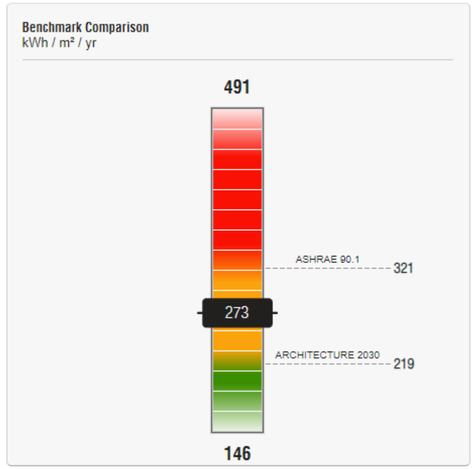
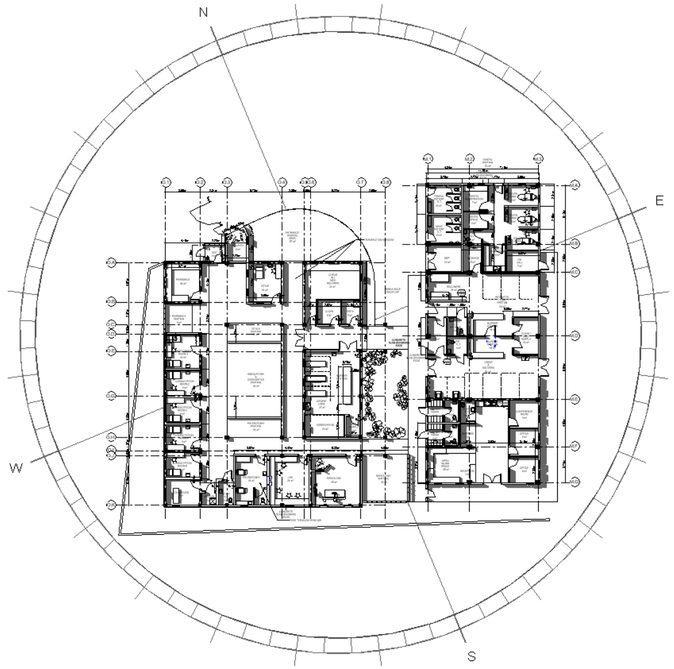
Practical Energy Analysis with Revit:

Case Studies from a Nonprofit Design Firm





Build Health International

MICRODESK

AUTODESK UNIVERSITY

Learning Objectives

LEARN HOW TO GENERATE A CONCEPTUAL-LEVEL REVIT MODEL SUITABLE FOR RUNNING THROUGH INSIGHT ENERGY ANALYSIS

LEARN ABOUT THE DIFFERENCE BETWEEN INPUT-BASED AND OUTPUT-DRIVEN DESIGN FACTORS THAT IMPACT ENERGY ANALYSIS

LEARN ABOUT HOW ENERGY AND DAYLIGHTING ANALYSIS IMPACTED RECENT PROJECTS, BASED ON CASE STUDIES

DISCOVER THE VALUE OF USING ANALYSIS TOOLS EARLY IN THE DESIGN PHASE OF A PROJECT

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About the speakers

CLARKE MORRISON

Strategic BIM Consultant, Microdesk

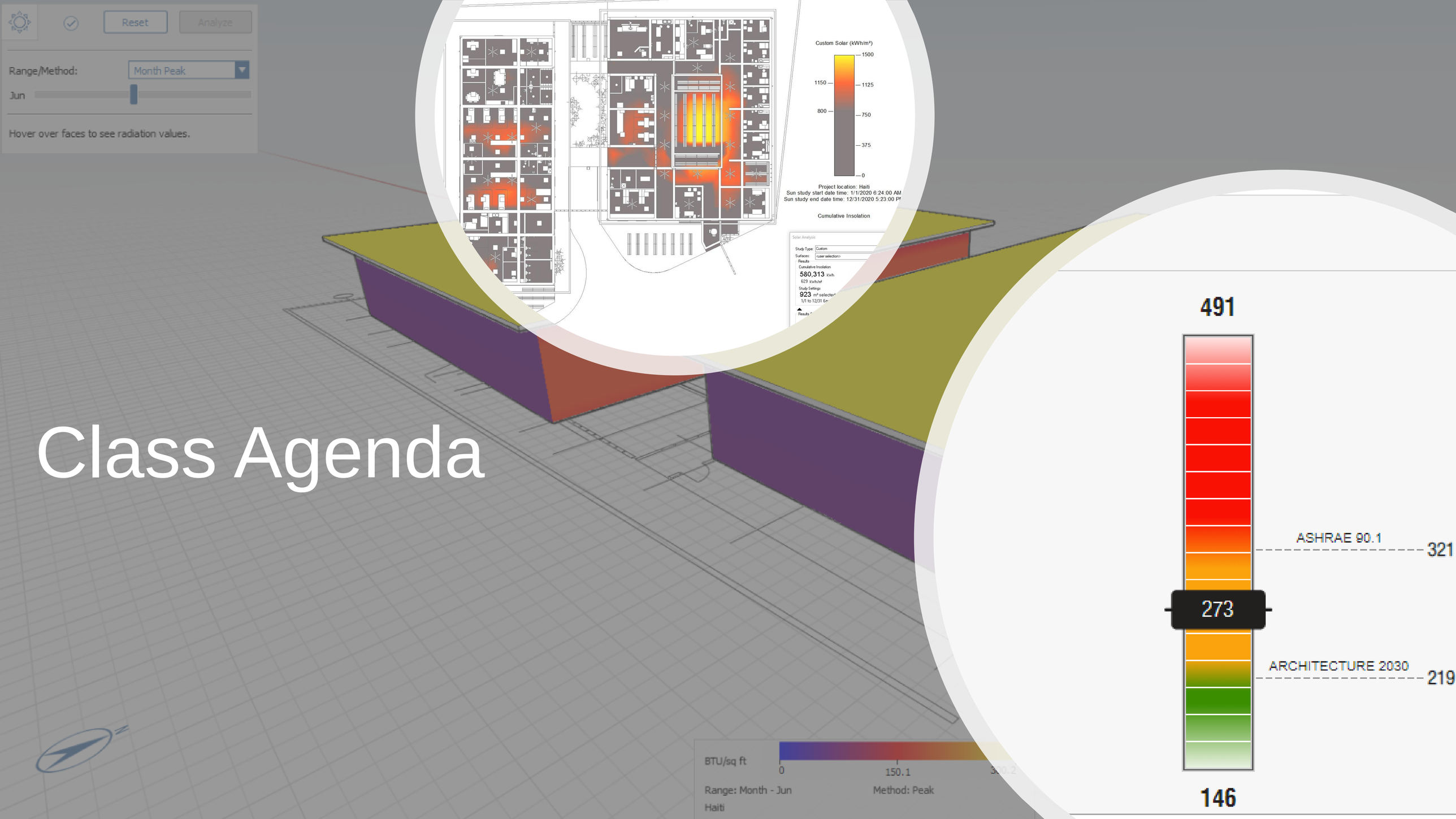
LUC WING

Solutions Specialist - MEP, Microdesk

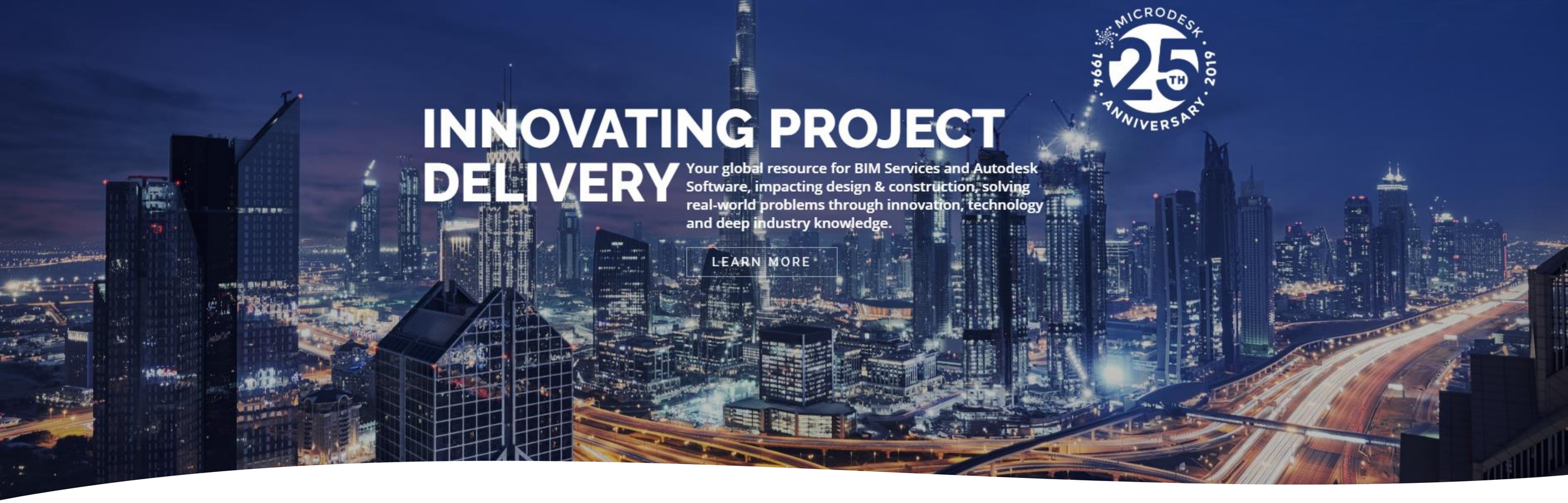
OMAR HERNANDEZ

Director of Engineering, Build Health International (BHI)

Class Agenda



About Build Health International



About Microdesk

- AECO Industry Consulting Firm
- Founded in 1994
- 12 locations nationwide + 1 in the UK
- 213+ AECO Consultants and Software Developers

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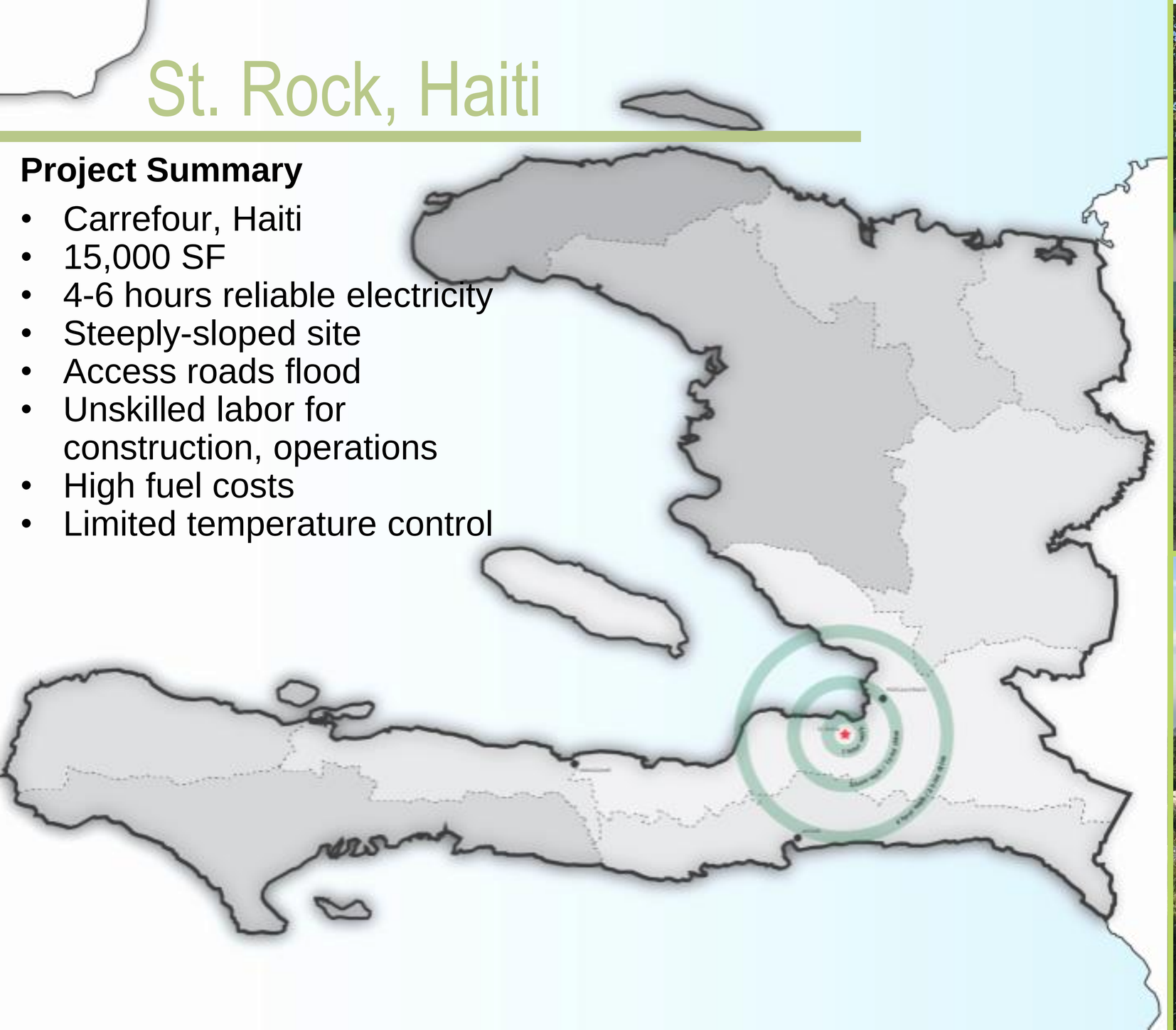
St. Rock, Haiti

Project Summary

- Carrefour, Haiti
- 15,000 SF
- 4-6 hours reliable electricity
- Steeply-sloped site
- Access roads flood
- Unskilled labor for construction, operations
- High fuel costs
- Limited temperature control



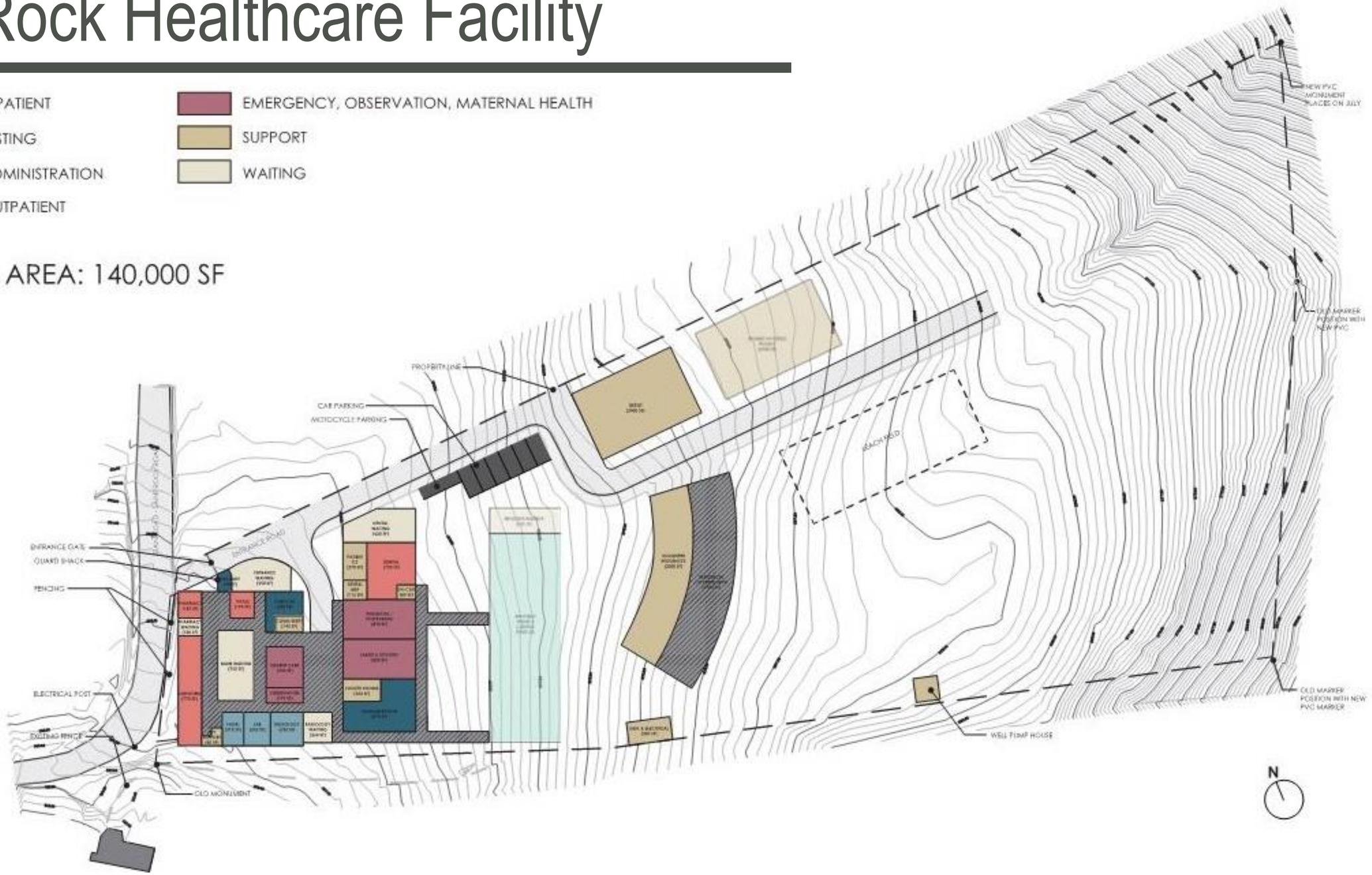

Dignified
care for
those who
need it
most.

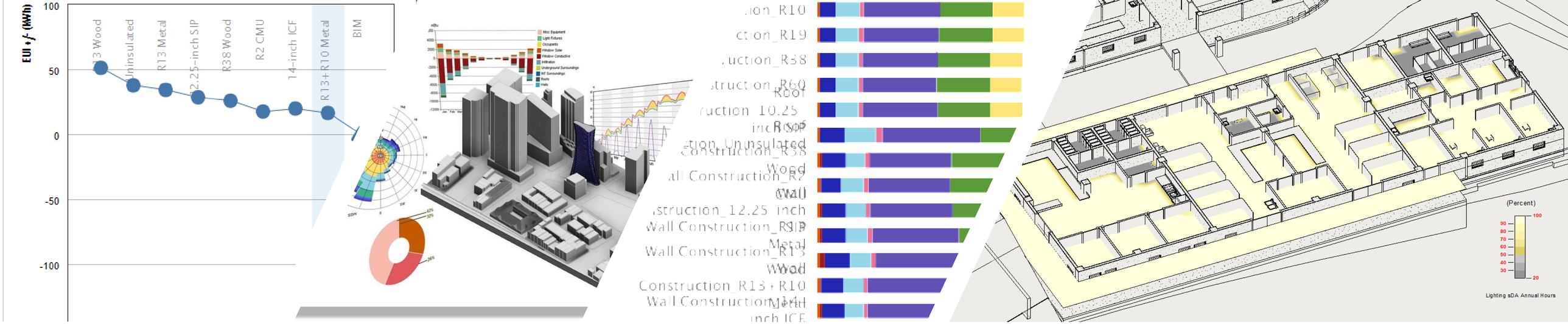
Insights that save lives

St. Rock Healthcare Facility

- INPATIENT
- TESTING
- ADMINISTRATION
- OUTPATIENT
- EMERGENCY, OBSERVATION, MATERNAL HEALTH
- SUPPORT
- WAITING

TOTAL AREA: 140,000 SF





Insight Energy Analysis

WHOLE BUILDING ANALYSIS

MULTIPLE SIMULATIONS AT ONCE

OUTPUT-DRIVEN

SEAMLESS INTEGRATION WITH MODELING TOOLS

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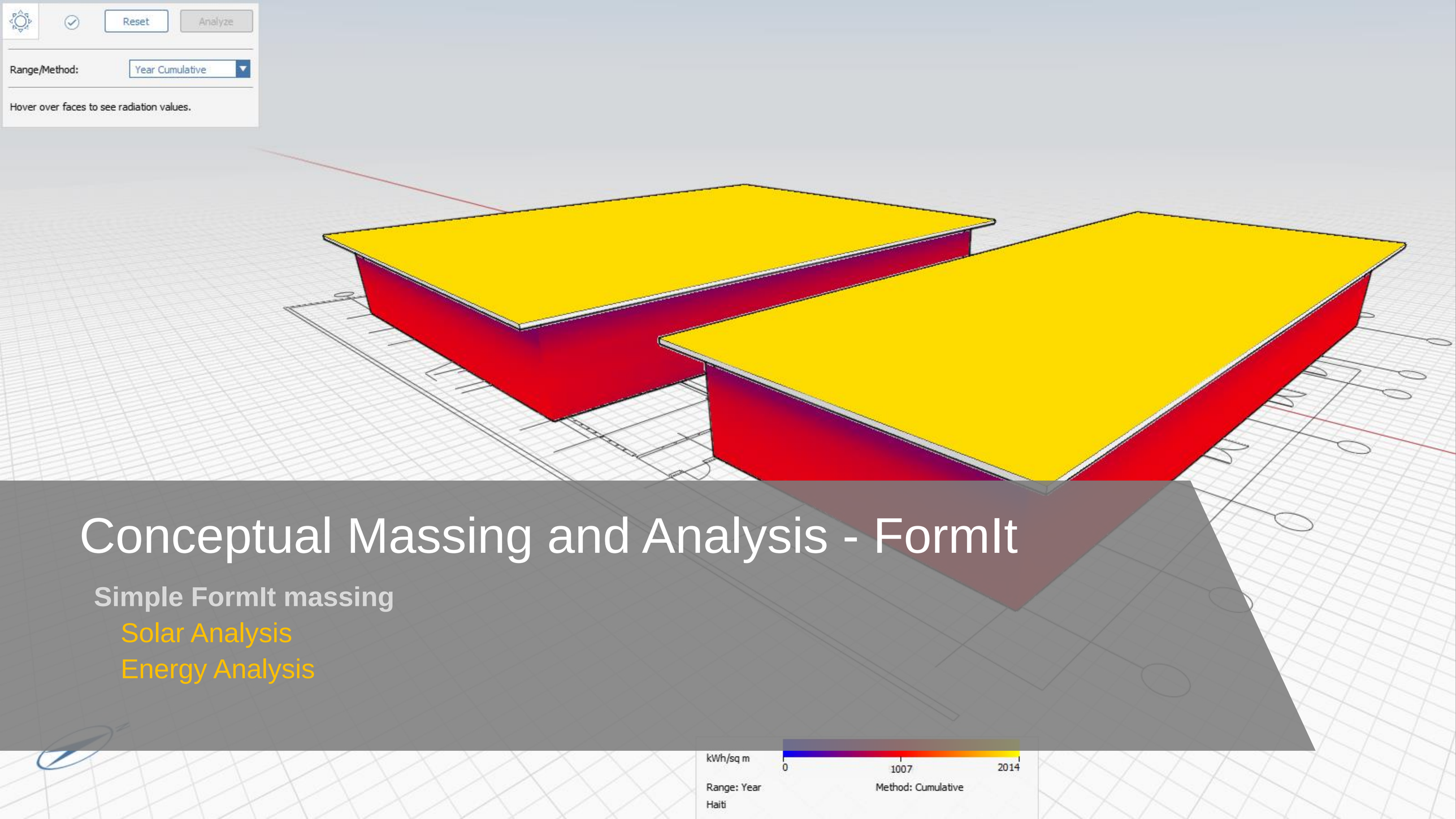
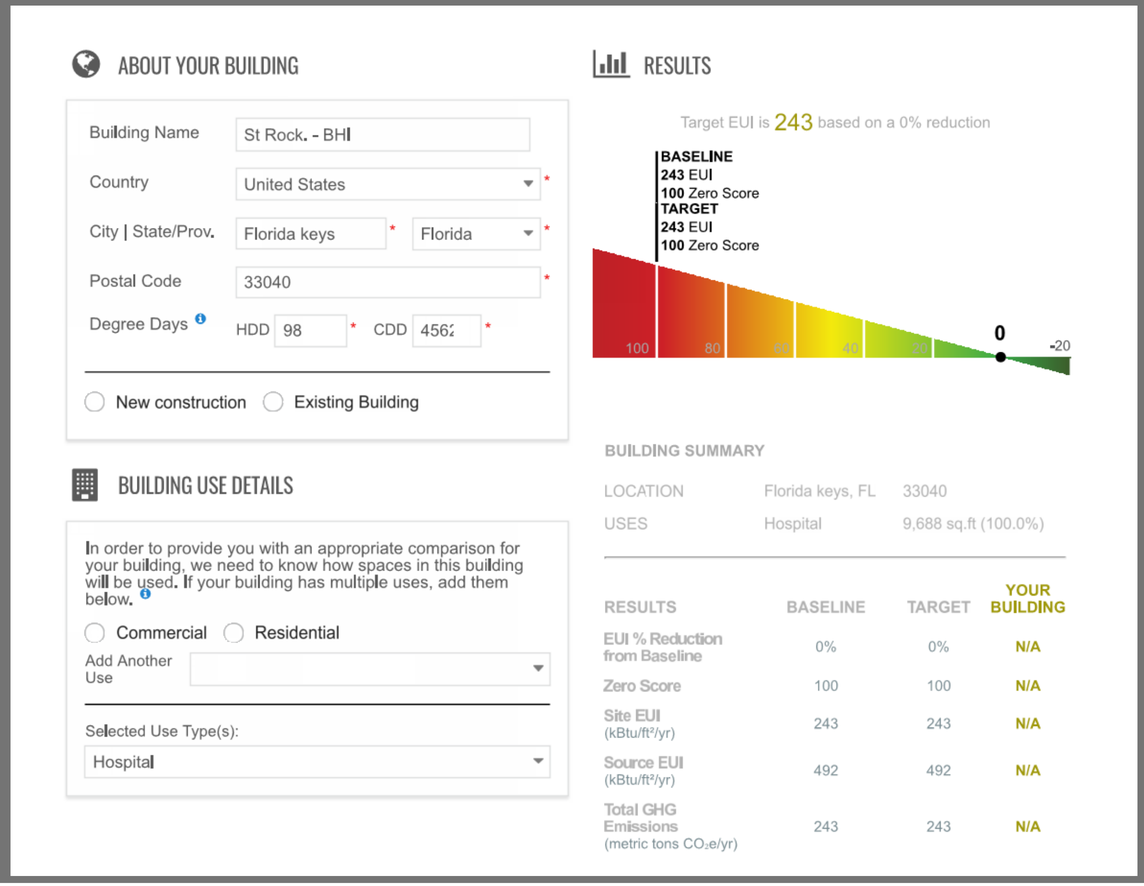


