

The image features two hands, one on the left and one on the right, holding two white speech bubbles. The background is a solid orange color. The top speech bubble contains the text 'Pathways to Net Zero Energy:'. The bottom speech bubble contains a bulleted list with three items: 'Envelope', 'Systems', and 'Economics'.

Pathways to

## **Net Zero Energy:**

- Envelope
- Systems
- Economics



**Re:Vision**

High Performance Architecture & Sustainability Consulting

Pathways to  
**Net Zero Energy:**

David Salamon  
*CPHD-C*

1. Envelope
2. Systems
3. Economics

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**Re:Vision**

[www.revisionarch.com](http://www.revisionarch.com)





**Special staff certifications**

- 1 LEED Fellow
- 2 Certified Charrette Planners
- 2 Certified Engineer (PE)
- 2 Passive House Verifier
- 1 Certified Planners / AICP

10 LEED BD+C, ID+C, O+M, and ND Accredited Professionals

1 WELL Accredited Professional

5 Registered Architects / AIA

7 Passive House Certified Designers / Consultants

1 Certified Building Analyst / Building Performance Institute

1 Building Enclosure Commissioning Process Provider (BECxP)



OUR WORK

OUR PRACTICE

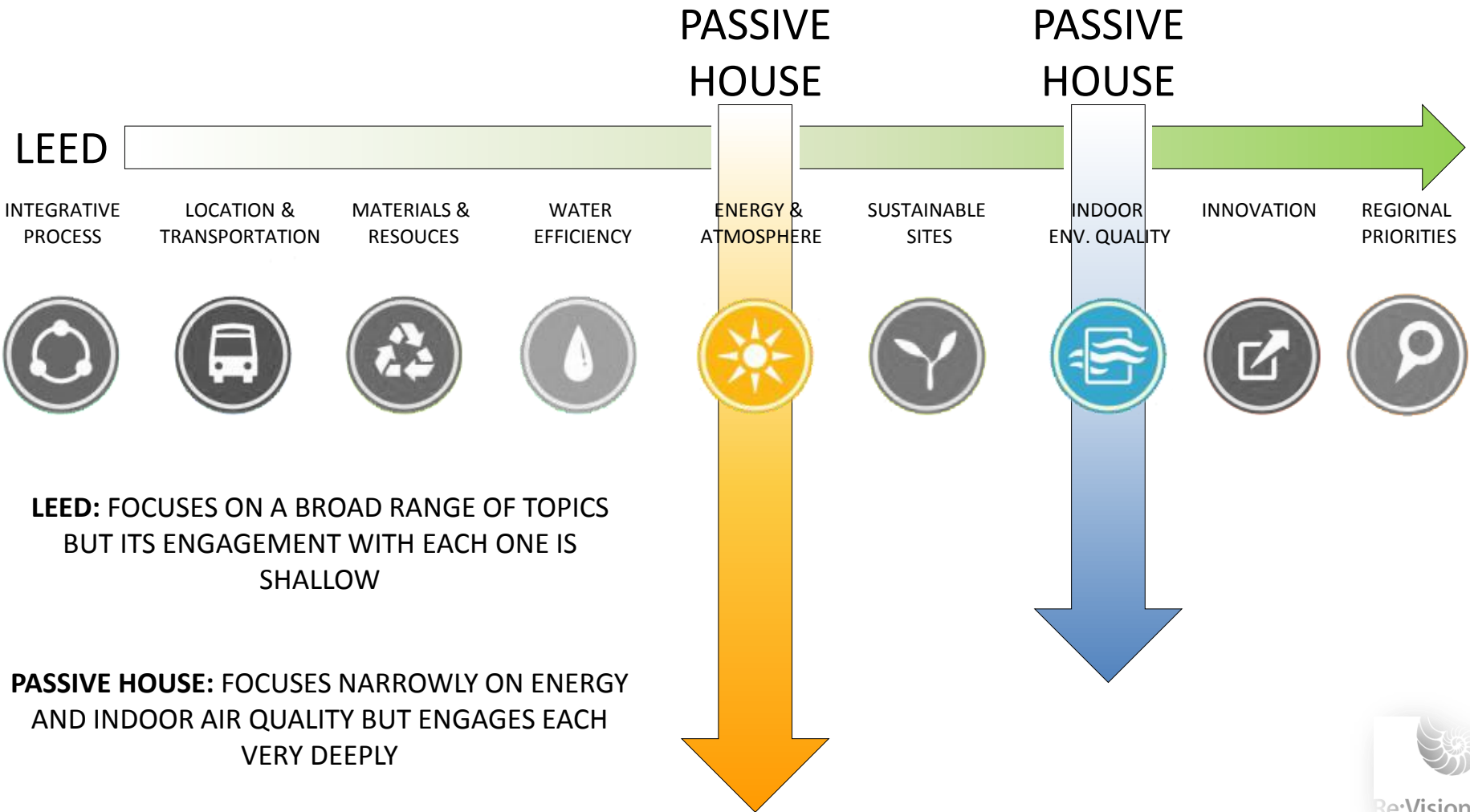
OUR THOUGHTS

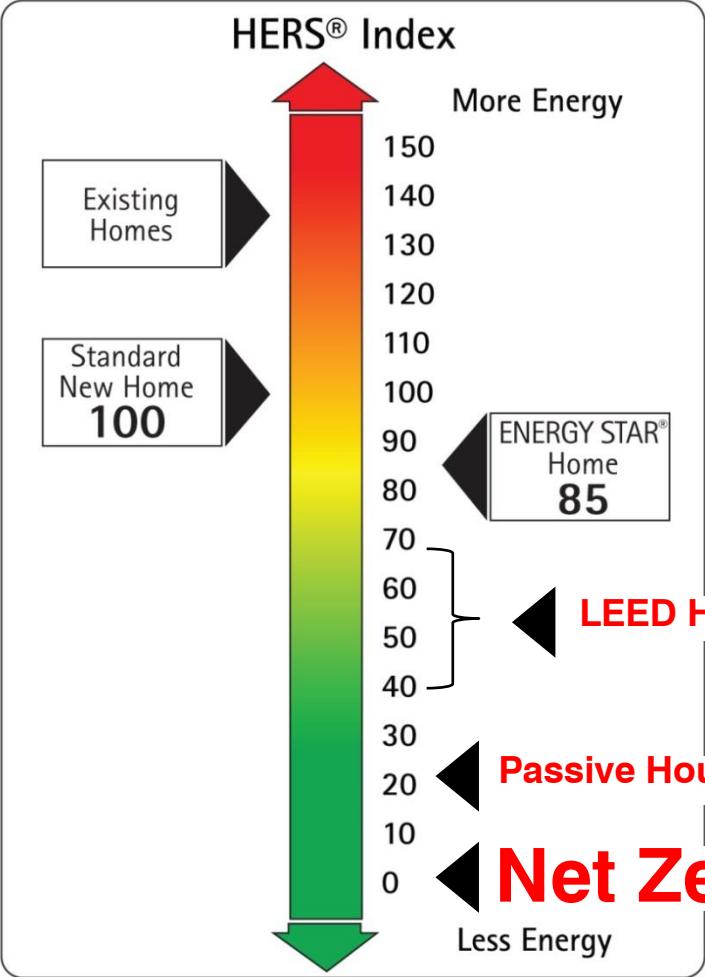


# Remove the barriers to green building

[www.revisionarch.com](http://www.revisionarch.com)

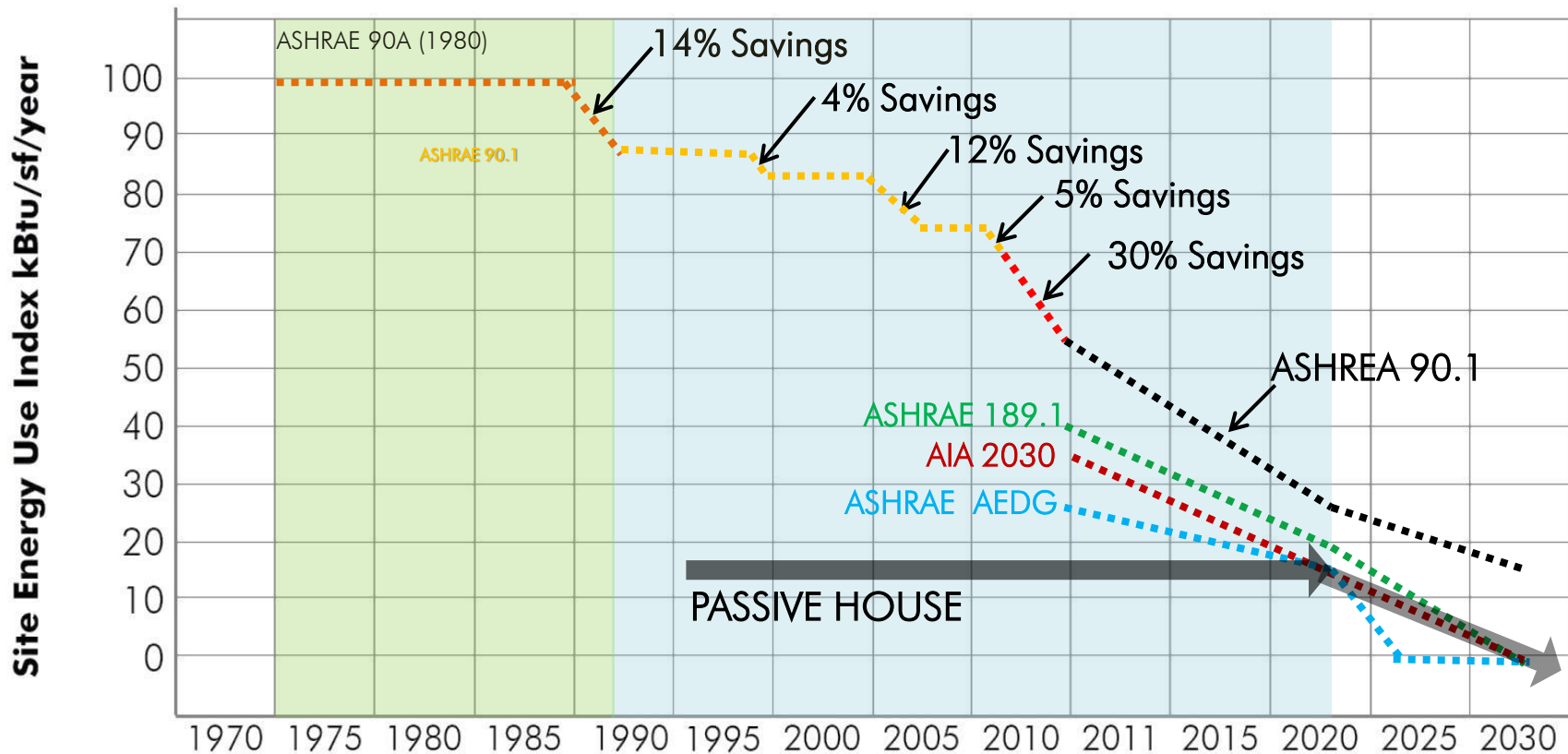






# A history of the energy code

(code = the minimum -we are allowed to do better!)

