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Solar Analysis: Calculating Shaded Areas in Revit for Sustainable Design

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Learning Objectives

- Learn how to setup Revit models for Solar Analysis
- Discover Insight plug-in for Revit and learn how to user Solar Analysis tool
- Learn how to calculate the shadow areas in model with the power of Dynamo and Revit API
- Understand how to use Revit to design and make a sustainable building

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, windows, or planting will be. One option to get this information is using the Solar Analysis tool – included in Insight plug-in in Revit software. The other option is applying advanced processes using Dynamo and Revit API to determine the sun direction and the shaded areas of the whole building or particular objects such as walls, roof, or windows in Revit models. This class provides a basis for using BIM models for the design and analysis of sustainable buildings.

Speaker



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He currently serves as a Technical Specialist at Autodesk Asean, supporting firms and organizations in the AEC sector to successfully implement Building Information Modelling, Cloud Collaboration, Computational Design, and Generative Design.

Table of contents

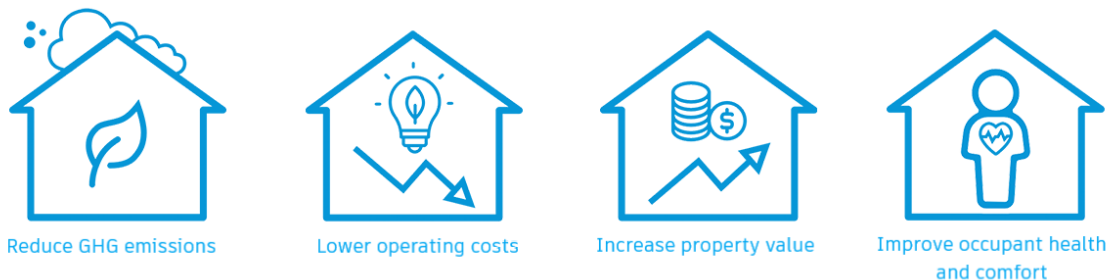
Solar Analysis: Calculating Shaded Areas in Revit for Sustainable Design	1
Learning Objectives	1
Description	1
Speaker.....	1
Sustainable Design – Why Solar Energy?	3
1. What is Sustainable Design	3
2. Sustainable Design in the AEC industry	4
3. Solar Energy	5
4. Solar Energy in Building	6
5. Autodesk Solution for Optimizing Solar Energy	7
Insight Solar Analysis with Revit	9
1. Solar Analysis in Revit	9
2. Workflow for Evaluating the PV potential	10
3. Workflow for Determining Solar Access.....	11
Shading Design.....	12
1. Shading Design	12
1.1. Overview	12
1.2. Adaptive Shades	13
2. Calculating Shaded Area with the power of Dynamo	14
3. Unlock full power using the Revit API	16
Conclusion	17

Sustainable Design – Why Solar Energy?

1. What is Sustainable Design

The intention of sustainable design is to "eliminate negative environmental impact completely through skillful, sensitive design". (McLennan, J. F. (2004), *The Philosophy of Sustainable Design*)

Manifestations of sustainable design require renewable resources, cause minimum environmental impact, and help connect people with the natural environment.

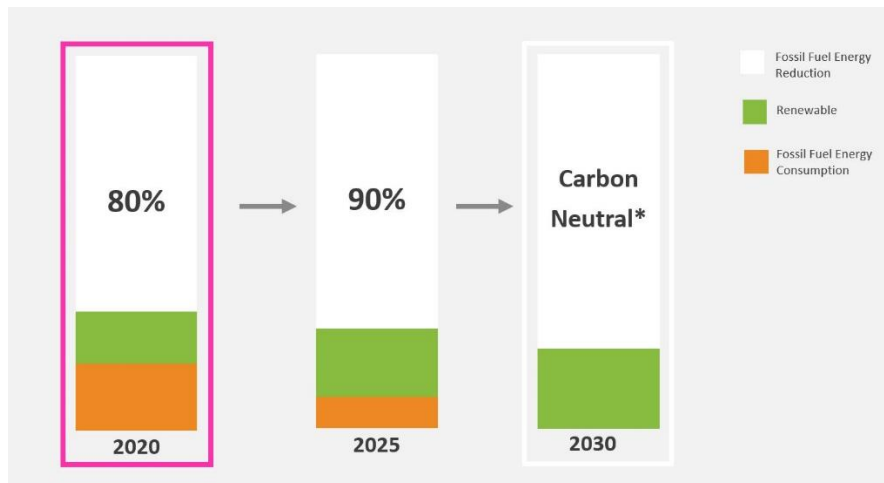


Slowing the growth rate of GHG emissions and then reversing it is the key to addressing climate change and keeping global average temperature below 2°C above pre-industrial levels.

To accomplish this, Architecture 2030 issued The 2030 Challenge asking the global architecture and building community to adopt the following targets:

- All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70% below the regional (or country) average/median for that building type.
- At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70% of the regional (or country) average/median for that building type.
- The fossil fuel reduction standard for all new buildings and major renovations shall be increased to:
 - 80% in 2020
 - 90% in 2025
 - Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate).

