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Sustainability Case Studies: Perkins + Will and Johnson Controls

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Learning Objectives

- Learn how 2 companies are utilizing the Autodesk sustainability tools
- See how Dynamo, FormIt, Revit, and Insight can be best capitalized on for the Architecture 2030 initiative
- Understand how the Insight sustainability workflow can be used by everyone in the firm, not just a select few, when compared to the competing products
- Learn how “accuracy” is the new method to determine energy use intensity (EUI) to better design and build sustainable buildings

Description

See how Autodesk sustainability design tools were used for the Architecture 2030 initiative with Perkins + Will, Johnson Controls, and MasterGraphics.aec.

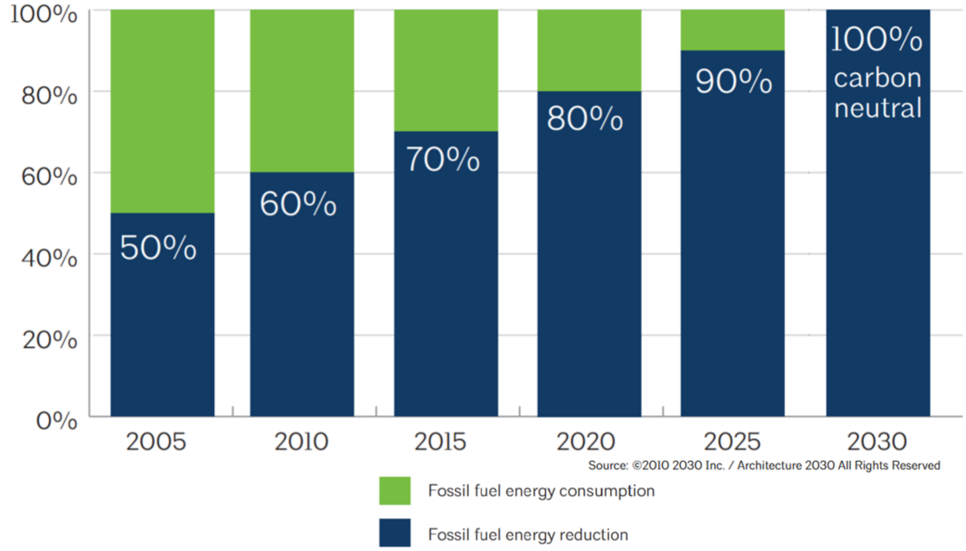
The Perkins + Will case study centers around Director of Research John Haymaker’s "Design Space Construction / Sprout Space" project. Discover how Perkins + Will and MasterGraphics.aec used Dynamo Studio, Fractal, FormIt, Revit software, and Insight to meet design, energy (2030), and view quality requirements.

Learn how Johnson Control’s Clay Nesler (VP of global energy and sustainability) and MasterGraphics.aec used FormIt, Revit, and Insight on the JCI Shanghai HQ project, where they compared the accuracy of their existing process using other competing tools to the Insight workflow. In Mr. Nesler’s words, “this is uncanny”—to see not only how close the results were, but also how few hours were used to generate the schematic design, design development, and construction documents models for the comparison, and that a large ROI was discovered.

Speaker

I help AEC firms streamline bottlenecks and pain points in their daily people, process, and technology workflows. With a business strategy session with key people I assess the current situation based on targeted Q/A and build a goal-oriented plan. My expertise is; Sustainability Solutions | Computation/Generative Design Processes | Delivering Creative Solutions | Architecture, Engineering and Construction Software | Strategic Growth, Process and Workflow Management | Software Development/Documentation | and Kaizen Event/Emotional Intelligence Practitioner.

2030 Challenge Goals



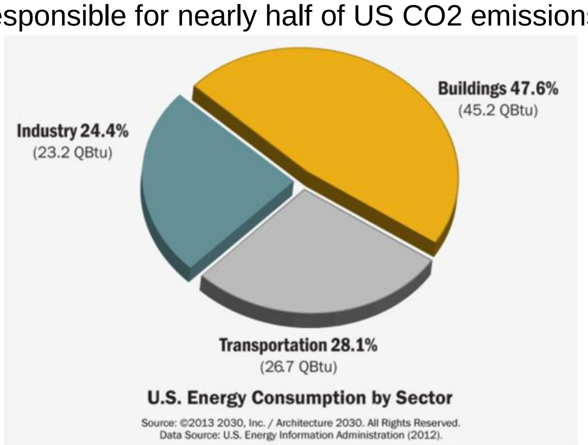
One of these industry demands are the Architecture 2030 Challenge goals. Architecture 2030 states that all new buildings, developments, and major renovations be carbon-neutral by 2030, with incremental benchmarks leading up to the goal date.

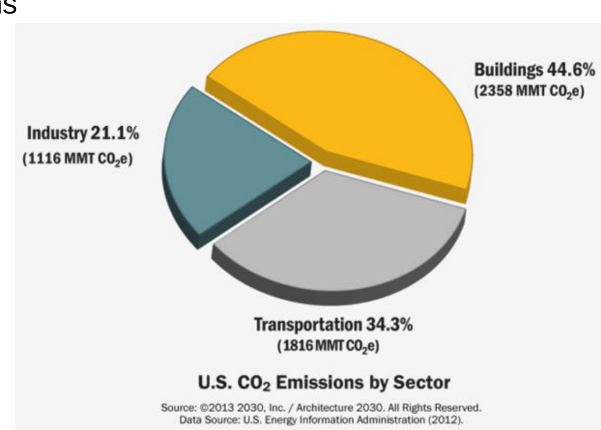
73% of the 20 largest A/E firms, responsible for over $100 billion in construction annually, have adopted and are implementing the 2030 Challenge. Approximately 40% of all US architecture firms have adopted the Challenge.

One of the first adopters of the 2030 Challenge was the AIA. They've been tracking progress through the AIA 2030 Commitment and require firms to report their progress through the Design Data Exchange (DDx).

Building = Biggest Polluters + Energy Consumption

Buildings consume nearly half of all the energy produced in the United States. Buildings are responsible for nearly half of US CO2 emissions





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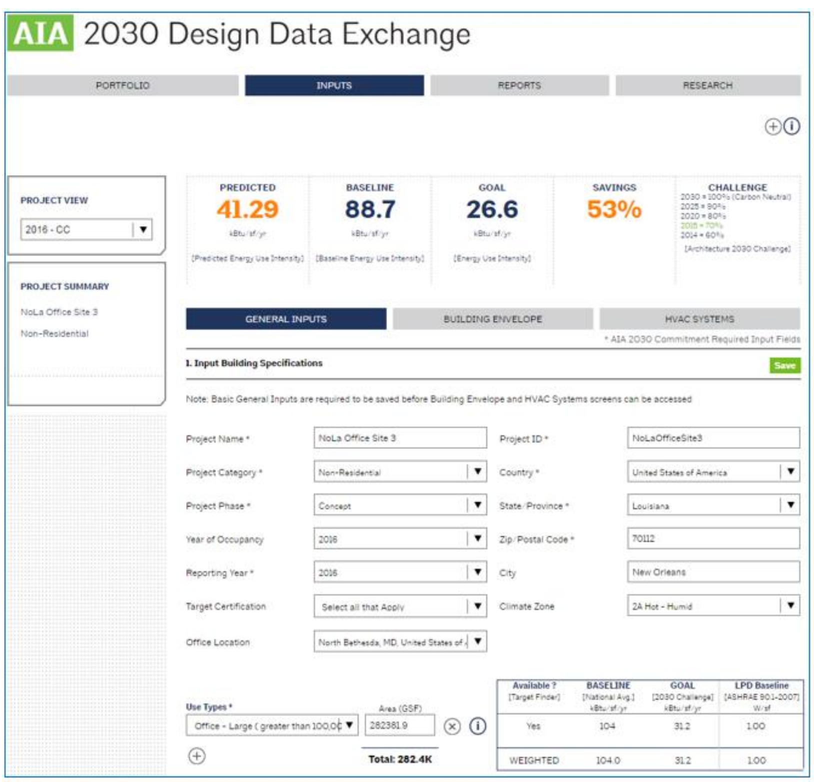
Energy Simulation

Energy modeling is critical to achieving these 2030 targets as well as other energy efficiency standards. Almost 80% of projects that did not have an energy model and failed to meet the 40% reduction goal (from before 2005).

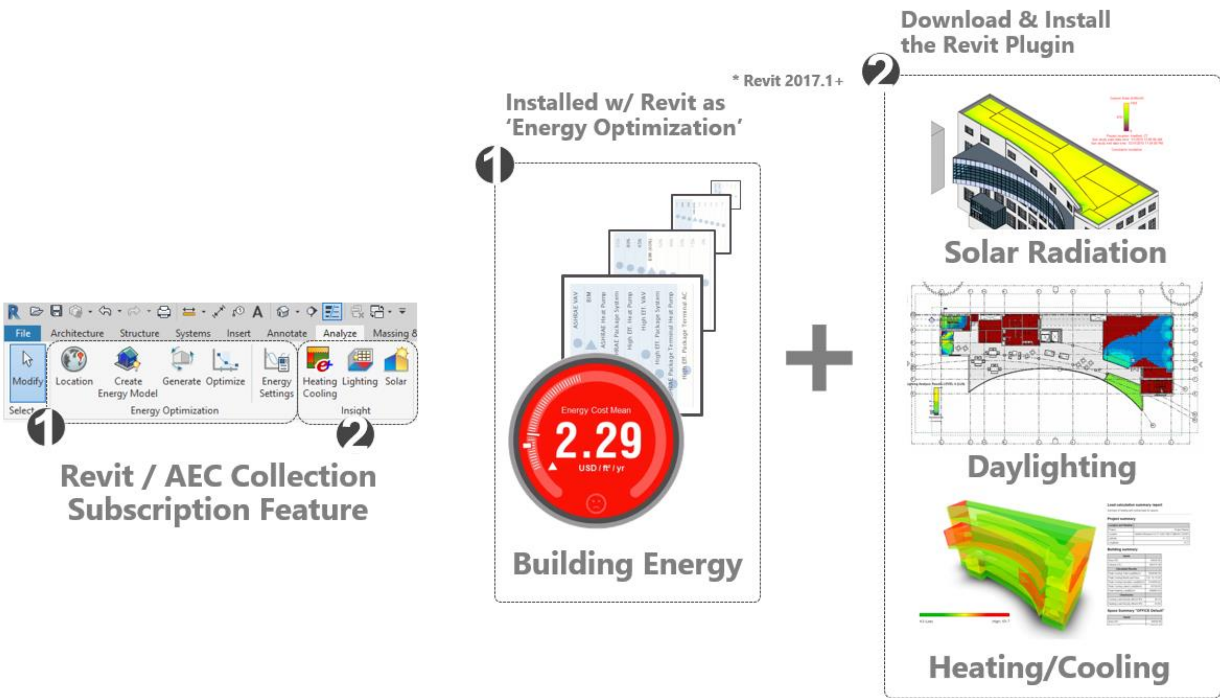
How can we expect to meet these targets and goals if we don't know how our design decisions are impacting performance?

AIA 2030

Autodesk is committed to helping customers achieve 2030 energy reduction targets, and to help with this, they have automated AIA 2030 Commitment reporting to the Design Data Exchange (DDx). Instead of manually entering your 2030 data for each project, you can simply send project data from Insight directly to the DDx. Over 500 firms committed; [LINK](#) 2030 Design Data Exchange; [LINK](#)



Autodesk Insight



Any Revit model works with Insight but let's not forget about FormIt for early conceptual design. Building Energy Analysis is built in starting with 2017.1 and going forward. Install Plugin for Solar Radiation, Daylighting, and Heating/Cooling Load Analysis. LINK

Building Energy Analysis – Computational - DOE2.2 + EnergyPlus engines and typically does 248 runs in the cloud on Green Building Studio; GBS, tested and documented against ASHRAE 140 Practical + Several customers

Daylighting - Uses Autodesk A360 Rendering, a cloud-based engine that uses bidirectional ray tracing. This engine has been validated against Radiance and real-world measurements.

Solar Radiation – Perez sky model, tested by NREL; National Renewable Energy Laboratory Golden Colorado

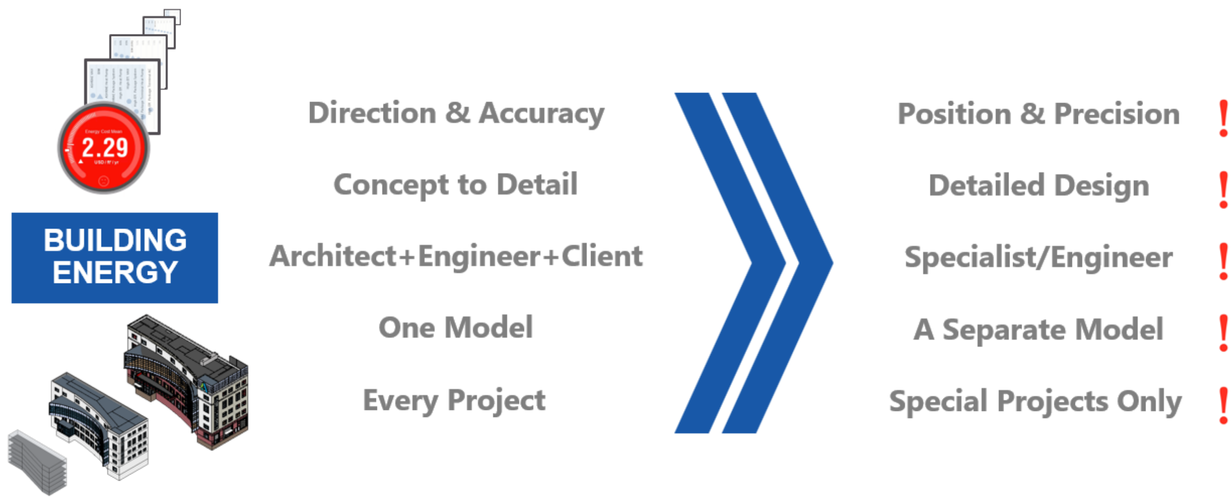
Heating/Cooling – EnergyPlus – ASHRAE 140

How is Insight Different

With over 177 different programs to choose from, and growing every month; International Building Performance Simulation Association USA – LINK why choose Insight? If I was to pick one word… BIM, not merely just in terms of Revit – we all know BIM is more than just Revit, it's about the process.

Here is a great example of how Insight is different compared to the other software products

On the right side using other software products you must use; specialists, separate model, only special projects, and additional cost.

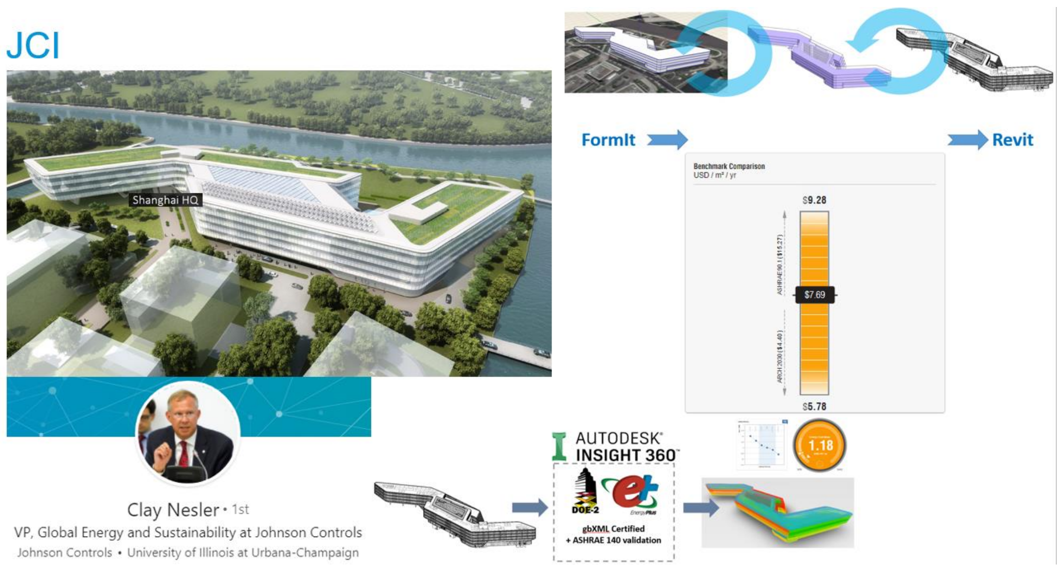


One the left you have Insight; does 248 runs for accuracy, Schematic Design to Construction Document, anyone can use it, single model usage, use it on every project, included in your AEC Collection.

Johnson Control Workflow

Validate Existing Analysis

Used other software products and wanted to see how Insight could be used to validate the workflow and see how the Energy Use Intensity or EUI outcome would be on Johnson Controls new Shanghai HQs.



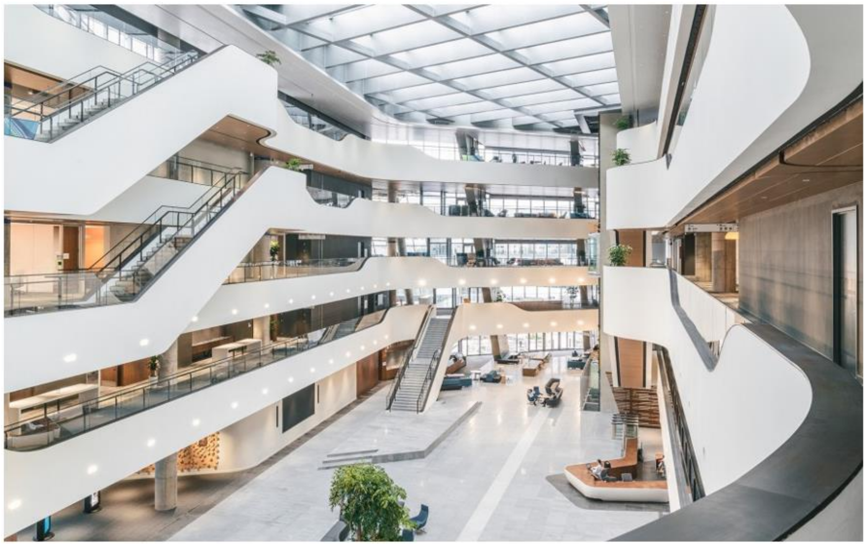
Building Overview

Numerous technologies used for energy savings. Expected to generate 44 percent savings in overall energy consumption compared to the local market standard. Additionally, the building is expected to reduce water usage by 42 percent via its grey water recycling and storm water recapture facilities

THE FIRST TRIPLE-CERTIFIED GREEN BUILDING IN CHINA PAVES THE WAY TOWARD A MORE SUSTAINABLE FUTURE

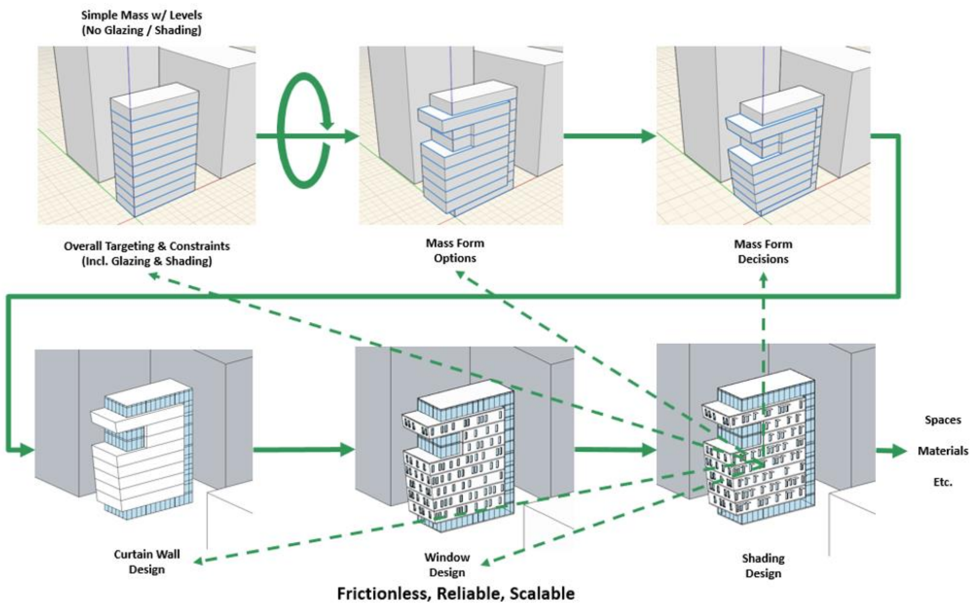
44,300-Square Meter building or for us Americans; 476,841.23 Square Feet, sizeable building compared to the average 19,000 SQ FT commercial building in U.S.

Sets a new standard for green and smart buildings, being the first in China to receive several top global energy efficiency awards including: IFC-World Bank Group's EDGE (Excellence in Design for Greater Efficiencies) Certification, U.S. Green Building Council's LEED (Leadership in Energy and Environmental Design) Platinum Certification, and the China Green Building Design Label Three Star Certification.