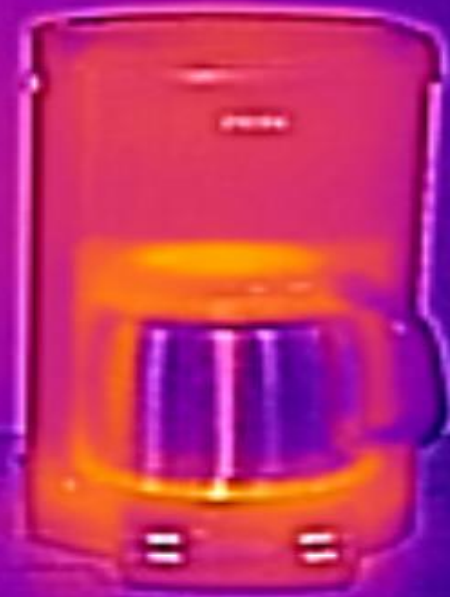




Typical Building Envelope



Passive House Building Envelope



Passive Houses save...



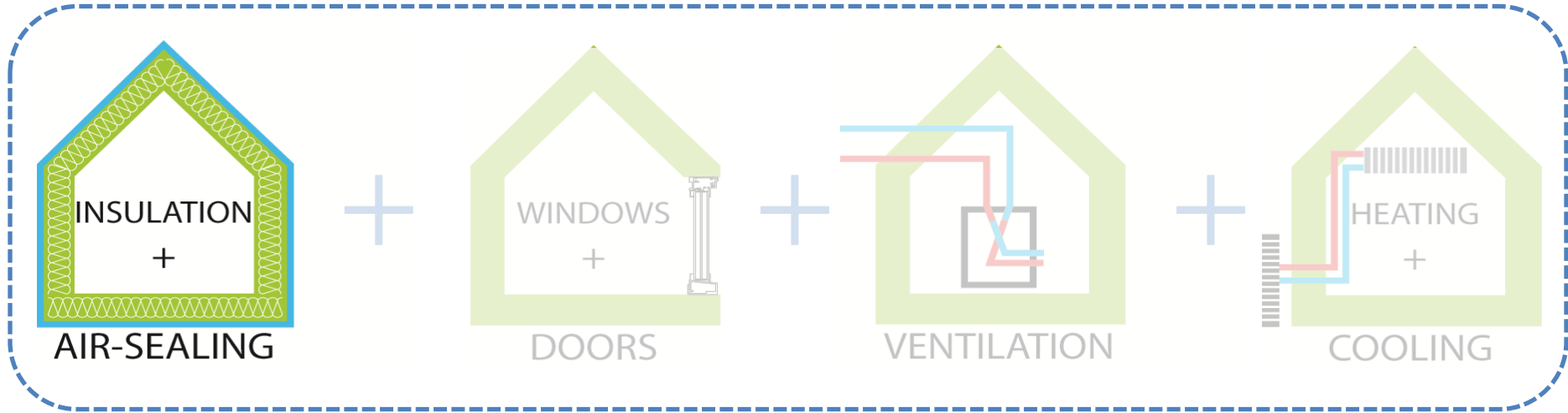
Photo Credit: [www.SGBUILD.com](http://www.SGBUILD.com)

as much as **80%** of the energy used by comparable buildings

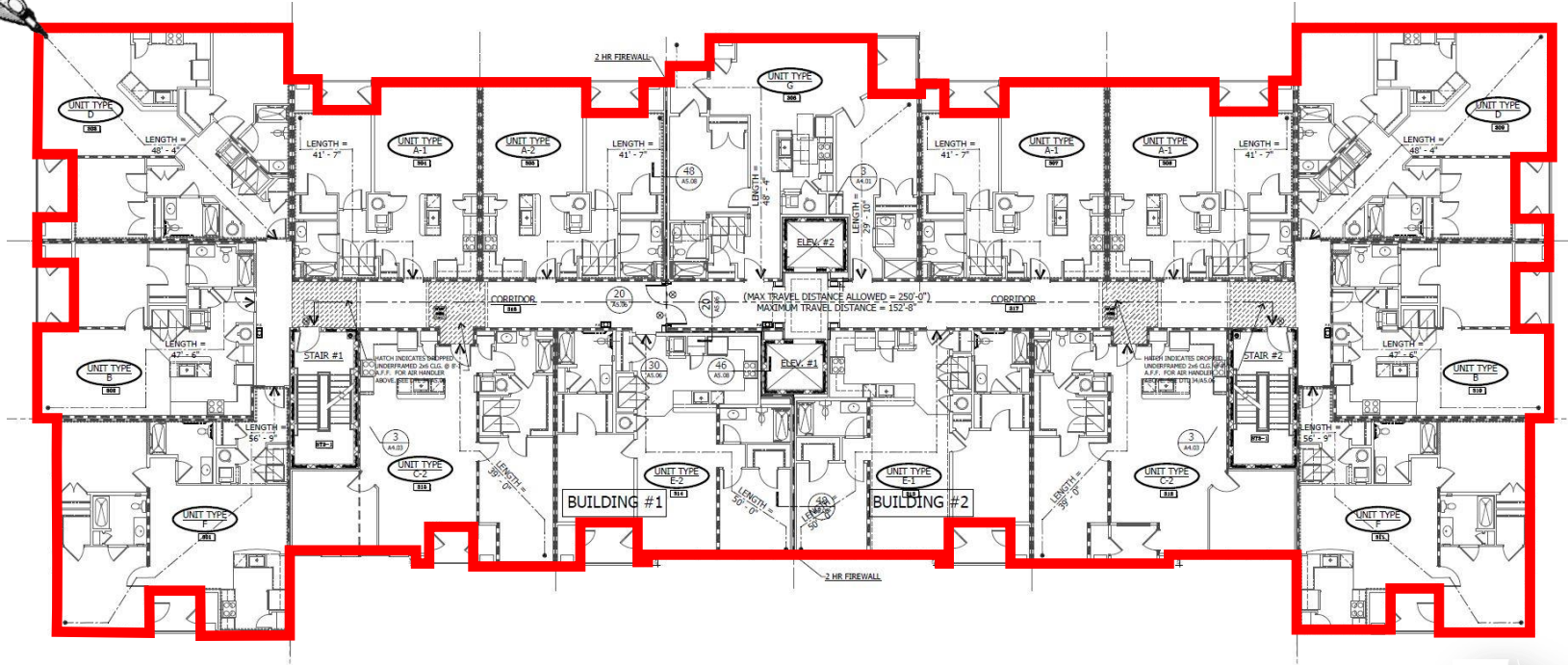
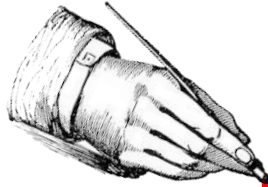




