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?

ARCHITECT

ENGINEER

scheduled energy models
WHY EARLY PHASE?

energy modeling at this stage is just verifying decisions that are already made.

ARCHITECT

ENGINEER

PD  SD  DD  CD  CA  Occupancy
WHY EARLY PHASE?
WHY EARLY PHASE?

- Want to use smarter inputs
- Not comfortable making claims early on that could potentially be held up later

PD | SD | DD | CD | CA | Occupancy

ARCHITECT

ENGINEER
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 commissioning
Setup for energy use data collection

ARCHITECT

ENGINEER

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
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
OVERVIEW

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350 PPM CO2

Scientists have set the maximum level of CO2 in the atmosphere at 350 ppm to ensure stable climate conditions globally. We have already exceeded this number and are at 397 ppm CO2. This has led to a global warming that is already underway. We must reduce the levels of CO2 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
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.
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
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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2030 CHALLENGE

BUILDINGS
44.6%

INDUSTRY
21.1%

TRANSPORTATION
34.3%

U.S. CO₂ Emissions by Sector

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2030 CHALLENGE

The 2030 Challenge

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*Using no fossil fuel GHG-emitting energy to operate.
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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 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).

ENERGY

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.

REPORT

AIA 2030 Commitment By the Numbers

An overview of the progress that projects and firms are making.

COURSE

AIA+2030 Online Series

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

This series aims to inspire architects to meet the 2030 Challenge through design strategies, efficient technologies and systems, and applying renewable energy resources.
33% increase in reported projects

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

*Data for total number of projects is unavailable for years prior to 2011.*
An ambitious pEUI% reduction target

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%

We are making important progress, but must accelerate our pace in order to meet our goals.

In whole building projects for 2016, pEUI savings averaged 42%—a continuation of the positive trend we've seen over the past several years, but still short of 70% target.

*Annual project average pEUI % reduction as compared to the Architecture2030 target

**ANNUAL AVERAGE ENERGY SAVINGS**
for all reported projects
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EUI IS MPG

EUI = ENERGY USE INTENSITY

ANNUAL ENERGY USE
PROJECT SIZE

KBTU
SF

ANNUAL FUEL COST

Fueleconomy.gov
Calculate personalized estimates and compare vehicles
OVERVIEW

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SOFTWARE

ENERGY+
CLIMATE CONSULTANT
SEFAIRA
HONEYBEE / LADYBUG
REVIT
IESVE
TRANE/TRACE
EQUEST
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<thead>
<tr>
<th>Energy Modeling Input Category</th>
<th>Design Team Responsibility</th>
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<tbody>
<tr>
<td>1) Climate Data</td>
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<td>2) Construction Types</td>
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<td>3) Building Form</td>
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## THE ANATOMY OF AN ENERGY MODEL

### Architect
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### Design Team Responsibility
- **Energy Modeling Input Category**
- **Design Team Responsibility**

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<thead>
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<th>Architect</th>
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Design Team Responsibility
- Architect
- Engineer
Intelligent Defaults

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### Climate Analysis

#### Energy Model

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## Envelope Optimization

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## Envelope Optimization
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## Massing Study
- **Energy Model**
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# Define Occupancy

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## Project-Specific Information

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### Massing + Systems Optimization

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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, etc.

• 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)
# U.S. National Average Site EUI