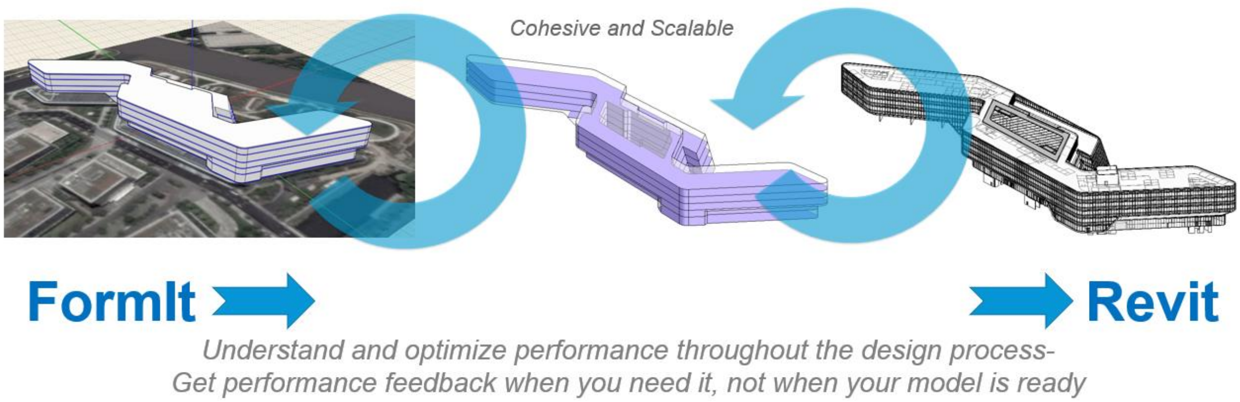


Validating Workflow

Not sure if anyone recognizes this building or has seen my presentation that I did in the spring of 2017. This was my comparison model when I was looking at Sefaira vs Insight and validating the workflow from FormIt to Revit based on the idea of Schematic Design, to Design Development, to Construction Document using Insight. LINK

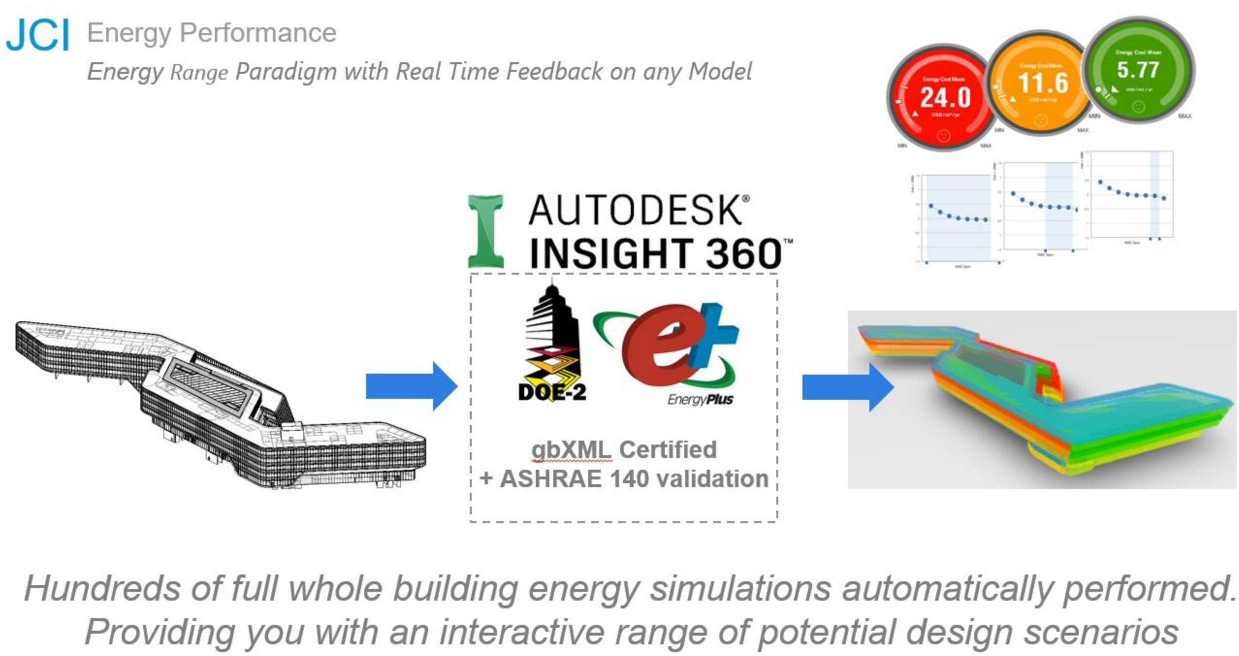


I took that same process and workflow and applied it to the Johnson Controls Shanghai project. This was a little different since I had to go backwards in the workflow; going from the CD model and developing a FormIt model for a SD model. Then taking that into Revit to develop the DD model.



Energy Analysis Engines

Remember Insight uses the DOE2.2 + EnergyPlus engines and typically does 248 runs in the cloud on [Green Building Studio](); GBS. This has been tested and documented against ASHRAE 140 Practical + Several customers.



Heating and Cooling Loads

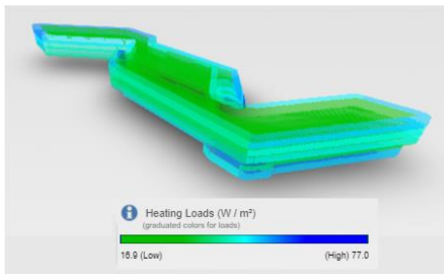
Additional data that is part of the EnergyPlus analysis is the heating and cooling load information. You can see a report inside Revit by going to the Analyze tab and selecting the Heating/Cooling button. For a visualization you can select the Optimize button to open Insight and at the top right select the Visualize drop-down

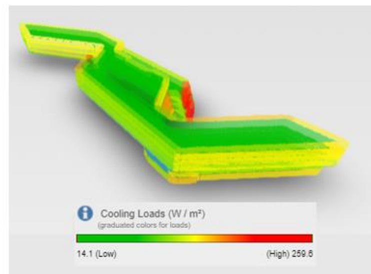
JCI Heating / Cooling Loads Table and Visual

The heating and cooling loads in the baseline model are calculated using EnergyPlus hourly simulation engine for design days.

Building summary

Inputs	
Area (SF)	406421.03
Volume (CF)	6393672.00
Calculated Results	
Peak Cooling Total Load(Btu/h)	6095364.00
Peak Cooling Month and Hour	7/21 16:00:00
Peak Cooling Sensible Load(Btu/h)	5801523.50
Peak Cooling Latent Load(Btu/h)	293837.91
Peak Heating Load(Btu/h)	-4129501.25
Checksums	
Cooling Load Density (Btu/(h·ft²))	15.00
Heating Load Density (Btu/(h·ft²))	-10.16



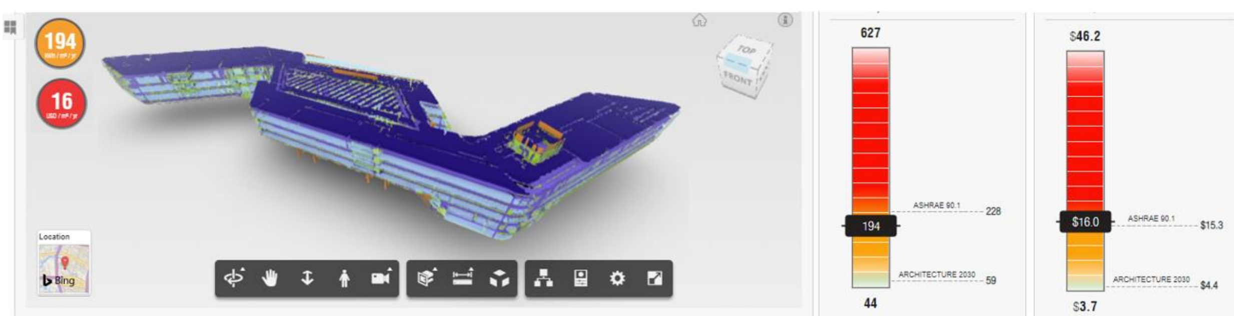


Components	Cooling		Heating	
	Loads(Btu/h)	Percentage of Total	Loads(Btu/h)	Percentage of Total
Wall	-877618.12	-14.40	-864756.19	-14.91
Window	3576154.50	58.67	3366379.25	58.03
Door	0.00	0.00	0.00	0.00
Roof	-768840.94	-12.61	-780564.94	-13.46
Partition	-1016701.31	-16.68	-1016701.31	-17.53
Floor	-509786.25	-8.36	-500759.12	-8.63
Infiltration	257194.95	4.22	212966.80	3.67
Ventilation	0.00	0.00	0.00	0.00
Lighting	2447163.25	40.15	2422644.50	41.76
Power	2181914.00	35.80	2168716.25	37.38
People	805882.75	13.22		
Other	0.00	0.00	0.00	0.00
Total	**6095364.00**	100.0	**5801042.00**	100.0

In the default color-coding scheme, blue indicates higher heating loads and green indicates lower heating loads. For the cooling loads, red indicates higher cooling loads and green indicates lower heating loads.

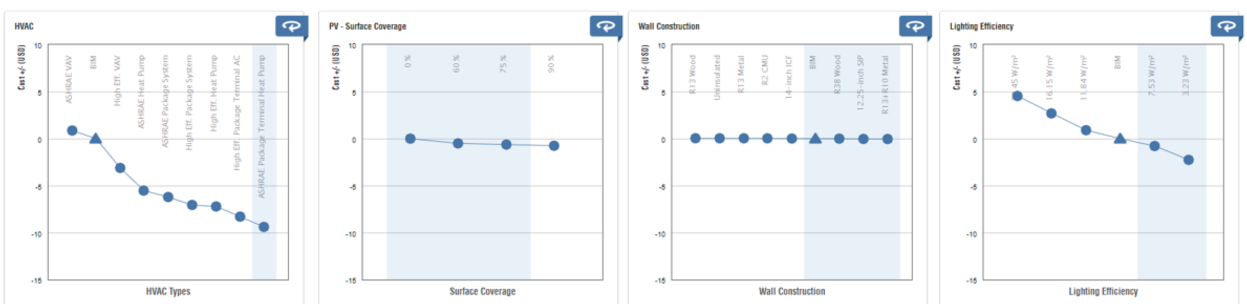
Findings

The below image shows what the energy number were based on by the default FormIt/Revit/Insight settings. Out the gate the Energy Use Intensity (EUI) numbers were: 194 kWh/m2/yr which is just below ASHRAE 90.1 at 228



The below image shows what the numbers were based on my investigation about the actual building elements: EUI 99.3 which is below ASHRAE 90.1 at 228 and closer to the Architecture 2030 EUI 59.0.

With some minor adjustments from Clay, being Lighting Efficiency, Wall Construction, HVAC, and PV Surface Coverage, it went down to: EUI 84.3.

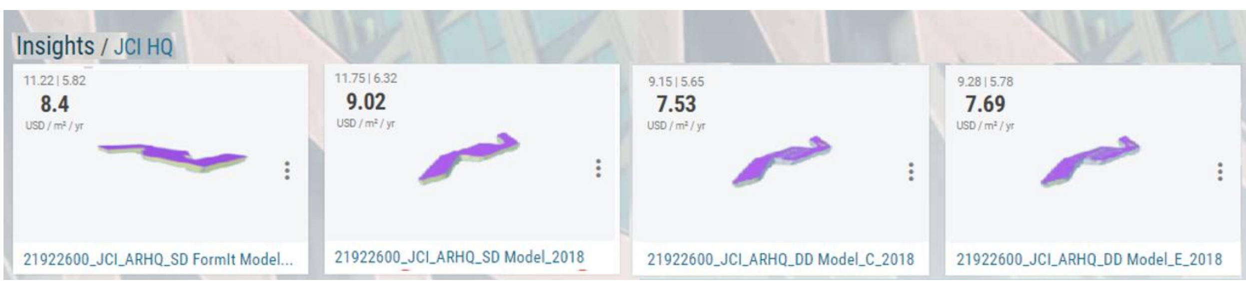


Using Clay's words once he saw the results; "uncanny on how close you got to our numbers"

The energy performance range is continuous and not a roller coaster ride as you go through the design changes and update the energy model, all within 10%. This is from my findings back in the spring of 2017; LINK

Energy performance—as a *range*

Below are the findings form the Johnson Control project.



Schematic Design: FormIt + Insight

For the below workflow you can watch my Autodesk University class called “Design Strategies with FormIt”; LINK

Key Learning

- Discover strategies on working between FormIt 360 and Revit models
- Learn best practices for helping convert SketchUp users to FormIt 360
- Learn how to take advantage of Insight 360 for facade and energy analysis
- Learn how to take the FormIt 360 model into Revit for further study

Using FormIt you can define the location of the project and import a satellite photo to start sketching a simple mass model based on the building foot print. You can include levels to divide the mass model vertically to help with your energy analysis. If it is an urban location, you can define simple masses of the buildings that surround the project to get a more accurate energy analysis.

With the FormIt model defined we can select the energy analysis tool in FormIt and generate an Insight energy model. Insight will give us a base energy cost range / EUI which we can save as a default scenario in Insight. With the benchmark set, we can start modifying the different factors; building orientation, wall to window ratios, window shades, building materials, etc. to better define the building elements.

As we change these factors we will get instant feedback on the benchmark of what factors will gives us the best sustainability for the building. With these new factors we can add additional scenarios to show the progression of what we changed so we can compare them at any given time.
Even at this early stage we can look at EnergyPlus heating and cooling loads from the model. Showing us load density, peak load, and floor area data. We can also export multiple energy model formats being; Energy Plus, GbXML, and DOE-2, if additional analysis is needed.

Design Development – FormIt + Revit + Insight

As the project progresses from schematic design to design development we can bring the FormIt model into Revit. The FormIt model will be converted to Revit masses and the levels will also be converted so we can continue to use them for documentation in Revit.
In Revit we have tools for walls, curtain walls, floors, and roofs to help us to convert from the mass to Revit building elements. We will use these building elements to help us move further into design development for our initial cartoon set.

Once the building elements have been placed we can generate another Insight 360 analysis and compare the base energy cost range / EUI from the previous FormIt model. Like before, we can look at the EnergyPlus data along with exporting the Energy Plus, GbXML, and DOE-2 files. We can also reuse the existing scenarios that we created earlier with this new Insight energy model for comparison.

Construction Document – Revit + Insight

We can continue developing the Revit model for construction document purposes. Adding additional detail to the model for construction clarification being; details, sections, elevations, enlarged plans, schedules, and annotation.

Even in this phase will can generate additional Insight energy models to help track the substantiality of the building. Reusing all of the previous mentioned scenarios and exporting of Energy Plus, GbXML, and DOE-2 files for further analysis.

Perkins + Will Workflow

Computational Design

The workflow that is shown is based on a Perkins + Will relocatable classroom building (Sprout Space). This was first presented at the ACADIA conference by John Haymaker called “Design Space Construction”, see Figure 1.

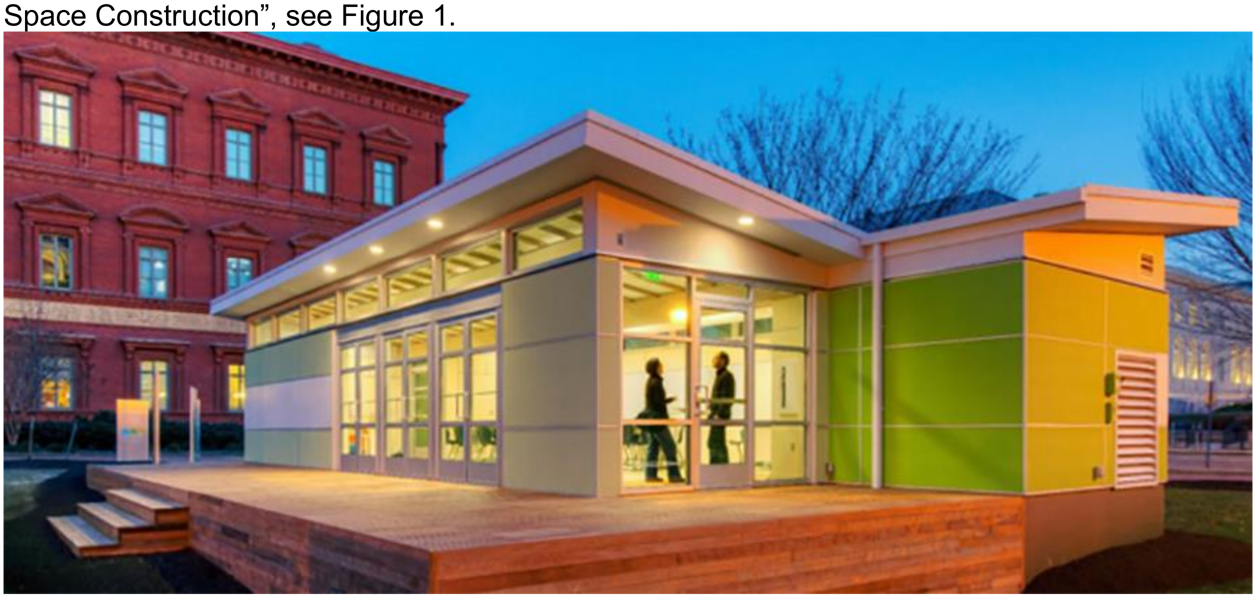
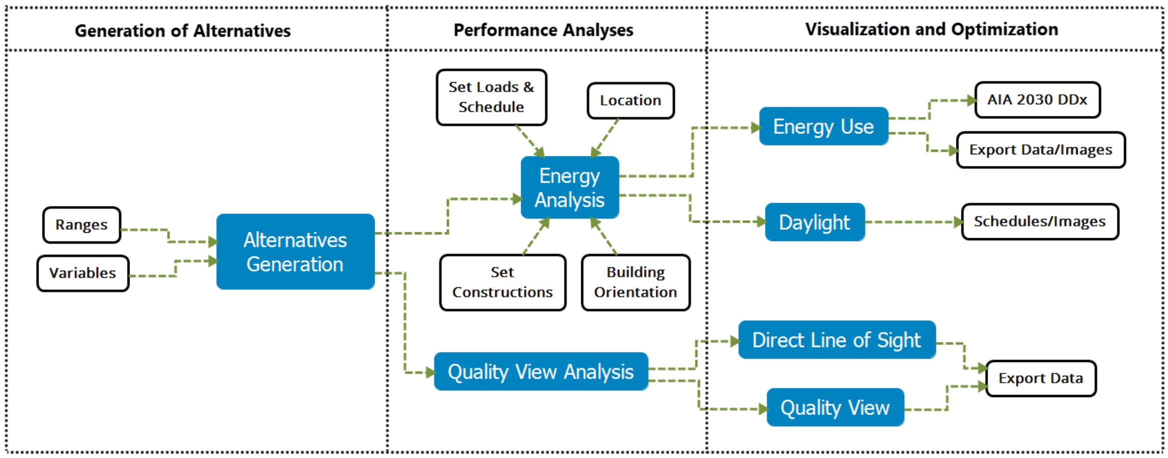
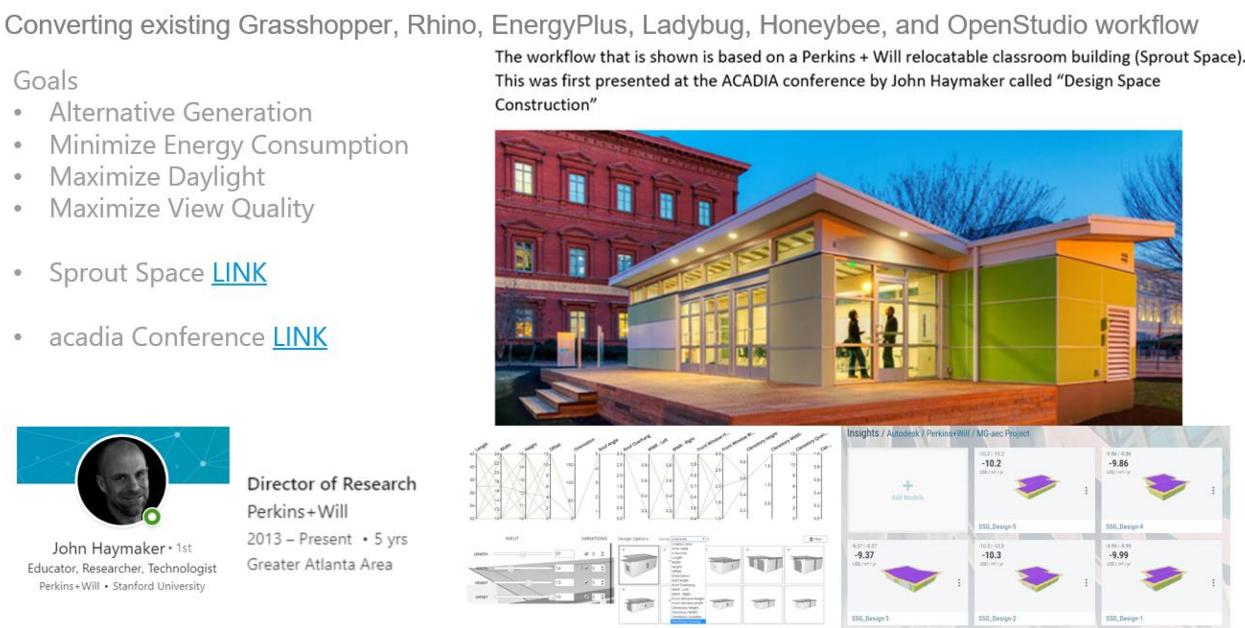


Figure 1: A Sprout Space Design, as constructed.



