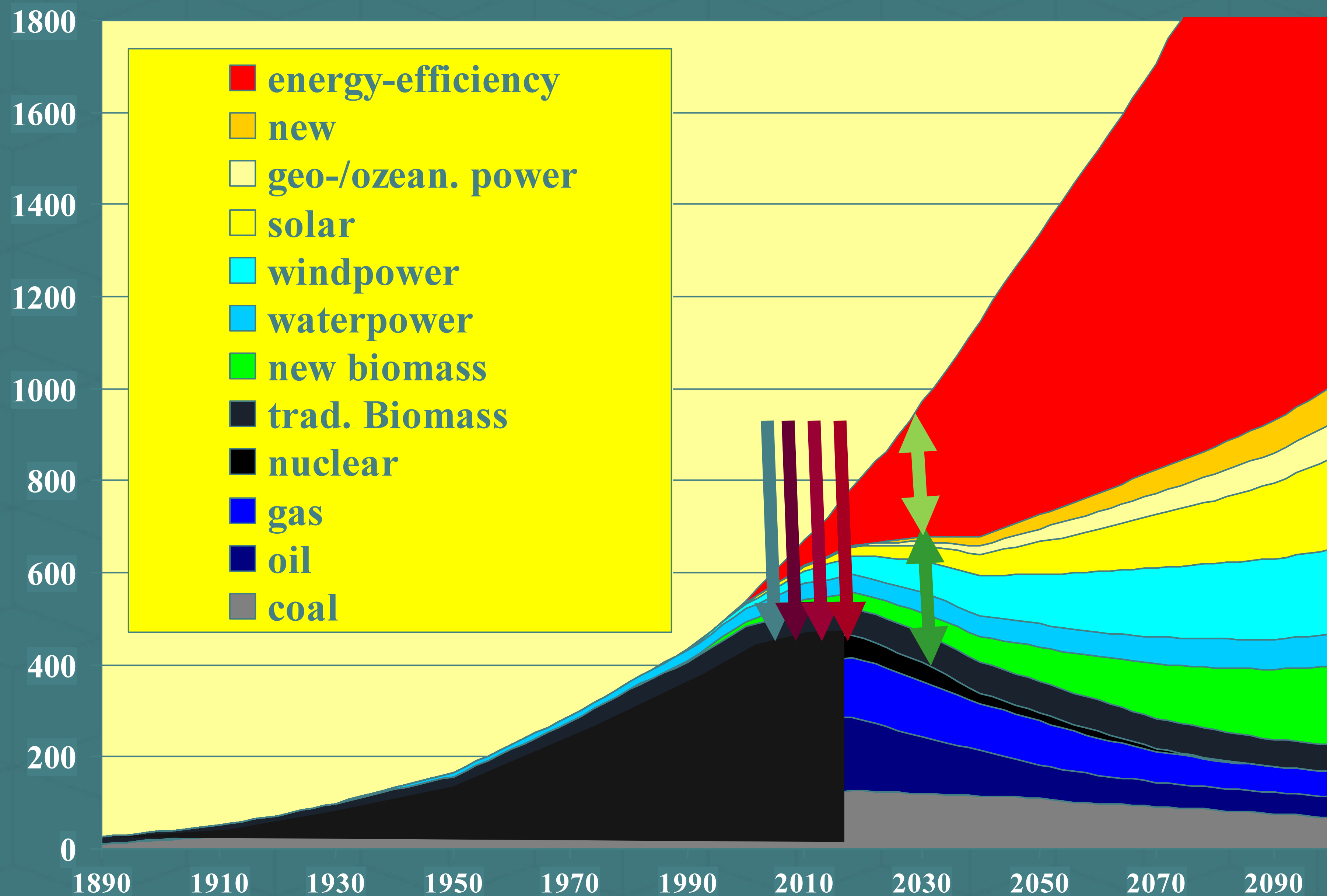
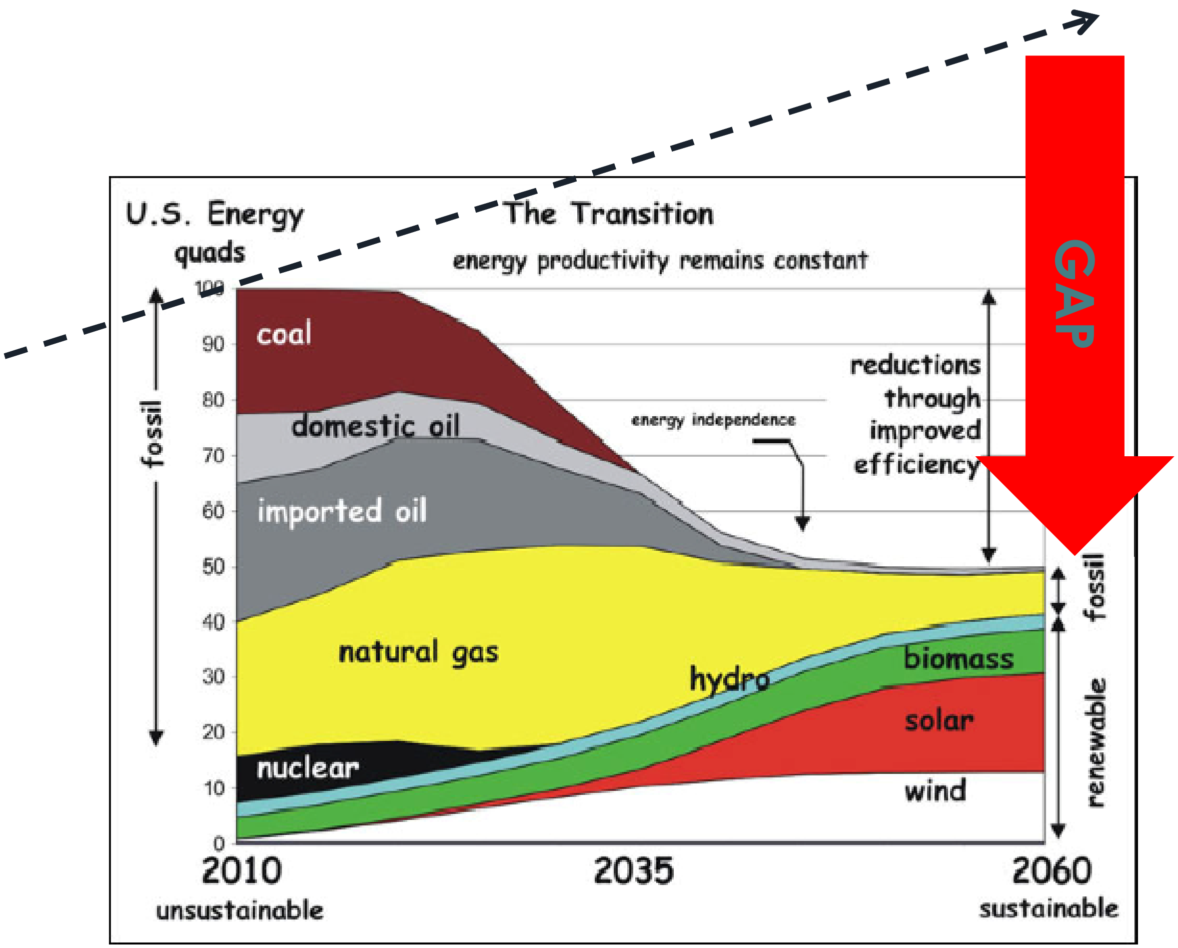
CLIMATE SPECIFIC PASSIVE BUILDING STANDARDS, TOOLS, COMPONENTS

FUTURE WORLDWIDE TRANSITION



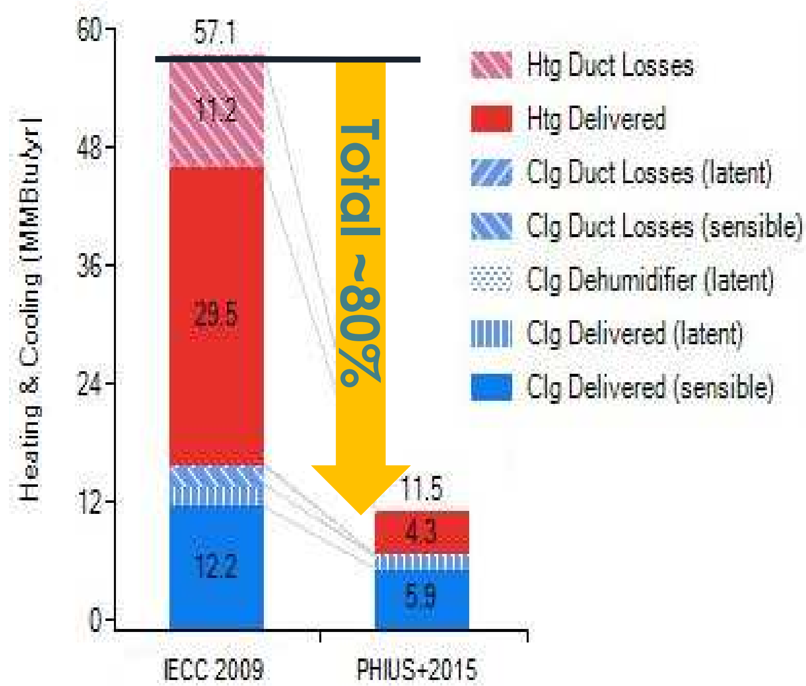
Reference: Shell-Study (till 2005), Scenario with high efficiency and regenerative usage of energy

PASSIVE BUILDING IS **EFFECTIVE** IN REDUCING ENERGY: ~ FACTOR 8-10

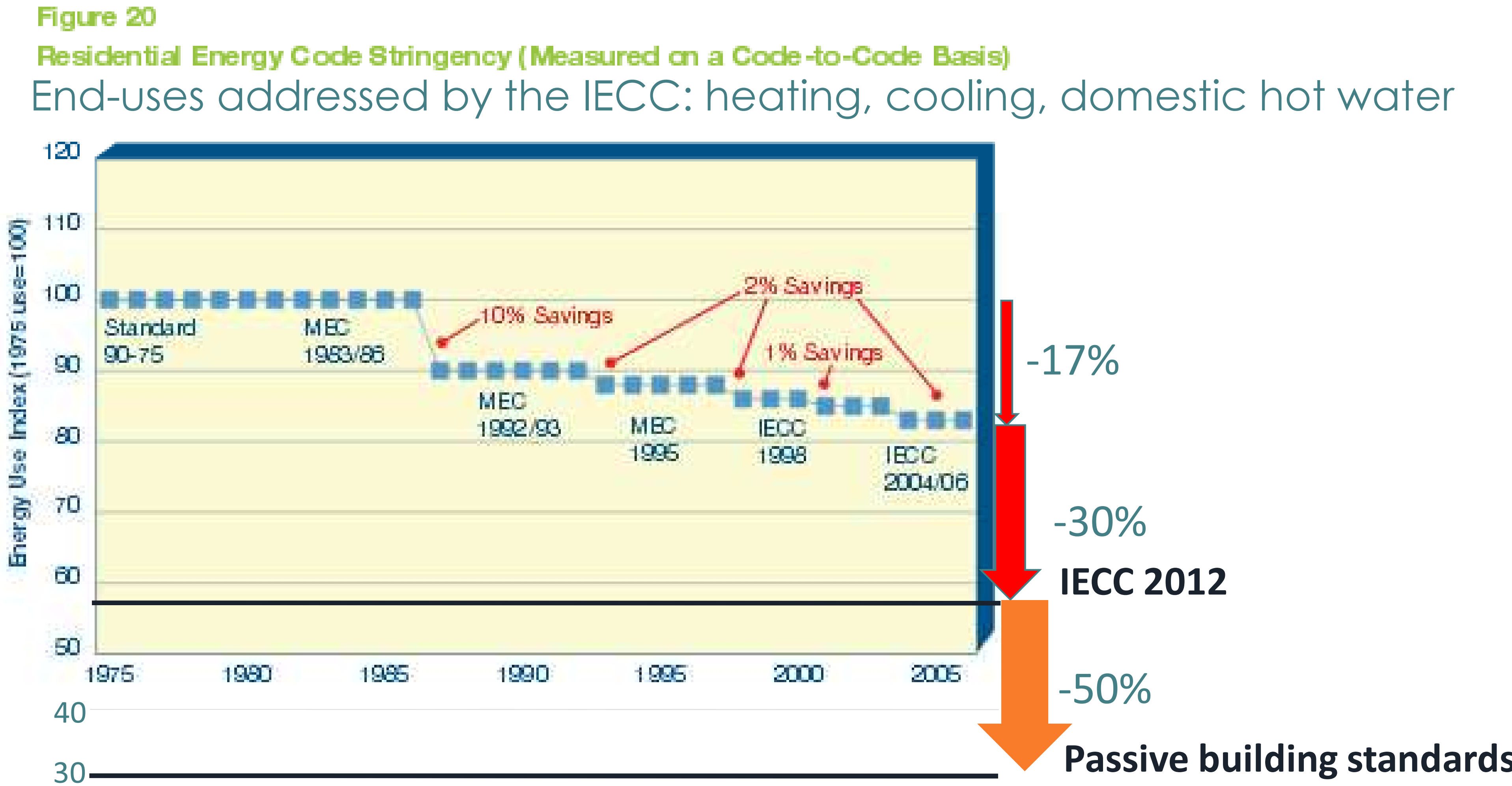


Graphic from Article: J. Douglas Balcomb, Ph.D., "The Energy Road Ahead", Solar Today Magazine, Apr 2010

