EVENT 24:

ENERGY MODELING

FOR

EARLY PHASE DESIGN COLLABORATION

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AIA MINNESOTA WEDNESDAY, NOVEMBER 15, 2017

LEARNING OBJECTIVES

As energy modeling tools continue to evolve we are finding ways to evolve the design process as well. Engaging engineering early in the process and getting real time feedback on how envelope design and massing affect the HVAC design can help to get projects on track to meet goals like LEED certification, the 2030 Challenge or Net Zero. In addition this workflow can also help to reduce capital budgets and limit redesign costs later in the process. We will discuss possible workflow paths that deliver meaningful feedback to all collaborators.

1. Understand the overlap of enclosure-oriented building performance modeling with mechanical energy modeling in early phase design.

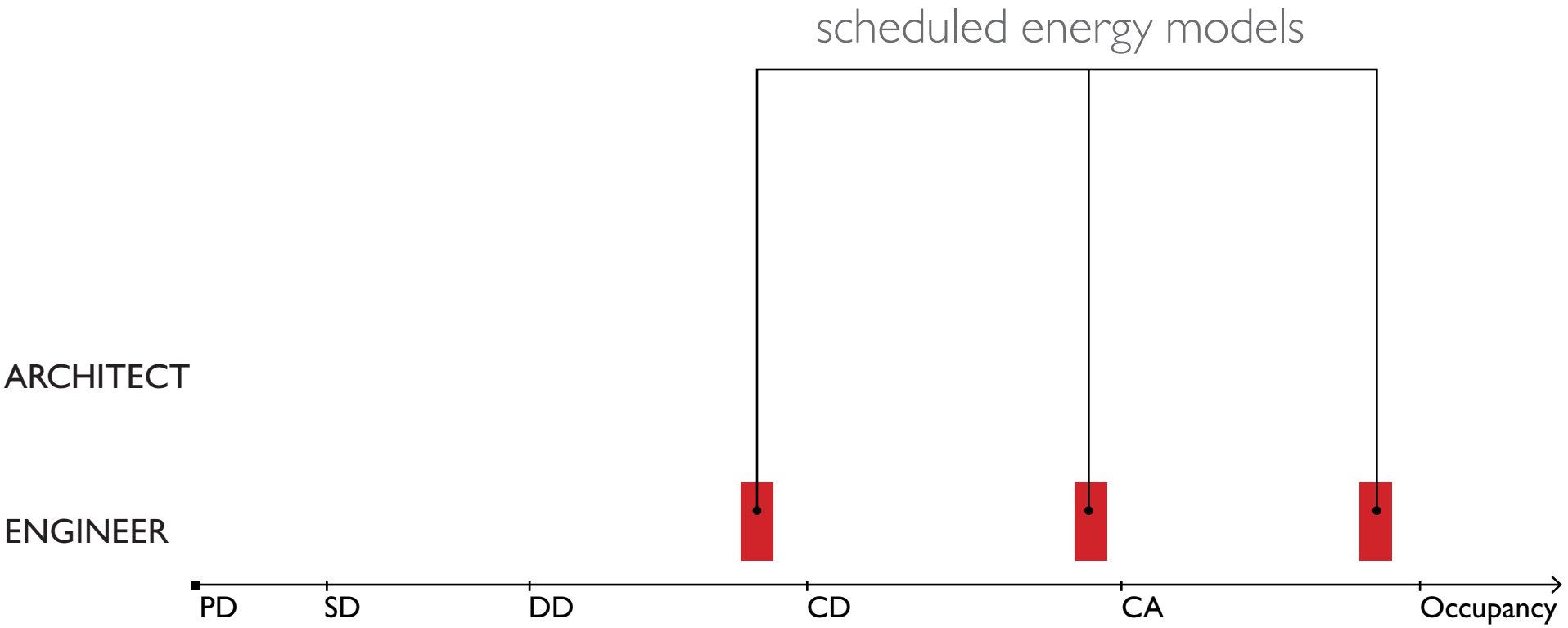
2. Identify where comparative studies can be done to better inform the whole building energy model to increase the speed of feedback.

3. Understand how different workflow approaches between the architects and engineers impact the design process.

4. The timeline and methodology for collaborative energy modeling earlier in project delivery.

WHY EARLY PHASE?

WHY EARLY PHASE?



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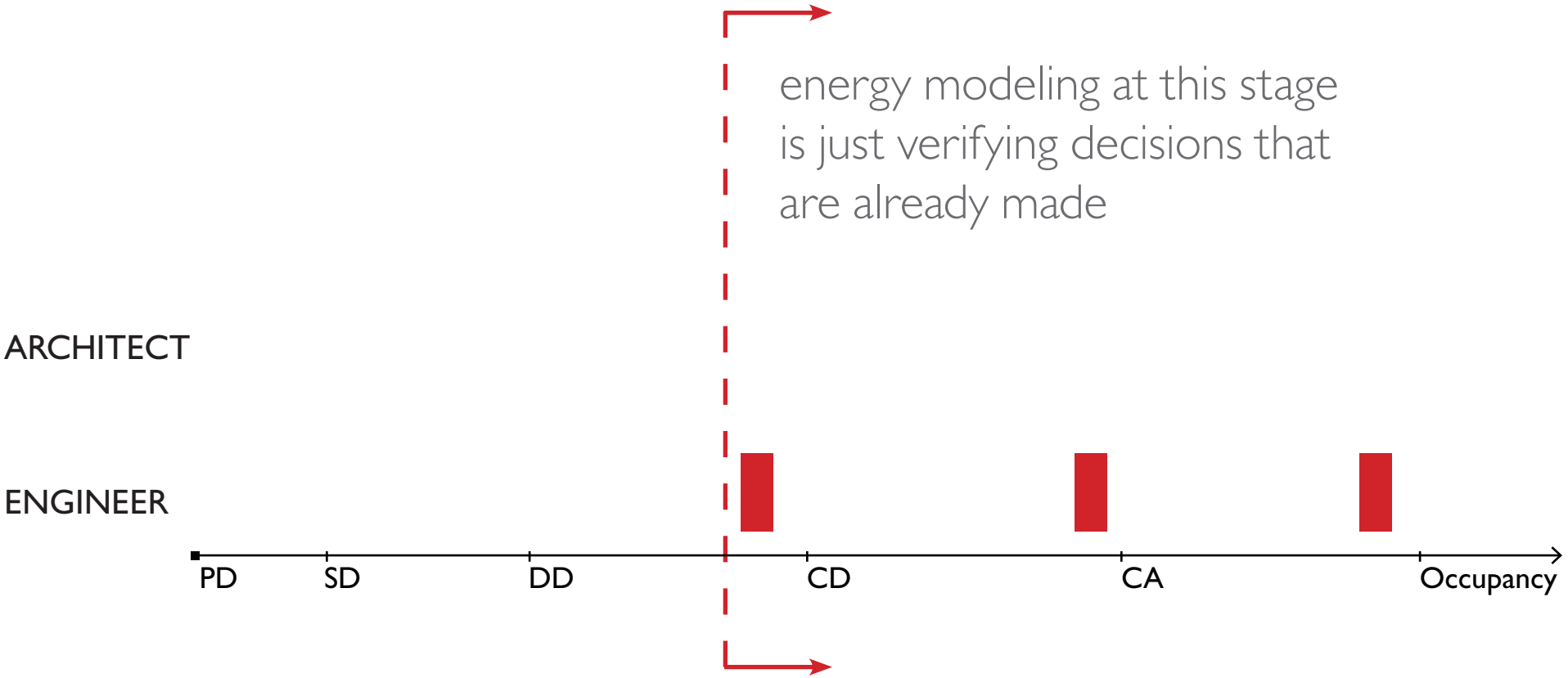

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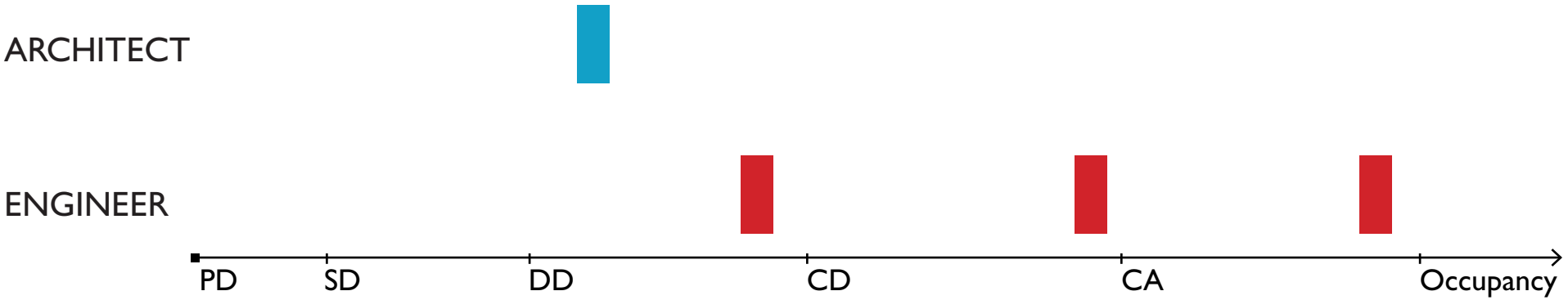

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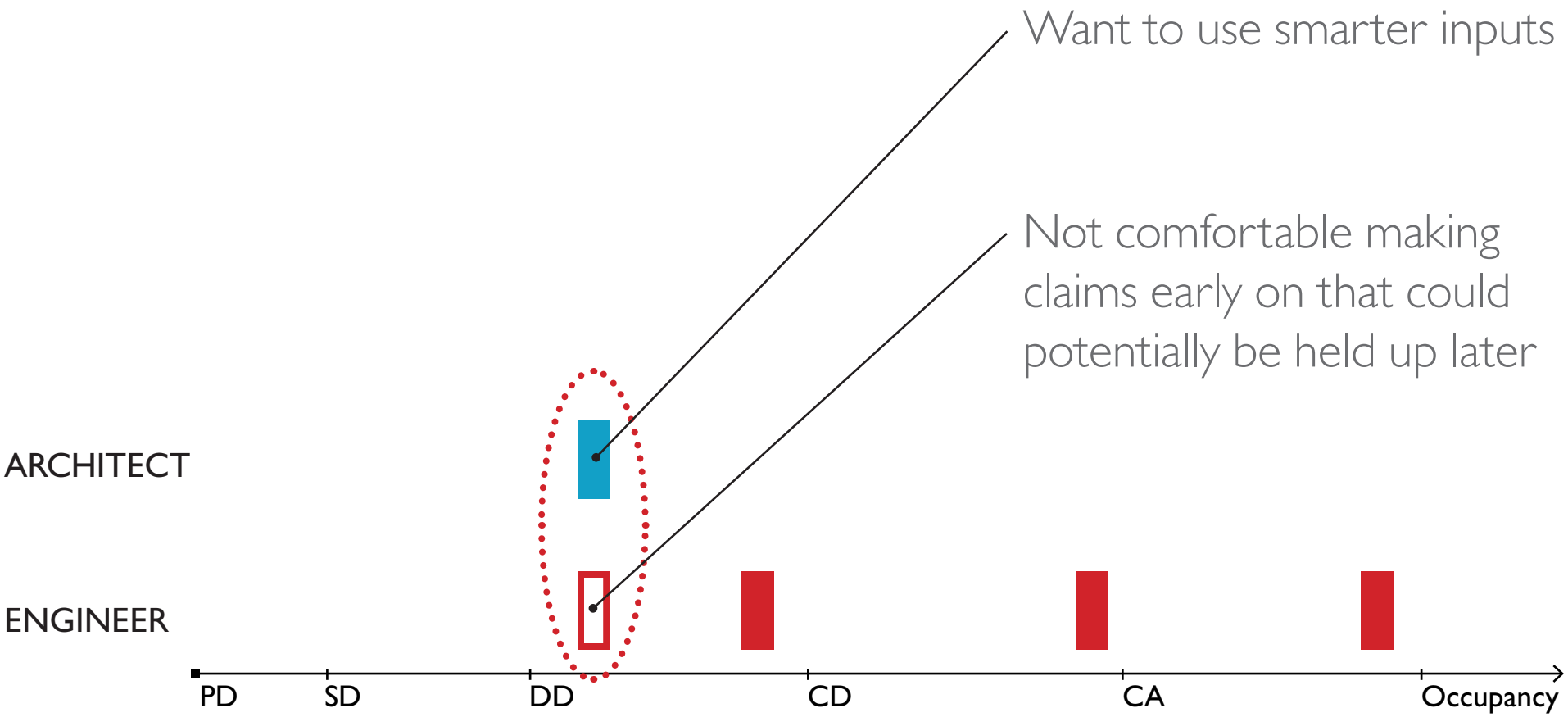
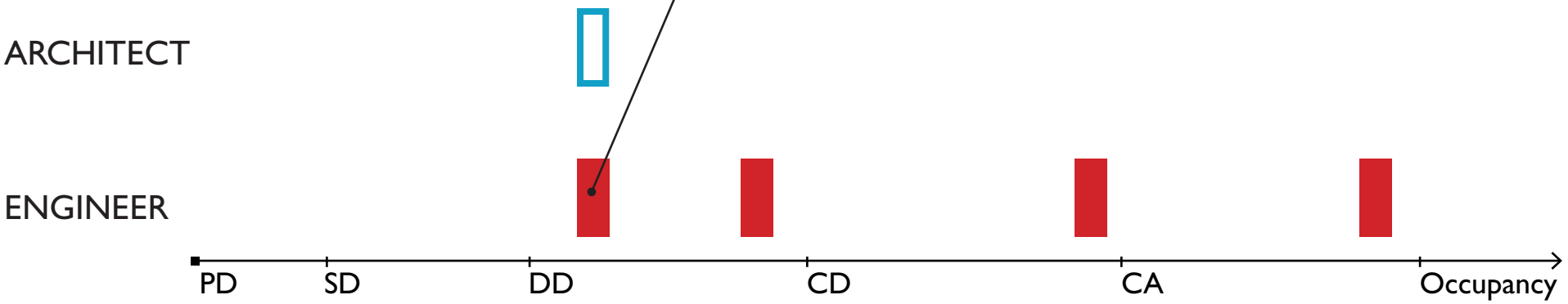
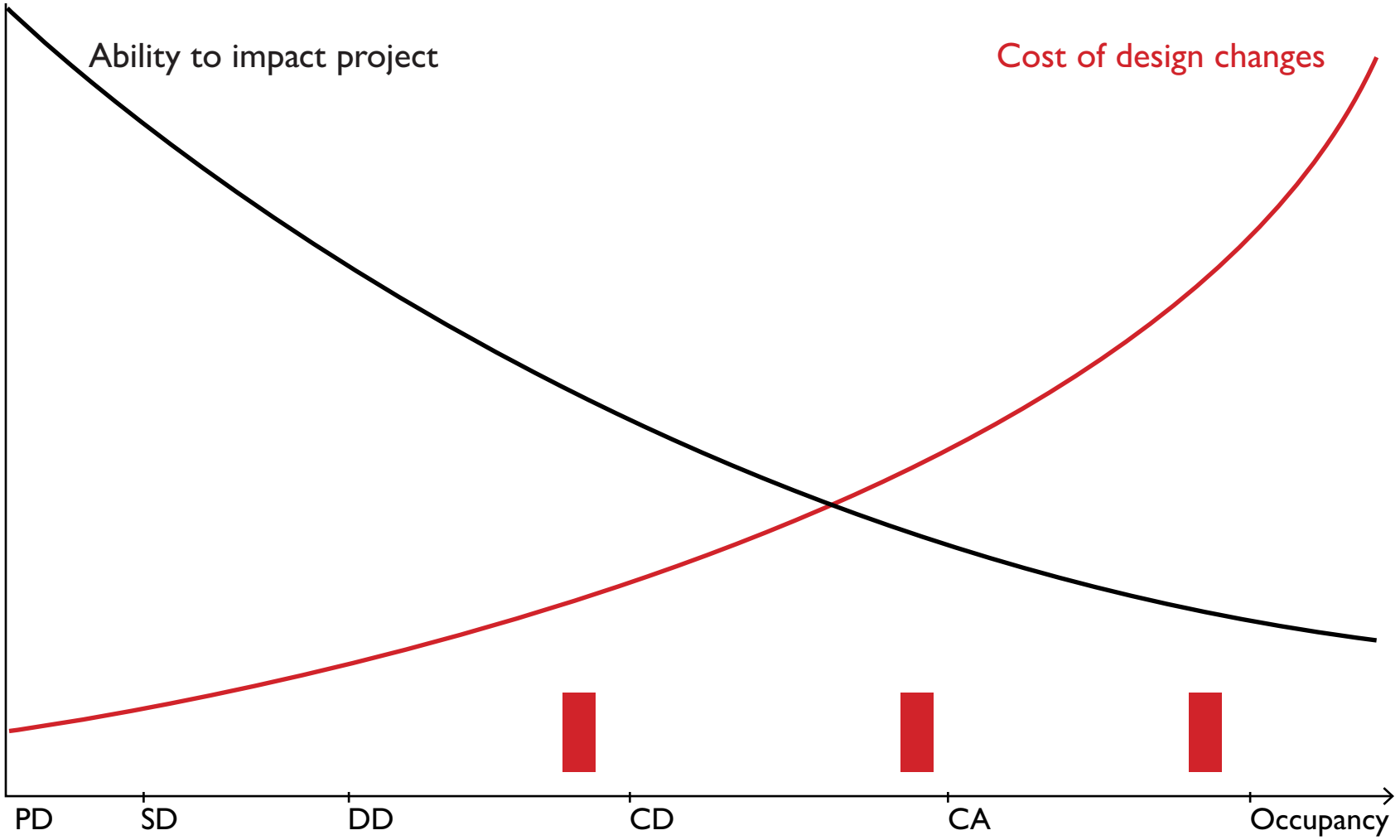


WHY EARLY PHASE?

Too detailed to quickly test massing strategies other than orientation

Cost-savings driven;
No overall carbon footprint reduction info



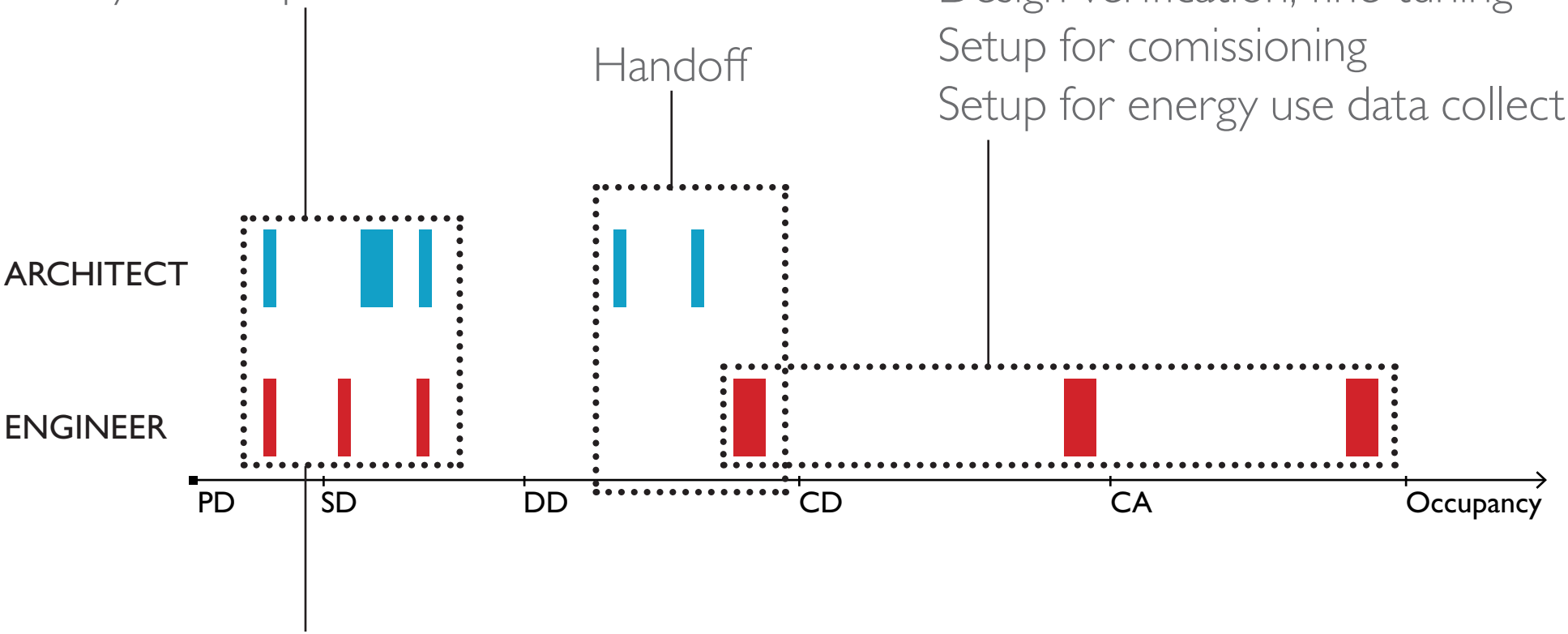

Ability to impact project
Cost of design changes
PD
SD
DD
CD
CA
Occupancy

THE PATH WE REALLY WANT

Baselines and targets
Climate analysis and passive strategies
Envelope optimization
Orientation / massing / glazing
Systems optimization

Handoff

Design verification, fine-tuning
Setup for comissioning
Setup for energy use data collection



Upfront input on systems alternatives
Modeling input

OVERVIEW

WHY ENERGY MODEL?

ENERGY, CARBON, AND GLOBAL WARMING

WHAT RESOURCES ARE AVAILABLE?

2030 CHALLENGE

AIA2030 COMMITMENT

EUI = ENERGY USE INTENSITY

ENERGY MODELING SOFTWARE

WHY ENERGY MODEL IN EARLY DESIGN?

INTEGRATION AND COLLABORATION

WHAT MAKES UP AN ENERGY MODEL?

THE ANATOMY OF AN ENERGY MODEL

METHODOLOGY

ESTABLISH BASELINES AND TARGETS

CLIMATE ANALYSIS + PASSIVE STRATEGIES

ENVELOPE OPTIMIZATION

ORIENTATION / MASSING / GLAZING

SYSTEMS OPTIMIZATION

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GLOBAL WARMING

Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released by people burning fossil fuels.

The impact of global warming is far greater than just increasing temperatures. Warming modifies rainfall patterns, amplifies coastal erosion, lengthens the growing season in some regions, melts ice caps and glaciers, and alters the ranges of some infectious diseases. Some of these changes are already occurring.

-Holli Riebeek, NASA Earth Observatory

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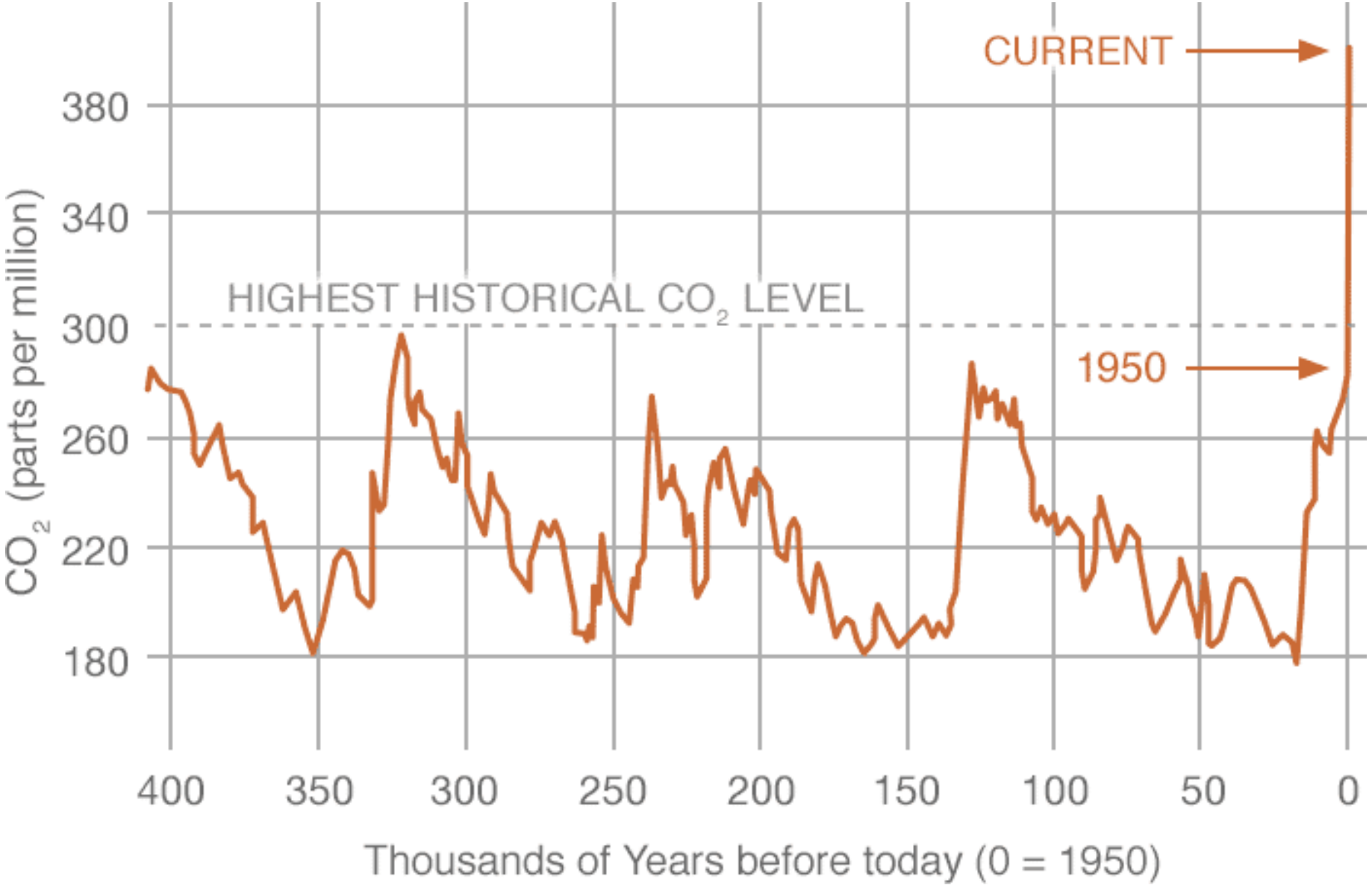
350 PPM CO2

Scientists have set the maximum level of C02 in the atmosphere at 350 ppm to ensure stable climate conditions globally. We have already exceeded this number and are at 397 ppm C02. This has led to a global warming that is already underway. We must reduce the levels of C02 in the atmosphere to below 350 ppm to avoid permanent global warming.

2 DEG CELSIUS

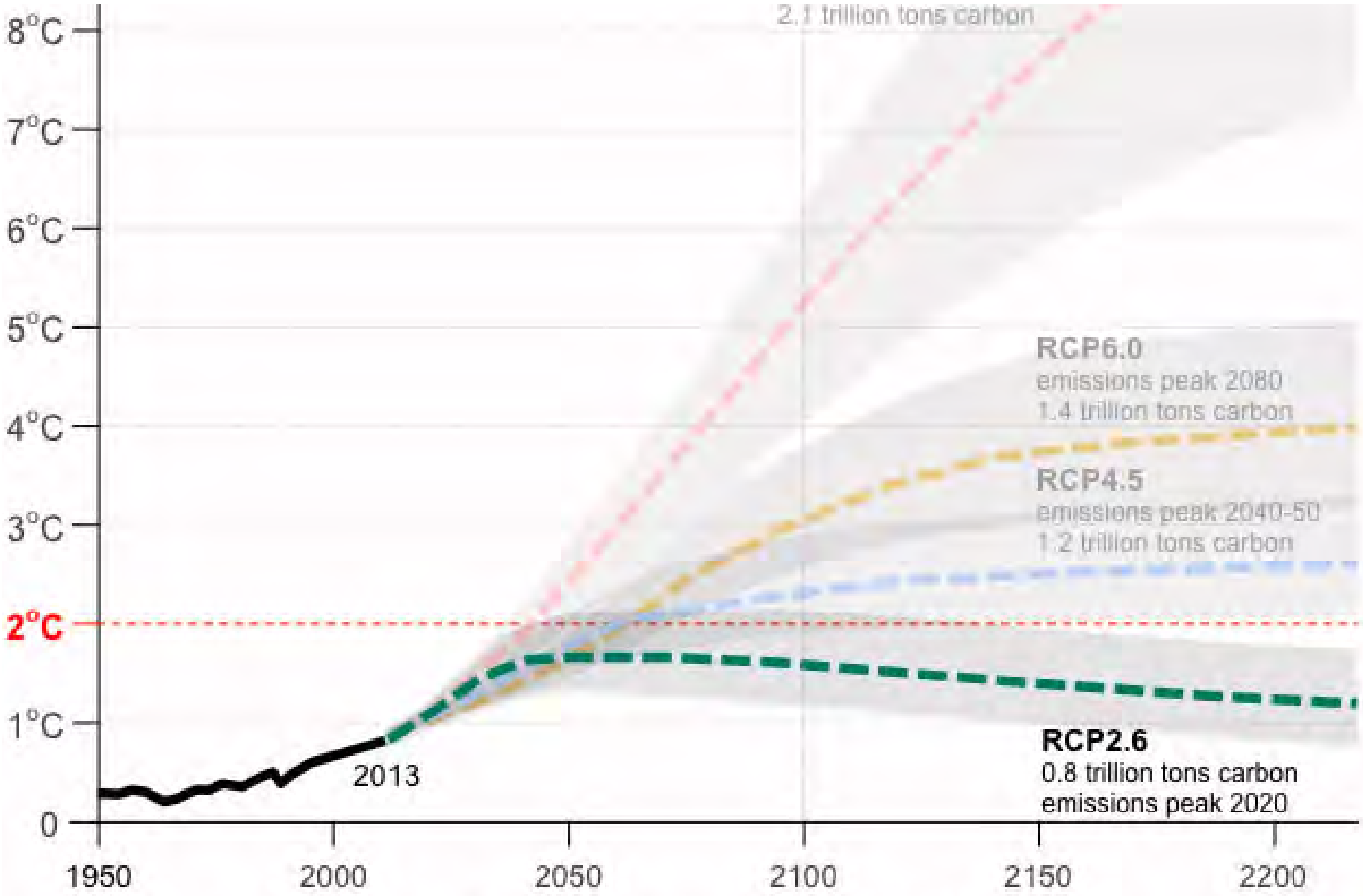
If global temperatures rise by more than 2 degrees Celsius, scientists predict this will set in motion a permanent and accelerated global warming. We have already recorded a global temperature increase of 0.8 degrees Celsius in the past decade. We must keep the global temperature rise under 2 degrees Celsius to avoid permanent global warming.