You must have the following software loaded or have logins to these cloud based tools; [Dynamo Studio](), [Project Fractal](), [Revit](), [Insight](), and [Insight Revit Plugin]().



Objective

The objective is to use computational design to help us with performance-based design to minimize energy consumption along with maximizing daylight and view quality. We will also analyze incident solar radiation, building orientation, wall to window ratio, photovoltaics (PV), and building element construction to help achieve our goals.

Goals

Goals can define specific Experiential, Ecological, or Economic targets. However, in most cases it is impossible to maximize all goals simultaneously and the optimization of a single goal must be compromised in order to maximize overall value. For example, maximizing View Quality (TO), but minimizing Energy Consumption (FP) for heating in the winter or cooling in the summer are both affected by the window/wall ratio of the building envelope.

Examples of goals:

- Minimize Energy Consumption
- Maximize Daylight
- Maximize View Quality

Constraints

Constraints are requirements. Alternatives that violate a constraint are not viable. For example, in the Sprout Space case study perhaps the floor area should be a constraint to ensure enough room is provided for the desired program, but not so large that it takes up too much of the site. Example of a Constraint:

- At least 75% of all occupied floor area must have a direct line of sight to the outside, according to LEED 4.0.
- Providing a larger % of view area might then be formulated as a goal that can be traded off against other Goals.

Metrics

In order to combine multiple Goals and Constraints into a single value function they must be quantifiable. The Metric is the unit in which a Goal or Constraint is quantified. While objectives are declared in qualitative terms, their related indicators are in quantitative ones. The Following metrics are examples that begin to allow the verification of fulfillment of the constraints, and the assessment of the degree of satisfactions of the goals (Table 1.1).

Table 1.1: Quantification of the qualitative objectives

Objectives	**Indicators**	**Metrics**
Minimize Energy Consumption	Energy Use	W/m2
Maximize Daylight	Daylight Factor	%
Maximize Quality View	Quality View (QV)	%
Maximize Quality View	Direct Line of Sight (DLS)	%

Preferences

Goals and Constraints, defined with proper metrics, can begin to be sorted in order of importance, from those that are mandatory to those that are merely desirable. Stakeholders define their unique preferences by prioritizing objectives. Gathering preferences can help drive the formulation, generation and analysis when compromises must occur. Ultimately, a set of design alternatives will be ranked differently depending on the set of Stakeholder Preferences used to evaluate them.

Examples of preferences:

- Student: Minimize Energy Consumption 20%, Maximize Daylight 30%, Maximize View Quality 50%
- Teacher: Minimize Energy Consumption 40%, Maximize Daylight 40%, Maximize View Quality 20%

Alternatives

There are many ways to generate a space of Alternatives, including manual, parametric, or computational strategies. This course focuses on the computational design and the alternates that we can get from Fractal.

A computational design model represents a space of alternatives by describing a configuration of variables, ranges, and relationships. It assumes that the optimal alternative for a design problem exists within the permutations made possible by the model. It is therefore crucial to define this information collaboratively, and iteratively. Finding an optimal solution within these boundaries does not necessarily represent the absolute optimal, since it is only the best design alternative derived from the model. A richer exploration can be achieved by exploring variations of different general configurations and intentionally manipulating the boundaries of the design space. Examples of alternatives:

- Alternative 1: Building Orientation = 45, Window Width = 20 ft. (6.09 m.)
- Alternative 2: Building Orientation = 45, Window Width = 15 ft. (4.572 m.)
- Alternative 3: Building Orientation = 30, Window Width = 15 ft. (4.572 m.)

Variables

Variables correspond to the set of inputs that drive the computational of design alternatives. The variables range from those that trigger geometric variation of the parametric model. Examples of variables:

- Window Wall Ratio (percentage)
- Window Width (feet)
- Building Length (feet)

Dependent Variables

In any design space, there are relationships between input and derived parameters. Derived parameters depend on input parameters controlling the size of both Wall and Window components. Examples of dependent variables in the Sprout Space model are:

- Floor Area
- Wall Surface Area

Ranges

Ranges define the breadth of acceptable input variable values by defining their lower and upper bounds and increment intervals. Due to the size and complexity of the design spaces, analyzing every possible design alternative can often be an impossible task. Specifying the range for each variable makes searching design solutions more efficient. Examples of ranges:

- Building Length (feet) = 32, 37, 42
- Window Width (feet) = 1, 5, 9

Impacts

Once stakeholders have defined objectives and designers have computational design alternatives, the next step is to determine the performance impact of each alternative on each Objective, see Figure 1.1. The impact is the amount of influence the combined variables in an alternative have on the performance of an objective. Example of impacts of variables over indicators.

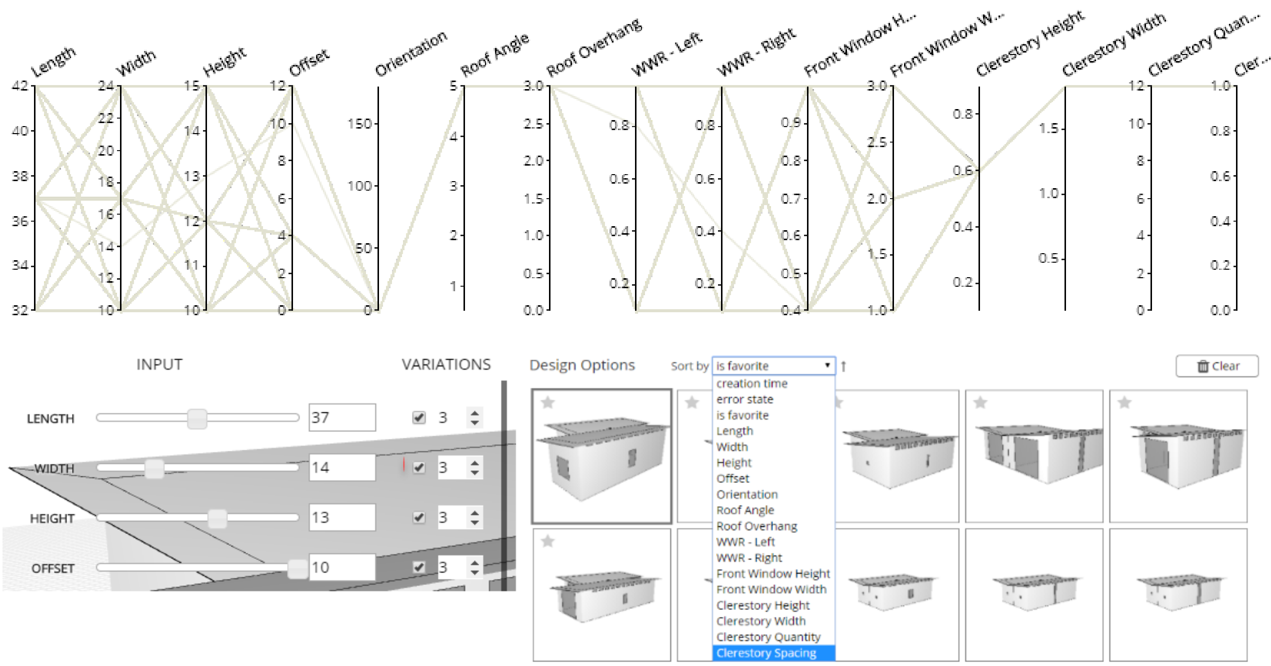


Figure 1.1: Visualization of the impact of the variables on indicators with Fractal

Value

The next steps require assessment of a Value for every design alternative so that they can be rationally compared, and choices made. Formulation of an effective value function is usually an iterative process of narrowing and expanding the search as decision makers, stakeholders, and designers learn more about the space and their own preferences. Depending of the preferences of the stakeholders and the accuracy of the analysis methods, different alternatives can score the highest value with different levels of certainty of their indicators. The process of sorting and prioritizing the design alternative, see Figure 1.2 should include the following steps:

- Ordering of alternatives according to their performance on each objective
- Ordering of alternatives with respect to goals, priorities, and certainty for each stakeholder
- Ordering of alternatives with respect to goals, priorities, and certainty for all stakeholders

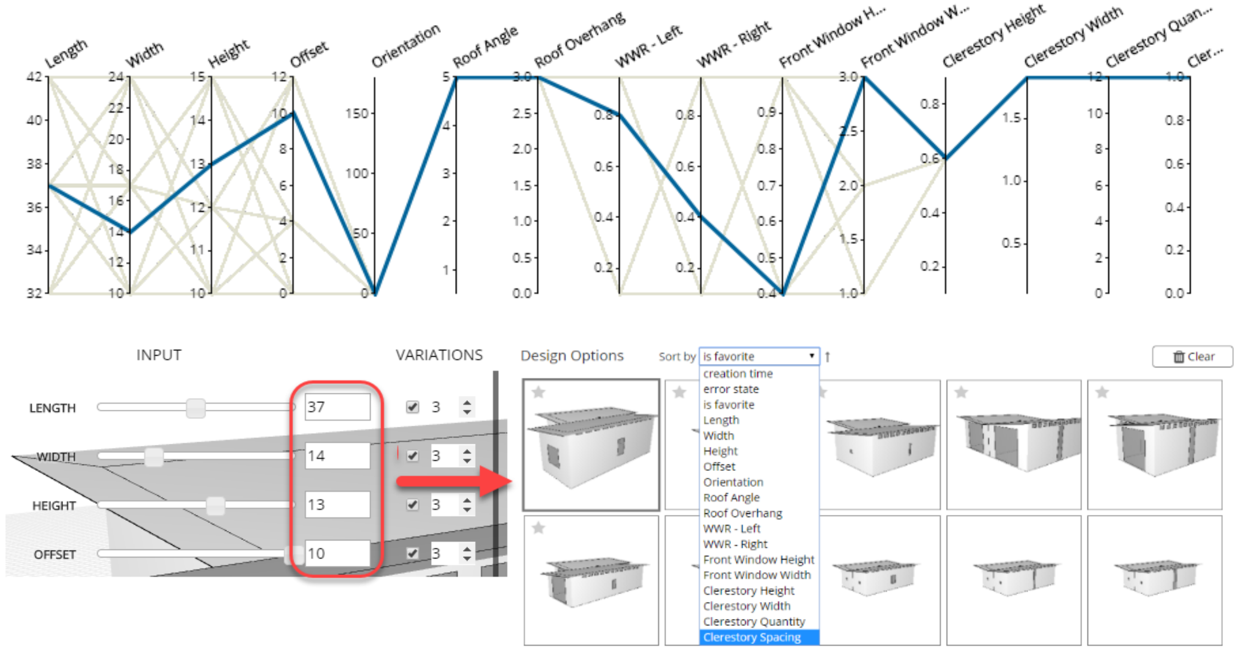


Figure 1.2: Selected alternative according to value from Fractal

Case Study: Sprout Space

Sprout Space is a flexible, modular, and mobile class room developed by Perkins + Will, see Figure 2. Sprout Space provides the case study to explain a multi-criteria design, optimization and decision-making workflow.

- Annual high temperature 71.7 F°
- Annual low temperature 55.9 F°
- Average temperature 63.8 F°
- Climate zone 3B

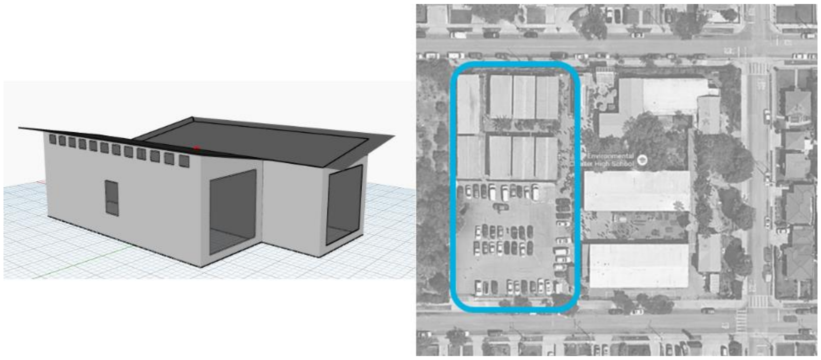


Figure 2: Sprout Space, 16315 Grevillea Ave. Los Angeles, CA.

Computational Workflow

The integration of their parametric model with analysis tools allows analyzing, evaluating and visualizing the performances of different alternatives in a design space and compare them based on their performance metrics. The computational workflow has three stages: computation of design alternatives that are based on a dynamo studio graph, performance analyses based on energy, view analysis, and visualization that shows the input variables and the resulting indicator for energy use, solar analysis, daylight factor, direct line of sight and quality view, see Figure 2.1.

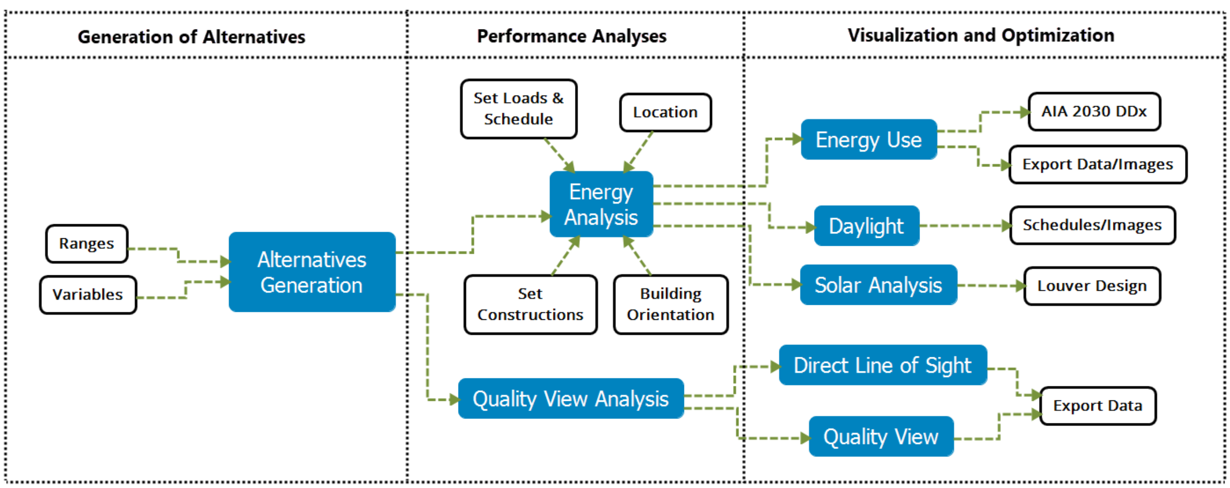


Figure 2.1: Compressed example of the Sprout Space workflow

Geometric Variables

Table 2 shows an example of how to define the main driving variables, metrics, their realistic ranges within the theoretical ones, and, in the last column, the number of options of every variable for this case study that combined produce 216 design alternatives. This information is needed to help us to determine the input needs for the Dynamo graph, the range of those values, what is realistic to that value range, and finally how many Fractal options. Understand the more options to these inputs the more alternates we will see from Fractal, which can be over 9 million!

Table 2: Geometric variables

Variable	Metrics	Range	Realistic Range	Options
Classroom Width	feet	10 -24	12	1
Classroom Length	feet	32 - 42	42	1
Classroom Height	feet	10 - 15	10	1
Classroom Offset	feet	0 - 60	0, 4, 12	3
Classroom Orientation	degree	0-360°	0	1
Front Window Width	feet	1 - 9	1, 5, 9	3
Front Window Height	feet	0.1 - 1.0	0.4, 0.7, 1.0	3
* Window Wall Ratio Left	%	0 - 1	0.58	1
* Window Wall Ratio Right	%	0 - 1	0.411	1
Roof Angle	degree	0 - 10	0.5, 5	2
Overhang Depth	feet	0 - 3	0, 1, 2, 3	4
Clerestory Width	%	0 - 1.828	1.2	1
Clerestory Height	%	10 - 75	60	1
Clerestory Spacing	feet	0 - 1	0.142	1
Number of Panes	unit	0 - 12	7	1

(*ENERGY STAR)

Alternative Generation

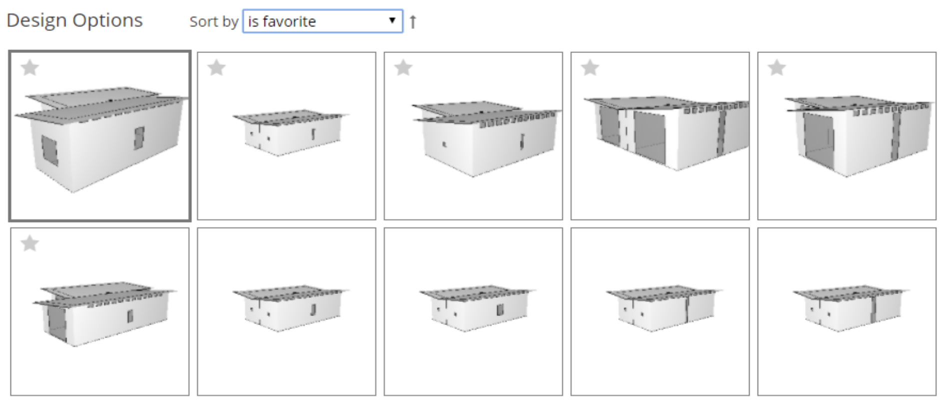


Figure 3: The Sprout Space Computational Design Space of Many Alternatives using Fractal

A design alternative consists of a selected group of options for every input decision variable, see Figure 3.

This section introduces a simple parametric model that creates Alternatives with geometric and other outputs suitable for analysis. The project uses a definition script file written in the visual graphical language of Dynamo Studio and Dynamo for Revit. Dynamo is easy to learn and use and can drive an environment for collaboration. Once the script is uploaded to Fractal Live it generates Sprout Space alternatives consisting of project geometry based on length, width, height, roof slope and other inputs. Subsequent chapters analyze and then decide among these alternatives.

Conceptual Model for Analysis

The conceptual parametric model provided represents with simple geometry the fundamental features required by the analyses, see Figure 3.1. The Sprout Space Generator cluster uses mainly single surfaces to represent walls, floors, roof, windows and overhangs rather than fully over detailed objects, see Figure 3.2. Generally, when constructing a parametric model, a modeler strives to be complete in terms of representing all the objects required by the design (nothing less, nothing more), general enough to represent the design space of alternatives, effective to support the geometric variations and efficient in terms of the use of computational resources.

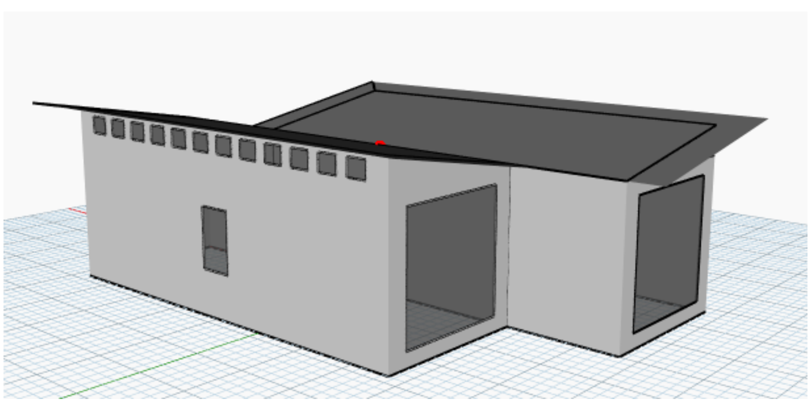


Figure 3.1: The Sprout Space Conceptual Model

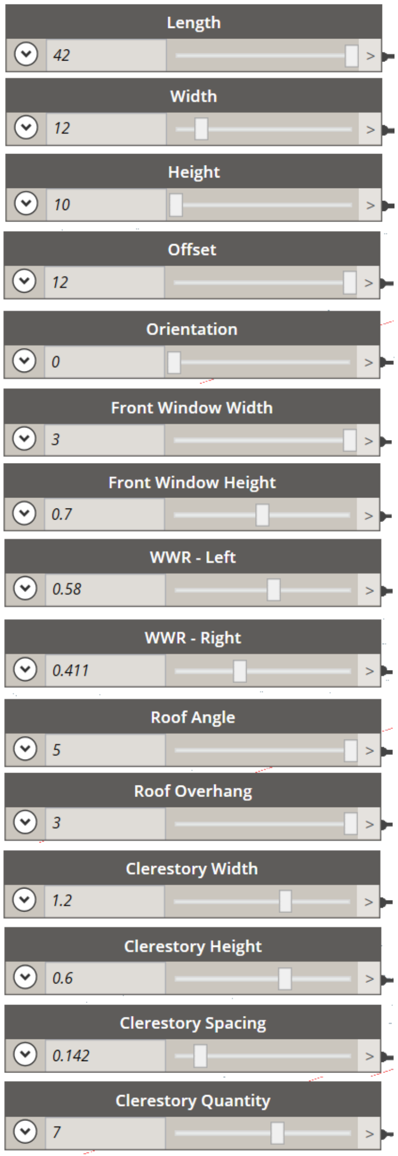


Figure 3.2: Sprout Space Generator cluster

Input Parameters

Several input geometric parameters from the problem formulation drive variations of the model. The variables are organized in four groups that control the building massing, windows, roof and clerestory.