Heating energy reduction in passive buildings: ~**80-90%**



WHERE TODAY'S US ENERGY CODES ARE - DEVELOPMENT SINCE THE **ENERGY CRISIS**



(Source : U.S. Department of Energy: Energy Efficiency Trends in Residential and Commercial Buildings)

HISTORY
PASSIVE BUILDING METRICS

FIRST GENERATION PIONEERS

PASSIVHAUS

PASSIVE HOUSE & BUILDINGS NORTH AMERICA

THE BASIC CONCEPT IS DEVELOPPED

PEAK LOAD TENET

80-90% PEAK REDUCTION – ALL CLIMATES

Developed by North American Scientists

Annual Heat/Cooling Demand	• **80-90% reduction from pre 1980 conventional**	Annual demands pay back investment
Peak Loads (heating/ cooling)	• ***~ 3.17 -5.39 BTU/hr.ft^2 or 10-17 W/m^2***	Low peak loads assure comfort & resilience
Airtightness	• **air-tight construction**	Assures envelope quality and longevity

THE CONCEPT CONTINUES TO DEVELOP

A PERFORMANCE METRIC

3 PASS/FAIL CRITERIA - MODERATELY COLD

Developed by Passivhaus Institut

Annual Heat/Cooling Demand	• ≤4.75 kBTU/ft²yr (15 kWh/m²a)	Annual demands pay back Investment in ***conservation***
--OR--		
Peak Loads (heating/ cooling)	• ≤ ***3.17*** *BTU/hr.ft² or 0.93W/ft² (10 W/m²)*	Low peak loads assure comfort & passive survivability
Primary Energy Demand	• ≤38 kBTU/ft²yr (120 kWh/m²a)	Global carbon reduction cap per person, addresses ***systems efficiency***
Airtightness	• ≤ 0.6 ACH_{50}	Assures envelope quality and Longevity, ***durability***

PASSIVHAUS CRITERIA

Primary Energy	kBTU/ft²/yr	38
Airtightness	ACH_{50}	0.6
Annual Heat Demand Annual Cooling Demand	kBTU/ft²/yr	4.75
Peak Heat Load	BTU/ft².hr	3.14
Peak Cooling Load		2.54
Ventilation	% efficiency	75%
	W/cfm	≤ 0.76
Thermal Envelope	hr. ft²°F/BTU	≥ R-38.5
	BTU/hr. ft² °F	≤ U-0.026
Thermal Bridge Free	BTU/ hr. ft °F	Ψ ≤ 0.006
Windows Installed	BTU/hr. ft² °F	Uw-install ≤ 0.15
SHGC	%	≈ 0.50 - 0.55

REFINING THE

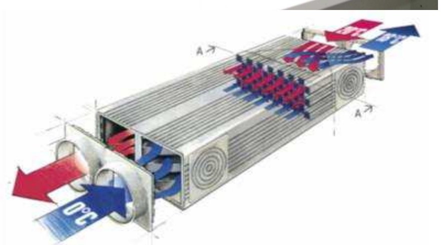
METHODOLOGY

Performance Components/Systems/Tools

Developed by European Industry

High performance windows

Smart Vapor Retarders



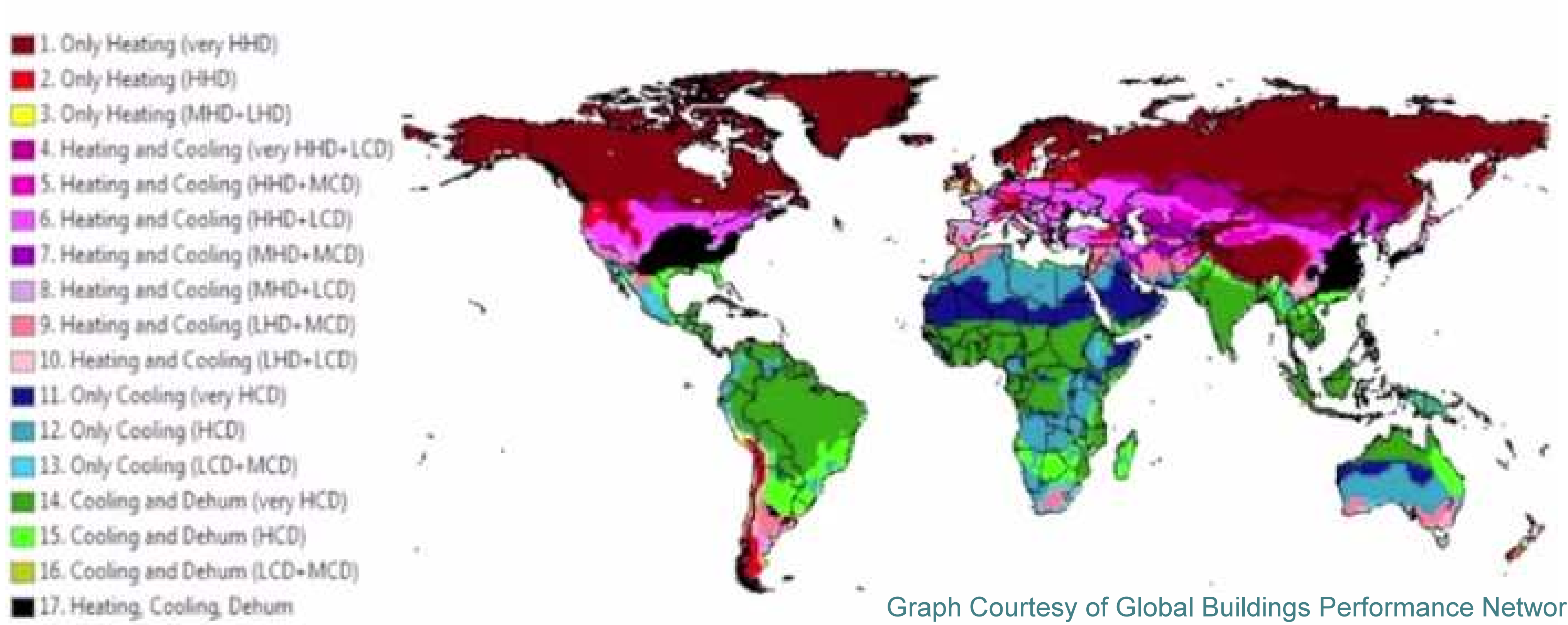
Highly efficient heat exchange cores for ventilators

Static Design&Verification Tool

PHPP

Integrated compact ventilation & space conditioning systems

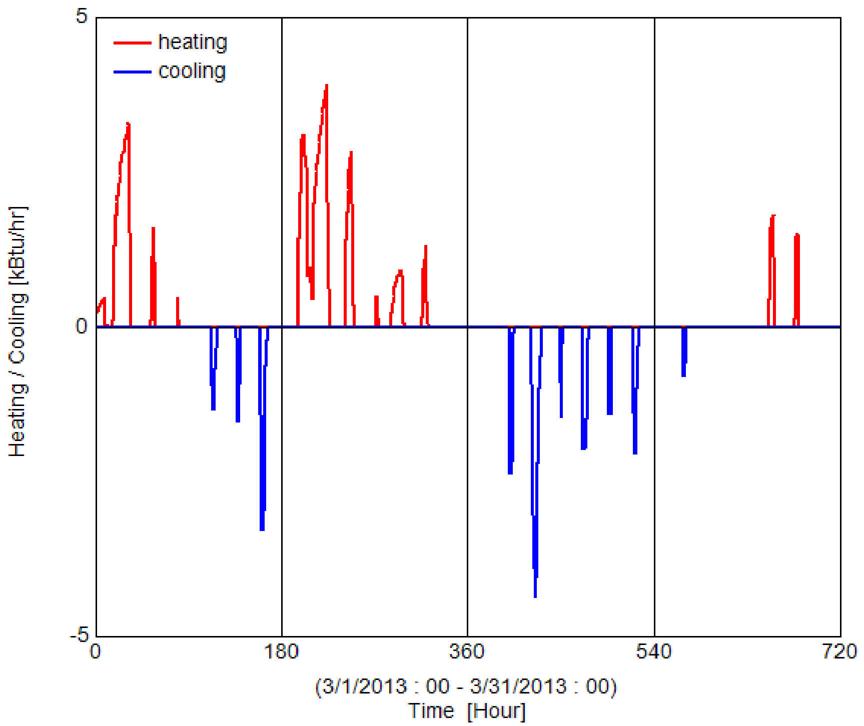
NEW CHALLENGES:
CLIMATE SPECIFIC DESIGN



Graph Courtesy of Global Buildings Performance Network

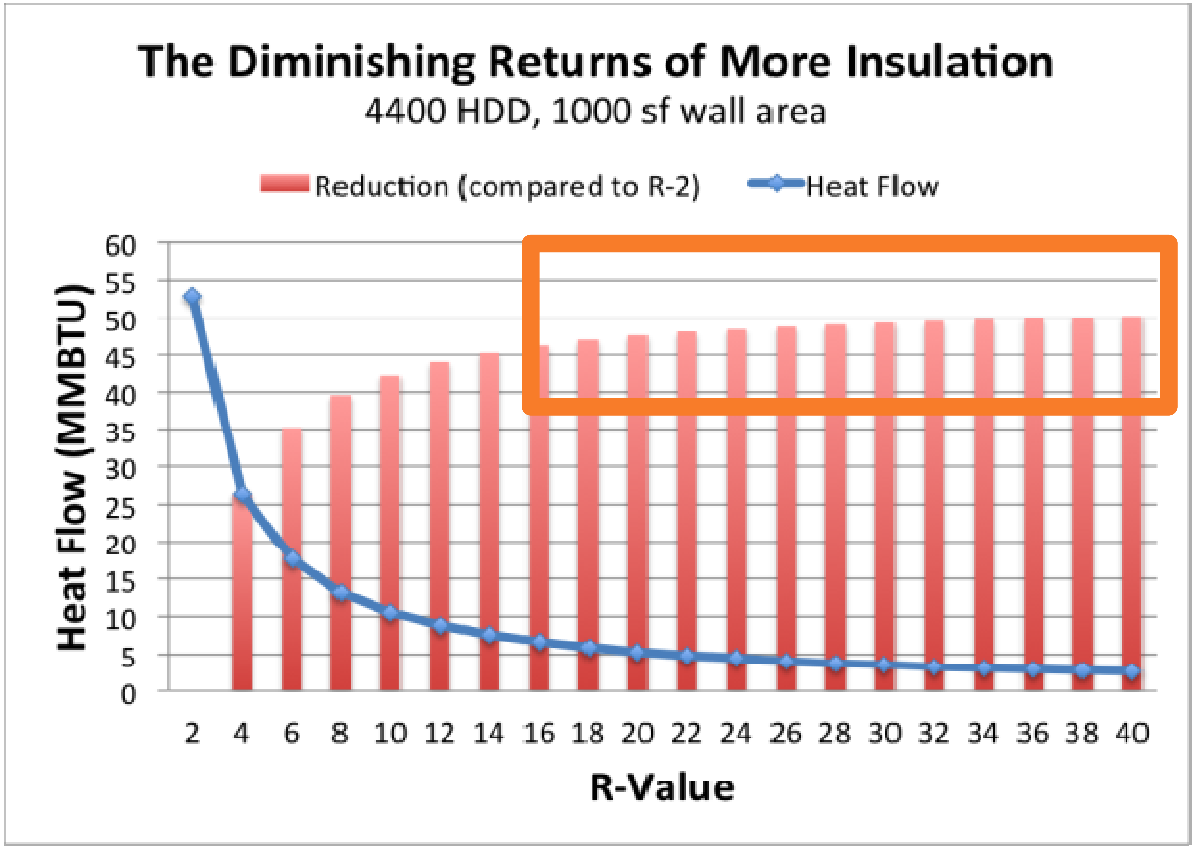
ONE SIZE DOES NOT FIT ALL

THERMAL COMFORT ISSUES



TOO MUCH FOCUS ON SOLAR

COST FOR TOO MUCH INSULATION PUSHES DESIGNS BACK INTO **DIMINISHING RETURNS**



(Source: www.energyvanguard.com)

LAST INCH OF INSULATION IN PASSIVE HOUSE PROJECT IN SOUTH DAKOTA SAVED 200 kWh ANNUALLY!

HOW FLAT IS TOO FLAT?

