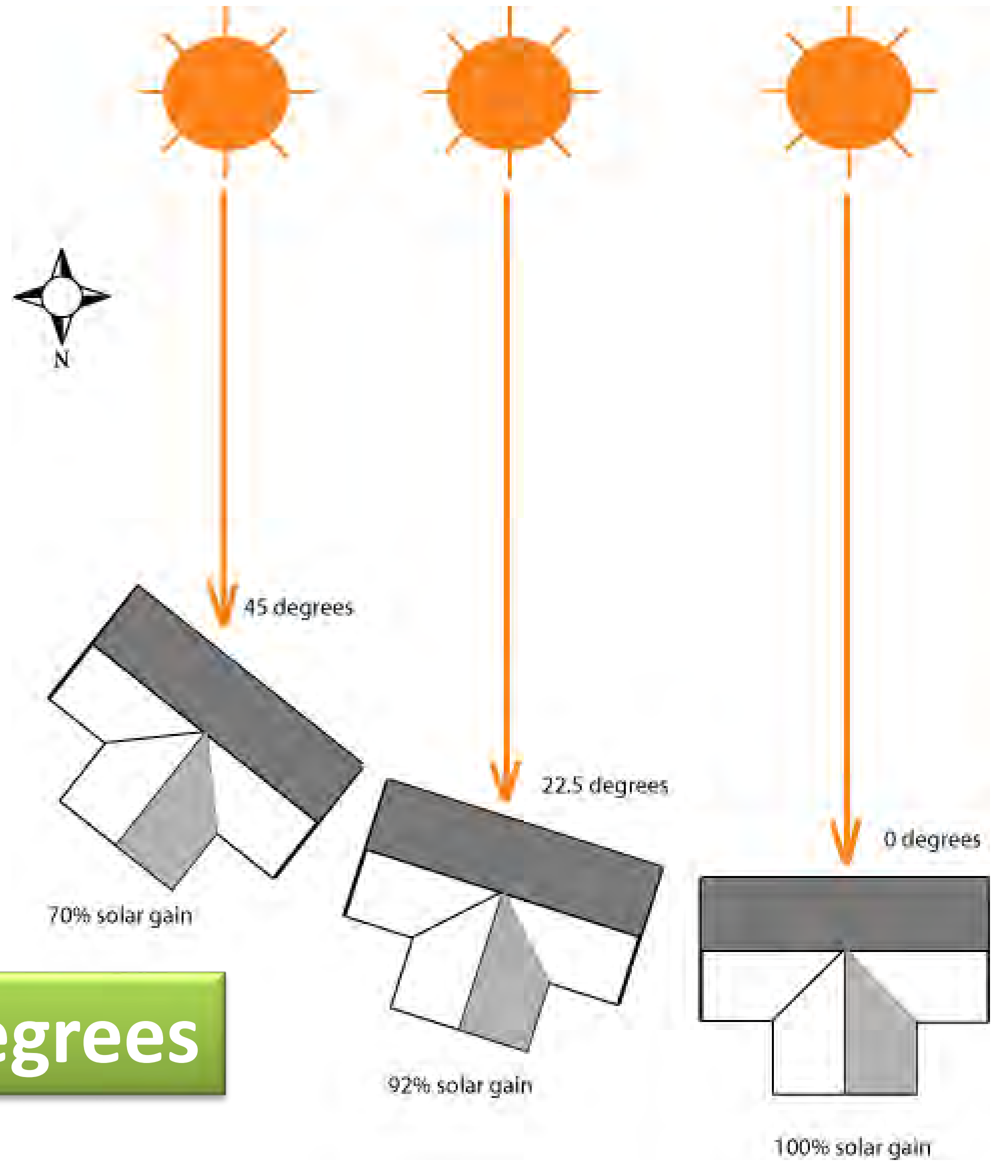


JTEL - Solar Access

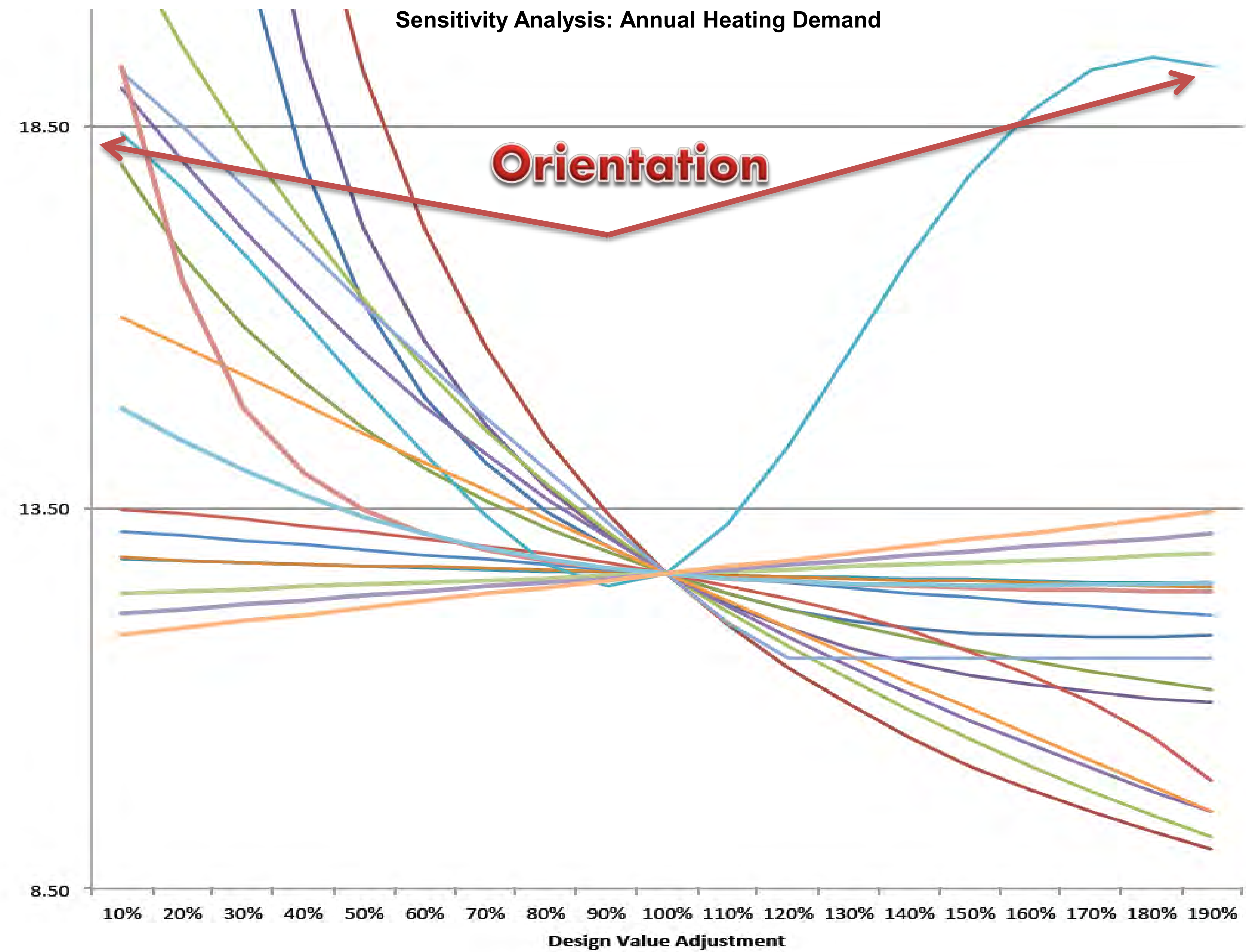

Orientation



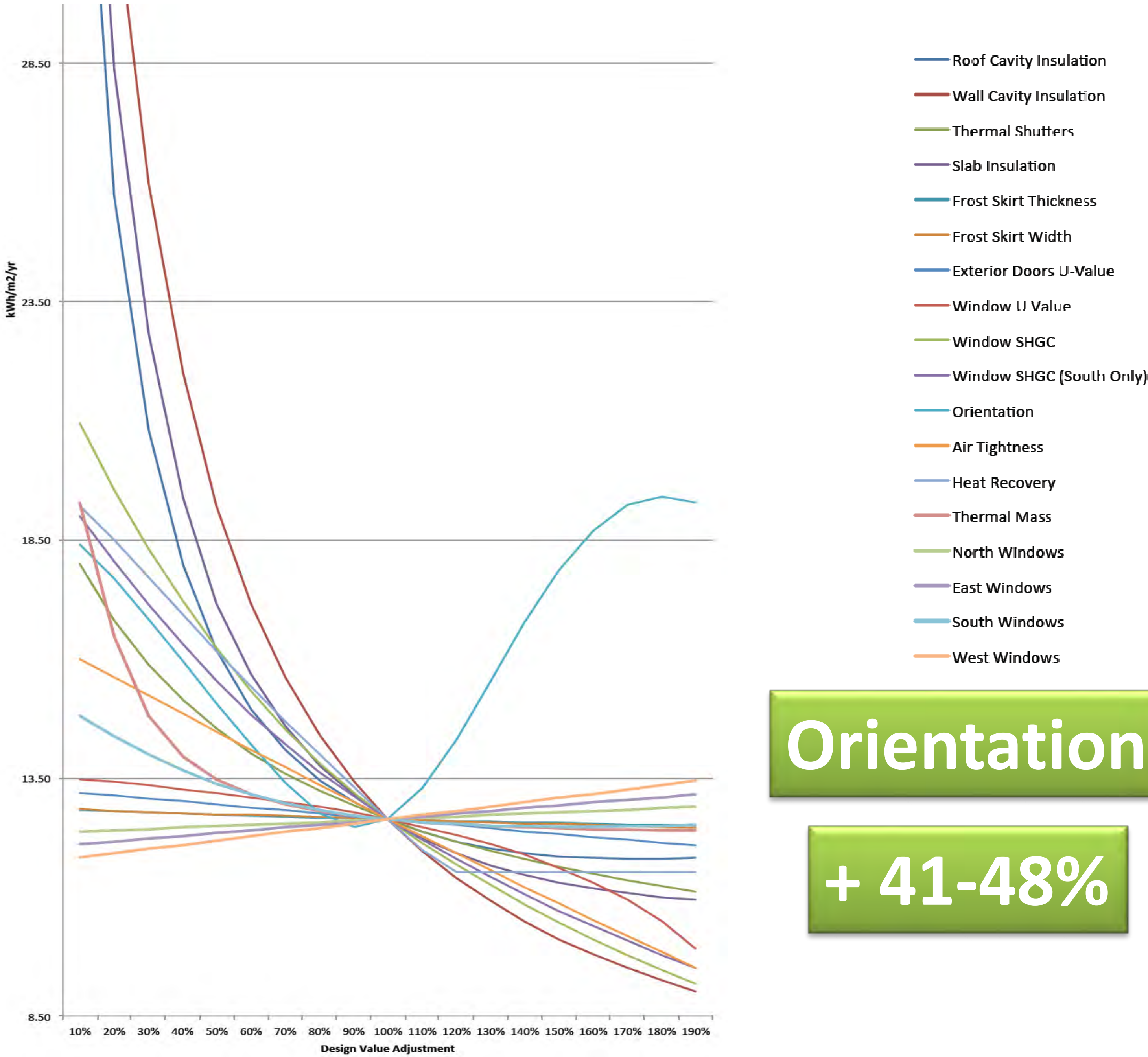
No Moving Parts – No Maintenance – Free Fuel


N
45 degrees
70% solar gain
22.5 degrees
92% solar gain
0 degrees
100% solar gain

+/- 10 degrees

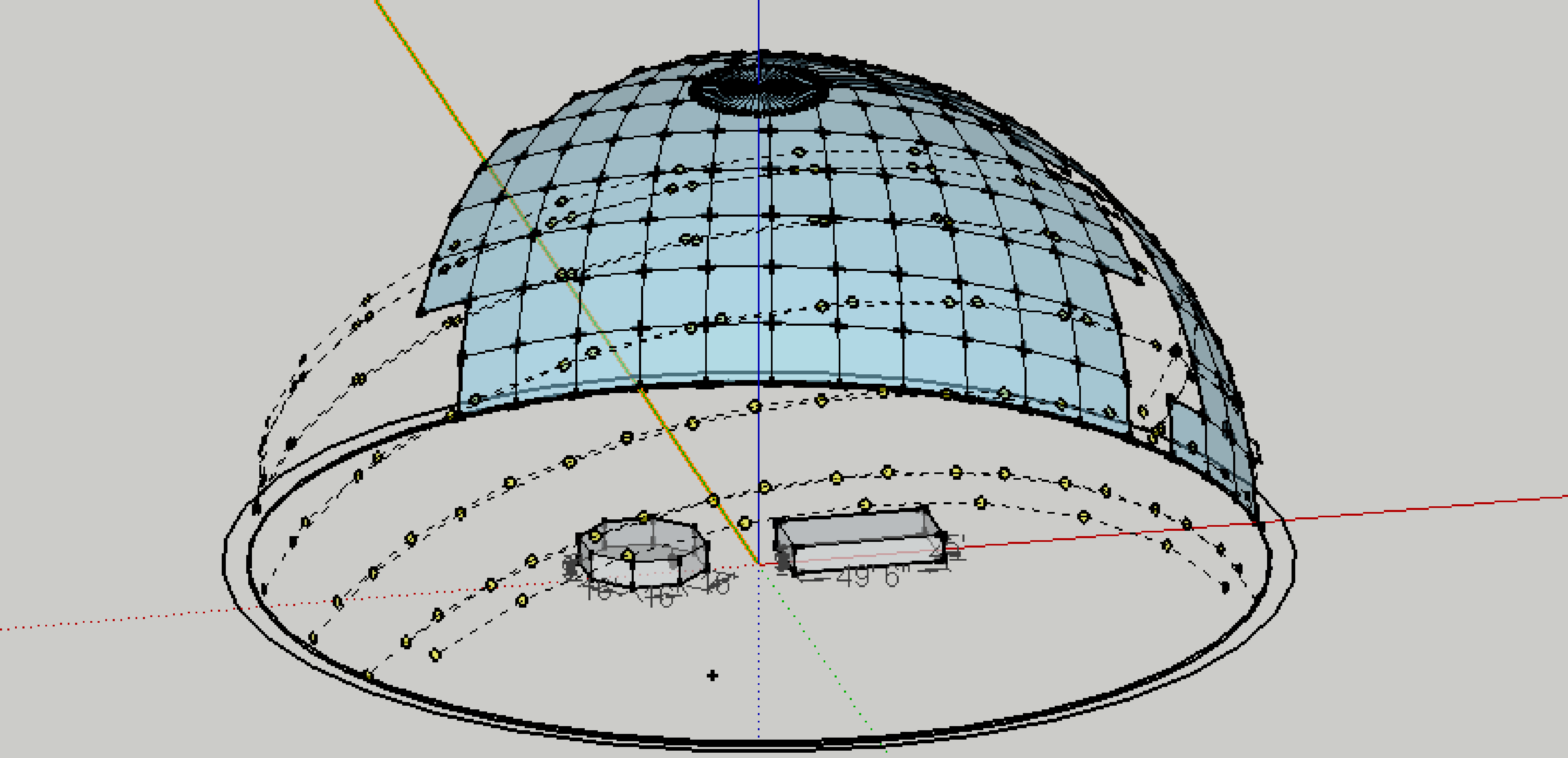


Sensitivity Analysis: Annual Heating Demand
18.50
13.50
8.50
Orientation
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
110%
120%
130%
140%
150%
160%
170%
180%
190%
Design Value Adjustment



Orientation

+ 41-48%



Octagonal Structure: Approx. 1237 Sq. Ft.

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

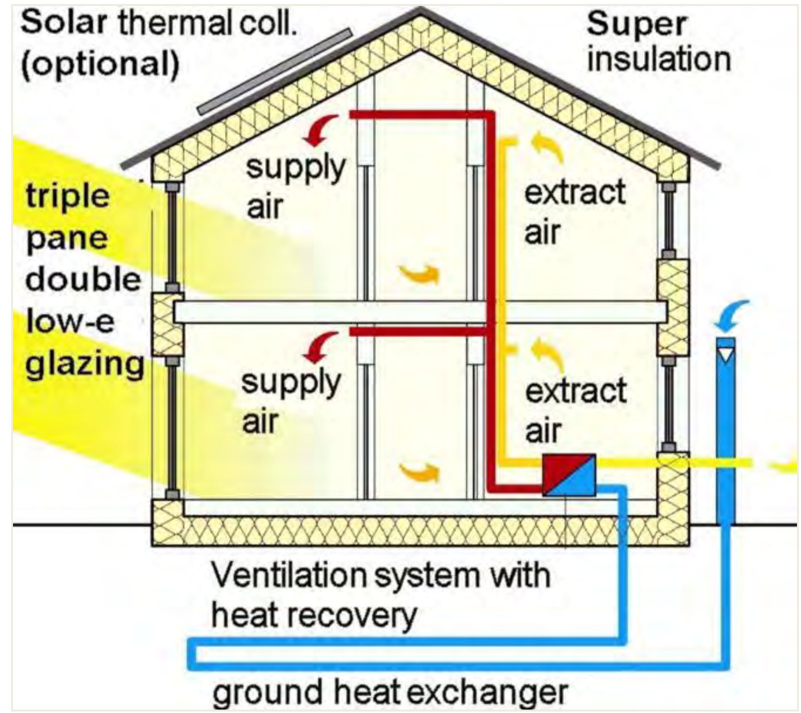
Rectangular Structure: Approx. 1237 Sq. Ft.

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

Efficiency by shape

Passiv Haus – The Key Principles

Continuous Insulation	• creating steady indoor temperatures that won't drop below 50 degrees without heating source
Thermal Bridge Free Construction	• minimizes condensation/ building deterioration
Compact Building Shape	• excellent surface-to-volume ratio (<1)
Airtightness	• minimizes moisture diffusion into wall assembly
Balanced Ventilation with Heat Recovery	• exceptional efficiency, indoor air-quality and comfort, minimal space conditioning system -
Optimal Solar Orientation and Shading	• maximizing solar gains for winter, minimizing gains for the summer case



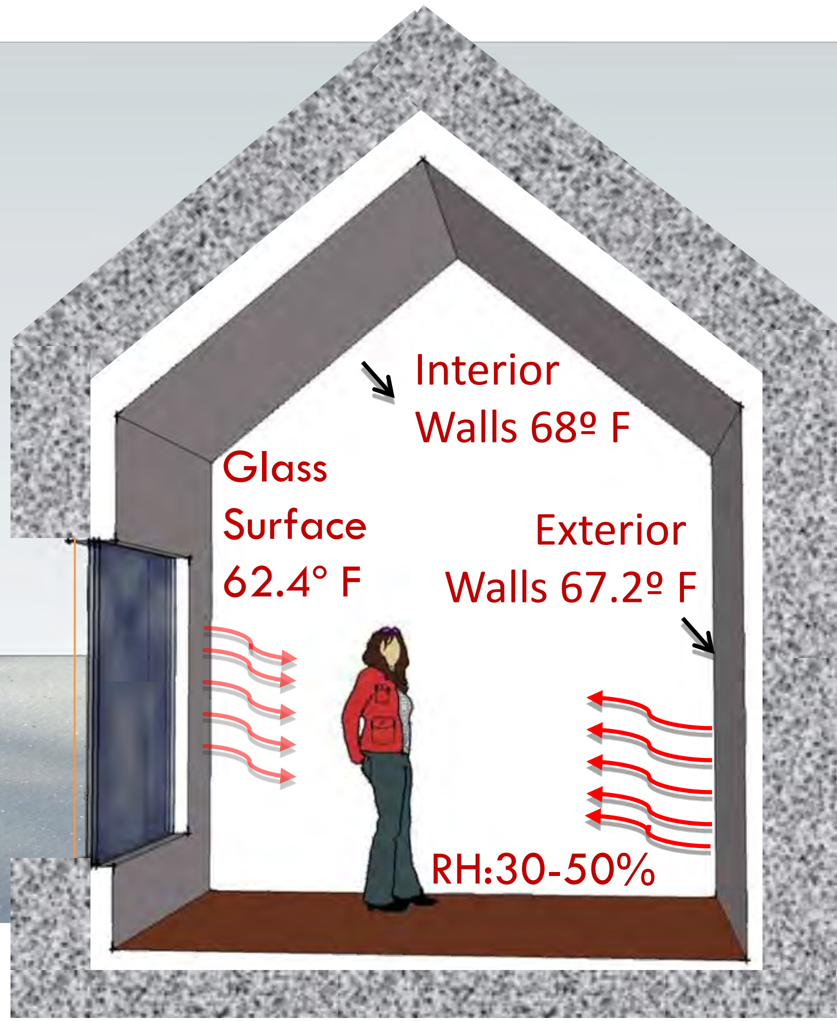
Energy Efficient Appliances and Lighting	• highly efficient use of household electricity
User Friendliness	• user manuals are recommended to be given homeowners

Human Comfort

Cold Winter Feels Comfortable!

Temperate glass and wall surfaces and *no drafts*

PH Example	
Envelope	• R 62
Window	• R -9 Triple glazed (Climate specific)
Outside Temp	• 0º F

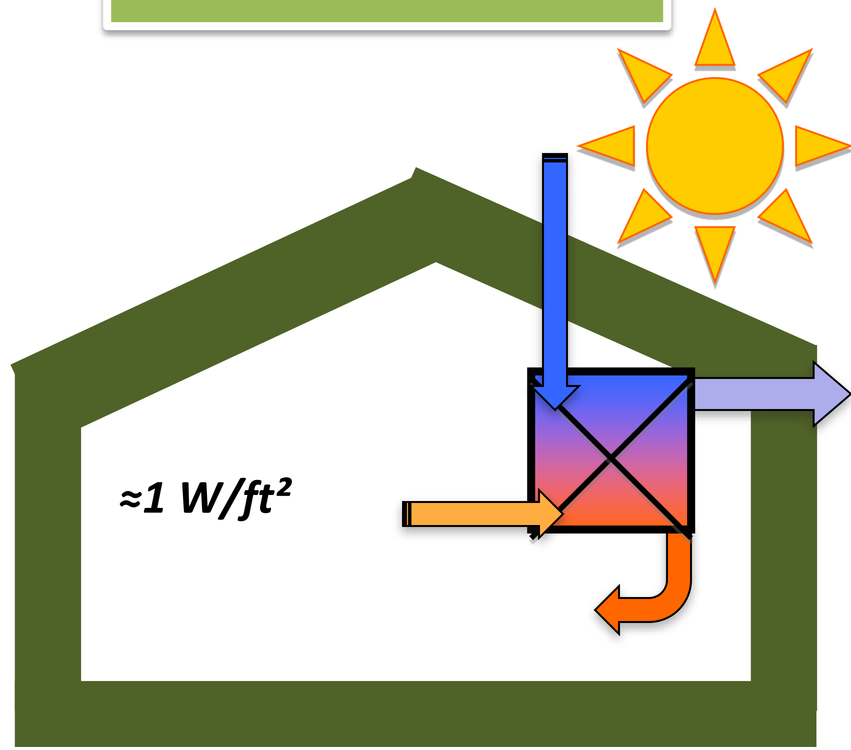


PH Comfort criteria:	
Air Temp	• (68 º F)
Relative Humidity	• (30-60 % for PH)
Air Velocity	• (<19.7 ft/min)
Radiant Condition	• Max Delta T <7.2 º F (4ºC)

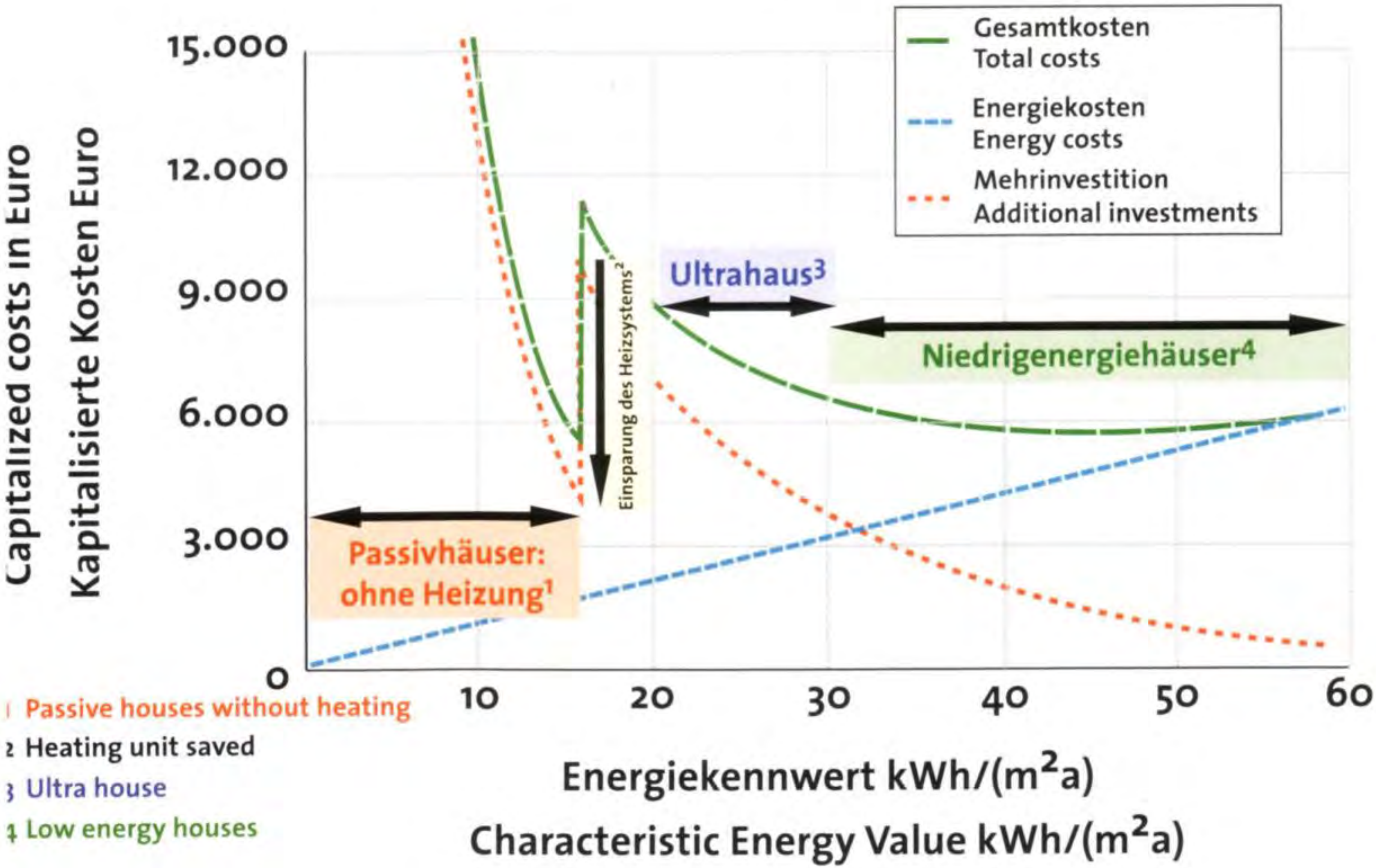
Passivhaus Criteria

Annual Heat Demand	• ≤4.75 kBTU/ft²yr (15 kWh/m²a)
Peak Heat Load	• *≤ 3.17 BTU/hr.ft² or 0.93W/ft² (10 W/m²)*
Primary Energy Demand	• ≤38 kBTU/ft²yr (120 kWh/m²a)
Airtightness	• ≤ 0.6 ACH_{50}
Ventilation	• ≥80% Recovery, ≥0.76 W/cfm
Thermal Envelope:	• R ≥ 38.5 hr. ft²°F/BTU, U ≤ 0.026 BTU/hr. ft²°F
Thermal-bridge Free	• Ψ ≤ .006 BTU/ hr. ft °F
Windows installed:	• $U_{w\text{-install}} \leq 0.15$ BTU/hr. ft² °F
SHGC	• 50 – 55 %

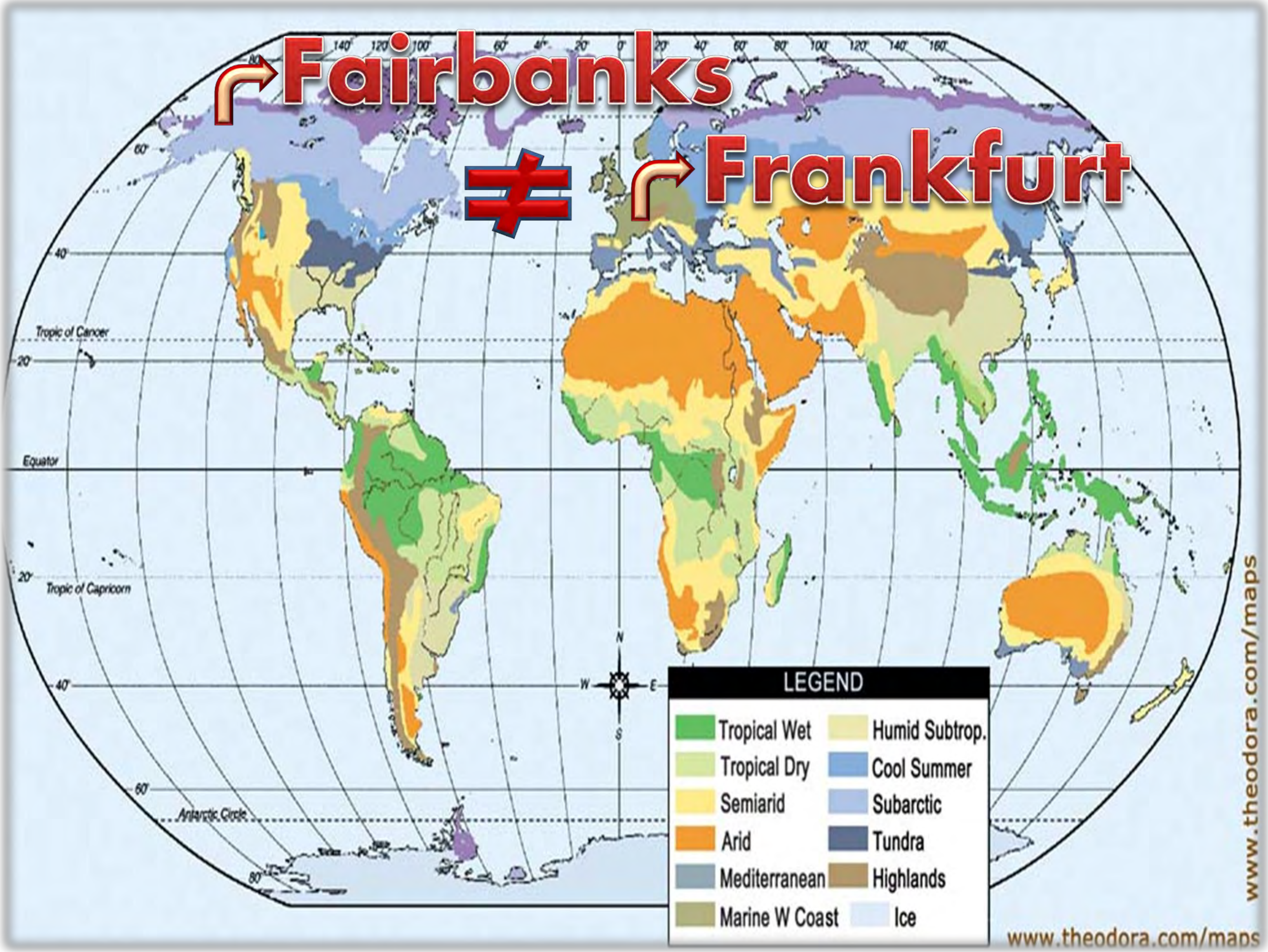
**Note: Window and Thermal envelope criteria Listed are for a Central European Climate. Recommendations for these values vary In N America based on climate*



Passiv Haus – Feasibility and savings



1 Passive houses without heating
2 Heating unit saved
3 Ultra house
4 Low energy houses



Fairbanks
≠
Frankfurt
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle
N
S
W
E
LEGEND
Tropical Wet
Tropical Dry
Semiarid
Arid
Mediterranean
Marine W Coast
Humid Subtrop.
Cool Summer
Subarctic
Tundra
Highlands
Ice
www.theodora.com/maps
www.theodora.com/maps

6376 HDD

Passive House Verification

4.63

Building:	Fairview II House
Location and Climate:	Urbana, IL — Chicago II, IL
Street Address:	
City, State, Zip:	Urbana, IL
Country:	USA
Building Type:	Single family detached residence
Home Owner(s) / Client(s):	Ecological Construction Laboratory
Street Address:	110 S. Race St. Suite 202
City, State, Zip:	Urbana, IL 61801
Architect:	
Street:	
City, State, Zip:	
Mechanical System:	
Street Address:	
City, State, Zip:	

Year of Construction:	2008				
Number of Dwelling Units:	1		Interior Temperature:	68.0	°F
Gross Enclosed Volume V_e:	16424	ft³	Internal Heat Gains:	0.7	BTU/hr.ft²
Number of Occupants:	3.3				

Energy Demands with Reference to the Treated Floor Area

Treated Floor Area: 1242 ft²

	Applied:	Monthly Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	4.63	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	Yes
Pressurization Test Result:	0.45	ACH_{50}	0.6 ACH_{50}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	33.3	kBTU/(ft²yr)	38.0 kBTU/(ft²yr)	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	14.4	kBTU/(ft²yr)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:		kBTU/(ft²yr)		
Heating Load:	4.73	BTU/(ft²hr)		
Frequency of Overheating:		%	over 77.0 °F	
Specific Useful Cooling Energy Demand:	0.24	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	Yes
Cooling Load:	2.29	BTU/(ft²hr)		

13769 HDD

Passive House Verification

19.67

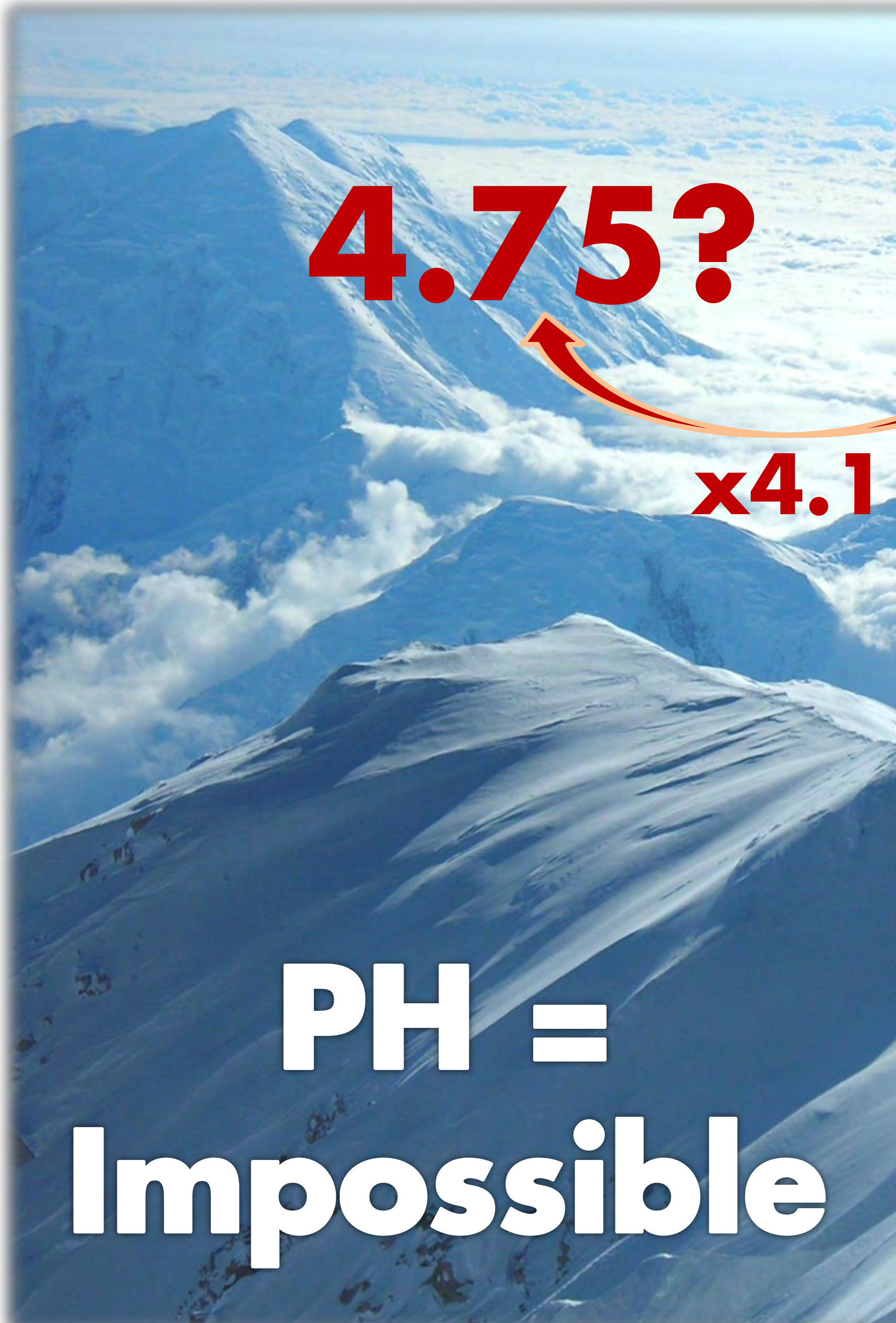
Building:	Fairview II House
Location and Climate:	Urbana, IL — Yellowknife
Street Address:	
City, State, Zip:	Urbana, IL
Country:	USA
Building Type:	Single family detached residence
Home Owner(s) / Client(s):	Ecological Construction Laboratory
Street Address:	110 S. Race St. Suite 202
City, State, Zip:	Urbana, IL 61801
Architect:	
Street:	
City, State, Zip:	
Mechanical System:	
Street Address:	
City, State, Zip:	

Year of Construction:	2008				
Number of Dwelling Units:	1		Interior Temperature:	68.0	°F
Gross Enclosed Volume V_e:	16424	ft³	Internal Heat Gains:	0.7	BTU/hr.ft²
Number of Occupants:	3.3				

Energy Demands with Reference to the Treated Floor Area

Treated Floor Area: 1242 ft²

	Applied:	Monthly Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	19.67	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	No
Pressurization Test Result:	0.45	ACH_{50}	0.6 ACH_{50}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	55.3	kBTU/(ft²yr)	38.0 kBTU/(ft²yr)	No
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	36.5	kBTU/(ft²yr)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:		kBTU/(ft²yr)		
Heating Load:		BTU/(ft²hr)		
Frequency of Overheating:		%	over 77.0 °F	
Specific Useful Cooling Energy Demand:	9.18	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	No
Cooling Load:		BTU/(ft²hr)		



Passive House Verification

Building:	Fairview II House		
Location and Climate:	Urbana, IL	Yellowknife	
Street Address:			
City, State, Zip:	Urbana, IL		
Country:	USA		
Building Type:	Single family detached residence		
Home Owner(s) / Client(s):	Ecological Construction Laboratory		
Street Address:	110 S. Race St. Suite 202		
City, State, Zip:	Urbana, IL 61801		
Architect:			
Street:			
City, State, Zip:			
Mechanical System:			
Street Address:			
City, State, Zip:			
Year of Construction:	2008		
Number of Dwelling Units:	1	Interior Temperature:	68.0 °F
Gross Enclosed Volume V_e:	16424 ft³	Internal Heat Gains:	0.7 BTU/hr.ft²
Number of Occupants:	3.3		

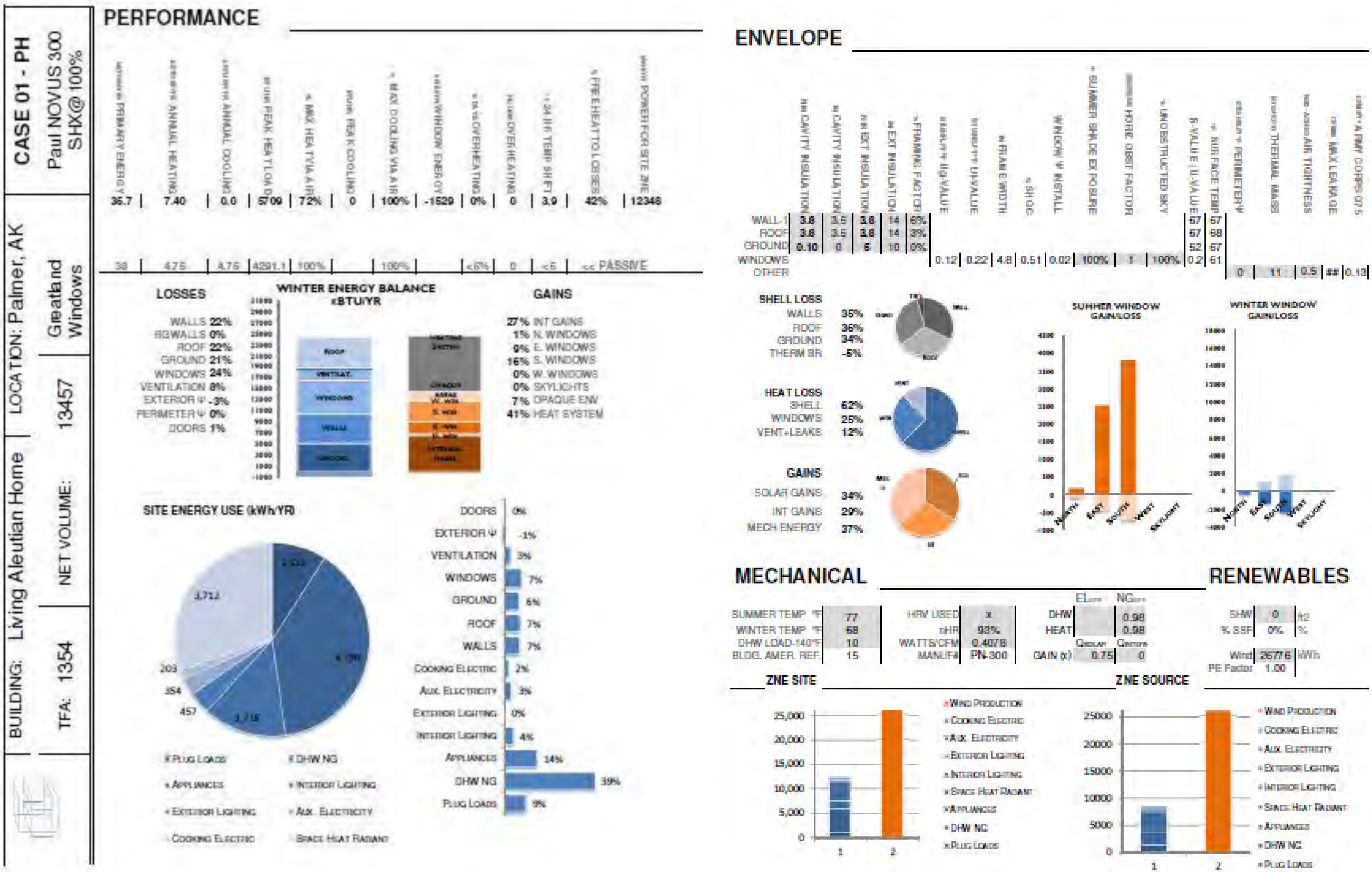
Energy Demands with Reference to the Treated Floor Area

Treated Floor Area: 1242 ft²

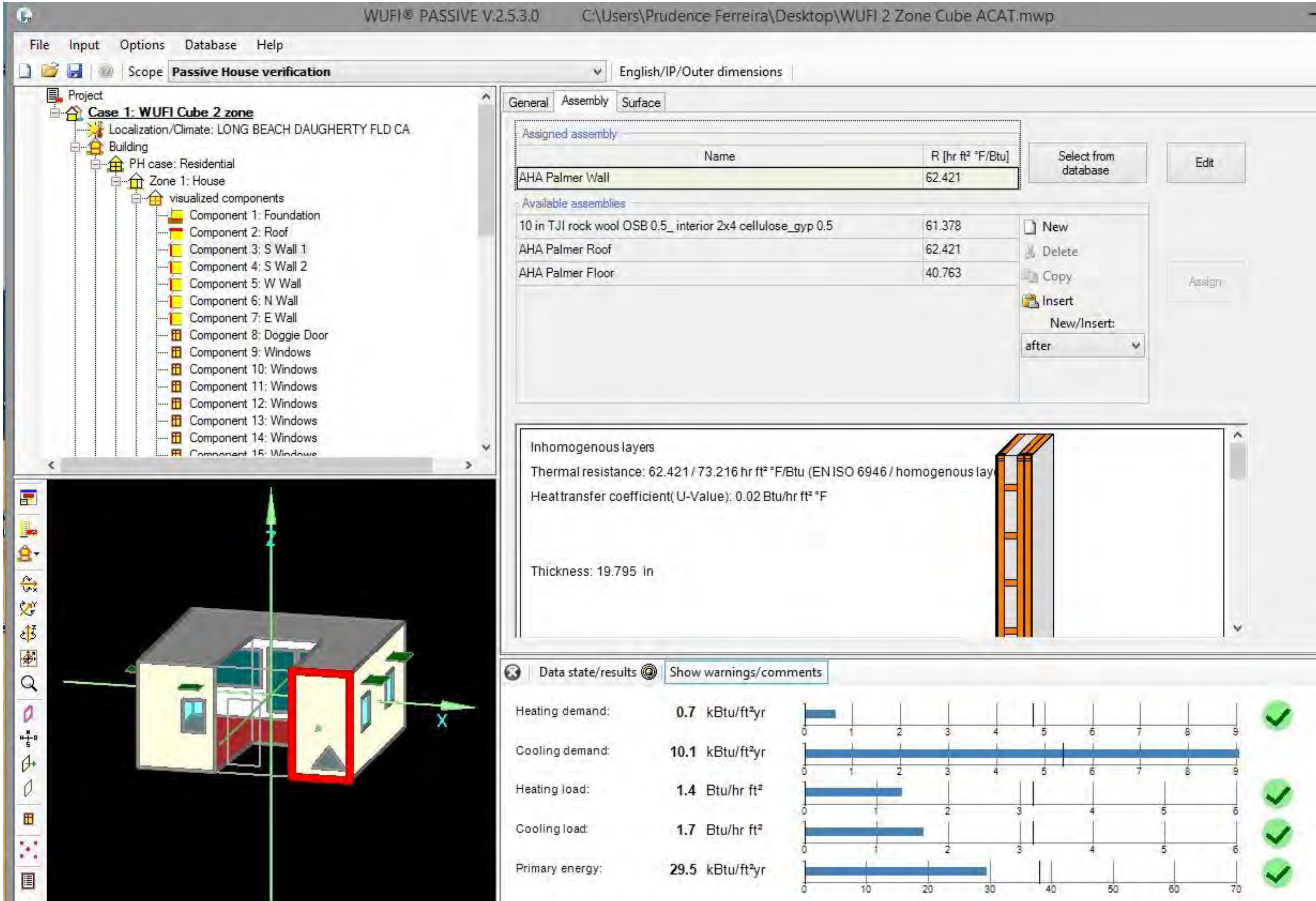
	Applied:	Monthly Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	19.67	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	No
Pressurization Test Result:	0.45	ACH_{50}	0.6 ACH_{50}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	55.3	kBTU/(ft²yr)	38.0 kBTU/(ft²yr)	No
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	36.5	kBTU/(ft²yr)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:		kBTU/(ft²yr)		
Heating Load:		BTU/(ft²hr)		
Frequency of Overheating:		%	over 77.0 °F	
Specific Useful Cooling Energy Demand:	9.18	kBTU/(ft²yr)	4.75 kBTU/(ft²yr)	No
Cooling Load:		BTU/(ft²hr)		

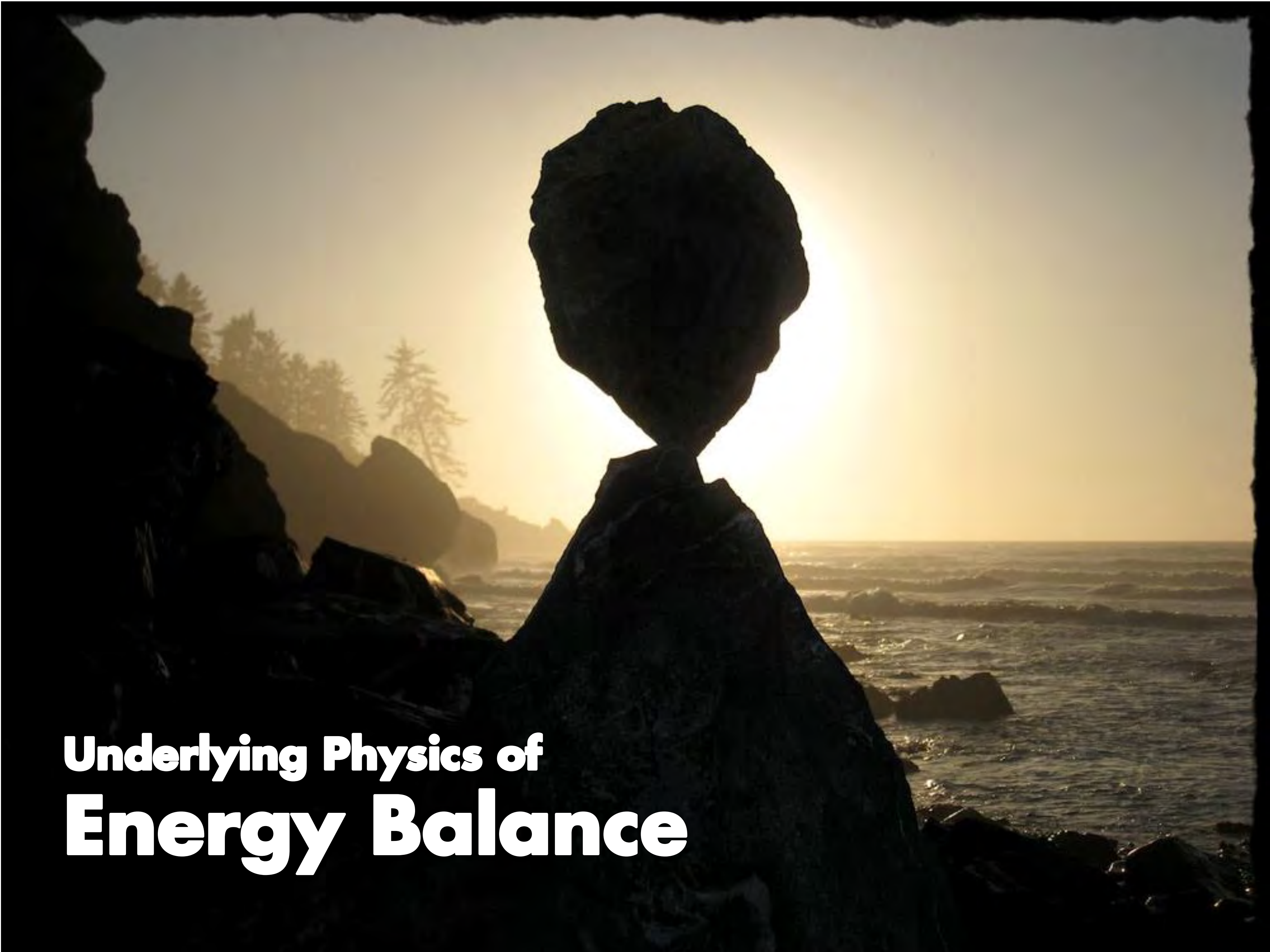

...or how to PHPP this?

