PASSIVE HOUSE ALLIANCE UNITED STATES

PHIUS

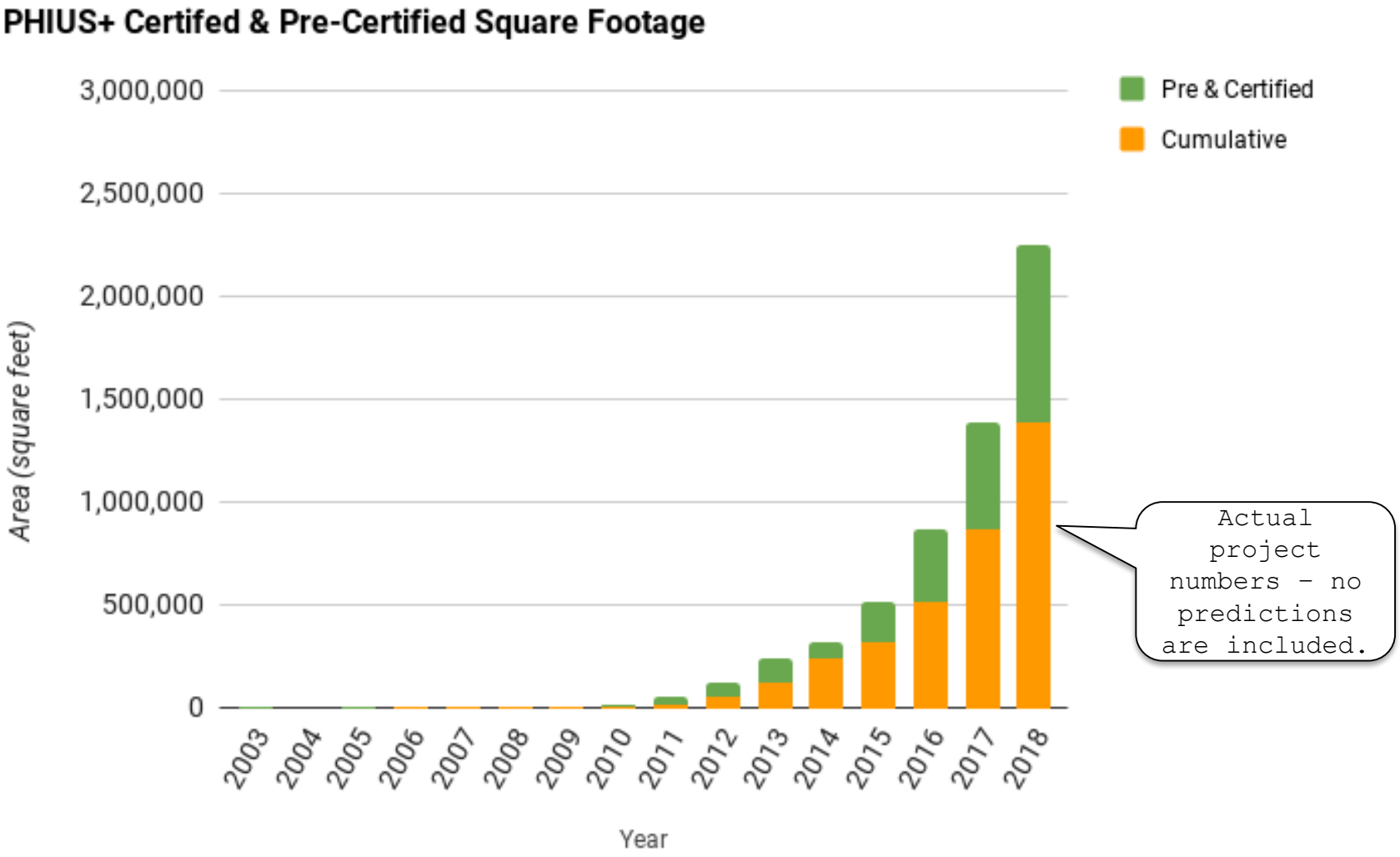
Passive House Institute US

PHIUS+ 2018

A Rational Exuberance for Passive Building

Graham S. Wright, Ph.D.
Lisa White, M.Sc.

PHIUS+ 2015 quite successful



Why certify? It shares the knowledge:

- Of how to do this
- That anything is happening

Overview

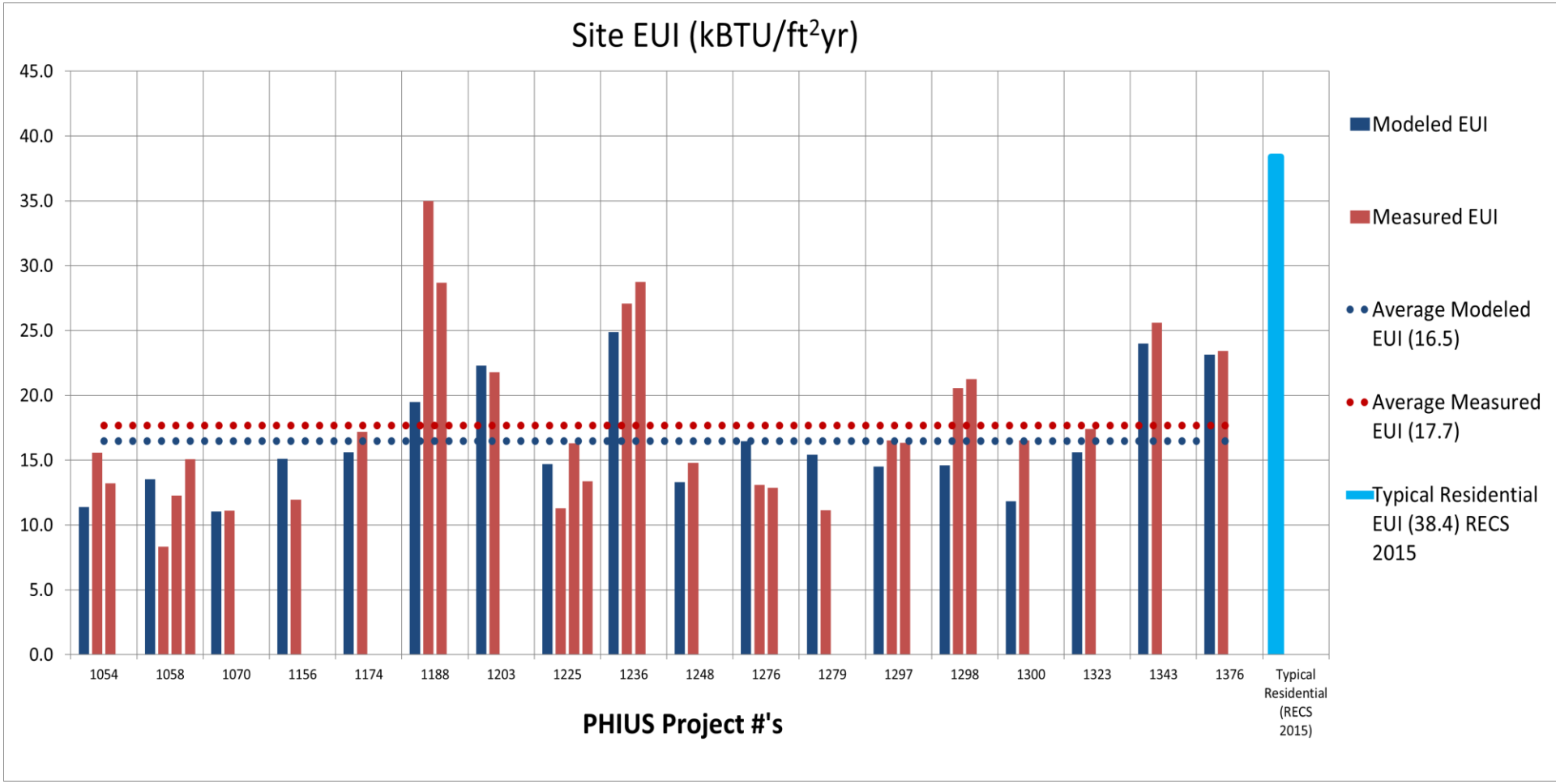
- Remembering the heart of this.

- “Architecture” of, and principles of, the standard.
- How the performance criteria were set.
- What we’ll work on next.

- In conclusion: Game over for the climate?

  The game is never over.

93% Modeled vs Measured



USA TODAY NEWS SPORTS LIFE

ACHIEVING

GLOBAL CLIMATE ACTION SUMMIT

HOME ABOUT PRESSROOM CHALLENGES PAR

19 GLOBAL CITIES COMMIT TO MAKE NEW BUILDINGS "NET-ZERO CARBON" BY 2030

Aug 23, 2018 | Feature, Pressroom, Summit News

Across the country, US
targets under the accord

STILL PASS/FAIL

Three pillars

- Heating and Cooling performance criteria
  - tied to economic feasibility
  - New for 2018 – sensitive to building size & occupancy.
- Overall source energy use criteria
  - tied to global CO2 emission ‘budget’
  - New for 2018 – more stringent, but off-site renewables allowed.
- Quality assurance and commissioning requirements – 3rd party verification.
  - New for 2018 – Nonresidential commissioning requirements.

Quality & Commissioning

As in 2015

- Whole-building air-tightness.
- EPA Indoor airPLUS, e.g.:
  - Materials*,
  - no ethanol fireplaces,
  - no building cavities used as ducts…
- DOE ZERH and Energy Star v3, e.g.:
  - ducts inside,
  - water management checklist…
- Moisture-managed assemblies (vapor control).
  - Window condensation resistance.
- Ventilator commissioning.