# Passive How?

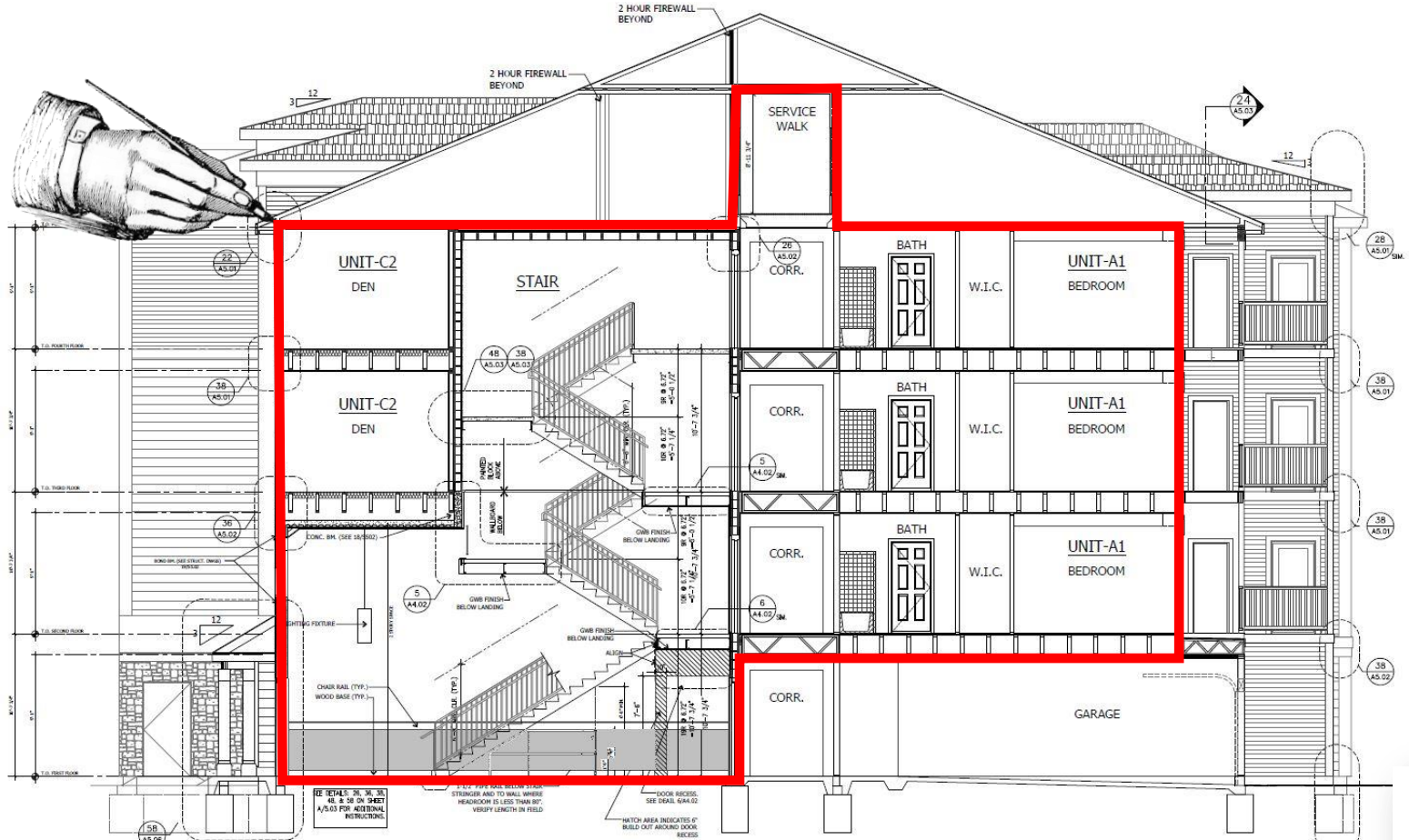


# CONTINUOUS THERMAL & AIRTIGHT BOUNDARY



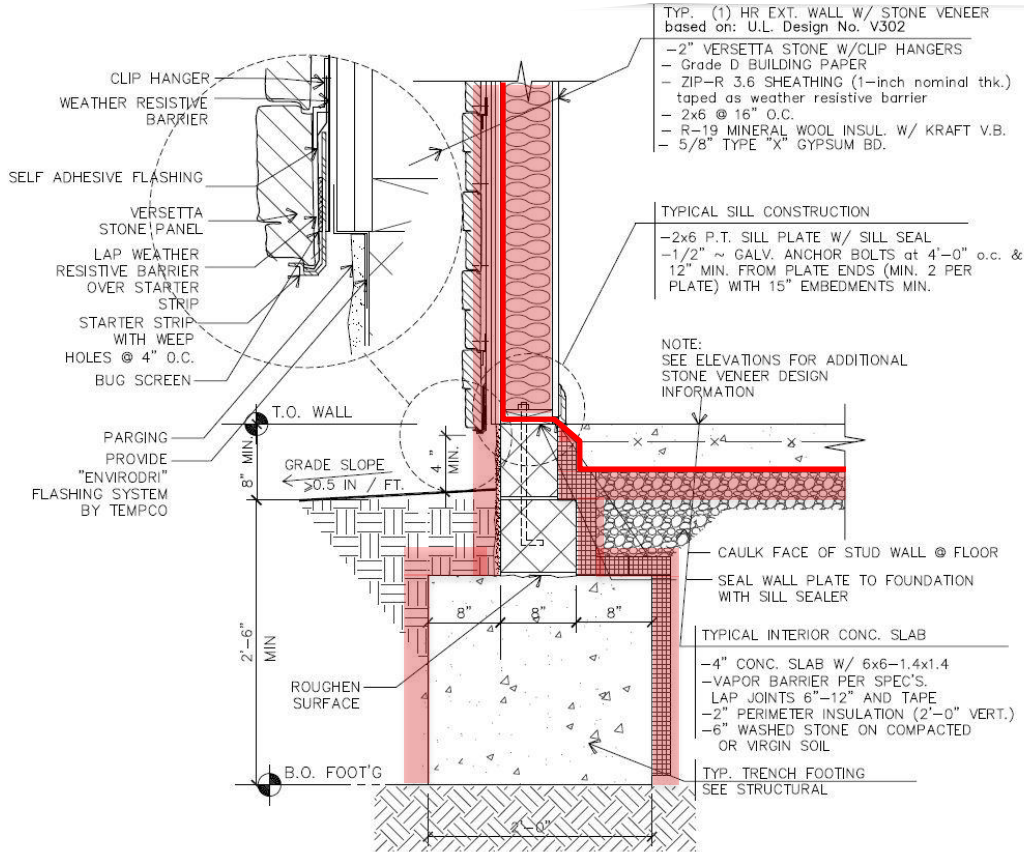


# CONTINUOUS THERMAL & AIRTIGHT BOUNDARY





# AIR BARRIER COORDINATION



58 DETAIL: FOUNDATION at 1 HOUR EXTERIOR @ UNIT  
DTL-071 SCALE: 1"=1'-0"