Essential Tools: PHPP



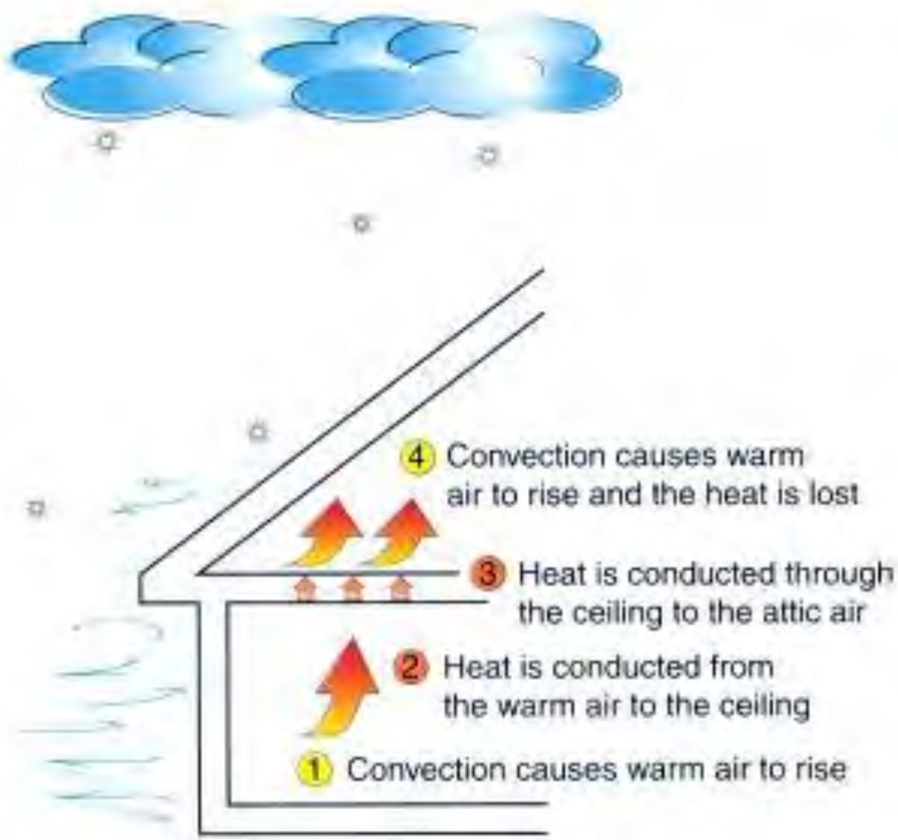
Essential Tools: WUFI Passive

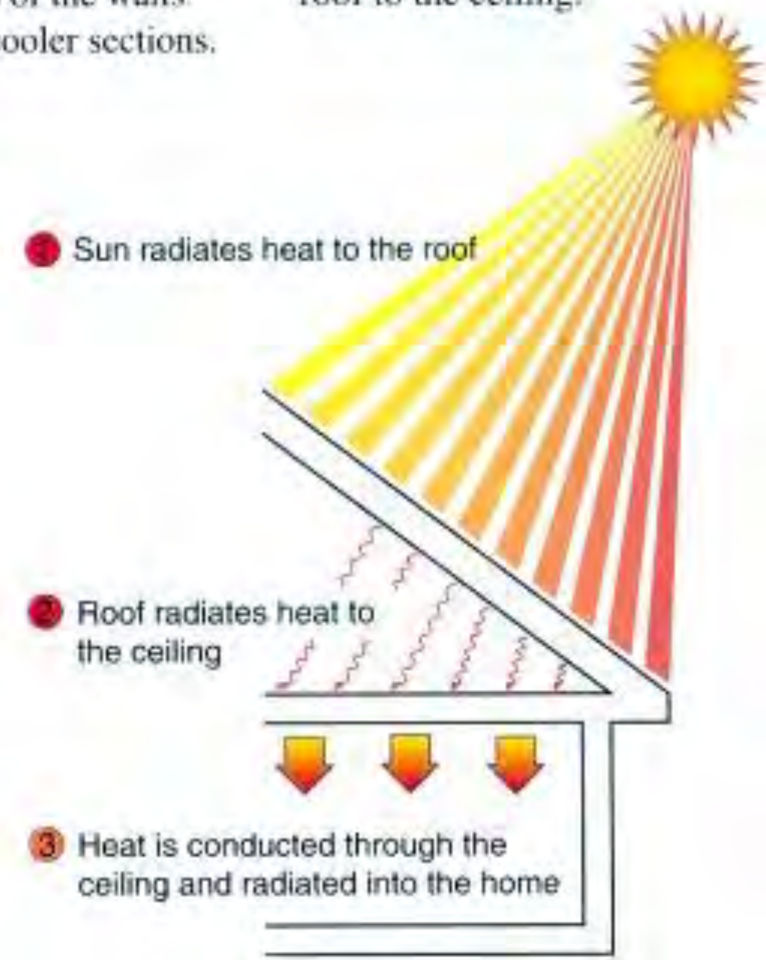



Underlying Physics of
Energy Balance

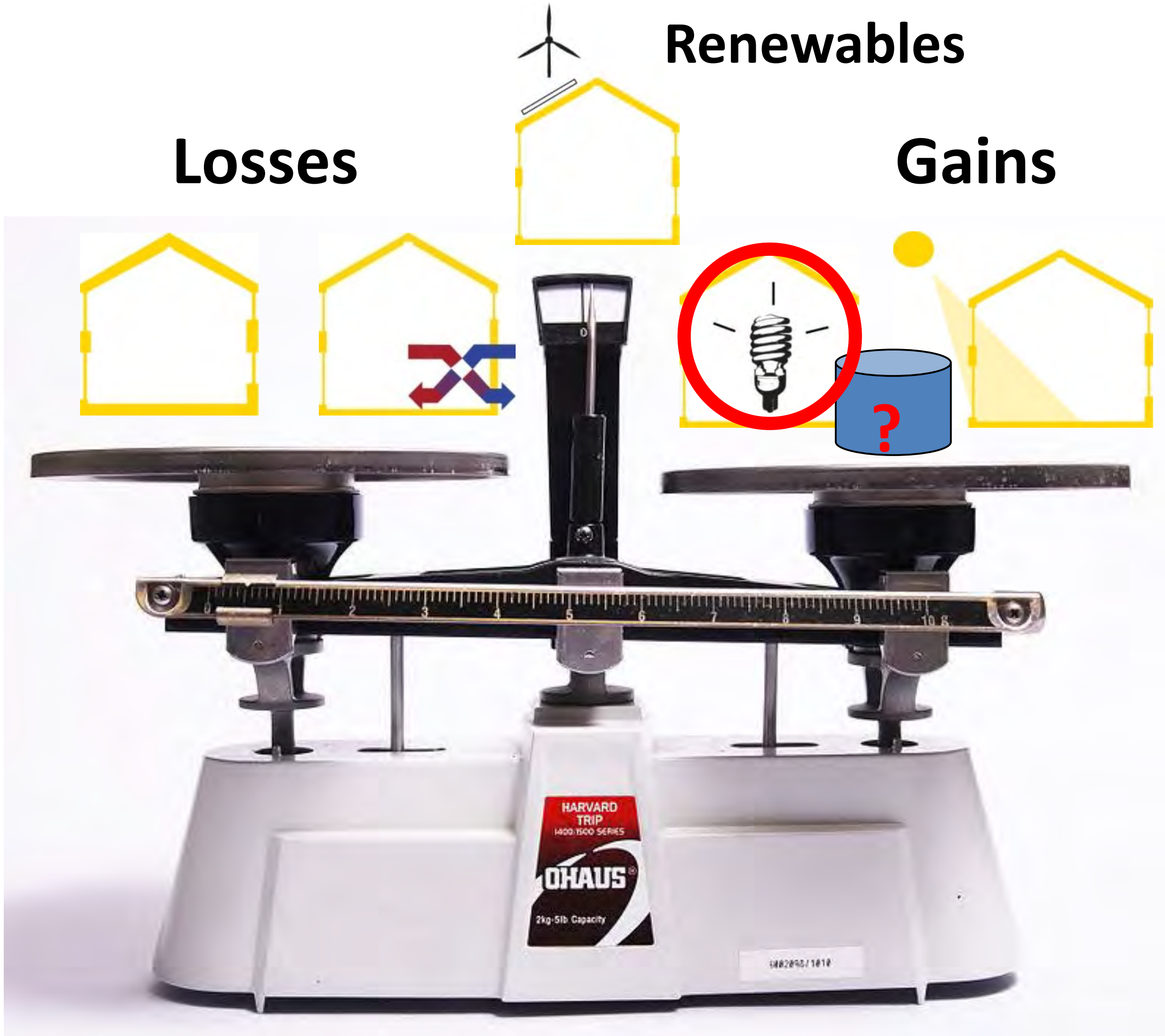
Your Home Loses and Gains Heat in 3 Ways

	Convection	Conduction	Radiation
Definition:	The transfer of heat by moving air.	The transfer of heat through a solid material.	The transfer of heat in the form of electromagnetic waves.
Example:	Warm air rises and transfers heat to the ceiling	Heat is transferred from warmer sections of the walls and ceilings to cooler sections.	Heat is transferred from the roof to the ceiling.





Balance Point



Annual Heat Demand

$$Q_H = Q_T + Q_V - \eta*(Q_S + Q_I)$$

Q_T	• (kBTU/yr) ***transmission heat loss***
Q_V	• (kBTU/yr) ***ventilation heat losses***
η	• ***Utilization % of free heat***
Q_S	• (kBTU/yr) ***solar gains*** heat supply through windows
Q_I	• (kBTU/yr) ***internal heat gains*** heat supply from internal sources

Peak Heat Load

$$P_H = P_T + P_V - (P_S + P_I)$$

P_T	(BTU/hr) ***peak heat loss*** through entire envelope
P_V	(BTU/hr) ***peak ventilation heat losses***
P_S	(BTU/hr) ***peak solar heat gains***
P_I	(BTU/hr) ***internal heat gains*** heat supply from internal heat sources

Losses Through Envelope

Q_T - Transmission Heat Loss Annual

Exterior Wall, Roof, Floor, Window

$$Q_T = A * U * f_T * G_t$$

Q_T	• (kBTU/yr or kWh/a) transmission heat loss
A	• (ft^2 or m^2) assembly area to exterior dimensions
U	• (BTU/hr.ft^2.°F or W/m^2K) heat transfer coefficient (DIN EN ISO 6946)
f_T	• ($\leq$1)temperature correction factor (used in cases like a ground condition or "X" where heat loss is mitigated)
G_t	• (k °F.hr/yr) or (kKh/a) heating degree hours = Σ ($\Delta\vartheta$ * $hr_{\Delta\vartheta}$)*To convert HDD to $G_{t,}$ multiply HDD by .024.

*PHPP AHD pg. 93

P_T - Transmission Heat Loss Peak

Exterior Wall, Roof, Floor, Window

$$P_T = A * U * f_T * \Delta\vartheta$$

P_T	• (BTU/hr or W) transmission heat loss
A	• (ft^2 or m^2) assembly area to exterior dimensions
U	• (BTU/hr.ft^2.°F or W/m^2K) heat transfer coefficient (IDN EN ISO 6946)
f_T	• temperature correction factor **ALWAYS 1 for peak calc, except for temperature zone "X" ($\leq$1) and slab condition**
$\Delta\vartheta$	• (°F, °K or °C) worst case of weather condition 1(cold, clear) or 2 (moderate, cloudy)

Q_T Linear Heat Loss Annual

Thermal Bridges

$$Q_T = L * \Psi * f_T * G_T$$

Q_T	(BTU/hr or W) transmission heat loss
L	(ft or m) length of thermal bridge
Ψ	(BTU/hr.ft.°F or W/mK) linear heat transfer coefficient
f_T	($\leq$1)temperature correction factor (used in cases like a ground condition or "X" where heat loss is mitigated)
G_t	(k°F.hr/yr) or (kKh/a) heating degree hours = Σ ($\Delta\vartheta$ * $hr_{\Delta\vartheta}$)*To convert HDD to $G_{t,}$ multiply HDD by .024.

P_T Linear Heat Loss Peak

Thermal Bridges

$$P_T = L * \Psi * f_T * \Delta\vartheta$$

P_T	• (BTU/hr or W) transmission heat loss
L	• (ft or m) length of thermal bridge
Ψ	• (BTU/hr.ft.°F or W/mK) linear heat transfer coefficient
f_T	• temperature correction factor **ALWAYS 1 for peak calc, except for temperature zone "X" (<u><</u>1) or slab condition**
$\Delta\vartheta$	• (°F, °K or °C) worst case or given temperature difference between indoor and outdoor

H_T = Total Specific Heat Losses

$$H_T = \Sigma\, A_j U_j + \Sigma\, \Psi_j l_j + \Sigma\, X_j$$

H_T	(kBTU/yr or kWh/a) total specific transmission heat losses
$\Sigma A_j U_j$	(kBTU/yr or kWh/a) sum of transmission heat loss envelope
$\Sigma \Psi_j l_j$	(kBTU/yr or kWh/a) sum of transmission heat losses linear thermal bridges (l=length)
ΣX_j	(kBTU/yr or kWh/a) sum of transmission heat losses of point thermal bridges

*PHPP Areas + AHD /Pg.50, 96

U VALUES, R VALUES & SURFACE TEMPERATURE

R-Value of Homogeneous Section*

You are given R per inch

d	• Thickness
R_{si}	• Interior surface film resistance
R_{se}	• Exterior surface film resistance

Rsi = R-0.74
5/8” Drywall = 0.91 R/in
5 ½“ Cellulose = 3.47 R/in
¾” Plywood = 1.28 R/in
2” Mineral Wool = 4.17 R/in
Rse = R-0.23

$$R_T = R_{si} + (d_1 * R_1) + (d_2 * R_2) + (d_3 * R_3) + (d_4 * R_4) + R_{se}$$

$$R_T = 0.74 + (0.625*0.91) + (5.5*3.47) + (0.75*1.28) + (2*4.17) + 0.23$$

$$R_T = 0.74 + (0.56875) + (19.085) + (0.96) + (8.34) + 0.23$$

$$R_T = 29.92375$$

$$R_T = 29.924\ \mathrm{hr.ft^{2\circ}\ F/BTU}$$

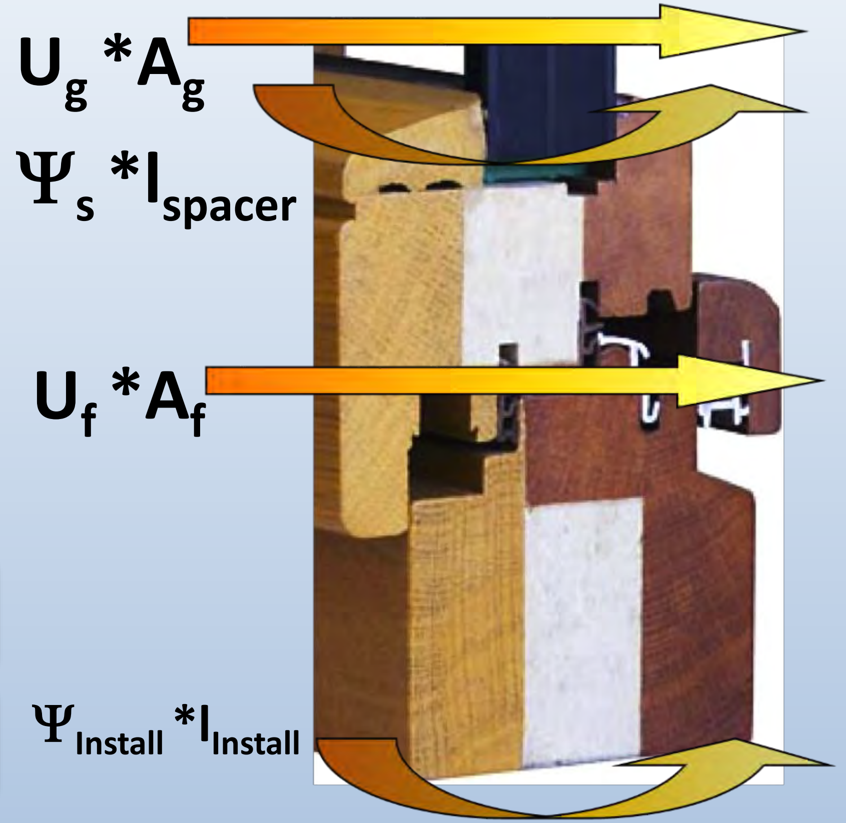
(*Per ISO 6946)

Installed U Value of Windows*

U_f	• BTU/hr.ft²°F
U_g	• BTU/hr.ft²°F
Ψ_{spacer}	• BTU/ hr.ft °F
$\Psi_{install}$	• BTU/hr.ft °F

Glazing dimensions

Frame dimensions



$$U_{W\text{-}install} = \frac{U_g * A_g + U_f * A_f + \Psi_{Spacer} * l_{Spacer} + \Psi_{install} * l_{install}}{A_g + A_f}$$

(*Per ISO 10077)

Calculation of the Interior Surface Temperature of an Assembly:

$$\Theta_{si} = \Theta_i - U * R_{si} * (\Theta_i - \Theta_e)$$

Θ_{si}	• Interior surface temperature
Θ_i	• Room temperature
U	• U-value of the assembly
R_{si}	• Interior surface film resistance
Θ_e	• Outdoor temperature

Losses Through Ventilation

$Q_{v:}$ Ventilation Heat Loss Annual :

$$Q_v = n_v * V_V * c_p\rho * G_t$$

Q_v	• (kBTU/yr) ***Ventilation heat loss***
n_v	• (ACH or 1/hr) ***energetically effective air exchange rate***
V_V	• (ft^3 or m^3)(=TFA* average height)
$c_p\rho$	• ***Specific heat capacity of air***: (0.018 BTU/ft^3F° or 33 Wh(m^3K) - aka c_{air}
G_t	• (k°F.hr/yr) or (kWh/a) ***heating degree hours*** = Σ ($\Delta\vartheta$ * $h_{\Delta\vartheta}$)*To convert HDD to $G_{t,}$ multiply HDD by 0.024.

*AHD/Pg. 97 in PHPP

$P_{v:}$ Ventilation Heat Loss Peak :

$$P_v = n_v * V_V * c_p\rho * \Delta\vartheta$$

P_v	• (kBTU/yr) ***Ventilation heat loss***
n_v	• (ACH or 1/hr) ***energetically effective air exchange rate***
V_V	• (ft^3 or m^3)(=TFA* average height)
$c_p\rho$	• ***Specific heat capacity of air***: (0.018 BTU/ft^3F° or 33 Wh(m^3K) - aka c_{air}
$\Delta\vartheta$	• (°F, °K or C°) ***Temperature difference*** (worst case or given temperature difference between indoor and outdoor

*AHD/Pg. 97 in PHPP

q_{50} : Air Permeability

$$q_{50} = n_{50} * Vn_{50} / \text{total extr. envelope area}$$

q_{50}

- (CFM_{50}/ft^2) leakage in reference to the exterior square foot area of the envelope (for very large buildings only)

n_{50}

- (ACH_{50} or 1/hr) Pressure test air changes at 50 pascal pressure difference

Vn_{50}

- (ft^3) Net enclosed air volume for air pressure test

*PHPP AHD/Pg. 98-99

Q_L : Total Heat Losses

$$Q_L = Q_T + Q_V$$

Q_L	• (kBTU/yr) ***Total heat loss***
Q_T	• (kBTU/yr) ***Transmission heat loss***
Q_V	• (kBTU/yr) ***Ventilation heat loss***
Q_L/ft^2	• (kBTU/ft^2yr) ***Total heat loss / TFA***

*AHD/Pg. 97 in PHPP

P_L : Peak **Heat Losses**

$$P_L = P_T + P_V$$

P_L	• (BTU/hr) ***Total peak heat loss***
P_T	• (BTU/hr) ***Peak transmission heat loss***
P_V	• (BTU/hr) ***Peak ventilation heat loss***
P_L/ft^2	• (BTU/hr.ft^2) ***Total peak heat loss / TFA***

*AHD/Pg. 97 in PHPP

Gains

Q_F Total Free Heat Annual:

Glazing, People, Equipment+ Lighting

$$Q_F = Q_S + Q_I$$

Q_F	• (kBTU/yr) ***total free heat***
Q_S	• (kBTU/yr) ***available solar heat gains***
Q_i	• (kBTU/yr) ***internal heat gains***

P_G Peak Heat Gains:

Glazing, People, Equipment+ Lighting

$$P_G = P_S + P_I$$

P_G

- (BTU/hr) ***total peak heat gains***

P_S

- (BTU/hr) ***peak solar heat gains***

P_i

- (BTU/hr) ***peak internal heat gains***

Q_S Solar Gains Annual:

Window, Door and Skylight Glazing:

$$Q_S = r * g * A_w * G$$

Q_S	• (kBTU/yr)
r	• (%) ***reduction factor*** for the frame portion, shading, dirt and non-perpendicular incidence of radiation
g	• (%)***total energy transmittance*** via perpendicular radiation, aka SHGC or g-value
A_w	• (ft^2 or m^2) ***window area***
G	• ($kBTU/ft^2yr$ or kWh/m^2a) ***global radiation*** averaged over during the heating season

*PHPP AHD pg. 100

P_S Solar Gains Peak:
Window, Door and Skylight Glazing:

$$P_S = r * g * A_w * G_{worst}$$

P_S	• (BTU/hr)
r	• (%) ***reduction factor*** for the frame portion, shading, dirt and non-perpendicular incidence of radiation
g	• (%)***total energy transmittance*** via perpendicular radiation, aka SHGC or g-value
A_w	• (ft^2 or m^2) ***window area*** –rough opening size
G_{worst}	• ($BTU/hr.ft^2$ or W/m^2) ***global radiation*** for worst case weather condition (cold, clear or moderate cloudy)

*PHPP AHD pg. 100

Internal Heat Gains Annual:

People, Equipment and Lighting

$$Q_I = t_{Heat} * q_i * TFA$$

Q_I	(BTU/hr) ***Internal heat gains***
t_{Heat}	***days per heating season*** * .024 hrs
q_i	(BTU/(hr.ft^2) 0.666 = ***residential default internal heat load***
TFA	(ft^2) ***energy reference area*** after PHPP

Internal Heat Gains Peak :

People, Equipment and Lighting

$$P_I = q_i * TFA$$

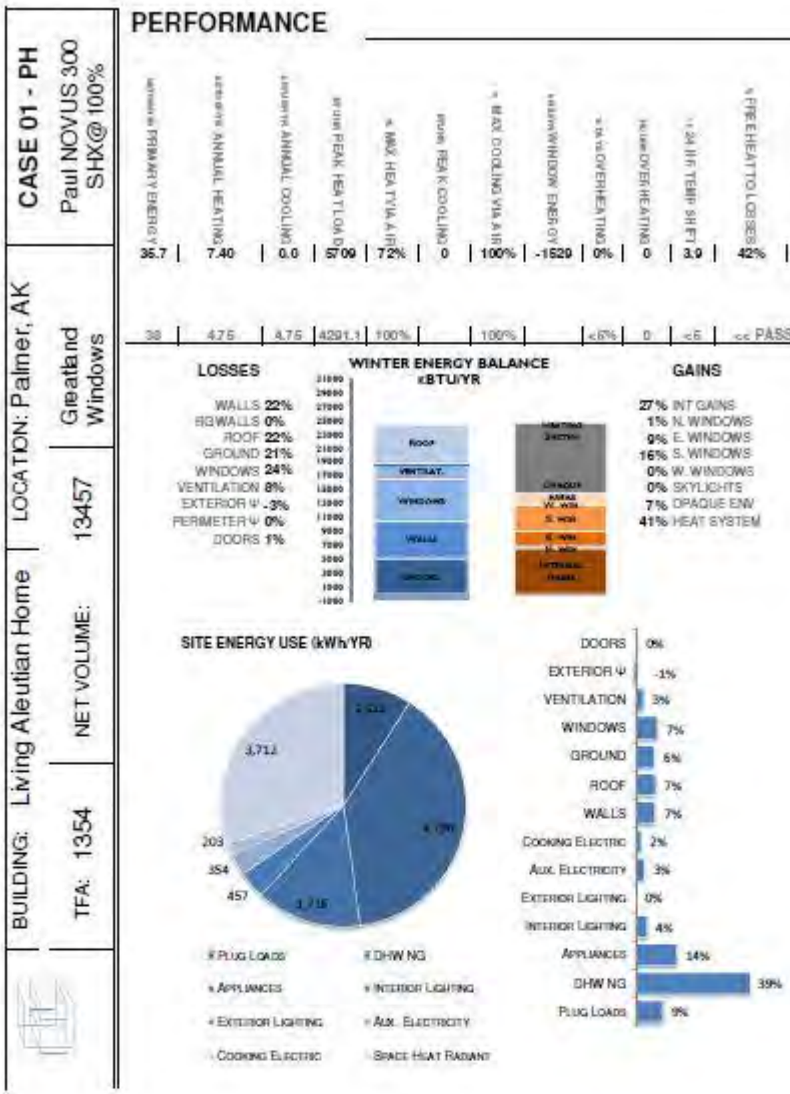
q_i

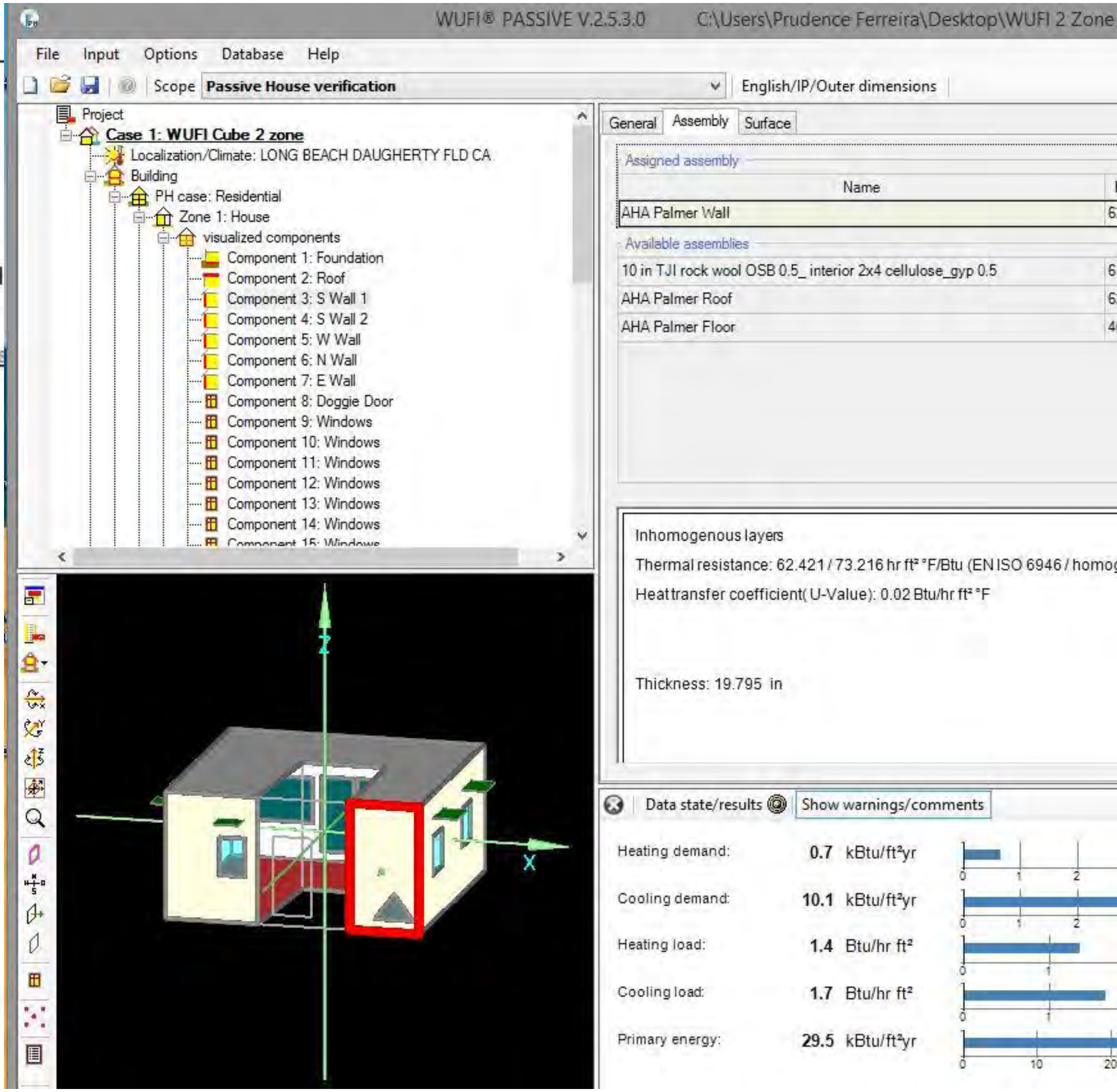
- 0.51 BTU/(hr.ft²) unoccupied building internal heat load (worst case)

