



# Introduction to Sketchbox

Simplified energy modeling tool for your classroom

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April 15, 2022



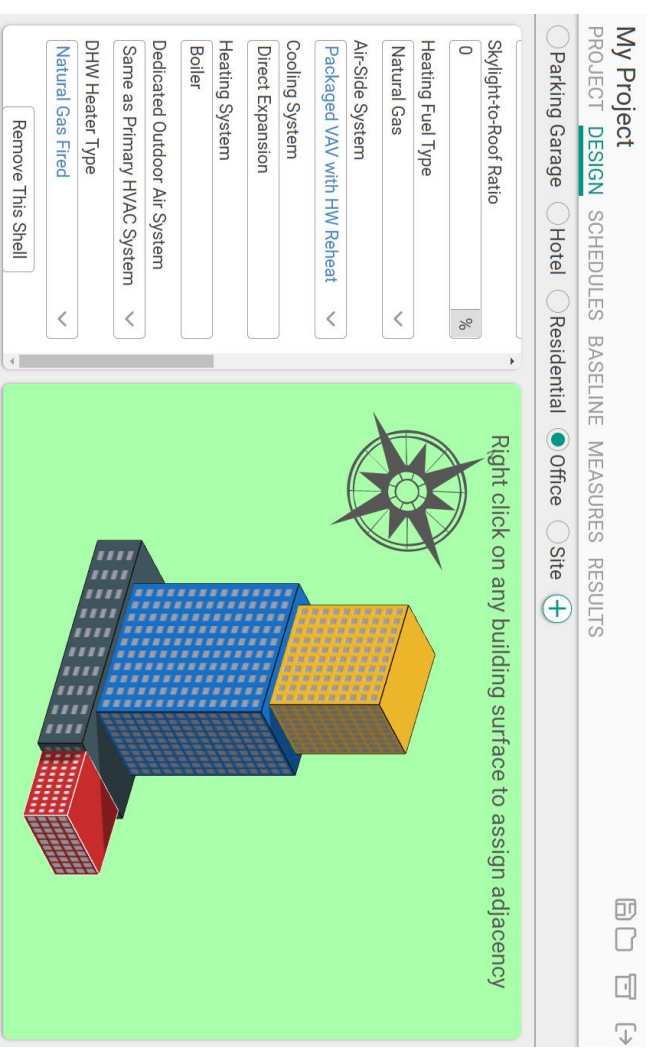
**Accelerating climate solutions. For everyone.**

**We deliver research, technical assistance, financing, education and training, and programs for stakeholders.**

# What Is It?

## Concept energy modeling tool

- Intuitive user interface
- Helps designers focus on what matters
- Supports most building types and HVAC system types
- 10x faster than traditional energy models



# Technical Overview

- Cloud-based modeling tool
- Based on DOE2 engine
  - Fast run time
  - Open source
- Includes all commercial building types including schools and multifamily
- Advanced HVAC options
  - Dedicated outside air (DOAS)
  - Ground-source heat pump (GSHP)
  - Variable refrigerant flow (VRF)
  - Radiant systems

My Project

PROJECT DESIGN SCHEDULES BASELINE **MEASURES** RESULTS

### 5 – Efficient Interior Lighting

Interior Lighting Power (W/ft<sup>2</sup>)


No Change 0.135	Better 0.105	Best 0.06	Custom	Parking Garage
No Change 0.675	Better 0.64	Best 0.55	Custom	Hotel
No Change 0.612	Better 0.49	Best 0.44	Custom	Residential
No Change 0.711	Better 0.65	Best 0.5	Custom 	Office

### 6 – Upgrade Cooling Equipment

Average Cooling Equipment Efficiency (kW/ton)

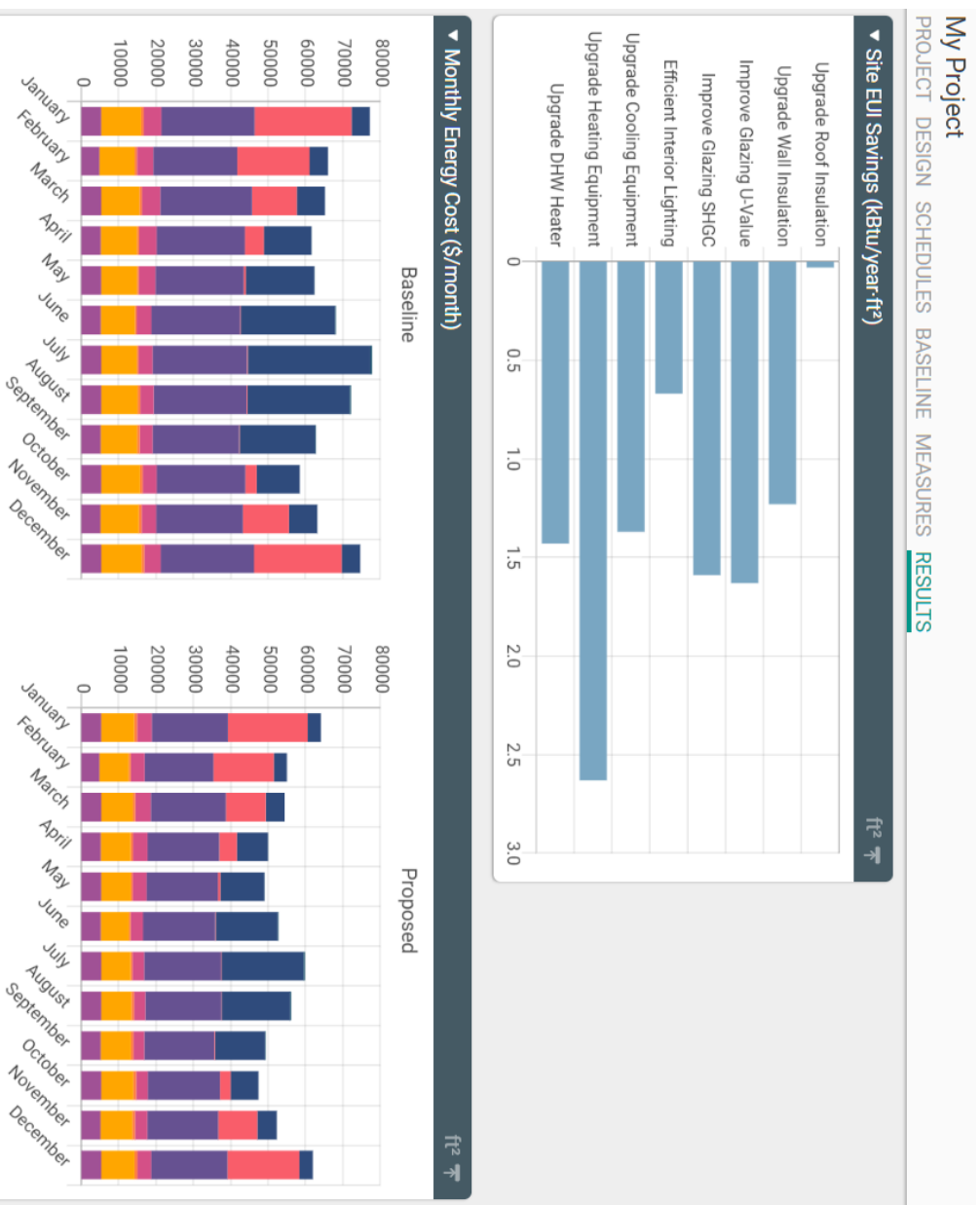
No Change 0.61	Better 0.45	Best 0.35	Custom	Parking Garage
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Average Cooling Equipment Efficiency (EER)

