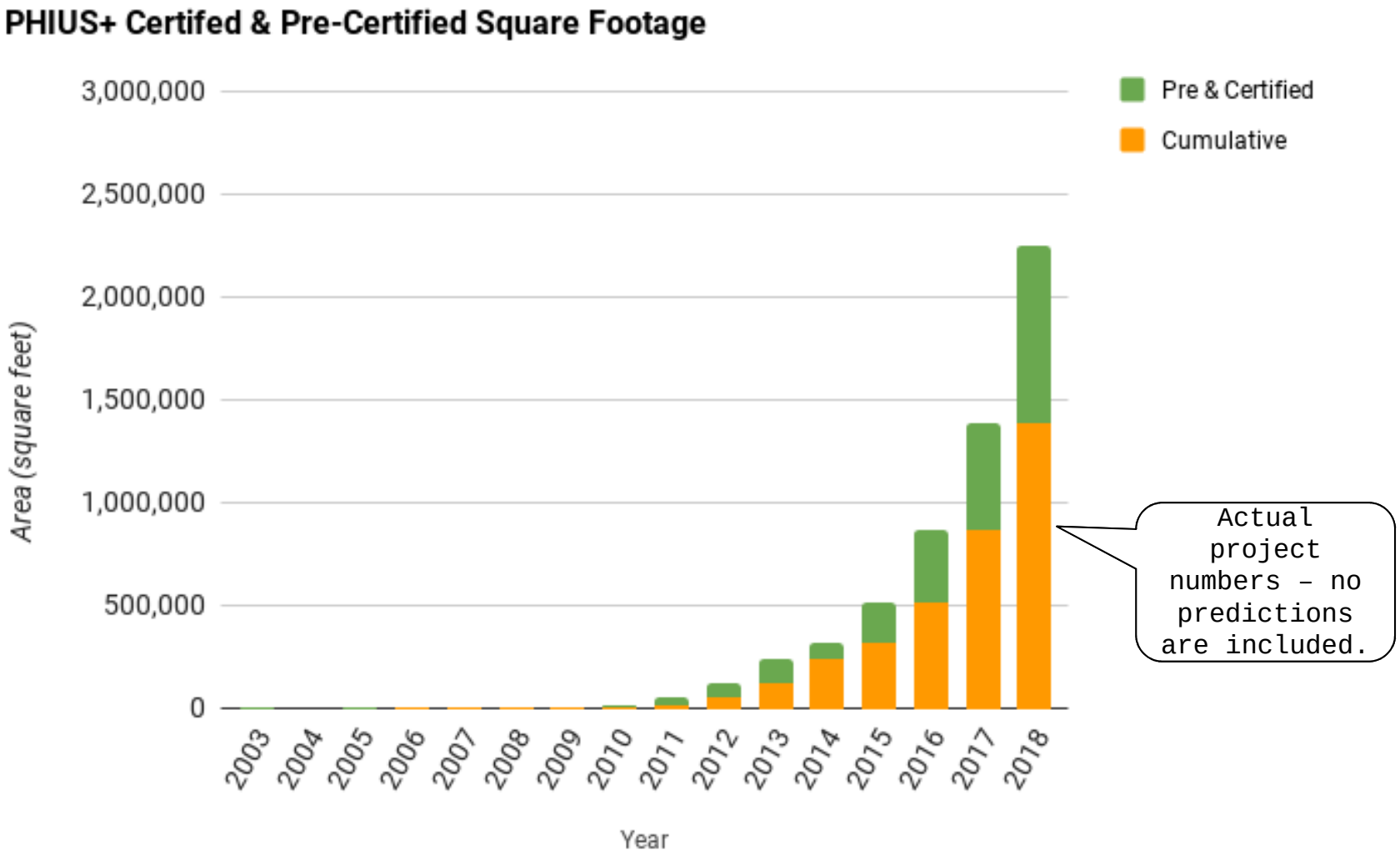
PASSIVE HOUSE ALLIANCE UNITED STATES

PHIUS

Passive House Institute US

PHIUS+ 2015 quite successful



Why certify? It shares the knowledge:

- Of how to do this
- That anything is happening

Overview

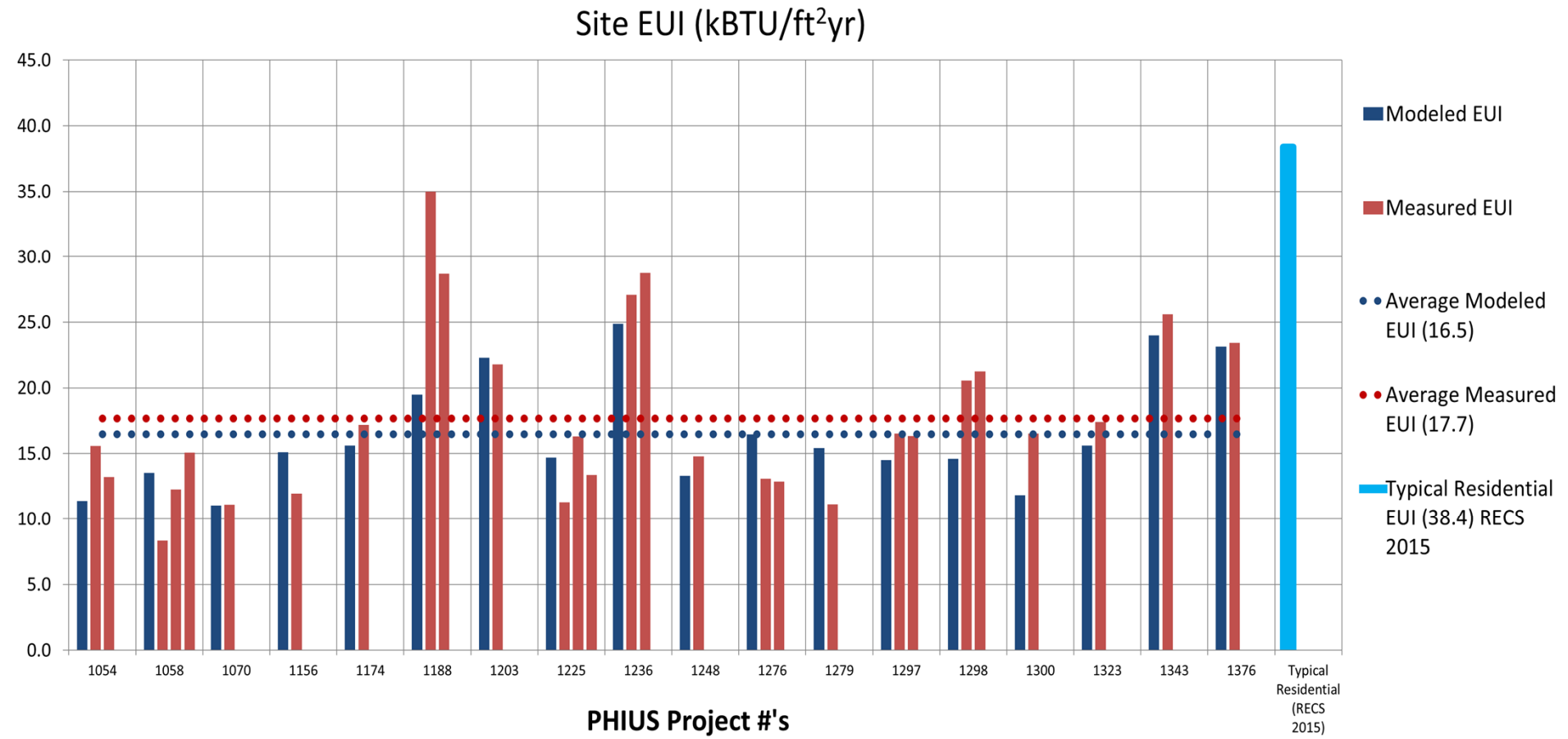
- Remembering the heart of this.

- “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

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:	

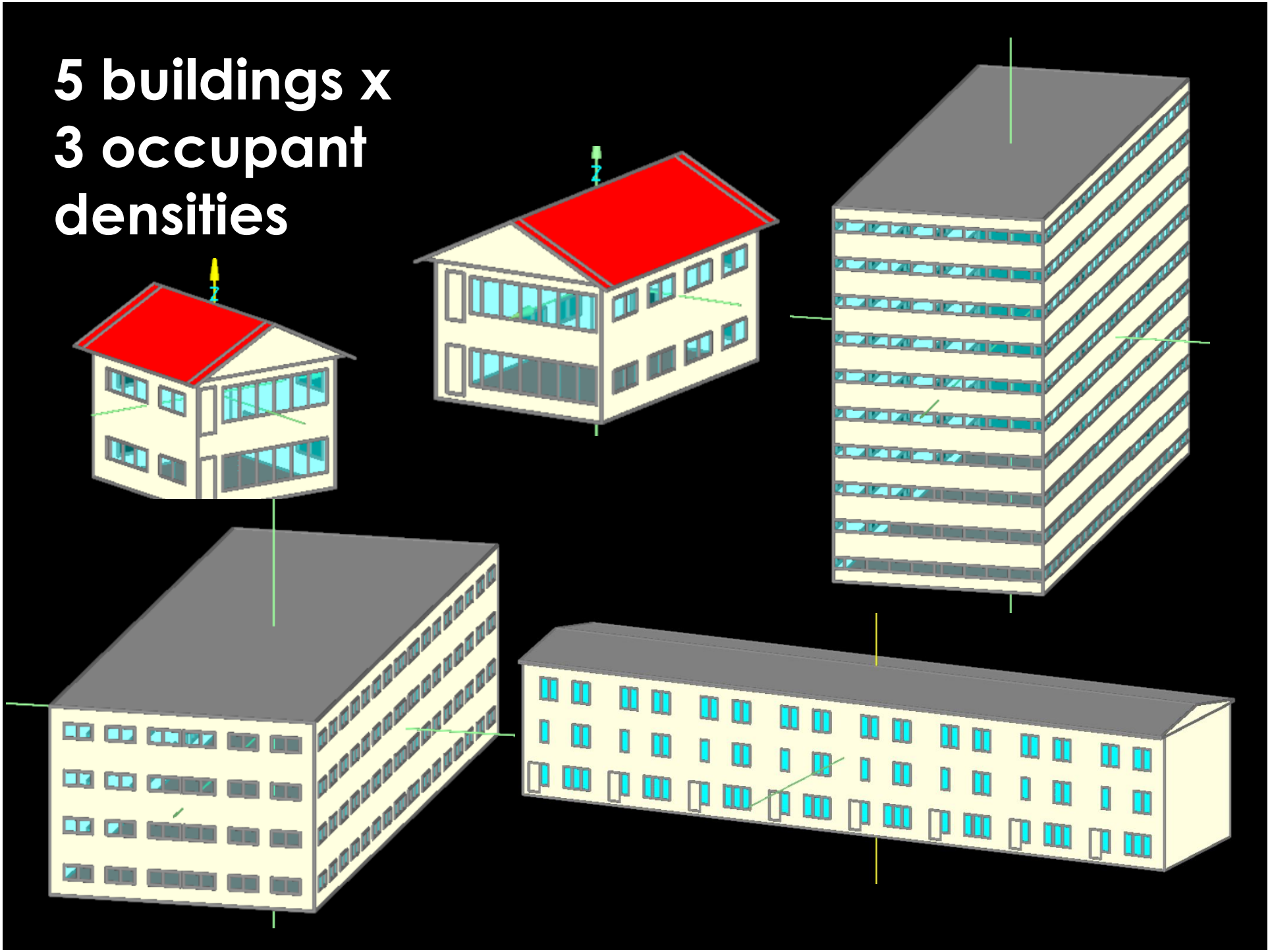
**Calculator method is used for official certification targets.*

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.