TFA

- (ft²) energy reference area after PHPP

PHPP + WUFI Passive Modeling

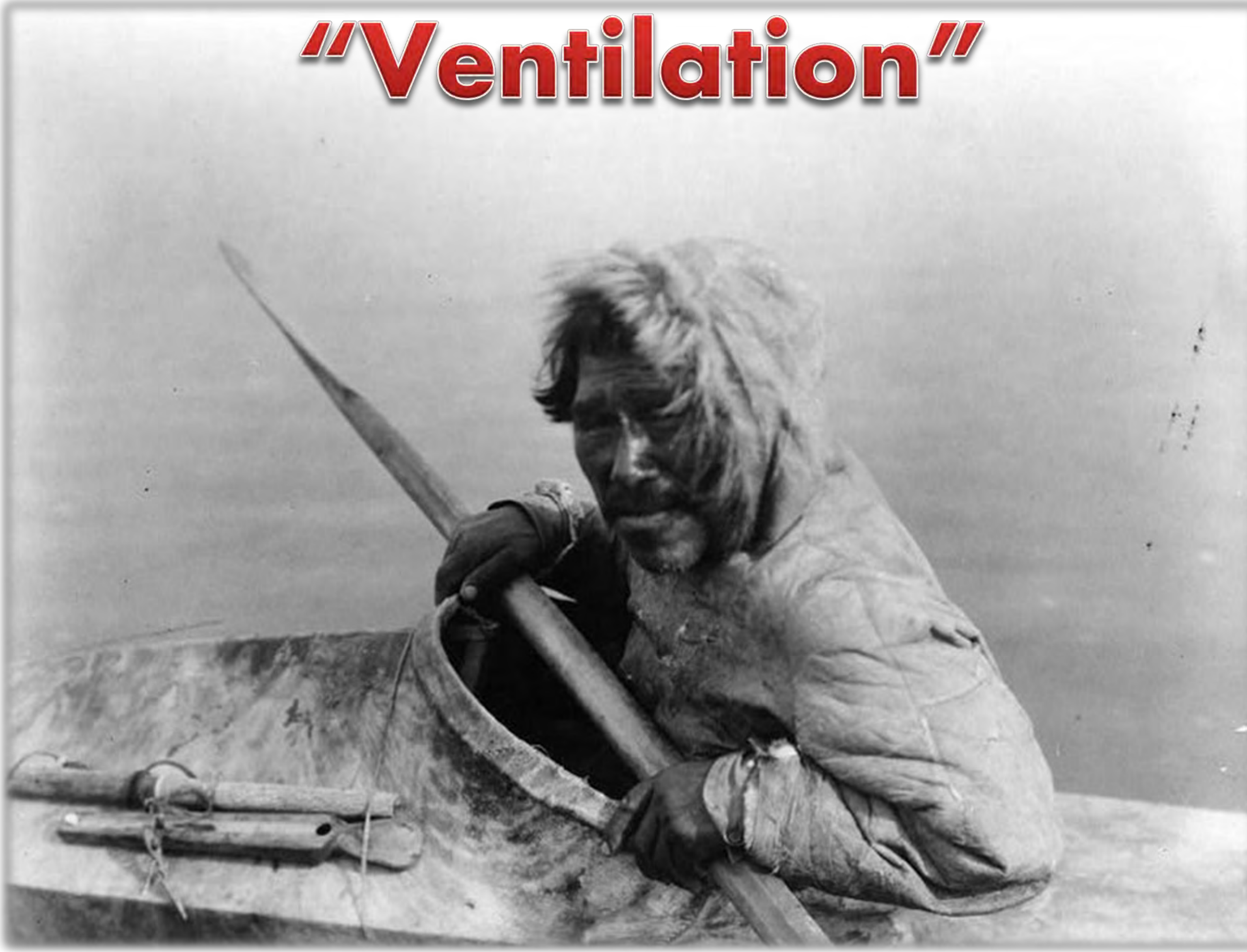


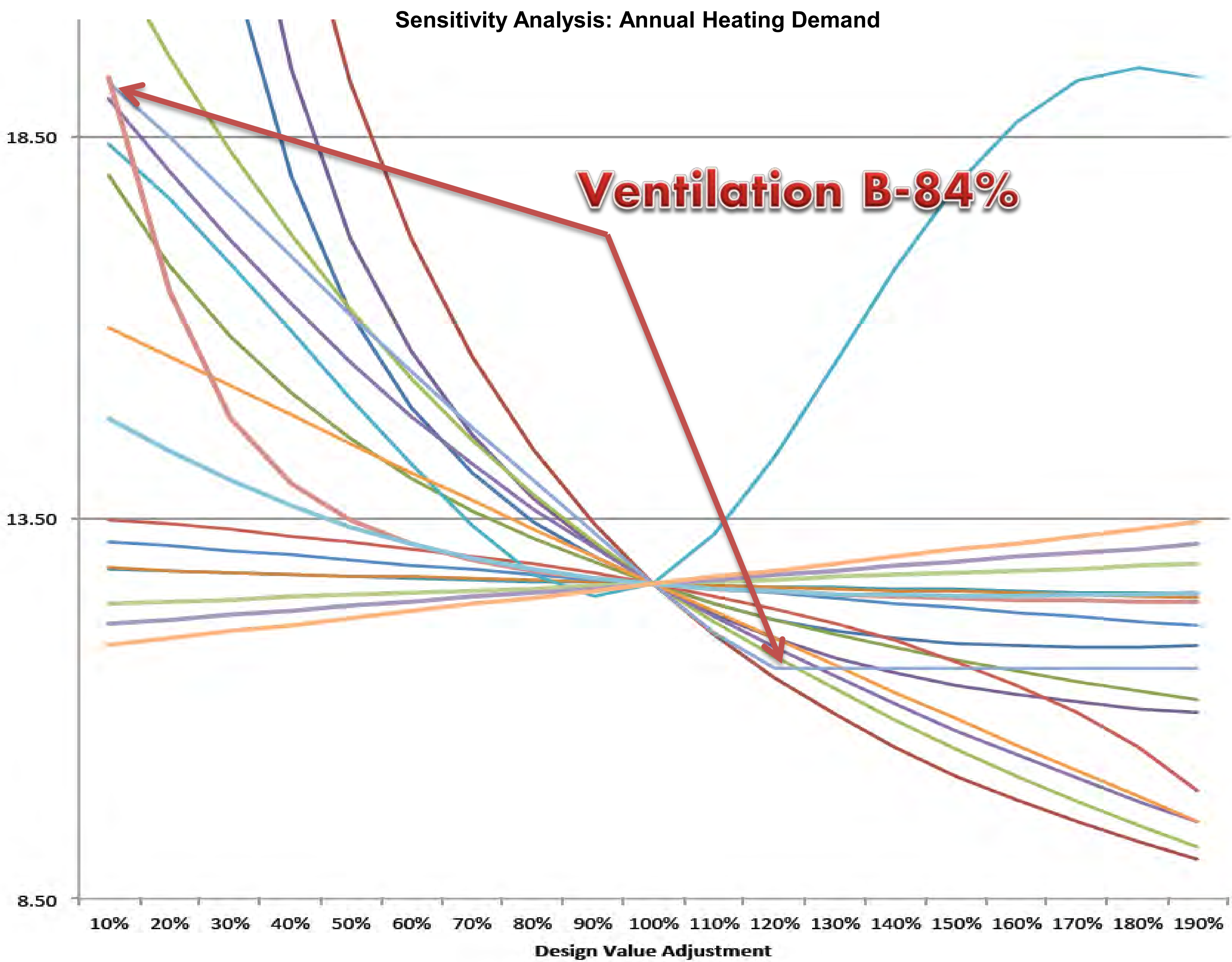


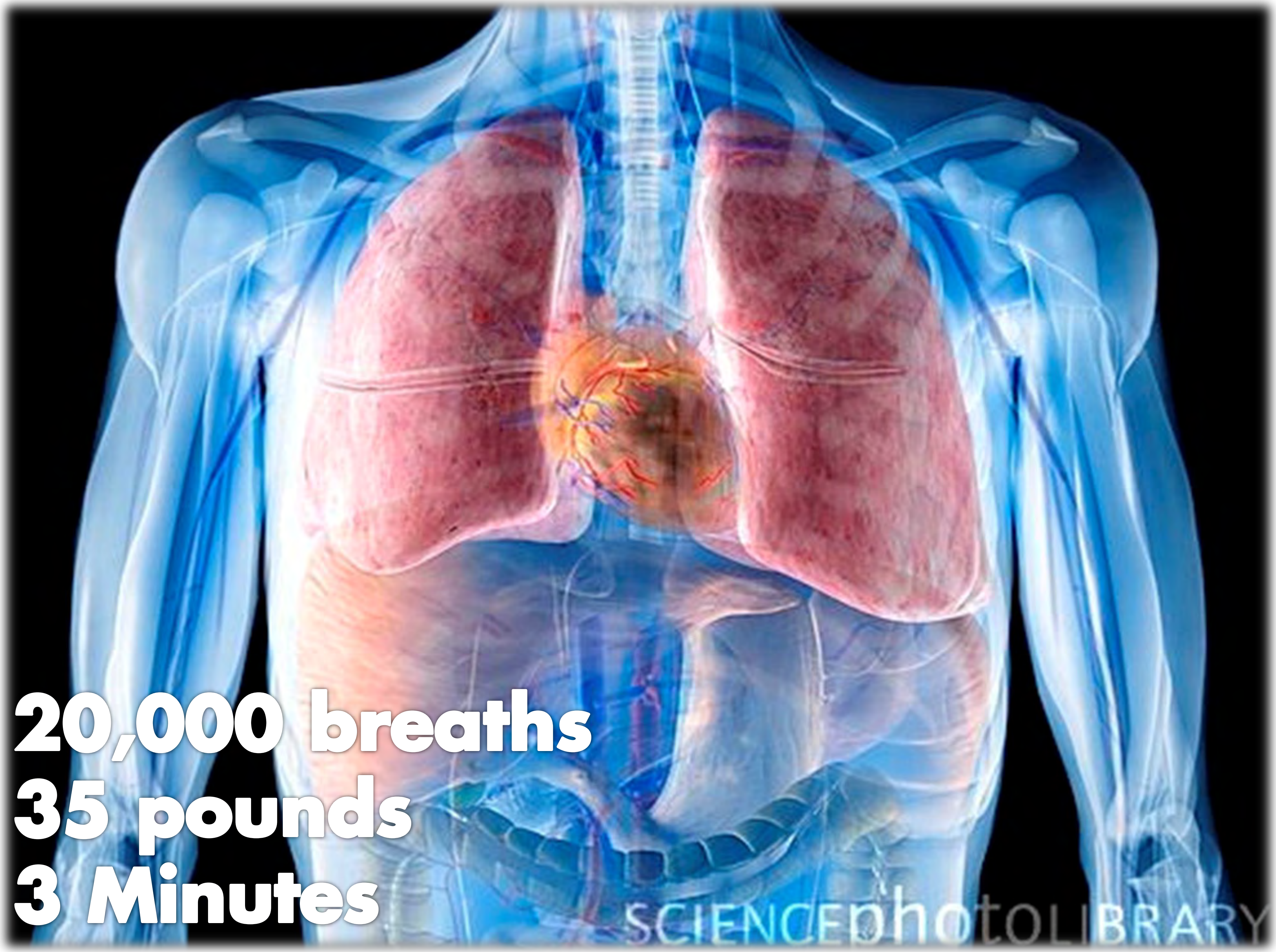
Essential Tools

- IR Camera
- Moisture Meter
- Indoor Air Quality Monitor
- Anemometer

“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

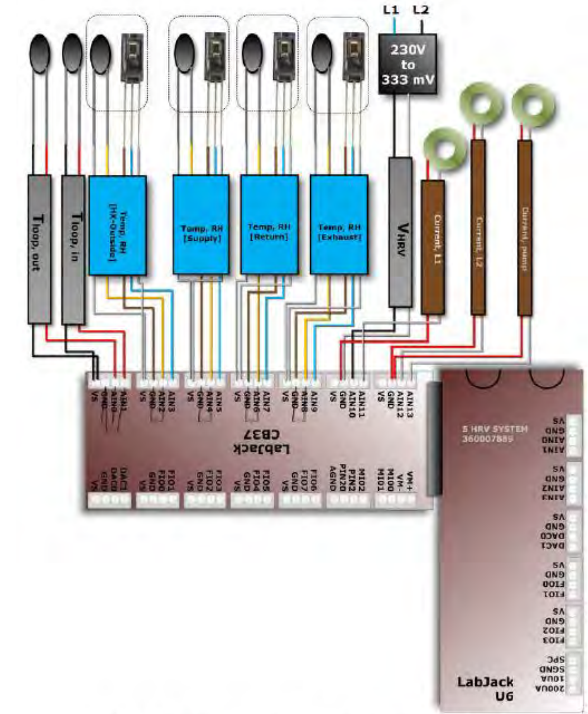

20,000 breaths
35 pounds
3 Minutes
SCIENCEPHOTOLIBRARY

Zehnder ComfoAir 350 @84% + ComfoFond

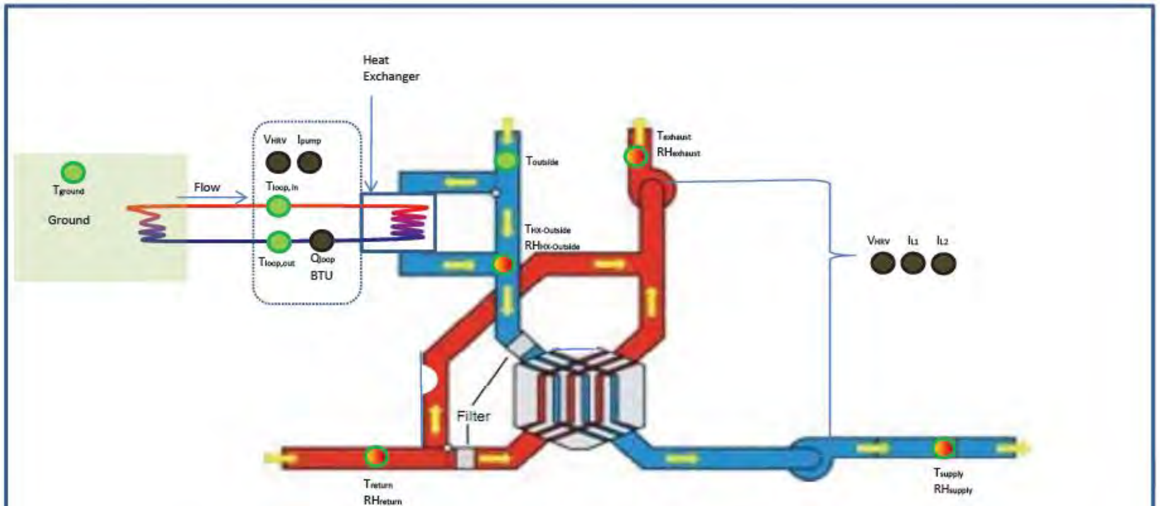
400 FT Ground loop

Heat exchanger @ 12 foot depth

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

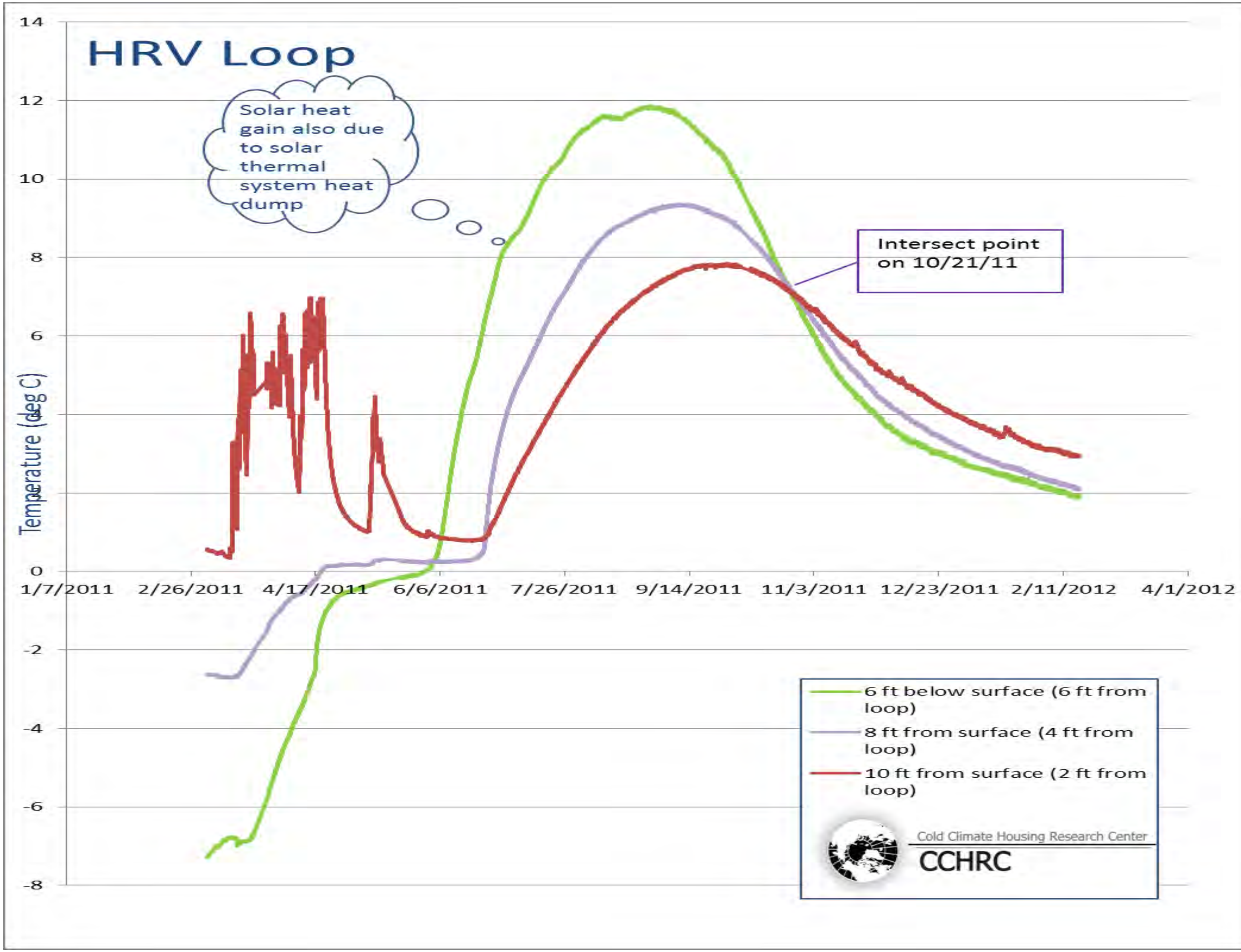


Labjack Wiring Configuration Diagram
BCG 9-21-11



HRV Sensor Locations

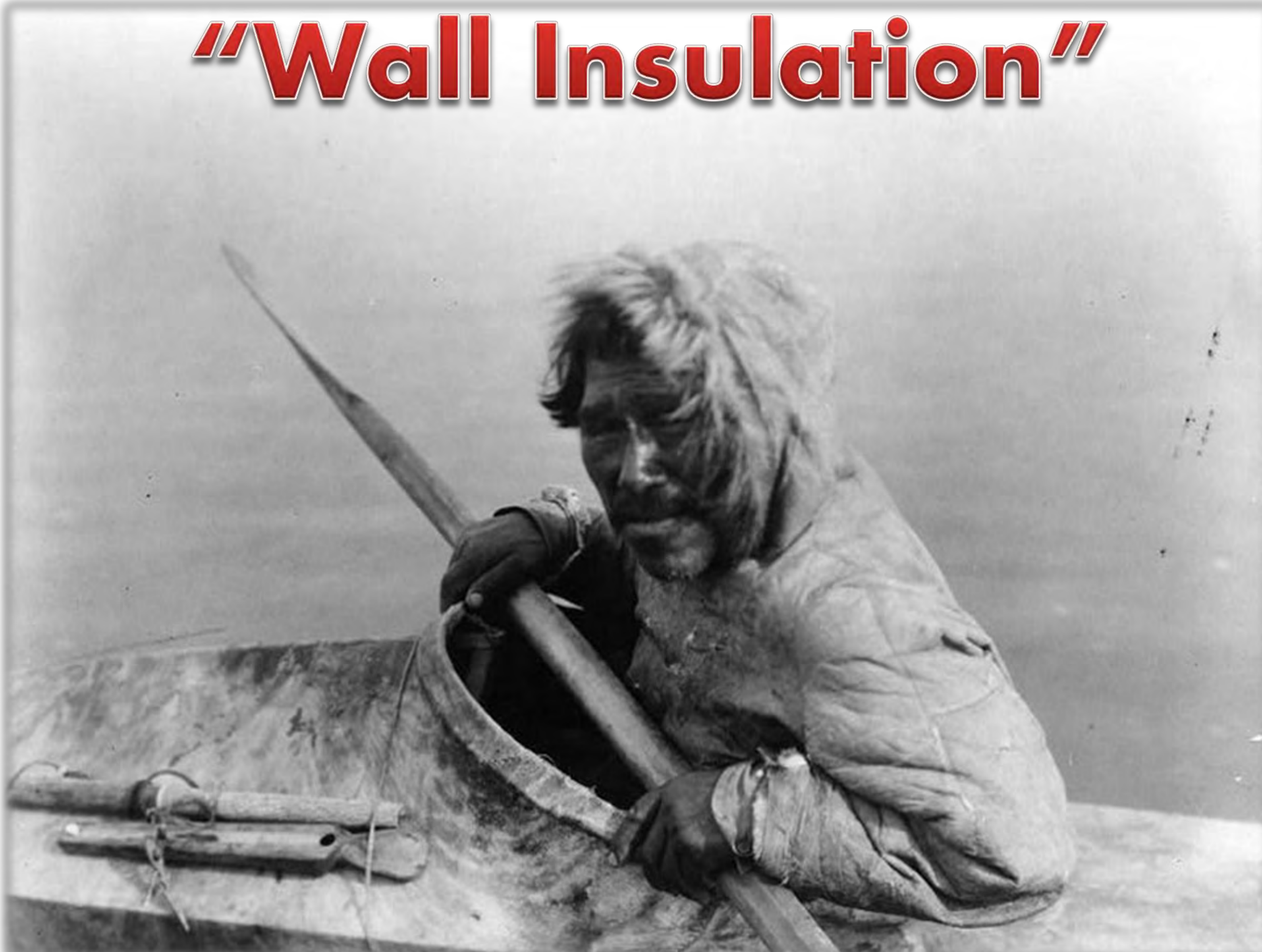

Clinside



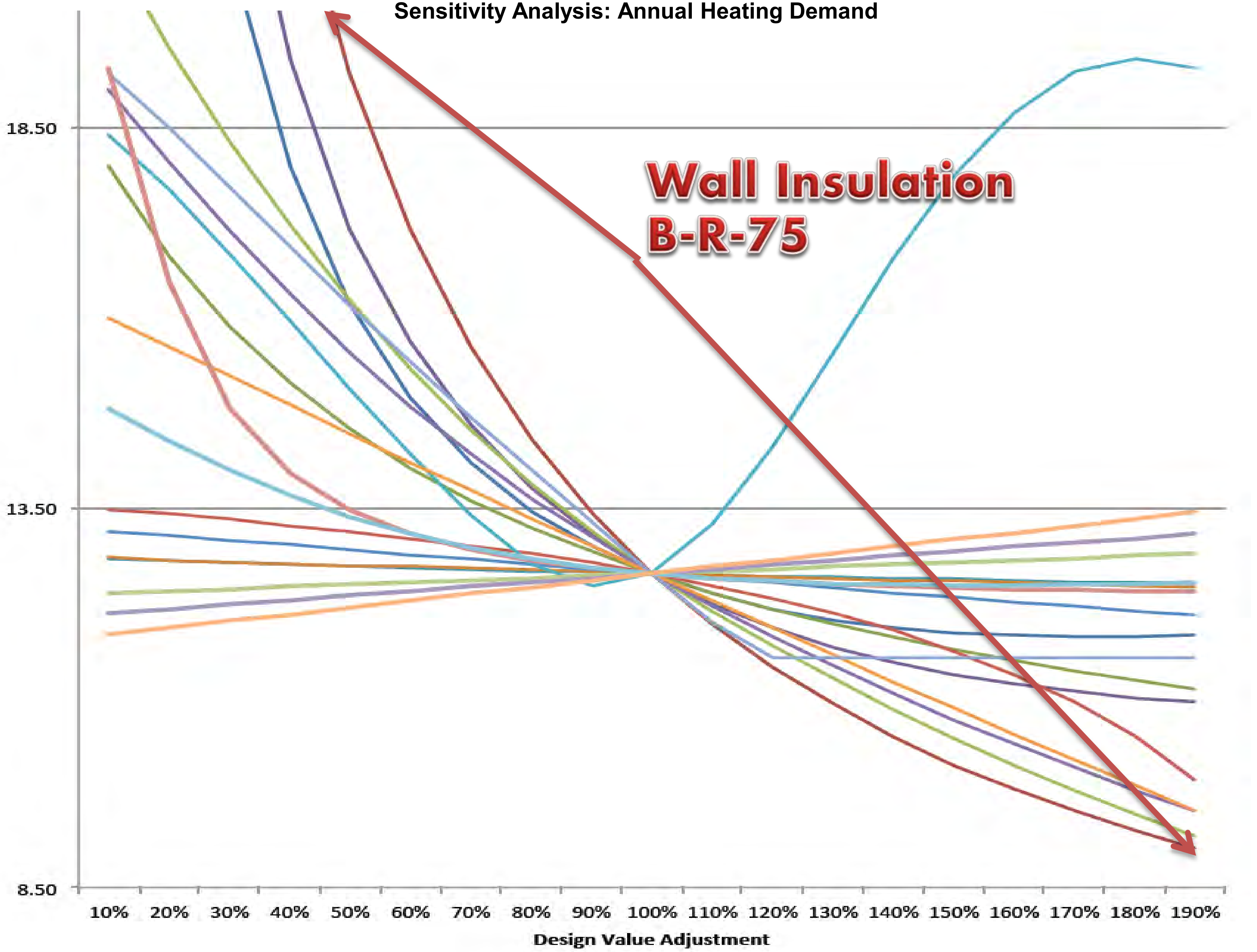
HRV Loop
Solar heat gain also due to solar thermal system heat dump
Intersect point on 10/21/11
Temperature (deg C)
14
12
10
8
6
4
2
0
-2
-4
-6
-8
1/7/2011
2/26/2011
4/17/2011
6/6/2011
7/26/2011
9/14/2011
11/3/2011
12/23/2011
2/11/2012
4/1/2012
6 ft below surface (6 ft from loop)
8 ft from surface (4 ft from loop)
10 ft from surface (2 ft from loop)
Cold Climate Housing Research Center
CCHRC

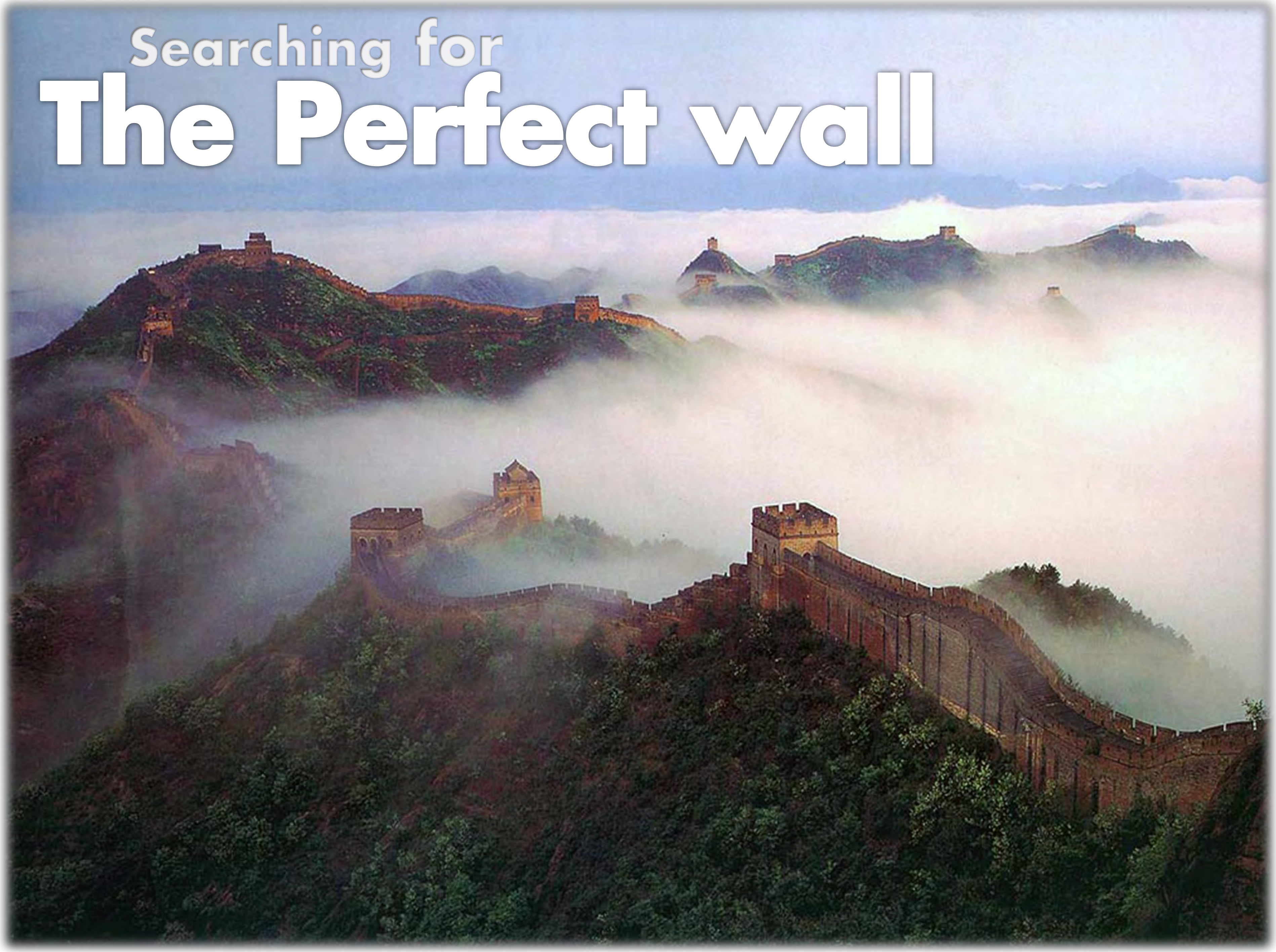
Living Walls

“Wall Insulation”

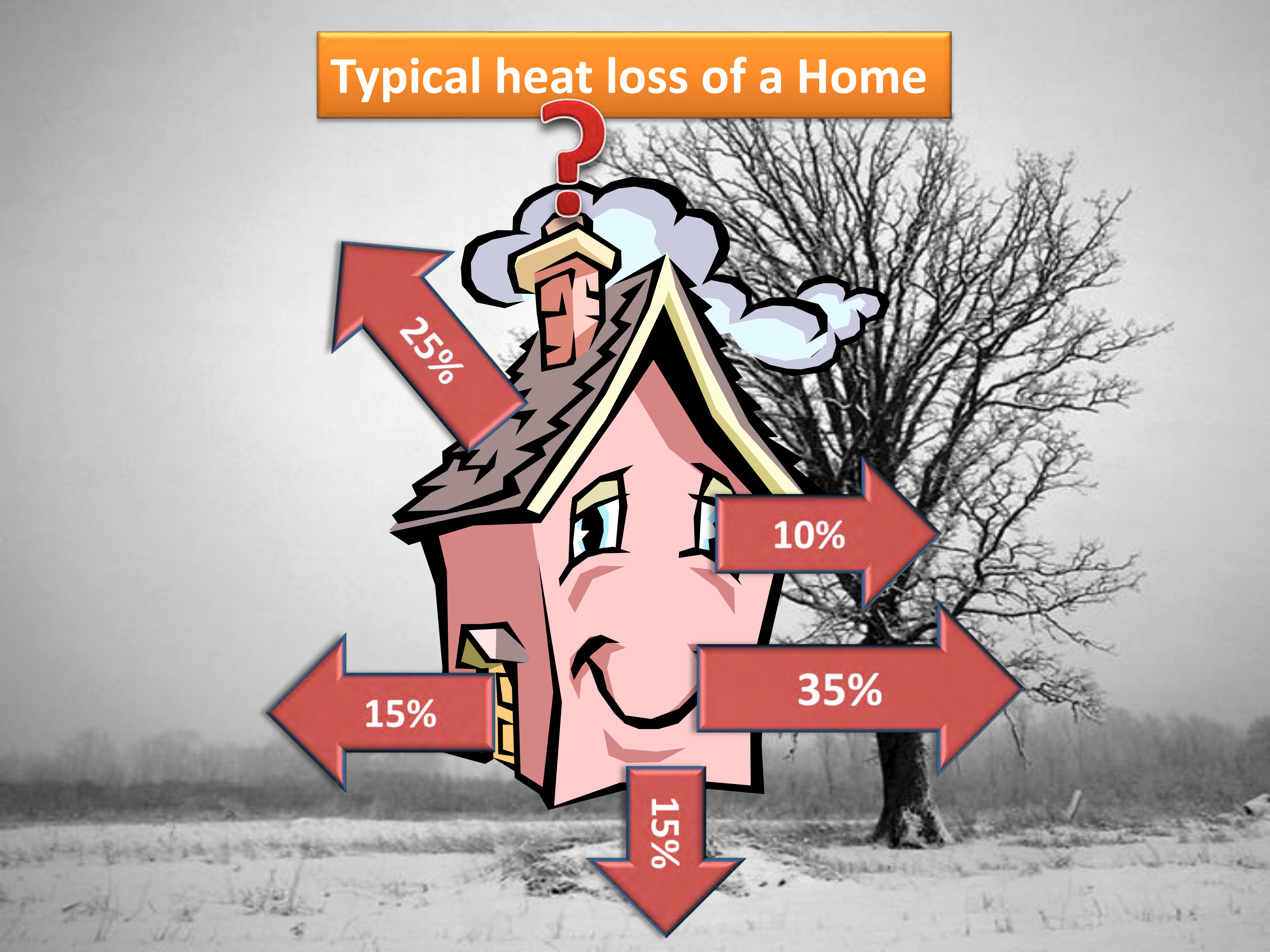


Sensitivity Analysis: Annual Heating Demand




Searching for
The Perfect wall

Typical heat loss of a Home



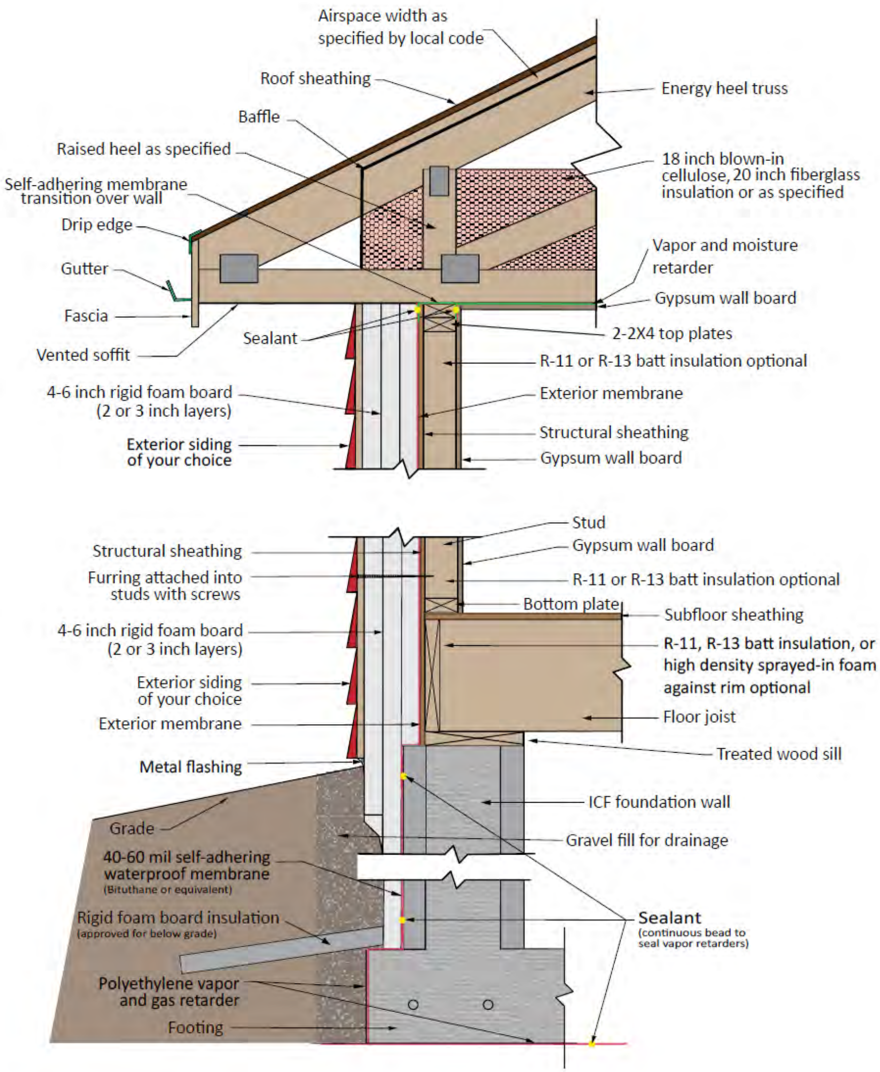
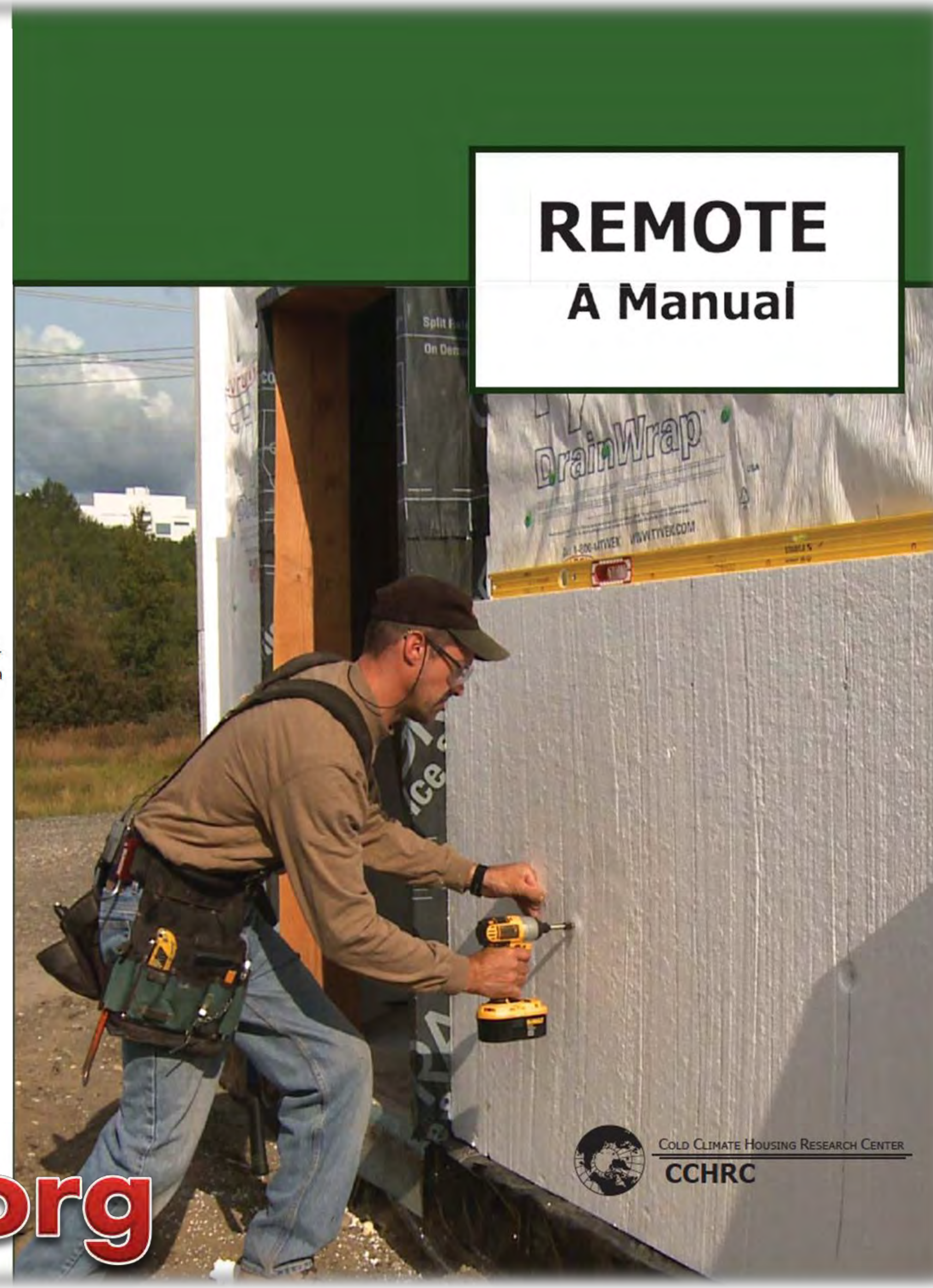
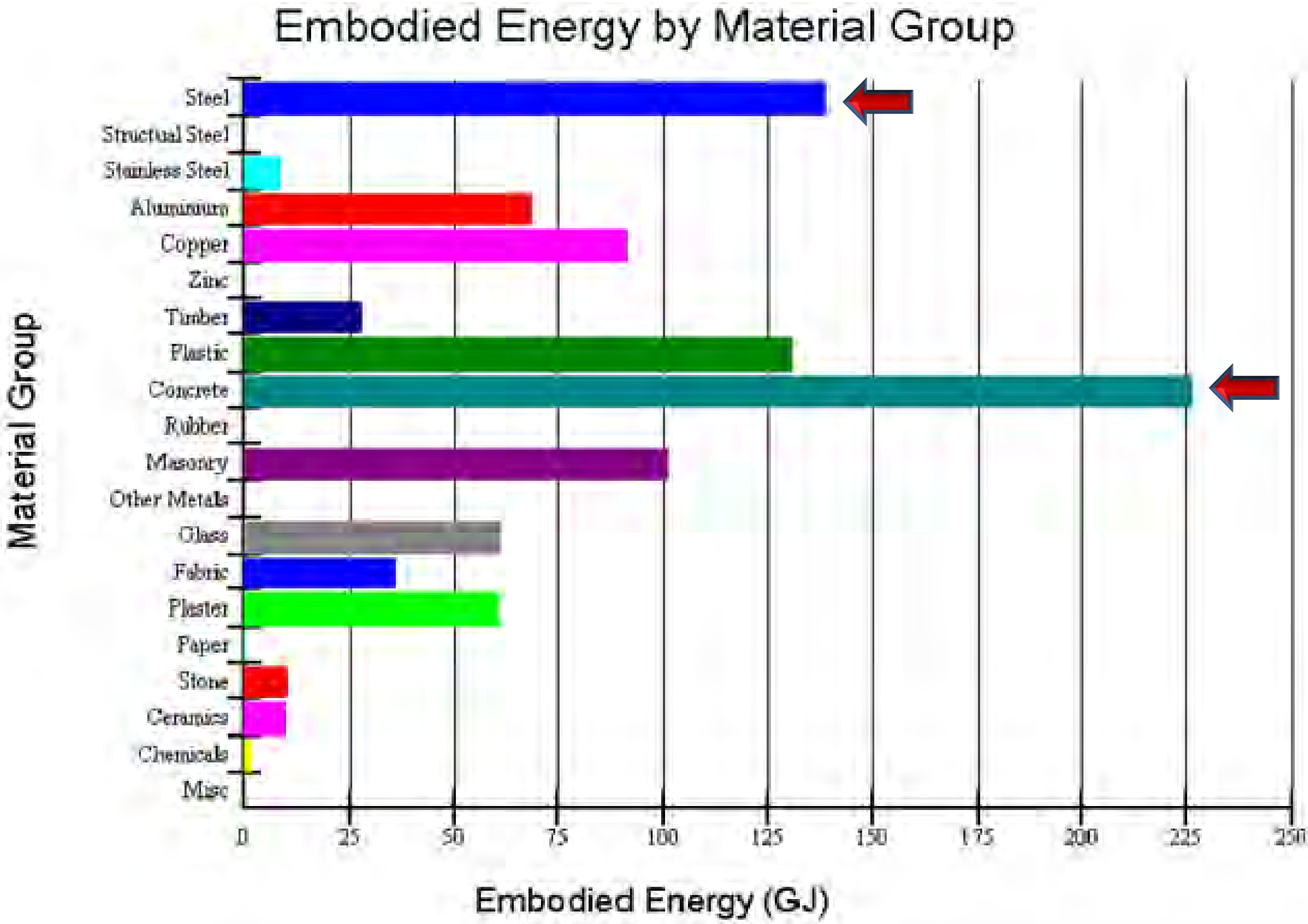


Figure 1. WALL CROSS SECTION

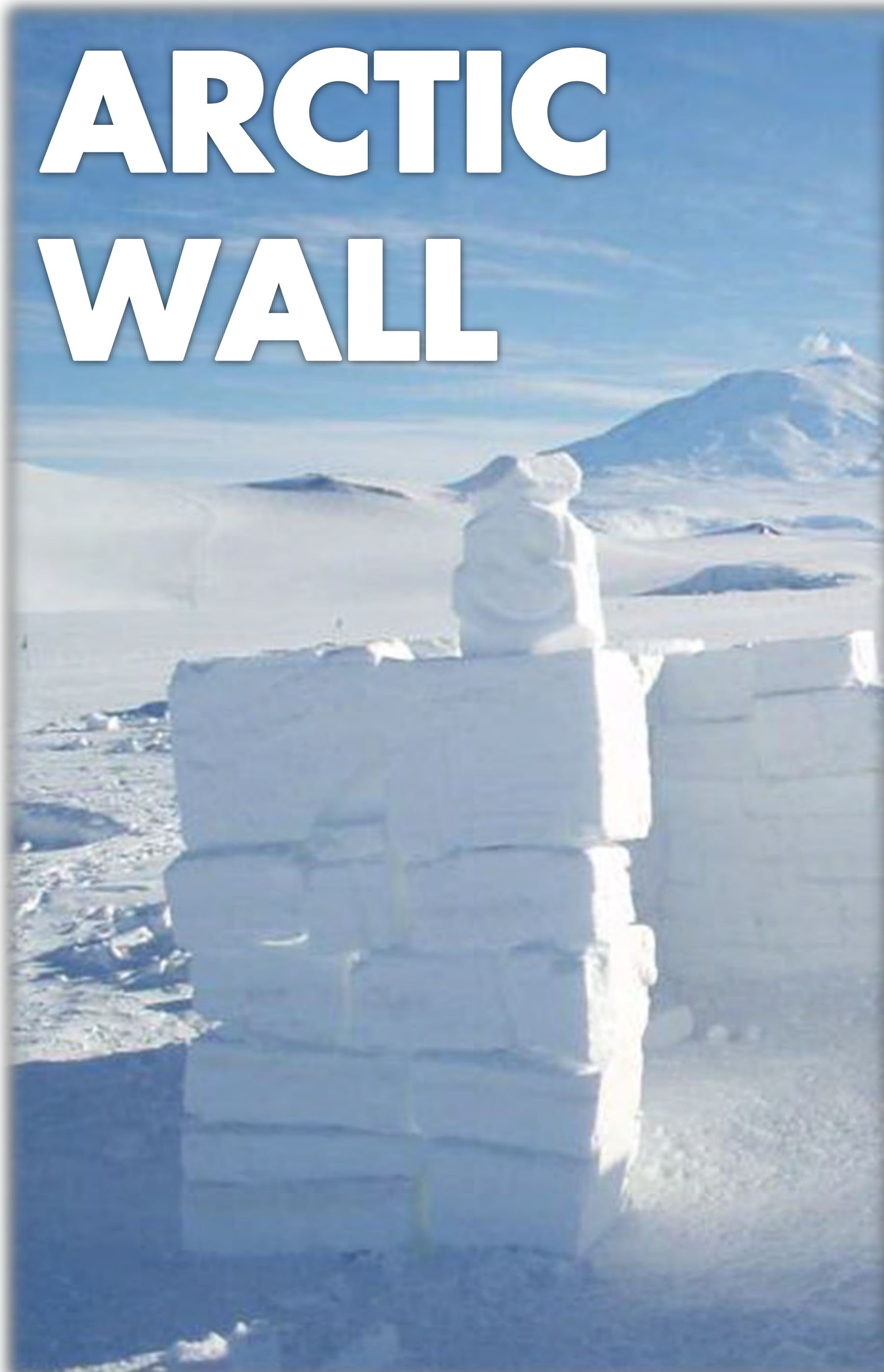


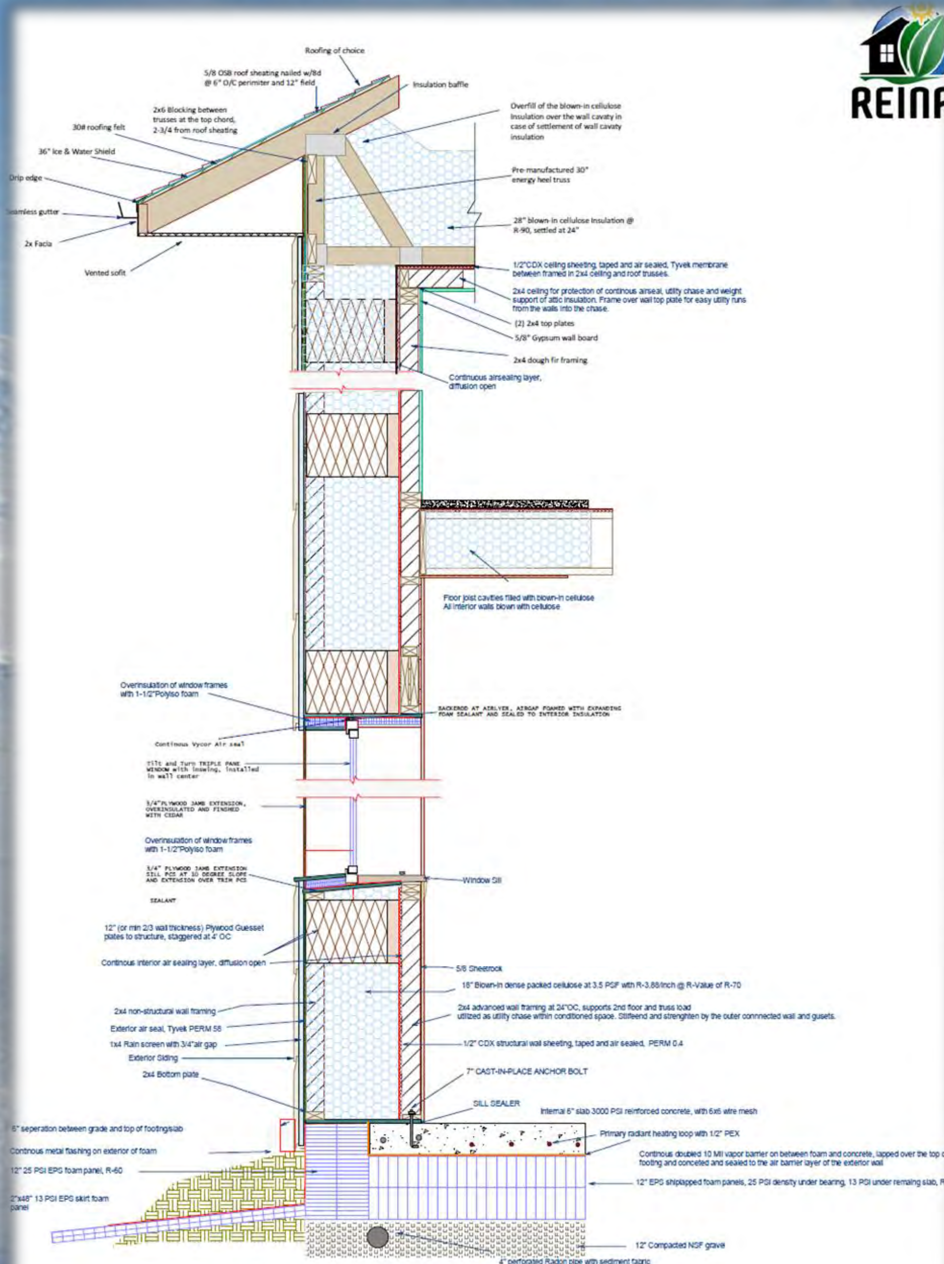
www.cchrc.org

Embodied energy
Embodied Energy
Cellulose/ Cotton
Mineral Fiber
Foam Plastics
Factor x64


Embodied Energy by Material Group
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
Embodied Energy (GJ)

ARCTIC WALL





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

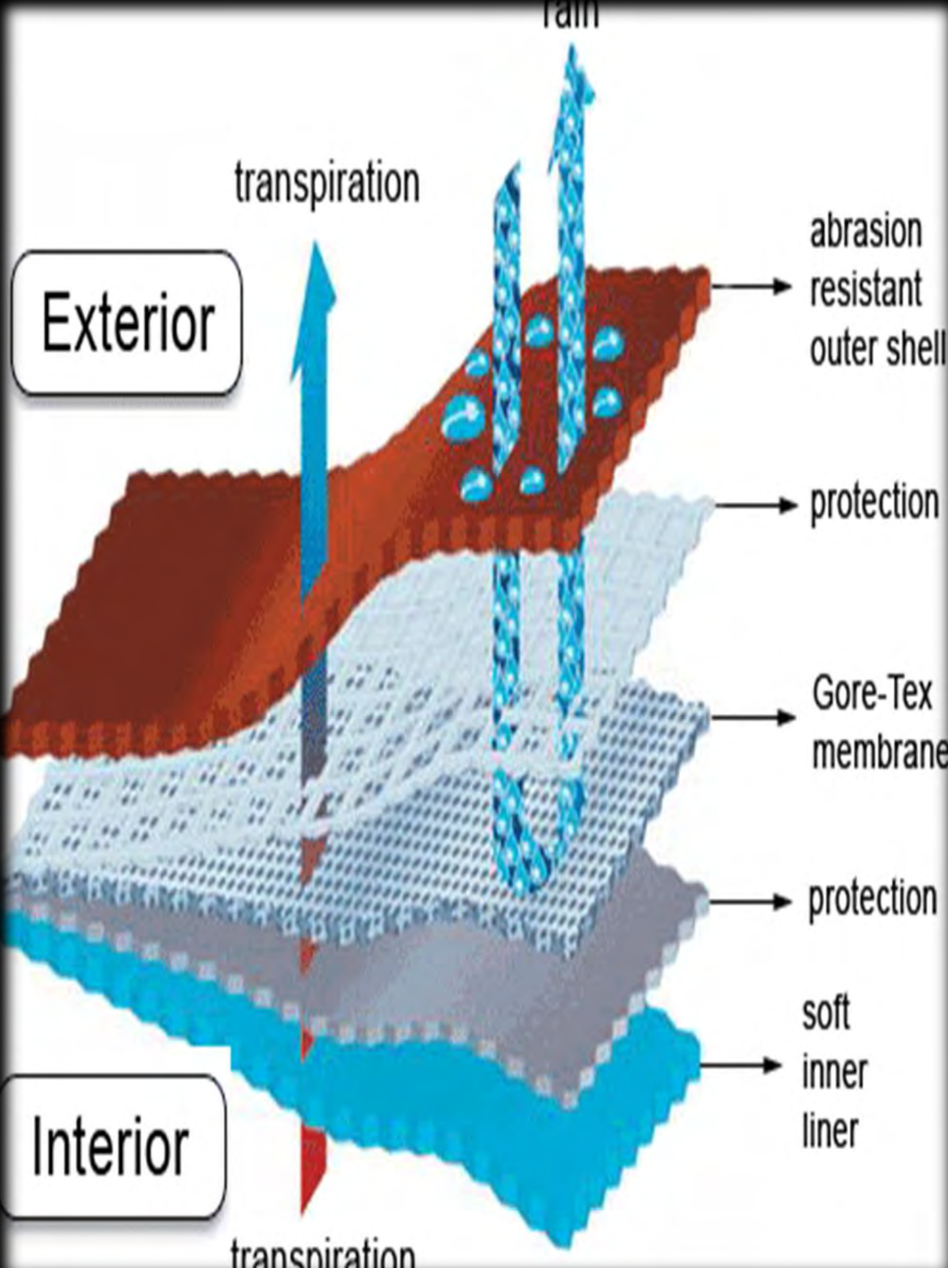
DESIGN by REINA, LLC - Thorsten Chlupp (print at 1"=1')


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


TIME


12 Tons
Cellulose
FORCE/3
4.0DP

Lambda value

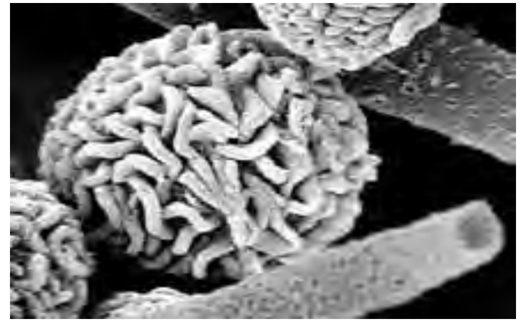
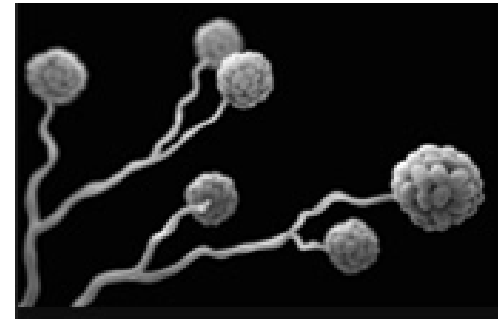
High density, high heat capacity - phase displacement

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


The Problem

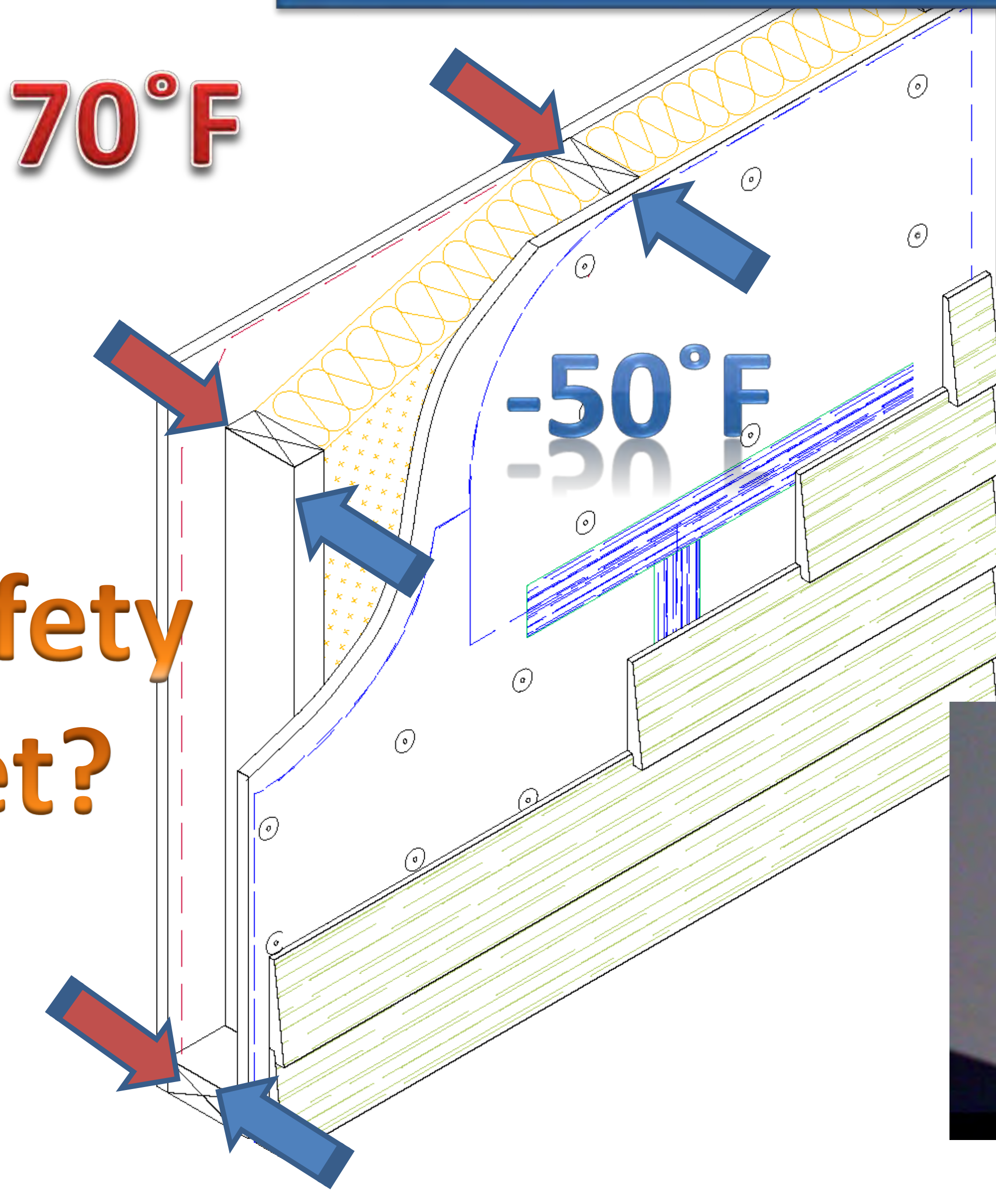
Building Moisture and Mold Issues are a Big Deal

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

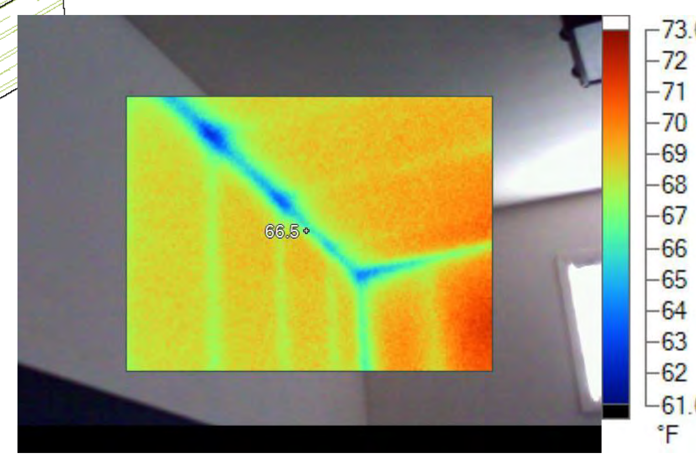


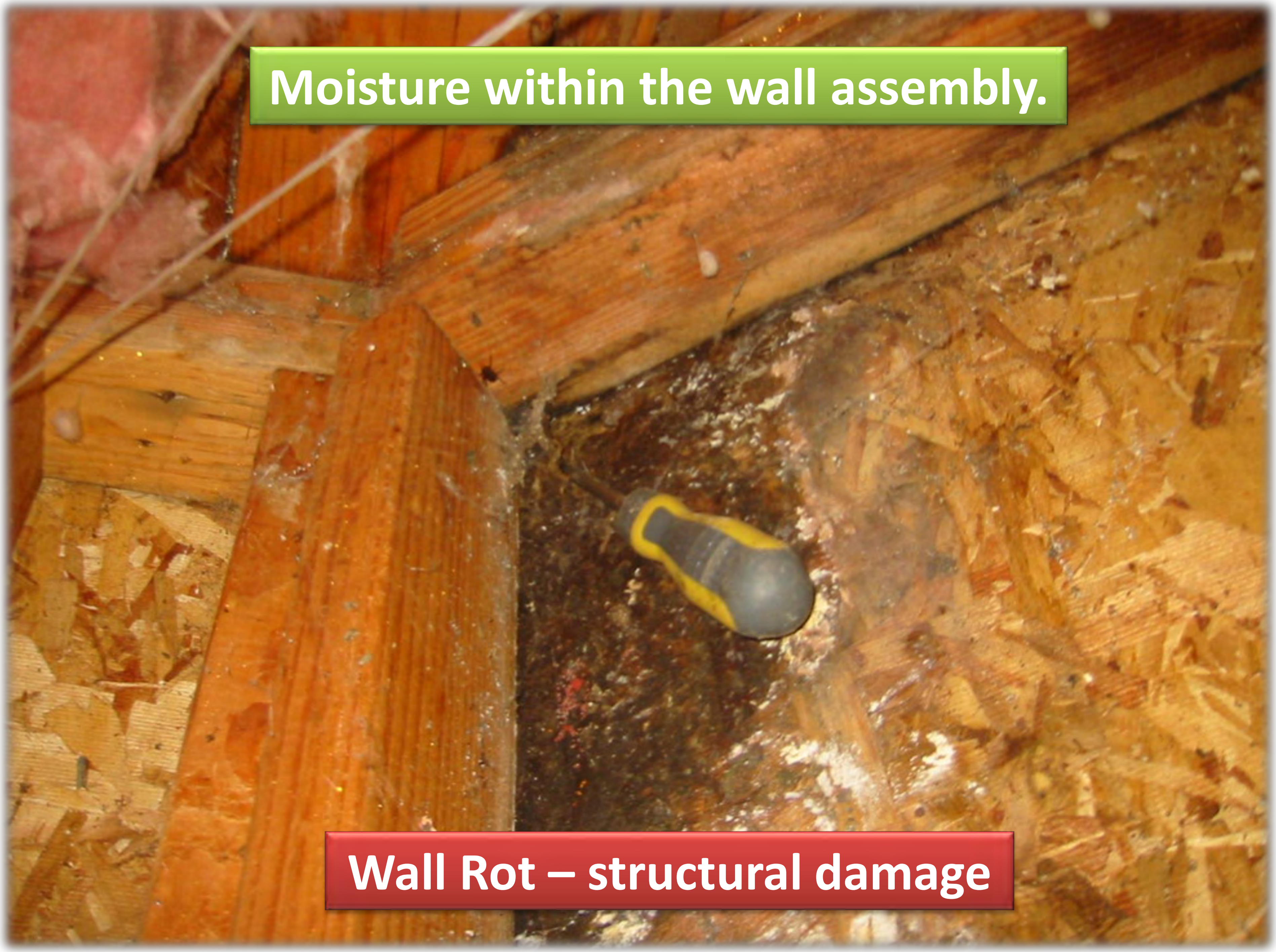
Conventional 2x6 wall w/batting insulation.