RELATIONSHIP BETWEEN DEGREE DAYS AND PEAKS CHANGES BY CLIMATE

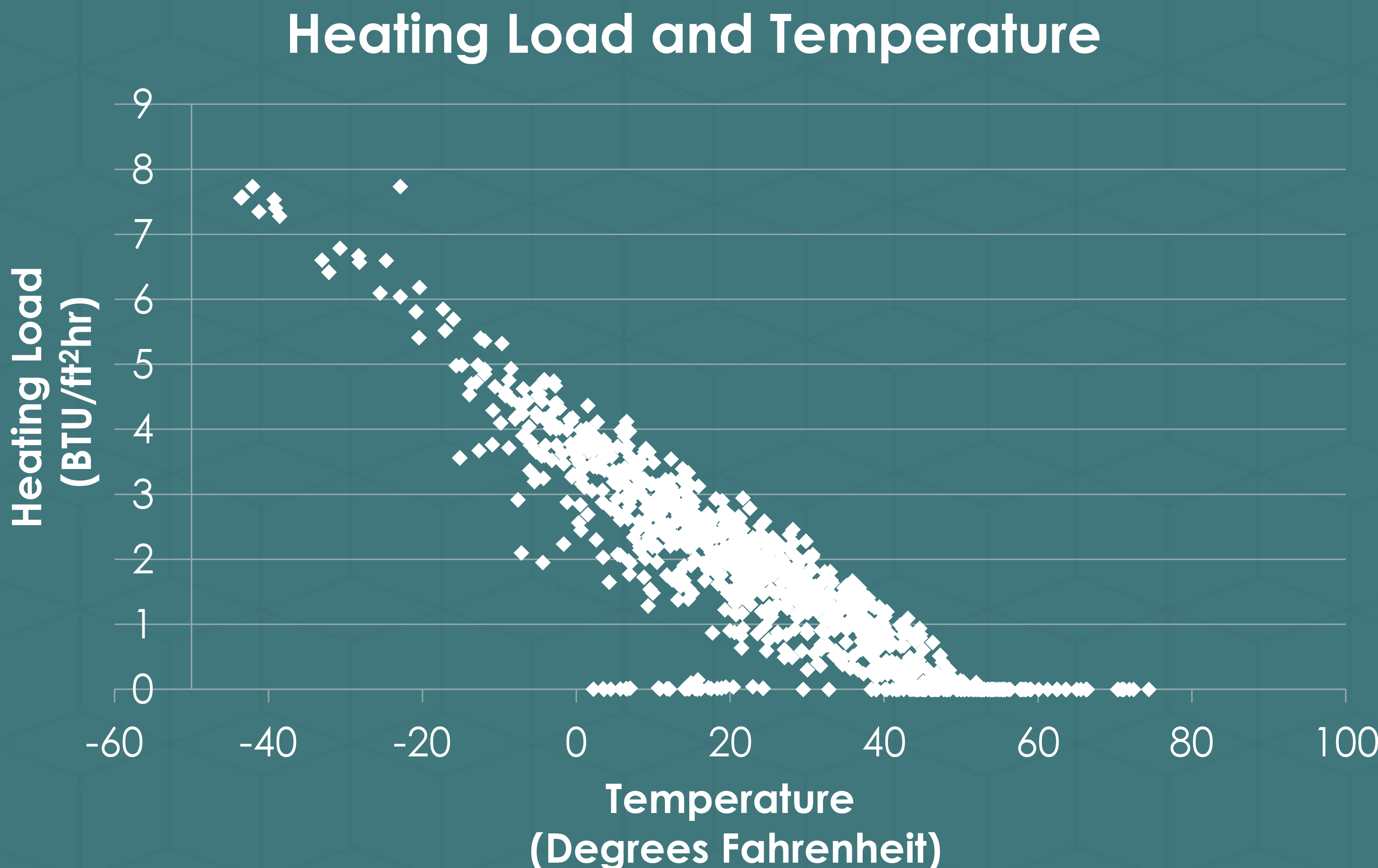
Table 2: Design temperatures and degree days, North America, Coastal, East

Cities	ASHRAE 99.6% design temp (°F)	ASHRAE 99% design temp (°F)	HDD65	CDD65
Frankfurt (5)	14.5	19.1	5570	308
Boston, MA (5A)	8.0	13.0	5596	750
Baltimore, MD (4A)	14.0	17.9	4552	1261
New York, NY (4A)	13.8	17.8	4843	984

Table 3: North America, Pacific Northwest

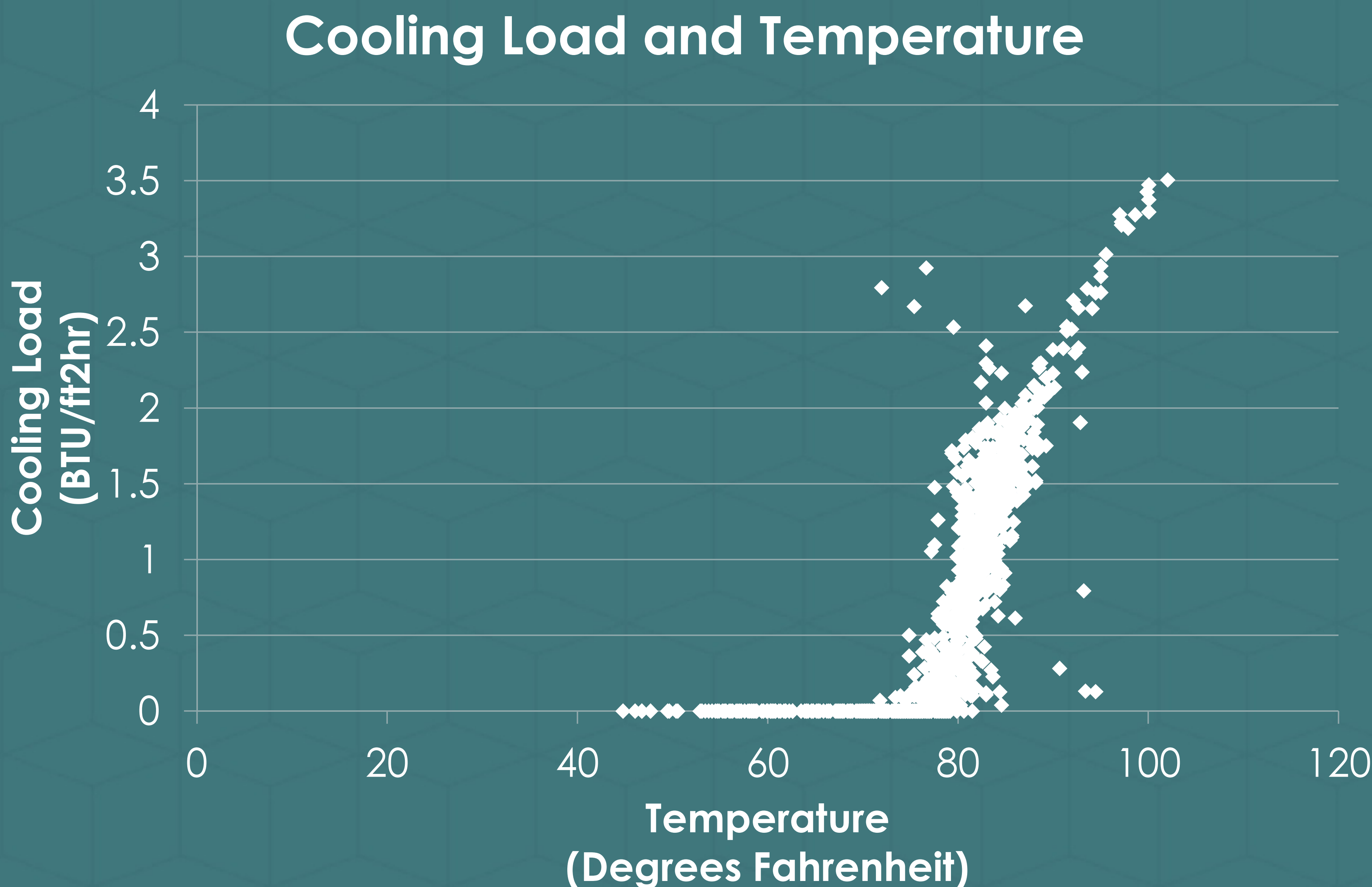
Cities	ASHRAE 99.6% design temp (°F)	ASHRAE 99% design temp (°F)	HDD65	CDD65
Frankfurt (5)	14.5	19.1	5570	308
Squamish, BC (5)	18.3	22.4	5987	115
Portland, OR (4C)	25.2	29.5	4214	433
Prince Rupert, BC (6)	13.3	18.4	6993	1

Peak Heat Load – United States



Peak Cooling Load – United States

(SENSIBLE ONLY)



INTERNAL GAINS AND CLIMATE

HAVE AN INFLUENCE ON WHERE CRITERIA NEED TO BE SET

Rue-Evans House, Salem, OR

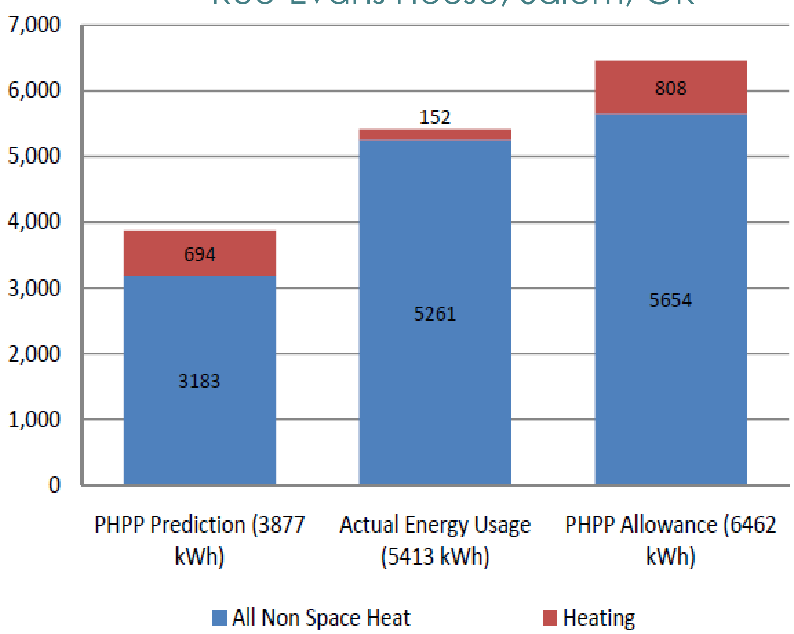


Figure 8: Modeled Energy Use Comparison

	Lighting kWh/person. yr	MELs kWh/person. yr
RESNET	~230	~610
Bldg. America	~320	~800-850
PHPP	31.9	94

Building:
2000 sf gross finished floor area Occupancy 4 persons
100% CFL
400 sf garage

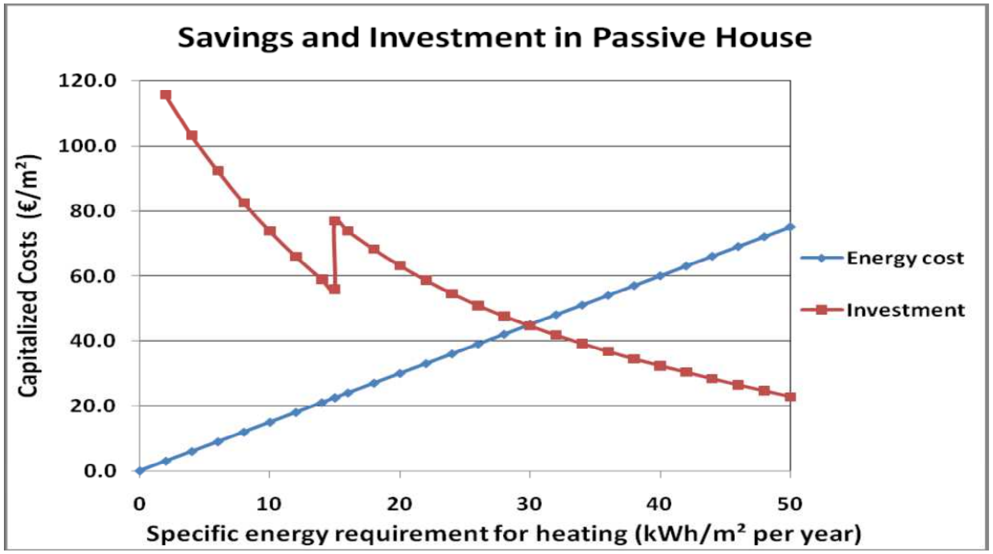
STUDY CONCLUSIONS:

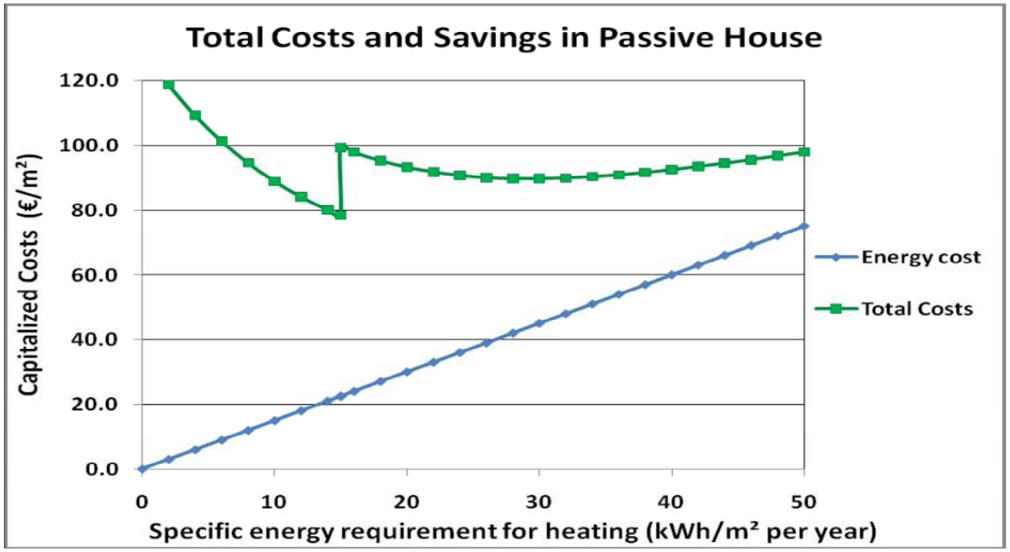
Therefore, taking North American construction cost, energy cost parameters, the cost of PV as well as different levels of investment required by climate into account will result in cost competitive climate specific space conditioning criteria ***other than 10 W/m² or 15 kWh/m²·yr (3.17 BTU/ft² hr or 4.75 kBTU/ft²·yr).***

One cannot optimize for PEAK LOAD and COST at the same time everywhere!!!!!