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

Note: These are estimates of code comparison based on analyses by Pacific Northwest National Laboratory, New Buildings Institute, and Architecture 2030. These percentages are provided to enable the inclusion of non-modeled projects in analysis for the AIA 2030 Commitment.
<table>
<thead>
<tr>
<th>Building Type</th>
<th>Code Equivalents</th>
<th>Approximate % Reduction from Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank/Financial</td>
<td>77 X 1.0 ASHRAE 90.1‐1999</td>
<td>10%</td>
</tr>
<tr>
<td>Courthouse</td>
<td>118 X 1.2 ASHRAE 90.1‐2001</td>
<td>10%</td>
</tr>
<tr>
<td>Data Center ‐ use Target Finder to derive comparison</td>
<td>TF ‐‐&gt; 1.0 ASHRAE 90.1‐2004</td>
<td>20%</td>
</tr>
<tr>
<td>Education ‐ College/University (campus‐level)</td>
<td>120 X 1.2 ASHRAE 90.1 ‐2007</td>
<td>25%</td>
</tr>
<tr>
<td>Education ‐ General</td>
<td>76 X 1.2 ASHRAE 90.1‐2010</td>
<td>40%</td>
</tr>
<tr>
<td>Education ‐ K‐12 School</td>
<td>75 X 1.2 ASHRAE 90.1‐2013</td>
<td>45%</td>
</tr>
<tr>
<td>Food Sales ‐ Convenience Store (w/ or w/out gas station)</td>
<td>241 X 1.5 California Title 24 2005 for high rise residential</td>
<td>35%</td>
</tr>
<tr>
<td>Food Sales ‐ General</td>
<td>225 X 1.5 California Title 24 2005 for single family residential</td>
<td>30%</td>
</tr>
<tr>
<td>Food Sales ‐ Supermarket/Grocery</td>
<td>213 X 1.5 California Title 24 2008</td>
<td>40%</td>
</tr>
<tr>
<td>Food Service ‐ Fast Food</td>
<td>534 X 1.5 IECC 2003</td>
<td>10%</td>
</tr>
<tr>
<td>Food Service ‐ General</td>
<td>351 X 1.5 IECC 2006</td>
<td>20%</td>
</tr>
<tr>
<td>Food Service ‐ Restaurant/Cafeteria</td>
<td>302 X 1.5 IECC 2009</td>
<td>35%</td>
</tr>
<tr>
<td>Health Care ‐ Clinic</td>
<td>84 X 1.0 IECC 2012</td>
<td>40%</td>
</tr>
<tr>
<td>Health Care ‐ Hospital Inpatient</td>
<td>227 X 1.2 Older than 1999</td>
<td>0%</td>
</tr>
<tr>
<td>Health Care ‐ Medical Office</td>
<td>59 X</td>
<td>X</td>
</tr>
<tr>
<td>Health Care ‐ Nursing/Assisted Living</td>
<td>124 X</td>
<td>X</td>
</tr>
<tr>
<td>Health Care ‐ Outpatient ‐ General</td>
<td>73 X</td>
<td>X</td>
</tr>
<tr>
<td>Laboratory ‐ recommend use of Labs21</td>
<td>370 Labs21</td>
<td></td>
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<tr>
<td>Lodging ‐ General</td>
<td>87 X</td>
<td>X</td>
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<tr>
<td>Lodging ‐ Hotel/Motel</td>
<td>94 X</td>
<td>X</td>
</tr>
<tr>
<td>Lodging ‐ Residence Hall/Dormitory</td>
<td>89 X</td>
<td>X</td>
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<tr>
<td>Mixed ‐ Use ‐ use Calculator tab to derive comparison</td>
<td>Calc --&gt;</td>
<td></td>
</tr>
<tr>
<td>Office ‐ 10,000 sf</td>
<td>74 X**</td>
<td></td>
</tr>
<tr>
<td>Office ‐ 10,001 to 100,000 sf</td>
<td>90 X**</td>
<td></td>
</tr>
<tr>
<td>Office ‐ 100,001 sf or greater</td>
<td>104 X**</td>
<td></td>
</tr>
<tr>
<td>Other ‐ see FAQ #29</td>
<td>104 X</td>
<td>X</td>
</tr>
<tr>
<td>Public Assembly ‐ Entertainment/Culture</td>
<td>95 X</td>
<td>X</td>
</tr>
<tr>
<td>Public Assembly ‐ General</td>
<td>66 X</td>
<td>X</td>
</tr>
<tr>
<td>Public Assembly ‐ Library</td>
<td>104 X</td>
<td>X</td>
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<tr>
<td>Public Assembly ‐ Recreation</td>
<td>65 X</td>
<td>X</td>
</tr>
<tr>
<td>Public Assembly ‐ Social/Meeting</td>
<td>52 X</td>
<td>X</td>
</tr>
<tr>
<td>Public Safety ‐ Fire/Police Station</td>
<td>78 X</td>
<td>X</td>
</tr>
<tr>
<td>Public Safety ‐ General</td>
<td>90 X</td>
<td>X</td>
</tr>
<tr>
<td>Religious Worship</td>
<td>46 X</td>
<td>X</td>
</tr>
<tr>
<td>Residential ‐ Mobile Homes</td>
<td>73 RECS</td>
<td></td>
</tr>
<tr>
<td>Residential ‐ Multi‐Family, 2 to 4 units</td>
<td>58 RECS</td>
<td></td>
</tr>
<tr>
<td>Residential ‐ Multi‐Family, 5 or more units</td>
<td>50 RECS</td>
<td></td>
</tr>
<tr>
<td>Residential ‐ Single‐Family Attached</td>
<td>44 RECS</td>
<td></td>
</tr>
<tr>
<td>Residential ‐ Single‐Family Detached</td>
<td>44 RECS</td>
<td></td>
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<tr>
<td>Category</td>
<td>CBECS Average EUI</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Residential Single Family Home</td>
<td>44 EUI</td>
<td></td>
</tr>
<tr>
<td>Office 10,001 to 100,000 sf</td>
<td>90 EUI</td>
<td></td>
</tr>
<tr>
<td>Lab</td>
<td>370 EUI</td>
<td></td>
</tr>
</tbody>
</table>