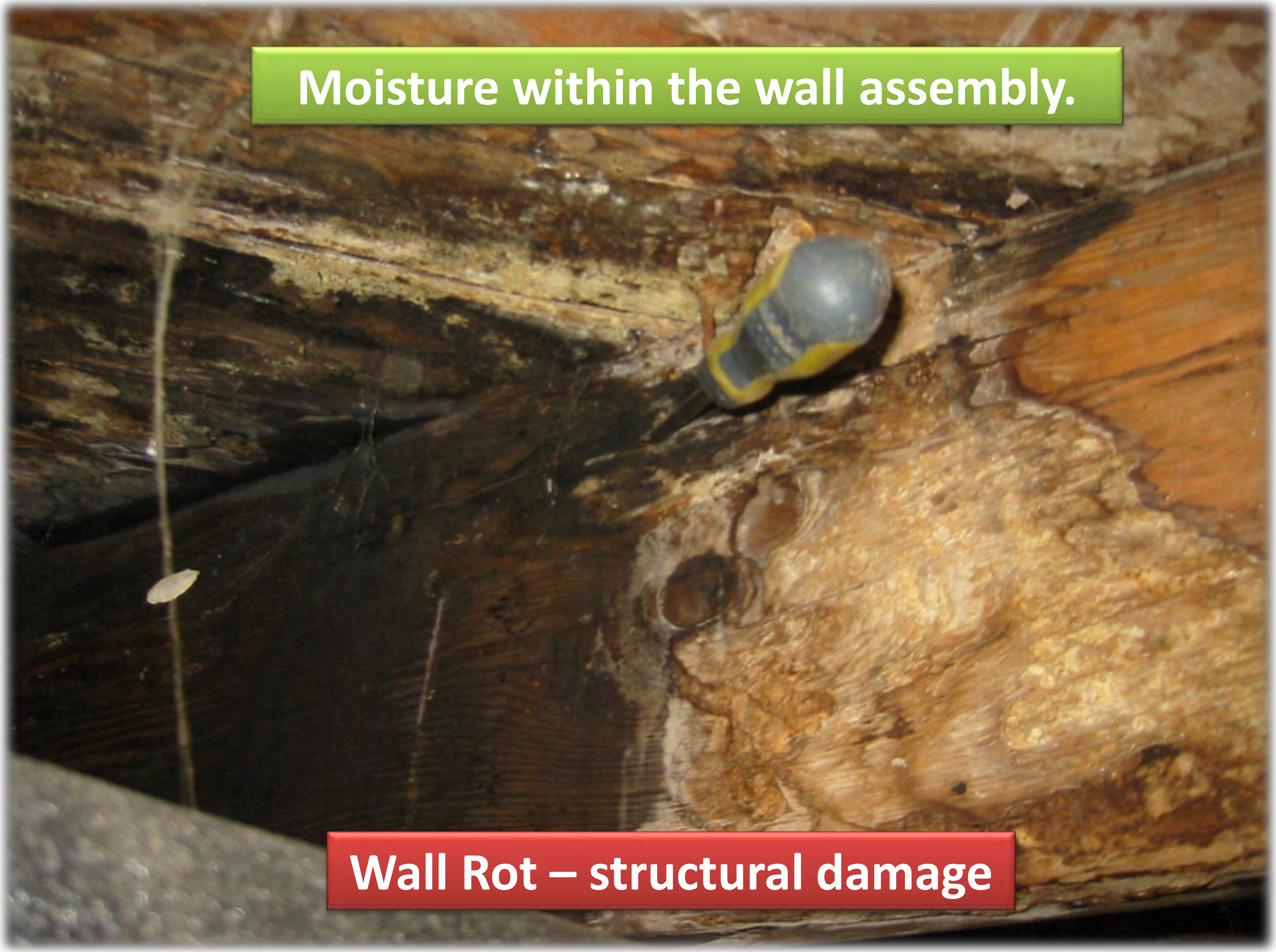


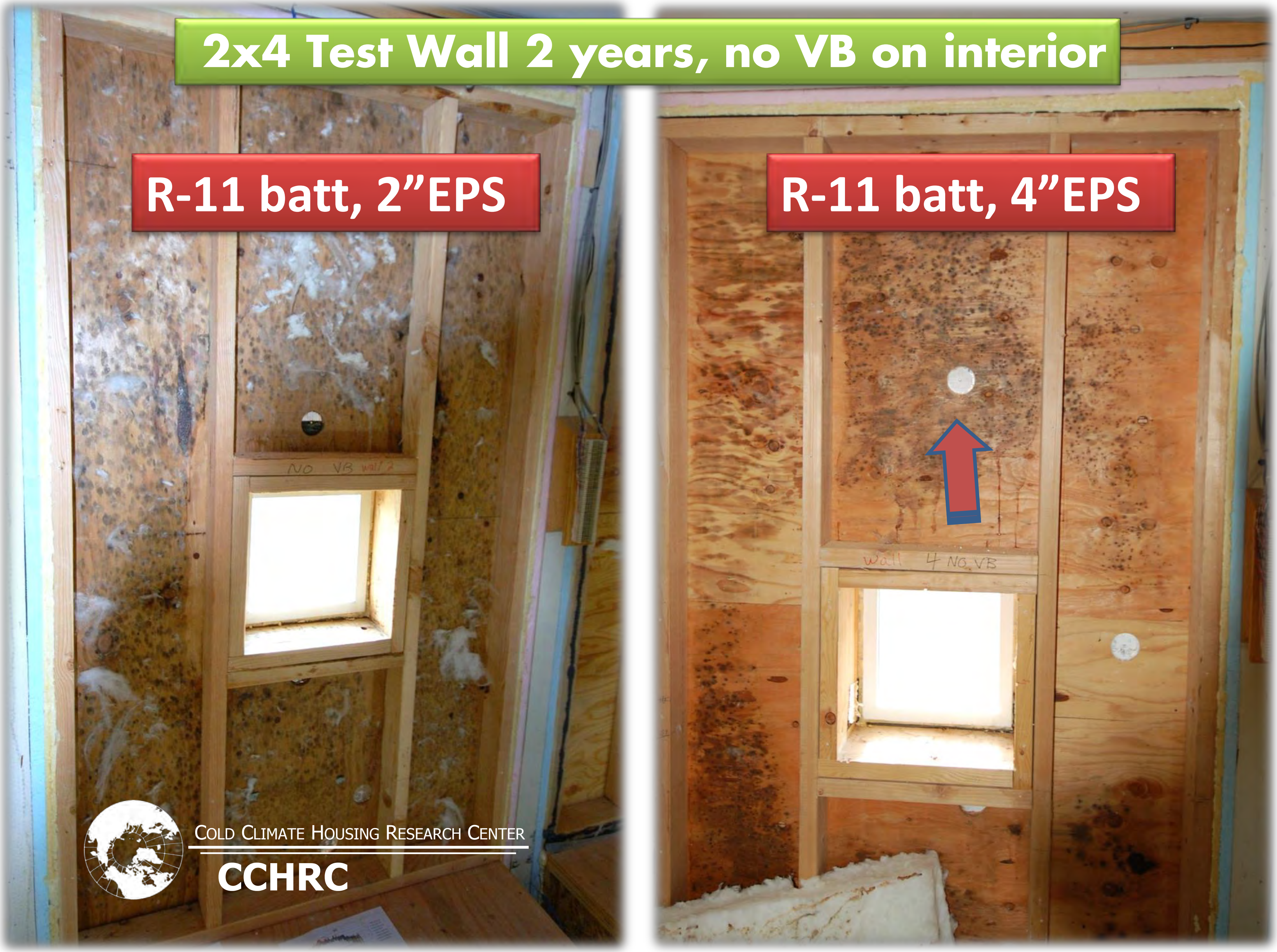
Safety Net?

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




Moisture within the wall assembly.
Wall Rot – structural damage


Moisture within the wall assembly.
Wall Rot – structural damage


2x4 Test Wall 2 years, no VB on interior
R-11 batt, 2"EPS
NO VB wall 2
R-11 batt, 4"EPS
wall 4 NO VB
COLD CLIMATE HOUSING RESEARCH CENTER
CCHRC

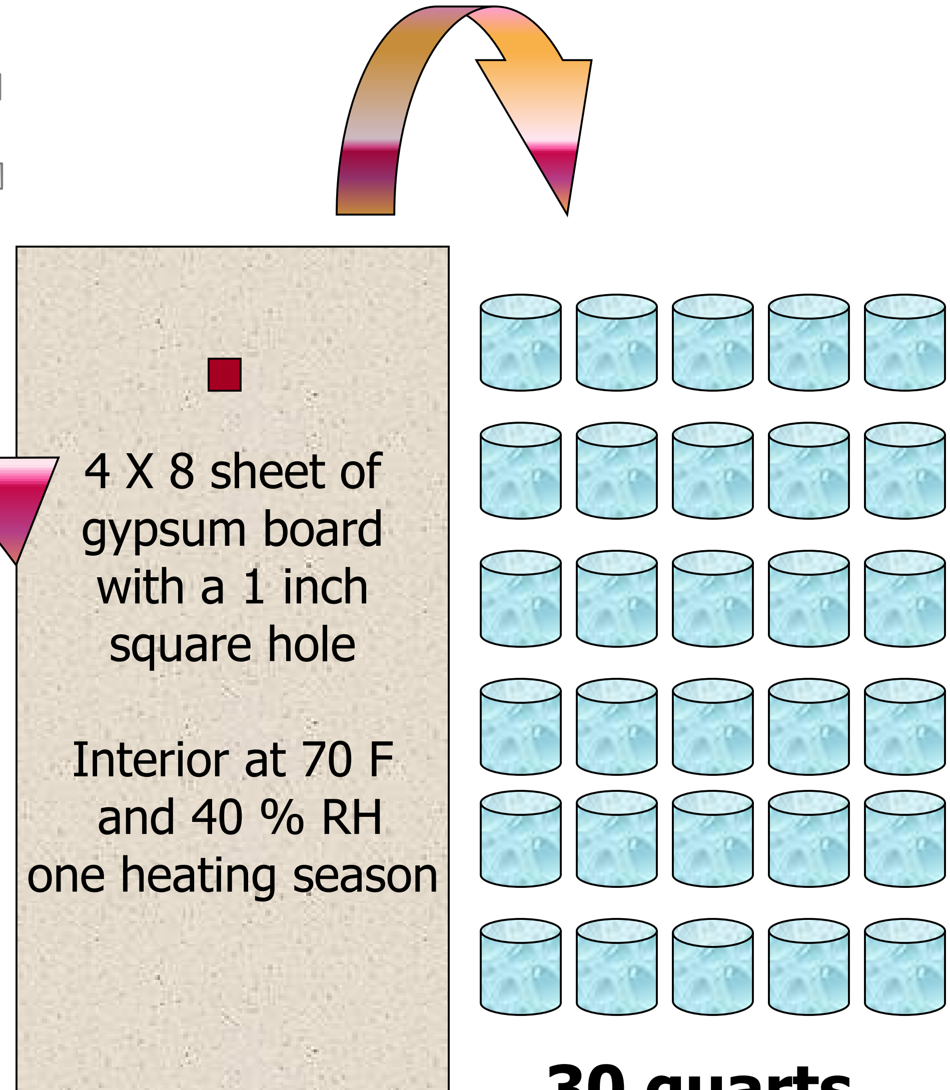
Moisture within the wall assembly.

=

Toxic Mold

Air Transport of Water Vapor

AIR LEAKAGE



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

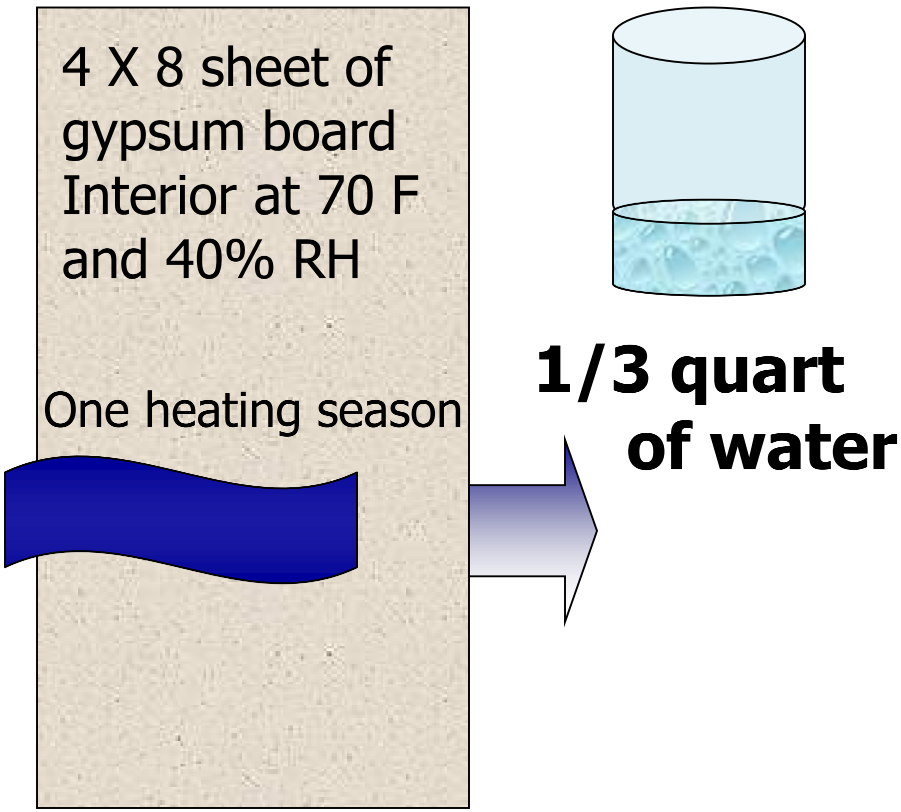
Diffusion Transport of Moisture

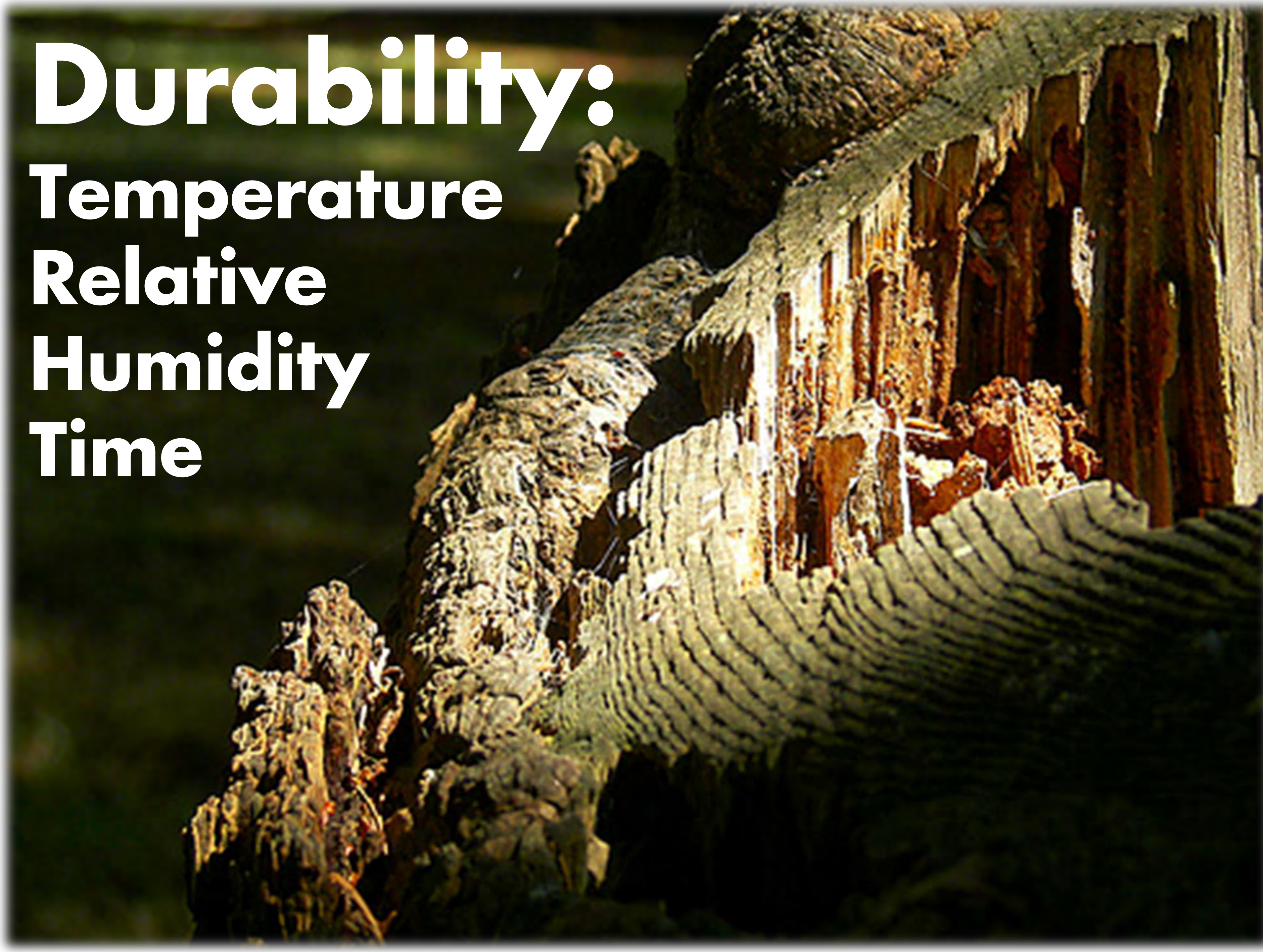
- **Diffusion**

  -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!!



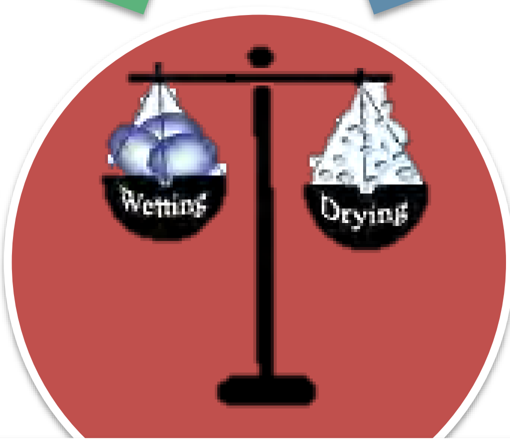

Durability:
Temperature
Relative
Humidity
Time

Moisture Management and IAQ Best Practices

Minimize the use of materials that are prone to rot and mold.

Create assemblies that are vapor permeable to facilitate drying.

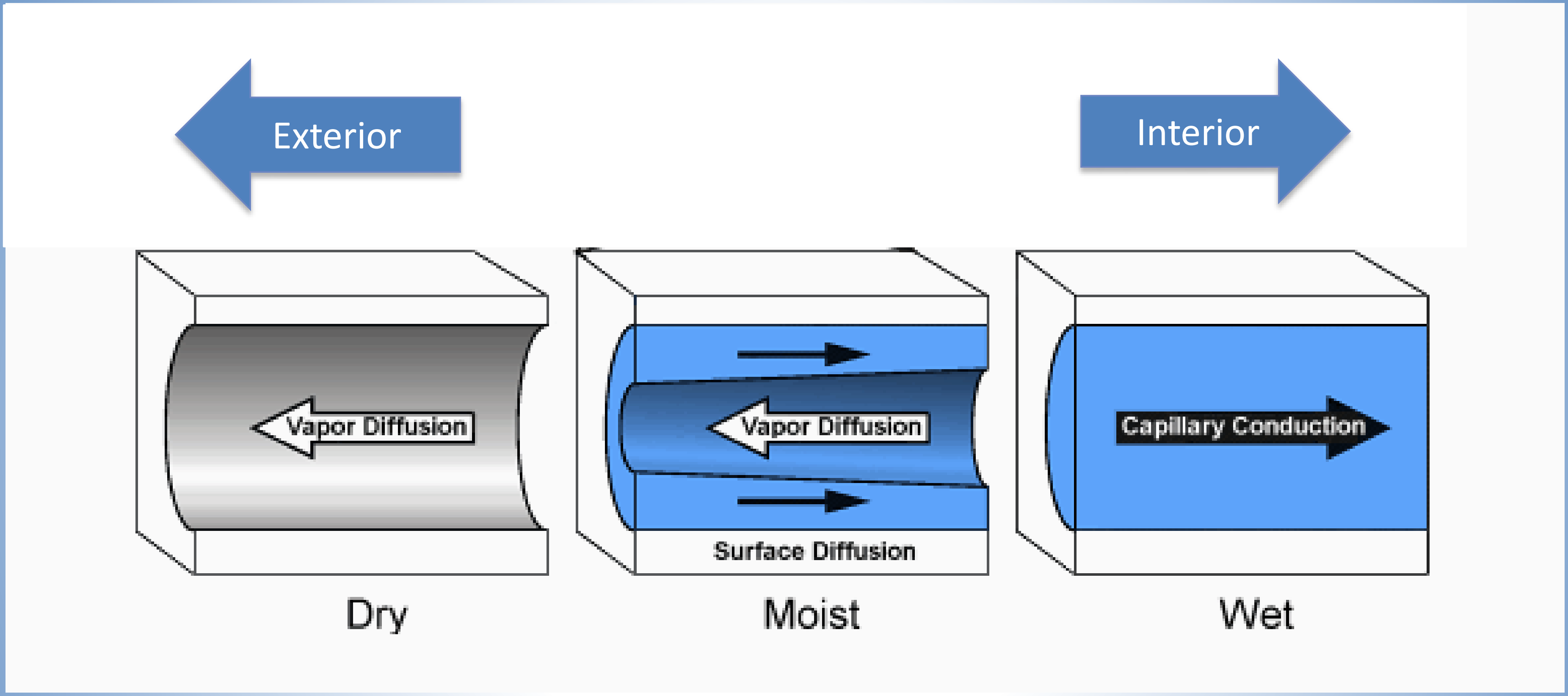
Waterproof and airseal to keep unwanted moisture and spores out of building assemblies.



Provide continuous balanced filtered mechanical ventilation to control indoor humidity and keep spores (and other allergens) out.

Prevent wetting and mold/fungus spore entry, promote drying.

Couple Heat and Moisture Transport is Complex!



These hygrothermal phenomenon can occur simultaneously

And Hygrothermal Calculations are Time Consuming

Coupled transport equations

- Exponential increase of saturation pressure with temperature
- Moisture dependent thermal conductivity
- Enthalpy flow by vapor diffusion with phase change
- Coupled differential equations have to be solved numerically.

Heat transfer

$$\frac{\partial H}{\partial T}\cdot\frac{\partial T}{\partial t} = \nabla\cdot\left(\lambda\nabla T\right) + h_v\nabla\cdot\left(\delta_p\nabla\left(\phi\ p_{sat}\right)\right)$$

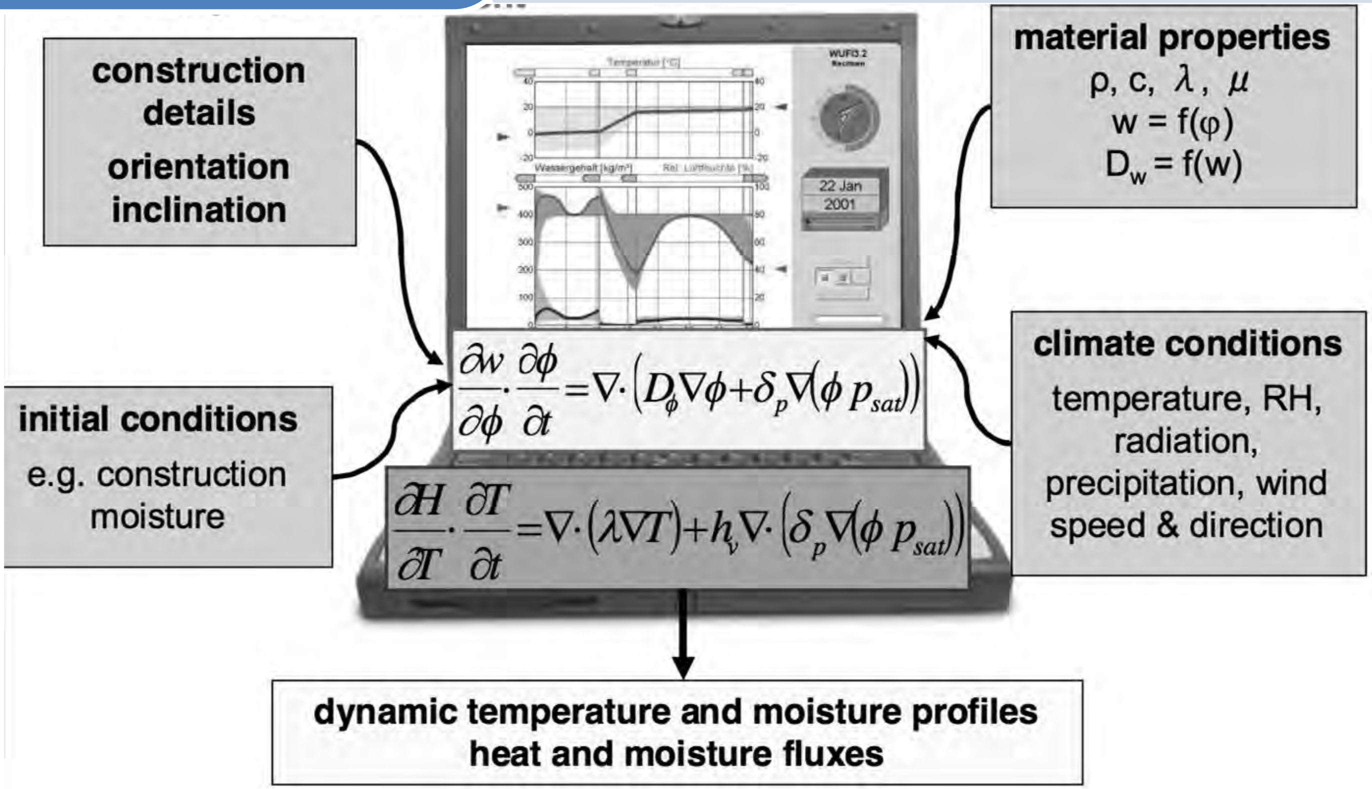
Moisture transfer

$$\frac{\partial w}{\partial \phi}\cdot\frac{\partial \phi}{\partial t} = \nabla\cdot\left(D_\phi\nabla\phi + \delta_p\nabla\left(\phi\ p_{sat}\right)\right)$$

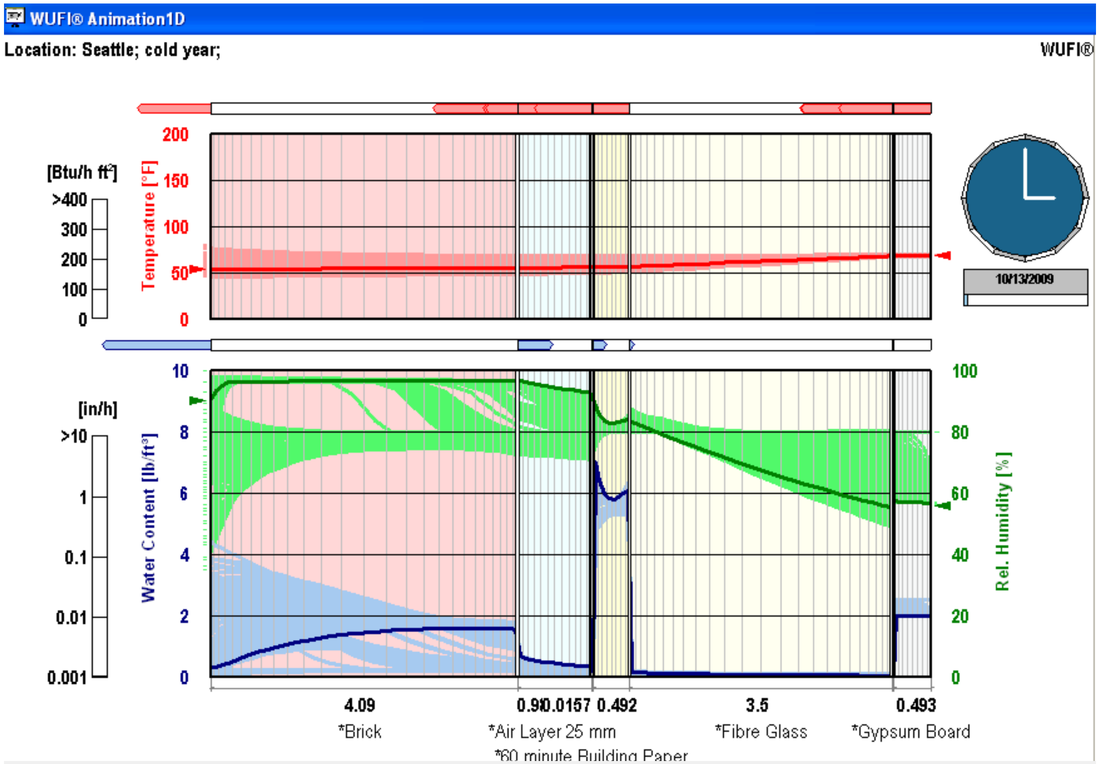
Solution: Make Computers do the Heavy Lifting

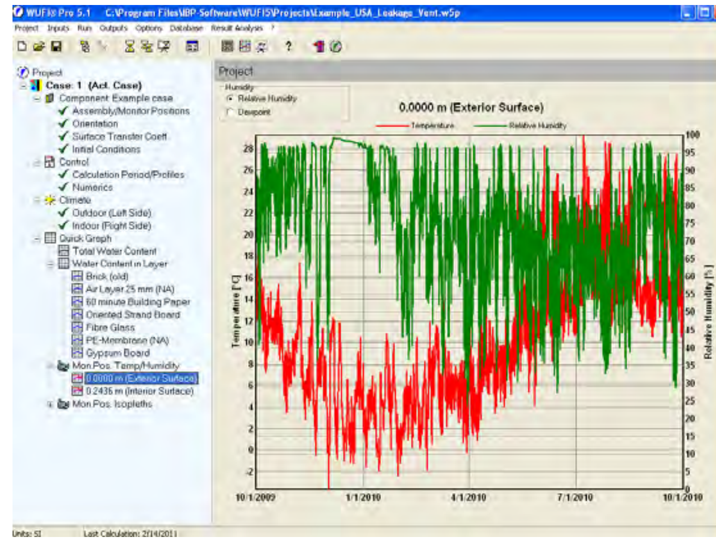
WUFI: Dynamic Hygrothermal Simulation:

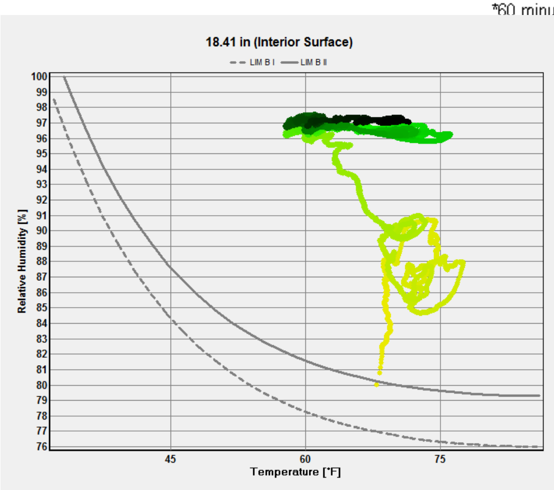
- ***Simulates change in properties and behaviors of materials in multilayer assemblies due to moisture absorption and temperature shifts caused by natural weather exposure and indoor environmental conditions***

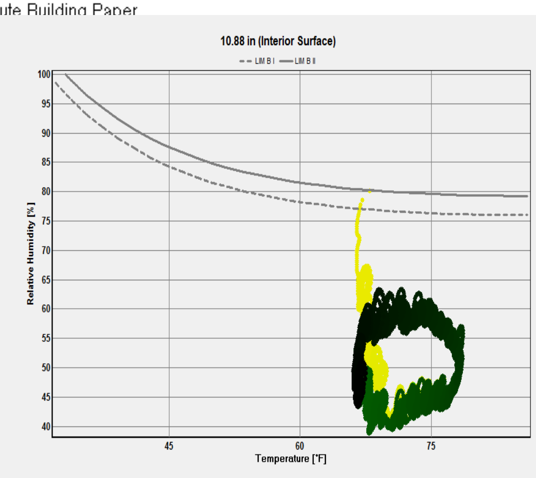


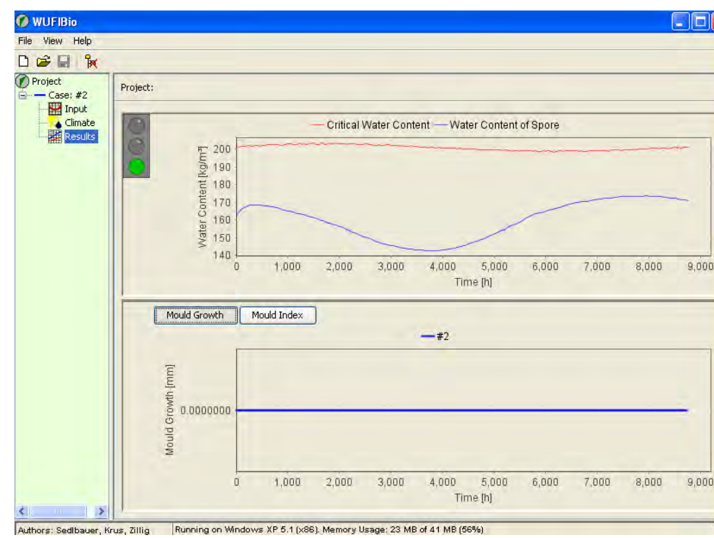
WUFI Hygrothermal Physics "Mold Prevention" Modeling



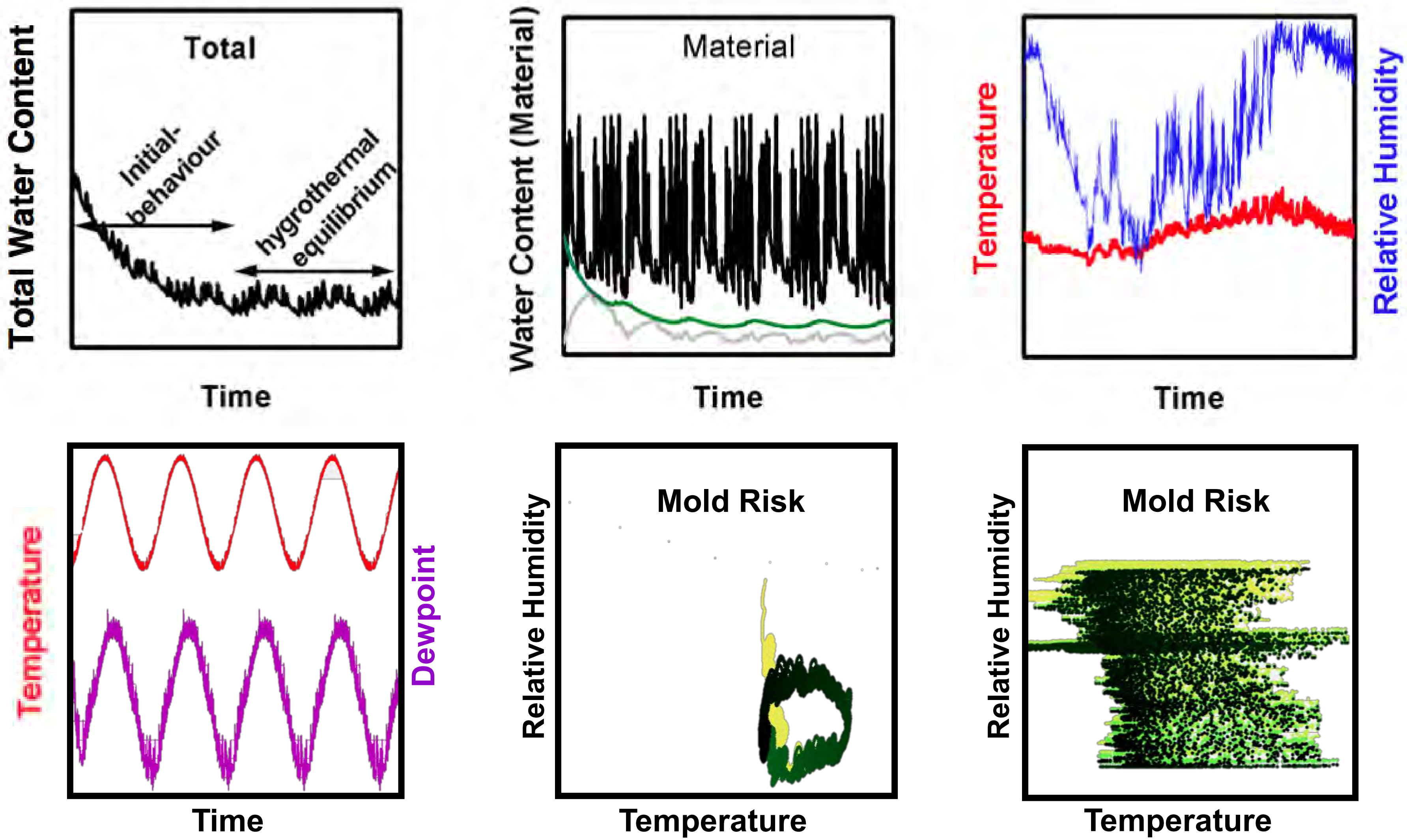








Reliable Results with Field and Lab Validation



Specific Risk Thresholds: Mold

Spore presence MUST be assumed! But to germinate, fungi need the following conditions:

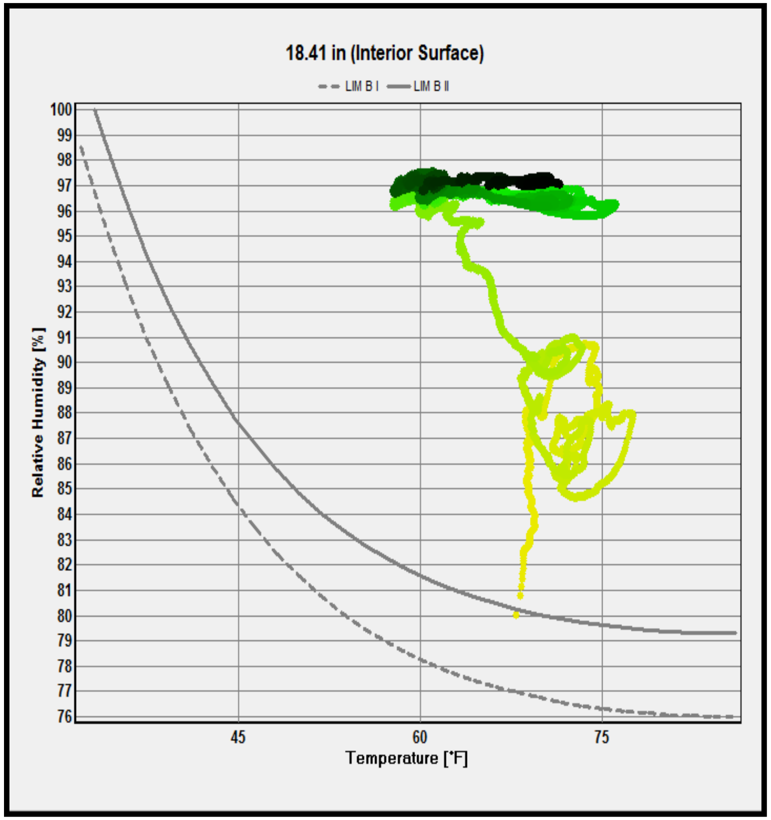
Nutrients: wood, paper, glues, paints, dust, dirt, soap

Favorable Temperature: 68°F -95°F is ideal, outside of 41°F-122°F growth stops

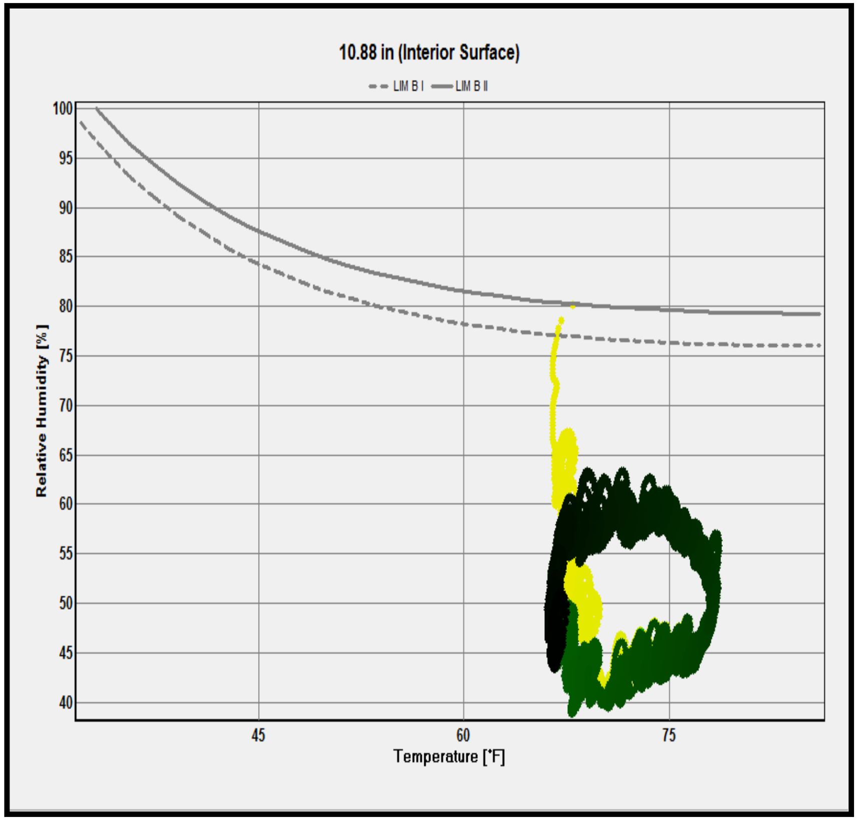
Moisture: Surface RH of 75-80%. Above 90-95% RH lack of oxygen stops fungal growth

Mold Isopleth Distribution

BAD NEWS

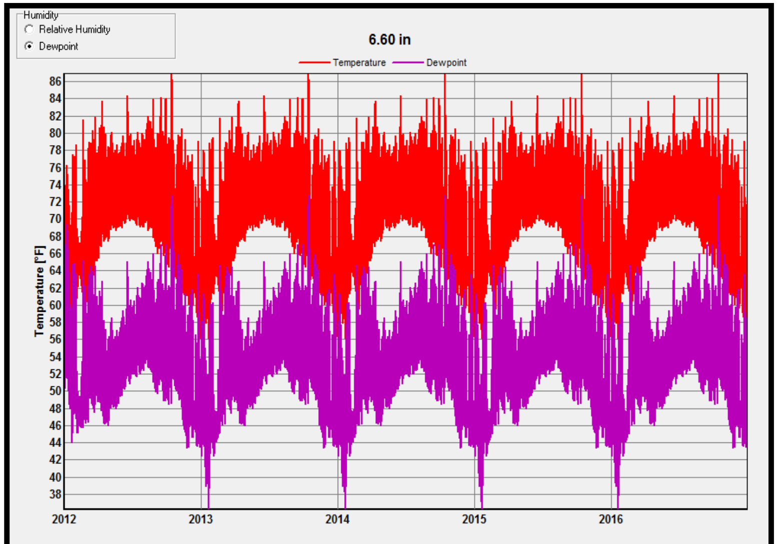


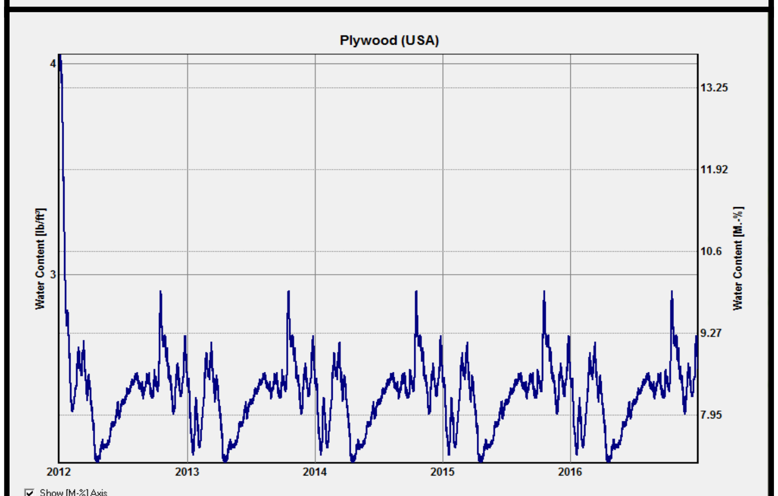
NO RISK



Scatter graph points should stay below curved mold risk lines

Specific Risk Thresholds + Example: Wood Decay





Wood Decay is due to fungal infections that require:

Favorable Temperature: > 50°F

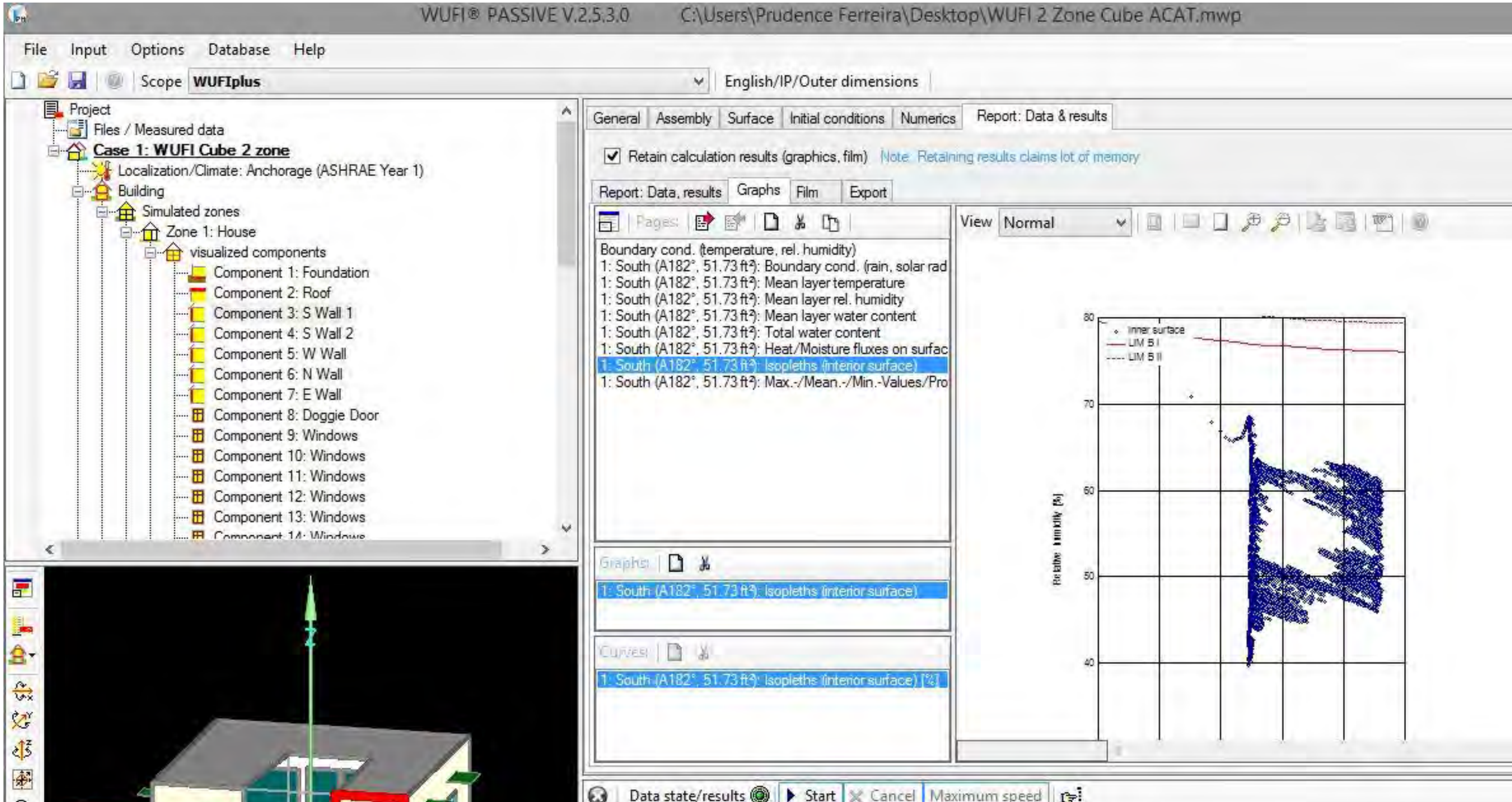
Moisture: H20 content by weight > 20%-M

In example, temperature is often above 50°F

H2O Mass % is below 20%

Wood rot risk is absent unless H2O Mass% increases

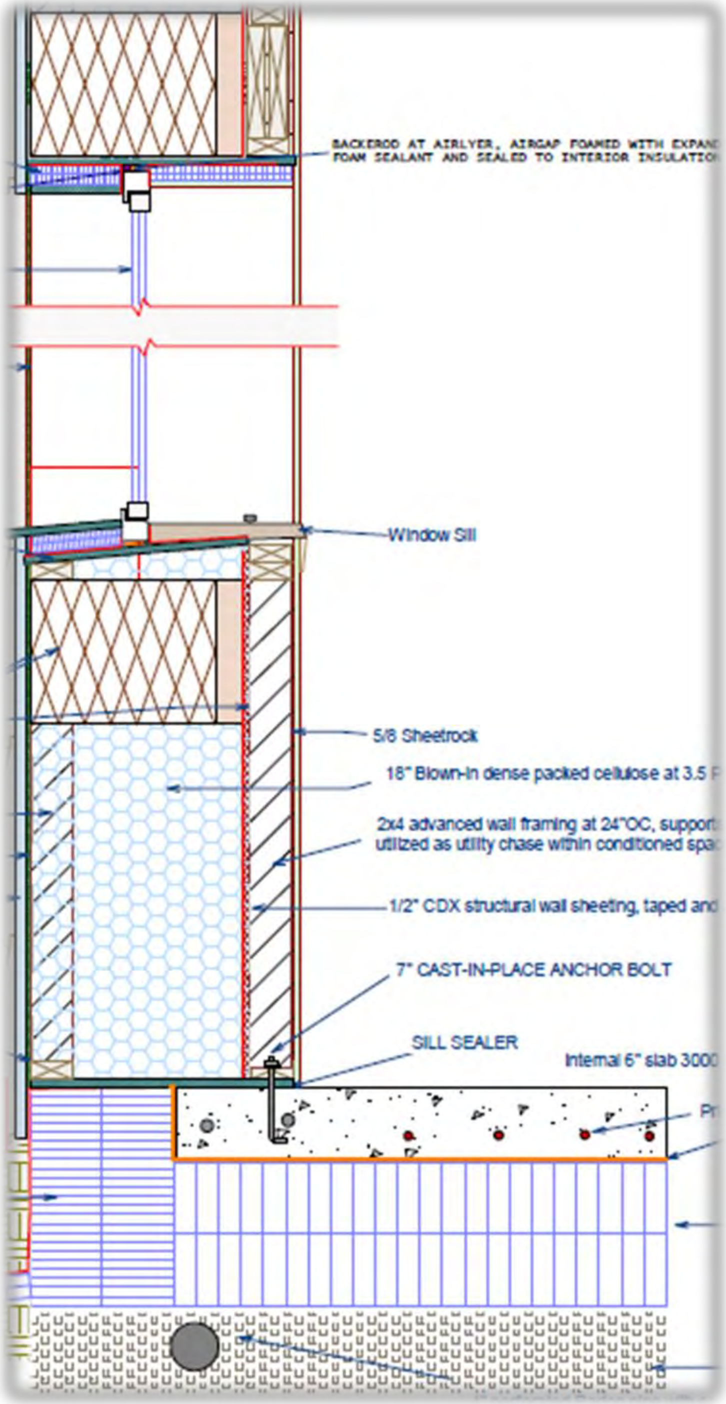
WUFI Plus Energy AND Hygrothermal Modeling



