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Solar Analysis: Calculating Shaded Areas in Revit for Sustainable Design

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About the speaker

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Phuc Le is a Digital Consultant, BIM Advisor, BIM Application Expert & Forge Developer.

He currently serves as Technical Specialist at Autodesk Asean, supporting organizations in Architecture, Engineering and Construction sector to successfully implement Building Information Modelling, Cloud Collaboration, Computational Design and Generative Design.

Class Description

When planning building areas, you may want to identify what a building's shadow looks like. In some cases, you want to determine how shaded exterior walls, shading devices, or planting will be. One option to get information is using the Solar Analysis tool – included in Insight plug-in in Revit software. We will also show advanced processes using Dynamo and Revit API to determine the sun direction and the shaded areas of a whole building or particular objects such as walls, roof, or shading devices,... in Revit models. This class provides a basis for using BIM models for the design and analysis of sustainable buildings.

Agenda

1

SUSTAINABLE DESIGN - WHY SOLAR ENERGY?

2

INSIGHT PLUG-IN FOR REVIT: SOLAR ANALYSIS TOOL

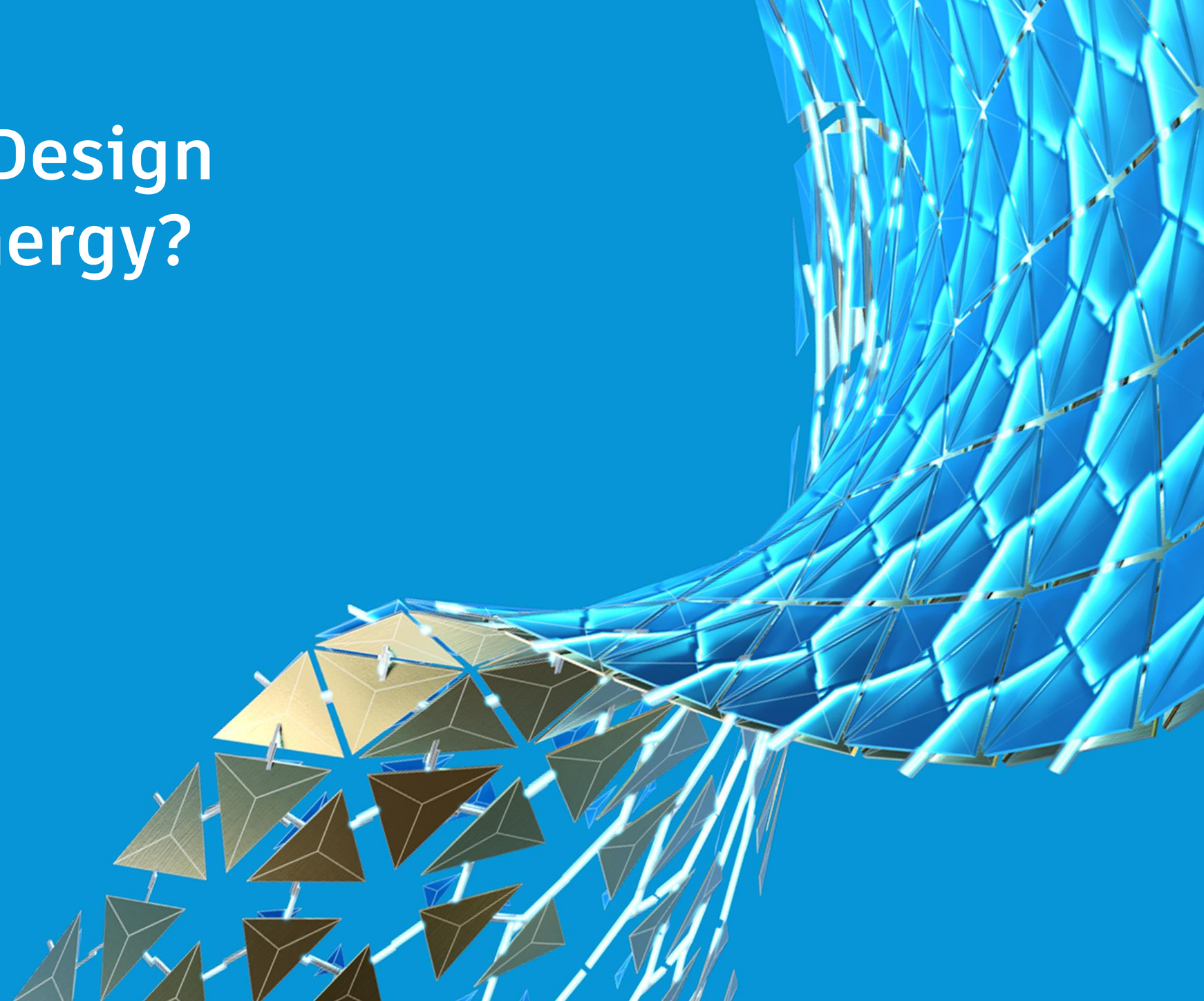
3

SHADING DESIGN

4

CALCULATING SHADED AREA WITH DYNAMO AND REVIT API

Sustainable Design
Why Solar Energy?



Reduce GHG emissions

Lower operating costs

Increase property value

Improve occupant health and comfort

Sustainable Design

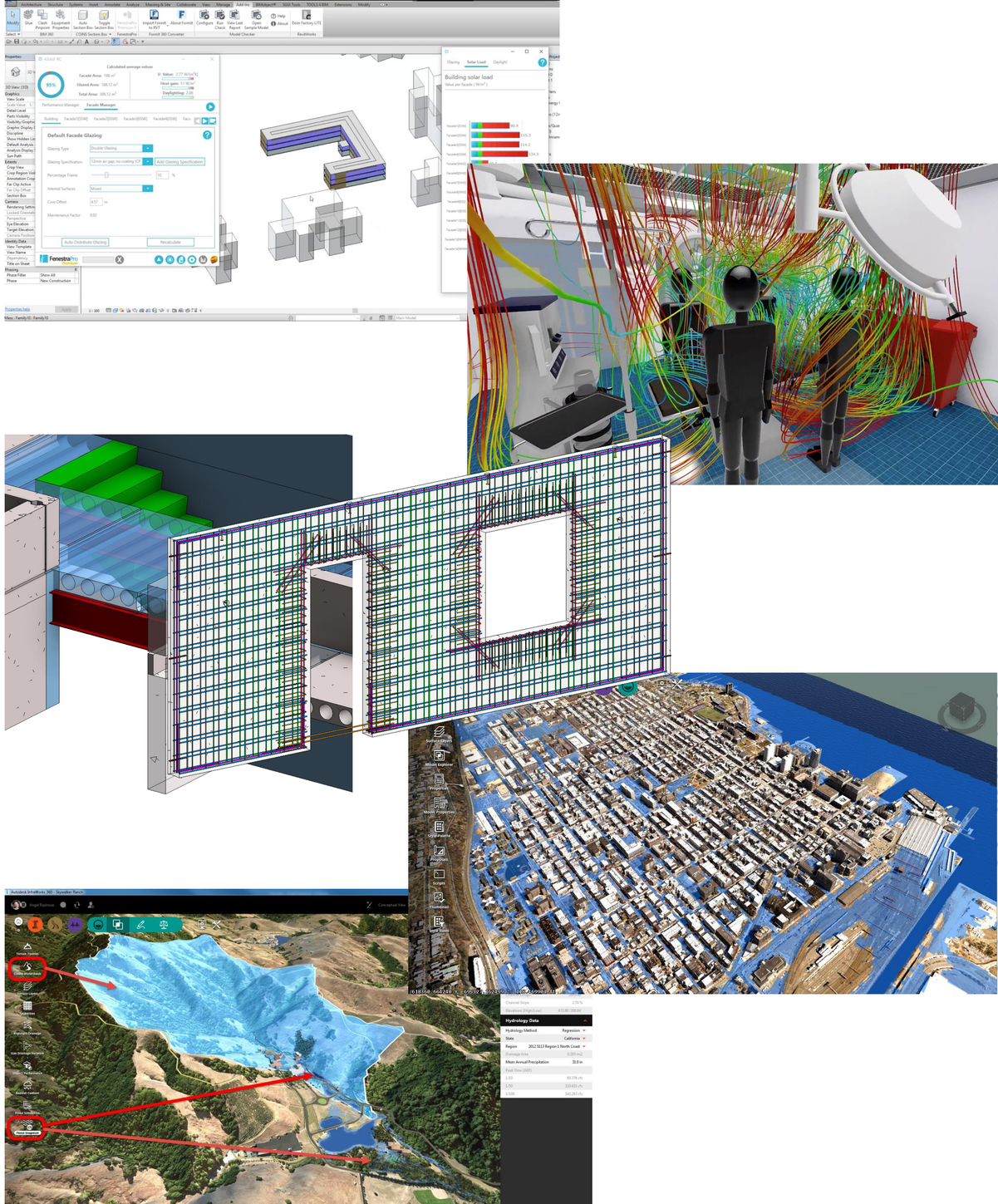
The intention of sustainable design is to "eliminate negative environmental impact completely through skillful, sensitive design".

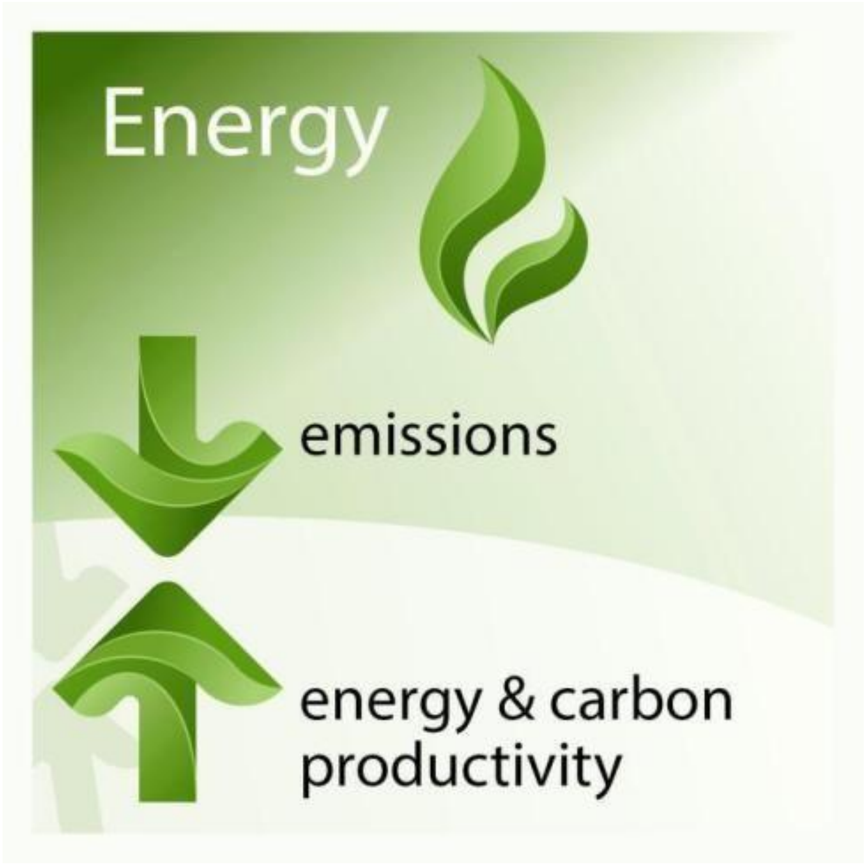
Manifestations of sustainable design require renewable resources, impact the environment minimally, and connect people with the natural environment.

Sustainable Deisgn

In the AEC industry, three trends are identified:

- **Net-zero energy building**
  - Building Performance Analysis
  - Optimizing Building Systems
  - Healthy Buildings
- **Circular and waste construction**
  - Preconstruction: Maximize Efficiency
  - Site Execution: Lean & Safe
  - Industrialized Construction
- **Sustainable Smart Cities and Infrastructure**
  - Resilience
  - Mobility
  - BIM + GIS





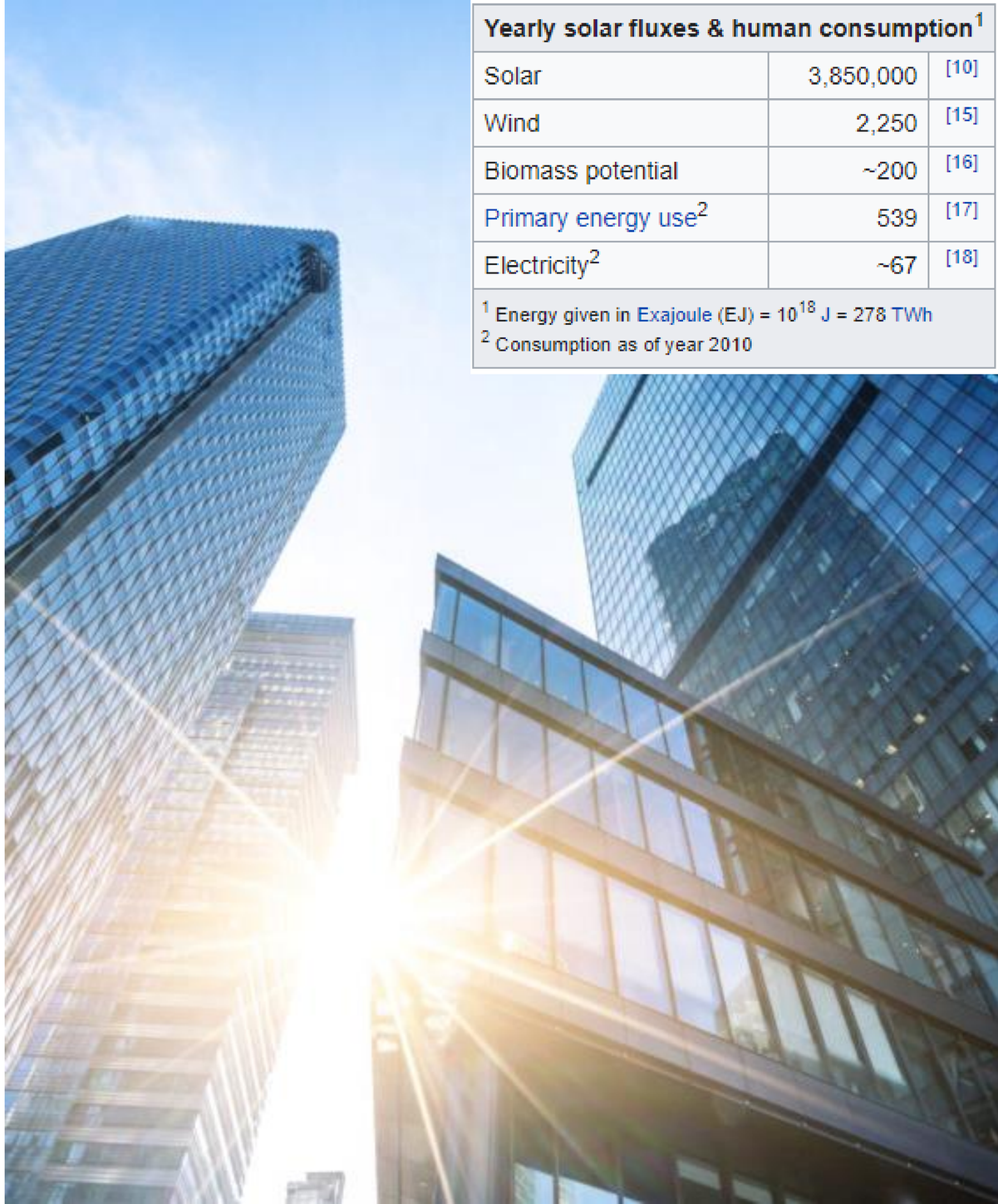
Energy

Materials

Why Solar Energy?