* 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.
**ZERO TOOL**

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

### ABOUT YOUR BUILDING

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Building Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>United States</td>
</tr>
<tr>
<td>City</td>
<td>State/Prov.</td>
</tr>
<tr>
<td>Postal Code</td>
<td>53704</td>
</tr>
<tr>
<td>Degree Days</td>
<td>HDD 7369, CDD 568</td>
</tr>
</tbody>
</table>

- 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

Selected Use Type(s):

- Adult Education

### RESULTS

**Target EUI is 25 based on a 70% reduction**

- **BASELINE** 84 EUI
- **100 Zero Score**

- **TARGET** 25 EUI
- **30 Zero Score**

### BUILDING SUMMARY

**LOCATION**
- madison, WI
- 53704

**USES**
- Adult Education
- 8,900 sq.ft (100.0%)

**RESULTS**

<table>
<thead>
<tr>
<th>Your Building</th>
<th>EUI % Reduction from Baseline</th>
<th>Zero Score</th>
<th>Site EUI (kBtu/ft²/yr)</th>
<th>Source EUI (kBtu/ft²/yr)</th>
<th>Total GHG Emissions (metric tons CO₂e/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>100</td>
<td>84</td>
<td>142</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>43</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**N/A**
ENERGY CODE BASELINE

-0% CBECs 2003 average

-10% IECC 2003

-20% IECC 2006

-35% IECC 2009

-40% IECC 2012

-60% AIA2030 2010

-70% AIA2030 2015

-80% AIA2030 2020

-90% AIA2030 2025

-100% AIA2030 2030

-20% ASHRAE 90.1 2004

-25% ASHRAE 90.1 2007

-40% ASHRAE 90.1 2010

-45% ASHRAE 90.1 2013
ESTABLISH BASELINES AND TARGETS

Regional Ave Baseline
School K-12
-35% from Regional Average

Code Baseline (IECC 2009)
-3% from Code Baseline

LEEDv3 Prereq. Min
-48% from Code Baseline
EAc1 1-18 points

LEEDv3 Max Points
-70% from Regional Ave Baseline

2030 Challenge
Site Net Zero

Net-Zero Energy

METHODOLOGY

ESTABLISH BASELINES AND TARGETS

CLIMATE ANALYSIS + PASSIVE STRATEGIES

ENVELOPE OPTIMIZATION

ORIENTATION / MASSING / GLAZING

SYSTEMS OPTIMIZATION

ENERGY USE
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, summers are by far the sunniest season.