# PASSIVE HOUSE CONSTRUCTION - Sacred Heart Residences

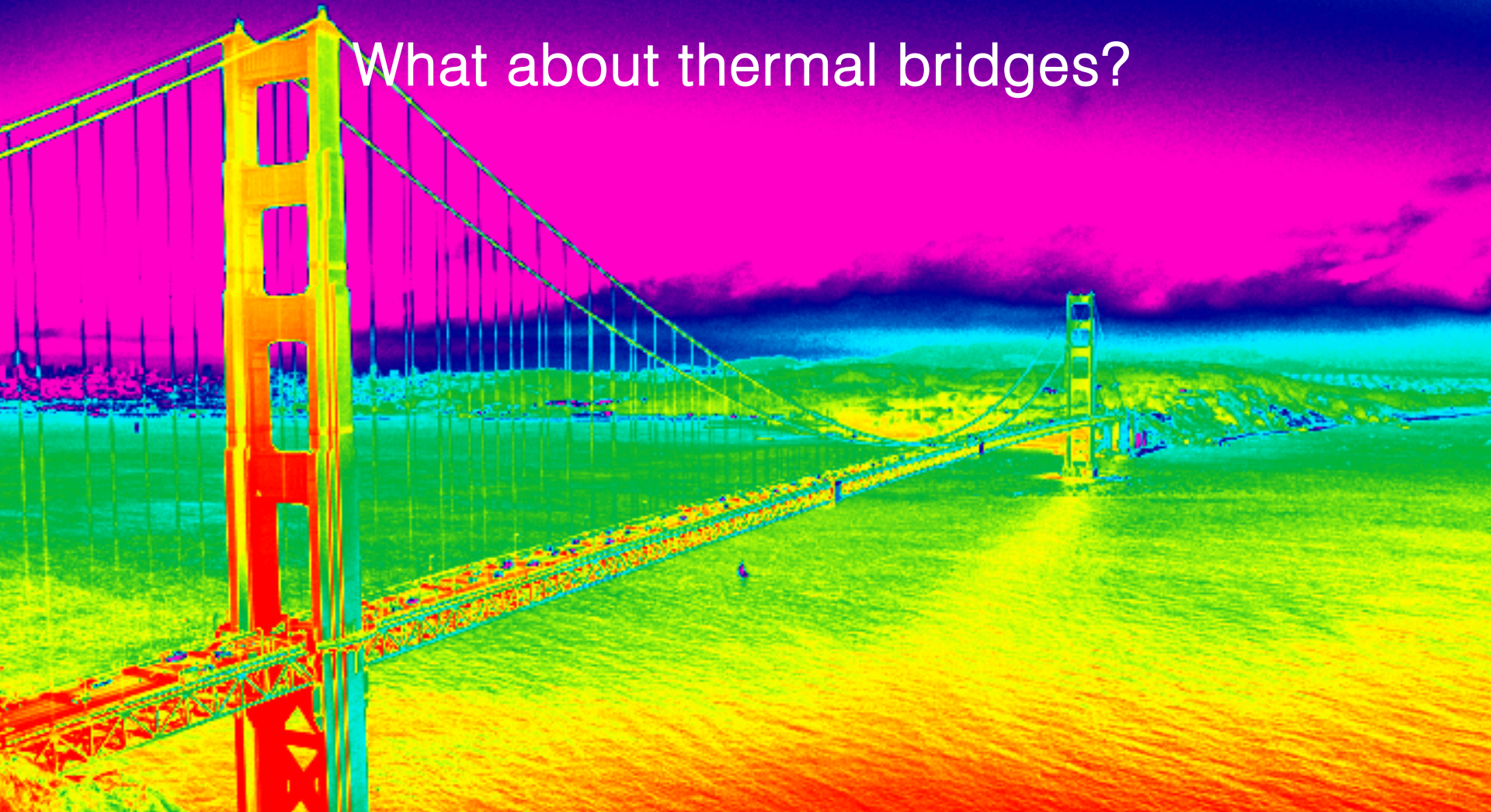


Photo courtesy of SB Conrad Construction





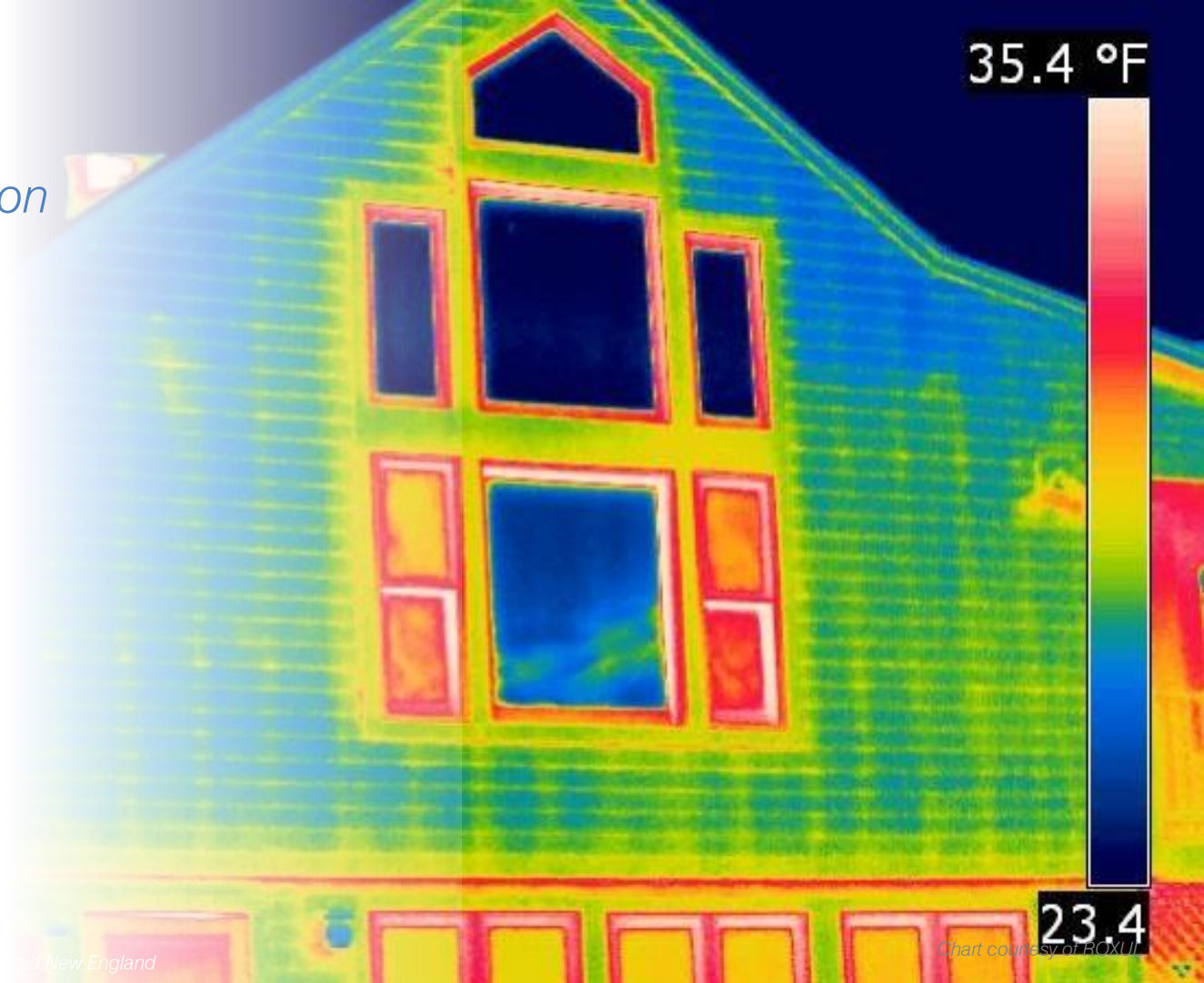
What about thermal bridges?

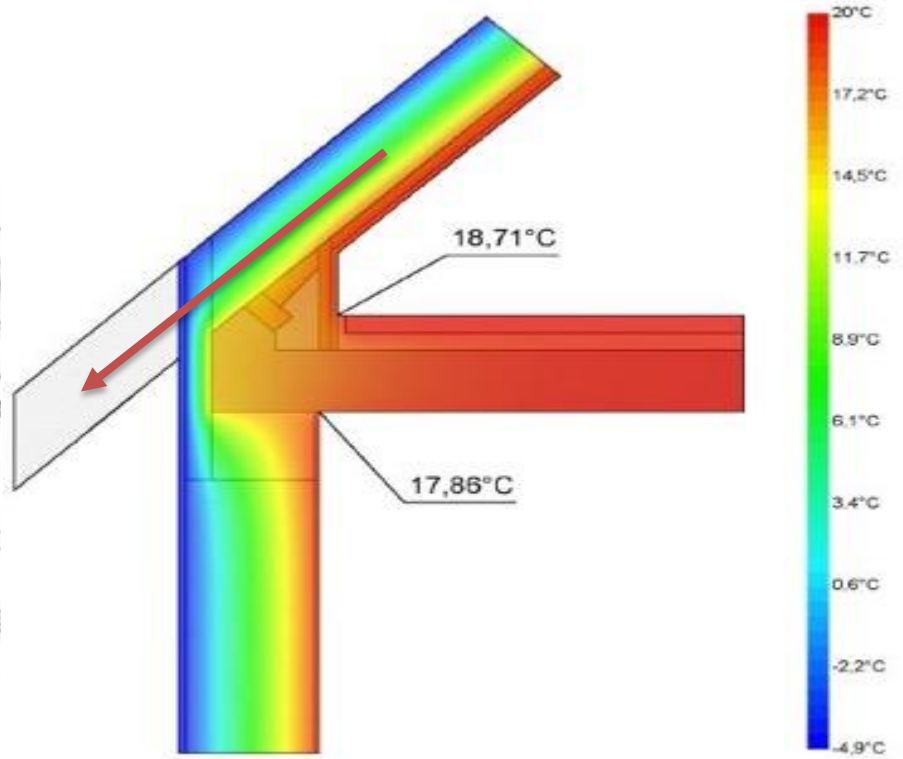
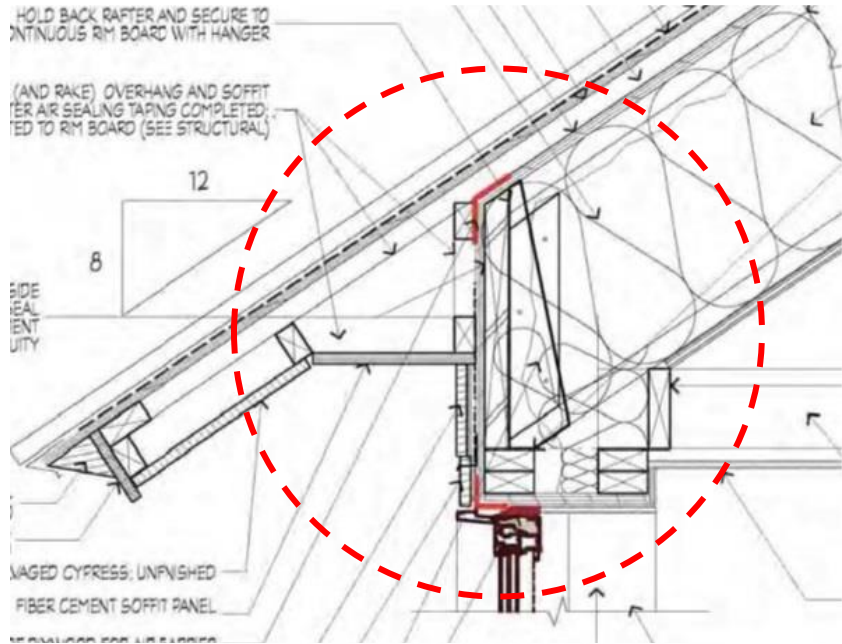