How efficient are Solar Energy Technologies for Buildings

- **Important source of renewable energy**
  - Passive solar or Active solar
- **Reasons to use Solar Energy:**
  - Increasing energy consumption
  - Environmental consciousness
  - Global climate change
  - CSR implication/ advantage for Corporate buildings
  - Attraction towards cleanest, renewable energy
  - High social value and an increase in the value of the property

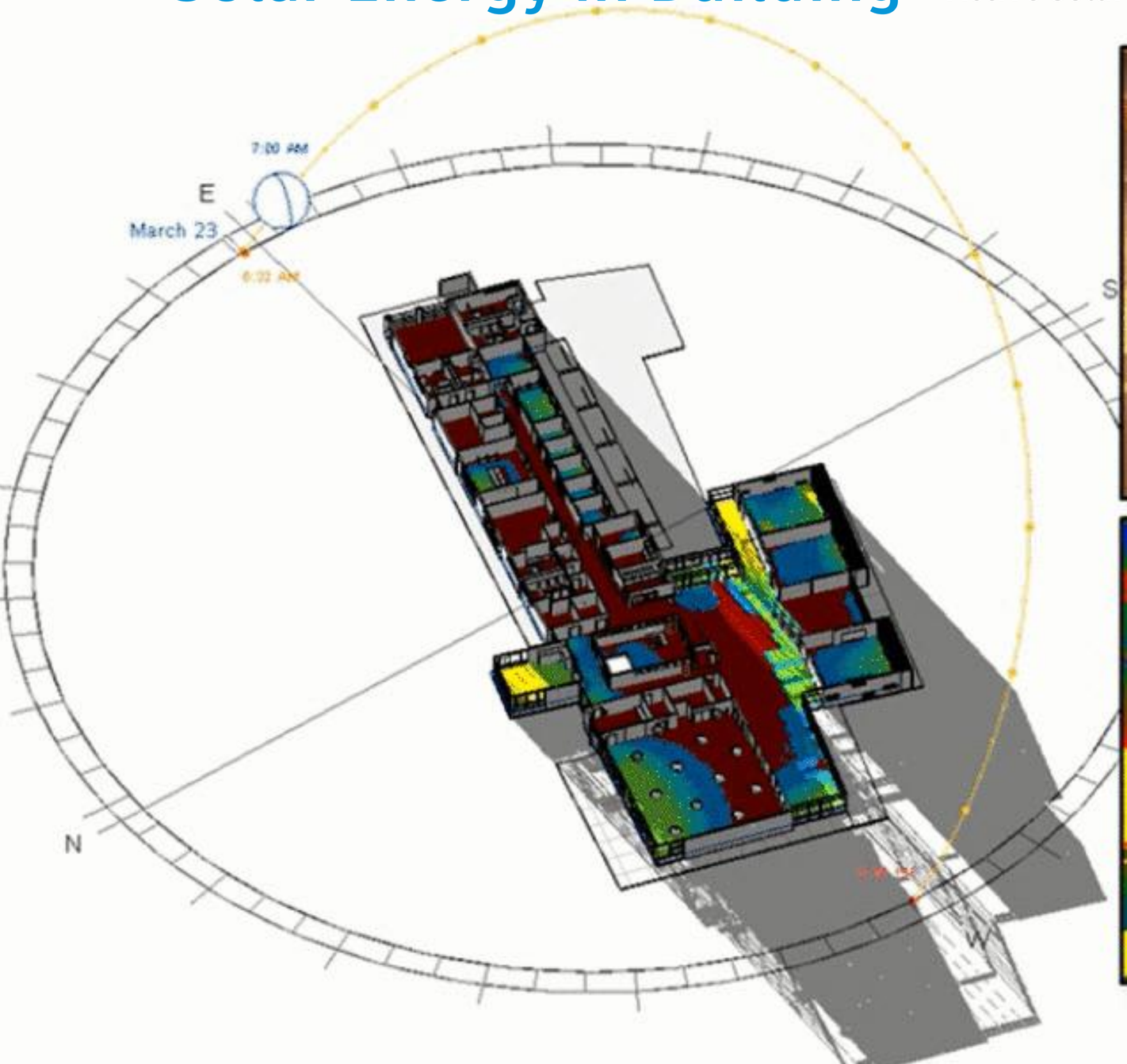


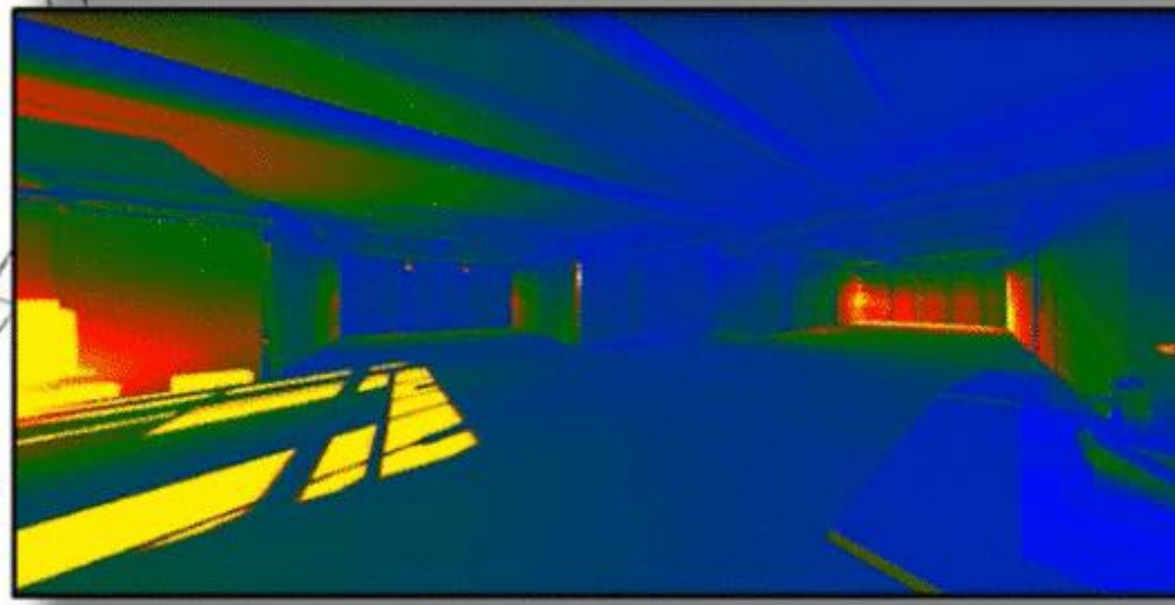
Yearly solar fluxes & human consumption[1]		
Solar	3,850,000	[10]
Wind	2,250	[15]
Biomass potential	~200	[16]
Primary energy use[2]	539	[17]
Electricity[2]	~67	[18]

[1] Energy given in Exajoule (EJ) = 10^{18} J = 278 TWh
[2] Consumption as of year 2010

Solar Energy in Building

Active solar techniques & Passive solar techniques

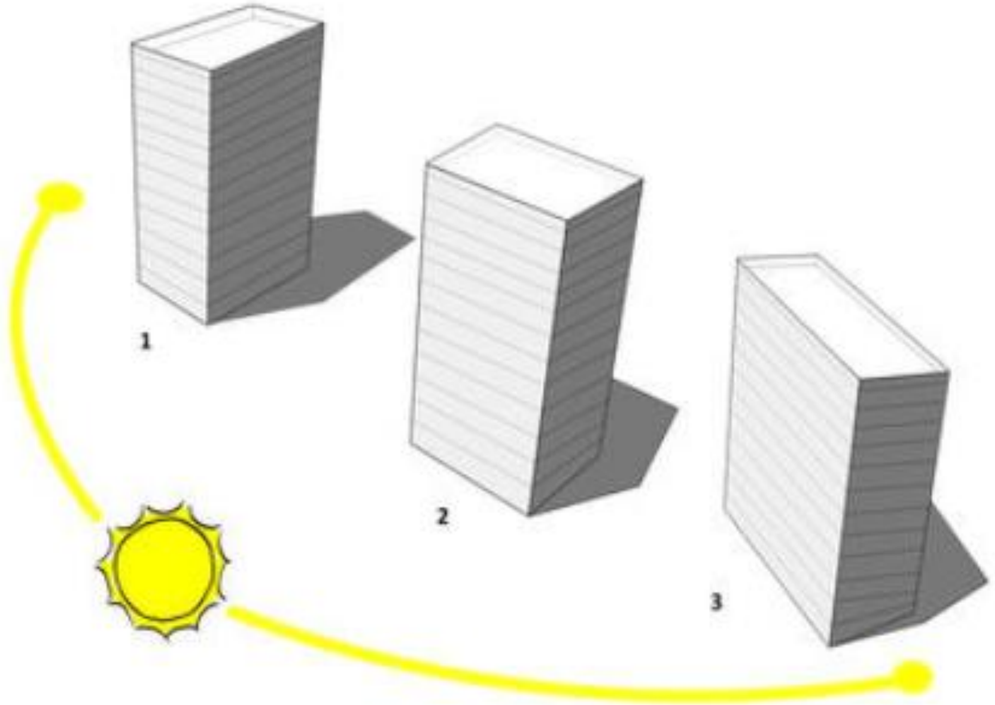




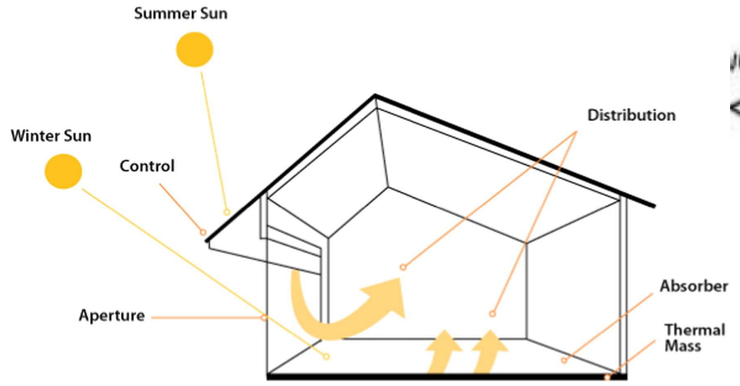
Solar Energy in Building

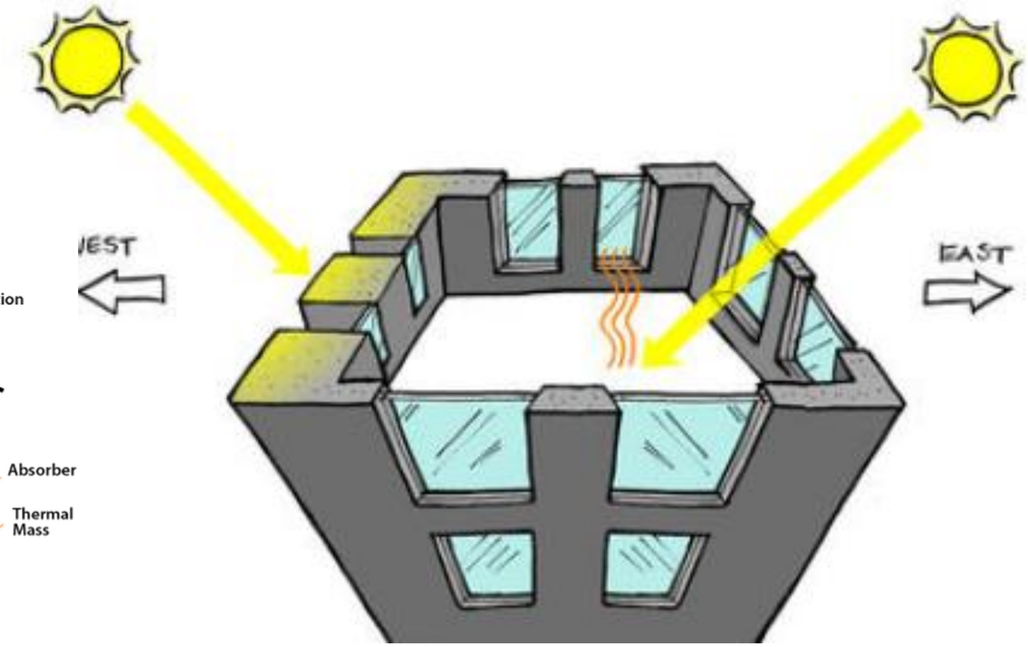
Key factors:

- Solar Position and Sun Path
- Building Orientation
- Building Shapes
- Facade Design: External Wall/Windows + Shading Design
- Material: Insulation, Absorber, Thermal mass, Distribution…



NAME	DATE (Sth.Hem.)	DATE (Nth.Hem.)	DESCRIPTION
Summer Solstice	22 Dec.	22 Jun.	Sun at its highest noon altitude
Autumn Equinox	21 Mar.	21 Sep.	Sun rises due east, sets due west
Winter Solstice	21 Jun.	21 Dec.	Sun at its lowest noon altitude
Spring Equinox	21 Sep.	21 Mar.	Sun rises due east, sets due west



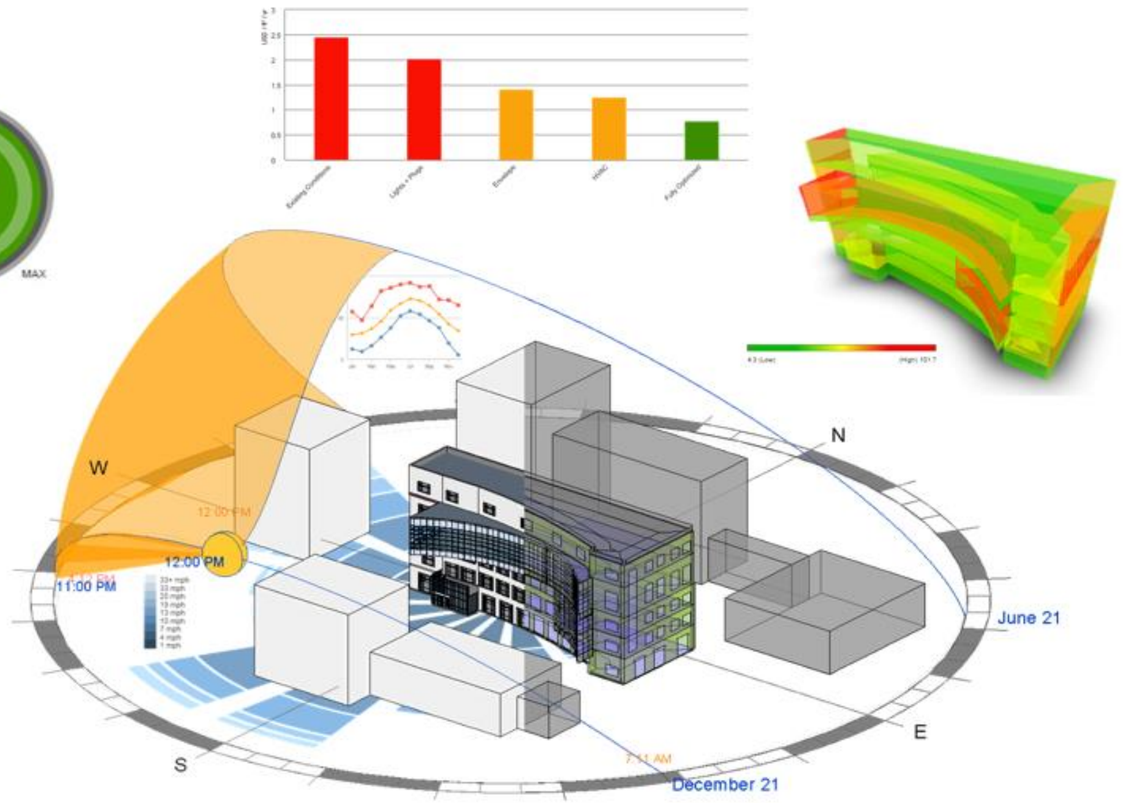


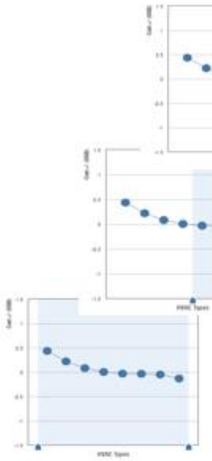
Autodesk Technology for Optimizing Solar Energy