350 PPM CO2



-National Oceanic and Atmospheric Administration

2 DEG CELSIUS



Global Temperature Projections for various RCP Scenarios

Source: Architecture 2030; Adapted from IPCC Fifth Assessment Report, 2013
Representative Concentration Pathways (RCP), temperature projections for SRES scenarios and the RCPs.

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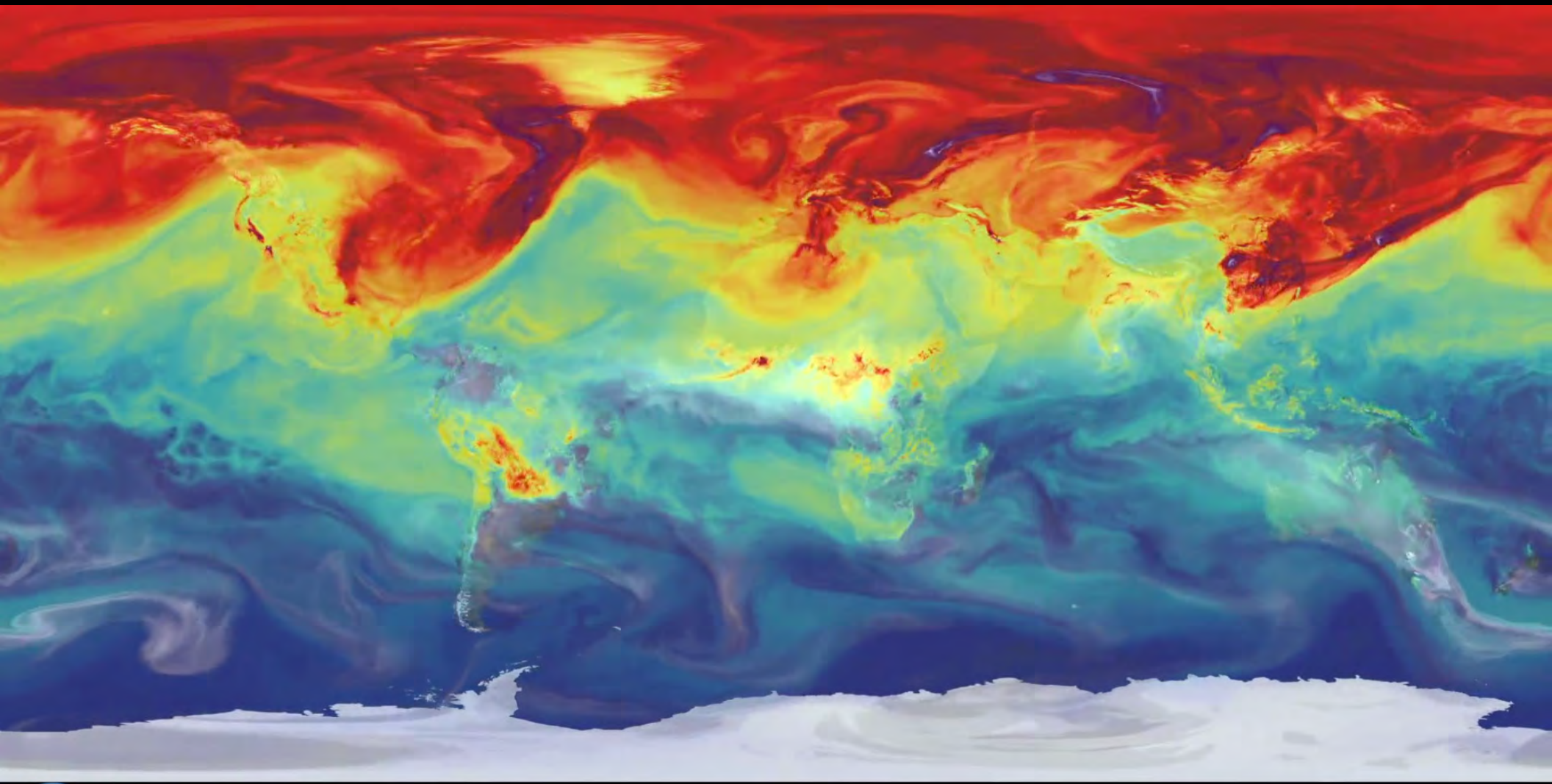
IMPACT

ARE YOU RICH ENOUGH TO SHIELD YOUR DESCENDANTS?

The simple reality is that people are already feeling the effects, whether they know it or not. Because of sea level rise, for instance, some 83,000 more residents of New York and New Jersey were flooded during Hurricane Sandy than would have been the case in a stable climate, scientists have calculated. Tens of thousands of people are already dying in heat waves made worse by global warming. The refugee flows that have destabilized politics around the world have been traced in part to climate change. Of course, as with almost all other social problems, poor people will be hit first and hardest.

- Climate Change Is Complex. We've Got Answers to Your Questions.
Justin Gillis, The New York Times



2006 / 12 / 18

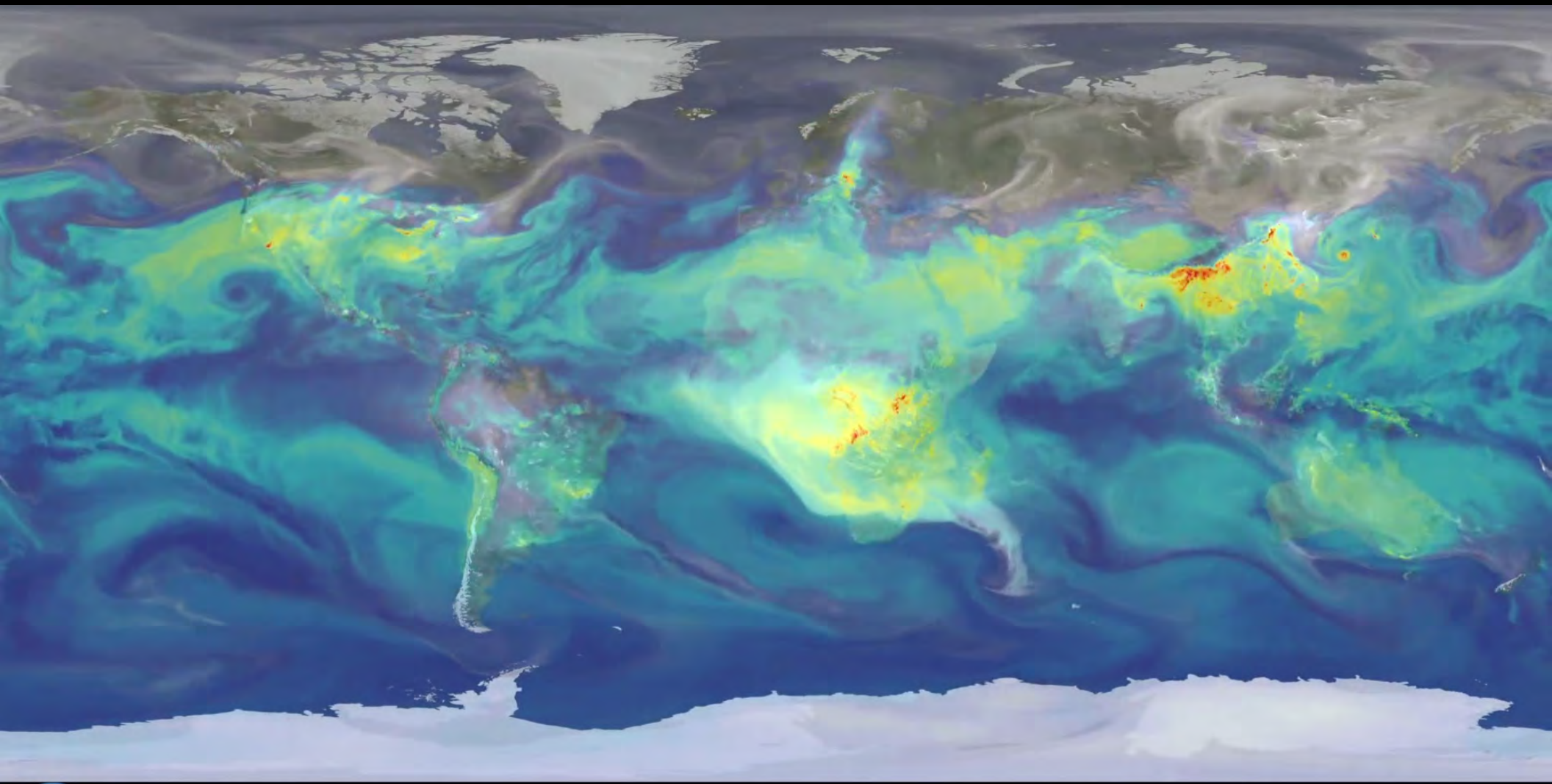
Global Modeling and Assimilation Office

Carbon Monoxide Column Abundance [1.0e18 molec cm-2]

0.0 0.6 1.2 1.8 2.4 3.0 3.6 4.2 4.8 5.4 6.0

Carbon Dioxide Column Concentration [ppmv]

377 379 381 383 385 387 389 391 393 395



2006 / 08 / 02

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2030 CHALLENGE

We're a non-profit think tank transforming climate change problems into solutions through the design of the built environment.

PROBLEM The urban built environment is responsible for most of the world's fossil fuel consumption and greenhouse gas emissions.

SOLUTION Planning and designing collaborative efforts that pave the way to a sustainable and carbon neutral future

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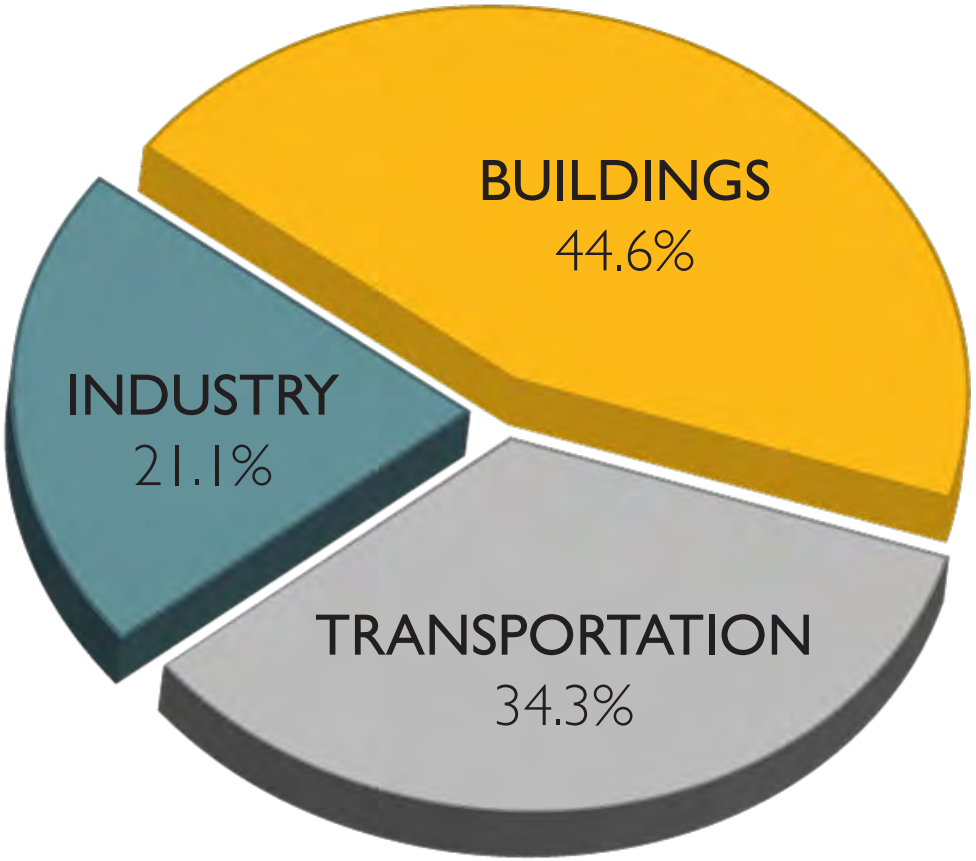

U.S. CO_2 Emissions by Sector

Source: ©2013 2030, Inc. / Architecture 2030. All Rights Reserved.
Data Source: U.S. Energy Information Administration (2012).

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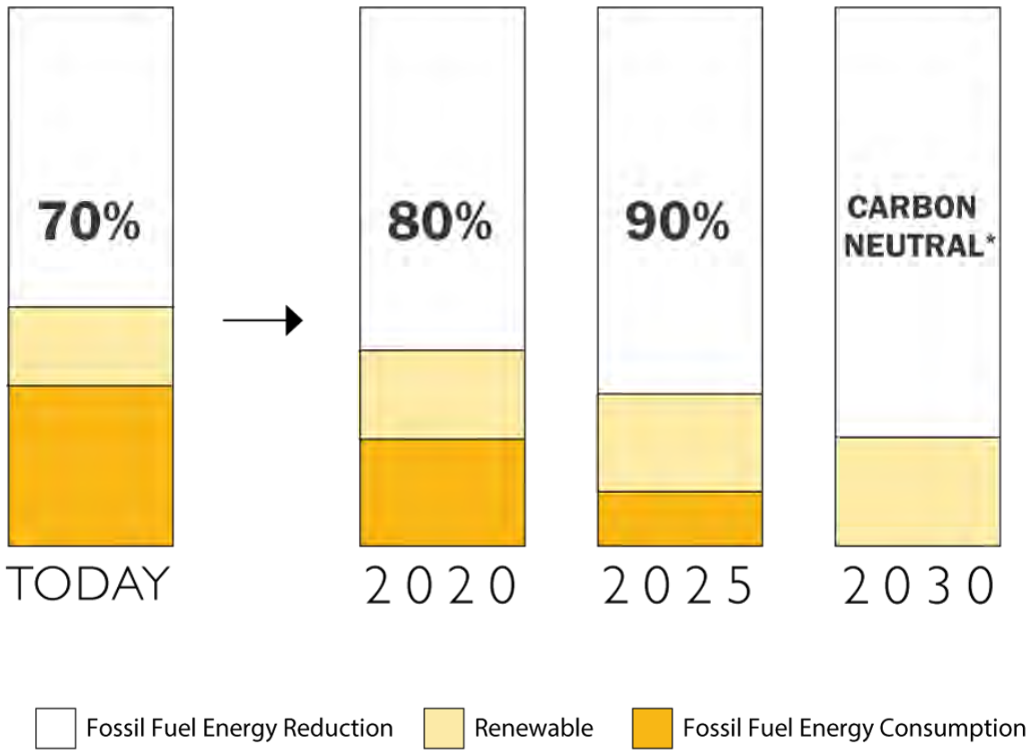

The 2030 Challenge

Source: ©2015 2030, Inc. / Architecture 2030. All Rights Reserved.
**Using no fossil fuel GHG-emitting energy to operate.*

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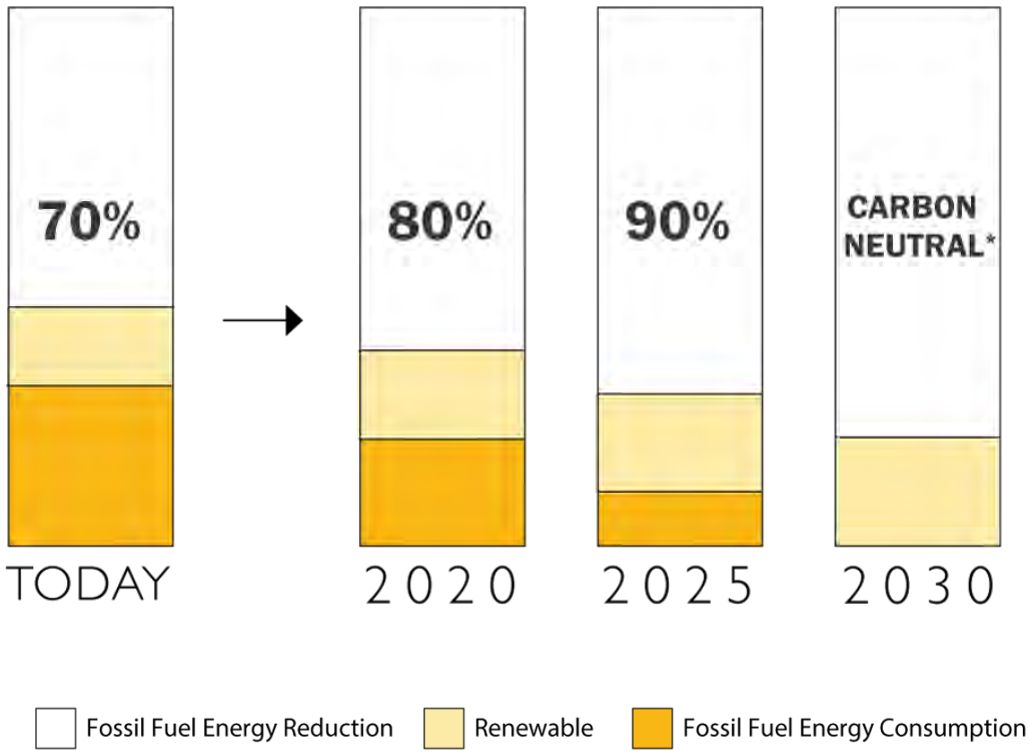

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AIA2030 COMMITMENT

In 2006, Architecture 2030 issued the 2030 Challenge, a breakthrough vision that calls for all new buildings, developments, and major renovations to be carbon-neutral by 2030. To support this call to action, we created the AIA 2030 Commitment—a national framework with simple metrics and a standardized reporting format—to provide a structure for tracking progress and help you meet the challenge.

The mission of The AIA 2030 Commitment is to transform the practice of architecture in a way that is holistic, firm-wide, project-based and data-driven, so that the AIA and the participating firms can prioritize energy performance and carbon reductions in the design toward carbon neutral buildings, developments and major renovations by 2030.

- https://www.aia.org/resources/6616-the-2030-commitment

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AIA2030 COMMITMENT

SIGN
the commitment

REPORT
energy performance of all projects you design every year

CONTRIBUTE
national database of project performance

IMPROVE
track performance, access resources, make progress

ENERGY

Join the AIA 2030 Commitment

In only five steps, you can be a part of the AIA 2030 Commitment and help ensure a carbon-neutral built environment.

2030 Commitment resources

When you join the 2030 Commitment, you get access to resources, courses and easy-to-use tools to help improve your energy performance and your practice.

2030 Design Data Exchange (DDx)

Track your firm's progress to 2030 carbon neutral goals and confidentially compare energy data with the AIA 2030 Design Data Exchange (DDx).

REPORT

AIA 2030 Commitment By the Numbers

An overview of the progress that projects and firms are making

ENERGY

2030 Commitment signatory firms

In 2016, 175 firms submitted their design portfolios covering 2.7 billions square feet.

COURSE

AIA+2030 Online Series

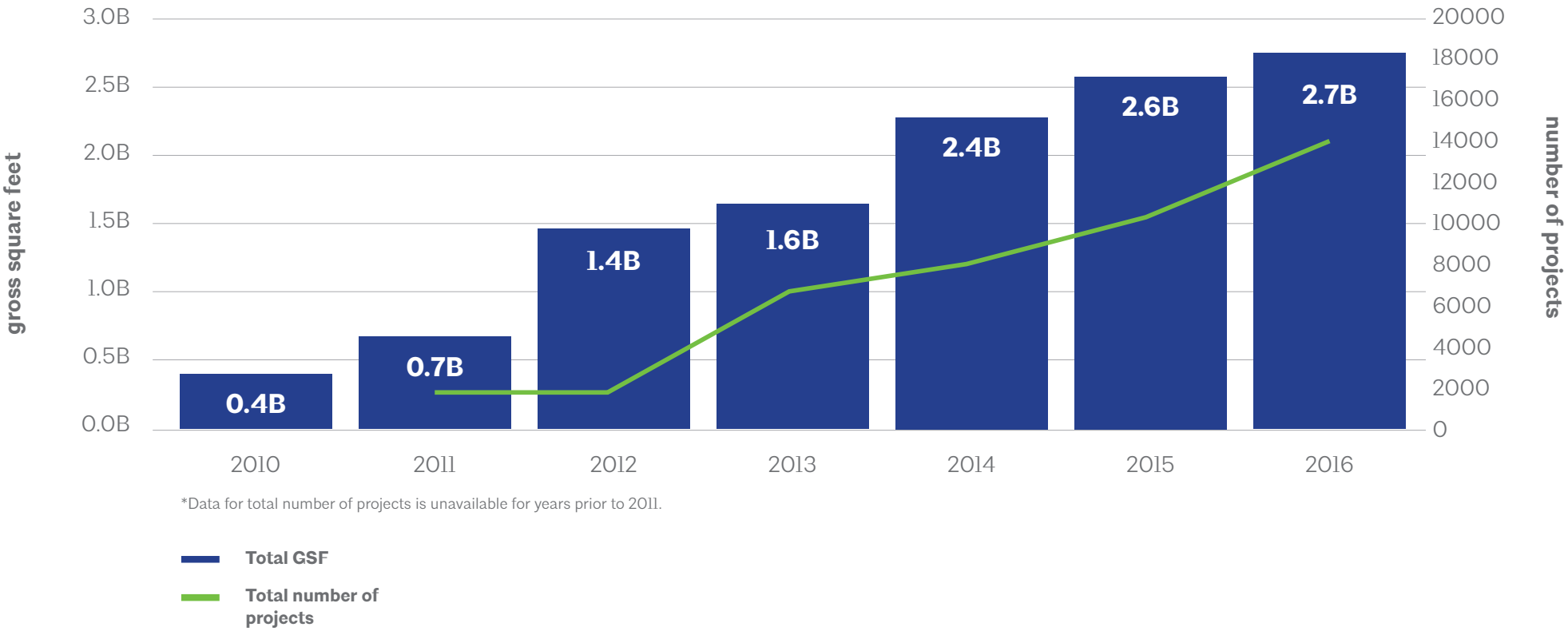
1.00 LU | HSW | RIBA

This series aims to inspire architects to meet the 2030 Challenge through design strategies, efficient technologies and systems, and applying renewable energy resources.

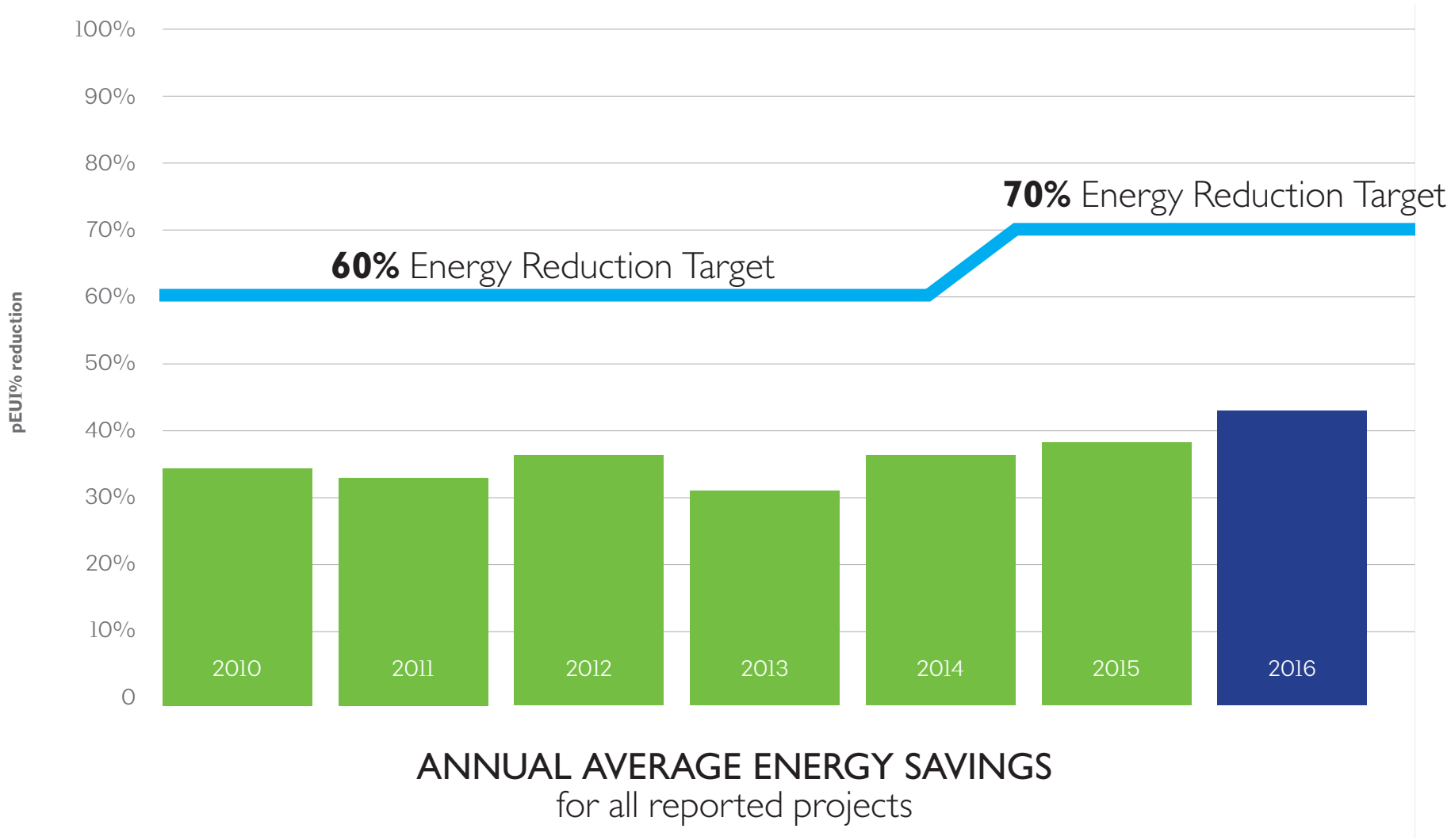
- https://www.aia.org/resources/6616-the-2030-commitment

33% increase in reported projects

Total reported area (GSF) of projects
& total number of projects



- 2016 AIA2030 Progress Report



ANNUAL AVERAGE ENERGY SAVINGS
for all reported projects

- 2016 AIA2030 Progress Report

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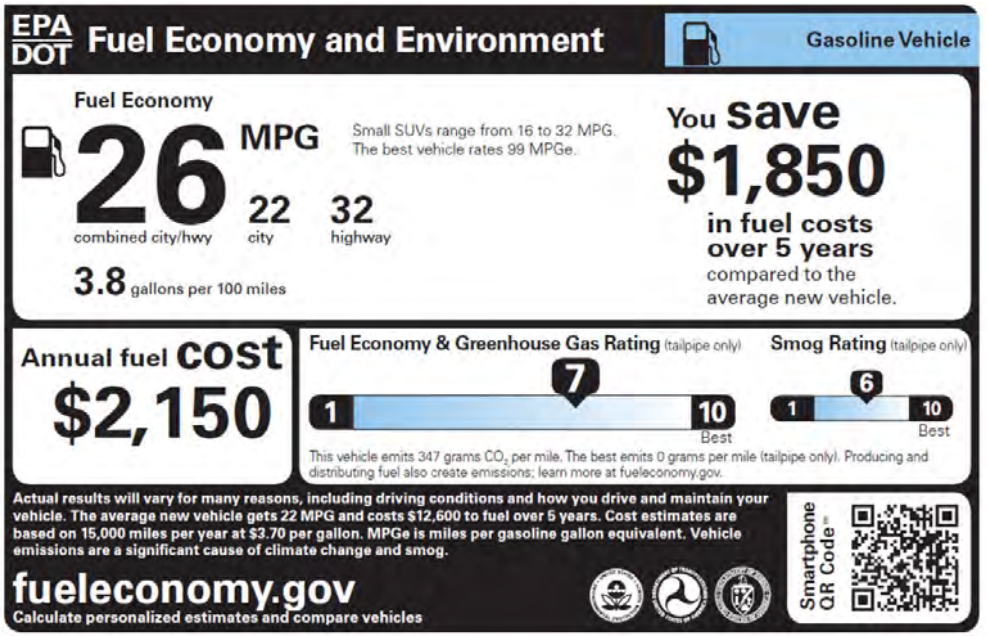
EUI IS MPG