Conceptual Massing and Analysis - FormIt

Simple FormIt massing

Solar Analysis

Energy Analysis



Building type	Definition	Includes these sub-categories from the CBECS questionnaire
Education	Buildings used for academic or technical classroom instruction, such as elementary, middle, or high schools, and classroom buildings on college or university campuses. Buildings on education campuses for which the main use is not classroom are included in the category relating to their use. For example, administration buildings are part of "Office," dormitories are "Lodging," and libraries are "Public Assembly."	• elementary or middle school • high school • college or university • preschool or daycare • adult education • career or vocational training • religious education
Food Sales	Buildings used for retail or wholesale of food.	• grocery store or food market • gas station with a convenience store • convenience store
Food Service	Buildings used for preparation and sale of food and beverages for consumption.	• fast food • restaurant or cafeteria • bar • catering service or reception hall • coffee, bagel, or doughnut shop • ice cream or frozen yogurt shop
Health Care (Inpatient)	Buildings used as diagnostic and treatment facilities for inpatient care.	• hospital • inpatient rehabilitation
Health Care (Outpatient)	Buildings used as diagnostic and treatment facilities for outpatient care. Medical offices are included here if they use any type of diagnostic medical equipment (if they do not, they are categorized as an office building).	• medical office (see previous column) • clinic or other outpatient health care • outpatient rehabilitation • veterinarian

https://www.eia.gov/consumption/commercial/building-type-definitions.php

Defining a baseline using Zero Tool and CBECs

COMMERCIAL BUILDINGS ENERGY CONSUMPTION SURVEY (CBECS)

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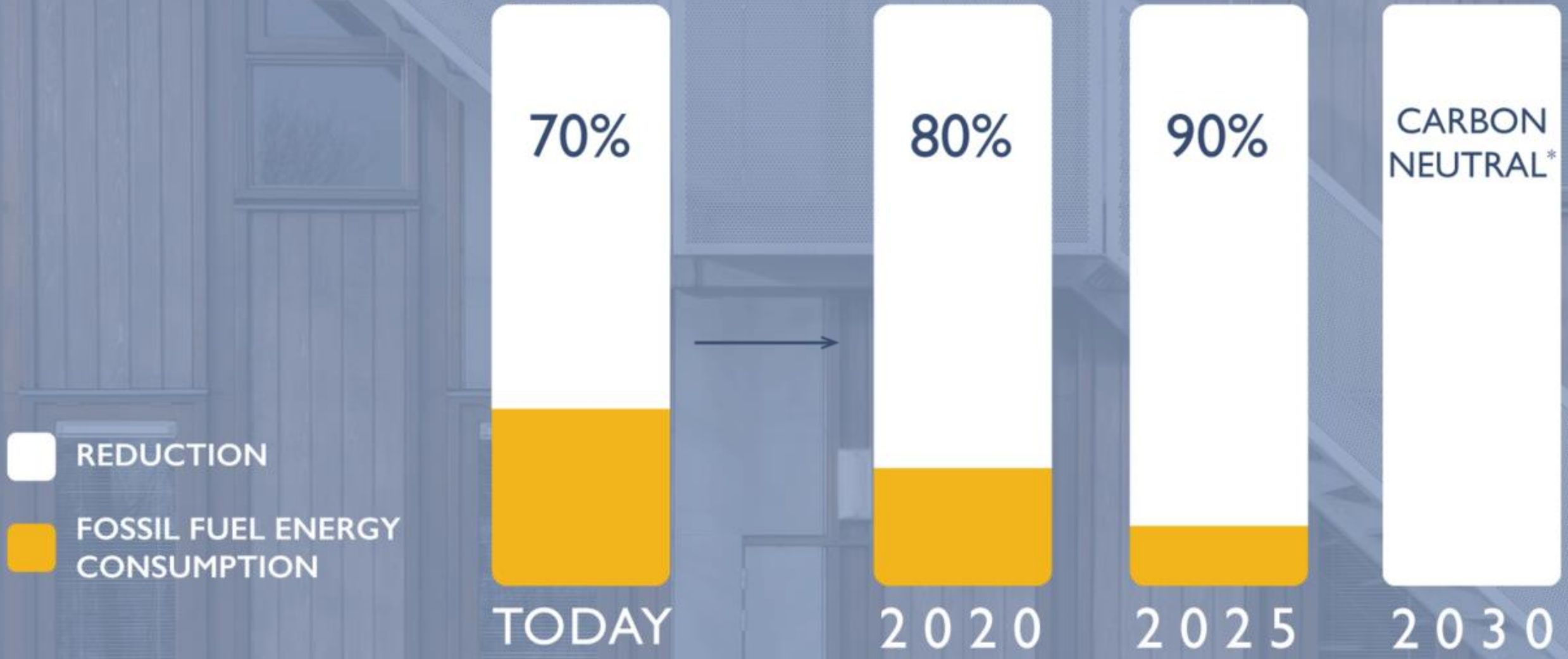
THE 2030 CHALLENGE



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WHAT'S YOUR EUI?

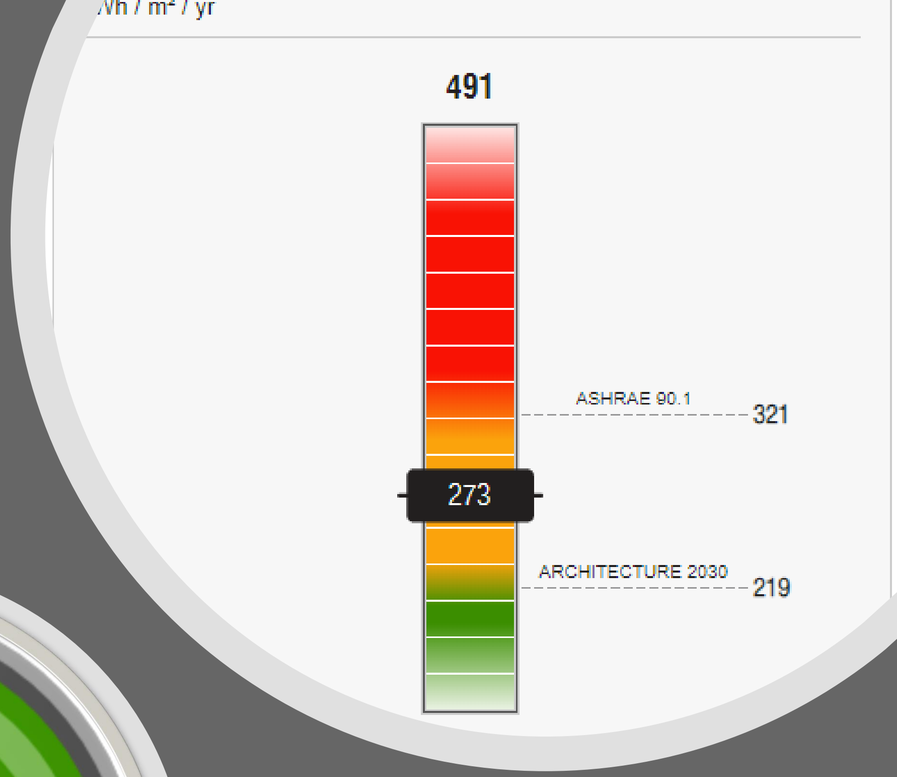
EUI = Energy Use Intensity

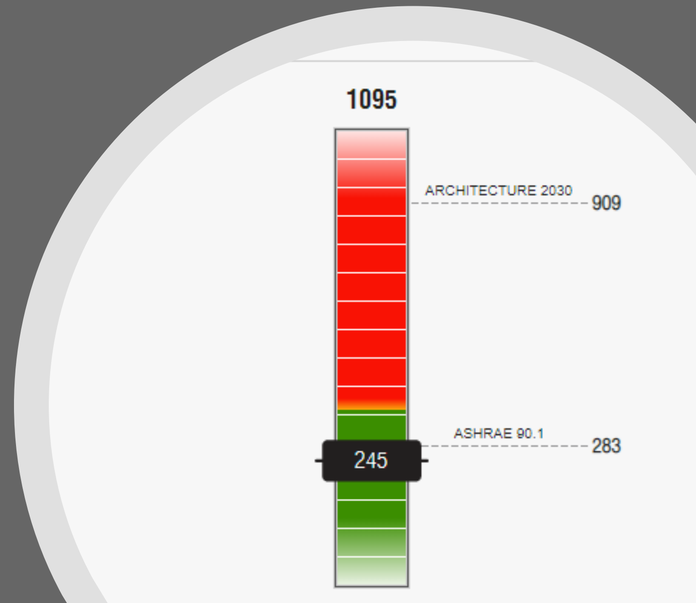
And is measured by:

- KWh/m2/yr = 3.6 megajoules
- Kilowatt Hours / Meters Squared / year
- 1000watts = kilowatt

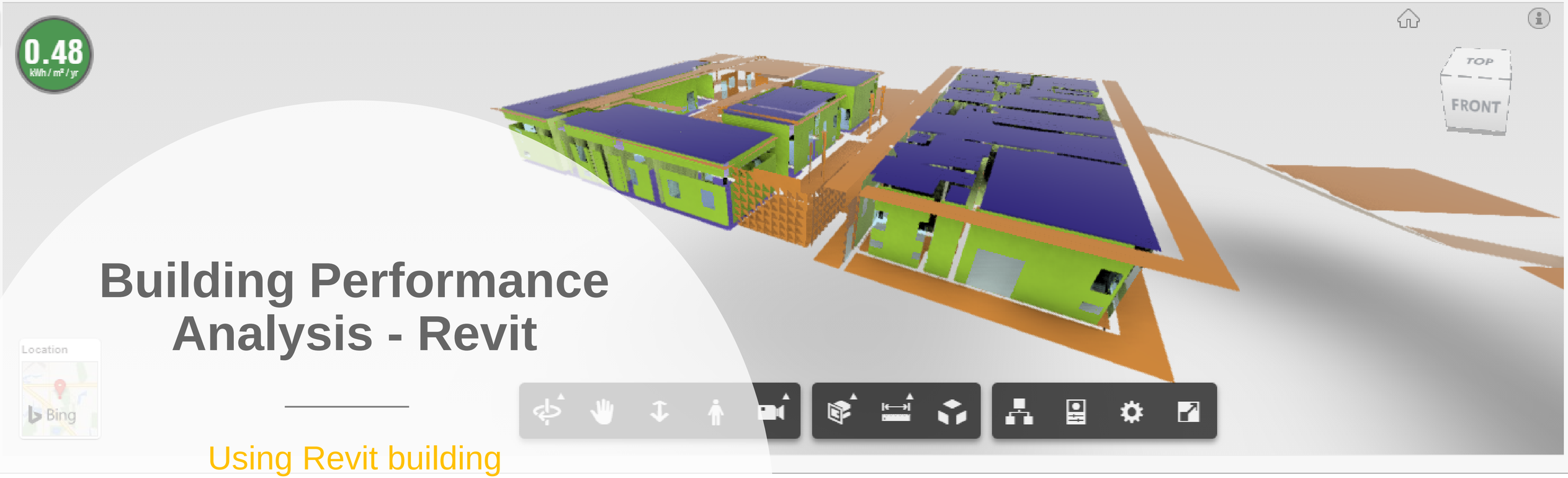
A kWh equals the amount of energy you would use by keeping a 1,000watt appliance running for one hour**.**

According to the U.S. Energy Information Administration, in 2008, the average annual electricity consumption for a U.S. residential utility customer was 11,040 kWh/ year.





Building Form

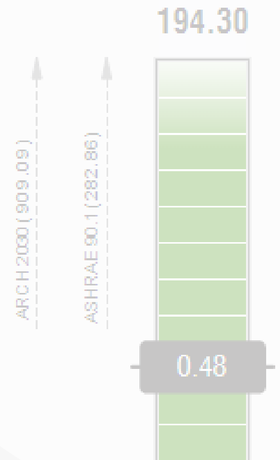


Building Performance Analysis - Revit

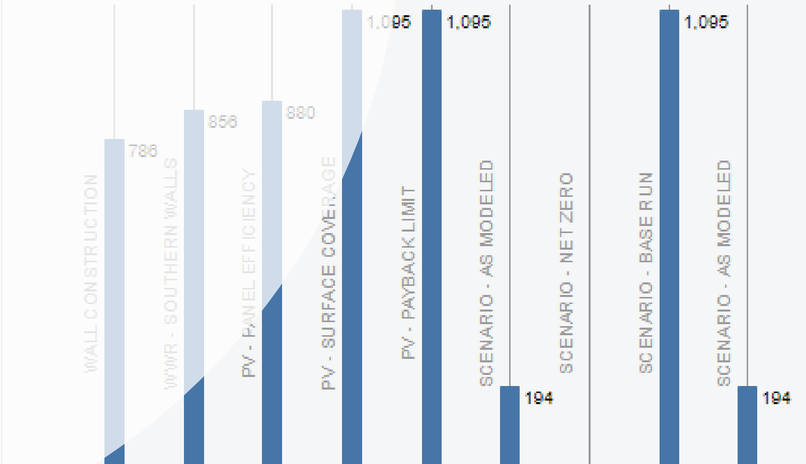
Location

Using Revit building elements and Insight to better inform your design

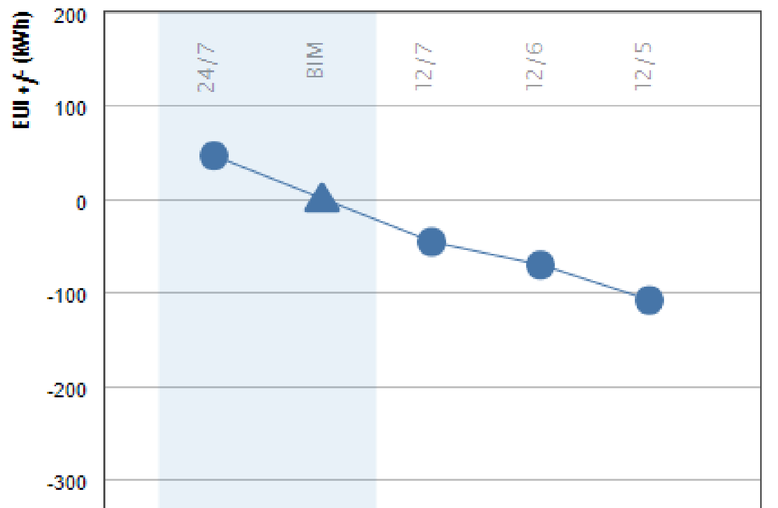
Benchmark Comparison
kWh / m² / yr



Model History
kWh / m² / yr



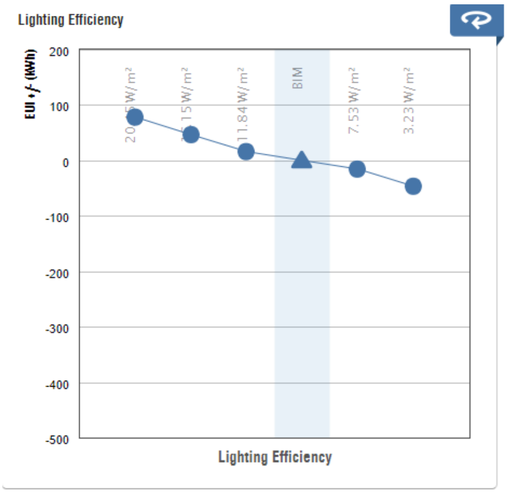
Operating Schedule

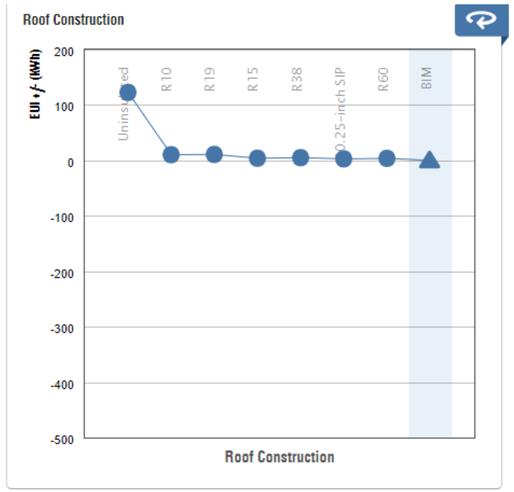


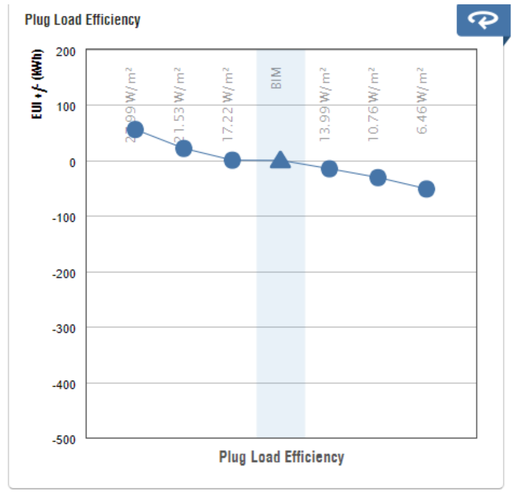
Building Element Analysis - Revit

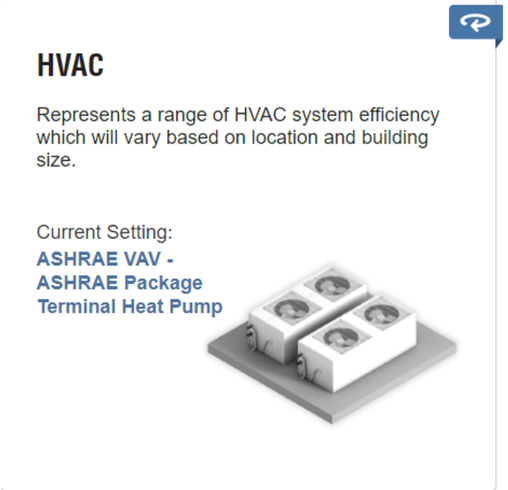
Most impactful factors:

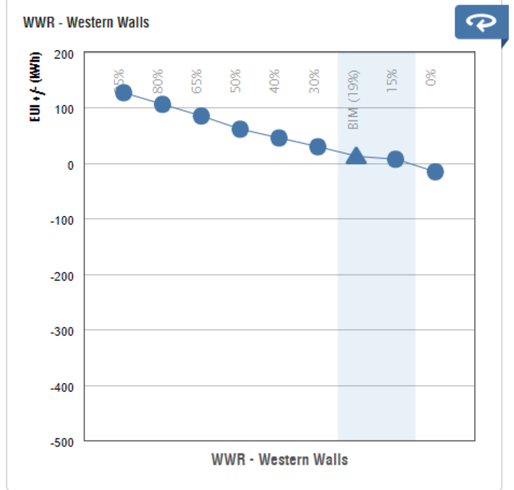
- Lighting Efficiency
- Roof Construction
- Plug Load Efficiency
- Window-wall ratio: S
- Window-wall ratio: W
- HVAC System
- Wall Construction

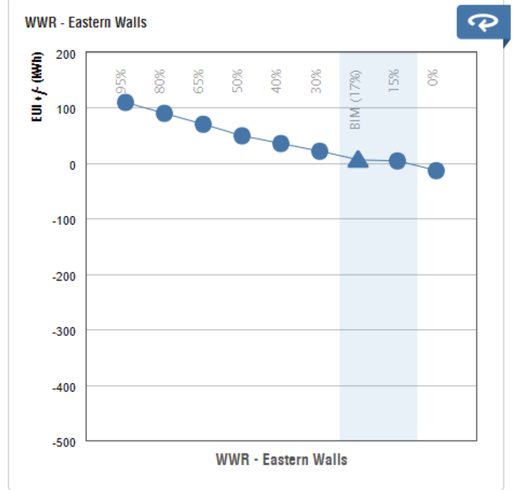




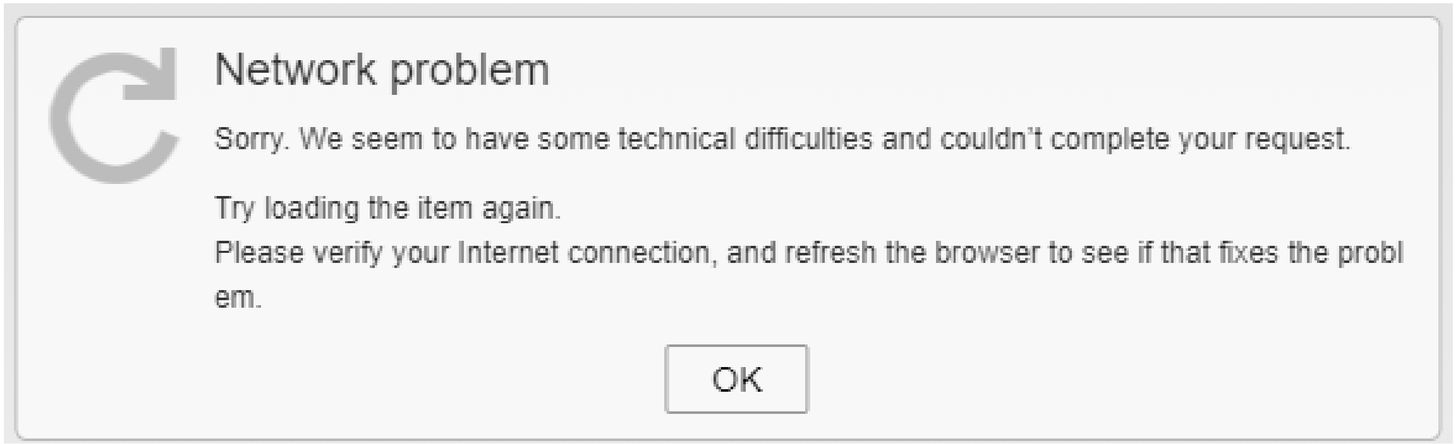








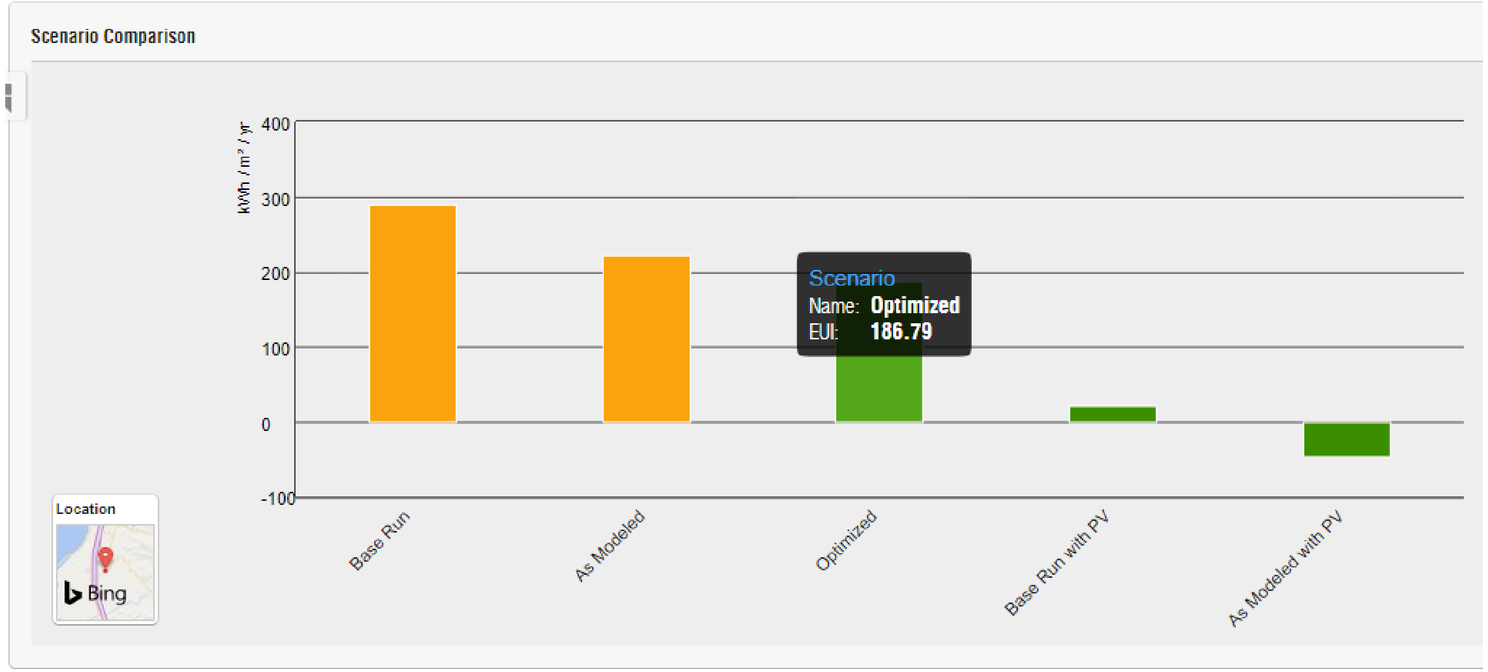
Show Insight!

