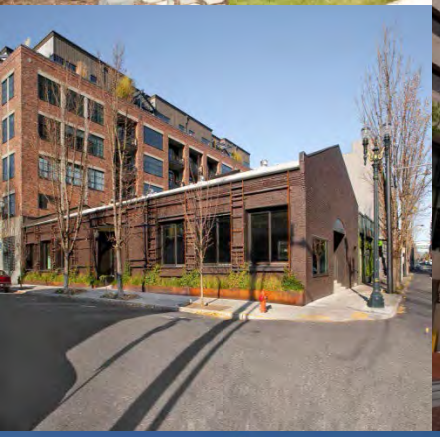
Setting Measurable Building Performance Targets for Deep Energy Savings

High Performance Design Training

December 07, 2017

EnergyTrust of Oregon



Who we are

Energy Trust is an independent nonprofit dedicated to helping 1.5 million utility customers invest in energy efficiency and clean, renewable power.

We provide:

- Information
- Technical services
- Engineering studies
- Cash incentives
- Contractor connections

Energy Trust New Buildings

- New construction
- Major renovation
- Tenant build-out
- Additions or expansions

Energytrust.org/commercial

New Buildings Training & Education

Allies for Efficiency (AFE)

- Case study presentations on high-performance design and construction projects
- Take place 3-5 times per year in Portland + regionally

High Performance Design Trainings

- Advanced training events for designers, architects and/or engineers
- Take place 2-3 times per year
- Content is focused on specific techniques or technologies

Building Energy Simulation Forum (BESF)

- Advanced energy modeling presentations
- Topics relevant to energy modelers / analysts, and engineers
- Take place every other month

Upcoming Building Energy Simulation Forum Trainings

BESF usually takes place the third Wednesday of every other month at the Ecotrust Building at noon.

December 13, 2017:

Energy Trust EDAPT Launch and a User's Perspective of OpenStudio

Presented by Forest Tanier-Gesner, CLEAResult

Training & Education Webpage

energytrust.org/commercial/commercial-training-events/

Boost your knowledge with Energy Trust's continuing education opportunities and special training events. Trainings include real-world examples, case studies, and detailed technical information presented by experts from the fields of architecture, engineering, construction and development, as well as specialists in a variety of building types and market sectors. Attendees may be eligible for continuing education units, CEUs.

Find Upcoming Trainings and Events

Questions?

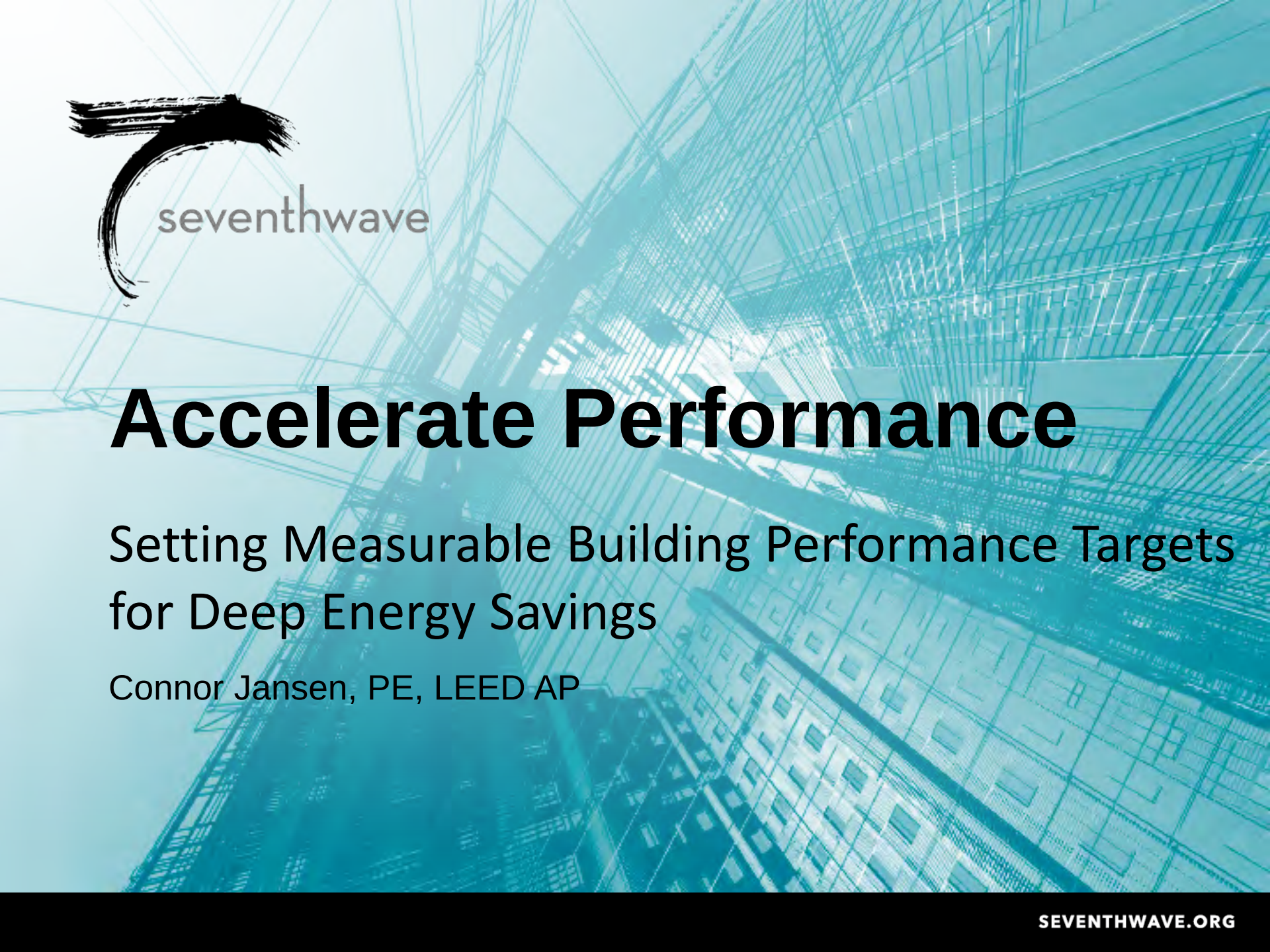
Have questions about upcoming training and education opportunities *or* about becoming an Energy Trust New Buildings Ally?

Contact Kirsten.Vogel@clearesult.com

Thank You

Kirsten Vogel
Market Outreach Specialist
kirsten.vogel@clearesult.com

EnergyTrust of Oregon



Accelerate Performance

Setting Measurable Building Performance Targets for Deep Energy Savings

Connor Jansen, PE, LEED AP

seventhwave | **ACCELERATE** PERFORMANCE

100 buildings **three** years

Department of Energy initiative to scale performance-based procurement

Partner with utility new construction programs and portfolio owners

Provide technical support to building owner

Rubenstein Forum, Chicago, IL
Rendering courtesy of University of Chicago

TEAM

Seventhwave

National Renewable Energy Laboratory

Institute for Sustainable Energy—Eastern Connecticut State University

UMN-Center for Sustainable Building Research (MN CARD pilot)

UTILITY PARTNERS

ComEd

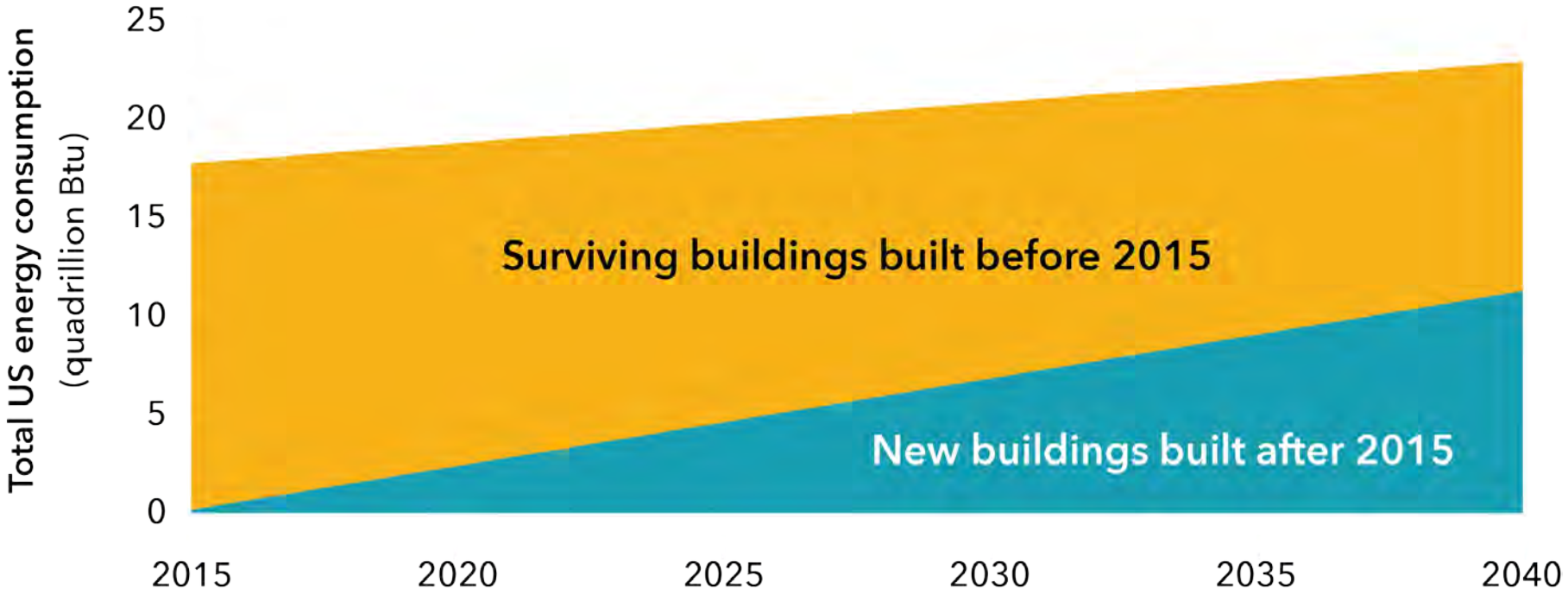
Eversource

United Illuminating

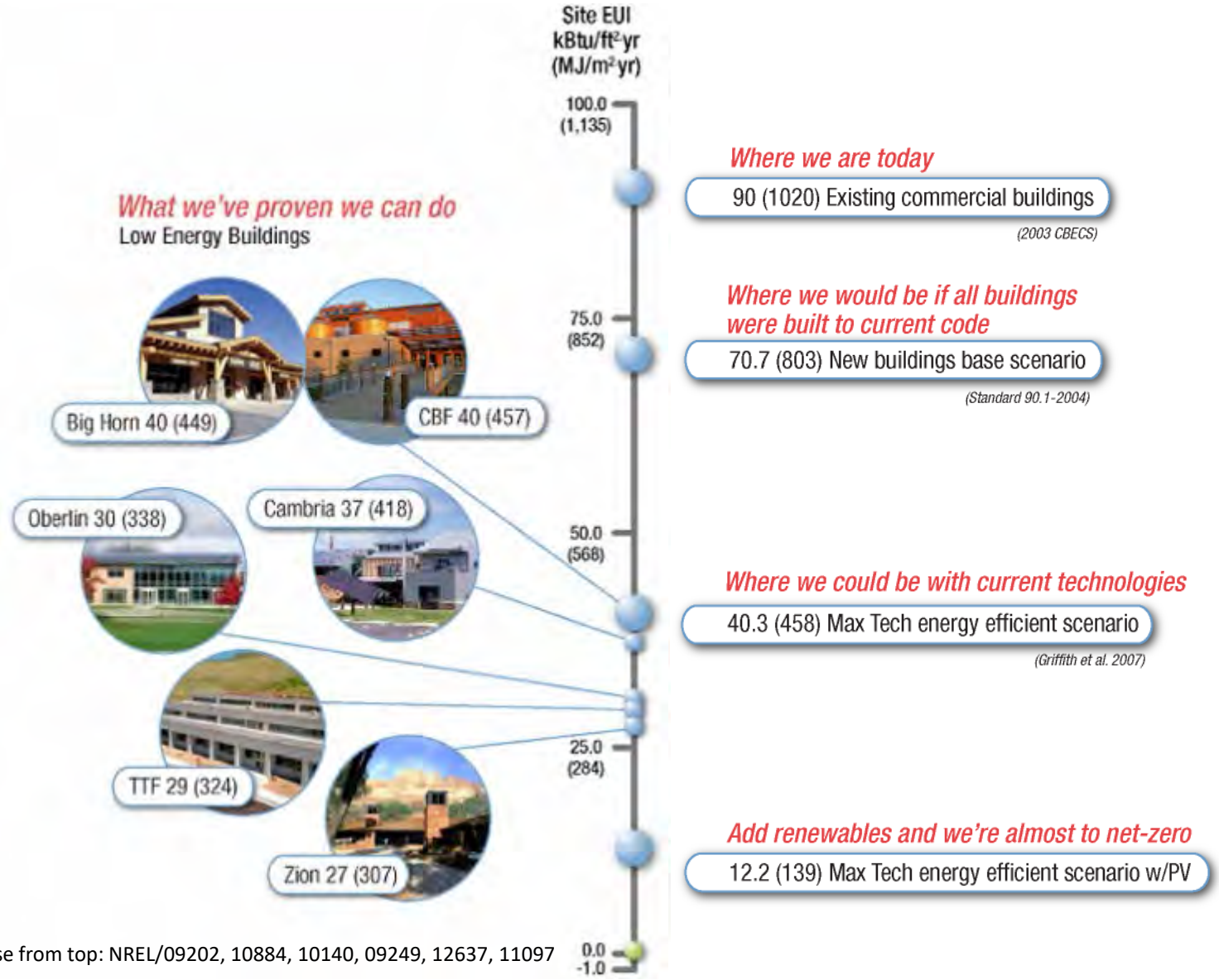
Xcel Energy (MN CARD pilot)

Photo Credit NREL

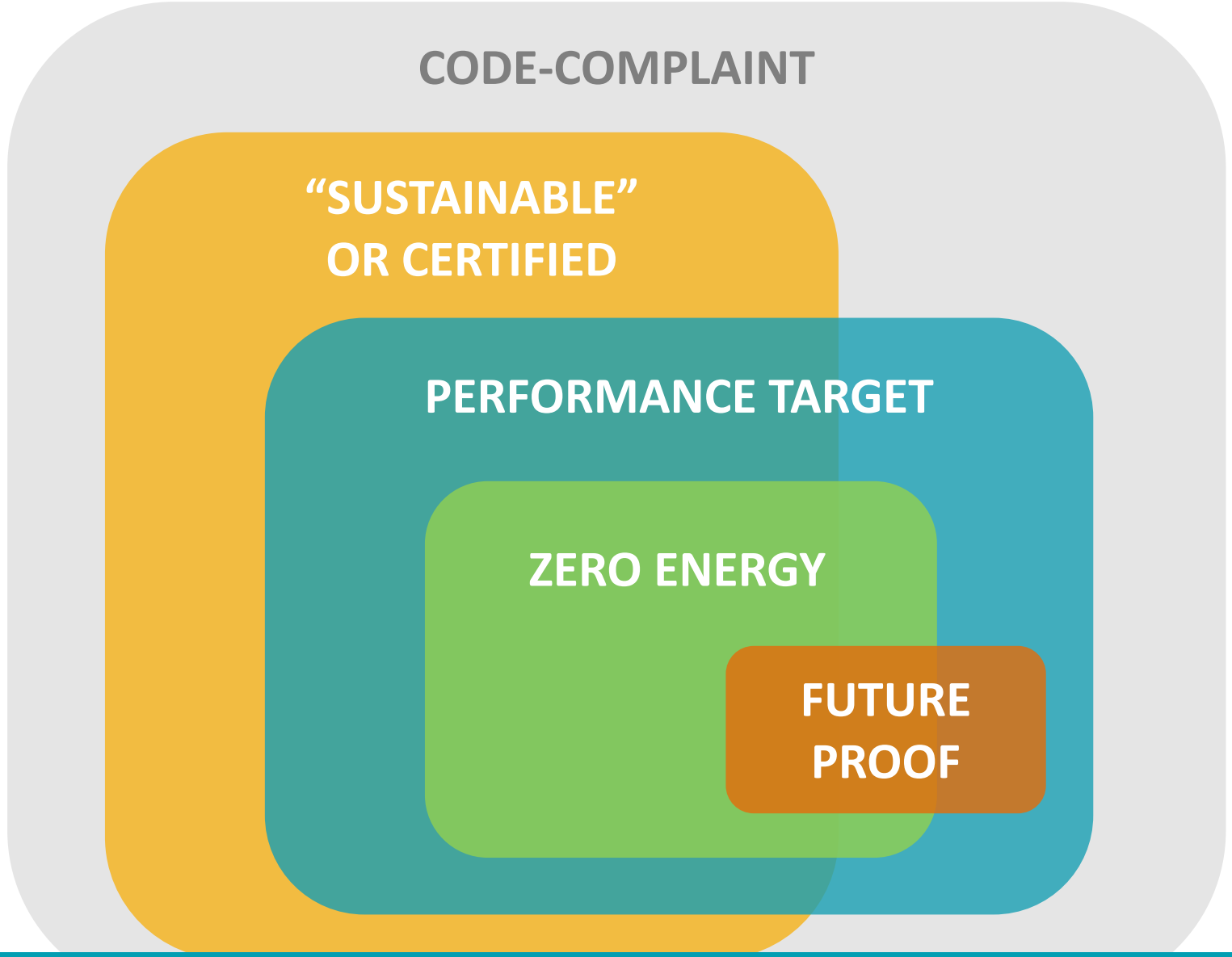
seventhwave | **ACCELERATE** PERFORMANCE