No Change 10.7	Better 12	Best 13	Custom	Hotel
No Change 10.7	Better 12	Best 13	Custom	Residential
No Change 9.8	Better 11	Best 12	Custom 	Office

# Results

- Visual results
- Measure-by-measure results
- Customizable
- Automatic energy efficiency recommendations based on real project experience
- Quickly evaluate 60+ common efficiency strategies



# Sketchbox simplified energy modeling tool

Received a grant to support lessons for tech colleges and high schools

- Educate students on energy efficiency and building design
- Approachable for less technical users
- Remote-hosted, scalable to many users
- Interactive web browser interface, works on mobile
- **FREE!**

# Building Energy Simulation

## SOFTWARE & SERVICE LEARNING

- 2<sup>nd</sup>-year class after HVAC, lighting and other building energy use fundamentals









**My Project**  
 PROJECT DESIGN SCHEDULES **BASELINE** MEASURES RESULTS

School  Site

**Lighting**

Exterior Lighting Zone

Base Site Allowance  W

Parking Areas and Drives  W/ft²

Walkways Less than 10 Ft Wide  W/ft

Door Allowance  W/ft  W/ft  KW

Main Entry

Exterior Lighting Power

Reduction from Controls

Leave both options under Baseline (School and Site) as is

**My Project**  
 PROJECT DESIGN SCHEDULES **BASELINE** MEASURES RESULTS

School  Site

**Envelope**

Roof U-Value  BTU/hr-ft²-F

Wall U-Value  BTU/hr-ft²-F

Slab F-Factor  BTU/hr-ft²-F

Infiltration  ACH

**Skylight**

U-Value  BTU/hr-ft²-F

Solar Heat Gain Coefficient

Visible Transmissivity

**Internal Loads**

Occupant Density  ft²/person

Occupant Heat Gain (BTU/hr-person)

Sensible  Latent

Misc. Equipment Power  W/ft²

**Heating and Cooling**

Average Equipment Efficiency

Cooling  EER  % E<sub>s</sub>

Average DOAS Equipment Efficiency

Cooling  Heating

Humidity Setpoint

Minimum  % Maximum  %

Fan Power  W/CFM

DOAS Fan Power

VAV Box Minimum  This Input

**Glazing**

U-Value (BTU/hr-ft²-F)

North	0.36	South	0.36	East	0.36	West	0.36
-------	------	-------	------	------	------	------	------

Solar Heat Gain Coefficient

North	0.4	South	0.4	East	0.4	West	0.4
-------	-----	-------	-----	------	-----	------	-----

Visible Transmissivity

North	0.7	South	0.7	East	0.7	West	0.7
-------	-----	-------	-----	------	-----	------	-----

Depth of Overhang (ft)

North	0	South	0	East	0	West	0
-------	---	-------	---	------	---	------	---

Depth of Fins (ft)