Building Parameters

The basic building block for the project consists of two similar classroom bars that join and share a common wall with an offset. The Dynamo script provides fine control over the classroom net area with width, length, height, offsets, and orientation, see Figure 3.3. Orientation will be best used once we bring the model into Revit and use Insight to check the energy performance.

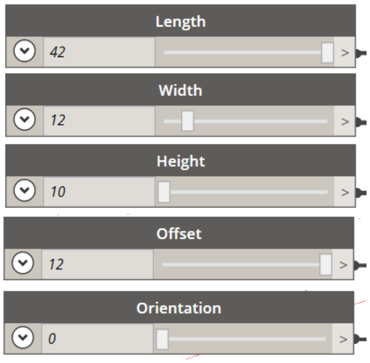


Figure 3.3: Basic building configuration parameters

Windows Parameters

The model uses a set of sliders to vary fenestration geometry, with independent control of the left and west window to wall ratio, see Figure 3.4.

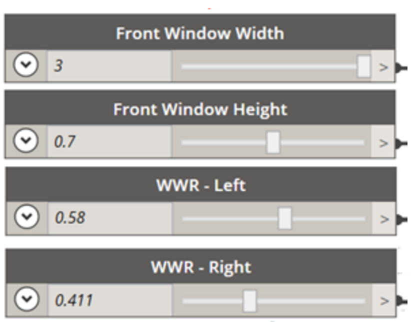


Figure 3.4: Fenestration Parameters

Roof and Overhang Parameters

The project uses single sloped roof geometry for each class room bar, see Figure 3.5. The overhang depth variable provides a variable feature for self-shading and aesthetics. The roof fascia geometry parameter delivers additional geometric variation.

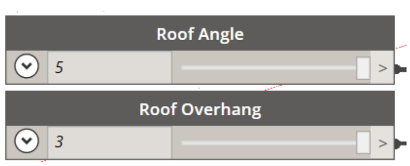


Figure 3.5: Roof and Overhang Depth Parameters

Clerestory and Pane Parameters

The project features a clerestory design option for delivering natural daylight into the class room spaces. The parameters define the width, and height, see Figure 3.6. Clerestory spacing, and number of panes parameters provide control over the geometry generation.

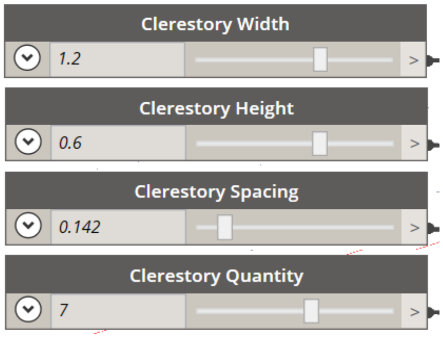


Figure 3.6: Clerestory Geometry Parameters

Development of Dynamo Graph

Sprout Space Dynamo Graph

The Dynamo graph that was produced for this workflow will require an intermediate knowledge of Dynamo, see Figure 4.0. With that said, if you have started to work with Dynamo and have produced some of your Dynamo graphs you should start to understand the logic behind the process. With the understanding of this logic you can easily start developing your own geometry shapes and based on your own input controls.

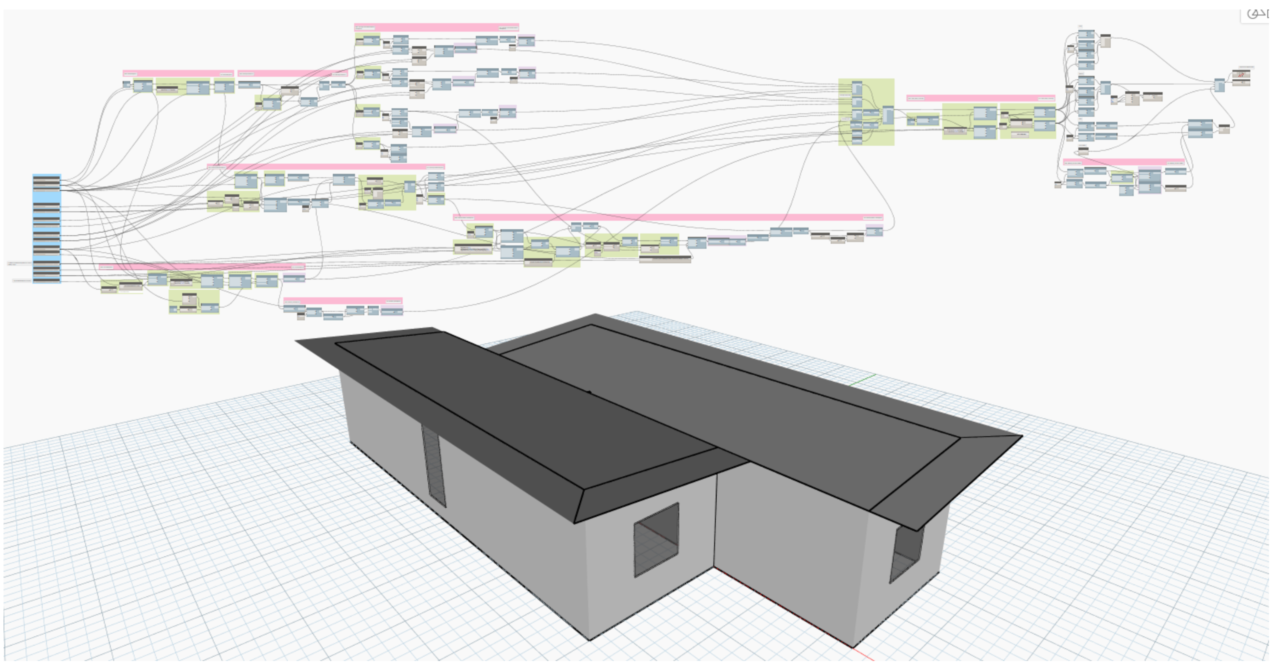


Figure 4.0: Sprout Space Dynamo graph

Design Alternatives Generation

The **Sprout Space Dynamo Graph** aggregates single or multiple alternative inputs, and routes it to the preview window either in Dynamo Studio (single) or Fractal Live (multiple) to show the final solution. In the below section we manually change the inputs and used the Run button to see one solution at a time. With the use of Fractal Live we can run the same Dynamo graph but see multiple alternates at the same time.

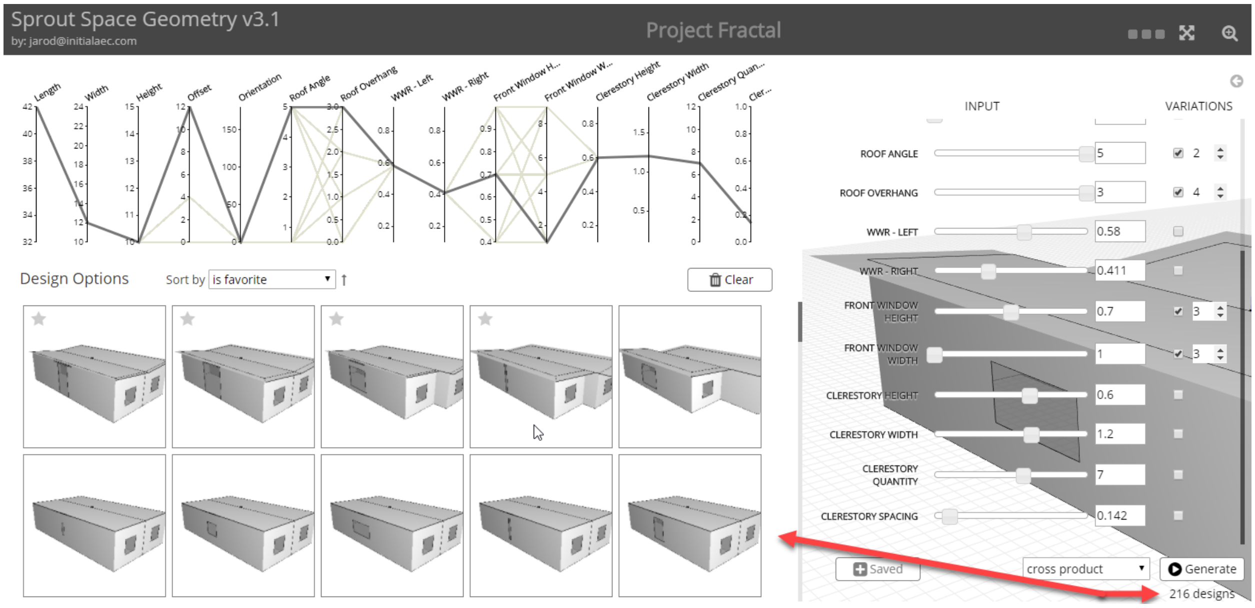


Figure 5.0: Seeing multiple alternates from the same dynamo graph; total of 216

Generation of a Single Alternative

The use of individual set of parameters provides for a single design alternative in Dynamo Studio, see Figure 5.1. Single alternative groups all of the options for the class room geometry, fenestration, roof, overhang parameters.

NOTE: Dynamo Studio is “unitless”, so “1” can mean “1” foot or “1” meter. There are two graph’s setup for the initial start of this workflow that have the “default” values setup correctly; Sprout Space Geometry Default_Values_I.dyn and Sprout Space Geometry Default_Values_M.dyn. This entire document set is using the “imperial” Dynamo graph; Sprout Space Geometry Default_Values_I.dyn.

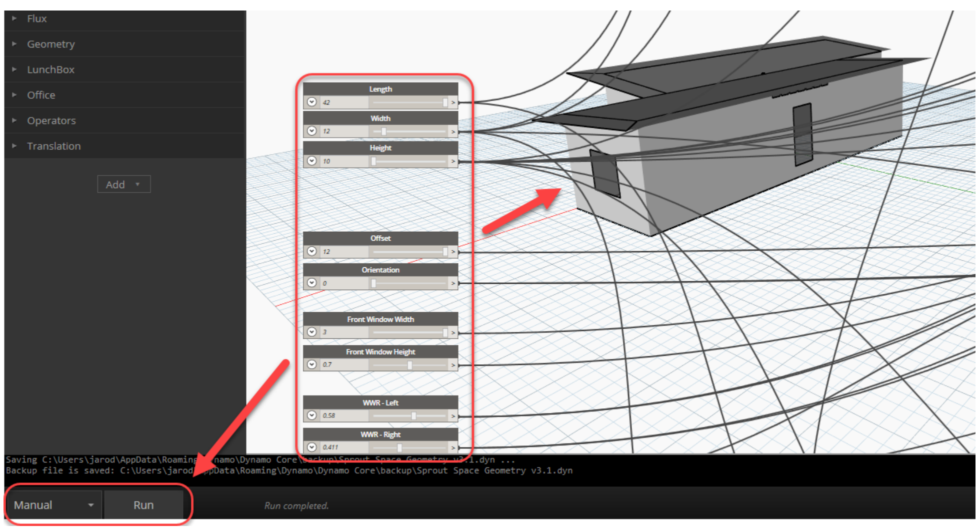


Figure 5.1: Parameters for a single alternative

Generation of Multiple Alternatives

The "Fractal Live" website provides an efficient workflow for entering multiple options for a unique parameter, and for very large design space exploration. Each single option is sent for analyses in a sequence. The number of options can easily exceed hundreds of iterations, so the feature should be used judiciously.

To try Fractal Live with a Dynamo graph for "multiple alternates", open the "Sprout Space Geometry Default_Values_I.dyn" in Dynamo Studio. From the File drop-down use, the "send to web" option to publish the Dynamo graph to Fractal Live. Give it a name of "Sprout Space" and pick Publish, see Figure 5.2.

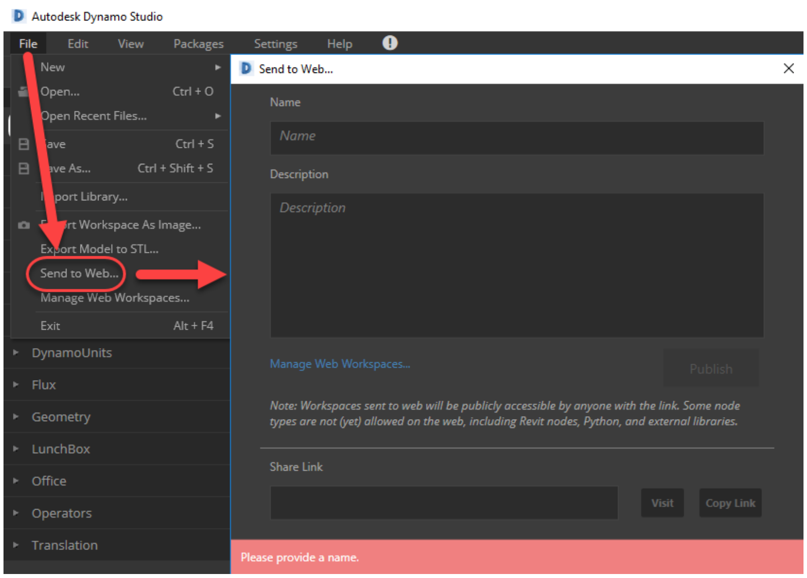


Figure 5.2: Dynamo Studio Graph to Fractal Live

Pick on the this LINK to go to the Autodesk Fractal Live website. You will need to pick on "My Workspaces" which will require a login before you can use it, see Figure 5.3.

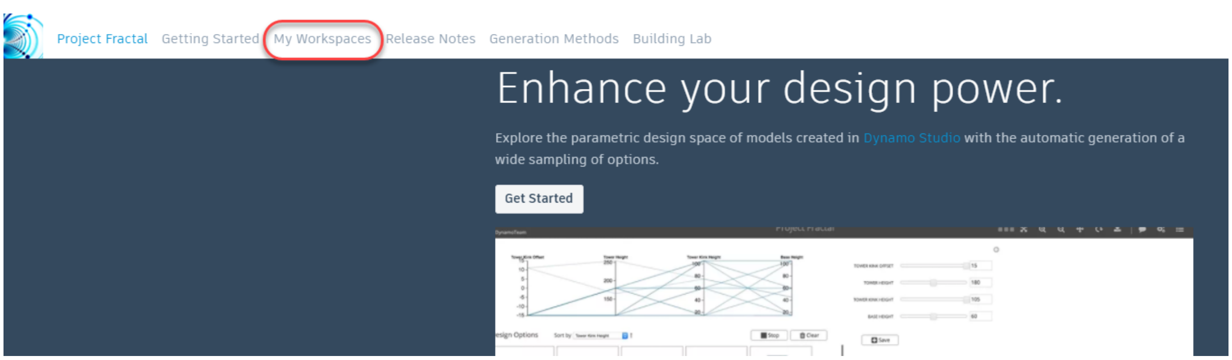


Figure 5.3: Fractal Live and My Workspaces

Once you login it will show all of the current published Dynamo graphs from Dynamo Studio. Select on the Sprout Space dynamo graph to open it, see Figure 5.4.

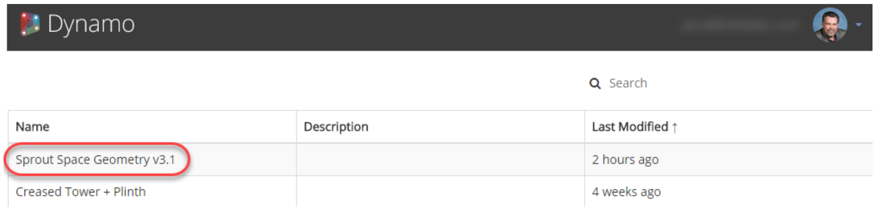


Figure 5.4: Fractal Live published dynamo graphs

Figure 5.5 shows an example of the automation process of the “window width” variable. The variable has a list of three possible options indexed from 0 to 3, The variable ranges from 1' to 3'. The Item component pulls out a different option from the list every time the “Front Window Width” option slider is updated. This process applies to automate the exploration of every variable. Noticed that if nothing is changed as for “variations” or the check marks left On, that there are 9.5 million alternates!

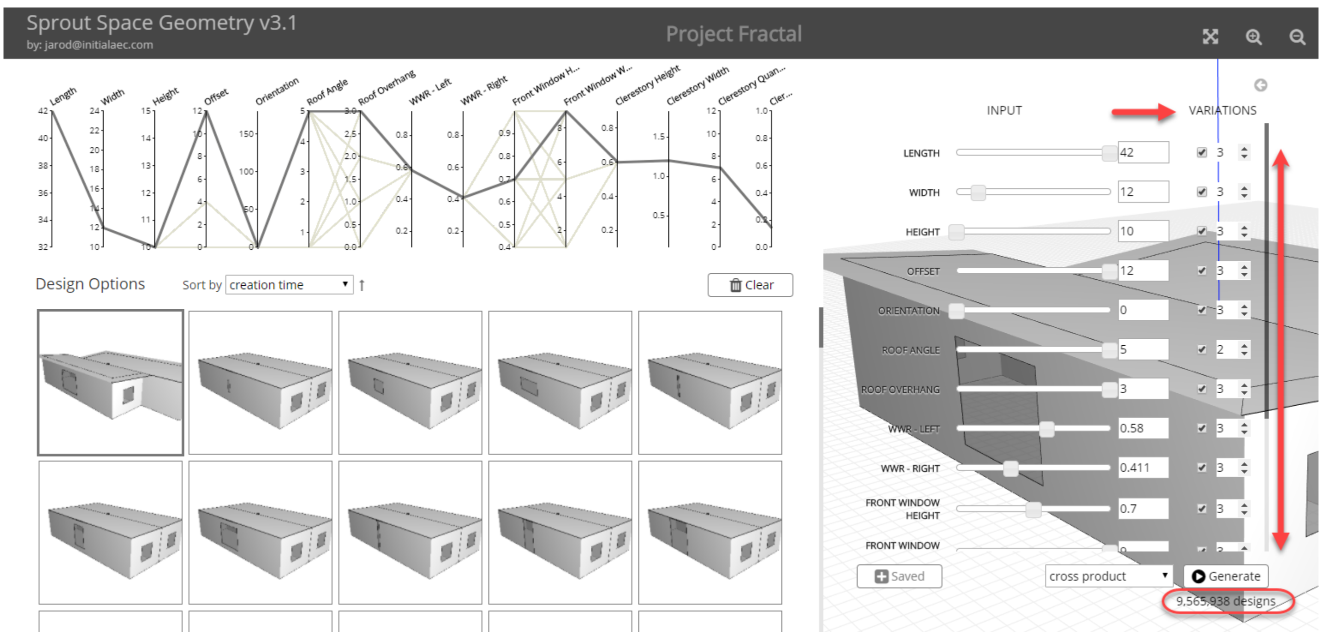


Figure 5.5: Automation of multiple options per variable

Design Space Matrix

The above automation process creates all possible combination of variables. A simple example shows two variables that have a mix of variables (Table 4). The first variable uses a set of values from 'a' to 'c' . The second one contains values from '1' to '3'. The combination of these two variables creates a matrix which is a set of rows and columns. This matrix is expressed as a '3 x 3' set. The total possible combination for this set of variables is a design space of a list of nine runs (Table 2.2). The design alternatives and the “Fractal Live” website works in this way to create potentially thousands of options. In this case; 9,565,938 to be exact, see Figure 5.4.

Table 4: Matrix of variables

Variable 1	Variable 2
a	1
b	2
c	3

Table 4.1: Iteration run design set

Iteration	Design Space
1	a,1
2	a,2
3	a,3
4	b,1
5	b,2
6	b,3
7	c,1
8	c,2
9	c,3

Filter Variations

Earlier we showed "Table 2" and the variations that we would like to use to see the different alternates. We will need to change the "variations" accordingly to filter down the designs from 9.5 million to more reasonable 216 designs.

Starting from the top input these values and change the option it uses variations:

NAME	VARIATIONS VALUE	VARIATIONS USEAGE
Length	42	No Check Mark
Width	12	No Check Mark
Height	10	No Check Mark
Offset	12	3 Variations

Orientation	0	No Check Mark
Roof Angle	5	2 Variations
Roof Overhang	3	4 Variations
WWR – Left	0.58	No Check Mark
WWR – Right	0.411	No Check Mark
Front Window Height	0.7	3 Variations
Front Window Width	1	3 Variations
Clerestory Height	0.6	No Check Mark
Clerestory Width	1.2	No Check Mark
Clerestory Quantity	7	No Check Mark
Clerestory Spacing	0.142	No Check Mark

The values should now match in Fractal, see Figure 5.5.