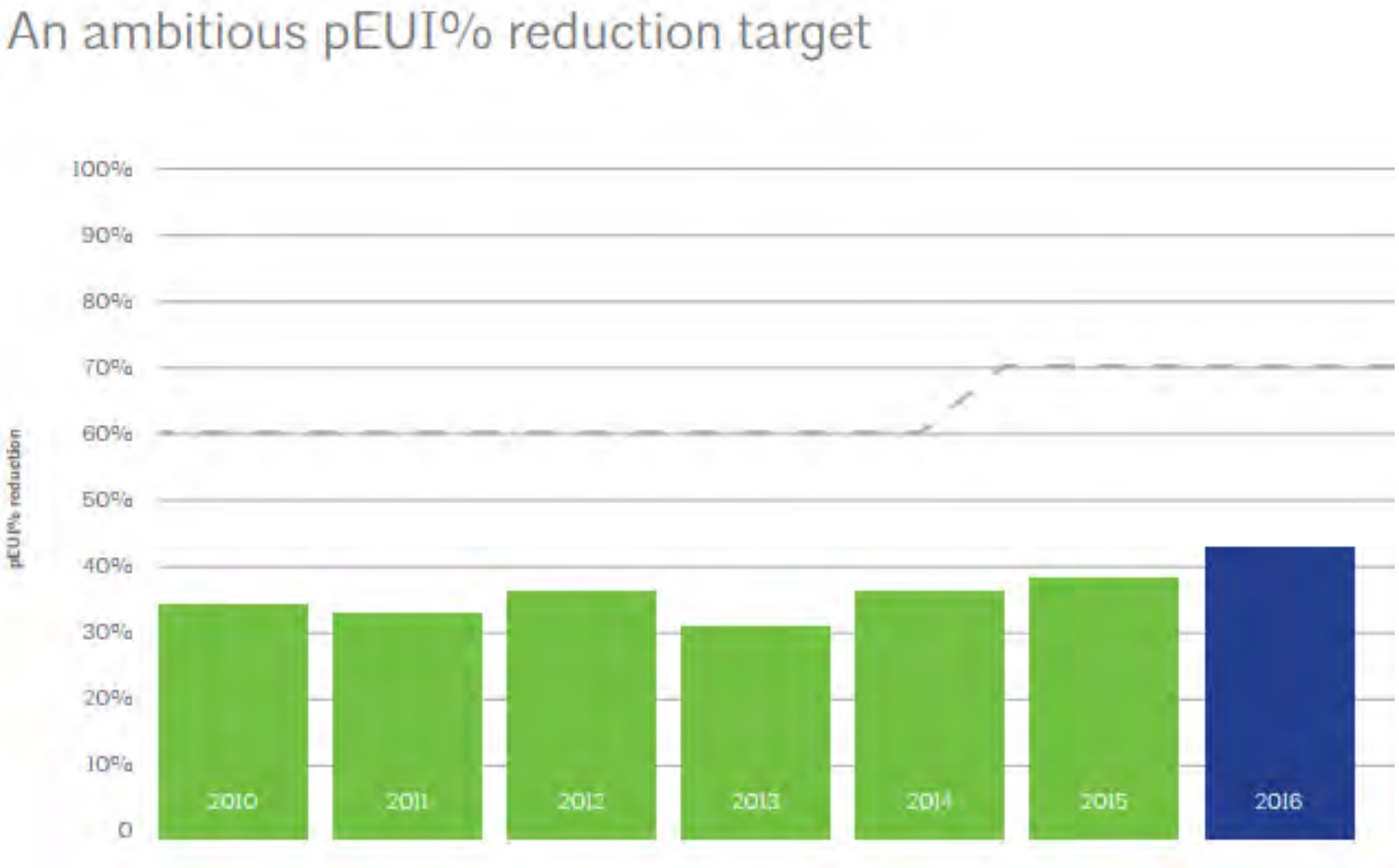
Great potential in commercial buildings



Clockwise from top: NREL/09202, 10884, 10140, 09249, 12637, 11097

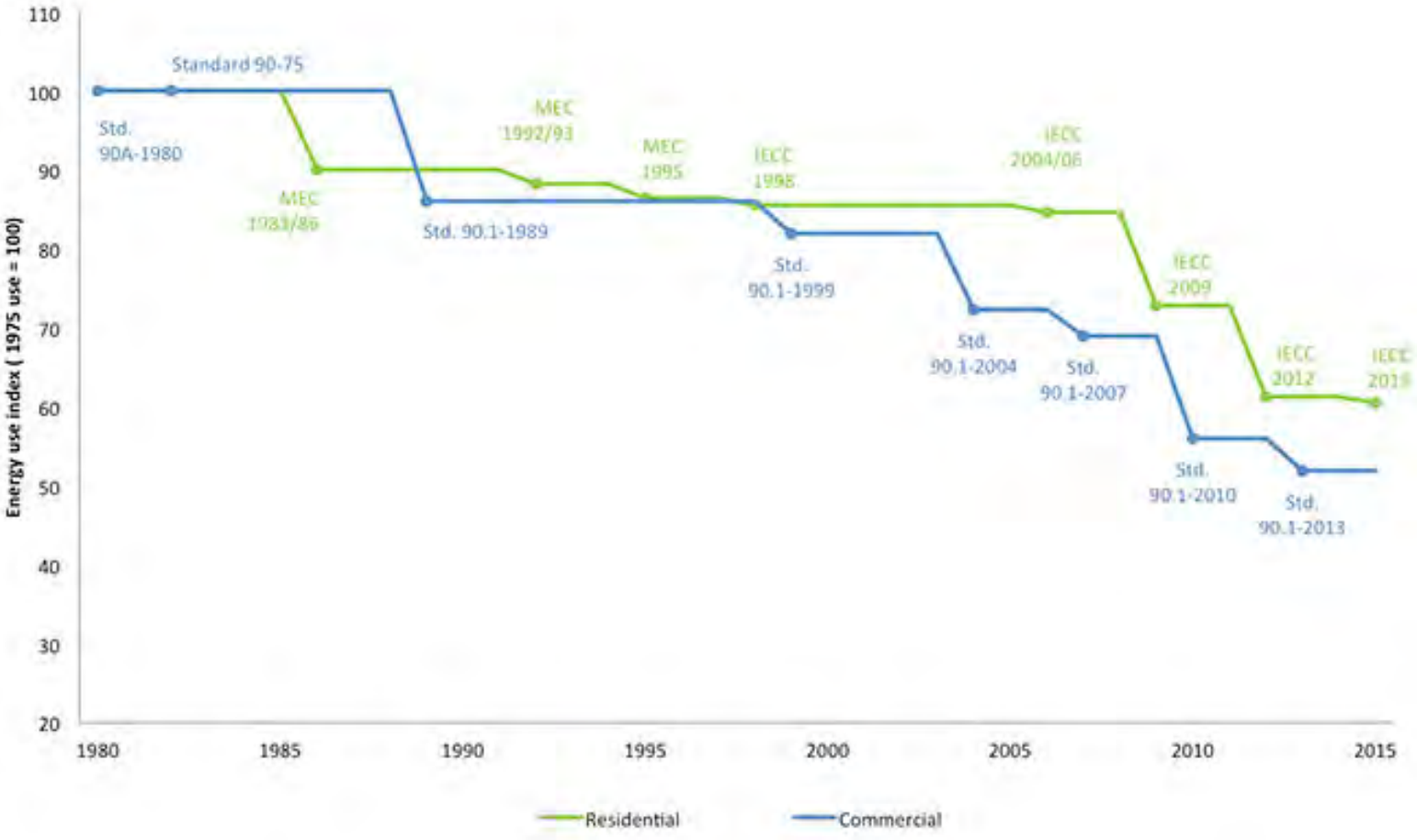

ALL NEW BUILDINGS
CODE-COMPLAINT
“SUSTAINABLE”
OR CERTIFIED
PERFORMANCE TARGET
ZERO ENERGY
FUTURE
PROOF

The 2030 Commitment



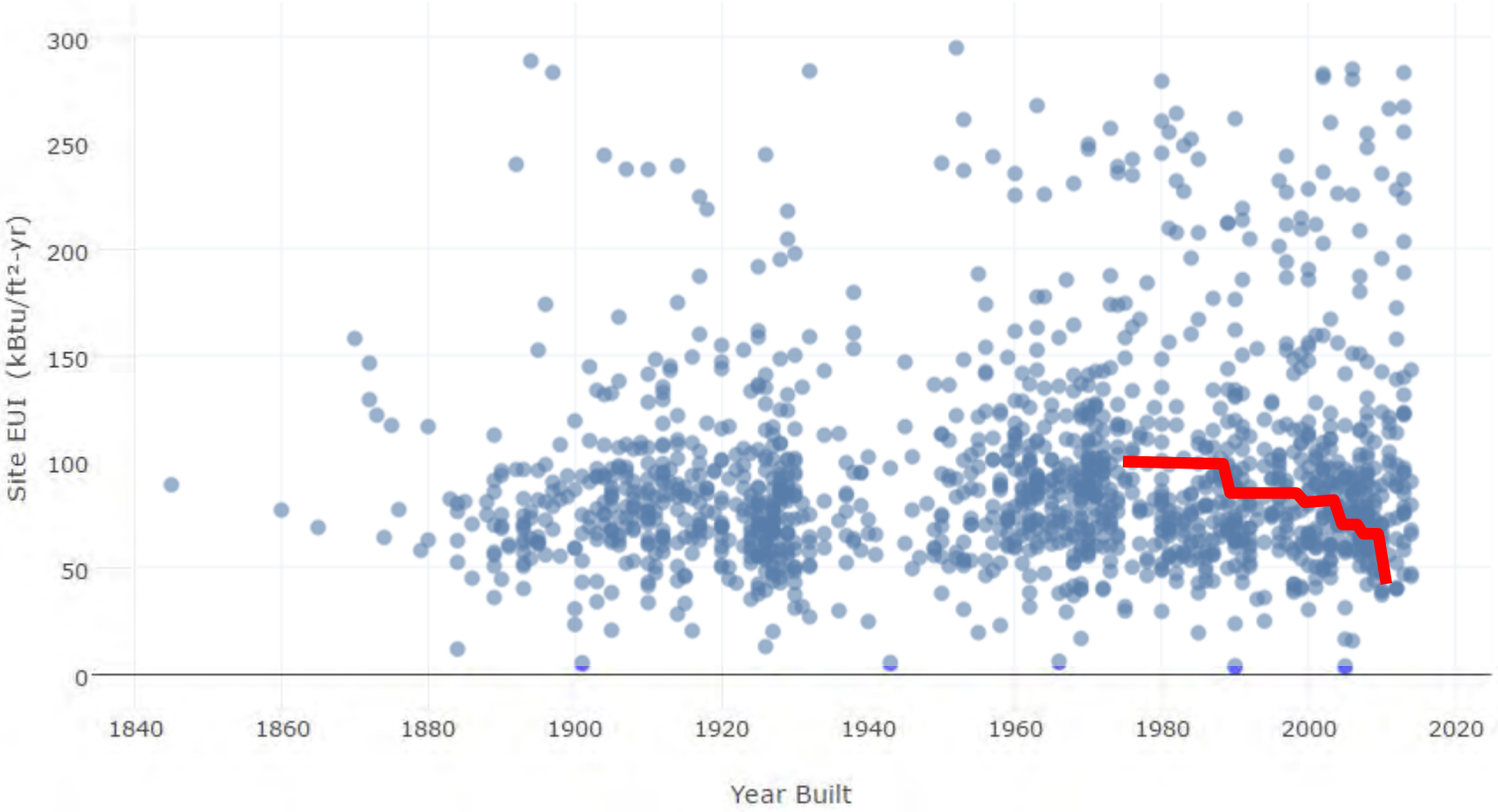
http://aiad8.prod.acquia-sites.com/sites/default/files/2017-07/2016BytheNumbers-AIA2030CommitmentFinal_0.pdf

Building Energy Codes

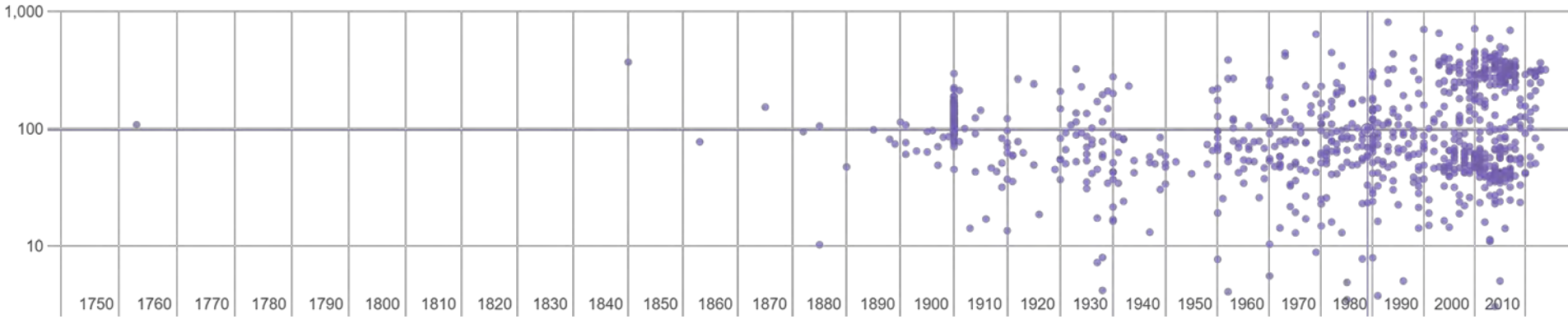


Source: ACEEE based on analysis from Pacific Northwest National Laboratory

Chicago Benchmarking Data



National Benchmarking



U.S. DEPARTMENT OF ENERGY

BERKELEY LAB Lawrence Berkeley National Laboratory

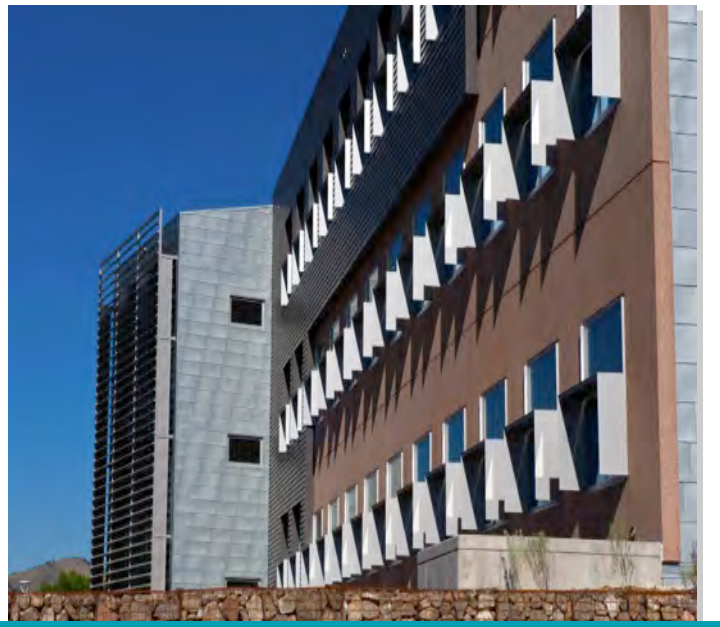
- ☑ Anonymous
- ☑ Boston Benchmarking Ordinance
- ☑ California Proposition 39 K-12 Program Data
- ☑ Chicago Benchmarking Ordinance
- ☑ Gainesville Green
- ☑ Minneapolis Benchmarking Ordinance
- ☑ New York City Benchmarking Ordinance (excl. audit data)
- ☑ Philadelphia Benchmarking Ordinance
- ☑ PNW Commercial Building Stock Assessment
- ☑ San Francisco Benchmarking Ordinance
- ☑ Washington D.C. Benchmarking Ordinance

NREL RSF
Golden Colorado
EUI 29 kBtu/ft^2
$259/ft^2

- RSF uses 50% less energy than if it were built to current commercial codes at no extra capital cost
- RSF increases space at NREL by 60% but only increases energy use by 6%

Owner Role

- Spend the time to get RFP right
  - Design/build team will study to pass the test
- Set up acquisition process to “force” integrated design
  - Energy modeling guides conceptual design decisions
  - Architecture and envelope are also efficiency measures



NREL/17833

Owner Role

- Unwavering commitment to problem statement
  - Unleash power of design/build team of experts to meet your needs
    - true value engineering
  - Commit to your objectives and the prioritization and don't adjust

Clockwise from top:
NREL/18784, 24690, 17823

Guidance for Unknowns

NREL/15884

- Benchmarked current plug loads and data center load
  - Provided peak uses and occupancy schedule by plug load type
    - Laptops, monitors, copiers, kitchen equipment, task lights, etc.
    - 65 Watts/occupant 24/7 for datacenter
  - Allowed design-build team to make recommendations on plug load reductions.

Steps…

- RFQ: Short list to 3 teams
- Pay for conceptual design (share the risk)
- Select best value for fixed price
- Incentives
- Require substantiation

NREL/21806

Problem Definition: RFP Objectives

MISSION CRITICAL

Attain safe work performance/Safe Design Practices

LEED Platinum

Energy Star “Plus”

HIGHLY DESIRABLE

800 staff Capacity

25 kBTU/ft^2/year

Architectural integrity

Honor future staff needs

Measurable ASHRAE 90.1

Support culture and amenities

Expandable building

Ergonomics

Flexible workspace

Support future technologies

Documentation to produce a “How to” manual

“PR” campaign implemented in real-time

Allow secure collaboration with outsiders

Building information modeling

Substantial Completion by 2010

IF POSSIBLE

Zero energy

Most energy efficient building in the world

LEED Platinum Plus

ASHRAE 90.1 + 50%

Visual displays of current energy efficiency

Support public tours

Achieve national and global recognition and awards

Support personnel turnover

PASSIVE ARCHITECTURE

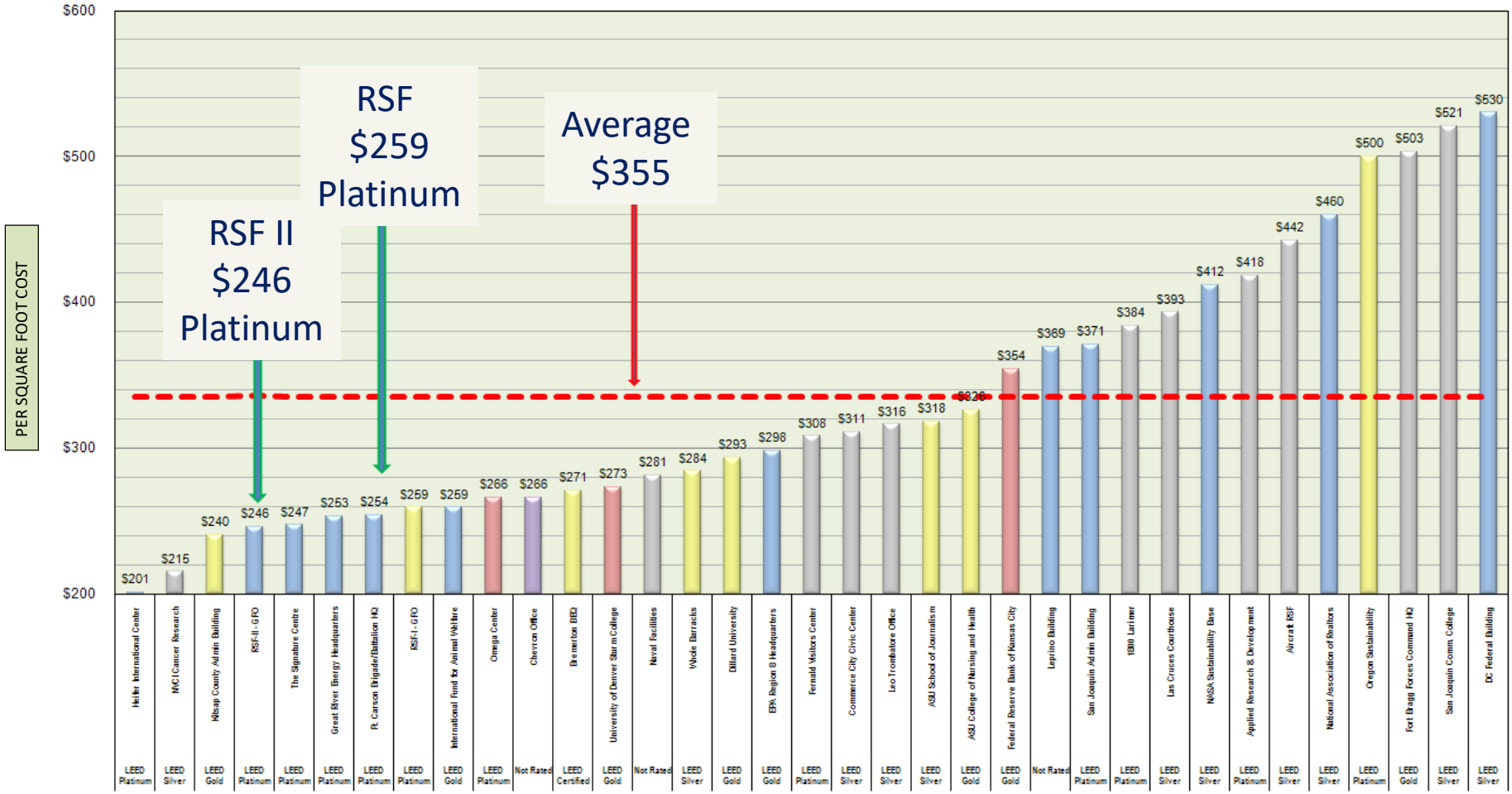
Construction Innovation

5 days per deck allowed
- 2 days per deck
- 85% faster

Offsite pre-fab of zones

Offsite pre-pressurized

COMMERCIAL BUILDING CONSTRUCTION COST



PROJECTS AND LEED CERTIFICATION

LEGEND:

- NOT RATED
- LEED CERTIFIED
- LEED GOLD
- LEED SILVER

SOURCES:

www.fayobserver.com
www.dbia.com
www.nasa.gov
www.eomega.org
www.oregonsustainabilitycenter.org
www.americas.rlb.com
http://greensource.construction.com
www.1800larimer.com
www.usgbc.org
www.smithgroup.com
www.cronkite.asu.edu

ESIF

Energy goal (supercomputer): **1.06 PUE**
Final EUI prediction: **1.05 PUE**
Actual performance: **1.05 PUE**

PARKING STRUCTURE

Energy goal: **175 kBtu/space/yr**

Final EUI prediction: **158 kBtu/space/yr**

Actual performance: **163 kBtu/space/yr**

CAFETERIA

EUI goal: 30% energy cost savings versus Standard 90.1-2007, which is **190 kBtu/ft^2/yr**

EUI prediction: **144 kBtu/ft^2/yr**

Actual performance: **143 kBtu/ft^2/yr**

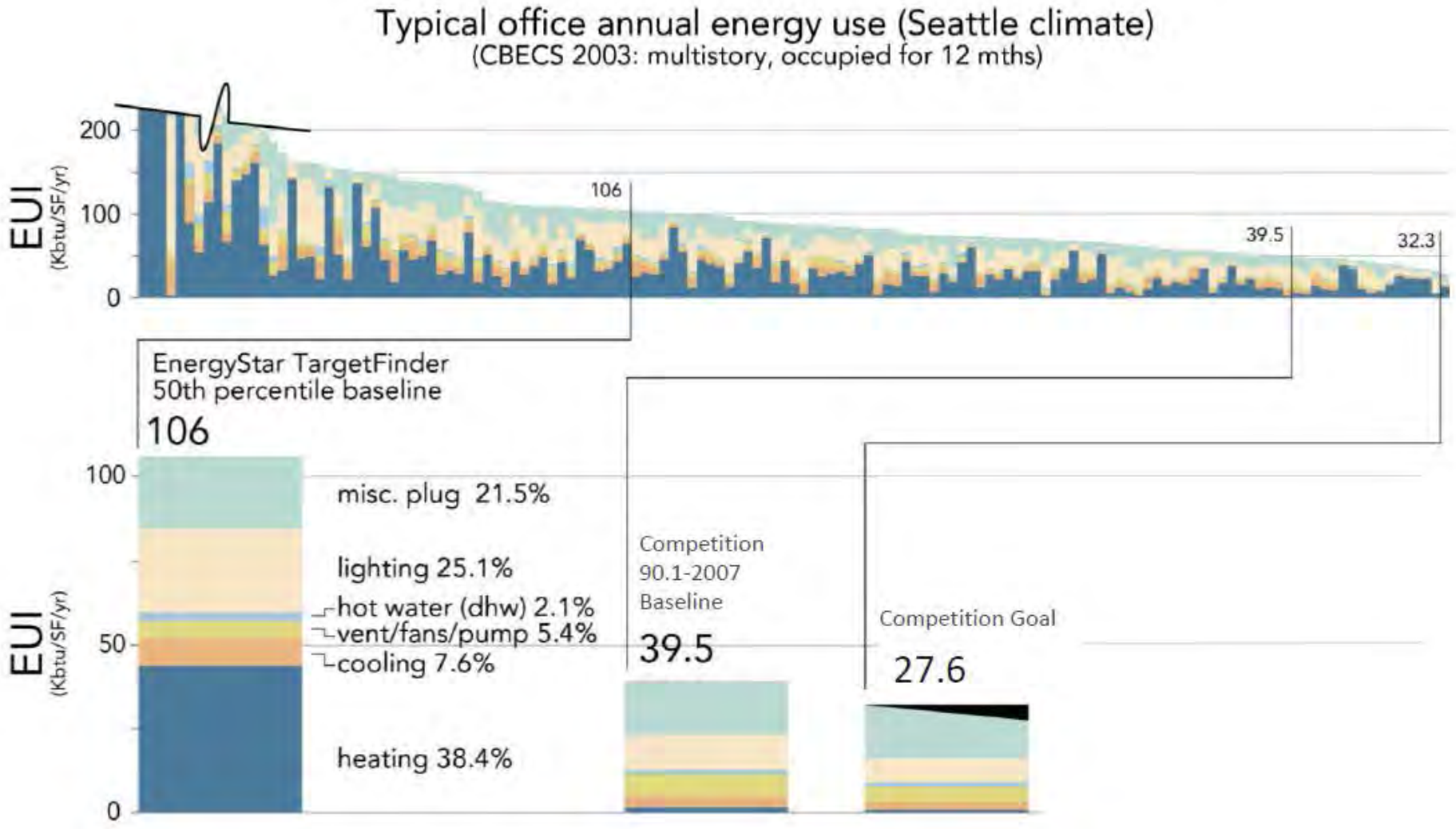
RSF I and II

Area weighted averages
EUI goal: **34 kBtu/ft^2/yr**

EUI prediction: **31 kBtu/ft^2/yr**

Actual performance: **33 kBtu/ft^2/yr**


Federal Center South
Seattle, WA
EUI 26 kBtu/ft²
$311/ft²
ww.gsa.gov/about-us/regions/northwestarctic-10/buildingsfacilities/washington/federal-center-south-modernization



https://www.gsa.gov/about-us/regions/northwestarctic-10/buildingsfacilities/washington/federal-center-south-modernization

Project Goals

- **LEED Gold minimum**
- Employ **integrated approach** to meet sustainability goals
- **30% reduction in energy usage** compared to ASHRAE 90.1-2007
- **Install advanced meters** for electricity, natural gas, and water
- Install **solar thermal hot water system** (integrated approach determined not cost effective)
- Plan for **on-site renewable energy** systems
- Reduce **indoor potable water** use by at least 20%
- Reduce **outdoor potable water** use by at least 50%
- Manage 95th **percentile rain event** onsite through infiltration
- Provide occupancy and **daylight sensors**
- **Pre-occupancy flush-out**
- **Salvage, recycle, or reuse at least 50% of construction and demolition waste**

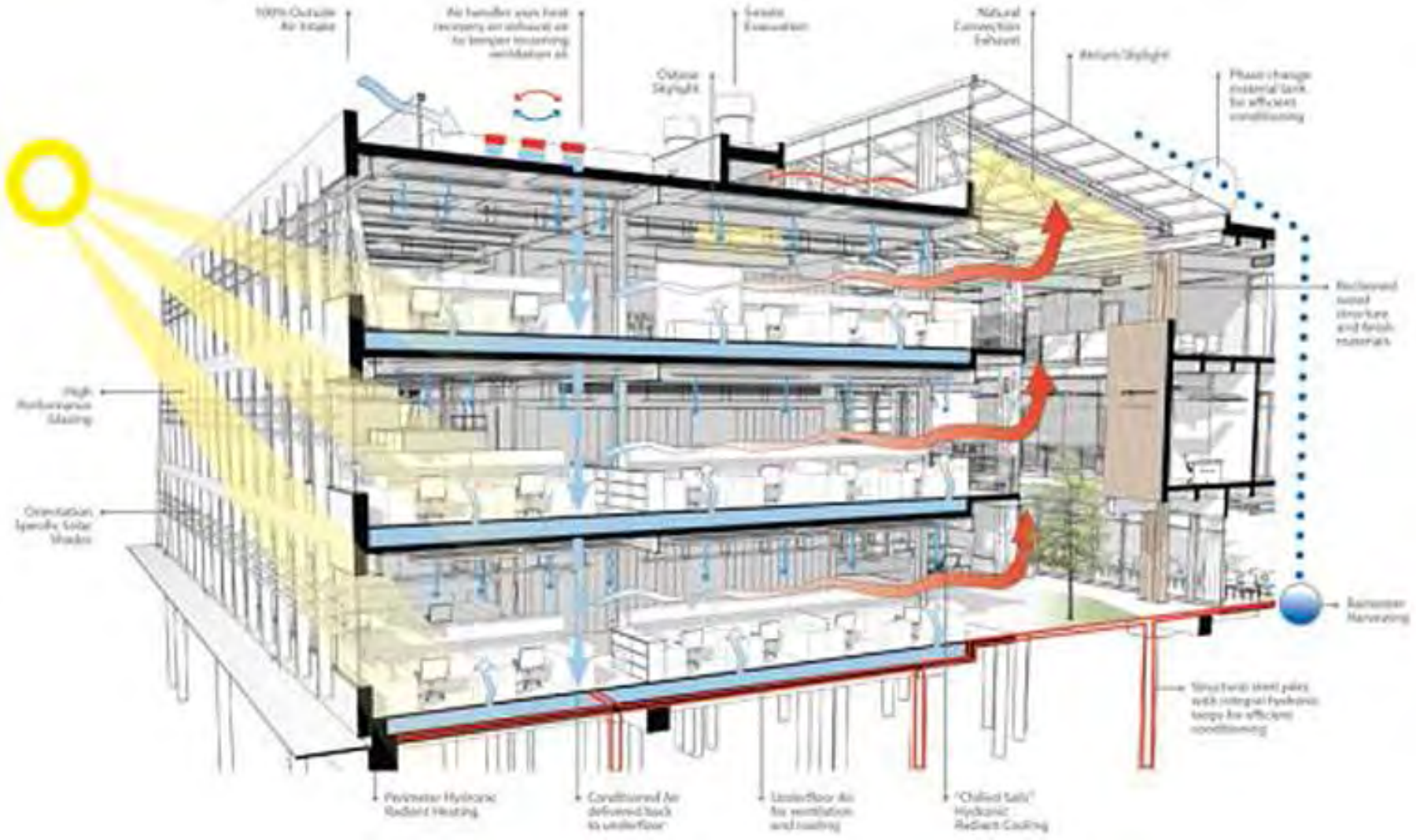


Photo Credit: ZGF Architects LLP

Performance Clause

The GSA used the contractual performance clause as a mechanism to clearly communicate the project goals, aligning the team to the owner's priorities. Until the building has proven that it meets the energy-performance targets, 0.5% of the original contract award is withheld from the team.

www.gsa.gov/about-us/regions/northwestarctic-10/buildingsfacilities/washington/federal-center-south-modernization

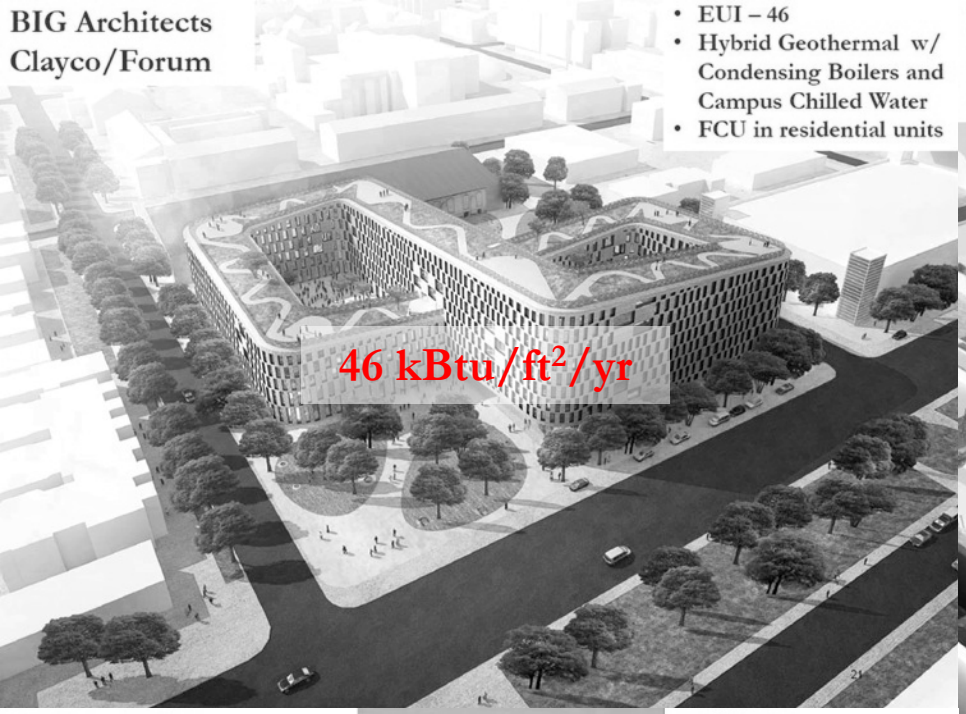
Campus North
Chicago, IL
$370/ft^2
pEUI 54 kBtu/ft^2

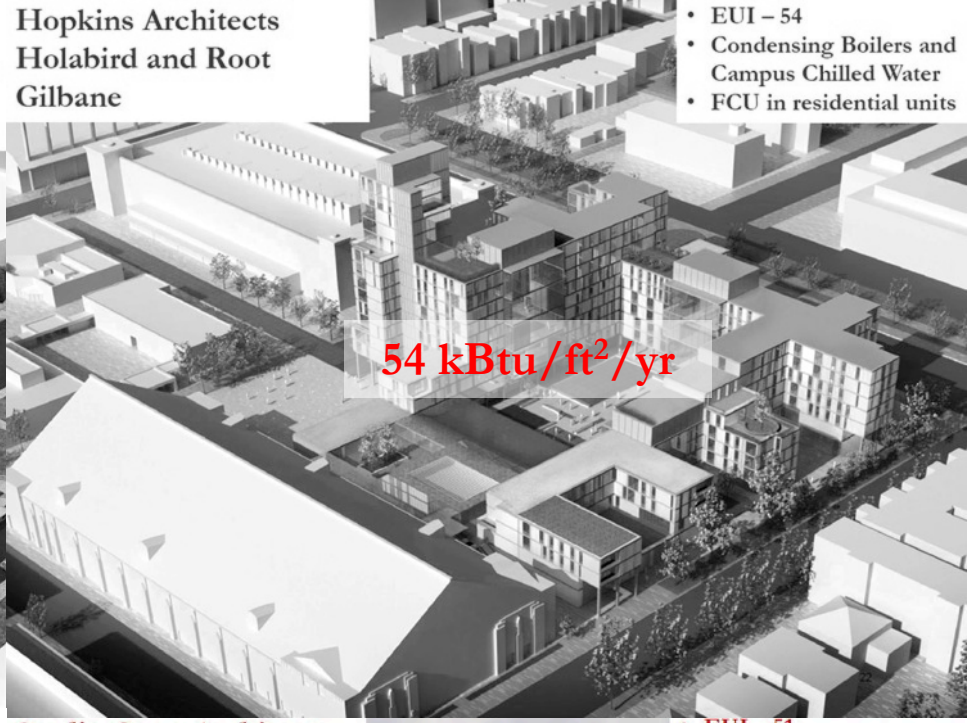

BIG Architects
Clayco/Forum
• EUI – 46
• Hybrid Geothermal w/ Condensing Boilers and Campus Chilled Water
• FCU in residential units

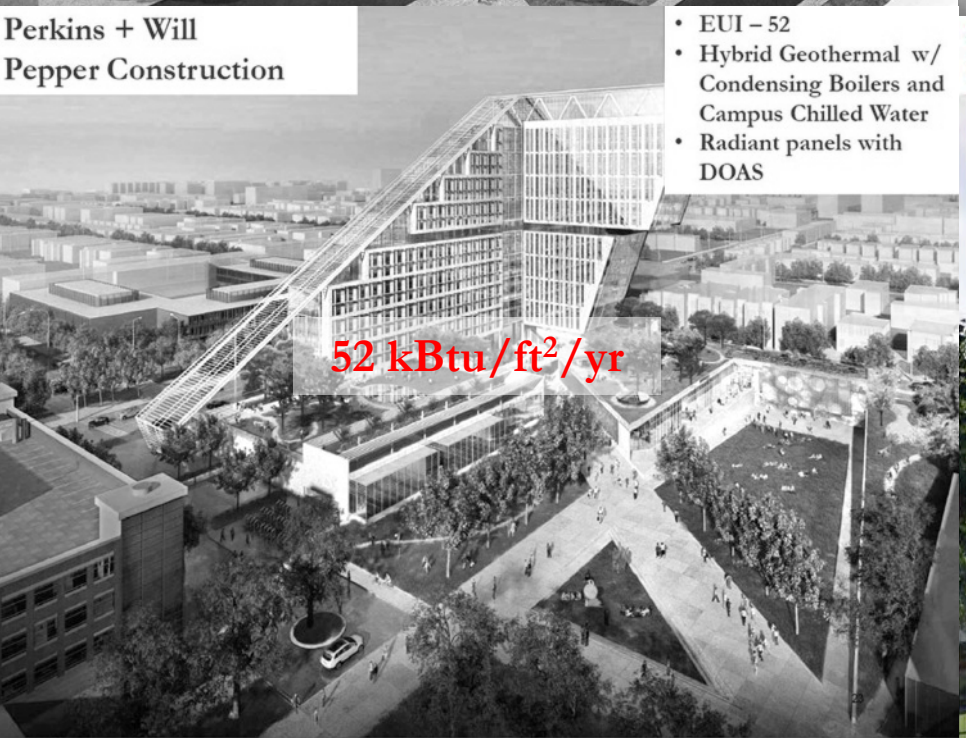

Hopkins Architects
Holabird and Root
Gilbane
• EUI – 54
• Condensing Boilers and Campus Chilled Water
• FCU in residential units


Perkins + Will
Pepper Construction
• EUI – 52
• Hybrid Geothermal w/ Condensing Boilers and Campus Chilled Water
• Radiant panels with DOAS

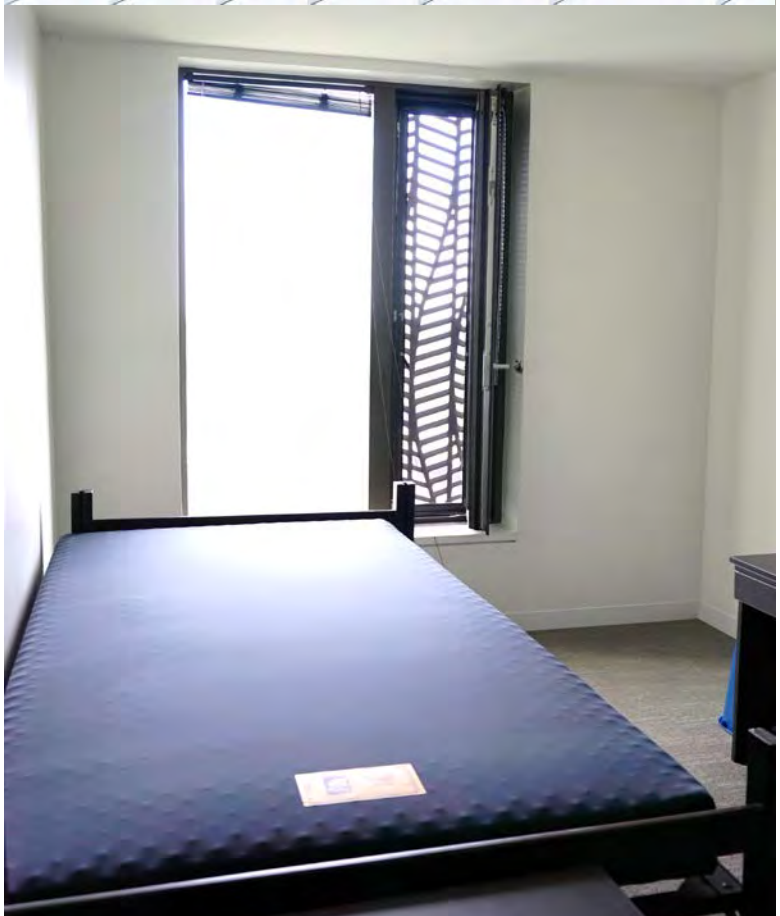

Studio Gang Architects
Mortenson Construction
• EUI – 51
• Condensing Boilers and Campus Chilled Water
• Radiant Slab with DOAS


BIG Architects
Clayco/Forum
• EUI – 46
• Hybrid Geothermal w/ Condensing Boilers and Campus Chilled Water
• FCU in residential units
46 kBtu/ft²/yr


Hopkins Architects
Holabird and Root
Gilbane
• EUI – 54
• Condensing Boilers and Campus Chilled Water
• FCU in residential units
54 kBtu/ft²/yr


Perkins + Will
Pepper Construction
• EUI – 52
• Hybrid Geothermal w/ Condensing Boilers and Campus Chilled Water
• Radiant panels with DOAS
52 kBtu/ft²/yr


Studio Gang Architects
Mortenson Construction
• EUI – 51
• Condensing Boilers and Campus Chilled Water
• Radiant Slab with DOAS
51 kBtu/ft²/yr



Case Study Discussion

- Which contractual requirement structure do you think worked the best?
  - Owners empowerment
  - Financial Retainer
  - Reputation
- What did all of these projects have in common?