*High Energy Consumption*

*Mold Potential*

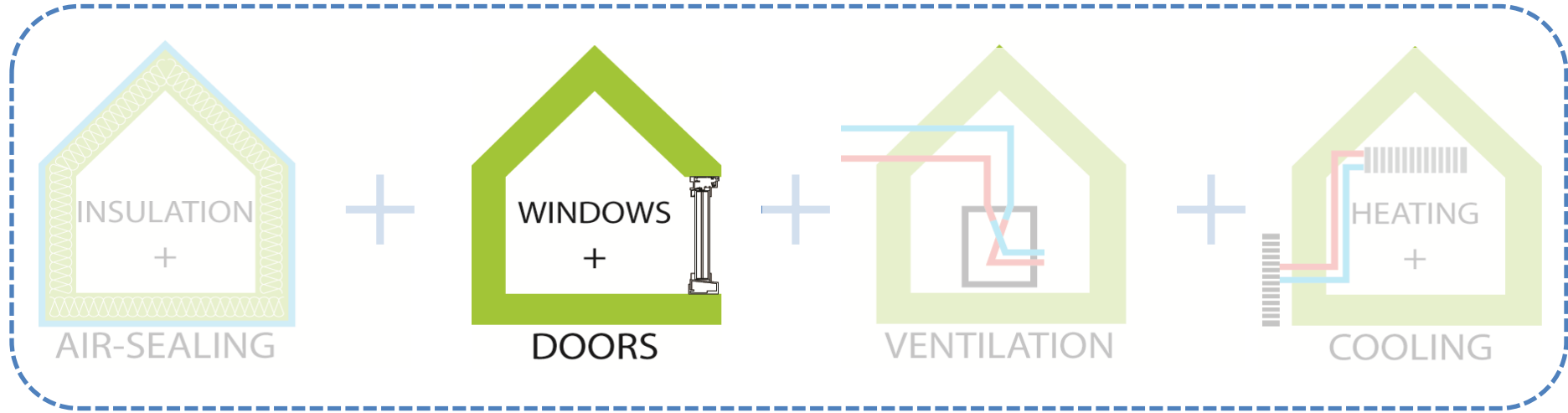
*Cold Zones*





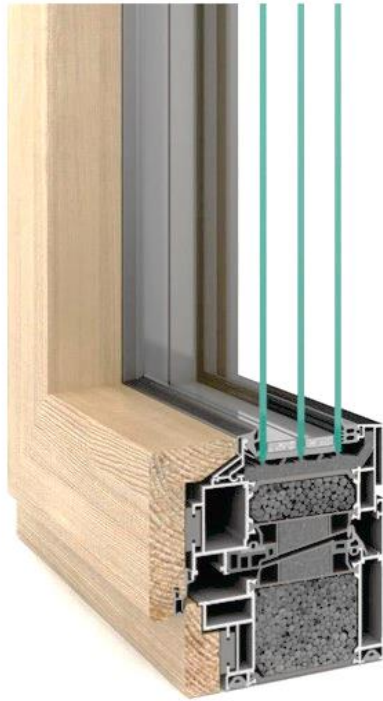


# Passive How?

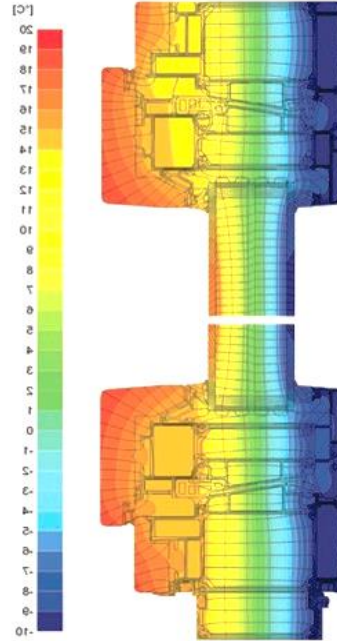




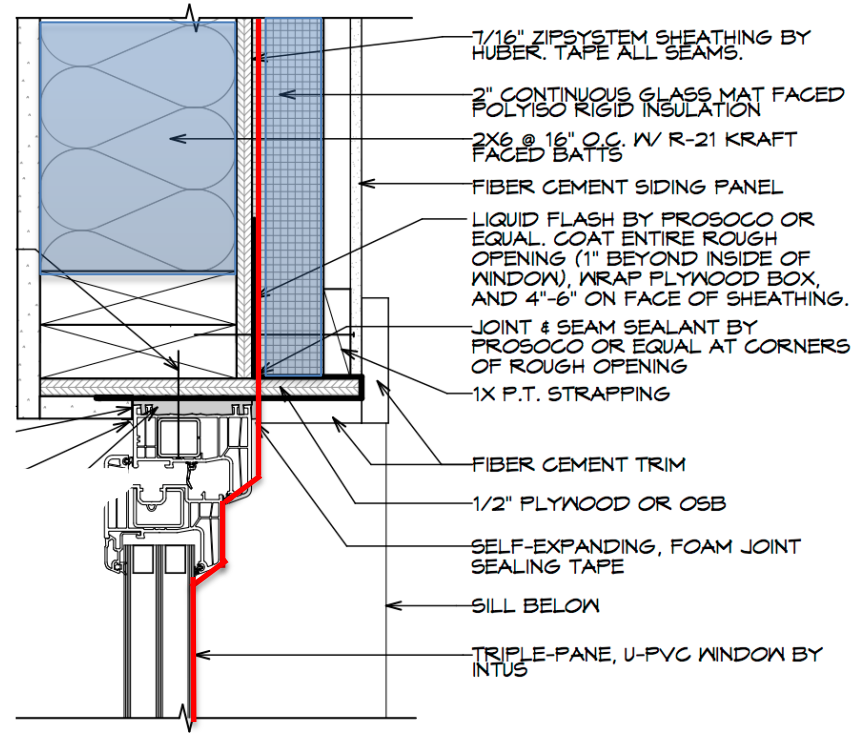
# WINDOWS AND DOORS



TRIPLE PANE,  
INSULATED FRAME

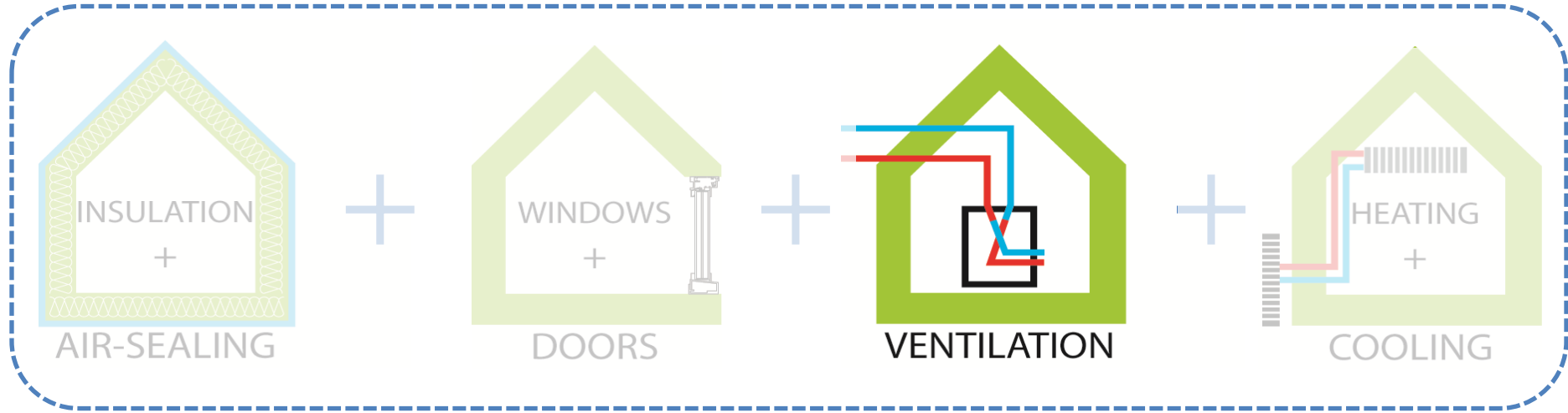


THERM ANALYSIS  
(CONTINUOUS  
THERMAL BOUNDARY)

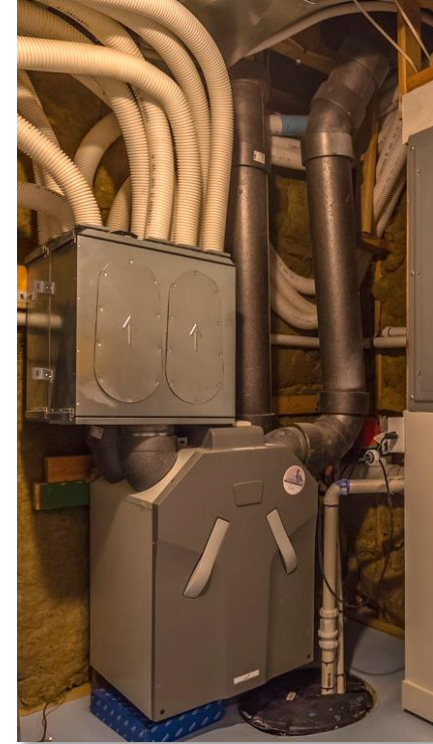
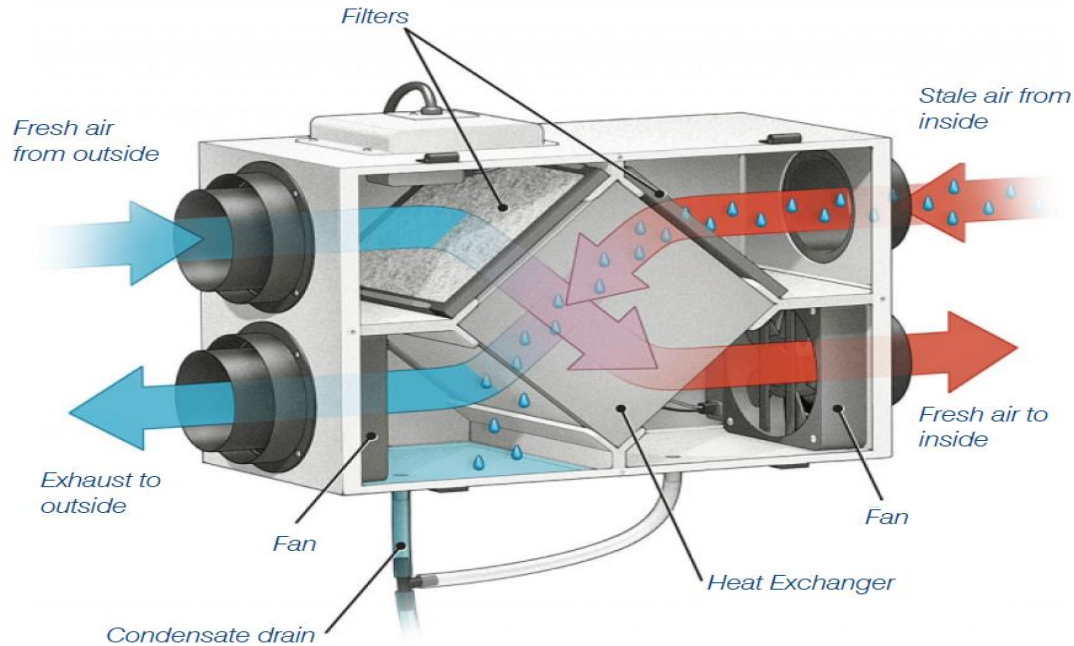


INSTALLATION DETAIL  
(CONTINUOUS AIR  
BOUNDARY)

# Passive How?



# passive design energy recovery ventilation



< ERV illust courtesy of Green Building Advisor  
> ERV photo from Fishtown Passive House, Re:Vision Architecture