EUI = ENERGY USE INTENSITY

$$\frac{\text{ANNUAL ENERGY USE}}{\text{PROJECT SIZE}}$$

$$\frac{\text{KBTU}}{\text{SF}}$$



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SOFTWARE

ENERGY+

CLIMATE CONSULTANT

SEFAIRA

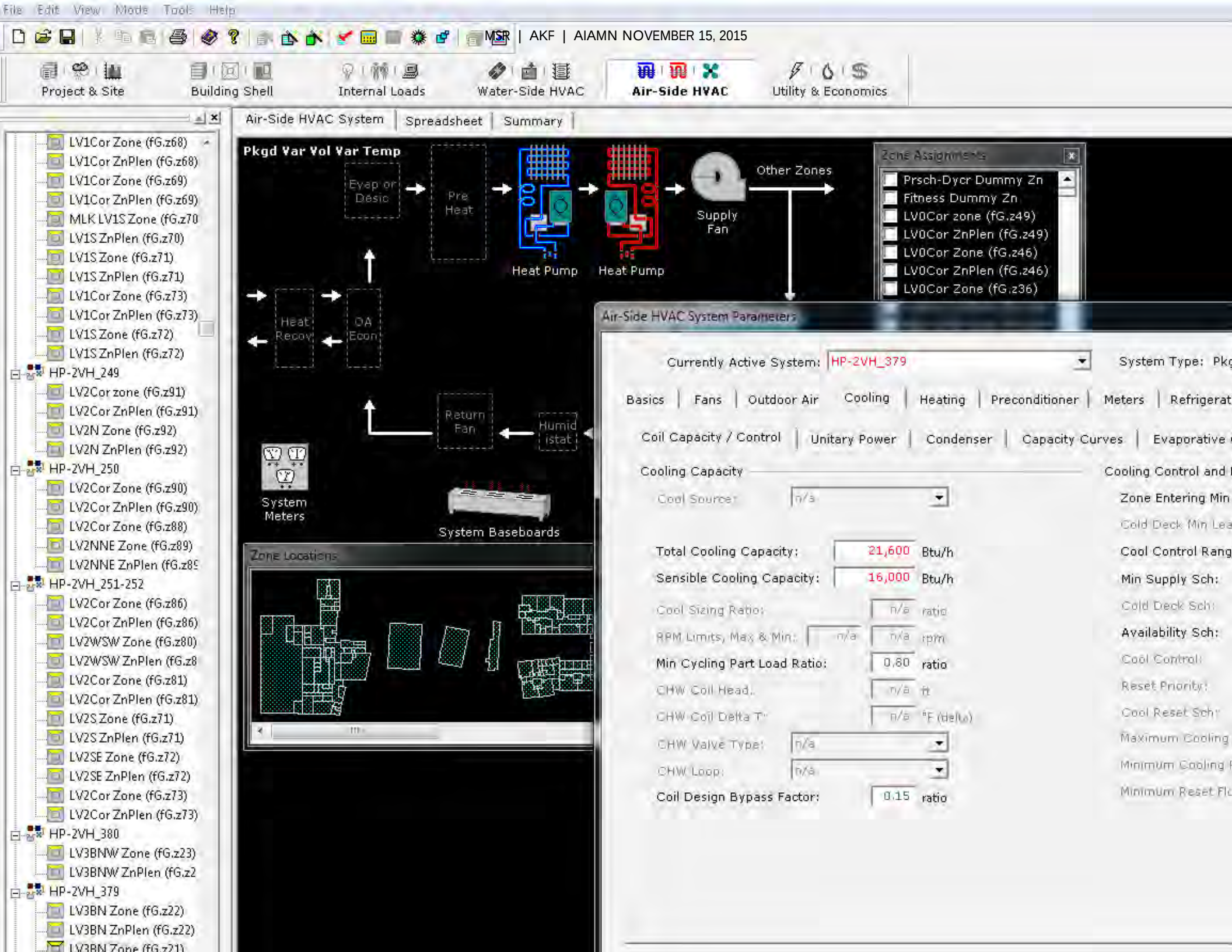
HONEYBEE / LADYBUG

REVIT

IESVE

TRANE/TRACE

EQUEST


File Edit View Mode Tools Help
Project & Site
Building Shell
Internal Loads
Water-Side HVAC
Air-Side HVAC
Utility & Economics
Air-Side HVAC System
Spreadsheet
Summary
LV1Cor Zone (fG.z68)
LV1Cor ZnPlen (fG.z68)
LV1Cor Zone (fG.z69)
LV1Cor ZnPlen (fG.z69)
MLK LV1S Zone (fG.z70
LV1S ZnPlen (fG.z70)
LV1S Zone (fG.z71)
LV1S ZnPlen (fG.z71)
LV1Cor Zone (fG.z73)
LV1Cor ZnPlen (fG.z73)
LV1S Zone (fG.z72)
LV1S ZnPlen (fG.z72)
HP-2VH_249
LV2Cor zone (fG.z91)
LV2Cor ZnPlen (fG.z91)
LV2N Zone (fG.z92)
LV2N ZnPlen (fG.z92)
HP-2VH_250
LV2Cor Zone (fG.z90)
LV2Cor ZnPlen (fG.z90)
LV2Cor Zone (fG.z88)
LV2NNE Zone (fG.z89)
LV2NNE ZnPlen (fG.z8
HP-2VH_251-252
LV2Cor Zone (fG.z86)
LV2Cor ZnPlen (fG.z86)
LV2WSW Zone (fG.z80)
LV2WSW ZnPlen (fG.z8
LV2Cor Zone (fG.z81)
LV2Cor ZnPlen (fG.z81)
LV2S Zone (fG.z71)
LV2S ZnPlen (fG.z71)
LV2SE Zone (fG.z72)
LV2SE ZnPlen (fG.z72)
LV2Cor Zone (fG.z73)
LV2Cor ZnPlen (fG.z73)
HP-2VH_380
LV3BNW Zone (fG.z23)
LV3BNW ZnPlen (fG.z2
HP-2VH_379
LV3BN Zone (fG.z22)
LV3BN ZnPlen (fG.z22)
LV3BN Zone (fG.z21)
Pkgd Var Vol Var Temp
Evap or Desic
Pre Heat
Heat Pump
Heat Pump
Supply Fan
Other Zones
Heat Recov
OA Econ
Return Fan
Humid istat
System Meters
System Baseboards
Zone Locations
Zone Assignments
Prsch-Dycr Dummy Zn
Fitness Dummy Zn
LV0Cor zone (fG.z49)
LV0Cor ZnPlen (fG.z49)
LV0Cor Zone (fG.z46)
LV0Cor ZnPlen (fG.z46)
LV0Cor Zone (fG.z36)
Air-Side HVAC System Parameters
Currently Active System: HP-2VH_379
System Type: Pkg
Basics | Fans | Outdoor Air | Cooling | Heating | Preconditioner | Meters | Refrigerat
Coil Capacity / Control | Unitary Power | Condenser | Capacity Curves | Evaporative
Cooling Capacity
Cool Source: n/a
Total Cooling Capacity: 21,600 Btu/h
Sensible Cooling Capacity: 16,000 Btu/h
Cool Sizing Ratio: n/a ratio
RPM Limits, Max & Min: n/a n/a rpm
Min Cycling Part Load Ratio: 0.60 ratio
CHW Coil Head: n/a ft
CHW Coil Delta T: n/a °F (delta)
CHW Valve Type: n/a
CHW Loop: n/a
Coil Design Bypass Factor: 0.15 ratio
Cooling Control and
Zone Entering Min
Cold Deck Min Lea
Cool Control Rang
Min Supply Sch:
Cold Deck Sch:
Availability Sch:
Cool Control:
Reset Priority:
Cool Reset Sch:
Maximum Cooling
Minimum Cooling
Minimum Reset Flo

2017-09-26 - SD Energy Model - SketchUp Make 2017

File Edit View Camera Draw Tools Window Extensions Help

Scene 89 | Scene 90 | Scene 91 | Scene 92 | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V10 | V11 | V12 | V13 | V14 | Elev - East | Elev - North | Elev - West | Elev - South | (S - L0) | (S - L1) | (S - L2) | (S - S1) | (S - S2) | Shadow - E | Shadow - W | D00 - Existing | D01 - Site Co

Sefaira Plugin

Model Properties Close

HVAC type: VAV - Return Air Package (System 5/6)

Baseline: ASHRAE 90.1 - 2013

ASHRAE Climate Zone: 6

Wall Insulation	Insulated
Floor Insulation	Insulated
Roof Insulation	Well Insulated
Glazing U-Factor	3 Pane
Visible Light Transmittance	2 panes
Solar Heat Gain Coefficient	Reflective
Infiltration Rate	Normal practice
Ventilation Rate	Typical Ventilation
Equipment	Good
Lighting	Standard

Total Floor / Close 8,083 ft²

MOSTLY WELL LIT

Guidance

Select objects. Shift to extend select. Drag mouse to select multiple.

OVERVIEW

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ENERGY, CARBON, AND GLOBAL WARMING

WHAT RESOURCES ARE AVAILABLE?

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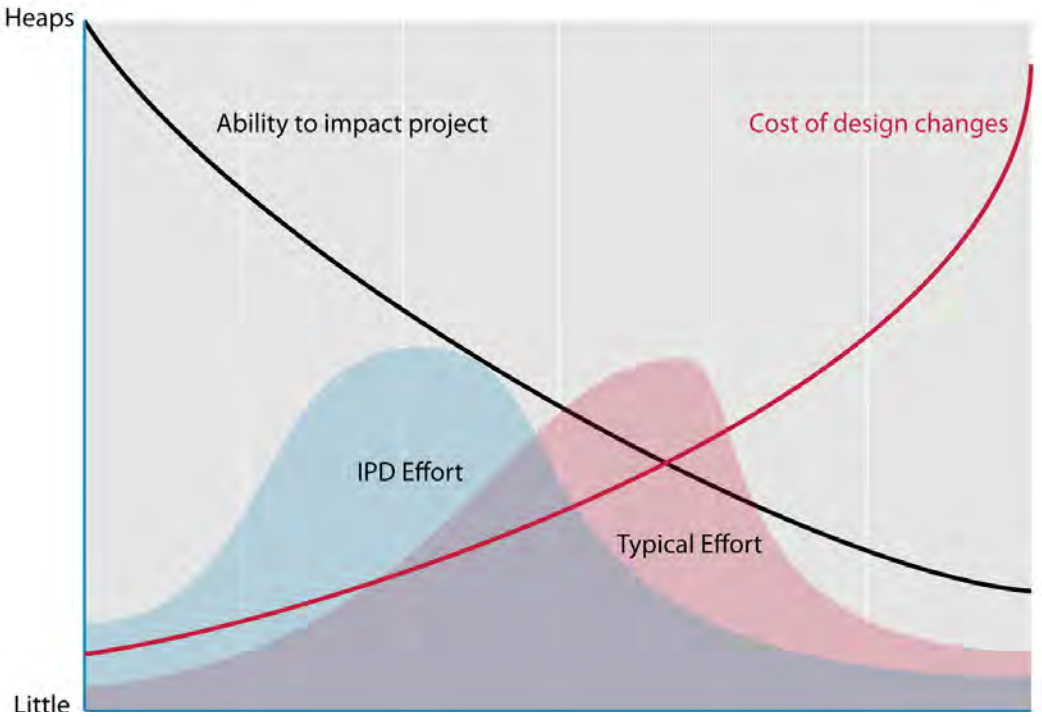

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WHAT MAKES UP AN ENERGY MODEL?

THE ANATOMY OF AN ENERGY MODEL

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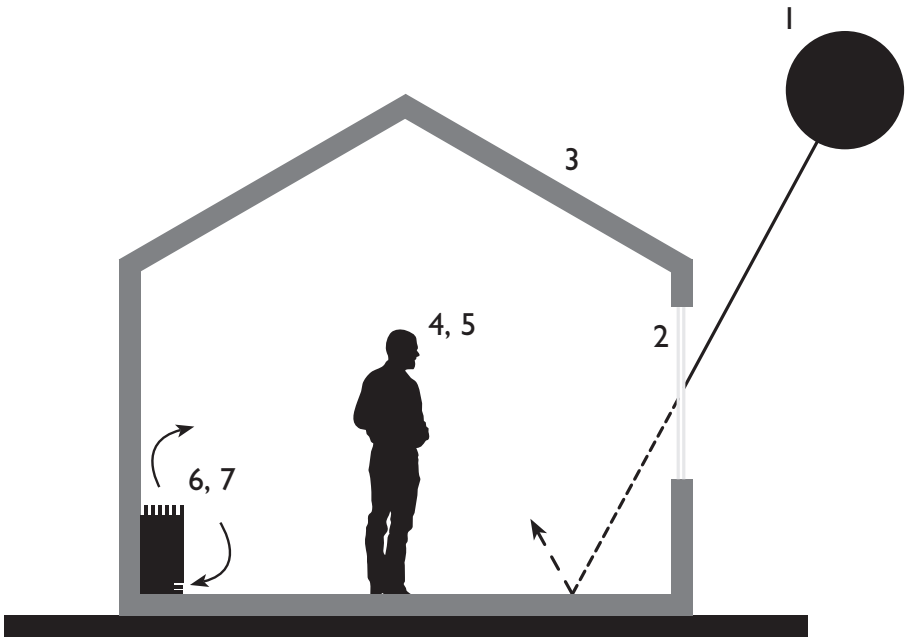
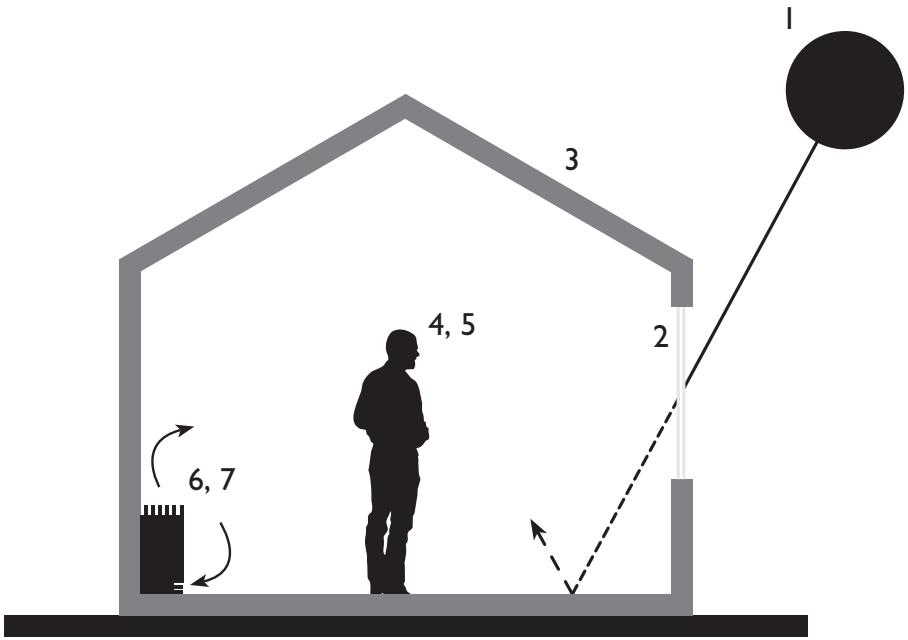


Energy Modeling Input Category	Design Team Responsibility
1) Climate Data	
2) Construction Types	
3) Building Form	
4) Occupancy Types	
5) Occupancy Loads	
6) Building Systems	
7) Building System Schedules	

THE ANATOMY OF AN ENERGY MODEL



Energy Modeling Input Category	Design Team Responsibility
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2) Construction Types	
3) Building Form	Architect
4) Occupancy Types	
5) Occupancy Loads	
6) Building Systems	
7) Building System Schedules	Engineer

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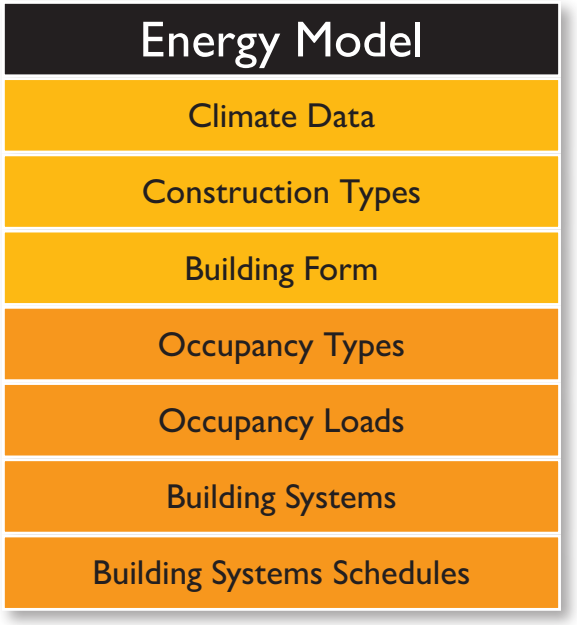

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2) Construction Types	
3) Building Form	Architect
4) Occupancy Types	
5) Occupancy Loads	
6) Building Systems	
7) Building System Schedules	Engineer

THE ANATOMY OF AN ENERGY MODEL

Intelligent Defaults

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

THE ANATOMY OF AN ENERGY MODEL

Climate Analysis

Energy Model

- Climate Data
- Construction Types
- Building Form
- Occupancy Types
- Occupancy Loads
- Building Systems
- Building Systems Schedules

THE ANATOMY OF AN ENERGY MODEL

Climate Analysis

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

Envelope Optimization

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

THE ANATOMY OF AN ENERGY MODEL

Climate Analysis

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

Envelope Optimization

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

Massing Study

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

THE ANATOMY OF AN ENERGY MODEL

Define Occupancy

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

THE ANATOMY OF AN ENERGY MODEL

Project-Specific Information

Energy Model
Climate Data
Construction Types
Building Form
Occupancy Types
Occupancy Loads
Building Systems
Building Systems Schedules

Envelope Optimization

Energy Model
Climate Data
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Building Form
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THE ANATOMY OF AN ENERGY MODEL

Project-Specific Information

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Climate Data
Construction Types
Building Form
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Envelope Optimization

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Climate Data
Construction Types
Building Form
Occupancy Types
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Building Systems
Building Systems Schedules

Massing + Systems Optimization

Energy Model
Climate Data
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METHODOLOGY

ESTABLISH BASELINES AND TARGETS

CLIMATE ANALYSIS + PASSIVE STRATEGIES

ENVELOPE OPTIMIZATION

ORIENTATION / MASSING / GLAZING

SYSTEMS OPTIMIZATION

METHODOLOGY

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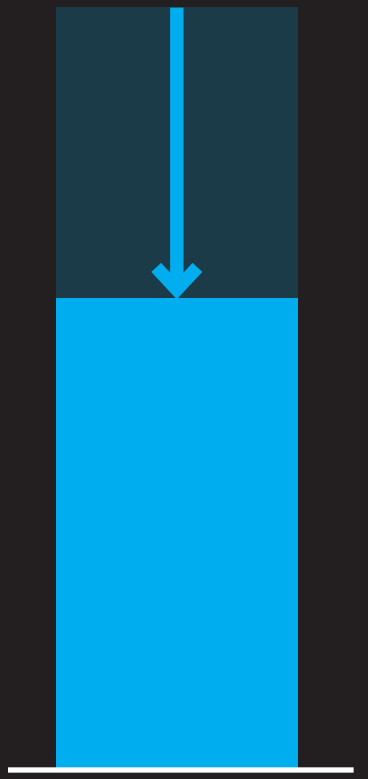

ENERGY USE

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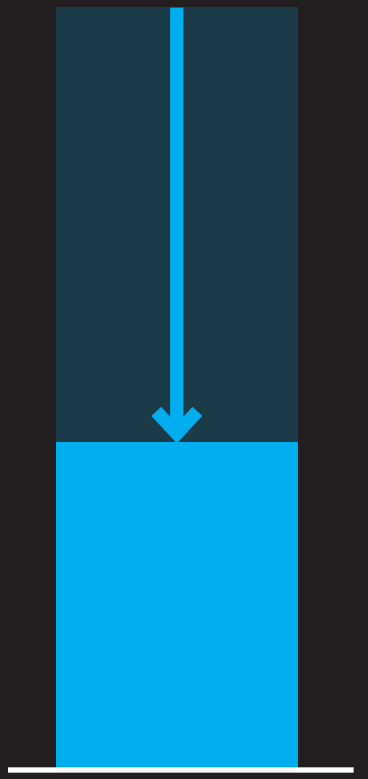

ENERGY USE

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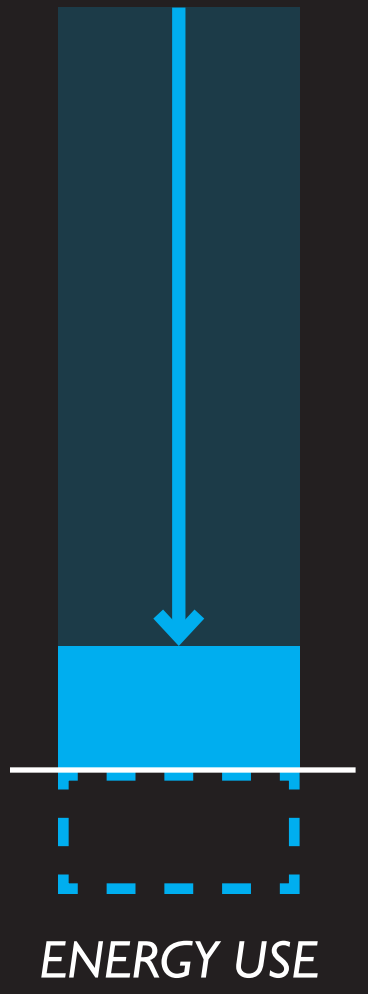

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ENERGY USE

ESTABLISH BASELINES AND TARGETS

- Establish a baseline to track energy saving strategies against
- Use an industry standard baseline to enable comparison to similar buildings in similar locations
- Facilitate reporting energy performance to LEED, AIA2030 Commitment, ect.

- **2003 CBECS Survey**
- (Commercial Buildings Energy Consumption Survey)
- Survey of US building stock in 2003 categorized by building type, size, and location

ESTABLISH BASELINES AND TARGETS

National Average Building EUI (Energy Use Intensity)

- Find your building type and associated average energy use (1 minute)

Regional Average Building EUI

- Use a website to input project type, size, and address (5 minutes)
- Use Regional Average EUI over National Average EUI whenever possible.

Target EUI

- 70% below your Regional Average Building EUI (30 seconds)

NATIONAL AVERAGE EUI

U.S. National Average Site EUI			
		Source	
Building Type	**U.S. National Average Site EUI**	2003 CBECS Average*	Other
Bank/Financial Institution	77	X	
Courthouse	118	X	
Data Center - use Target Finder to derive comparison	TF -->		
Education - College/University (campus-level)	120	X	
Education - General	76	X	
Education - K-12 School	75	X	
Food Sales - Convenience Store (w/ or w/out gas station)	241	X	
Food Sales - General	225	X	
Food Sales - Supermarket/Grocery	213	X	
Food Service - Fast Food	534	X	
Food Service - General	351	X	
Food Service - Restaurant/Cafeteria	302	X	
Health Care - Clinic	84	X	
Health Care - Hospital Inpatient	227	X	

NATIONAL AVERAGE EUI

Health Care - Medical Office	59	X	
Health Care - Nursing/Assisted Living	124	X	
Health Care - Outpatient - General	73	X	
Laboratory - recommend use of Labs21	370		Labs21
Lodging - General	87	X	
Lodging - Hotel/Motel	94	X	
Lodging - Residence Hall/Dormitory	89	X	
Mixed-Use - use Calculator tab to derive comparison	Calc -->		
Office - 10,000 sf	74	X**	
Office - 10,001 to 100,000 sf	90	X**	
Office - 100,001 sf or greater	104	X**	
Other - see FAQ #29	104	X	
Public Assembly - Entertainment/Culture	95	X	
Public Assembly - General	66	X	
Public Assembly - Library	104	X	
Public Assembly - Recreation	65	X	
Public Assembly - Social/Meeting	52	X	
Public Safety - Fire/Police Station	78	X	
Public Safety - General	90	X	
Religious Worship	46	X	
Residential - Mobile Homes	73		RECS
Residential - Multi-Family, 2 to 4 units	58		RECS
Residential - Multi-Family, 5 or more units	50		RECS
Residential - Single-Family Attached	44		RECS
Residential - Single-Family Detached	44		RECS

Residential Mid-Rise/High-Rise - see FAQ #29	Calc -->		
Retail - Mall	107	X	
Retail - Non-mall, Vehicle Dealerships, misc.	82	X	
Retail Store	72	X	
Service (vehicle repair/service, postal service)	77	X	
Storage - Distribution/Shipping Center	44	X	
Storage - General	26	X	
Storage - Non-refrigerated warehouse	31	X	
Storage - Refrigerated warehouse	127	X	
Warehouse - Self-storage	4	X	
X - none apply, provide Design Energy Code	NA		

* CBECS (Commercial Building Energy Consumption Survey) Average calculated as the arithmetic mean of reported EUIs across all survey buildings of the given type. See FAQ for more detailed explanation.
** CBECS averages weighted by square footage, within size groups.

National Average Building Energy Use

- Residential Single Family Home **44 EUI**
- Office 10,001 to 100,000 sf **90 EUI**
- Lab **370 EUI**

REGIONAL AVERAGE EUI + TARGET EUI

ZERO TOOL

- https://zerotool.org
- building address
- building type
- building size

11/14/2017 2030 Baseline

ABOUT YOUR BUILDING

Building Name: Building Name

Country: United States *

City | State/Prov.: madison * Wisconsin *

Postal Code: 53704 *

Degree Days: HDD 7369 * CDD 568 *

(•) New construction ( ) Existing Building

BUILDING USE DETAILS

In order to provide you with an appropriate comparison for your building, we need to know how spaces in this building will be used. If your building has multiple uses, add them below.

(•) Commercial ( ) Residential

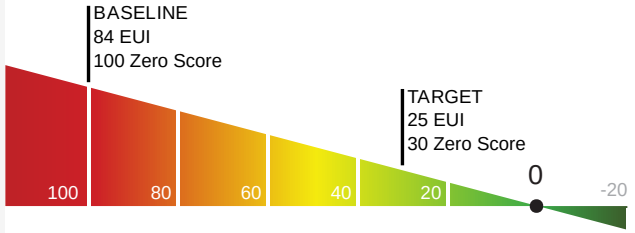
Add Another Use:

Selected Use Type(s):

Adult Education

RESULTS

Target EUI is 25 based on a 70% reduction

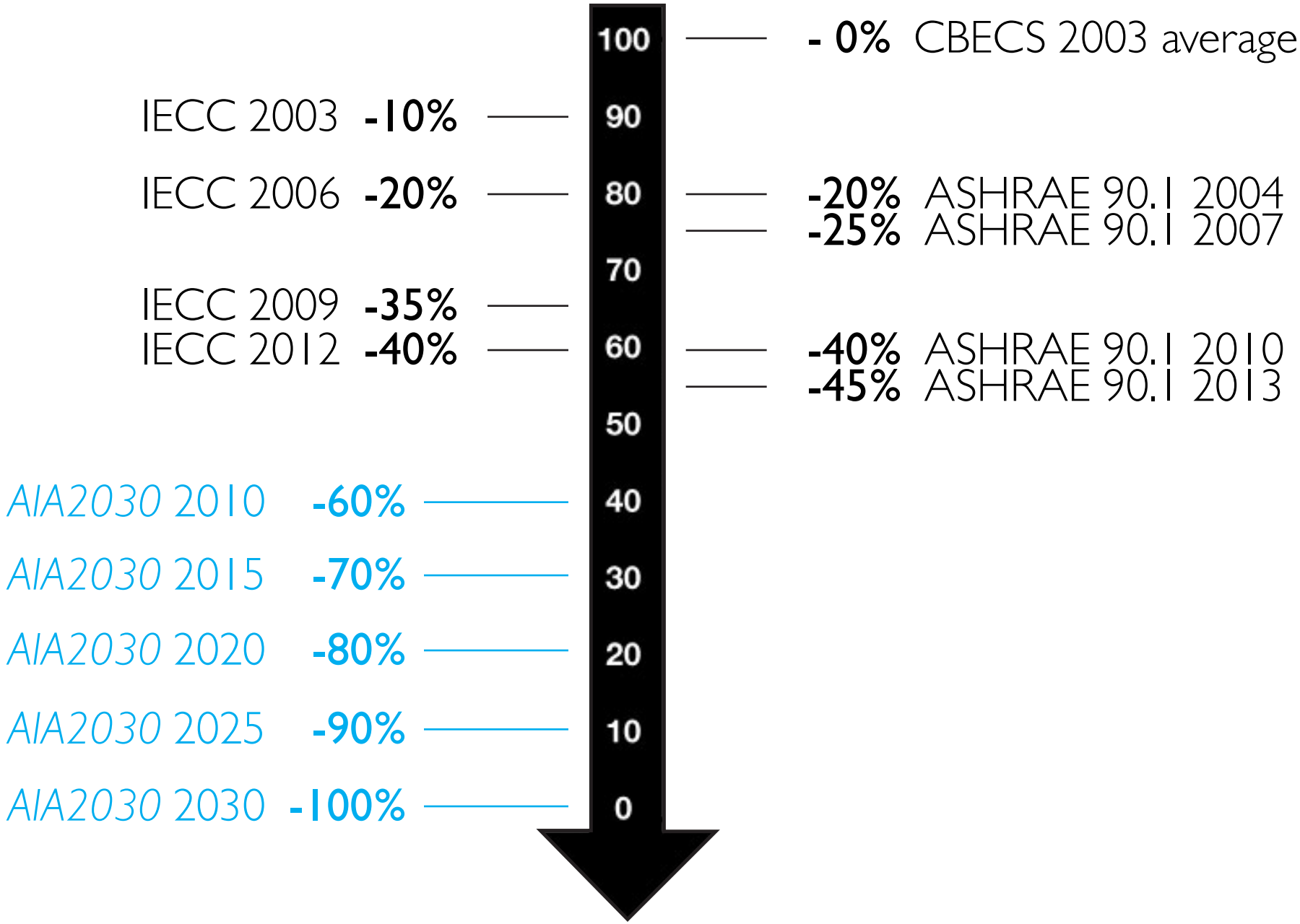


BUILDING SUMMARY

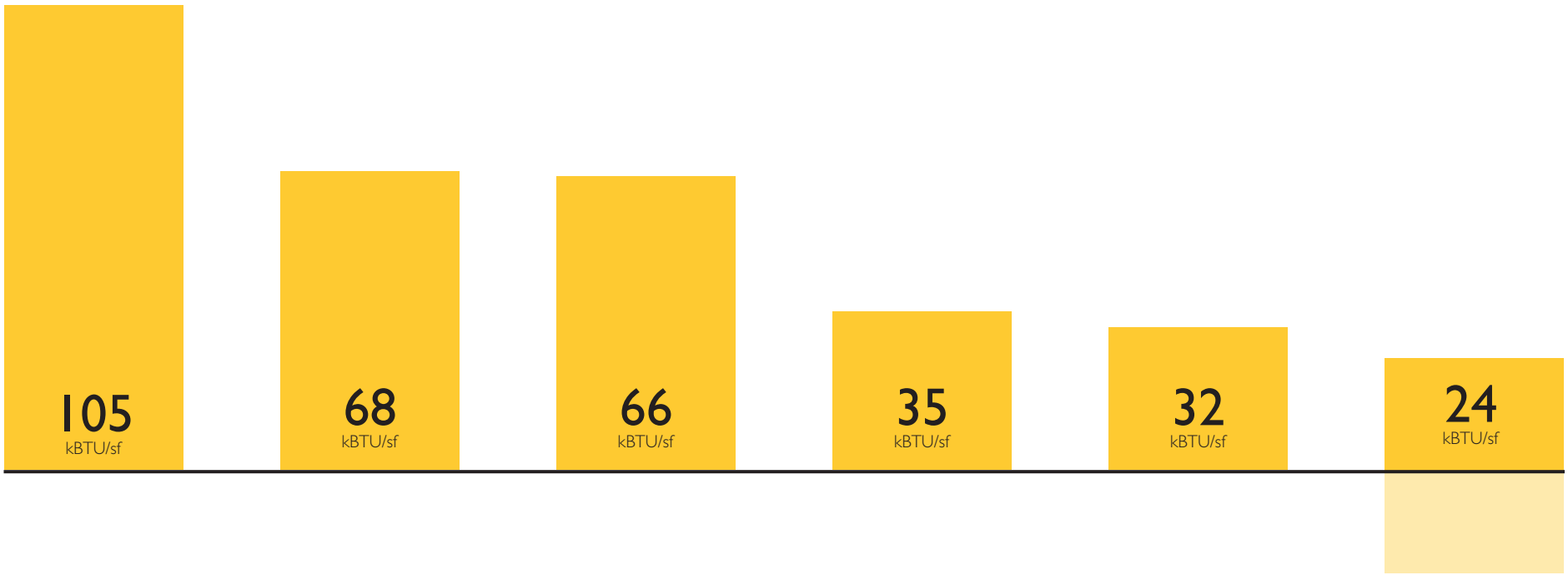
LOCATION	madison, WI	53704
USES	Adult Education	8,900 sq.ft (100.0%)