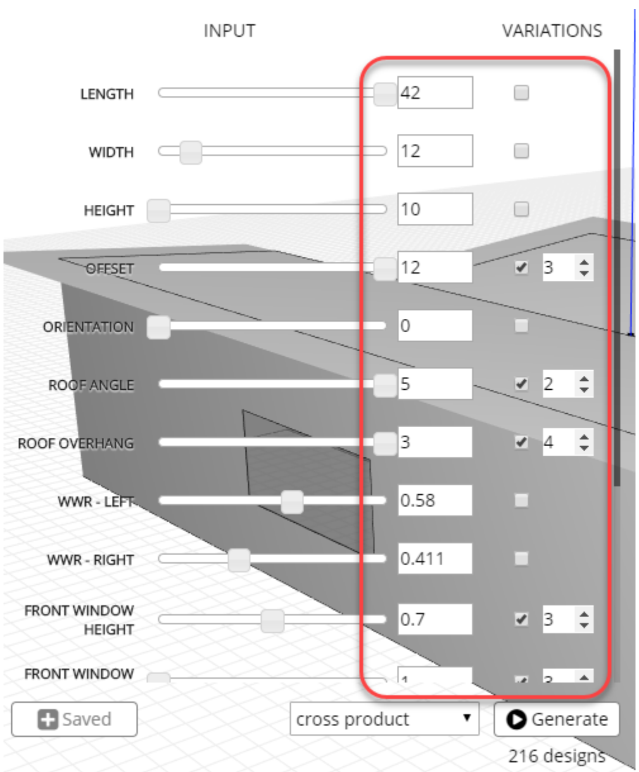


Figure 5.5: New values added, and variations updated

Now select the “Generate” button to start Fractal on working out the different values, build the different models, and update the graph to graphically show the variations, see Figure 5.6.

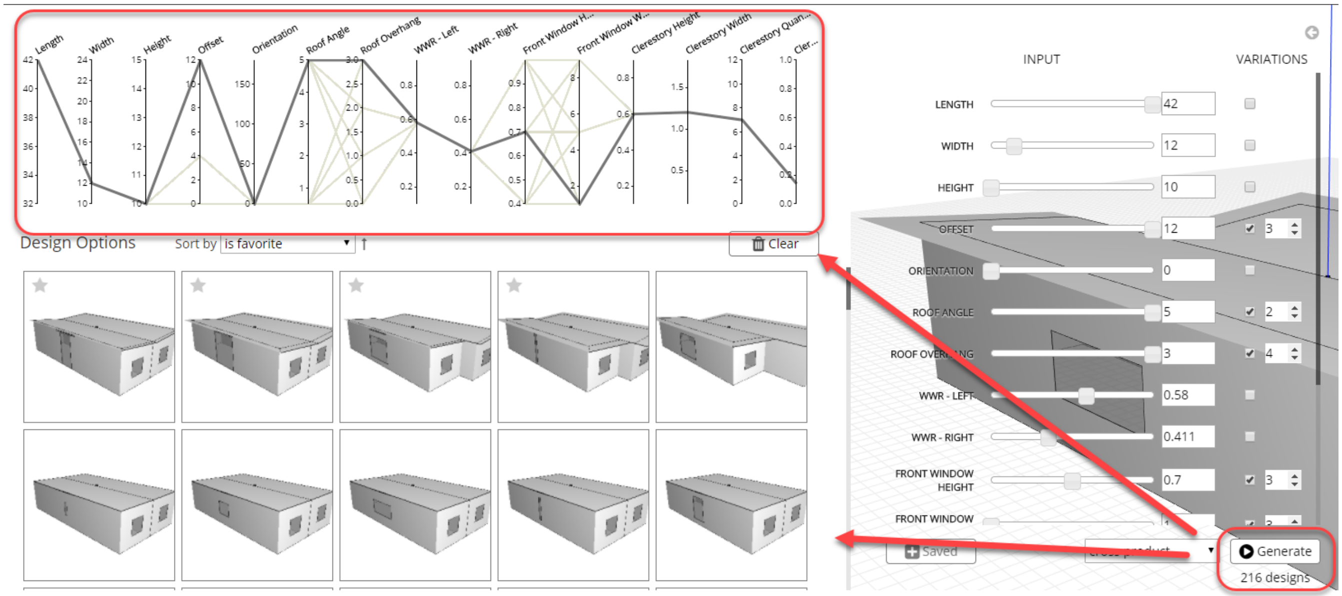


Figure 5.6: 216 alternates created from variations

Filter Design Alternates

To filter the 216 alternates, you can use the graph which has a dynamic interface to it. Let's use the Front Window Height as a filter, pick and drag within the column on the graph. A selection window will be generated to highlight the selection, see Figure 5.7.

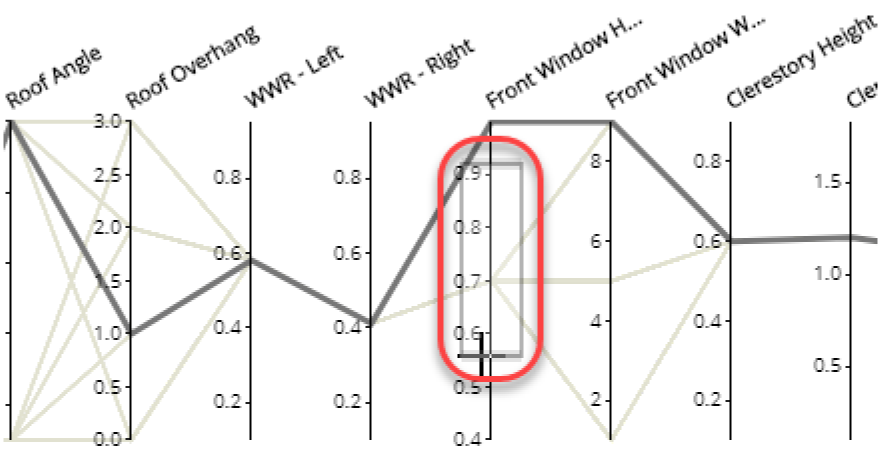


Figure 5.7: Filtering variations using the interface of the graph

Use the same approach on some of the other columns and notice the variations that are shown is getting smaller based on these filters. If you need to clear a filter just select the edge of the box and move it to the top or bottom so the box collapses, see Figure 5.8.

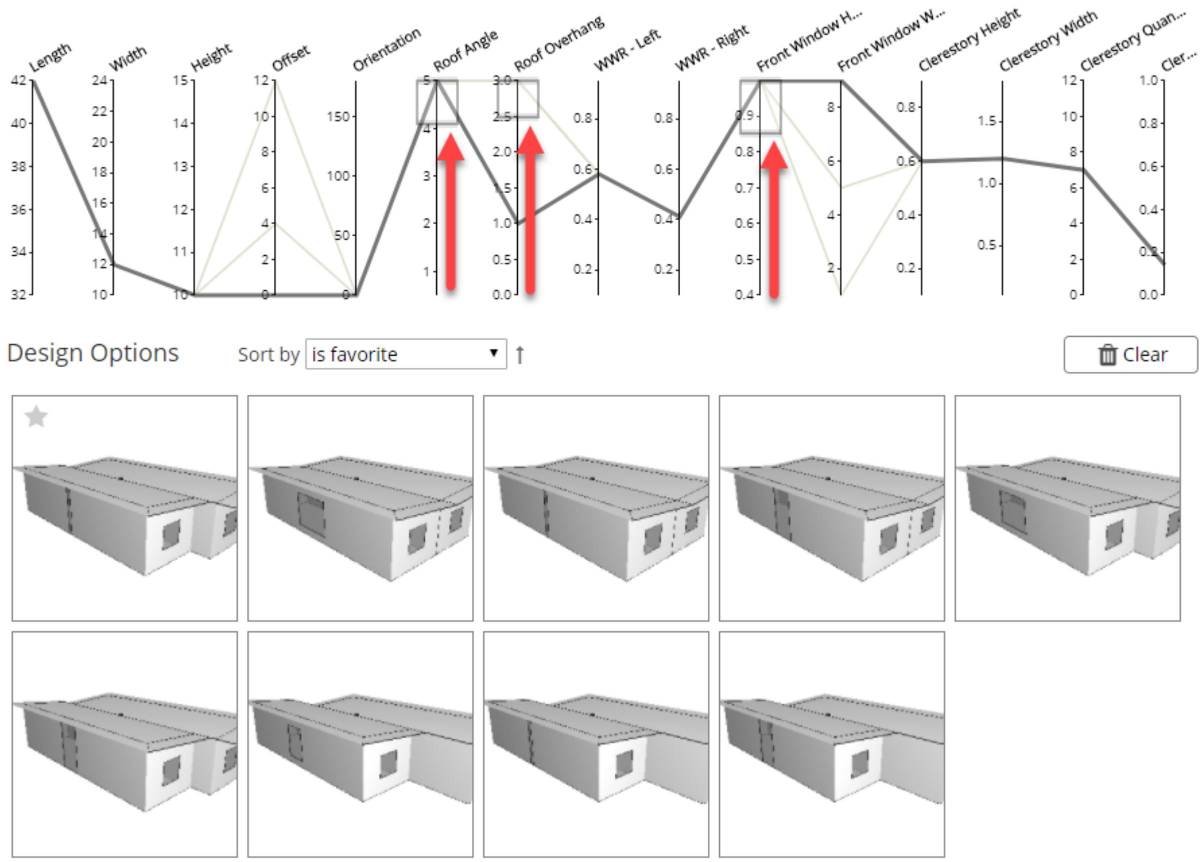


Figure 5.8: Less variations being shown using the filters on the columns

With this method you can start to determine what alternates might best fit the design intent for form and shape. From here you can start selecting some of your favorites by picking on the "star" in the top left corner of the preview, see Figure 5.9.

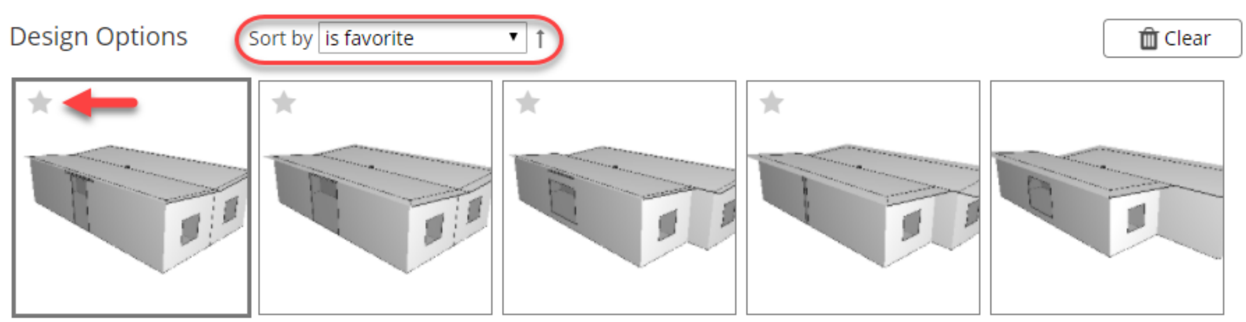


Figure 5.9: Using the Favorite option for sorting

You can also move the columns around on the graph if you would rather see some columns closer to each other, see Figure 5.10.

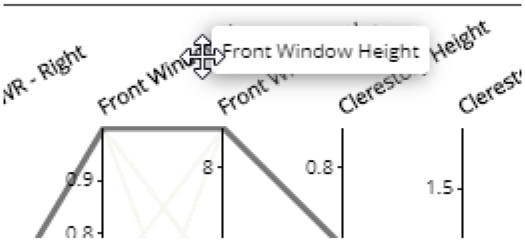


Figure 5.10: Shifting columns on the interface of the graph

Fractal – Export Favorite Designs

Once you have filtered out your “favorites”, see Figure 5.11, we can start downloading the new Dynamo graph’s, these will have the inputs already defined based on the “favorites” data. Once we download them we can then use “Dynamo for Revit” to build the Revit mass models.

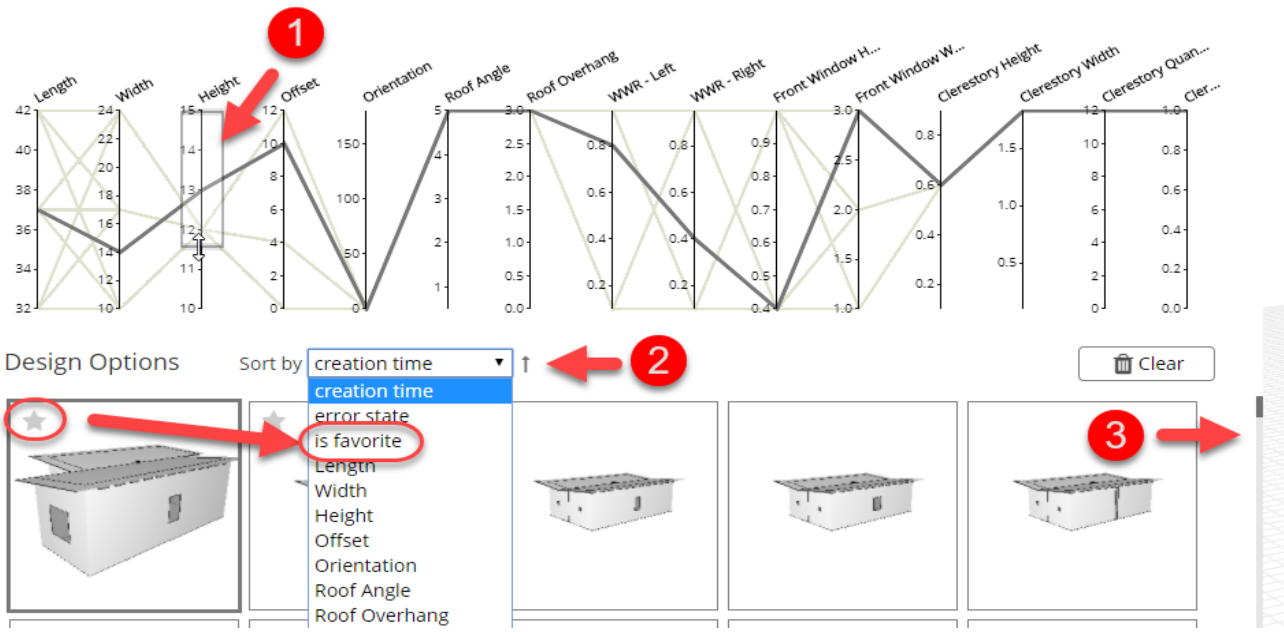
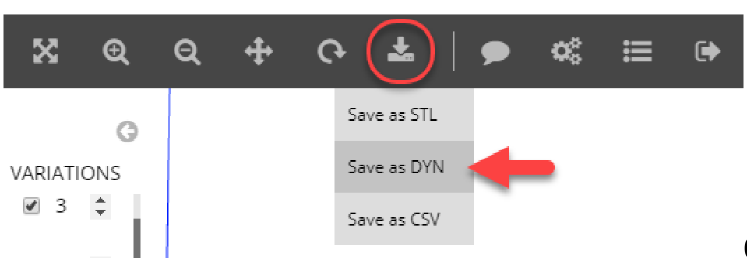


Figure 5.11: Using favorites to sort the computational models

With the “is favorite” selected, use the “download” button to download the Dynamo graph that has those value inputs set as a default, see Figure 5.12.



0.

Figure 5.12: Download and save individual Dynamo graphs

You can also download a CSV file that has the entire set of design options in a table format for other purposes, see Figure 5.13. If you have used the “sort by” for your favorites, then those values will be at the top of the table.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Generated	Length	Width	Height	Offset	Orientation	Roof Angle	Roof Overhang	WWR - Left	WWR - Right	Front Window Height	Front Window Width	Clerestory Height	Clerestory Width	Clerestory Quantity	Clerestory Spacing
2	9/4/2017, 5:26 PM	37	14	13	10	0	5	3	0.8	0.4	0.4	3	0.6	1.828	12	1
3	9/4/2017, 5:29 PM	32	10	10	0	0	5	3	0.1	0.1	0.4	1	0.6	1.828	12	1
4	9/4/2017, 5:56 PM	37	24	12	12	0	5	3	0.95	0.1	0.4	1	0.6	1.828	12	1
5	9/4/2017, 5:57 PM	37	24	15	0	0	5	3	0.95	0.95	0.999	3	0.6	1.828	12	1
6	9/4/2017, 5:58 PM	37	24	15	12	0	5	3	0.1	0.95	0.999	3	0.6	1.828	12	1
7	9/4/2017, 6:07 PM	42	17	10	12	0	5	3	0.1	0.95	0.4	2	0.6	1.828	12	1

Figure 5.13: Download and save Dynamo graphs in table format

Section 2 – Early Design Modeling

Figure 1: A Sprout Space Design, as constructed.

Overview

When we run an energy simulation we are first creating a mass model from a Dynamo graph. This graph is either from your own single alternative from Dynamo Studio or a series of multiple alternatives from Fractal Live. Either way, we will be converting those surfaces over to Revit building elements to develop the energy model. We will use this same model to do daylighting, direct line of sight, and view quality analysis.

A compressed example workflow is shown below, see Figure 1, while the next sections will detail the Energy Modeling section of the Sprout Space workflow. A more compressive workflow outline is shown in the PDF called “P+W Generative Process” as part of the “resource” package.

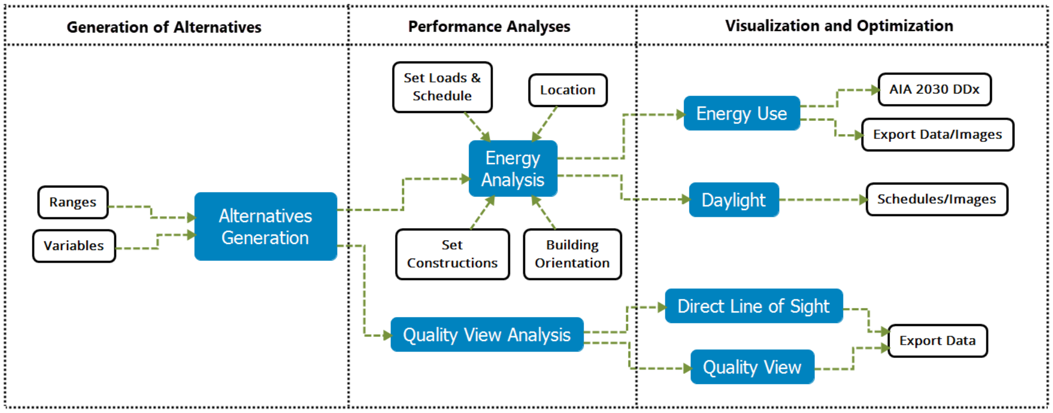


Figure 1.0: Compressed example of the Sprout Space computational workflow

In this section we will look at how to bring the computational design favorites into Dynamo for Revit to create the mass models. Once the mass models are created we will walk-thru the process of converting the mass models to Revit building elements. Below is a quick overview.

Windows

These surfaces are required to add the curtain glazing elements of the front, side, and clerestory windows once the mass model is inside Revit, see Figure 6.0.

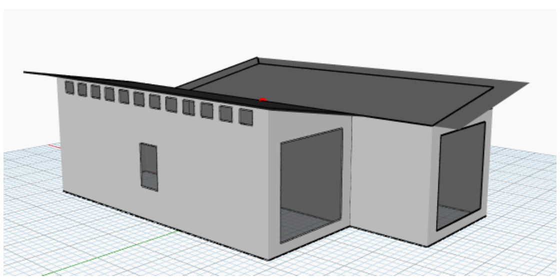


Figure 6.0: Glazing areas

Shading Surfaces

Shading surfaces compute areas of the building under direct solar radiation, see Figure 6.1. Once in Revit as a mass model we will add roof elements to the surfaces.

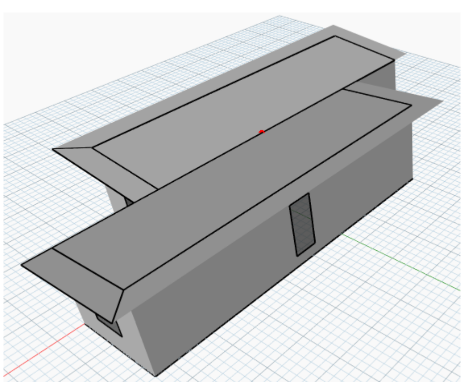


Figure 6.1: Shading areas

Partitions
Once we create a mass model in Revit we add a wall partition which is required to subdivide the space to properly calculate the dark areas of the building that have no exterior view, when performing the quality view analysis and daylighting analysis, see Figure 6.2.

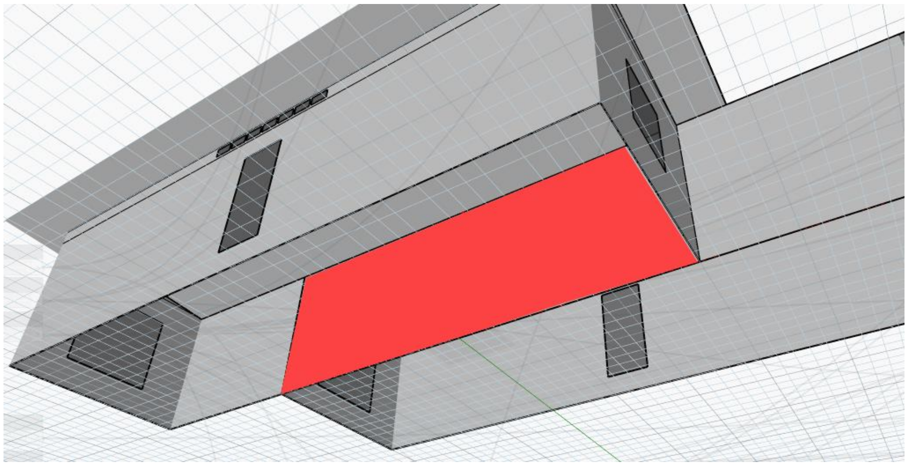


Figure 6.2: Wall partition between zones of the building

Envelope Geometry
Like Figure 6.2, the view quality analysis needs the complete geometry of the envelope of the building including walls as closed planes with co-planar windows, roof and floor to identify the glazing areas required to perform the analyses.