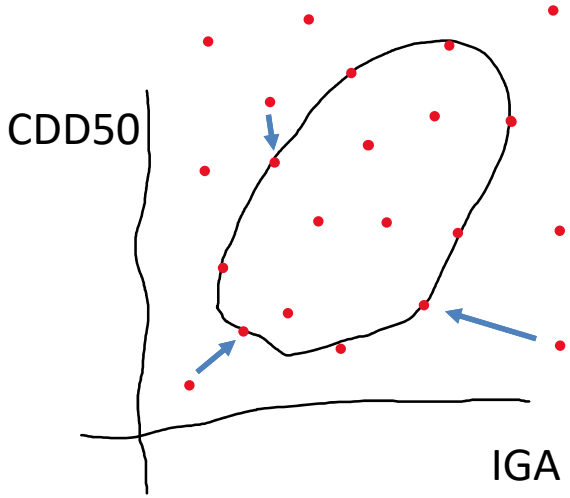
Update Reset


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



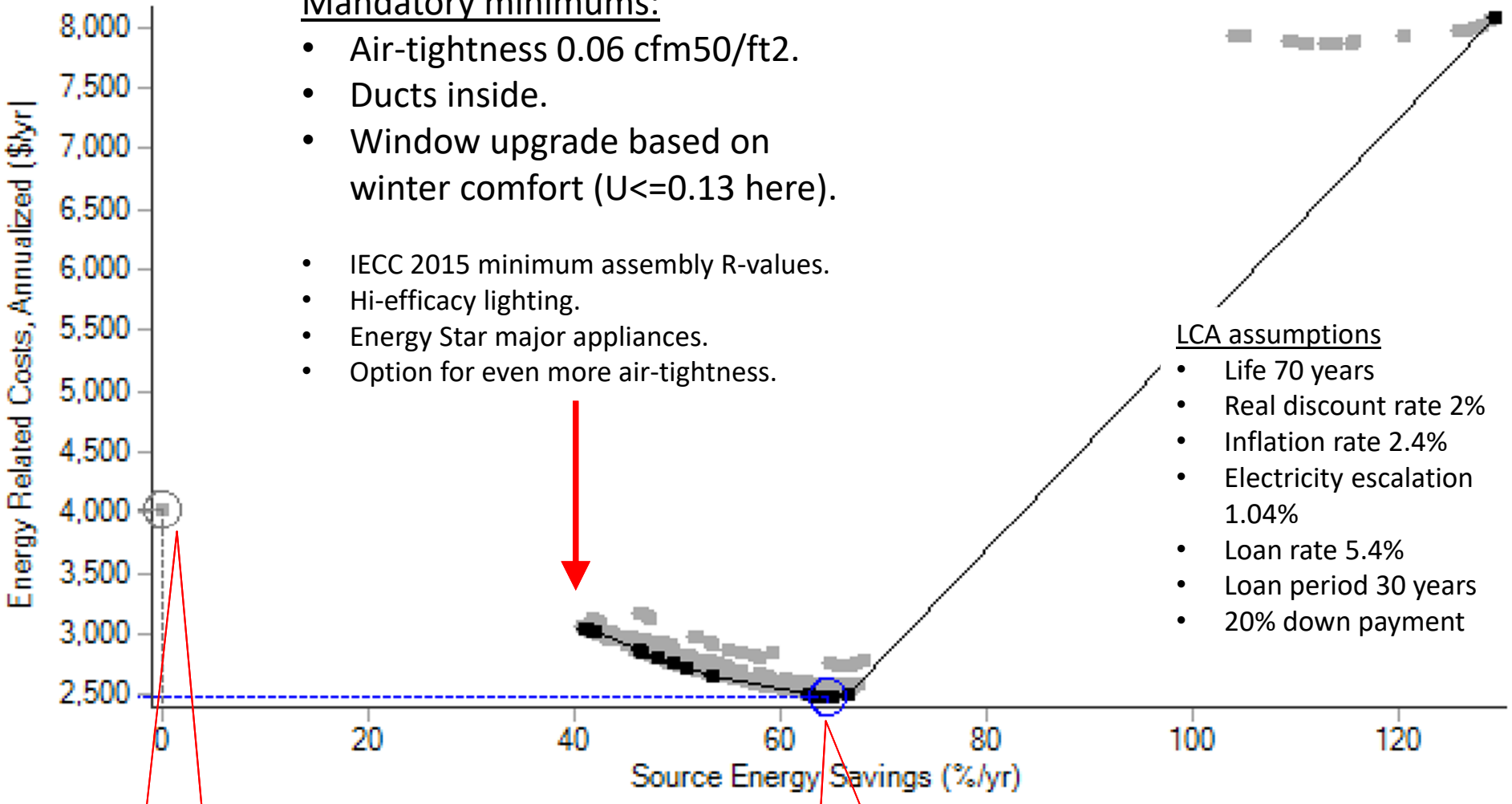
- Generate a “space-filling” experiment design.
- Then find best matches among actual climate locations.
  - 1040 available with both EPW and WP data files.
  - 300 runs.
  - 137 unique locations chosen.

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.



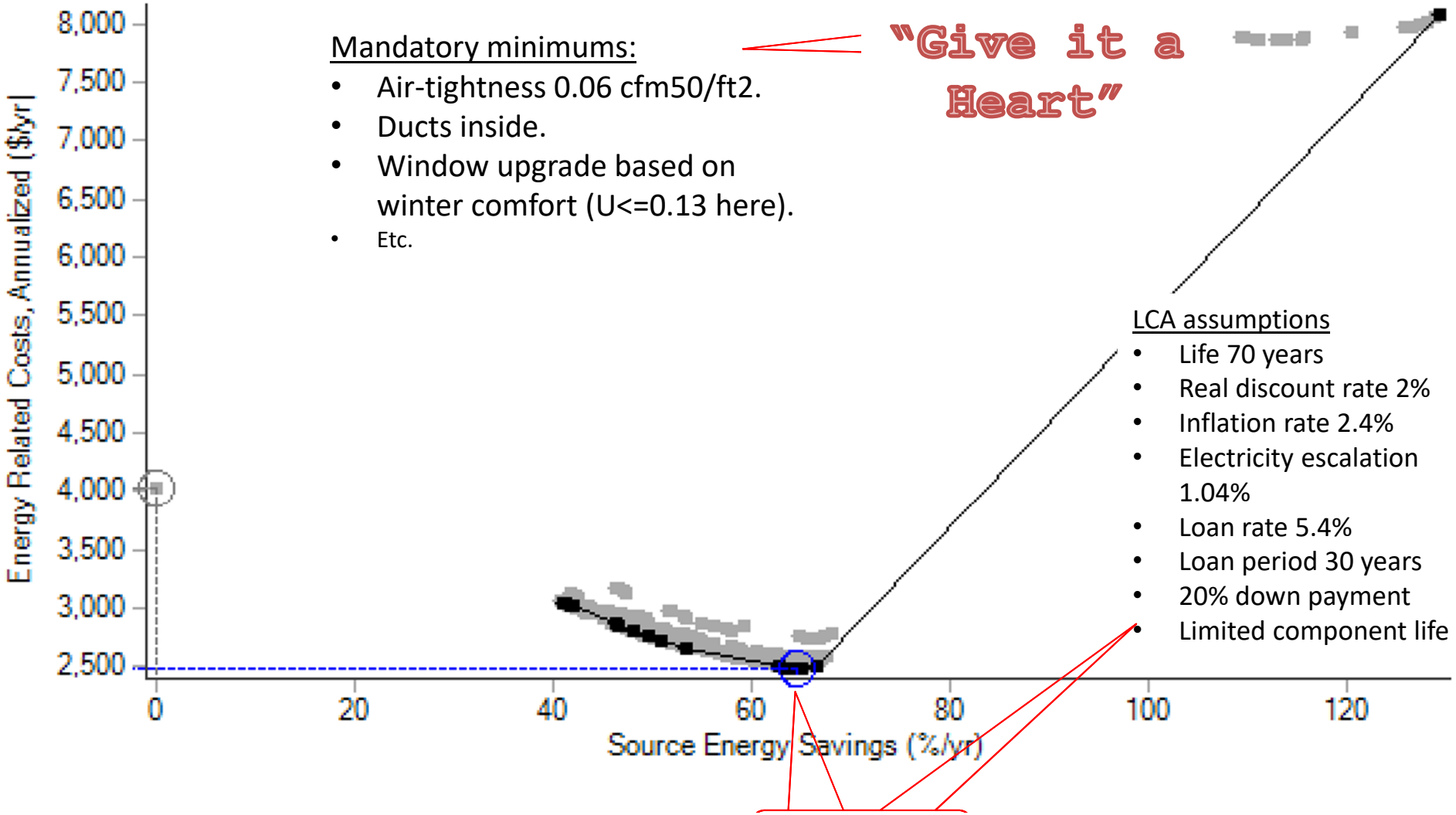
<u>LCA assumptions</u>

- 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



Mandatory minimums:

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

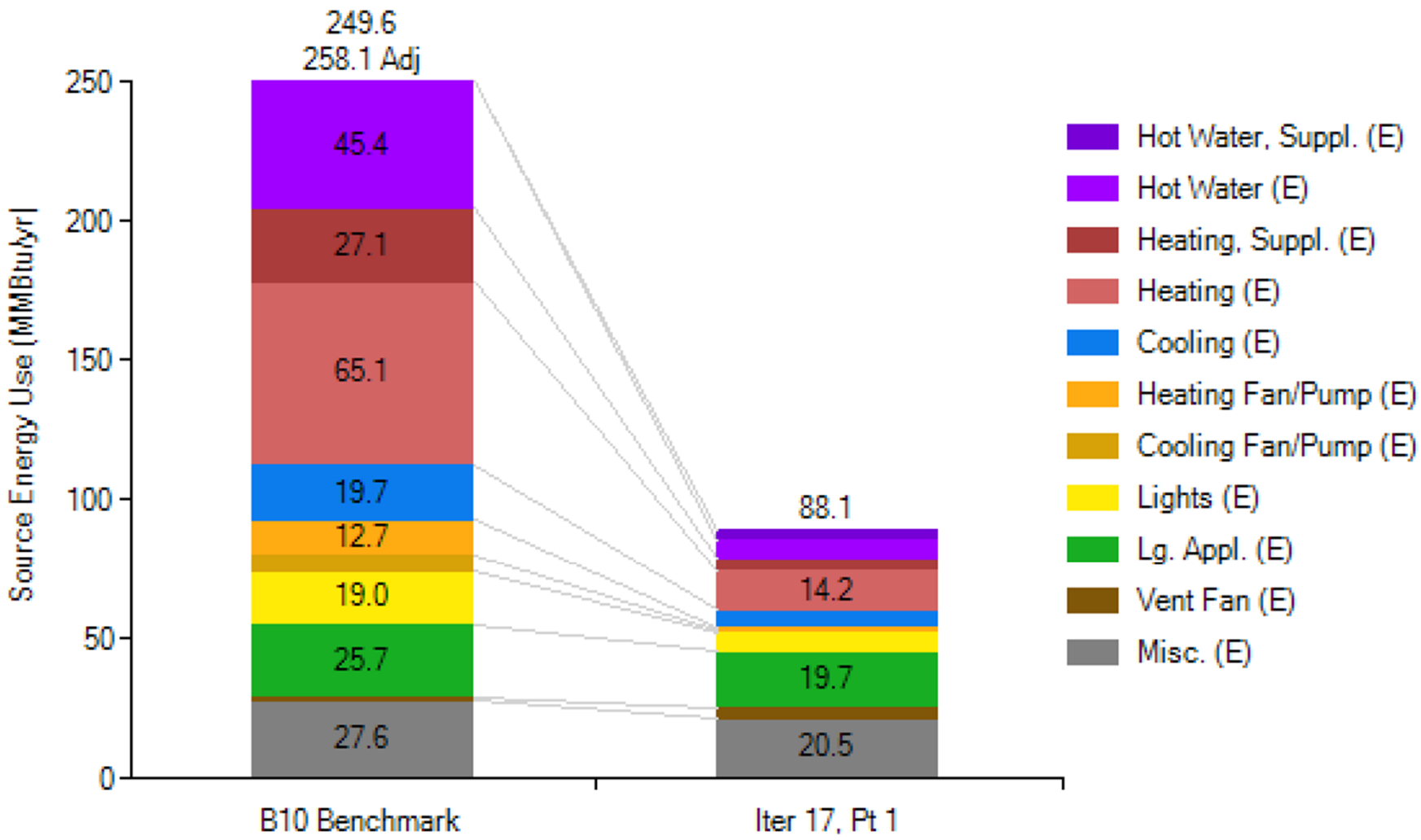
"Give it a Heart"

LCA assumptions

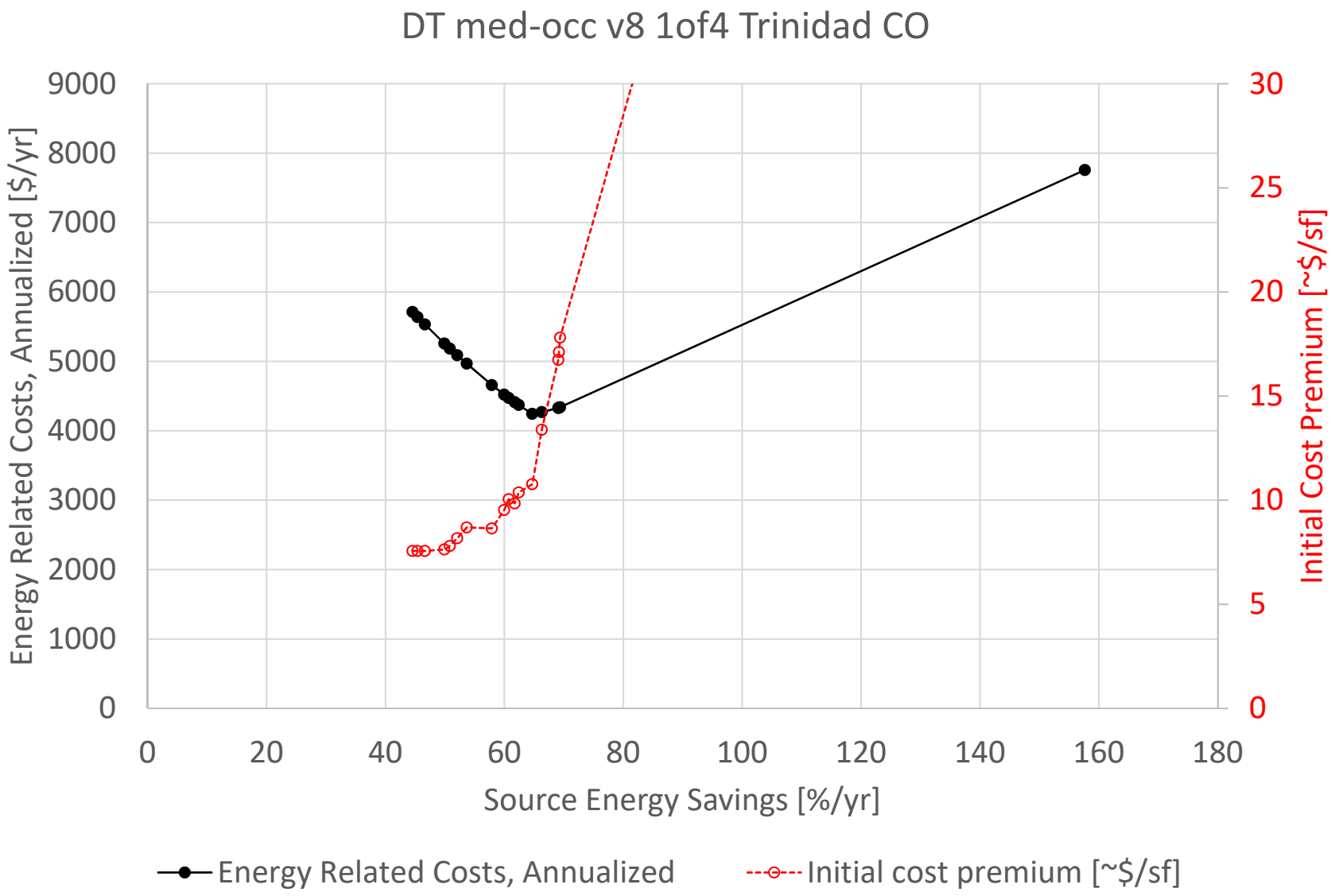
- Life 70 years
- Real discount rate 2%
- Inflation rate 2.4%
- Electricity escalation 1.04%
- Loan rate 5.4%
- Loan period 30 years
- 20% down payment
- Limited component life

"Using our Head"

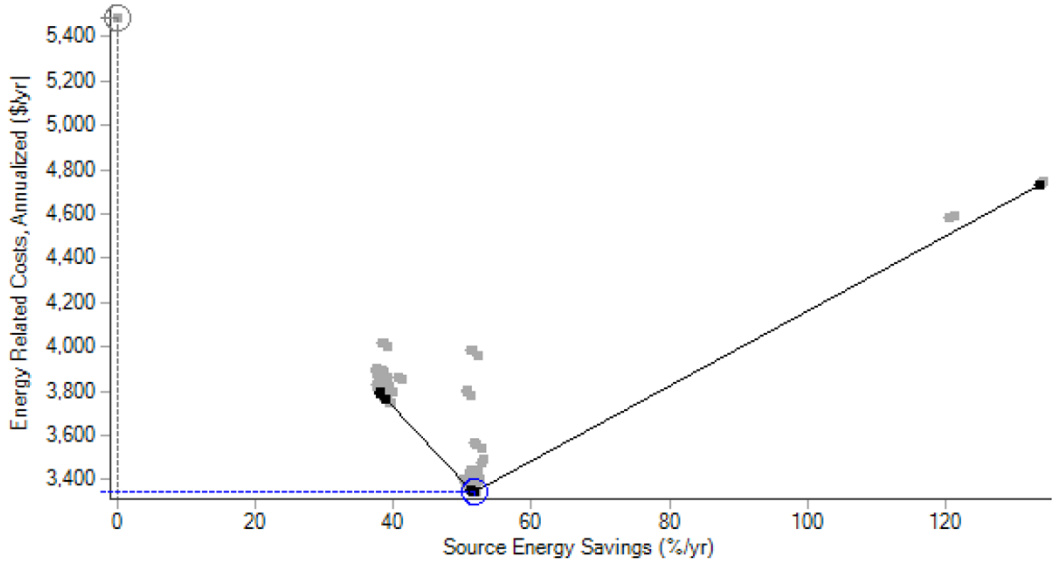
SF-typcl med-occ, Clarinda IA , $0.11/kWh