North	0	South	0	East	0	West	0
-------	---	-------	---	------	---	------	---

**Lighting**

Interior Lighting Power  W/ft²

Reduction from Controls  %

Daylighting

Daylight Control Method

Illuminance Target  ft

**Domestic Hot Water**

Demand  BTU/hr-person

Heater Efficiency  %

**Ventilation**

Ventilation Rate  CFM/person

Ventilation Minimum Flow Fraction

Air-Side Economizer

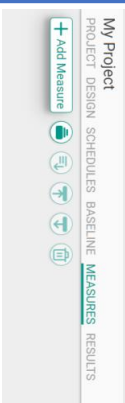
Demand Control Ventilation

Energy Recovery Ventilation

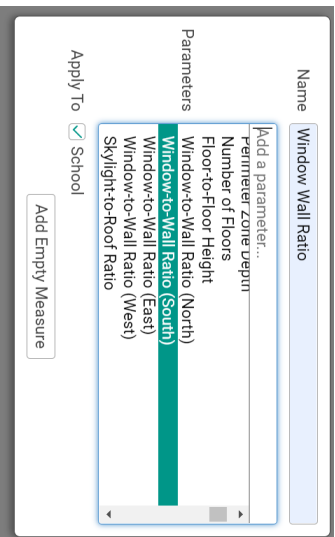
ERV Type

ERV Effectiveness

# MEASURES



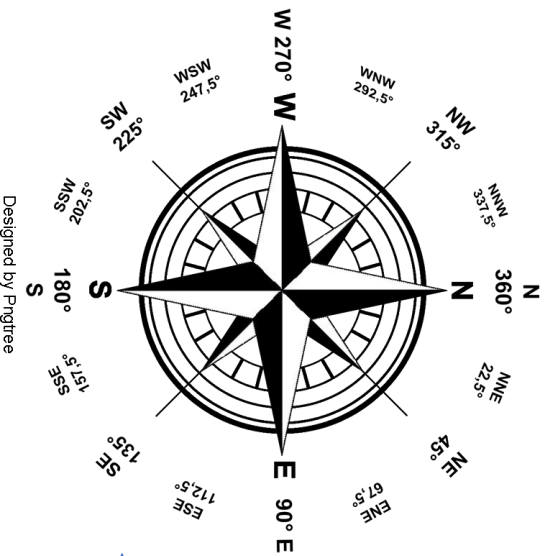
Select "Add Measures"



Select the "Window to Wall Ratio" and "Orientation" that holds potential for optimizing the buildings energy efficiency by your geographical location

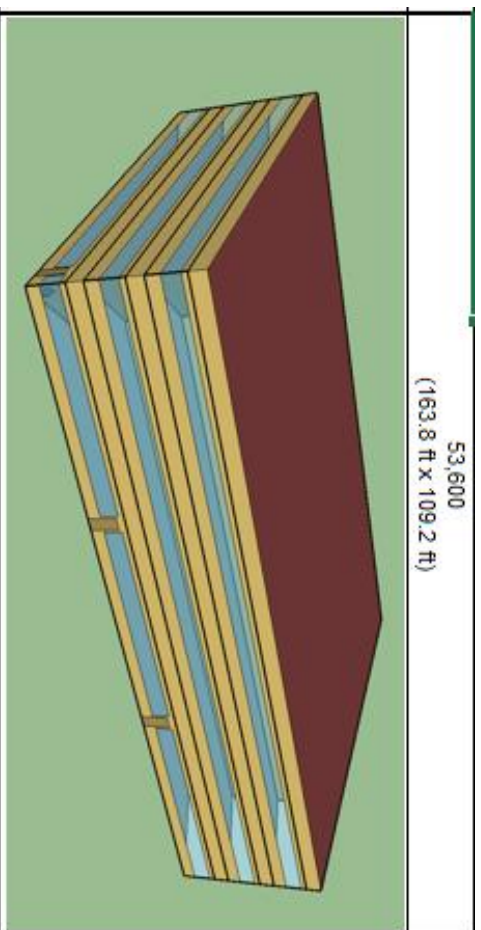


Select "Custom" to input a new "Window to Wall Ratio" and "Orientation"



Reference for degree orientation

## Prototype model – Medium office



- Location – Chicago, Zone 5A
- Medium office
- 60,000 sf
- 3 floors
- All electric building

# Project Description

## Demo - office

PROJECT DESIGN SCHEDULES BASELINE MEASURES RESULTS

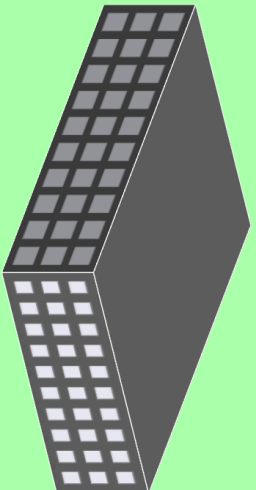
General	
Project Name	Demo - office
State	Illinois
Nearest City	Chicago
Energy Code	IECC 2018
Compliance Path	ASHRAE 90.1-2016

Financial	
Rate Category	Commercial
Cost of Electricity	0.09 \$/kWh
Cost of Natural Gas	0.693 \$/therm

Emissions	
Energy Source to Site Ratio	
Electricity	2.8
Natural Gas	1.05
CO <sub>2</sub> Equivalence for Electricity	0.371 kg of CO <sub>2</sub> e/kWh
CO <sub>2</sub> Equivalence for Natural Gas	5.3 kg of CO <sub>2</sub> e/therm



# Project Design



## Geometry

Name	Office	Color	
Building Type	Office - Medium		
Parent Shell	None	Adjacency	Not Used
Area	60000 ft <sup>2</sup>	Aspect Ratio	1.5
Floors Number	3	Height	13 ft
Perimeter Zone Depth	15 ft		

## Building description

Heating Fuel Type	Electricity
Air-Side System	Packaged Heat Pumps
Cooling System	Water Source Heat Pumps
Heating System	Water Source Heat Pumps
Dedicated Outdoor Air System	Same as Primary HVAC System
DHW Heater Type	Electric Resistance