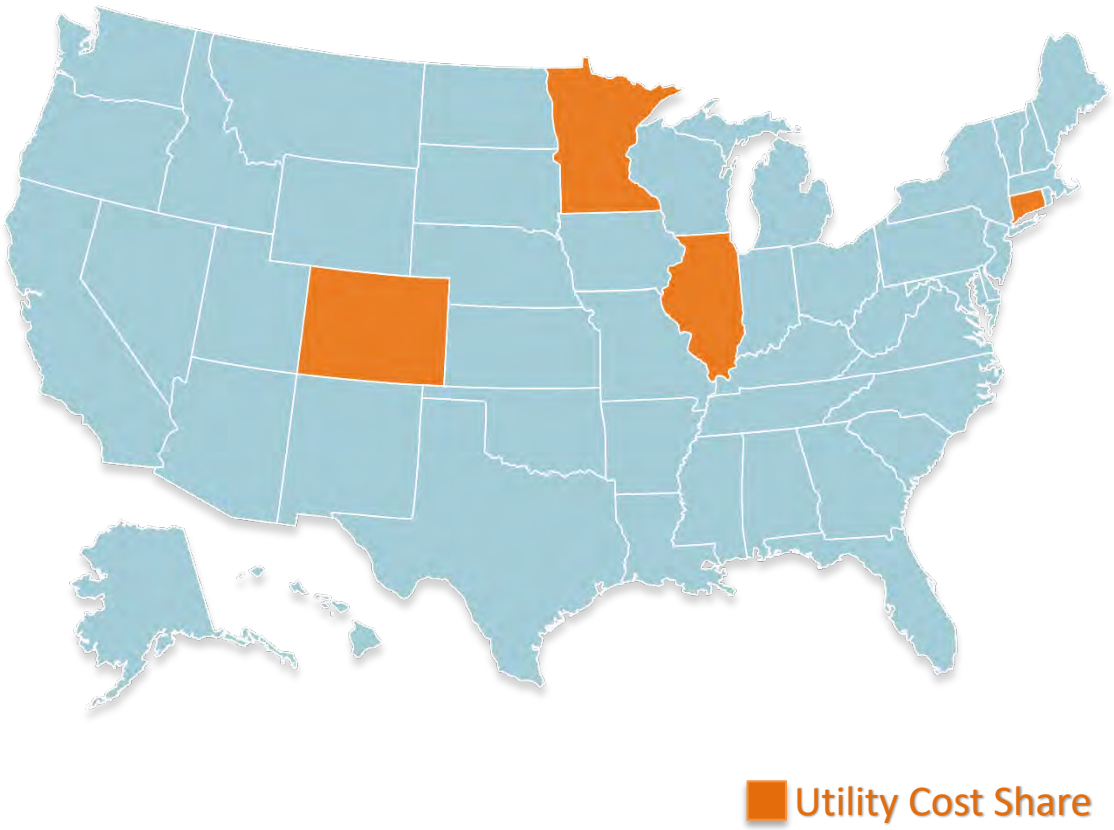
773.834.8508

Scaling the Pilot

Can we help create a better RFP and contract?

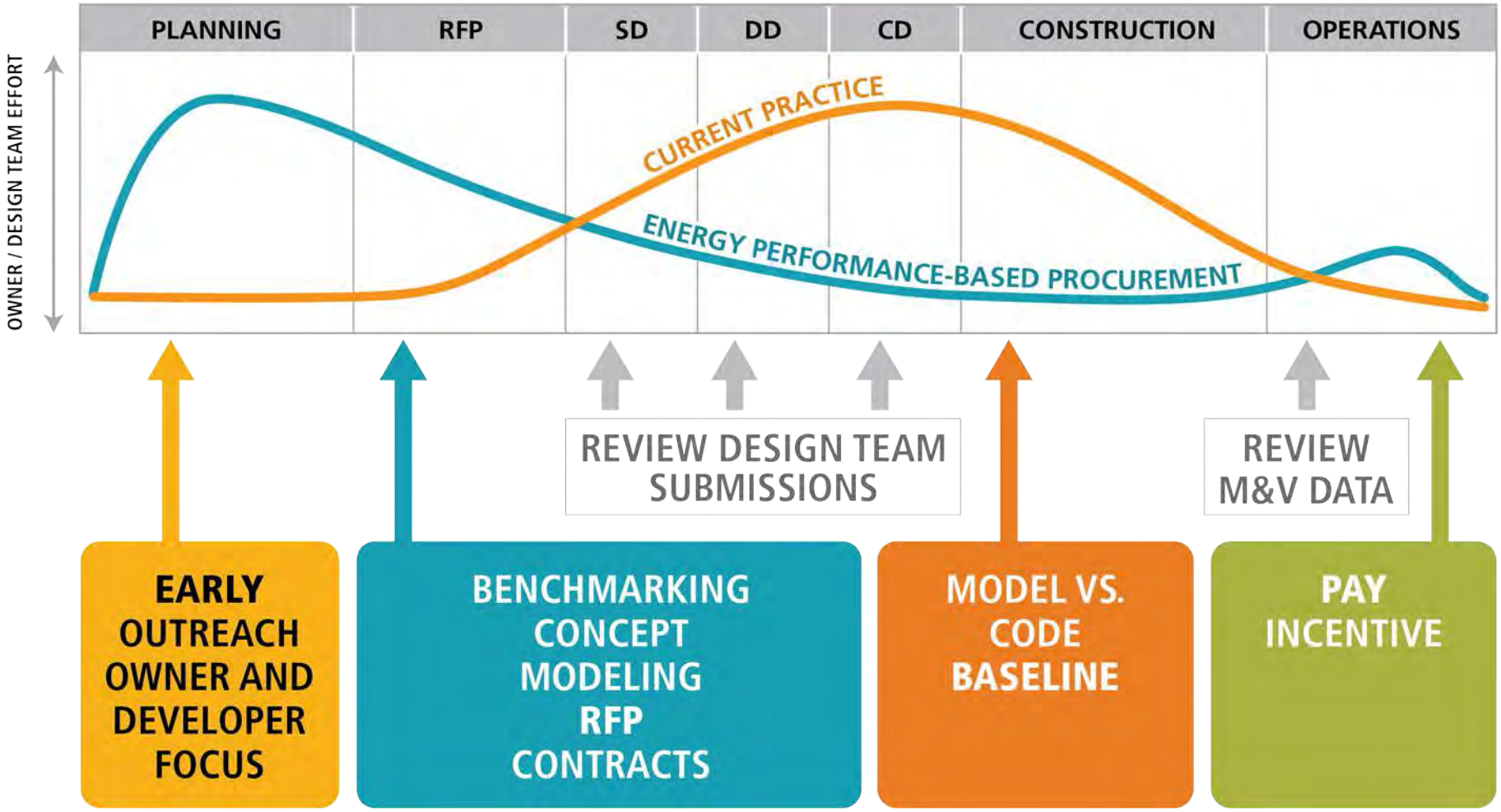
- ✓ Share risk with contractor and design team
- ✓ Minimize value engineering and change orders
- ✓ Bridge planning and operations teams
- ✓ Minimize increased demand on utility usage and costs
- ✓ Path to NZB over time
- ✓ ***Ensure project performs as expected!***

Eligibility requirements for Accelerate Performance

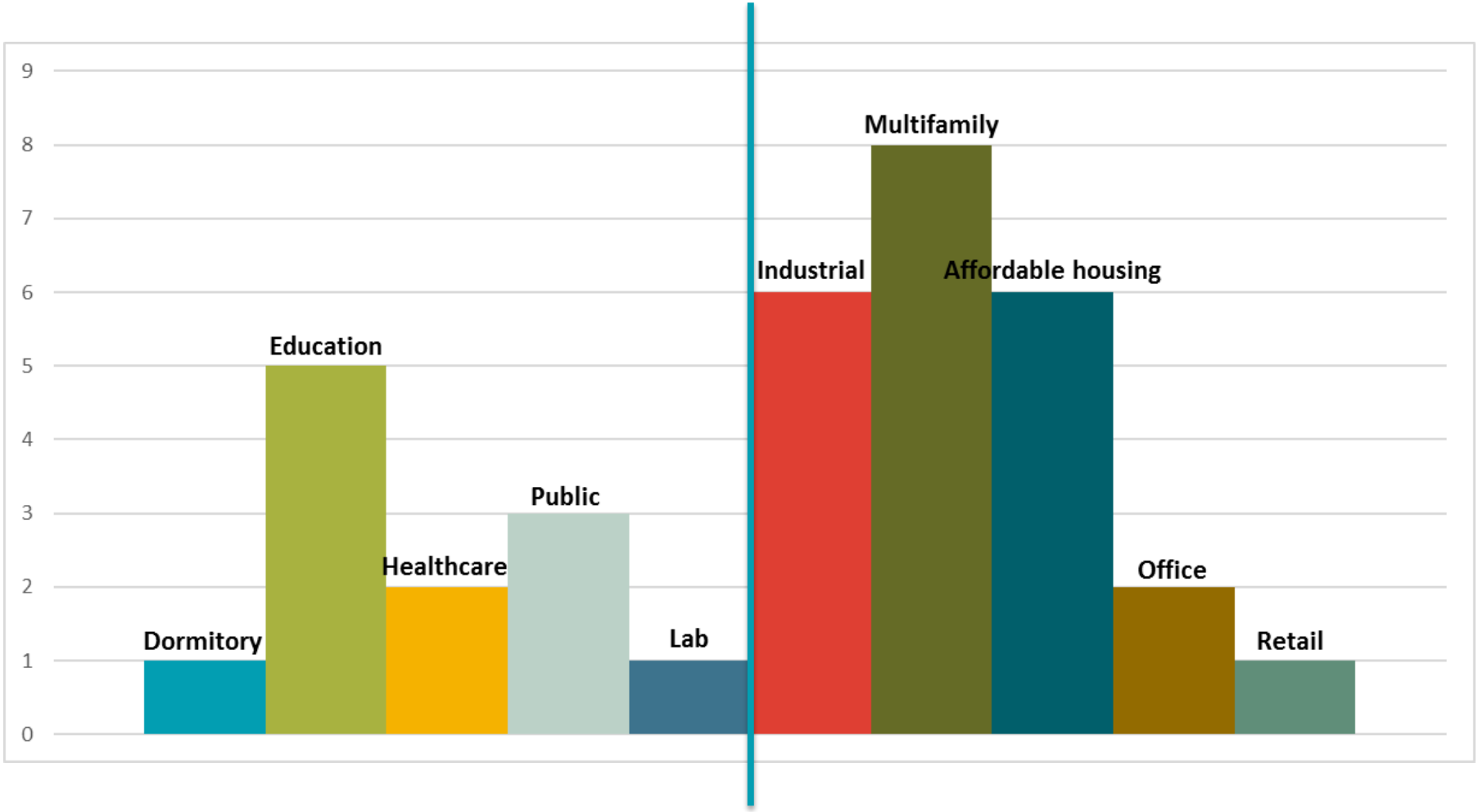


- **New construction and major renovations**
- **Commercial, industrial or multifamily buildings**
- **Projects must be in the pre-planning phase (before the design team is under contract)**
- **35-70% energy reduction goals**

The process


PLANNING
RFP
SD
DD
CD
CONSTRUCTION
OPERATIONS
OWNER / DESIGN TEAM EFFORT
CURRENT PRACTICE
ENERGY PERFORMANCE-BASED PROCUREMENT
REVIEW DESIGN TEAM SUBMISSIONS
REVIEW M&V DATA
EARLY OUTREACH OWNER AND DEVELOPER FOCUS
BENCHMARKING CONCEPT MODELING RFP CONTRACTS
MODEL VS. CODE BASELINE
PAY INCENTIVE

Current Projects



773.834.8508

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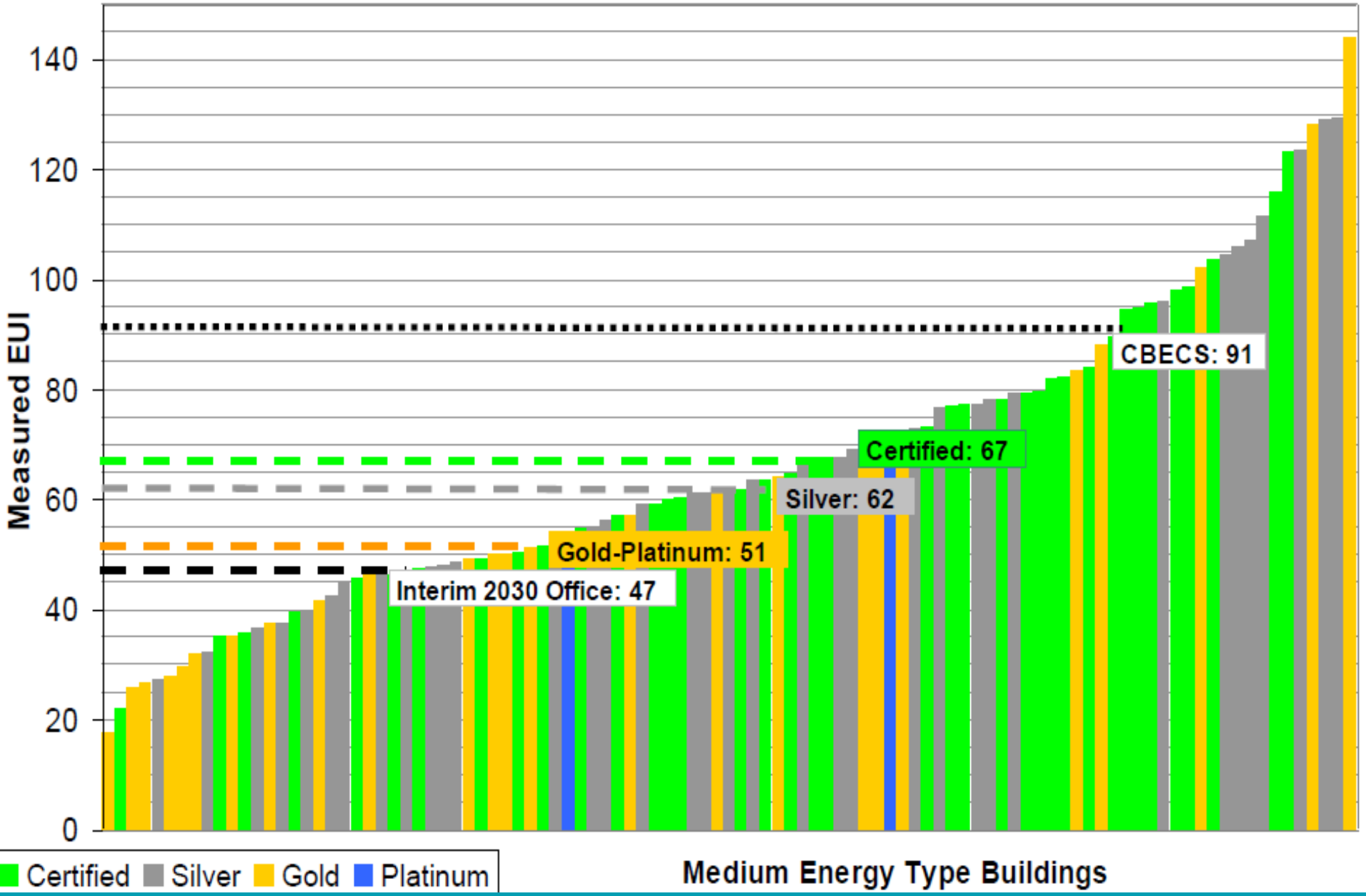
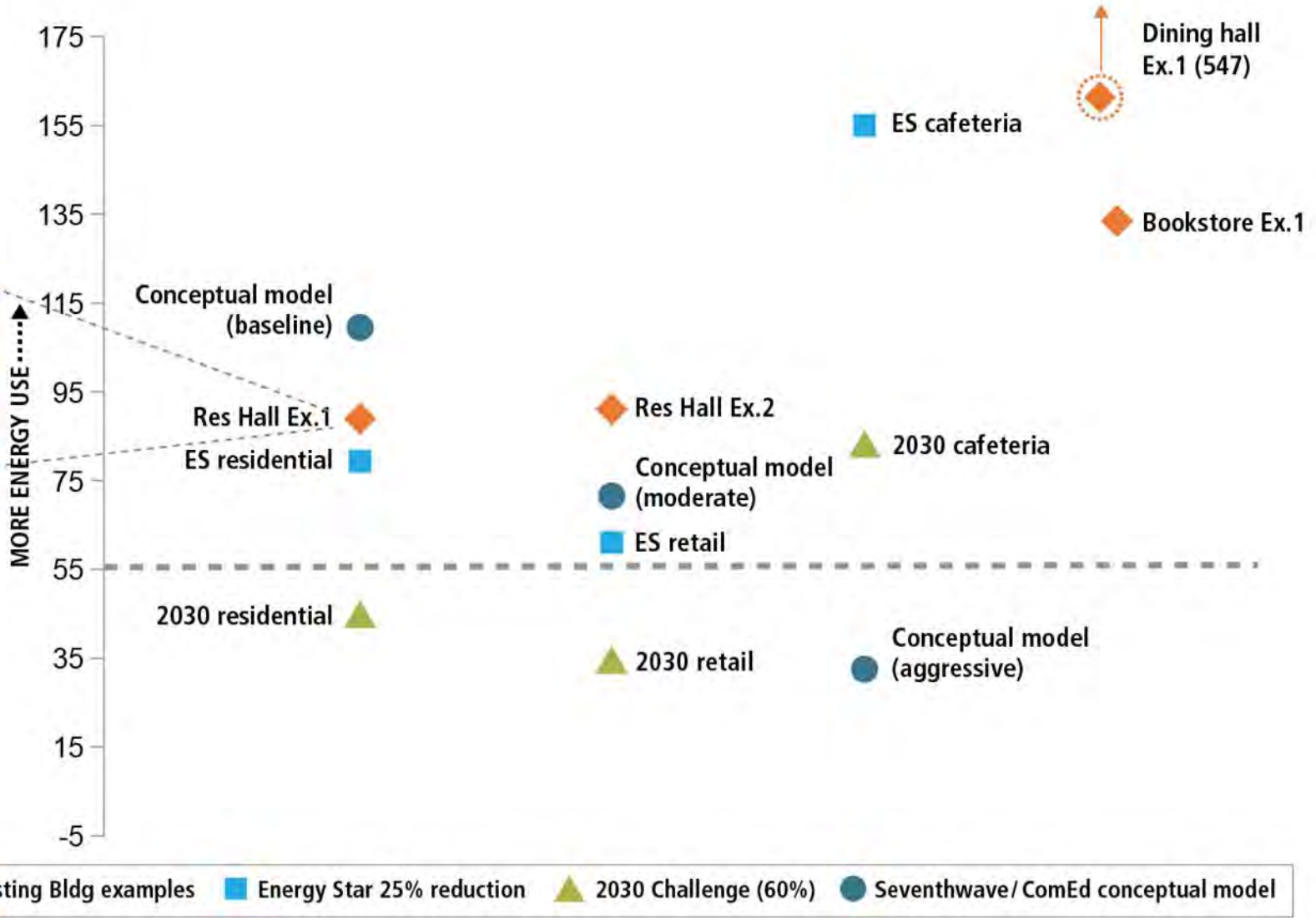
Setting your EUI Target