RESULTS	BASELINE	TARGET	YOUR BUILDING
EUI % Reduction from Baseline	0%	70%	N/A
Zero Score	100	30	N/A
Site EUI (kBtu/ft²/yr)	84	25	N/A
Source EUI (kBtu/ft²/yr)	142	43	N/A
Total GHG Emissions (metric tons CO_2e/yr)	77	24	N/A

ENERGY CODE BASELINE



ESTABLISH BASELINES AND TARGETS



Regional Ave Baseline
School K-12

Code Baseline (IECC 2009)
-35% from Regional Average

LEEDv3 Prereq. Min
-3% from Code Baseline

LEEDv3 Max Points
-48% from Code Baseline
EAc1 1-18 points

2030 Challenge
-70% from Regional Ave Baseline

Net-Zero Energy
Site Net Zero

METHODOLOGY

ESTABLISH BASELINES AND TARGETS

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ENERGY USE

CLIMATE ANALYSIS + PASSIVE STRATEGIES

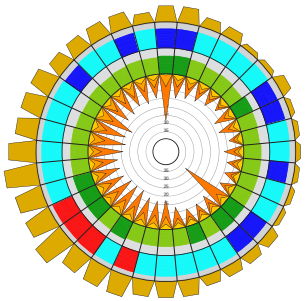
Climate Study

Location	Pittsburgh, PA
Weather File	Pittsburgh International Air Port, TMY3
Climate Type	5A - Cool Humid
Heating (HDD)	5834.6
Cooling (CDD)	2972.5

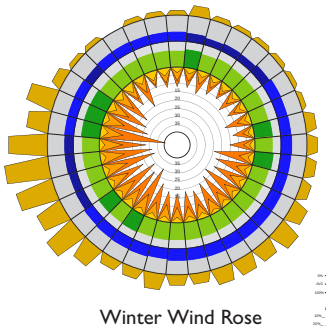
Pittsburgh lies in the humid continental climate zone as it transitions to the humid subtropical climate. The area has four distinct seasons: winters are cold, cloudy, and moderately snowy, springs and falls generally mild with moderate levels of sunshine, and summers warm to hot and humid. As measured by percent possible sunshine, summer is by far the sunniest season.

The warmest month of the year in Pittsburgh is July, with a 24-hour average of 72.6 deg F. Conditions are often humid, and combined with highs reaching 90 deg F. on average 9.5 days a year, a considerable heat index arises. Pittsburgh averages 112 days of at or below freezing temperatures, and lows of 0 deg F or below can be expected on average 2.6 nights per year.

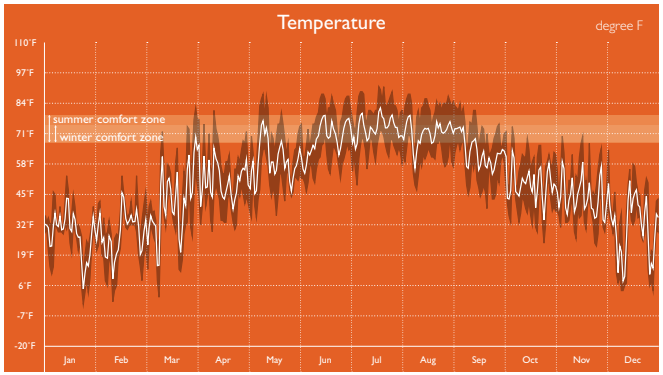
Average annual precipitation is 28.3 inches and total precipitation is greatest in May while least in October. Snowfall averages 41.4 inches per season. There is an average of 59 clear days, 103 partly cloudy days, and 203 cloudy days per year. In terms of annual percent-average possible sunshine received, Pittsburgh (455) is similar to Seattle (43%).

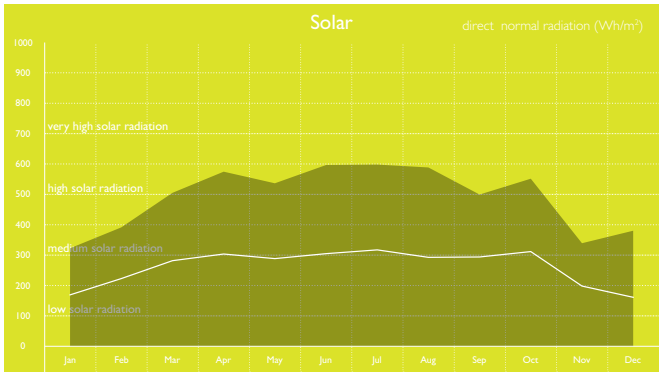


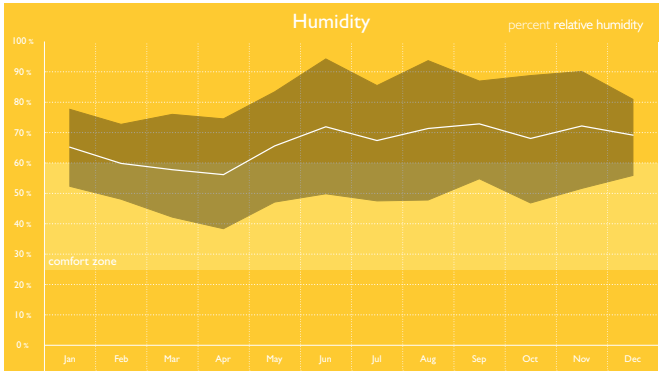
Summer Wind Rose

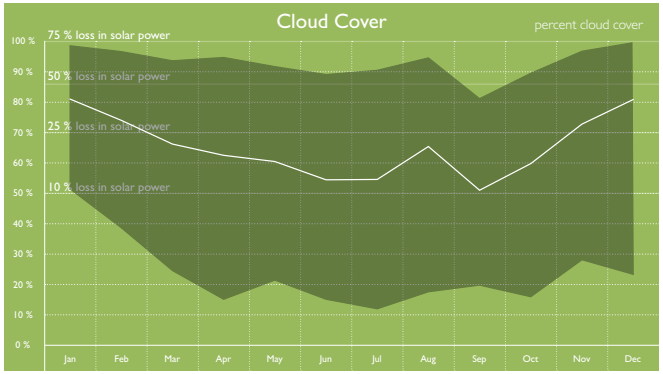


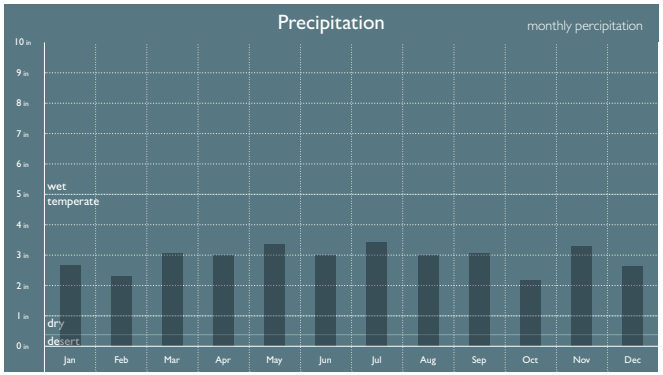
Winter Wind Rose

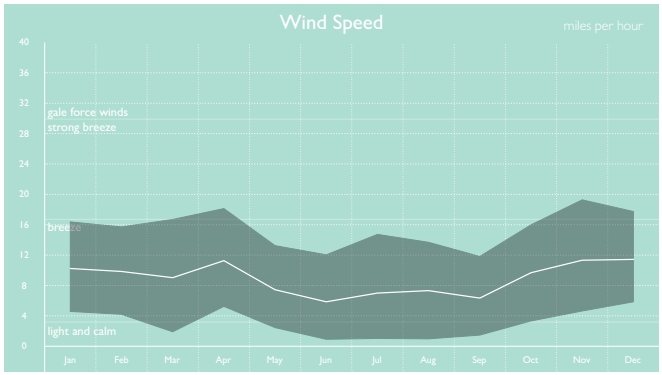




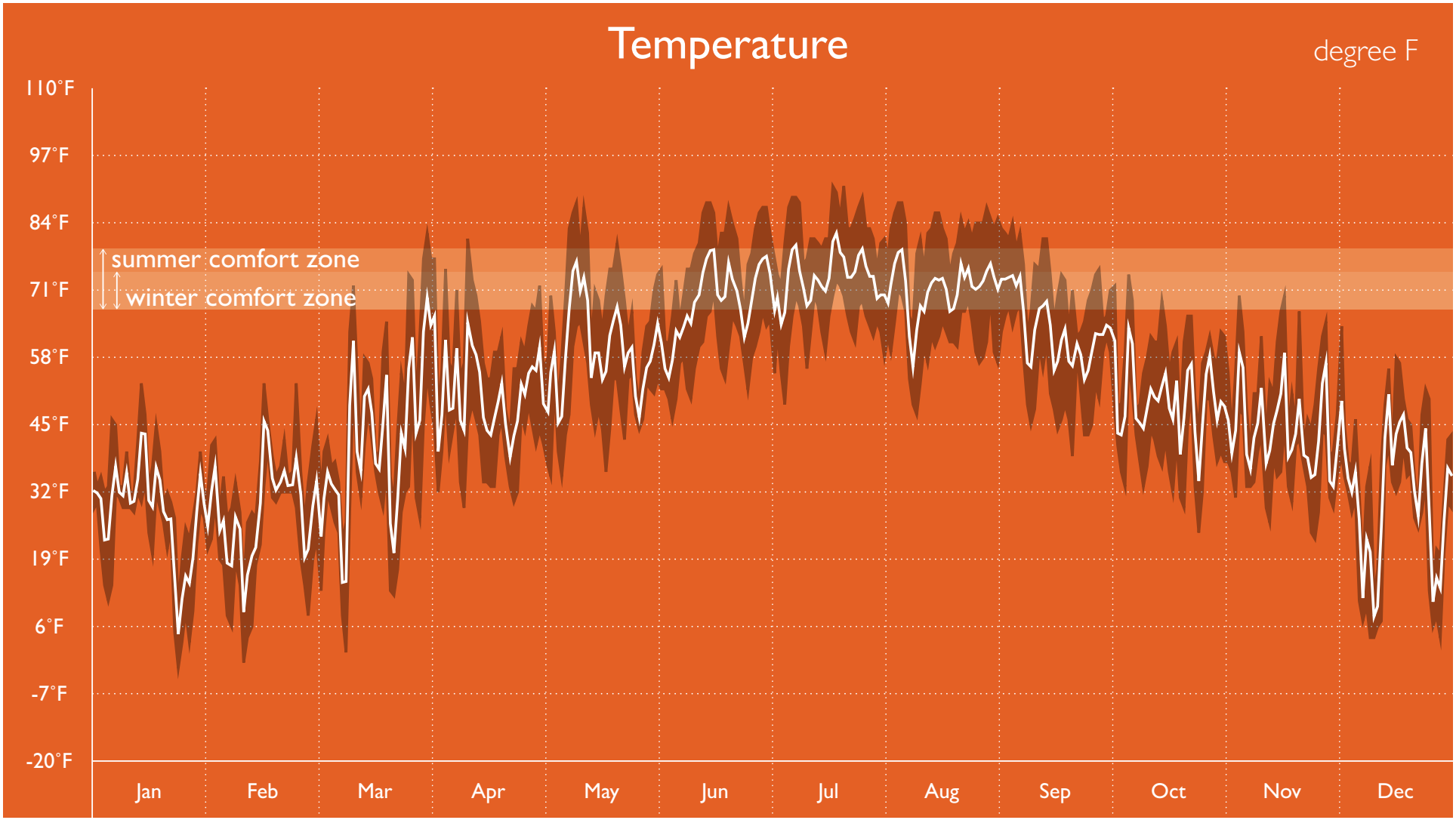








CLIMATE ANALYSIS + PASSIVE STRATEGIES



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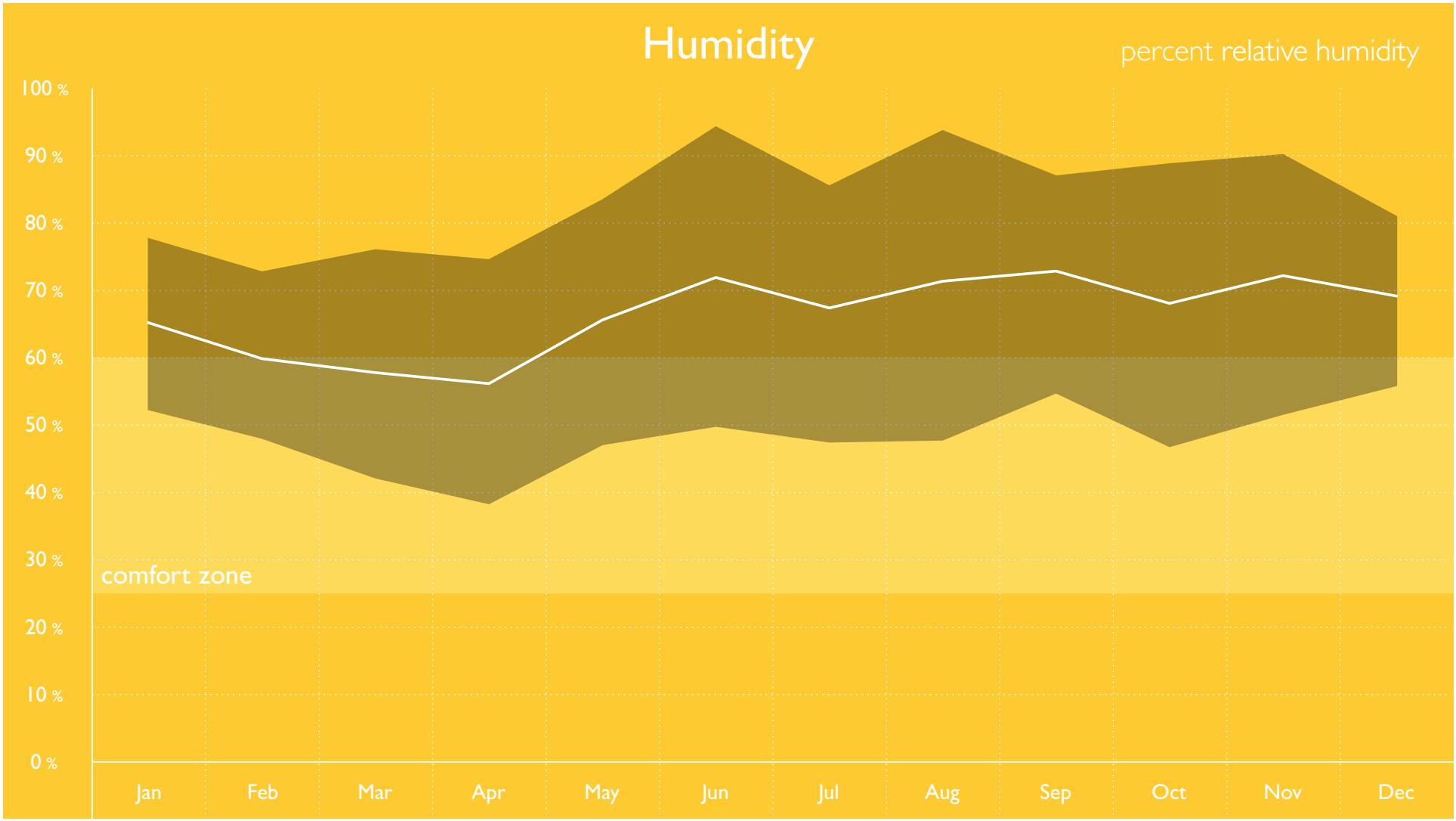
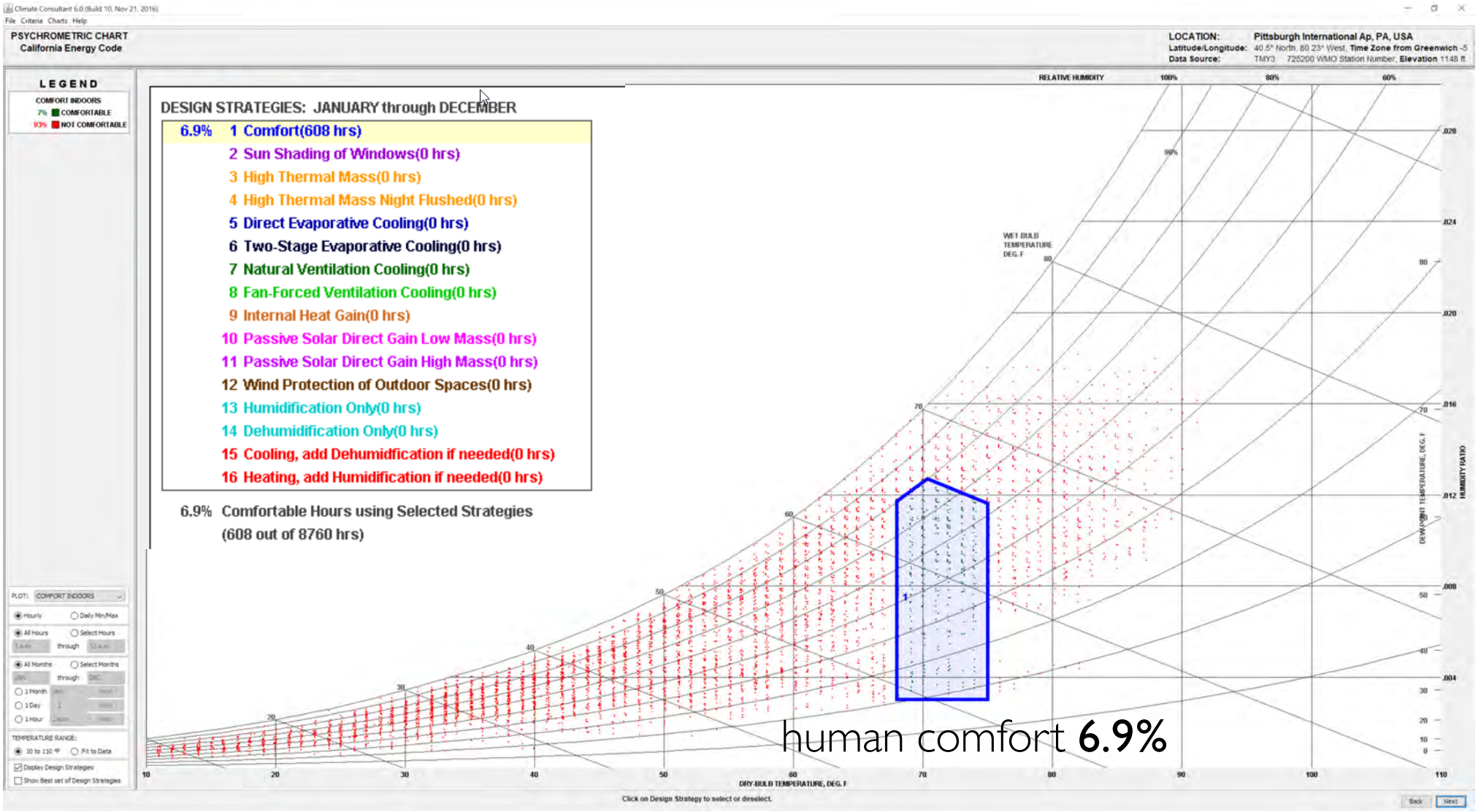


CLIMATE ANALYSIS + PASSIVE STRATEGIES

PSYCHROMETRIC CHART



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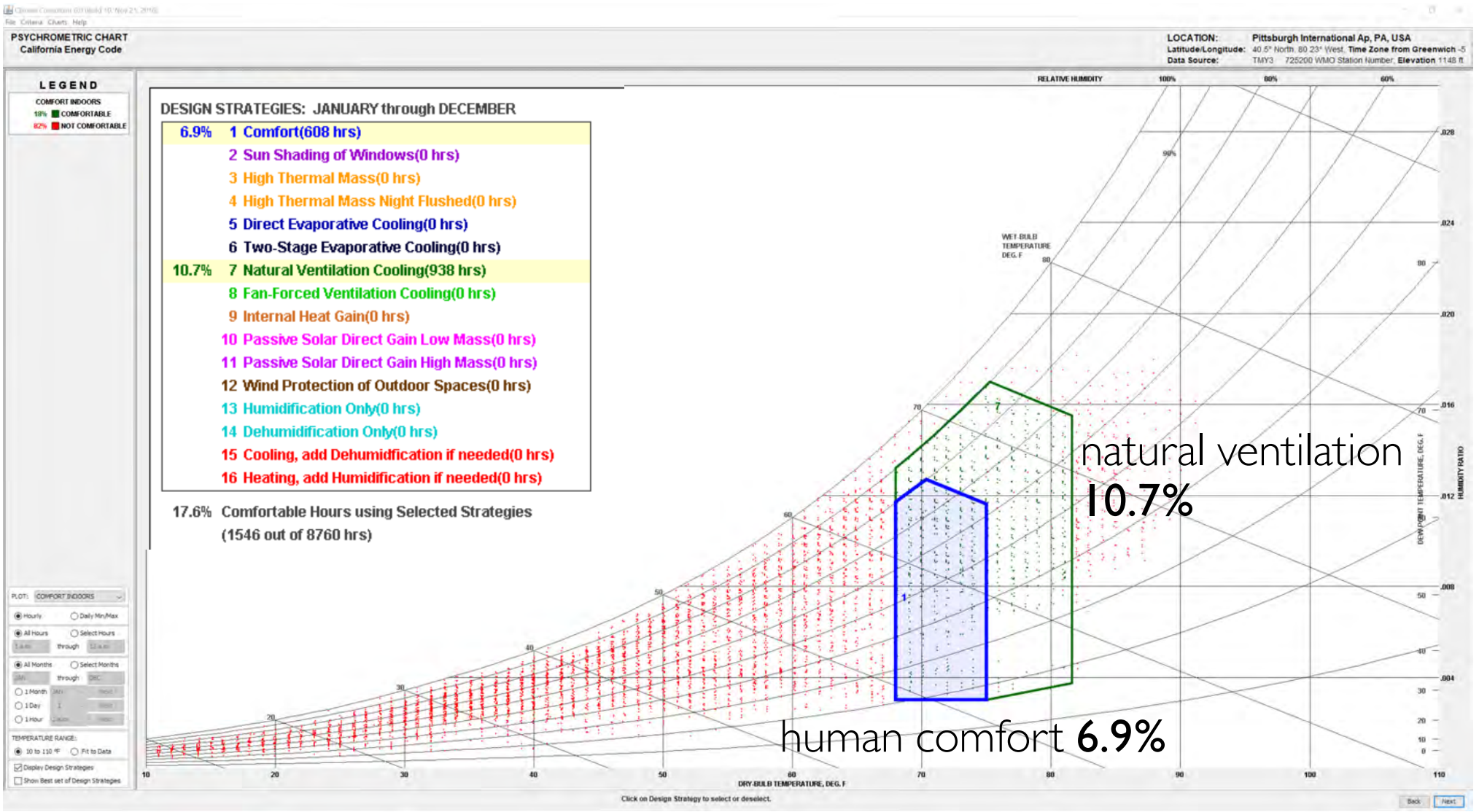

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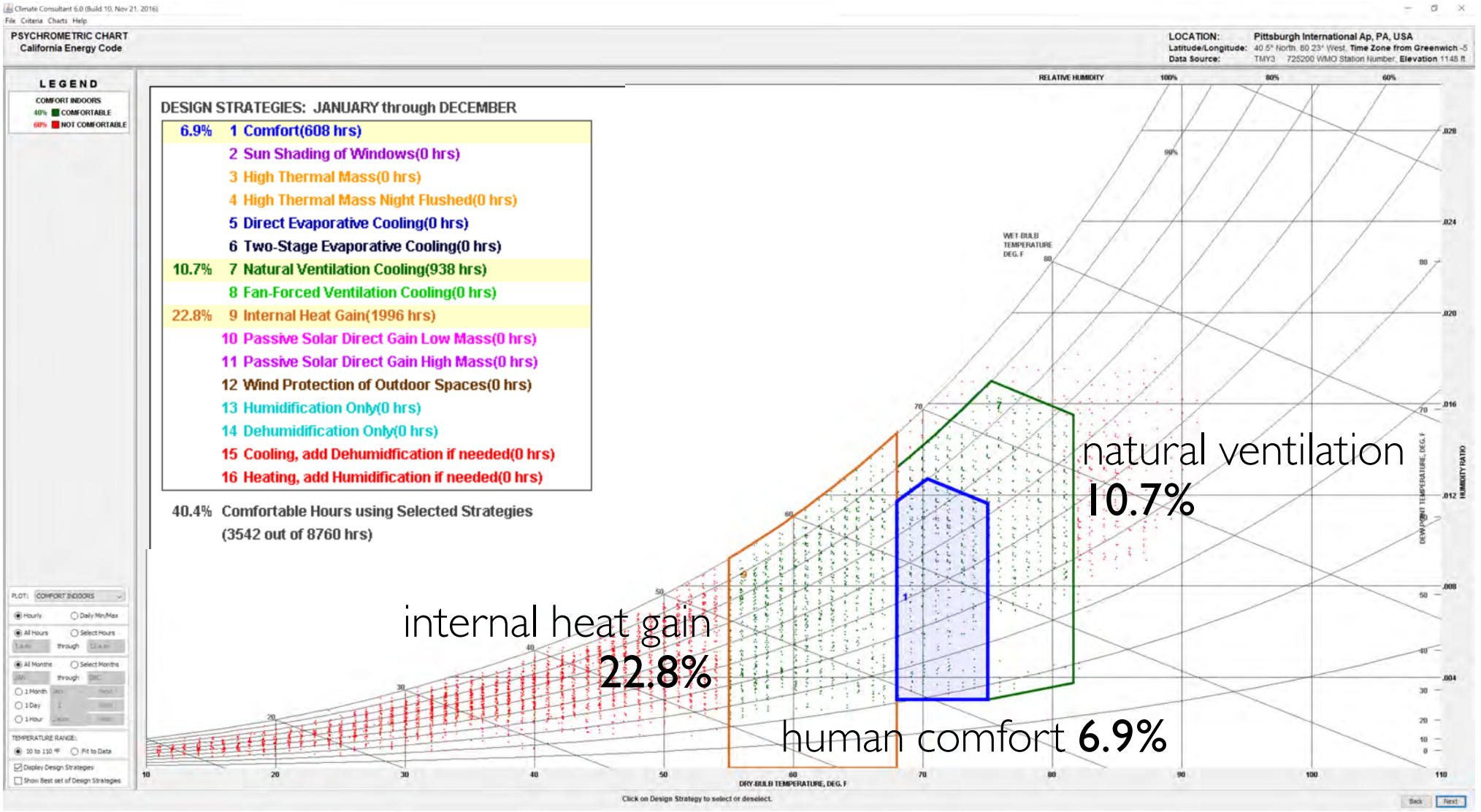

METHODOLOGY

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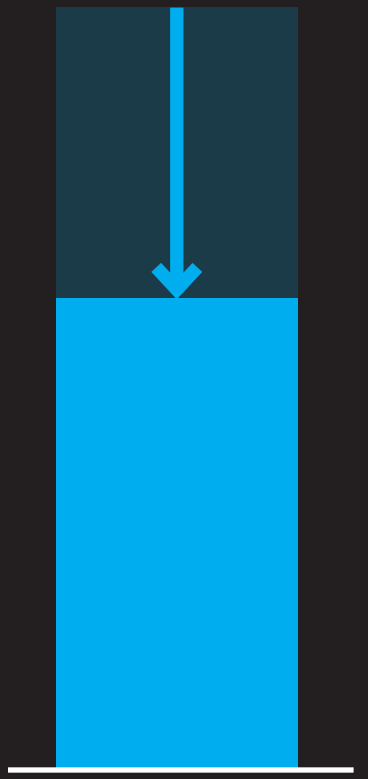


ENERGY USE

ENVELOPE OPTIMIZATION

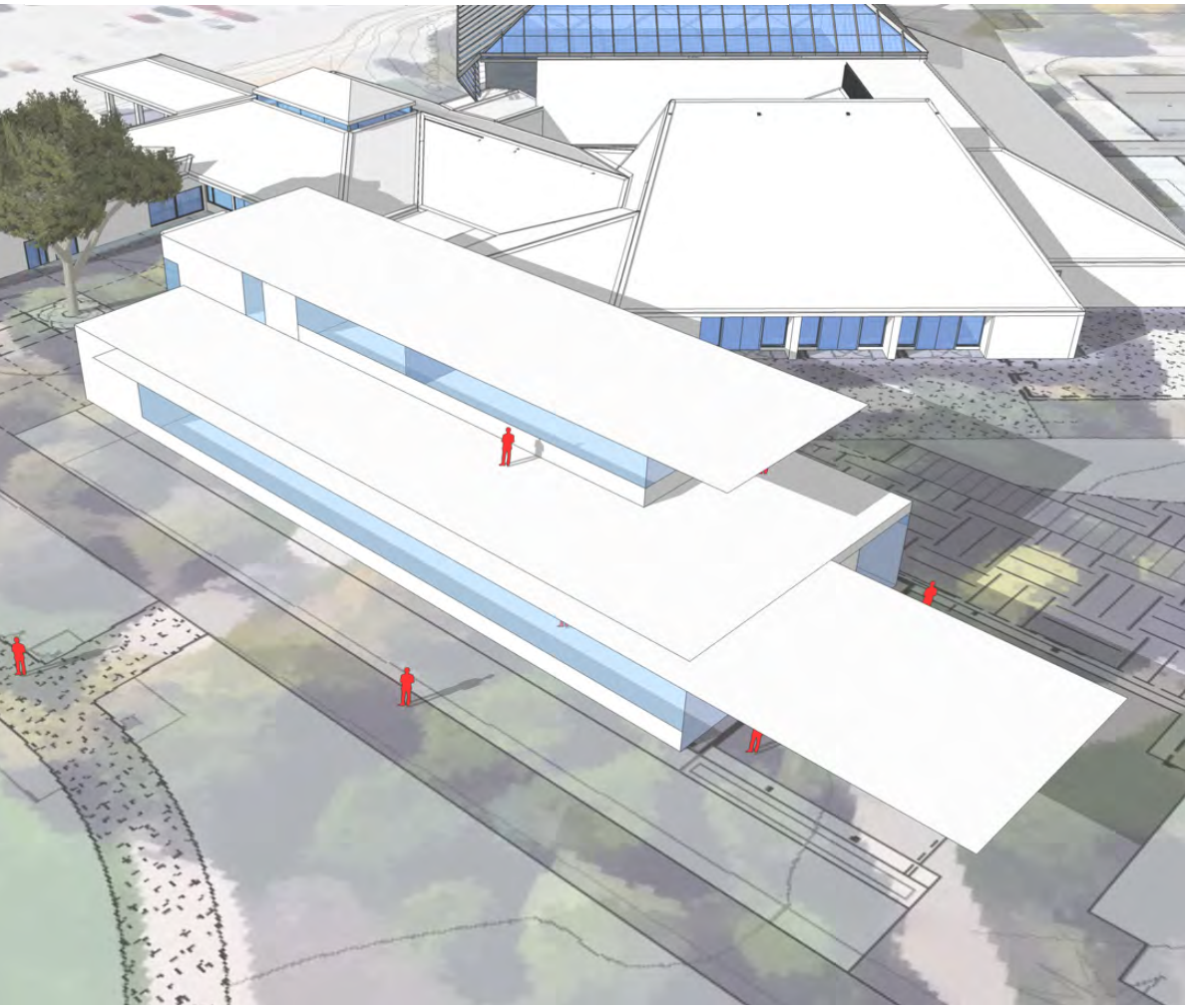
Why?