Last calculation	[date/time]	11/1/2013 2:07:08 AM	Date & time of last calculation
Calculation period	[hr]	8760	1/1/2013 : 00 - 1/1/2014 : 00
Heating	[kBtu]	8392.8	Calculated sum of heating energy
Cooling	[kBtu]	739.1	Calculated sum of cooling energy
Humidification	[lb]	0	Calculated sum of humidification
Dehumidification	[lb]	0	Calculated sum of dehumidification
Min. Ti	[°F]	68	Minimal inner temperature
Max. Ti	[°F]	77	Maximal inner temperature
Min. RHi	[%]	38.7	Minimal inner rel. humidity
Max. RHi	[%]	78.8	Maximal inner rel. humidity


SunRise
Home


GRACE VYCOR® PL
VYCOR® PL


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
2x4 advanced wall framing at 24"OC, suppor
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


GRACE VYCOR PLUS
GRACE VYCOR PLUS


R-80
Arctic Wall


Boise Cascade® VERSA-LAM® 2.0


Tyvek
HomeWrap
SIGA-Majcoat
www.siga.ch


SIGA-Majcoat
www.siga.ch


SIGA-Majcoat
www.siga.ch

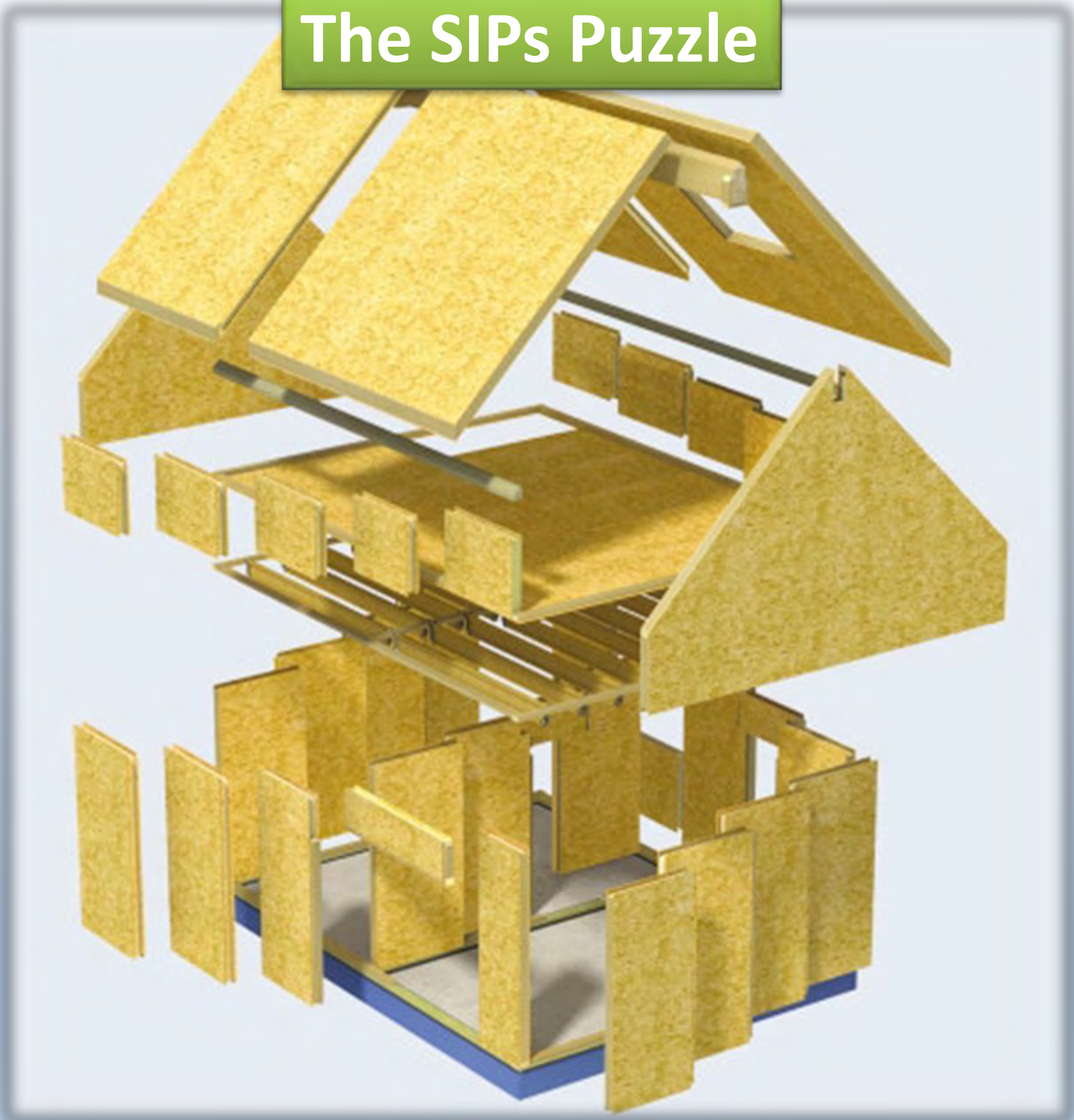
SIGA-Majcoat
www.siga.ch
SIGA-Wigluv


Majcoat
siga.ch
SIGA-Wigluv


siga.ch
SIGA-Wigluv
Majcoat
siga.ch

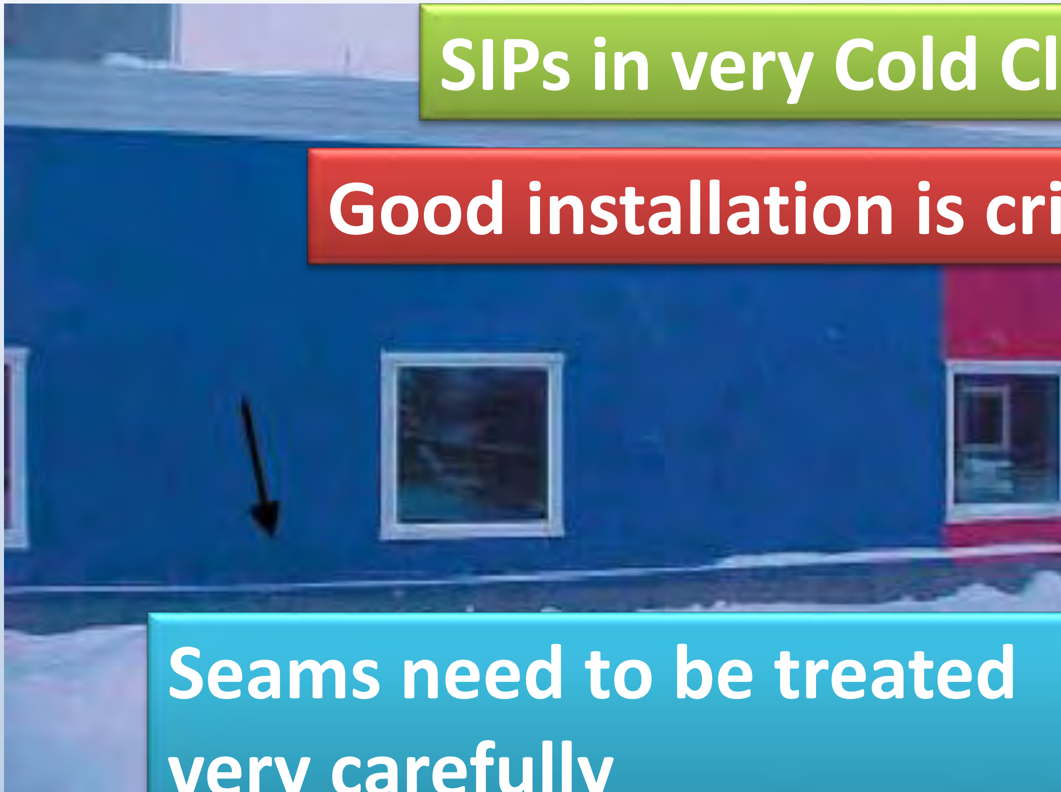

BOISE VERSA LAM 2.0

The SIPs Puzzle



SIPs in very Cold Climates

Good installation is critical

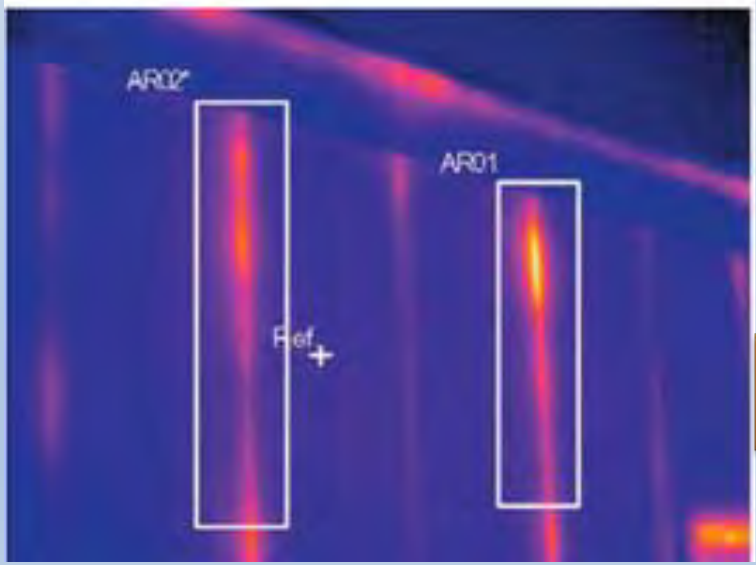


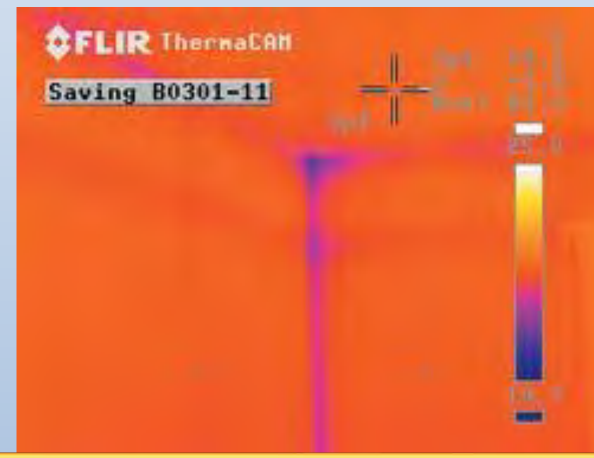
Seams need to be treated very carefully

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

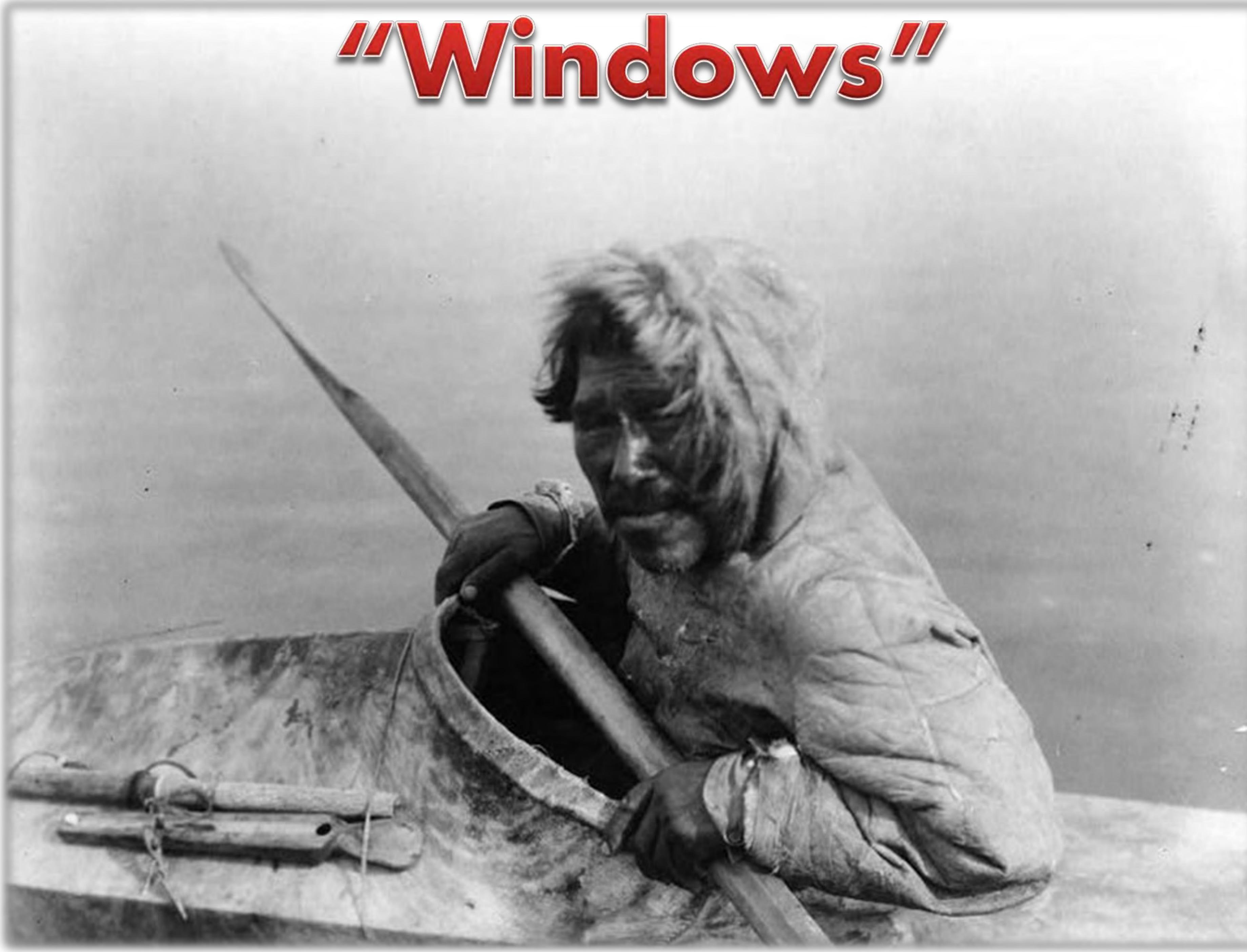
R-values of R-50 and more are NOT confirmed.

BUT - Thermal Mass Factor

Very Air tight!

Put the insulation where it belongs – the OUTSIDE

“Windows”



Principals for Appropriate Window Selection

Appropriate glazing!

Appropriate spacers!

Appropriate frame!

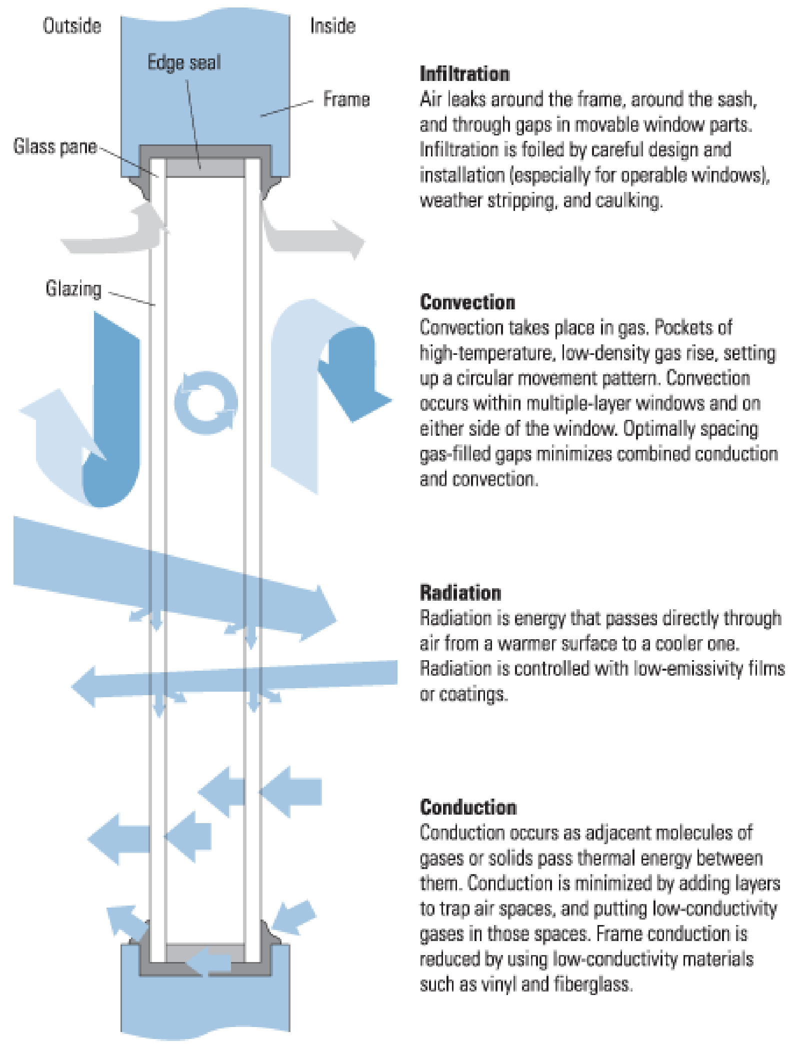
Installation thermal bridge-free!

- (Placed in insulation layer, if possible joint is insulated additionally on the outside)

Airtight installation!

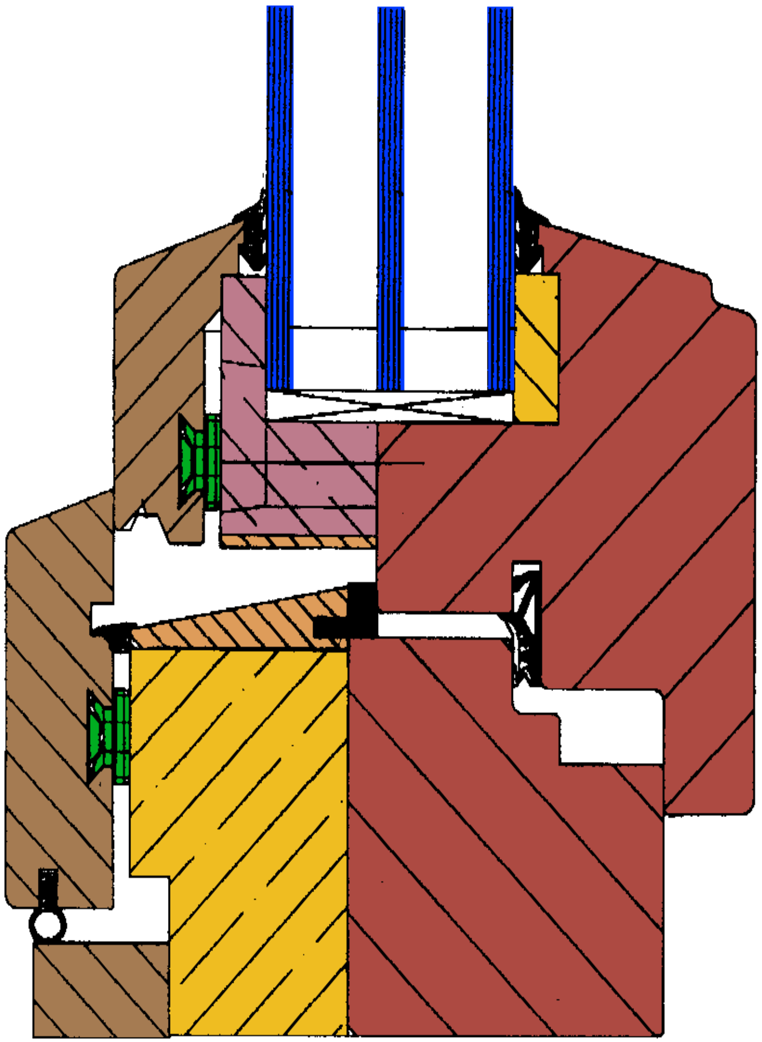
Window Considerations

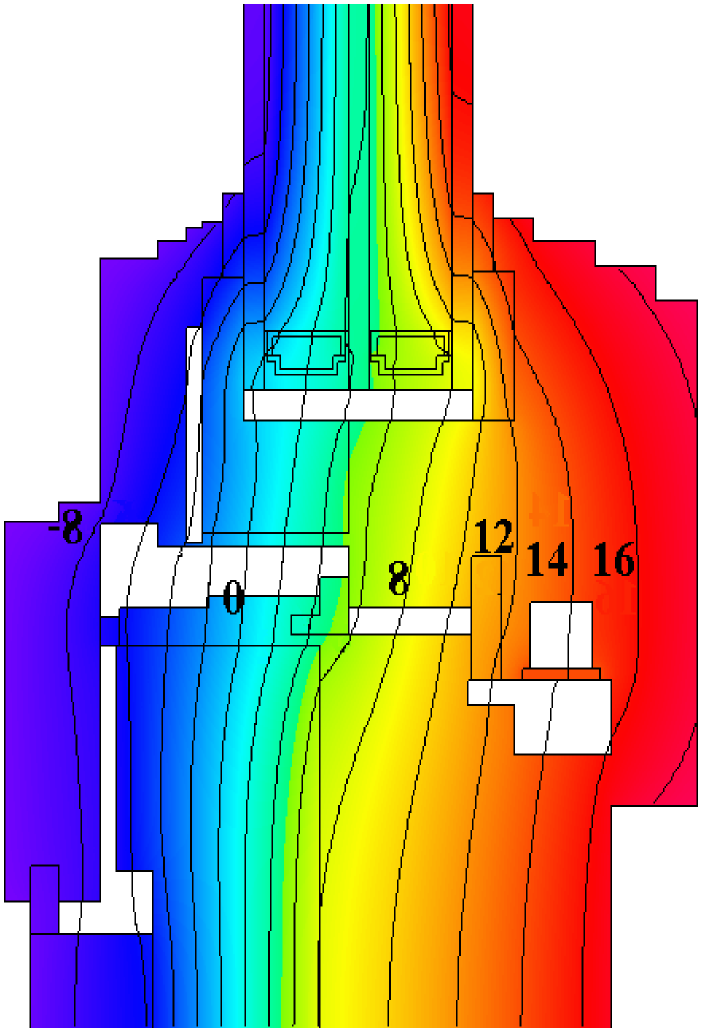
U-value	• glazing and overall U-value, creating warm surface temperatures, avoiding convection, insulated, thermally broken frames
Quality of Spacers	• warm spacers or super spacers
Solar Heat Gain Coefficient	• 0.50 – 0.6 starting value, optimized per climate/project
Air Leakage	• multilock systems, 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



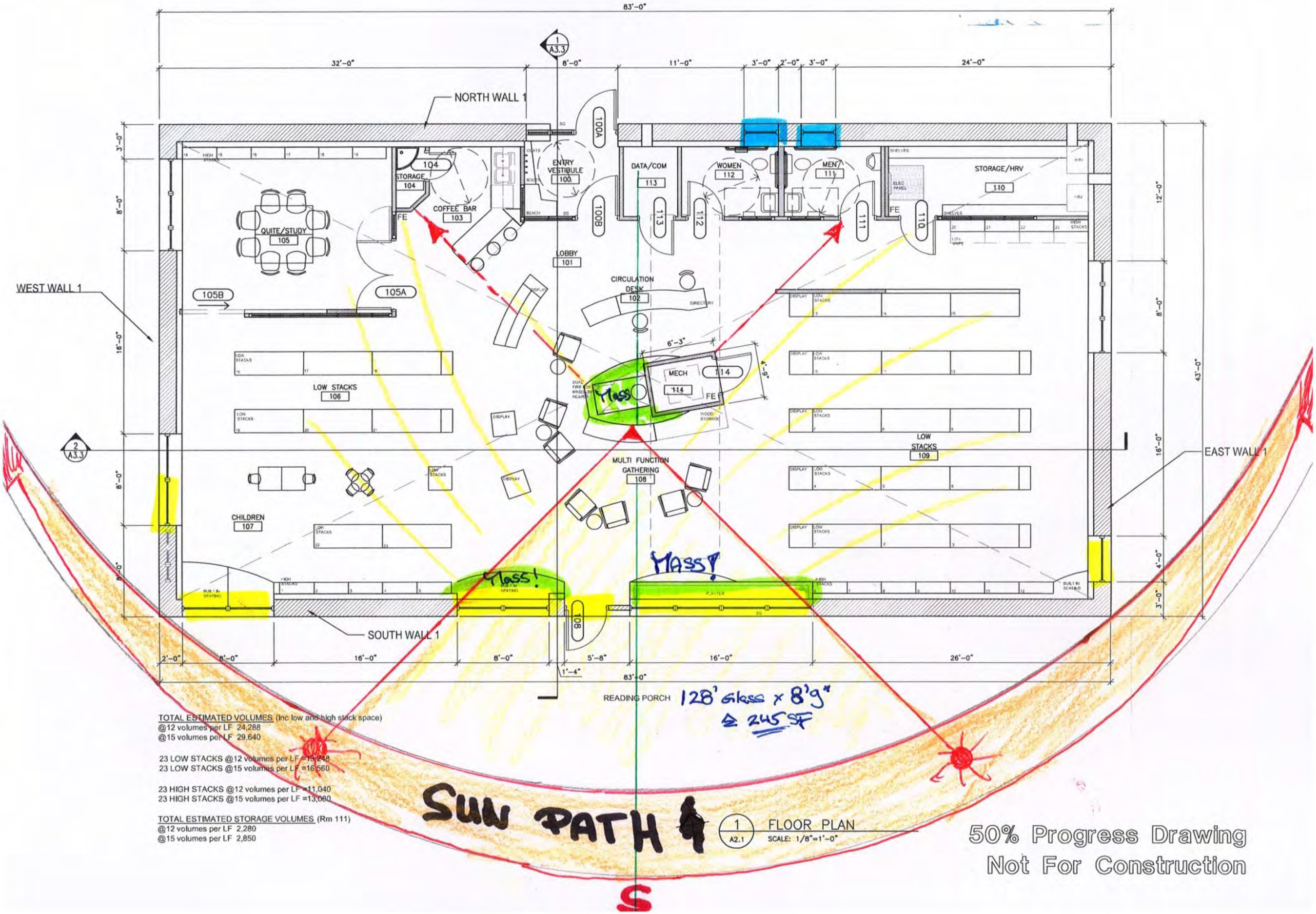
Courtesy: E SOURCE

Highly Efficient Window Profile



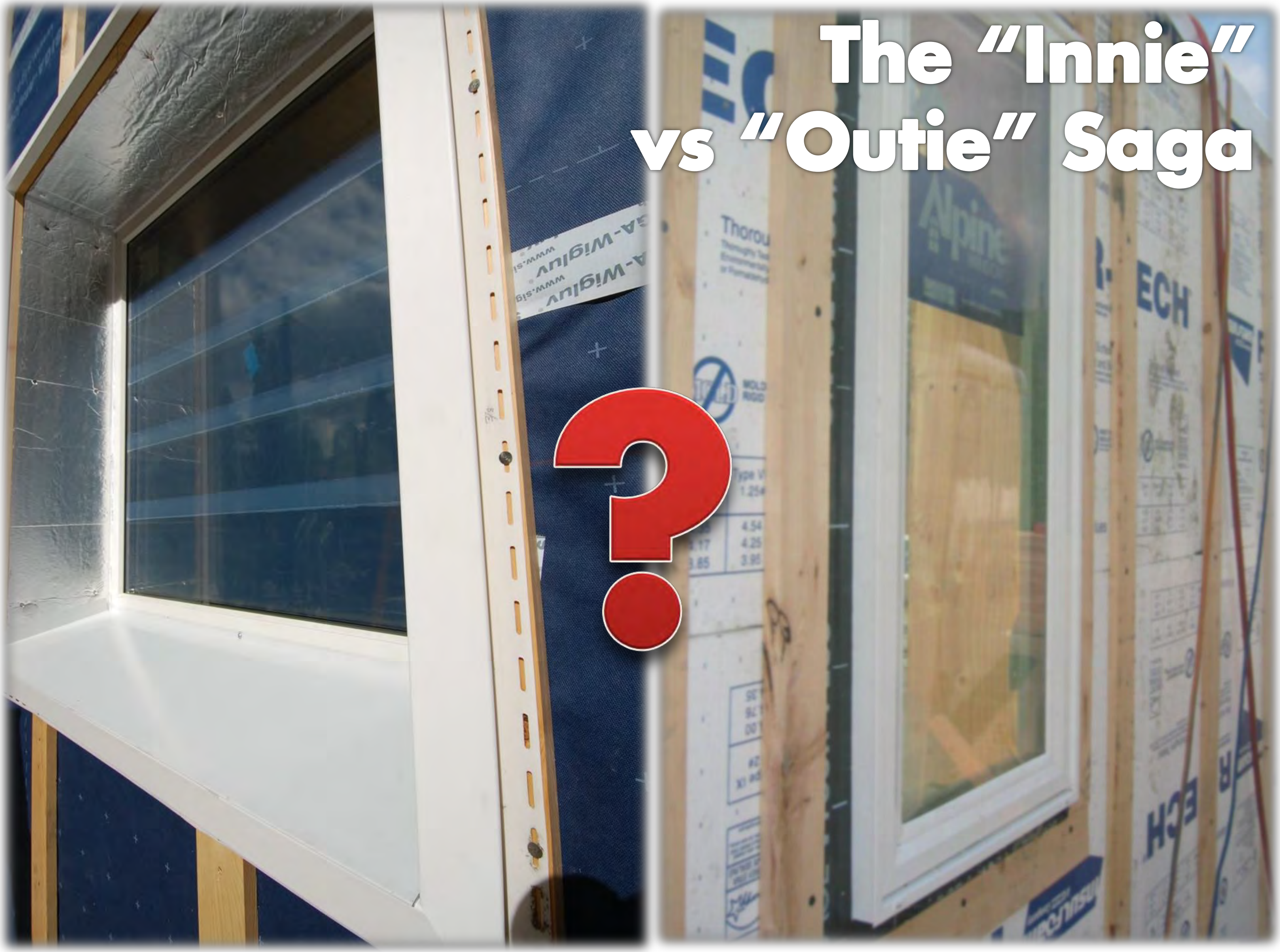


Maximize Passive Solar Gain



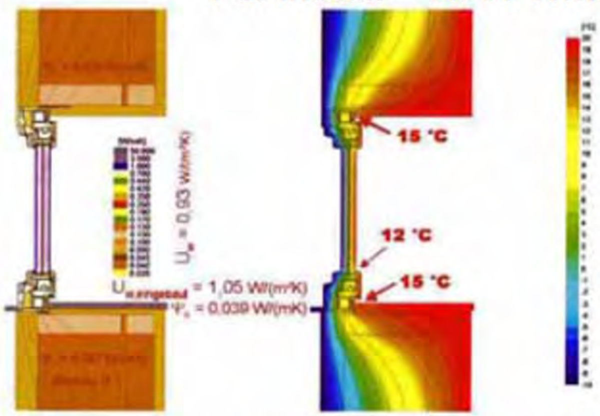
50% Progress Drawing
Not For Construction


Clear Glass
Min 60% SHGC
NO North windows

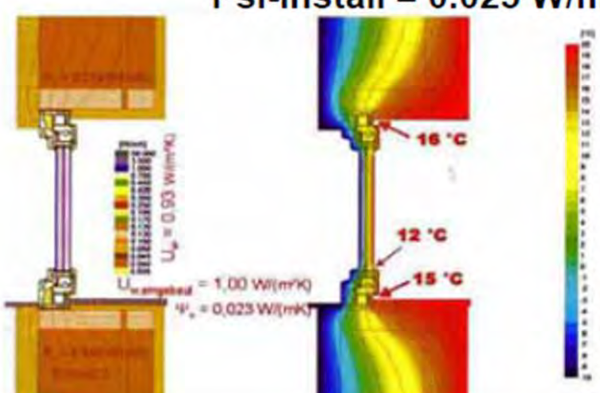

The "Innie"
vs "Outie" Saga

Position

POOR: U_w(installed) = 1.05 W/m²K
Psi-install = 0.039 W/m²K

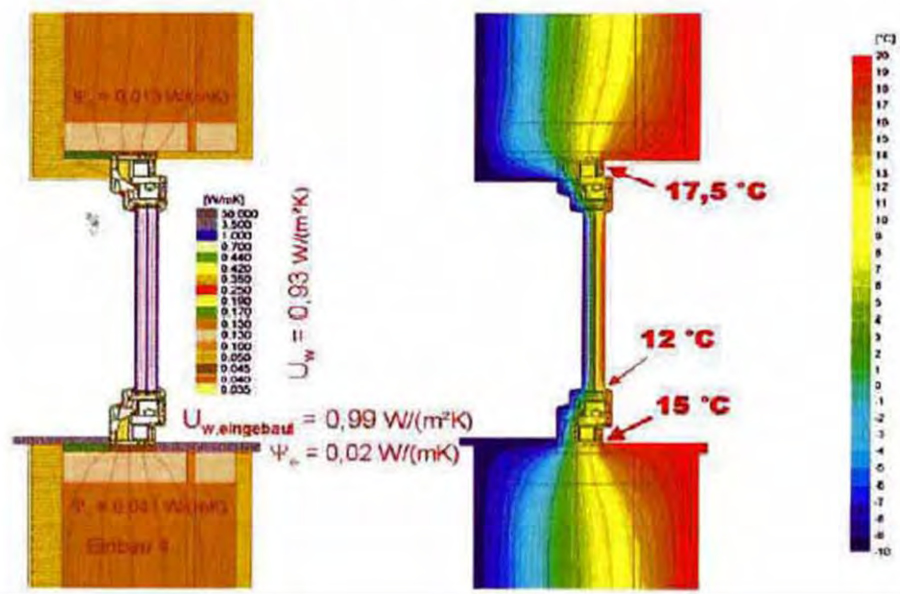


BETTER: U_w(installed) = 1.00 W/m²K
Psi-install = 0.023 W/m²K

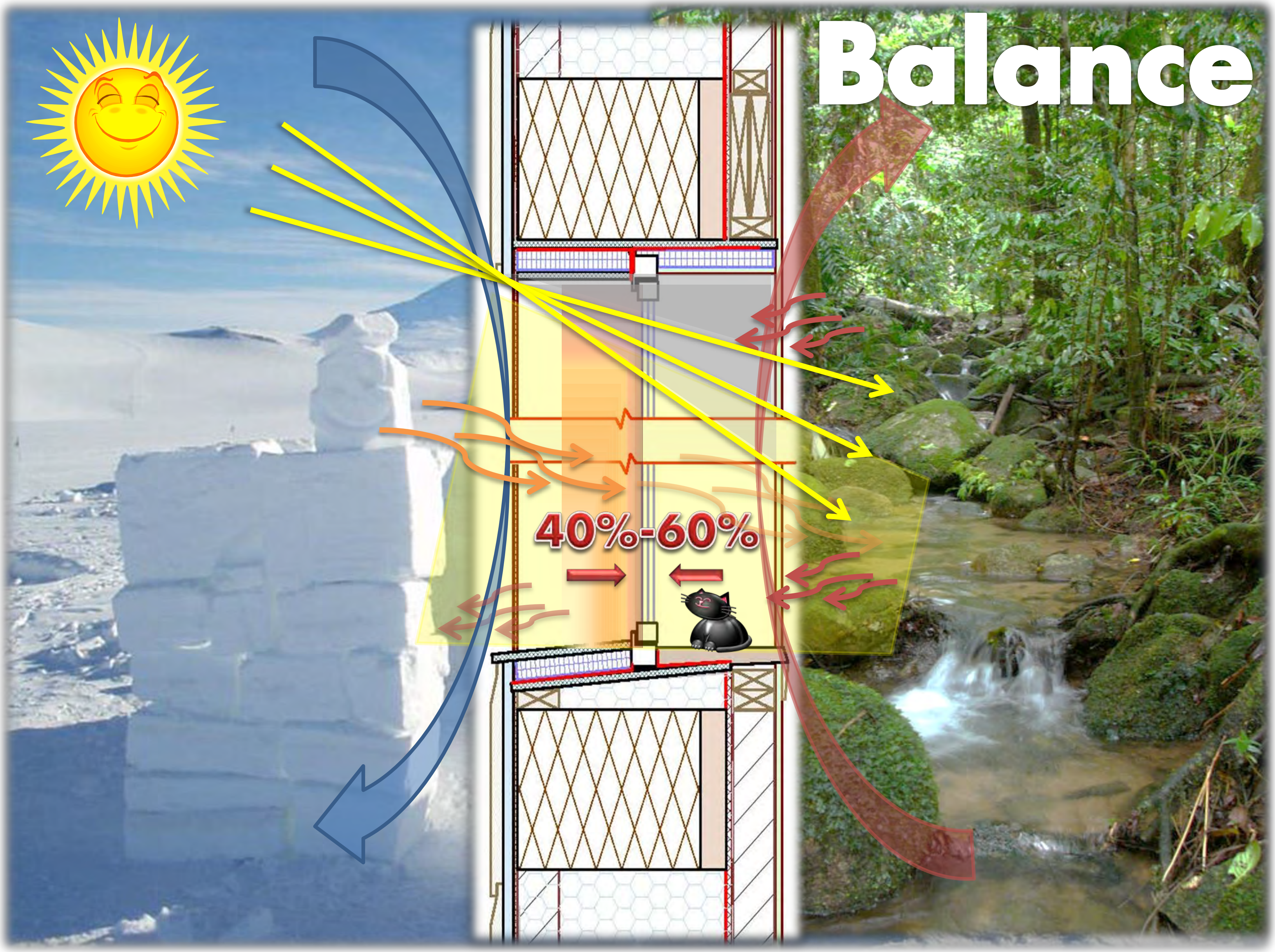


Placing the window in the best location within the wall cavity : Horizontal direction

BEST: U_w(installed) = 0.99 W/m²K
Psi-install = 0.02 W/m²K




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



Balance
40%-60%

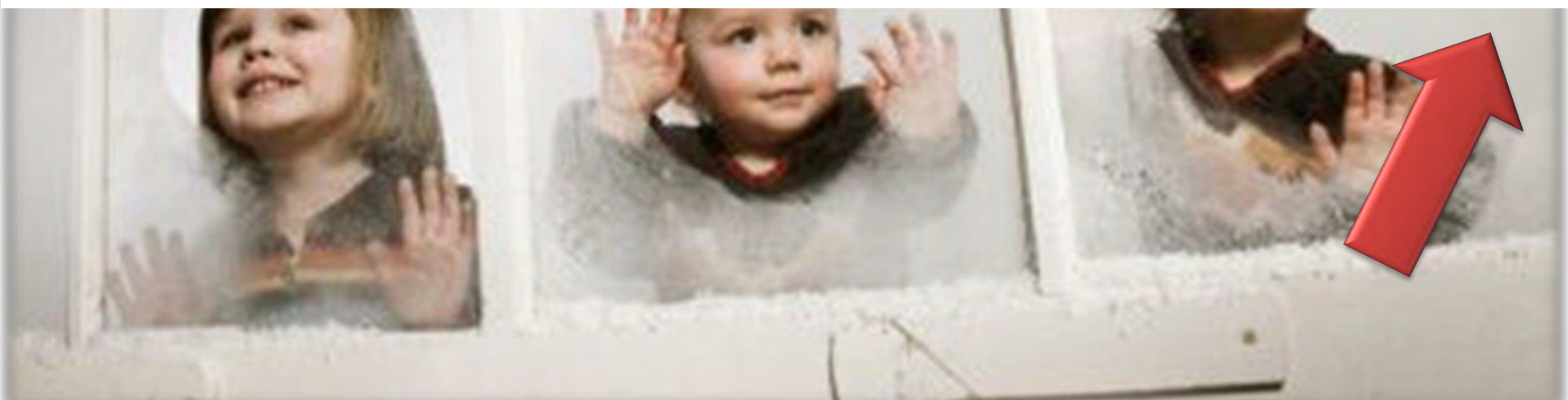
Passive House Planning

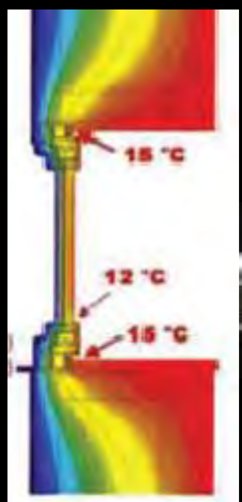
REDUCTION FACTOR SOLAR RADIATION, WINDOW U-VALUE

Annual Heat Demand: 4.33 kBTU/(ft²yr)

Heating Degree Days: 12056

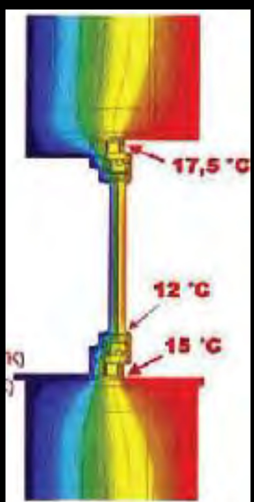
raction	SHGC	Reduction Factor for Solar Radiation	Window Area	Window U-Value	Window R-Value	Glazing Area	Glazing Area as % of Gross	Average Global Radiation	Transmission Losses	Heat Gains Solar Radiation
			ft^2	$BTU/hr.ft^2.F$	$hr.ft^2.F/BTU$	ft^2		$kBTU/ft^2yr$	kBTU/yr	kBTU/yr
00	0.00	0.00	0.0	0.00	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



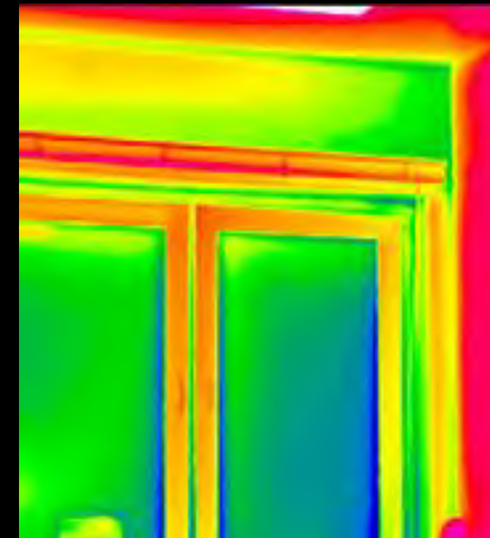


Think.

+20%



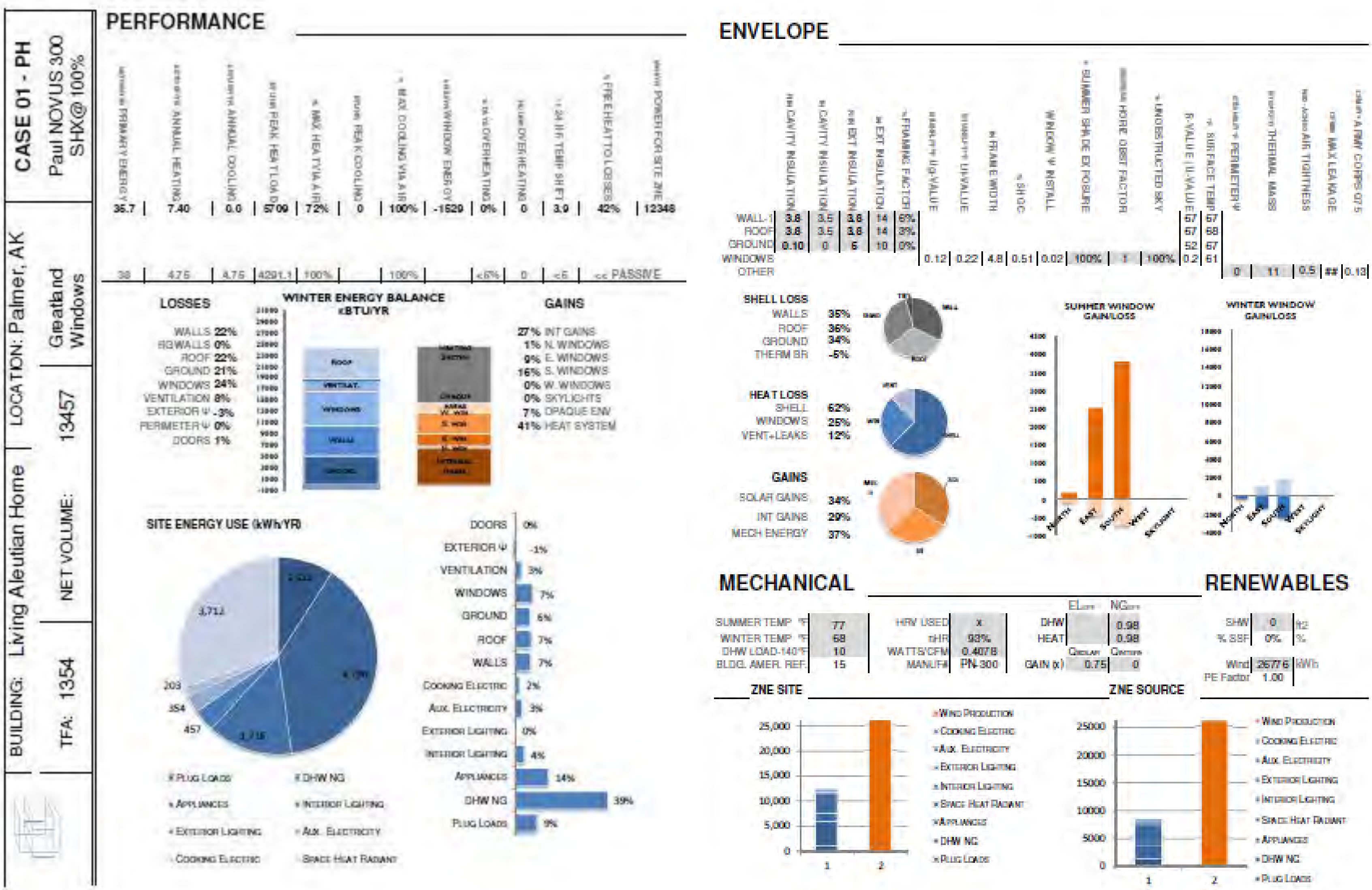

PLUS

Alpine
WINDOWS


Please! Inset & Over-insulate

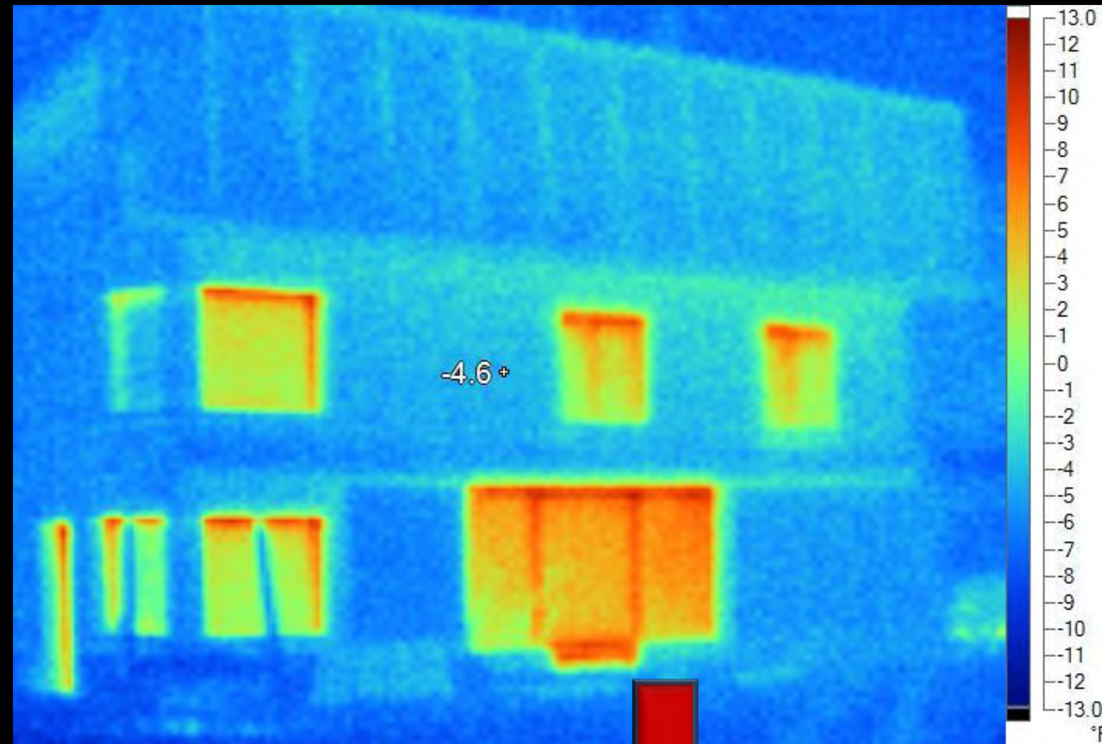
Thank you.