140
120
100
80
60
40
20
0
Measured EUI
CBECS: 91
Certified: 67
Silver: 62
Gold-Platinum: 51
Interim 2030 Office: 47
Certified
Silver
Gold
Platinum
Medium Energy Type Buildings

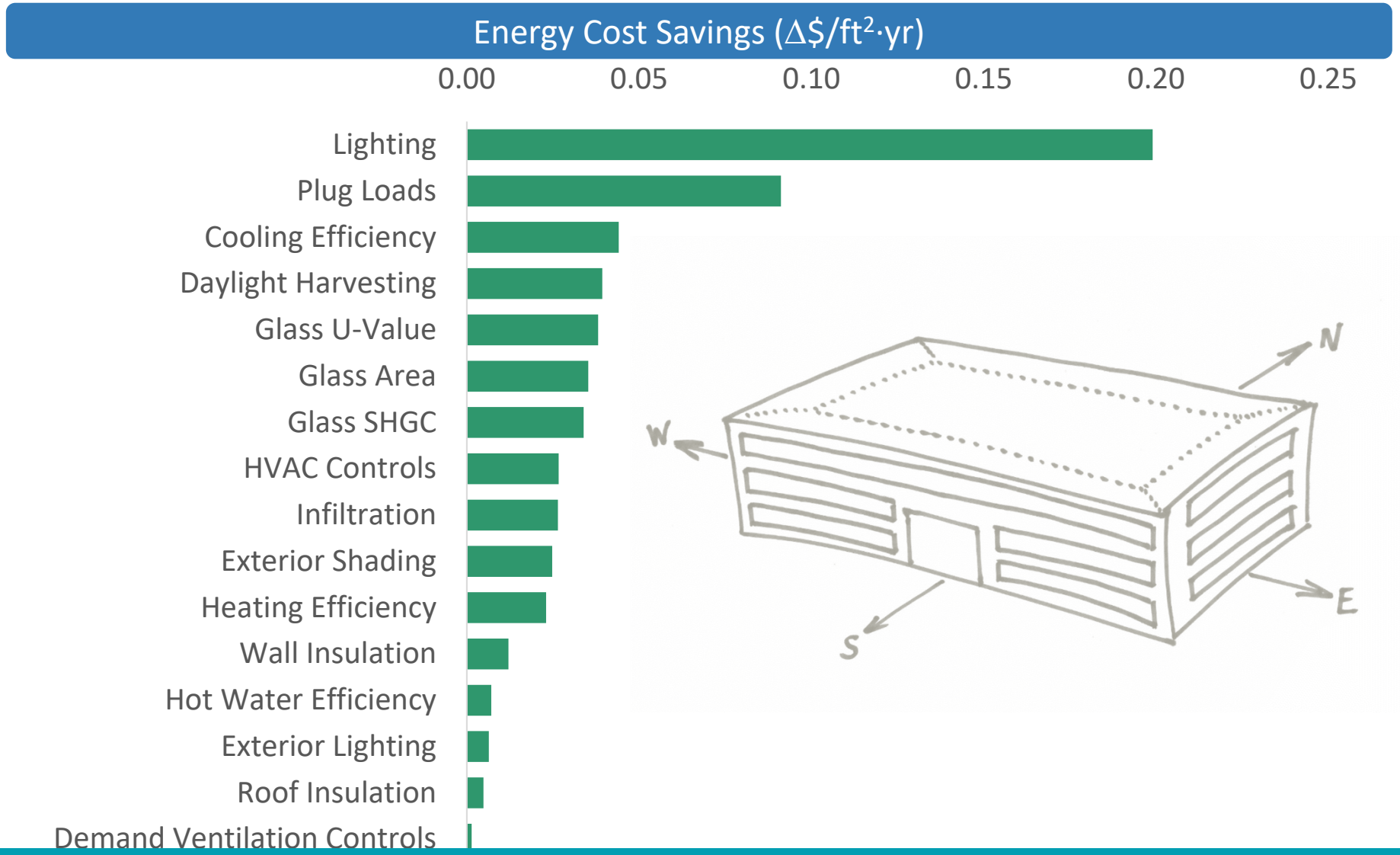
Define the energy requirement

Project energy goals			
Good	Sustainable building	Lack of clarity with unbounded interpretation. Rating schemes help resolve this but do not drive a certain metric.	Same budget
Better	30% savings over energy code	Often this is a comparison between simulated results. There is very little opportunity to verify actual savings.	Same budget
Best	An annual energy use intensity (EUI) of 45 kBtu/sq ft/year	This is a measurable target; requires upfront research to establish a realistic benchmark.	**Same budget**

Set your EUI target before team is selected



Focus on high-impact decisions



seventhwave | ACCELERATE PERFORMANCE

DATA PLOT

INDUSTRY BENCHMARKS

- Code
- AIA 2030
- Energy Star

DATA SELECTION

13 databases

> 25,000 Buildings

BUILDING TYPES

FILTERS

CBECS Nomenclature

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Plot Options

X-Axis Variable

Gross Floor Area

Custom Markers

Custom Marker

X Value

Y Value

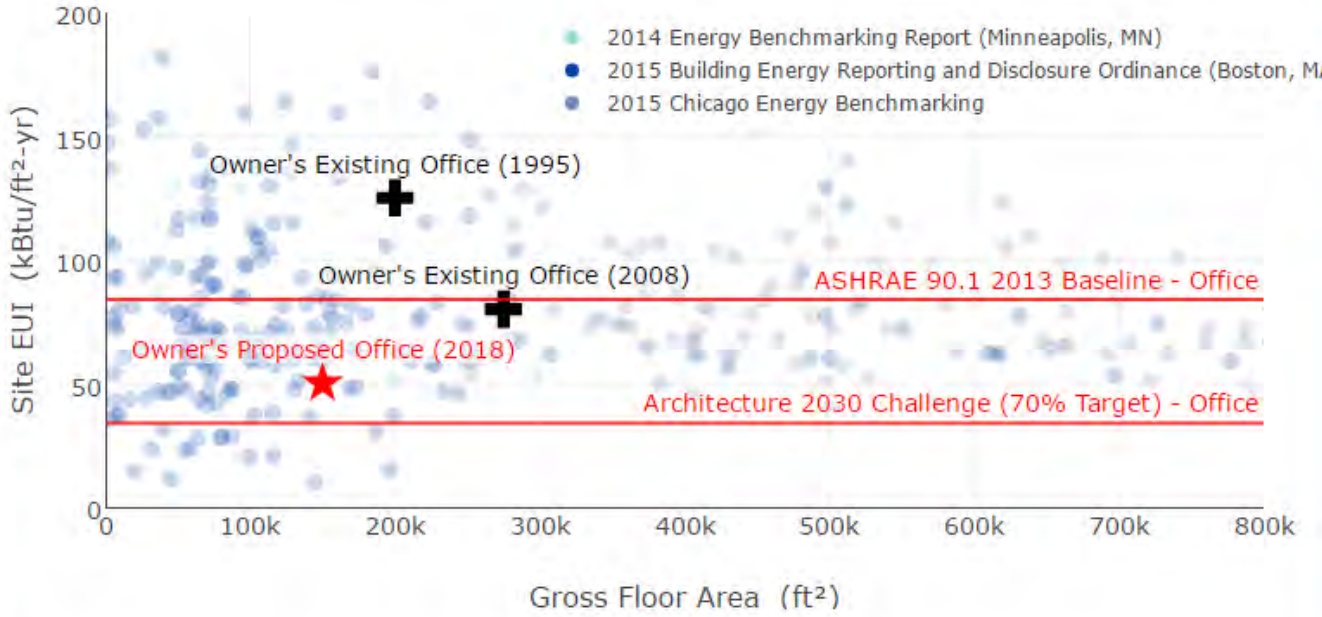
125

Symbol

Cross

Seventhwave EUI Analyzer Plot - Google Chrome

http://seventhwave.org/accelerateperformance/EUI



Benchmarking Databases Clear All Select All

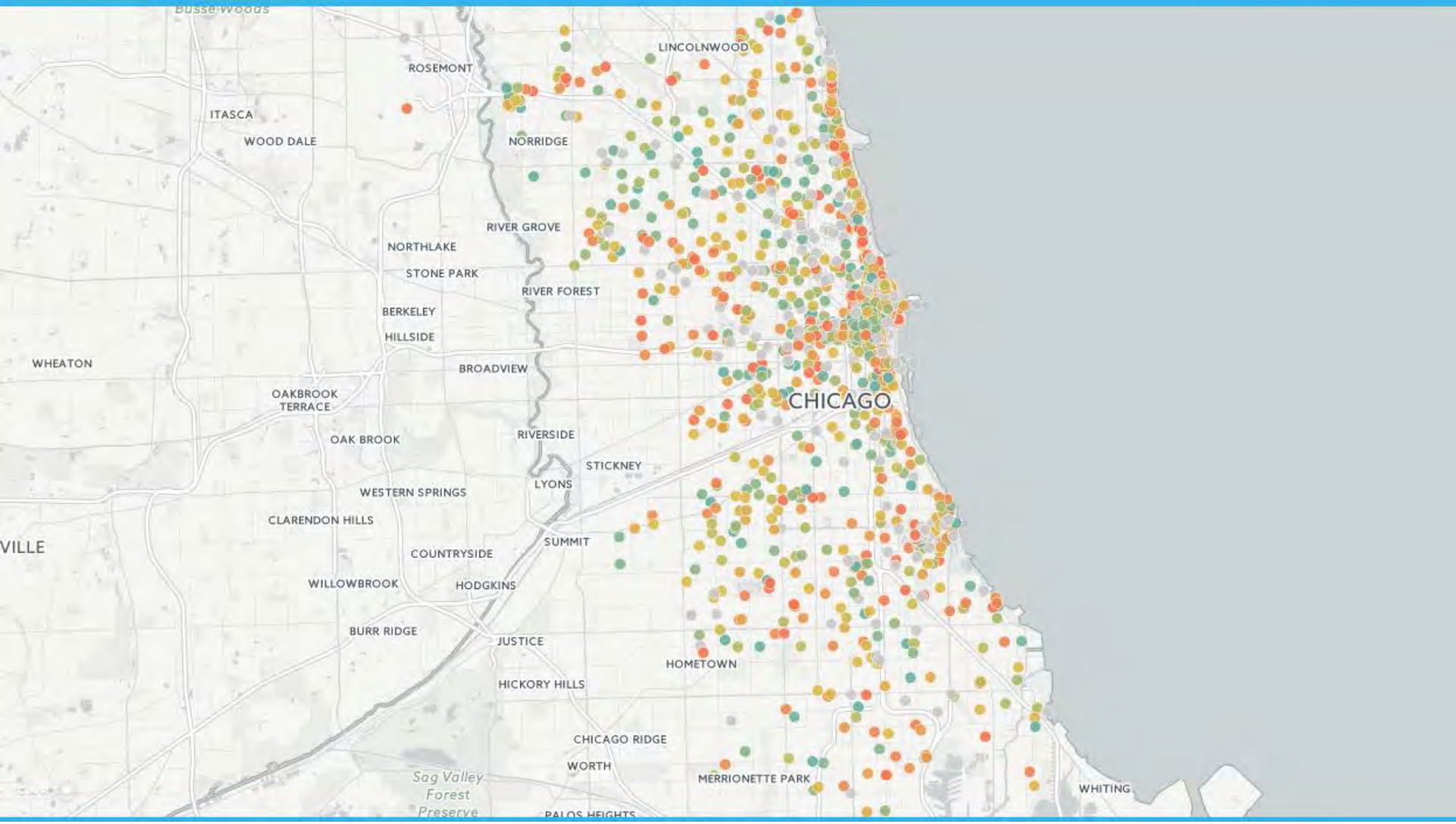
Building Types

BENCHMARKING

CITY ENERGY

SUSTAINABLE CHICAGO

Neighborhood | Property Type



500 Lakeshore - Related
62 EUI

EnV – Lynd Co
56 EUI

Chicago Architecture Today - Flickr

Xavier -Gerding Edlen
48 EUI (design)

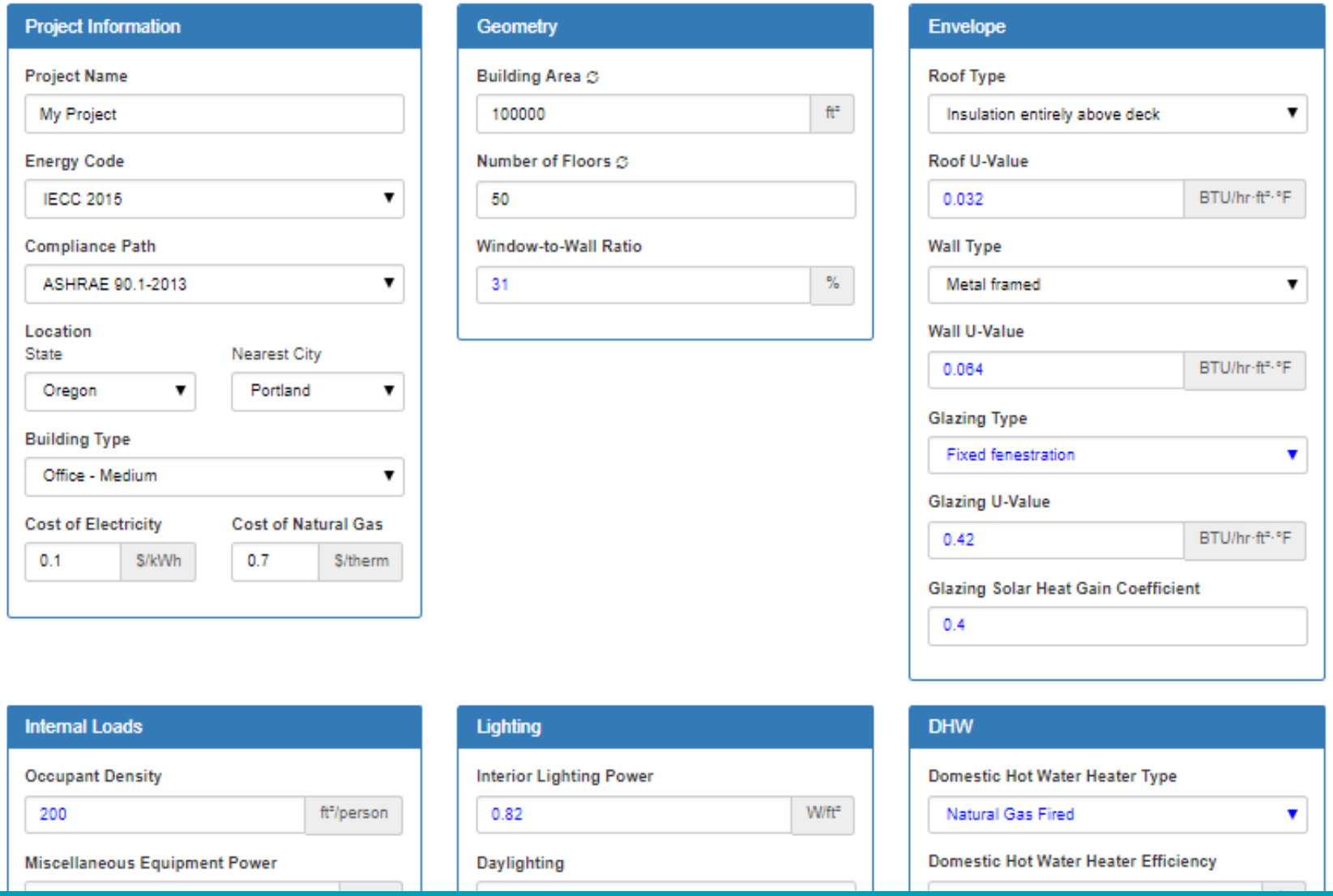
Clark st Lofts - AMLI
40 EUI

Google Streetview

Hypothetical building

150,000 ft2 Office in Portland, OR…..

Quick energy modeling tool



Chose best practices

ECM #4 – Improve Glazing SHGC — Disable Measure

Baseline Glazing Solar Heat Gain Coefficient: 0.4

Better	Best	Custom
0.3	0.25	

ECM #5 – Efficient Interior Lighting — Disable Measure

Baseline Interior Lighting Power: $0.82 \frac{W}{ft^2}$

Better	Best	Custom
0.73	**0.5**	

ECM #6 – Efficient Exterior Lighting — Disable Measure

Baseline Exterior Lighting Power: 9.27 kW

Better	Best	Custom
6.95	**4.64**	

ECM #7 – Upgrade Cooling Equipment — Disable Measure

Baseline Average Cooling Equipment Efficiency: $0.61 \frac{kW}{ton}$

Better	Best	Custom
0.45	0.35	

ECM #8 – Upgrade Heating Equipment — Disable Measure

Baseline Average Heating Equipment Efficiency: 80 % (Et)

Better	Best	Custom
88	**95**	

Review Results

Baseline | Measures | Results

Download Results

High-Level Results

Proposed Energy Cost: $105757

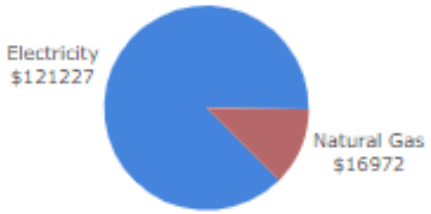
Energy Cost Savings: $32442 (23.5%)