- stop guessing about how much insulation we should use
- help make early, informed decisions about envelope using a simple energy model
- bring engineering to the table as early as possible.
- facilitate simultaneous energy analysis between architects and engineers

Tools

- simple shoebox energy model required (about 12 hours)

ENVELOPE OPTIMIZATION



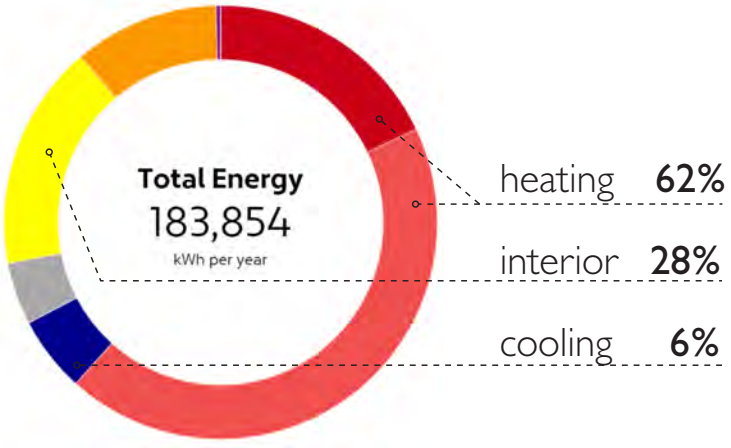
regional average baseline

105 eui

code baseline energy model

67 eui

36%



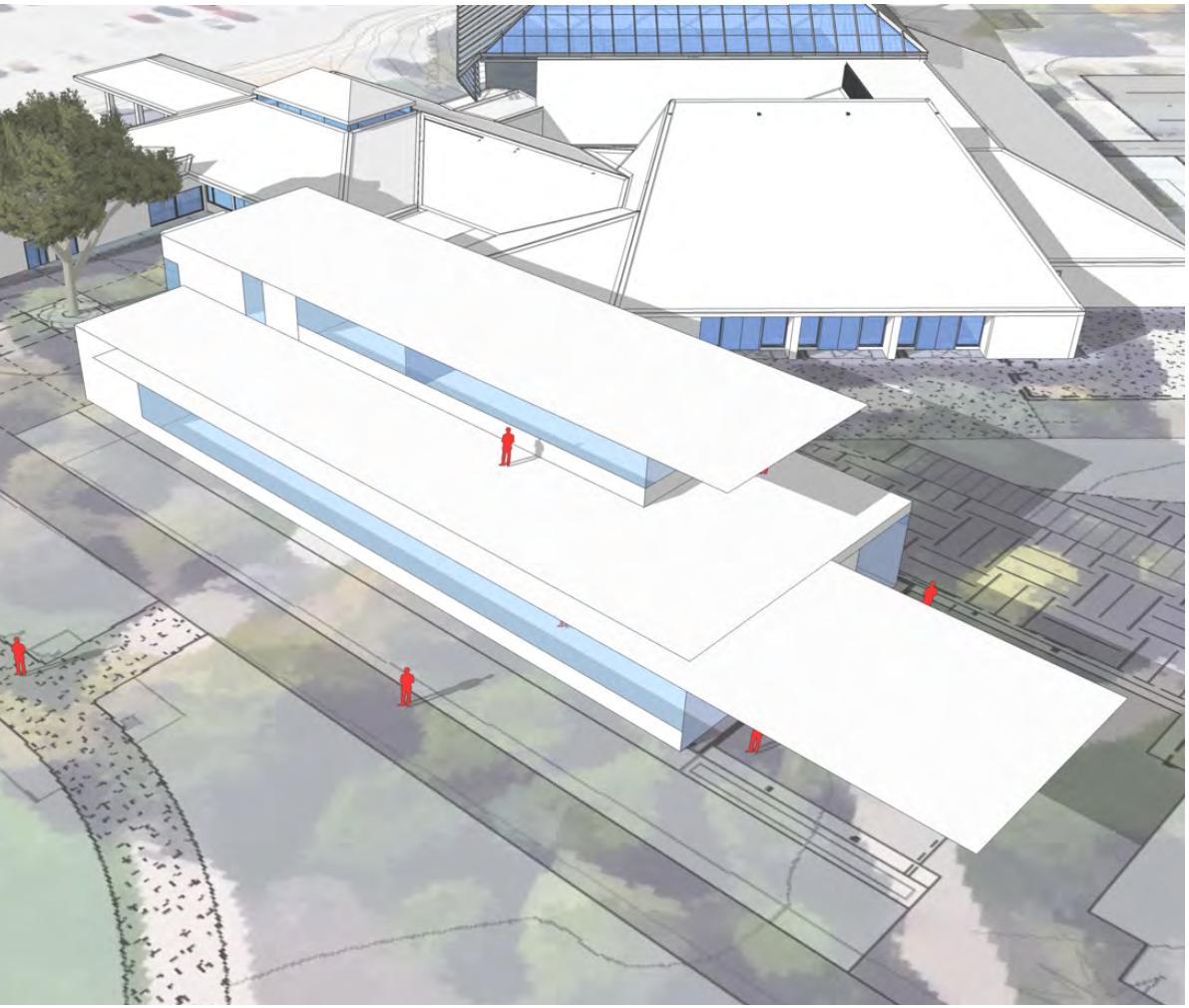
SPACE USE

occupant density (sf / per)	90
equipment power density (W/sf)	0.9
lighting power density (W/sf)	1.4
outside air rate / person (cfm/per)	21.2
outside air rate / unit area (cfm/sf)	0

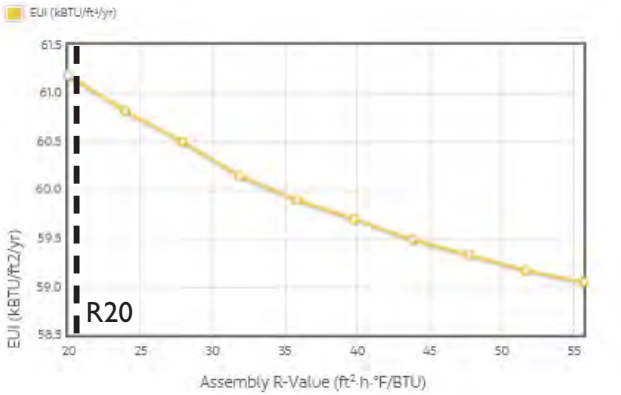
ENVELOPE

window to wall ratio	40%
wall (r value)	20
roof (r value)	20
slab (r value)	12.5
glazing (uvalue)	0.45
glazing (shgc)	0.3
infiltration (cfm/sf)	0.394

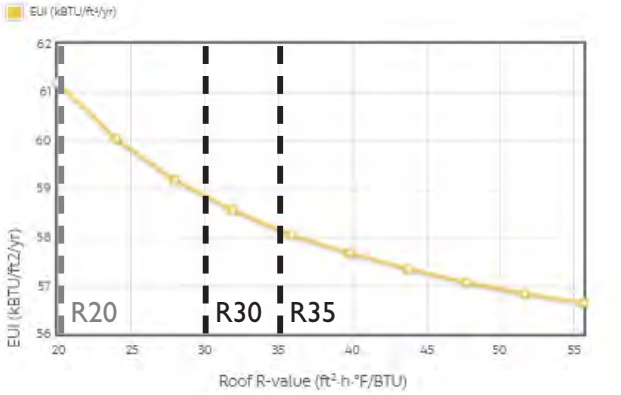
ENVELOPE OPTIMIZATION



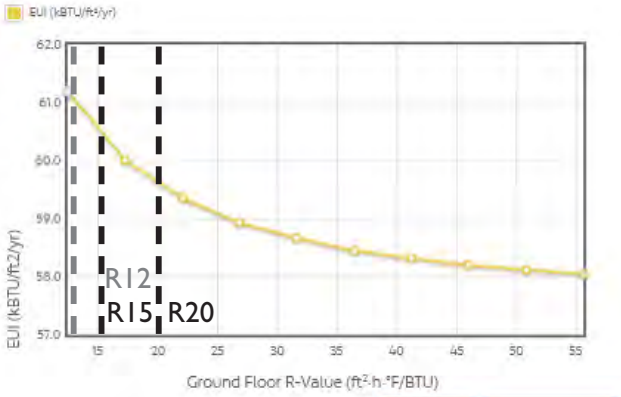
wall r value 0%



roof r value 4%



slab r value 2%



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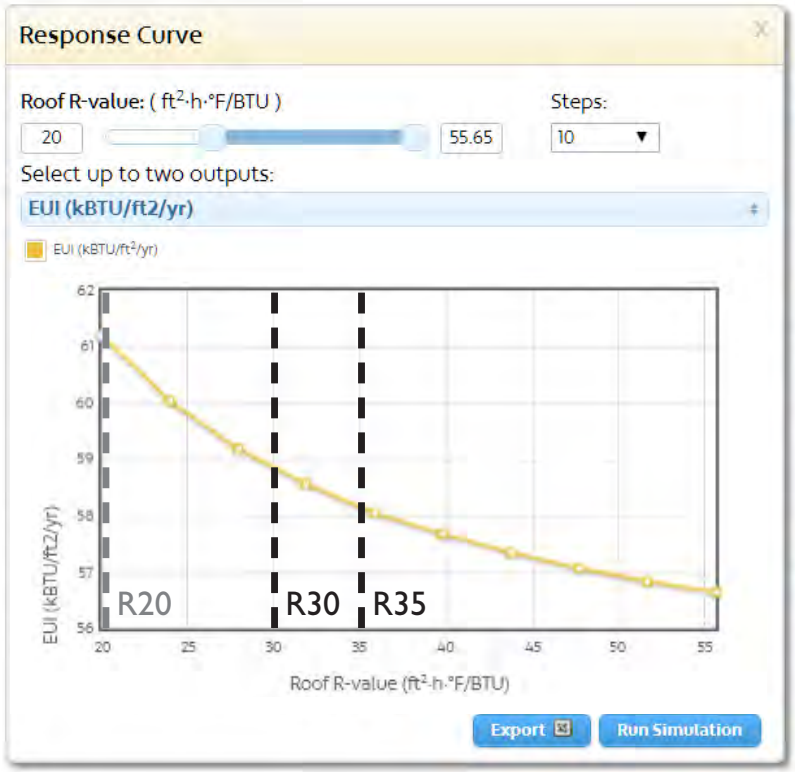
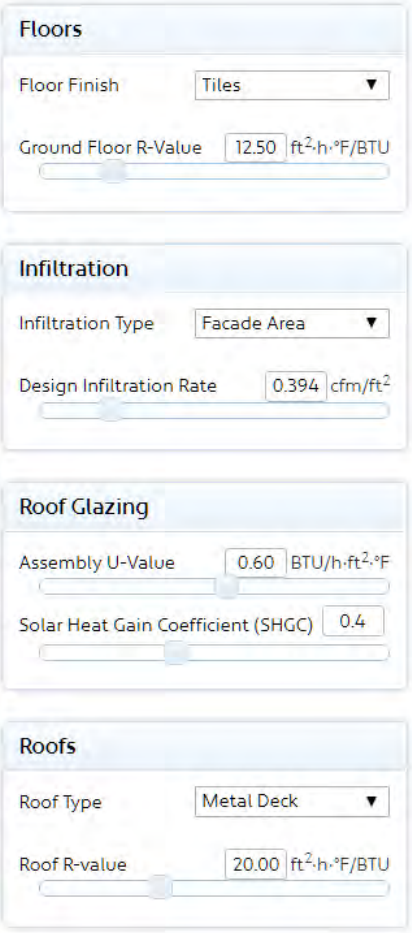
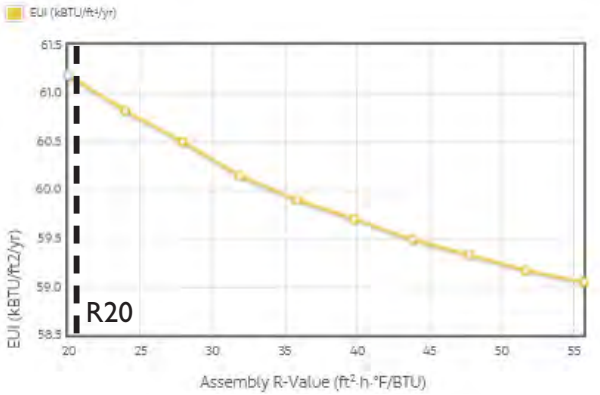
glazing (uvalue)	0.45
glazing (shgc)	0.3
infiltration (cfm/sf)	0.394

ENVELOPE OPTIMIZATION

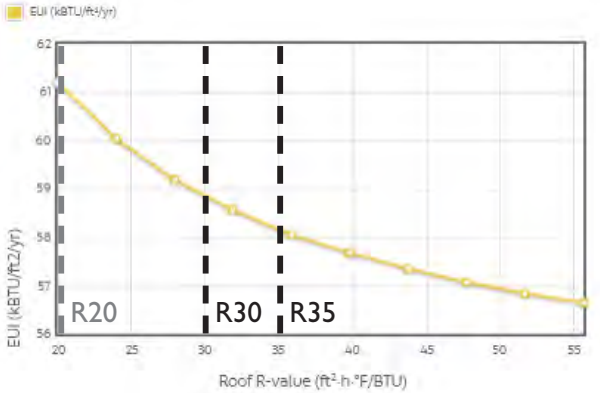




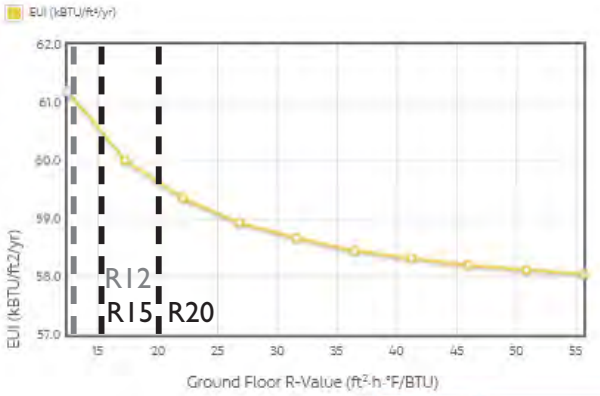
wall r value *0%*



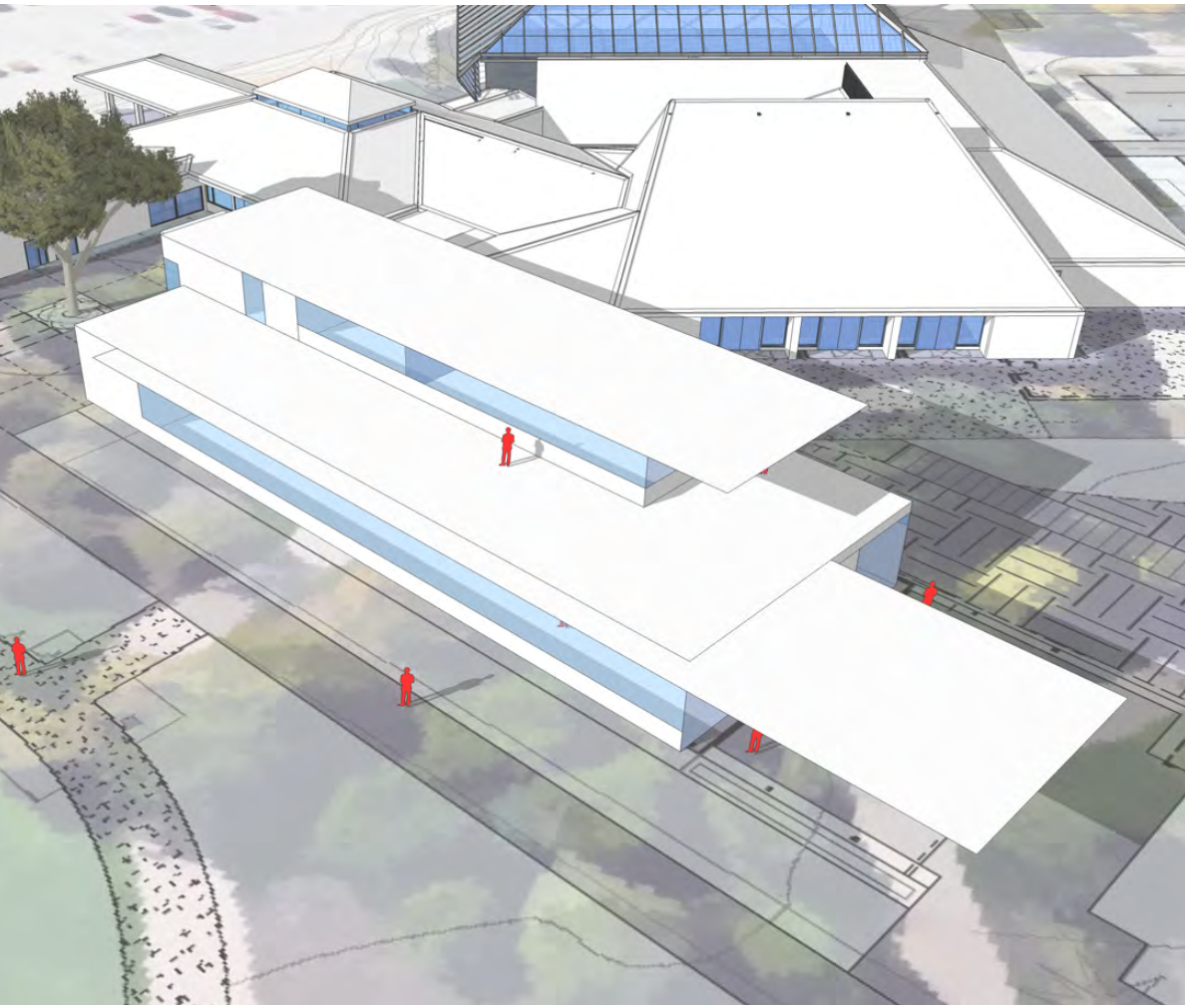
roof r value *4%*



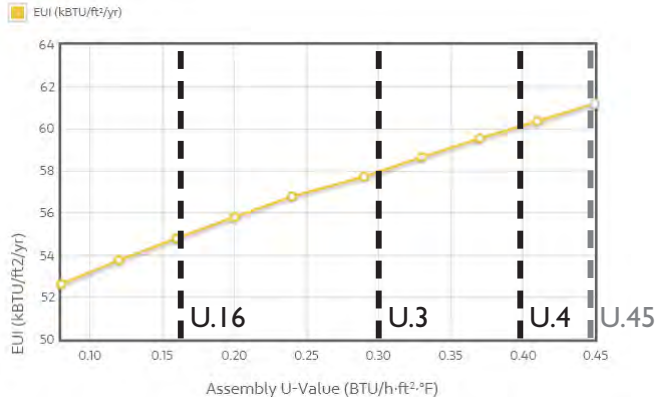
slab r value *2%*



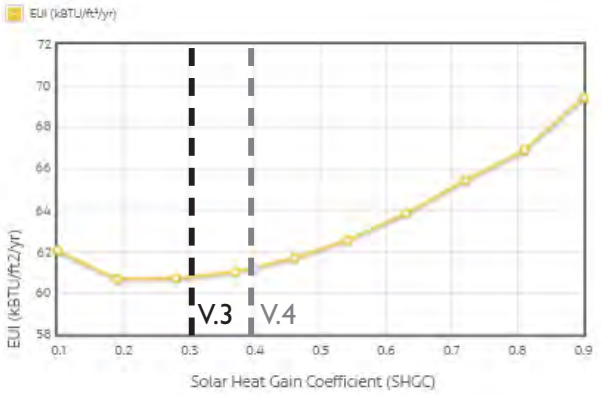
ENVELOPE OPTIMIZATION



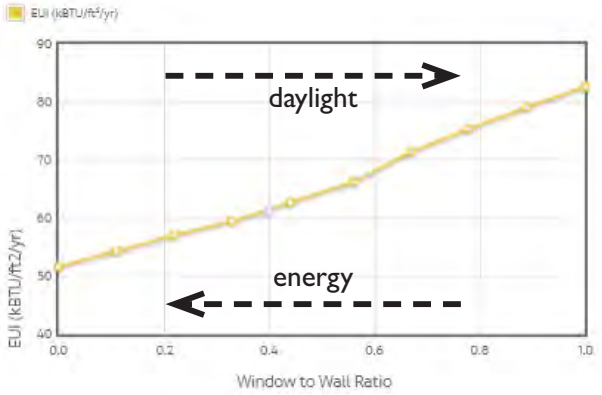
glazing u value *10%*



glazing shgc value *0%*



glazing window to wall ratio



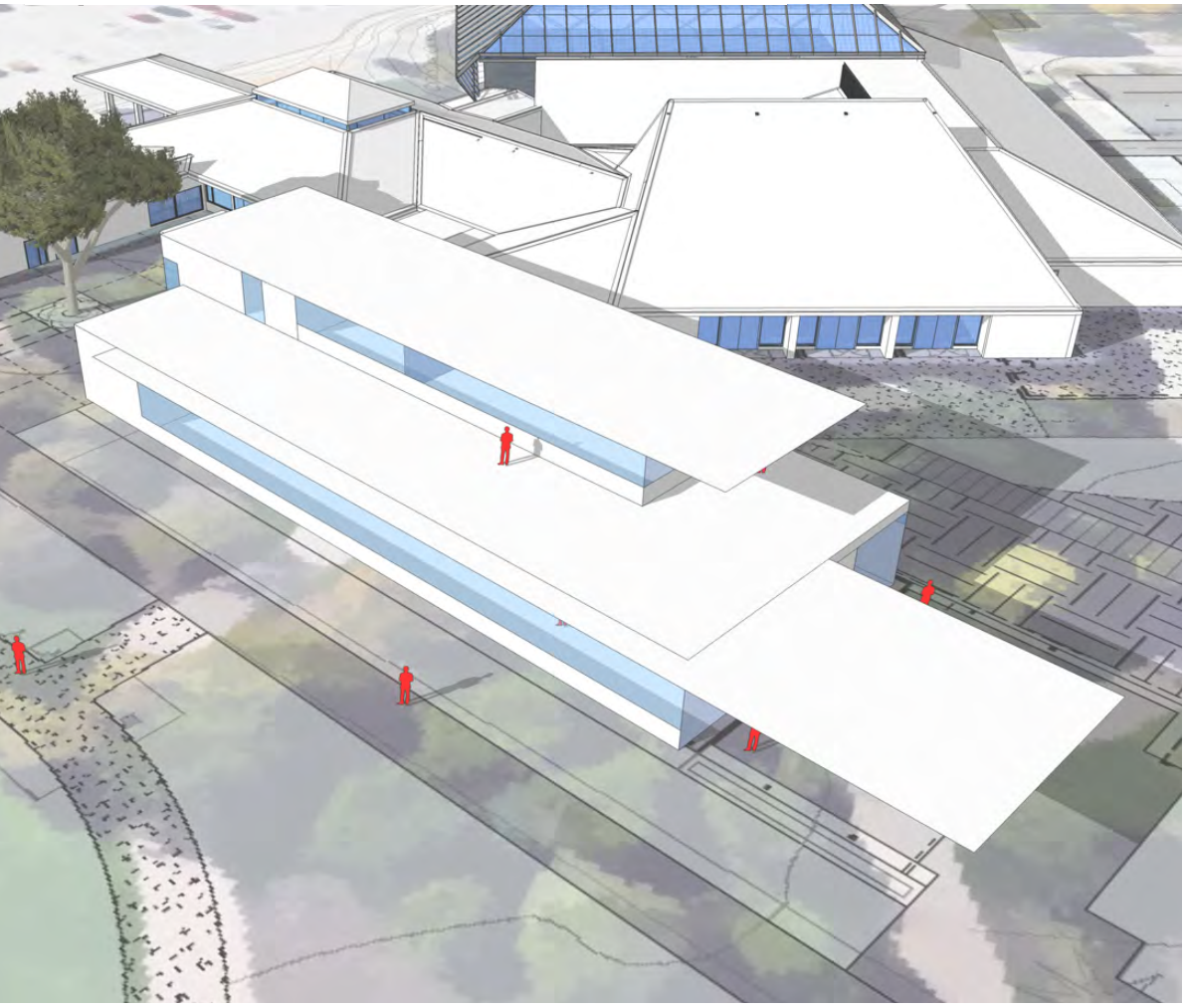
SPACE USE

occupant density (sf / per)	90
equipment power density (W/sf)	0.9
lighting power density (W/sf)	1.4
outside air rate / person (cfm/per)	21.2
outside air rate / unit area (cfm/sf)	0

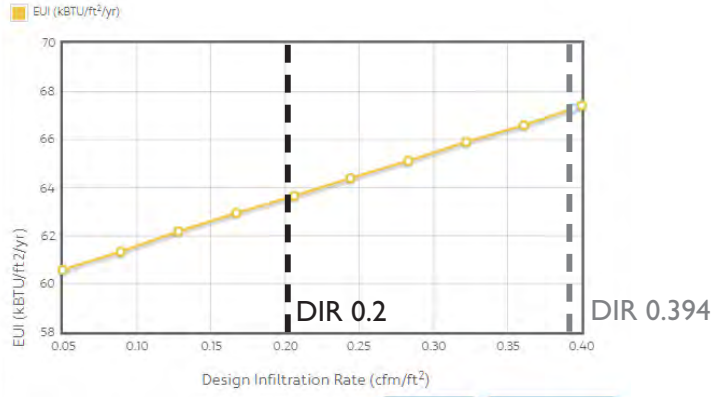
ENVELOPE

window to wall ratio	40%
wall (r value)	20
roof (r value)	20
slab (r value)	12.5
glazing (uvalue)	0.45
glazing (shgc)	0.3
infiltration (cfm/sf)	0.394