## HVAC



# Medium office - Schedules

**Weekday**

Schedule Type **Simplified**

Use Simple Thermostats

Occupancy **Normal**

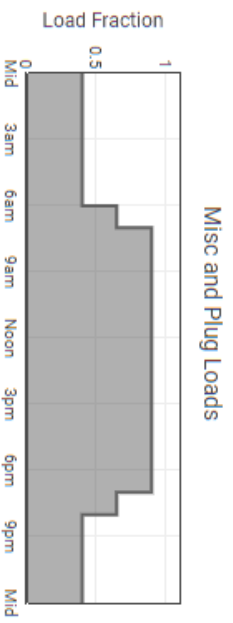
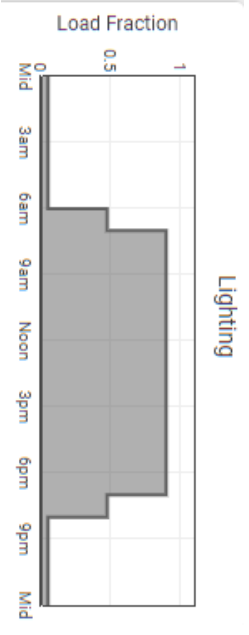
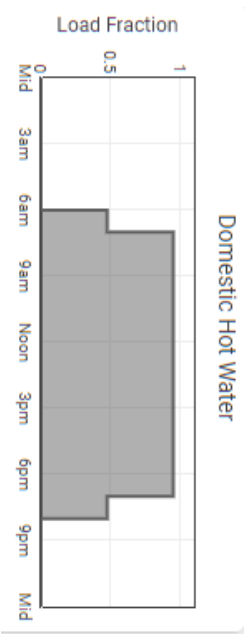
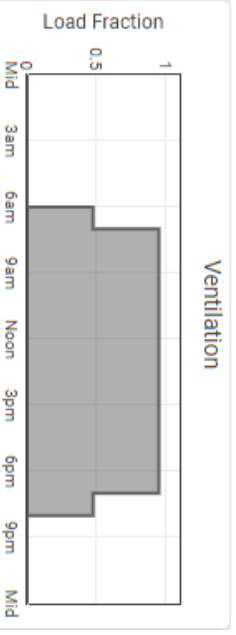
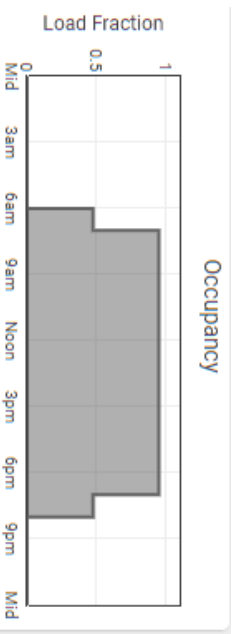
Weekday Schedule **7 am to 7 pm**

**Weekend**

Schedule Type **Simplified**

Use Simple Thermostats

Occupancy **Never Occupied**



# Medium office - Schedules

## Thermostats

Cooling Setpoint

Occupied  °F

°F

Heating Setpoint

Occupied  °F

°F

Unoccupied  °F

°F

Unoccupied  °F

°F

Setpoint Offset

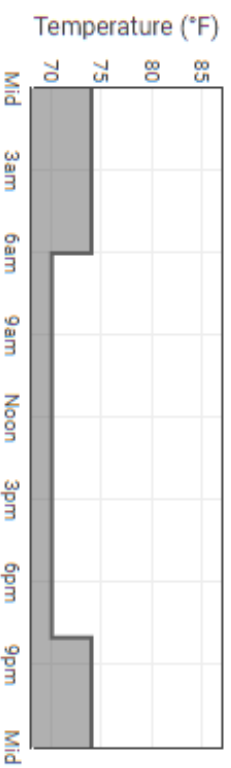
Cooling  °F

°F

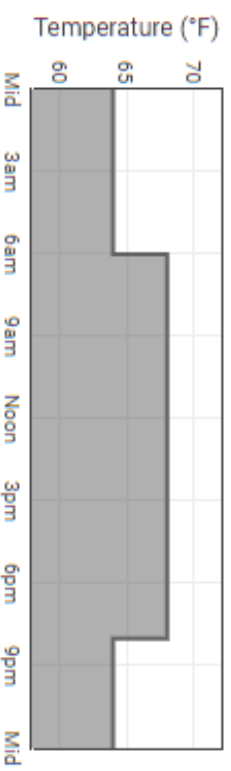
Heating  °F

°F

Cooling Setpoint



Heating Setpoint



# Baseline – Envelope and Lighting

### Envelope

Roof U-Value	<input type="text" value="0.032"/>	BTU/hr-ft <sup>2</sup> -°F
Wall U-Value	<input type="text" value="0.055"/>	BTU/hr-ft <sup>2</sup> -°F
Slab F-Factor	<input type="text" value="0.52"/>	BTU/hr-ft <sup>2</sup> -°F
Infiltration	<input type="text" value="0.6"/>	ACH

### Glazing

U-Value (BTU/hr-ft <sup>2</sup> -°F)		North	South	East	West
<input type="text" value="0.38"/>		<input type="text" value="0.38"/>	<input type="text" value="0.38"/>	<input type="text" value="0.38"/>	<input type="text" value="0.38"/>
Solar Heat Gain Coefficient		North	South	East	West
<input type="text" value="0.38"/>		<input type="text" value="0.38"/>	<input type="text" value="0.38"/>	<input type="text" value="0.38"/>	<input type="text" value="0.38"/>
Visible Transmissivity		North	South	East	West
<input type="text" value="0.7"/>		<input type="text" value="0.7"/>	<input type="text" value="0.7"/>	<input type="text" value="0.7"/>	<input type="text" value="0.7"/>
Depth of Overhang (ft)		North	South	East	West
<input type="text" value="0"/>		<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Depth of Fins (ft)		North	South	East	West
<input type="text" value="0"/>		<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

### Lighting

Interior Lighting Power	<input type="text" value="0.79"/>	W/ft <sup>2</sup>
Reduction from Controls	<input type="text" value="0"/>	%
Daylighting	<input type="text" value="Yes"/>	
Daylight Control Method	<input type="text" value="Stepped"/>	
Illuminance Target	<input type="text" value="30"/>	fc