The warmest month of the year in Pittsburgh is July, with a 24-hour average of 73.8 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 12 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%).
CLIMATE ANALYSIS + PASSIVE STRATEGIES

Temperature

-20°F to 110°F

Winter comfort zone: -20°F to 6°F
Summer comfort zone: 32°F to 110°F

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
CLIMATE ANALYSIS + PASSIVE STRATEGIES

Humidity

percent relative humidity

comfort zone

MSR | AKF | AIAMN NOVEMBER 15, 2015
CLIMATE ANALYSIS + PASSIVE STRATEGIES

PSYCHROMETRIC CHART

DESIGN STRATEGIES: JANUARY through DECEMBER

6.9% 1 Comfort(608 hrs)
   2 Sun Shading of Windows(0 hrs)
   3 High Thermal Mass(0 hrs)
   4 High Thermal Mass Night Flushed(0 hrs)
   5 Direct Evaporative Cooling(0 hrs)
   6 Two-Stage Evaporative Cooling(0 hrs)
   7 Natural Ventilation Cooling(0 hrs)
   8 Fan-Forced Ventilation Cooling(0 hrs)
   9 Internal Heat Gain(0 hrs)
  10 Passive Solar Direct Gain Low Mass(0 hrs)
  11 Passive Solar Direct Gain High Mass(0 hrs)
  12 Wind Protection of Outdoor Spaces(0 hrs)
  13 Humidification Only(0 hrs)
  14 Dehumidification Only(0 hrs)
  15 Cooling, add Dehumidification if needed(0 hrs)
  16 Heating, add Humidification if needed(0 hrs)

6.9% Comfortable Hours using Selected Strategies
(608 out of 8760 hrs)

human comfort 6.9%
PSYCHROMETRIC CHART

DESIGN STRATEGIES: JANUARY through DECEMBER

6.9% 1 Comfort (608 hrs)
  2 Sun Shading of Windows (0 hrs)
  3 High Thermal Mass (0 hrs)
  4 High Thermal Mass Night Flushed (0 hrs)
  5 Direct Evaporative Cooling (0 hrs)
  6 Two-Stage Evaporative Cooling (0 hrs)

10.7% 7 Natural Ventilation Cooling (938 hrs)
  8 Fan-Forced Ventilation Cooling (0 hrs)
  9 Internal Heat Gain (0 hrs)
  10 Passive Solar Direct Gain Low Mass (0 hrs)
  11 Passive Solar Direct Gain High Mass (0 hrs)
  12 Wind Protection of Outdoor Spaces (0 hrs)
  13 Humidification Only (0 hrs)
  14 Dehumidification Only (0 hrs)
  15 Cooling, add Dehumidification if needed (0 hrs)
  16 Heating, add Humidification if needed (0 hrs)

17.6% Comfortable Hours using Selected Strategies
(1546 out of 8760 hrs)

natural ventilation 10.7%
human comfort 6.9%
CLIMATE ANALYSIS + PASSIVE STRATEGIES

PSYCHROMETRIC CHART

- Natural Ventilation: 10.7%
- Internal Heat Gain: 22.8%
- Human Comfort: 6.9%

DESIGN STRATEGIES: JANUARY through DECEMBER

1. Comfort (608 hrs)
2. Sun Shading of Windows (0 hrs)
3. High Thermal Mass (0 hrs)
4. High Thermal Mass Night Flushed (0 hrs)
5. Direct Evaporative Cooling (0 hrs)
6. Two-Stage Evaporative Cooling (0 hrs)
7. Natural Ventilation Cooling (938 hrs)
8. Fan-Forced Ventilation Cooling (0 hrs)
10. Passive Solar Direct Gain Low Mass (0 hrs)
11. Passive Solar Direct Gain High Mass (0 hrs)
12. Wind Protection of Outdoor Spaces (0 hrs)
13. Humidification Only (0 hrs)
14. Dehumidification Only (0 hrs)
15. Cooling, add Dehumidification if needed (0 hrs)
16. Heating, add Humidification if needed (0 hrs)

40.4% Comfortable Hours using Selected Strategies
(3542 out of 8760 hrs)
METHODOLOGY

ESTABLISH BASELINES AND TARGETS

CLIMATE ANALYSIS + PASSIVE STRATEGIES

ENVELOPE OPTIMIZATION

ORIENTATION / MASSING / GLAZING

SYSTEMS OPTIMIZATION

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

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

Total Energy
183,854 kWh per year

heating 62%
interior 28%
cooling 6%
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: 20
- Roof r value: 20
- Slab r value: 12.5
- Glazing (u-value): 0.45
- Glazing (shgc): 0.3
- Infiltration (cfm/sf): 0.394
ENVELOPE OPTIMIZATION