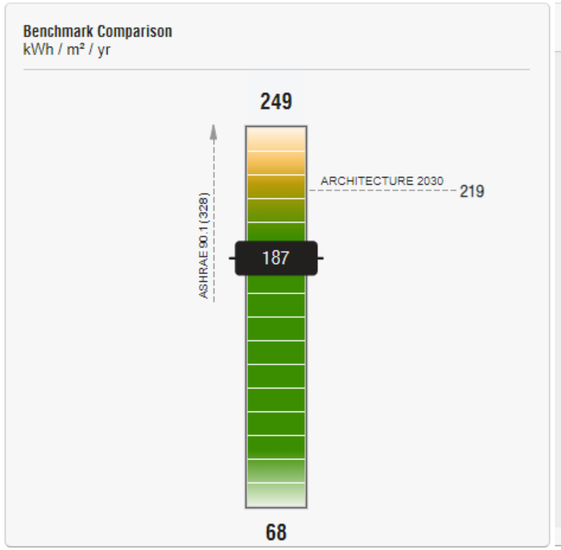


Building Element Analysis - Revit

Insight Scenarios:

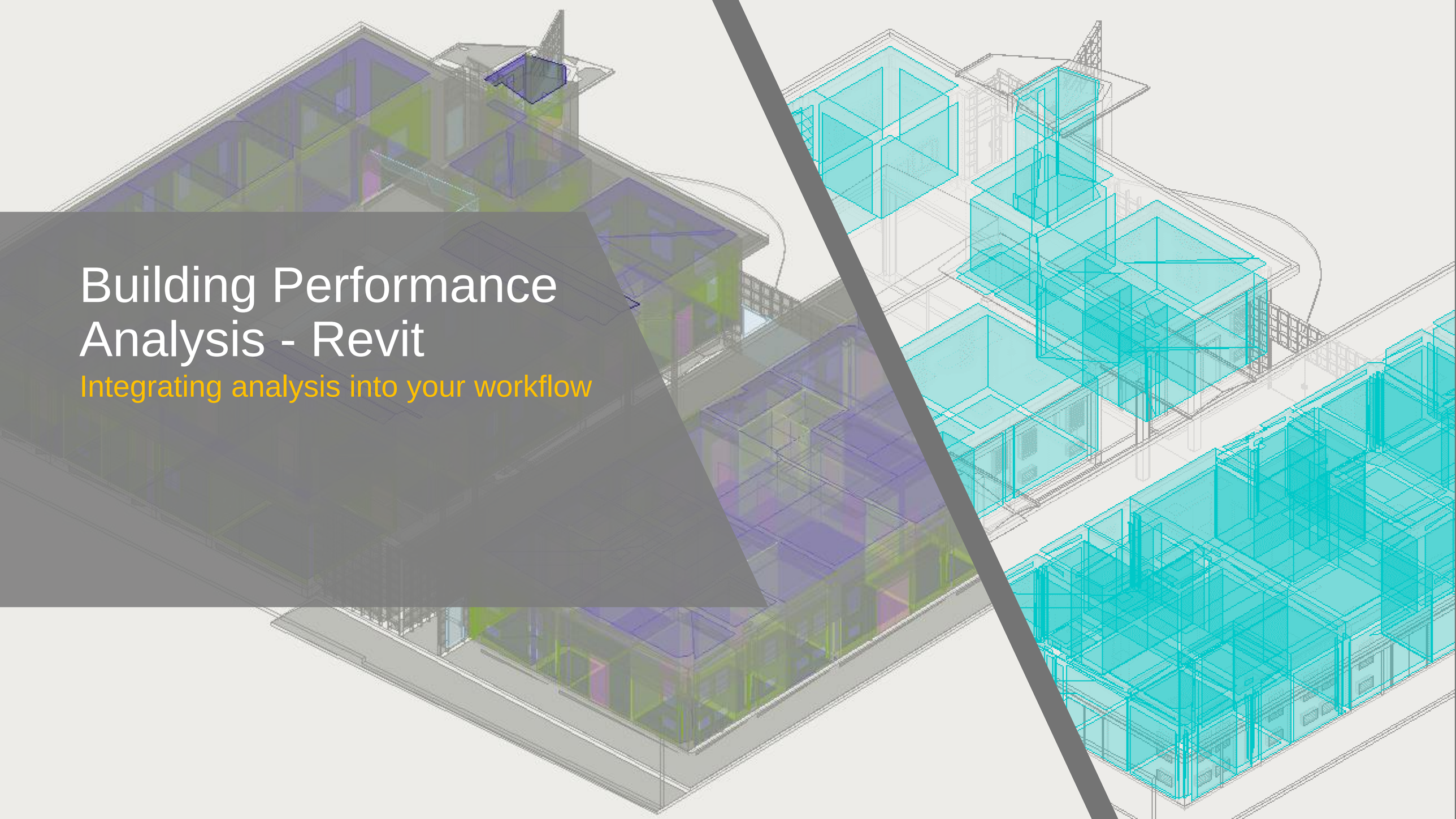
- Base Run
- As modeled
- Net Zero
- PV Panels





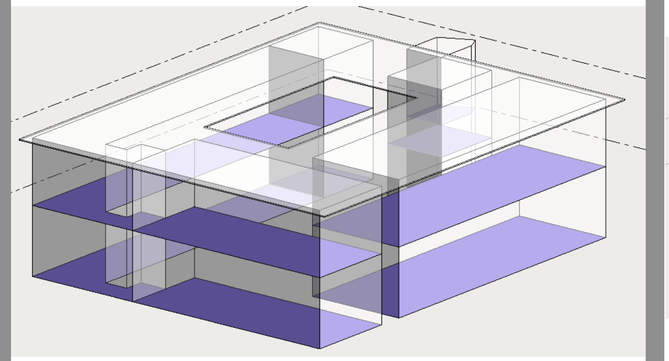
Building Performance Analysis - Revit

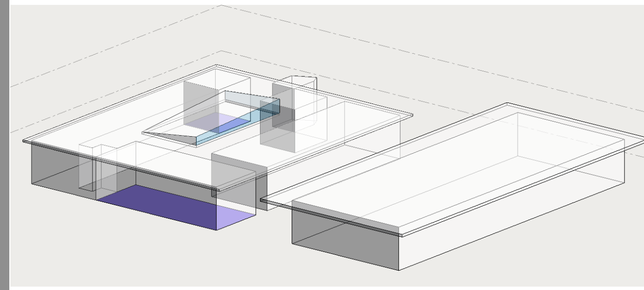
Integrating analysis into your workflow

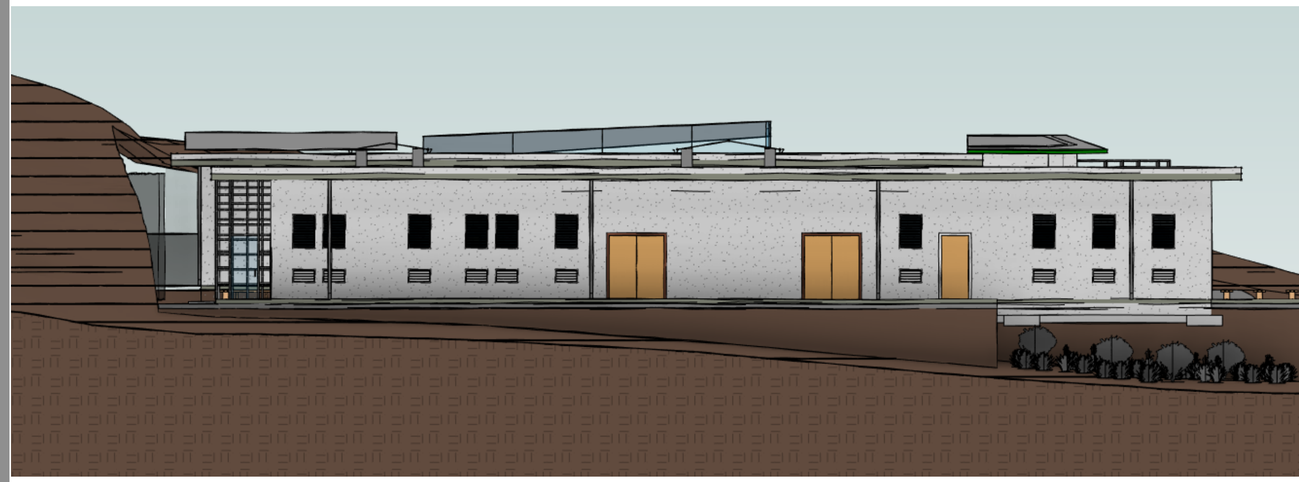


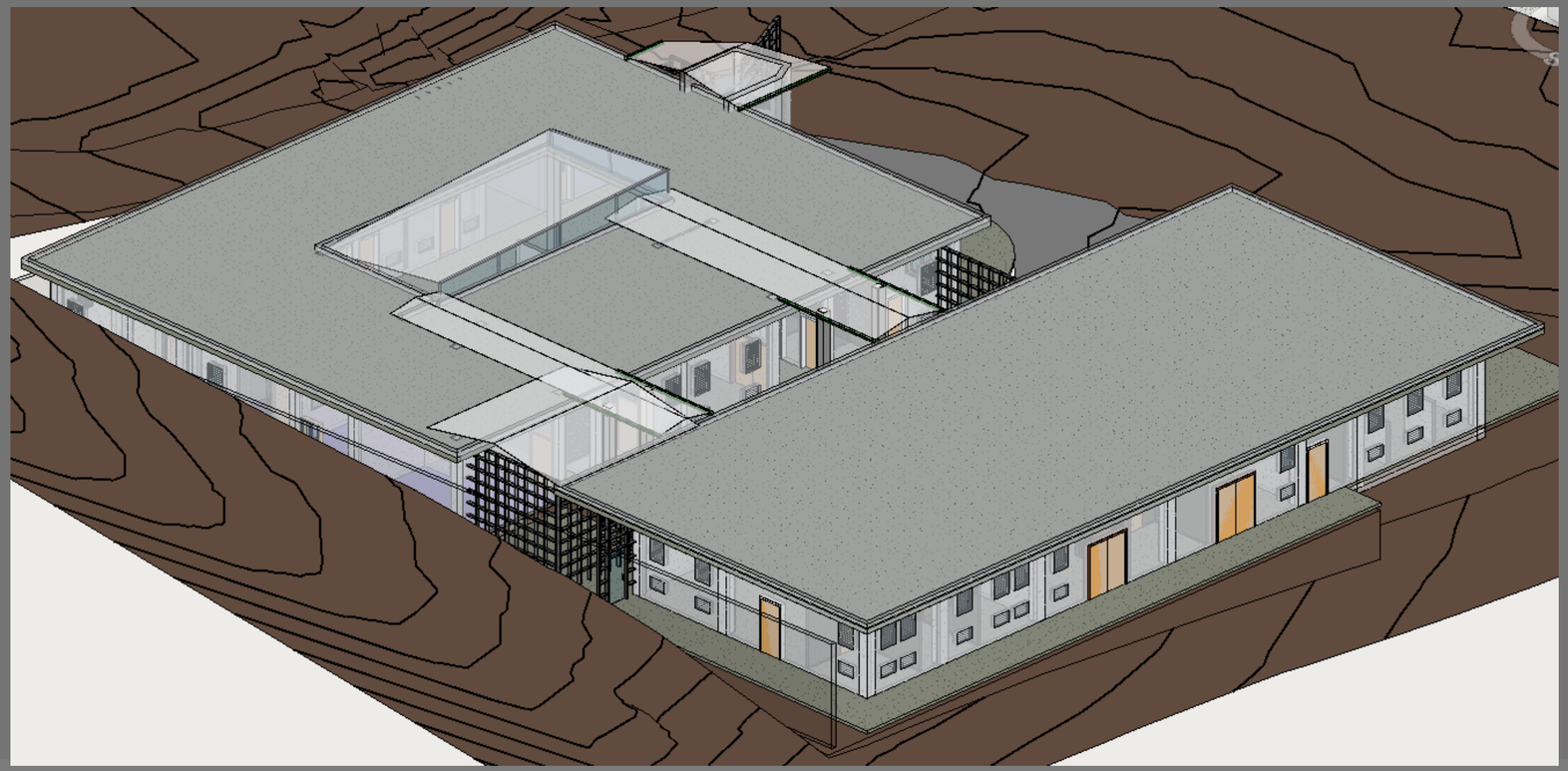
Conceptual Massing and Analysis - Revit

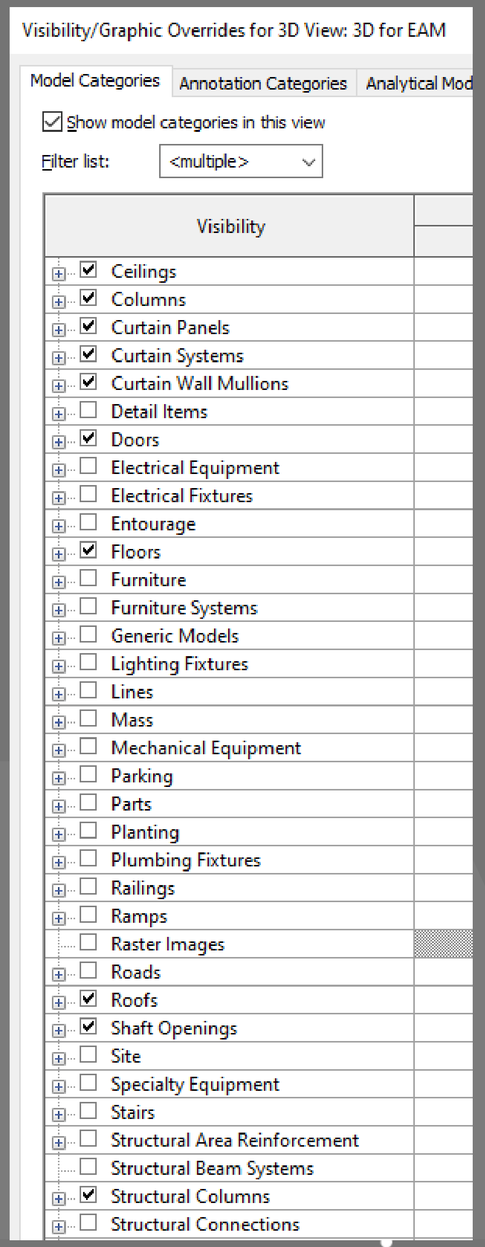
- 1-story, multiple buildings
- 2-story, single building
- Partially below-grade











Creating the Energy Analytical Model

- Isolate Categories
- Model Cleanup

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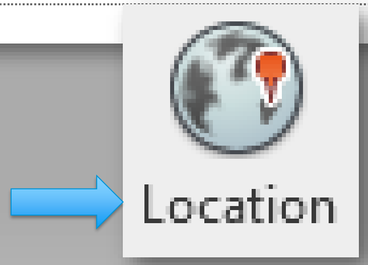
Building Element Analysis - Revit

Output-driven analysis

Energy Settings

Parameter	Value
Energy Analytical Model	
Mode	Use Conceptual Masses and Building Elements
Ground Plane	MATERNAL HEALTH G.L.
Project Phase	PHASE 1
Analytical Space Resolution	0.4572 m
Analytical Surface Resolution	0.3048 m
Perimeter Zone Depth	4.5720 m
Perimeter Zone Division	☑
Average Vertical Void Height Threshold	1.8288 m
Horizontal Void/Chase Area Threshold	0.093 m²
Advanced	
Other Options	Edit...
Identity Data	
Workset	Project Info
Edited by	Cmorrison2



Factors that are analyzed by Insight, no input needed:

Advanced Energy Settings

Parameter	Value
Detailed Model	
Target Percentage Glazing	0%
Target Sill Height	0.7500 m
Glazing is Shaded	☐
Shade Depth	0.4572 m
Target Percentage Skylights	0%
Skylight Width & Depth	0.9144 m
Building Data	
Building Type	Hospital or Healthcare
Building Operating Schedule	Default
HVAC System	Central VAV, HW Heat, Chiller 5.96 COP, Boilers 84.5 eff
Outdoor Air Information	Edit...
Room/Space Data	
Export Category	Rooms
Material Thermal Properties	
Conceptual Types	Edit...
Schematic Types	<Building>
Detailed Elements	☐
Identity Data	
Workset	Project Info
Edited by	Cmorrison2

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Building Element Analysis - Revit

Advanced Energy Settings

Parameter	Value
Detailed Model	
Target Percentage Glazing	0%
Target Sill Height	0.7500 m
Glazing is Shaded	☐
Shade Depth	0.4572 m
Target Percentage Skylights	0%
Skylight Width & Depth	0.9144 m
Building Data	
Building Type	Hospital or Healthcare
Building Operating Schedule	Default
HVAC System	Central VAV, HW Heat, Chiller 5.96 COP, Boilers 84.5 eff
Outdoor Air Information	Edit...
Room/Space Data	
Export Category	Rooms
Material Thermal Properties	
Conceptual Types	Edit...
Schematic Types	<Building>
Detailed Elements	☐
Identity Data	
Workset	Project Info
Edited by	Cmorrison2

Analysis Properties

By default, analysis properties are generated from information in Conceptual Types.
Properties of Schematic Types are used when override is selected.

Category	Override	Analytic Construction
Roofs	☐	4 in lightweight concrete (U=1.2750 W/(m²·K))
Exterior Walls	☑	8 in heavyweight concrete block (U=2.0846 W/(m²·K))
Interior Walls	☐	Frame partition with 3/4 in gypsum board (U=1.4733 W/(m²·K))
Ceilings	☐	8 in lightweight concrete ceiling (U=1.3610 W/(m²·K))
Floors	☐	Passive floor, no insulation, tile or vinyl (U=2.9582 W/(m²·K))
Slabs	☐	Un-insulated solid (U=0.7059 W/(m²·K))
Doors	☐	Metal (U=3.7021 W/(m²·K))
Exterior Windows	☐	Large double-glazed windows (reflective coating) - industry (U=2.9214 W/(m²·K),
Interior Windows	☐	Large single-glazed windows (U=3.6898 W/(m²·K), SHGC=0.86)
Skylights	☐	Large double-glazed windows (reflective coating) - industry (U=3.1956 W/(m²·K),

All | None

Shading factor for exterior windows: 0

OK | Cancel

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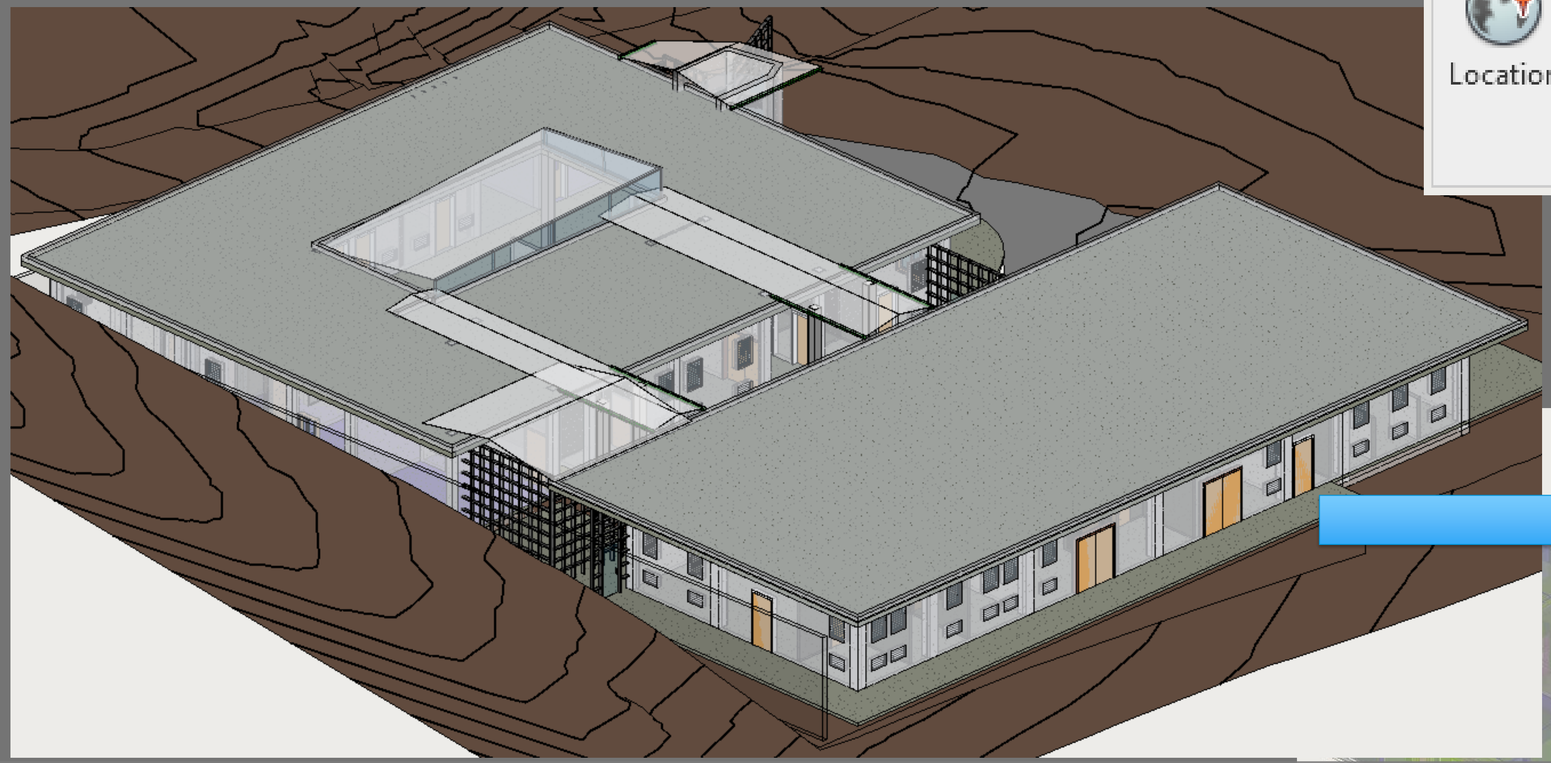