AUTODESK® **ARCHITECTURE, ENGINEERING & CONSTRUCTION COLLECTION**

Autodesk Solutions:

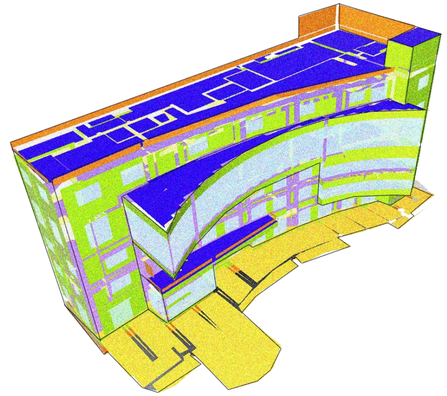
- An in-BIM building energy analysis tool– no more “throw away” models!
- Fast, easy, and intuitive tools for energy performance, that can be used by designers (not just specialists anymore)
- Cost-effective + highly accurate
- Offers TRUE real-time feedback
- Detailed design analysis from early stage throughout lifecycle





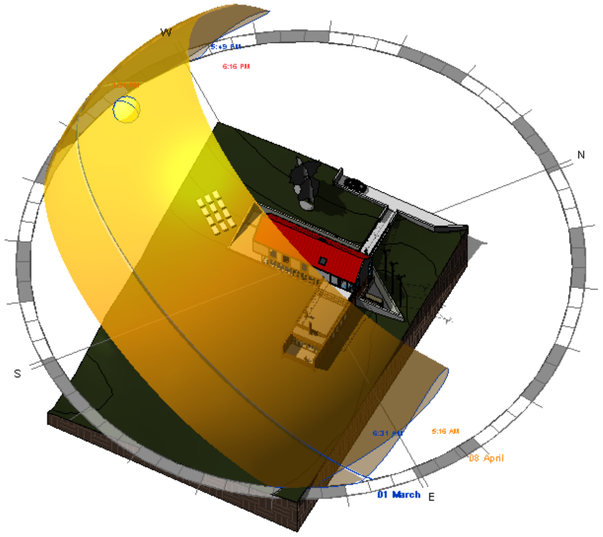
PRO 360

Perform solar analysis during building design



PV energy (Solar Photovoltaic):

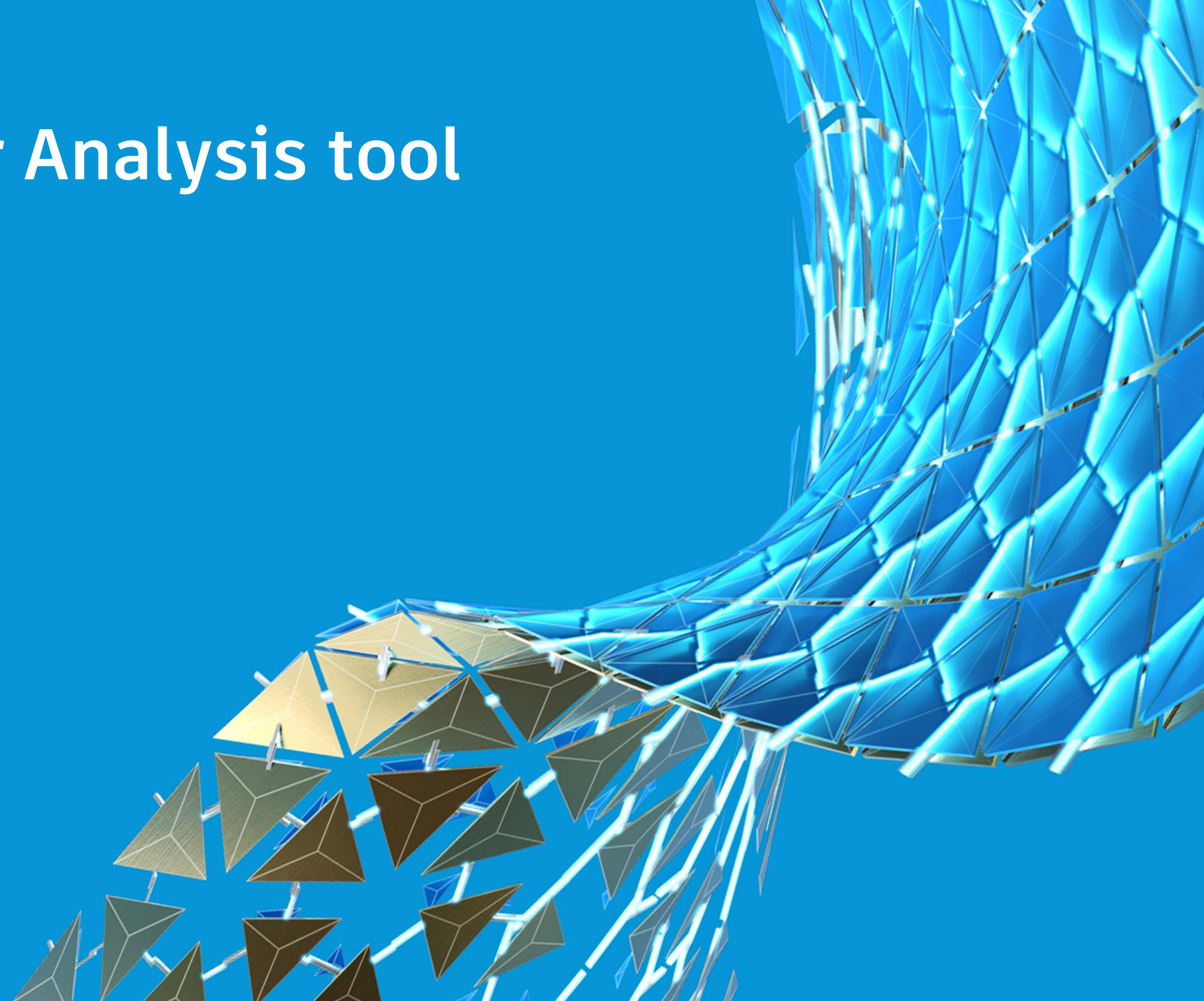
- Whole building energy analysis
- Real-time feedback
- Compare cost and performance information across different design options



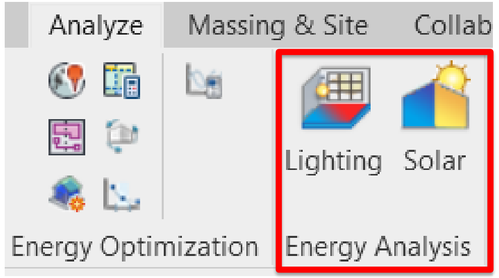
Shading Design:

- Early stage design analysis
  - Daylighting
- Detailed design analysis
  - Thermal performance
  - External Shades
  - Optimize & specify glazing

Insight Solar Analysis tool in Revit



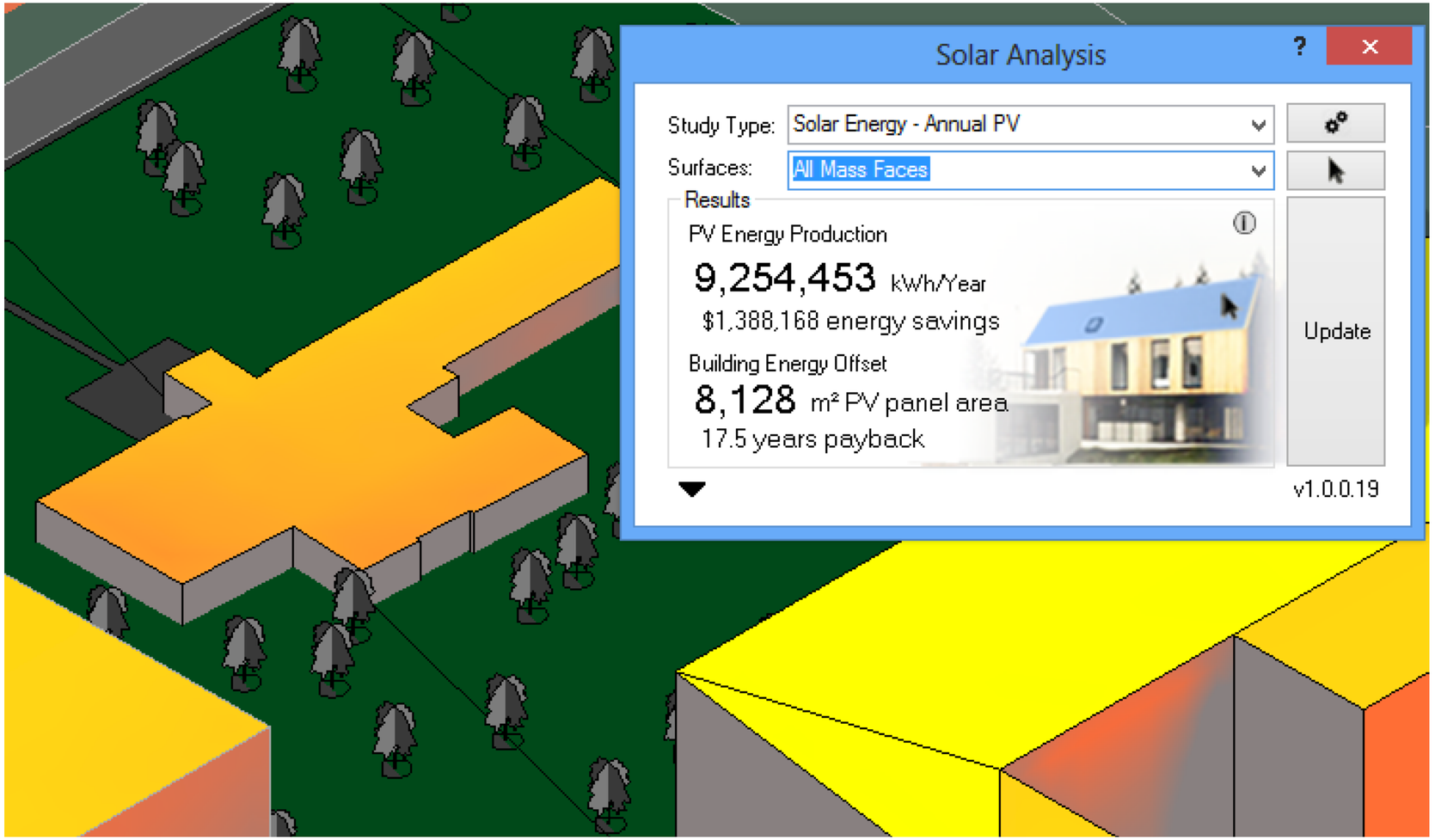
Solar Analysis in Revit



Solar Radiation is an important consideration in any building that strives for energy efficiency

Solar Insolation is the amount of solar radiation energy received on a given surface during a given time.

Solar Photovoltaics (PVs) create electricity directly from sunlight. “Solar panels” or “Solar power”



Workflow for Evaluating the PV potential

AUTODESK® **REVIT**®

Verify Project Location and Sun Settings

AUTODESK® **REVIT**®

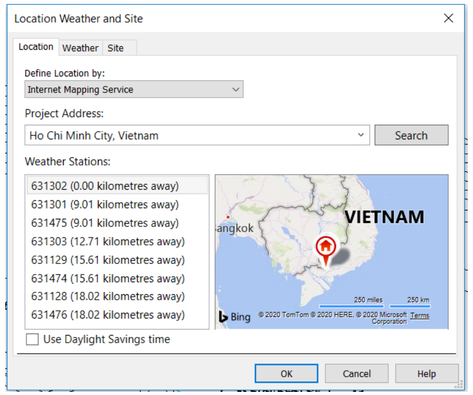
Prepare 3D view for analysis. Define Study type and Surfaces

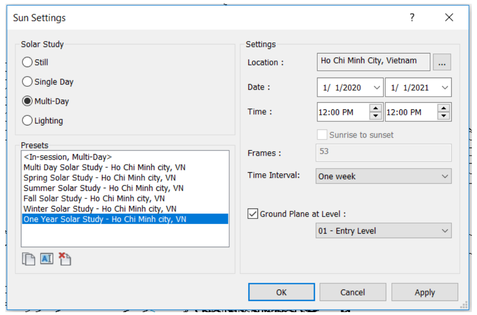
Solar Energy Analysis

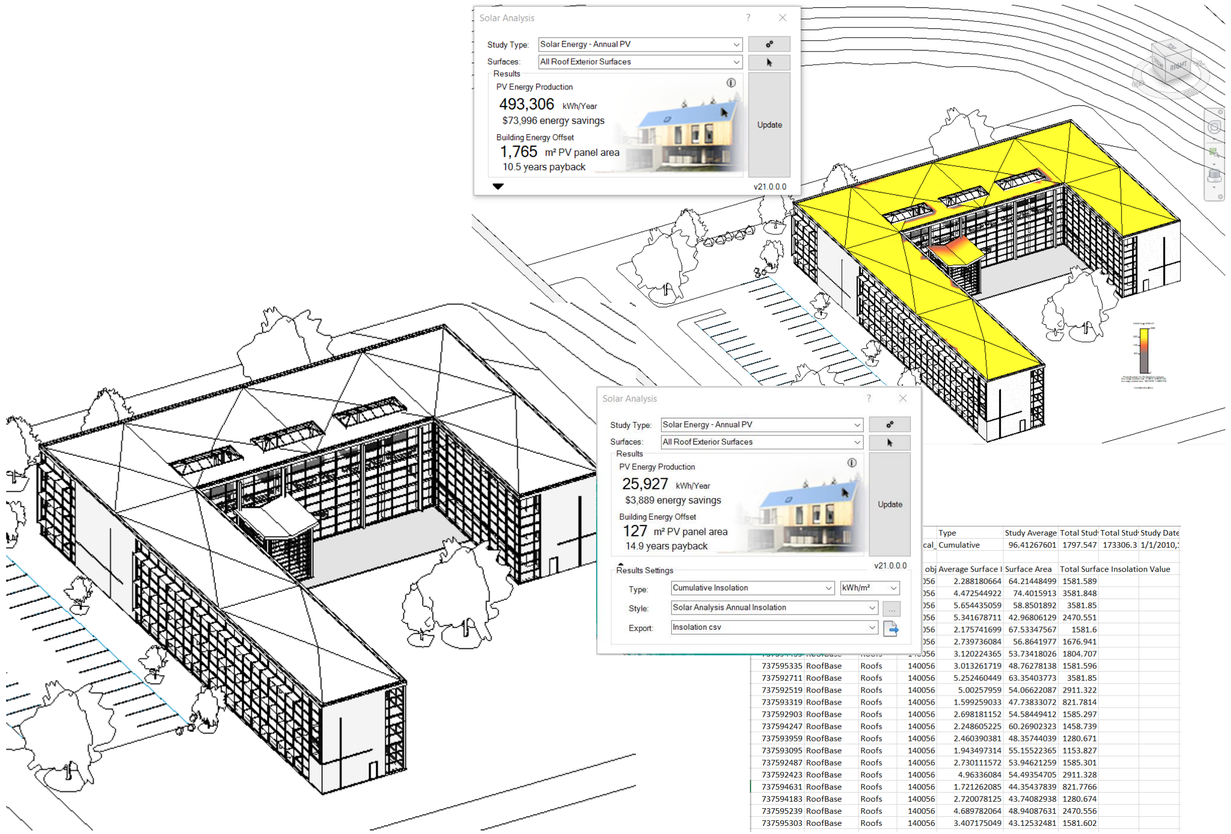
Simulate for determining PV energy production estimates