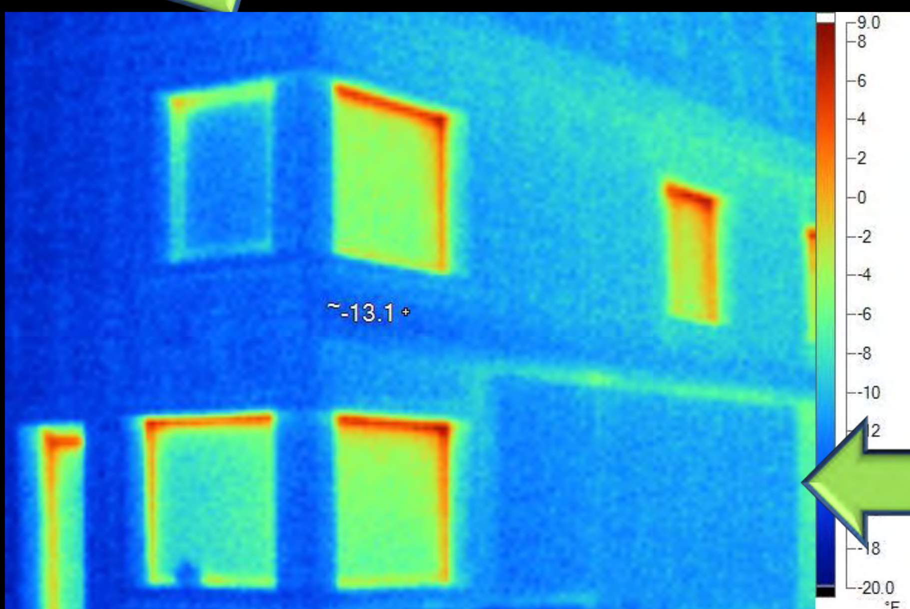
PHPP Modeling




Thermal
Shutters

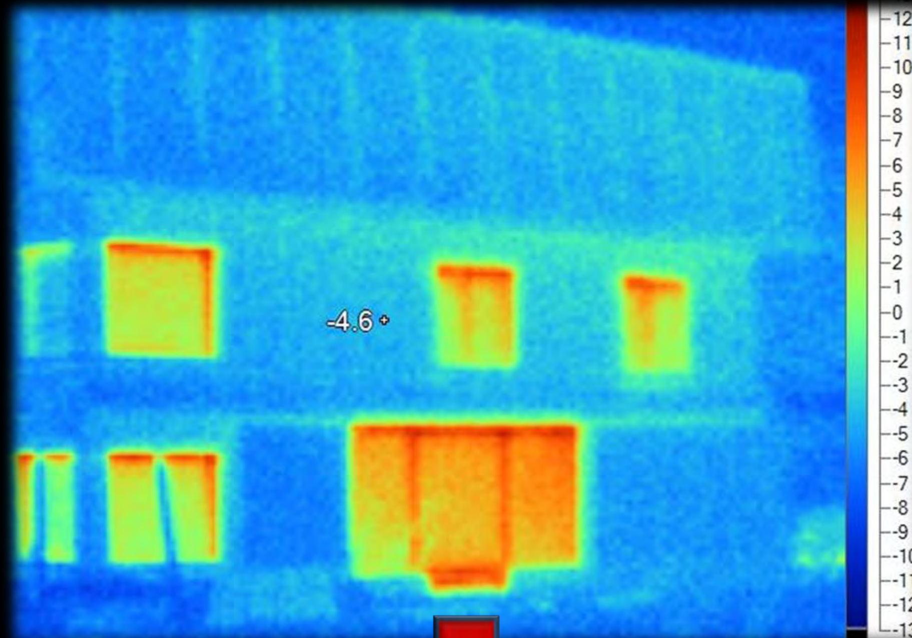
Thermal Shutters

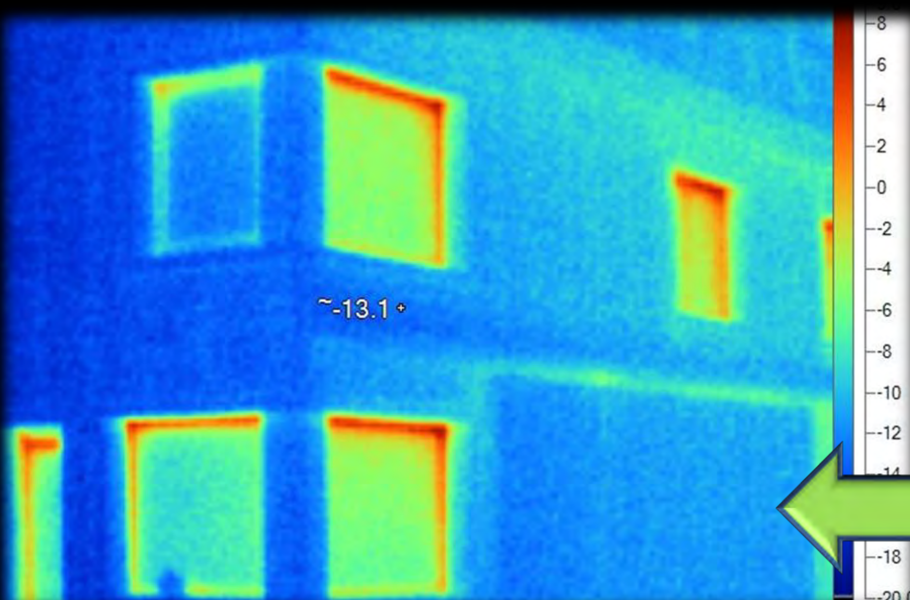




R-40 Shutters

Weakest link of the Assembly





Thermal Shutters

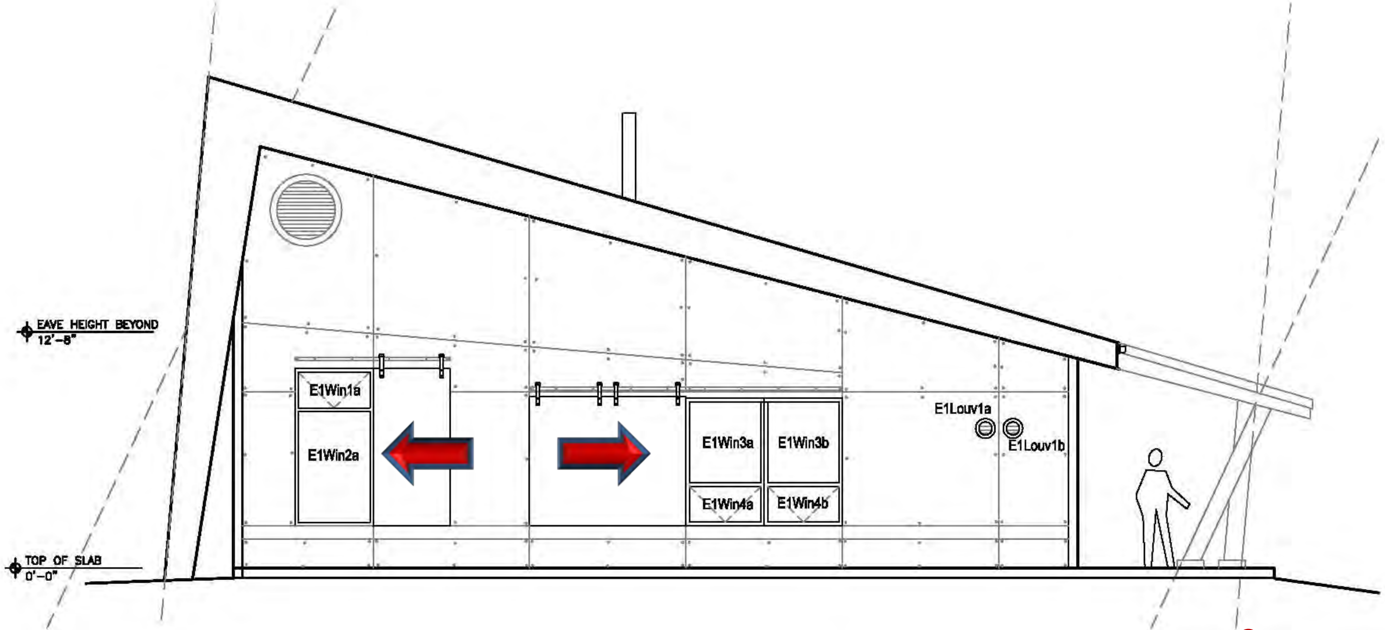
Interior Thermal Shutters function BUT:

Sealing/Icing issues

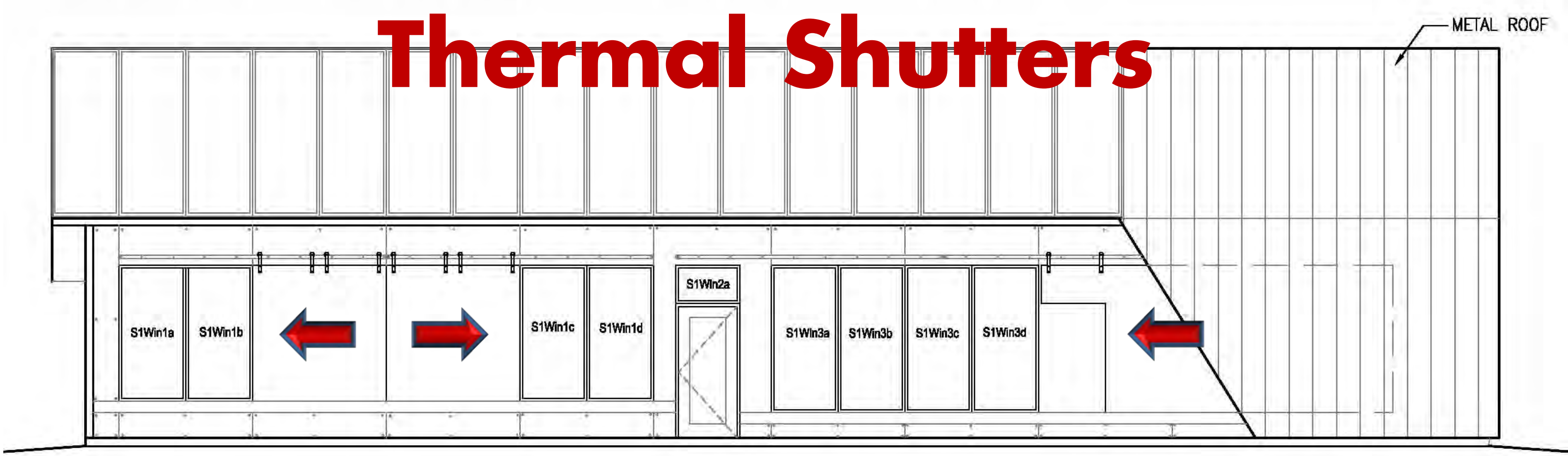
Proved difficult

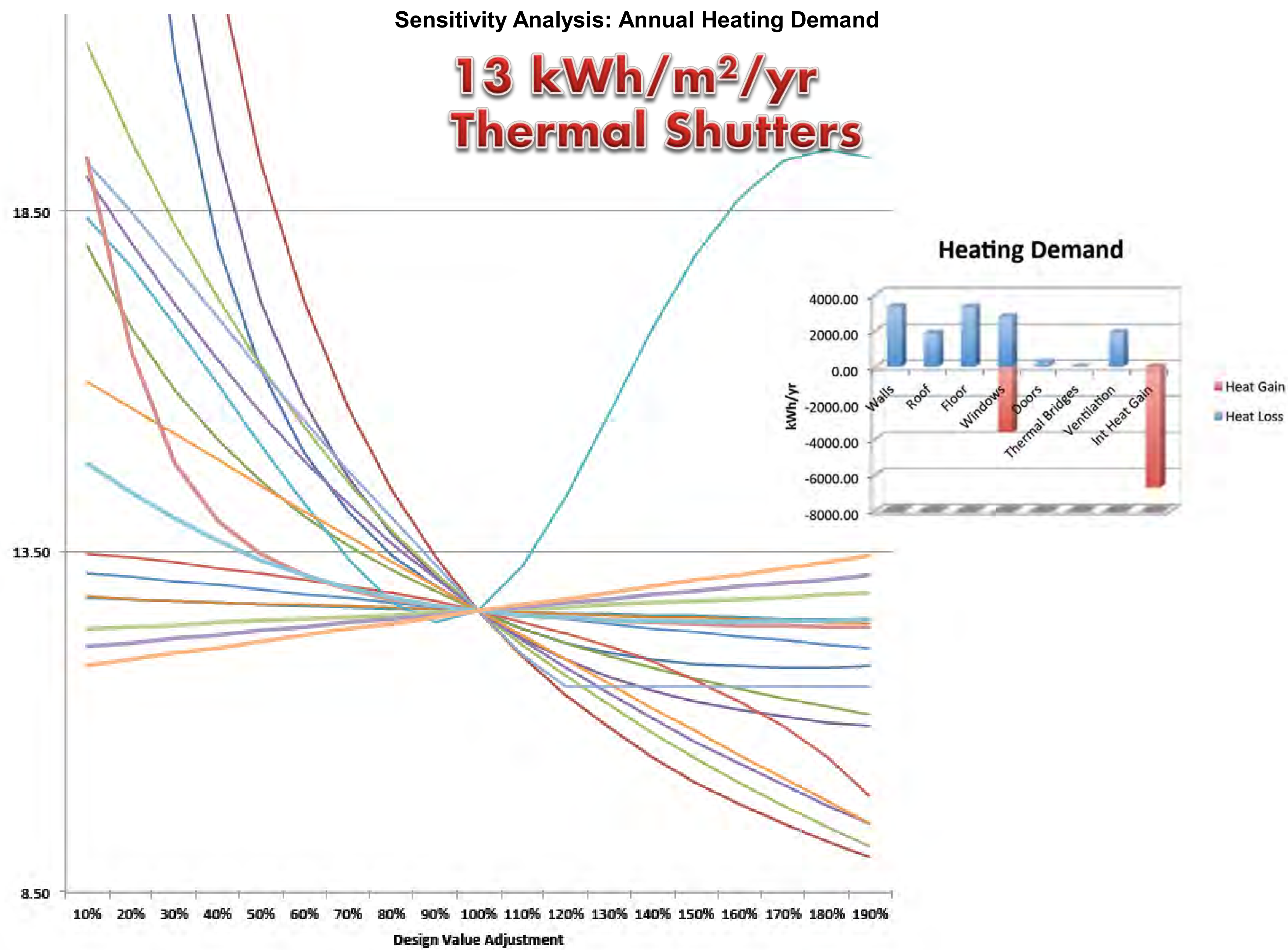
Under-perform

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

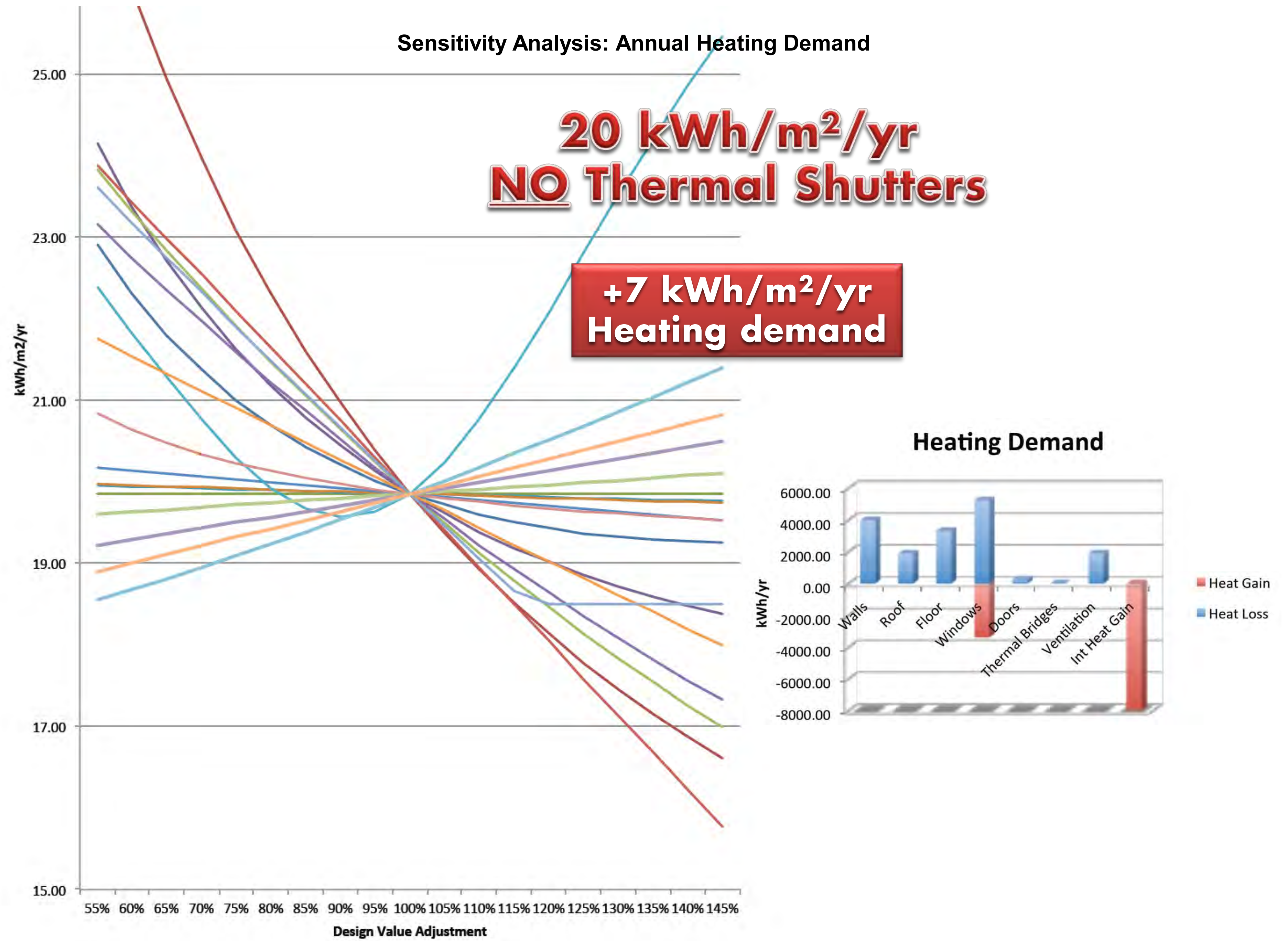


R-20 or U-0.05 Exterior Thermal Shutters





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 Shutter Calc for PHPP07

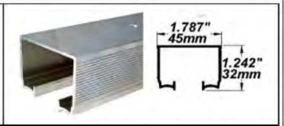
						Baseline 100%		Annual Average			Heating Season			Add Window		Assembly at 58%		
Shutter values	R/inch	inch	R-value	U-value	R-Airspace	%	Total R	Total U	%	Annual R	Annual U	%	Heating R	Heating U	Win-R	Win-U	S-Win-R	S-Win-U
Polyiso	6.5	2	13	0.0769	1.596	100%	14.596	0.0685	44%	6.4222	0.1557	58%	8.4657	0.1181	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%								

MATERIAL DETAILS

(1) TRACK

JOHNSON, U-TRACK, SINGLE TRACK, ALUMINUM, 200lb WEIGHT LIMIT
NO. JOH 100A
HANGING DOOR HARDWARE



(2) TRACK ROLLER

JOHNSON, U-TRACK ROLLER ASSEMBLY, 1" (D) WHEELS, 200lb WEIGHT LIMIT
NO. J1125
HANGING DOOR HARDWARE

(3) MOTOR

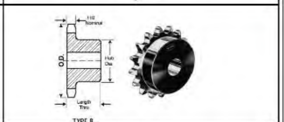
WORM GEAR MOTOR, UL/CSA
NO.BC2000/M 80 B3 115V 60
MINI MOTOR USA, INC.

(4) IDLER SPROCKET

BALL BEARING, (20) HARDENED TEETH
1.73" O.D.
NO. 25BB20 3/8
MARTIN SPROCKET

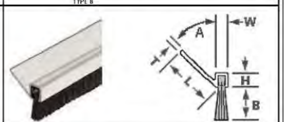
(5) DRIVE SPROCKET

B STYLE
1.083" O.D.
NO. 25B12
MARTIN SPROCKET



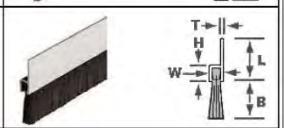
(6) BRUSH MOUNT SEAL

REVERSE ANGLE 45(DEG)
NO. 245R.69100
VECTERS BRUSH



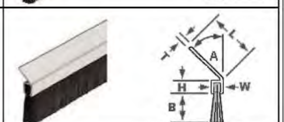
(7) BRUSH MOUNT SEAL

STRAIGHT MOUNT BRUSH SEAL
NO. 200.87050
VECTERS BRUSH



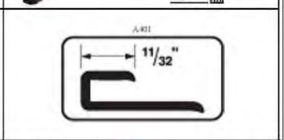
(8) BRUSH MOUNT SEAL

ANGLE MOUNT BRUSH SEAL 40(DEG)
NO. 240.5081
VECTERS BRUSH



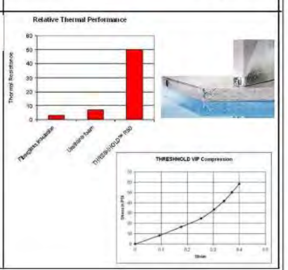
(9) ANODIZED ALUMINUM CAP

NO. MD A - 401
M-D BUILDING PRODUCTS



(10) VACUUM INSULATION PANELS (VIP)

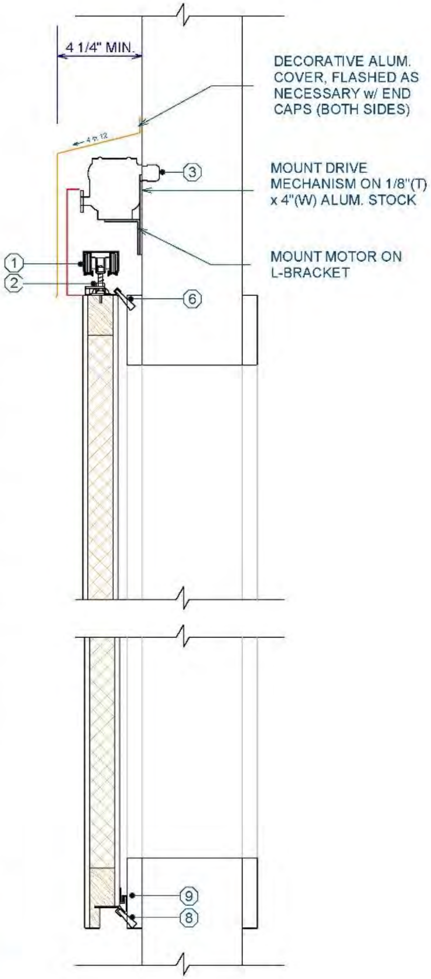
1 1/4"(T)
R-60 INSULATION VALUE
MATERIAL THERMAL CONDUCTIVITY:
(0.020 BTU-IN/FT²-HR-F)
OR (2.88 MW/M-K)
THERMAL VISIONS THRESHOLD

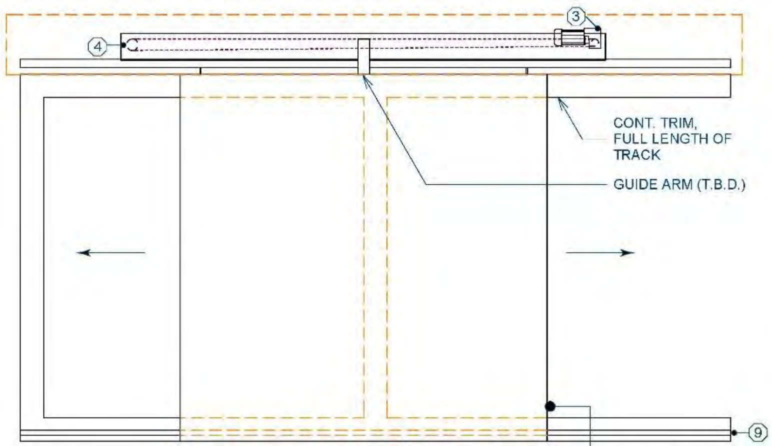


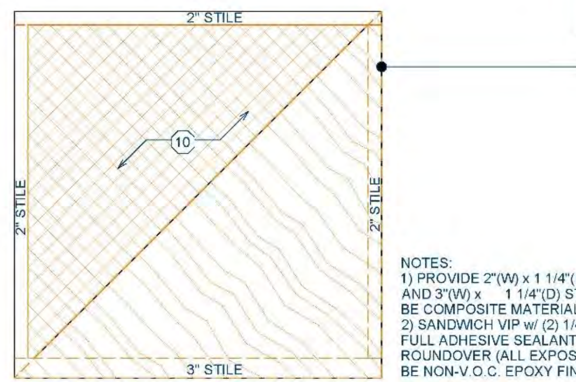
THE ARCTIC SHUTTER – THERMAL WINDOW SHUTTER FOR COLD CLIMATES

HIGH PERFORAMNCE MOTORIZED EXTERIOR WINDOW INSULATION SHUTTER SYSTEM WITH R-60 INSULATION CORE AND WEATHER RESILIENT CONSTRUCTION

- VERY LOW THERMAL CONDUCTIVITY AND LIGHTWEIGHT CONSTRUCTION
- HIGHEST INSULATION VALUE WITH VACUUM INSULATED CORE PANELS AT R-60 PERFORMANCE
- AIR TIGHT SEALING
- TEMPERATURE STABLE CONSTRUCTION WITH THE USE OF ENGINEERED WOOD AND LAMINATION PROCESS
- HIGH PERFORMANCE REVERSABLE 115V MICRO MOTOR







NOTES:
1) PROVIDE 2"(W) x 1 1/4"(D) STILES @ TOP AND SIDES AND 3"(W) x 1 1/4"(D) STILE @ BOTTOM. STILES TO BE COMPOSITE MATERIAL.
2) SANDWICH VIP w/ (2) 1/4"(T) PLY SKINS. PROVIDE FULL ADHESIVE SEALANT @ STILES AND 1/16"(R) ROUNDOVER (ALL EXPOSED EDGES.) FINISH COAT TO BE NON-V.O.C. EPOXY FINISH.

Project:

The ARCTIC Shutter

REINA LLC

ArcticSun, LLC
1050 Deere St., Fairbanks, Alaska 99709
Phone 907-457-1297
Fax 907-457-3397
Email info@arcticsun-llc.com

Design by: Thorsten Chlupp

Scale: 1" = 1'-0" U.N.O.

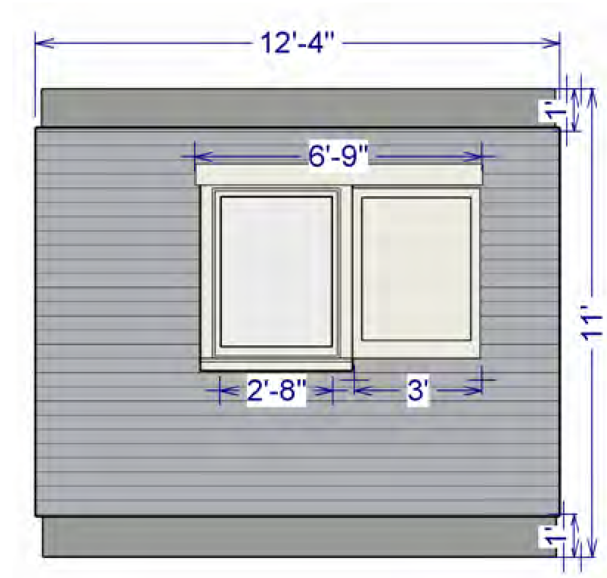
Date: 4/22/13

Sheet No.: 1 of 1

Thermal Shutter TestLab

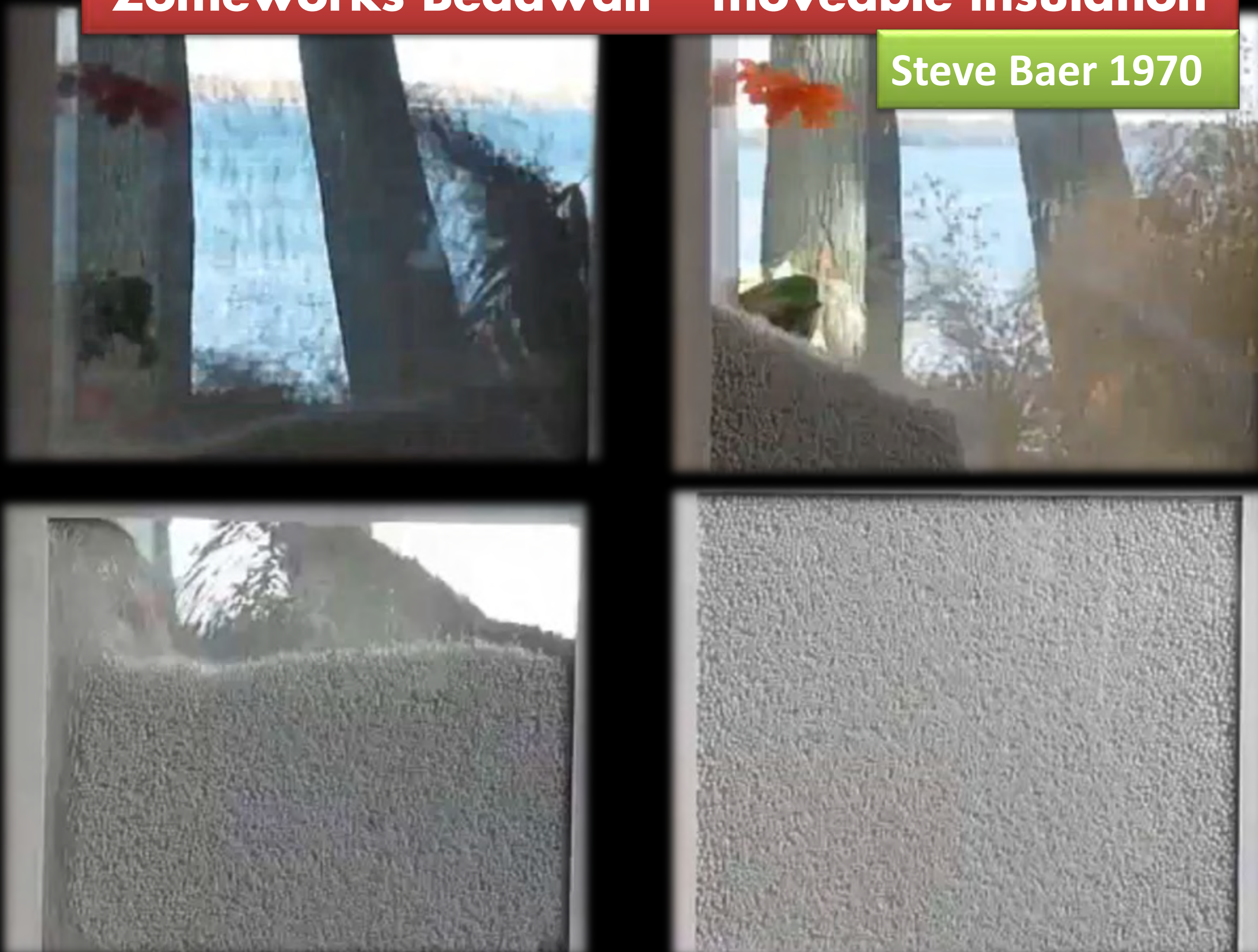
<u>Thermal Shutter test LabBox</u>

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

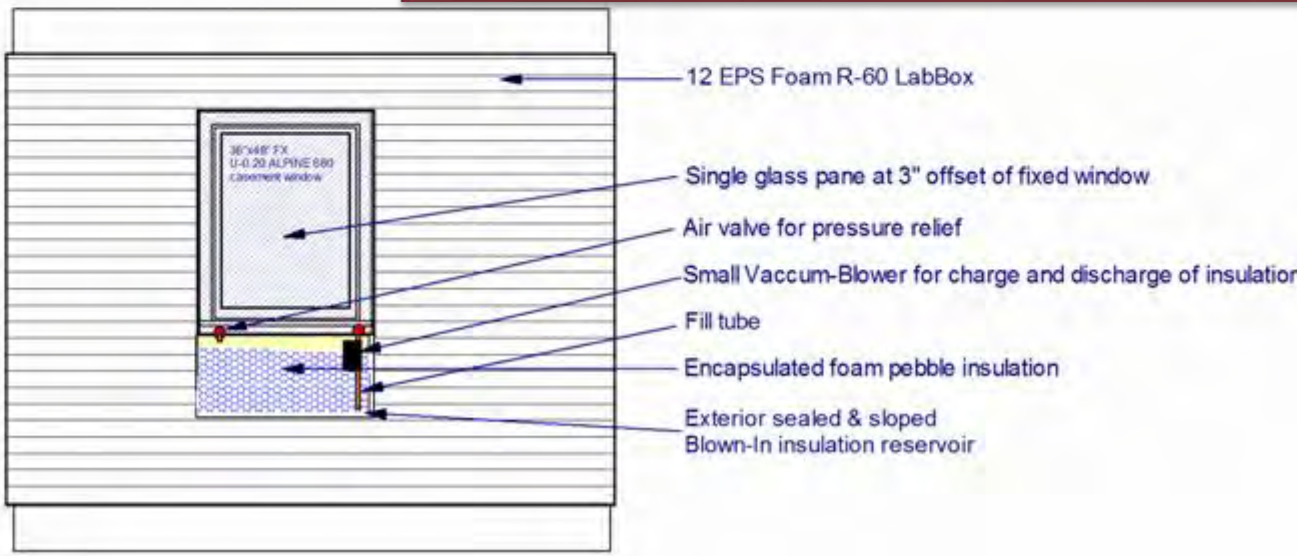


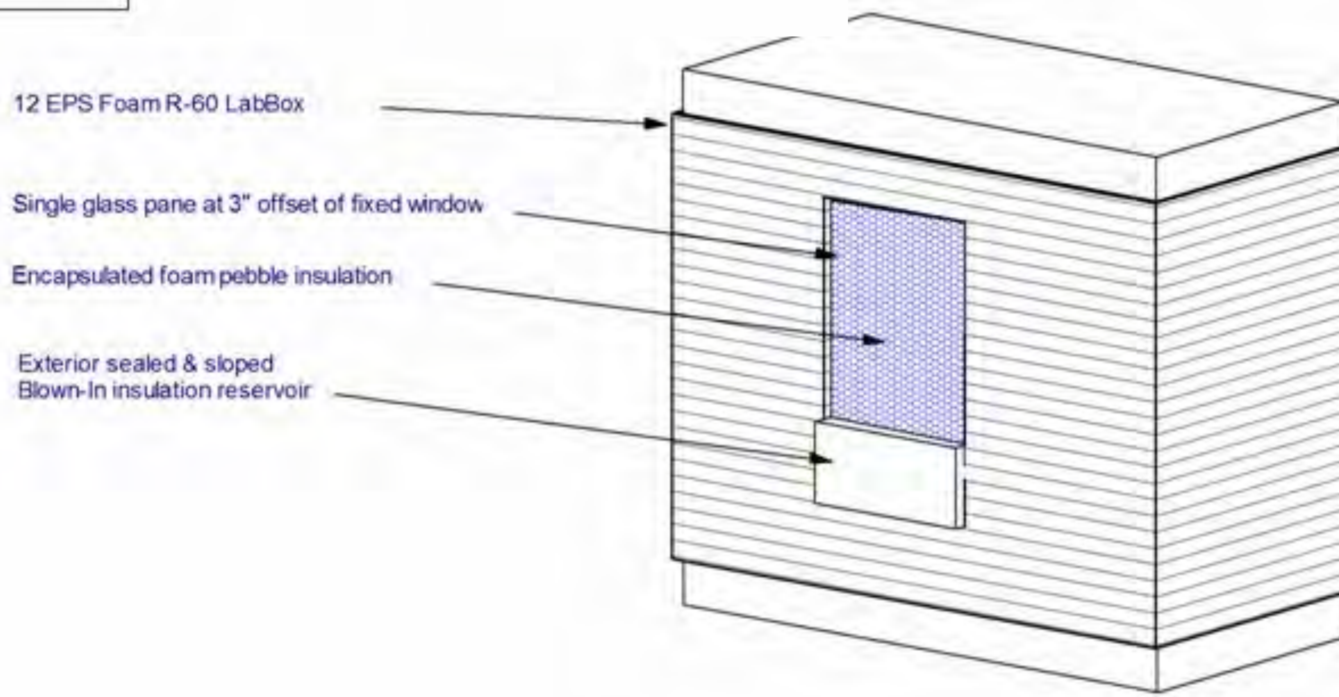
Zomeworks Beadwall™ moveable insulation

Steve Baer 1970

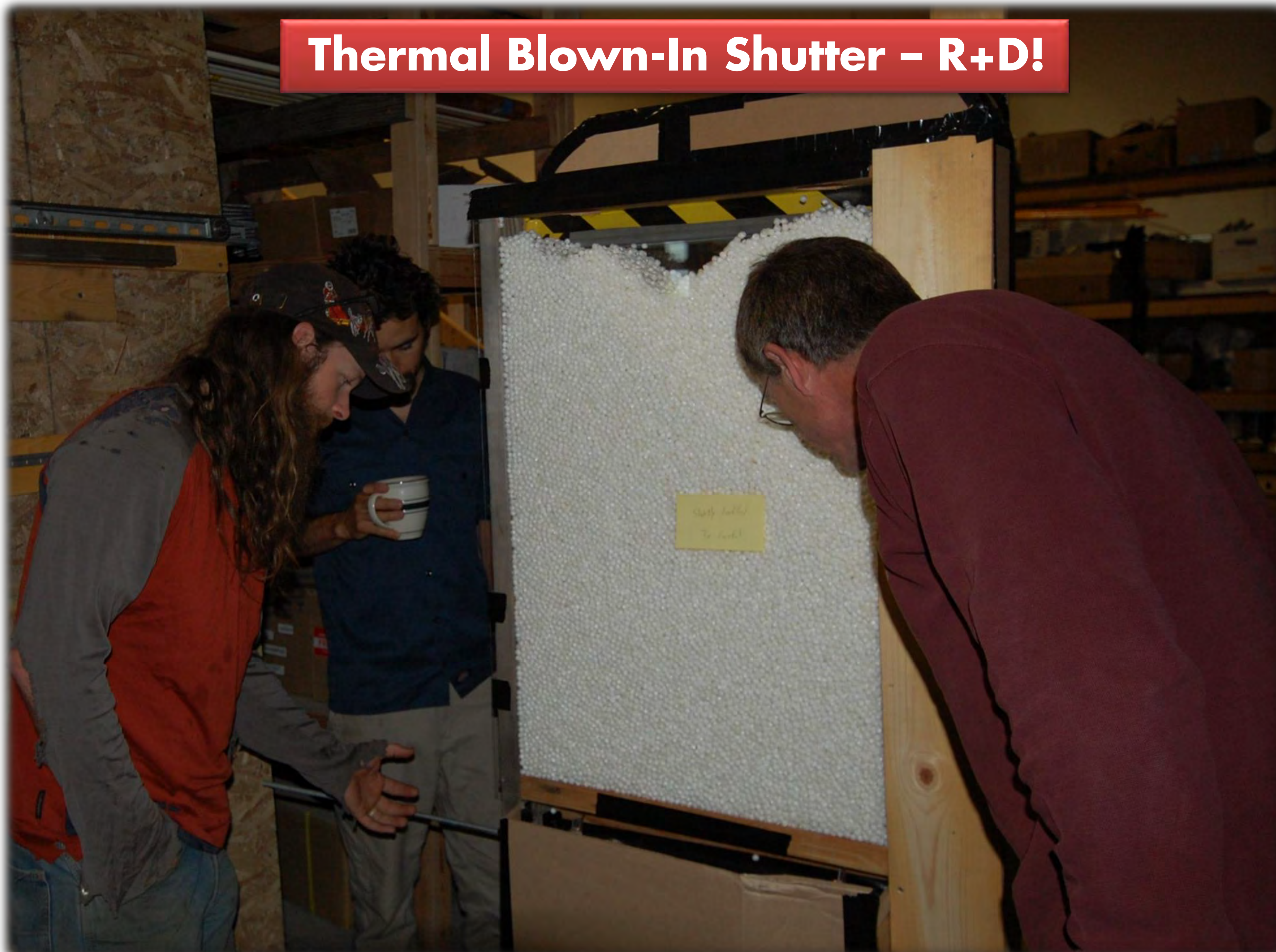


Thermal Blown-In Shutter



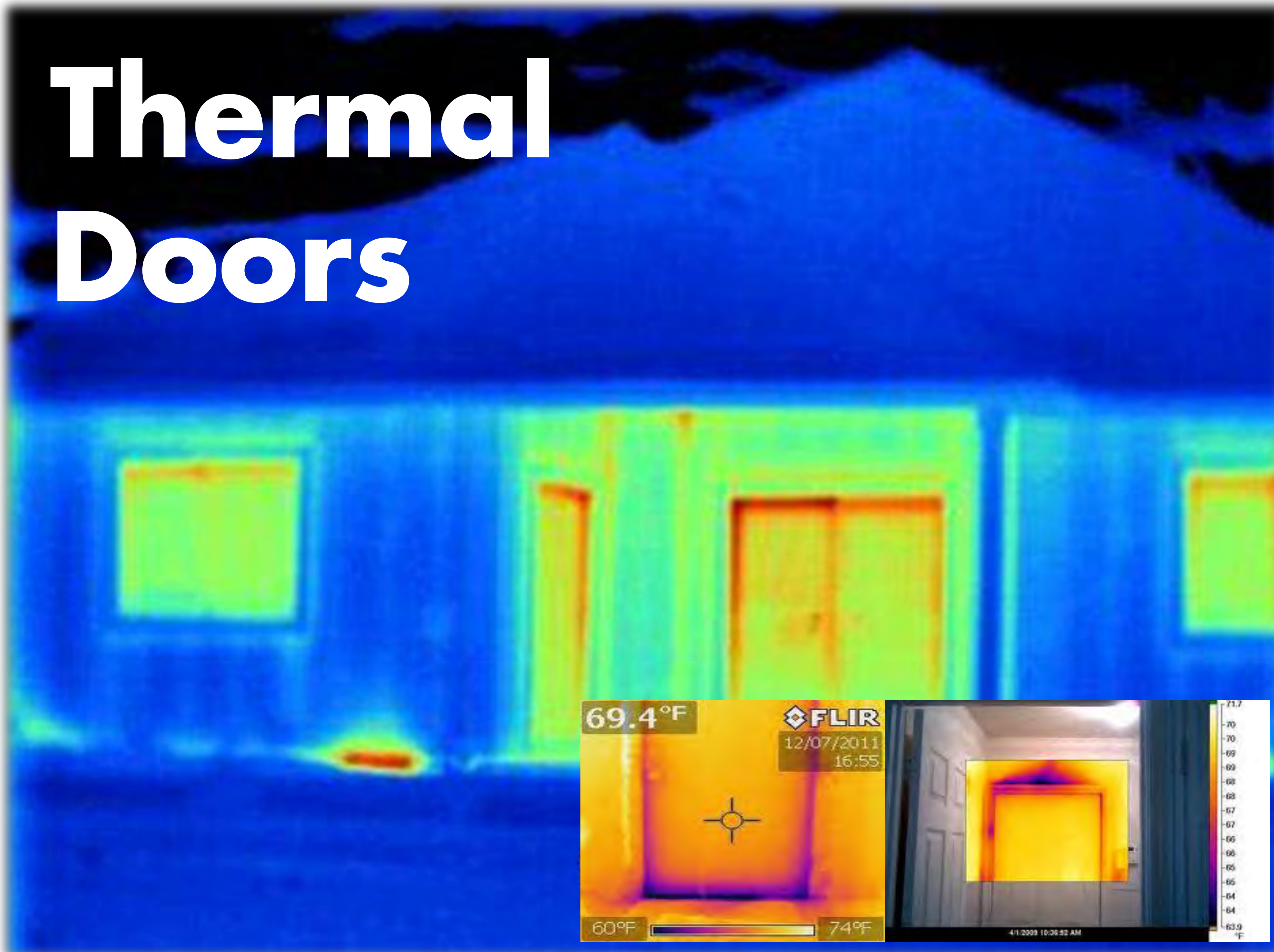


Thermal Blown-In Shutter – R+D!



Thermal Blown-In Shutter

Thermal Doors



ARCTIC Entry Doors

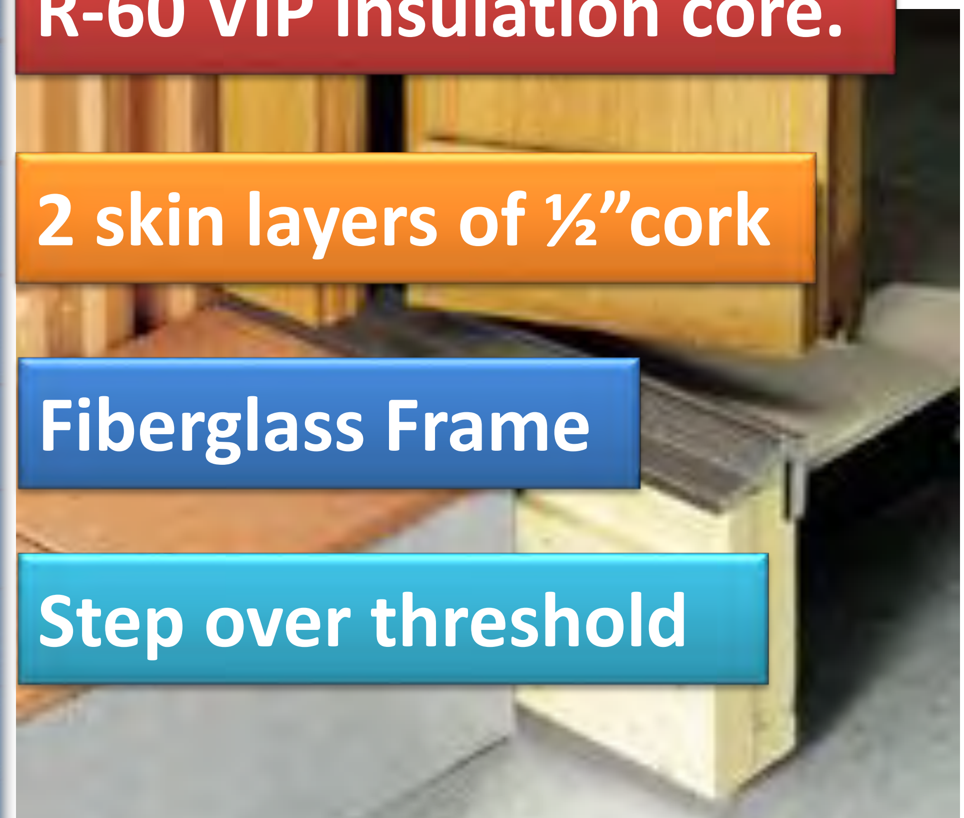
Airtight, 7 point lock system.

R-60 VIP insulation core.

2 skin layers of ½”cork

Fiberglass Frame

Step over threshold



Thermal break free installation.