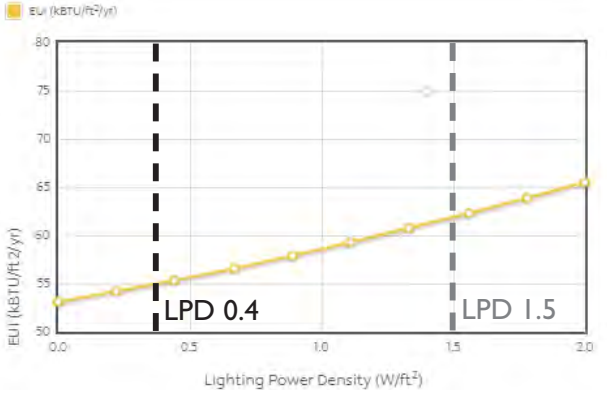
ENVELOPE OPTIMIZATION



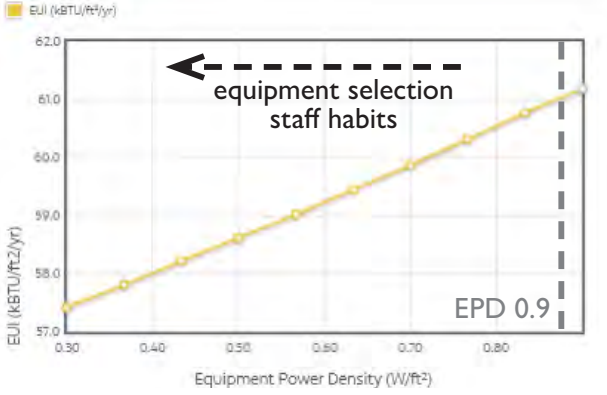
infiltration envelope tightness 5%



lighting power density 5%



equipment power density



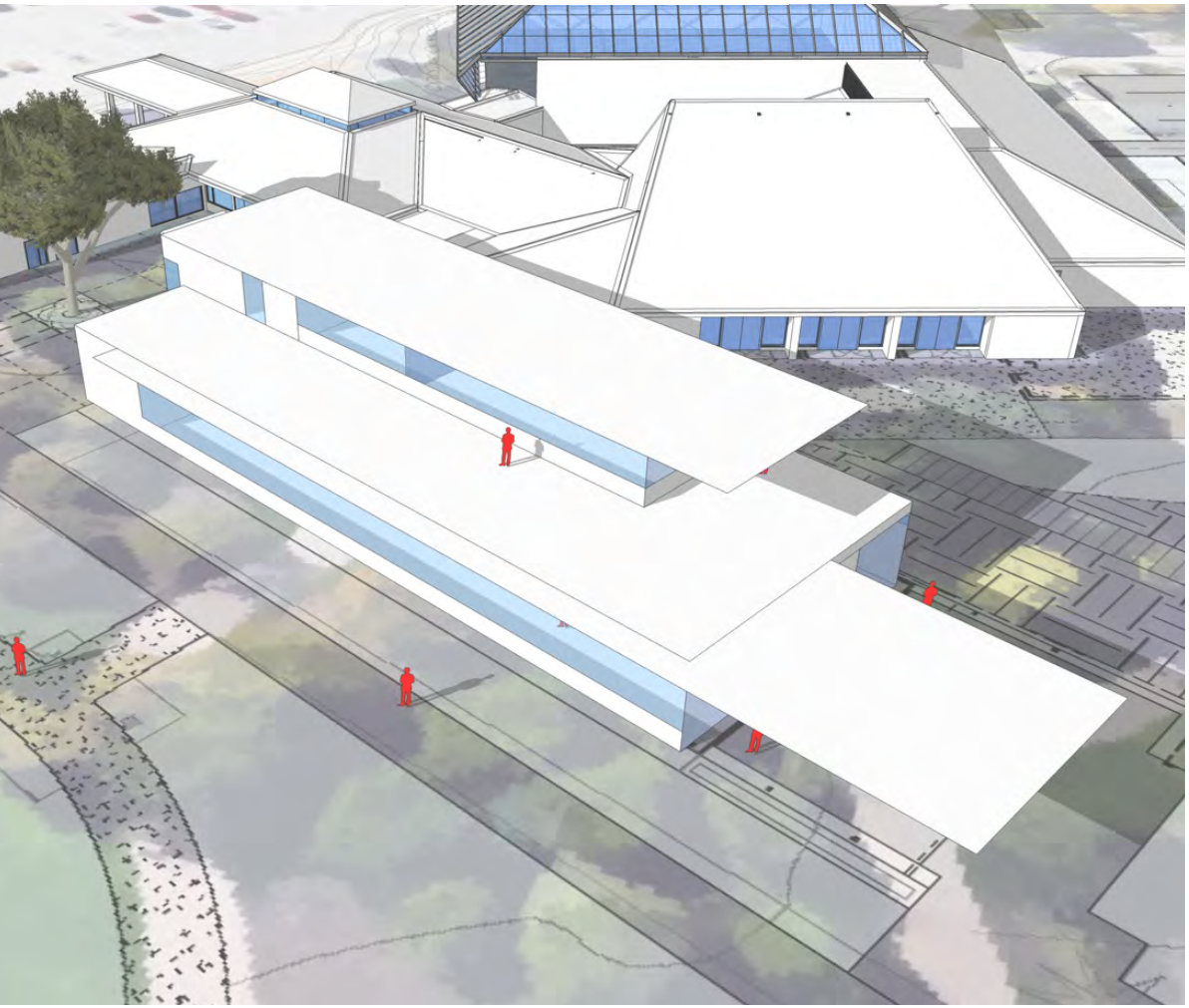
SPACE USE

occupant density (sf / per)	90
equipment power density (W/sf)	0.9
lighting power density (W/sf)	1.4
outside air rate / person (cfm/per)	21.2
outside air rate / unit area (cfm/sf)	0

ENVELOPE

window to wall ratio	40%
wall (r value)	20
roof (r value)	20
slab (r value)	12.5
glazing (uvalue)	0.45
glazing (shgc)	0.3
infiltration (cfm/sf)	0.394

ENVELOPE OPTIMIZATION



SPACE USE

occupant density (sf / per)	90
equipment power density (W/sf)	0.9
lighting power density (W/sf)	1.4
outside air rate / person (cfm/per)	21.2
outside air rate / unit area (cfm/sf)	0

ENVELOPE

window to wall ratio	40%
wall (r value)	-
roof (r value)	-
slab (r value)	-
glazing (uvalue)	-
glazing (shgc)	0.3
infiltration (cfm/sf)	-

regional average baseline

105 eui

code baseline energy model

67 eui — 36%

better envelope 1

59 eui — 12% — 44%

glazing (u value)	0.4
roof (r value)	30
wall (r value)	20
slab (r value)	15
infiltration (cfm/sf)	0.2

better envelope 2

56 eui — 16% — 46%

glazing (u value)	0.3
roof (r value)	35
wall (r value)	20
slab (r value)	15
infiltration (cfm/sf)	0.2

better envelope 3

52 eui — 22% — 50%

glazing (u value)	0.16
roof (r value)	35
wall (r value)	20
slab (r value)	15
infiltration (cfm/sf)	0.2

METHODOLOGY

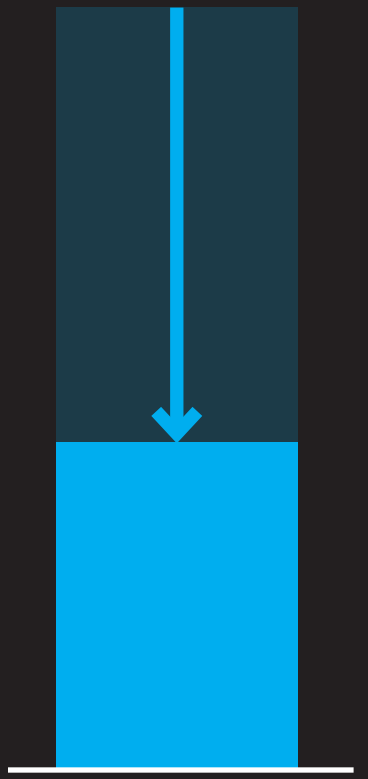
ESTABLISH BASELINES AND TARGETS

CLIMATE ANALYSIS + PASSIVE STRATEGIES

ENVELOPE OPTIMIZATION

ORIENTATION / MASSING / GLAZING

SYSTEMS OPTIMIZATION



ENERGY USE

ORIENTATION / MASSING / GLAZING

Why?

- form should respond to more than aesthetics
- form should respond to more than energy analysis
- visualize the impact of form on energy performance and respond accordingly
- design with an emphasis on daylight
- collaborate with engineers - massing / orientation / glazing choices can impact peak loads, system selection, system sizing, and system balance

Tools

- energy modeling software - time required varies widely according to your iterative process, depth of study, and graphic presentation

ORIENTATION / MASSING / GLAZING

2030 Challenge Energy Metrics

Location	Climate Zone 4
Building Type	Library
National Average EUI	104 kbtu/sf
Regional Average EUI	97 kbtu/sf

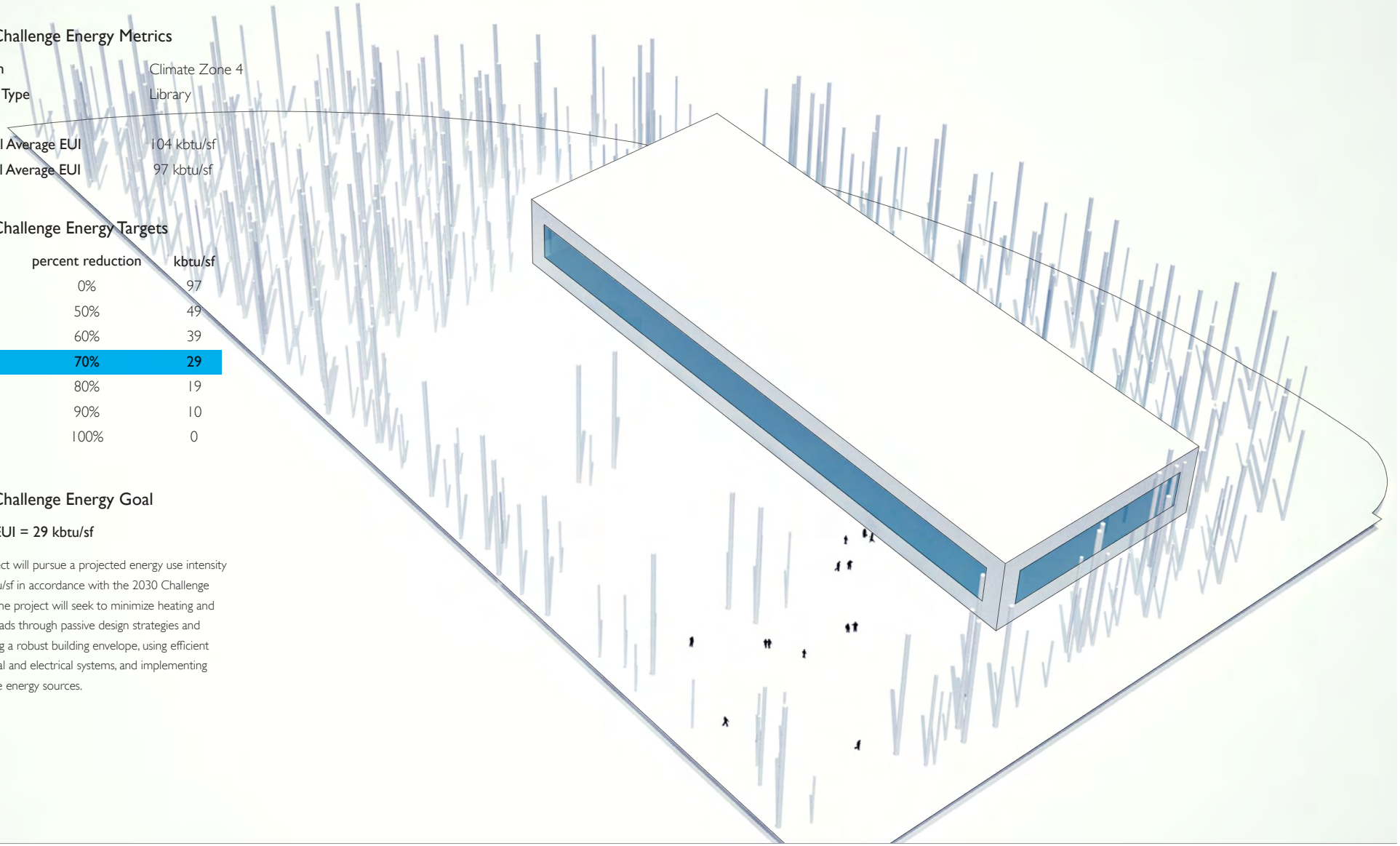
2030 Challenge Energy Targets

year	percent reduction	kbtu/sf
base	0%	97
2005	50%	49
2010	60%	39
2015	**70%**	**29**
2020	80%	19
2025	90%	10
2030	100%	0

2030 Challenge Energy Goal

Target EUI = 29 kbtu/sf

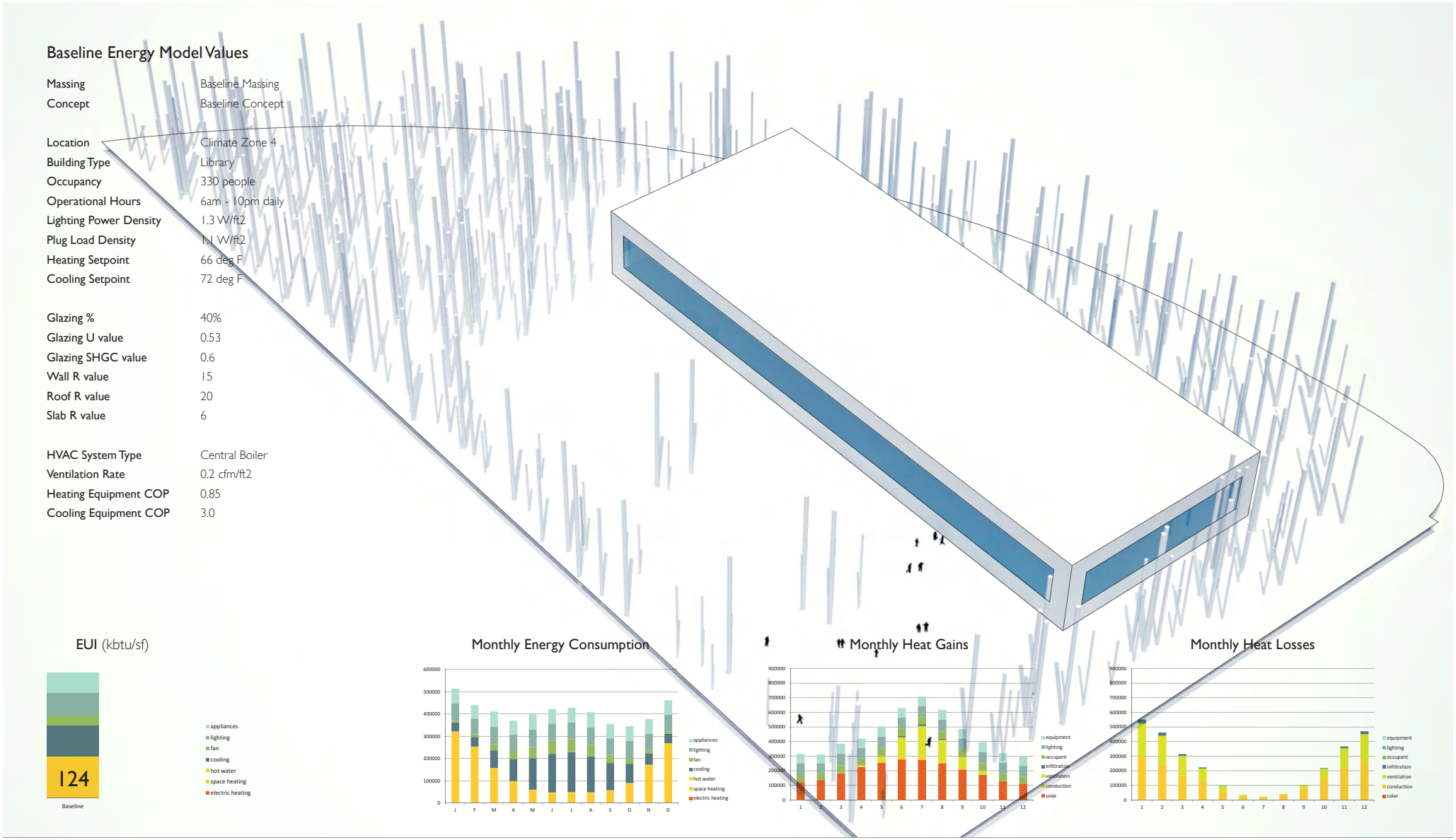
This project will pursue a projected energy use intensity of 29 kbtu/sf in accordance with the 2030 Challenge targets. The project will seek to minimize heating and cooling loads through passive design strategies and developing a robust building envelope, using efficient mechanical and electrical systems, and implementing renewable energy sources.



ORIENTATION / MASSING / GLAZING

Baseline Energy Model Values

Massing	Baseline Massing
Concept	Baseline Concept
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.53
Glazing SHGC value	0.6
Wall R value	15
Roof R value	20
Slab R value	6
HVAC System Type	Central Boiler
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	0.85
Cooling Equipment COP	3.0



EUI (kbtu/sf)

Monthly Energy Consumption

Monthly Heat Gains

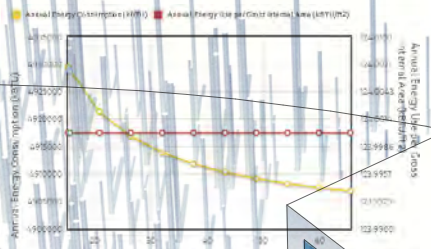
Monthly Heat Losses

ORIENTATION / MASSING / GLAZING

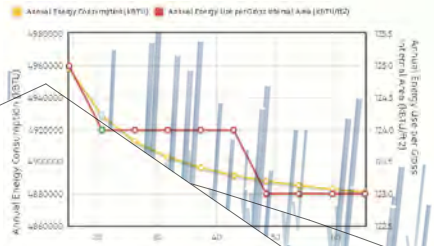
Improved Envelope + HVAC Values

Massing	Baseline Massing
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller

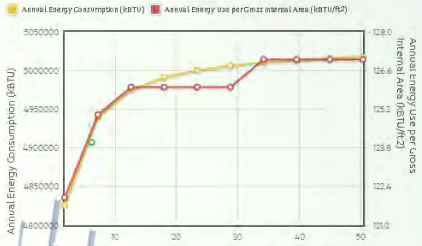
Wall R Value



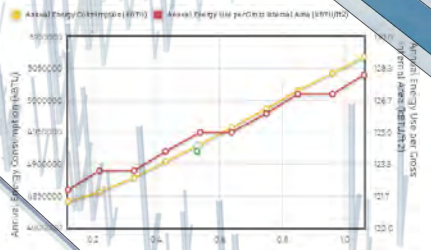
Roof R Value



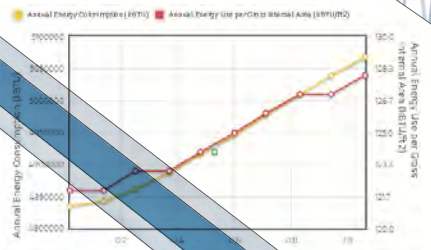
Slab R Value



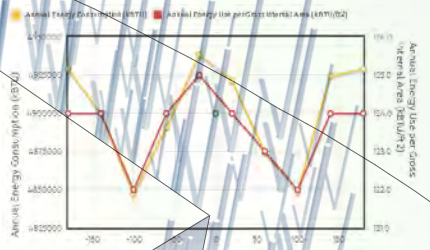
Glazing U Value

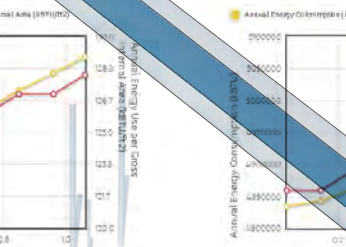


Glazing SHGC Value

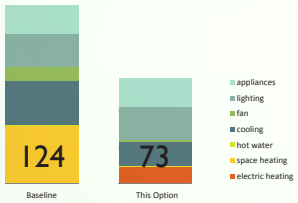


Orientation Value

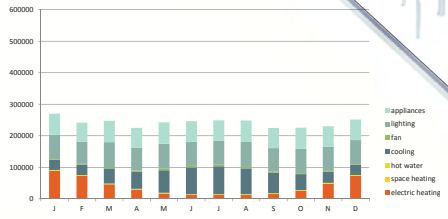




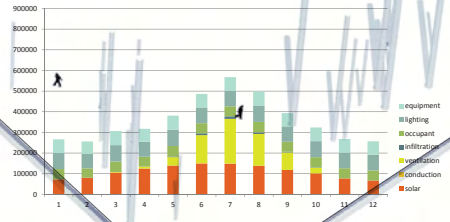
EUI (kbtu/sf)



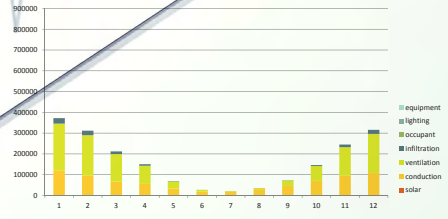
Monthly Energy Consumption



Monthly Heat Gains



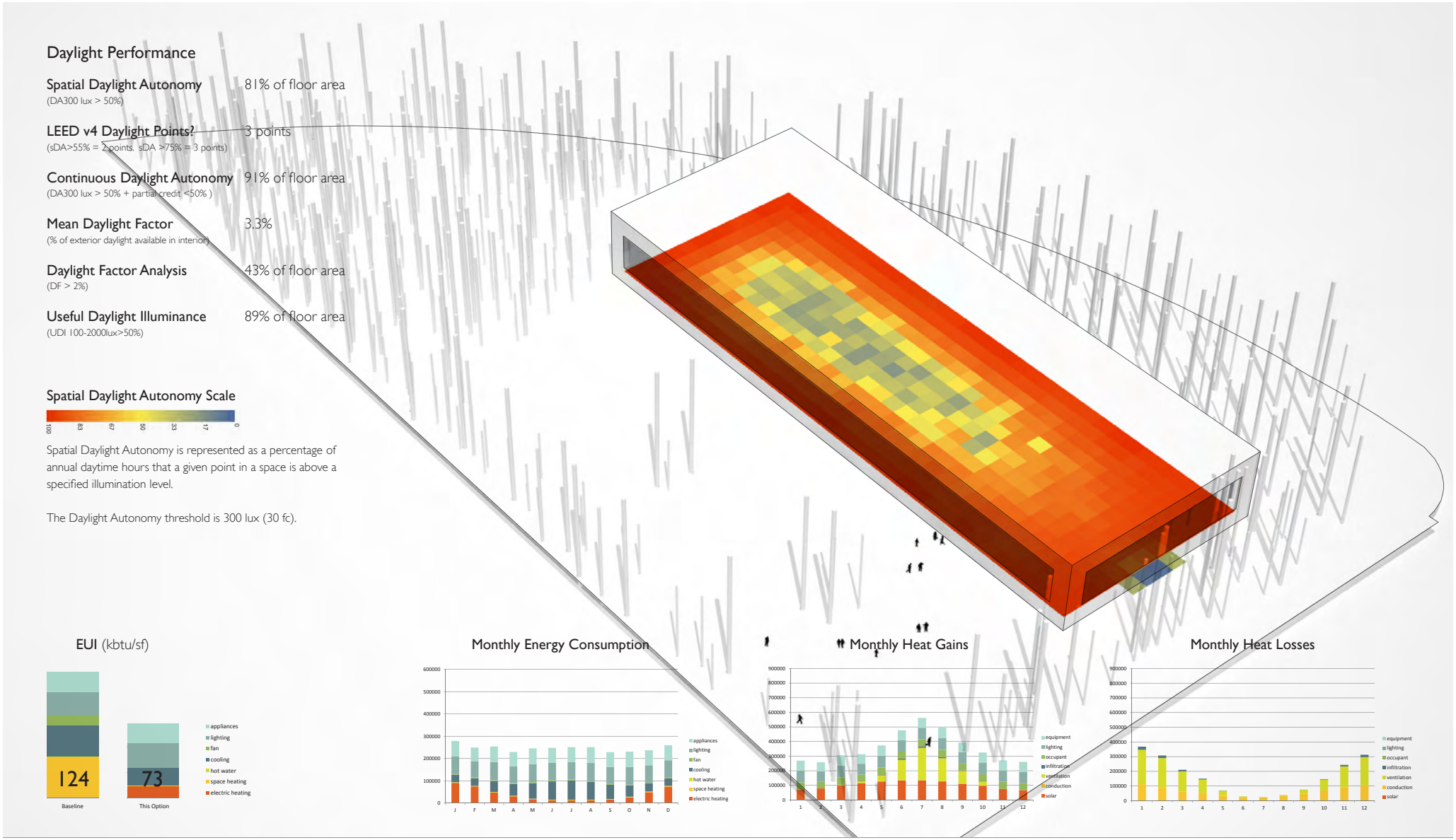
Monthly Heat Losses



ORIENTATION / MASSING / GLAZING

Daylight Performance

Spatial Daylight Autonomy (DA300 lux > 50%)	81% of floor area
LEED v4 Daylight Points? (sDA>55% = 2 points, sDA >75% = 3 points)	3 points
Continuous Daylight Autonomy (DA300 lux > 50% + partial credit <50%)	91% of floor area
Mean Daylight Factor (% of exterior daylight available in interior)	3.3%
Daylight Factor Analysis (DF > 2%)	43% of floor area
Useful Daylight Illuminance (UDI 100-2000lux>50%)	89% of floor area



Spatial Daylight Autonomy Scale

Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).