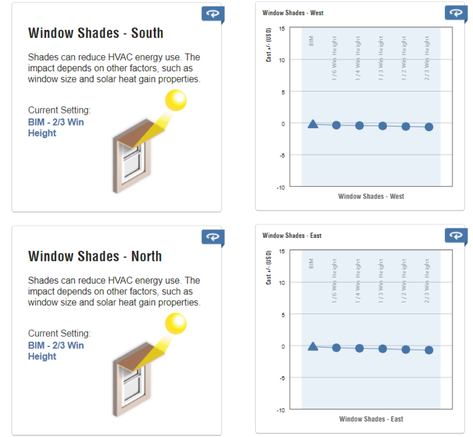
AUTODESK® **INSIGHT**™

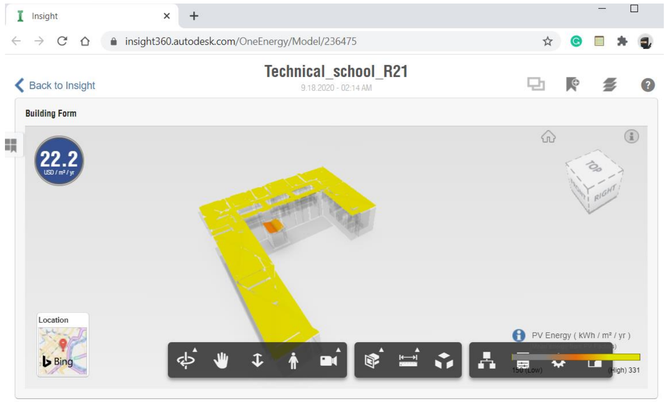
Visualize the Solar Performance in the Insight Model Viewer











Workflow for Determining Solar Access

AUTODESK® REVIT®

Verify Project Location and Define Rooms

Lighting Energy Analysis

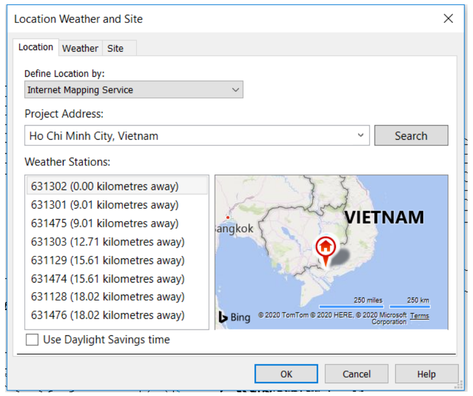
Set Lighting Study settings with Solar Access analysis type

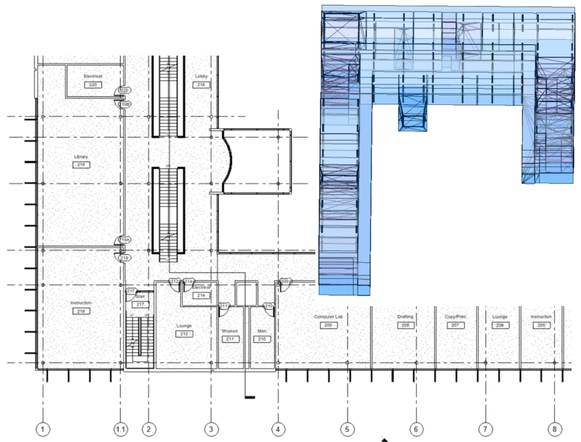
Lighting Energy Analysis

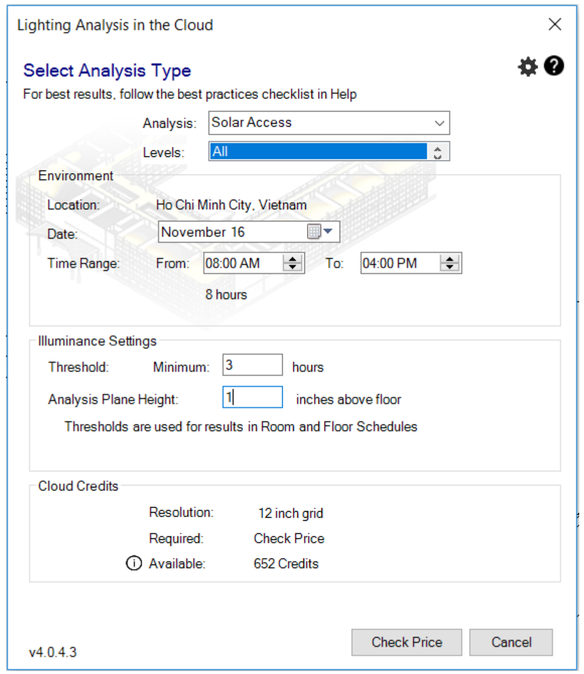
Generate and Simulate Solar Access in the cloud

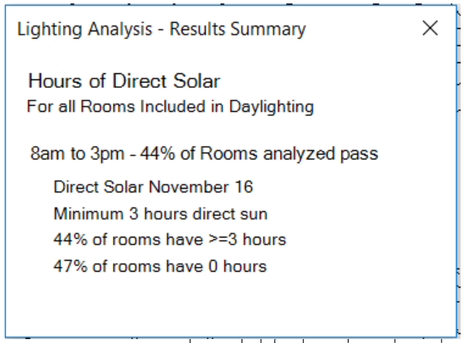
AUTODESK® REVIT®

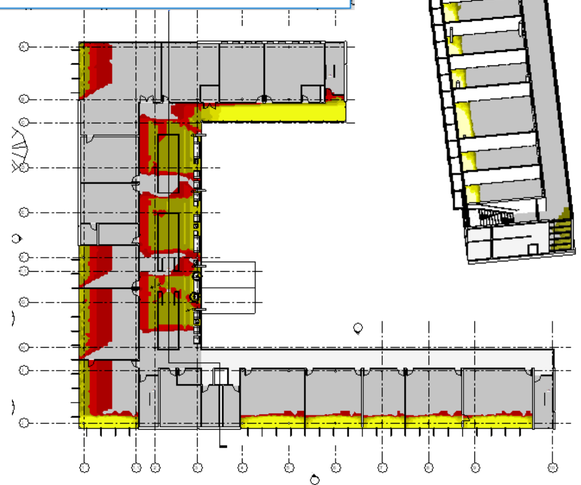
Visualize the Solar Analysis results in plans, 3D, and schedule

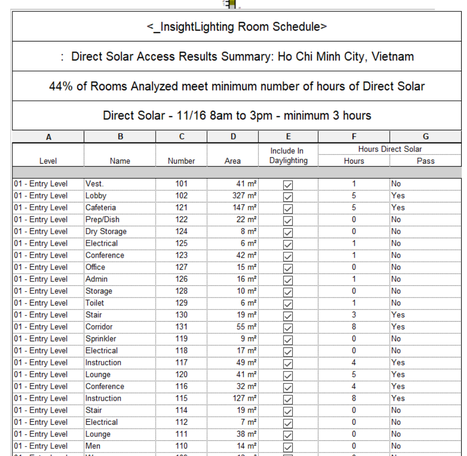












<_InsightLighting Room Schedule>

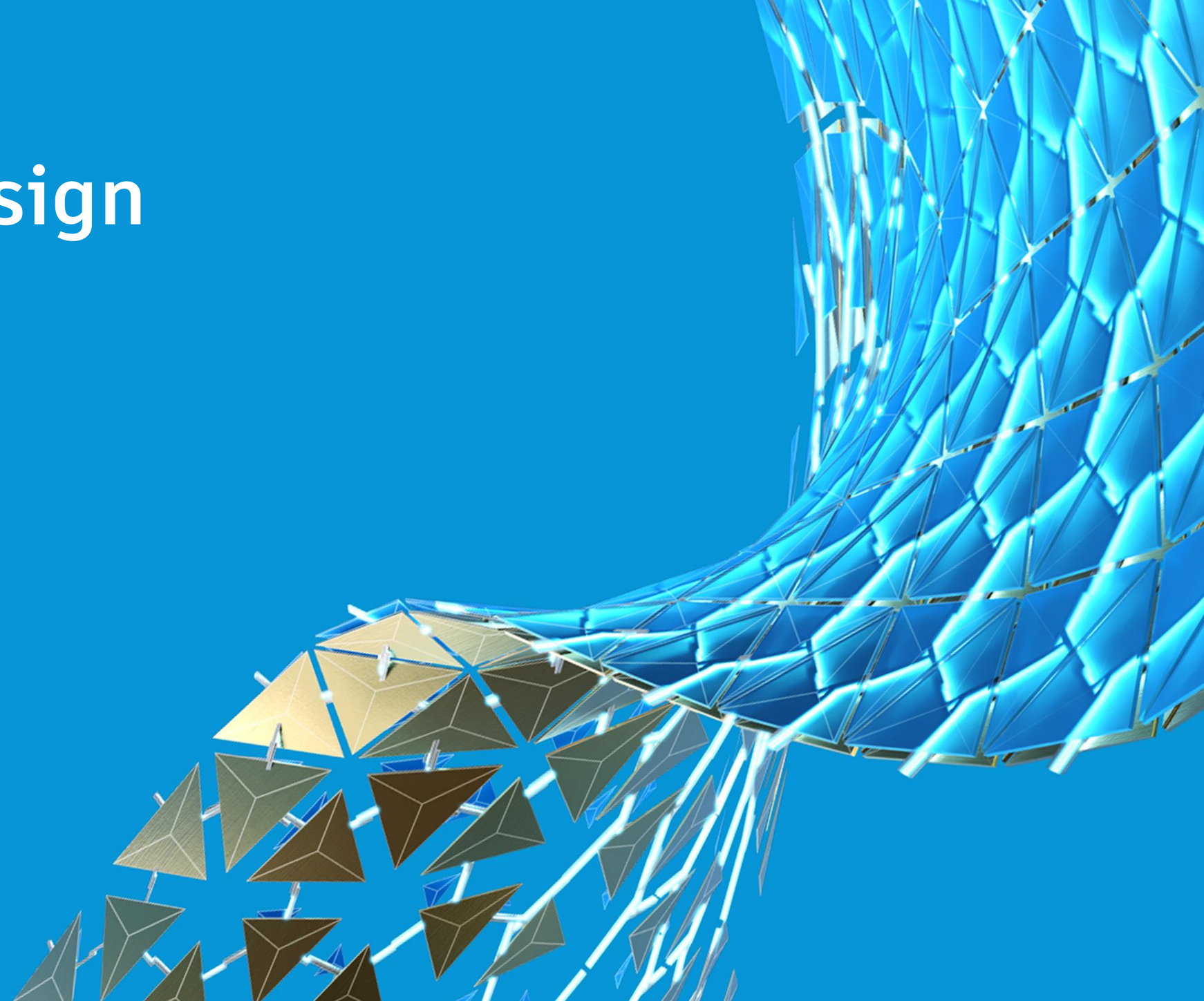
: Direct Solar Access Results Summary: Ho Chi Minh City, Vietnam

44% of Rooms Analyzed meet minimum number of hours of Direct Solar

Direct Solar - 11/16 8am to 3pm - minimum 3 hours

A	B	C	D	E	F	G
Level	Name	Number	Area	Include In Daylighting	Hours Direct Solar Hours	Hours Direct Solar Pass
01 - Entry Level	Vest.	101	41 m²	☑	1	No
01 - Entry Level	Lobby	102	327 m²	☑	5	Yes
01 - Entry Level	Cafeteria	121	147 m²	☑	5	Yes
01 - Entry Level	Prep/Dish	122	22 m²	☑	0	No
01 - Entry Level	Dry Storage	124	8 m²	☑	0	No
01 - Entry Level	Electrical	125	6 m²	☑	1	No
01 - Entry Level	Conference	123	42 m²	☑	1	No
01 - Entry Level	Office	127	15 m²	☑	0	No
01 - Entry Level	Admin	126	16 m²	☑	1	No
01 - Entry Level	Storage	128	10 m²	☑	0	No
01 - Entry Level	Toilet	129	6 m²	☑	1	No
01 - Entry Level	Stair	130	19 m²	☑	3	Yes
01 - Entry Level	Corridor	131	55 m²	☑	8	Yes
01 - Entry Level	Sprinkler	119	9 m²	☑	0	No
01 - Entry Level	Electrical	118	17 m²	☑	0	No
01 - Entry Level	Instruction	117	49 m²	☑	4	Yes
01 - Entry Level	Lounge	120	41 m²	☑	5	Yes
01 - Entry Level	Conference	116	32 m²	☑	4	Yes
01 - Entry Level	Instruction	115	127 m²	☑	8	Yes
01 - Entry Level	Stair	114	19 m²	☑	0	No
01 - Entry Level	Electrical	112	7 m²	☑	0	No
01 - Entry Level	Lounge	111	38 m²	☑	0	No
01 - Entry Level	Men	110	14 m²	☑	0	No

Shading Design



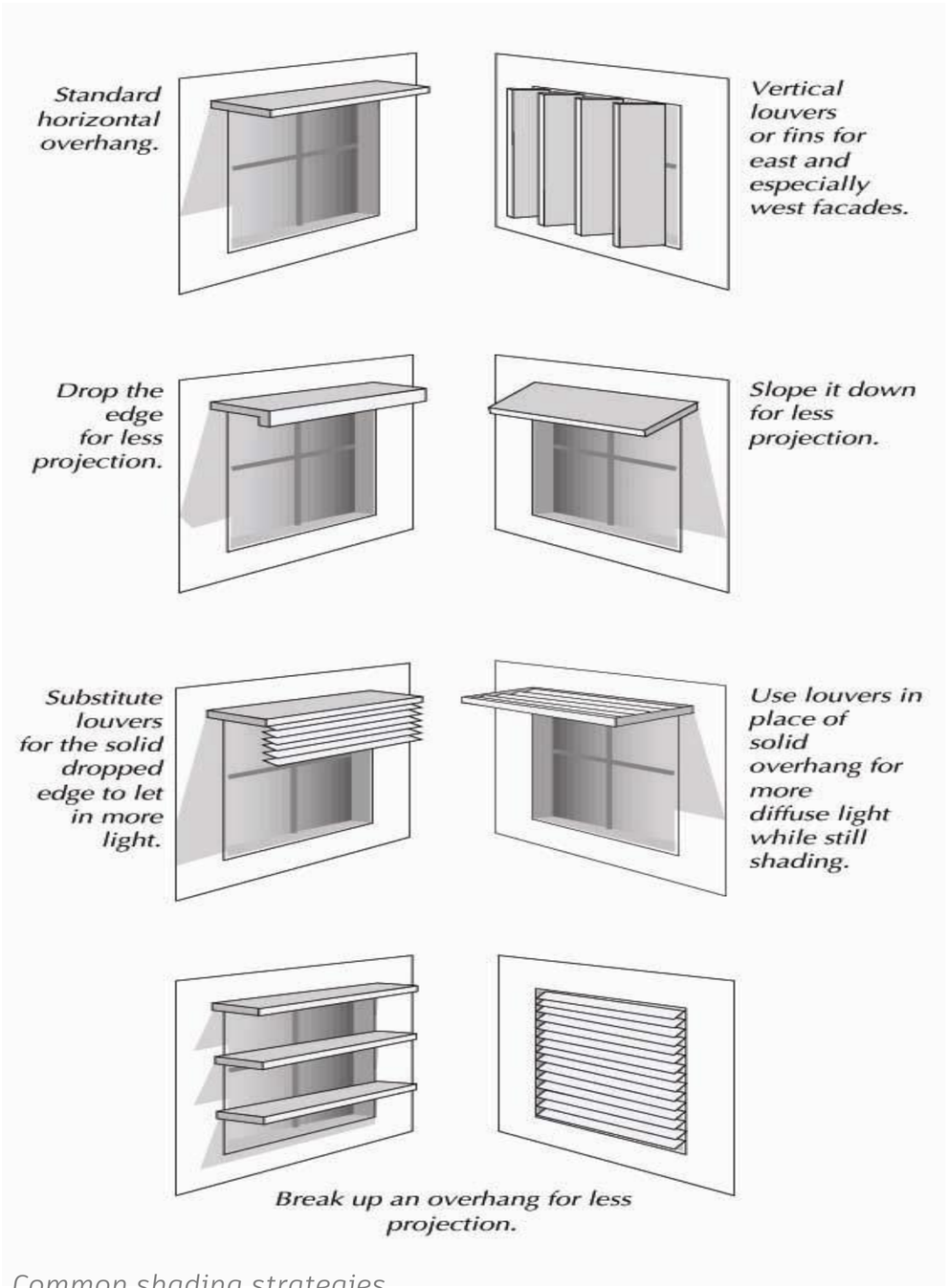
Shading Strategies

Objective: Control intense direct sunlight to ensure a comfortable workspace.