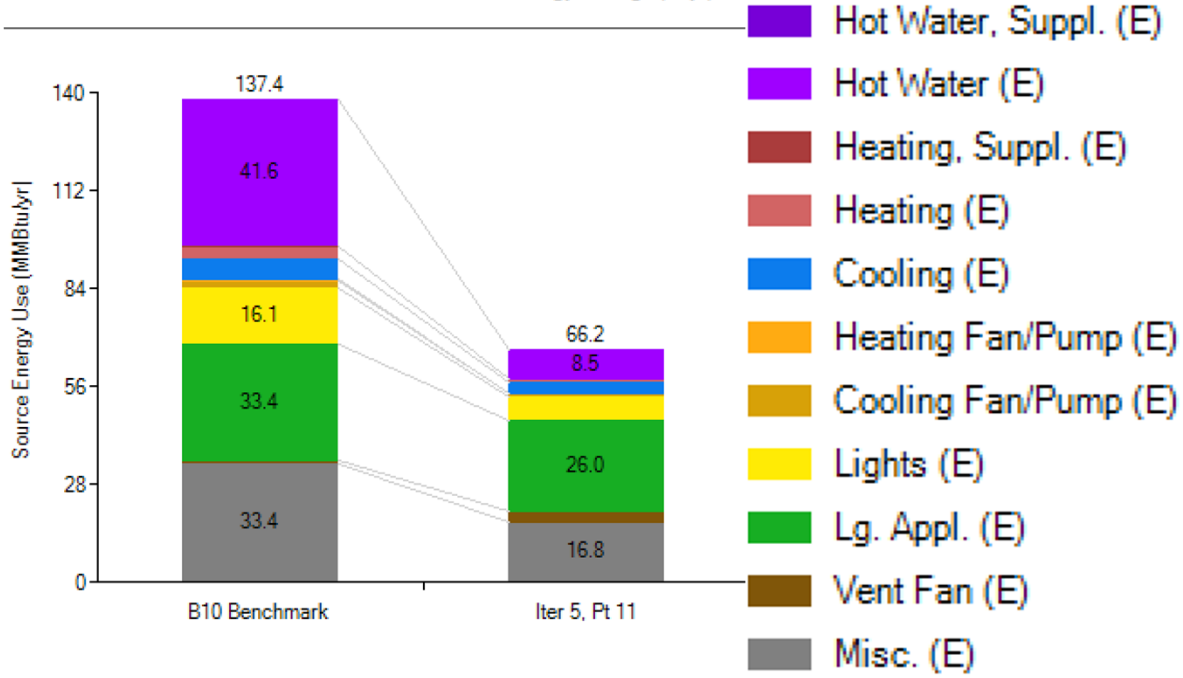


SF-typcl med-occ, Trinidad CO

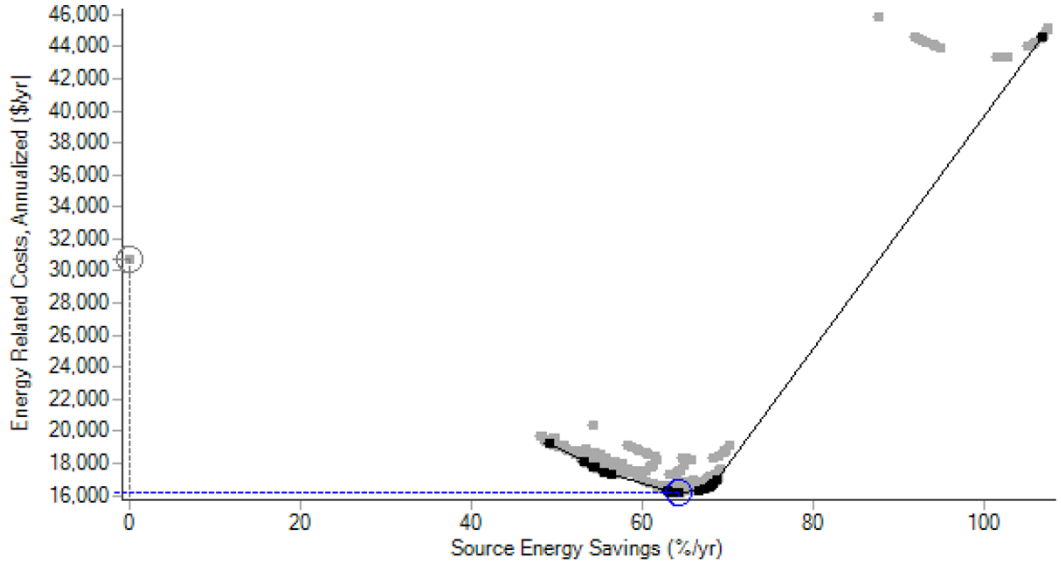


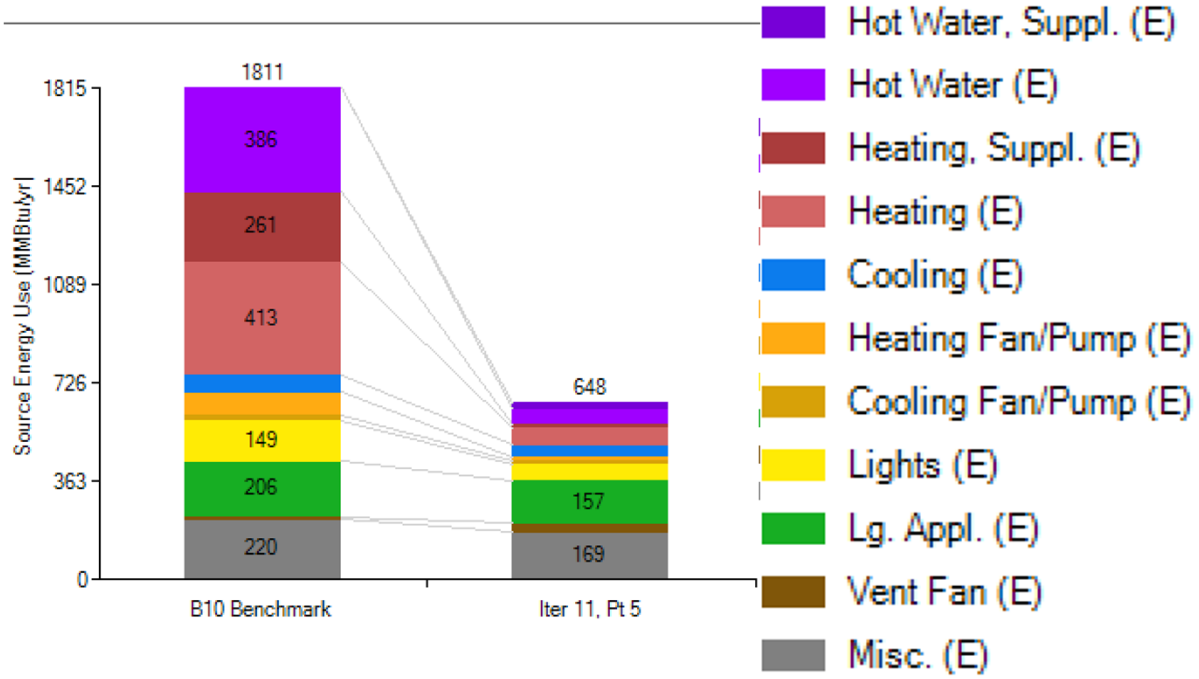
Duplex-small hi-occ Chula Vista CA (Zone 3B)



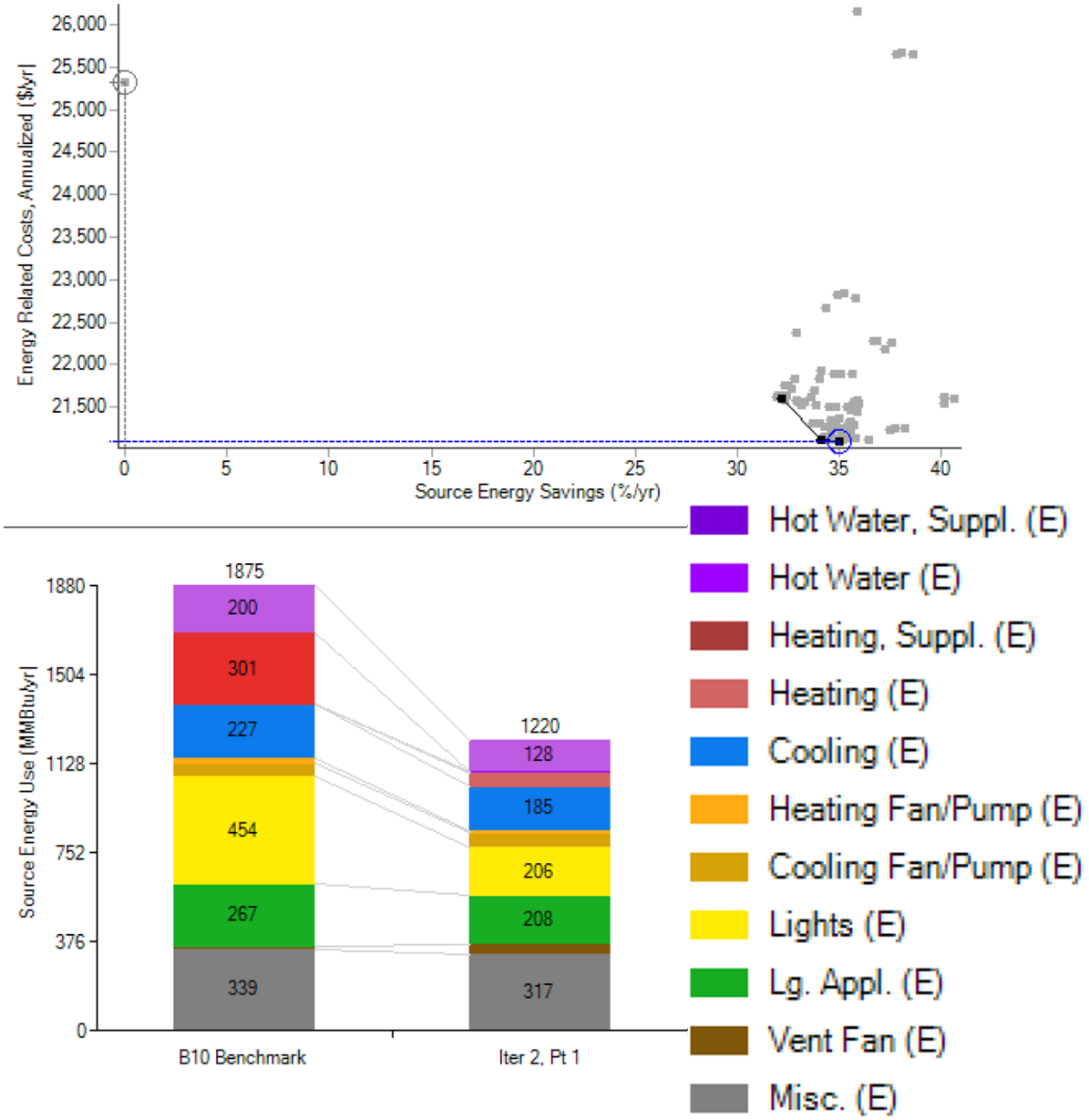


Townhouse med-occ Chicago-Waukegan IL





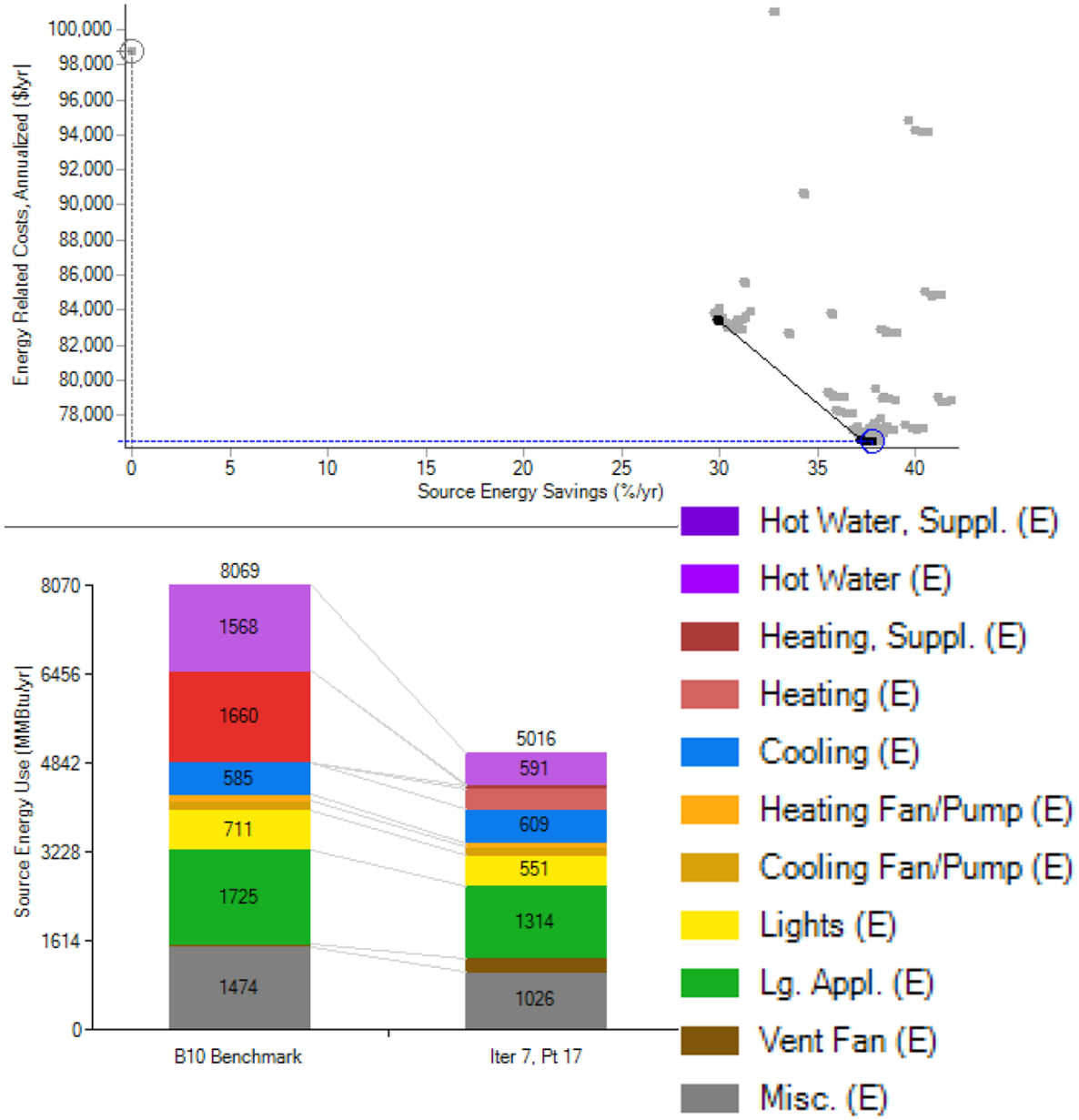
MF Mid-rise lo-occ McAlester OK (Zone 3A)



Ignore PV for setting space conditioning targets.