Dynamo to Revit Mass Family
These next steps show the conversion from a Dynamo mass model to Revit building components. Using Revit start a new “conceptual mass family” (Mass.rft). If you are using metric then use the “conceptual mass family” (Metric Mass.rft). Using Dynamo for Revit run the graph to create the mass and save the family, see Figure 1.3 / 1.4.

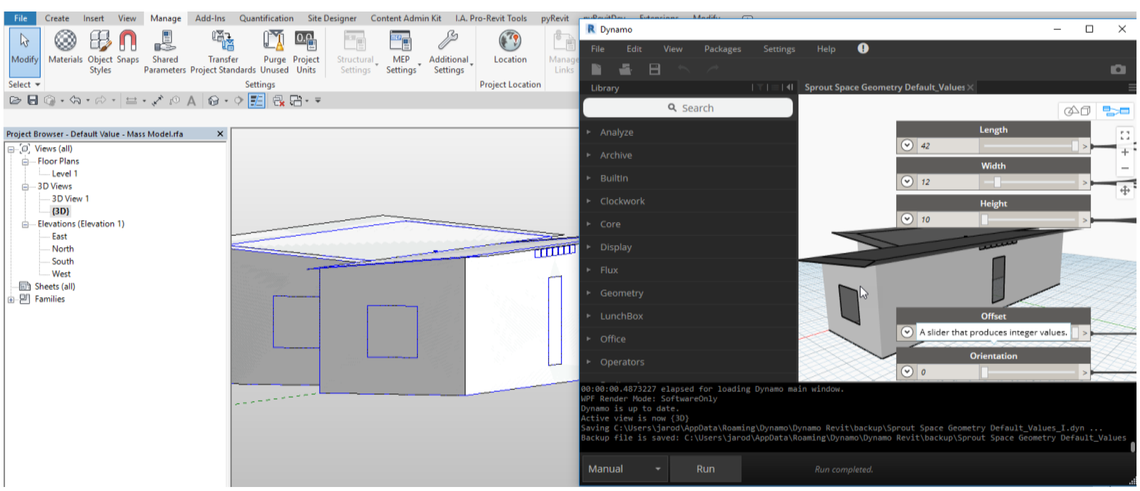


Figure 1.3: Dynamo for Revit graph using mass family template

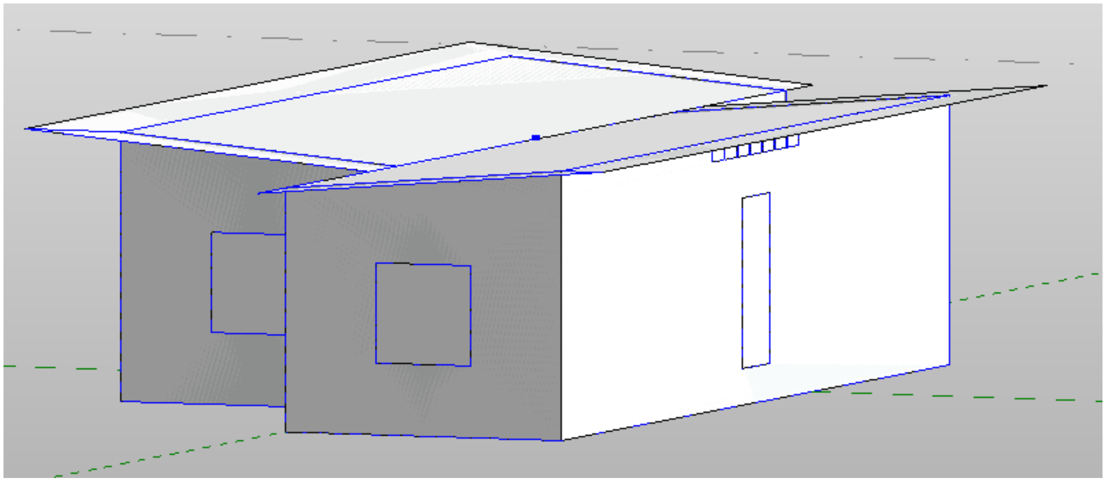


Figure 1.4: The resulting representation of the geometry of a Dynamo graph

Dynamo Graph to Mass Family

We will need open Revit and start a new “Conceptual Mass” family. This can be done by selecting “File” on the ribbon, selecting New, and Conceptual Mass, see Figure 1.5.

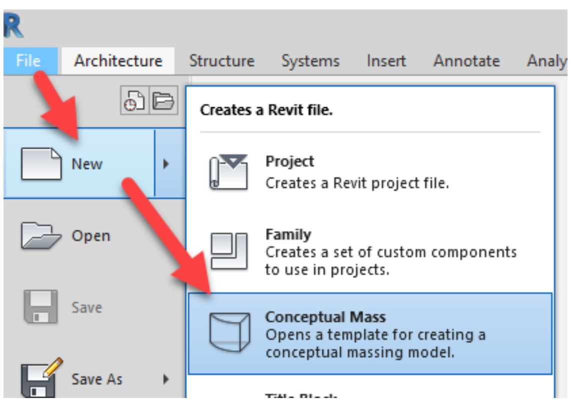


Figure 1.5: Start a new mass family

On the ribbon select Manage and select Dynamo, this will start Dynamo for Revit and open a separate window, see Figure 1.6.

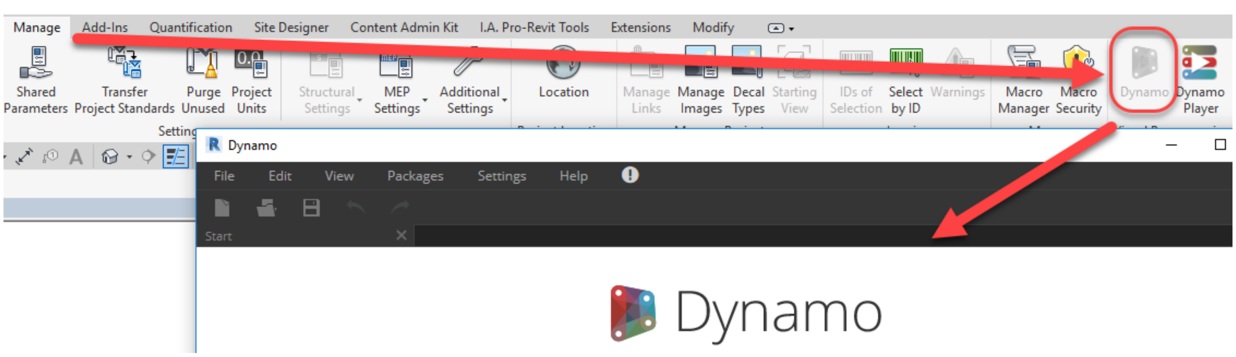


Figure 1.6: Open Dynamo for Revit

Select Open and browse to the folder that holds one of the download Dynamo graphs that we did earlier with Fractal form section 1, see Figure 1.7.

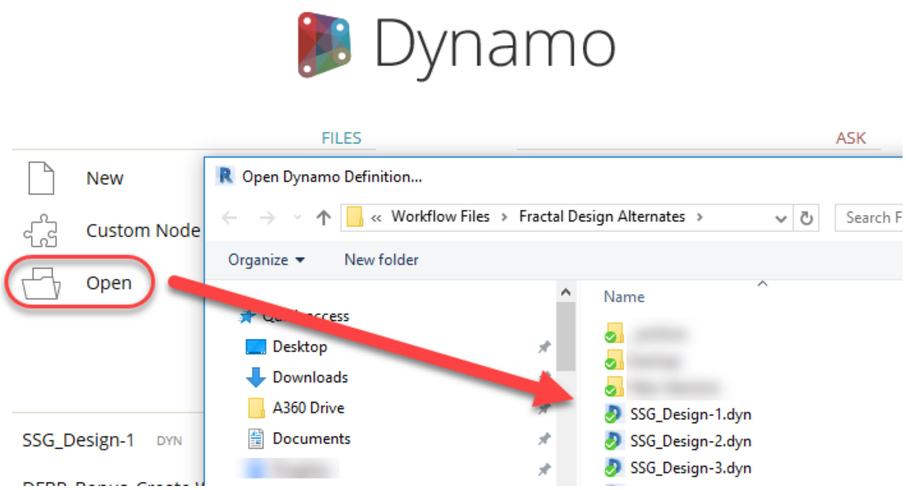


Figure 1.7: Open Fractal design alternate Dynamo graph

Using the navigation tools at the top right you can zoom and pan either the Dynamo graph or the drawing window. Select the “Run” button to have Dynamo build the Mass in Revit. Once done go ahead and close Dynamo without saving, see Figure 1.8.

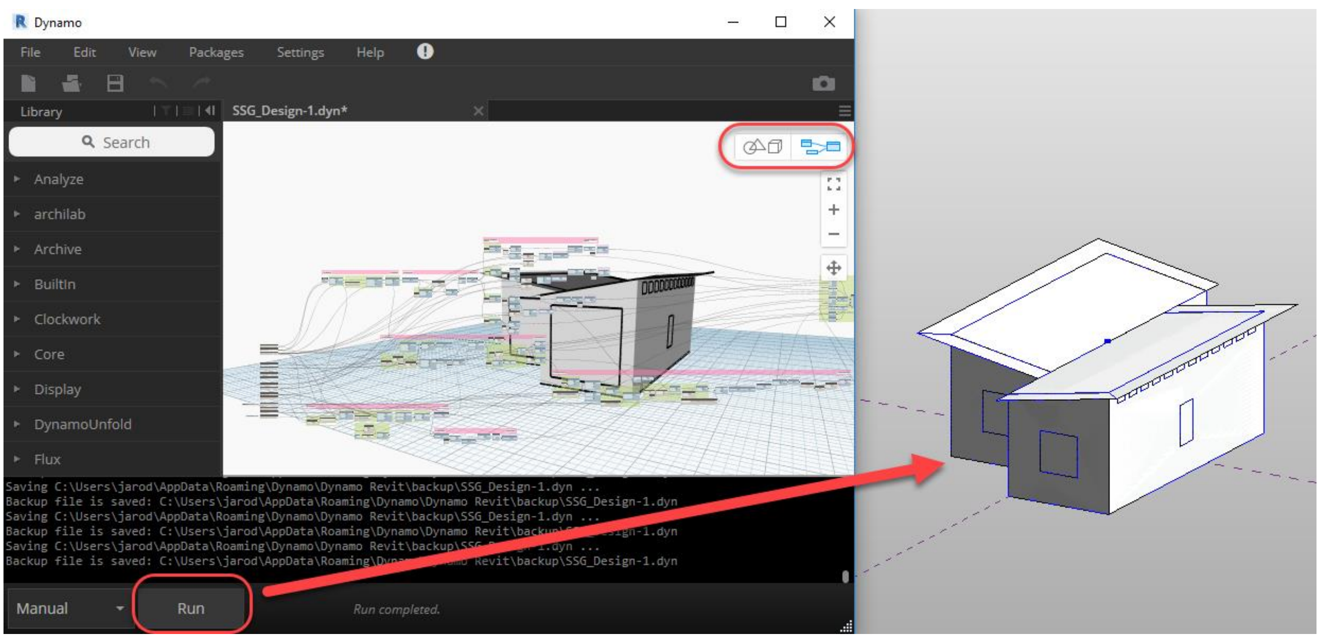


Figure 1.8: Use the Run button to create the mass in Revit

Load Mass into Project

With the mass now created from the Dynamo graph go ahead and save the mass family, call it the same name as the Dynamo graph “SSG_Design-1”. In Revit start a new project for this design study using the supplied template called “Revit Model Template.rte”. To do this select

“File” on the ribbon, select New, and select Browse to go to the appropriate folder that has the dataset files, See Figure 1.9.

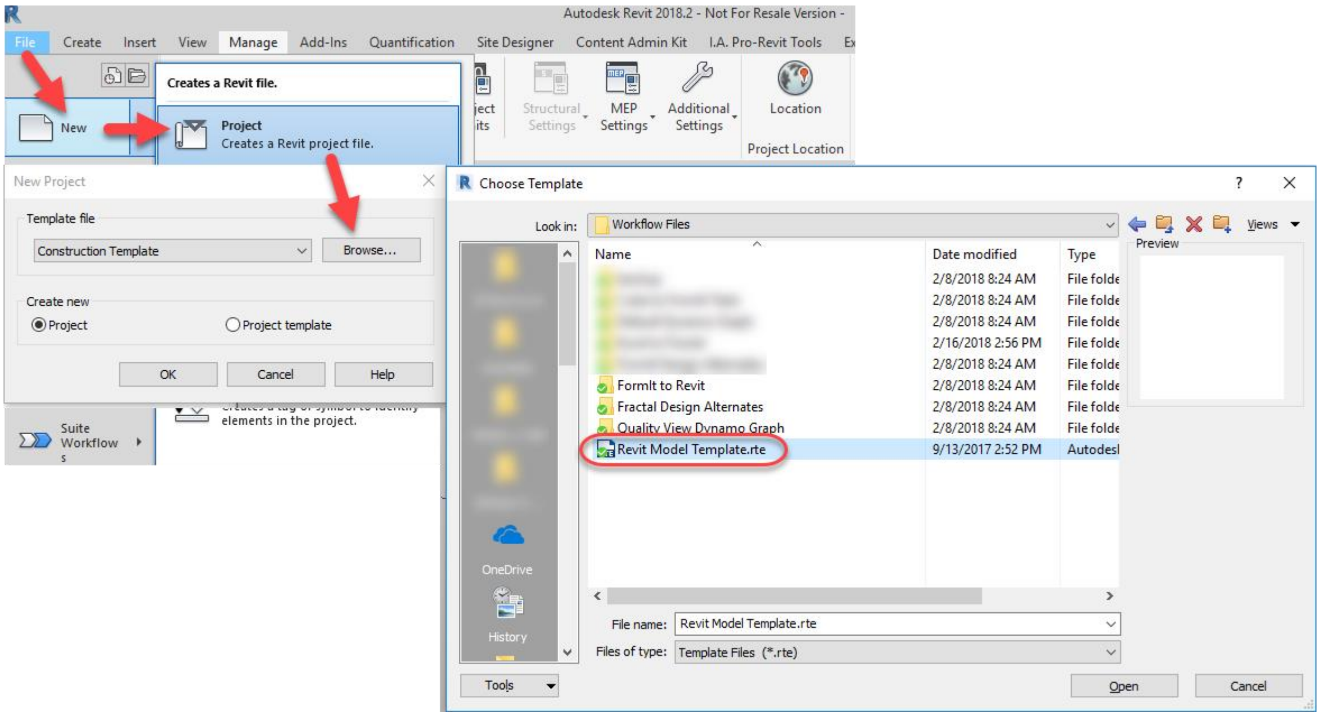


Figure 1.9: Start new project using supplied Revit template

Leave the new project open and use the keyboard combo of Ctrl+Tab to go back to the mass family. We need to import the mass family into Revit by using the “load into project and close” button to finish, see Figure 1.10.

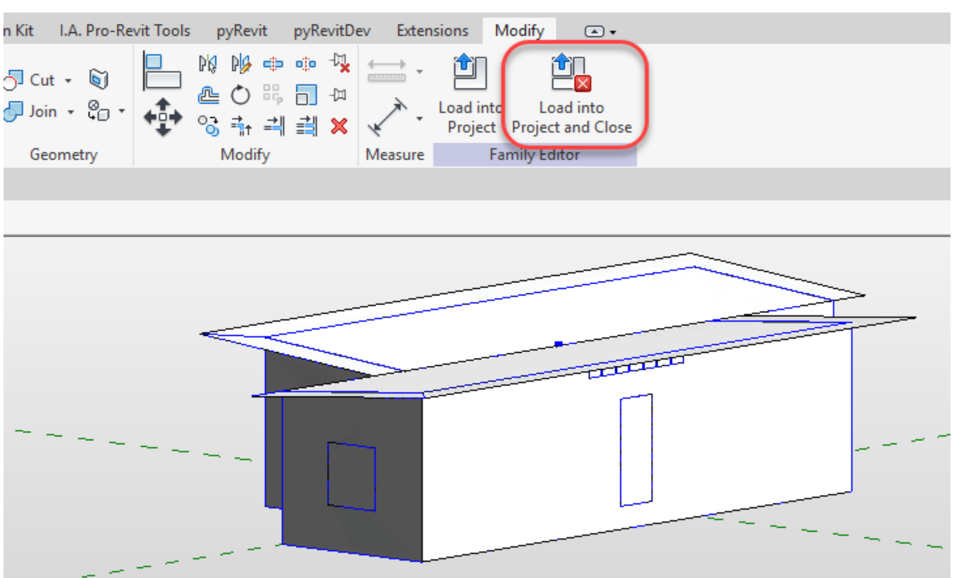


Figure 1.10: Mass family being loaded into project

Once you are in the project you will get a warning about enabling the Show Mass mode. This needs to happen so you can see the Mass family once it is inserted, select Close to accept the new display setting. Also, you will need to pick a point in the drawing window to place the mass family, so it is in your project. Once done then go ahead and hit the Escape key twice to finish. Lastly, a warning will come up about the mass contains mesh, this is because of how the Dynamo graph created the geometry, this is fine for our usage. Go ahead and hit the red X to close it, see Figure 1.11.

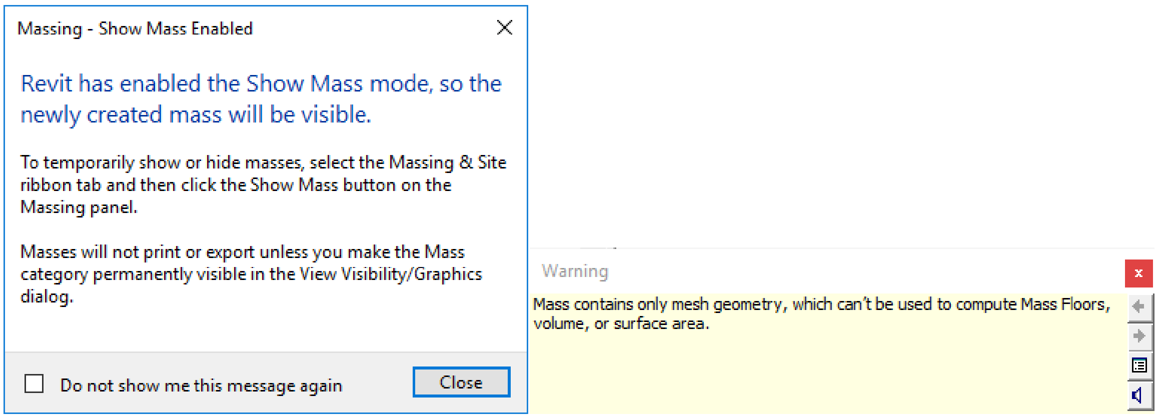


Figure 1.11: Warnings when inserting the mass family into a project

Select the newly loaded mass and add one mass floor, see Figure 1.12.

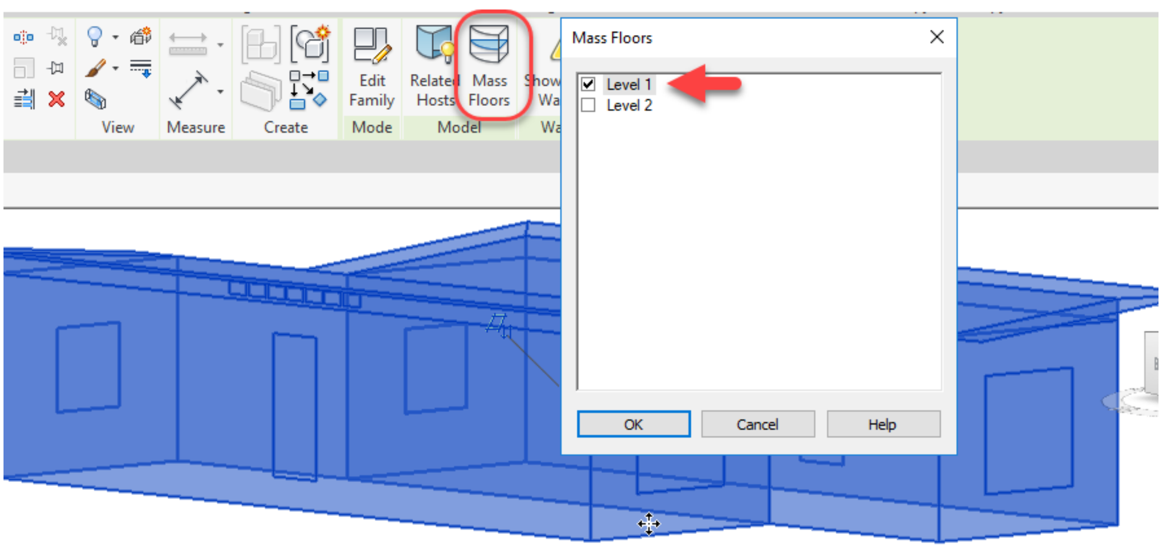


Figure 1.12: Adding mass floor

Add Curtain Wall Glazing to Surfaces

Using the Massing & Site tab you will use the Curtain System tool to apply glaze onto the surfaces of the mass. In this case we are using a type that has no divisions or frames, see Figure 1.13.