THE ARCTIC DOOR – A HIGH PERFORMANCE ENTRY DOOR FOR COLD CLIMATES

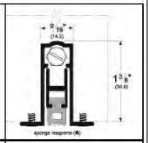
SUPERIOR PERFORMANCE THROUGH:

- VERY LOW THERMAL CONDUCTIVITY
- HIGHEST INSULATION VALUE WITH VACUUM INSULATED CORE PANELS AT R-60 PERFORMANCE
- AIR TIGHT SEALING WITH DOUBLE AIR SEALS AND MULTIPOINT LOCK SYSTEM
- TEMPERATURE STABLE CONSTRUCTION WITH THE USE OF ENGINEERED WOOD AND LAMINATION PROCESS

MATERIAL DETAILS

DOOR BOTTOM

AUTOMATIC, NON-HANDED, REVERSIBLE
NO. 411_RL
PEMKO



KERF WEATHERSTRIPPING

SPONGE NEOPRENE, OVAL-SHAPED SEAL
NO.Z8052
TM HARDWARE

DOOR HINGE

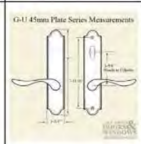
HOPPE F1713,
2009 ADJUSTABLE GUIDE HINGE,
NON-HANDED, GOLD
NO.3033852
ALL ABOUT DOORS & WINDOWS

MULTIPOINT LOCK KIT

G-U EAGLE NEW BREED w/ LATCHBOLTS, KEY ABOVE HANDLE, for 6'-8" DOOR
NO.499039168
ALL ABOUT DOORS & WINDOWS

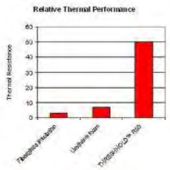
HANDLE & 45mm PLATE

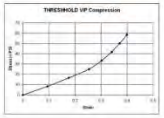
G-U VENICE
BRASS, FINISH (SN), for 1 3/4" DOOR,
HANDLE BELOW CYLINDER
NO. 403072
ALL ABOUT DOORS & WINDOWS



Vacuum Insulation Panels (VIP)

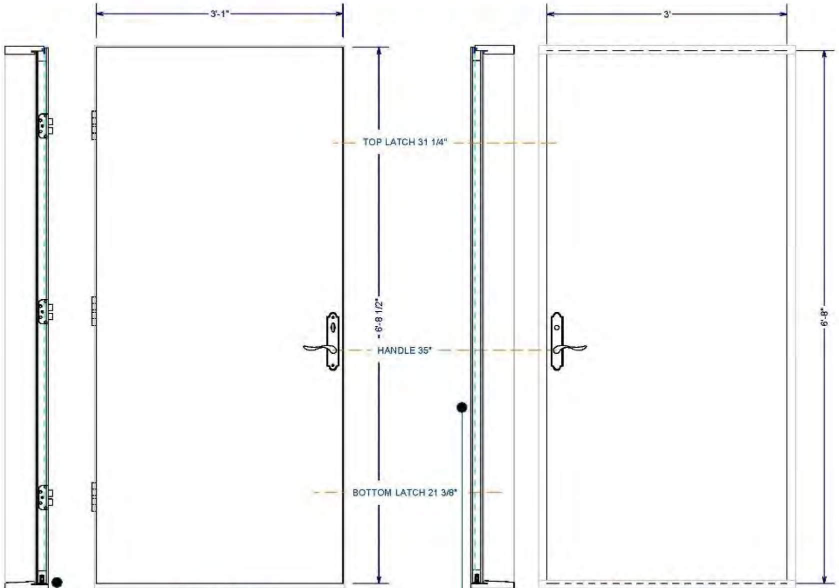
INSULATION CORE FOR DOOR PANEL TO BE THERMAL VISIONS THRESHOLD VACCUM INSULATION PANELS. USE TWO 31X38X1.25 INCH PANLES AT R-60 INSULATION VALUE
MATERIAL THERMAL CONDUCTIVITY 0.020 BTU-IN/FT²-HR-F OR 2.88 MW/M-K





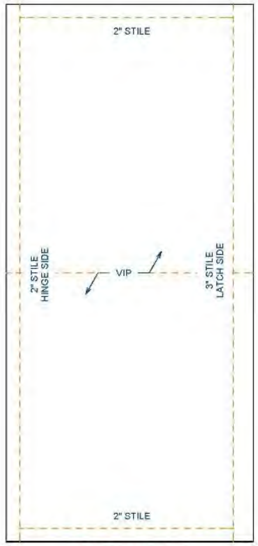
GENERAL NOTES:

1) PROVIDE 2" x 1 1/4" STILES AT TOP, BOTTOM AND HINGE SIDE, AND 3" x 1 1/4" STILE @ LATCH SIDE. STILES TO BE ENGINEERED WOOD
2) FINISH COAT @ DOOR SKINS TO BE NON V.O.C. EPOXYY FINISH

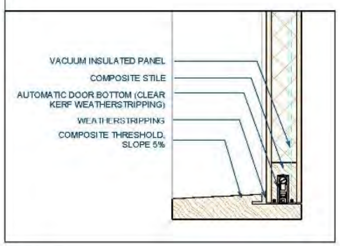


INTERIOR ELEVATION

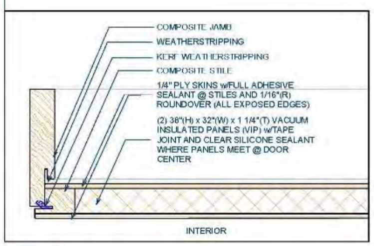
EXTERIOR ELEVATION



DOOR CONSTRUCTION



SCALE: 3"=



SCALE: 3"=

Project:

The ARCTIC Door

ArcticSun, LLC
1050 Deere St., Fairbanks, Alaska 99709

Phone 907-457-1297
Fax 907-457-3397
Email info@arcticsun-llc.com

Design by: Thorsten Chlupp

Scale: 1" = 1'-0" U.N.O.

Date: 4/22/13

Sheet No.: 1 of 1



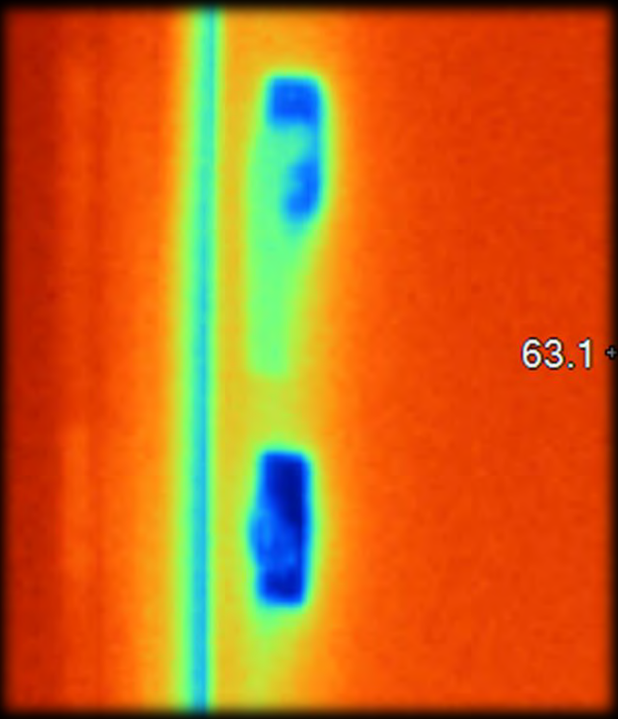
R-60
Thermal Breaks

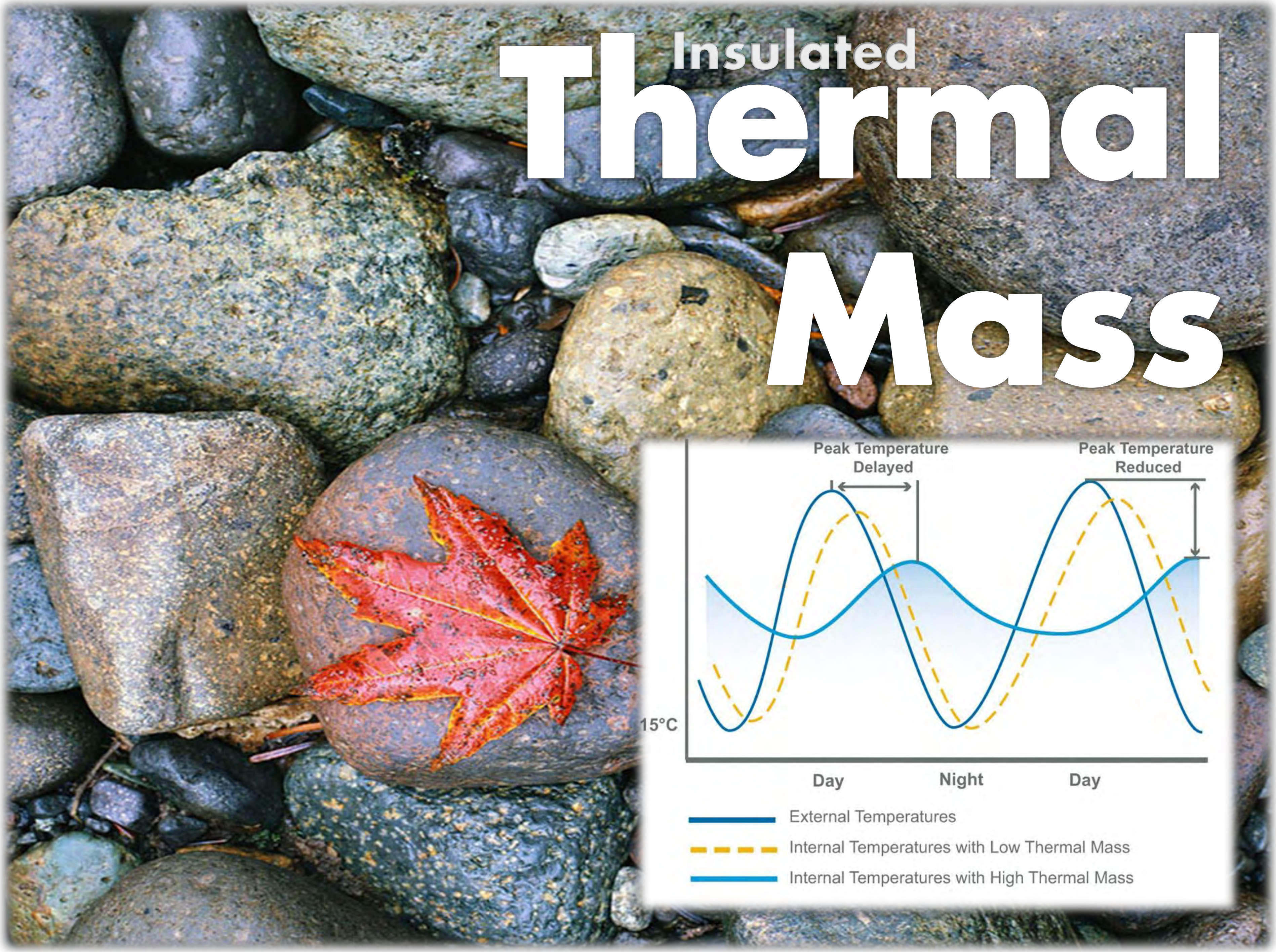

R-60
Thermal Breaks

Hidden

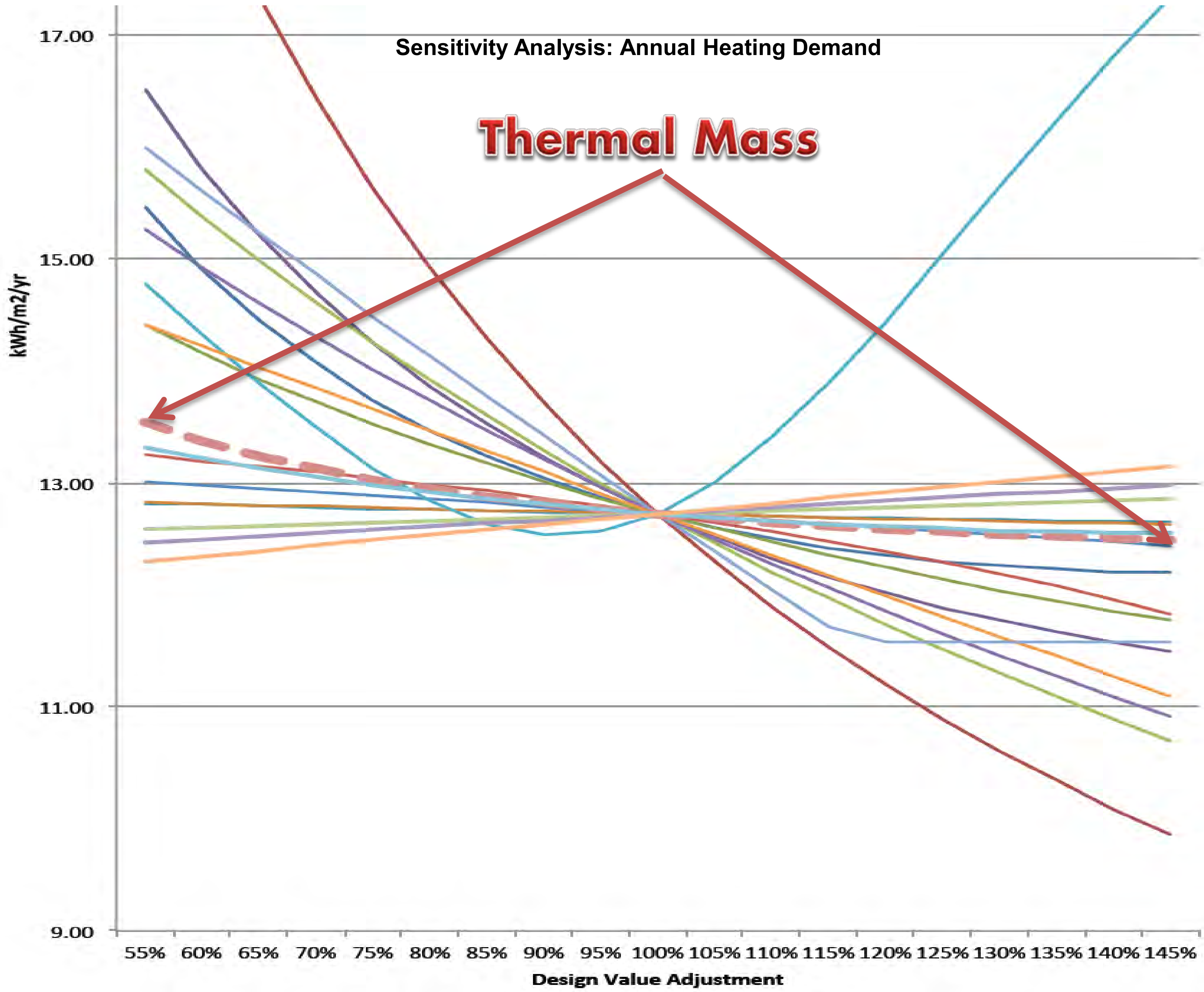
Thermal bridges

@ 40 Below



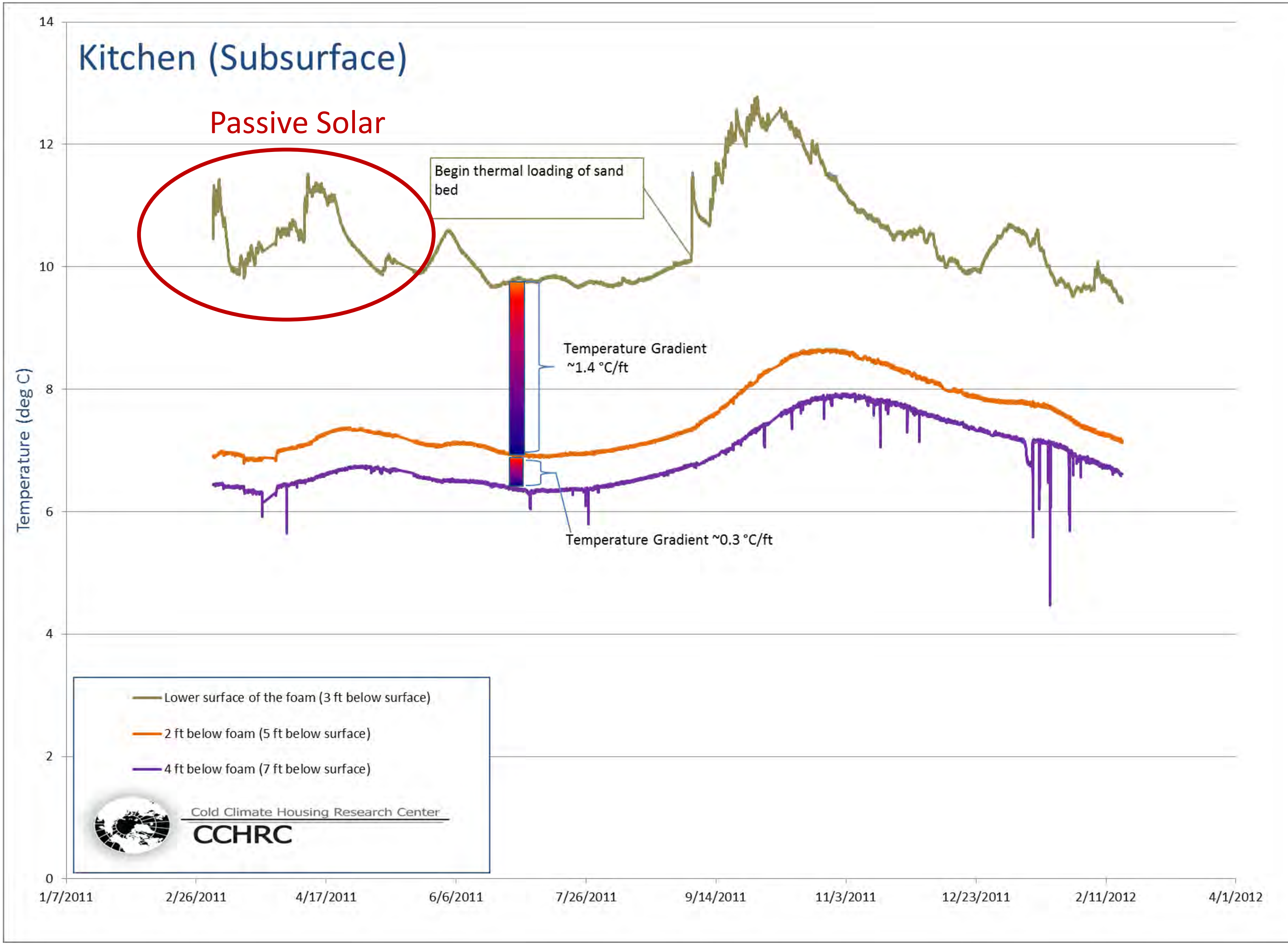


Insulated
Thermal
Mass
Peak Temperature Delayed
Peak Temperature Reduced
15°C
Day
Night
Day
External Temperatures
Internal Temperatures with Low Thermal Mass
Internal Temperatures with High Thermal Mass


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

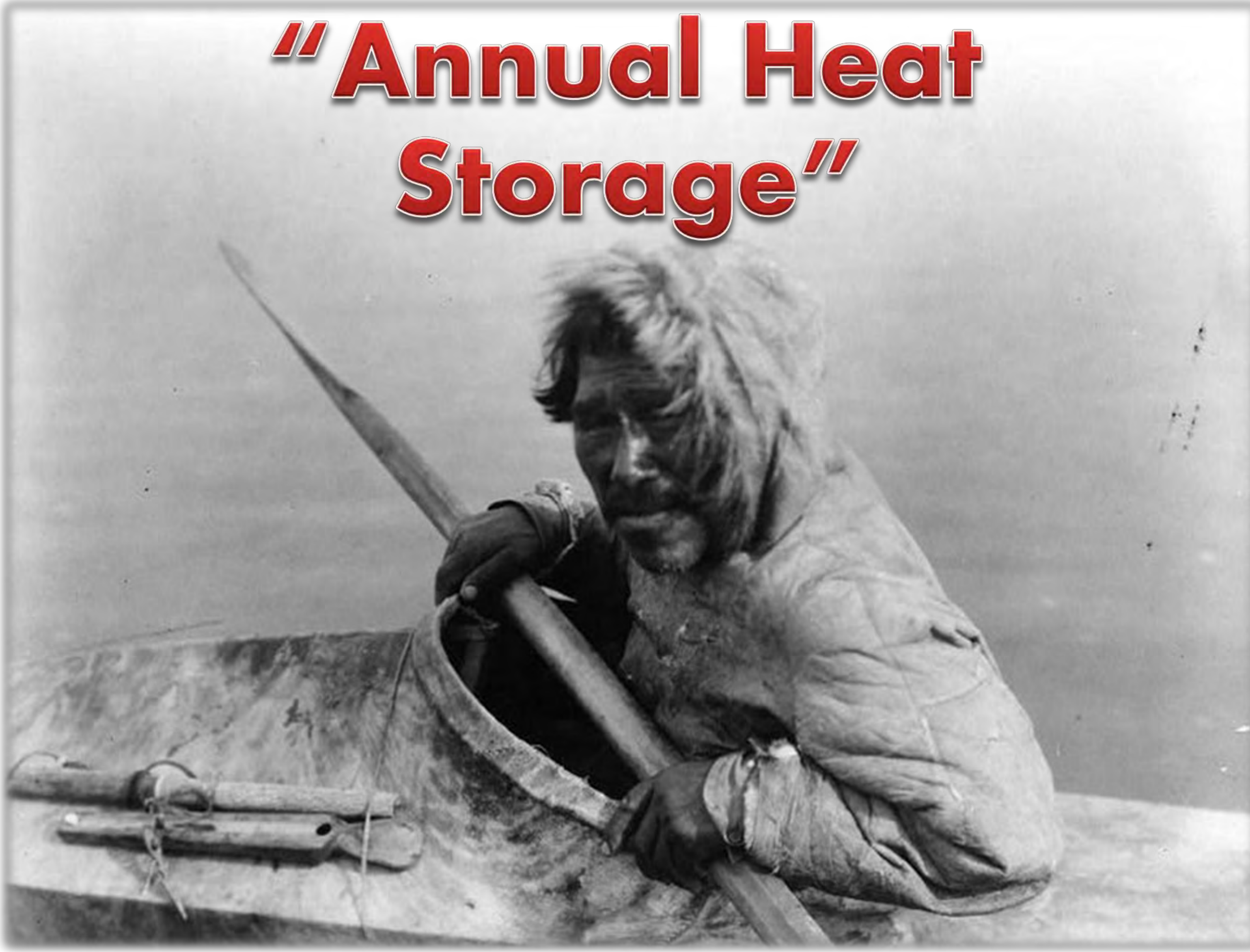

Solar Slab

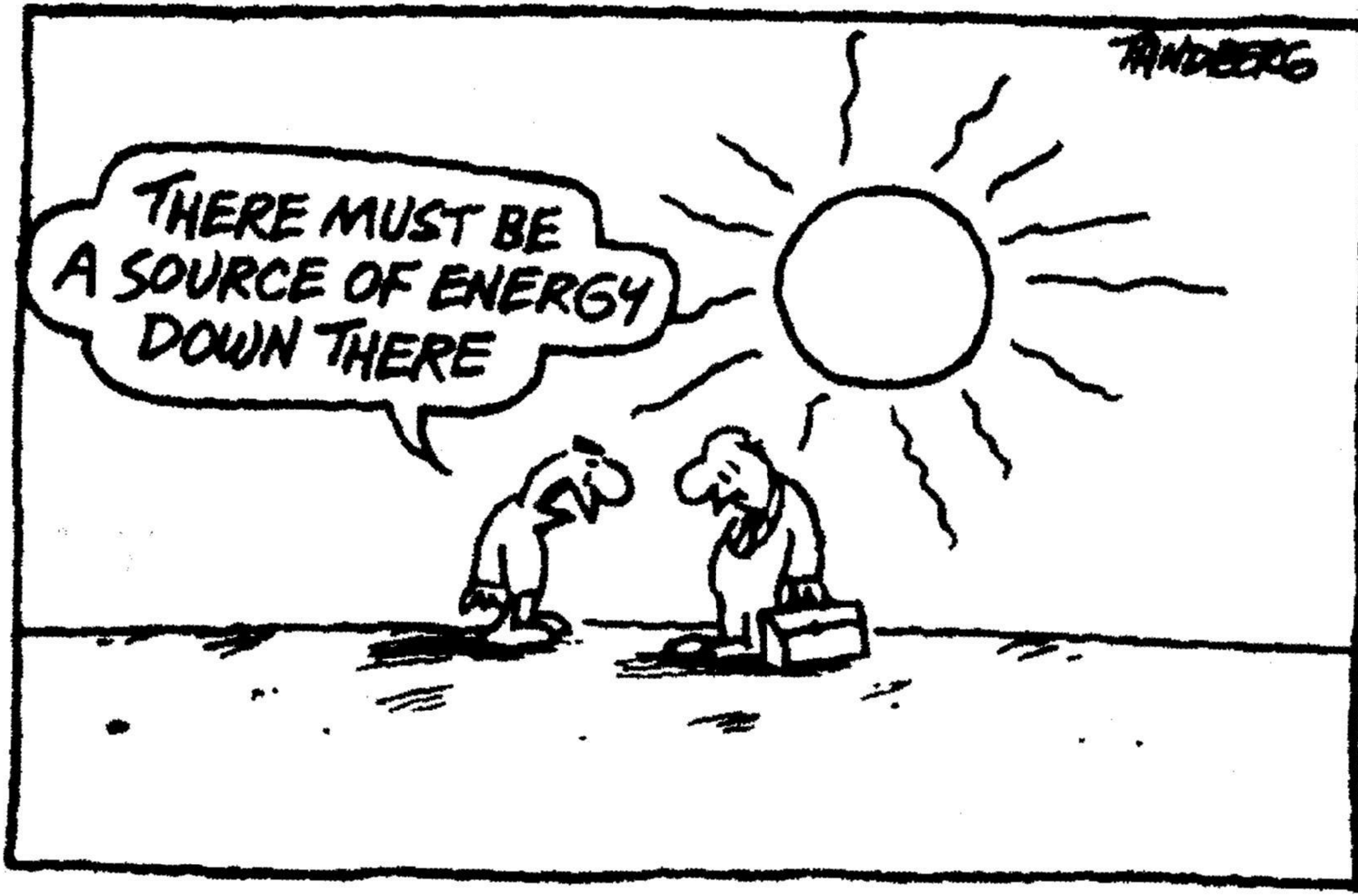

Clear Glass
High Mass



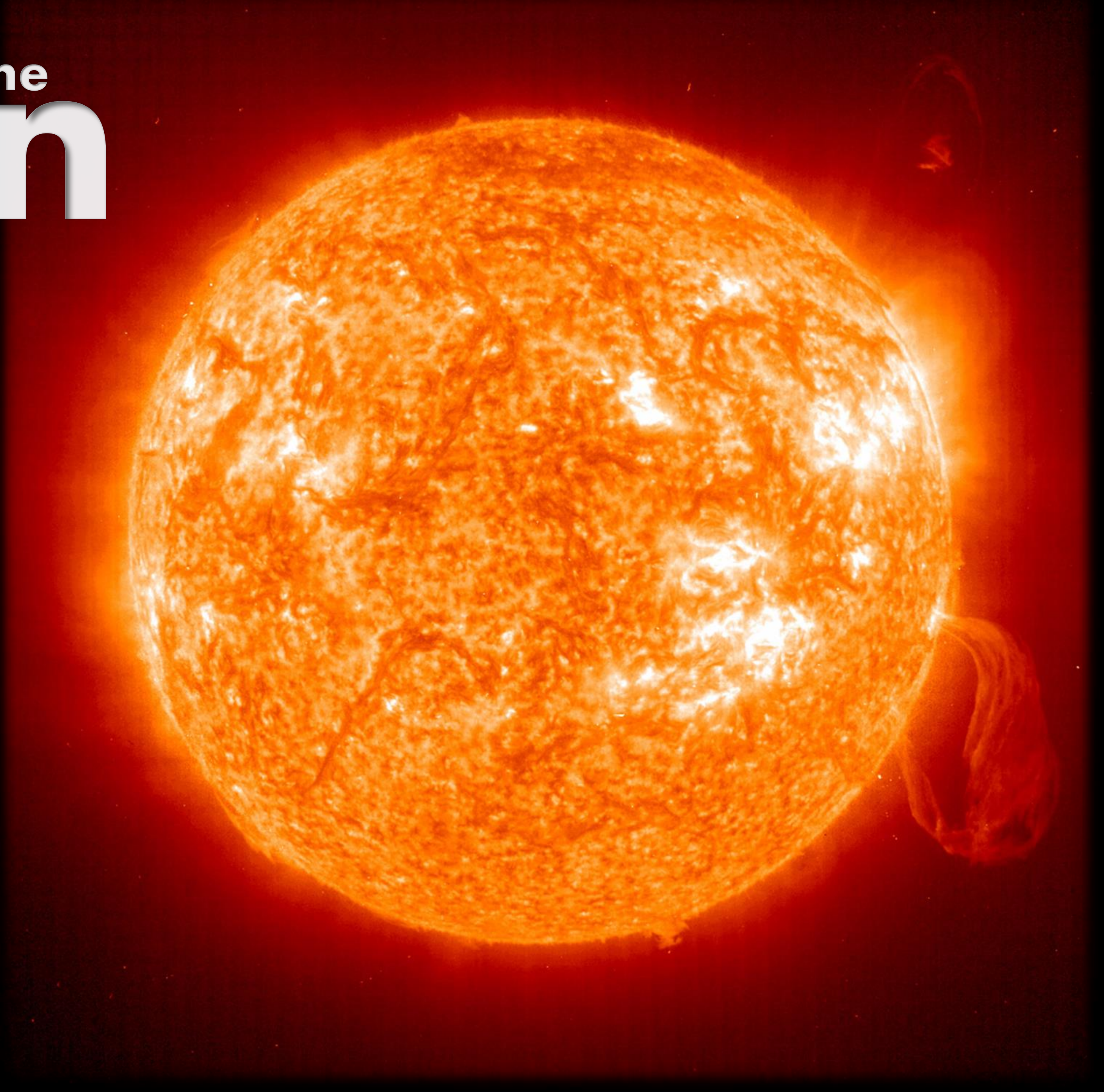
Kitchen (Subsurface)
Passive Solar
Begin thermal loading of sand bed
Temperature Gradient ~1.4 °C/ft
Temperature Gradient ~0.3 °C/ft
Temperature (deg C)
14
12
10
8
6
4
2
0
1/7/2011
2/26/2011
4/17/2011
6/6/2011
7/26/2011
9/14/2011
11/3/2011
12/23/2011
2/11/2012
4/1/2012
Lower surface of the foam (3 ft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

“Annual Heat Storage”