Response Curve

Roof R-value (ft^2·h·°F/ BTU)
Steps: 10

Select up to two outputs:
EUI (kBTU/ft²/yr)

Roof EUI (kBTU/ft²/yr)

Floors
Floor Finish: Tiles
Ground Floor R-Value: 12.50 ft²·h·°F/ BTU

Infiltration
Infiltration Type: Facade Area
Design Infiltration Rate: 0.394 cfm/ft²

Roof Glazing
Assembly U-Value: 0.60 BTU/h·ft²·°F
Solar Heat Gain Coefficient (SHGC): 0.4

Roofs
Roof Type: Metal Deck
Roof R-Value: 20.00 ft²·h·°F/ BTU

wall r value 0%

roof r value 4%

slab r value 2%
## ENVELOPE OPTIMIZATION

### SPACE USE
- Occupant density (sf/pt): 90
- Equipment power density (W/sf): 0.9
- Lighting power density (W/sf): 1.4
- Outside air rate / person (cfm/pt): 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 (u value): 0.45
- Glazing (shgc): 0.3
- Infiltration (cfm/sf): 0.394

### Glazing U Value

![Graph showing glazing u value 10%]

### Glazing SHGC Value

![Graph showing glazing shgc value 0%]

### Glazing Window to Wall Ratio

![Graph showing glazing window to wall ratio]
**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) 20
- Roof (r value) 20
- Slab (r value) 12.5
- Glazing (uvalue) 0.45
- Glazing (shgc) 0.3
- Infiltration (cfm/sf) 0.394

**Infiltration**
- Envelope tightness 5%

**Lighting**
- Power density 5%

**Equipment**
- Power density
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 (u value): -
- glazing (shgc): -
- infiltration (cfm/sf): -

**regional average baseline**
- 105 eui

**code baseline energy model**
- 67 eui

**better envelope 1**
- 59 eui
  - 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
  - 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
  - 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
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

<table>
<thead>
<tr>
<th>Year</th>
<th>Percent Reduction</th>
<th>kbtu/sf</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>50%</td>
<td>49</td>
</tr>
<tr>
<td>2010</td>
<td>60%</td>
<td>39</td>
</tr>
<tr>
<td>2015</td>
<td>70%</td>
<td>29</td>
</tr>
<tr>
<td>2020</td>
<td>80%</td>
<td>19</td>
</tr>
<tr>
<td>2025</td>
<td>90%</td>
<td>10</td>
</tr>
<tr>
<td>2030</td>
<td>100%</td>
<td>0</td>
</tr>
</tbody>
</table>

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.
### Baseline Energy Model Values

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

### EUI (kbtu/sf)

- **Baseline**

### Energy Consumption

- **Monthly Energy Consumption**
- **Monthly Heat Gains**
- **Monthly Heat Losses**

**Note:** The diagrams show the energy consumption and gains/losses for various appliances and systems throughout the year. The energy consumption is categorized into different months, and the gains and losses are categorized into different seasons and equipment types.
### Improved Envelope + HVAC Values

<table>
<thead>
<tr>
<th>Massing</th>
<th>Baseline Massing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Climate Zone 4</td>
</tr>
<tr>
<td>Building Type</td>
<td>Library</td>
</tr>
<tr>
<td>Occupancy</td>
<td>330 people</td>
</tr>
<tr>
<td>Operational Hours</td>
<td>6am - 10pm daily</td>
</tr>
<tr>
<td>Lighting Power Density</td>
<td>1.3 W/ft²</td>
</tr>
<tr>
<td>Plug Load Density</td>
<td>1.1 W/ft²</td>
</tr>
<tr>
<td>Heating Setpoint</td>
<td>66 deg F</td>
</tr>
<tr>
<td>Cooling Setpoint</td>
<td>72 deg F</td>
</tr>
<tr>
<td>Glazing %</td>
<td>40%</td>
</tr>
<tr>
<td>Glazing U value</td>
<td>0.10</td>
</tr>
<tr>
<td>Glazing SHGC value</td>
<td>0.3</td>
</tr>
<tr>
<td>Wall R value</td>
<td>35</td>
</tr>
<tr>
<td>Roof R value</td>
<td>40</td>
</tr>
<tr>
<td>Slab R value</td>
<td>6</td>
</tr>
</tbody>
</table>

#### HVAC System Details
- **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)
- Baseline: **124**
- This Option: **73**
Spatial Daylight Autonomy (DA) 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).