Nonresidential commissioning

New for 2018

- The process will be comprehensive of USGBC's LEED requirements for basic level commissioning.
  - Supports dual certification
- Provider requirements
  - Two projects experience, or certification from CPMP, BCxP, ACG.
- Procedures follow either:
  - ASHRAE Standard 202 – 2013
  - NEBB Procedural Standards for Whole Building Systems Commissioning for New Construction

Nonresidential commissioning – scope of requirements

- Systems manual for building operators
- Hot water systems
- Heating/Cooling systems
- Ventilation systems
- Envelope systems
- Fenestration systems
- Lighting
- Process loads

Setting the Heating / Cooling criteria

- A “computer experiment”
- 5 building sizes, 3 occupancies -> 15 base buildings.
- Each in 20 climate / energy-price situations.
- Life cycle cost optimization using BEopt
  - Chooses upgrade packages to minimize annualized cost (utility bills + financed upgrade cost)
  - Mandatory minimums enforced.
  - Re-model the chosen optimal packages in WUFI Passive.
- Curve-fit the heating and cooling loads to Env/iCFA, occupant density, climate factors, and energy price. Separate fits for:
  - Annual Heating Demand,
  - Annual Cooling Demand,
  - Peak Heating Load, and
  - Peak Cooling Load.
- Online calculator pre-sets climate factors by city – Choose location and enter building size & occupancy.

R-squared of 0.88 to 0.92

WHEN-TO-STOP INVESTING IN PASSIVE MEASURES

PHIUS+ 2018
Space Conditioning Criteria Calculator

METHOD: CALCULATOR

STATE / PROVINCE MASSACHUSETTS

CITY BOSTON LOGAN INT ARPT

Envelope/iCFA	2.50	or enter here:	
iCFA/person	380	or enter here:	

**Calculator method is used for official certification targets.*

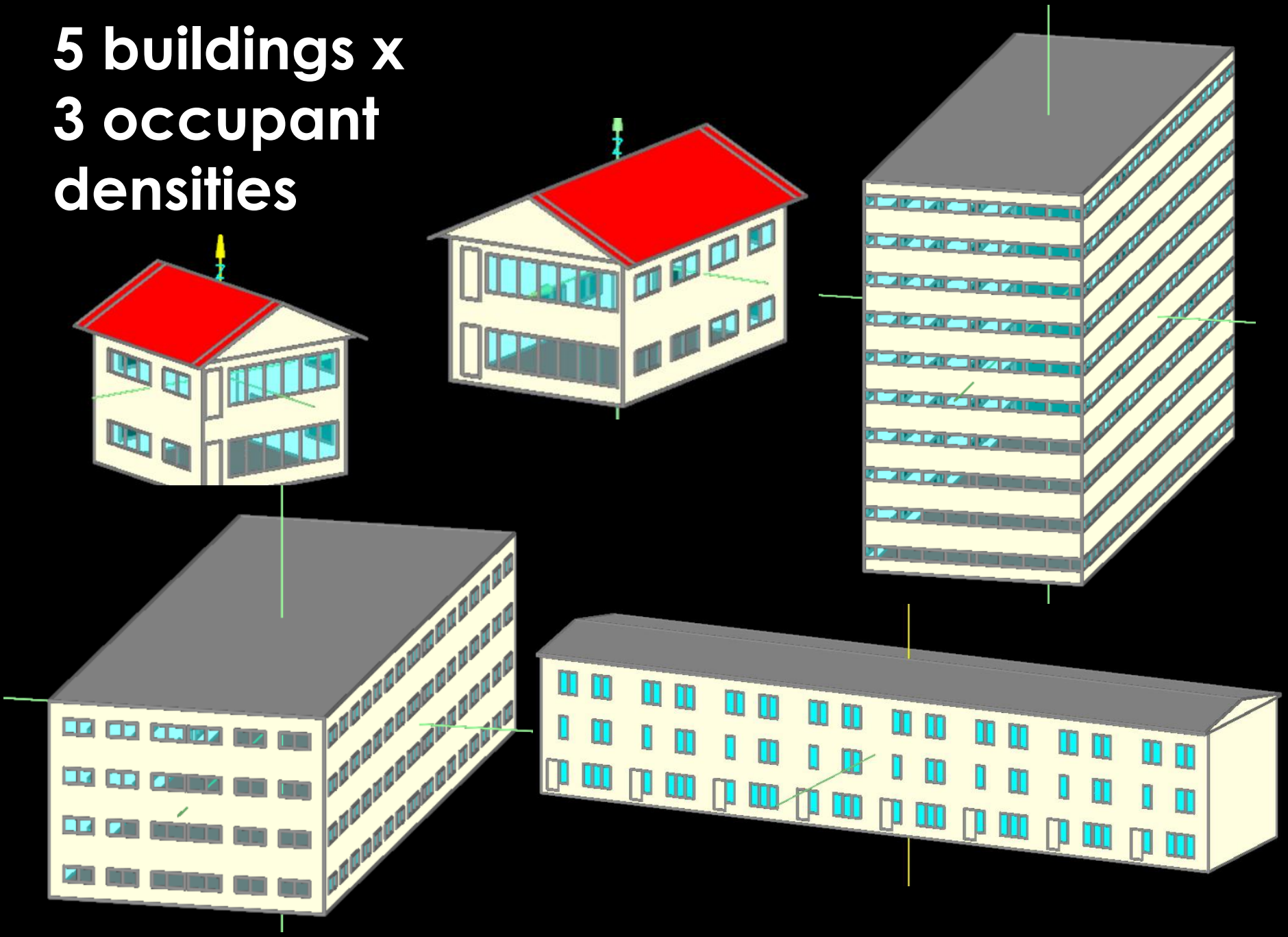
Space Conditioning Criteria

Annual Heating Demand	**6.4**	**kBTU/ft²yr**
Annual Cooling Demand	**4.4**	**kBTU/ft²yr**
Peak Heating Load	**4.5**	**BTU/ft²hr**
Peak Cooling Load	**3.9**	**BTU/ft²hr**

Typed entry will override sliding scale.
The results of the CALCULATOR method take precedence over the ESTIMATOR method.

Update Reset

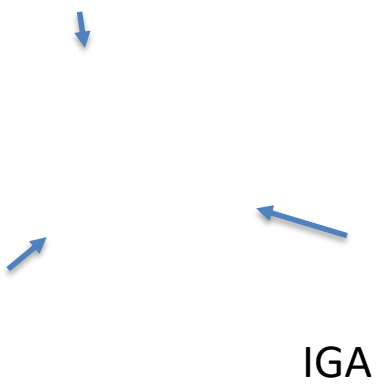
5 buildings x 3 occupant densities



List of runs: Explore the parameter space of climate factors

- 5 to 7 dimensions

Annual Heat Demand	Peak cooling load
EnvA/iCFA	EnvA/iCFA
Occ/iCFA	Occ/iCFA
HDD65	CDD50
IGA	TCD
$elec	IGCL
	DDHR*
	$elec



- Generate a “space-filling” experiment design.
- Then find best matches among actual climate locations.
  - 1040 available with both EPW and WP data files.
  - 300 runs.
  - 137 unique locations chosen.