INVESTMENT IN DURABLE **ENCLOSURE** IS OFFSET BY DOWNSIZED MECHANICALS AND SAVINGS

Cost assumptions for Central Europe

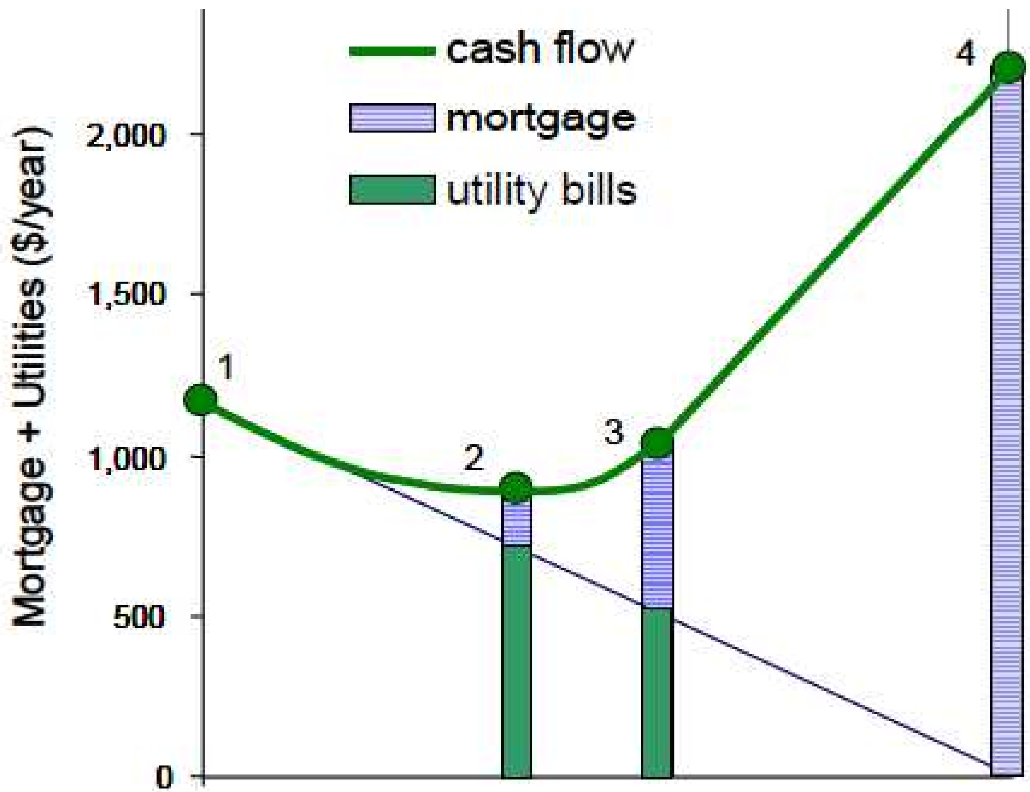




(Source: IEA Information Paper: Energy Efficiency requirements in Building Codes, Author Jens Laustsen)

DIFFERENT US COST STRUCTURE IMPLIES DIFFERENT **ECONOMIC** OPTIMUM

Cost assumptions for US



(Source: NREL/DOE)

THE CONCEPT CONTINUES TO DEVELOP

CLIMATE SPECIFIC METRICS

4 PASS/FAIL CRITERIA – 3 HURDLES TO ZERO

Developed by PHIUS/BSC

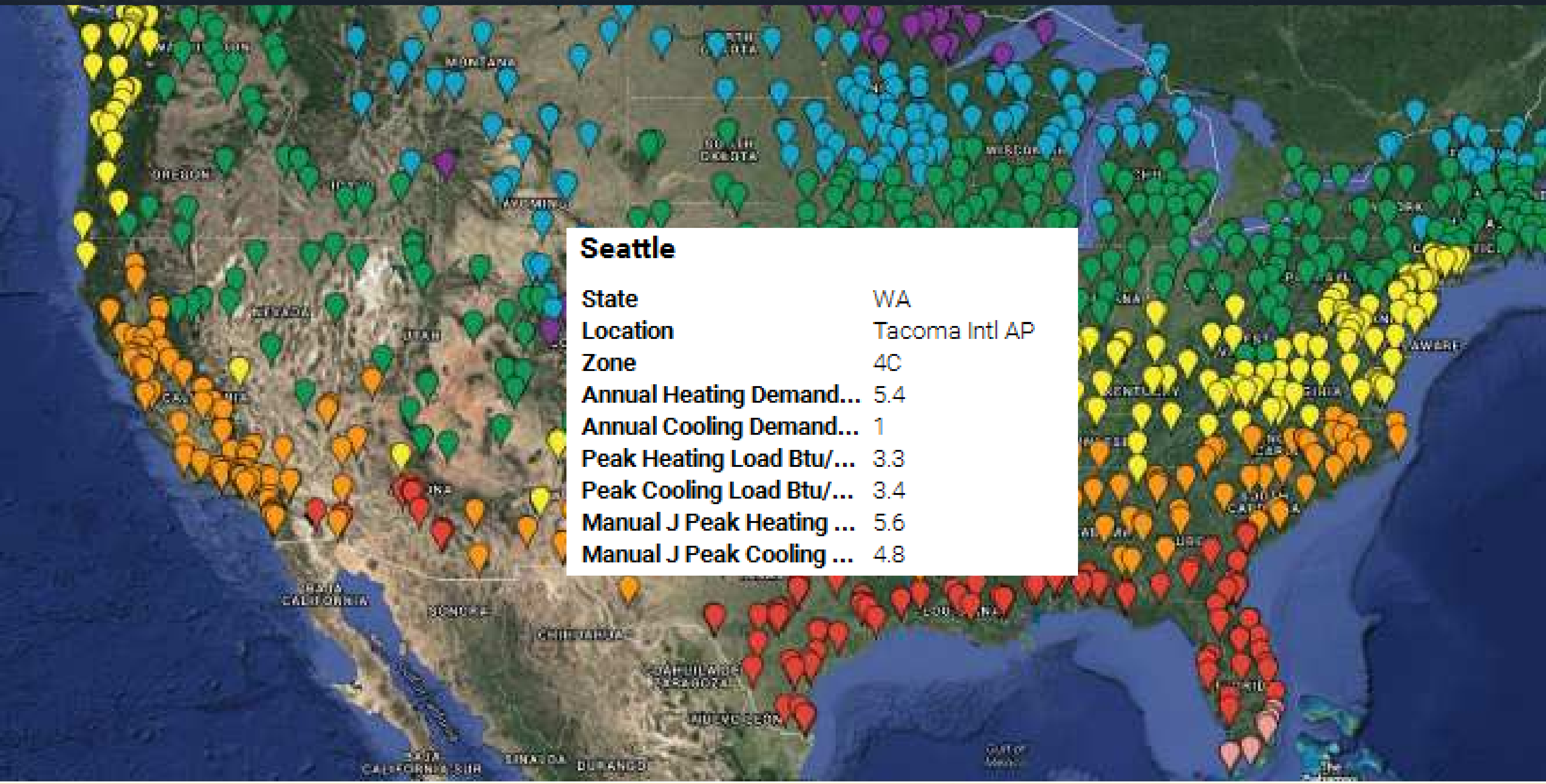
Annual Heat/Cooling Demand	• *Heat load ≤ varies by climate* • *Cooling load ≤ varies by climate*	Sliding scale by climate, cold climate example
--*AND*--		
Peak Loads	• *Peak heat load ≤ varies by climate* • *Peak cooling load ≤ varies by climate*	Sliding scale by climate, cold climate example
Primary Energy Demand	• ≤ 4200 (6200 TEMP) kWh/person	Change to a per person metric for residential and some PV counts
Airtightness	• ≤ 0.05 cfm50/sf envelope	ACH50 does not scale for larger buildings

PHIUS+ 2015 PASSIVE BUILDING CRITERIA

Primary Energy	kBTU/ft²/yr	(Bedrooms+1 * (6000 kWh *3.412 kBTU/kWh))/iCFA
Airtightness	cfm/ft²	0.05 cfm/gross ft² shell @ 50 pa
		0.08 cfm/gross ft² shell @ 75 pa
Annual Heat Demand	kBTU/ft²/yr	1.0 - 12.0
Annual Cooling Demand		1.0 - 21.4
Peak Heat Load	BTU/ft².hr	0.8 - 5.4
Peak Cooling Load		1.8 - 8.9
Ventilation	% efficiency	53% - 95%
	W/cfm	0.27 - 2.23
Thermal Envelope	hr. ft²°F/BTU	≈ R-25 - R-80
	BTU/hr. ft² °F	≈ U-0.04 - U-0.0125
Thermal Bridge Free	BTU/ hr. ft °F	Ψ ≤ 0.006
Windows Installed	BTU/hr. ft² °F	Uw-install 0.41 - 0.08
SHGC	%	≈ 0.27 - 0.61

CLIMATE SPECIFIC METRICS

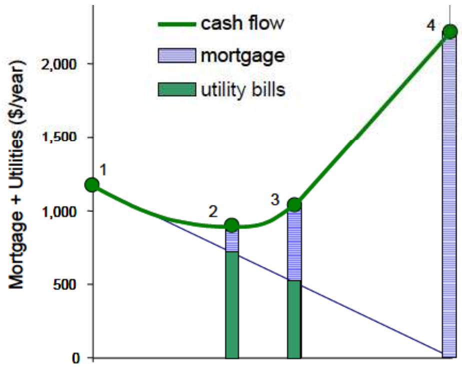
PASSIVE STANDARDS IN VARYING CLIMATES

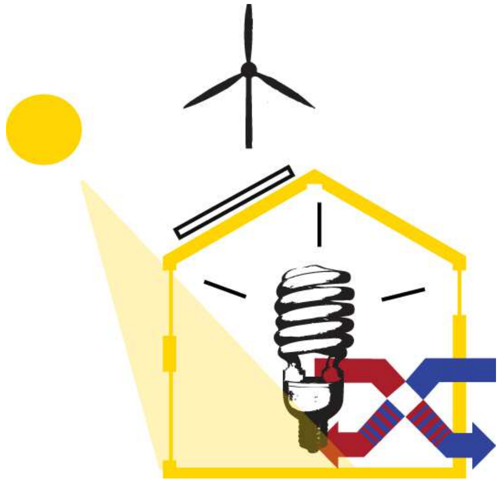


REFINING THE
METHODOLOGY

Climate Specific & Cost Optimal Standards

Developed by US Industry



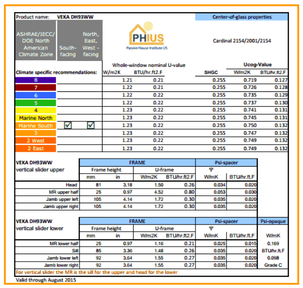


- NREL BEopt optimizes upgrade package by climate
- Standards defined as cost optimal/competitive sweetspot between conservation and generation ***on the path to zero***

REFINING THE METHODOLOGY

Climate Specific Components/Tools

Developed by European & US Industry



Product name: VEKA DH93WW

PHIUS Passive House Institute US

Center-of-glass properties: Cardinal 2154/2001/2154

ASHRAE/IECC/DOE North American Climate Zone	South-facing	North, East, West - facing	Whole-window nominal U-value W/m2K	Whole-window nominal U-value BTU/hr.ft2.F	SHGC	Ucog-Value W/m2K	Ucog-Value BTU/hr.ft2.F
Climate specific recommendations:							
8			1.21	0.21	0.255	0.719	0.127
7			1.22	0.21	0.255	0.726	0.128
6			1.22	0.22	0.255	0.735	0.129
5			1.22	0.22	0.255	0.737	0.130
4			1.23	0.22	0.255	0.741	0.131
Marine North			1.23	0.22	0.255	0.745	0.131
Marine South	☑	☑	1.23	0.22	0.255	0.750	0.132
3			1.23	0.22	0.255	0.747	0.132
2 West			1.23	0.22	0.255	0.749	0.132
2 East			1.23	0.22	0.255	0.749	0.132