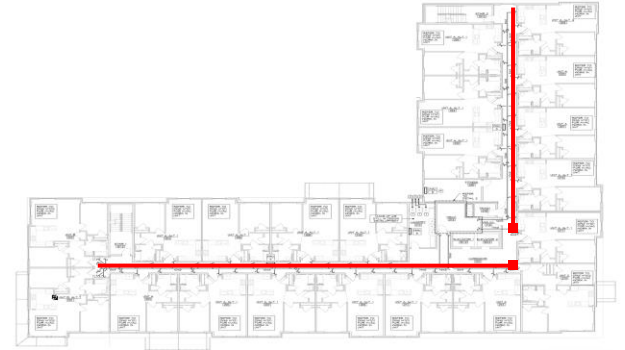
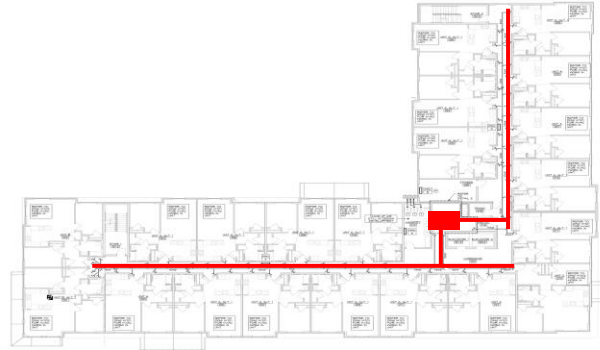
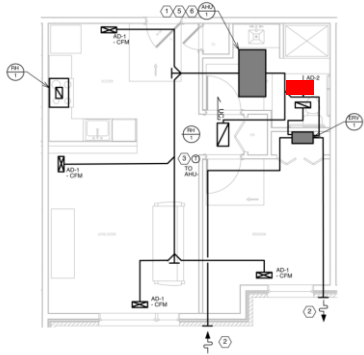
S



M



L

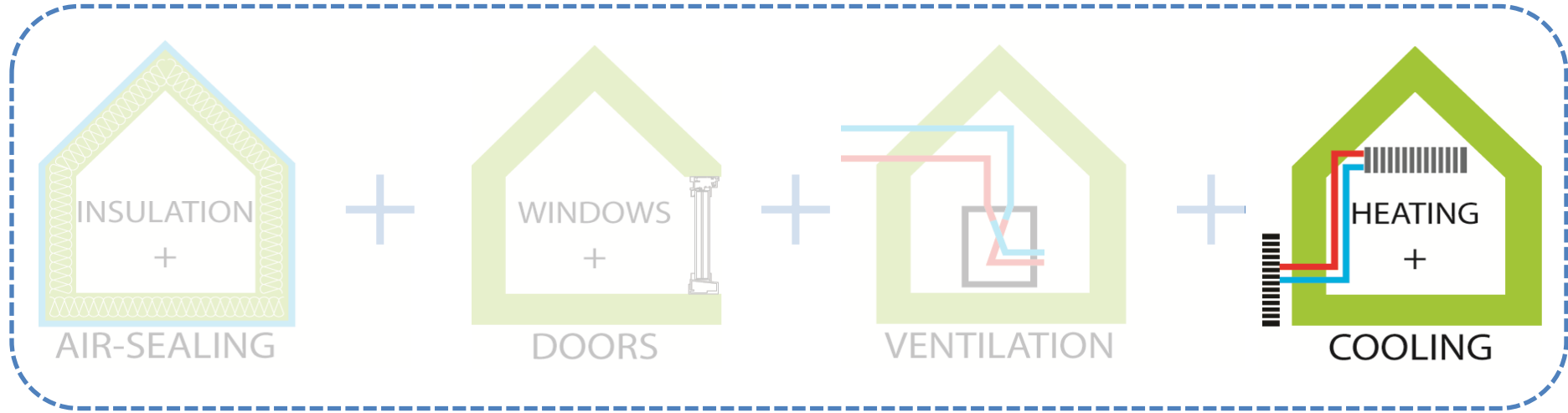


Decentralized

Semi-Centralized

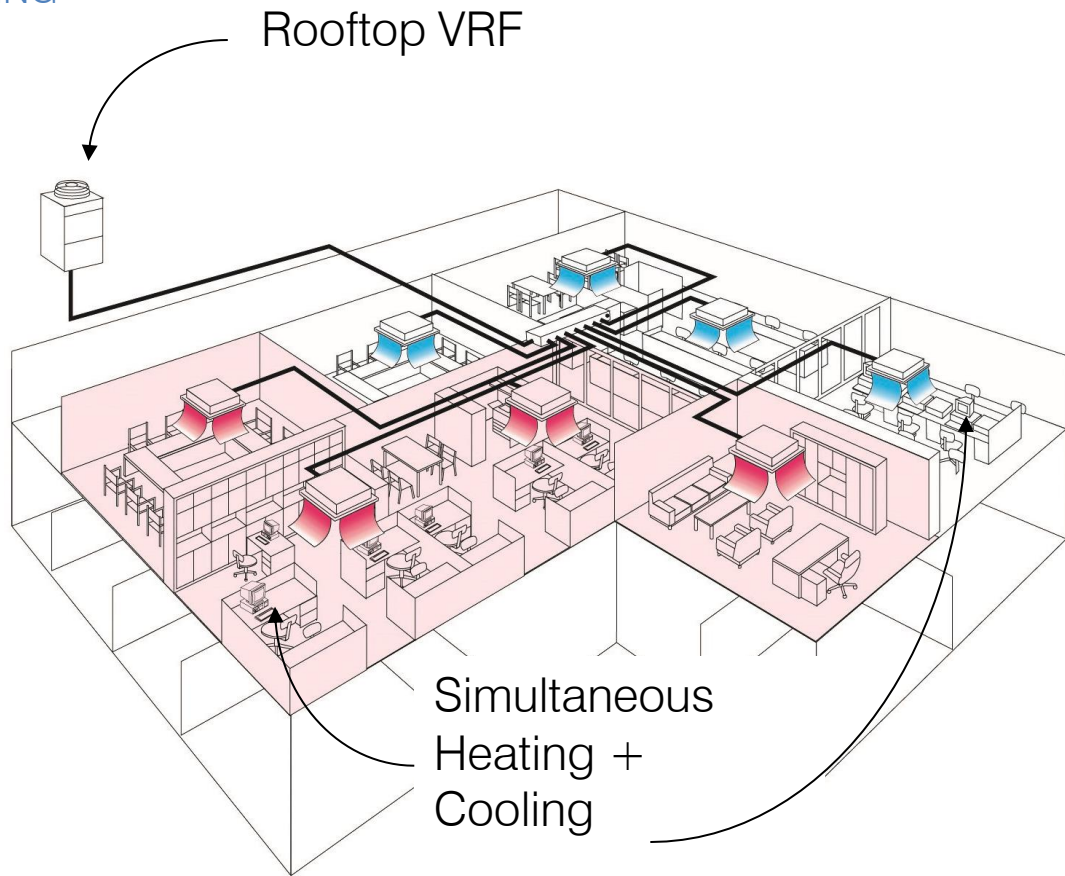
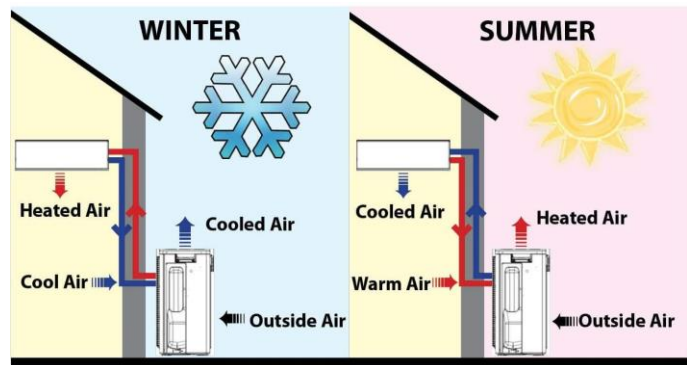
Centralized

# Passive How?



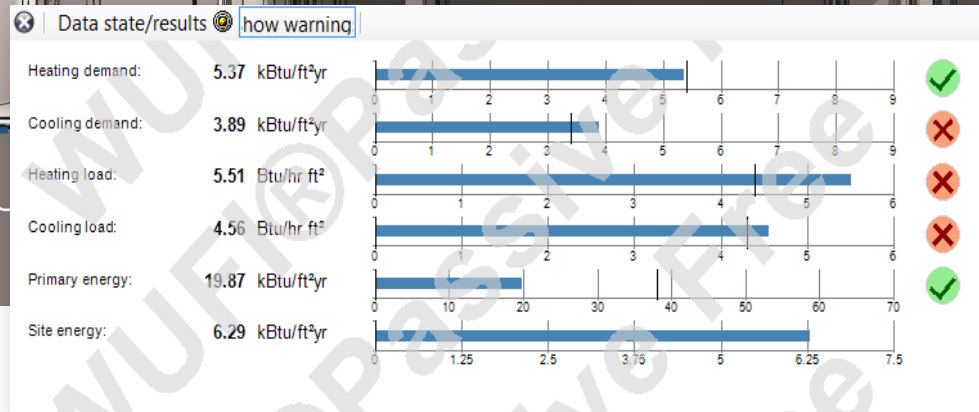
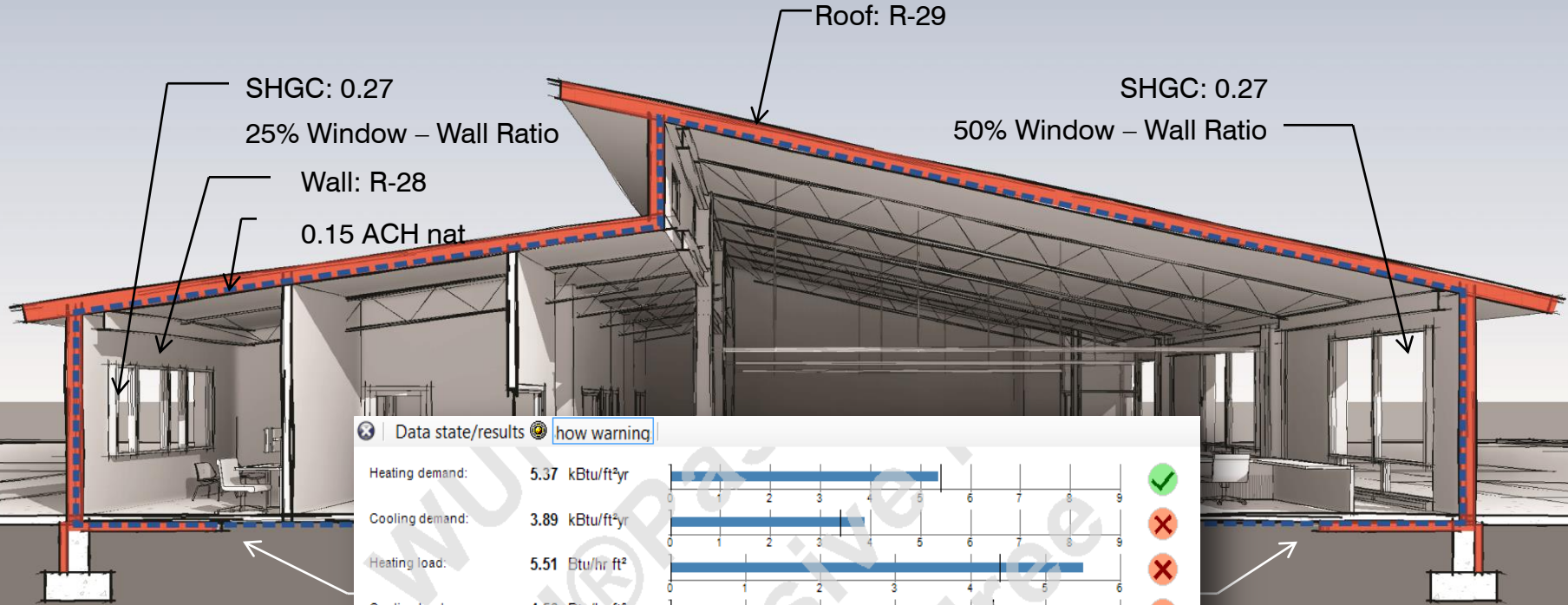