# Medium office - HVAC

## Heating and Cooling

### Average Equipment Efficiency

Cooling

13 EER

Heating

4.3 COP

### Average DOAS Equipment Efficiency

Cooling

13 EER

Heating

4.3 COP

### Humidity Setpoint

Minimum

0 %

Maximum

60 %

### Fan Power

0.821 W/CFM

### DOAS Fan Power

1.119 W/CFM

### VAV Box Minimum

Not Used

## Ventilation

### Ventilation Rate

17 CFM/person

### Ventilation Minimum Flow Fraction

0

### Air-Side Economizer

Yes

### Demand Control Ventilation

No

### Energy Recovery Ventilation

No

### ERV Type

Not Used

### ERV Effectiveness

Not Used

# Medium office - ECMS

## 1 – Upgrade Roof Insulation

Roof U-Value (BTU/hr-ft<sup>2</sup>-F)

No Change 0.032 Better 0.03 Best 0.028 Custom Office

## 2 – Upgrade Wall Insulation

Wall U-Value (BTU/hr-ft<sup>2</sup>-F)

No Change 0.055 Better 0.043 Best 0.036 Custom Office

## 3 – Improve Glazing U-Value

Glazing U-Value – North (BTU/hr-ft<sup>2</sup>-F)

No Change 0.38 Better 0.34 Best 0.3 Custom Office

Glazing U-Value – South (BTU/hr-ft<sup>2</sup>-F)

No Change 0.38 Better 0.34 Best 0.3 Custom Office

Glazing U-Value – East (BTU/hr-ft<sup>2</sup>-F)

No Change 0.38 Better 0.34 Best 0.3 Custom Office

Glazing U-Value – West (BTU/hr-ft<sup>2</sup>-F)

No Change 0.38 Better 0.34 Best 0.3 Custom Office

## 4 – Improve Glazing SHGC

Glazing Solar Heat Gain Coefficient – North

No Change 0.38 Better 0.3 Best 0.25 Custom Office

Glazing Solar Heat Gain Coefficient – South

No Change 0.38 Better 0.3 Best 0.25 Custom Office

Glazing Solar Heat Gain Coefficient – East

No Change 0.38 Better 0.3 Best 0.25 Custom Office

Glazing Solar Heat Gain Coefficient – West

No Change 0.38 Better 0.3 Best 0.25 Custom Office

## 5 – Efficient Interior Lighting

Interior Lighting Power (W/ft<sup>2</sup>)

No Change 0.79 Better 0.65 Best 0.5 Custom Office

## 6 – Efficient Exterior Lighting

Exterior Lighting Power (kW)

No Change 3.93 Better 2.67 Best 1.46 Custom Exterior

# Medium office - ECMS

## 7 – Upgrade Cooling Equipment

Average Cooling Equipment Efficiency (EER)

No Change 13 Better 16 Best 21 Custom Office

## 8 – Upgrade Heating Equipment

Average Heating Equipment Efficiency (COP)

No Change 4.3 Better 5.3 Best 6 Custom Office

## 9 – Upgrade DHW Heater

Domestic Hot Water Heater Efficiency (%)

No Change 100 Better Not Available Best Not Available Custom Not Available Office

## 10 – WWR

Window-to-Wall Ratio – West (%)

No Change 40 Better Not Available Best Not Available Custom 20 Office

Window-to-Wall Ratio – South (%)

No Change 40 Better Not Available Best Not Available Custom 20 Office

## 11 – Infil

Infiltration (ACH)

No Change 0.6 Better Not Available Best Not Available Custom 0.4 Office

## 12 – Orientation

Orientation (°)

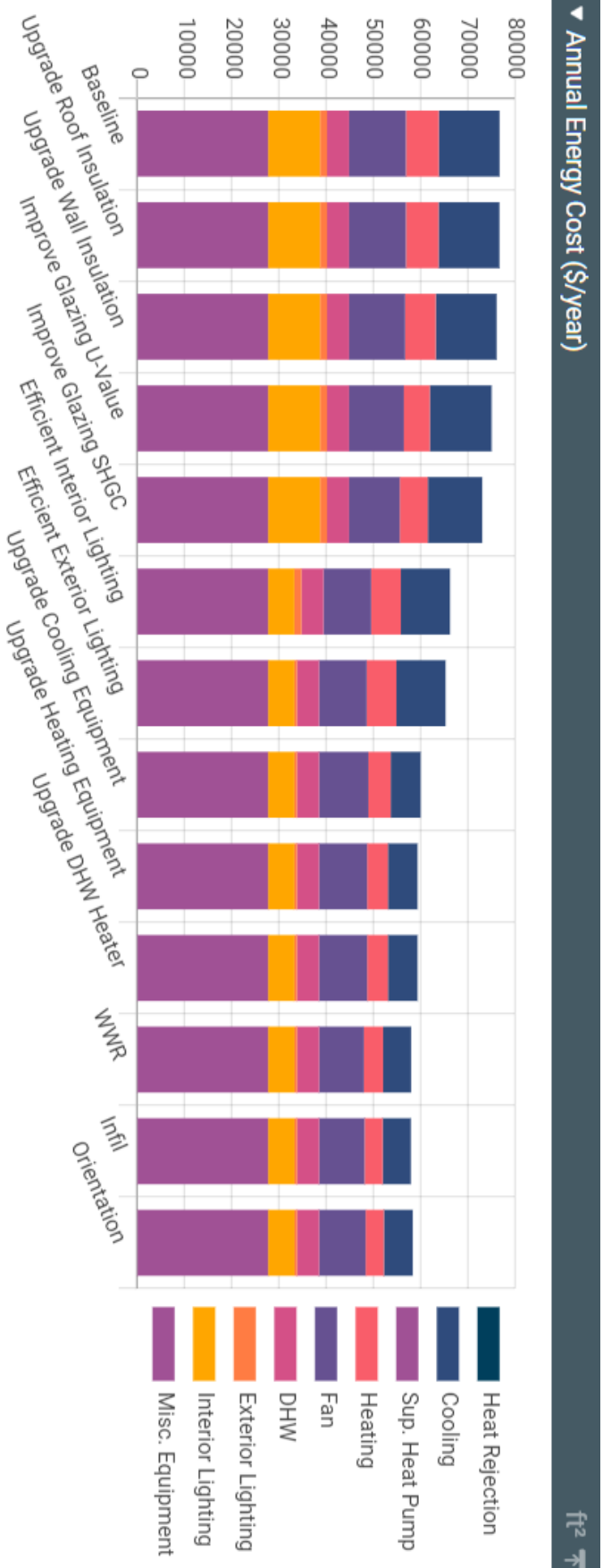
No Change 0 Better Not Available Best Not Available Custom 90 Exterior