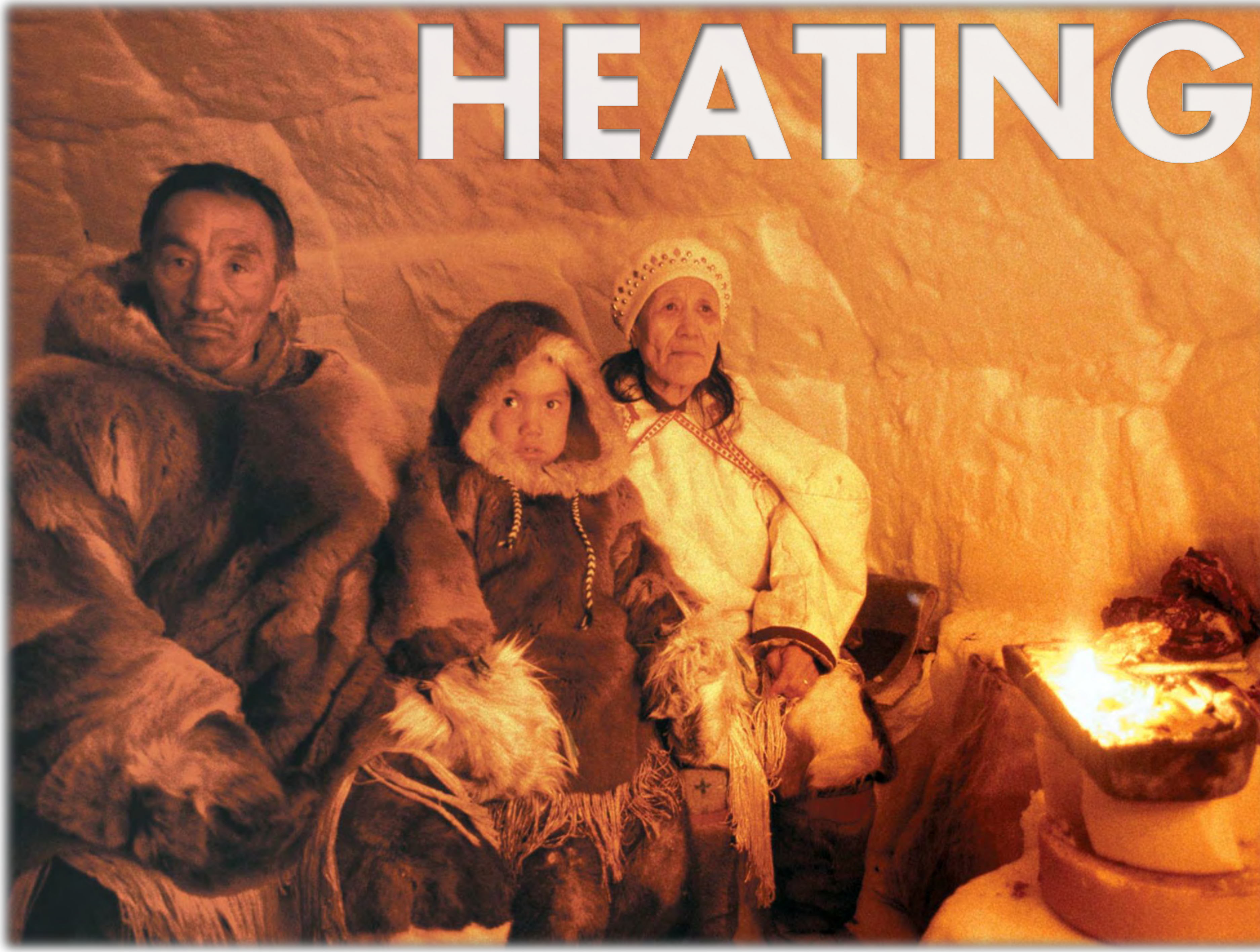



TANDBERG
THERE MUST BE A SOURCE OF ENERGY DOWN THERE

Love the Sun



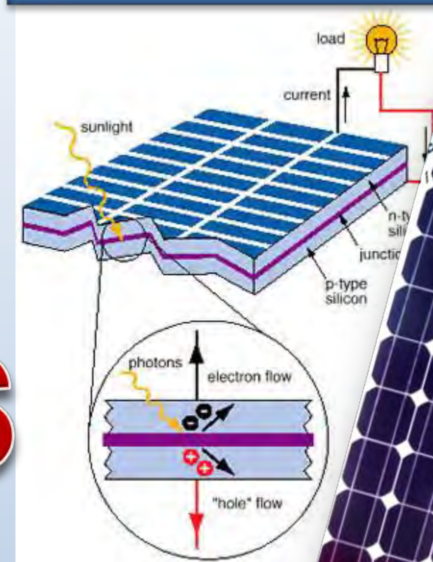
3 months without Sun

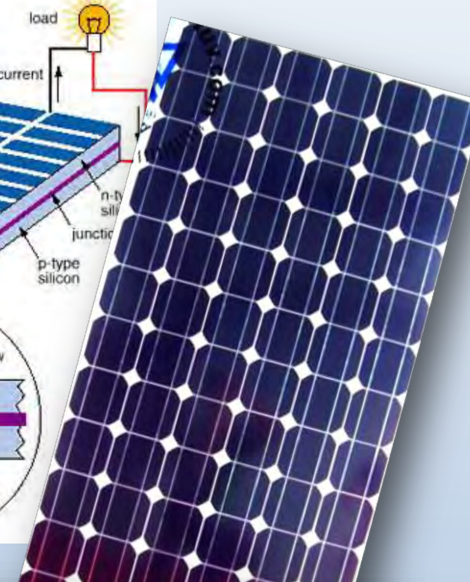

HEATING

Solar Hot Water

VS

Solar PV



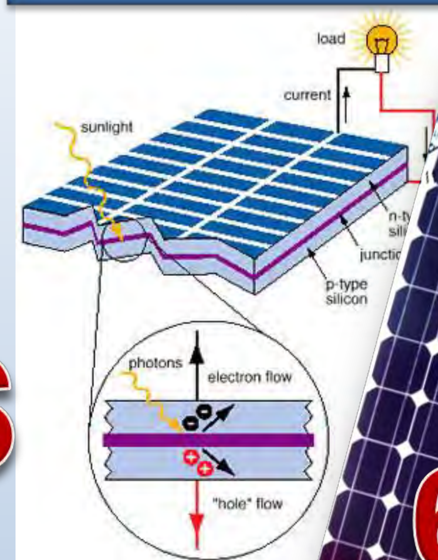


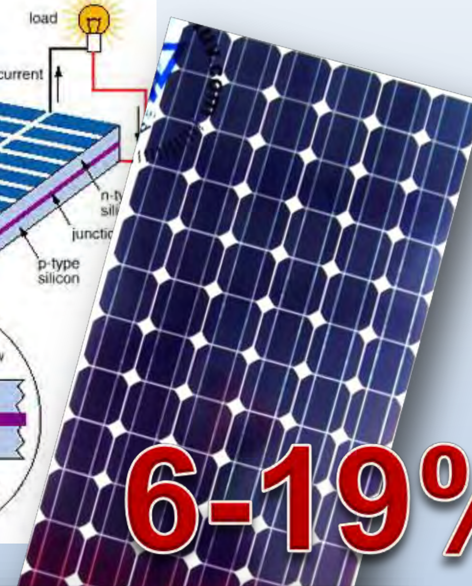
Solar Hot Water

70-85%

VS

Solar PV

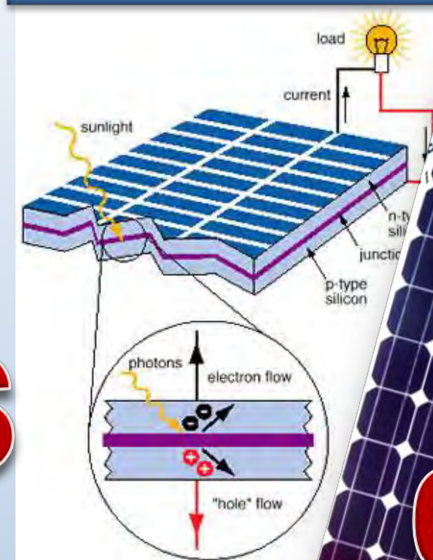


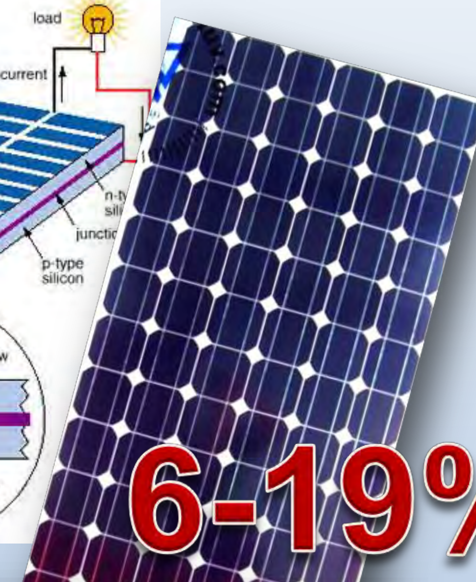


6-19%

Solar Hot Water

Solar PV





VS

70-85%

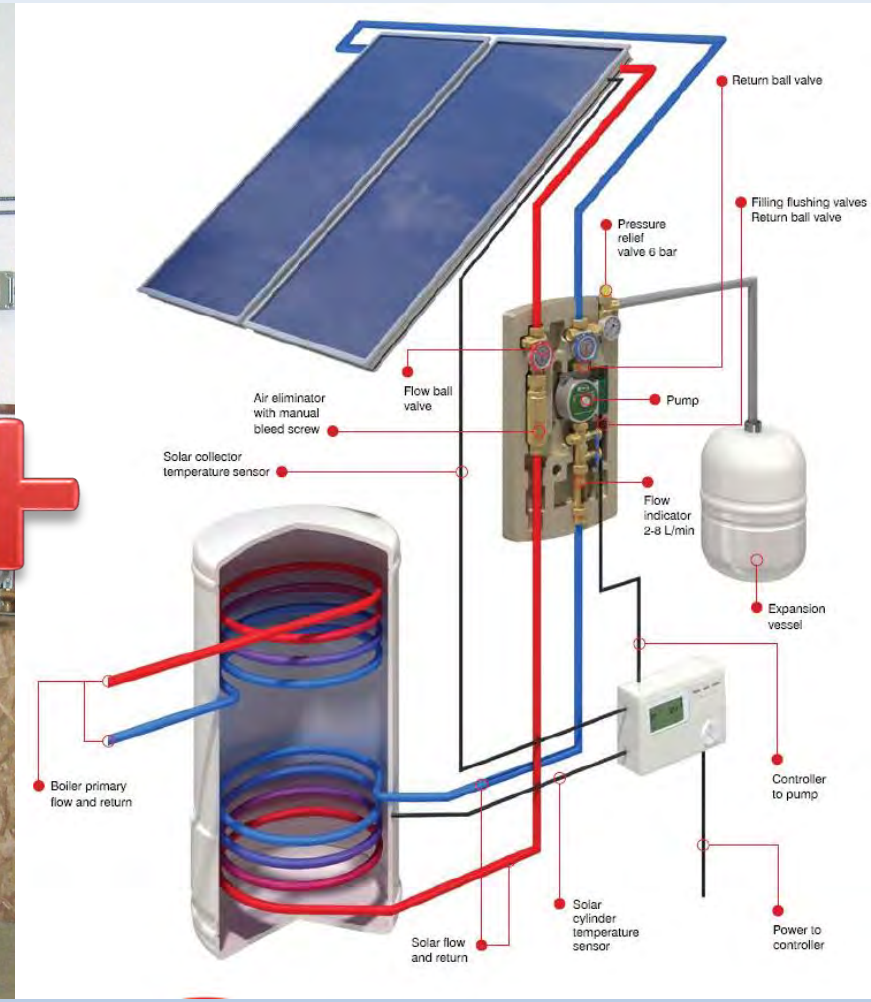
6-19%

Delivered Energy

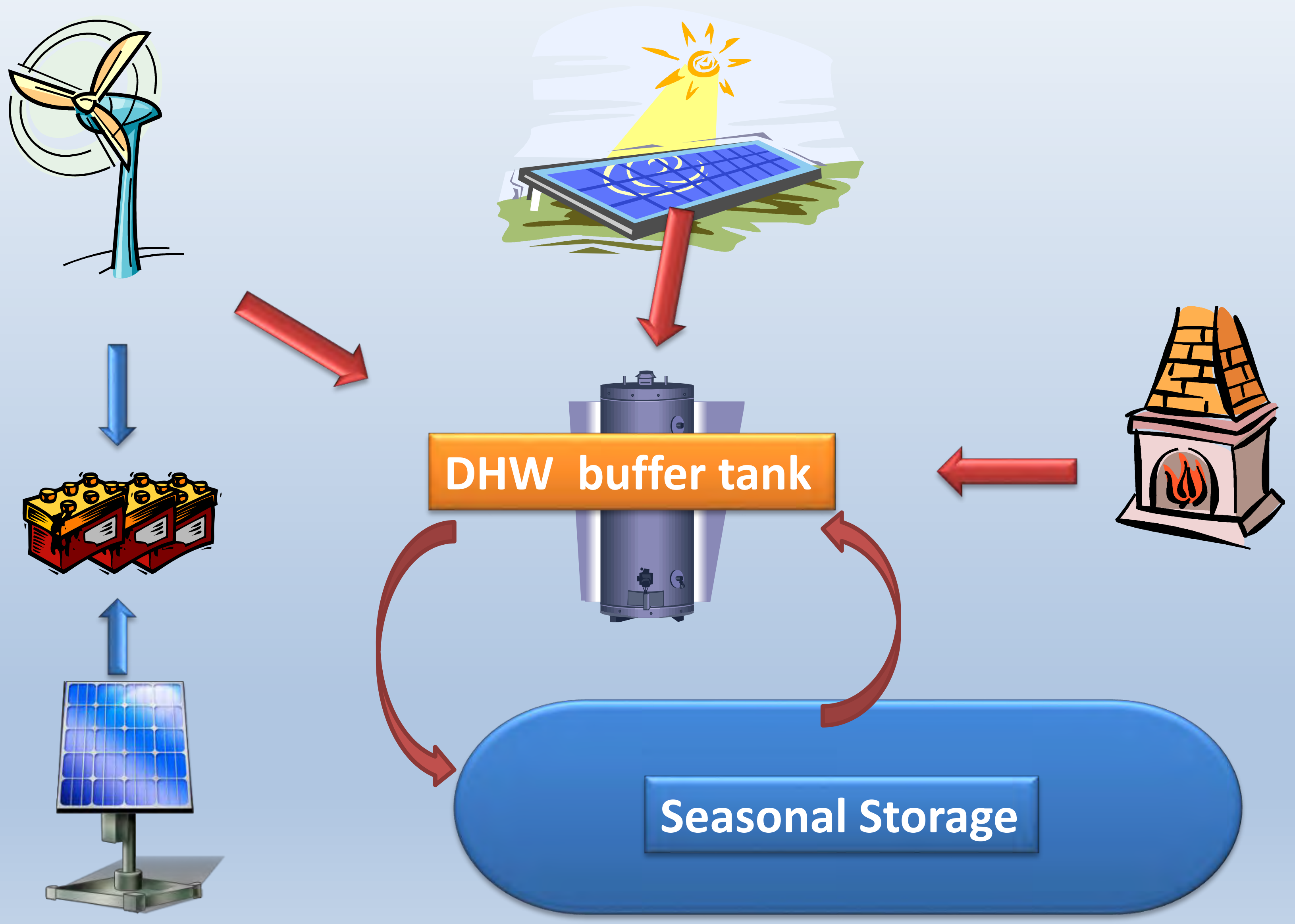
20-45%

5-17%

Solar Hot Water

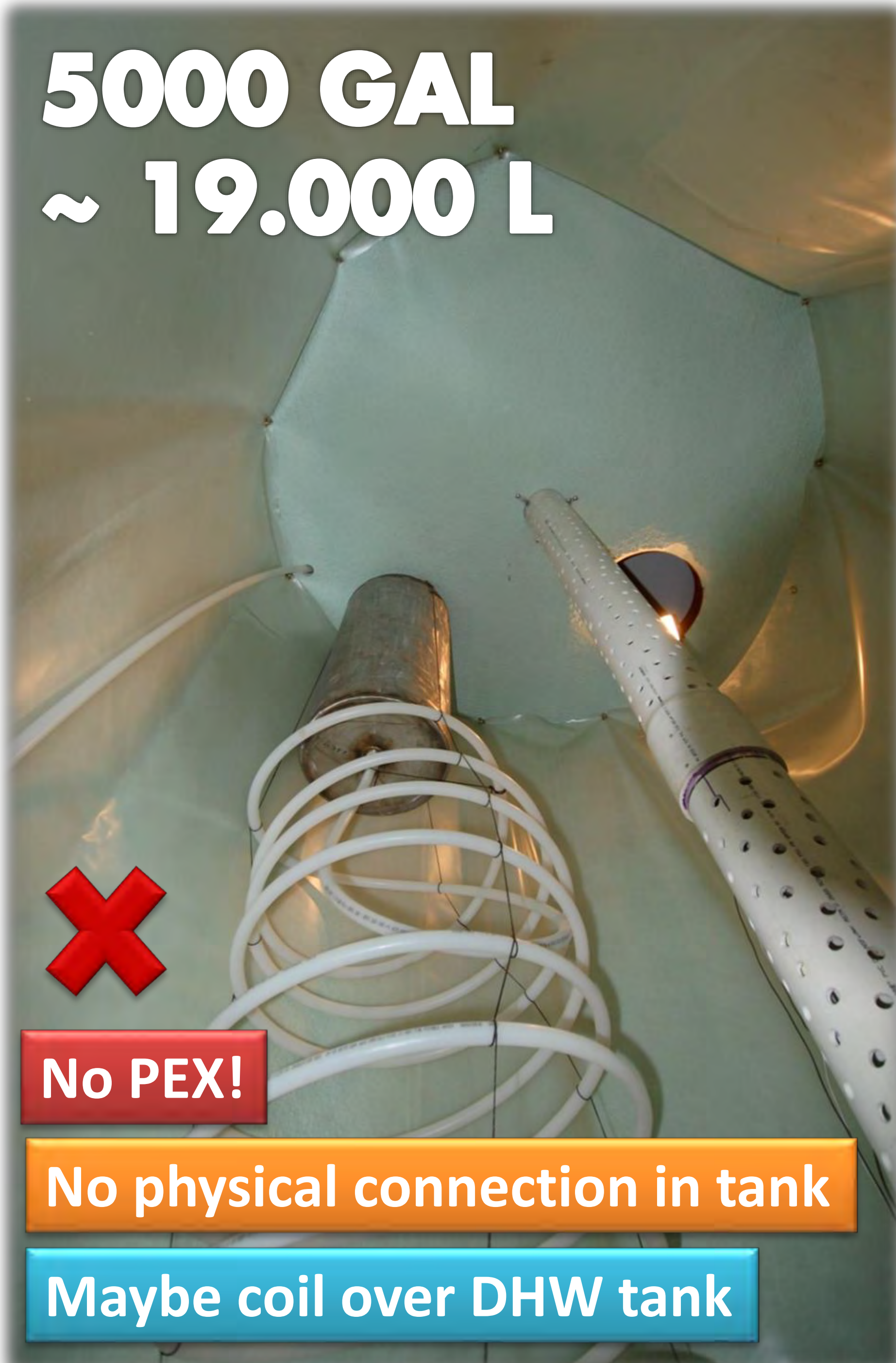


Micro Hybrid Energy System for the Arctic

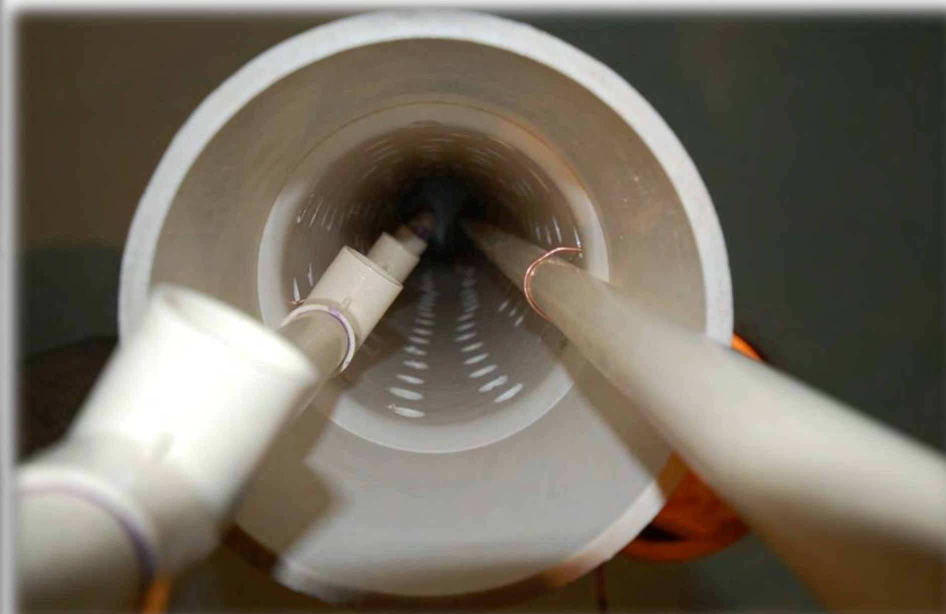


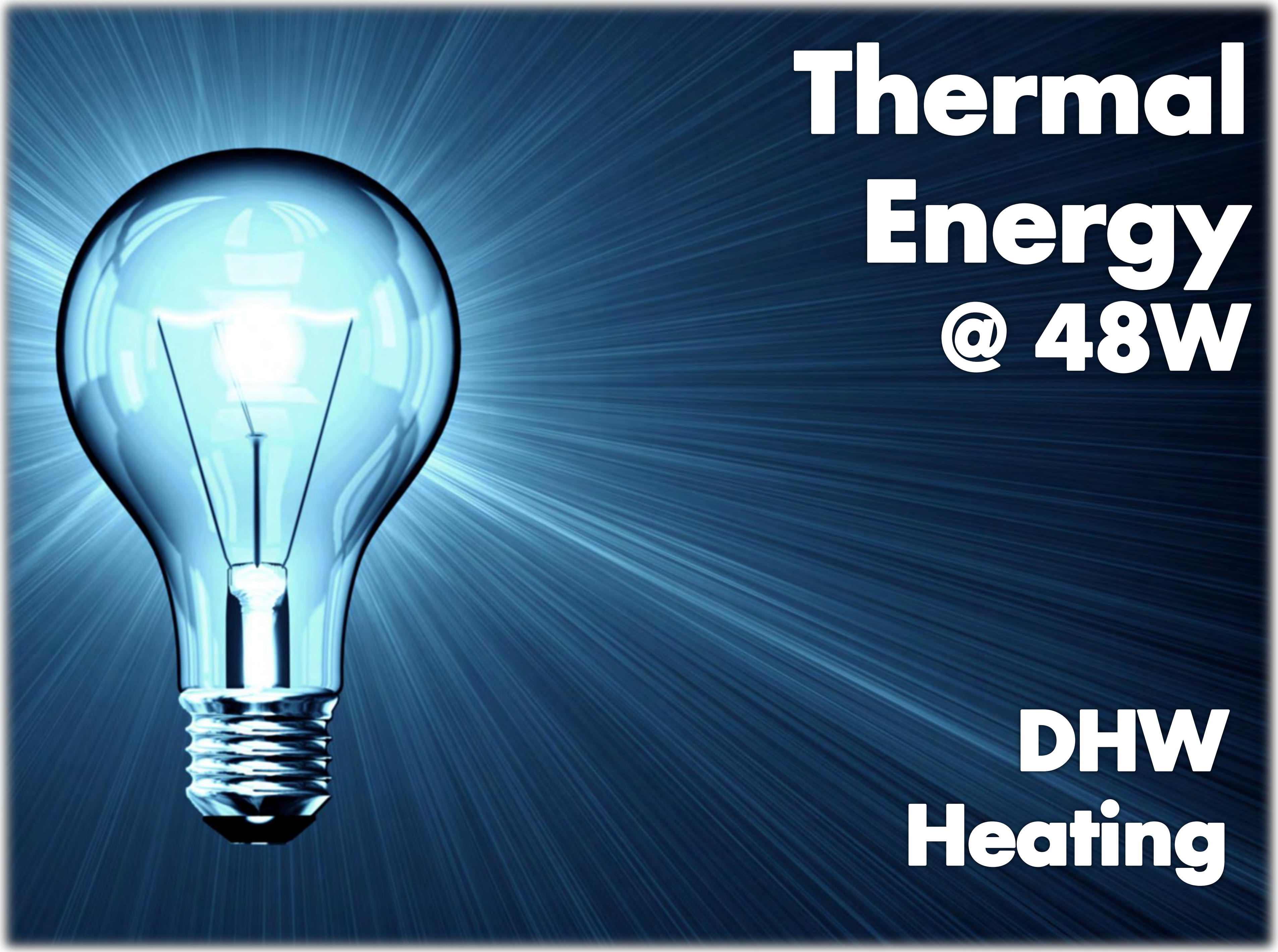

480 SF Thermal Collectors
Drainback System only!
Shoulder season is critical

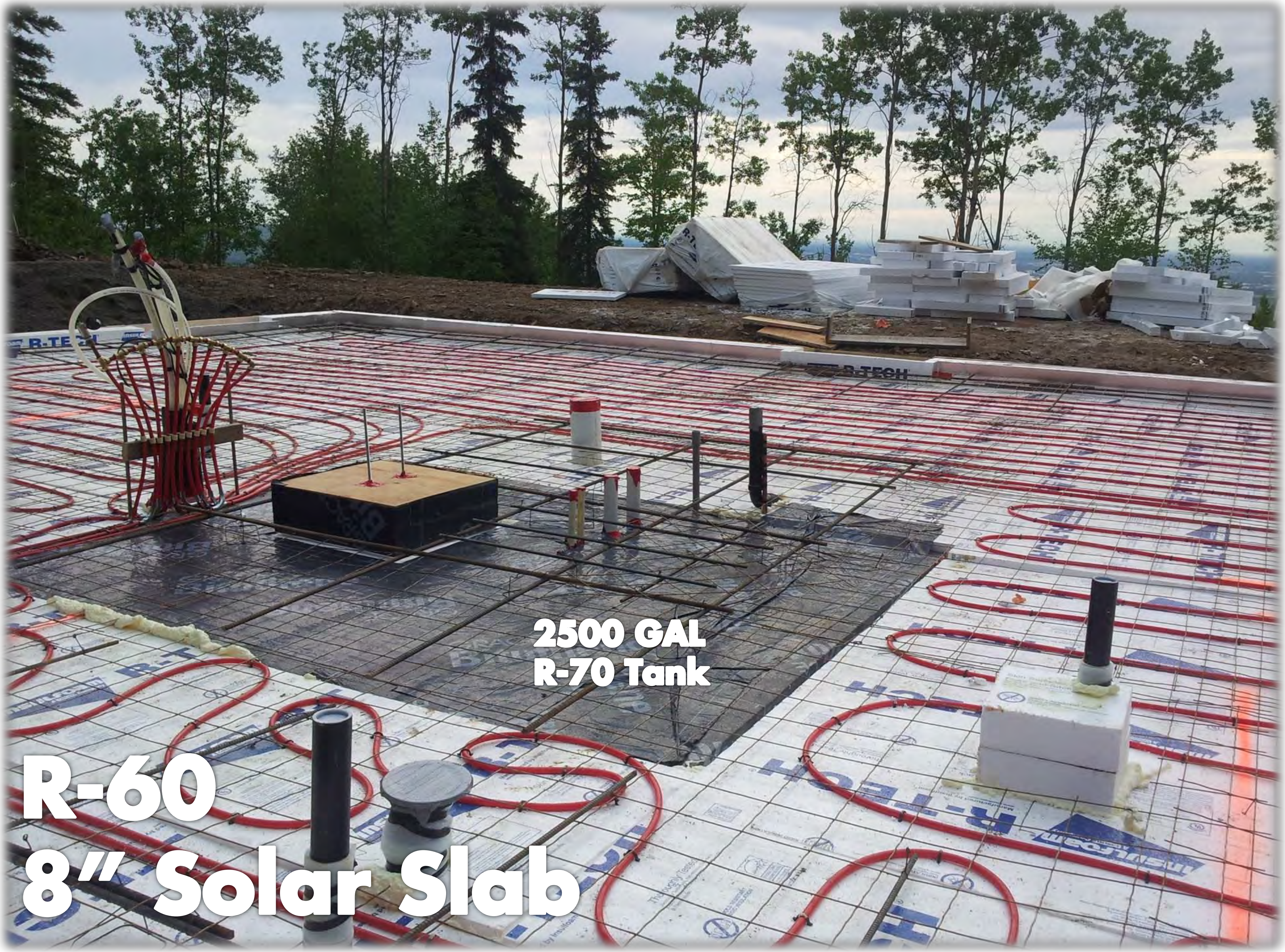

Seasonal
Storage


5000 GAL
~ 19.000 L
No PEX!
No physical connection in tank
Maybe coil over DHW tank

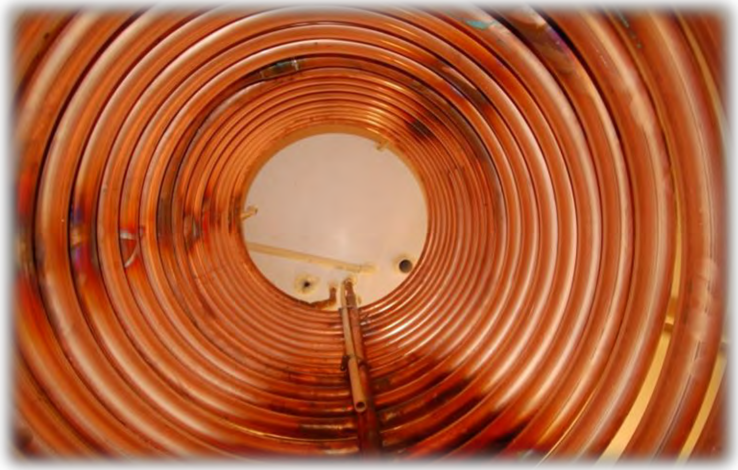
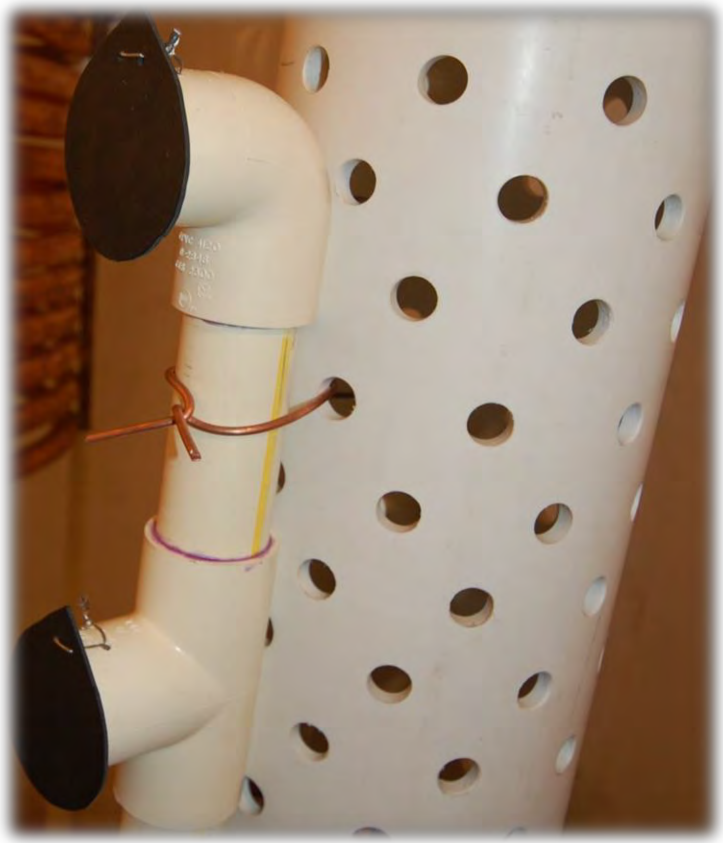

Virtual unlimited
Hot water
Excellent stratification




Thermal
Energy
@ 48W
DHW
Heating


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


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


eco
SMART

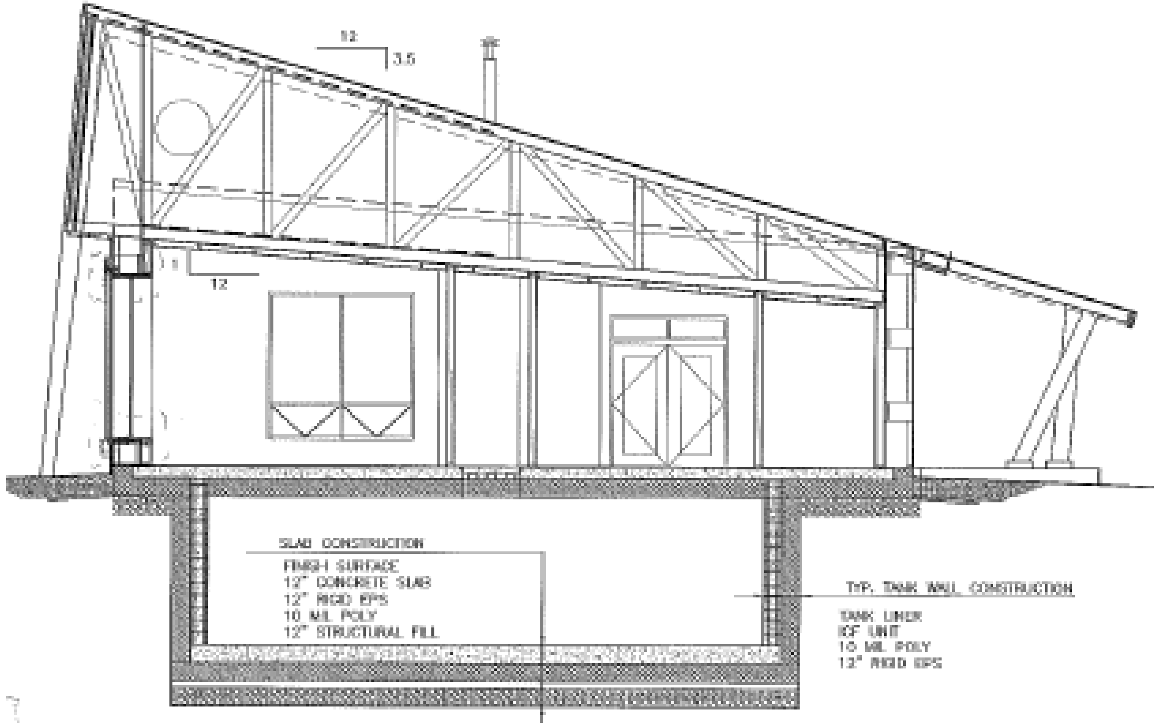

Integral Solar
Heating System
10,000 GAL Storage

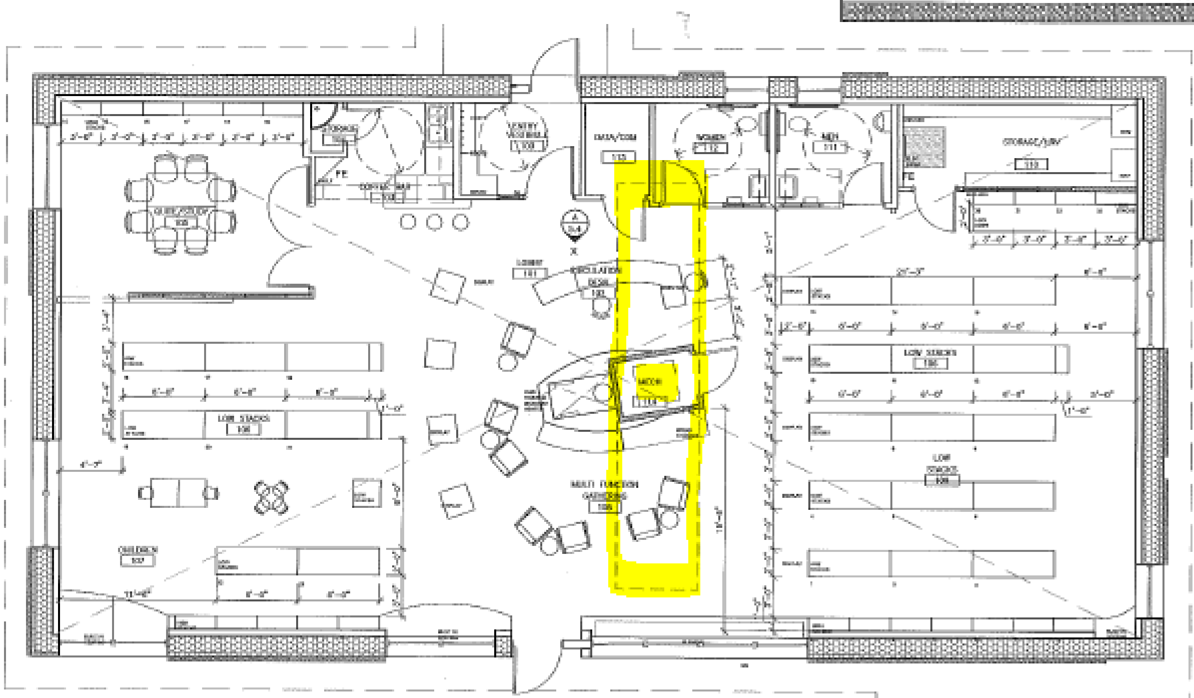




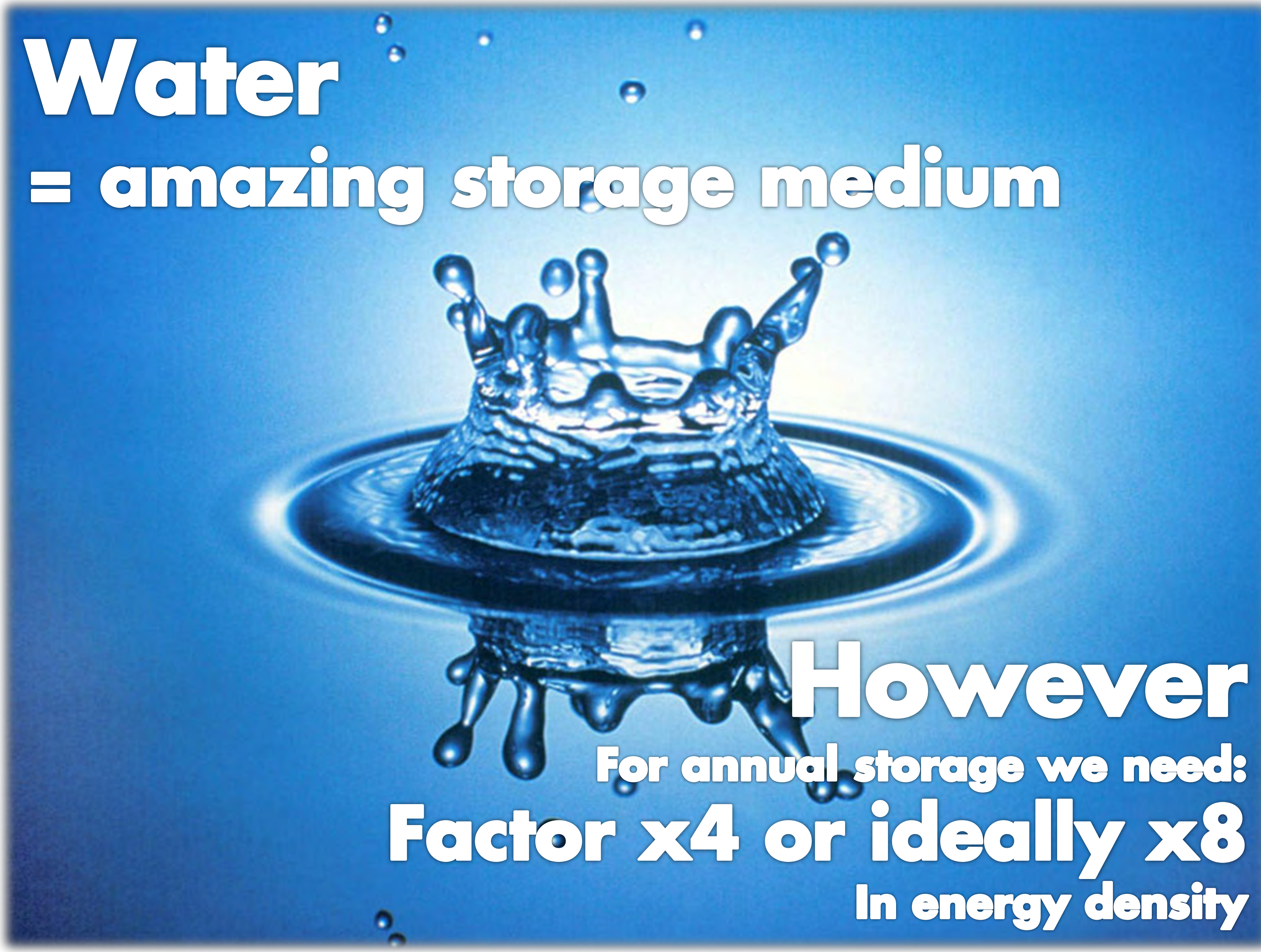
engaging the sun
RESOL
RESOL

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

Home Kassel System Live Logout

RESOL

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]

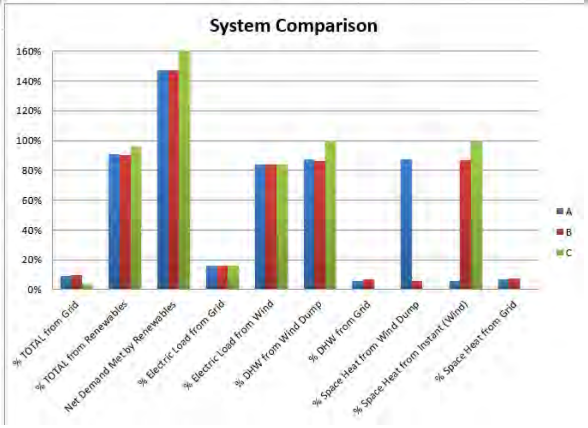
Heat quantity	245045.38 BTU
Heat quantity today	0.00 BTU
Heat quantity week	2456.73 BTU

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

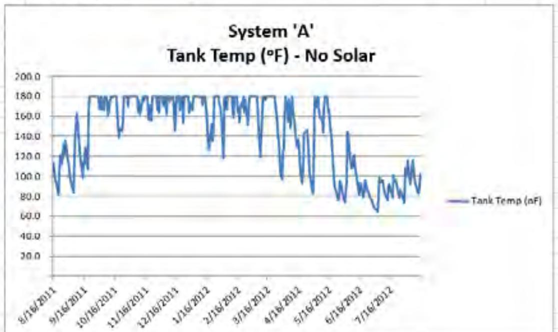
Electric Rate	$	0.87
Seasonal Tank Size:		1000 (Gallons)
System 'A' Tanks Size:		1000 (Gallons)
stem 'A' Average COP Derate:		1
Standby Loss Factor Sys 'A'		2

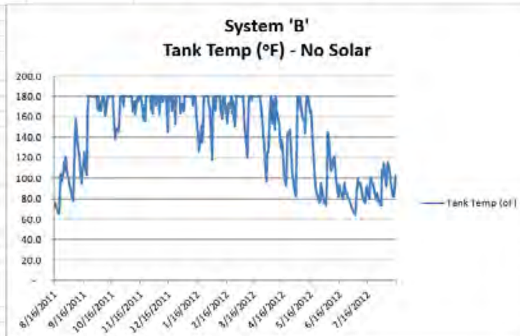
WIND

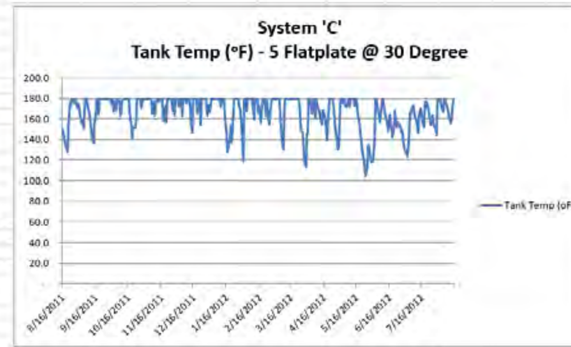
Tower Height	59 (ft)
Wind Shear:	0.28

(AEA Wind Shear) 0.298024

7



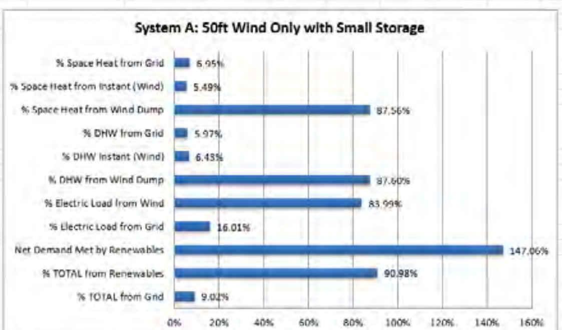


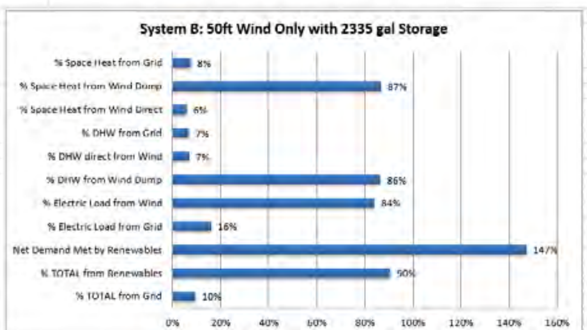


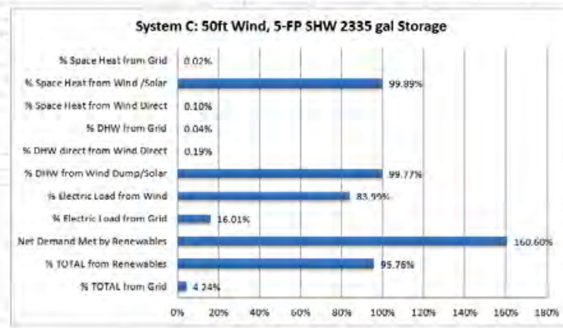
System A		
Heat:	$	(699.12)
Electric:	$	(613.23)
Total:	$	(1,312.35)

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

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







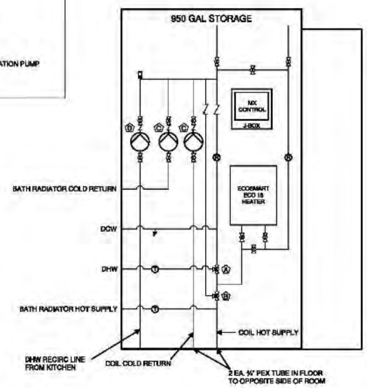
System Design and Sensitivity Analyses

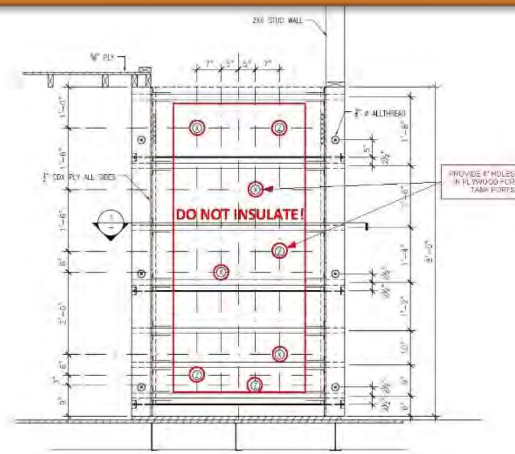
Date	M	Reference (7m) Wind Speed MPH	Turbine Wind Speed MPH	kWh Produced	Electric Load (kWh)	Balance after electric load met	Domestic Load (kWh)	Wind % of DHW Load	Wind % of DHW Load	Balance after DHW (Includes DHW from tank)	Heating Load (kWh)	Heat Load x Coil Supply COP(kWh)	Balance (kWh) (includes 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

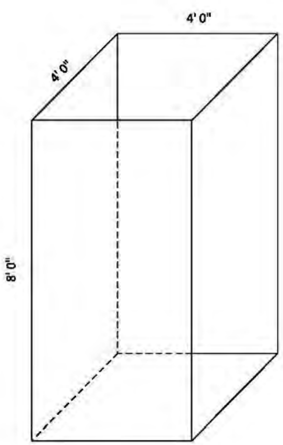
KEY:
- ISOLATION VALVE
- HOSE BIBB CONNECTION W/ ISOLATION VALVE
- AUTO AIR VENT W/ ISOLATION VALVE
- WELL TYPE THERMOMETER
- WELL TYPE TRIADICATOR
- CHECK VALVE
- 3 WAY THERMOSTATIC MIXING VALVE HONEYWELL AM101C-US-1U
- 3 WAY CCV MIXING VALVE BELIMO B320+LRB120-3
- GRUNDFOS ALPHA UP15-55 SF
- ACT D'MAND S-50T-PF RECIRCULATION PUMP

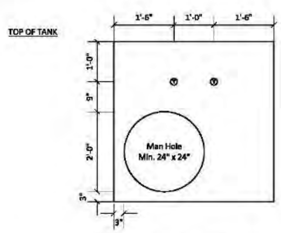


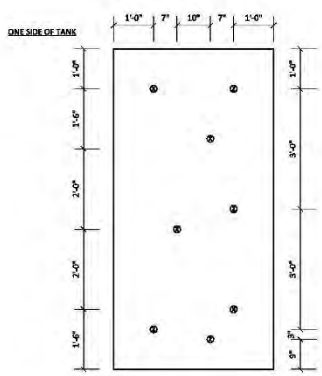


TANK LINER CONSTRUCTION (SUPPLIED BY OTHERS)

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

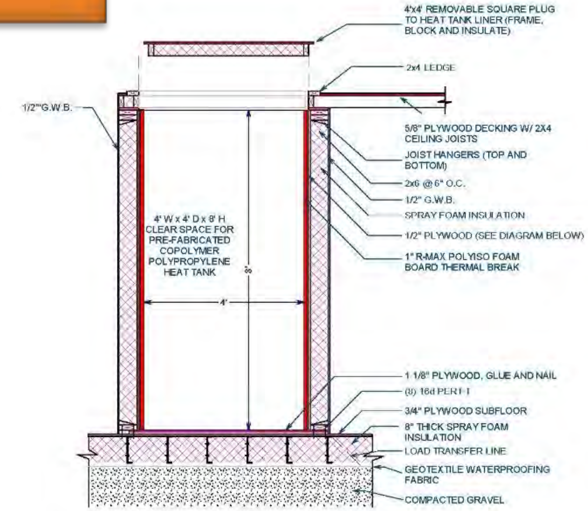


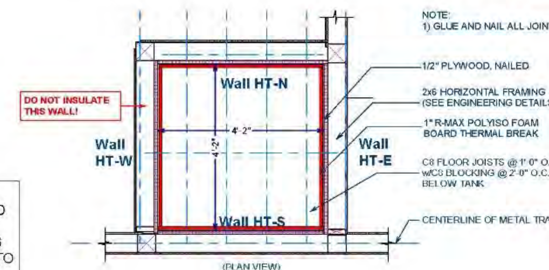




⊗ = 1" Threaded Bung
⊗ = 7/8" O.D. Pass through copper pipe
⊗ = 1/2" Threaded Bung

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"

Project:

Living Aleutian Home Design - Sand Point - SPF

REINA LLC
PO Box 74798 Fairbanks, Alaska 99709
Phone 907-457-1297
Fax 907-457-3397
Email info@reina-properties.com

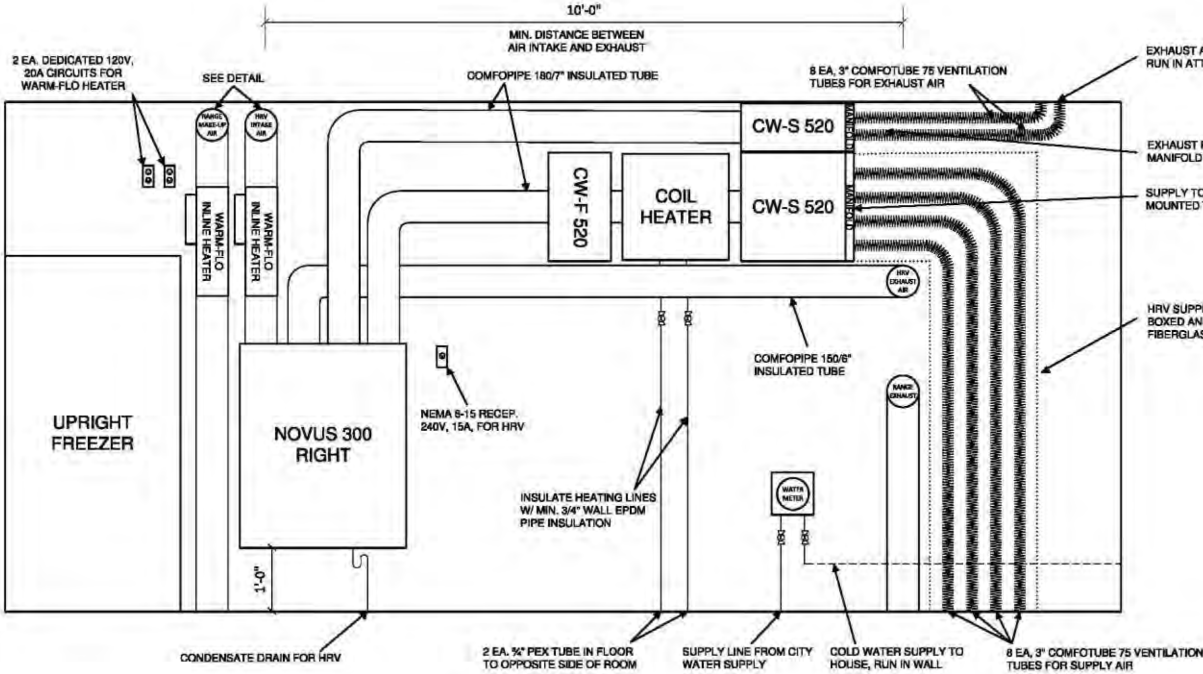
Design by: Thorsten Chlupp

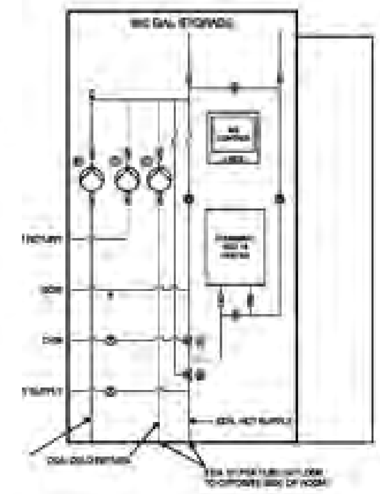
Scale: 1/4" = 1'-0"

Date: 07/14/2013

M3

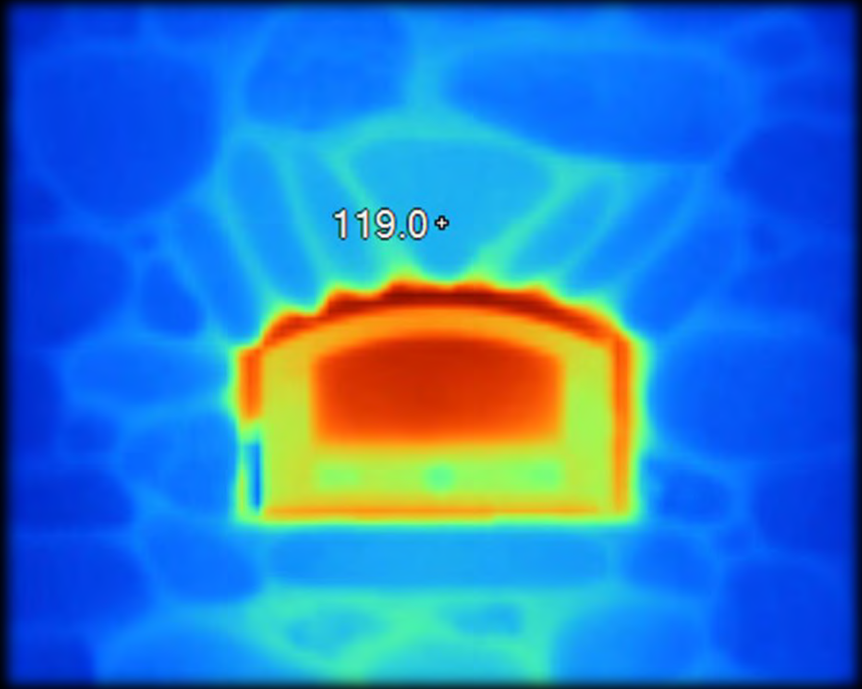
Integrated heating system





6" INSULATED
COMFOTUBE I
ALL BUILDING
PENETRATION


Masonry
Heater

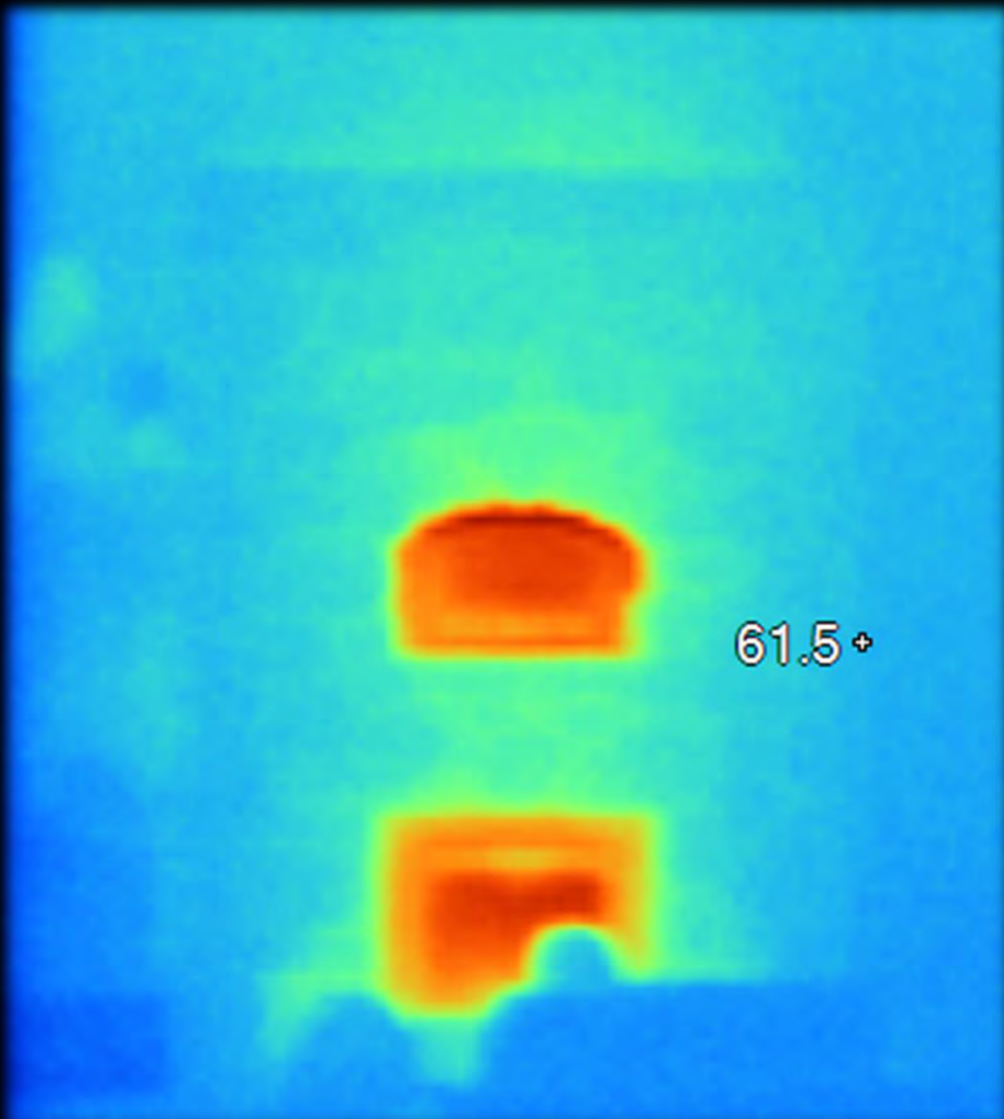

119.0


Masonry
Heater
61.5

1-1/2 cords of wood

=22.5 MBTU = $ 340

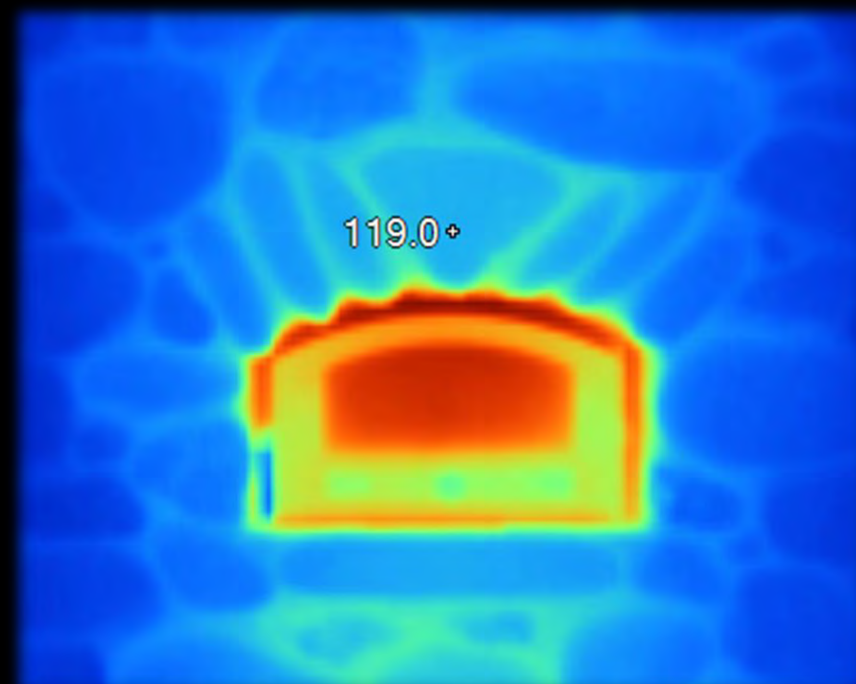
180 Gallons or 680 L oil
= $ 720



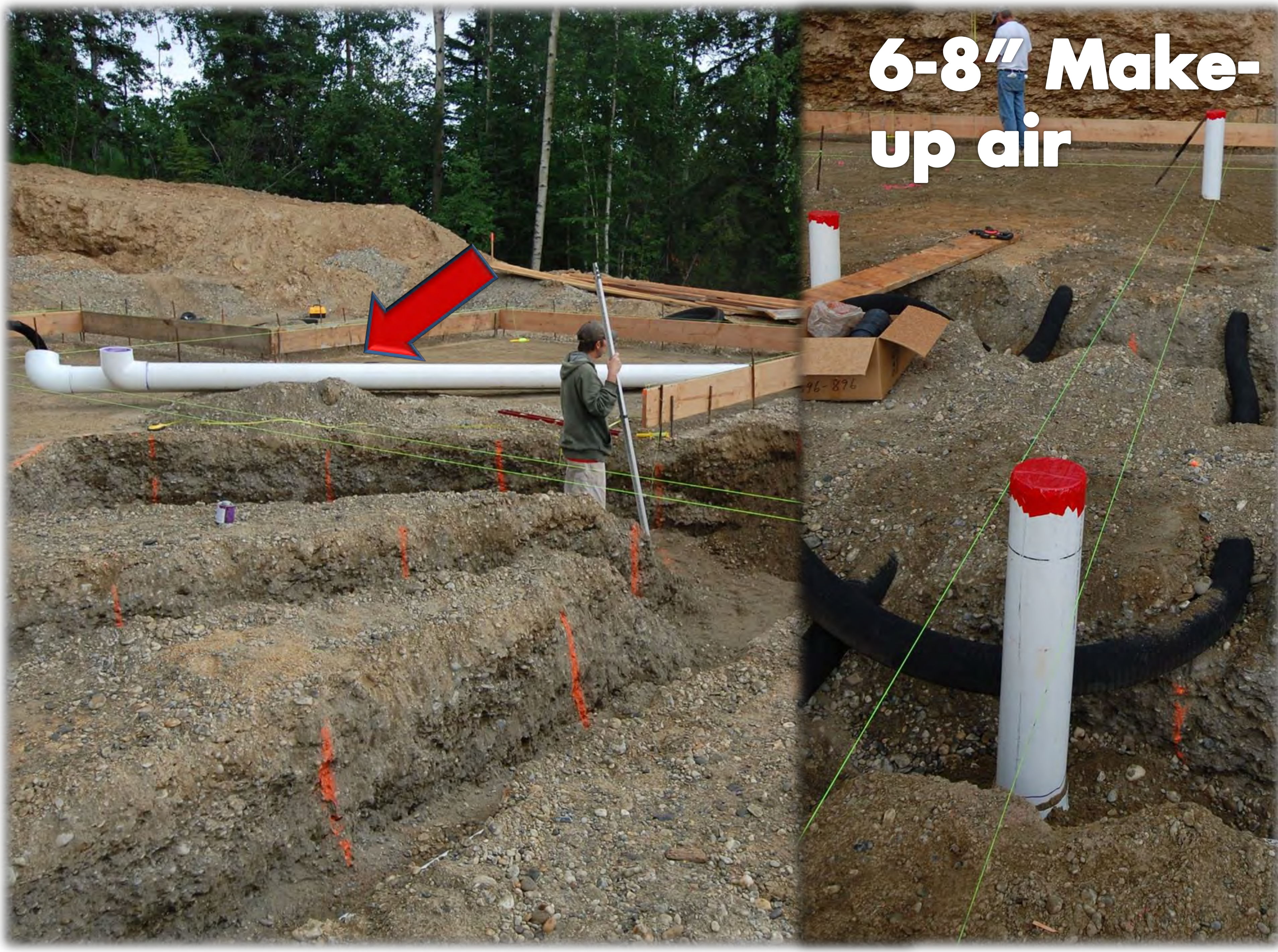
98 days, 3 Girls, 1 Geek, 2210 SF TFA
Heating + DHW @ 40 below
14,000 HDD

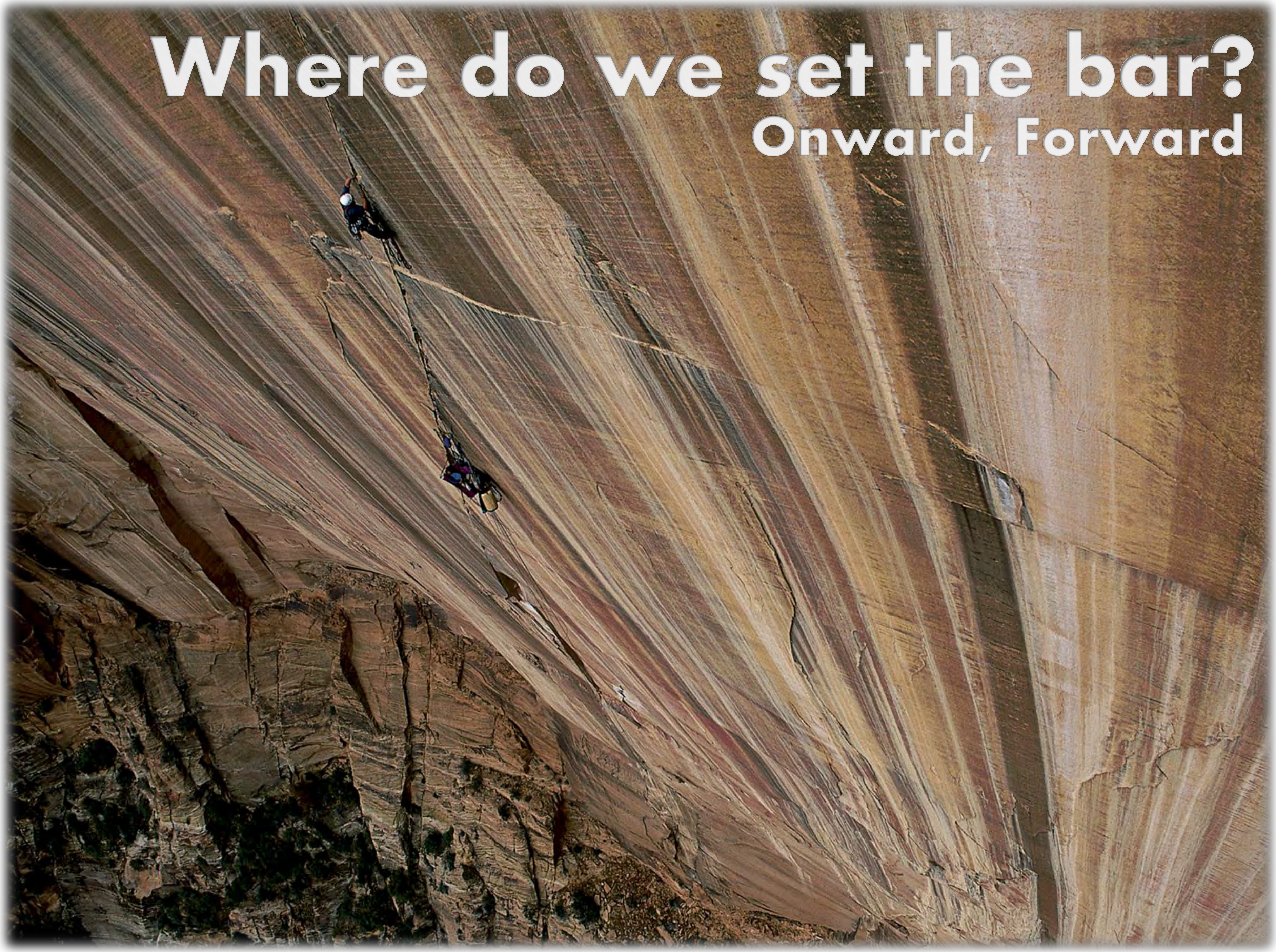
±4.32 BTU/HR

=1.26 Watts




6" Make-
up air


6-8" Make-up air


Where do we set the bar?
Onward, Forward


Learn to
Love the Sun
Thank you.
Prudence Ferreira
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www.integralimpactinc.com
thorsten@reina-llc.com
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COLD CLIMATE HOUSING RESEARCH CENTER
CCHRC
ArcticSun LLC
REINA LLC