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

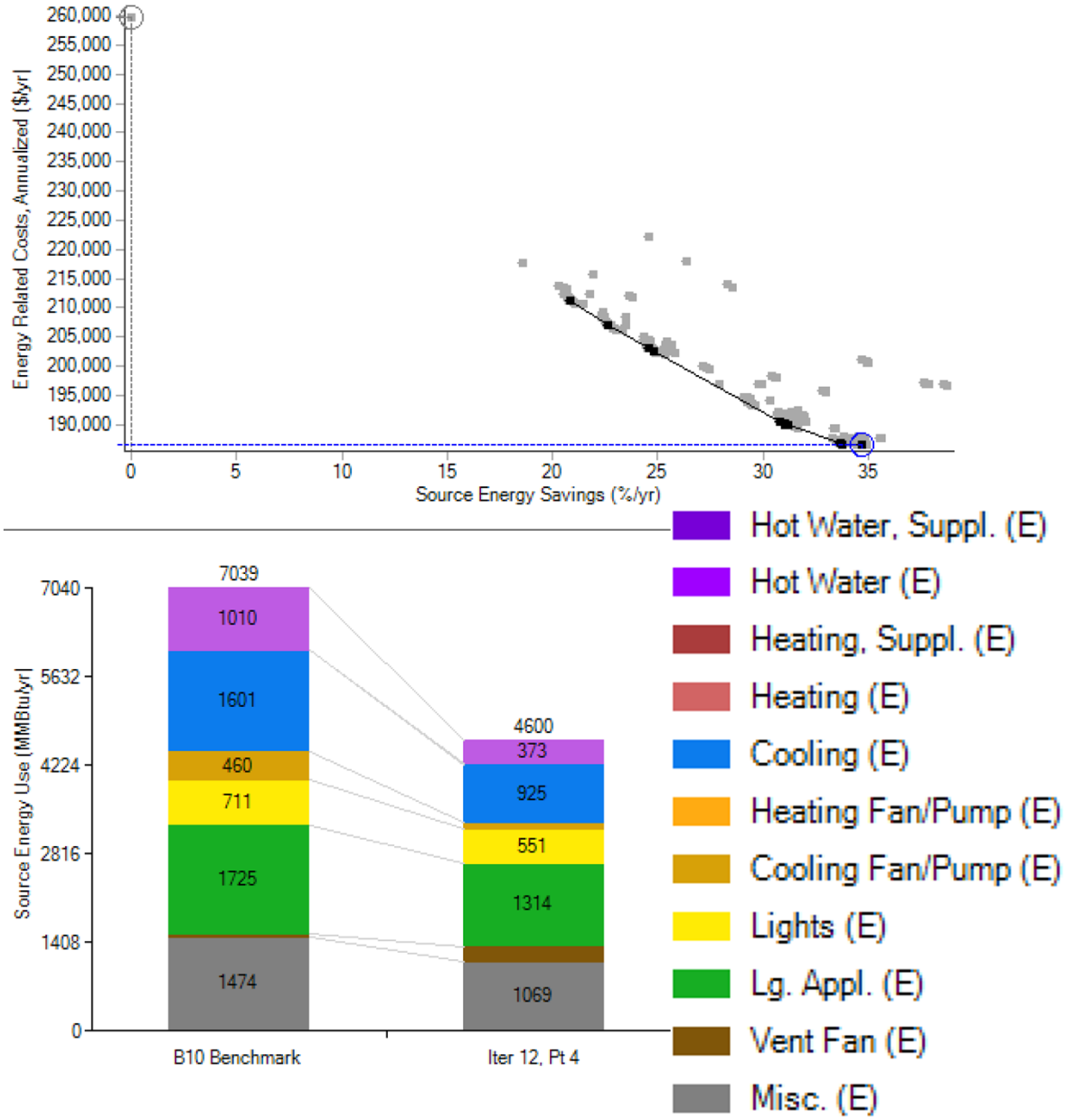
MF High-rise hi-occ Chariton IA (5A)



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.

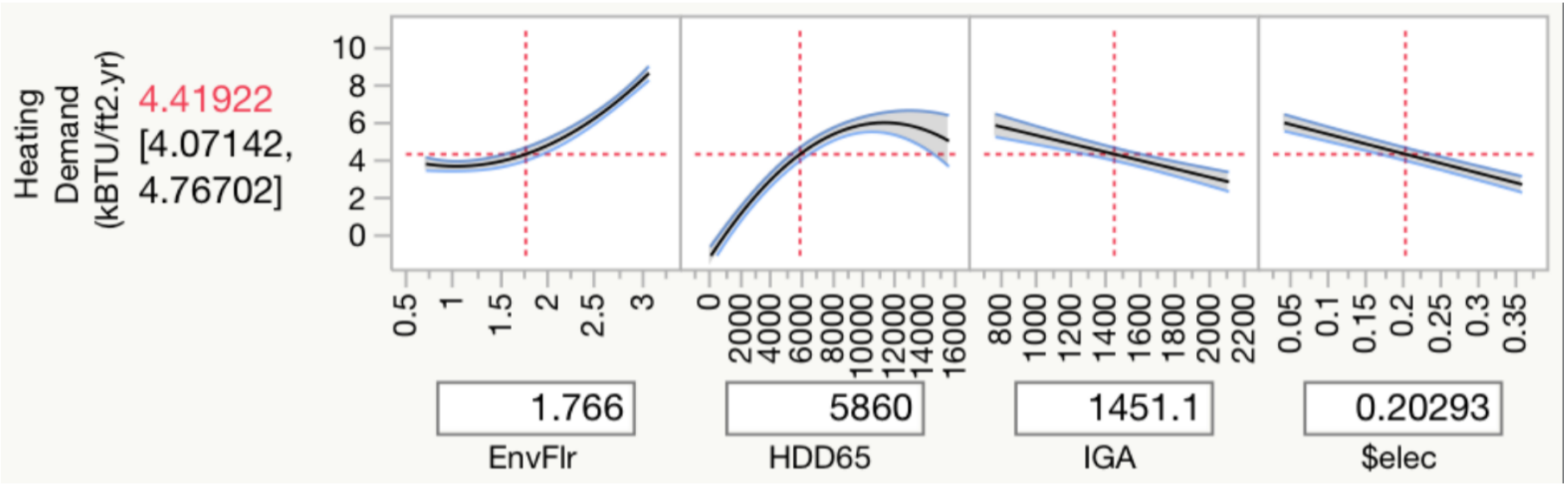
MF High-rise hi-occ Molokai HI



Curve-fitting JMP 13.2

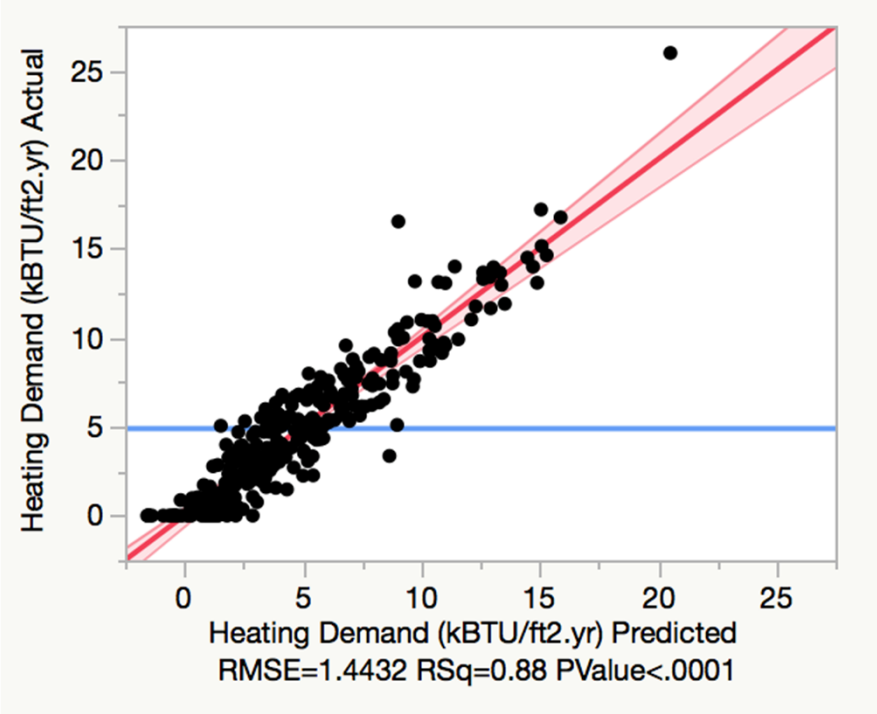
$$
\begin{aligned}
&3.0741786353 \\
&+ 1.7570744179 \bullet EnvFlr \\
&+ 0.0006094673 \bullet HDD65 \\
&+ -0.002236765 \bullet IGA \\
&+ -10.26787567 \bullet \$elec \\
&+ (EnvFlr - 1.766) \bullet (EnvFlr - 1.766) \bullet 1.1967248787 \\
&+ (EnvFlr - 1.766) \bullet (HDD65 - 5860.0833333) \bullet 0.0002735396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

Fitted formula for Annual Heat Demand Criterion



Curve-fitting

Curve-fitting



Annual heating demand, WUFI Passive results vs Fitting formula.