# Results – Annual energy use summary

Annual Summary		ft <sup>2</sup> ↴		
	Baseline	Proposed	Absolute Savings	Relative Savings
Energy Cost (\$)	85,902	64,646	21,256	25%
Electric Consumption (kWh)	954,422	718,227	236,195	25%
Natural Gas Consumption (therm)	7	7	0	0%
Site EUI (kBtu/ft <sup>2</sup> )	54.3	40.9	13.4	25%
Source EUI (kBtu/ft <sup>2</sup> )	152	114.4	37.6	25%
CO <sub>2</sub> Equivalent (kg of CO <sub>2</sub> e)	354,128	266,498	87,630	25%



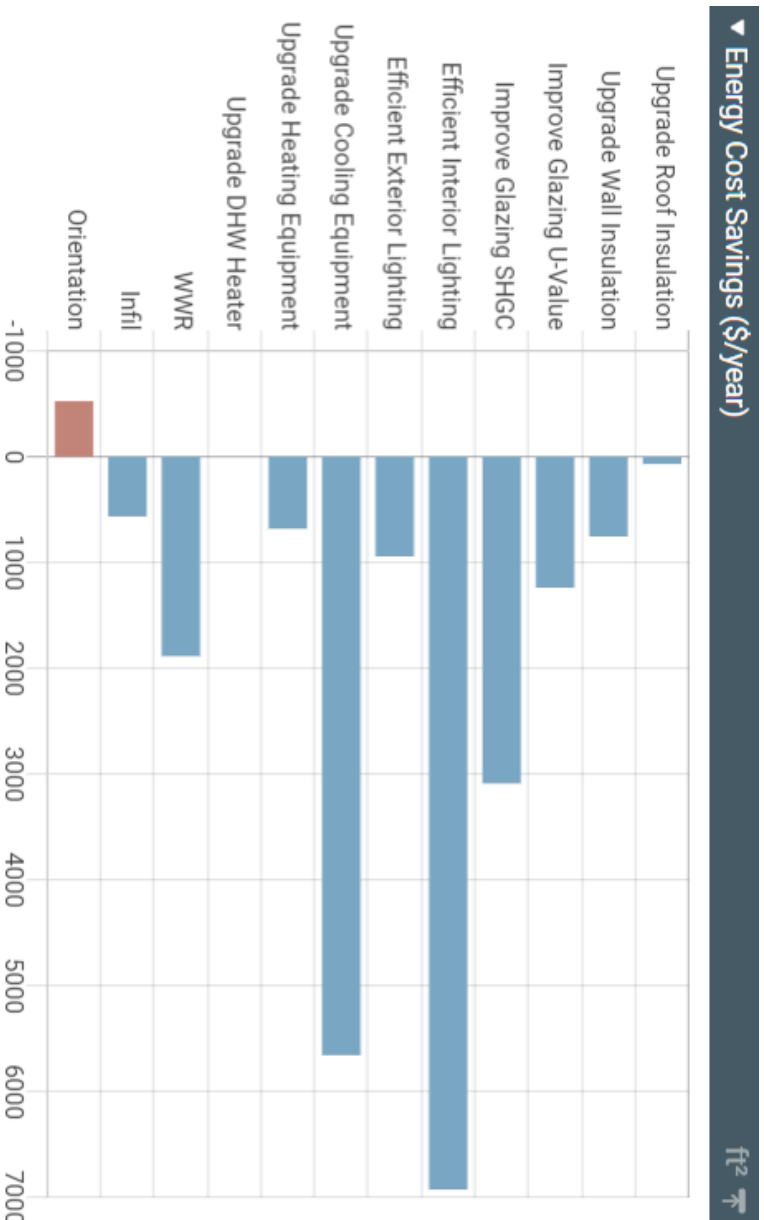
# Results – Annual energy cost



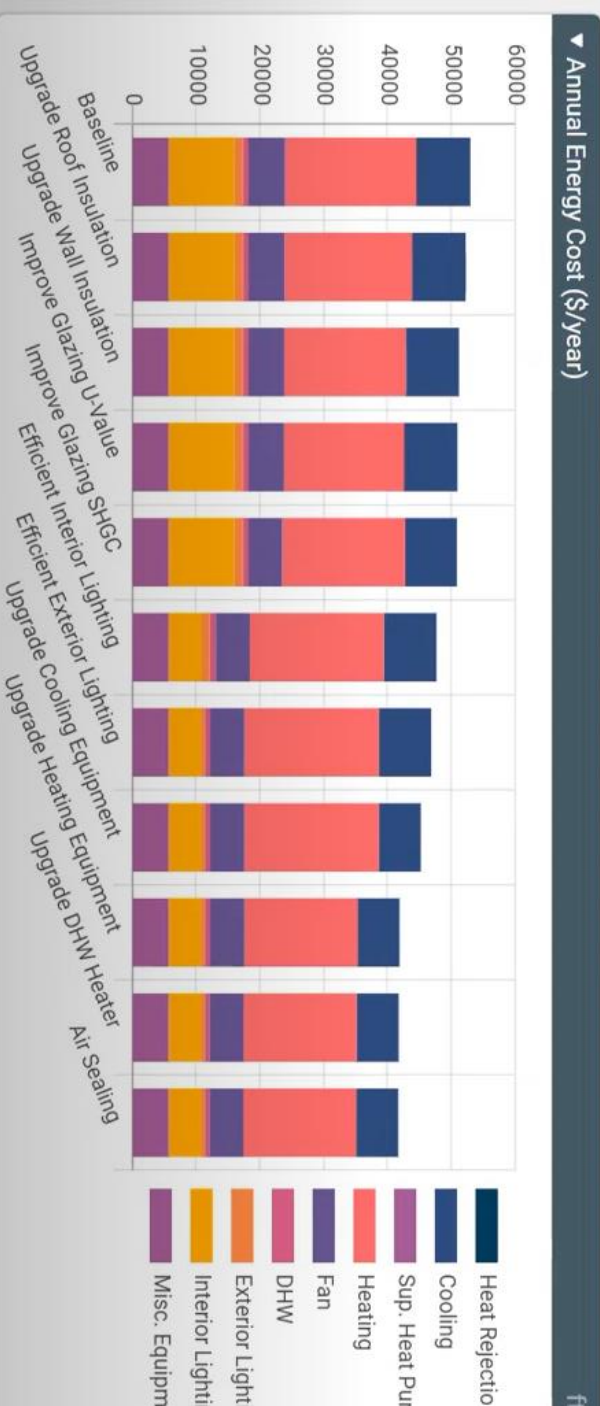
# Results – Monthly energy cost



# Results – Monthly energy cost



Annual Summary				ft <sup>2</sup>
	Baseline	Proposed	Absolute Savings	Relative Savings
Energy Cost (\$)	53,374	42,089	11,285	21%
Electric Consumption (kWh)	354,617	263,156	91,460	26%
Natural Gas Consumption (therm)	30,965	26,559	4,406	14%
Site EUI (kBtu/ft <sup>2</sup> )	39.1	32.3	6.8	17%
Source EUI (kBtu/ft <sup>2</sup> )	60.4	48.2	12.1	20%