SF-typcl med-occ Clarinda IA , $0.11/kWh

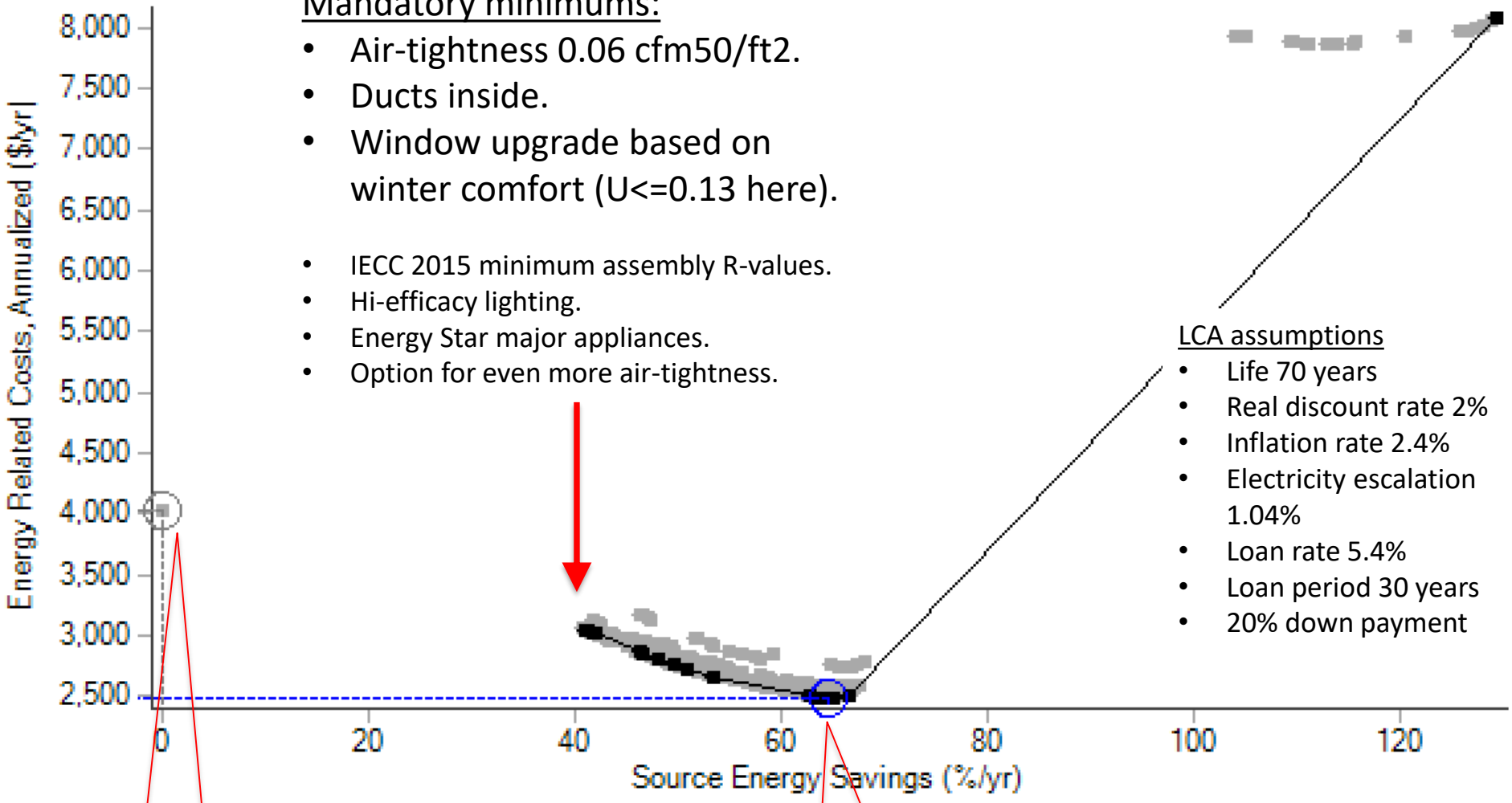
<u>Mandatory minimums:</u>

- Air-tightness 0.06 cfm50/ft2.
- Ducts inside.
- Window upgrade based on winter comfort (U<=0.13 here).

- IECC 2015 minimum assembly R-values.
- Hi-efficacy lighting.
- Energy Star major appliances.
- Option for even more air-tightness.

<u>LCA assumptions</u>

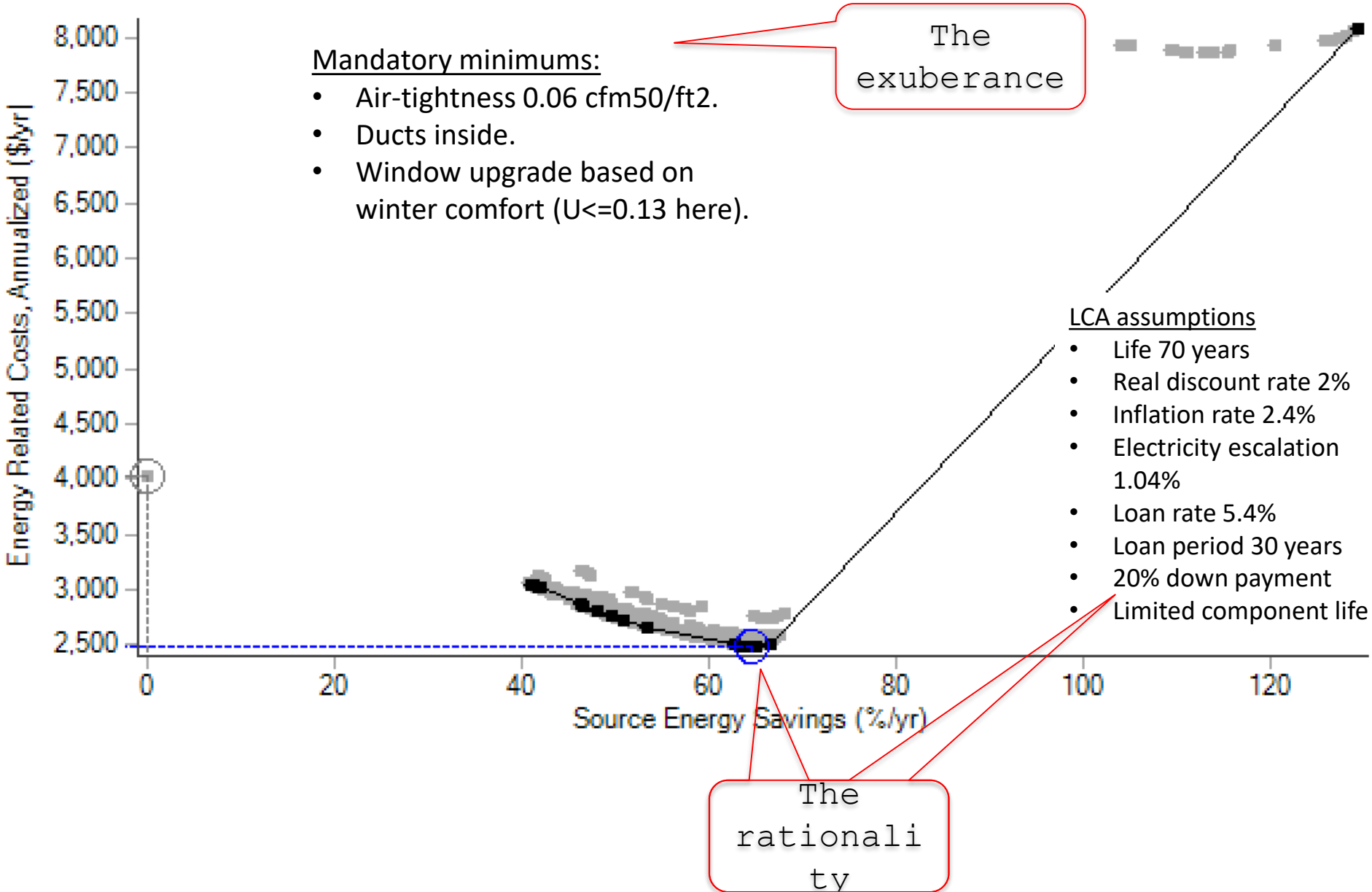
- Life 70 years
- Real discount rate 2%
- Inflation rate 2.4%
- Electricity escalation 1.04%
- Loan rate 5.4%
- Loan period 30 years
- 20% down payment



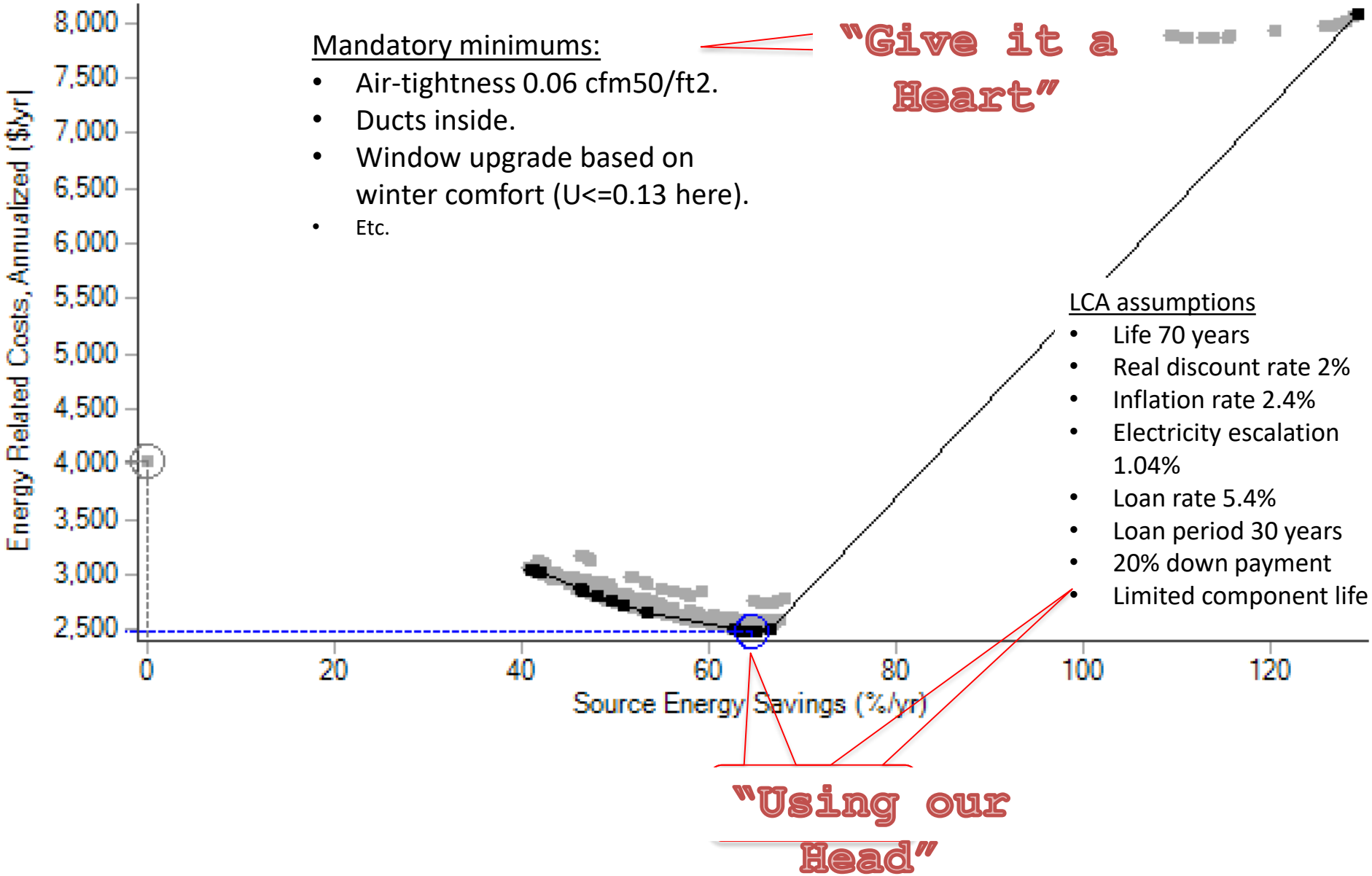
Building America Benchmark (IECC 2009)

Minimum cost point

SF-typcl med-occ Clarinda IA , $0.11/kWh



SF-typcl med-occ Clarinda IA , $0.11/kWh



Mandatory minimums:

- Air-tightness 0.06 cfm50/ft2.
- Ducts inside.
- Window upgrade based on winter comfort (U<=0.13 here).
- Etc.