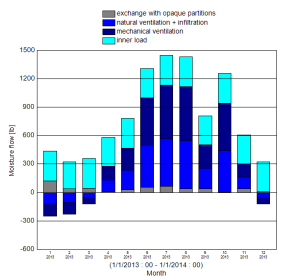
VEKA DH93WW vertical slider upper	FRAME: Frame height mm	Frame height in	U-frame W/m2K	U-frame BTU/hr.ft2.F	Psi-spacer Ψ W/mK	Psi-spacer BTU/hr.ft.F
Head	81	3.18	1.50	0.26	0.034	0.020
MR upper half	25	0.97	4.52	0.80	0.053	0.030
Jamb upper left	105	4.14	1.72	0.30	0.035	0.020
Jamb upper right	105	4.14	1.72	0.30	0.035	0.020

VEKA DH93WW vertical slider lower	FRAME: Frame height mm	Frame height in	U-frame W/m2K	U-frame BTU/hr.ft2.F	Psi-spacer Ψ W/mK	Psi-spacer BTU/hr.ft.F	Psi-opaque W/mK
MR lower half	25	0.97	1.16	0.21	0.025	0.015	0.169
Sill	85	3.36	1.48	0.26	0.035	0.020	BTU/hr.ft.F
Jamb lower left	92	3.64	1.55	0.27	0.035	0.020	0.098
Jamb lower right	92	3.64	1.55	0.27	0.035	0.020	Grade C

For vertical slider the MR is the sill for the upper and head for the lower

Valid through August 2015

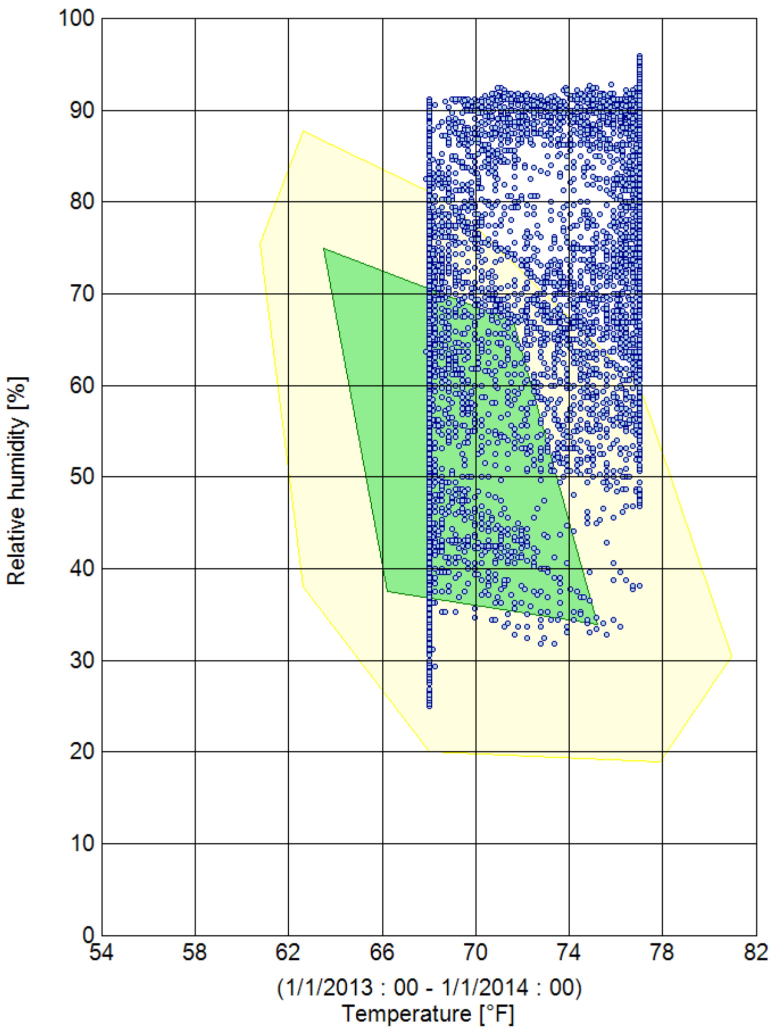
- High performance window performance rating by climate

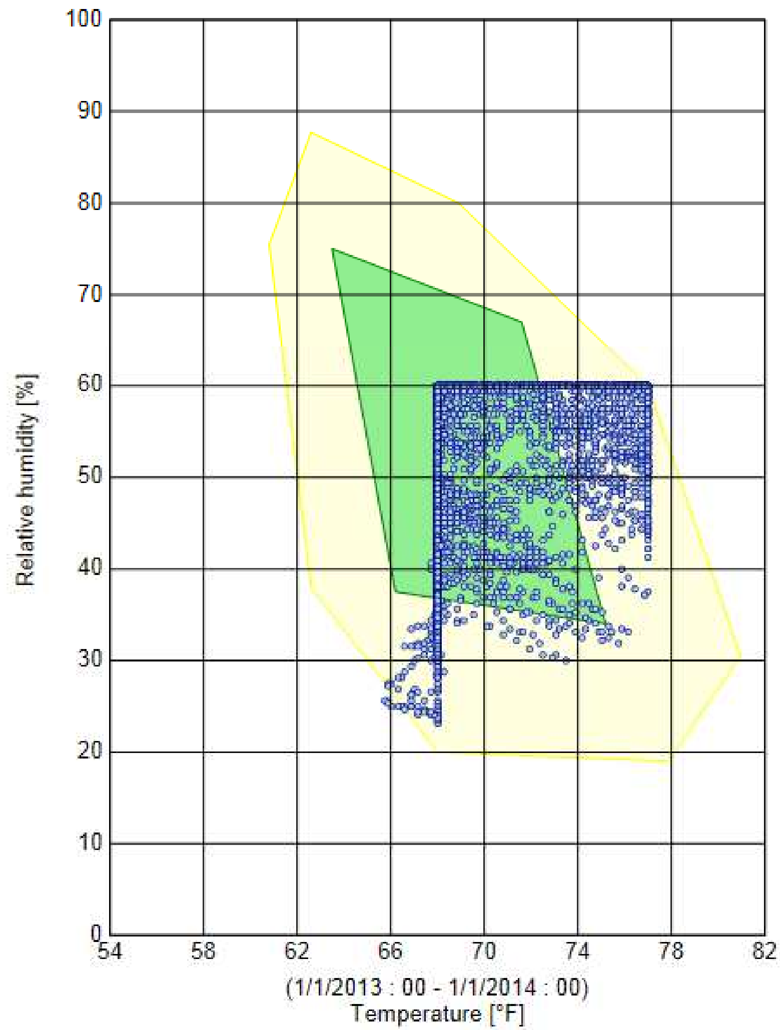


- Dynamic Design&Verification Tool **WUFI Passive**

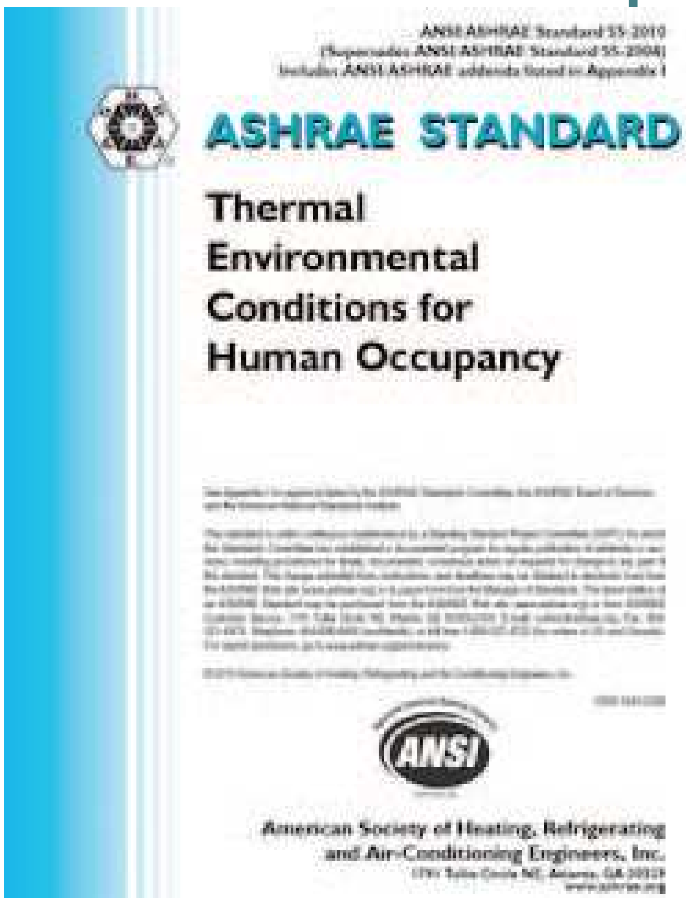
- On demand integrated ventilation & space conditioning systems

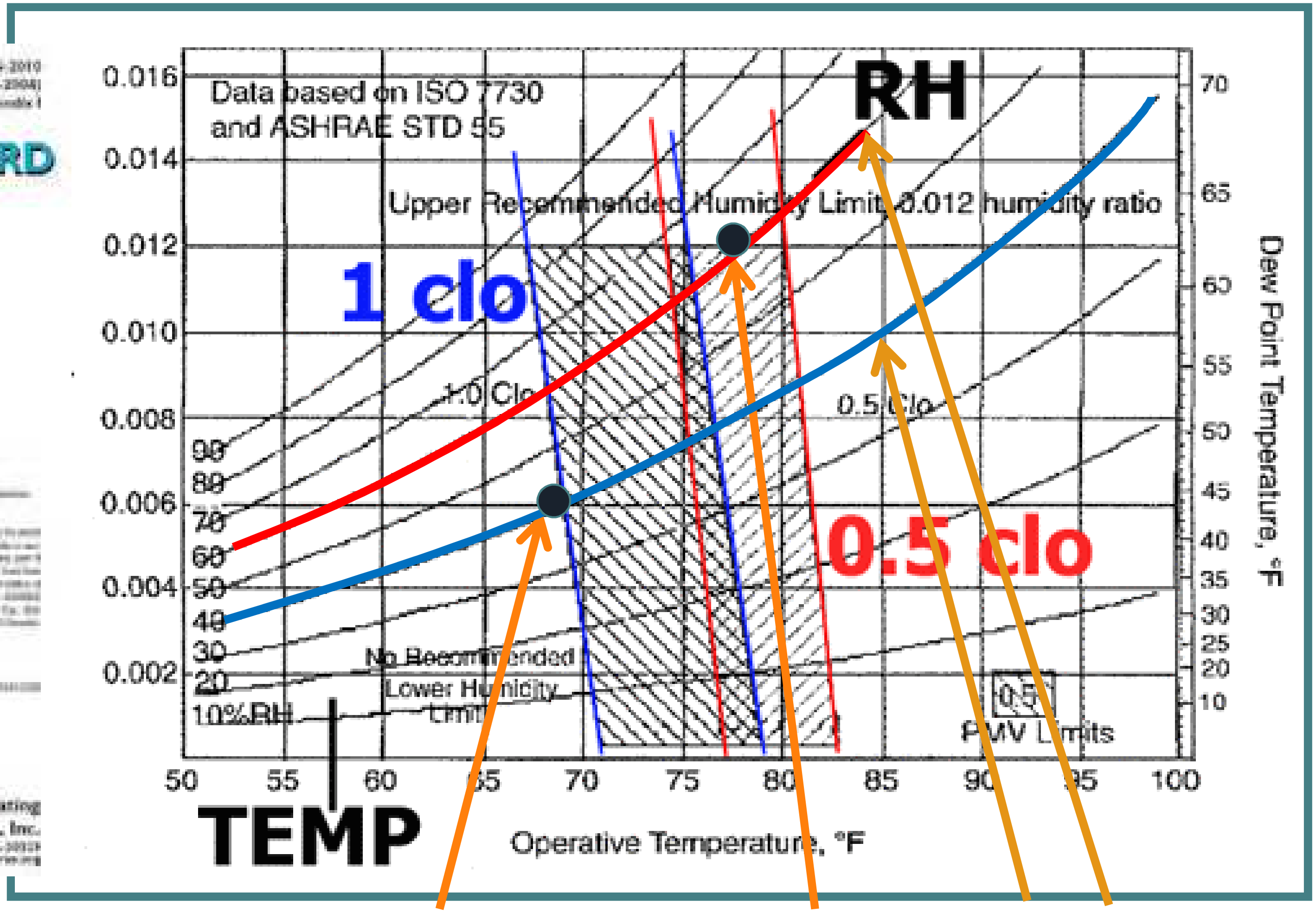
STATIC MODEL NEEDS TO BE REPLACED WITH DYNAMIC MODELING TO ASSESS THERMAL COMFORT