CO <sub>2</sub> Equivalent (kg of CO <sub>2</sub> e)	295,675	238,391	57,284	19%



## Create lessons

- Demonstrate how building systems interact
- Explain energy savings beyond code baseline
- Discuss energy efficiency measures that have the most impact
- Examine pathways to net zero buildings
- Identify carbon impacts
- Model your own school

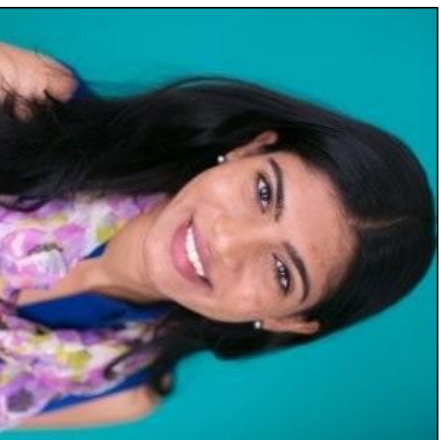


Sign up for free access to Sketchbox

<https://slipstreamdemo.paperform.co/>

# Learn more about Sketchbox for your classroom

- Received a **grant** to support lessons for tech colleges and high schools
- Looking for **teachers** to help guide the lessons so it is suitable for learning.
- **Inspire** students to consider careers in the emerging clean energy sector
- **Contact us** if interested to pilot Sketchbox in your class or to learn more.



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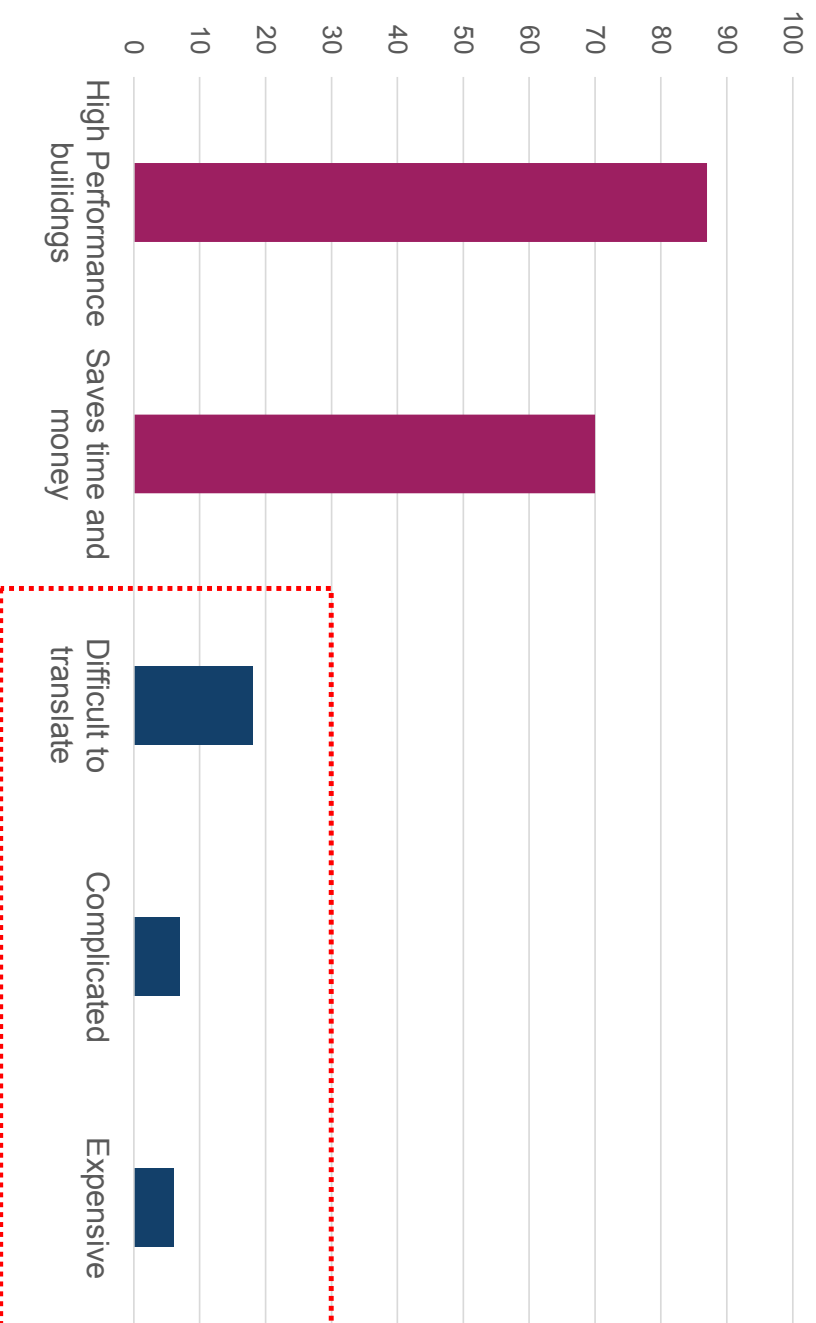