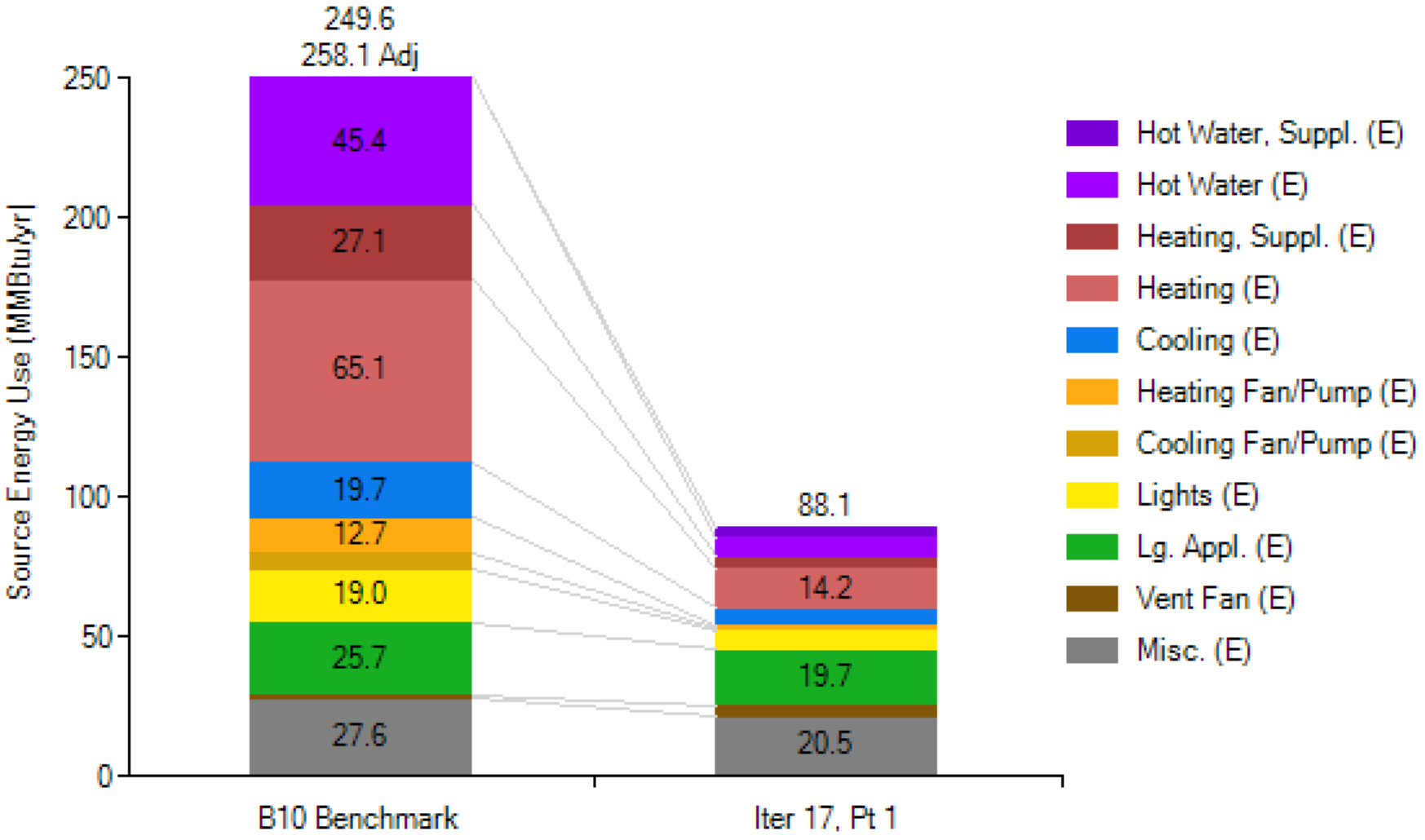
"Give it a Heart"

LCA assumptions

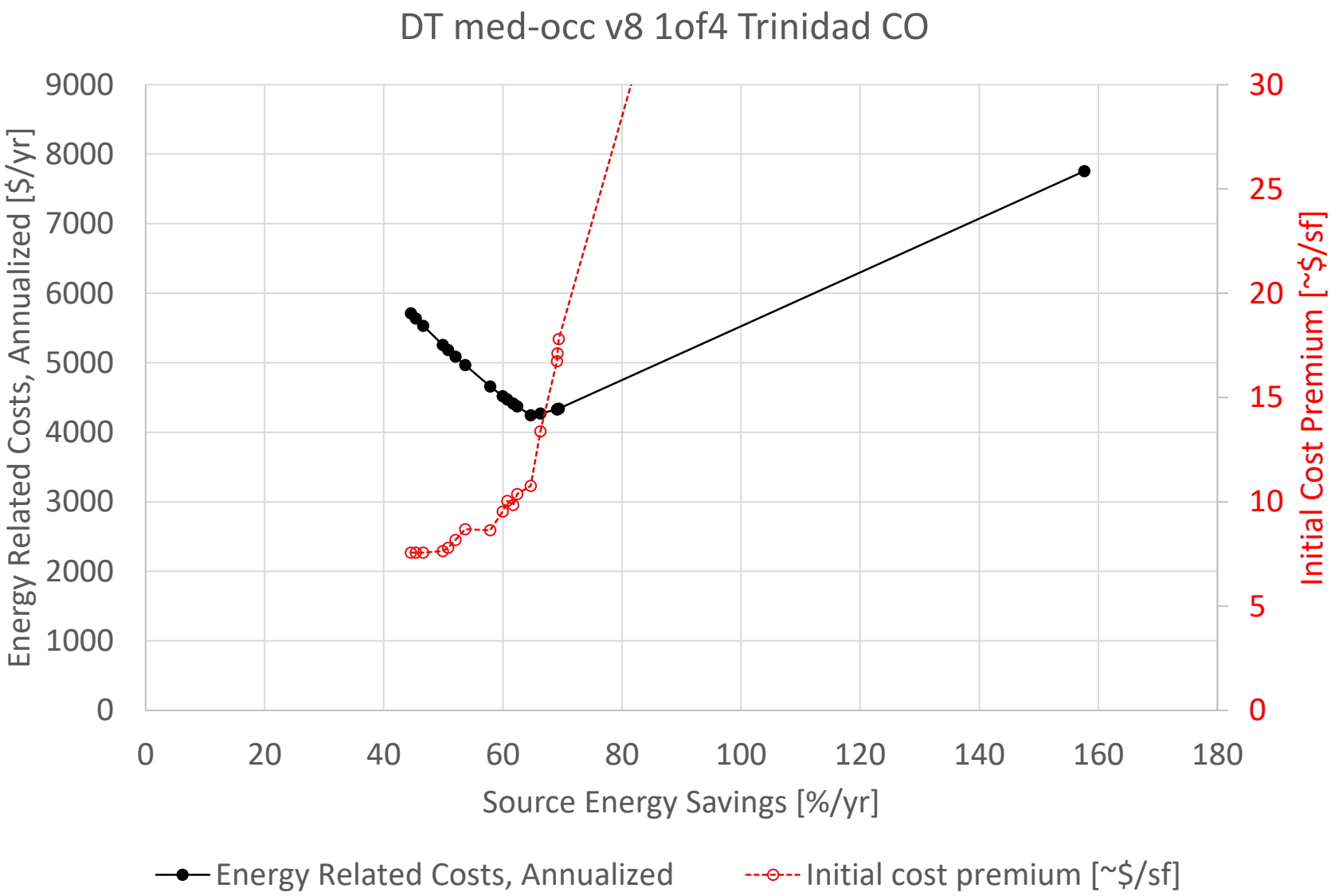
- Life 70 years
- Real discount rate 2%
- Inflation rate 2.4%
- Electricity escalation 1.04%
- Loan rate 5.4%
- Loan period 30 years
- 20% down payment
- Limited component life

"Using our Head"