- **Spatial Daylight Autonomy**: 81% of floor area
- **LEED v4 Daylight Points?**: 3 points
  - (sDA>55% = 2 points, sDA>75% = 3 points)
- **Continuous Daylight Autonomy**: 91% of floor area
- **Mean Daylight Factor**: 3.3%
  - (% of exterior daylight available in interior)
- **Daylight Factor Analysis**: 43% of floor area
  - (DF > 2%)
- **Useful Daylight Illuminance**: 89% of floor area
  - (UDI 100-2000lux=150%)

**Spatial Daylight Autonomy Scale**

- **Spatial Daylight Autonomy Scale**: 5%
  - 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

**Daylight Performance**

- **Baseline**
- **This Option**

**EUI (kbtu/sf)**

- **Baseline**: 124
- **This Option**: 73

**Monthly Energy Consumption**

- **Baseline**
- **This Option**

**Monthly Heat Gains**

- **Baseline**
- **This Option**

**Monthly Heat Losses**

- **Baseline**
- **This Option**
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)**
Baseline
This Option

**Monthly Energy Consumption**

**Monthly Heat Gains**

**Monthly Heat Losses**
**Daylight Performance**

Spatial Daylight Autonomy (DA300 lux > 30%) 88% of floor area

LEED v4 Daylight Points? (sDA>35% = 2 points; sDA >50% = 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=2 points) 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).
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

EUI (kBTU/sf)

- Baseline: 124
- This Option: 98

Monthly Energy Consumption

- Appliances
- Lighting
- Fan
- Cooling
- Hot Water
- Space Heating
- Electric Heating

Monthly Heat Gains

- Equipment
- Lighting
- Occupant
- Infiltration
- Ventilation
- Conduction
- Solar

Monthly Heat Losses

- Equipment
- Lighting
- Occupant
- Infiltration
- Ventilation
- Conduction
- Solar
**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%)
  - 98% of floor area

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

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

- **Useful Daylight Illuminance**
  - (UDI 100-2000lux>150%)
  - 7% 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)**

- **Baseline**
  - 124

- **This Option**
  - 98

---

**Monthly Energy Consumption**

- **MONTHLY ENERGY CONSUMPTION**

<table>
<thead>
<tr>
<th>Month</th>
<th>Appliances</th>
<th>Lighting</th>
<th>Fan</th>
<th>Cooling</th>
<th>Hot Water</th>
<th>Space Heating</th>
<th>Electric Heating</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MONTHLY HEAT GAIN**

- **MONTHLY HEAT LOSS**

<table>
<thead>
<tr>
<th>Month</th>
<th>Equipment</th>
<th>Lighting</th>
<th>Occupant</th>
<th>Infiltration</th>
<th>Ventilation</th>
<th>Conduction</th>
<th>Solar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EUI (kbtu/sf)**

- **Baseline**
  - 124

- **This Option**
  - 98
Improved Envelope + HVAC Values

- Massing Concept: 3C 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)

- Baseline
- This Option

Monthly Energy Consumption

- Appliances
- Lighting
- Fan
- Cooling
- Hot water
- Space heating
- Electric heating

Monthly Heat Gains

- Appliances
- Lighting
- Fan
- Cooling
- Hot water
- Space heating
- Electric heating

Monthly Heat Losses

- Appliances
- Lighting
- Fan
- Cooling
- Hot water
- Space heating
- Electric heating

ORIENTATION / MASSING / GLAZING
Daylight Performance

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

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

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

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

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

Useful Daylight Illuminance
(UDI 100-2000lux=50%): 81% 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)