- These targets may be accomplished **by implementing innovative sustainable design strategies**, generating on-site renewable power and/or purchasing (20% maximum) renewable energy.



Source: http://architecture2030.org/2030_challenges/2030-challenge/

2. Sustainable Design in the AEC industry

In AEC, the three trends we identified are: Net-zero energy buildings, circular and zero waste construction and sustainable smart cities and infrastructure.

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

3. Solar Energy

Solar Energy is an essential source of renewable energy, and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power.

Active solar techniques include the use of photovoltaic systems, concentrated solar power, and solar water heating to harness the energy.

Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

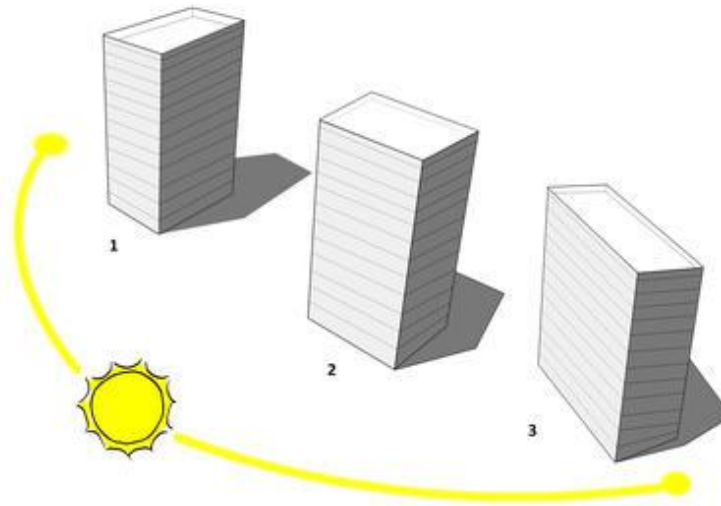
Yearly solar fluxes & human consumption ¹		
Solar	3,850,000	[10]
Wind	2,250	[15]
Biomass potential	~200	[16]
Primary energy use ²	539	[17]
Electricity ²	~67	[18]
¹ Energy given in Exajoule (EJ) = 10^{18} J = 278 TWh ² Consumption as of year 2010		

¹ https://en.wikipedia.org/wiki/Solar_energy

Benefits of using Solar Energy:

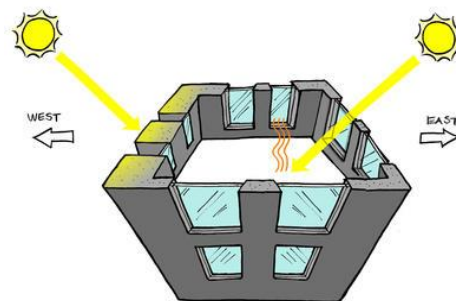
- Increasing energy consumption
- Environmental consciousness
- Global climate change
- CSR implication/ advantage for Corporate buildings
- Attraction towards cleanest, renewable energy
- High social value and an increase in the value of the property

4. Solar Energy in Building



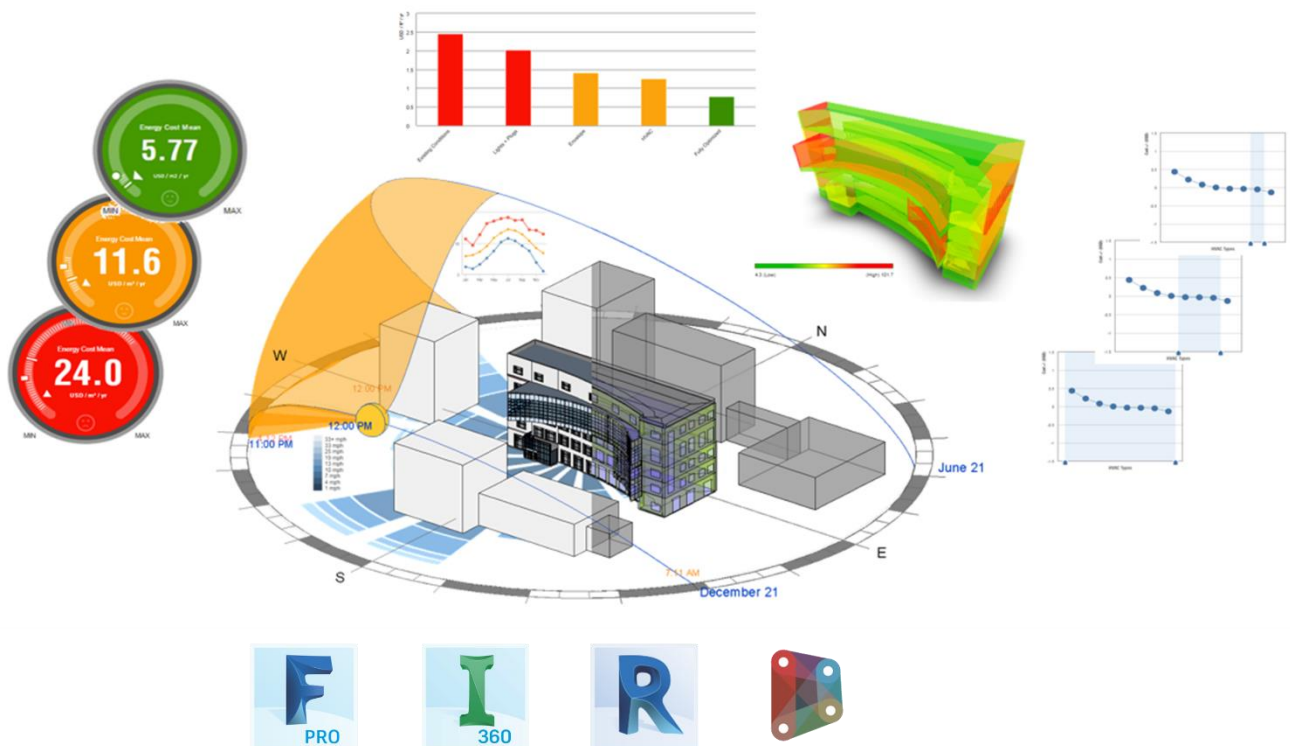
The earth movement around the sun generates sun paths that varied through the day and the year, and it is one of most crucial environmental factors to understand when designing high performance buildings.