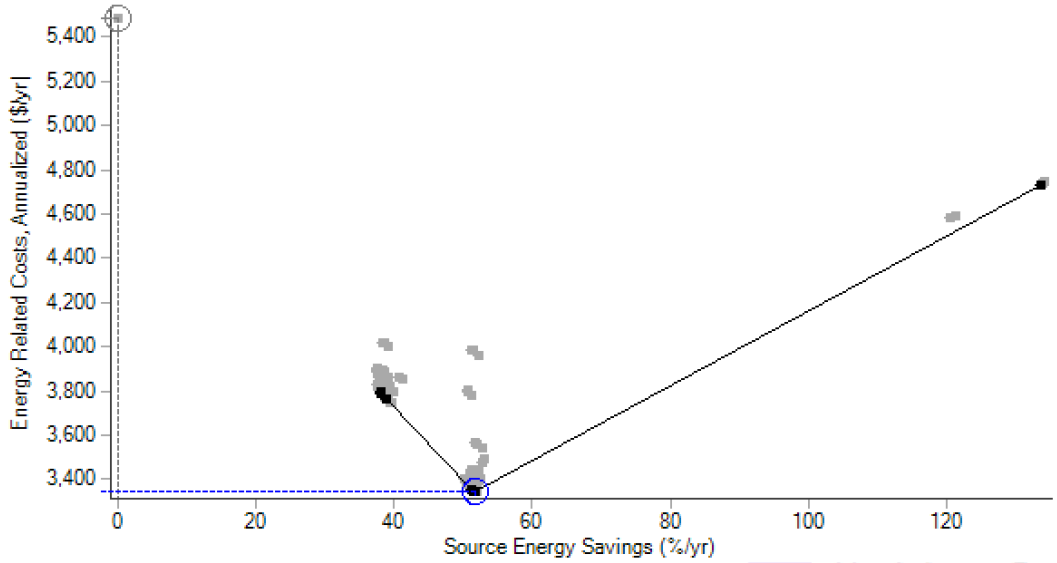
SF-typcl med-occ, Clarinda IA , $0.11/kWh

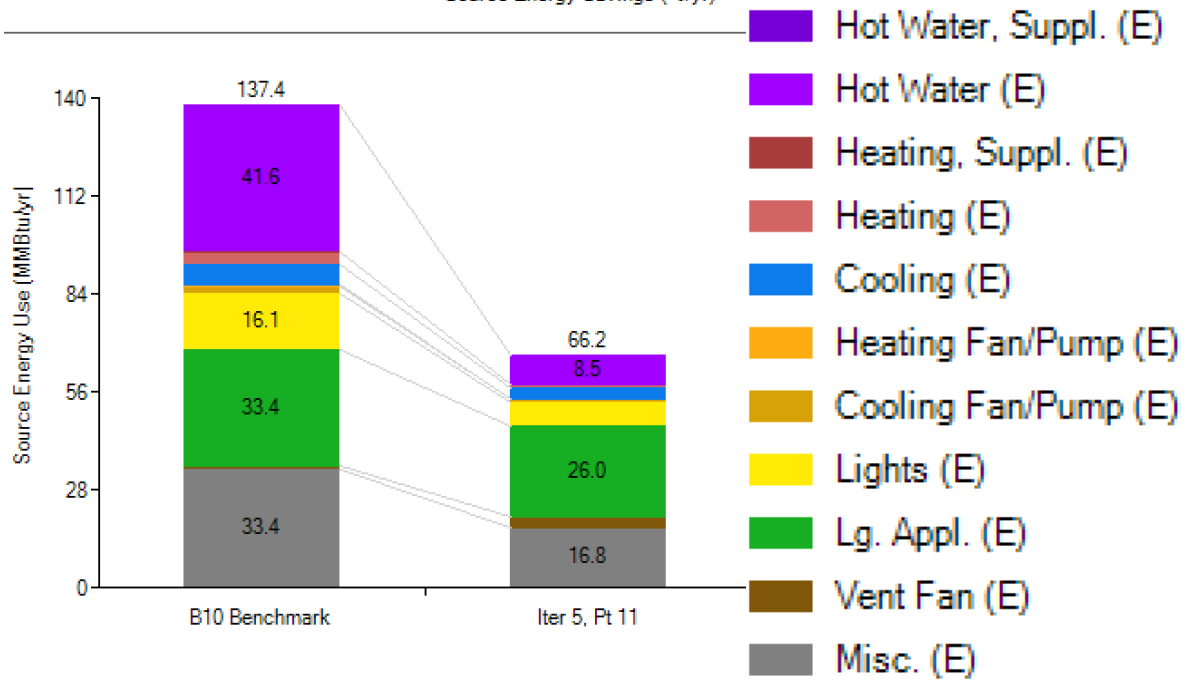


SF-typcl med-occ, Trinidad CO

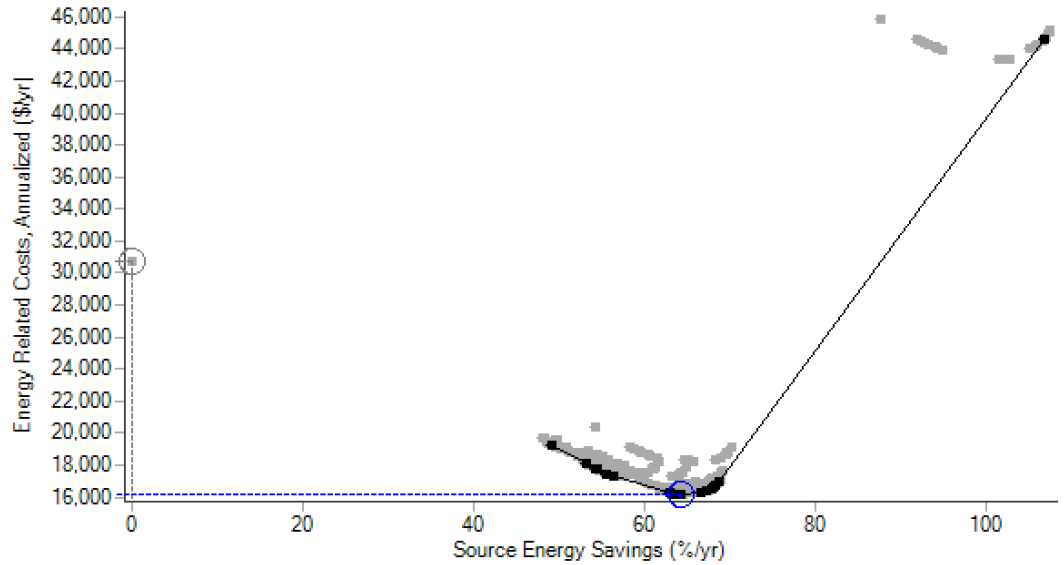


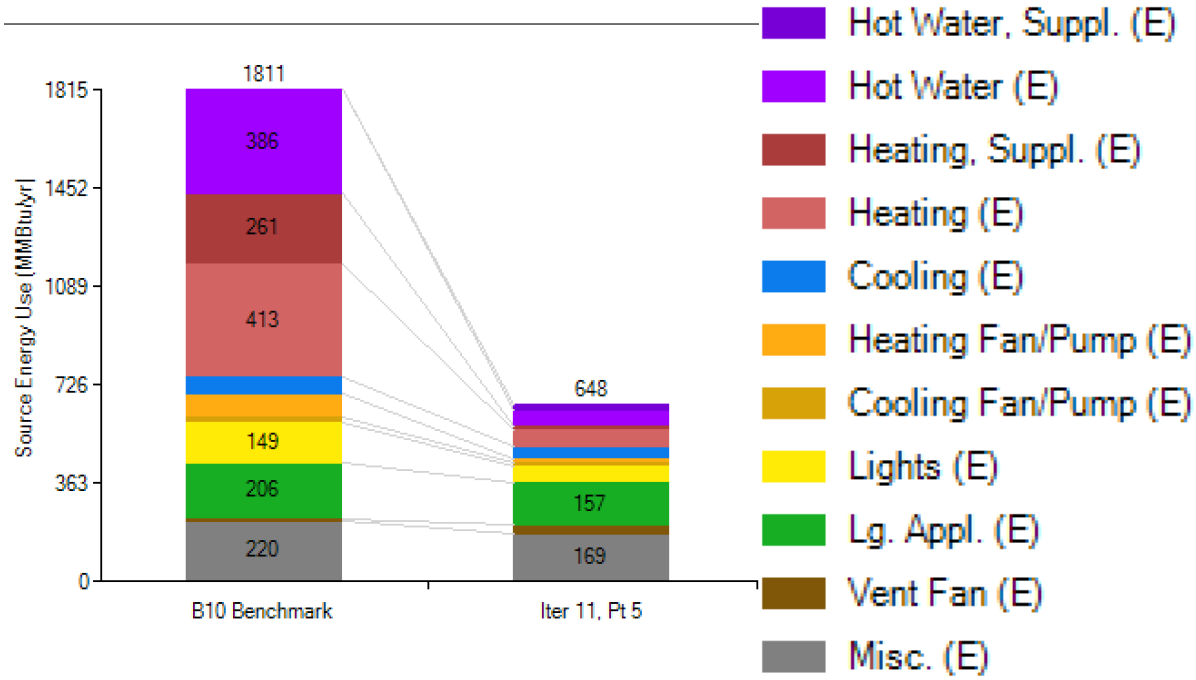
Duplex-small hi-occ Chula Vista CA (Zone 3B)