# Backup



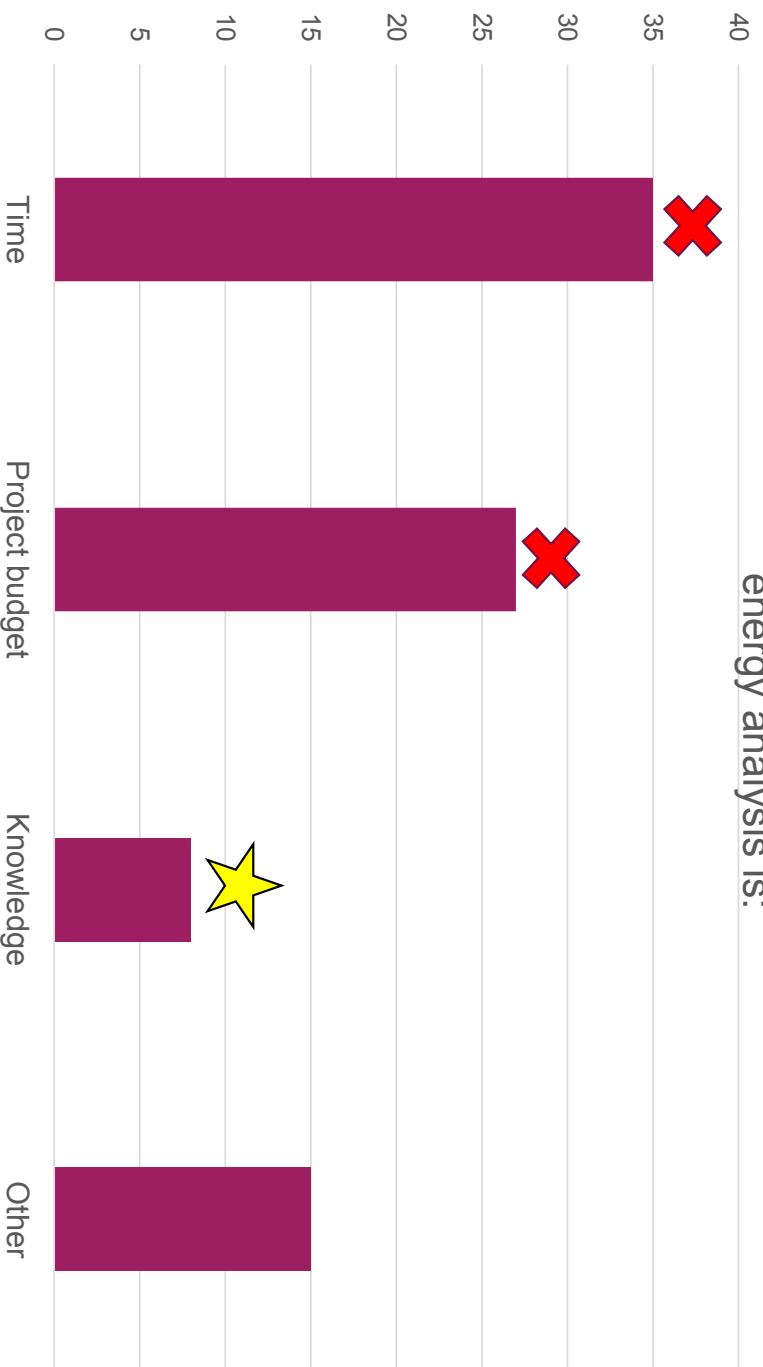
# Early design modeling

IBPSA-USA ArchSim Survey Results



# Early design modeling

IBPSA-USA ArchSim survey - biggest hurdle to incorporating energy analysis is:





## What is BEM?

“Whole-Building Energy Modeling (BEM) is a versatile, multipurpose tool that is used in new building and retrofit design, code compliance, green certification, qualification for tax credits and utility incentives, and real-time building control. BEM is also used in large-scale analyses to develop building energy-efficiency codes and inform policy decisions.” (Energy.gov)

- Architectural Design
- HVAC Design and Operation
- Building Performance Rating
- Building Stock Analysis