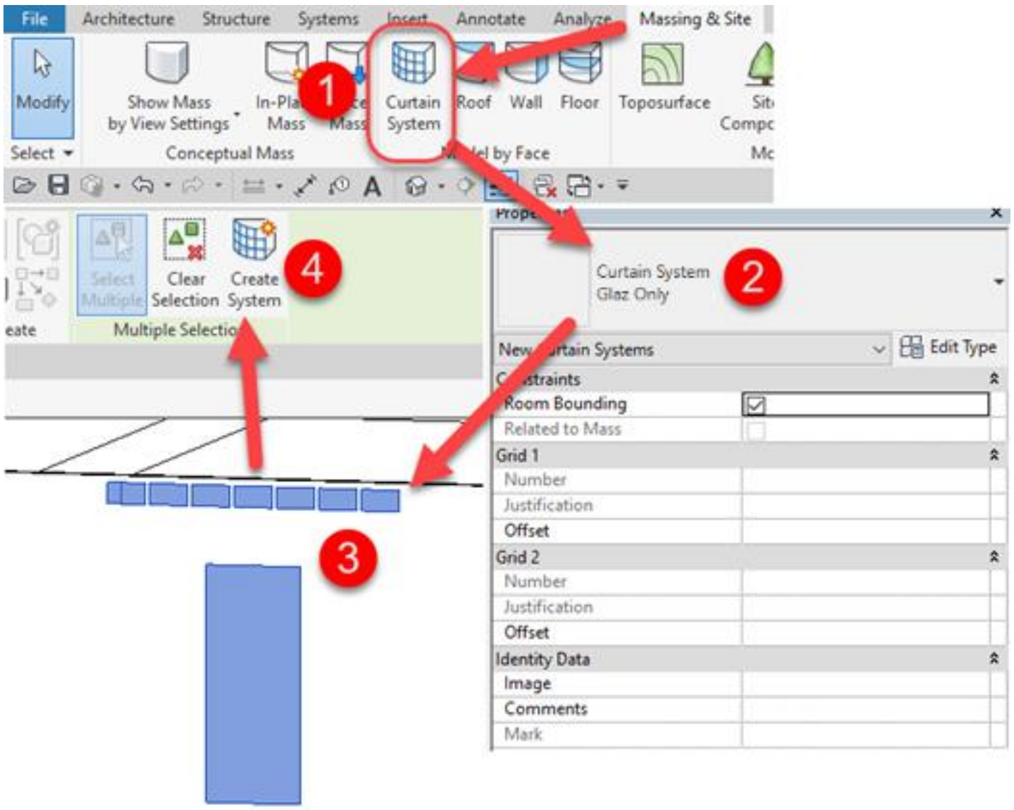


Figure 1.13: Steps to add glaze to the surfaces

Adding Walls to Surfaces

Repeat this process using the Wall tool from the Mass & Site tab. We will use the “Generic - 8” wall type, make sure the “Location Line” is set to “Finish Face: Exterior”. Also make sure to add a wall for the interior partition that separates the two rooms, see Figure 1.14.

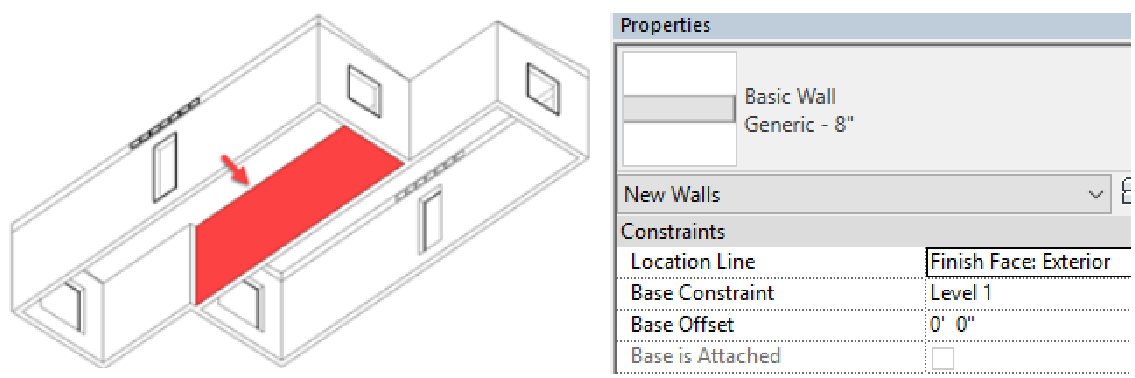


Figure 1.14: Applying walls to exterior surfaces along with the one interior surface

Adding Roofs to Surfaces

Repeat the process again for the roofs. In “properties” use the “Generic – 12” roof type and change the option to “faces at bottom of the roof” to apply it correctly. On the ribbon select Create Roof to finish, see Figure 1.15.

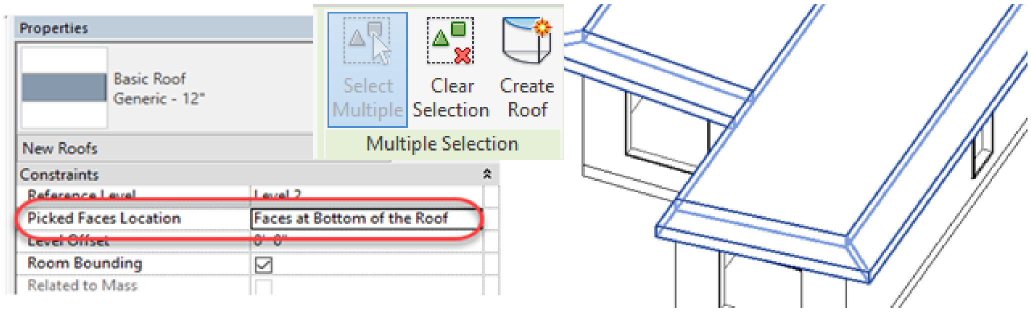


Figure 1.15: Adding roof to surfaces

Adding Floors

Select the "Level 1" floor plan view and add a floor using the "pick wall" tool that encompasses the exterior of the building, select the green check mark to finish, see Figure 1.16.

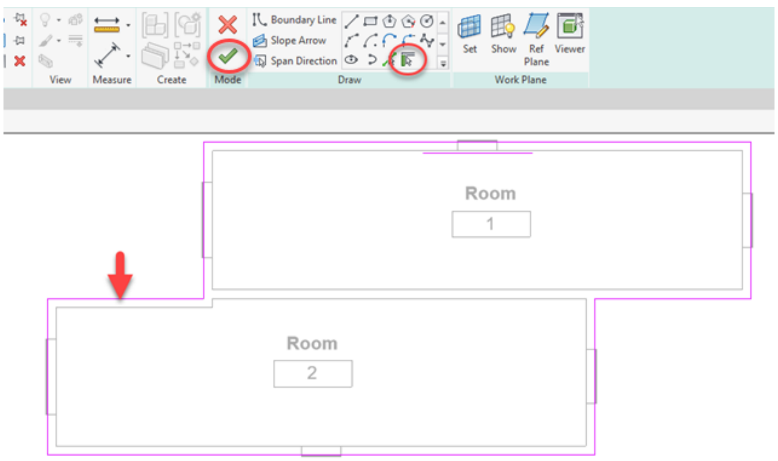


Figure 1.16: Add a floor to the building

Adding Rooms

Add two rooms, use the existing room definitions from the "options bar", see Figure 1.16 / 1.17.

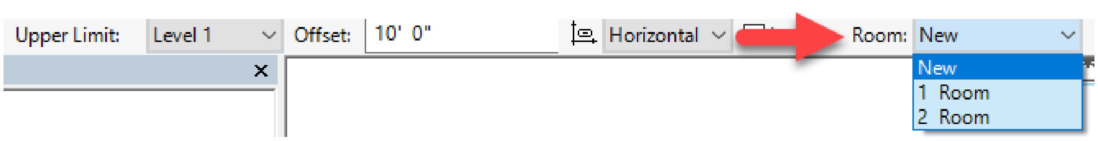


Figure 6.17: Adding rooms to the model

Energy Model Location

The next 3 steps are the typical workflow when you want to create an energy model for analysis using Insight. Step 1: Set location, Step 2: Settings, Step 3: Create energy model, and Step 4: Generate analysis.

On the Project Browser, under 3D Views, open the 3D Energy Model view. On the Analyze tab set the "location" to "16315 Grevillea Ave, Lawndale, CA 90260", see Figure 1.18.

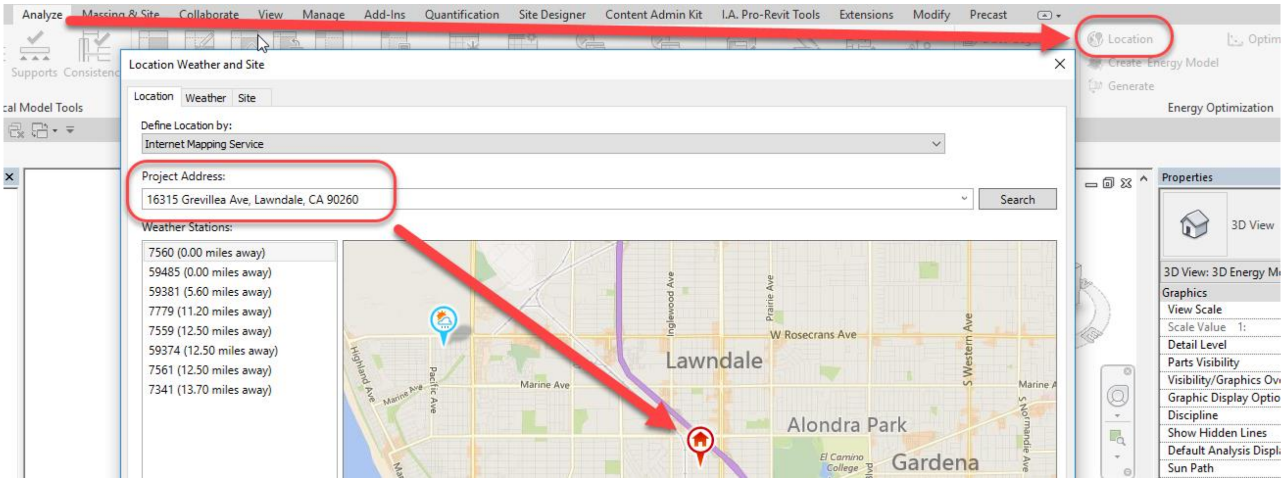


Figure 1.18: Set location for weather data

Energy Model Settings

On the Analyze tab change the Energy Settings so “Analytical Space Resolution” is set to 6” and “Analytical Surface Resolution” is set to 3”. Along with setting the “Perimeter Zone Depth” to 0”. Because of how small the model is we need to change these settings to the minimum, see Figure 1.19.

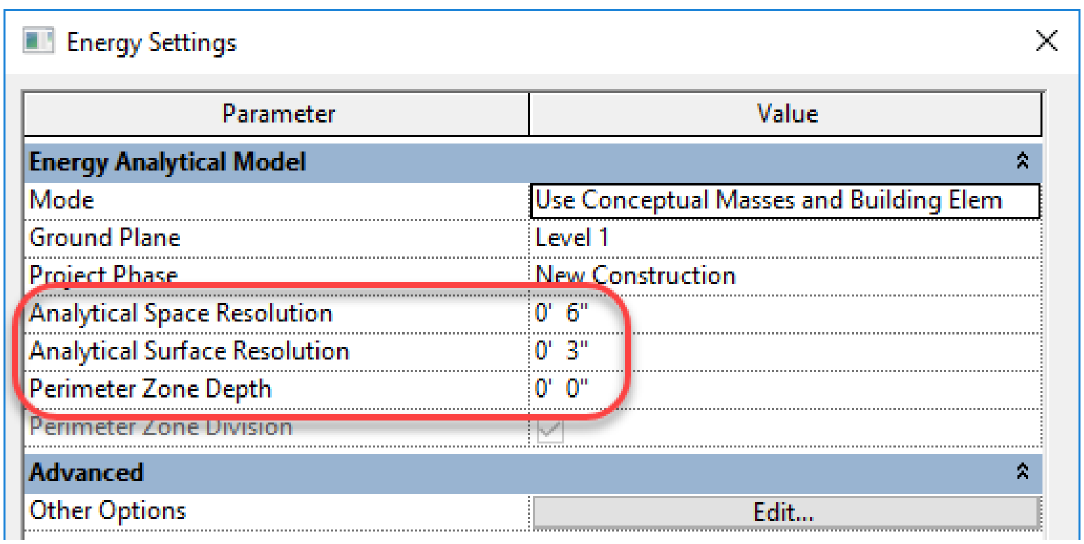


Figure 1.19: Changing the settings to work with the model size

Create Energy Model

On the Analyze tab pick on “Create Energy Model” to generate the energy model, by default it always uses or creates a view called “3D Energy Model, see Figure 1.20.

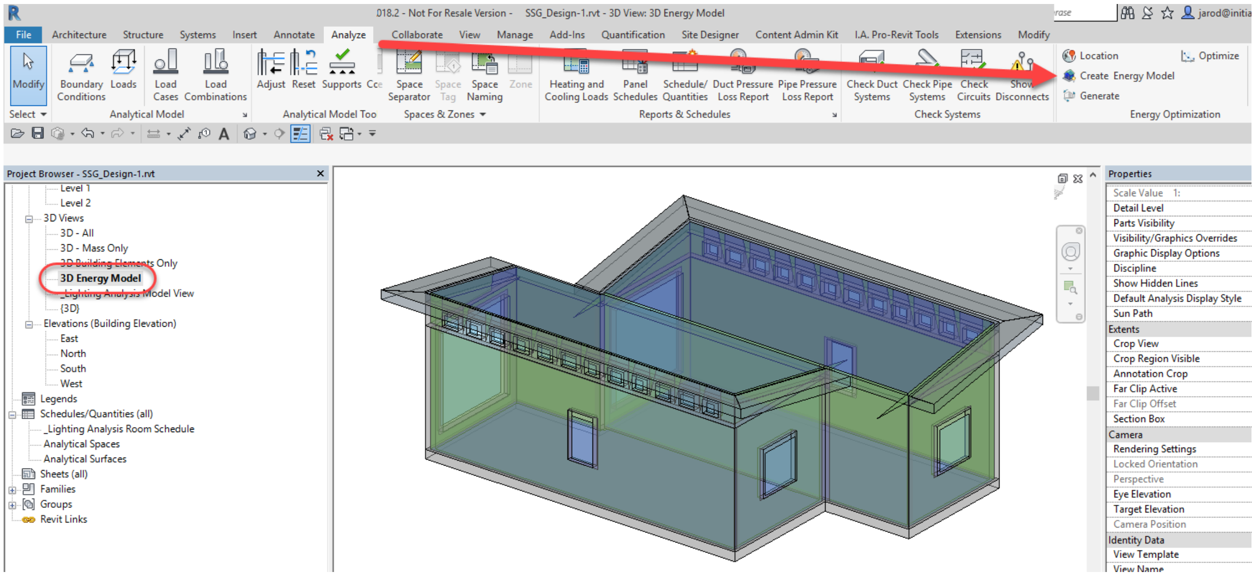


Figure 1.20: Creating the energy model

Changing the View Display

Currently the energy model view shows the building elements and the energy analytical surfaces. To best see the energy model, you can turn Off all of the model categories using “Visibility/Graphic Overrides” tool. Either type in “VV”, “VG”, or go to the Properties palette and in the Model tab take the check mark Off for “Show model categories in this view”, see Figure 1.21.

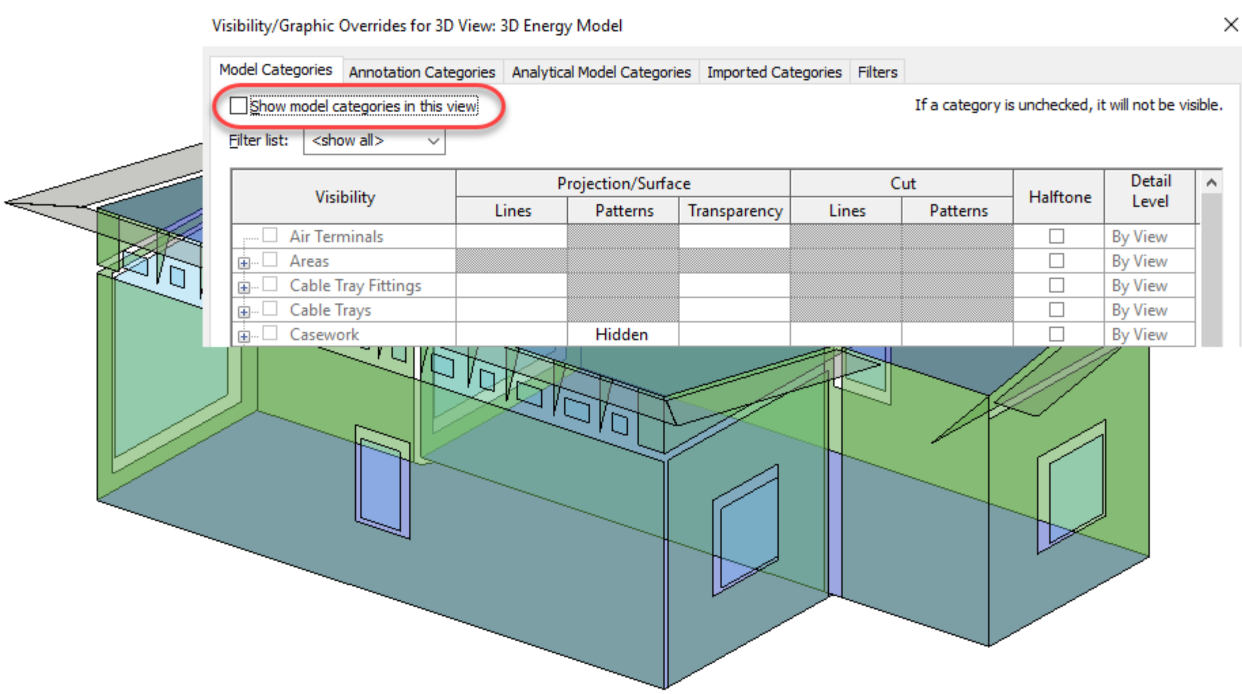


Figure 1.21: Turning Off the model categories to best see the energy model

Develop Insight Analysis

With the energy model now created when need to upload it to Insight to do the energy analysis. From the Analyze tab select “Generate” to upload the energy model to Insight, see Figure 1.22.

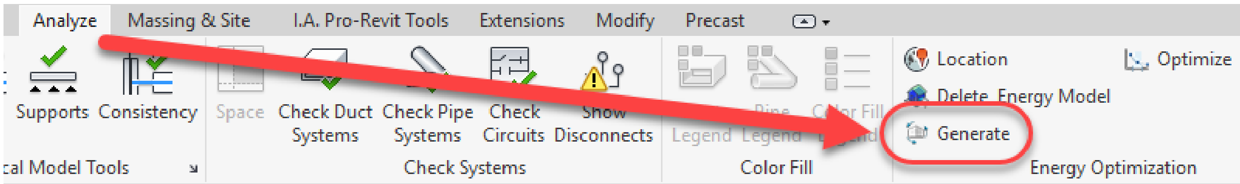


Figure 1.22: Uploading the energy model to Insight for energy analysis

You will get some final messages, the first one select “Use existing Energy Analytical Model”, on the second one simply select Ok, see Figure 1.23.

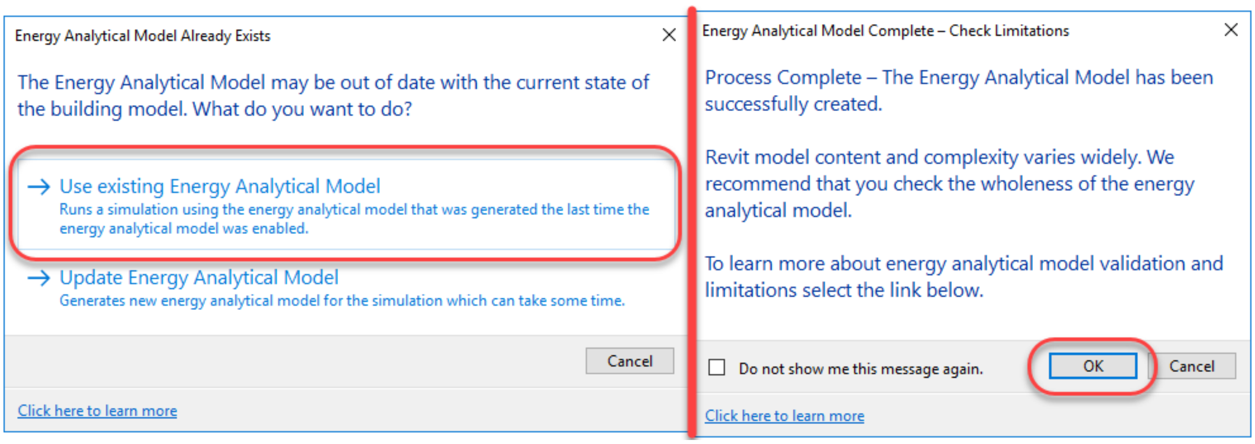


Figure 1.23: Final messages before uploading to Insight

Design Alternates

In section 1 we used Fractal to create at least 5 favorites, we have now completed one of those design alternates. You will need to repeat the above processes to finish the other 4 design alternates, see Figure 1.24.