PH **THERMAL COMFORT** RANGE

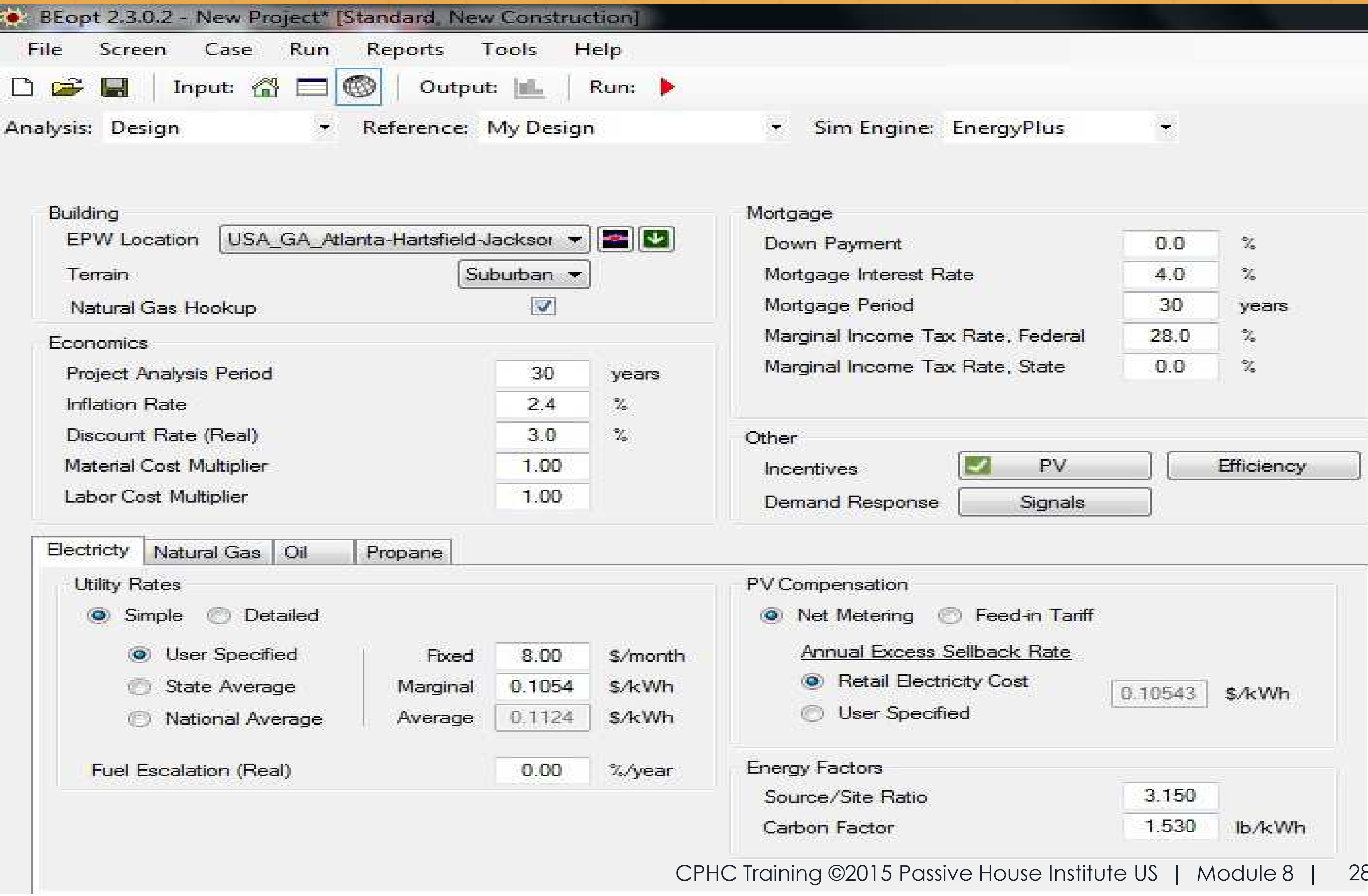




Interior comfort conditions winter 68 º F, summer 77 º F, RH 40-60%

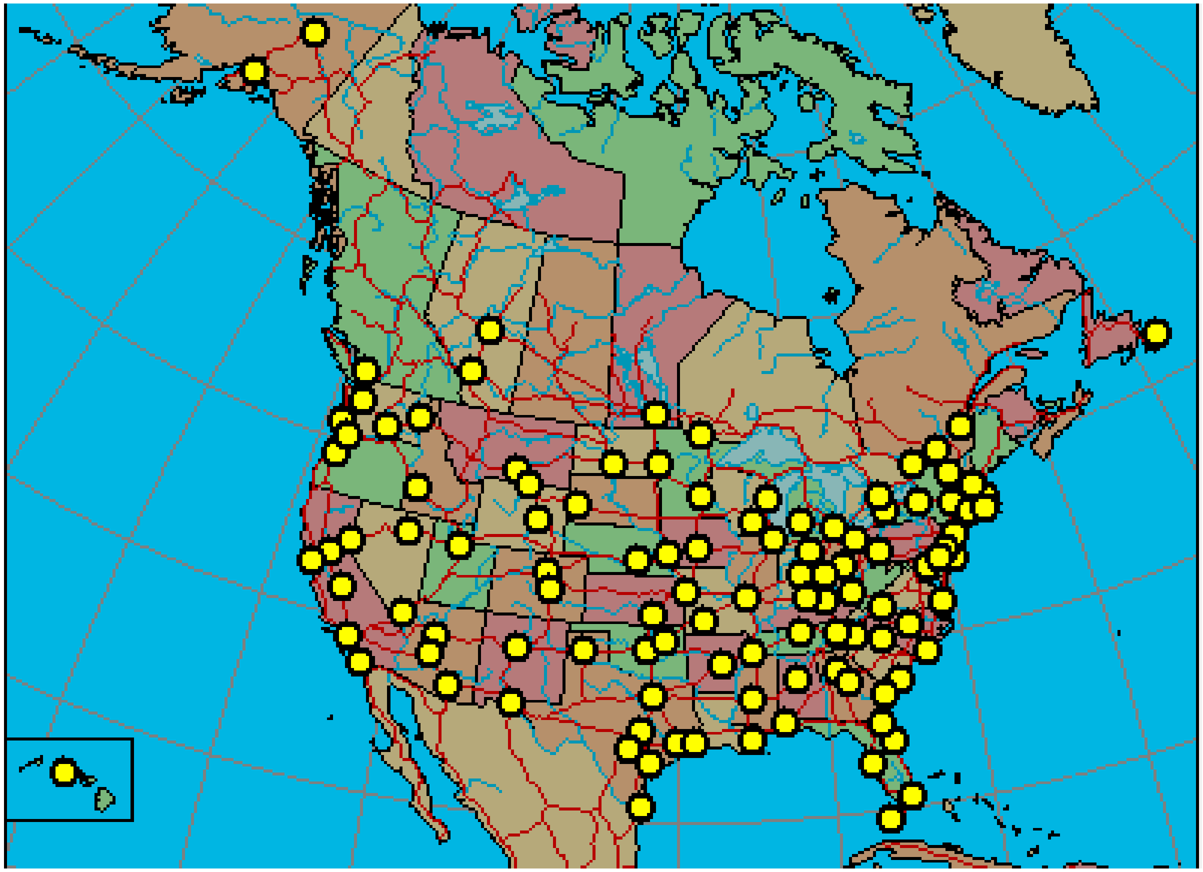
Source: ASHRAE Standard 55-2010 Thermal Environmental Conditions for Human Occupancy

BEOPT COST ANALYSIS **FACTORS**



(Source: NREL/DOE)

100+ LOCATIONS IN **NORTH AMERICA** WERE CALCULATED IN BEOPT FOR A 2000 SQFT TEST HOUSE

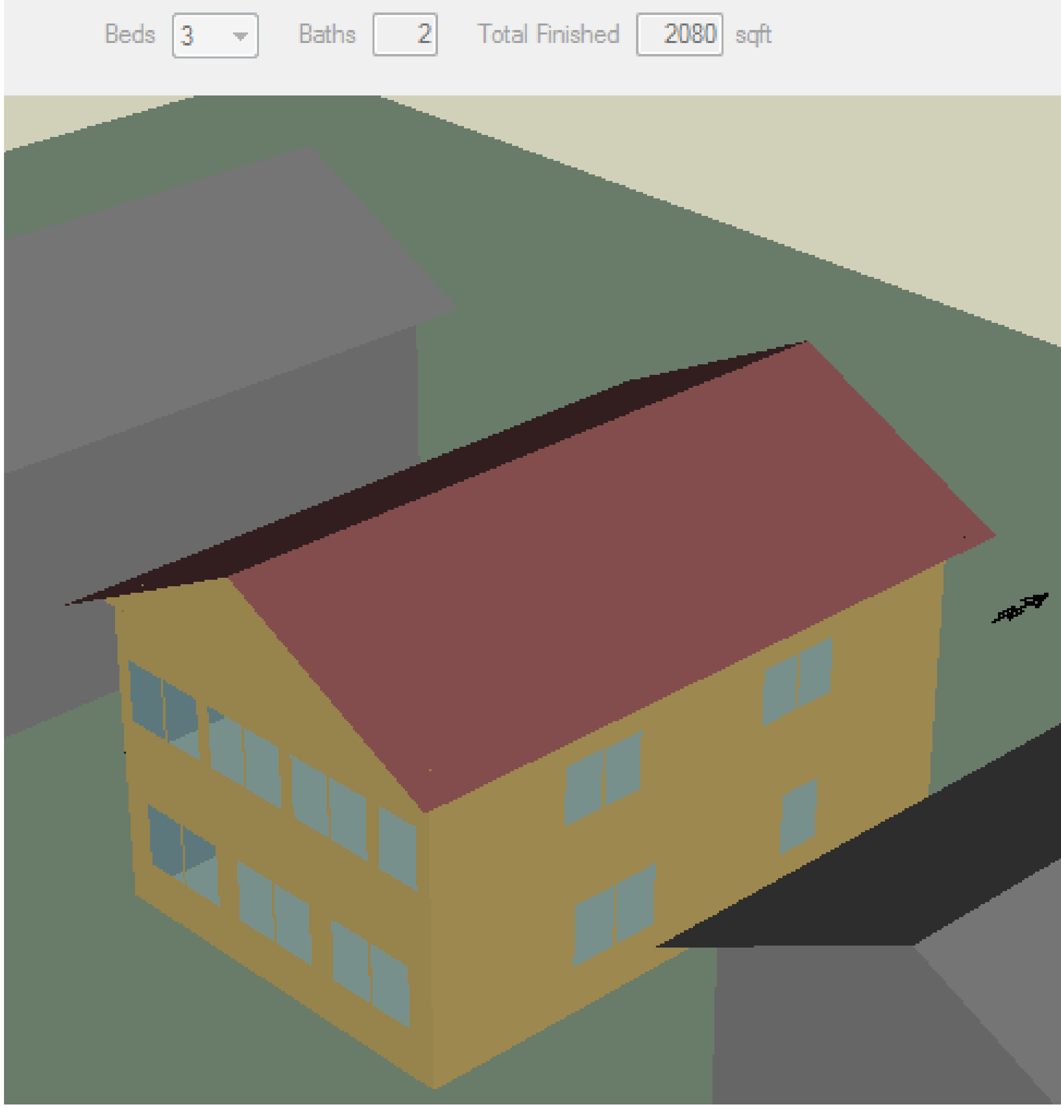


These are the locations for which WUFI weather data is available, which supports dynamic calculations for comfort verification and hygrothermal checks.

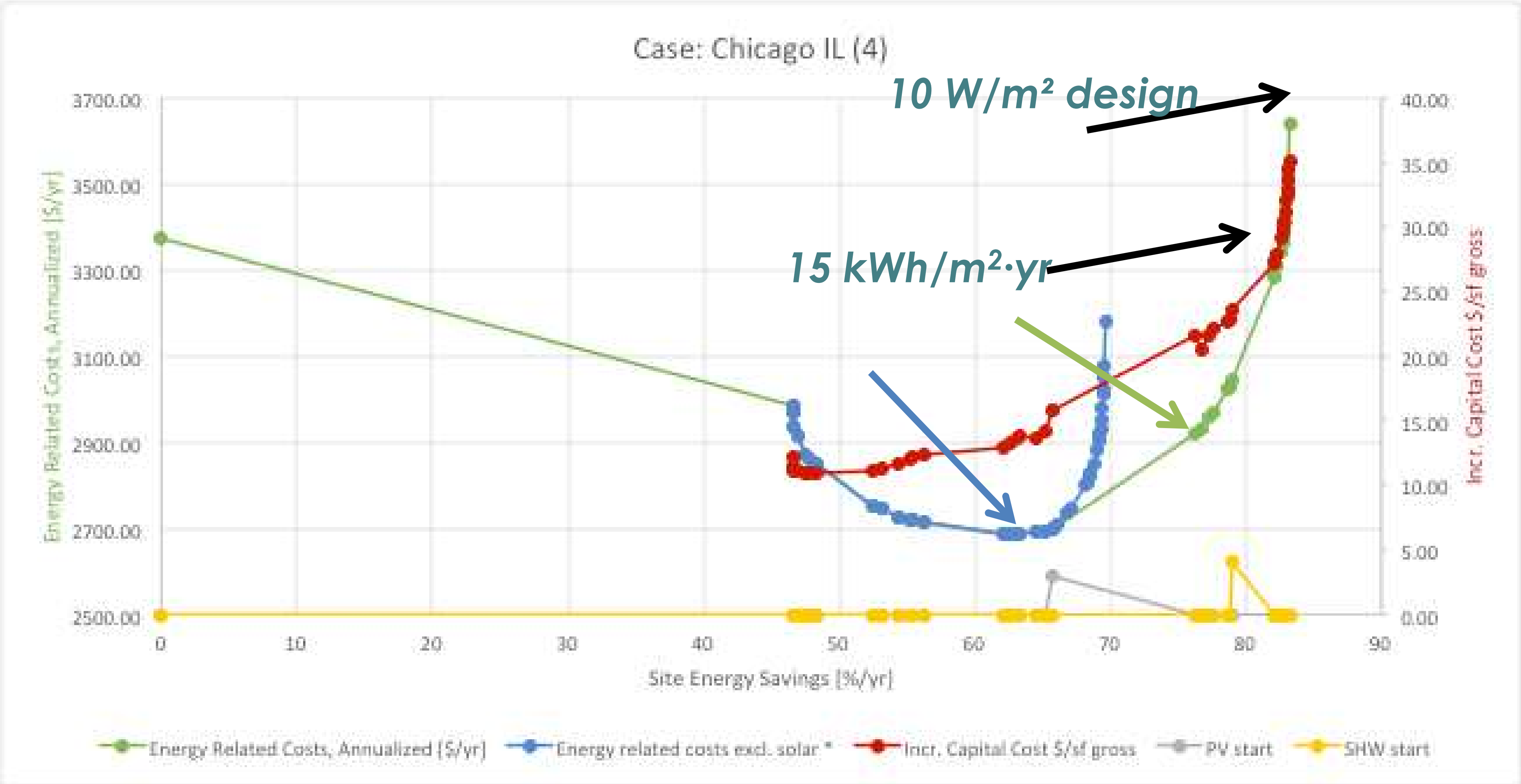
COST –ENERGY **STUDIES**

Studies with BEopt:

- 40x26 ft exterior, short south.
- 2 stories. Nbrs @ 20 feet.
- 3-bdrm 2-bath.
- Vented attic.
- Wall exterior-foam.
- Slab foundation.
- Window U-values constrained for comfort.
- Window area 15% of wall area, up to 40% conc. on South.
- Air-tight, ducts inside.
- All-electric.