If you design your building with careful consideration of the sun's path, you can take advantage of strategies such as natural daylighting, passive heating, PV energy generation and even natural ventilation. However, if you are not careful, these same opportunities can work against you, producing glare or overheating.



Therefore, sustainable building design, especially optimizing Solar energy is moving from being a good-to-have to a must-have for building projects worldwide, as more clients are demanding architects and engineers design buildings to perform better and contribute to green building goals, such as those put forward by the Architecture 2030 Challenge.

5. Autodesk Solution for Optimizing Solar Energy



Impact all countries, the sustainable building industry expected to reach \$234 billion by 2019, sustainable design and its contribution to green building is now adding business value for many architecture firms.

Contributing to this value, data and collaboration is now at the forefront of driving green performance. Architects and engineers are equipped with various data and collaboration tools to help them achieve sustainability goals, one of which is **Autodesk Revit**. Revit users can use the tool’s energy analysis capabilities with **Insight**, a plug-in for building performance, to meet sustainability goals.

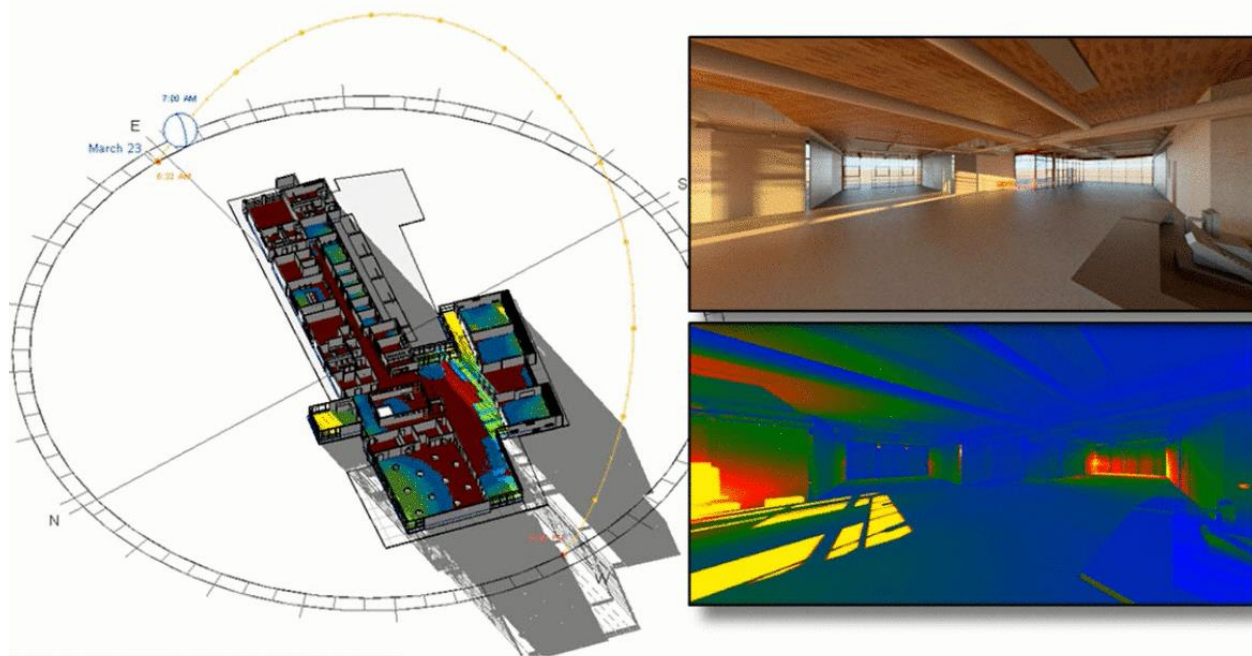
Autodesk Solution provides:

- 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.