Challenges:

- **Shading devices Design**
  - Form of exterior shading
  - Adaptive Shades

- **Shaded Area**
  - ETTV Calculation
  - Shadow Studies



Common shading strategies
Lawrence Berkeley Lab's "Tips for Daylighting With Windows"

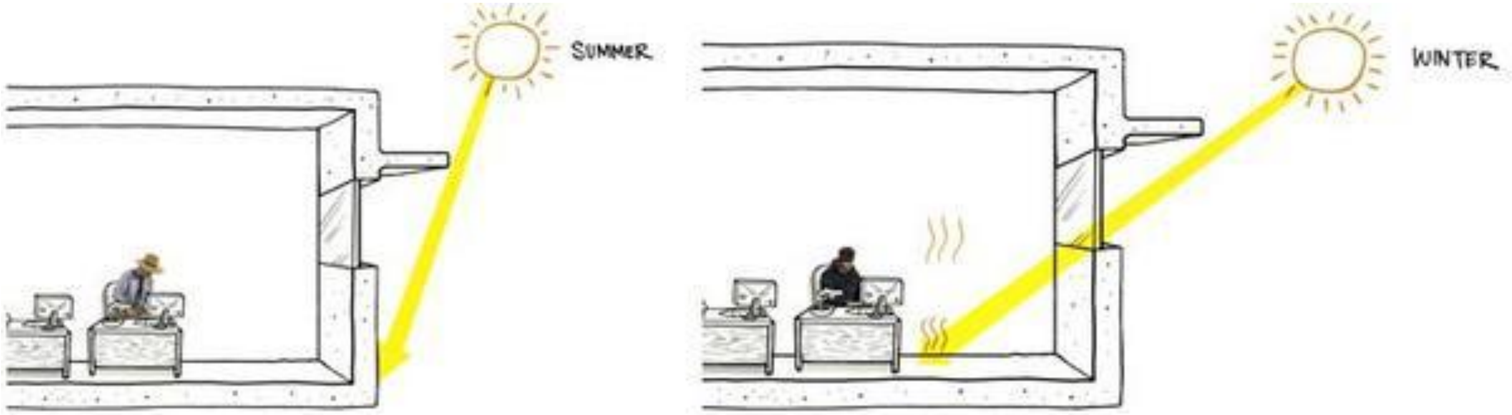
Shading Devices Design

Use exterior shading, either a device attached to the building skin or an extension of the skin itself, to keep out unwanted solar heat.

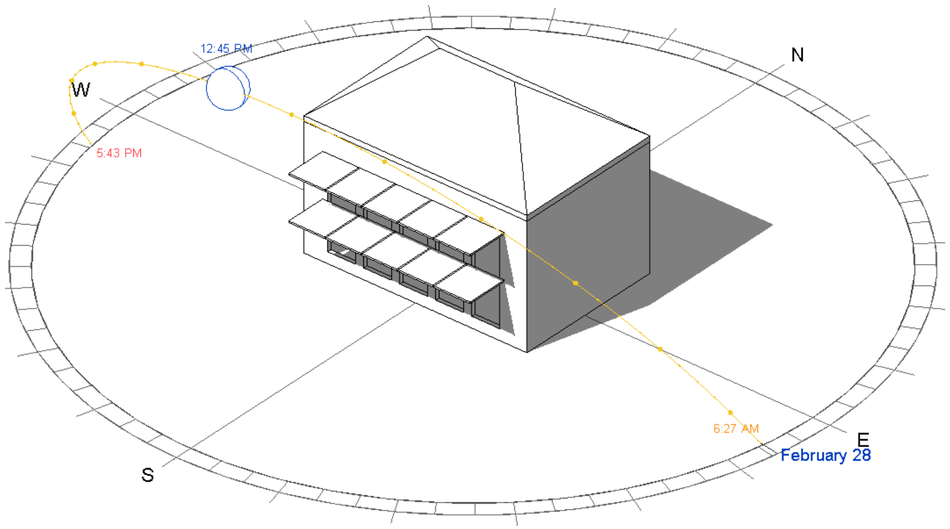
Exterior systems are typically more effective than interior systems in blocking solar heat gain.

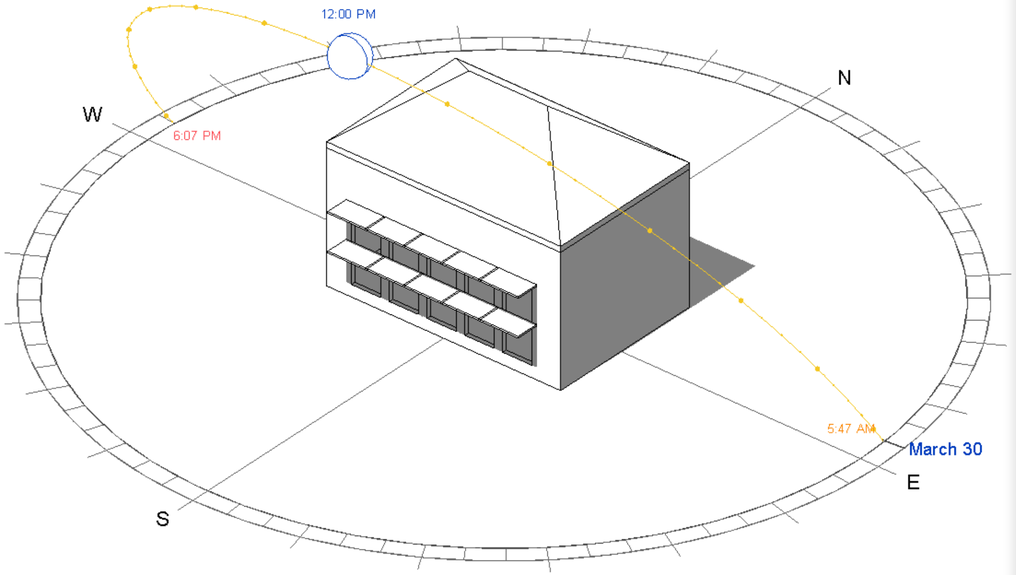
Shading can be designed to allow the sun's light and heat into the building at some times of day or year, while rejecting it at other times.

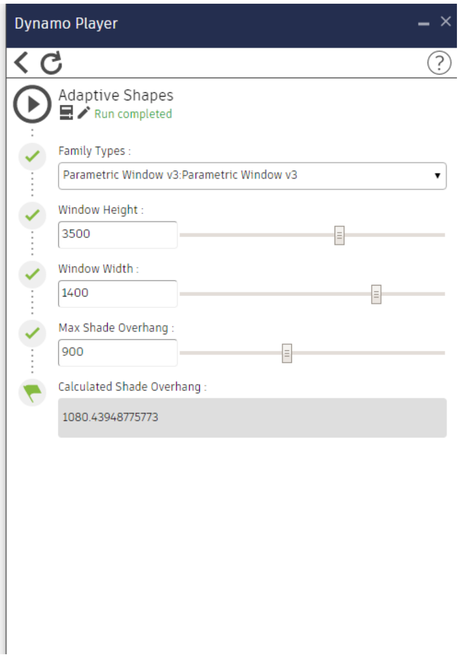
An overhang shades in summer but lets heat in during winter



Adaptive Shades



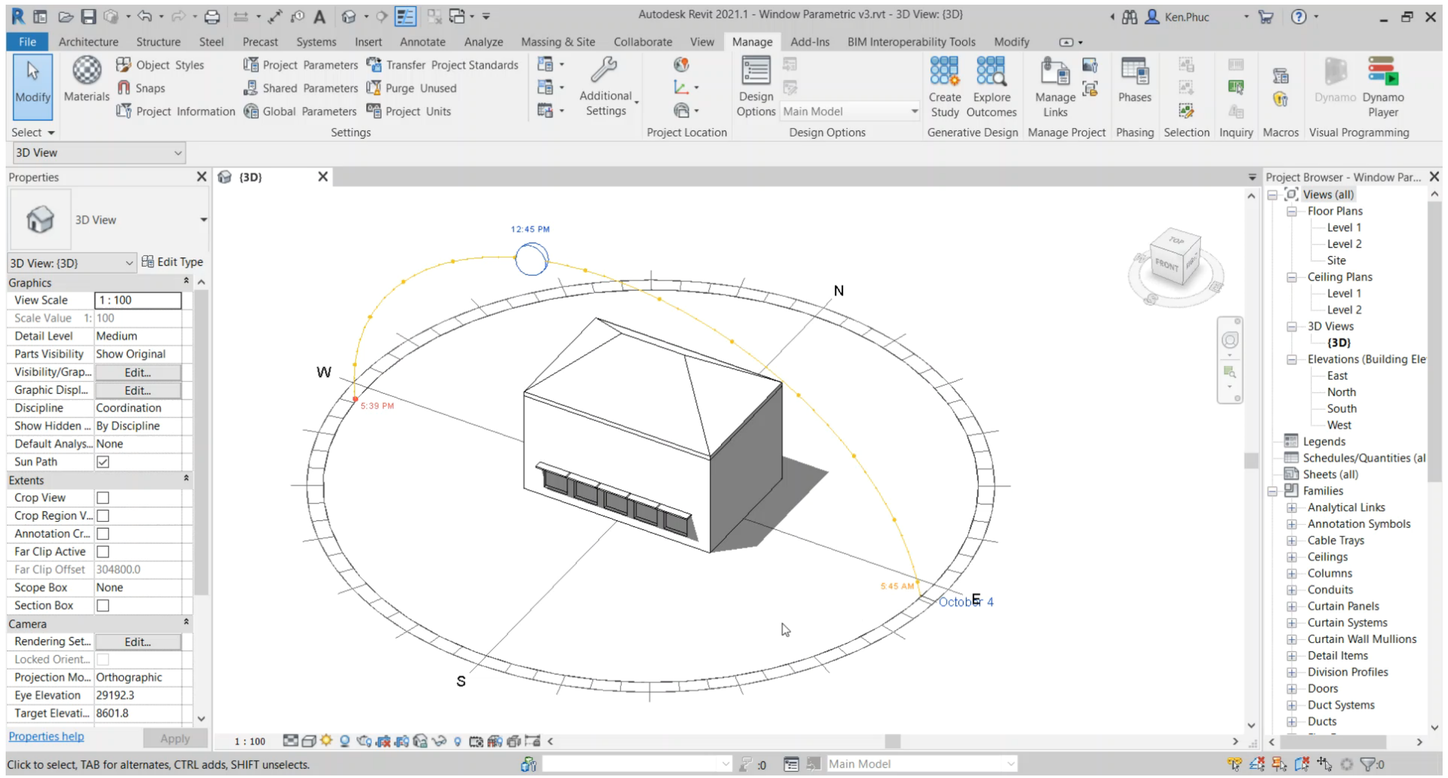




The shade depth (shade overhang) and number of shades are automatically generated to completely shade the window vertically depending on input variables: the Window Height, Window Width, Max Shade Overhang and the Solar Position.

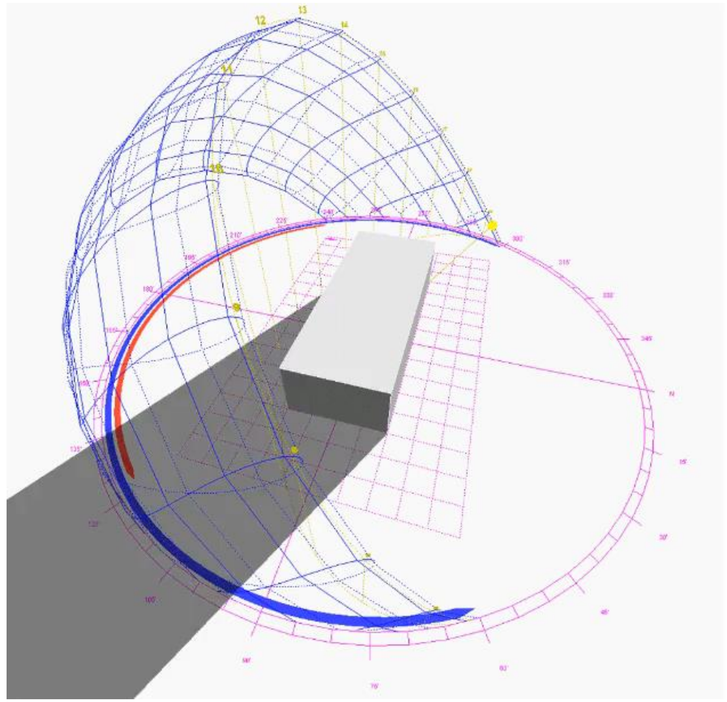
Original Source: David Scheer - Product Owner, Architect - BPA, Autodesk