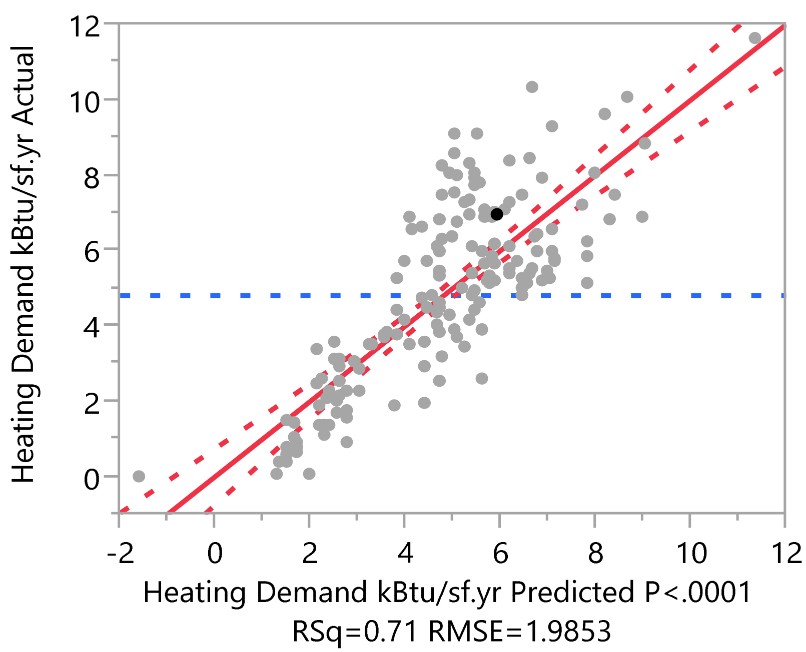


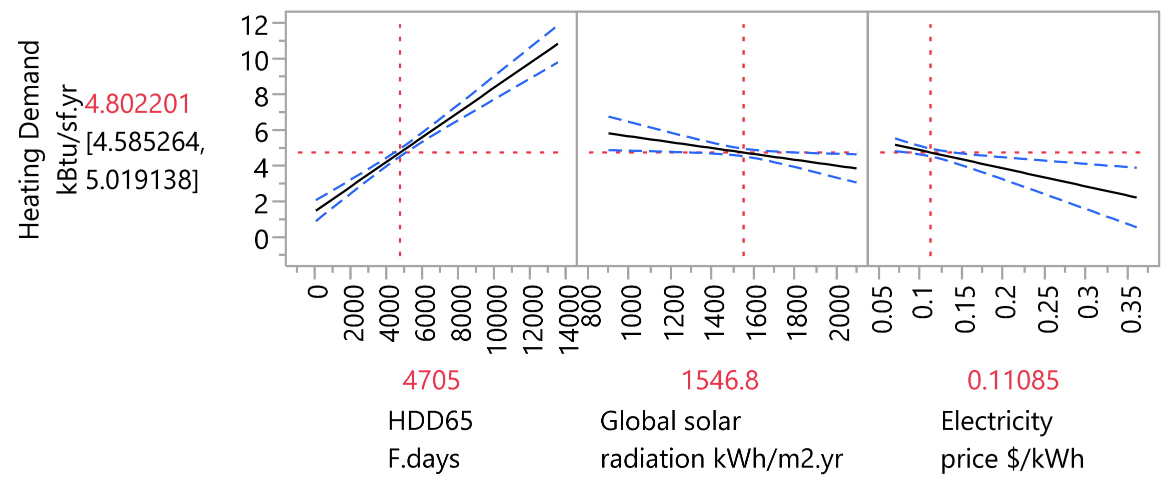
STANDARDS WERE SET JUST PAST THE **ECONOMIC** OPTIMUM



CURVE FIT OF ALL RESULTS - SIMPLIFIED FORMULA FOR ANNUAL HEATING DEMAND & ADJUSTMENTS FOR SOLAR AND ELECTRICITY COST

Actual by Predicted Plot – Annual Heating Demand





$$SSHD\ kBtu/ft2.yr = 5.2 + \frac{HDD65}{1445} - \frac{Solar\frac{kWh}{m2\cdot yr}}{610} - 10.1 * Elec\ \$/kWh$$

THE SIMPLIFIED **FORMULA** IS THEN INCORPORATED INTO THE ENERGY MODEL FOR DESIGN **VERIFICATION**

PASSIVEHOUSE REQUIREMENTS

Certificate Criteria:

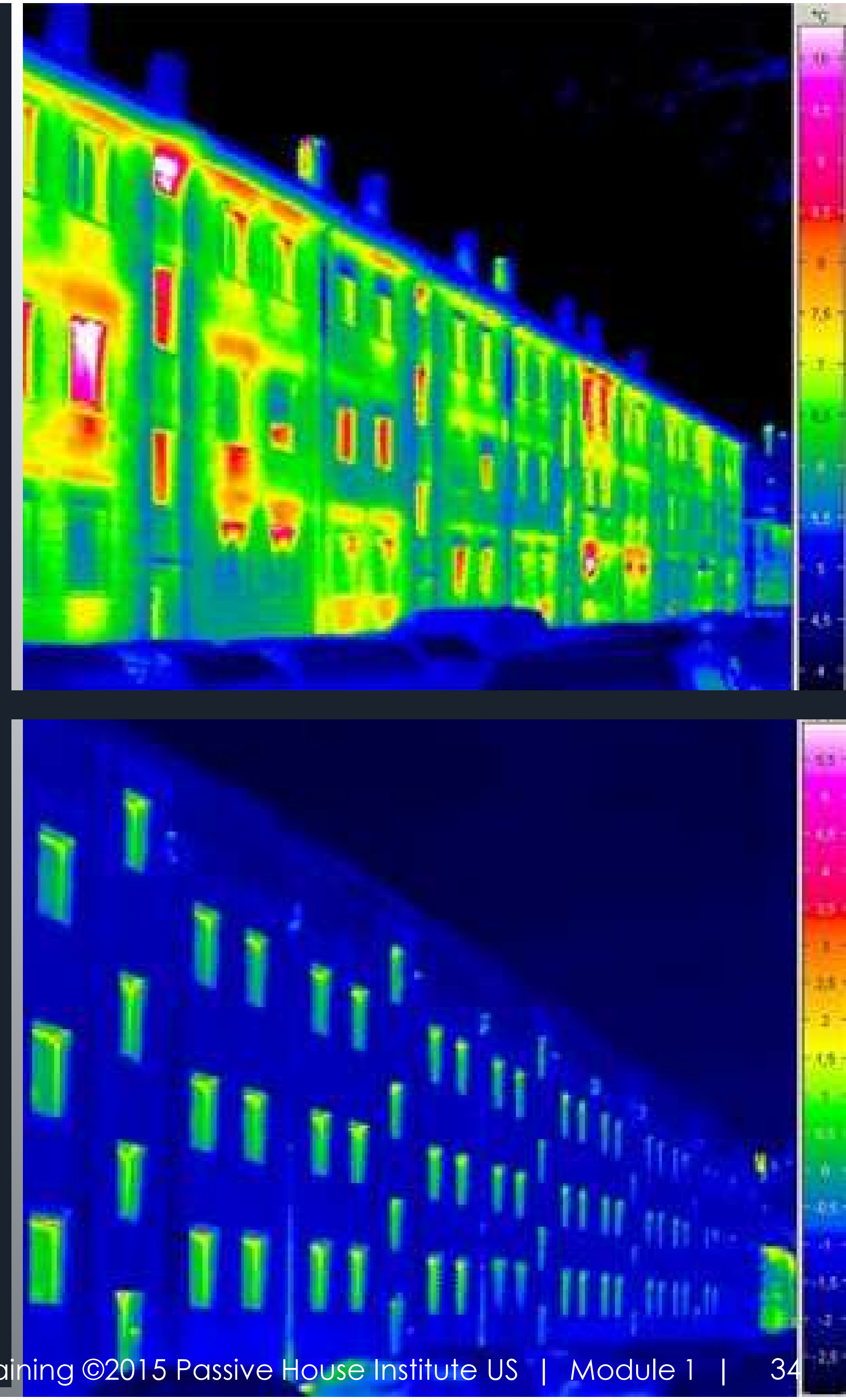
Heating Demand			
specific:	**4.3**	kBtu/ft²yr	✓
total:	7892.5	kBtu/yr	
peak (month):	1.5	kBtu/ft²	
Cooling Demand			
specific:	**7.5**	kBtu/ft²yr	
total:	13824.8	kBtu/yr	
peak (month) - sensible:	1.2	kBtu/ft²	
latent:	3.1	kBtu/ft²yr	
Heating Load			
specific:	**4.8**	Btu/hr ft²	
total:	8804.6	Btu/hr	
Cooling Load			
specific:	**2.6**	Btu/hr ft²	✓
total:	4869.4	Btu/hr	
Primary Energy			
specific:	**33.2**	kBtu/ft²yr	✓
total:	61468.6	kBtu/yr	
Air Tightness ACH50	**0.6**	1/hr	✓