Approximate Incentive: $31051

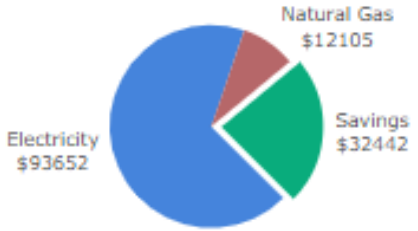
Proposed EUI: 49 kBTU/ft²

CO_2 Savings: 275.4 metric tons

Baseline Energy Costs

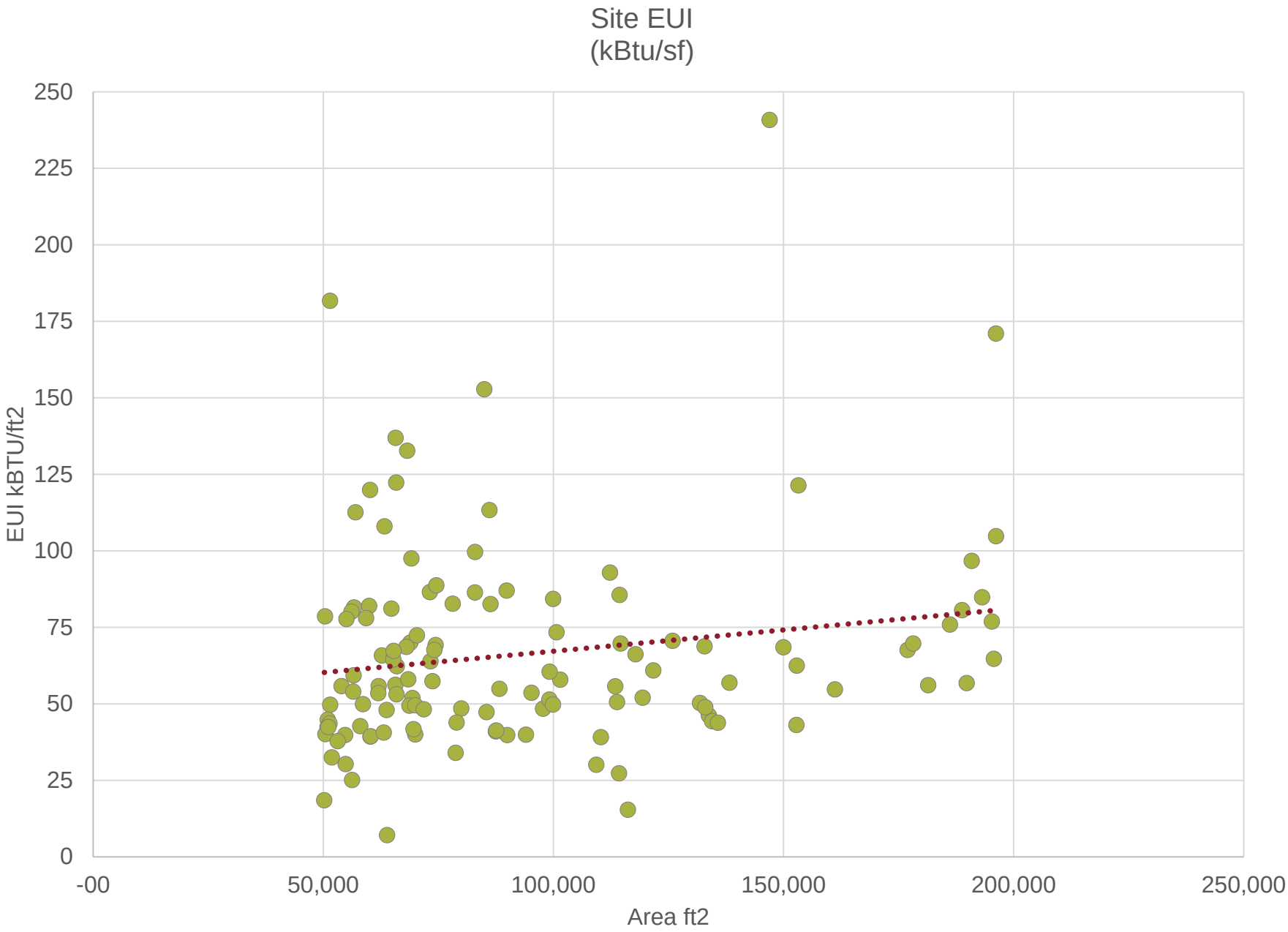


Proposed Energy Costs



Joint Template Results

	Peak Cooling (kBTU/hr)	Peak Heating (kBTU/hr)	Peak Electric Demand (kW)	Annual Electric Use (kWh)	Annual Natural Gas Use (therm)	Annual Energy Cost ($)	Winter Peak Electric Demand (kW)	Summer Peak Electric Demand (kW)
Baseline Design	2842.814	1437.895	416.8	1212265	24246	138199	261.7	416.829
Upgrade Roof Insulation – ECM #1	2842.606	1437.739	416.8	1212245	24236	138190	261.697	416.805
Upgrade Wall Insulation – ECM #2	2816.747	1435.527	413.7	1207925	23256	137072	261.001	413.706
Improve Glazing U-Value – ECM #3	2785.03	1322.763	410.4	1213201	20566	135717	261.537	410.39
Improve Glazing SHGC – ECM #4	2493.387	1308.888	374.4	1109058	20565	125302	244.765	374.414
Efficient Interior Lighting – ECM #5	2436.095	1312.724	355.1	995996	20535	113974	209.104	355.108


Site EUI
(kBtu/sf)
EUI kBTU/ft2
250
225
200
175
150
125
100
75
50
25
0
-00
50,000
100,000
150,000
200,000
250,000
Area ft2

DEFINE YOUR PATH TO NET ZERO

EUI TARGETING AND PLANNING WORKSHEET FOR EDUCATIONAL BUILDINGS

The net-zero scale

The table below shows the EUI breakdown for a typical educational building.

EUI is a simple measure of a building's energy use, expressed as the energy use per square foot per year. For further information on EUI targets and the 2030 Challenge visit **www.energytrust.org/zero**.

Target EUI

Building name

Location

Owner contact

EnergyTrust of Oregon

Goal Discussion

- What other goals can we add?
- What are we missing in this exercise?
- Are there building types that this process is especially challenging?

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RFP and Contract Language

Owner Defines Desires

- Creating a list of what the building could accomplish.

  - Critical: Project success hinges on this element
  - Highly Desirable: What the owner wants
  - If Possible: The wish list

Owner Defines Desires

Energy goals
- Best performer in your portfolio
- Be in top X% of similar buildings nationally
- Be in top Y% of similar buildings locally
- Net zero energy or better

Water goals
- Standard practice
- Reduce usage by 30%
- No potable water for flushing and irrigation
- Net zero water

Sustainability driver
- Interested in sustainability where it helps keep operating costs low
- Organizational sustainability goals
- For its own sake

Operations personnel
- Operators primarily respond to maintenance requests, little equipment scheduling
- Operators actively schedule systems on/off on a weekly basis
- Energy performance is directly tied to evaluation of operator job performance

Comfort
- Meet standard of care
- My occupants are highly sensitive to temperature
- My occupants will tolerate swings in order to save energy

Air quality
- Meet current standard of care
- Exceed standard of care
- Space should have no recirculated air

Prioritization

If this exercise leads to too many competing priorities to organize, consider having each member of the ownership team **rank the following goals for the project on a scale from 1 – 3**, with 1 being the most important goals and 3 being less important.

____ Architectural integrity
____ Ease of maintenance
____ Minimize utility bills
____ Prepare for future net zero potential
____ Maximize number of people per sf
____ Superior interior finish
____ Intelligent feedback to operators
____ Intelligent feedback to tenants/visitors
____ Minimize construction schedule
____ High interaction with outdoors
____ Flexible/expandable interior design
____ High community engagement
____ Receive external recognition for building performance
____ Low first cost
____ Project performs as expected in design
____ Bridge planning and operations team

Project goals for NREL's Research Support Facility

MISSION CRITICAL

Attain safe work performance/Safe Design Practices
LEED Platinum
ENERGY STAR "Plus"

HIGHLY DESIRABLE

800 staff Capacity
25 kBtu/sf/year
Architectural integrity
Honor future staff needs
Measurable ASHRAE 90.1
Support culture and amenities
Expandable building
Ergonomics
Flexible workspace
Support future technologies
Document "How to" manual
"PR" campaign
Allow secure collaboration
Building information modeling
Substantial Completion by 2010

IF POSSIBLE

Net Zero/design approach
Most energy efficient building in the world
LEED Platinum Plus
ASHRAE 90.1 + 50%
Visual displays of current energy efficiency
Support public tours
Achieve national and global recognition and awards
Support personnel turnover

RFP and contract language

PROJECT GOAL LIST: Project goals help design teams prioritize their focus on the MEP and building performance design. Goals are categorized in three main sections:

Mission critical goals—required by contract and critical to success

Highly desirable goals—not required by contract and have influence on the recommended design

If possible goals—influence recommended design and are considered highly beneficial if included in the solution

MISSION CRITICAL

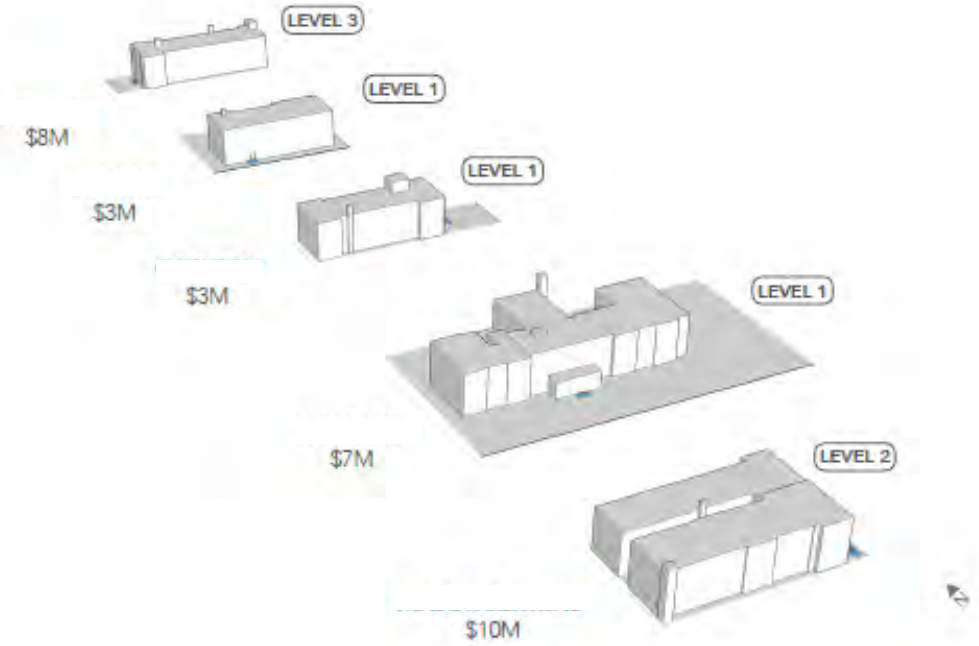
- Maximum energy target of 65 KBTU/gsf annually; lower is preferred
- LEED NC Silver Certification
- Superior occupant comfort
- EnergyStar certified building

HIGHLY DESIRABLE

- Maximum energy target of 55 kBtu/gsf annually; lower is preferred
- Passive design strategies (i.e. daylighting, passive solar heating, etc.)
- Ease of maintenance
- Visual displays of current energy efficiency
- Exceed LEED NC version 4, Silver Certification

IF POSSIBLE

- Living Building full certification
- Net Zero Energy Design



LEVEL 1

PRIMARY

EUI 70

$100-150 /SF

- Public Zone Updates
- Replace Kitchens & Bathrooms
- Focus on Reducing Air Infiltration
- LED Lighting Throughout
- Add Air Conditioning to All Spaces
- High-Efficiency Hot Water Heaters & Storage
- Basic Exterior Repairs
- Replace Roofing

LEVEL 2

ADVANCED

EUI 45

$150-250 /SF

- Exterior Insulation Where Possible
- Replace Windows Where Insulation Is Added
- Energy Recovery Ventilation
- Upgrade Mechanical Equipment for Efficiency / Performance

LEVEL 3

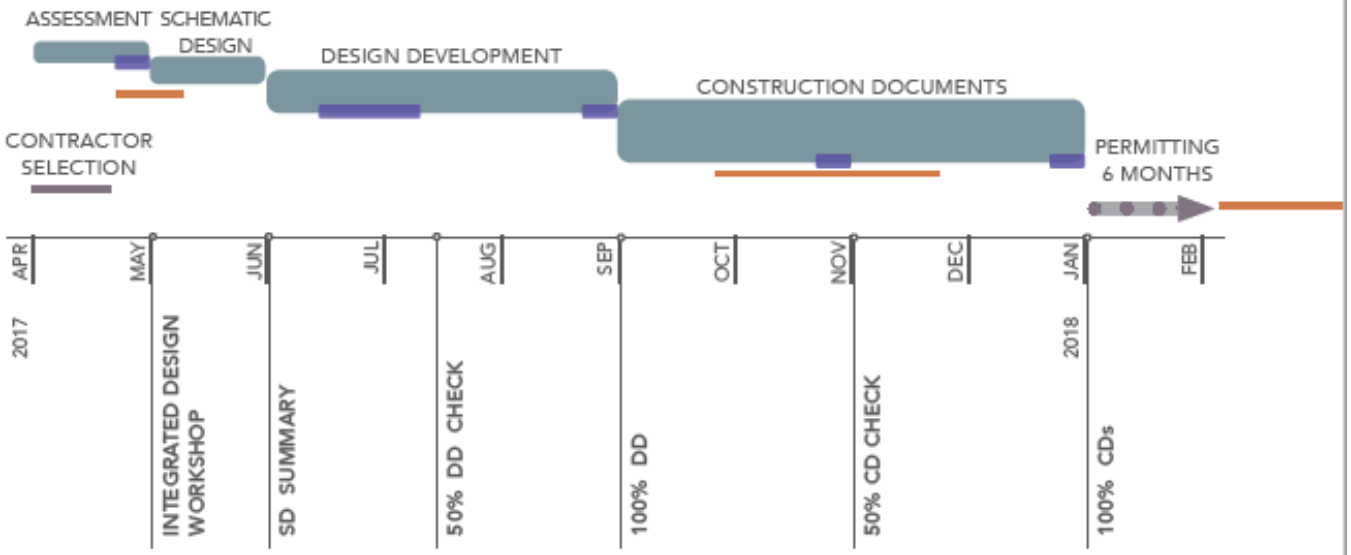
FULL REHAB

EUI 25*

+$300 /SF

- Net-Zero Energy Potential
- Combination of Interior and Exterior Insulation
- Replace All Windows
- All New Mechanical Systems
- Photovoltaic Panels
  *reduces EUI to 0
- Opportunity for $1M Grant from ICECF

DESIGN PHASE SCHEDULE



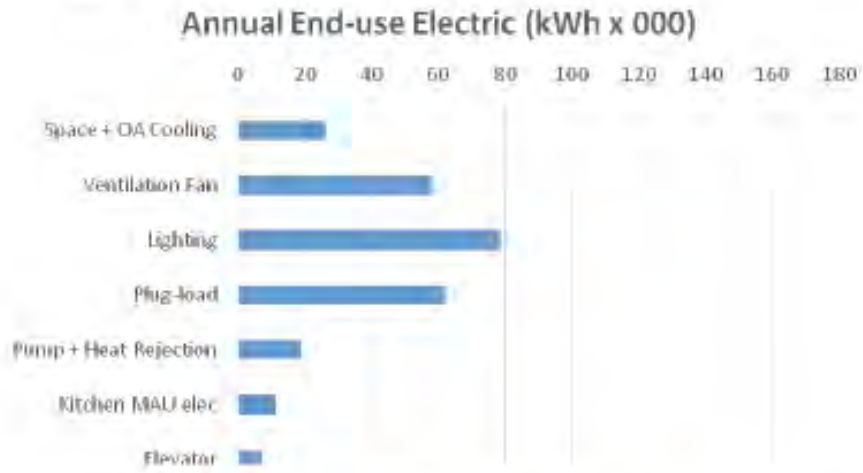
PROJECT SCHEDULE & MILESTONES

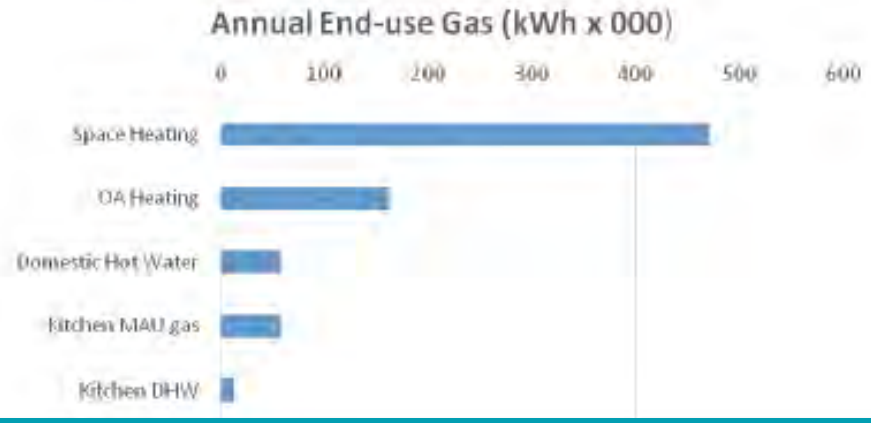
Assessment & Evaluation	1 months
Schematic Design	1 months
Design Development	3 months
Construction Documents	4 months
	13 months
Permitting	6 months
Construction	15 months
Closeout	12 months

DESIGN
ENERGY MODEL
MEASUREMENT & VERIFICATION

2.A.8 // ANNUAL ENERGY CONSUMPTION BY END USE

	Electric (kWh x 000)		Gas (kWh x 000)
Space + OA Cooling	26	Space Heating	471
Ventilation Fan	58	OA Heating	152
Lighting	79	Domestic Hot Water	59
Plug-load	62	Kitchen MAU gas	58
Pump + Heat Rejection	19	Kitchen DHW	14
Kitchen MAU elec	11	Kitchen Process	119
Elevator	7		
Total	261		883
Gross floor area (m²)	8578		
EUI	42 kBtu/sf		





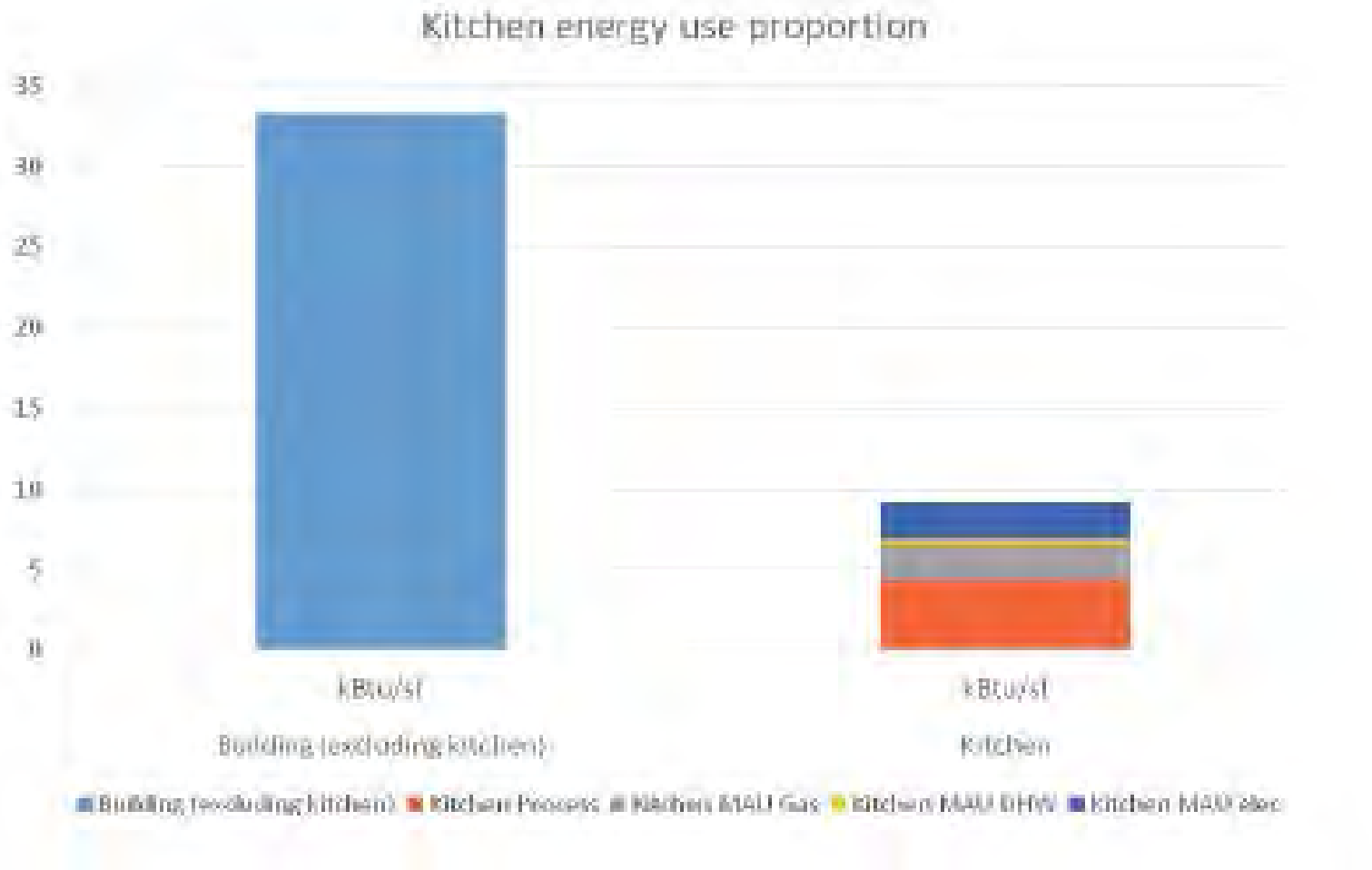
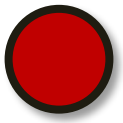
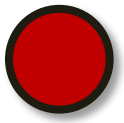