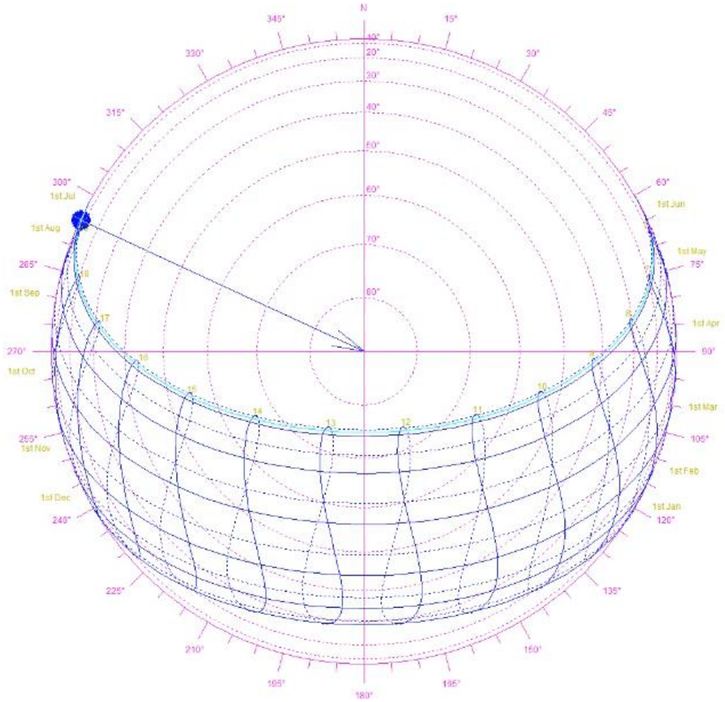
Adaptive Shades



https://youtu.be/RWdIy_YNEOw

Calculating Shaded Area

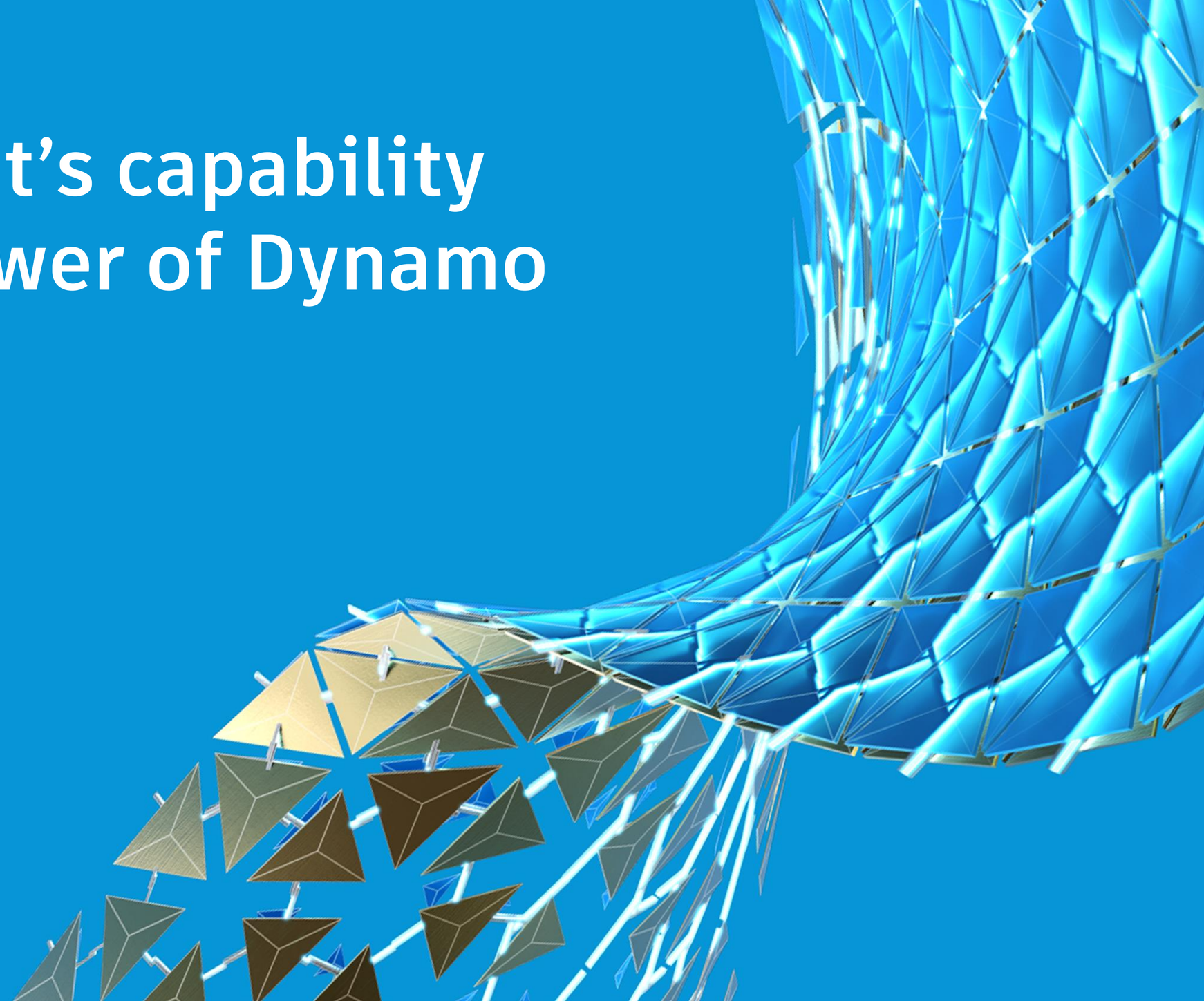


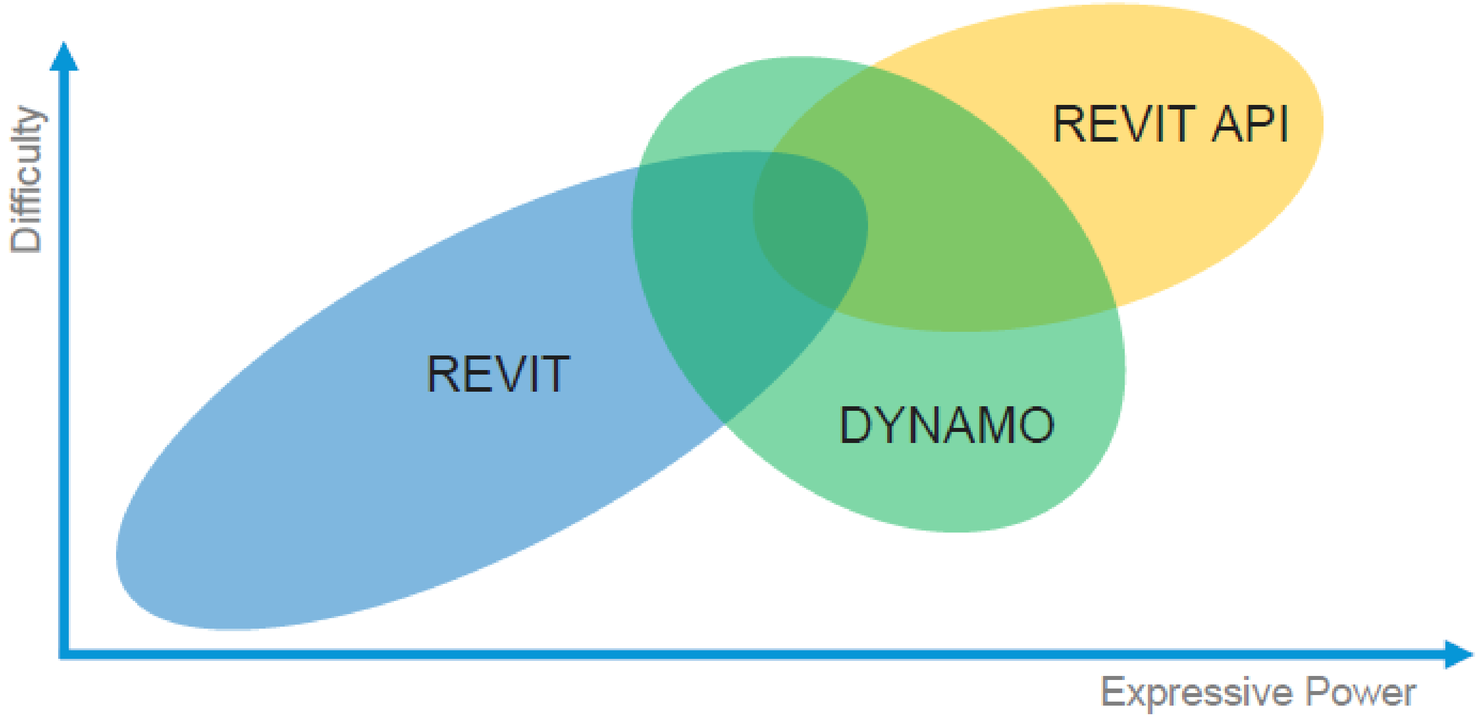


How to determine the physical shape of the shadow and calculate its area?

The shadow of the building? Shaded area of windows?

Extend Revit’s capability with the power of Dynamo



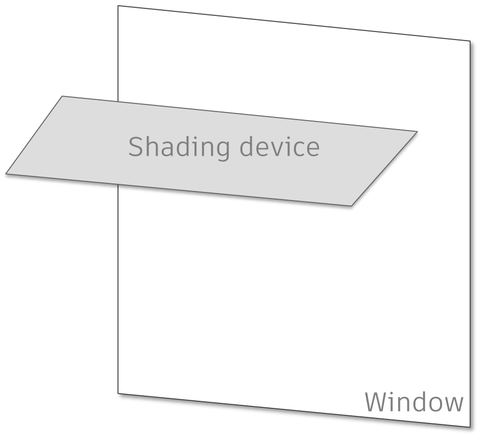


Why Dynamo

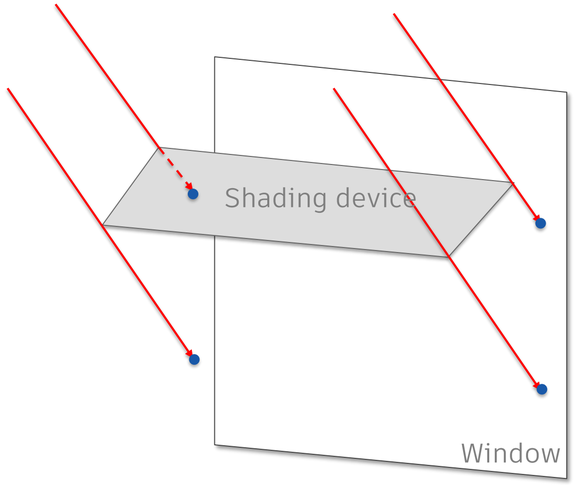
Visual Programing for Computational Design

- **Explore** visual programming without coding
- **Flexible** to suit the varying needs
- **Engage** an active community of users, contributors, and developers

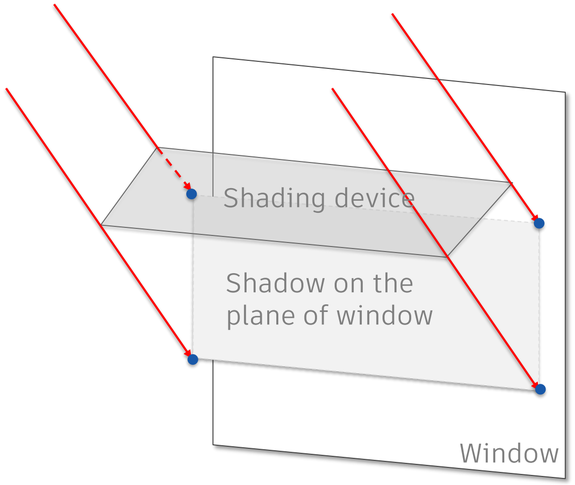
Sample Workflow



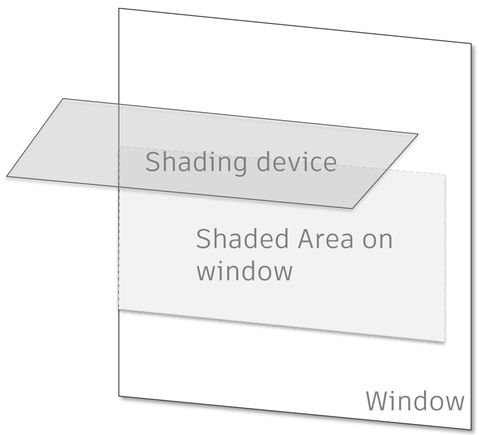
Get window and shading devices, check the sun direction if needed



Project each edge of the shade onto the plane of window by sun direction

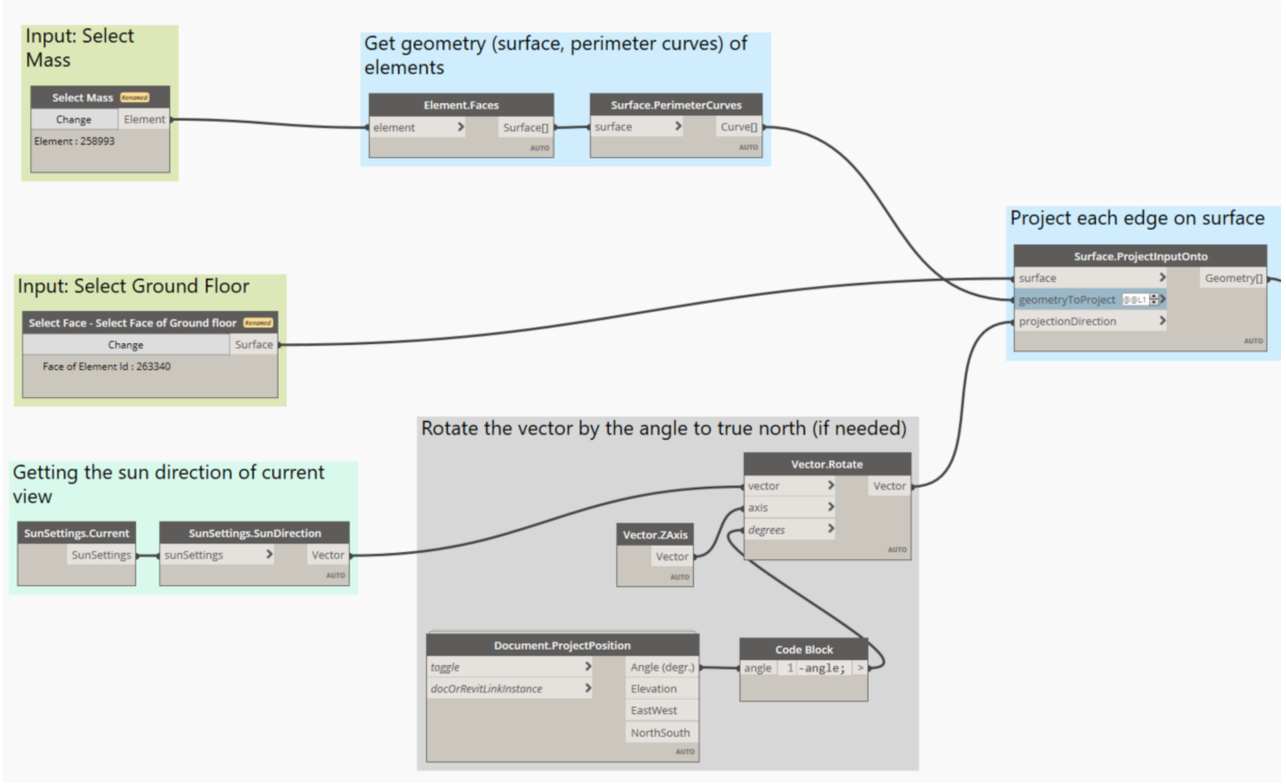


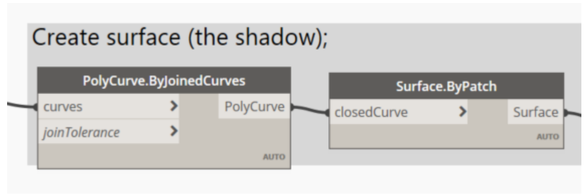
Join all received curves from projection to retrieve the whole shadow on the plane