Allows for designers:

- Whole building energy analysis: full dynamic thermal simulation for FormIt 360 Pro and Revit models. Energy Cost Range results guide users and aid in making informed design decisions.
- Early stage design analysis: inform fundamental decisions such as orientation and form, aperture sizing and placement, envelope constructions, and shading design
- Detailed design analysis: energy, lighting, and solar performance for detailed Revit architectural models
- Real-time feedback: quickly compare design scenarios through cause and effect feedback
- Compare cost and performance information across different design options
- For individual buildings or whole building portfolios



Insight Solar Analysis with Revit

1. Solar Analysis in Revit

There are some common terms in Solar Analysis:

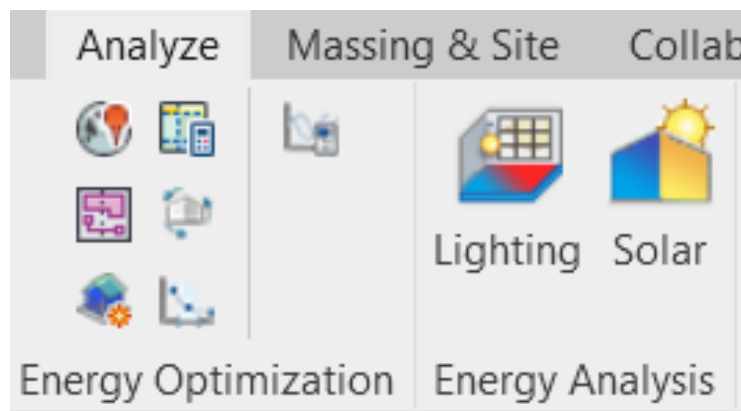
- **Solar Radiation** is an important consideration in any building that strives for energy efficiency
- **Solar Insolation** is the amount of solar radiation energy received on a given surface during a given time.
- **Solar Photovoltaics (PVs)** create electricity directly from sunlight. “Solar panels” or “Solar power”

Revit lets you calculate incident solar radiation per building surface, articulate PV potential, and payback period. Analyzing the impact of the sun on a site can help designers increase the energy efficiency, comfort and financial value of the building. Designers can improve the efficiency of buildings by incorporating energy offsets relating to sun exposure. By estimating building performance through the use of solar models, you can incorporate photovoltaic systems into building plans.

Insight Solar Analysis with Revit provides in context solar radiation analysis results to help you track solar energy throughout your design. The plugin provides automated settings for specific study types, as well as customizable options.

Please visit this link to download Insight Plug-in for your Revit:
<https://insight360.autodesk.com/oneenergy/Landing/Download>

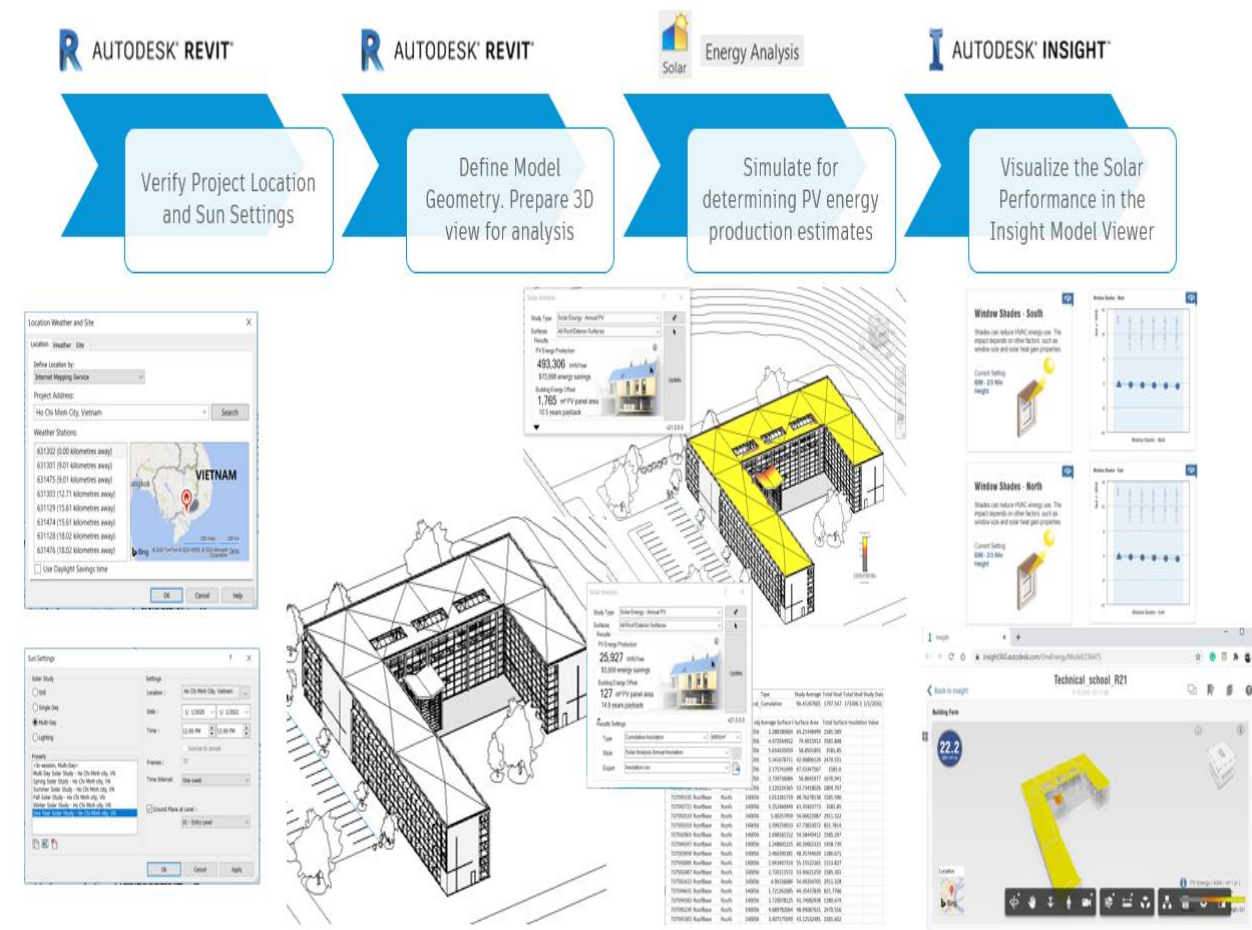
Insight Getting Started Guide:
<https://s3.amazonaws.com/gbs-prod-faq/InsightGettingStarted.pdf>