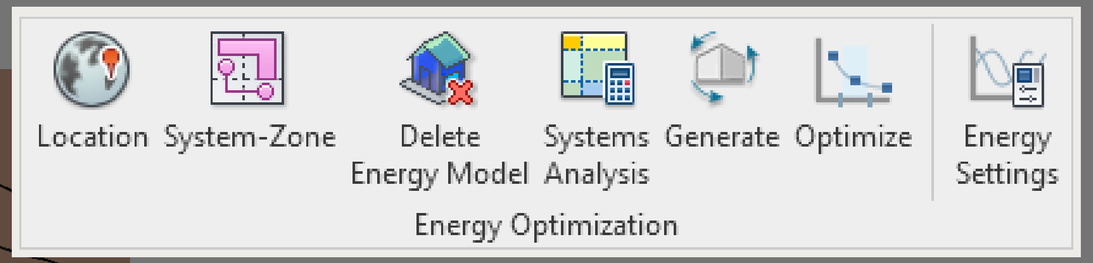

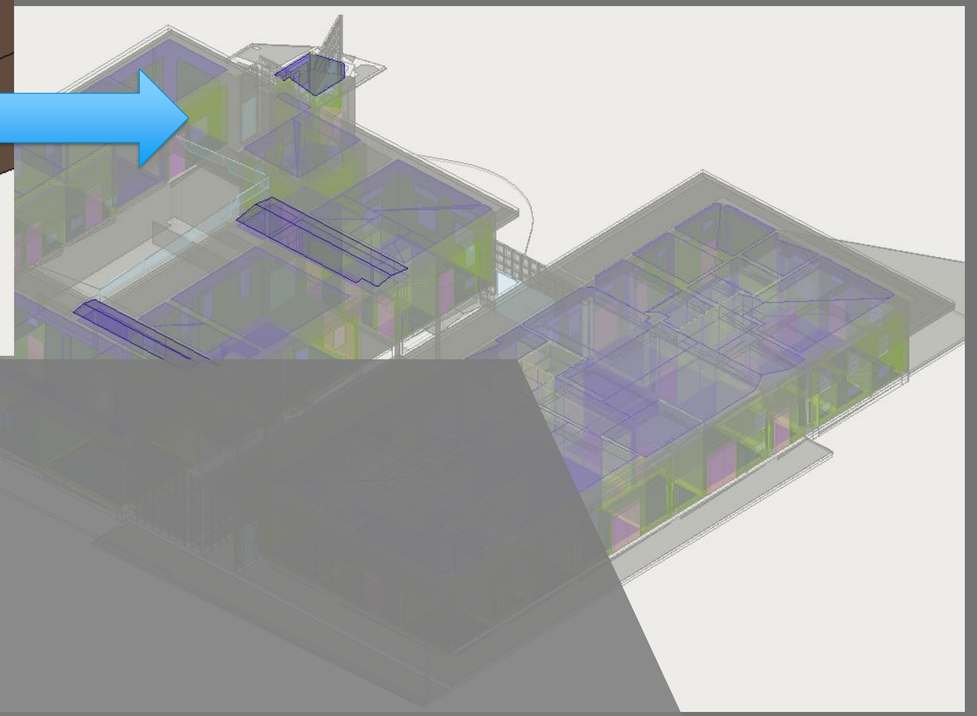

Creating the Energy Analytical Model

- Create Energy Model (EAM)
- Review EAM for gaps and surface types

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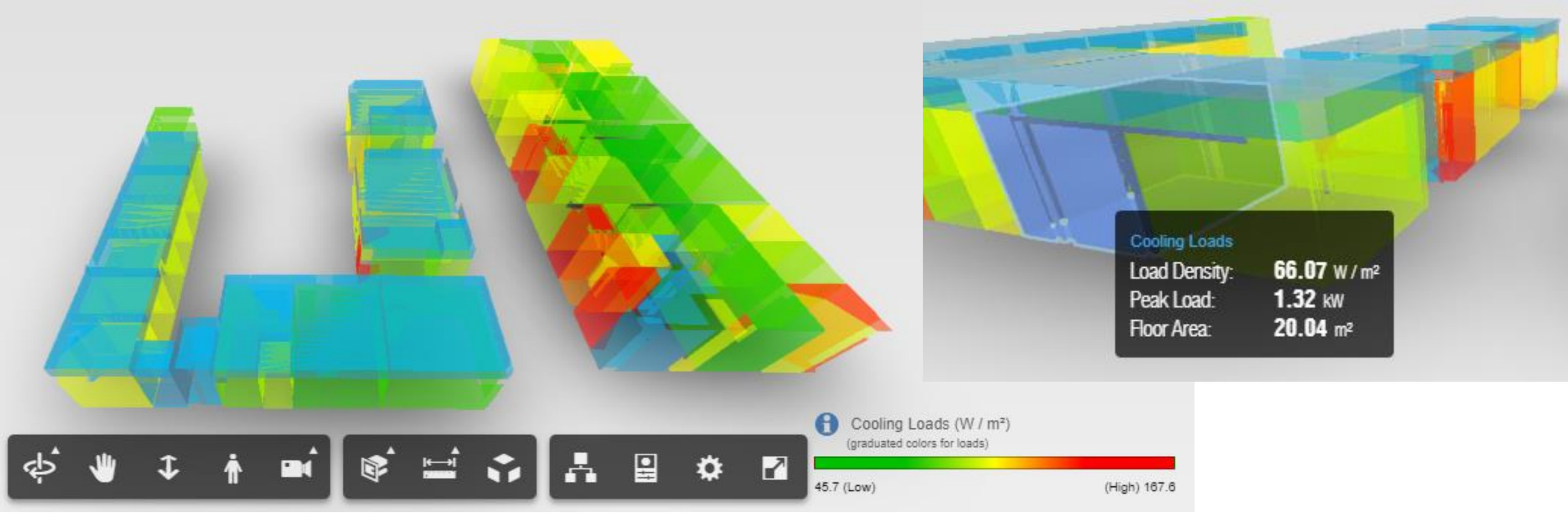

Building Element Analysis - Revit

Insight – Cooling Loads

Build Health International

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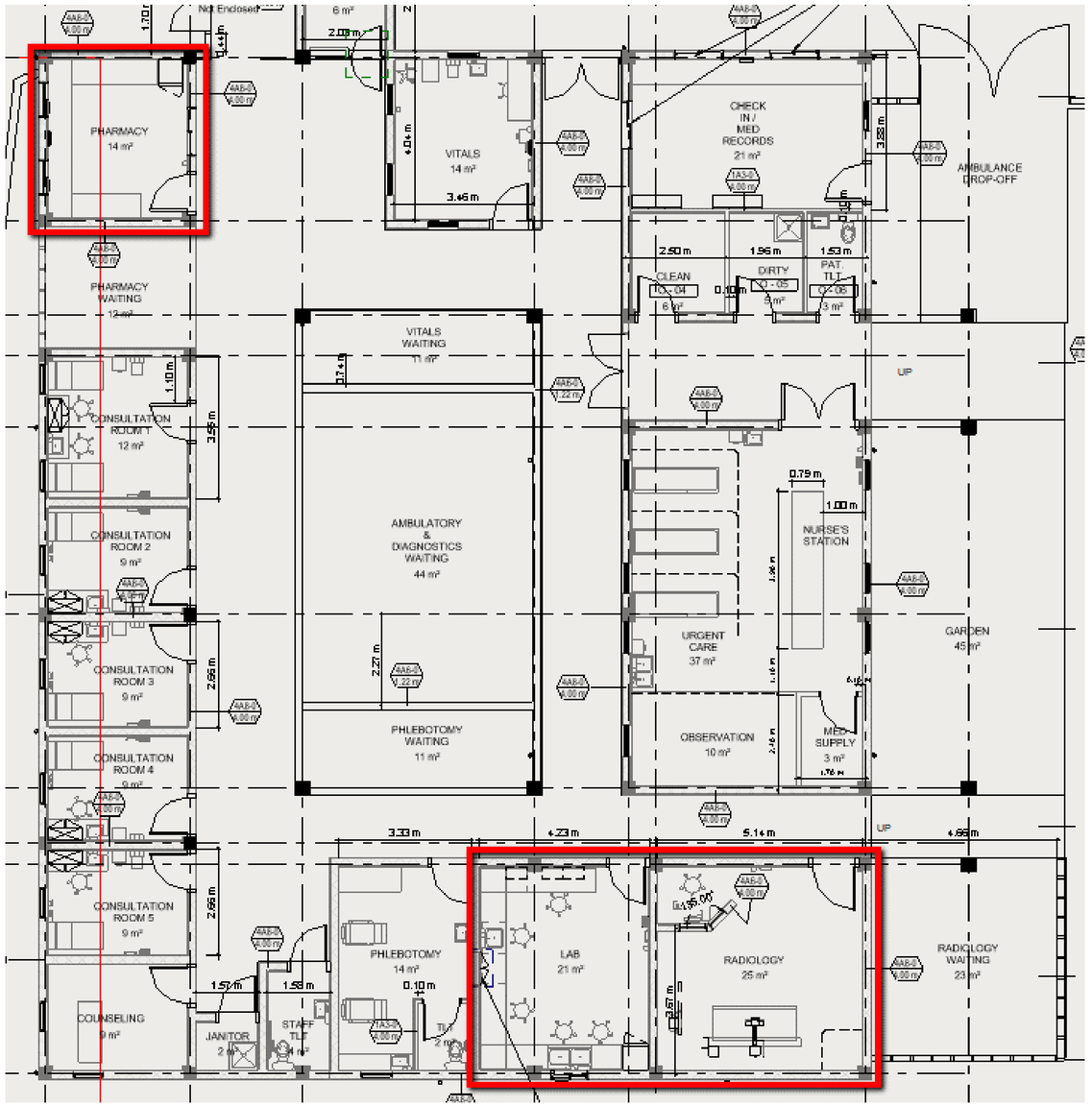
Building Element Analysis - Revit

Defining the spaces:

- Cooling Loads
- Naturally Ventilated only
- Massing – mass floors
- Space Types

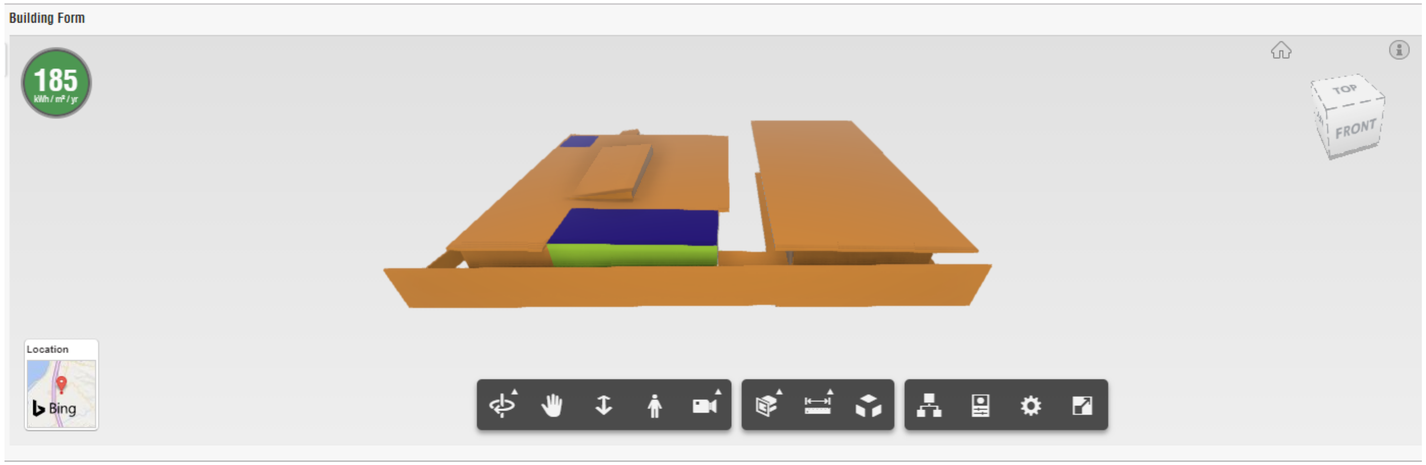


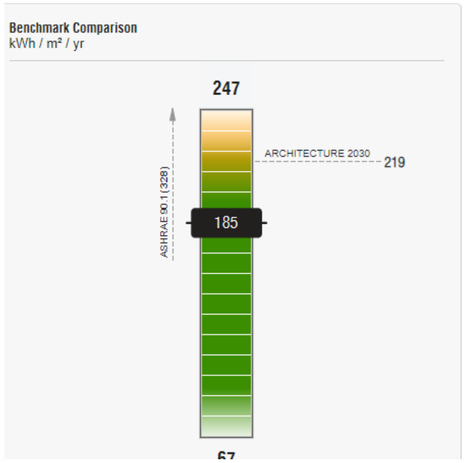
Building Element Analysis - Revit

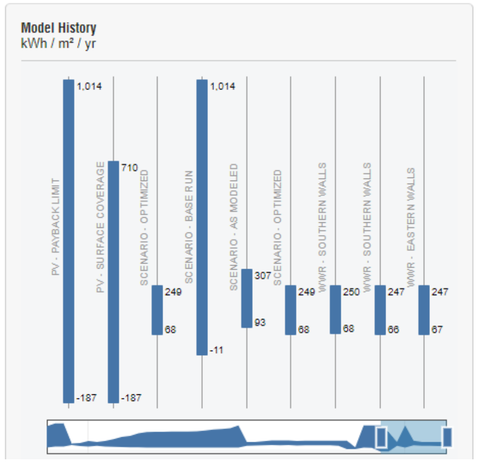
https://insight.autodesk.com/oneenergy/Model/179200#

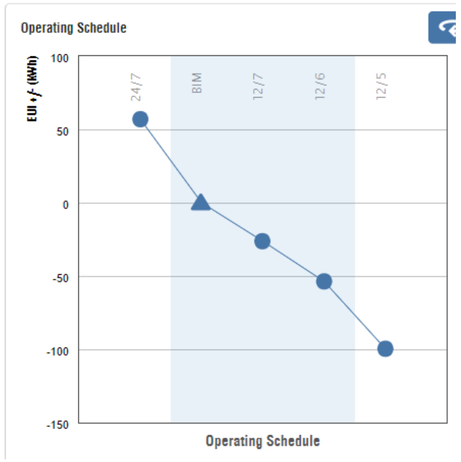
Optimizing the Design:

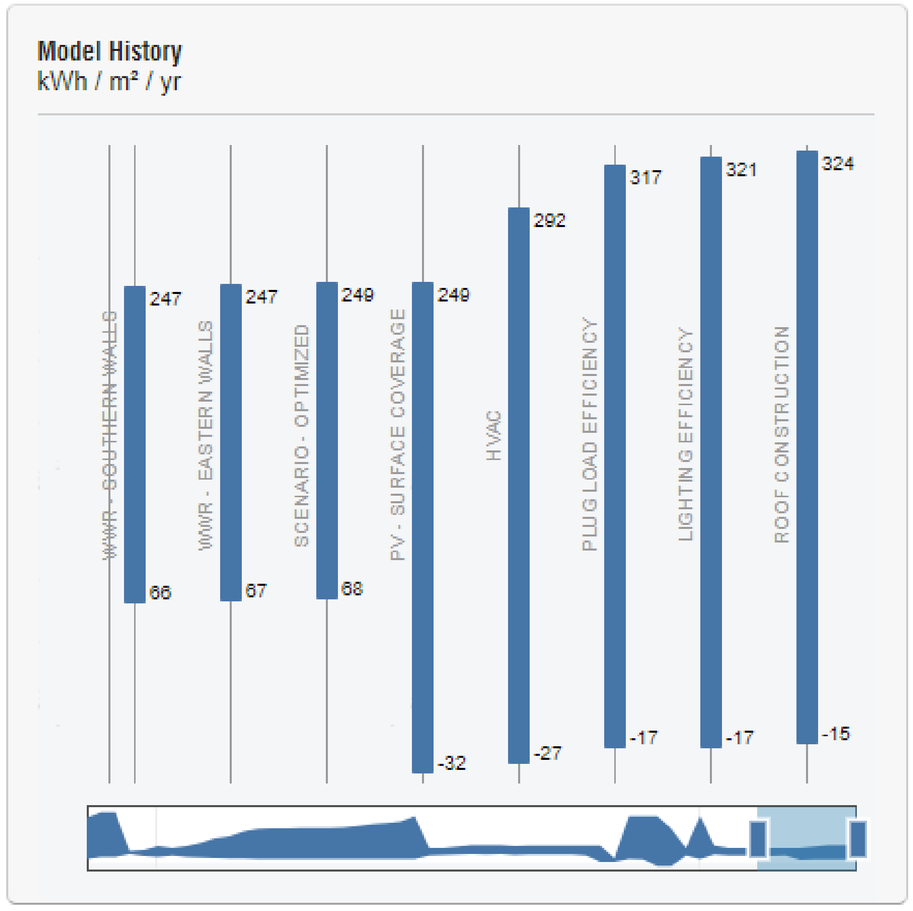
- Cooling Loads
- Natural Ventilation
- Window-Wall Ratio
- Wall Construction
- Roof Construction

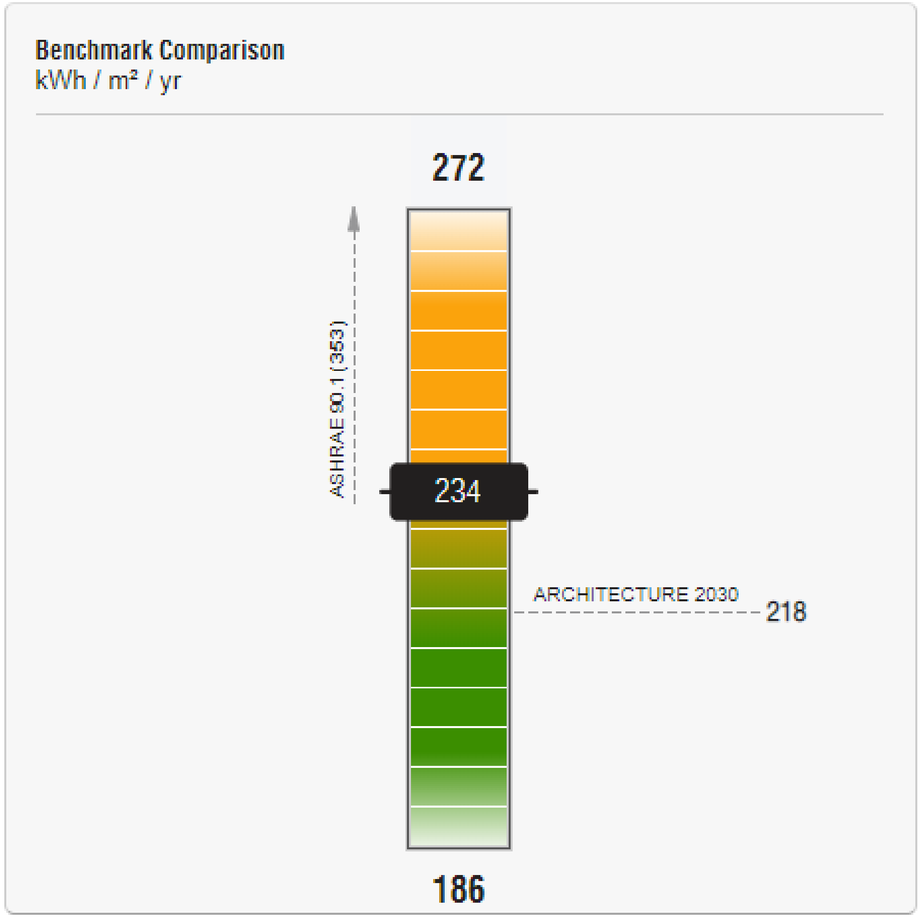












Insight – Final EUI – Design Phase

Build Health International

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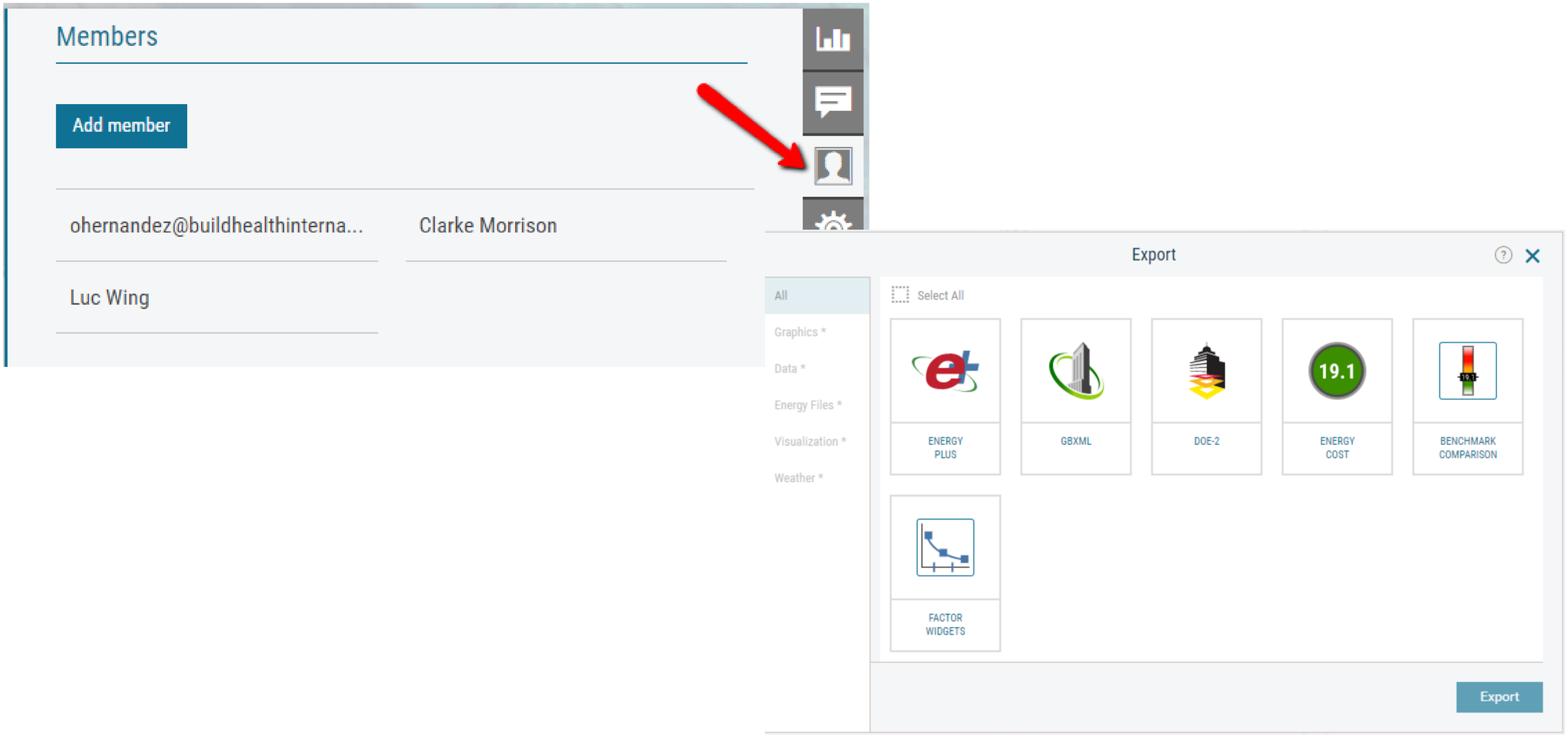
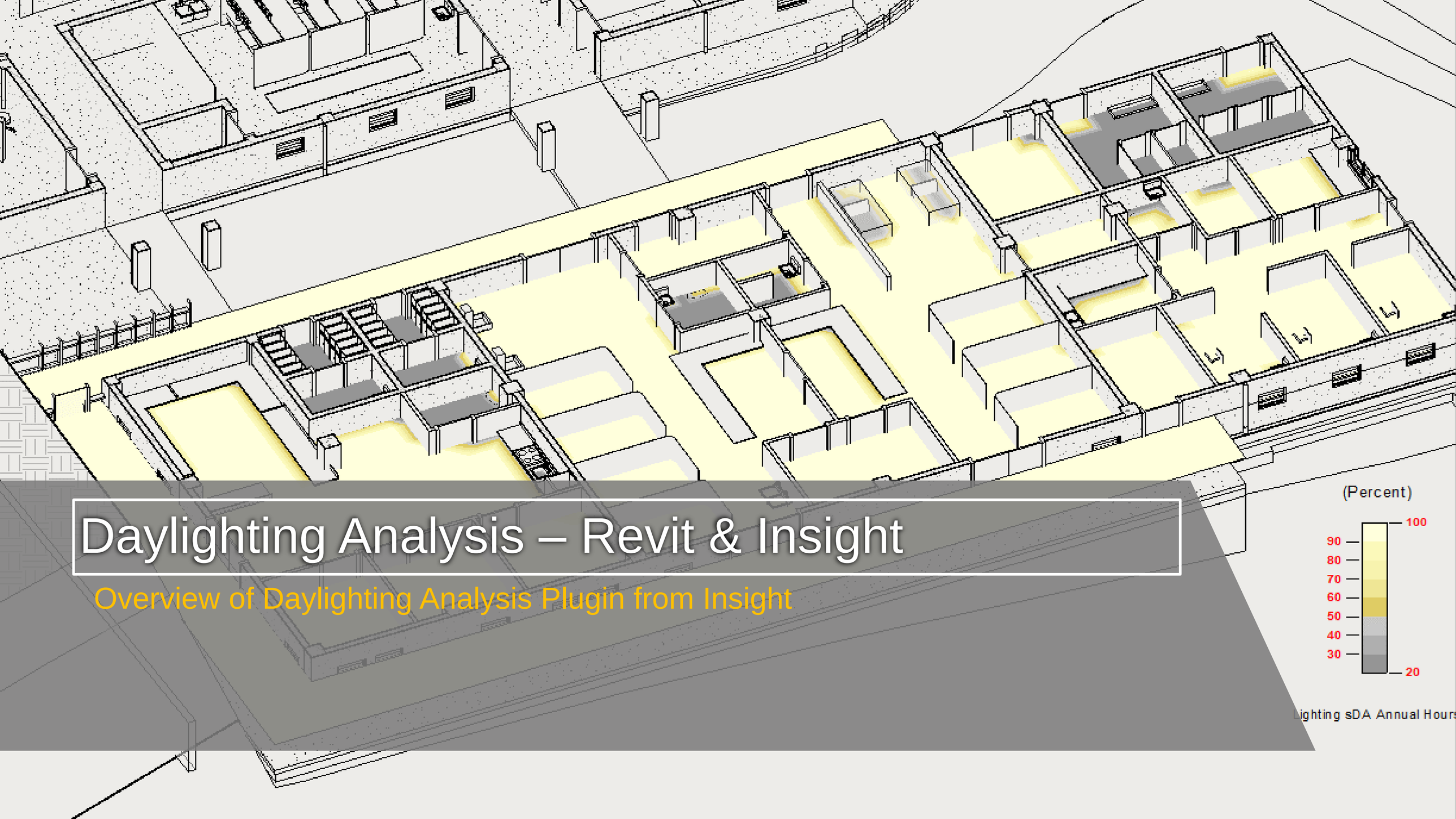