EUI (kbtu/sf)

Monthly Energy Consumption

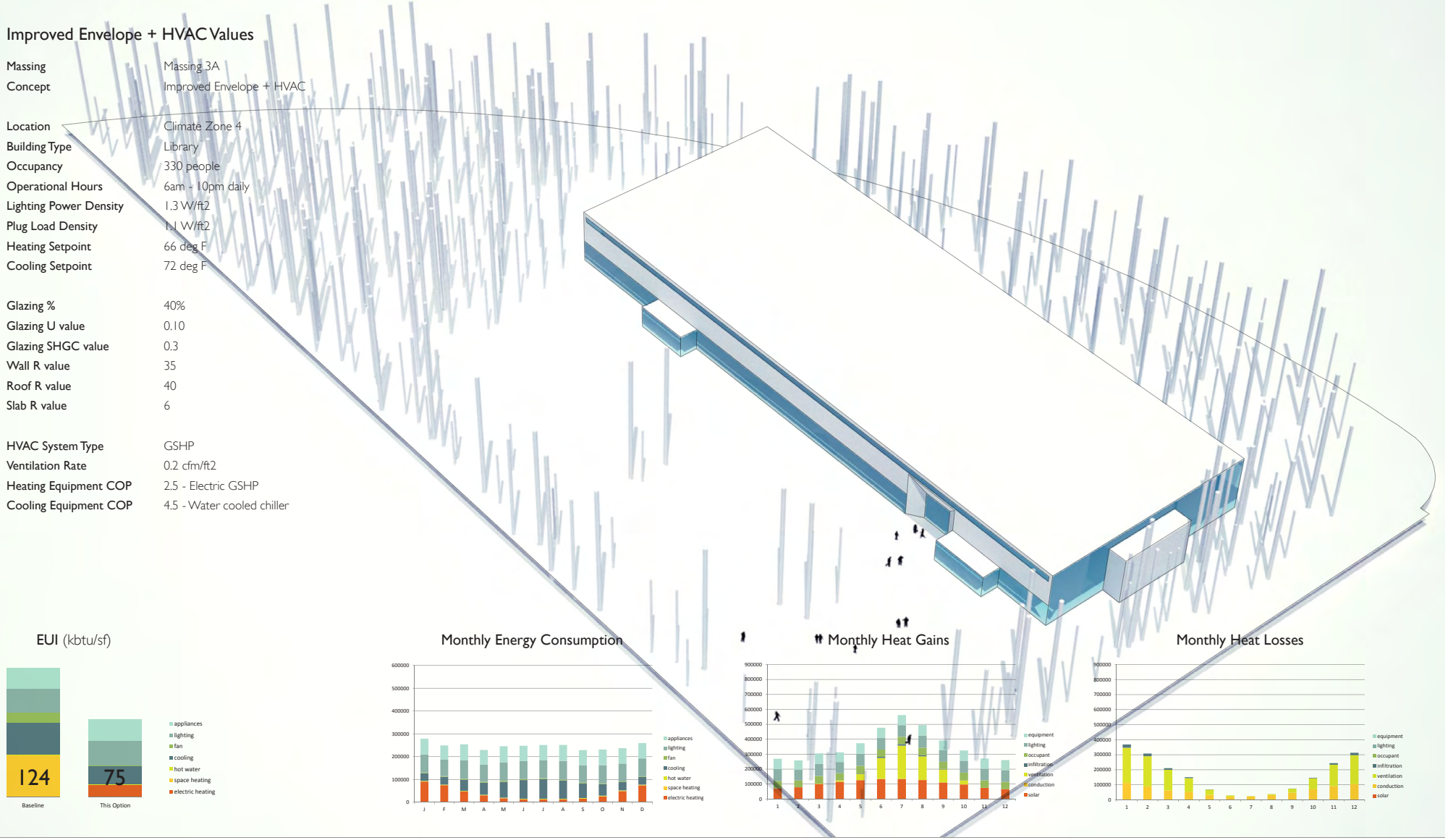
Monthly Heat Gains

Monthly Heat Losses

ORIENTATION / MASSING / GLAZING

Improved Envelope + HVAC Values

Massing	Massing 3A
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller



EUI (kbtu/sf)

Monthly Energy Consumption

Monthly Heat Gains

Monthly Heat Losses

ORIENTATION / MASSING / GLAZING

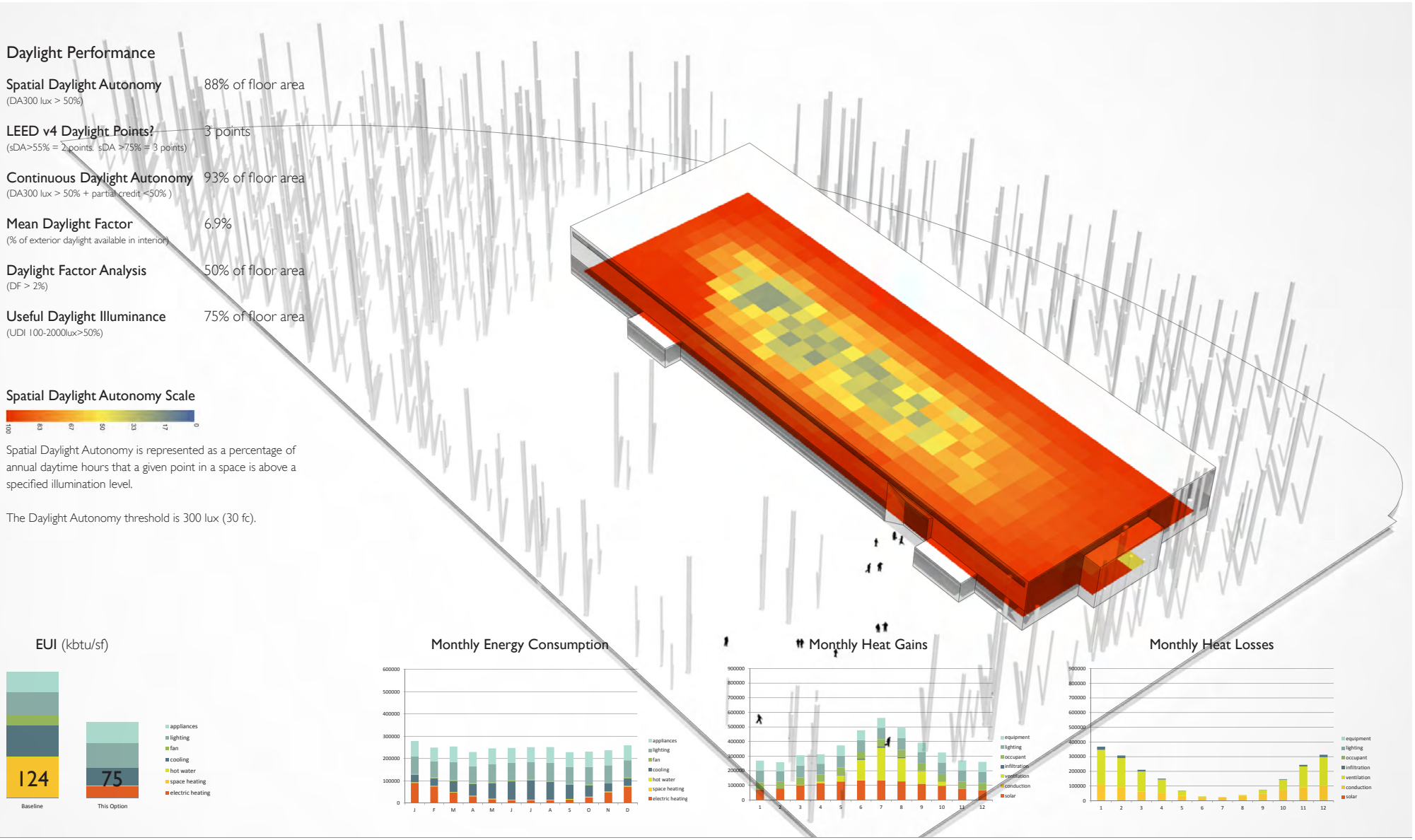
Daylight Performance

Spatial Daylight Autonomy (DA300 lux > 50%)	88% of floor area
LEED v4 Daylight Points? (sDA>55% = 2 points. sDA >75% = 3 points)	3 points
Continuous Daylight Autonomy (DA300 lux > 50% + partial credit <50%)	93% of floor area
Mean Daylight Factor (% of exterior daylight available in interior)	6.9%
Daylight Factor Analysis (DF > 2%)	50% of floor area
Useful Daylight Illuminance (UDI 100-2000lux>50%)	75% of floor area

Spatial Daylight Autonomy Scale

Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).



EUI (kbtu/sf)

Monthly Energy Consumption

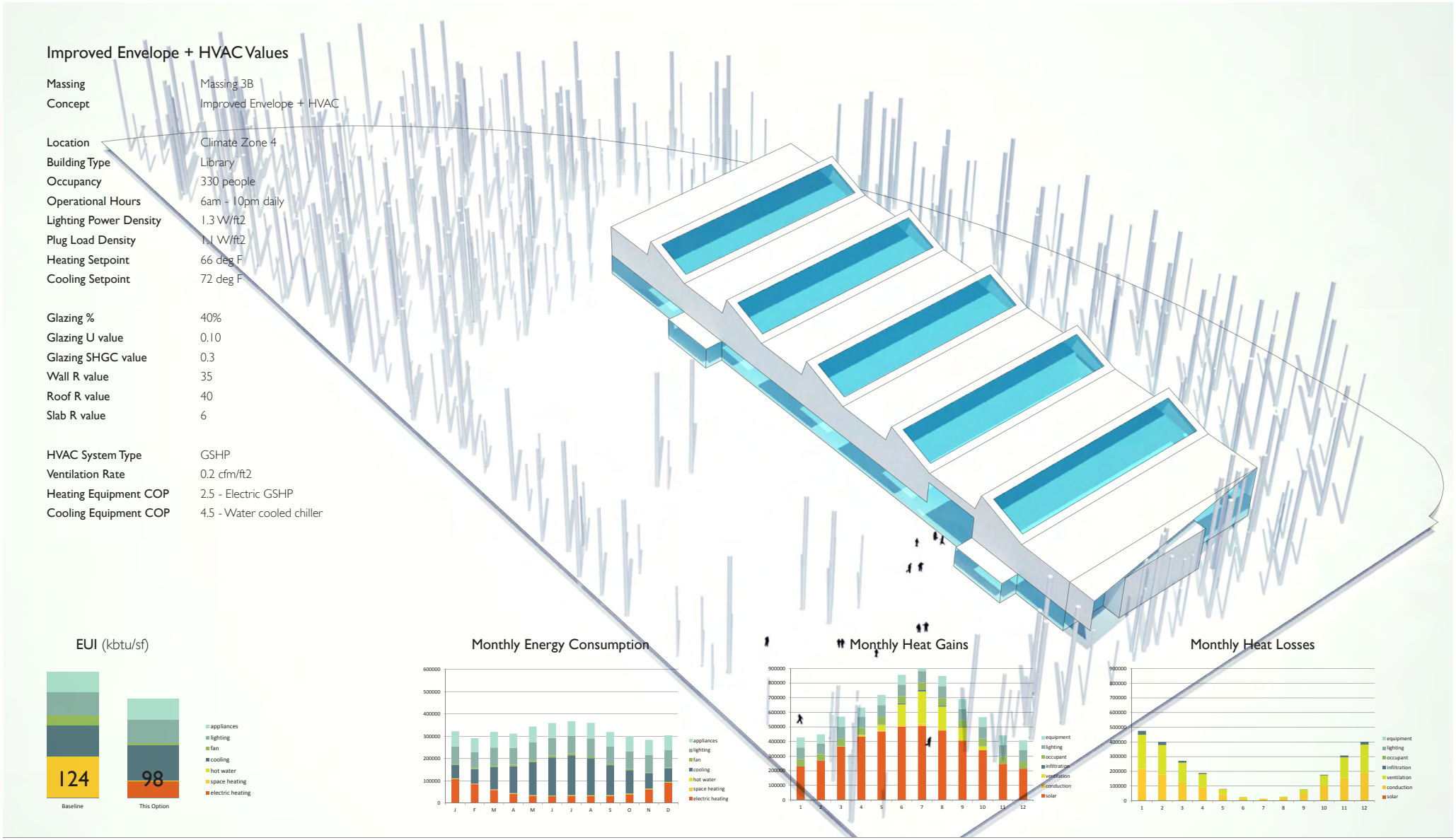
Monthly Heat Gains

Monthly Heat Losses

ORIENTATION / MASSING / GLAZING

Improved Envelope + HVAC Values

Massing	Massing 3B
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller



ORIENTATION / MASSING / GLAZING

Daylight Performance

Spatial Daylight Autonomy 99% of floor area
(DA300 lux > 50%)

LEED v4 Daylight Points? 3 points
(sDA>55% = 2 points. sDA >75% = 3 points)

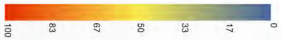
Continuous Daylight Autonomy 98% of floor area
(DA300 lux > 50% + partial credit <50%)

Mean Daylight Factor 10.7%
(% of exterior daylight available in interior)

Daylight Factor Analysis 99% of floor area
(DF > 2%)

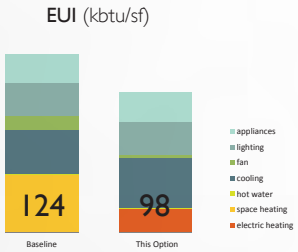
Useful Daylight Illuminance 7% of floor area
(UDI 100-2000lux>50%)

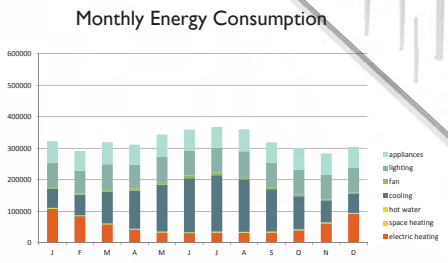
Spatial Daylight Autonomy Scale

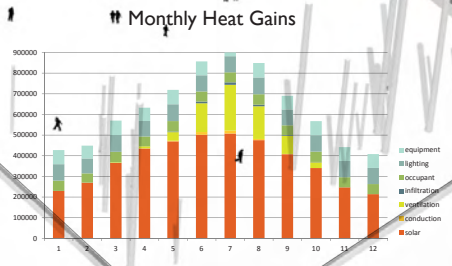


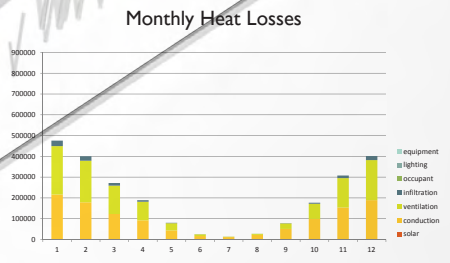
Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).





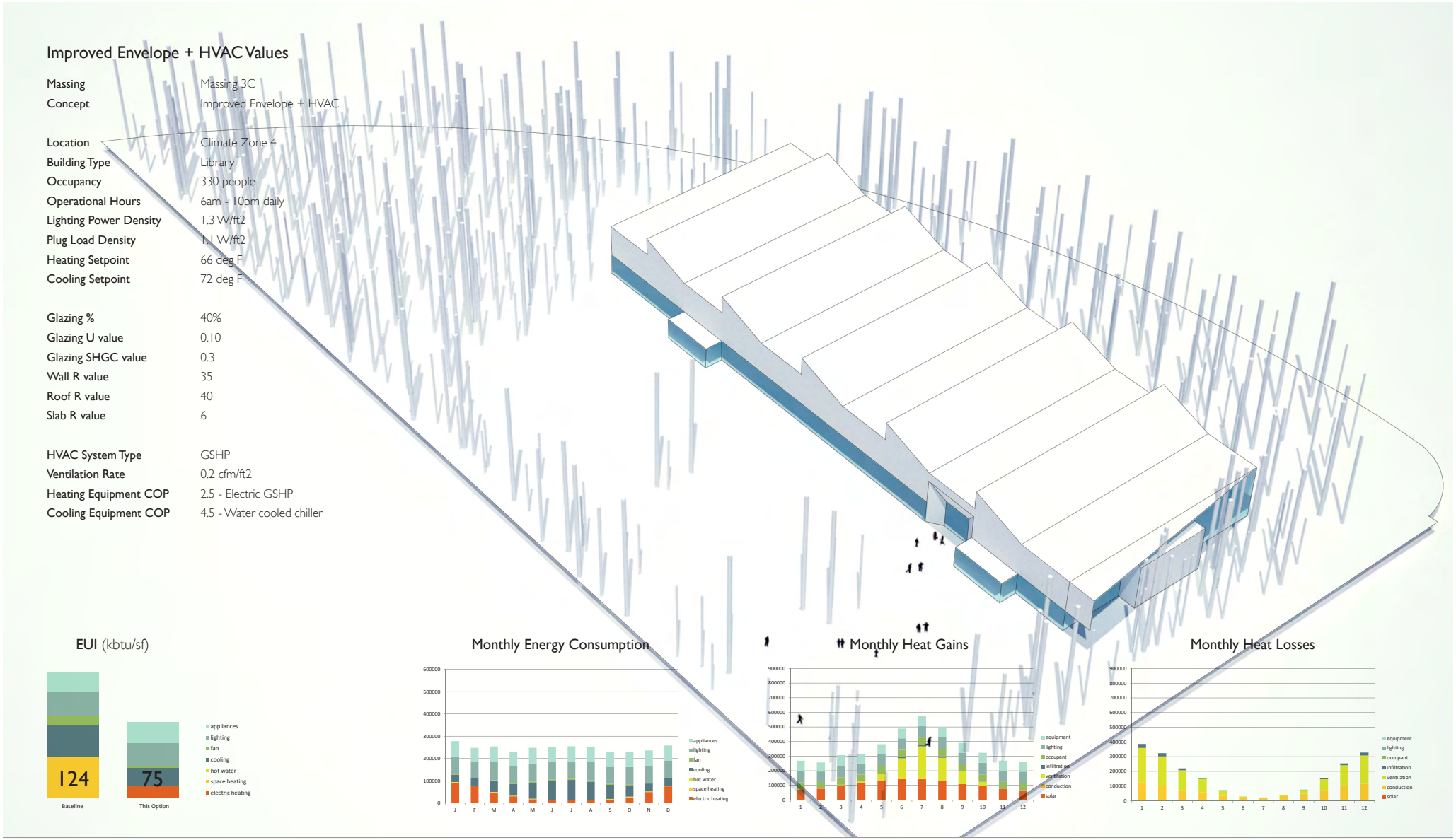




ORIENTATION / MASSING / GLAZING

Improved Envelope + HVAC Values

Massing	Massing 3C
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller



ORIENTATION / MASSING / GLAZING

Daylight Performance

Spatial Daylight Autonomy 96% of floor area
(DA300 lux > 50%)

LEED v4 Daylight Points? 3 points
(sDA>55% = 2 points. sDA >75% = 3 points)

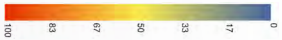
Continuous Daylight Autonomy 95% of floor area
(DA300 lux > 50% + partial credit <50%)

Mean Daylight Factor 5.8%
(% of exterior daylight available in interior)

Daylight Factor Analysis 65% of floor area
(DF > 2%)

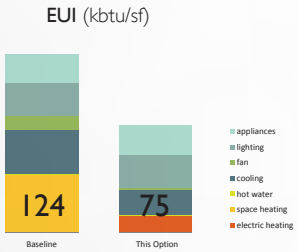
Useful Daylight Illuminance 81% of floor area
(UDI 100-2000lux>50%)

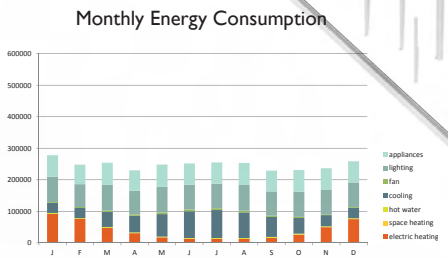
Spatial Daylight Autonomy Scale

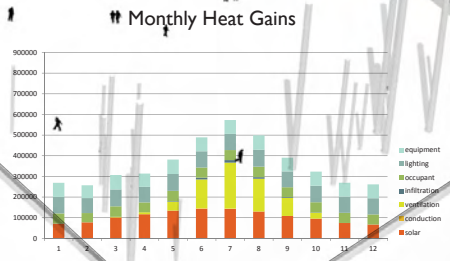


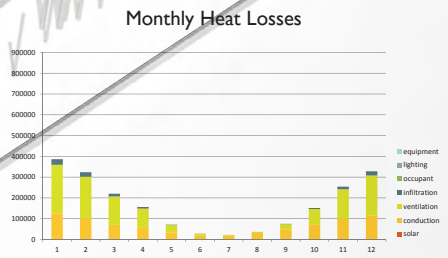
Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).





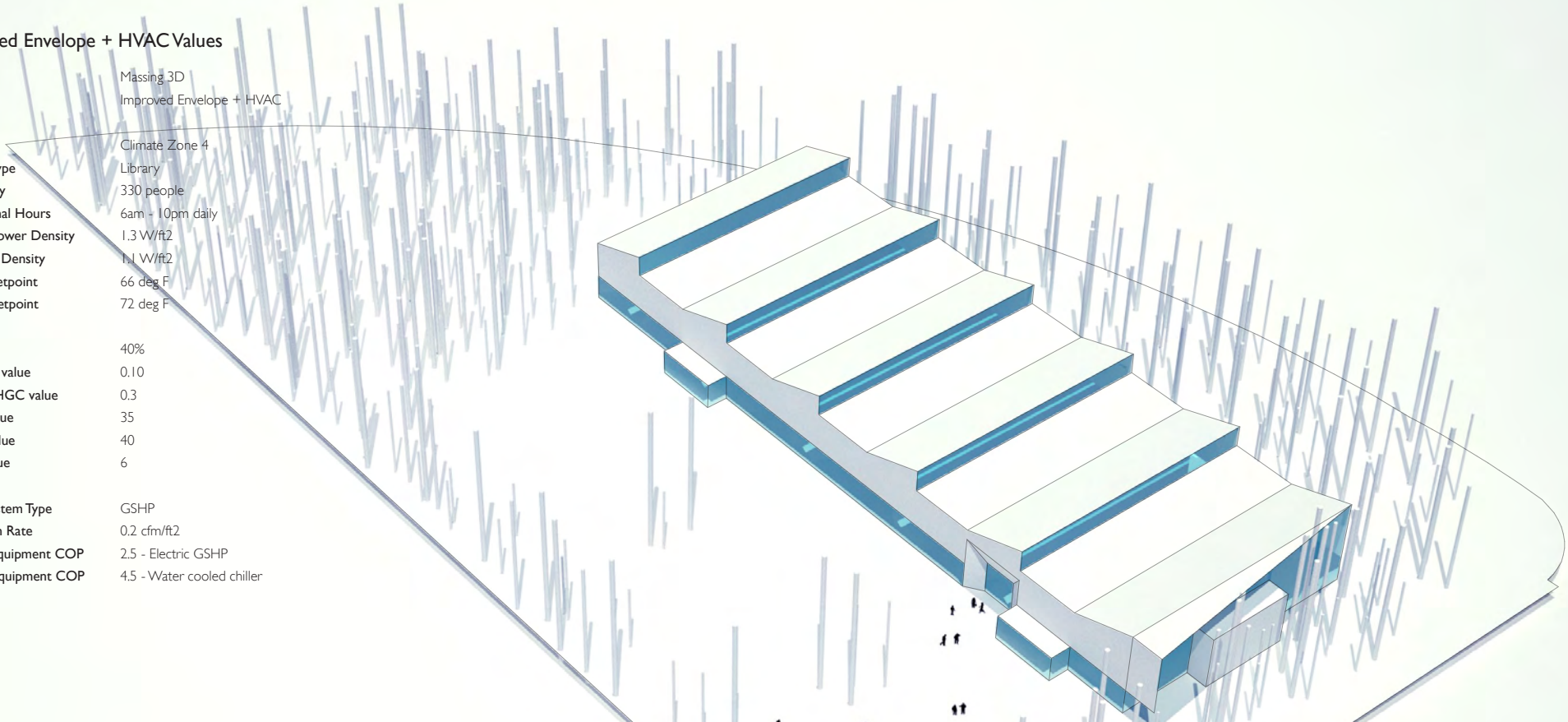




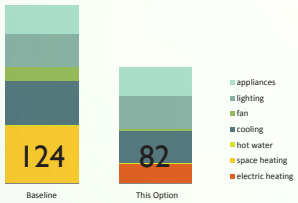
ORIENTATION / MASSING / GLAZING

Improved Envelope + HVAC Values

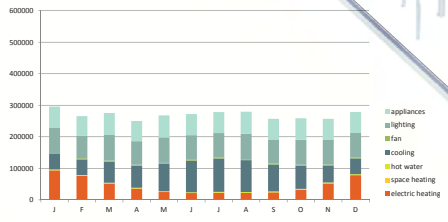
Massing	Massing 3D
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller



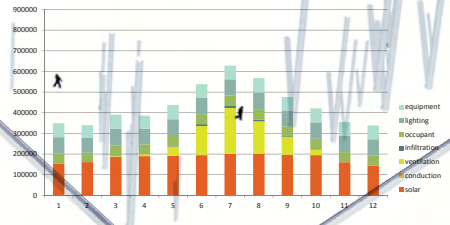
EUI (kbtu/sf)



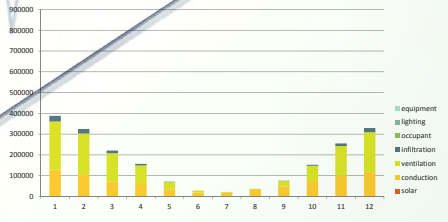
Monthly Energy Consumption



Monthly Heat Gains



Monthly Heat Losses



ORIENTATION / MASSING / GLAZING

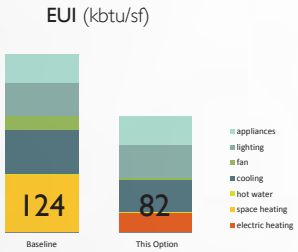
Daylight Performance

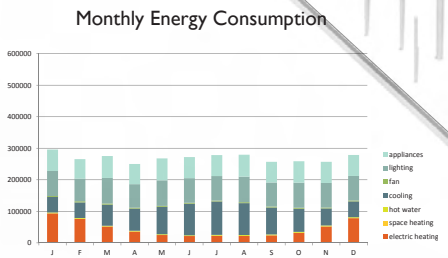
Spatial Daylight Autonomy (DA300 lux > 50%)	99% of floor area
LEED v4 Daylight Points? (sDA>55% = 2 points. sDA >75% = 3 points)	3 points
Continuous Daylight Autonomy (DA300 lux > 50% + partial credit <50%)	96% of floor area
Mean Daylight Factor (% of exterior daylight available in interior)	5.0%
Daylight Factor Analysis (DF > 2%)	63% of floor area
Useful Daylight Illuminance (UDI 100-2000lux>50%)	78% of floor area

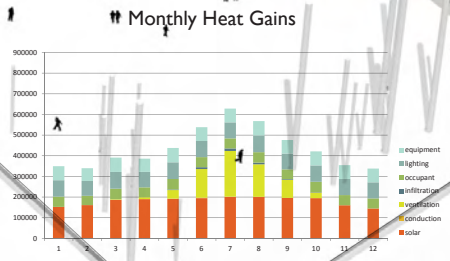
Spatial Daylight Autonomy Scale

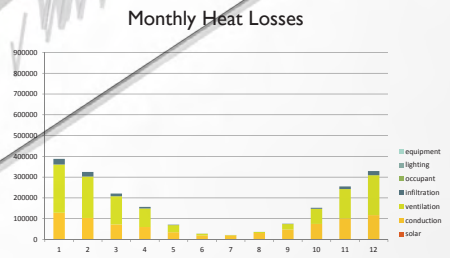
Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).





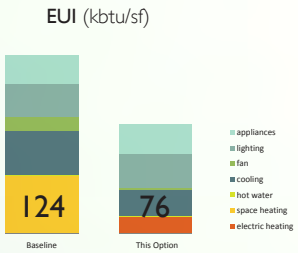


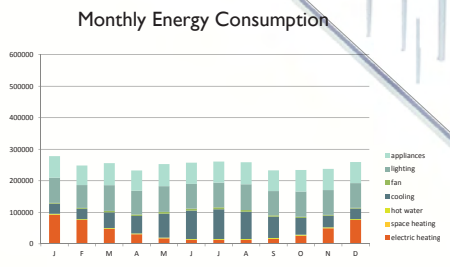


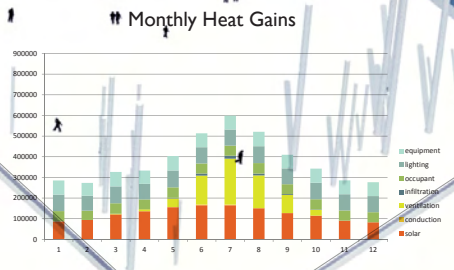
ORIENTATION / MASSING / GLAZING

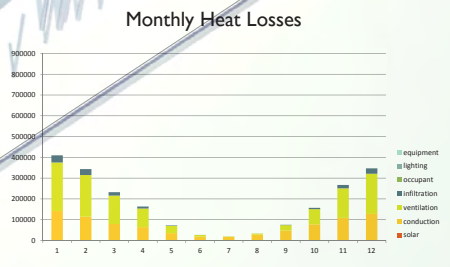
Improved Envelope + HVAC Values

Massing	Massing 3F
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller







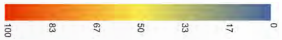


ORIENTATION / MASSING / GLAZING

Daylight Performance

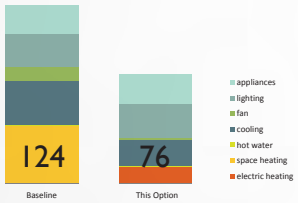
Spatial Daylight Autonomy (DA300 lux > 50%)	99% of floor area
LEED v4 Daylight Points? (sDA>55% = 2 points. sDA >75% = 3 points)	3 points
Continuous Daylight Autonomy (DA300 lux > 50% + partial credit <50%)	95% of floor area
Mean Daylight Factor (% of exterior daylight available in interior)	4.1%
Daylight Factor Analysis (DF > 2%)	60% of floor area
Useful Daylight Illuminance (UDI 100-2000lux>50%)	88% of floor area

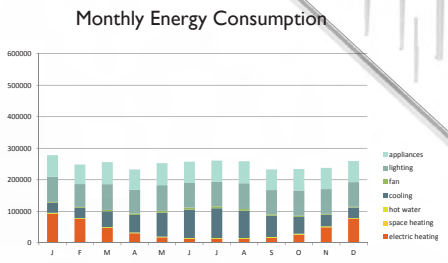
Spatial Daylight Autonomy Scale

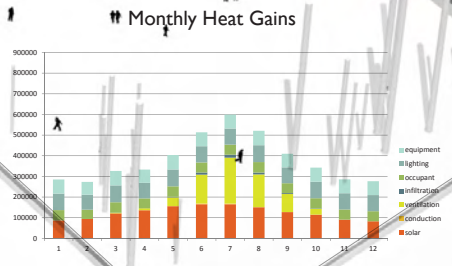


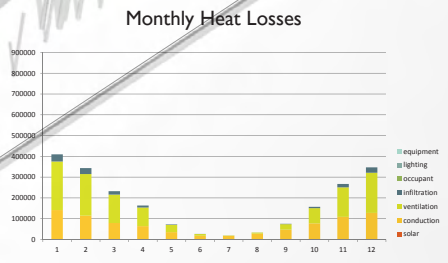
Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).