2. Workflow for Evaluating the PV potential

You can assess the amount of solar radiation available to any surface of your building design in the Revit application as well as in Insight web interface. You can use the Solar analysis tool in Revit or generate Insight and visualize the PV Potential in the Insight Model Viewer.

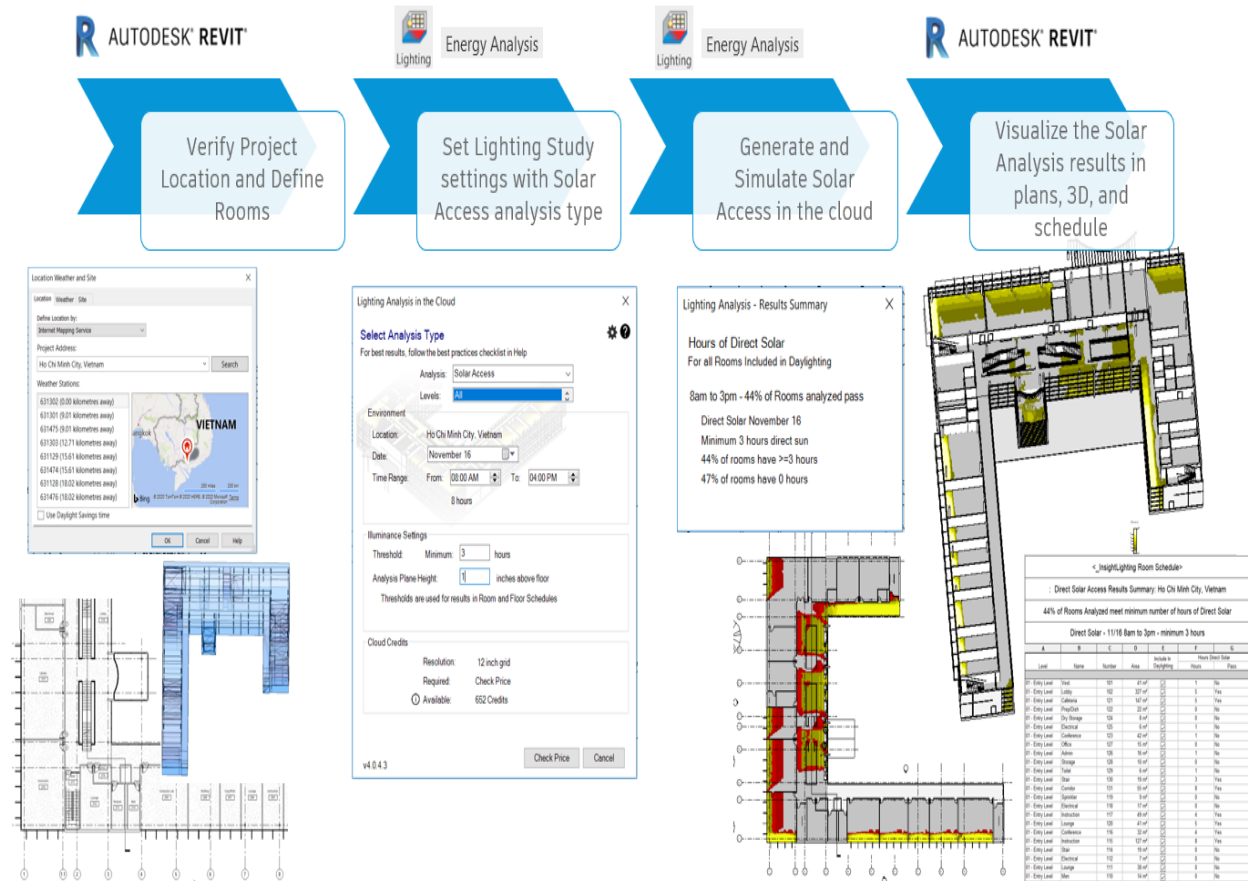
This information is helpful for determining the solar radiation load as well as the potential for generating energy through photovoltaic panels on any surface of your model.