Insight – Collaboration and Interoperability

Build Health International

MICRODESK



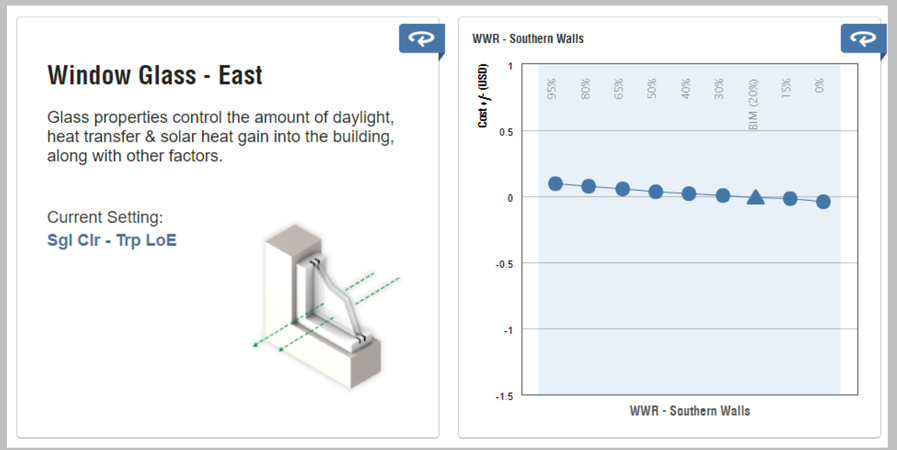
Daylighting Analysis – Revit & Insight

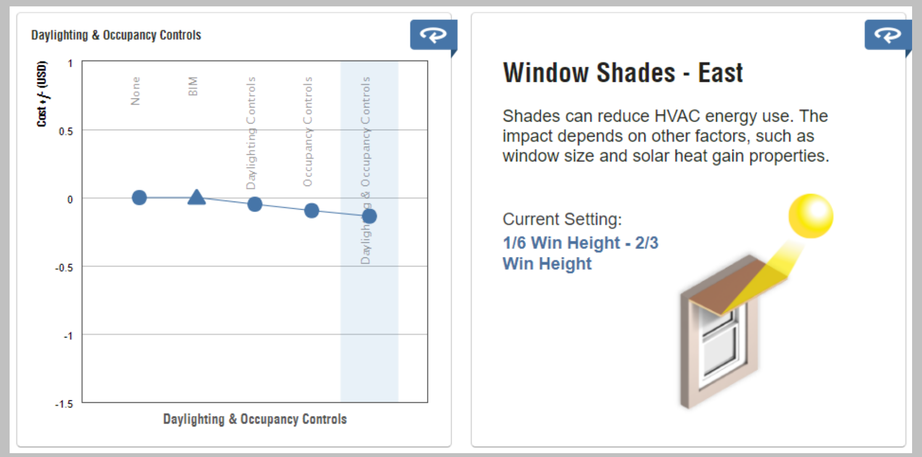
Overview of Daylighting Analysis Plugin from Insight

Daylighting Analysis – Insight

Insight – factors that impact daylighting:

- Window to Wall Ratio
- Glazing Types
- Daylight Controls
- Shading Devices



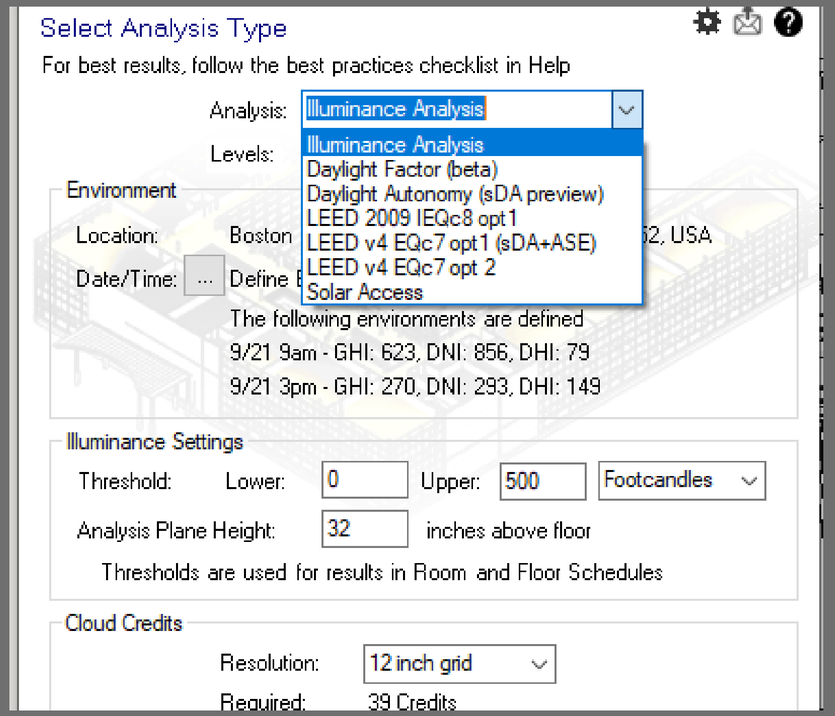


Daylighting Analysis - Revit

MULTIPLE TYPES OF ANALYSIS

MINIMAL USER INPUT

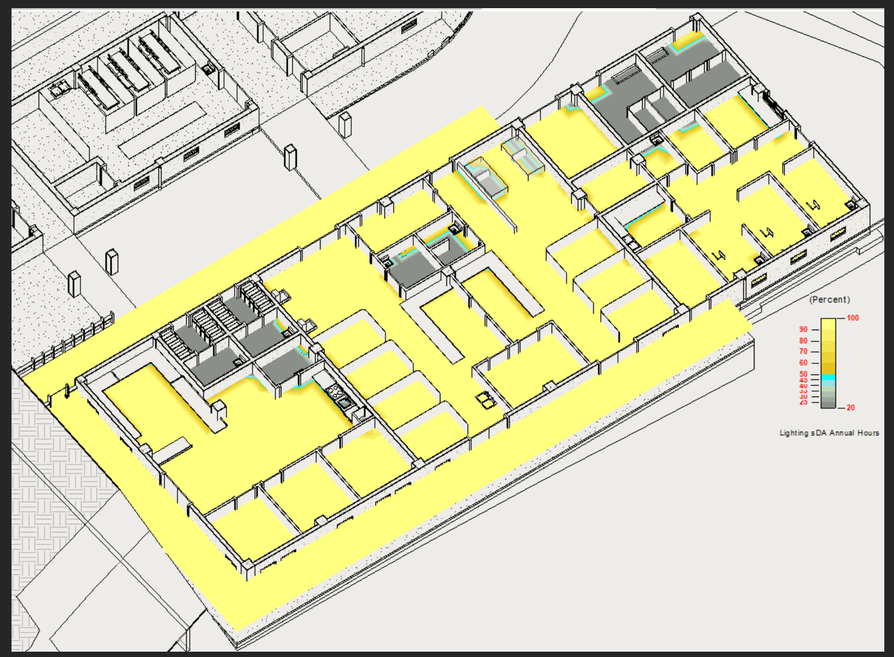
VISUALIZE THE RESULTS



Analytical Properties	
Analytic Construction	Double glazing - 1/4 in thick -
Define Thermal Properties by	Schematic Type
Visual Light Transmittance	0.600000
Solar Heat Gain Coefficient	0.310000
Thermal Resistance (R)	2.8573 (h·ft²·°F)/BTU
Heat Transfer Coefficient (U)	0.3500

Daylighting Analysis - Revit

Insight: Daylight Autonomy and Annual Sunlight Exposure



Lighting Analysis - Results Summary

LEED v4 EQc7 opt1 sDA/ASE
For all Rooms Included in Daylighting

Jan 1 to Dec 31, 8:00 am to 6:00 pm
(Both sDA and ASE must be met for Room area to qualify)

$sDA_{300/50}$ + $ASE_{1000/250}$ 3 Points

78% of Building area meets sDA % hours
in Rooms with <20% area above ASE

Detailed Summary:
78% of Building area meets sDA % hours
0% of sDA Building area fails for Rooms >ASE

1% of Building area >ASE hours threshold

85% of Rooms meet sDA >55% Room area
70% of Rooms meet sDA 75% Room area
0% of Rooms >ASE hours >20% Room area

Design Tips

Daylight Autonomy Tips

Included rooms are illuminated by natural daylight most hours of the year, and direct sun levels are within recommended limits. Take care to maintain solar shading and limit glazing transparency.

Building geometry

Design changes should maintain or increase ceiling and window head heights, and rooms currently have a good depth from glazed walls or skylights.

Glazing specification

Glazing transparency is good for overall daylight levels, ande may be decreased to reduce the potential impact of direct sun on occupant comfort and thermal energy management.

Shading

Direct sun is sufficiently shaded from affecting occupant comfort levels in included rooms. Avoid changes that would increase direct sun by reviewing sun and shading patterns using the Solar tool.

Daylighting Pattern Guide

<_InsightLighting Room Schedule>

LEED Daylight Autonomy Results Summary: 26.09, -81.75 - 45178

Building scores 3 LEED points with 78% Building area passing thresholds

At least 55% must exceed sDA300/50 in Rooms with ASE1000/250 < 20% of Room area

A	B	C	D	E	F	G	H	I	J	K
					sDA 300/50		ASE 1000/250		sDA/ASE	
Level	Name	Number	Area	Include In Daylighting	%	Points	%	Pass	%	Points
MATERNAL HEALT	FEMALE PATIENT T	MAT - 30	10 m²	☑	7	none	7	Yes	7	none
MATERNAL HEALT	MALE PATIENT TLT	MAT - 31	10 m²	☑	7	none	3	Yes	7	none
MATERNAL HEALT	DENTAL REGISTR	MAT - 33	7 m²	☑	75	3 pt	0	Yes	75	3 pt
MATERNAL HEALT	DENTAL OFFICE	MAT - 34	4 m²	☑	87	3 pt	0	Yes	87	3 pt
MATERNAL HEALT	STAFF TLT	MAT - 35	3 m²	☑	78	3 pt	0	Yes	78	3 pt
MATERNAL HEALT	MEP	MAT - 32	10 m²	☑	93	3 pt	7	Yes	93	3 pt
MATERNAL HEALT	STORAGE	MAT - 36	5 m²	☑	89	3 pt	0	Yes	89	3 pt
MATERNAL HEALT	DENTAL WORKRO	MAT - 37	6 m²	☑	55	2 pt	0	Yes	55	2 pt
MATERNAL HEALT	ON CALL	MAT - 41	7 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	ANTENATAL / POS	MAT - 43	39 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	RECLINERS	MAT - 42	11 m²	☑	69	2 pt	0	Yes	69	2 pt
MATERNAL HEALT	NURSE'S STATION	MAT - 47	11 m²	☑	74	2 pt	0	Yes	74	2 pt
MATERNAL HEALT	CLEAN / MED SUPP	MAT - 49	10 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	NURSE'S STATION	MAT - 48	11 m²	☑	91	3 pt	0	Yes	91	3 pt
MATERNAL HEALT	PAT. TLT	MAT - 46	4 m²	☑	0	none	0	Yes	0	none
MATERNAL HEALT	DIRTY	MAT - 44	7 m²	☑	96	3 pt	0	Yes	96	3 pt
MATERNAL HEALT	LABOR & DELIVER	MAT - 50	51 m²	☑	95	3 pt	1	Yes	95	3 pt
MATERNAL HEALT	LOCKER ROOM	MAT - 51	4 m²	☑	0	none	0	Yes	0	none
MATERNAL HEALT	LOCKER ROOM	MAT - 53	4 m²	☑	0	none	0	Yes	0	none
MATERNAL HEALT	STAFF TLT	MAT - 55	4 m²	☑	0	none	0	Yes	0	none
MATERNAL HEALT	SUPPLIES	MAT - 56	4 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	CONFERENCE ROO	MAT - 59	9 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	OFFICE	MAT - 60	8 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	OFFICE	MAT - 61	8 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	OPEN WORK SPAC	MAT - 57	15 m²	☑	60	2 pt	0	Yes	60	2 pt
MATERNAL HEALT	RECEPTION	MAT - 58	3 m²	☑	100	3 pt	0	Yes	100	3 pt
MATERNAL HEALT	TLT	MAT - 52	3 m²	☑	0	none	0	Yes	0	none
MATERNAL HEALT	TLT	MAT - 54	3 m²	☑	0	none	0	Yes	0	none
MATERNAL HEALT	PATIENT TLT / SHO	MAT - 45	4 m²	☑	0	none	0	Yes	0	none
MATERNAL HEALT	DENTAL WAITING	MAT - 29	53 m²	☑						

Lighting Analysis Schedules

- Room Schedule
- Floor Area Schedule

Daylighting Analysis - Revit

MICRODESK

Lighting Analysis - Results Summary

Custom Analysis
For all Rooms Included in Daylighting

Total Both - 85% Passing

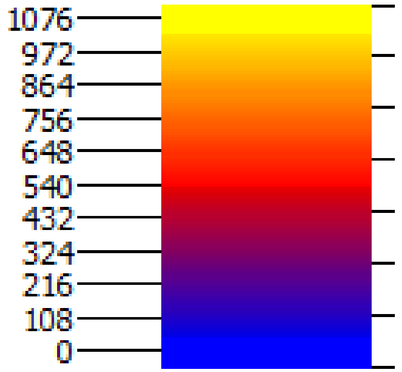
0% either time below threshold
15% either time above threshold

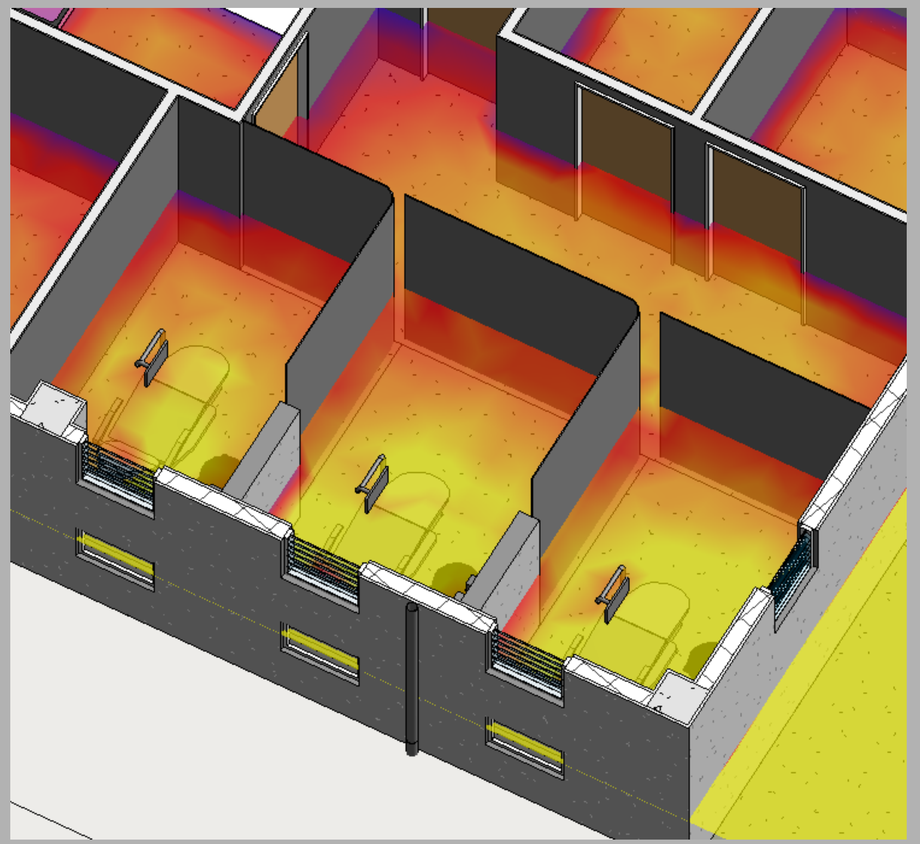
9:00 am - 85% Passing

June 21
GHI: 614, DNI: 694, DHI: 84
0% below threshold
15% above threshold w/o shades

9:00 am - 85% Passing

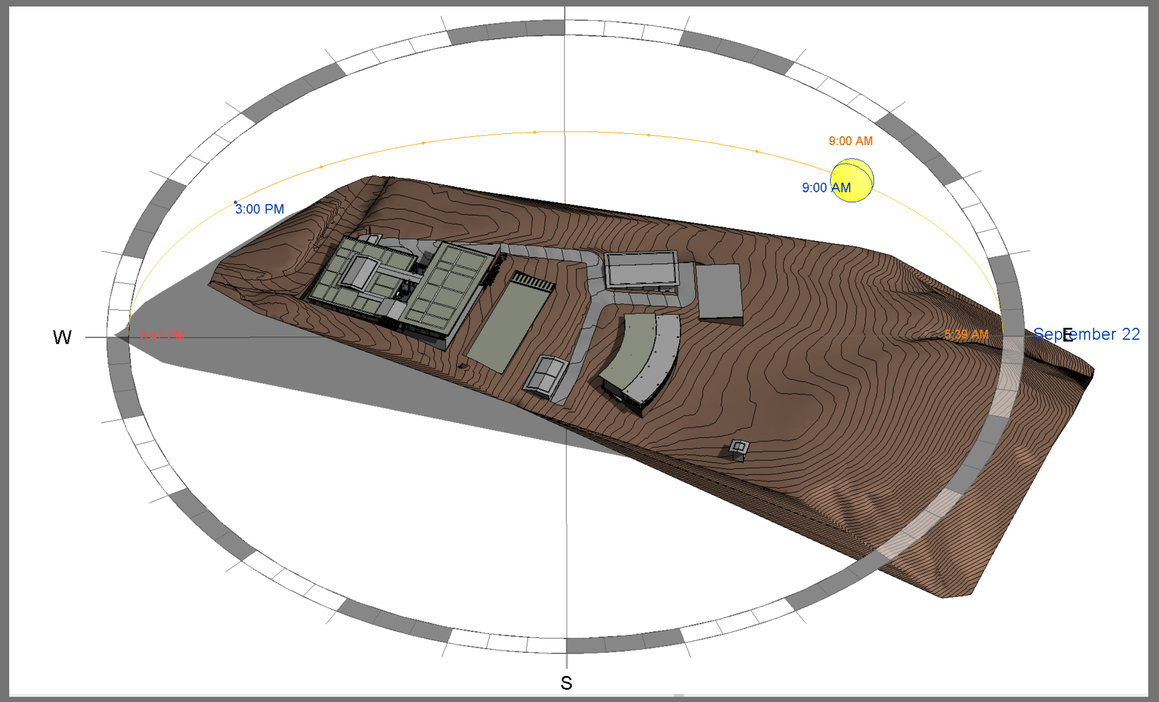
June 21
GHI: 614, DNI: 694, DHI: 84
0% below threshold
15% above threshold w/o shades





Daylighting Analysis - Revit

MICRODESK



Solar Studies in Revit

Illuminance study

Solar Insolation

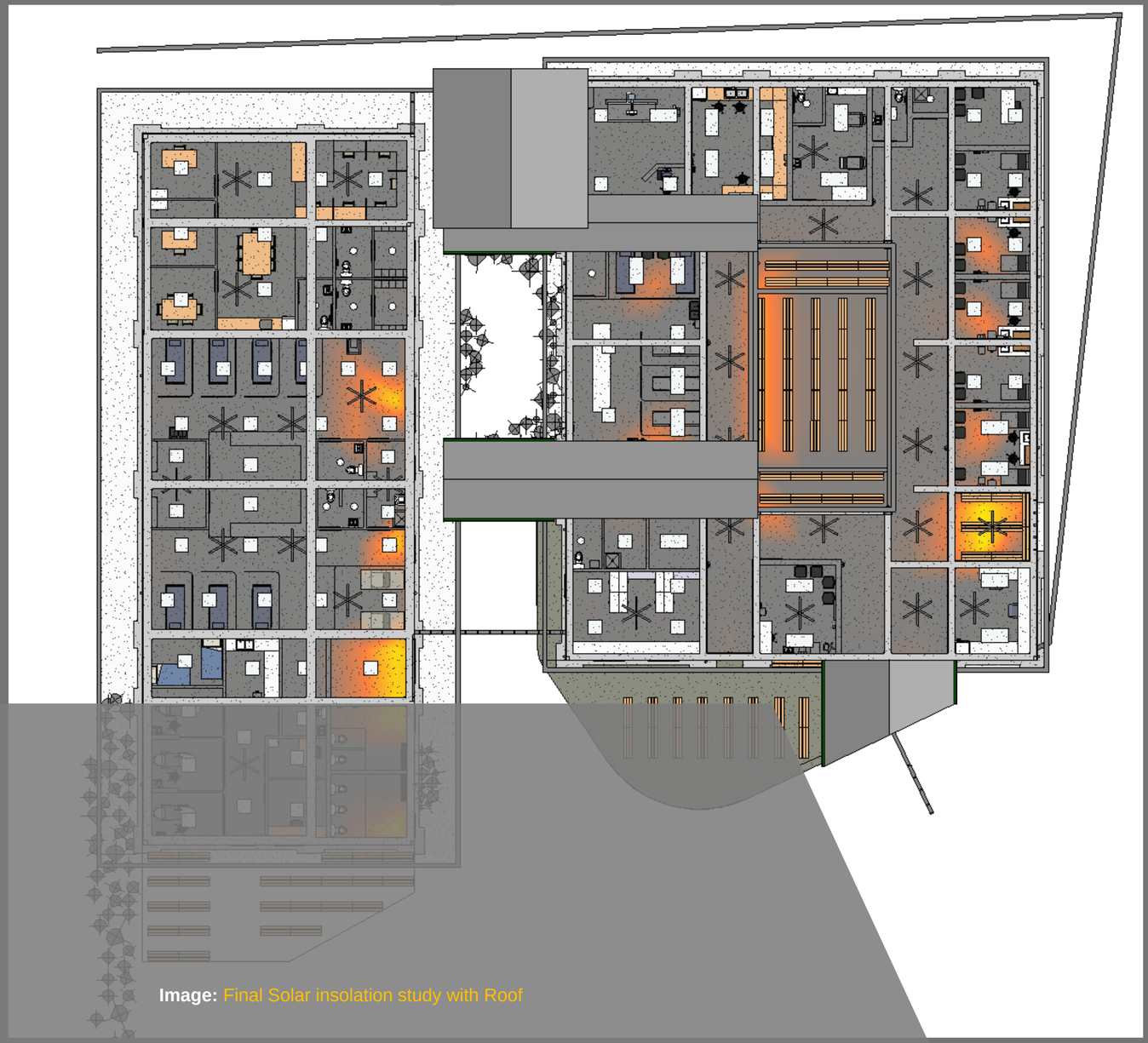
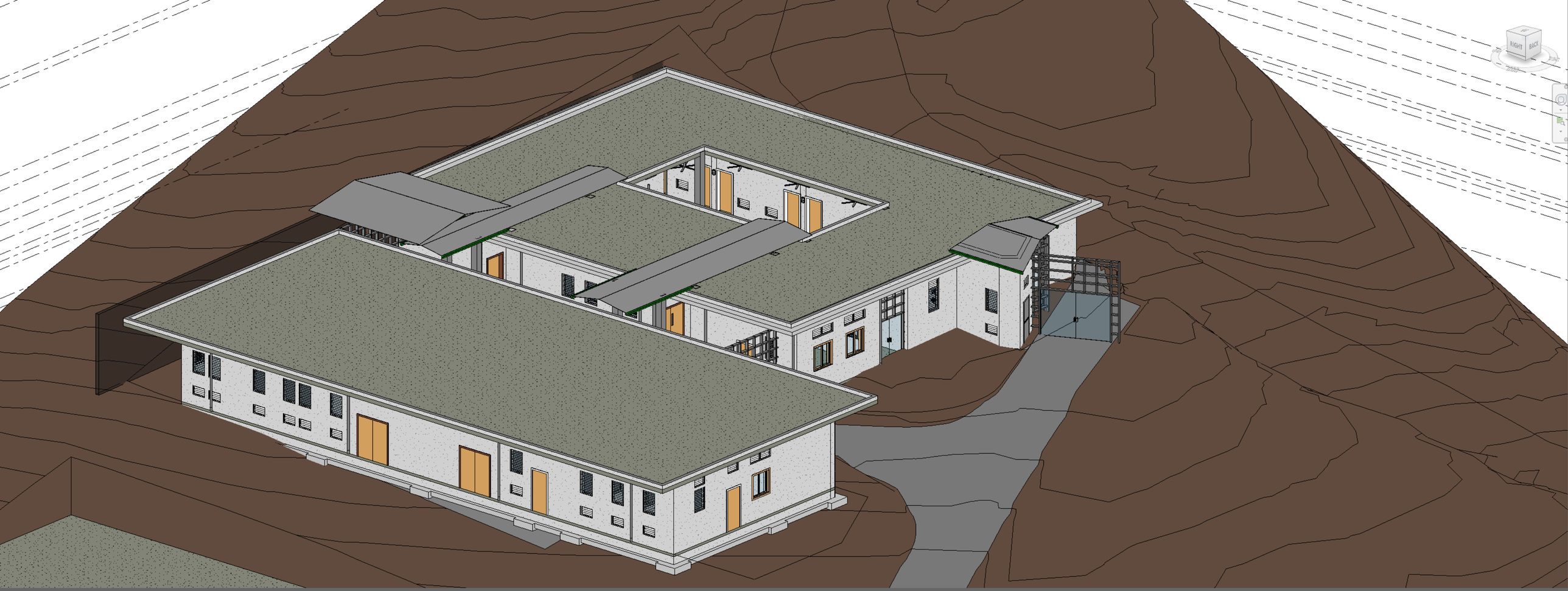