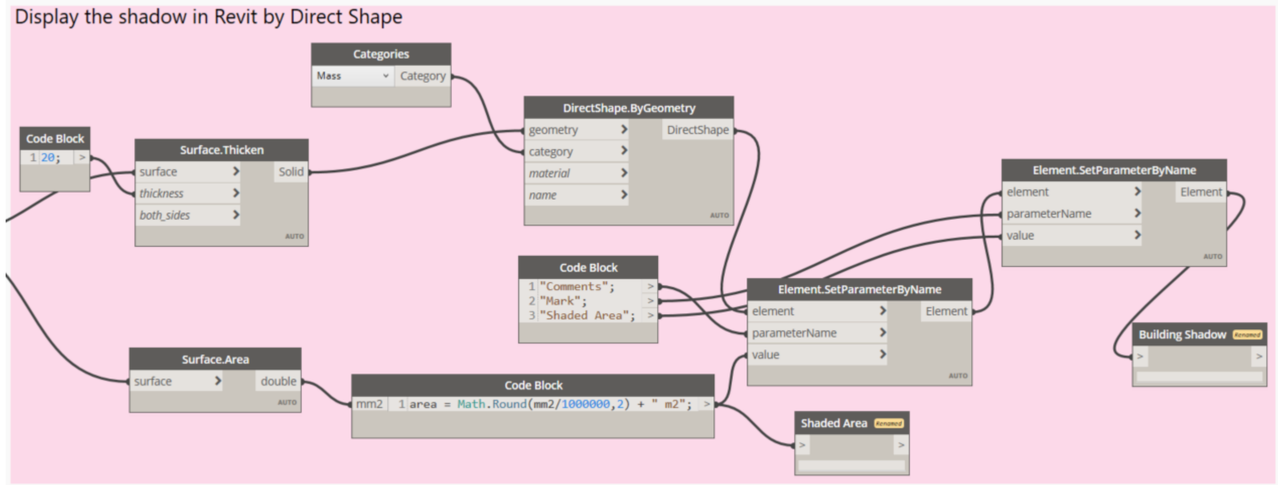


Intersect to get the shadow on window, display and calculate its area

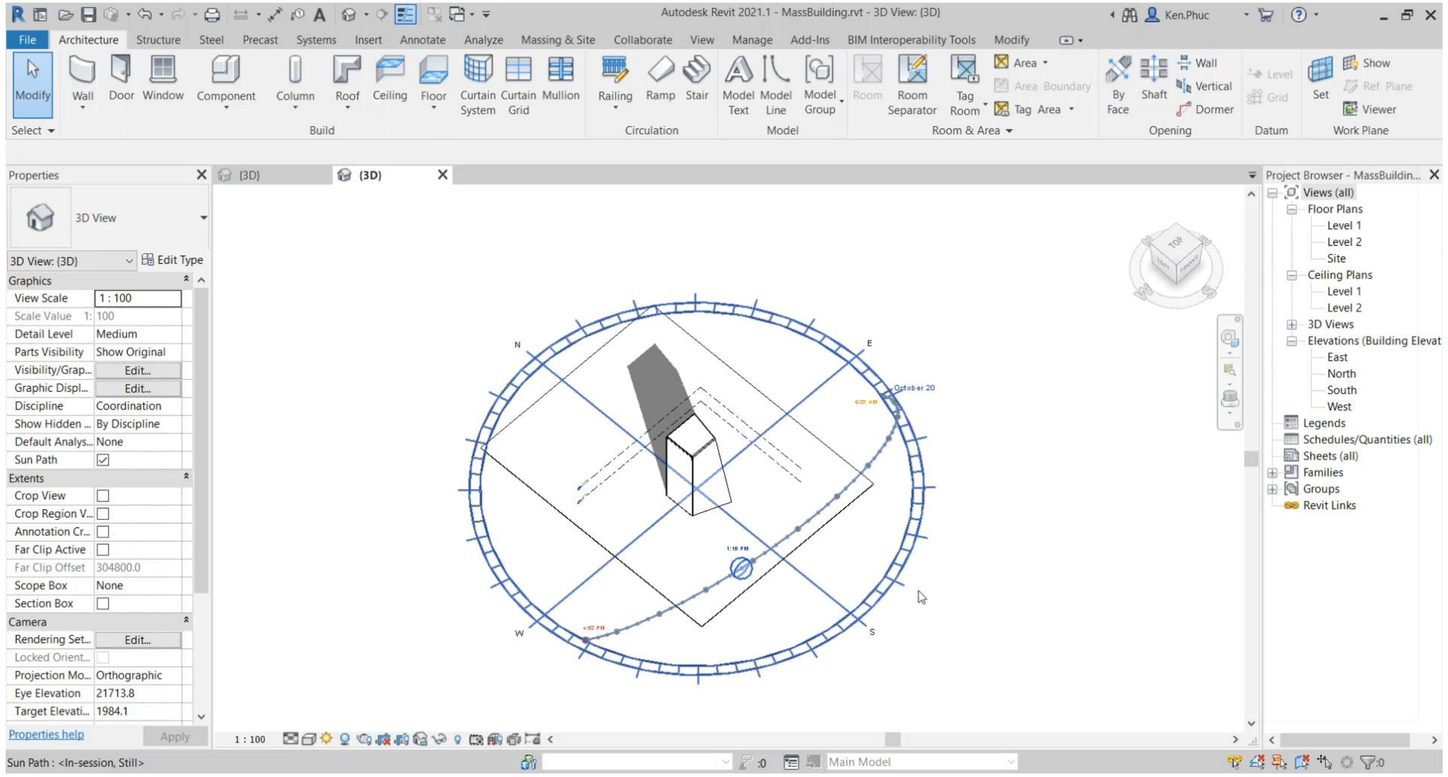
Sample Dynamo script





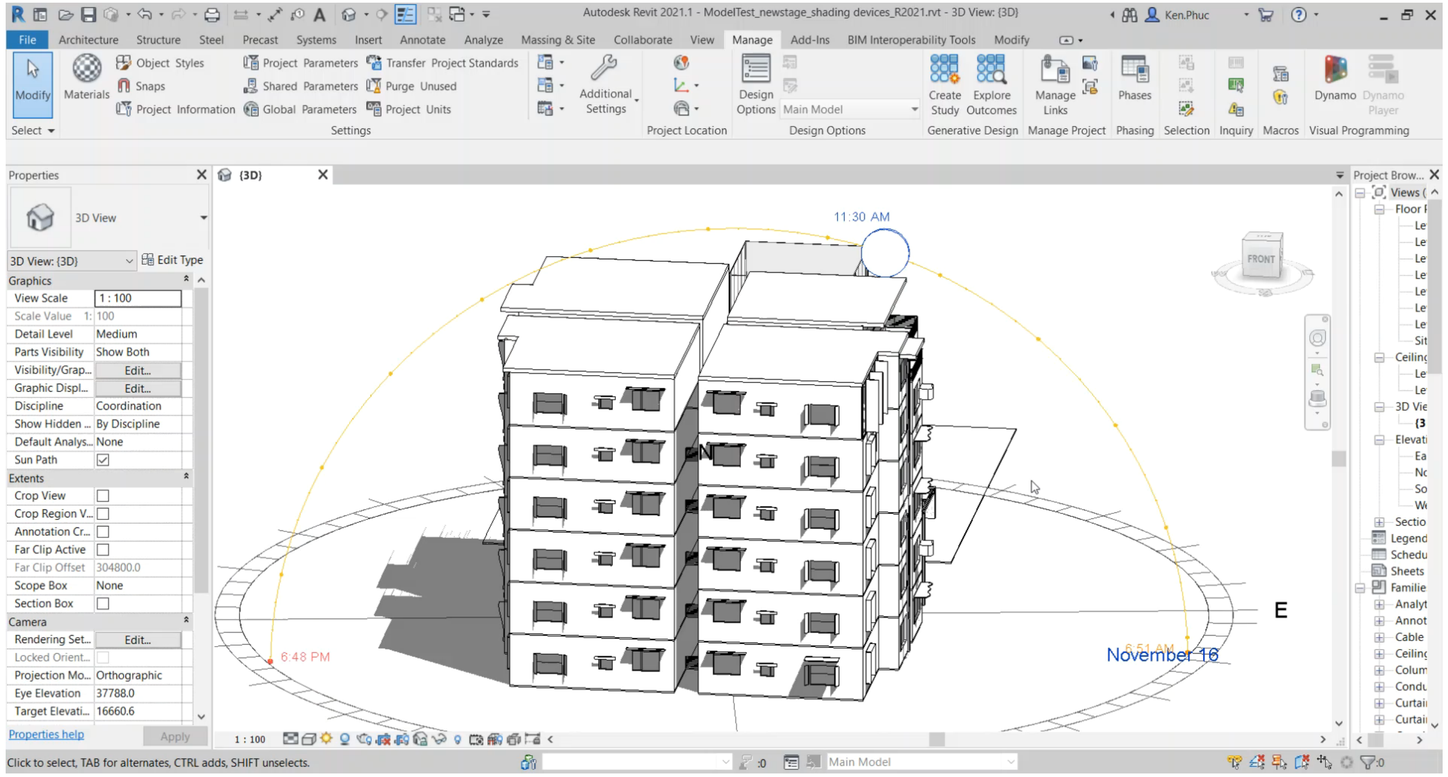


Shadow area of the building



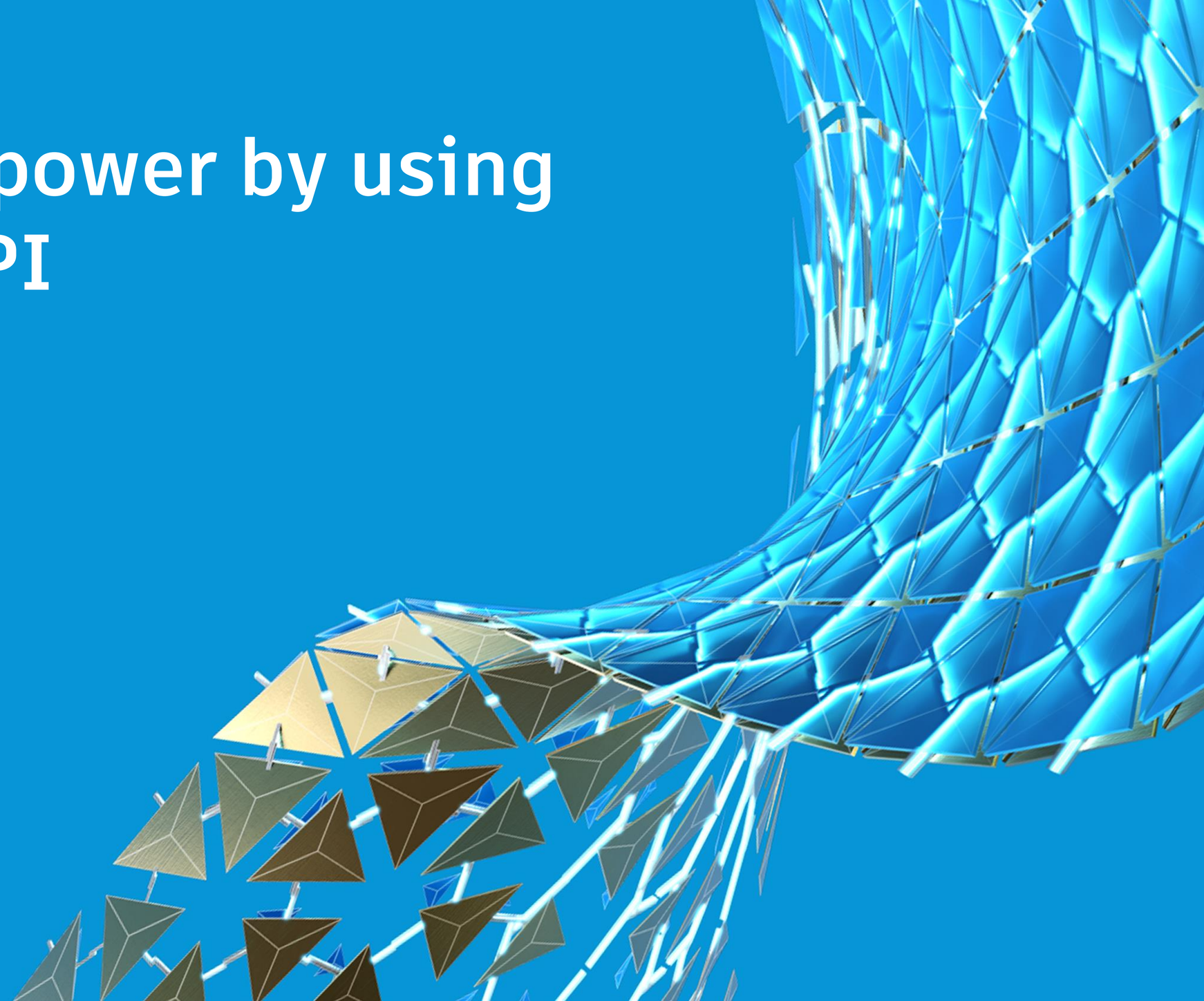
https://youtu.be/M8wvsFnjp0g

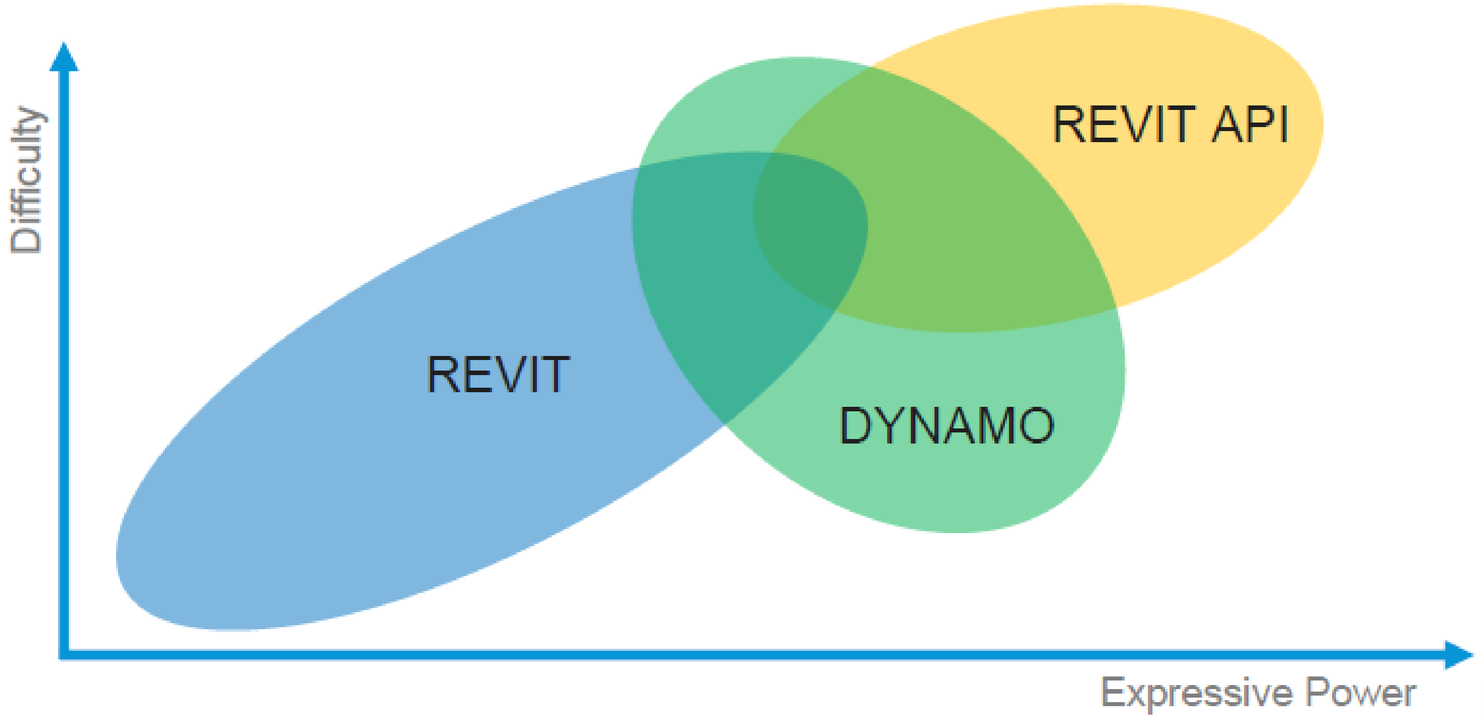
Shaded area of the window



https://youtu.be/r_rJErCcv5I

Unlock full power by using the Revit API

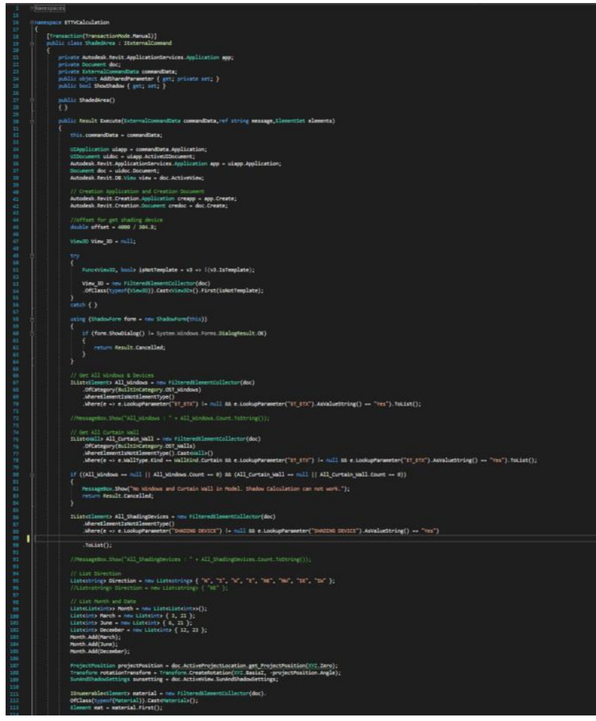




Why Revit API

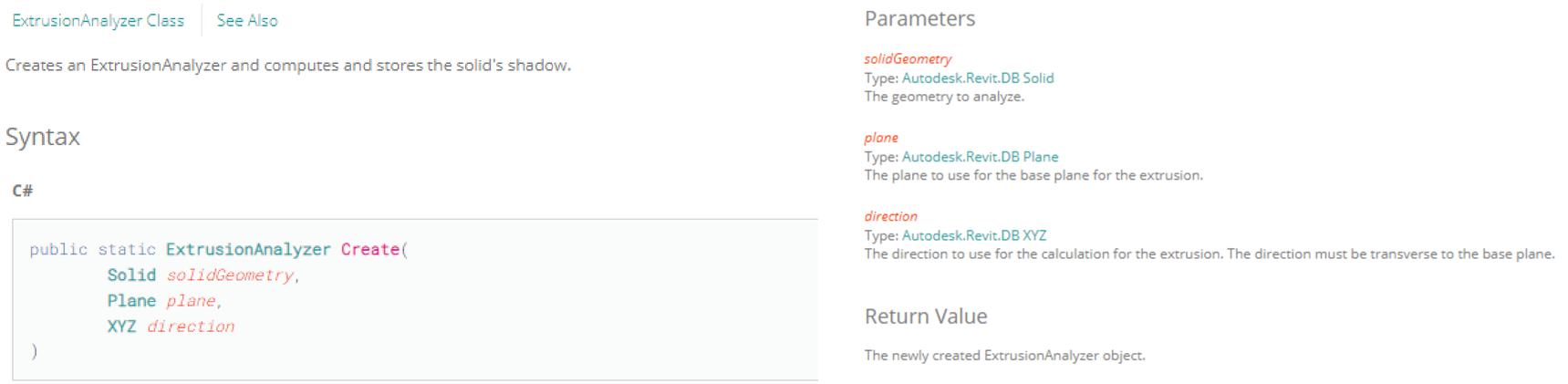
Application Programming Interface

- **Unlock Full power** to the coder and ultimately the end user
- Provide a **Controlled workflow** to specific problem
- **Integrate** with third party software for automating powerful applications



Sample Workflow

- Getting all Windows/Curtain walls
- Getting all Shading devices of building
- Filter by direction (N/S/W/E/NE/NW/SE/SW)
- Getting the sun direction on Vernal Equinox, Summer Solstice, Winter Solstice
- Generate the shadow by using ExtrusionAnalyzer Class in Revit API
- Union all shadows from shading devices on one window/curtain wall
- Show the physical shape of the shadow with its area



ExtrusionAnalyzer Class | See Also

Creates an ExtrusionAnalyzer and computes and stores the solid's shadow.

Syntax

C#

```
public static ExtrusionAnalyzer Create(
        Solid solidGeometry,
        Plane plane,
        XYZ direction
)
```

Parameters

solidGeometry
Type: Autodesk.Revit.DB Solid
The geometry to analyze.

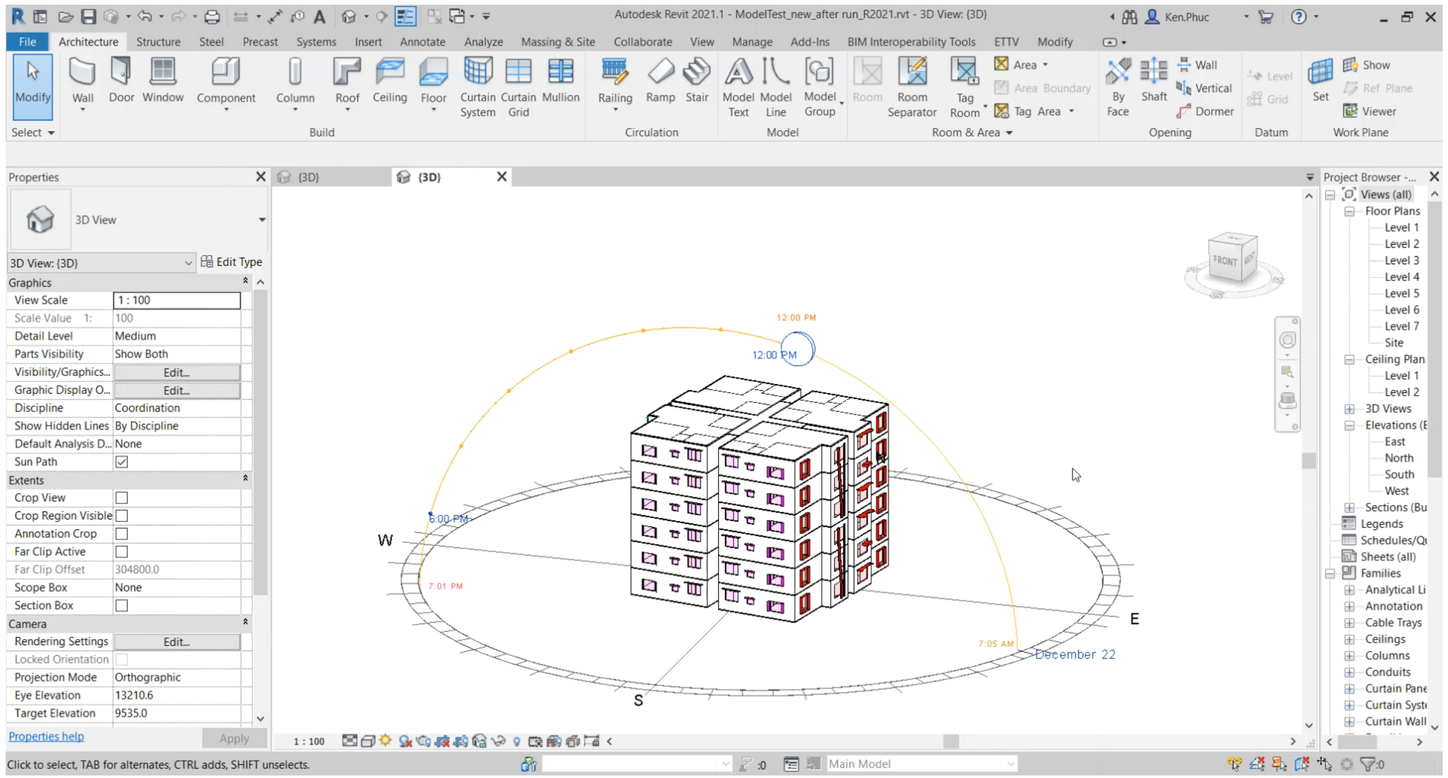