WUFI® PASSIVE Passive — Page 2

PRINCIPLE 3:
HIGH PERFORMANCE WINDOWS/ DOORS

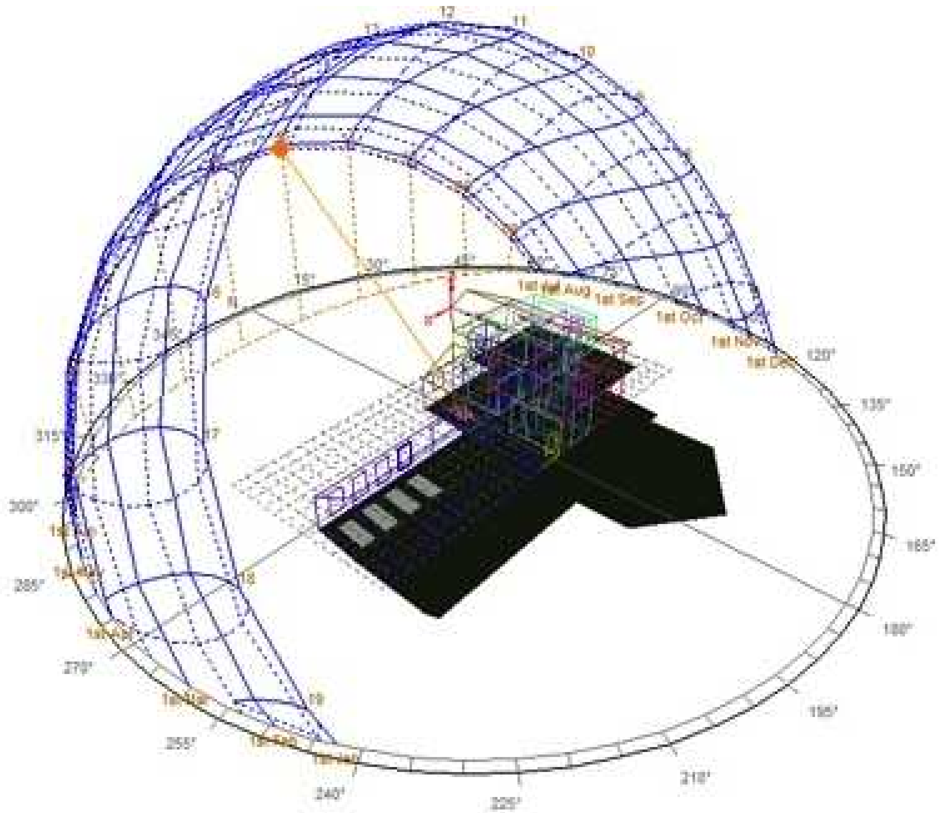
MINIMIZE LOSSES

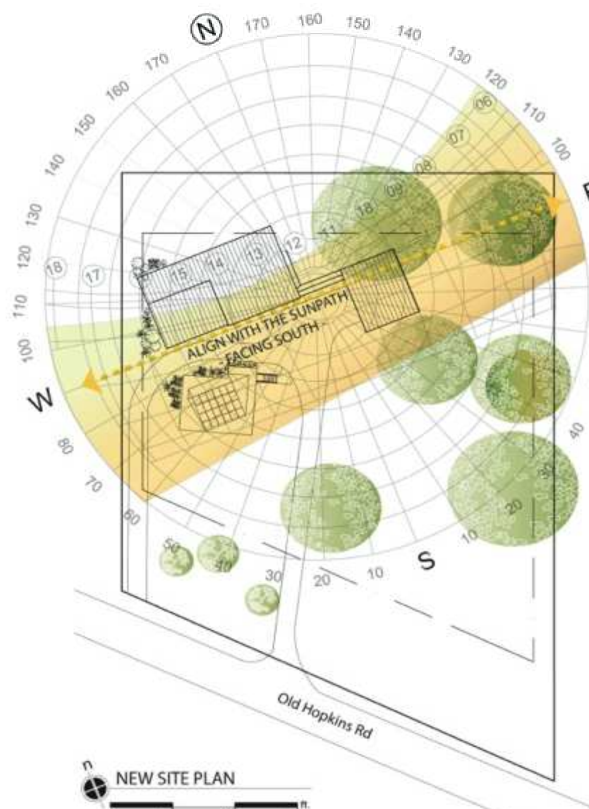
OPTIMIZE GAINS



BEGIN WITH UNDERSTANDING THE SITE AND CLIMATE

SITE AND CLIMATE

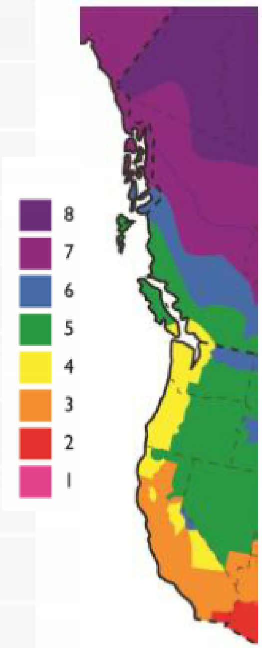




WINDOW PERFORMANCE CERTIFICATION

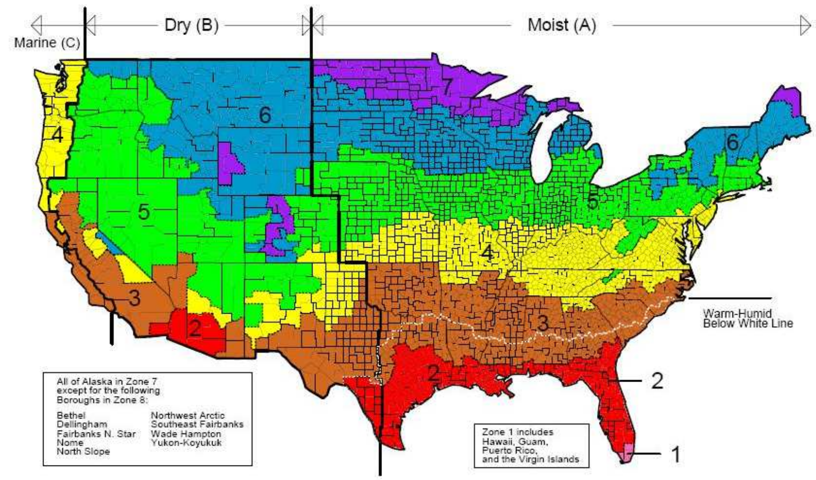
WINDOWS NEED TO BE DESIGNED TO RESPOND TO THE CLIMATE CONDITIONS

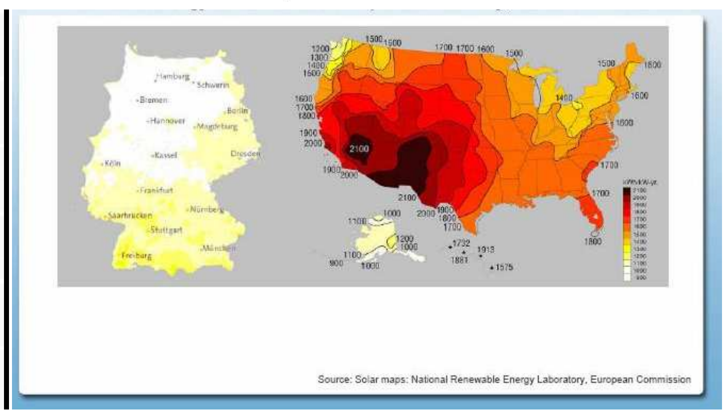
PHIUS – Climate Specific Window Selection Guidelines



ASHRAE/DOE North American Climate Zone	Overall Installed Window U-value - U_w Btu/hr·ft²·°F	Center of Glass U-value - U_g Btu/hr·ft²·°F	SHGC – South	SHGC – North East, West
8	≤0.11	≤0.10	≥0.50	≤0.40
7	≤0.12	≤0.11	≥0.50	≤0.40
6	≤0.13	≤0.12	≥0.50	≤0.40
5	≤0.14	≤0.13	≥0.50	≤0.40
4	≤0.15	≤0.14	≥0.50	≤0.40
Marine North	≤0.16	≤0.15	≥0.50	≤0.40
Marine South	≤0.22	≤0.20	≤0.50	≤0.30
3 (west)	≤0.18	≤0.16	≤0.50	≤0.30
2 (west)	≤0.18	≤0.16	≤0.30	≤0.30
2 (east)	≤0.20	≤0.18	≤0.30	≤0.30

Reference: Table Values PHIUS, Climate Map DOE/ASHRAE/NECB Zones by RDH





Source: www.energycodes.gov

Product name: VEKA DH93WW

Cardinal 2154/2001/2154

ASHRAE/IECC/ DOE North American Climate Zone	South-facing	North, East, West - facing	Whole-window nominal U-value W/m2K	Whole-window nominal U-value BTU/hr.ft2.F	Center-of-glass properties SHGC	Ucog-Value W/m2K	Ucog-Value BTU/hr.ft2.F
Climate specific recommendations:							
8			1.21	0.21	0.255	0.719	0.127
7			1.22	0.21	0.255	0.726	0.128
6			1.22	0.22	0.255	0.735	0.129
5			1.22	0.22	0.255	0.737	0.130
4			1.23	0.22	0.255	0.741	0.131
Marine North			1.23	0.22	0.255	0.745	0.131
Marine South	☑	☑	1.23	0.22	0.255	0.750	0.132
3			1.23	0.22	0.255	0.747	0.132
2 West			1.23	0.22	0.255	0.749	0.132
2 East			1.23	0.22	0.255	0.749	0.132

VEKA DH93WW vertical slider upper	FRAME Frame height mm	FRAME Frame height in	U-frame W/m2K	U-frame BTU/hr.ft2.F	Psi-spacer Ψ W/mK	Psi-spacer Ψ BTU/hr.ft.F
Head	81	3.18	1.50	0.26	0.034	0.020
MR upper half	25	0.97	4.52	0.80	0.053	0.030
Jamb upper left	105	4.14	1.72	0.30	0.035	0.020
Jamb upper right	105	4.14	1.72	0.30	0.035	0.020

VEKA DH93WW vertical slider lower	FRAME Frame height mm	FRAME Frame height in	U-frame W/m2K	U-frame BTU/hr.ft2.F	Psi-spacer Ψ W/mK	Psi-spacer Ψ BTU/hr.ft.F	Psi-opaque W/mK
MR lower half	25	0.97	1.16	0.21	0.025	0.015	0.169
Sill	85	3.36	1.48	0.26	0.035	0.020	BTU/hr.ft.F
Jamb lower left	92	3.64	1.55	0.27	0.035	0.020	0.098
Jamb lower right	92	3.64	1.55	0.27	0.035	0.020	Grade C

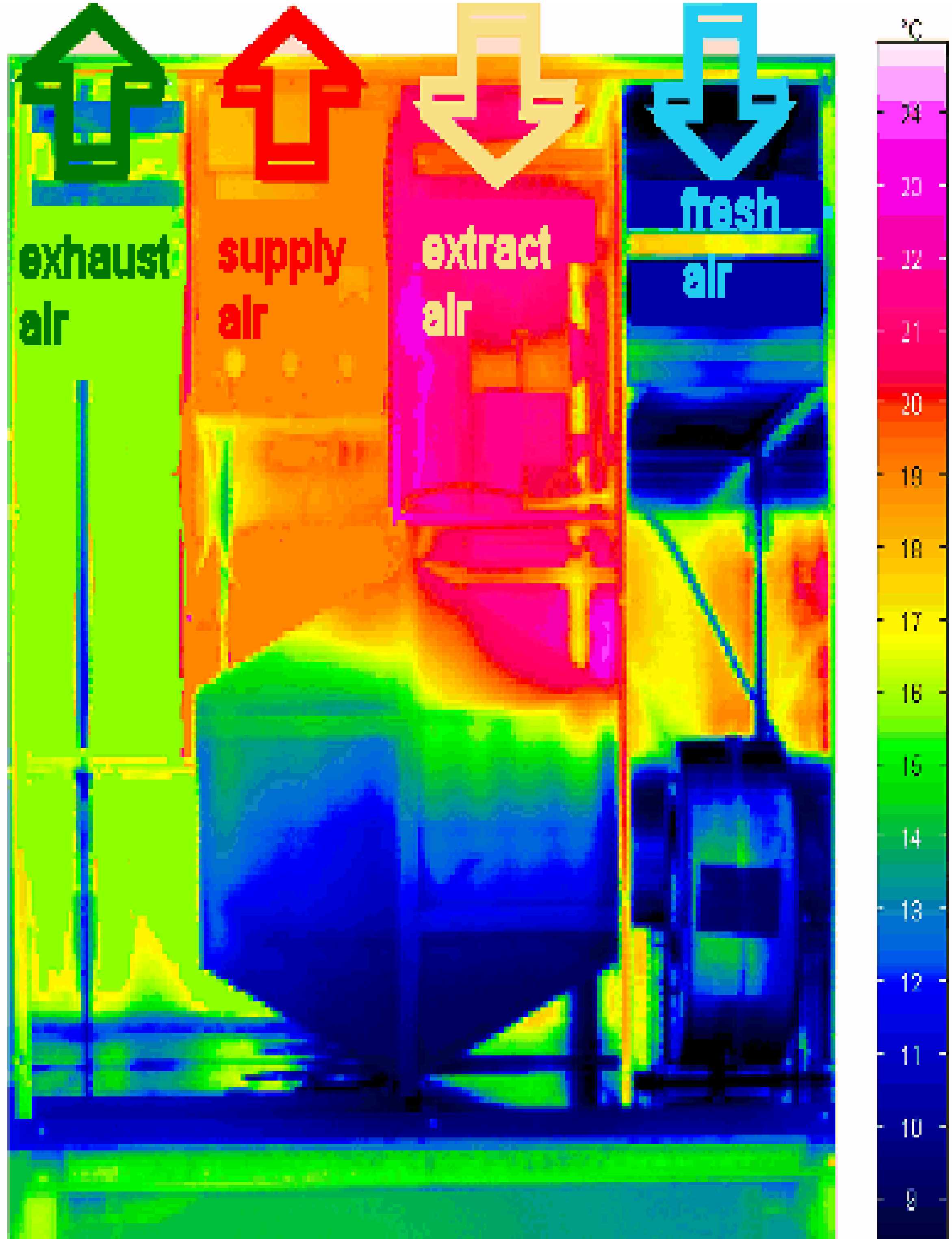
For vertical slider the MR is the sill for the upper and head for the lower

Valid through August 2015

PERFORMANCE DATA VERIFIED BY CLIMATE ZONE

PRINCIPLE 4: **BALANCED VENTILATION:**

HEAT & **MOISTURE** RECOVERY
POLLUTANT REMOVAL



Most Popular Models

Zehnder ComfoAir 350 (ERV/HRV)

UltimateAir 200DX (ERV)

STUDY CONCLUSIONS

Apply uniform source energy limit per person – fair-share principle to meet globally needed reduction targets.

Space conditioning criteria optimized to benefit the building owners and occupants, recalibrated for economic feasibility, comfort and resilience.

Under the both-and system, more projects will likely find themselves challenged on peak loads and source instead of annual heat demand.

It will tend to favor higher occupancy and more efficient forms of housing, discourage under populated McMansions, soften the small homes penalty.

Mileage will vary but level of envelope improvement should be much closer to an economic optimum in relationship to zero and the cost of PV

THANK YOU

Passive House Institute US

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