Image: Final Solar insolation study with Roof

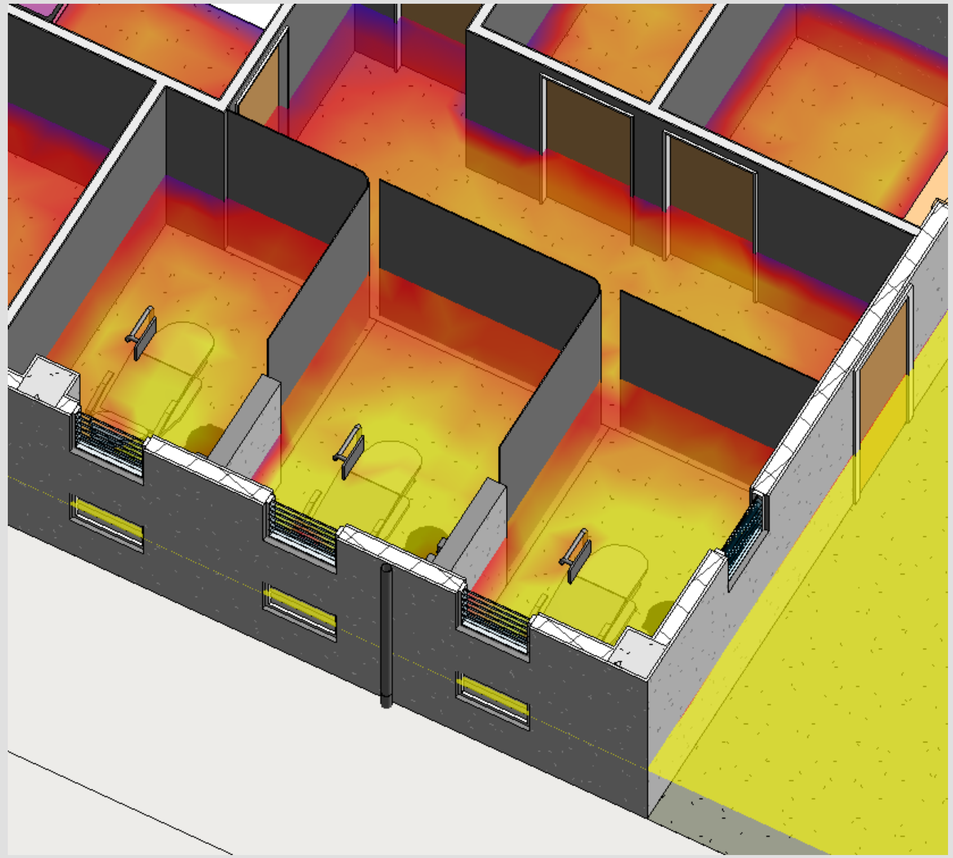


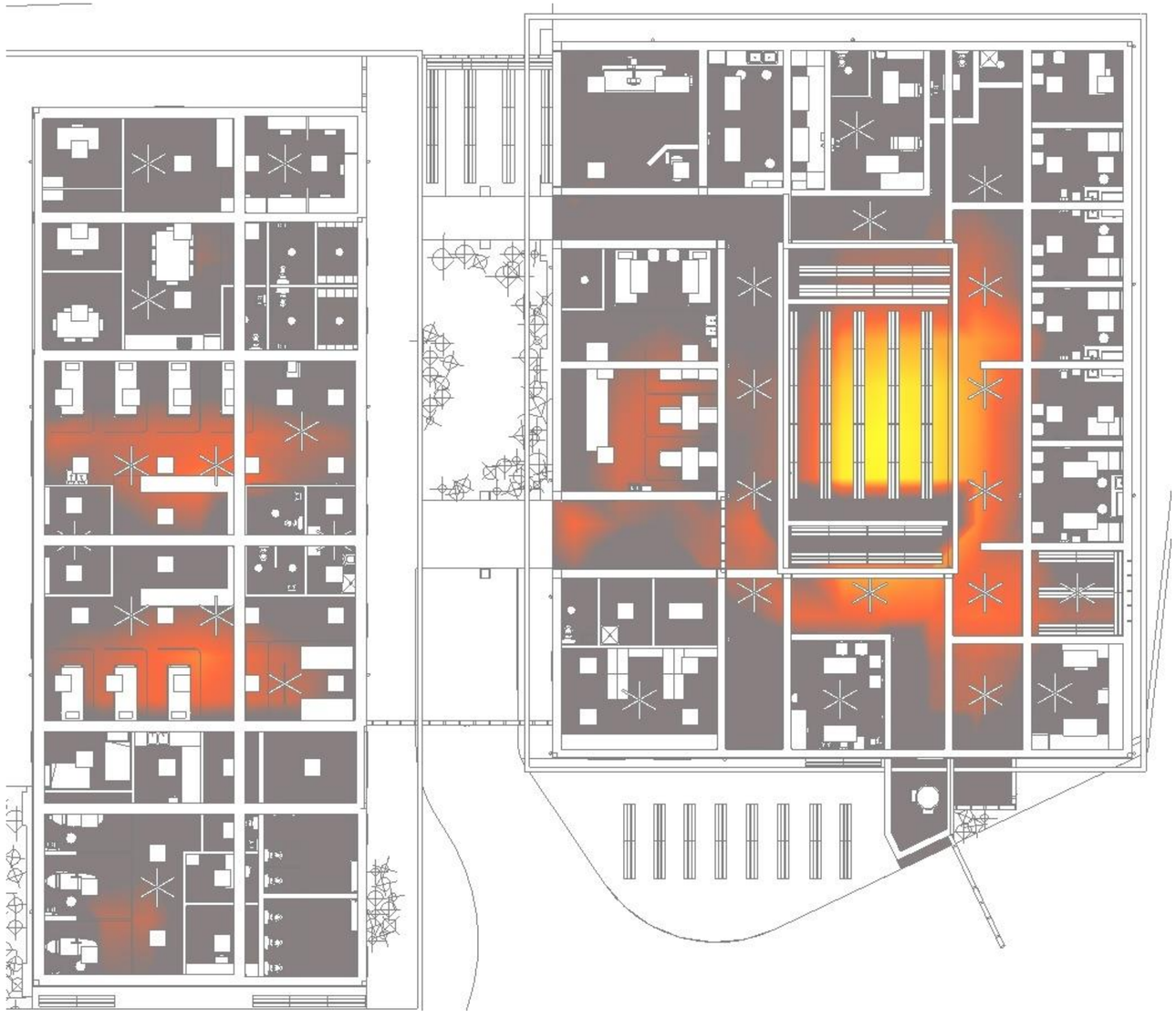
Courtyard | Shading Study

Solar Insolation

Custom Illuminance

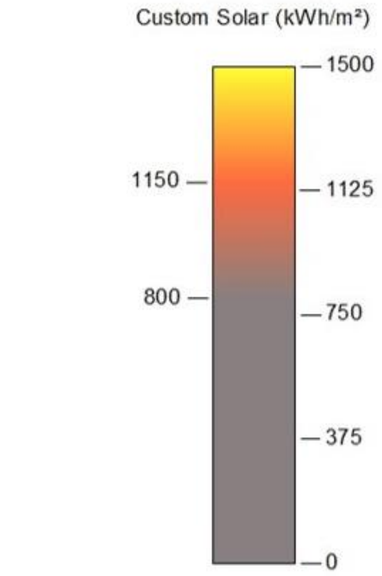
Solar insolation is the amount of electromagnetic energy (**solar radiation**) incident on the surface of the earth. This refers to the amount of sunlight shining down on the area under consideration.





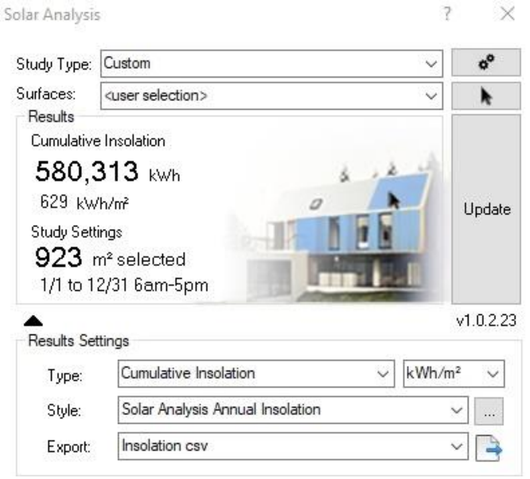
Solar Insolation – Annual Insolation

No Canopy



Project location: Haiti
Sun study start date time: 1/1/2020 6:24:00 AM
Sun study end date time: 12/31/2020 5:23:00 PM

Cumulative Insolation

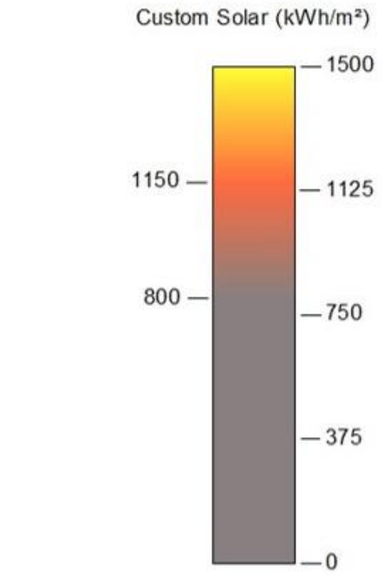


Solar Studies - Revit

MICRODESK

Solar Insolation – Annual Insolation

With Canopy



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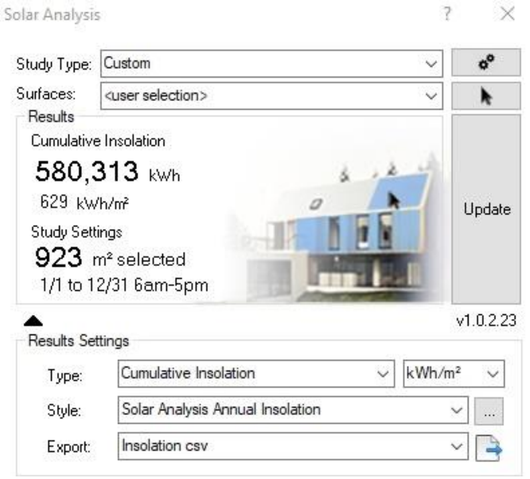
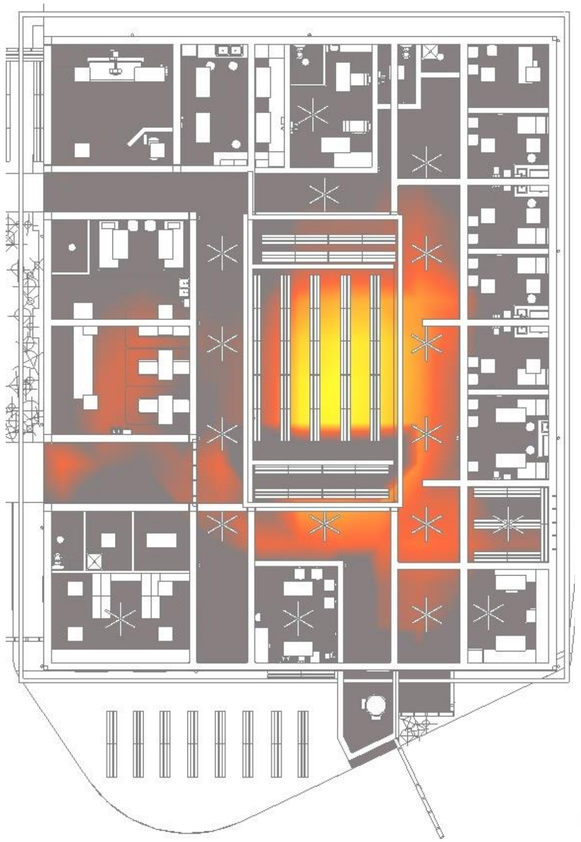
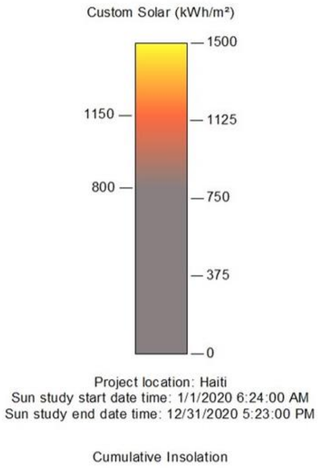
Cumulative Insolation



Solar Studies - Revit

MICRODESK





Solar Insolation – Annual Insolation

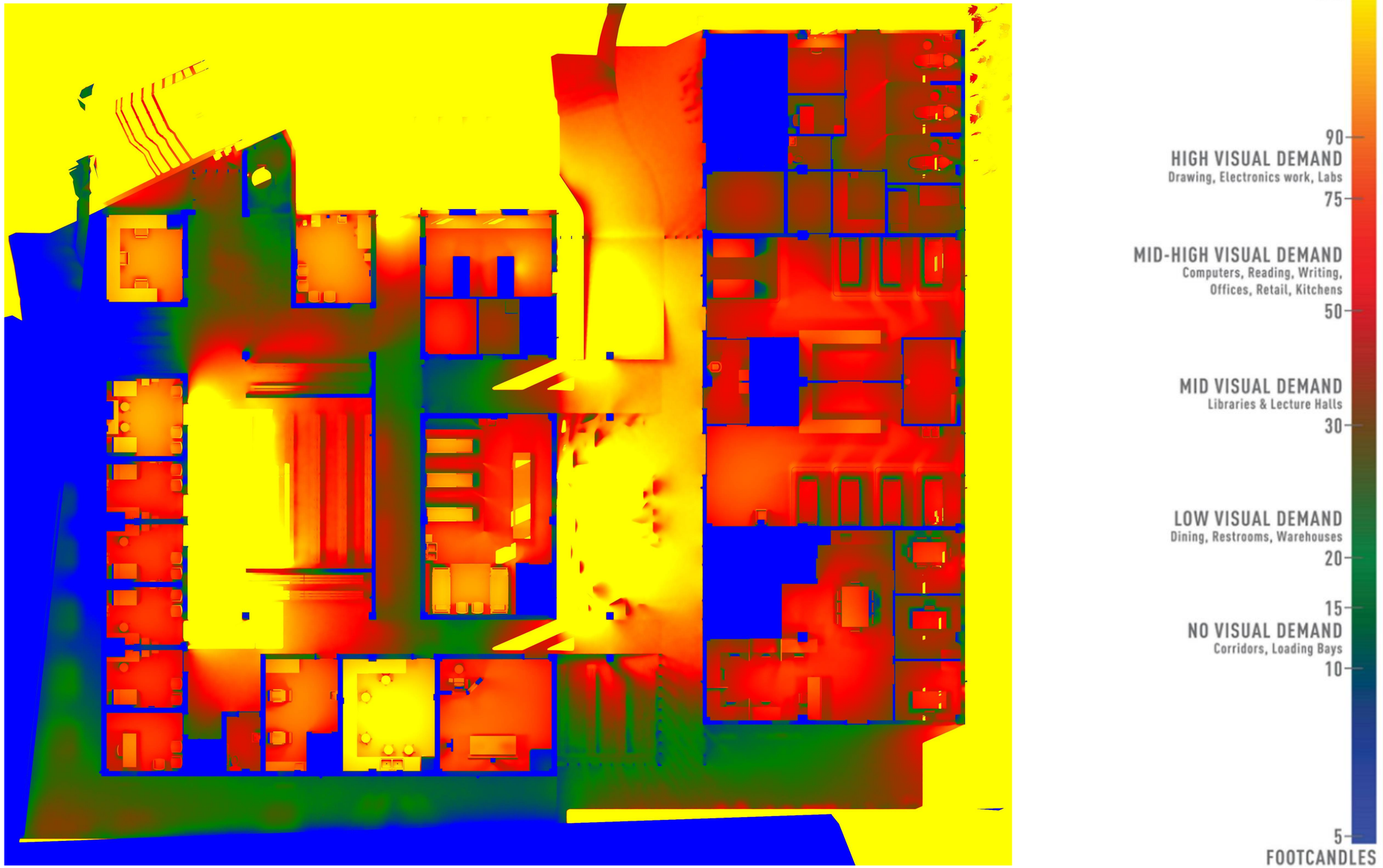
With Canopy & without – Comparison

More Solar exposure means, more **Energy** transferred into your space

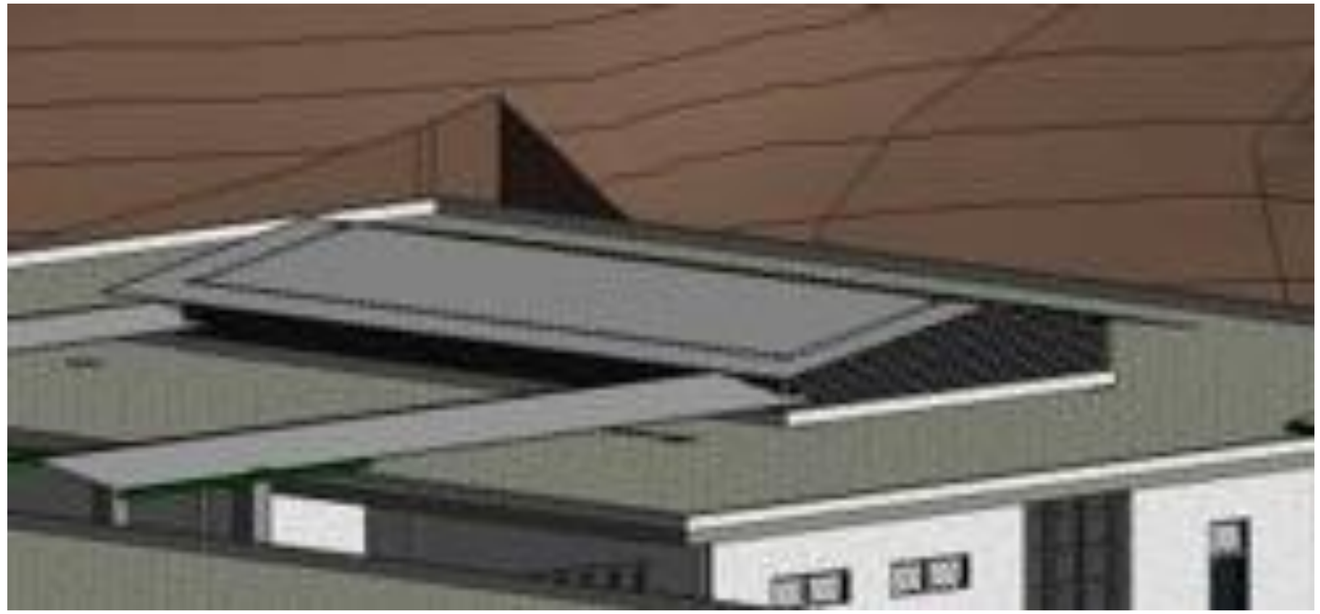
Energy = Heat
Measured in:(kWh/M_2)

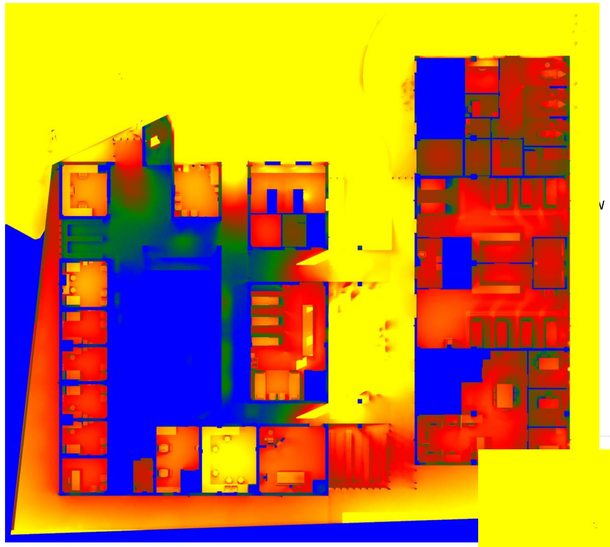
Solar Studies - Revit

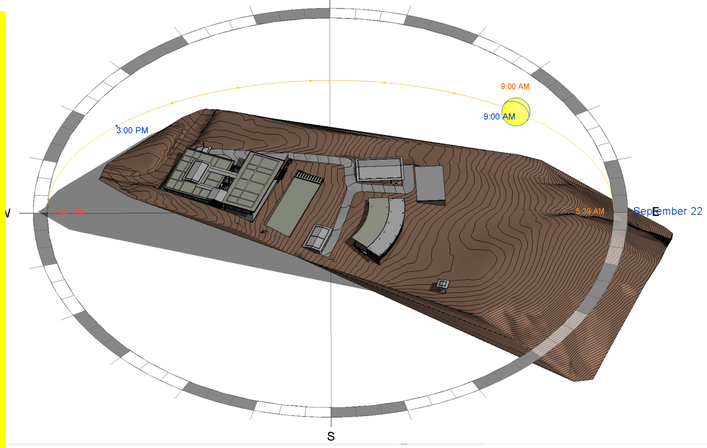
MICRODESK



FALL EQUINOX – NO ROOF OVER COURTYARD







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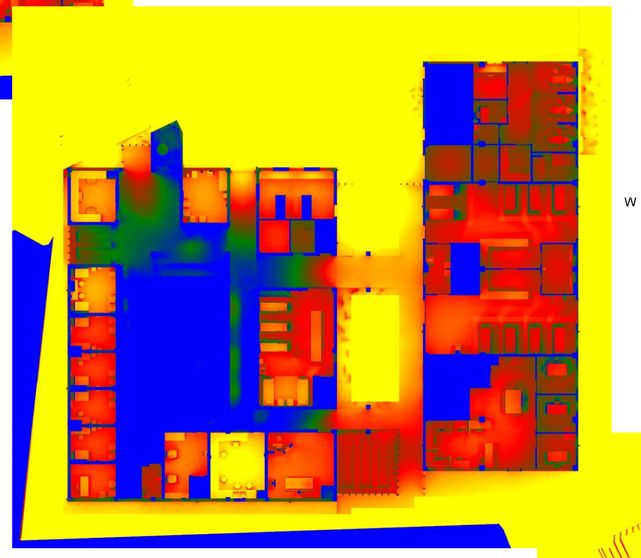

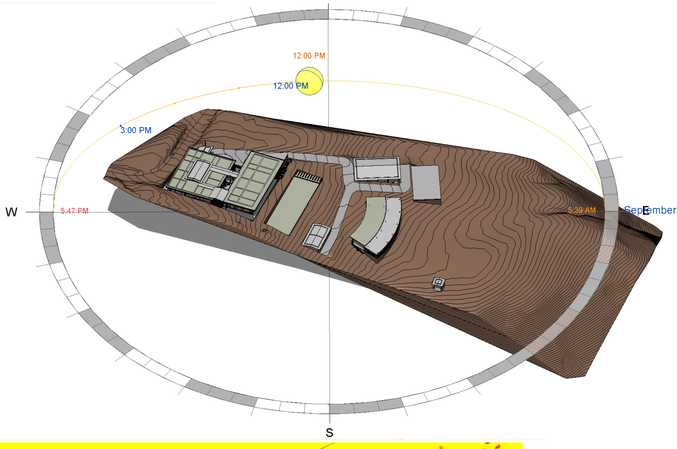

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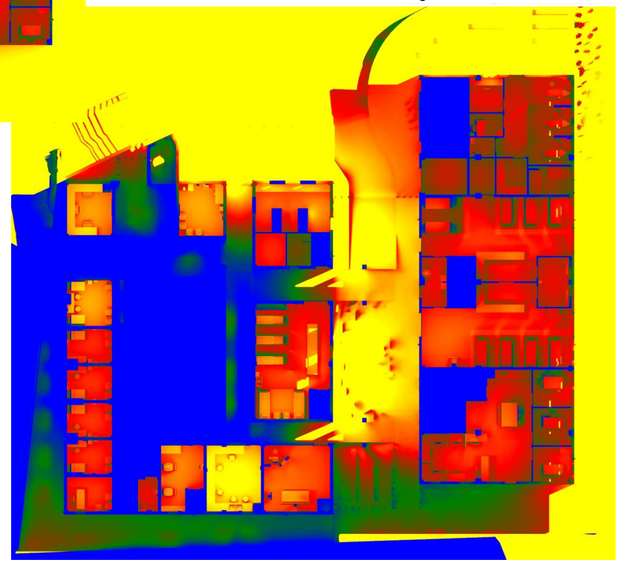

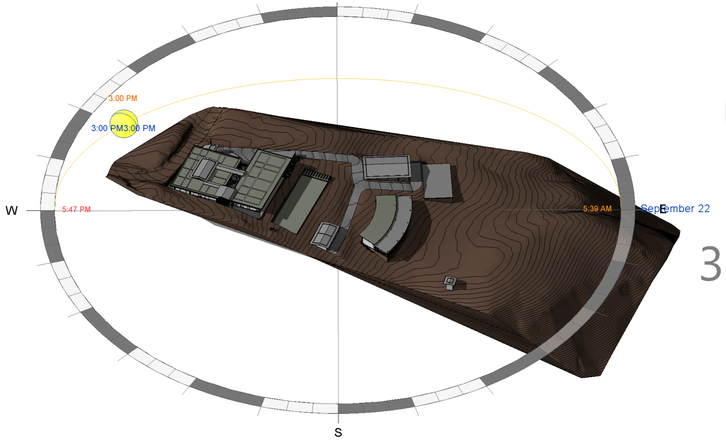

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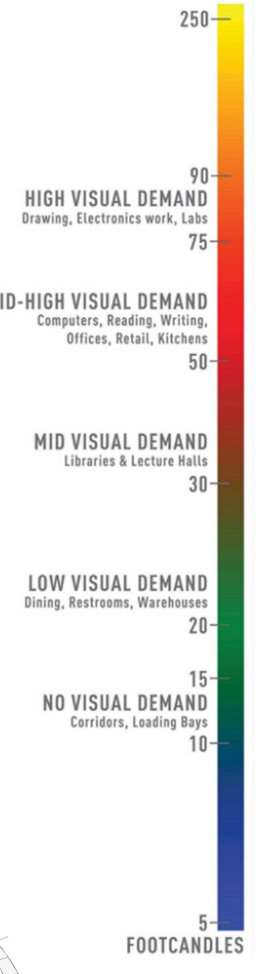
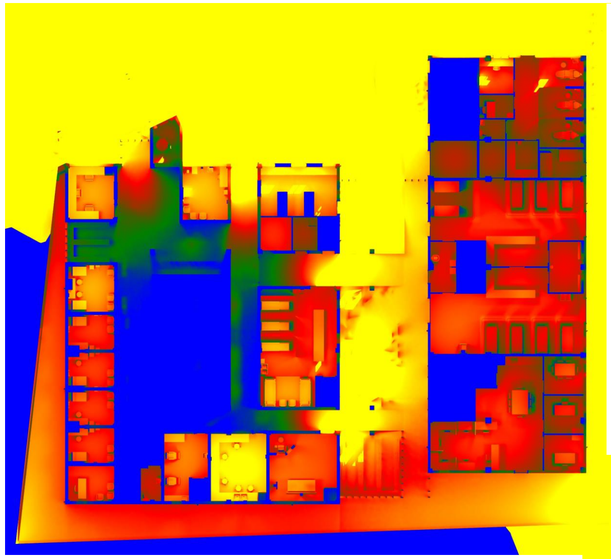
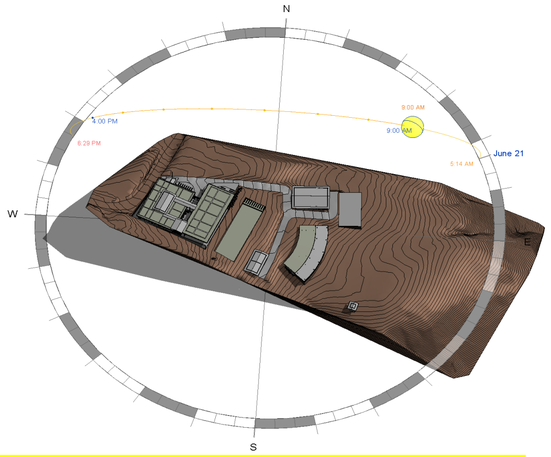