Reference: <https://knowledge.autodesk.com/support/revit-products/getting-started/caas/simplecontent/content/evaluating-pv-potential-revit.html>

3. Workflow for Determining Solar Access

Solar access is a great way to determine if a space is achieving enough daylight throughout the day. Also referred to as daylight access, many countries and regions are now requiring new buildings meet specific solar access standards, such as SEPP 65 in Australia.



Reference: <https://blogs.autodesk.com/insight/solar-access-with-insight-revit-2017-plugin/>

Shading Design

1. Shading Design

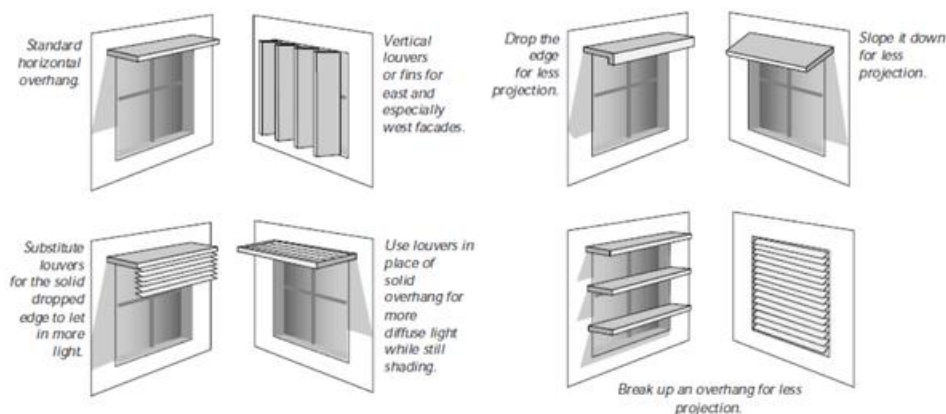
1.1. Overview

Shading devices can play an important role in improving the energy efficiency of buildings. You can assess the impact of adding shading devices and fine tune their placement using solar studies in the Revit application.

There are two challenges in shading design: **Shading devices Design** and **Calculating Shaded Area**.

The most common form of shade is an exterior fixed horizontal overhang. Exterior systems are typically more effective than interior systems in blocking solar heat gain. These are used on the side of the building facing the sun's path, sometimes including east and west faces. However, east and west faces often have more need of vertical fins to avoid low-angled sun.

There are many variations on fixed external shades, to reduce the profile and/or let more diffuse light in.



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

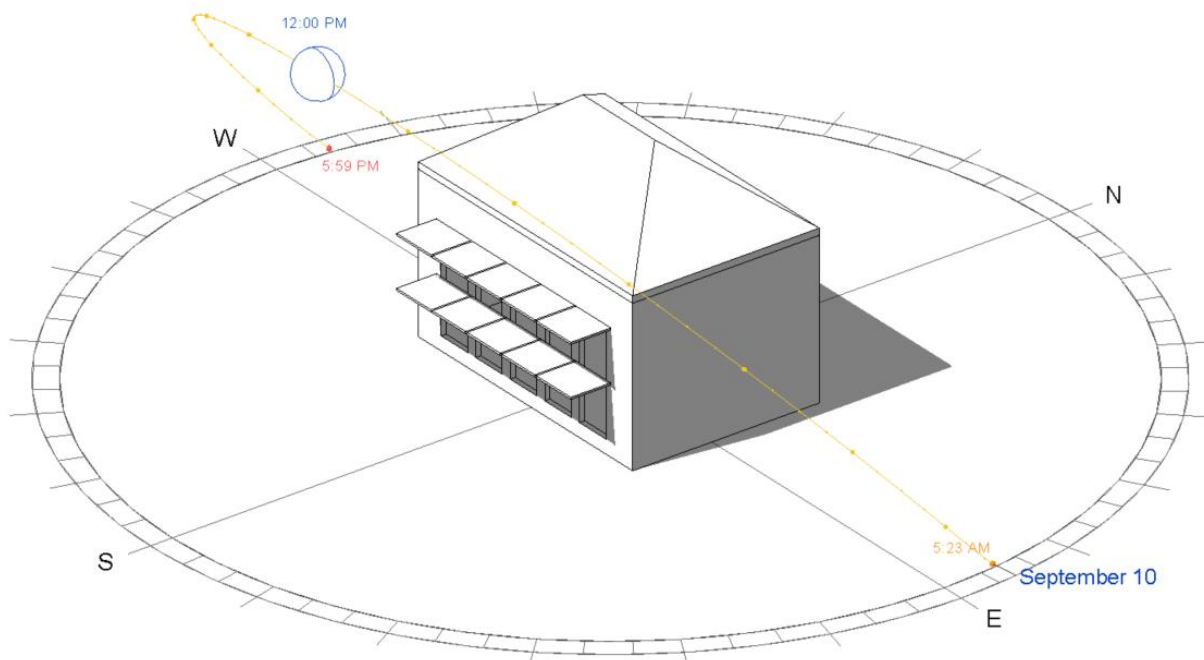
Shading can be designed to allow the sun's light and heat into the building at some times of day or year, while rejecting it at other times.