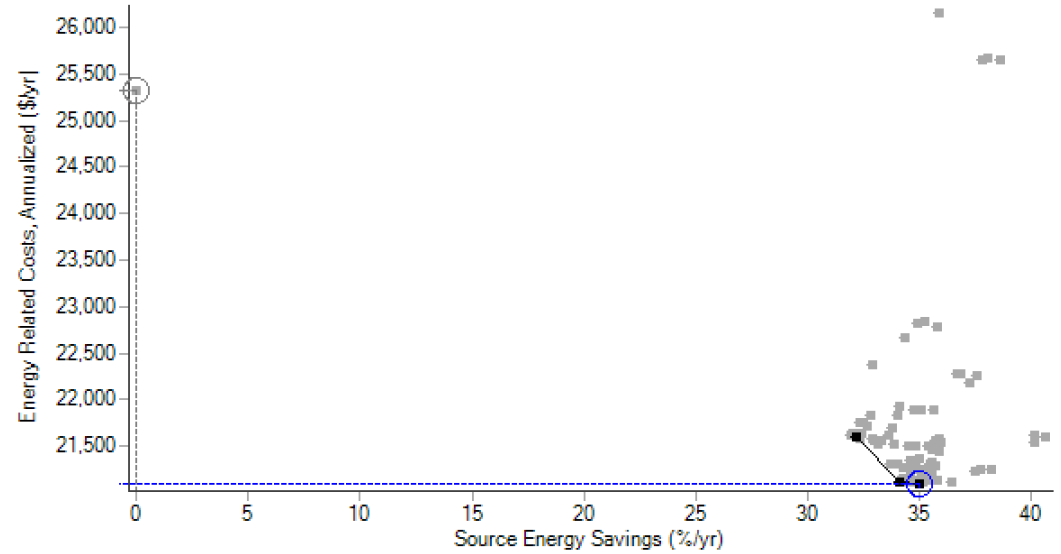


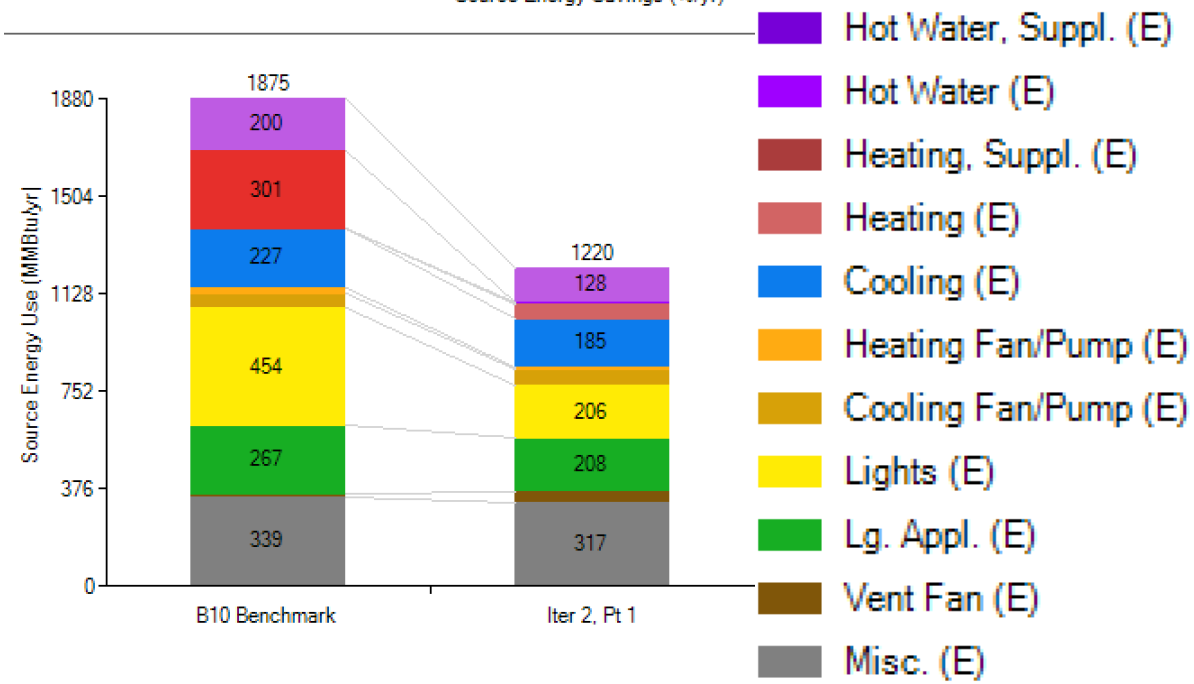
Townhouse med-occ Chicago-Waukegan IL





MF Mid-rise lo-occ McAlester OK (Zone 3A)

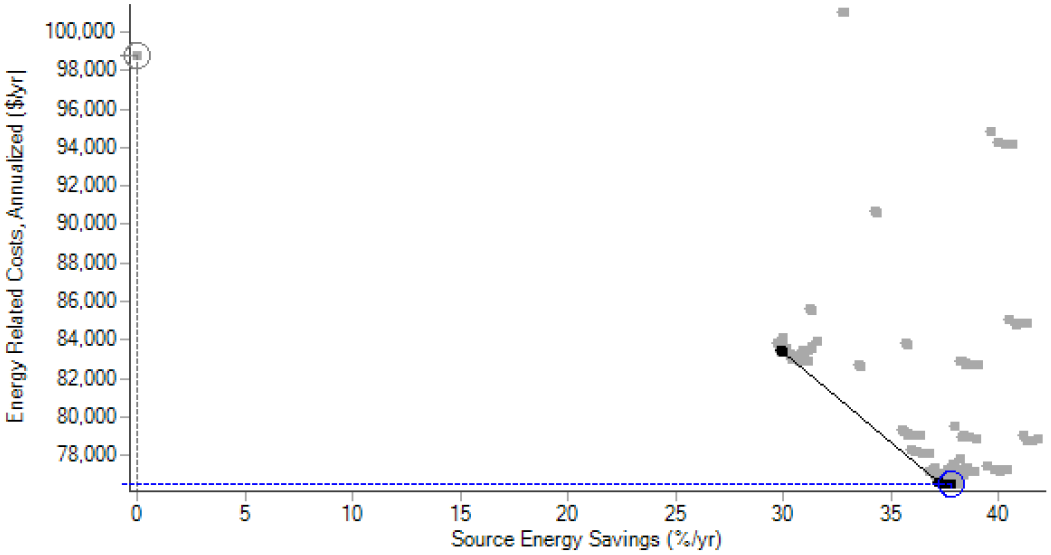


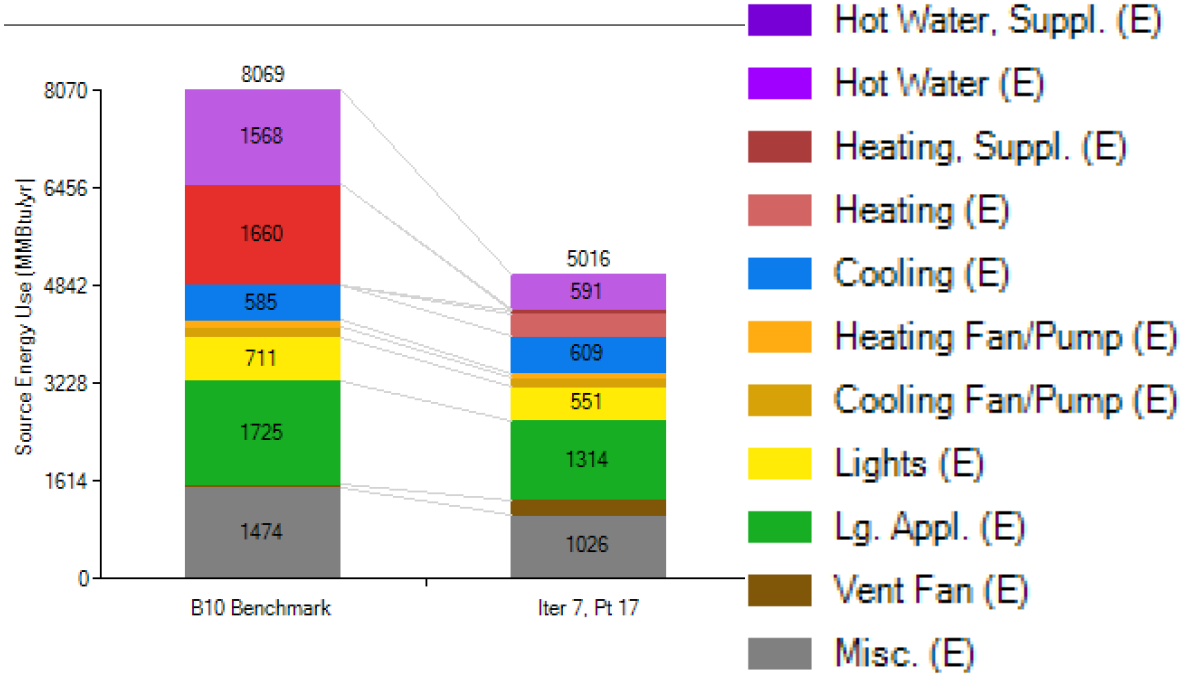


Ignore PV for setting space conditioning targets.

"You can't heat your house with PV."