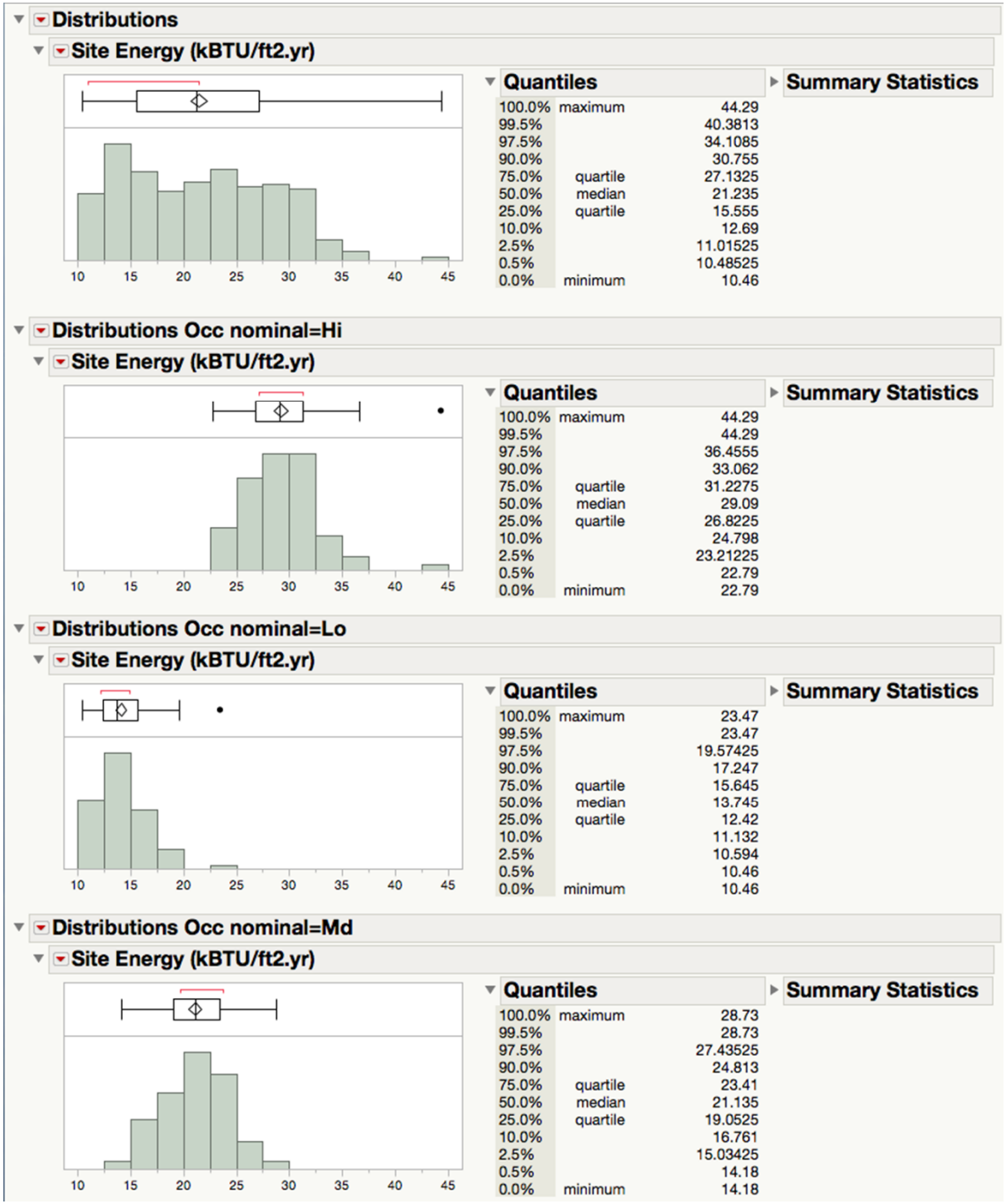
When-to-stop with passive measures

- 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


REALIZE
Industrial Approaches to Net Zero Energy Retrofits
PHIUS National Conference 2018 | Boston, Massachusetts
ROCKY MOUNTAIN INSTITUTE
Transforming global energy use to create a clean, prosperous, and secure low-carbon future.

Building AMERICA
U.S. Department of Energy

Rocky Mountain Institute (RMI)

Partners

- Passive House Institute US (PHIUS)
- Net Zero Energy Coalition (NZEC)

Topic Area

Moisture Managed High-R Envelopes

Success Metrics: Precipitate the market transformation needed to accelerate the wide-scale adoption of zero energy ready retrofits in the United States (U.S.) market.

Experimental Integrated Zero Energy Ready Retrofit Solution for Multifamily Renovations

- Develop a "building delivery system" for residential retrofits that provides a cost-effective zero energy ready solution
  - Minimally invasive
  - At least a 50% lower energy use intensity
  - Performs hygrothermally

Image courtesy of Energiesprong

REALIZE: GOAL AND MISSION

REALIZE seeks to create a business model inspired by Energiesprong to catalyze industry to develop industrialized, deep energy retrofits for the US residential market

ENERGIESPRONG: A MODEL OF INSPIRATION

Core offering: A net zero carbon retrofit bundle that is 1) affordable, 2) attractive, 3) ensures energy performance, and 4) can be delivered in less than two weeks

QUALITY

Net-zero energy homes with long performance warranties

NON-INTRUSIVE

Refurbishment within a week to 10 days

AFFORDABLE

Financeable through energy cost savings

LOOK & FEEL

Attractive and comfortable homes


NOW

MECHANICAL PODS

Scale essential to transform industry and achieve manufacturing efficiencies


NOW
23-PV-GN

Netherlands Field Trip

- RMI, NZEC, and PHIUS joined RetrofitNY on a field trip to the Netherlands to observe Energiesprong projects and factories

- Big takeaways:
  - Technical solutions are not as complex as we thought
  - General contractors need to be bought into this program
  - Demand aggregation is key to reducing costs
  - Financing
    - Financing solutions will be needed to support the long-term development of large volumes of demand
    - Gap funding will be necessary in the prototype phase and until demand aggregation is fully mature

Energiesprong Field Trip

Interior details

US FEASIBILITY

Building Typology Study

Major Question:
What kind of buildings should be targeted, and in what climate?

- Focus where the majority of the multifamily building stock is
  - ASHRAE climate zones 3, 4, and 5
  - Major cities with majority of multifamily building stock:
    - New York City (CZ4)
    - Chicago (CZ5)
    - Los Angeles (CZ3)
    - Dallas (CZ3)
- Most common building characteristics
  - Low-rise
    - 3-story, 15-unit, mass-masonry, pre-war
  - Mid-rise
    - 5-story, 50-unit, brick over steel, 1970s-80s

Typology Study: Identifying an Optimal Geographic Region

Multifamily unit populations living in 40 largest core-based statistical area (CBSA) as defined by the Office of Management and Budget (OMB)*

ASHRAE Climate Zone	Total MF Population	Share in 5-19	Share in 20-49	Share in 50+	Total MF Population	Share in 5-19	Share in 20-49	Share in 50+
1	1,390,820	558,562	363,066	469,192	5.1%	2.0%	1.3%	1.7%
2	3,057,990	1,849,022	578,175	630,792	11.2%	6.8%	2.1%	2.3%
3	8,246,314	4,648,993	1,701,574	1,895,747	30.2%	17.0%	6.2%	6.9%
4	9,779,106	4,232,109	2,046,220	3,500,777	35.8%	15.5%	7.5%	12.8%
5	4,118,733	2,383,905	735,447	999,381	15.1%	8.7%	2.7%	3.7%
6	690,943	261,591	183,687	245,666	2.5%	1.0%	0.7%	0.9%
Total	27,283,906	13,934,183	5,608,168	7,741,556	100.0%	51.1%	20.6%	28.4%

- **Climate Zone (CZ) 4 has the largest percentage of multifamily housing above 5 units per structure in the U.S.**
- **CZ 3 was not selected as a secondary region because the majority of building stock is found in Los Angeles which was out of the geographic scope to be considered for this project; CZ 5 was chosen instead.**
- **Key Finding: Target CZ 4 or 5.**

*Data extracted from "Small and Medium Multifamily Housing Units: Affordability, Distribution, and Trends," Yeokwang An, Raphael W. Bostic, Andrew Jakabovics, Anthony W. Orlando, and Seva Rodnyansky, November 3, 2015. Paper data from the American Community Survey (ACS), the American Housing Survey (AHS), and the county transaction records from DataQuick. The first two—released by the U.S. Census Bureau and the U.S. Department of Housing and Urban Development, respectively.

PREFERRED RETROFIT CANDIDATE

Retrofit Package: “Feasibility” Study to Inform Design

Purpose

- To determine rough, preliminary retrofit package needed to reach:
  - 50% source and site energy use reduction from a historical baseline (in this case, it will be the typology’s existing conditions assumptions)
  - Guided by PHIUS+ 2018 performance targets for air-tightness and peak heating/cooling loads.

Process

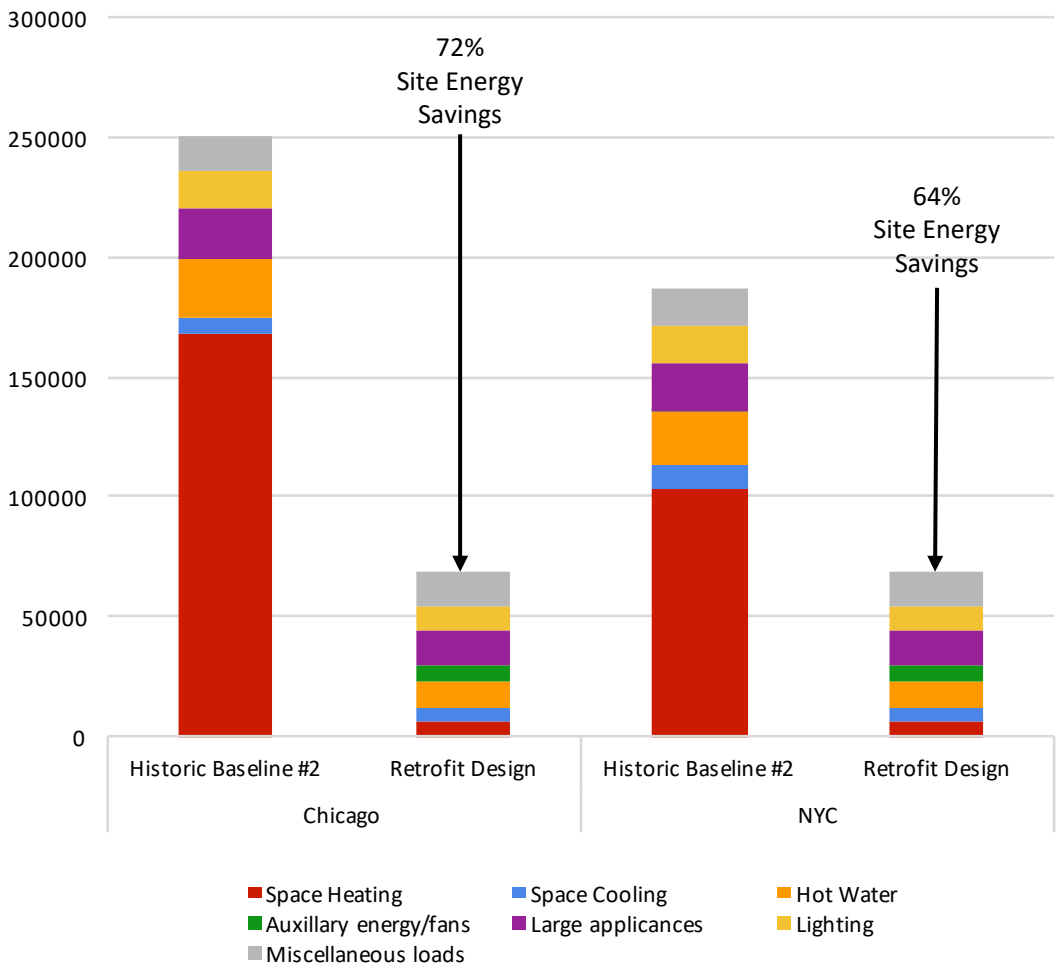
- Using PHIUS expertise, model the 3 building typologies for the 2 largest units/structure categories in two climate zones to determine:
  - Envelope design targets (ACH, R-values, U-values, etc.)
  - HVAC system types and efficiencies
  - Annual energy savings
  - Peak heating and cooling loads