1.2. Adaptive Shades

Shading can also be adapted by making it movable--either manually operated by occupants or automatically controlled. Such systems can be much more responsive and finely tuned, but they are also more expensive, and require more maintenance and repair over the years. User-operated systems may require occupant training, and are often not properly used.

This example is a proof of concept piece looking at automating design in relation to environmental variables affecting building energy use.

The author of the original sample file is [David Scheer](#).



This example allows for handling the horizontal shading device, which is a simple parametric window family with two shading devices and type parameters for the main window form variables. With Dynamo, shade depth and number of shades are automatically generated to completely shade the window vertically depending on two variables: the Window Height and the Solar Position.

Watch the video of this example in Revit 2021 and Dynamo at the link below:

https://youtu.be/RWdly_YNEOw

2. Calculating Shaded Area with the power of Dynamo

One of the biggest problems in Solar Analysis is how to determine the physical shape of the shadow and calculate its shaded area.

With the help of Dynamo, we can solve this problem.

Dynamo is a visual programming environment that enables designers to explore parametric conceptual designs and automate tasks.

Benefits of using Dynamo in this case:

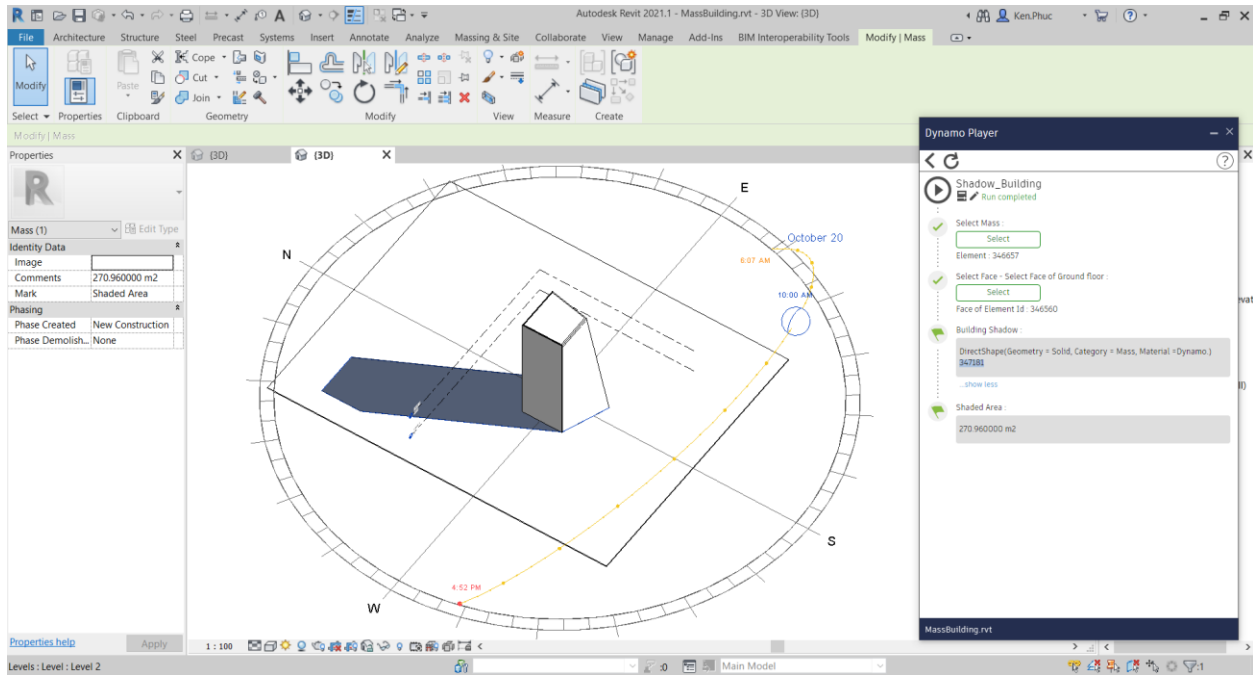
- Explore visual programming without coding
- Flexible to suit the varying needs
- Engage an active community of users, contributors, and developers

The sample Dynamo workflow can be:

- Getting the geometry of shading devices
- Extract to get their surfaces and each edge of a surface
- Project the input edge onto the window in the input Sun direction
- Create the poly curves by joined output curves after projection
- Create a surface by filling a closed boundary defined by poly curves.
- Union a collection of surfaces into one surface, it is a shadow that we looking for.
- Extruding the surface to solid with a thickness
- Create a Revit DirectShape to show the physical shape of the shadow
- Calculate the surface area and set the value to the shadow's parameter.