Kitchen energy use proportion
35
30
25
20
15
10
5
0
kBtu/sf
kBtu/sf
Building (excluding kitchen)
Kitchen

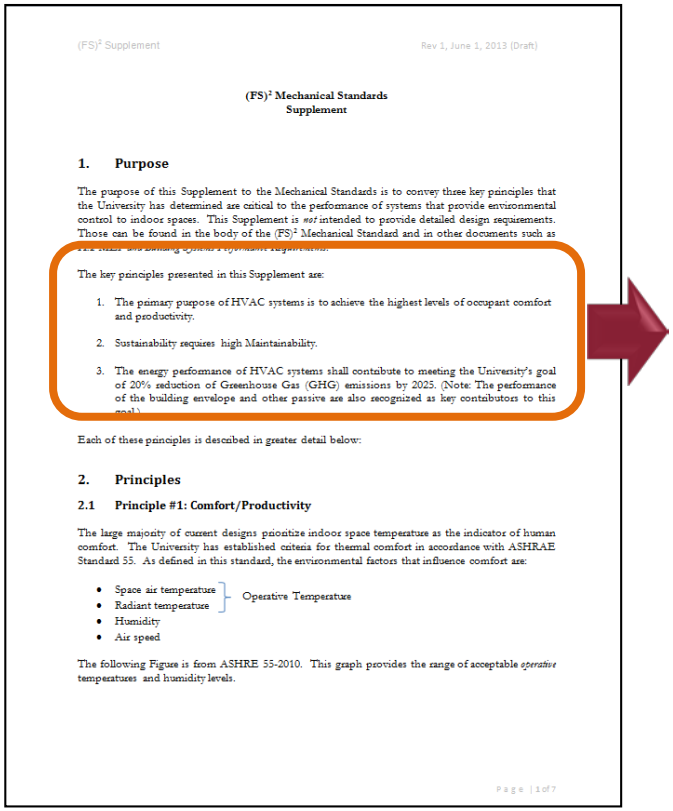
Table 1 - Measurement and Verification Impact/Responsibility Matrix

Project Role	Performance Impact/Responsibility	
	Capital	Operational
User/Occupant	NA	Usage
Owner/Operator	Project financing O&M Contracts and Materials Additional Corrective Scope	System Operation (temperature, Schedules, etc.) System Maintenance Corrective Action
Design/EM	Payback Analysis Energy Model Effective Design Intent	Design Intent (Sequence of Operations) Corrective Action
M&V EM	M&V Design	Data Analysis Reporting Deviations Corrective Action
Cx Agent	Commissioning Practice	System Commissioning Reporting Deviations
Controls Cont.	Effective Design Installation Efficiency and Quality	Calibration/Warranty Period BAS System Maintenance Corrective Action
EOR/GC & Subs	Effective Design Construction and Installation Efficiency	Warranty Period Corrective Action

Evaluate submittals

Team	Risk – Confidence performance meets intent	Energy Target	Daylight, Views, Connection to Nature	Comfort and HVAC Response	Maintainability	Innovation
1						
2						
3						
4						

University of Chicago added a supplement to its standards.



(FS)² Supplement Rev 1, June 1, 2013 (Draft)

(FS)² Mechanical Standards Supplement

1. Purpose

The puepose of this Supplement to the Mechanical Standards is to convey three key principles that the University has determined are critical to the performance of systems that provide environmental control to indoor spaces. This Supplement is *not* intended to provide detailed design requirements. Those can be found in the body of the (FS)² Mechanical Standard and in other documents such as [illegible]

The key principles presented in this Supplement are:

1. The primary puepose of HVAC systems is to achieve the highest levels of occupant comfort and productivity.
2. Sustainability requires high Maintainability.
3. The energy performance of HVAC systems shall contribute to meeting the University's goal of 20% reduction of Greenhouse Gas (GHG) emissions by 2025. (Note: The performance of the building envelope and other passive are also recognized as key contributors to this goal.)

Each of these principles is described in greater detail below:

2. Principles

2.1 Principle #1: Comfort/Productivity

The large majority of current designs prioritize indoor space temperature as the indicator of human comfort. The University has established criteria for thermal comfort in accordance with ASHRAE Standard 55. As defined in this standard, the environmental factors that influence comfort are:

- Space air temperature
- Radiant temperature
- Humidity
- Air speed

} Operative Temperature

The following Figure is from ASHRE 55-2010. This graph provides the range of acceptable *operative* temperatures and humidity levels.

Page | 1 of 7

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Team Selection Discussion

- What makes a good team, who are the members?

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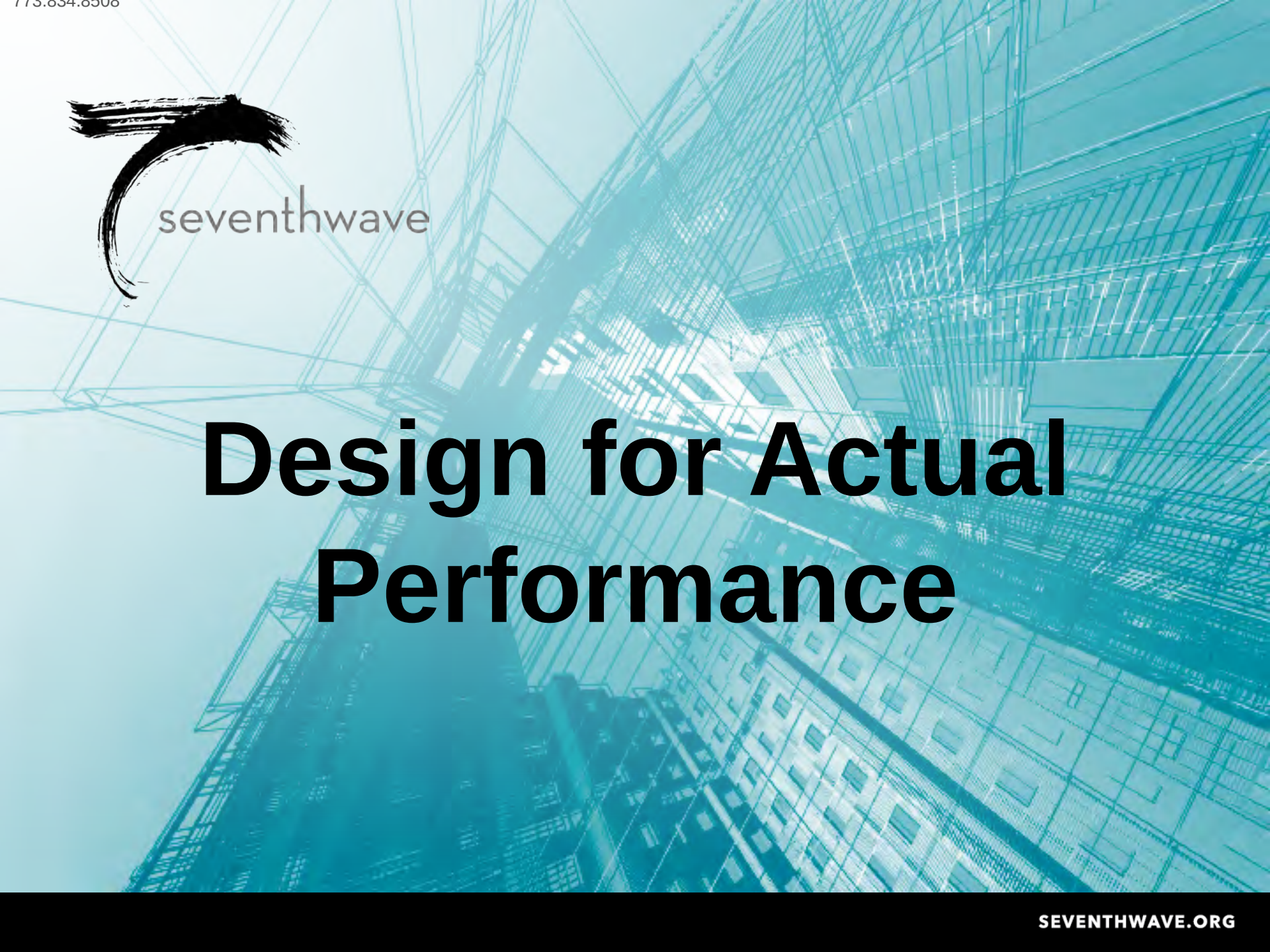


Design for Actual Performance

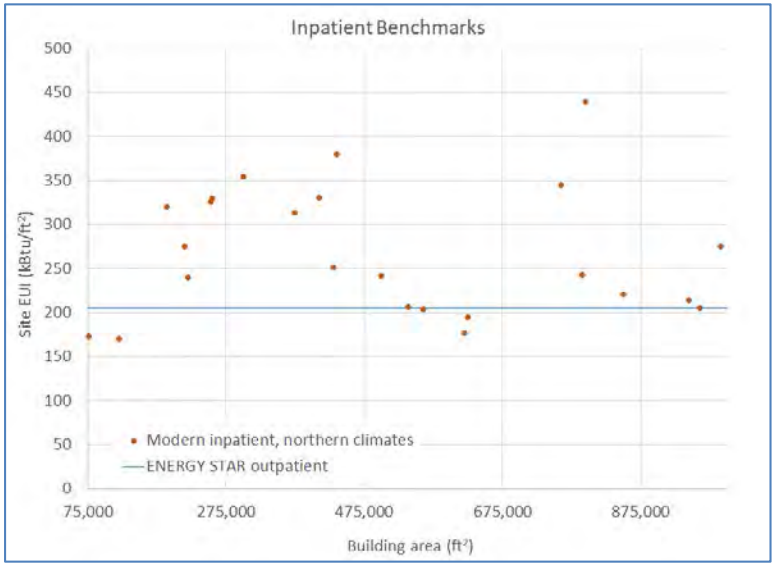
Existing Generose Building

Generose Expansion

Performance goal

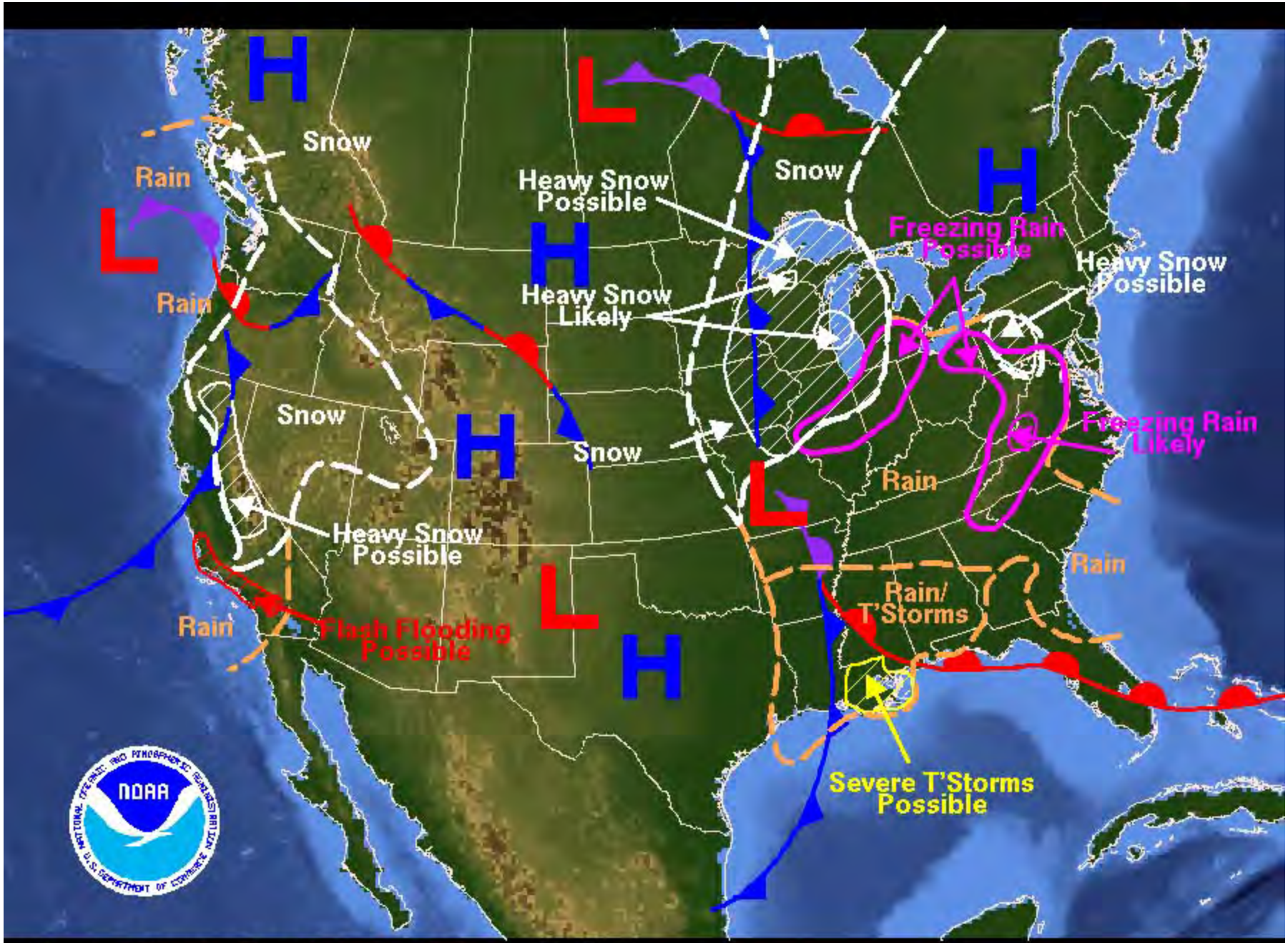
122 kBtu/sf target

- Existing program and trend data: 153 kBtu/sf
- Proposed program
- Industry benchmarks
  - Inpatient: 205 kBtu/sf
  - Outpatient: 95 kBtu/sf



Design solution

Design solution



Weather Forecast for Monday, February 02, 2004
DOC/NOAA/NWS/NCEP/Hydrometeorological Prediction Center
Prepared by Hatchett/Eckert based on HPC, SPC, and TPC forecasts.

https://www.youtube.com/watch?v=u3wbcxhHdHk

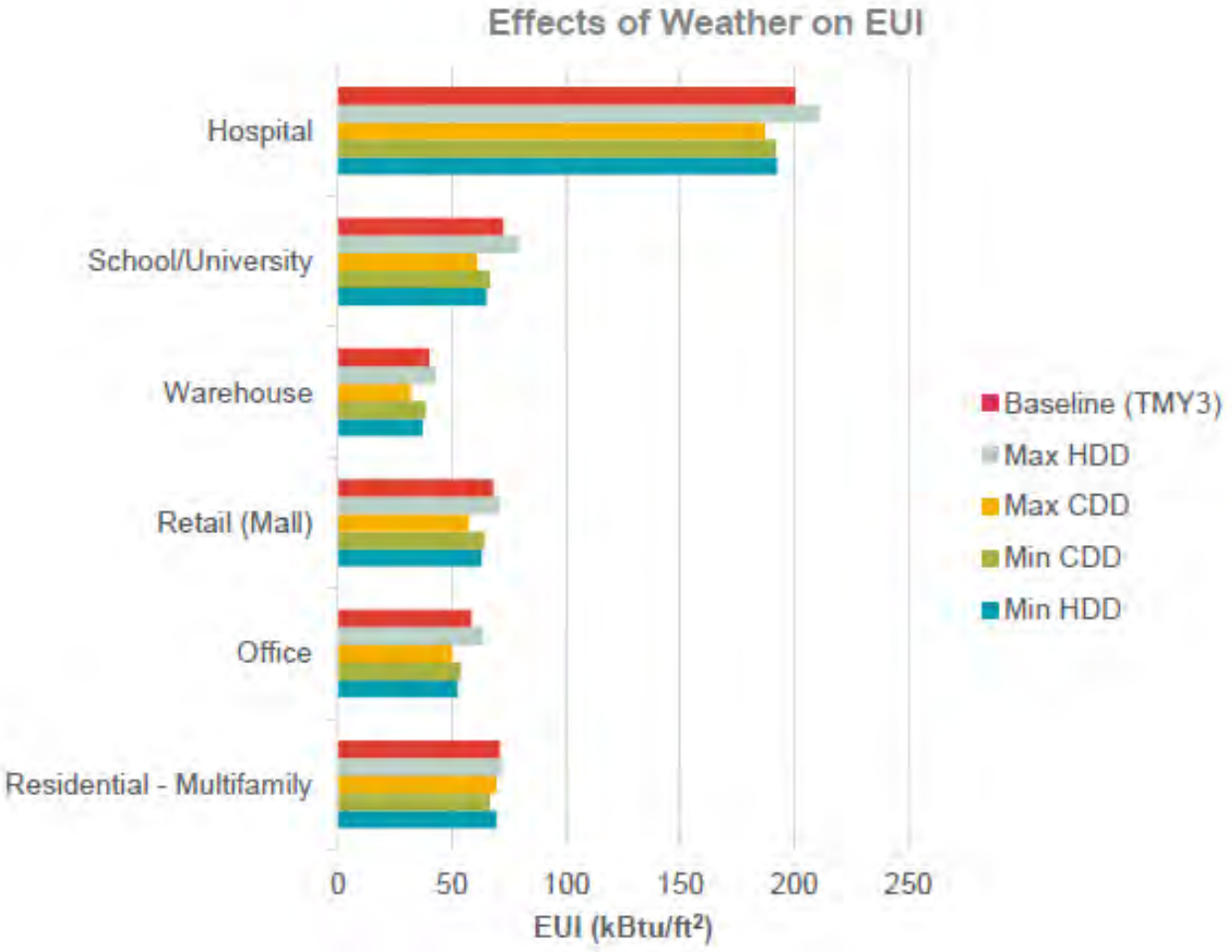
Analysis Overview

- **Factors affecting EUI**
  - Weather
  - Occupancy
- **Building Types**
  - Education, Hospital, Warehouse, Retail, Residential Multifamily, Office.
- **HVAC Systems for Building Types**
  - Education and Hospital – VAV with water-cooled chillers
  - Warehouse and Retail – PSZ with DX cooling and furnace
  - Residential Multifamily – PVVT with WSHP
  - Office – PVV Hot water system with DX cooling
- **Software Used**
  - Seventhwave's Batch runner tool

Weather Analysis

- **Analyzed 40 years of actual weather data for Chicago**
- **Identified 4 years with extreme temperatures**
  - Max HDD and CDD
  - Min HDD and CDD
- **Code compliant and high performance**
- **Ran models with varying weather**
- **Compared results to TMY3 weather**