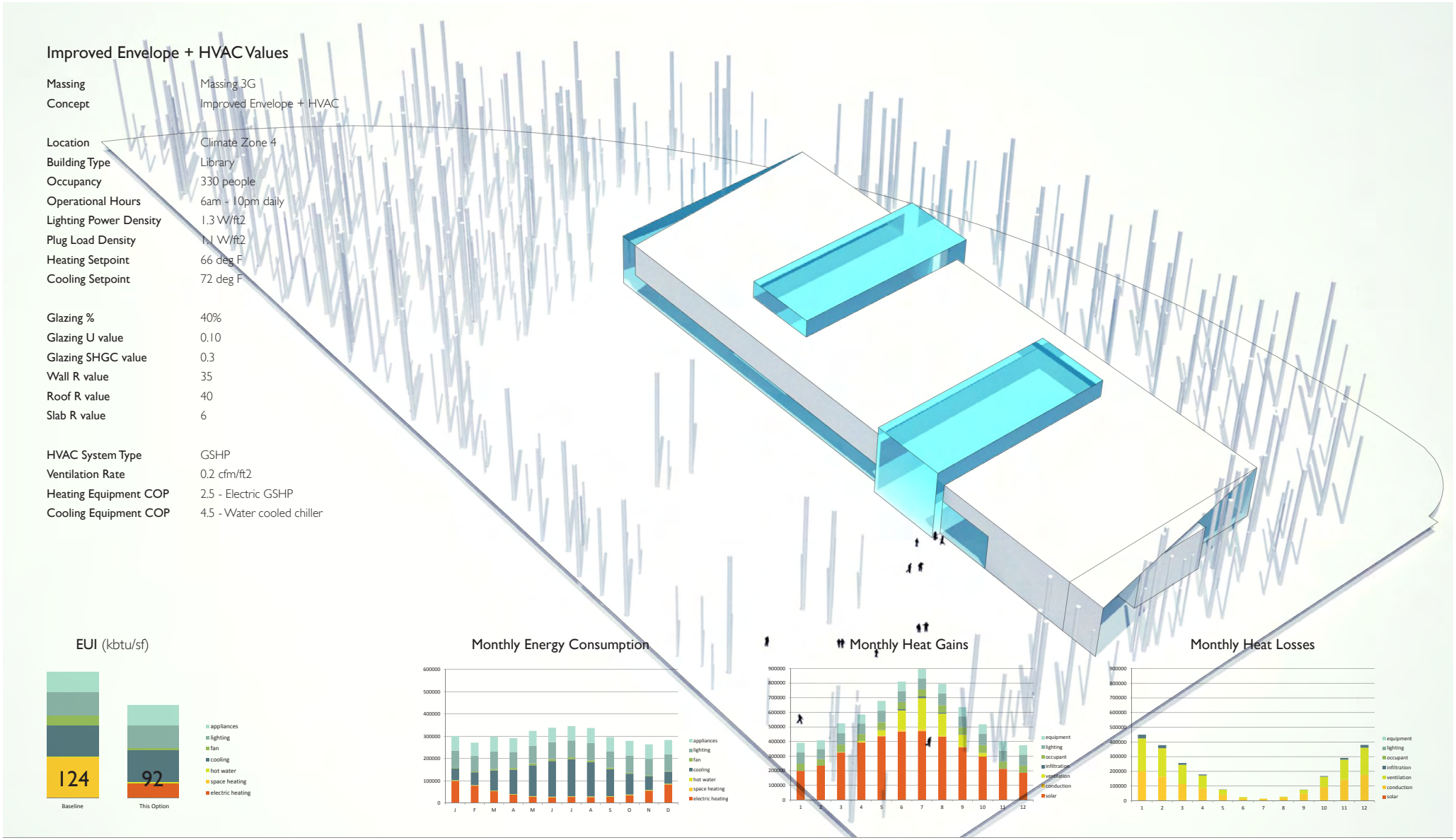




ORIENTATION / MASSING / GLAZING

Improved Envelope + HVAC Values

Massing	Massing 3G
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller



ORIENTATION / MASSING / GLAZING

Daylight Performance

Spatial Daylight Autonomy 99% of floor area
(DA300 lux > 50%)

LEED v4 Daylight Points? 3 points
(sDA>55% = 2 points. sDA >75% = 3 points)

Continuous Daylight Autonomy 98% of floor area
(DA300 lux > 50% + partial credit <50%)

Mean Daylight Factor 13.5%
(% of exterior daylight available in interior)

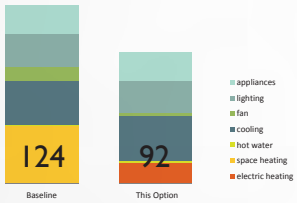
Daylight Factor Analysis 94% of floor area
(DF > 2%)

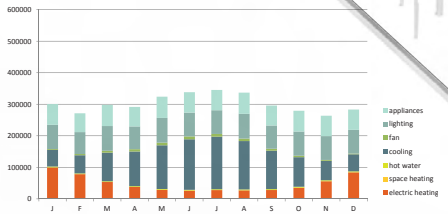
Useful Daylight Illuminance 41% of floor area
(UDI 100-2000lux>50%)

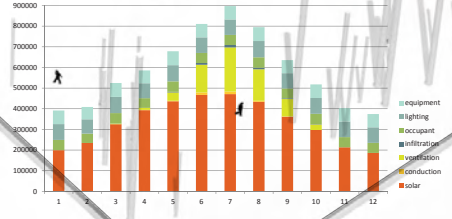
Spatial Daylight Autonomy Scale

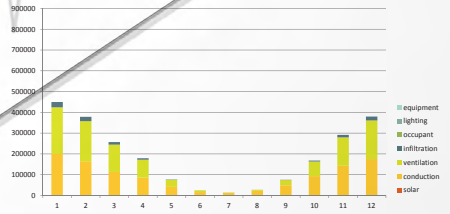
Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).





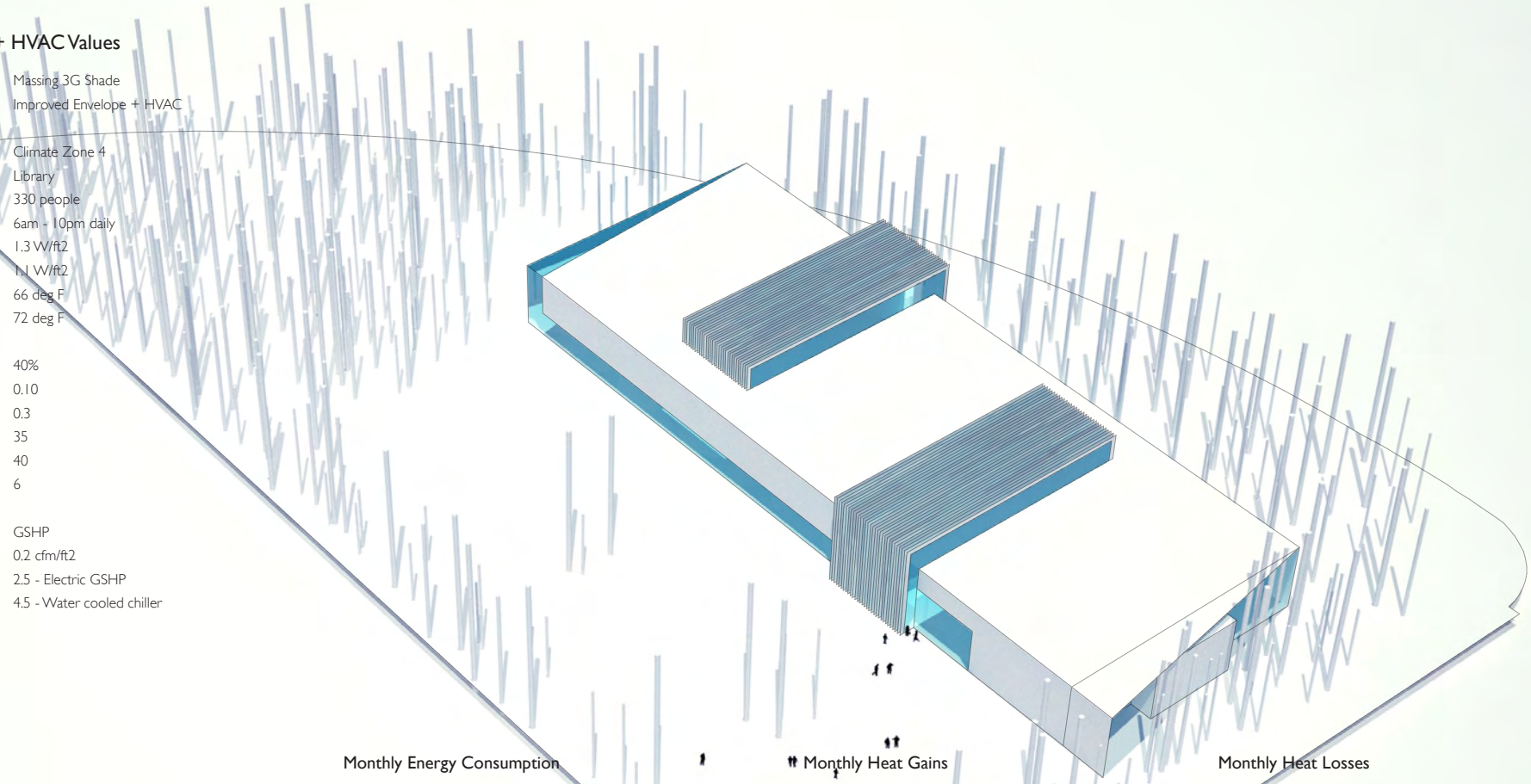


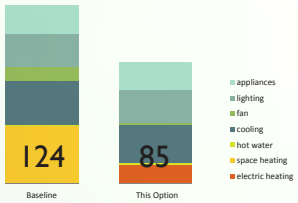


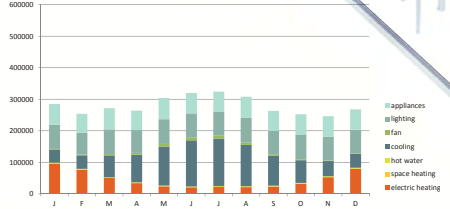
ORIENTATION / MASSING / GLAZING

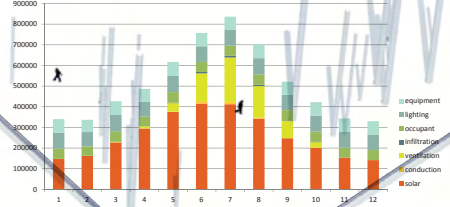
Improved Envelope + HVAC Values

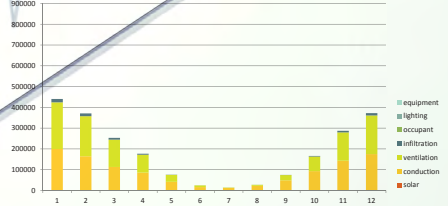
Massing	Massing 3G Shade
Concept	Improved Envelope + HVAC
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing %	40%
Glazing U value	0.10
Glazing SHGC value	0.3
Wall R value	35
Roof R value	40
Slab R value	6
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller











ORIENTATION / MASSING / GLAZING

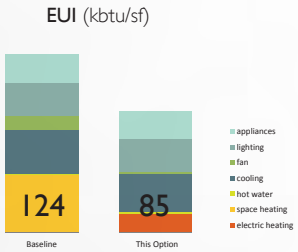
Daylight Performance

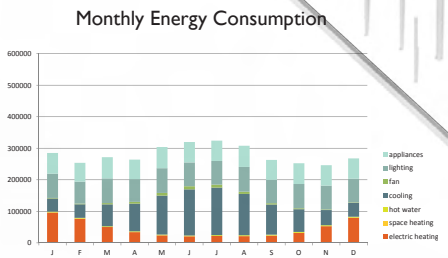
Spatial Daylight Autonomy (DA300 lux > 50%)	98% of floor area
LEED v4 Daylight Points? (sDA>55% = 2 points. sDA >75% = 3 points)	3 points
Continuous Daylight Autonomy (DA300 lux > 50% + partial credit <50%)	95% of floor area
Mean Daylight Factor (% of exterior daylight available in interior)	8.7%
Daylight Factor Analysis (DF > 2%)	72% of floor area
Useful Daylight Illuminance (UDI 100-2000lux>50%)	59% of floor area

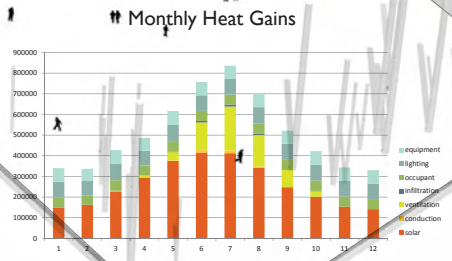
Spatial Daylight Autonomy Scale

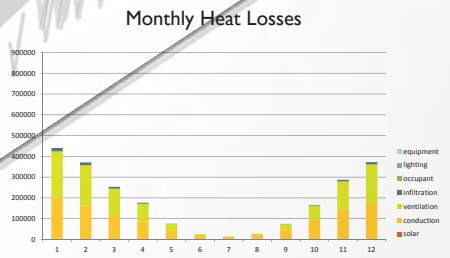
Spatial Daylight Autonomy is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

The Daylight Autonomy threshold is 300 lux (30 fc).







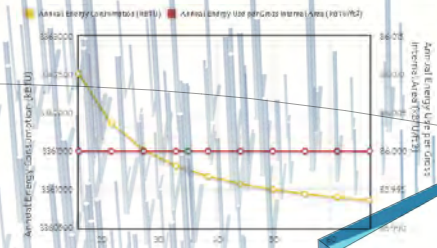


ORIENTATION / MASSING / GLAZING

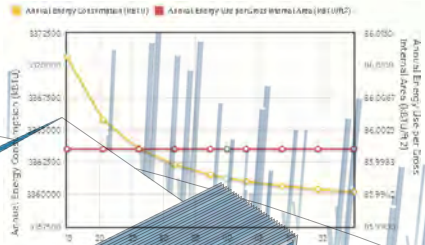
Improved Envelope + HVAC Values

Massing	Massing 3G Shade
Concept	Optimized Envelope
Location	Climate Zone 4
Building Type	Library
Occupancy	330 people
Operational Hours	6am - 10pm daily
Lighting Power Density	1.3 W/ft2
Plug Load Density	1.1 W/ft2
Heating Setpoint	66 deg F
Cooling Setpoint	72 deg F
Glazing U value	0.4
Glazing SHGC value	0.2
Wall R value	15
Roof R value	20
Slab R value	2
HVAC System Type	GSHP
Ventilation Rate	0.2 cfm/ft2
Heating Equipment COP	2.5 - Electric GSHP
Cooling Equipment COP	4.5 - Water cooled chiller

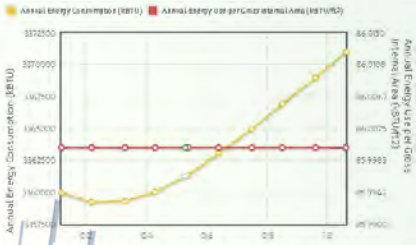
Wall R Value



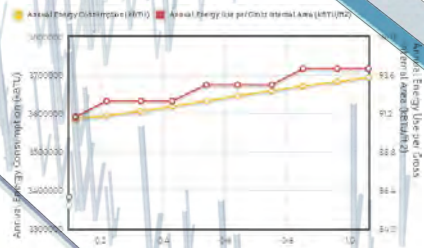
Roof R Value



Roof Glazing U Value

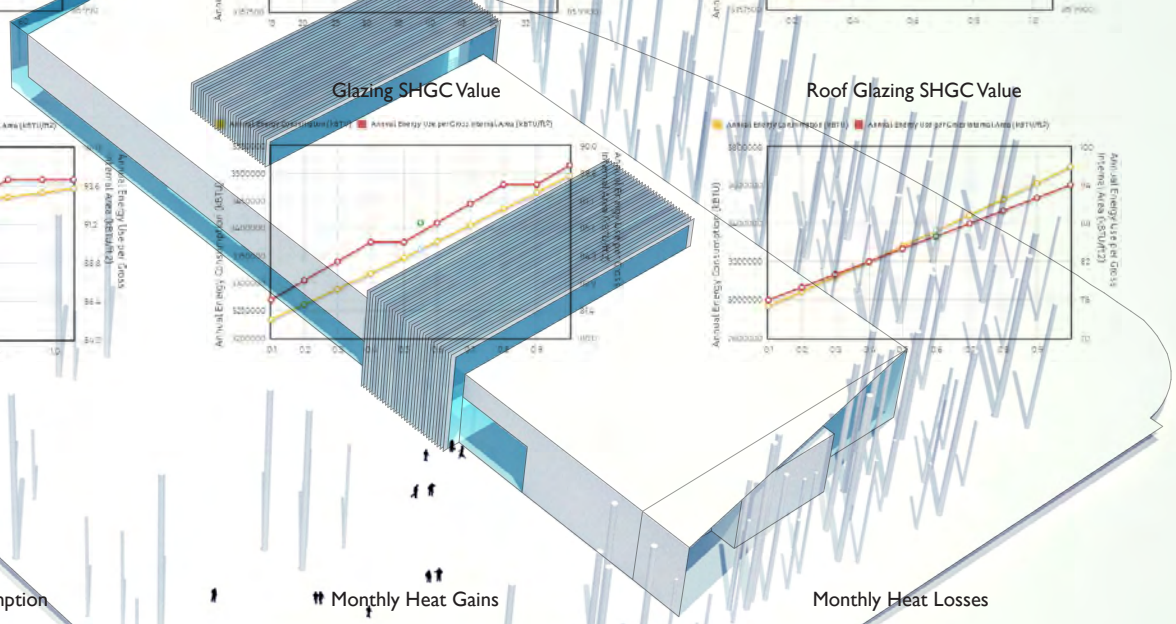


Glazing U Value

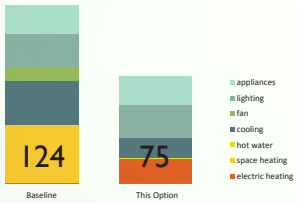


Glazing SHGC Value

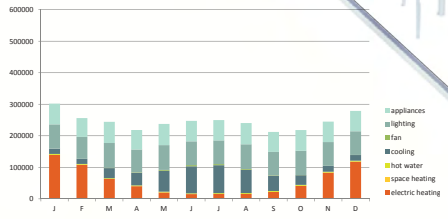
Roof Glazing SHGC Value



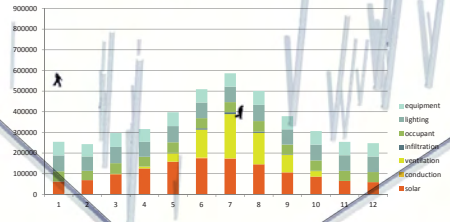
EUI (kbtu/sf)



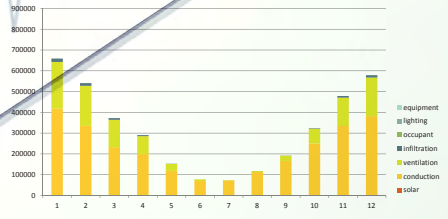
Monthly Energy Consumption



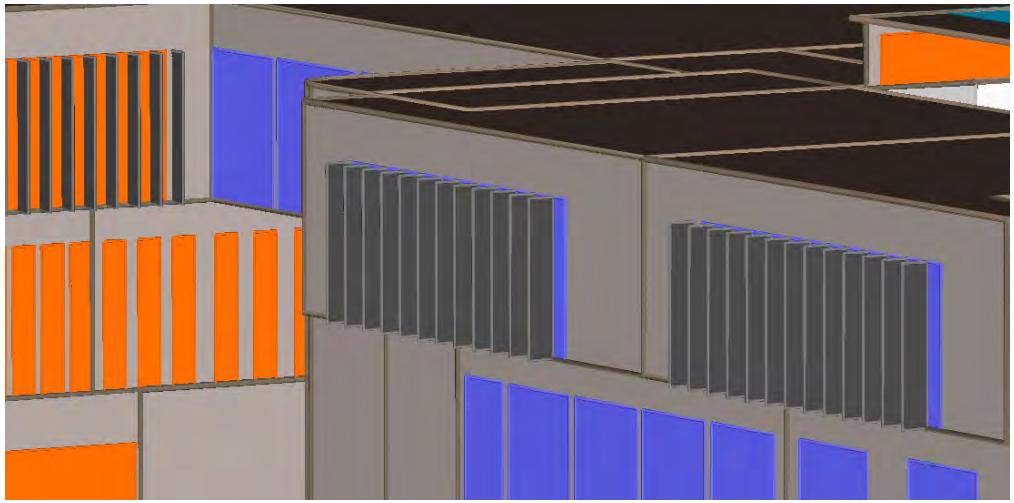
Monthly Heat Gains



Monthly Heat Losses



ORIENTATION / MASSING / GLAZING



Vertical Window Fins

Direct Savings

- Reduces energy cost by 0.1%

Indirect Savings

- Reduction to peak cooling load
- 10% reduction in solar load (Whole Building)
- 25% less cooling energy (South facing room)
- Smaller ductwork and fewer diffusers
- Smaller HVAC equipment
- Reduced electrical service

METHODOLOGY

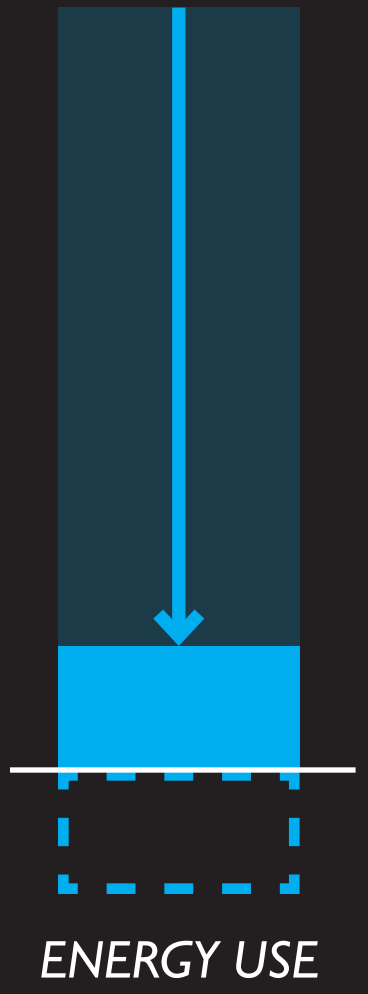
ESTABLISH BASELINES AND TARGETS

CLIMATE ANALYSIS + PASSIVE STRATEGIES

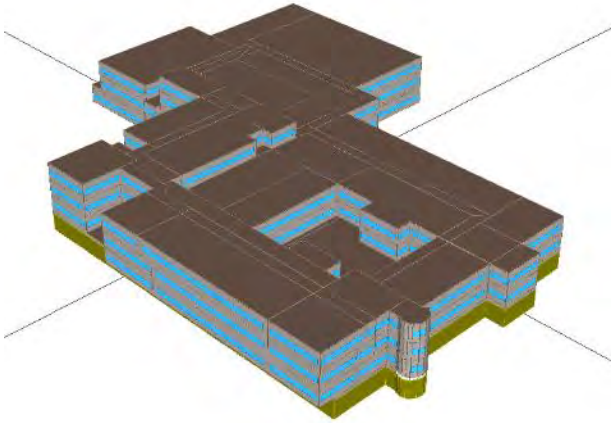
ENVELOPE OPTIMIZATION

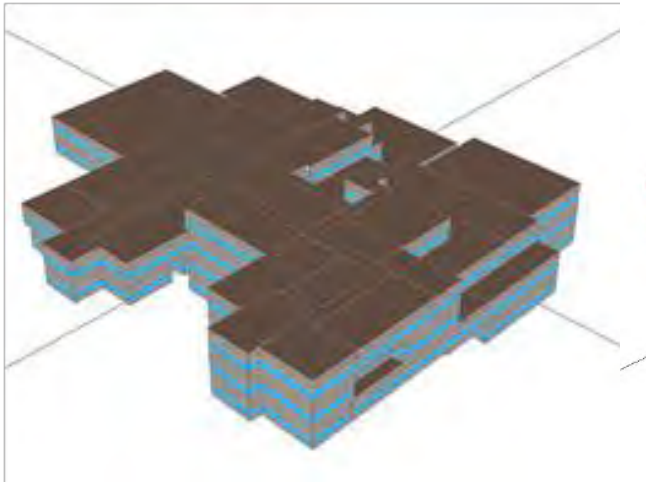
ORIENTATION / MASSING / GLAZING

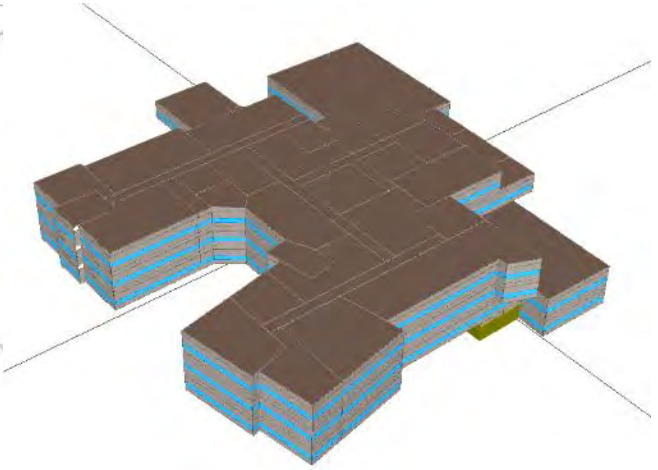
SYSTEMS OPTIMIZATION



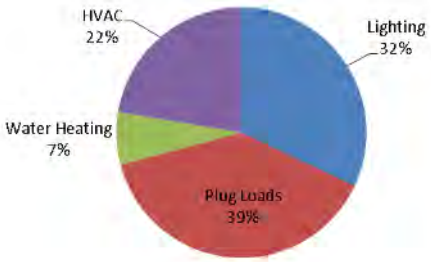
SYSTEMS OPTIMIZATION



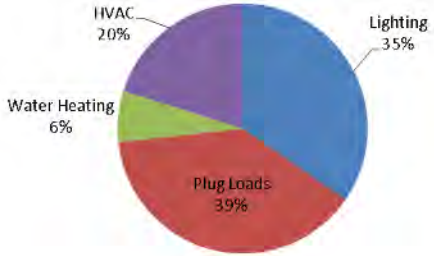




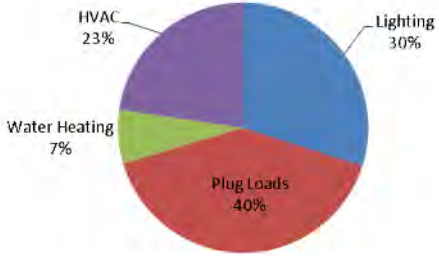
Ex Mod



Clover



Pi



METHODOLOGY

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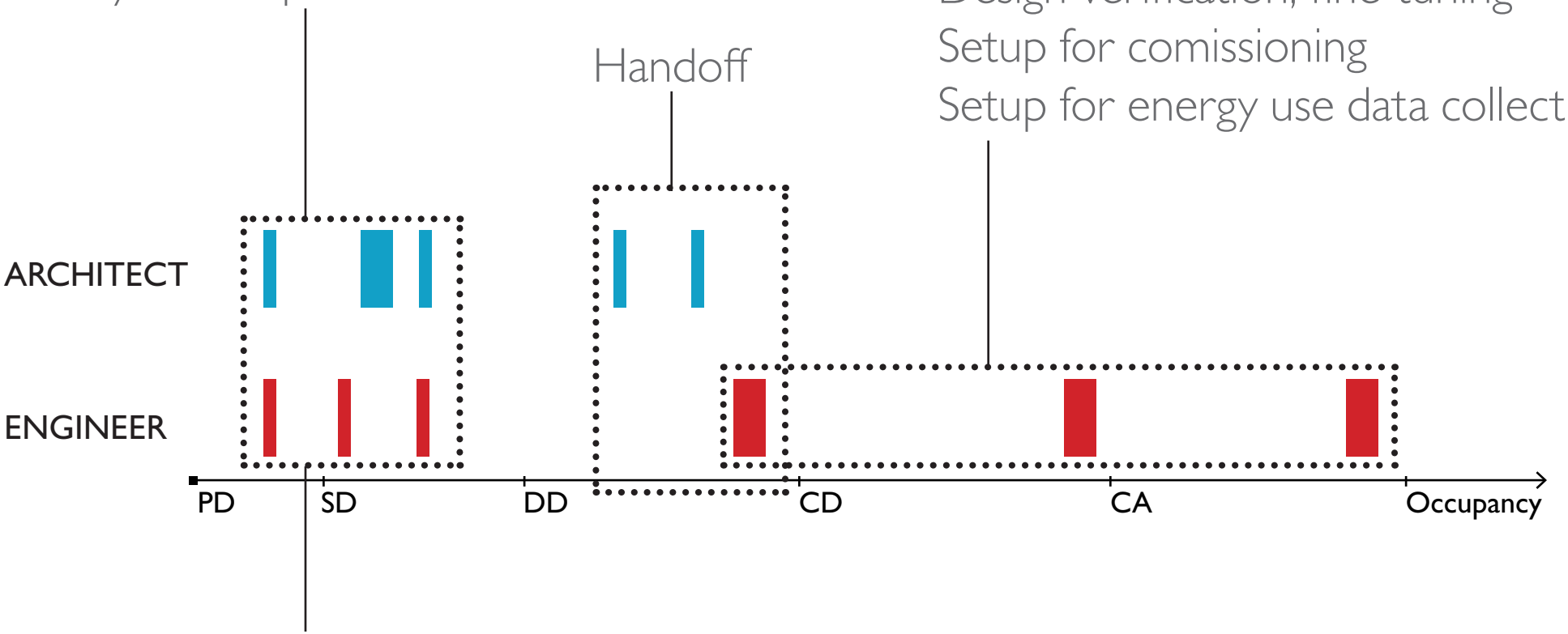
SYSTEMS OPTIMIZATION

COLLABORATIVE ENERGY MODELING

Baselines and targets
Climate analysis and passive strategies
Envelope optimization
Orientation / massing / glazing
Systems optimization

Handoff

Design verification, fine-tuning
Setup for comissioning
Setup for energy use data collection



Upfront input on systems alternatives
Modeling input

CONCLUSIONS

1. AIA 2030 COMMITMENT

CONCLUSIONS

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2. TALK ENERGY SOONER

CONCLUSIONS

1. AIA 2030 COMMITMENT

2. TALK ENERGY SOONER

3. TALK ENERGY SOONER TOGETHER

THANK YOU

Baselines and targets
Climate analysis and passive strategies
Envelope optimization
Orientation / massing / glazing
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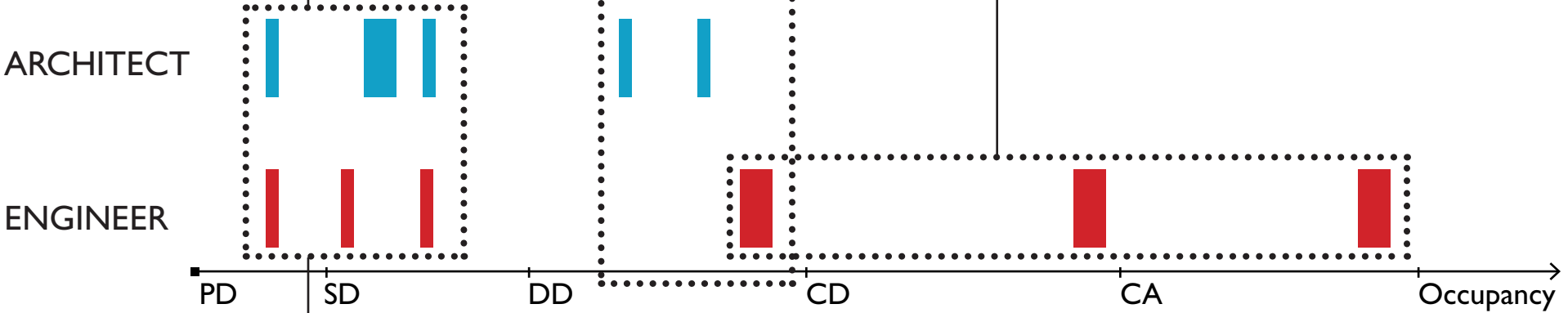

Upfront input on systems alternatives
Modeling input