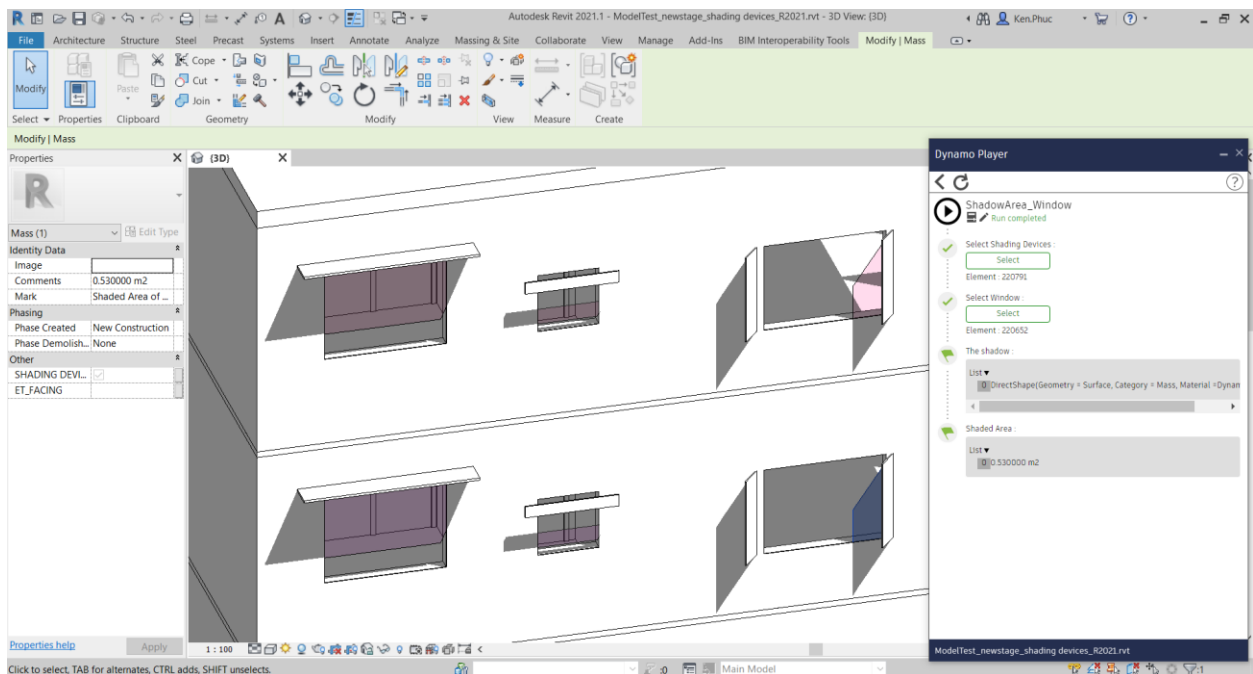


The sample Dynamo script to determine the shaded area of a building on ground level



Watch the video of calculating the shaded area of the building at the link below:

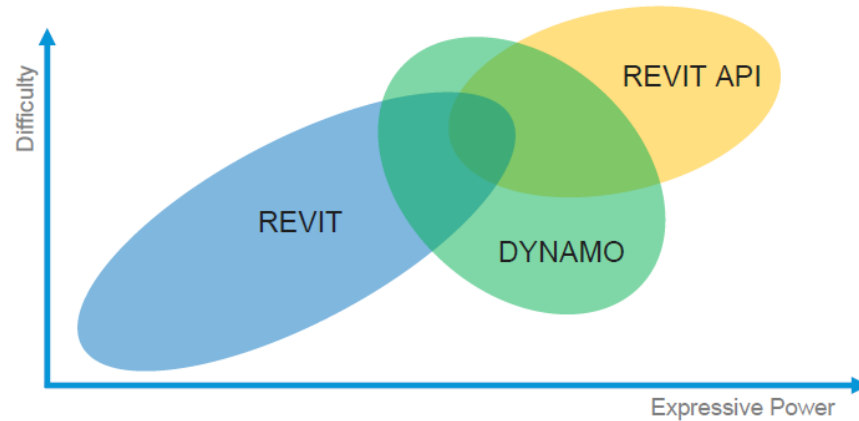
<https://youtu.be/M8wvsFnjp0g>



Watch the video of calculating the shaded area on the window at the link below:

https://youtu.be/r_rJErcCv5l

3. Unlock full power using the Revit API



Autodesk Revit® provides a rich and powerful .NET API which can be used to automate repetitive tasks, extend the core functionality of Revit in simulation, conceptual design, construction and building management, and much more. Revit .NET API allows you to program with any .NET compliant language including VB.NET, C#, and C++/CLI.

In 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.

Here is the sample workflow to develop a Revit add-in

- Getting all Windows/Walls/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/wall
- Show the physical shape of the shadow with its area

The following video will help you have a better look at the Revit add-in:

https://youtu.be/0NrKa30lf_Q

Conclusion

Recognizing the long-term environmental impact of buildings, sustainable design is an imperative for many architecture firms. Autodesk BIM tools such as Revit, Insight and Dynamo make it easier than ever to incorporate sustainable design decision making even at the earliest stages of design.

Autodesk powerful analysis tools use leading simulation engines for whole building analysis, including energy, cooling, heating, daylighting, and solar radiation. The tools also provide a mechanism for architects to work with owners to better monitor building performance and costs during its operation.