MF High-rise hi-occ Chariton IA (5A)

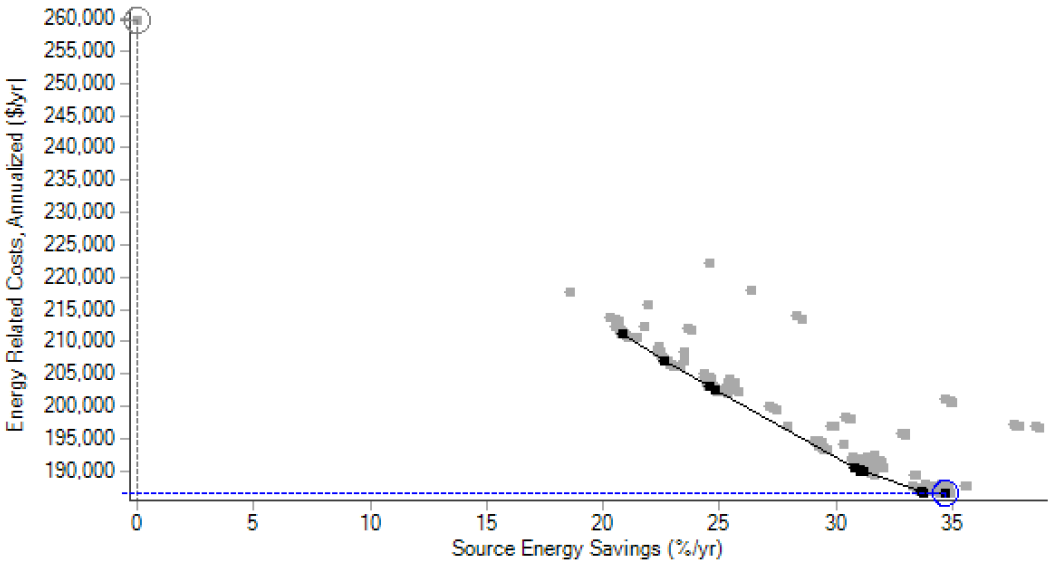


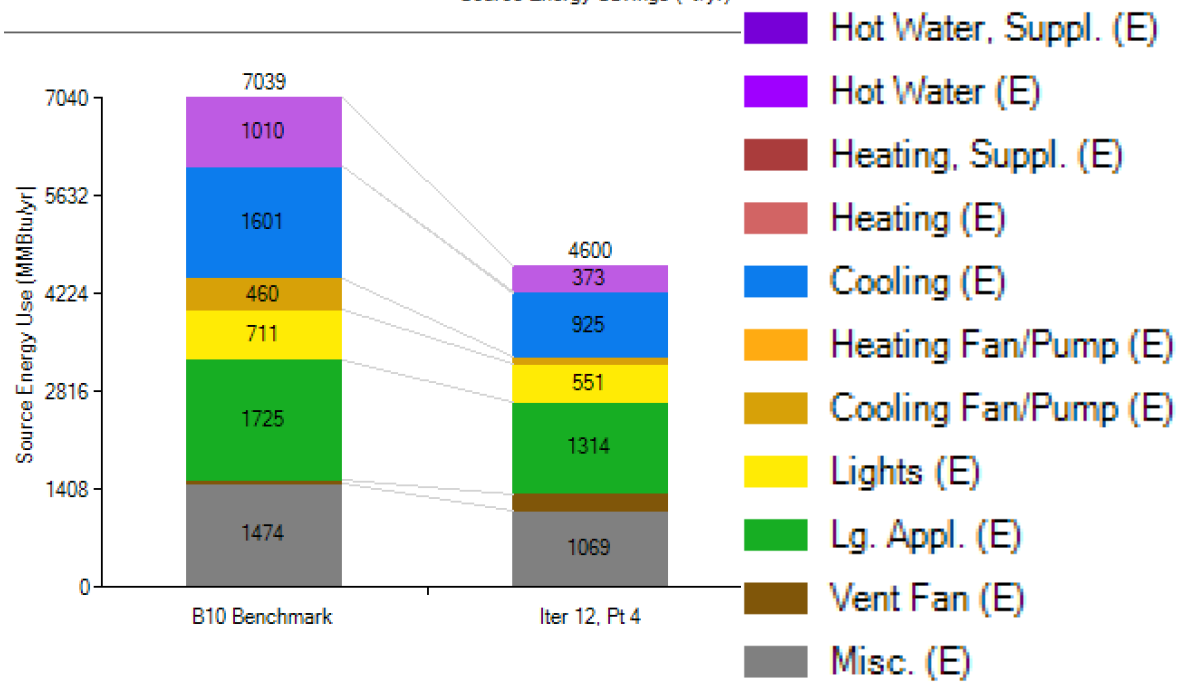


Window comfort constraint was relaxed for Mid-rise and High-rise study buildings. (Based on Pilot Program feedback.)

Will add comfort guardrail on window U-value to project certification requirements, depending on climate & window height, to limit cold air pooling under windows.

MF High-rise hi-occ Molokai HI

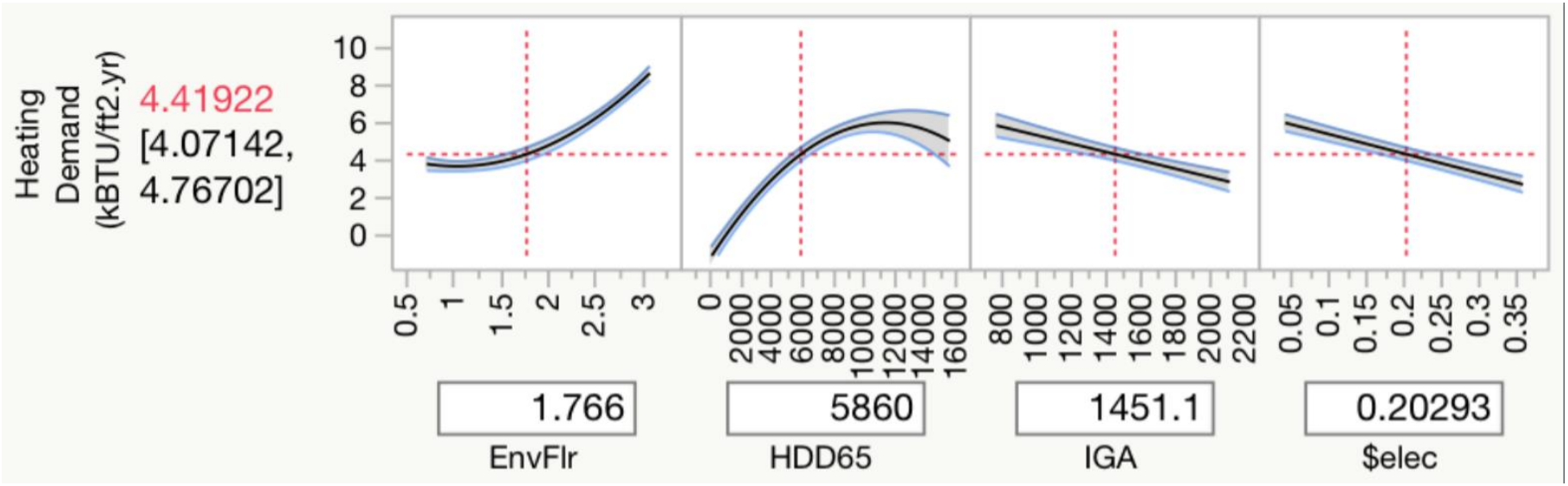




Curve-fitting JMP 13.2

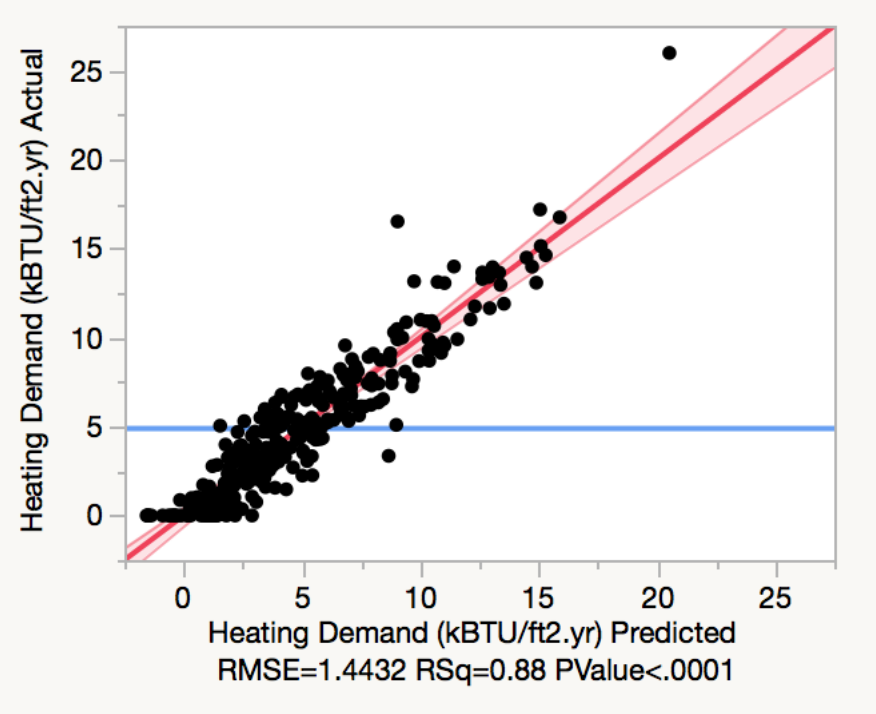
Fitted formula for Annual Heat Demand Criterion

$$
\begin{aligned}
&3.0741786353 \\
&+ 1.7570744179 \cdot EnvFlr \\
&+ 0.0006094673 \cdot HDD65 \\
&+ -0.002236765 \cdot IGA \\
&+ -10.26787567 \cdot \$elec \\
&+ (EnvFlr - 1.766) \cdot (EnvFlr - 1.766) \cdot 1.1967248787 \\
&+ (EnvFlr - 1.766) \cdot (HDD65 - 5860.0833333) \cdot 0.0002735396 \\
&+ (HDD65 - 5860.0833333) \cdot (HDD65 - 5860.0833333) \cdot -5.520236e\text{-}8 \\
&+ (EnvFlr - 1.766) \cdot (IGA - 1451.0633333) \cdot -0.001480515 \\
&+ (HDD65 - 5860.0833333) \cdot (IGA - 1451.0633333) \cdot -4.578714e\text{-}7 \\
&+ (EnvFlr - 1.766) \cdot (\$elec - 0.2029333333) \cdot -2.773120743 \\
&+ (HDD65 - 5860.0833333) \cdot (\$elec - 0.2029333333) \cdot -0.001507354
\end{aligned}
$$



Curve-fitting

Curve-fitting



Annual heating demand, WUFI Passive results vs Fitting formula.