# HIGH PERFORMANCE HEATING AND COOLING

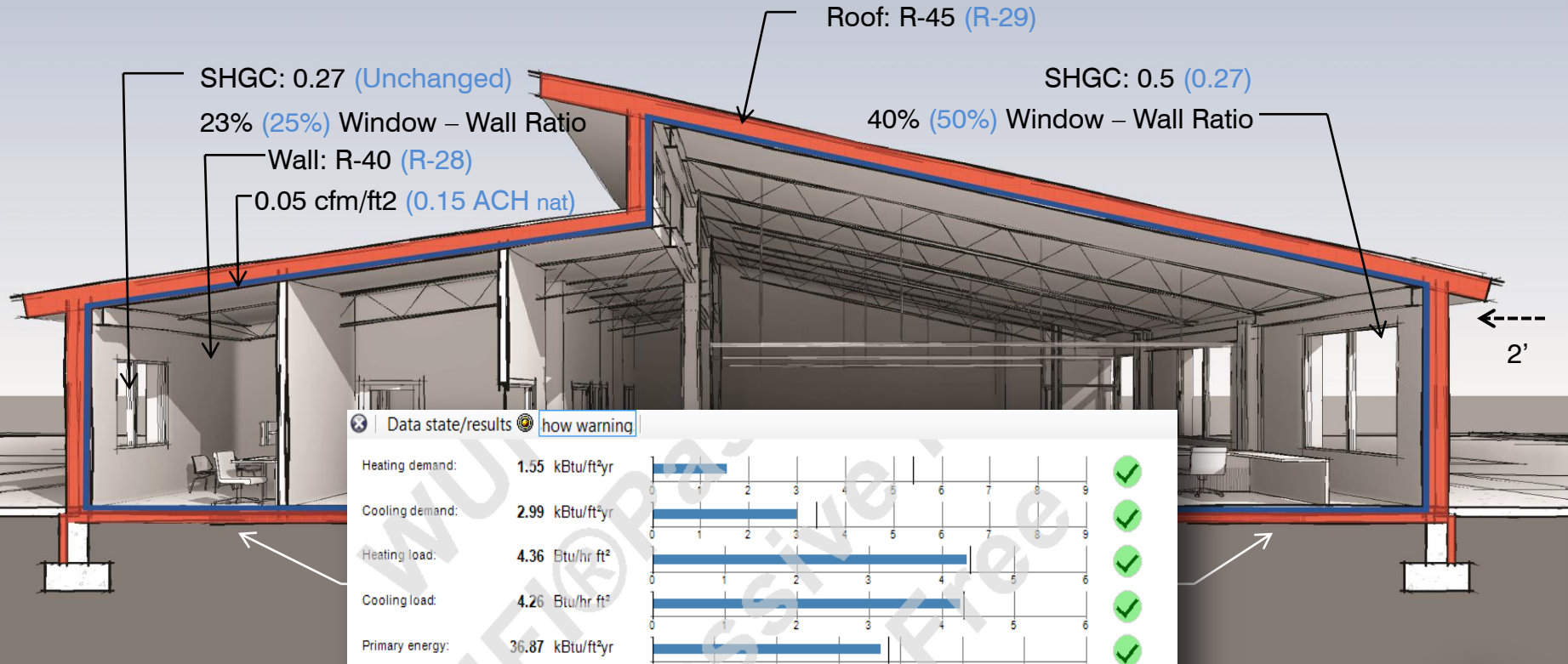




# ENERGY MODELLING – Optimizing the Envelope AND systems



# ENERGY MODELLING – Optimizing the Envelope AND systems



# MARKET FEASIBILITY– Optimizing the Envelope AND systems: the cost of reducing EUI

	Baseline	Optimized	ECM #1	ECM #2	ECM #3	ECM #4	ECM #5	ECM #6	ECM #7	ECM #8	ECM #9	ECM #10	ECM #11	ECM #12
						Proposed Geometry, Glass - u-val	Proposed Geometry, "Good" ins	Proposed Geometry, Glass - uval "Good" ins	Proposed Geometry, HVAC ONLY	Proposed Geometry, Interior Loads ONLY	Proposed Geometry, Extreme Plug Load Run (0.5W/sf)	"Less Good" Walls - SIP R-15 Roof - SIP R-23	ECM #8 + LPD @ 0.45	ECM #9 + LPD @ 0.45
	"Good" Envelope	"Better" Envelope	"Best" Envelope	Proposed Geometry										
Energy Consumption (kWh)	233,327	103,081	99,028	98,204	235,885	230,846	226,602	221,838	159,039	224,962	208,428	104,792	200,542	184,272
Cost	\$22,679	\$10,019	\$9,626	\$9,545	\$22,928	\$22,438	\$22,026	\$21,563	\$15,459	\$21,866	\$20,259	\$10,186	\$19,493	\$17,911
EUI	51.0	22.4	21.5	21.3	51.6	50.5	49.5	48.5	34.5	49.2	45.6	22.8	43.8	40.3
<b>Enduses</b>														
Lights	49,346	18,799	18,911	18,911	49,346	49,346	49,346	49,346	49,346	49,346	49,346	18,799	22,206	22,206
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc Equip	60,324	48,145	48,145	48,145	60,324	60,324	60,324	60,324	60,324	48,145	29,582	48,145	48,145	29,582
Space Heating	14,727	9,012	4,743	3,981	18,108	16,461	12,418	10,643	15,950	19,608	21,956	10,408	22,963	25,521
Space Cooling	23,887	10,459	11,153	11,234	20,923	19,974	22,634	21,738	13,714	19,877	18,314	10,345	17,659	16,134
Heat Reject	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumps & Aux	2,301	0	0	0	2,169	2,252	2,399	2,475	0	2,118	2,035	0	2,002	1,916
Vent Fans	71,258	10,853	10,548	10,464	73,516	71,639	69,745	68,344	13,406	73,962	74,679	11,138	74,833	75,623
Refrig Display	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HT Pump Supplem	6,309	637	355	296	6,321	5,672	4,561	3,793	1,121	6,727	7,336	779	7,554	8,109
DHW	5,175	5,176	5,173	5,173	5,178	5,178	5,175	5,175	5,178	5,179	5,180	5,178	5,180	5,181
Ext Usage	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>233,327</b>	<b>103,081</b>	<b>99,028</b>	<b>98,204</b>	<b>235,885</b>	<b>230,846</b>	<b>226,602</b>	<b>221,838</b>	<b>159,039</b>	<b>224,962</b>	<b>208,428</b>	<b>104,792</b>	<b>200,542</b>	<b>184,272</b>
% savings over Optimized			3.9%	4.7%										
% Savings over Baseline		55.8%	57.6%	57.9%	-1.1%	1.1%	2.9%	4.9%	31.8%	3.6%	10.7%	55.1%	14.1%	