Weather Analysis



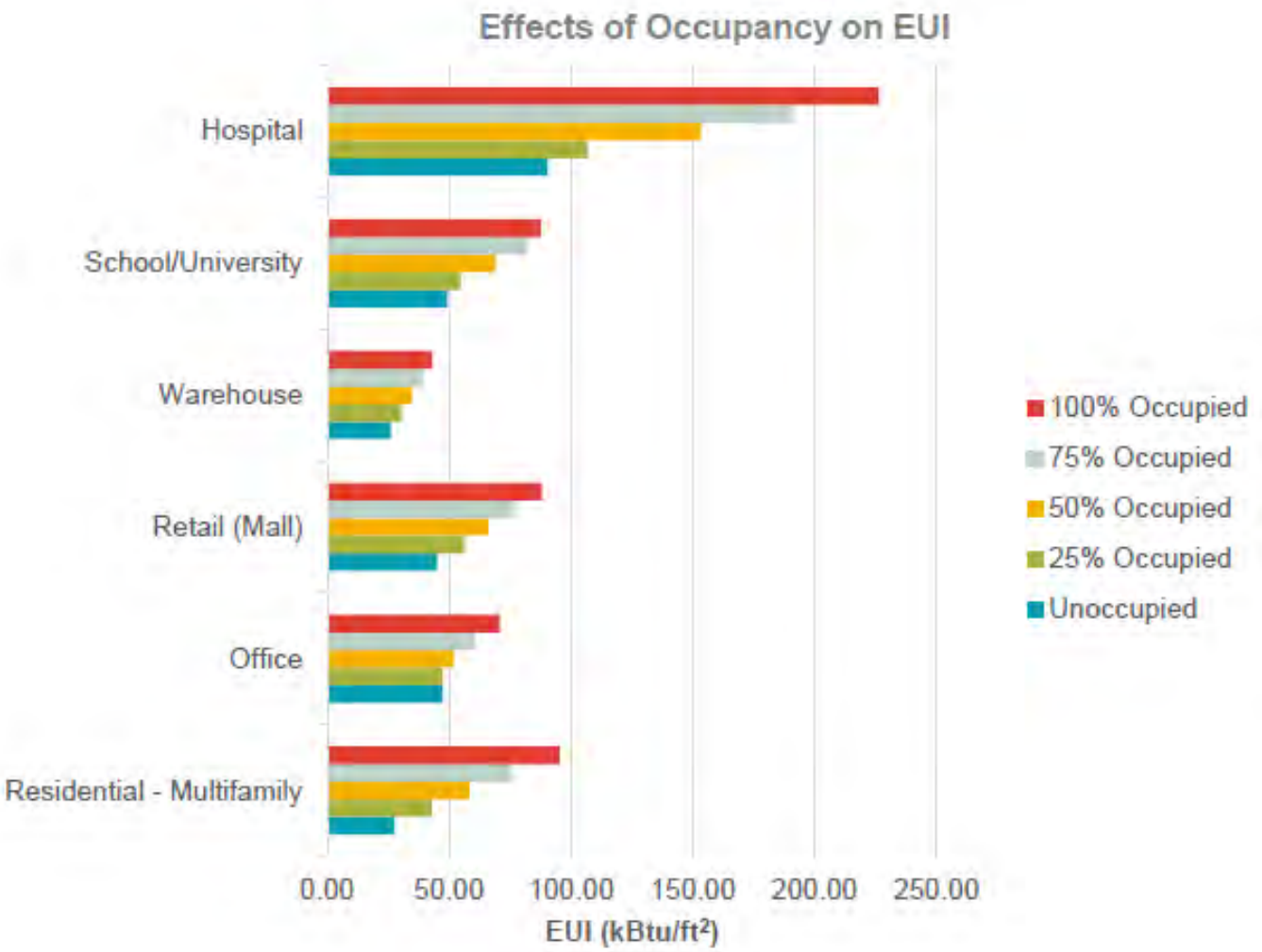
Weather Analysis

Code Compliant Building			High Performance Building		
Building Type	% difference		Building Type	% difference	
Multifamily	Min	-5%	Multifamily	Min	-6%
	Max	3%		Max	1%
Office	Min	-15%	Office	Min	-15%
	Max	10%		Max	9%
Retail	Min	-15%	Retail	Min	-16%
	Max	5%		Max	4%
Warehouse	Min	-18%	Warehouse	Min	-19%
	Max	7%		Max	7%
Education	Min	-16%	Education	Min	-16%
	Max	10%		Max	9%
Hospital	Min	-7%	Hospital	Min	-7%
	Max	6%		Max	5%

Occupancy Analysis

- **Loads affected by occupancy**
  - LPD
  - Plug loads
  - Occupant Density
  - DHW
- **Baseline Assumption**
  - Load Fraction (LF) of 1
- **Proposed Case**
  - LF of 0.75
  - LF of 0.5
  - LF of 0.25
  - Very small loads (~0)

Occupancy Analysis

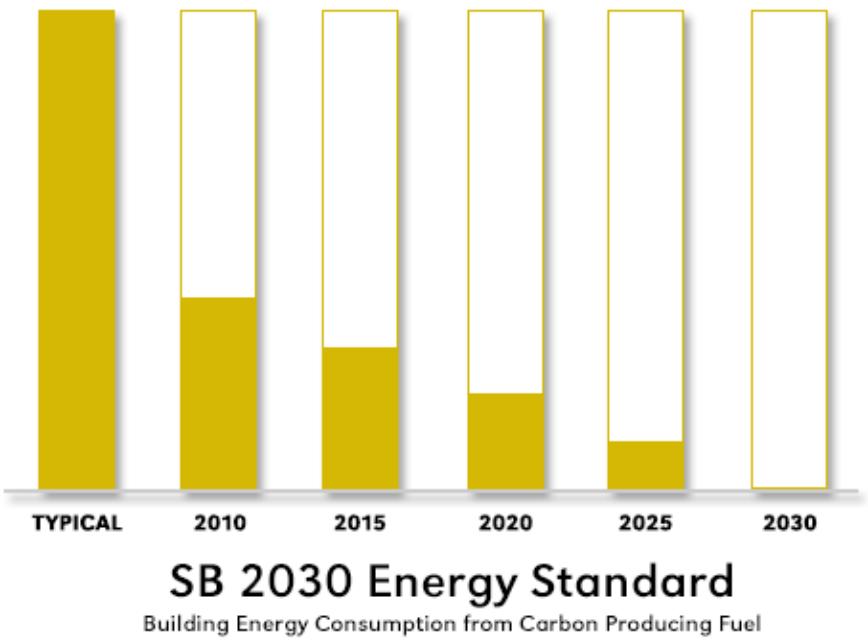


PBP and Minnesota SB 2030

SB 2030

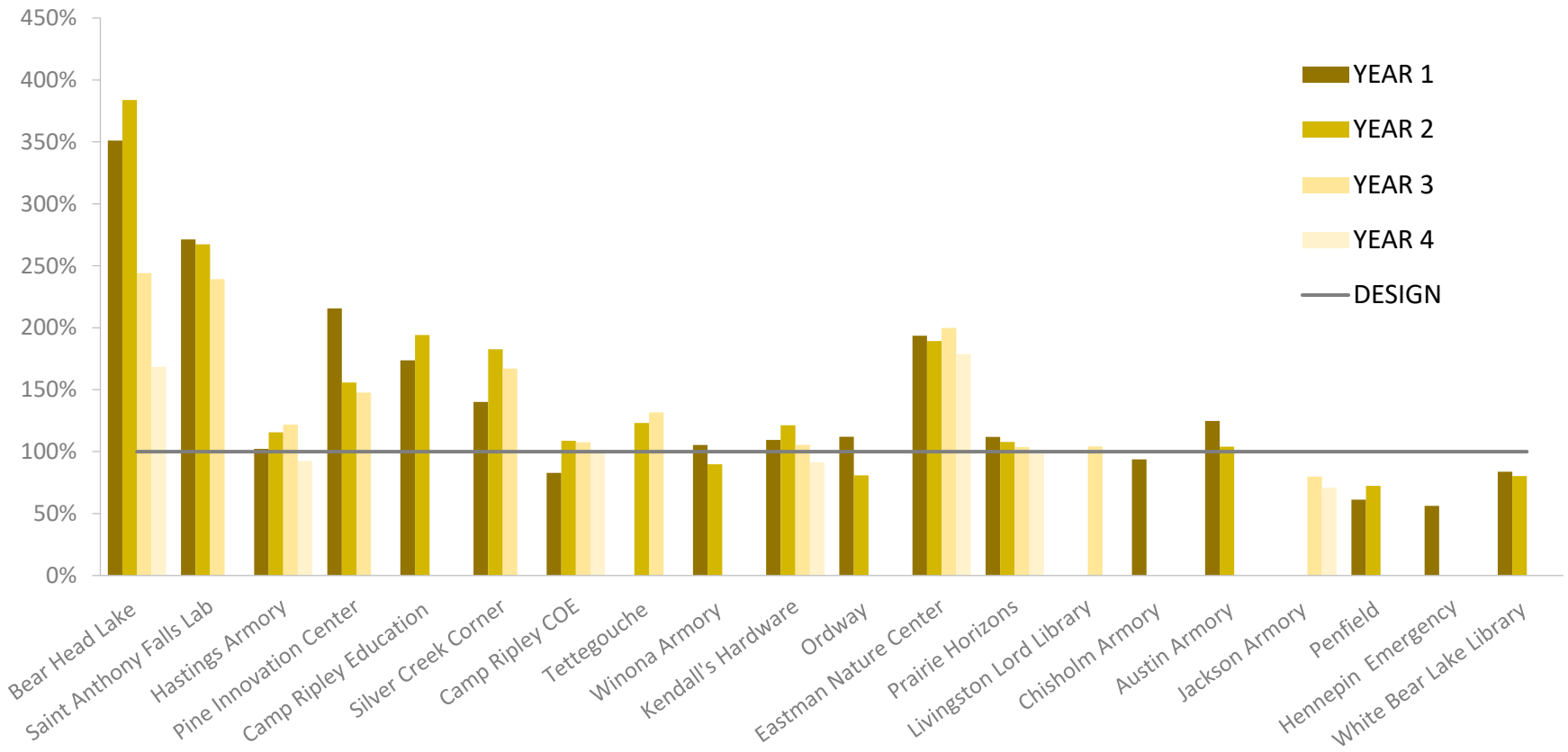
- The SB2030 initiative was passed by the Minnesota legislature in the 2008 session.
- The purpose is “to establish cost-effective energy-efficiency performance standards for new and substantially reconstructed commercial, industrial and institutional buildings that can significantly reduce carbon dioxide emissions by lowering energy use ...”
- These standards have become the energy use requirements for state-bonded projects through the B3 Guidelines.

SB 2030: Increasing performance targets



- Increasing reductions from 2003 baseline
- Target steps every five years
- Reduction requirement for renovations lower

SB 2030 opportunities



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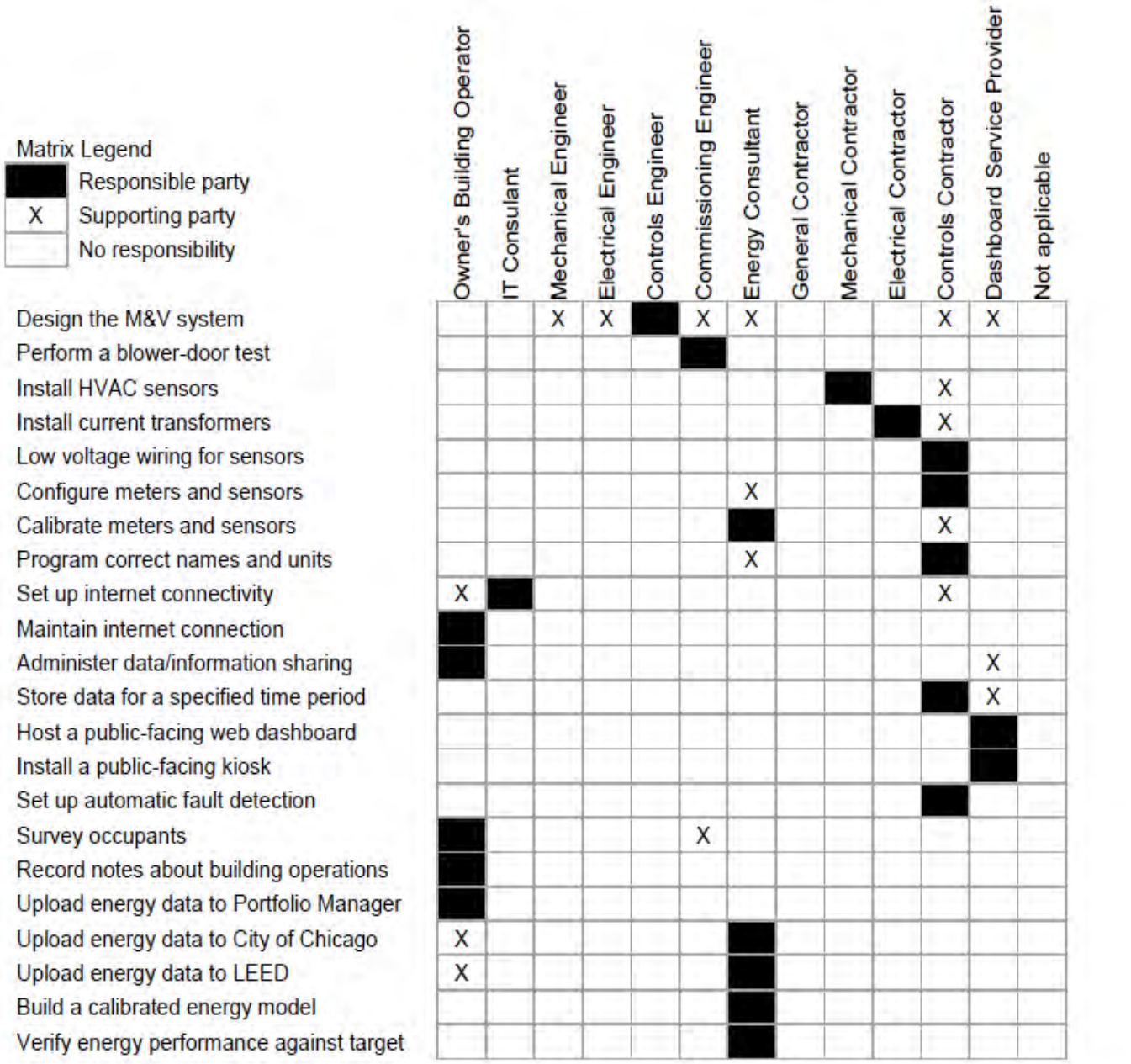
Measurement & Verification


Matrix Legend
Responsible party
X
Supporting party
No responsibility
Owner's Building Operator
IT Consulant
Mechanical Engineer
Electrical Engineer
Controls Engineer
Commissioning Engineer
Energy Consultant
General Contractor
Mechanical Contractor
Electrical Contractor
Controls Contractor
Dashboard Service Provider
Not applicable
Design the M&V system
Perform a blower-door test
Install HVAC sensors
Install current transformers
Low voltage wiring for sensors
Configure meters and sensors
Calibrate meters and sensors
Program correct names and units
Set up internet connectivity
Maintain internet connection
Administer data/information sharing
Store data for a specified time period
Host a public-facing web dashboard
Install a public-facing kiosk
Set up automatic fault detection
Survey occupants
Record notes about building operations
Upload energy data to Portfolio Manager
Upload energy data to City of Chicago
Upload energy data to LEED
Build a calibrated energy model
Verify energy performance against target

Tier 1

Tier I: This is the minimum M&V required to execute the contract language.

- Whole building energy meters for electric and gas service(s). Install current transformers and gas flow meters (separate from utility meters) that report to the client's database on hourly or sub-hourly intervals. The database may be provided by a third party (hosted on the web) and must be accessible to designers, contractors, and operators. Database must be capable of storing data for 3 years or more.
- Sub meter plug loads separately from all other loads.
- Sub meter lighting loads separately from all other loads.
- Building manager records notes about building occupancy and significant control changes or commissioning activities.

Tier 2

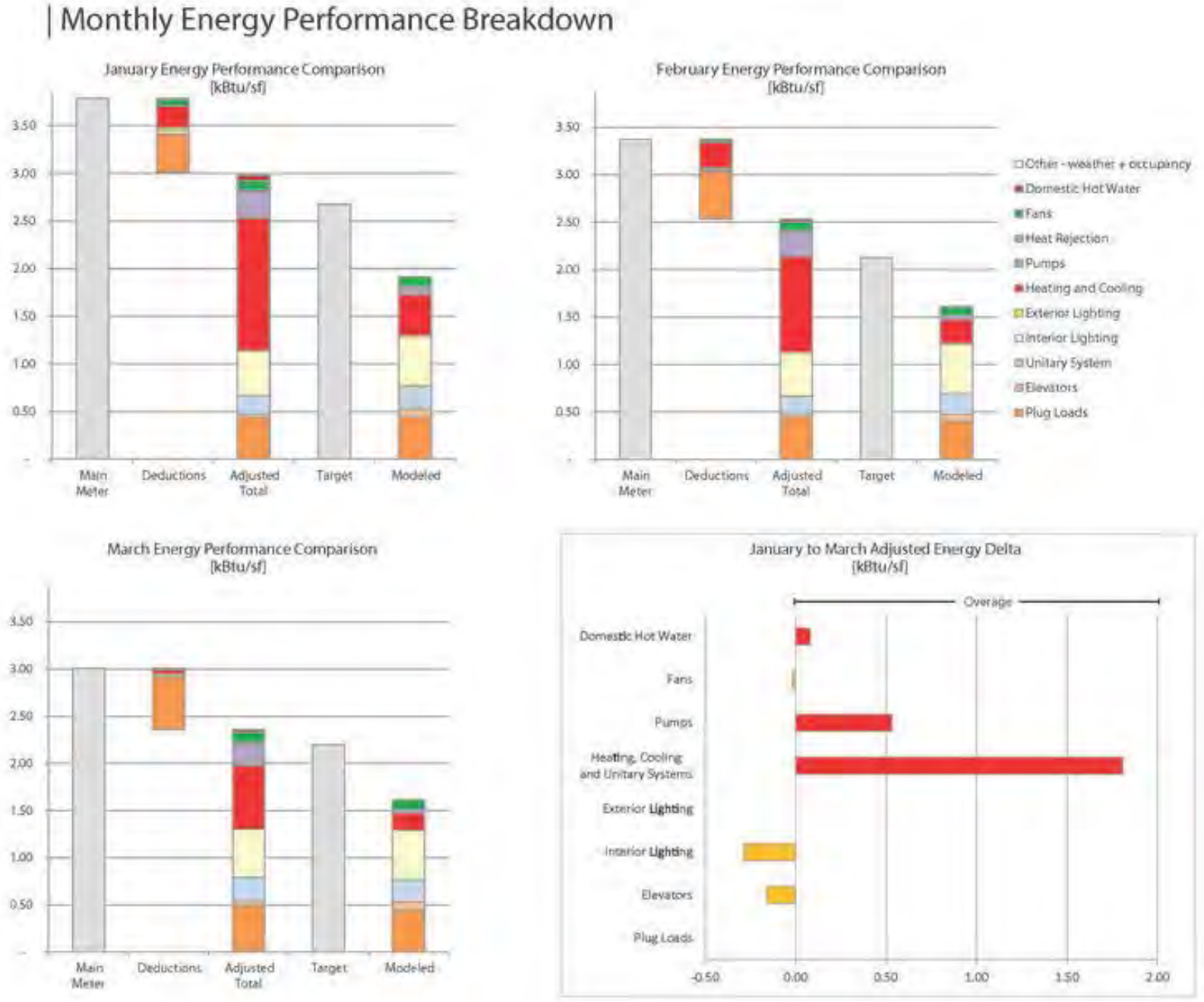
Tier II: These options help with commissioning and model calibration.

- Sub meters are added to above system for each tenant space (keep light and plug loads separated).
- Sub meters for all major equipment and special areas (air handlers, chillers, boilers, exterior lights, data rooms, etc.)
- Perform a blower-door infiltration test and share the results with the design team.

Tier 3

Tier III: These options help the building meet and even exceed its goals more easily.

- Install an automatic fault detection and diagnostics system. Incorporate control system points, meter and sub meter data, and weather data to help identify and repair building system performance issues.
- Install a building dashboard or kiosk that is accessible to the tenants or the public.
- Send data to ENERGY STAR Portfolio Manager; use to benchmark building.
- Install a weather station for the building. Record horizontal solar radiation, ambient air temperature, and ambient relative humidity (at a minimum).
- Survey the occupants to assess comfort, determine actual operational hours, and identify opportunities for training and behavior-based conservation.



Measurement and verification performance data. - Photo Credit: WSP Built Ecology

https://www.nrel.gov/continuum/energy_integration/living_laboratory.html

Discussion and Questions

- Which is better, using metered data or an as-built energy model?
- Who holds responsibility if the building doesn’t work as intended?

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