Outcome

- A list of high-level design guidelines for HVAC and envelope to inform pilot design and that can be refined upon project completion for broader industry distribution

Retrofit Package for 15-unit Building

Annual Energy Use Comparison for Case #2 – Chicago vs. NYC



Measures Implemented:

Envelope:

- Air-sealing: 10X improvement
- Wall: R4 -> NYC - R24; Chicago - R32
- Roof: R14 -> NYC - R38; Chicago - R42
- Basement ceiling: R4 -> NYC - R14; Chicago - R23
- Window U-value: 0.76 -> 0.26
- Window SHGC: 0.76 -> 0.35, 0.41

Ventilation:

- ERV 84% efficient; 0.75 W/CFM

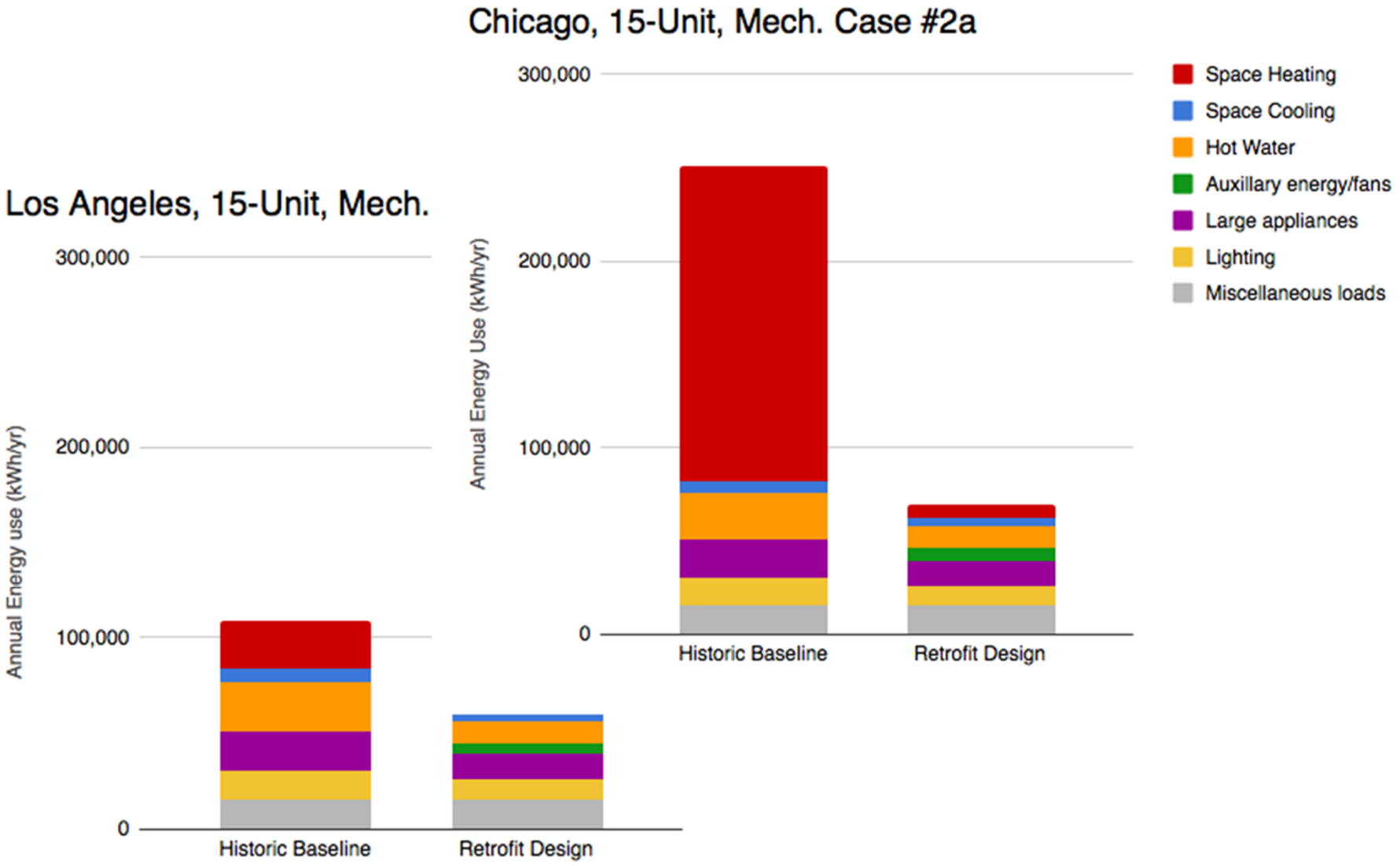
Heating, Cooling, and Domestic Hot Water:

- Air-source heat pump: heating COP 2.5; cooling COP 4.0
- DHW system upgrade: in-unit heat pump water heater, EF 2.25

Lighting and Appliances:

- High-efficacy lighting: 60% -> 100%
- Energy Star appliances (33% better)
- Condensation dryers

RETROFIT RESULTS



US FEASIBILITY

Hypothetical Retrofit Analysis

Building / Climate	50 % site savings?	Site net zero?
15-unit, New York City	64%	103%
15-unit, Chicago	72%	101%
15-unit, Dallas	55%	113%
15-unit, Los Angeles	45%	138%
50-unit, New York City	51%	82%
50-unit, Chicago	62%	86%

Summary of REALIZE RFP Process

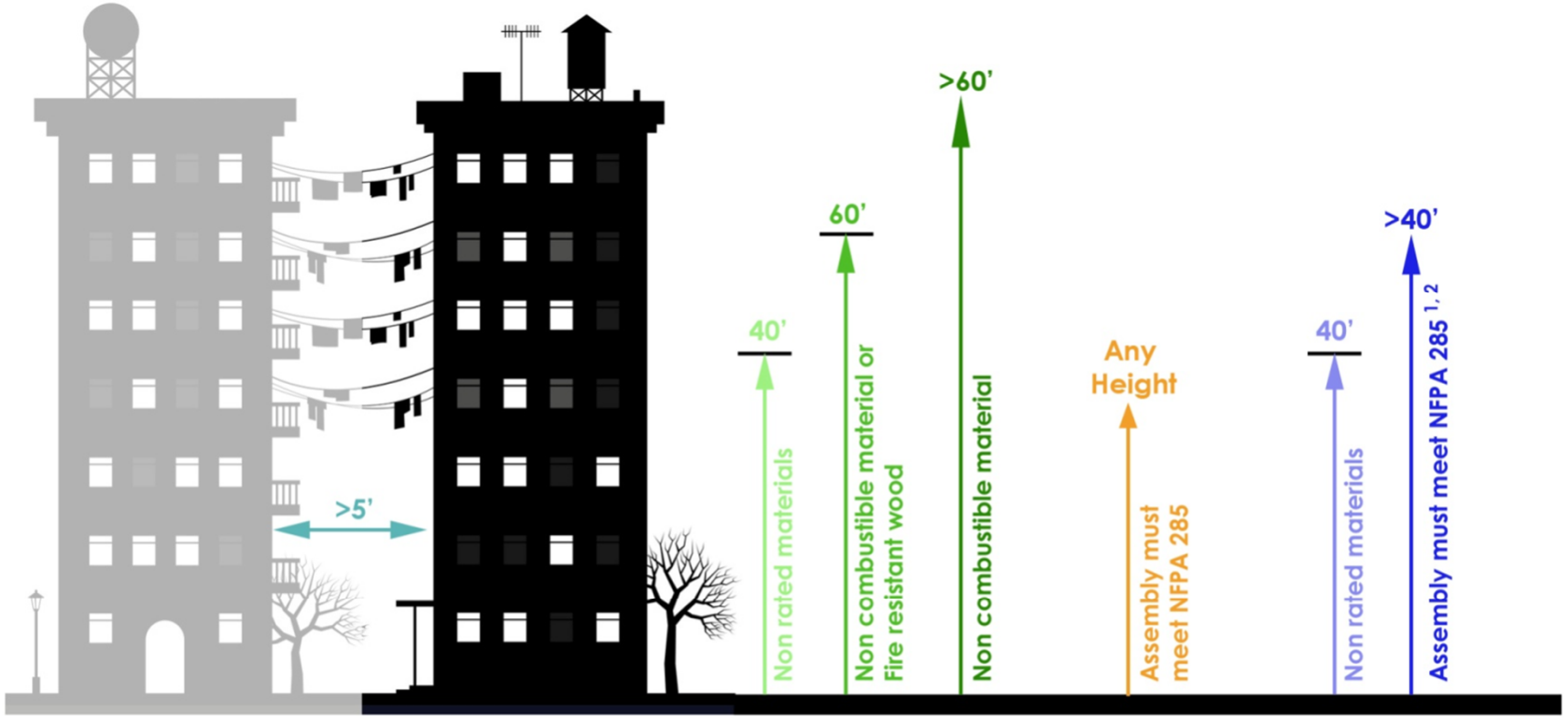
- The project team is releasing RFP's for:
  - Façade panel manufacturers (interviews underway, final selection by end of September)
  - Pilot buildings (initial applications in review, final selection by end of November)
  - Mechanical manufacturers (to be issued in November)

- The purpose of this process is to see how the market responds to our model's needs and to identify key areas where research and development will be needed

- RFP's can be found here: https://www.rmi.org/our-work/buildings/realize/rfps/

DESIGN PARAMETERS

Construction Type | **Bldg Height** | Panel Weight | Unitized Panel | Attachment | Below Grade



CONSTRUCTION TYPE I-IV
GREATER THAN 5' FROM NEIGHBORING BUILDING
(BUILDINGS LESS THAN 5' FROM NEIGHBORING BUILDINGS HAVE MORE RESTRICTIVE CODE REQUIREMENTS)

EXTERIOR WALL COVERING [1406.2]

FOAM PLASTIC INSULATION [2603.5]

WEATHER RESISTIVE BARRIER [1403.5]