Baseline
This Option

Monthly Energy Consumption

Monthly Heat Gains

Monthly Heat Losses

ORIENTATION / MASSING / GLAZING
Improved Envelope + HVAC Values

- Massing Concept: Massing 3D
- 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)

- Baseline: 124
- This Option: 82

Monthly Energy Consumption

- Appliances: electricity
- Lighting: electricity
- Fan: electricity
- Cooling: electricity
- Hot Water: electricity
- Space Heating: electricity
- Electric Heating: electricity

Monthly Heat Gains

- Appliances: electricity
- Lighting: electricity
- Fan: electricity
- Cooling: electricity
- Hot Water: electricity
- Space Heating: electricity
- Electric Heating: electricity

Monthly Heat Losses

- Appliances: electricity
- Lighting: electricity
- Fan: electricity
- Cooling: electricity
- Hot Water: electricity
- Space Heating: electricity
- Electric Heating: electricity
Daylight Performance

Spatial Daylight Autonomy (DA 300 lux > 50%) 99% of floor area

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

Continuous Daylight Autonomy (DA 300 lux > 50% + partial credit < 50%) 96% of floor area

Mean Daylight Factor (% of exterior daylight available in interior) 51.0%

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).

EUI (kBTU/sf)

124 82

Baseline This Option

Monthly Energy Consumption

Monthly Heat Gains

Monthly Heat Losses

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).
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

EUI (kbtu/sf)

Baseline
This Option

Monthly Energy Consumption

Monthly Heat Gains

Monthly Heat Losses
Daylight Performance

Spatial Daylight Autonomy (DA>300 lux > 50%)
99% of floor area

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

Continuous Daylight Autonomy (DA>300 lux > 50% + partial credit)<50%)
95% of floor area

Mean Daylight Factor (% of exterior daylight available in interior)
41.9%

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).

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).

Daylight Performance

Spatial Daylight Autonomy (DA>300 lux > 50%)
99% of floor area

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

Continuous Daylight Autonomy (DA>300 lux > 50% + partial credit)<50%)
95% of floor area

Mean Daylight Factor (% of exterior daylight available in interior)
41.9%

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).

Daylight Performance

Spatial Daylight Autonomy (DA>300 lux > 50%)
99% of floor area

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

Continuous Daylight Autonomy (DA>300 lux > 50% + partial credit)<50%)
95% of floor area

Mean Daylight Factor (% of exterior daylight available in interior)
41.9%

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).
### Improved Envelope + HVAC Values

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

### Monthly Energy Consumption

- **This Option**
  - appliances
  - lighting
  - fan
  - cooling
  - hot water
  - space heating
  - electric heating

### Monthly Heat Gains

- **This Option**
  - equipment
  - lighting
  - occupant
  - infiltration
  - ventilation
  - conduction
  - solar

### Monthly Heat Losses

- **This Option**
  - equipment
  - lighting
  - occupant
  - infiltration
  - ventilation
  - conduction
  - solar

---

**EUI (kbtu/sf)**

<table>
<thead>
<tr>
<th>Option</th>
<th>EUI (kbtu/sf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>124</td>
</tr>
<tr>
<td>This Option</td>
<td>92</td>
</tr>
</tbody>
</table>

---

**ORIENTATION / MASSING / GLAZING**
Daylight Performance

Spatial Daylight Autonomy
(DA > 300 lux > 50%)
99% of floor area

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

Continuous Daylight Autonomy
(DA > 300 lux > 50% + partial credit < 50%)
98% of floor area

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

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

Useful Daylight Illuminance
(UDI > 100-2000 lux > 50%)
41% 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).