FALL EQUINOX

PITCHED ROOF OVER
COURTYARD





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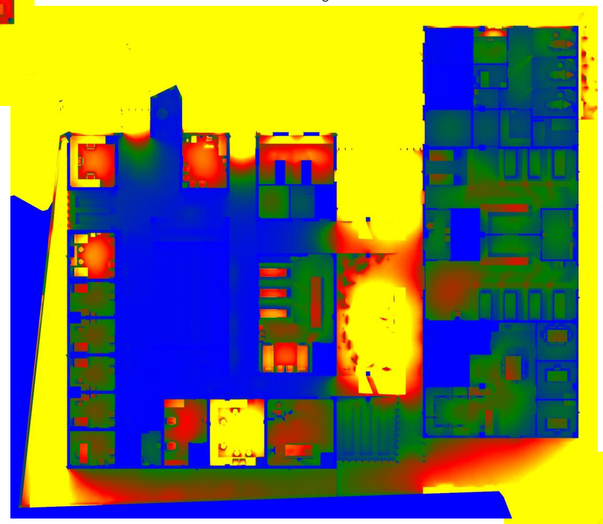
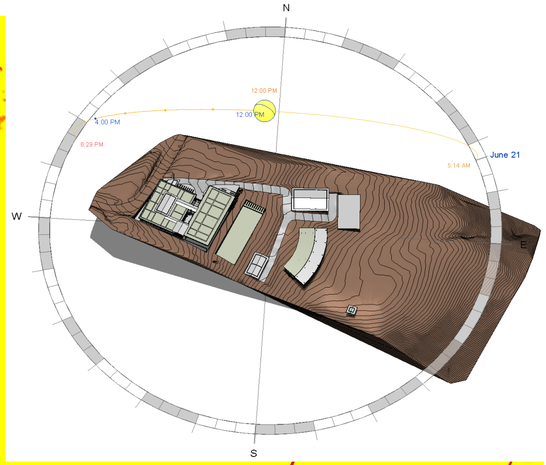
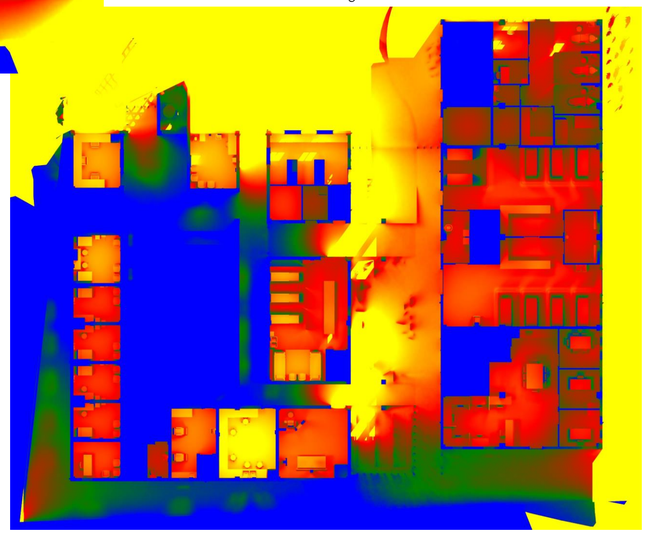
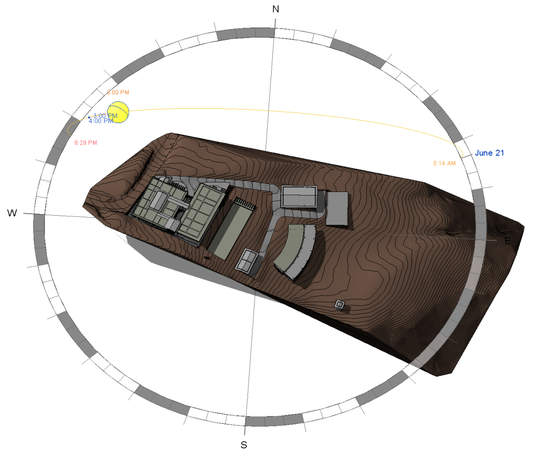




12:00 P.M.

250
90
HIGH VISUAL DEMAND
Drawing, Electronics work, Labs
75
MID-HIGH VISUAL DEMAND
Computers, Reading, Writing,
Offices, Retail, Kitchens
50
MID VISUAL DEMAND
Libraries & Lecture Halls
30
LOW VISUAL DEMAND
Dining, Restrooms, Warehouses
20
15
NO VISUAL DEMAND
Corridors, Loading Bays
10
5
FOOTCANDLES

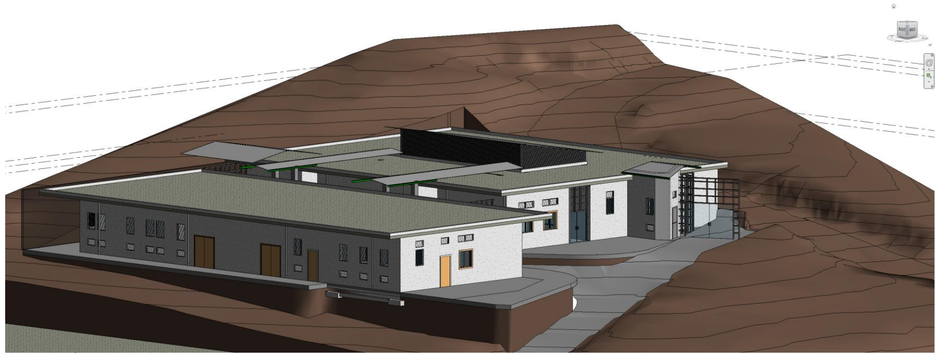


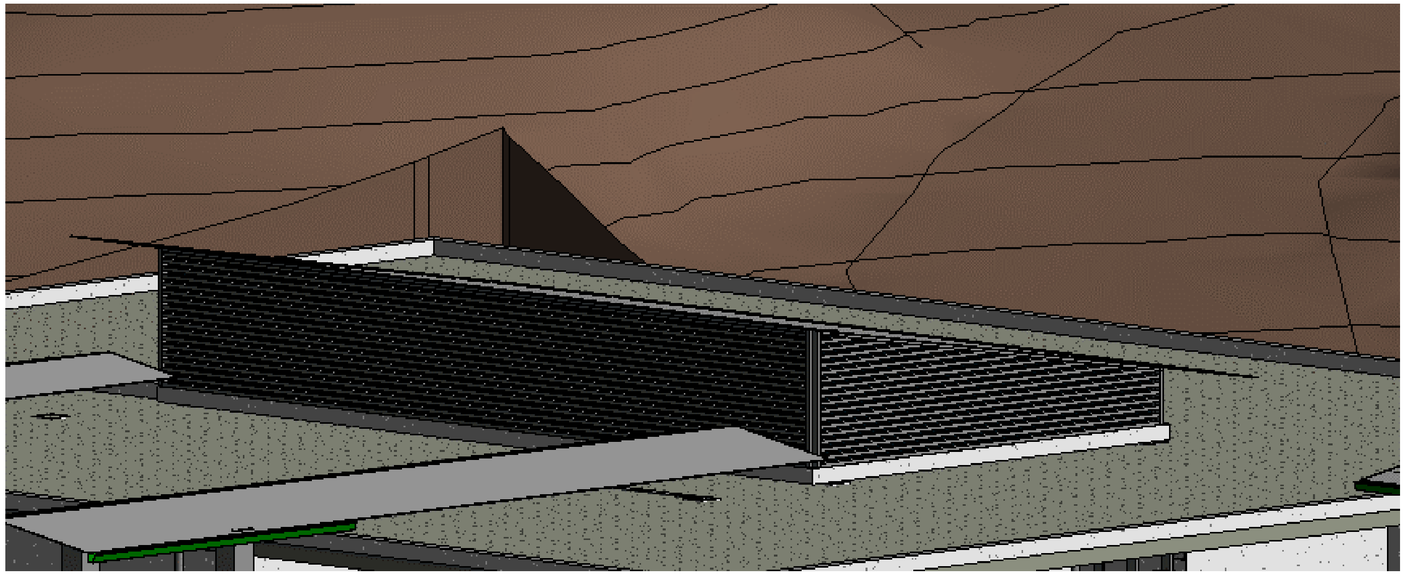


3:00 P.M.

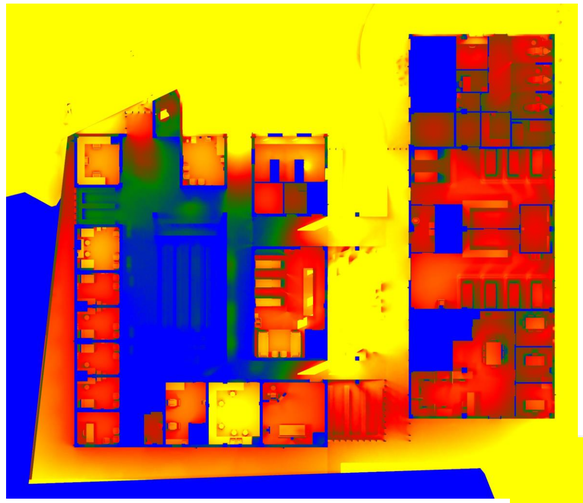
SUMMER SOLSTICE

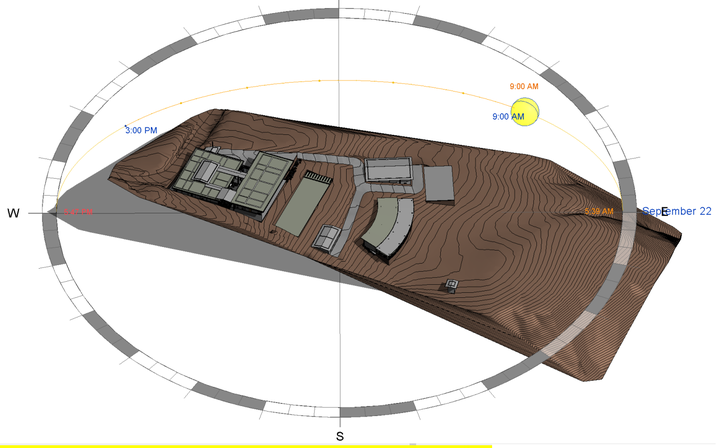
PITCHED ROOF OVER COURTYARD



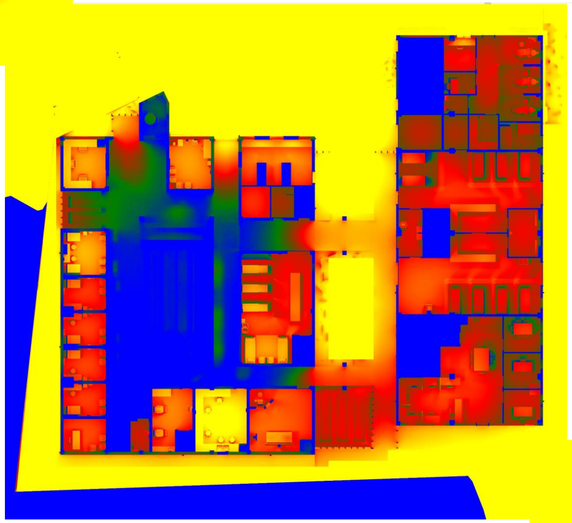


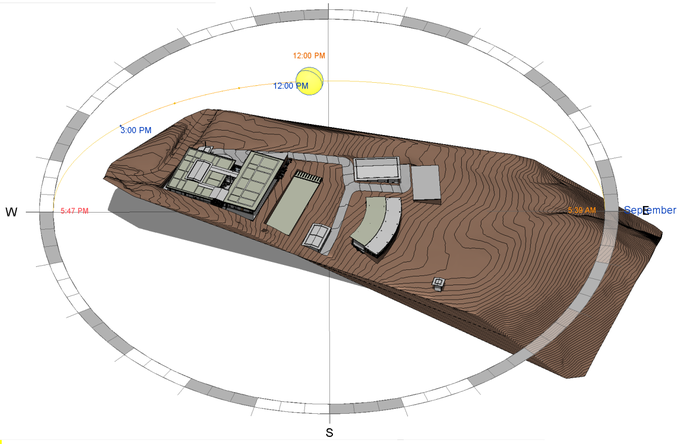
Roof Studies - Daylighting





9:00 A.M.





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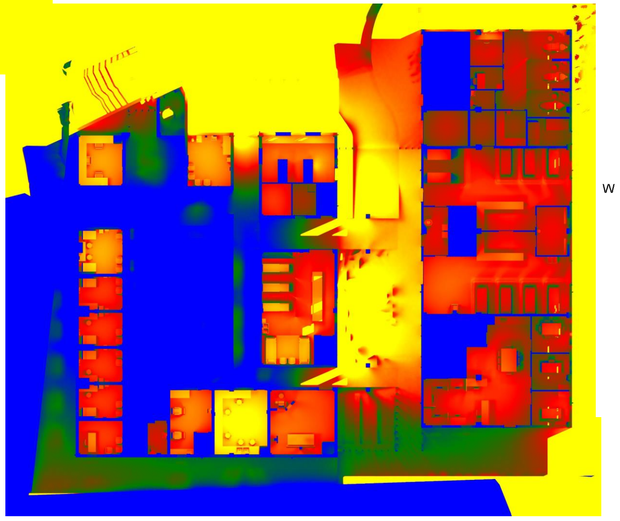
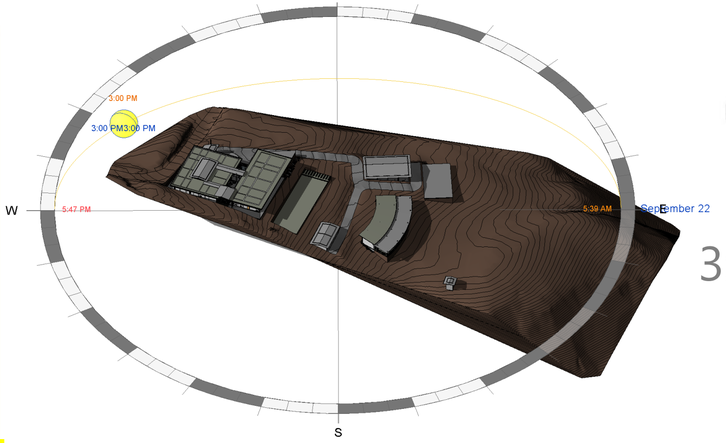
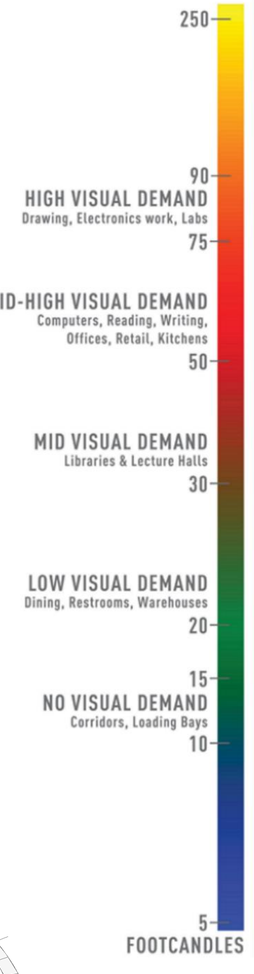




3:00 P.M.