DESIGN PARAMETERS

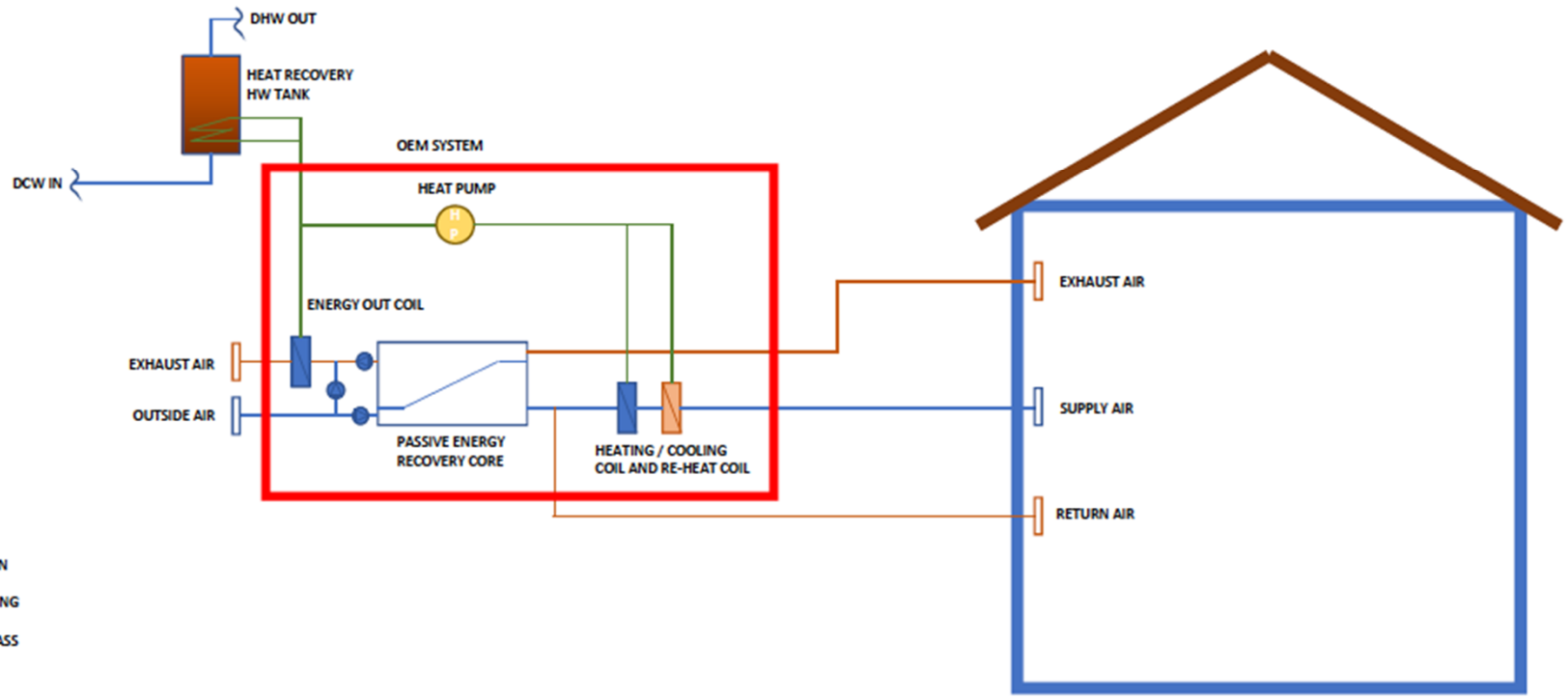
Construction Type | Bldg Height | Panel Weight | Unitized Panel | Attachment | **Below Grade**

Exterior Solution ?

Interior Solution ?

MECHANICAL SYSTEM SOLUTION

AIR-TO-AIR HEAT PUMP "MAGIC BOX" CONCEPT



FUNCTIONS:

- HEATING
- COOLING
- DEHUMIDIFICATION
- VENTILATION
- HOT WATER HEATING
- AIR FILTRATION
- ECONOMIZER BYPASS
- MONITORING

COMPONENTS:

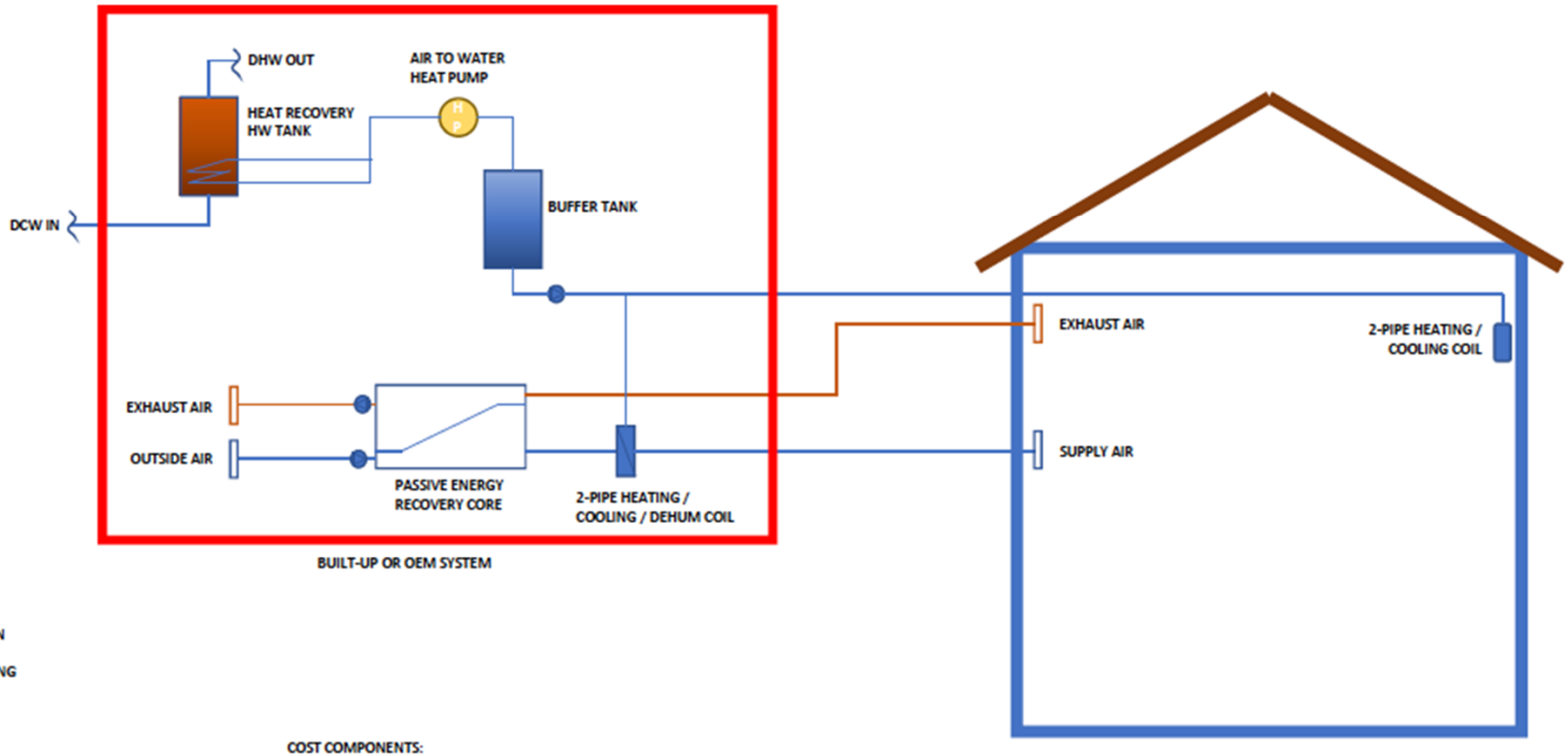
- AIR TO AIR HP WITH REVERSING VALVE
- DOMESTIC HW HEAT EXCHANGER FOR WASTE HEAT
- VARIABLE SPEED FANS AND COMPRESSOR
- RE-HEAT CAPABILITY
- PASSIVE HEAT RECOVERY CORE
- AIR FILTERS
- LOW GWP REFRIGERANT OR NATURAL REFRIGERANT

COST COMPONENTS:

- MAGIC BOX
- HW TANK
- INTERIOR DUCTWORK DISTRIBUTION

MECHANICAL SYSTEM SOLUTION

AIR-TO-WATER HEAT PUMP CONCEPT



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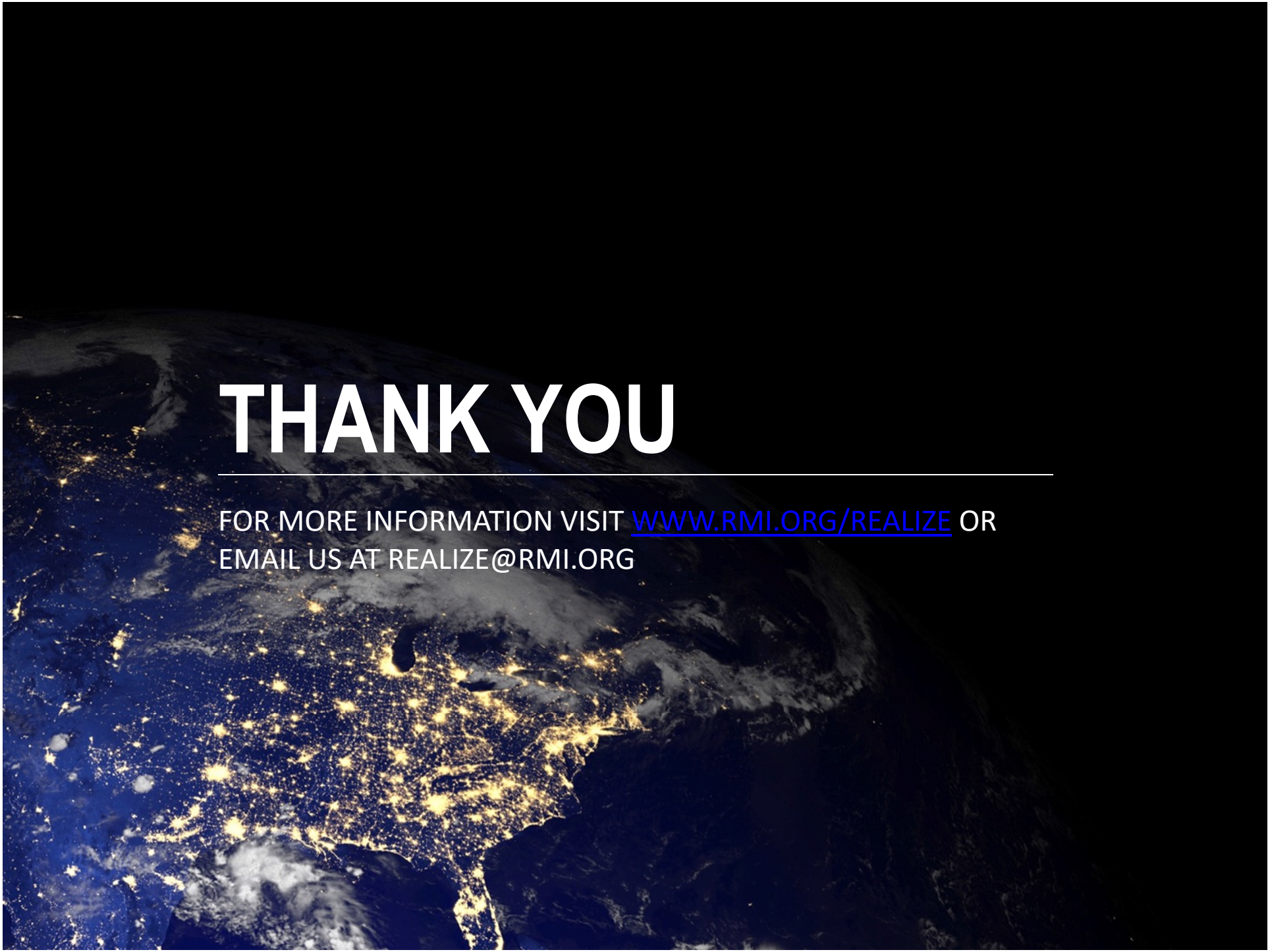
- AIR FILTERS
- LOW GWP REFRIGERANT OR NATURAL REFRIGERANT

COST COMPONENTS:

- AIR-TO-WATER HEAT PUMP
- HW TANK
- PASSIVE ERV
- INTERIOR PIPING
- INTERIOR FAN COILS



THANK YOU

FOR MORE INFORMATION VISIT WWW.RMI.ORG/REALIZE OR
EMAIL US AT REALIZE@RMI.ORG