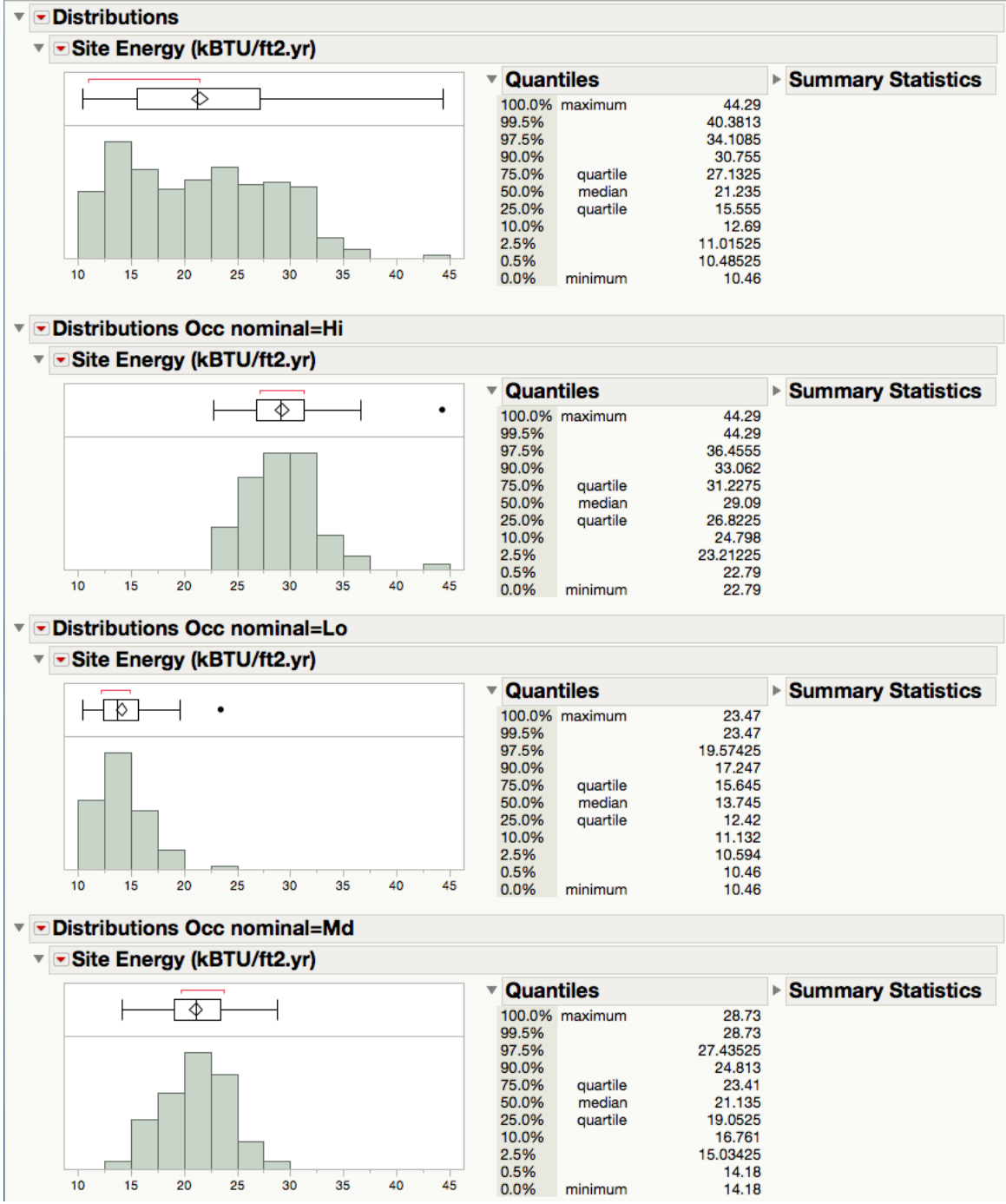
When-to-stop with passive measures

- PHIUS+2018 – at a life-cycle cost optimum, subject to:
  - Some mandatory minimums.
  - Passive measures competing with mechanical, but not with PV.
- Other ideas
  - R-20 floor, R-40 wall, R-60 ceiling everywhere.
  - Benedict-Gibson limit on heating/cooling system size.
  - Limited peak load - supply-air heating sufficient.
  - Conservation only if cheaper than generation.
  - Uniform “% reduction” by conservation.

When to stop with conservation and turn to on-site renewables to offset?

- For 2018 – change of metric, PHIUS+ now regulates annual **net** energy use, and counts both on-site and off-site renewables as offsets.

But FYI, site EUIs should be about 13-31 kBtu/ft2.yr



Net Source Energy Limit

- The question we answer instead:

When has the building done all it can with both conservation and on-site renewables and must look to its energy suppliers for clean/renewable energy?

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

FOR THE SAKE OF EVERYTHING, we-humanity must get to *absolute* zero CO2-equivalent emissions (or less).

Let's review: As of 2015, the remaining emission budget is 270 to 470 GtCO2 according to IPCC ÷ 7 Gpeople -> 39 to 67 tCO2/person. Average emission budget over 35 years is 1.1 to 1.9 tCO2. If the glide path is linear, the beginning year emission budget is twice the average -> 2.2 to 3.8 tCO2/p for all purposes. Allocating 1/3 to the *building sector* gives about 1 tCO2/p for the beginning year. In an all-electric scenario, a building site energy use of 1400 kWh/person scaled to source energy by a factor of 3 gives 4200 kWh/p source; the same site energy scaled to CO2 emissions by a factor of 0.68-0.76 kgCO2/kWh-site-delivered gives 950-1050 kgCO2/p or again about 1 tCO2/p. Thus a *year-2015* source energy limit of 4200 kWh/person corresponds to an equal share of the building sector's emission budget. At a typical occupancy of 35 m2/person, this corresponds to 4200/35 = 120 kWh/m2. The limit should ratchet down every year thereafter.

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

Year-2015 source energy budget for the building sector was plausibly 4200 kWh/person for residential, 120 kWh/m2 [38 kBtu/sf] for nonresidential. (If all-electric but supplied by mostly-nonrenewable-generation.)

Temporarily relieved in PHIUS+2015 to 6200 kWh/year due to calculation protocol increase in residential lighting/plug load usage assumptions.

Use of nonrenewable generation should taper off to zero.

Current PHIUS protocol for building certification recognizes only on-site renewables for reducing source energy use.

Tapering the limit to zero with that framework would force all buildings off-grid.

At some point the building has “done all it can” with conservation and on-site renewables, and responsibility shifts to the energy provider to decarbonize / go-renewable.

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

For PHIUS+2018, change of framework:

Source energy limit tapers to zero by 2050 *at the latest*. Limit for 2018 is **3840 kWh/p** for residential**,**
110 kWh/m2 [34.8 kBtu/sf] nonresidential.

But: the limit is on Net source energy use and all of the following renewables are recognized as offsets:

- All on-site generation (not just the use-coincident fraction)
- Directly owned off-site renewables.
- Community renewable energy
- Virtual Power Purchase Agreements
- Green-E Certified Renewable Energy Certificates, discounted 80%.

GETTING TO ZERO EMISSION / 100% RENEWABLE ENERGY

Additional provisos:

For PPAs, Community RE, and RECs, the building owner must present an actual contract to purchase sufficient RE to meet the (current-year) net source energy target for 20 years.

For onsite renewables or directly-owned off-site, RECs may not be sold off but must be retained/retired.

> Where the building owner does not have ownership of the RECs associated with the on-site RE system, owner must obtain and retire equivalent RECs.

Source energy factor for grid electricity has dropped from 3.14 to 2.80 for U.S., and from 2.06 to 1.96 for Canada. ☺

Timeline

September 21, 2018 – Full launch of PHIUS+ 2018
October 1, 2018 – PHIUS+ 2018 pilot ends

October 2018–March 2019 – Submit under 2015 or 2018

March 31, 2019 – PHIUS+ 2015 ends
April 1, 2019 – All new projects must be under PHIUS+ 2018

***Must have project contract in to secure**
Note: Only WUFI Passive accepted for PHIUS+ 2018

In Conclusion

Opportunities for further improvement

- Better planning tools to get you to the right energy design as fast as possible.
  - Longer-term: Supporting people with both more and less planning resources than it takes to make a WUFI Passive model.
- Revising the peak load calculation so that it is more directly useful for system sizing.
- Grid citizenship – replace net-zero accounting with a metric that values energy differently by hour of day and season of year. (NBI GridOptimal?)
  - Use not just for source energy criteria but also in the standard-setting studies for the heating/cooling criteria.
- Impact of materials – CO2 emission payback is delayed if we build and retrofit with high GWP materials. (MIT – new LCA tool?)

Thank You PHIUS Technical Committee

- Achilles Karagiozis
- Chris McTaggart
- Colin Schless
- Florian Antretter
- Galen Staengl
- Günther Gantioler
- Graham Wright
- John Semmelhack
- Katrin Klingenberg
- Lisa White
- Prudence Ferreira
- Russell Richman
- Ryan Abendroth
- Skylar Swinford
- Stuart Fix

Passive building is both sword and shield against the climate change monster.

And there is an army coming up behind you.

THANK YOU

PHIUS
Passive House Institute US

PASSIVE HOUSE ALLIANCE
UNITED STATES

www.PHIUS.org/www.PHAUS.org