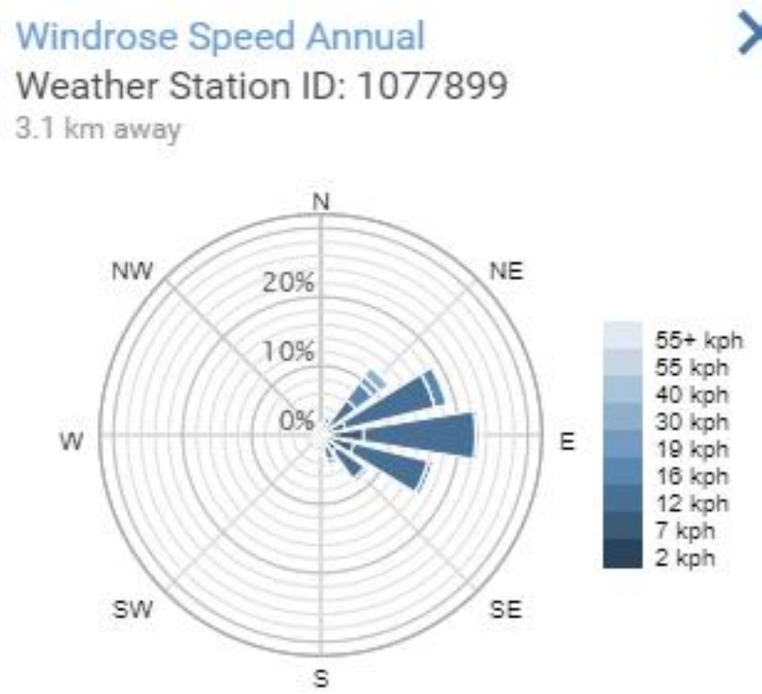


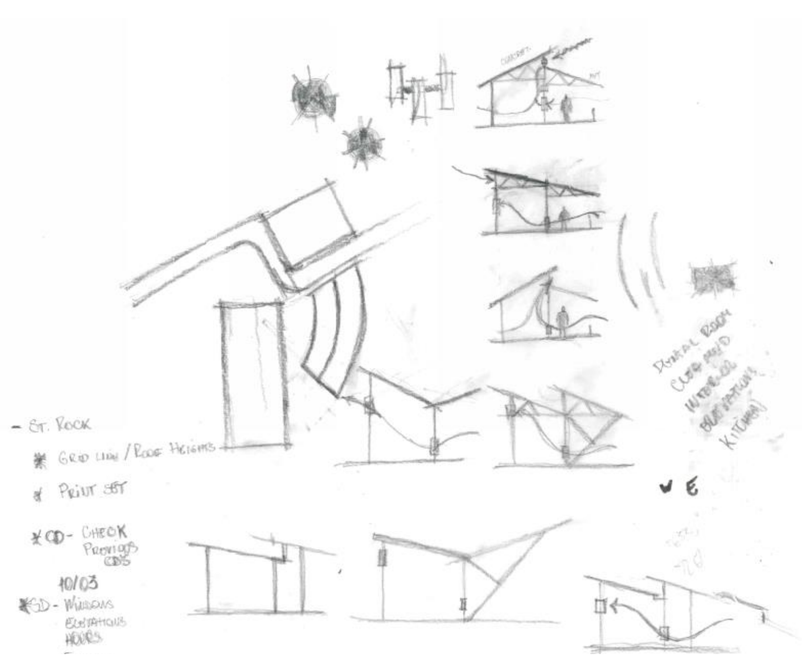
FALL EQUINOX

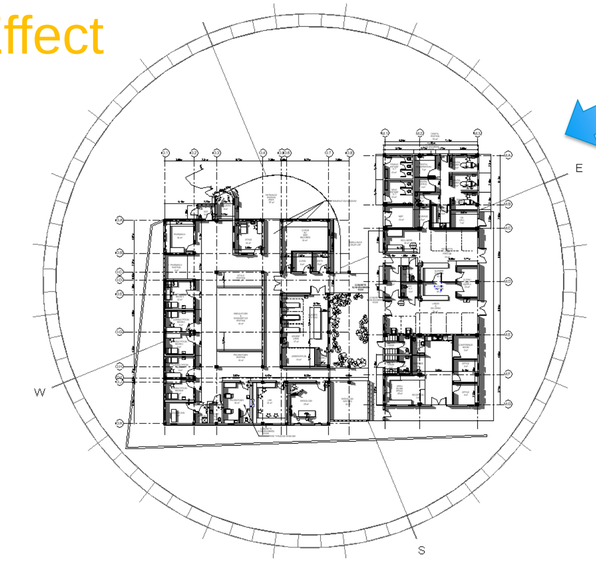
SINGLE SLOPED ROOF OVER COURTYARD

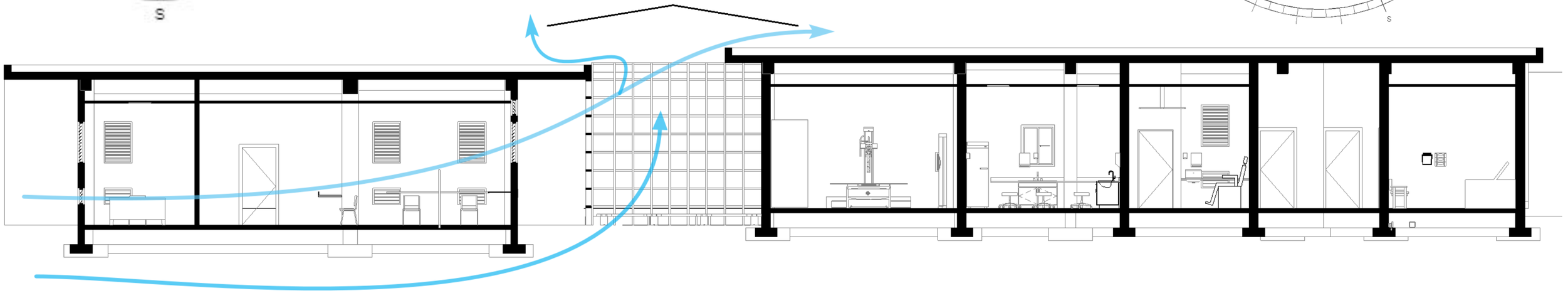
Natural Ventilation

Stack Effect









Wind Flow

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PV Analysis – Revit

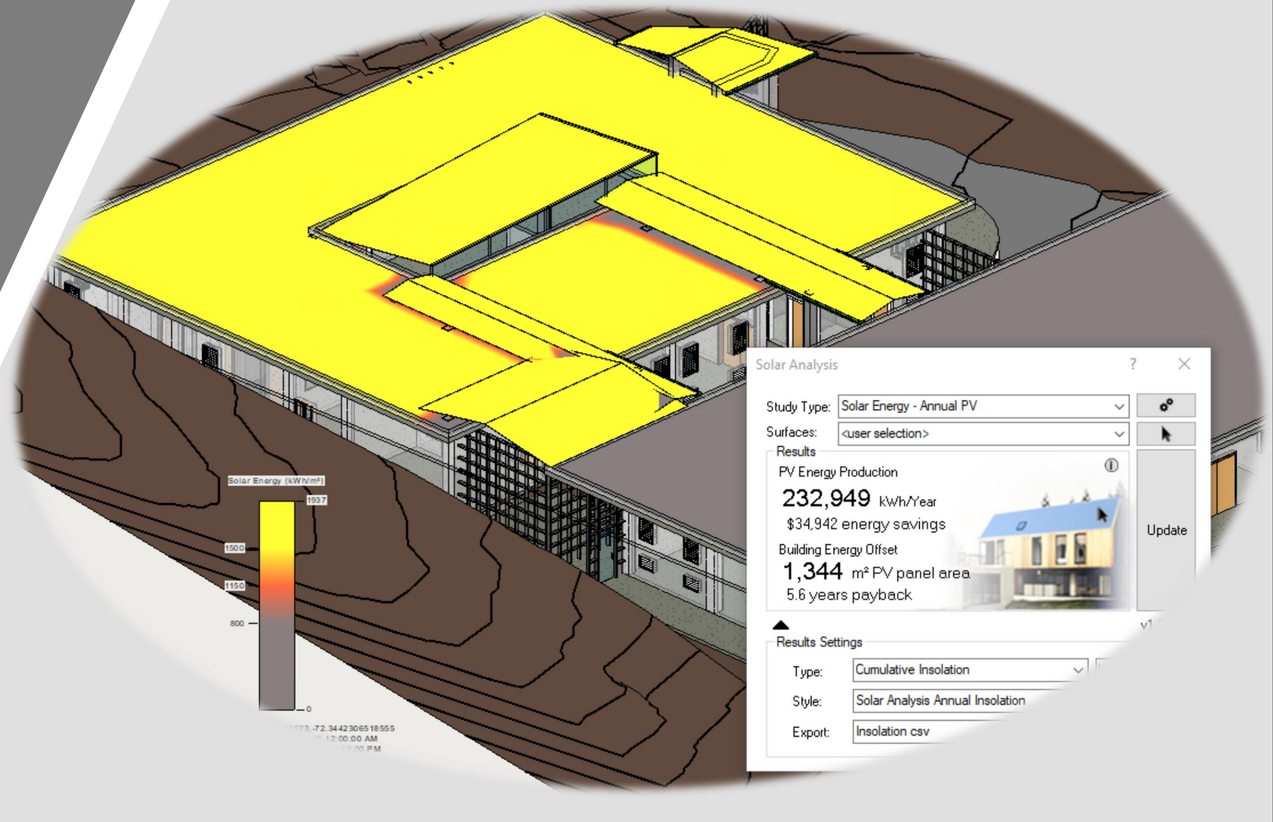
Photovoltaic (PV) Analysis

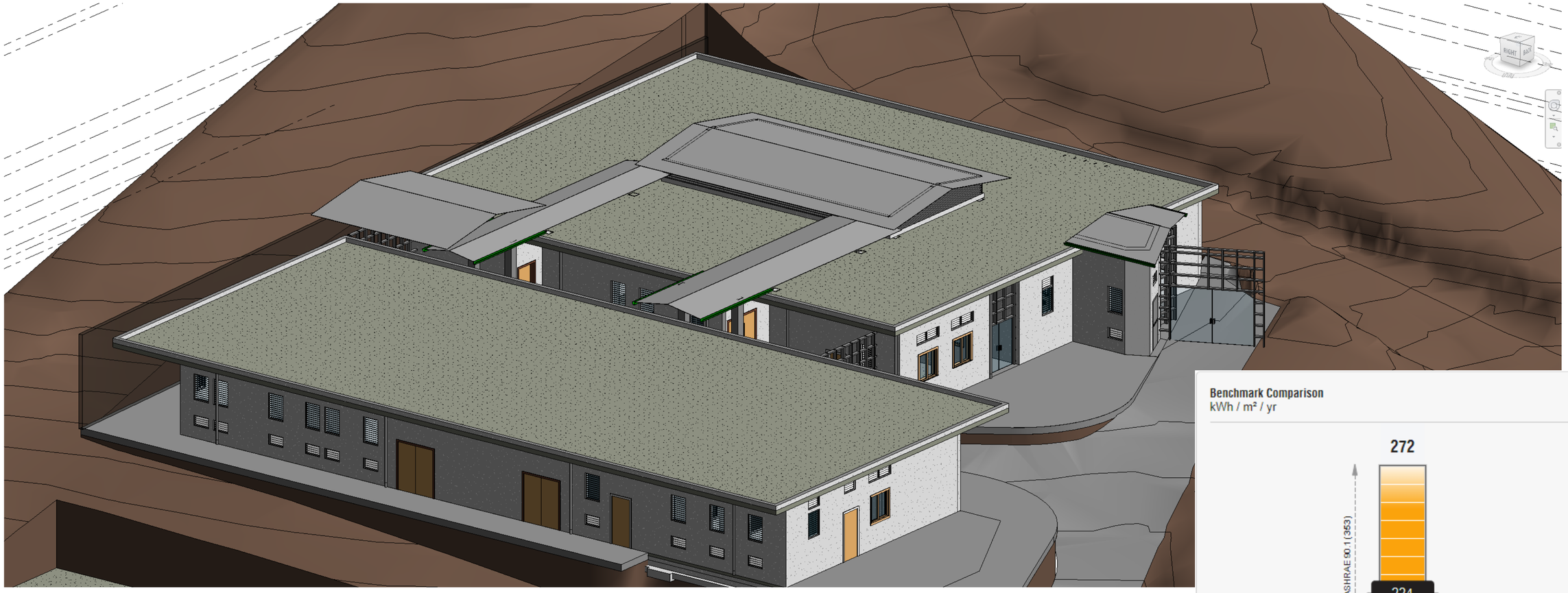
Determine prime locations

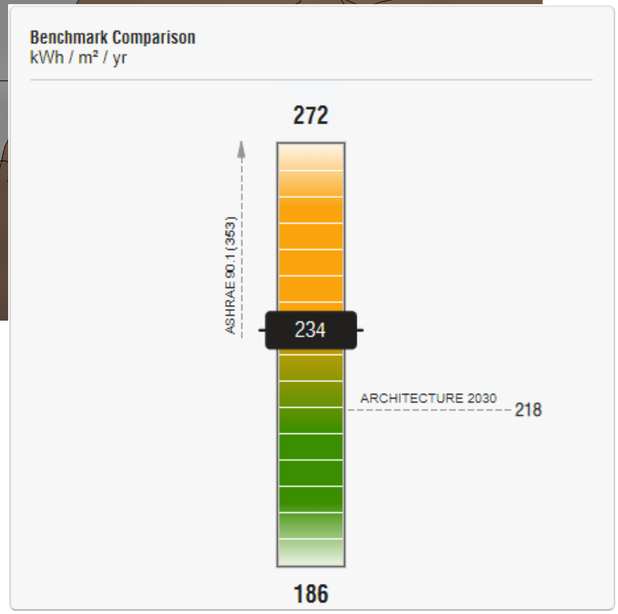
Estimate PV production

Estimate building energy offset

Roughly predict payback period.







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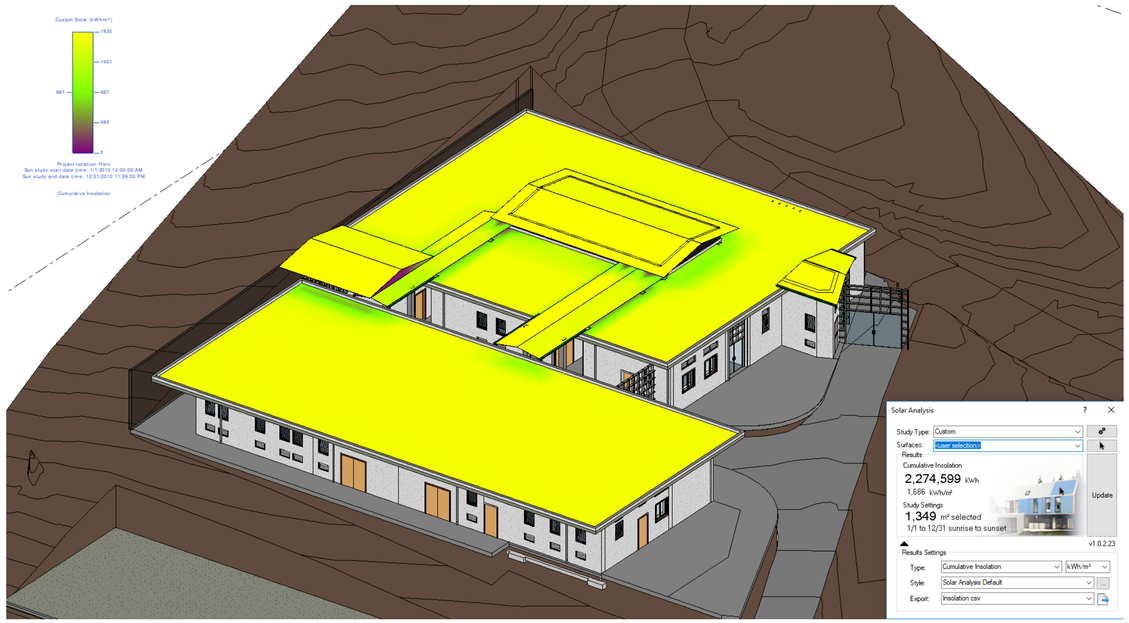
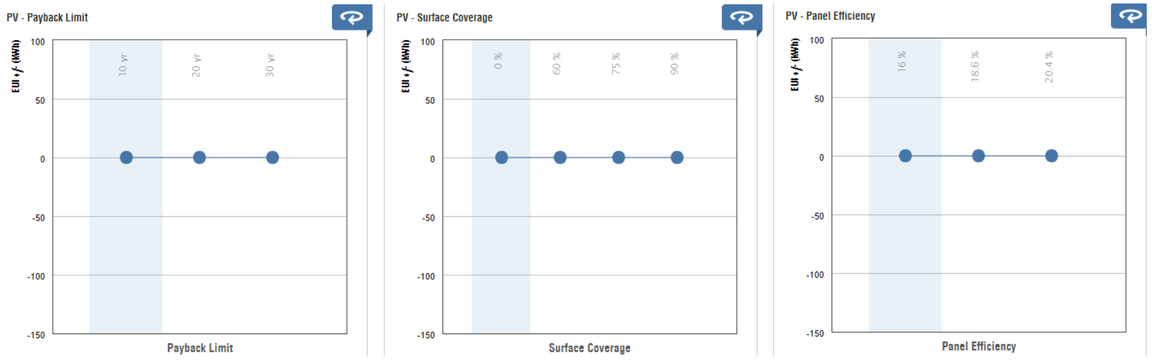
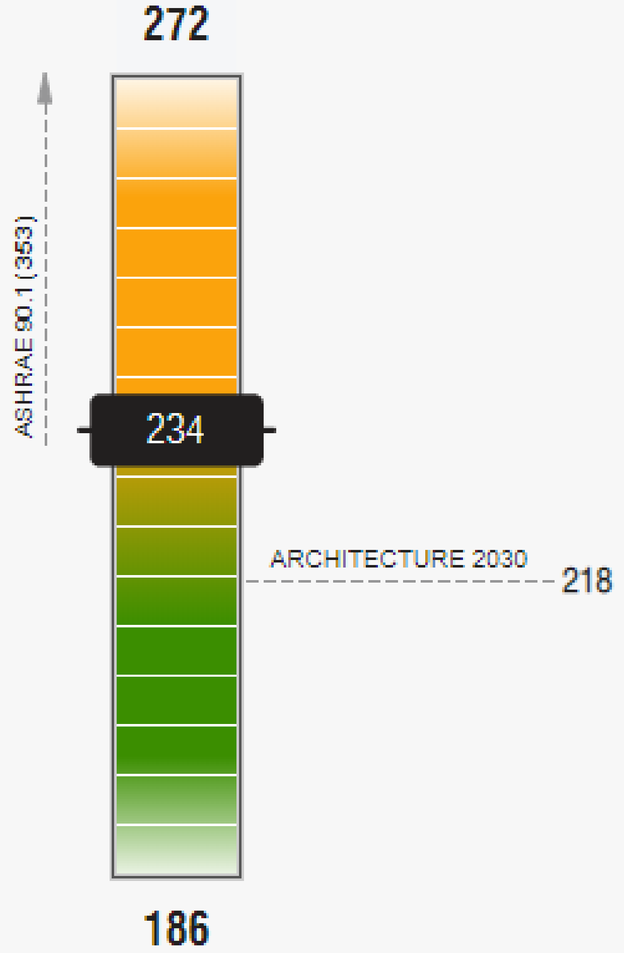




Benchmark Comparison
kWh / m² / yr



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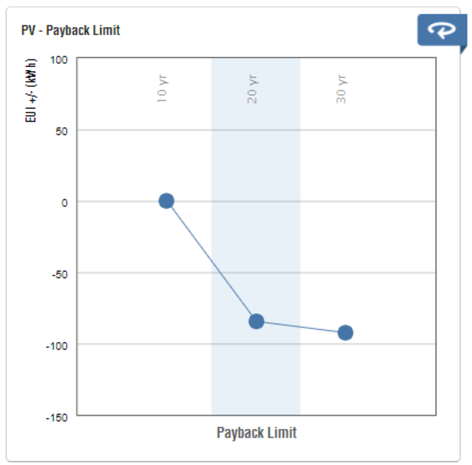

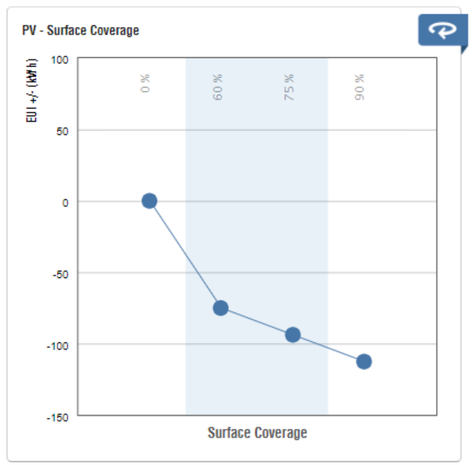

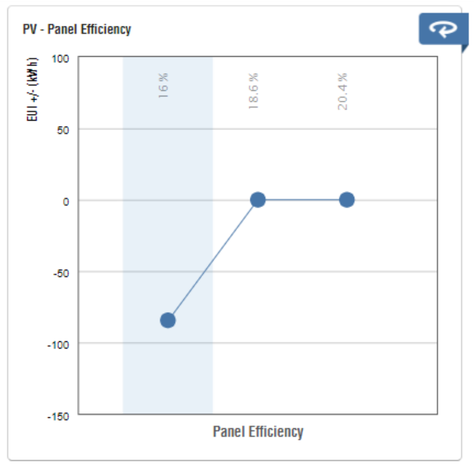

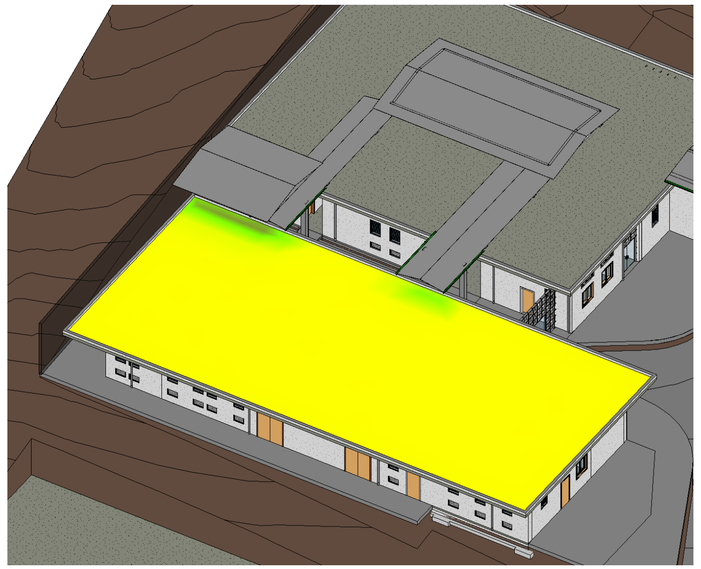

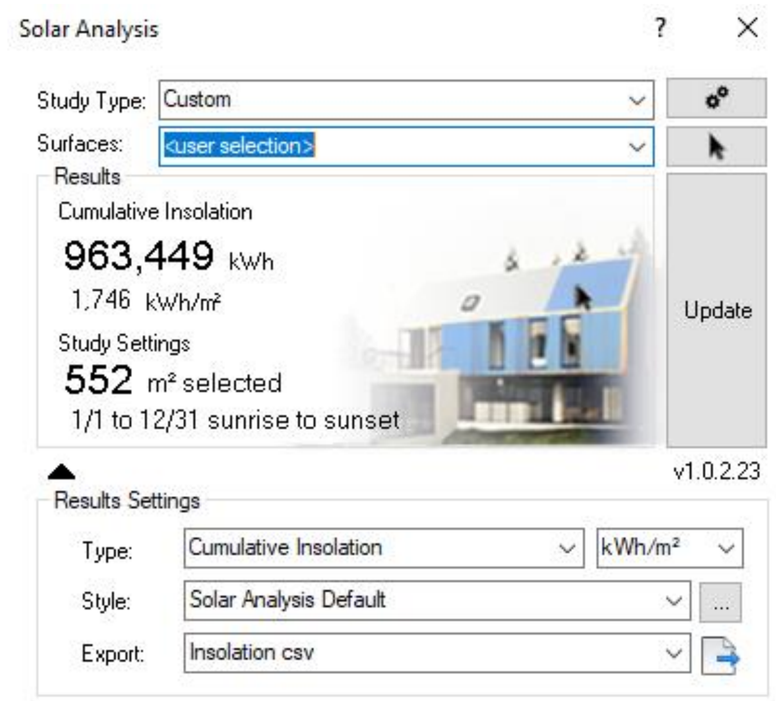

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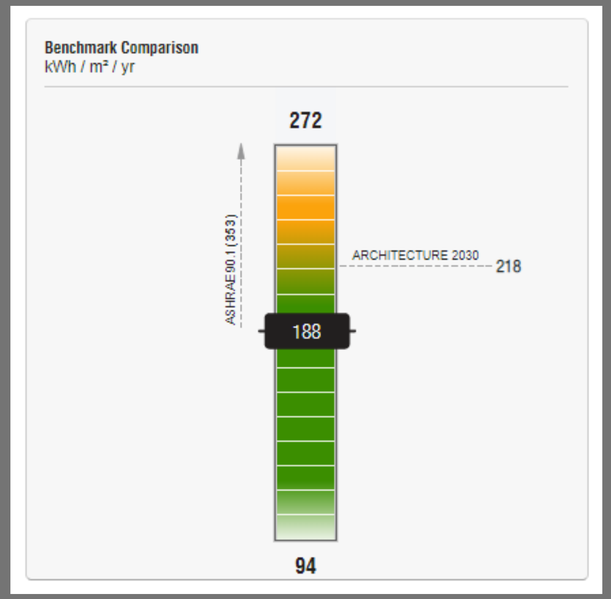

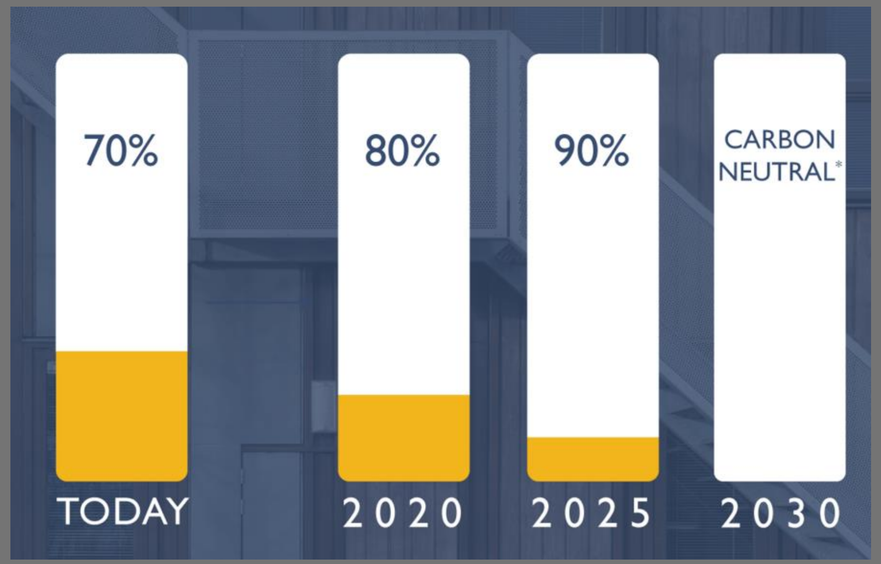

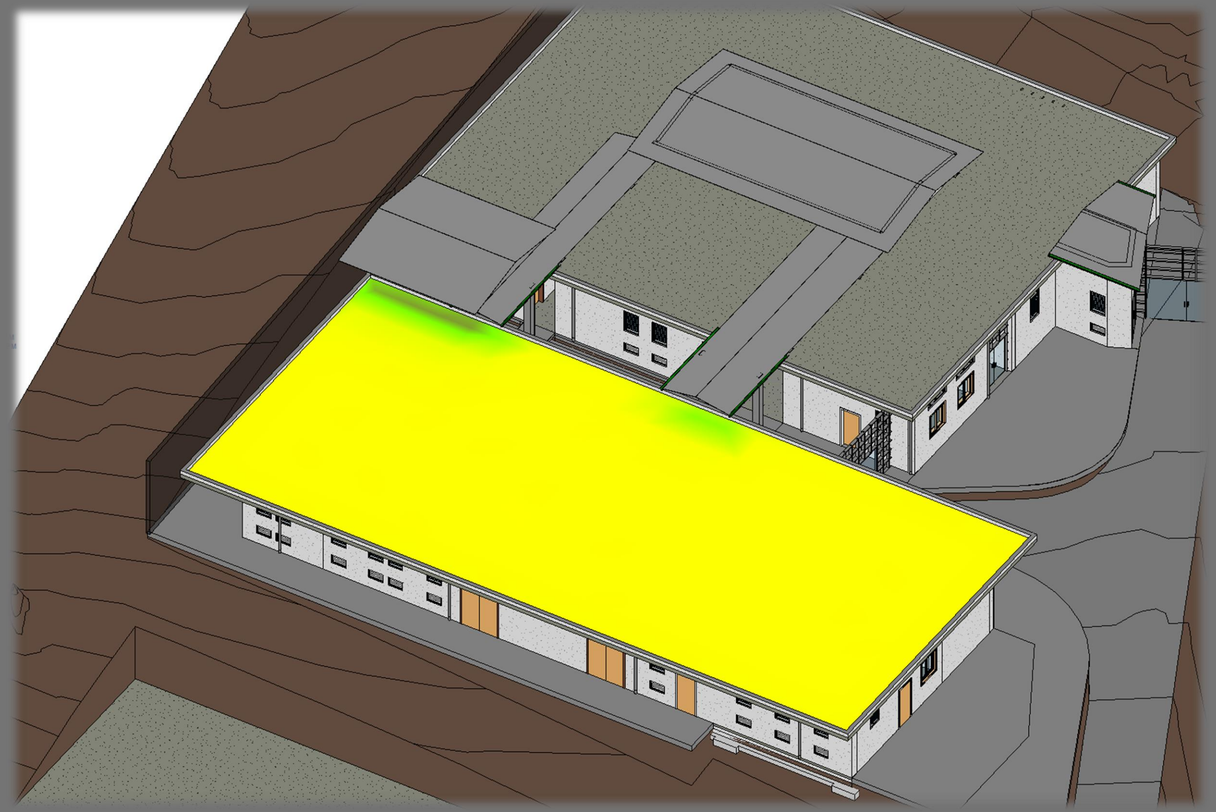

Time invested for analysis: ~30 hours

Revit Massing
Revit Modeling
Multiple Insight Iterations
Daylighting
Solar Insolation
Illuminance
Wind Studies

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Reminders

- Take the class survey in the app
- Check out socials and meetups in the Expo and Community Quads
- Schedule time to meet after class if you'll be in the Quads yourself

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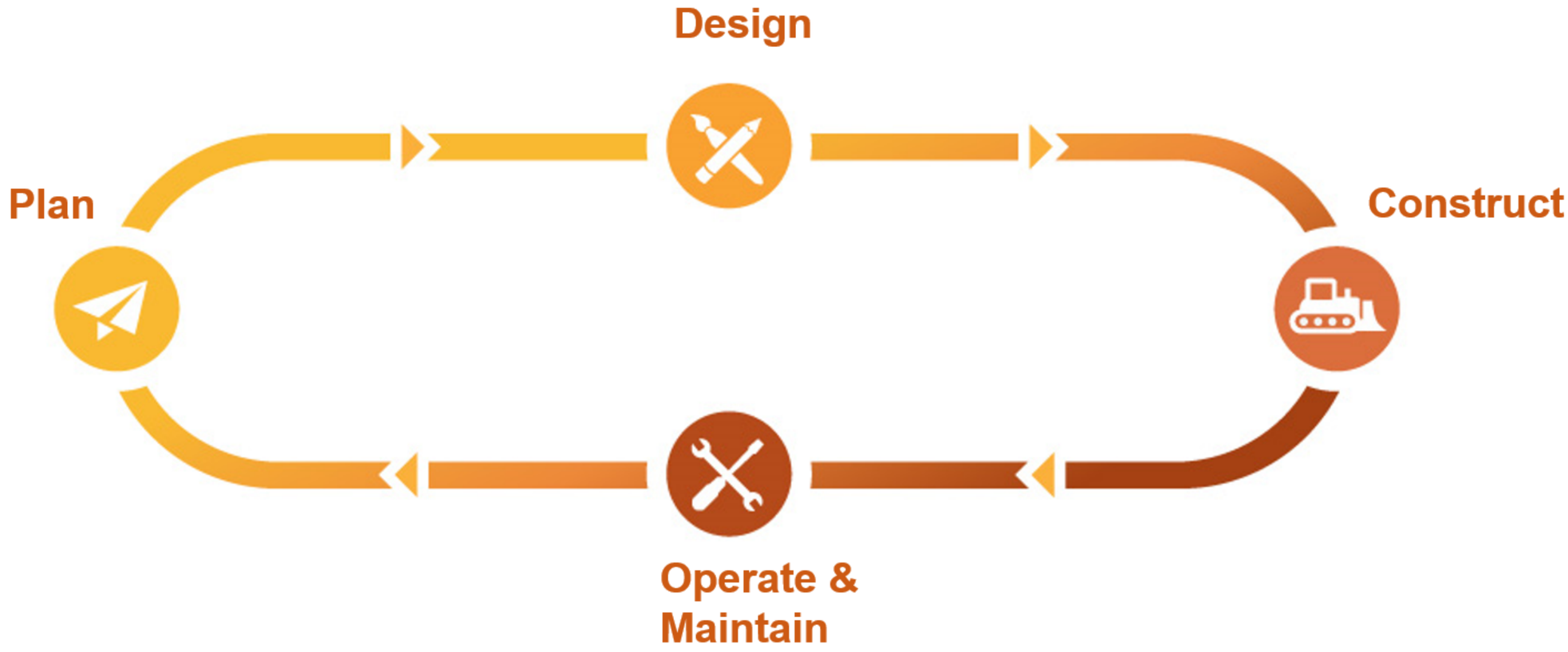

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