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).
Improved Envelope + HVAC Values

<table>
<thead>
<tr>
<th>Massing Concept</th>
<th>Massing 3G Shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Climate Zone 4</td>
</tr>
<tr>
<td>Building Type</td>
<td>Library</td>
</tr>
<tr>
<td>Occupancy</td>
<td>330 people</td>
</tr>
<tr>
<td>Operational Hours</td>
<td>6am - 10pm daily</td>
</tr>
<tr>
<td>Lighting Power Density</td>
<td>1.3 W/ft²</td>
</tr>
<tr>
<td>Plug Load Density</td>
<td>1 W/ft²</td>
</tr>
<tr>
<td>Heating Setpoint</td>
<td>68 deg F</td>
</tr>
<tr>
<td>Cooling Setpoint</td>
<td>72 deg F</td>
</tr>
<tr>
<td>Glazing %</td>
<td>40%</td>
</tr>
<tr>
<td>Glazing U value</td>
<td>0.10</td>
</tr>
<tr>
<td>Glazing SHGC value</td>
<td>0.3</td>
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<tr>
<td>Wall R value</td>
<td>35</td>
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<td>Roof R value</td>
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</tr>
<tr>
<td>HVAC System Type</td>
<td>GSHP</td>
</tr>
<tr>
<td>Ventilation Rate</td>
<td>0.2 cfm/ft²</td>
</tr>
<tr>
<td>Heating Equipment COP</td>
<td>2.5 - Electric GSHP</td>
</tr>
<tr>
<td>Cooling Equipment COP</td>
<td>4.5 - Water cooled chiller</td>
</tr>
</tbody>
</table>

EUI (kbtu/sf)

Monthly Energy Consumption

Monthly Heat Gains

Monthly Heat Losses

Orient ation / Massing / Glazing

MSR | AKF | AIAMN November 15, 2015
Daylight Performance

Spatial Daylight Autonomy
(\(DA_{300} \) lux \(>30\%\))
98% of floor area

LEED v4 Daylight Points?
(\(sDA_{>55\%} = 2\) points \(; sDA_{>75\%} = 3\) points)
3 points

Continuous Daylight Autonomy
(\(DA_{300} \) lux \(>30\%\) + partial \(<50\%\))
95% of floor area

Mean Daylight Factor
(% of exterior daylight available in interior)
87%

Daylight Factor Analysis
(\(DF \geq 2\%\))
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).

EUI (kbtu/sf)

Baseline
This Option

Baseline
This Option

Monthly Energy Consumption

Monthly Heat Gains

Monthly Heat Losses
MSR | AKF | AIAMN NOVEMBER 15, 2015

ORIENTATION / MASSING / GLAZING

Improved Envelope + HVAC Values

- Massing 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

EUI (kbtu/sf)

- Baseline: 124
- This Option: 75

Monthly Energy Consumption

- Appliances
- Lighting
- Fan
- Cooling
- Hot Water
- Space Heating
- Electric Heating

Monthly Heat Gains

- Equipment
- Lighting
- Occupant
- Infiltration
- Ventilation
- Conduction
- Solar

Monthly Heat Losses

- Equipment
- Lighting
- Occupant
- Infiltration
- Ventilation
- Conduction
- Solar

ANNUAL ENERGY USE

- Baseline
- This Option

ANNUAL ENERGY USE

- Baseline
- This Option

EUI (kbtu/sf)

- Baseline: 124
- This Option: 75

ANNUAL ENERGY USE

- Baseline
- This Option

EUI (kbtu/sf)

- Baseline: 124
- This Option: 75
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

ENERGY USE
SYSTEMS OPTIMIZATION

Ex Mod

Clover

Pi

- HVAC
- Lighting
- Water Heating
- Plug Loads

39%
32%
6%
22%

35%
35%
6%
21%

40%
30%
7%
23%
METHODOLOGY

ESTABLISH BASELINES AND TARGETS

CLIMATE ANALYSIS + PASSIVE STRATEGIES

ENVELOPE OPTIMIZATION

ORIENTATION / MASSING / GLAZING

SYSTEMS OPTIMIZATION
COLLABORATIVE ENERGY MODELING

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

Upfront input on systems alternatives
Modeling input

Handoff

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

ARCHITECT

ENGINEER

PD  SD  DD  CD  CA  Occupancy

MSR | AKF | AIAMN NOVEMBER 15, 2015
CONCLUSIONS

1. AIA 2030 COMMITMENT
CONCLUSIONS

1. AIA 2030 COMMITMENT

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
Systems optimization

Upfront input on systems alternatives
Modeling input

Handoff

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

ARCHITECT

ENGINEER

PD | SD | DD | CD | CA | Occupancy