plane
Type: Autodesk.Revit.DB Plane
The plane to use for the base plane for the extrusion.

direction
Type: Autodesk.Revit.DB XYZ
The direction to use for the calculation for the extrusion. The direction must be transverse to the base plane.

Return Value

The newly created ExtrusionAnalyzer object.

Demo Revit add-in for Shaded Area calculation

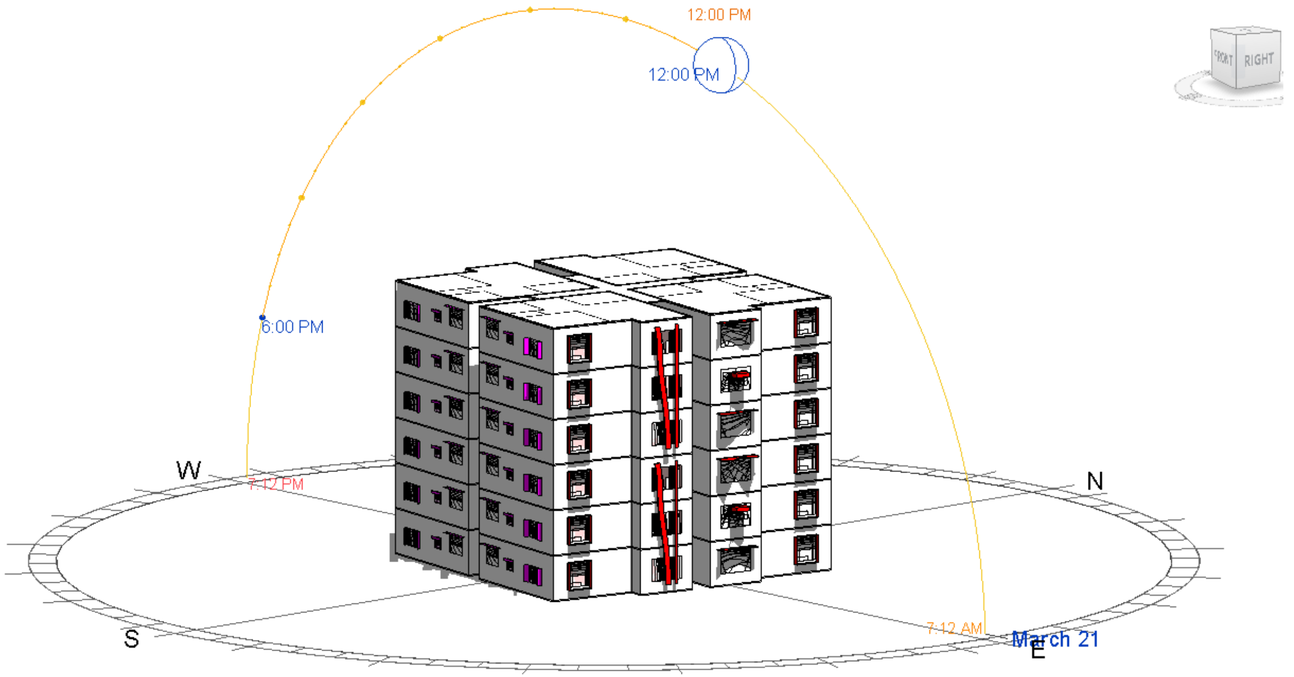


https://youtu.be/0NrKa30lf_Q

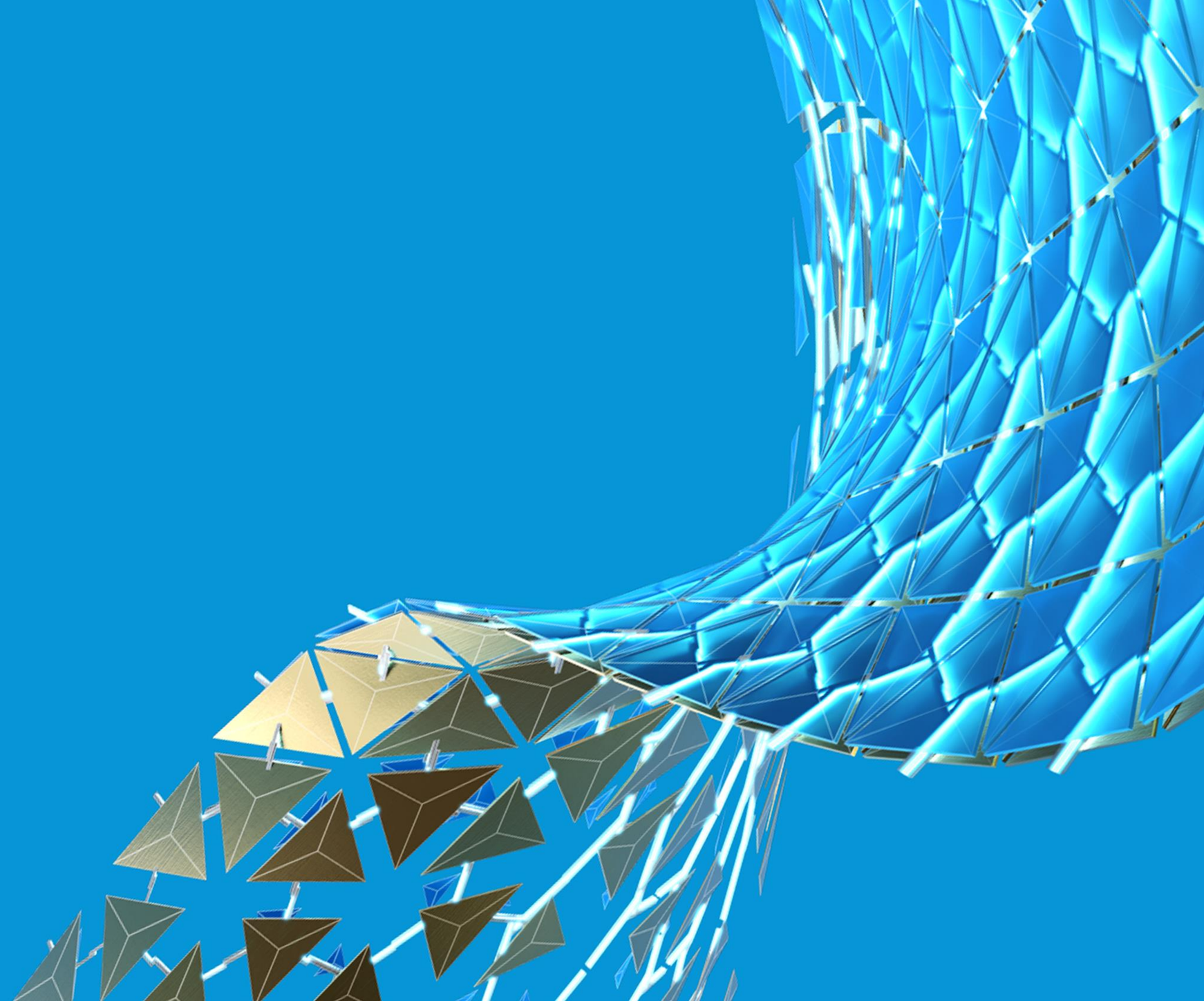
Result

With the power of Dynamo and Revit API, we can use the advantage of high-end computers to calculate shaded areas for the entire windows and curtain walls of a building at any specific time of year.

The algorithms provided in Revit API can perform calculations of shaded areas for complex, organic shapes of shading devices so that the designer can optimize their building design.



Conclusion



Learning Objectives

1

SET UP REVIT MODEL

Learn how to setup Revit models for Solar Analysis

2

INSIGHT PLUG-IN

Discover Insight plug-in for Revit and learn how to user Solar Analysis tool

3

DYNAMO & REVIT API

Learn how to calculate the shadow areas in model with the power of Dynamo and Revit API

4

SUSTAINABLE BUILDING

Understand how to use Revit to design and make a sustainable building


More
Better
Less

Thank you!

If you have any questions or concerns, please feel free to comment on the class page.

Don’t forget to press the Recommend button and get all materials of my AU classes at the following link

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