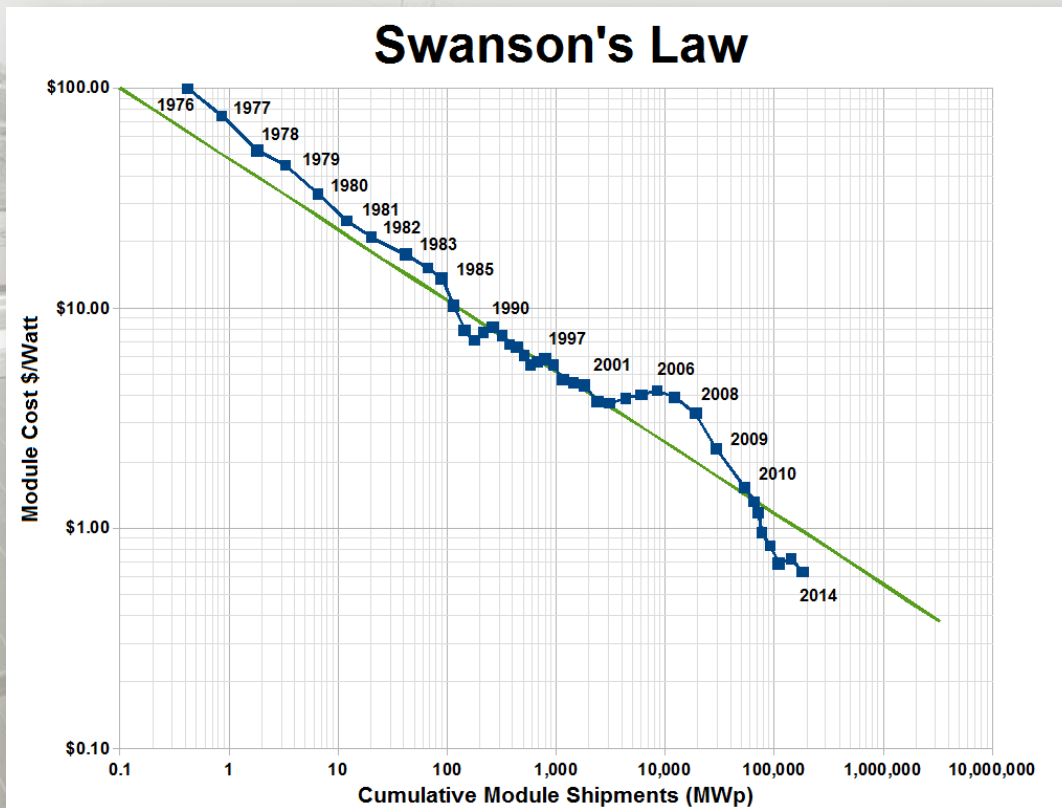


## MARKET FEASIBILITY– Optimizing the Envelope AND systems: the cost of reducing EUI

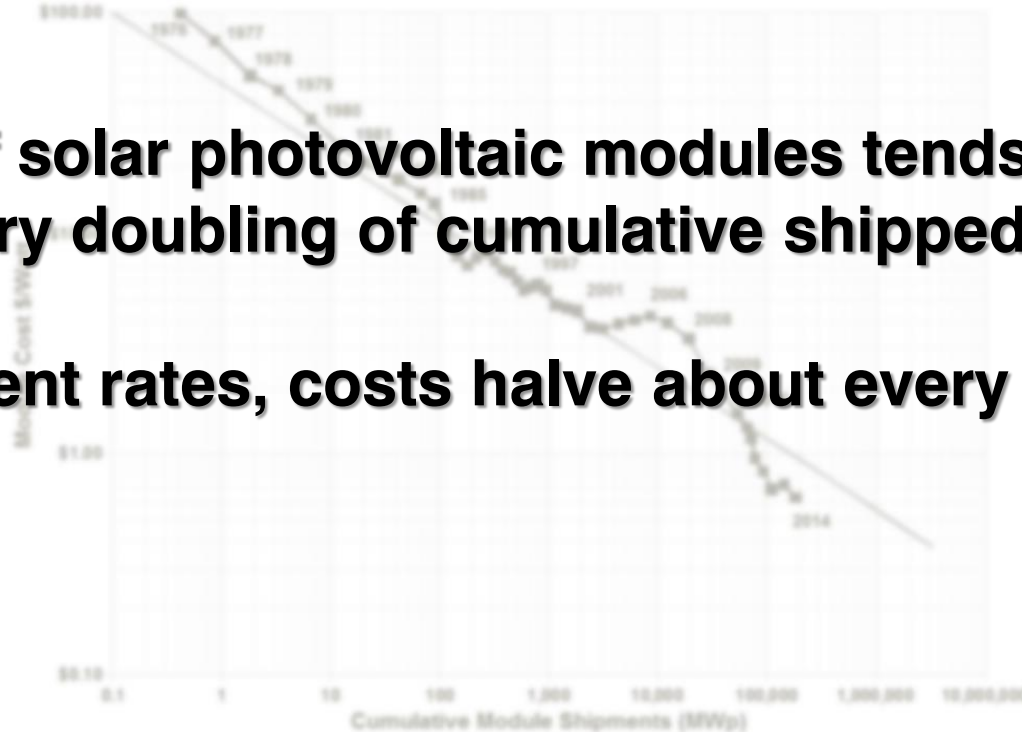
ECM	EUI REDUCTION	2016		
		1 <sup>ST</sup> COST ADD	\$/EUI	
“Good” Envelope Package	1.5	\$37,500	\$25,000	if necessary
“Better” Envelope Package	2.2	\$105,000	\$47,727	unlikely
Improved Glazing	1.1	\$71,000	\$64,545	thermal comfort
HVAC System	16.5	\$103,000	\$6,242	← 2 <sup>nd</sup>
LED Lighting Package	5.4	\$30,000	\$5,555	← 1 <sup>st</sup>
PV Array	25.4	\$262,725	\$10,343	← 3 <sup>rd</sup>

# PV FORECAST

how will the cost equation change?



## Swanson's Law



**the price of solar photovoltaic modules tends to drop 20% for every doubling of cumulative shipped volume.**

**At present rates, costs halve about every 10 years.**

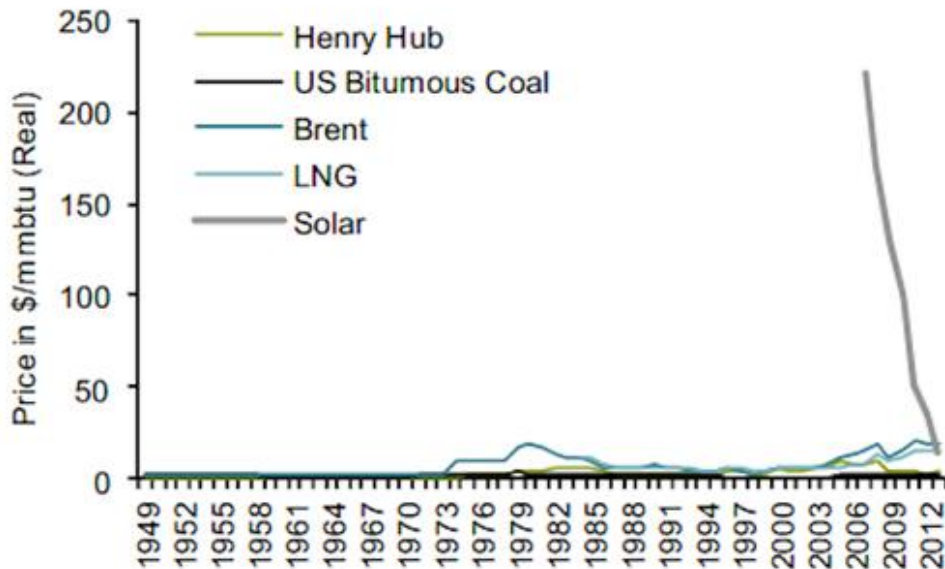


# PV FORECAST

how will the cost equation change?

## Exhibit 2

### Welcome to the Terrordome... \$/MMBTU by Energy Type



Source: EIA, CIA, World Bank, Bernstein analysis

Exhibit 2

Welcome to the Tornado... SMMRTU by Energy Type

**“The behavior from here seems clear: the solar industry will expand. Retaliatory steps from distribution utilities will increase the market for cost-effective battery storage. This becomes – initially – a secondary market for battery technologies being developed”**

**-AllianceBernstein's Michael Parker and Flora Chang**

Source: EIA, CIA, World Bank, Bernstein analysis

## PV FORECAST

how will the cost equation change?

ECM	EUI REDUCTION	2016	
		1 <sup>ST</sup> COST ADD	\$/EUI
“Good” Envelope Package	1.5	\$37,500	\$25,000
“Better” Envelope Package	2.2	\$105,000	\$47,727
Improved Glazing	1.1	\$71,000	\$64,545
HVAC System	16.5	\$103,000	2 \$6,242
LED Lighting Package	5.4	\$30,000	1 \$5,555
PV Array	25.4	\$262,725	3 \$10,343

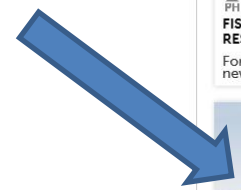
# PV FORECAST













how will the cost equation change?

ECM	EUI REDUCTION	2016		2026	
		1 <sup>ST</sup> COST ADD	\$/EUI	1 <sup>ST</sup> COST* ADD	\$/EUI
“Good” Envelope Package	1.5	\$37,500	\$25,000	\$50,397	\$33,598
“Better” Envelope Package	2.2	\$105,000	\$47,727	\$141,111	\$64,141
Improved Glazing	1.1	\$71,000	\$64,545	\$95,418	\$86,743
HVAC System	16.5	\$103,000	<b>2</b> \$6,242	\$138,423	<b>3</b> \$8,389
LED Lighting Package	5.4	\$30,000	<b>1</b> \$5,555	\$40,317	<b>2</b> \$7,466
PV Array	25.4	\$262,725	<b>3</b> \$10,343	\$131,363	<b>1</b> \$5,172



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 <p><b>REGIONAL OPERATIONS CENTER</b> Operations Center, new</p>	 <p><b>AERZEN USA HEADQUARTERS</b> Office/manufacturing, expansion</p>	 <p><b>MAIN LINE RESIDENCE</b> Age-in-place home, new</p>	 <p><b>JONES LANG LASALLE PHILA</b> High-rise corporate interiors</p>
 <p><b>FISHTOWN RESIDENCE</b> For-sale urban home, new</p>	 <p><b>B MINOR RESIDENCE</b> For-sale urban home, new</p>	 <p><b>NORTHERN LIBERTIES RESIDENCE</b> Passive House designed home, new</p>	 <p><b>SWARTHMORE COLLEGE</b> Pavilion &amp; Courtyard, new</p>
 <p><b>SUSTAINABLE ENERGY FUND</b> Multi-Tenant Headquarters</p>	 <p><b>NEW ENGLAND WILD FLOWER SOCIETY</b> Campus expansion, master plan</p>	 <p><b>AERZEN USA HEADQUARTERS</b> Office + manufacturing, new</p>	 <p><b>BERKS COUNTY COMMUNITY</b> Multi-tenant offices + conf center, new</p>



Center City Philadelphia, 1973

courtesy of US National Archives/ Flickr

# Thank You



**David Salamon**  
*CPHD-C*

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