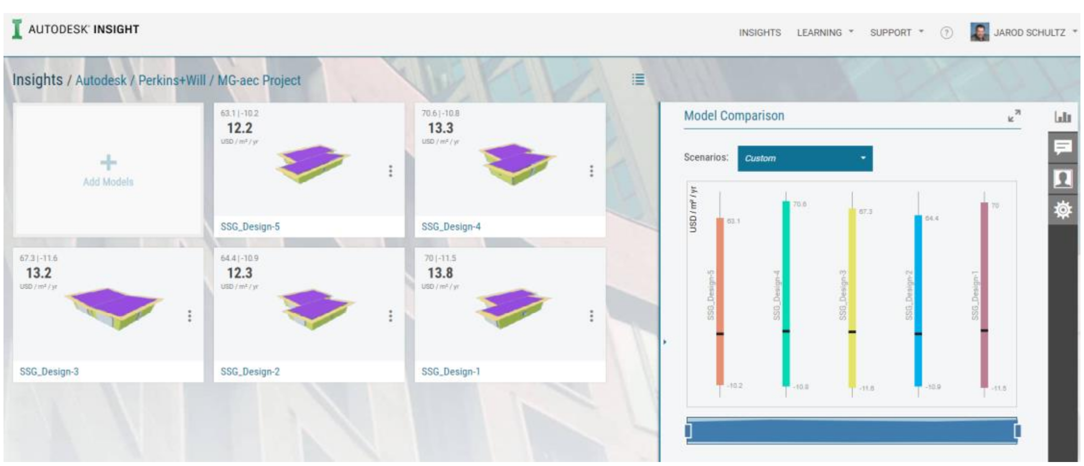


Figure 1.24: All design alternates uploaded to Insight

Section 3 – Energy, Daylighting, View, and Solar Analysis

Figure 1: A Sprout Space Design, as constructed.

Energy Analysis

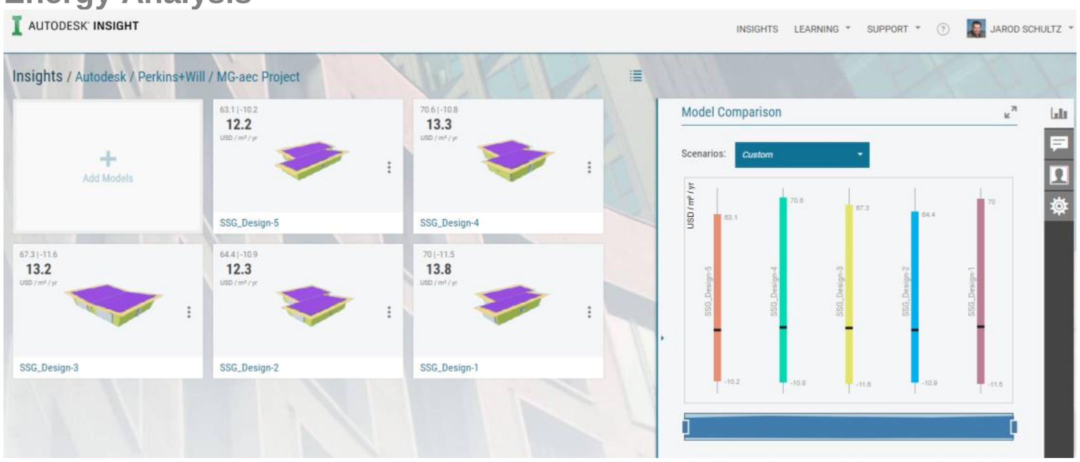


Figure 1.1: Energy analyses of Sprout Space alternatives

An energy simulation calculates the heating and cooling energy required to keep the building at a comfortable temperature throughout the year (typically this means keeping the building between 19 C and 26 C). Each simulation we can define the attributes of each design in terms of their PV, internal loads, occupancy scheduling, and the material properties of the design.

Energy simulation uses details of the spaces, building constructions, and weather data to calculate the temperature inside each room for every hour of the year (8760 hours) to calculate the heating and cooling energy required to keep the temperature inside each room comfortable when people are using each room.

The Autodesk Insight cloud tool used in this course is simply an interface to two engines called DOE-2.2 and EnergyPlus, which does the calculations described above. Both have been tested against ANSI/ASHRAE 140.

Insight will measure performance against Architecture 2030 and ASHRAE 90.1 benchmarks, making early targeting and feasibility seamless. Insight also links to AIA 2030 Design Data Exchange for easy transfer of data and filling the forms.

Install Insight Plugin

Regardless of the type of analysis you wish to do, to get started with Insight Solar Analysis with Revit, you should install the most recent version of the Insight plugin.

Insight Energy Analysis

I assume that you did the previous section and have an Insight project to work with. In Revit, on the Analysis tab pick on “Optimize” to open the Insight analysis, see Figure 1.7. You can also go directly to the website; insight360.autodesk.com and sign in using your Autodesk Account information.

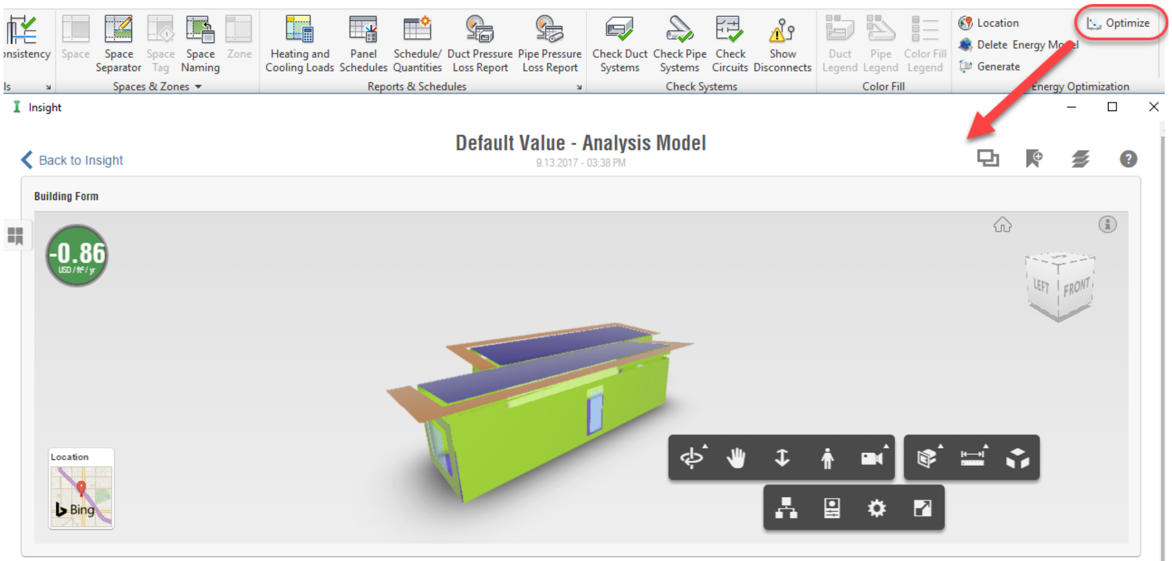


Figure 1.7: Opening the Insight website

Interface

On the interface there is 5 main items to know about. (1) Understand your design’s Energy Cost or EUI, (2) The key factors driving building energy performance, (3) Use the factor ranges to explore different outcomes and sensitivity, (4) Save scenarios and compare those scenarios to visualize potential energy savings, (5) Visualize PV energy generation potential and heating and cooling loads in your model context, see Figure 1.8.

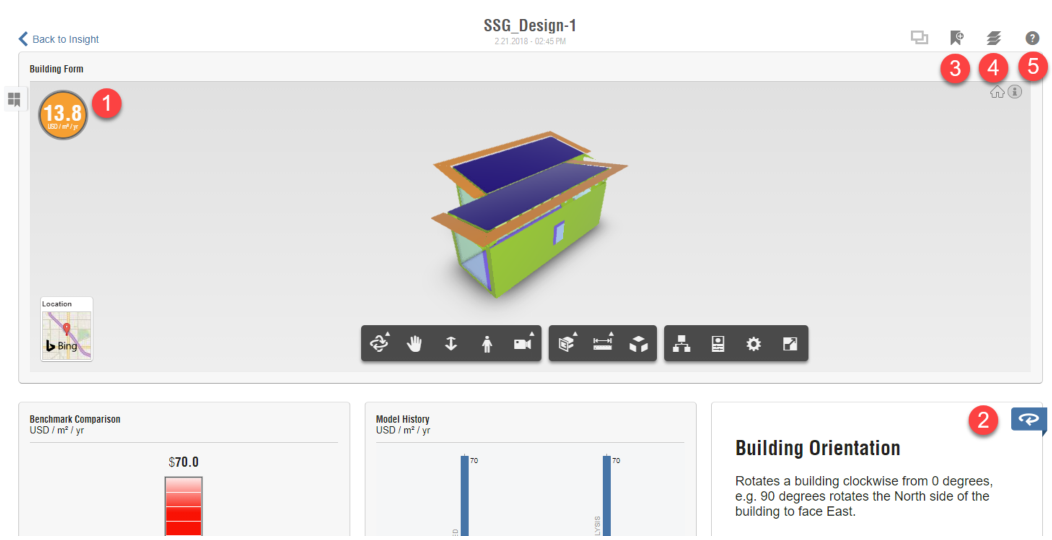


Figure 1.8: The 5 main areas of the Insight interface

Adding Scenario

When first looking at the energy model we need to add a "default" scenario to capture the initial settings before making any changes. This way we can see how the energy model is progressing, and if needed, be able to go back to the original settings, see Figure 1.9.

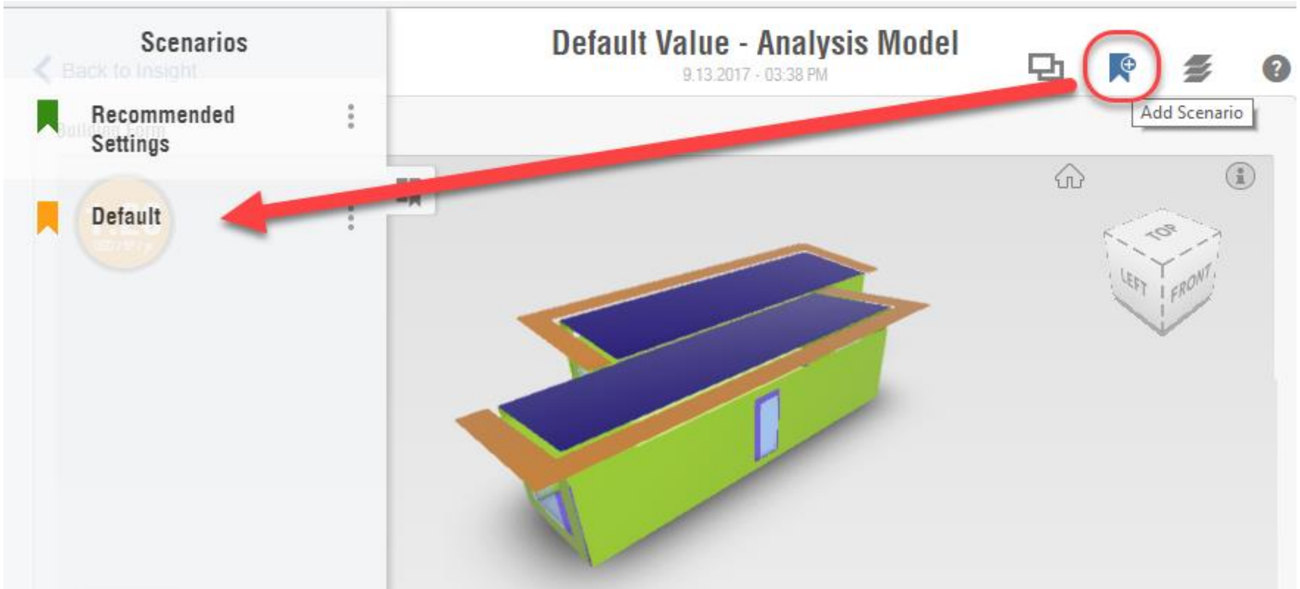


Figure 1.9: Adding the default scenario

Let's add one more where the photovoltaics (PV) is not being counted by default. Scroll-down to the bottom and select "PV – Surface Coverage" to open the tile. Select it and change the sliders so it is set to "0%" for PV, see Figure 1.10.

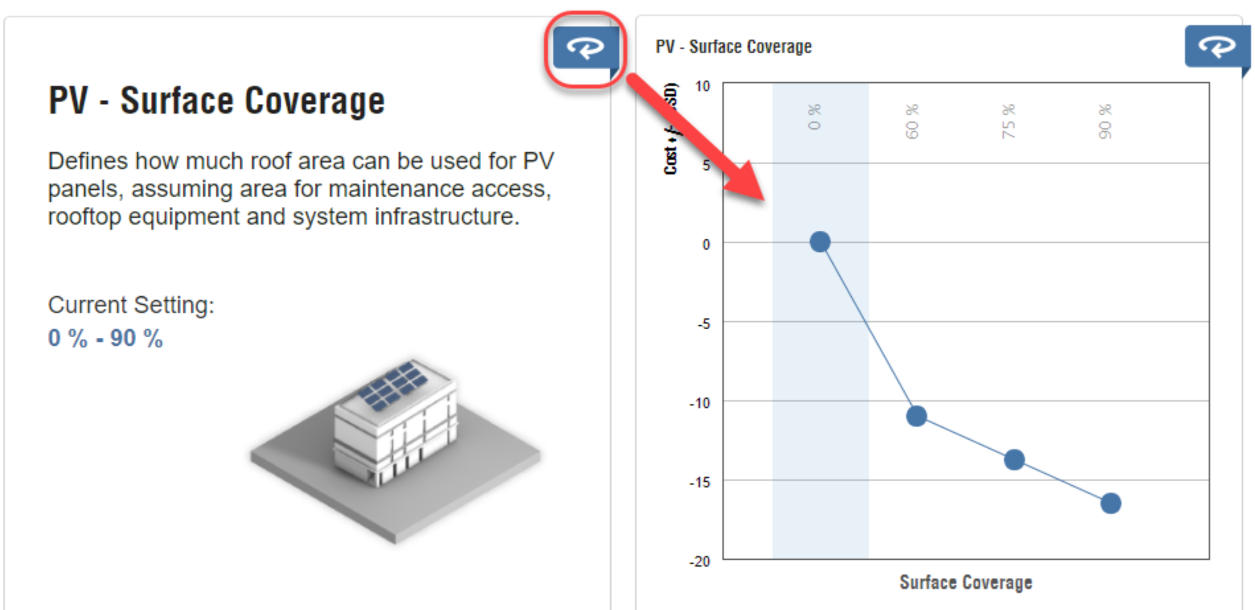


Figure 1.10: Changing the PV to 0%

Now go back up to the top and create a new "Scenario" and call it "Default – PV", see Figure 1.11.

Figure 1.11: Adding new Scenario with PV set to 0%

Select each one to note the huge difference in the energy usage between using PV and not using PV. If you are looking at SSG_Design-1 the setting goes from 13.8 to 23.7.

Updating Settings

Scroll down to the WWR – Sourthern Walls tile and select the "circle arrow" at the top right corner to open it. The values that show "BIM" are the Dynamo values that came from the Revit Model. So, the Window-Wall-Ratio (WWR) is exactly what was used in the Dynamo graph when we converted it to Revit building elements. You can see by the graph if there is a better value to use or if you add a percentage increase what it will do to the energy performance, see Figure 1.12.

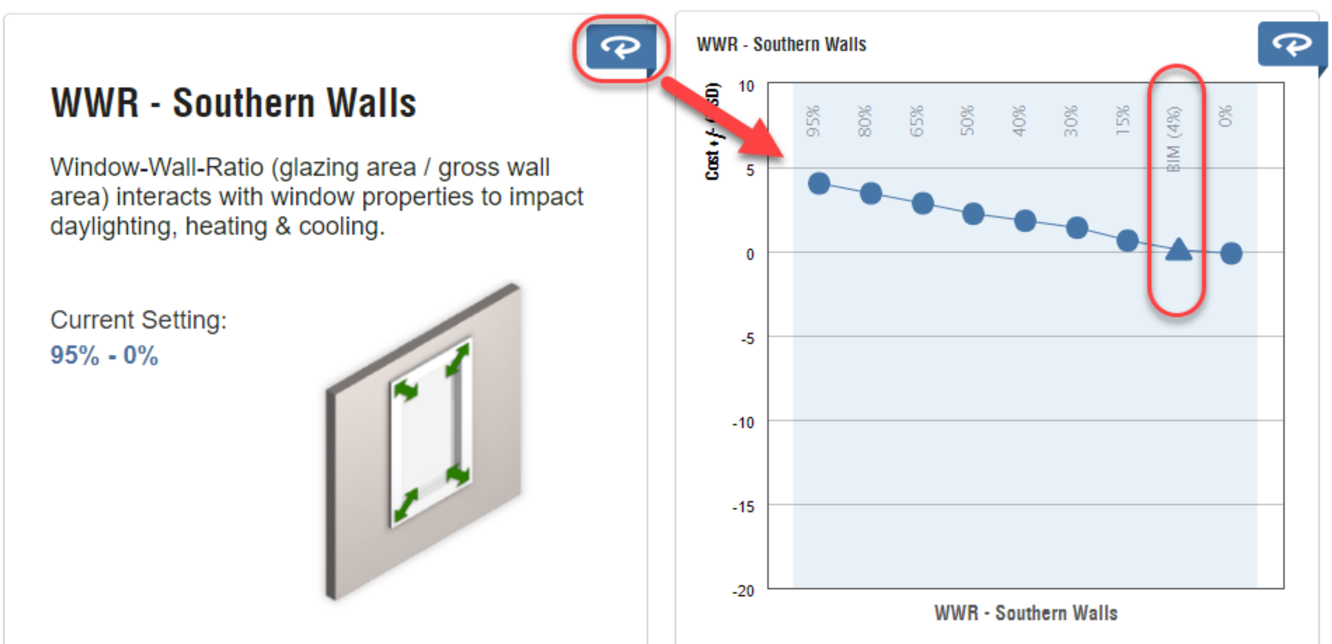


Figure 1.12: Seeing the (WWR) and its effect on energy performance

Material Properties for LA, CZ3

Below are the values that we will changing in Insight to reflect the ideal data that we would like to use for this design. These material values will be used in Insight to help show the progression of the energy range though the scenarios that we will develop. We will use the "Default" scenario as the baseline and as we add these values you will see the energy performance increase. Table 2.1 Shows the specification of material properties of the components of the Sprout Space located in Los Angeles Climate Zone 3 according to the recommendation of ASHRAE 90.1. The values in "**RED**" are the ones we need to use, the value of "BIM" is coming from the Dynamo graph.

*Table 2.1: Material properties - (*Min 28%, Preferred 40-60%)*

Properties	**Imperial Units**	option	**SI Units**	option	**Used by**
Building Orientation	Real Number (0-315)	270	Real Number (0-315)	**270**	Energy Model
WWR - Southern Walls	Real Number (0-95)	3	Real Number (0-95)	**BIM**	Energy Model
Window Shades - South	Real Number (1/6-2/3)	1/4	Real Number (1/6-2/3)	**BIM**	Energy Model
Window Glass - South	U-Value (kBtu/hr_ft2)	Dbl Clr	U-value (kWh/m2)	**Trp LoE**	Energy Model
WWR - Northern Walls	Real Number (0-95)	3	Real Number (0-95)	**BIM**	Energy Model
Window Shades - North	Real Number (1/6-2/3)	1/4	Real Number (1/6-2/3)	**BIM**	Energy Model
Window Glass - North	U-Value (kBtu/hr_ft2)	Trp LoE	U-value (kWh/m2)	**Trp LoE**	Energy Model
WWR - Western Walls	Real Number (0-95)	32	Real Number (0-95)	**BIM**	Energy Model
Window Shades - West	Real Number (1/6-2/3)	1/4	Real Number (1/6-2/3)	**BIM**	Energy Model
Window Glass - West	U-Value (kBtu/hr_ft2)	Trp LoE	U-value (kWh/m2)	**Trp LoE**	Energy Model

Properties	Imperial Units	option	SI Units	option	Used by
WWR - Eastern Walls	Real Number (0-95)	14	Real Number (0-95)	**BIM**	Energy Model
Window Shades - East	Real Number (1/6-2/3)	1/4	Real Number (1/6-2/3)	**BIM**	Energy Model
Window Glass - East	U-Value (kBtu/hr_ft2)	Trp LoE	U-value (kWh/m2)	**Trp LoE**	Energy Model
Wall Construction - Walls steel framed (Cavity+continuous insulation)	U-Value (kBtu/hr_ft2)	R13 Metal	U-value (kWh/m2)	**R13 Metal**	Energy Model
Roof Construction - Metal (Continuous+cavity insulation)	U-Value (kBtu/hr_ft2)	R38	U-value (kWh/m2)	**R38**	Energy Model
Infiltration	(ACH) Real Number (0.17-2.0)	0.4	(ACH) Real Number (0.17-2.0)	**0.4**	Energy Model
Lighting Efficiency	w/sf	0.7	W/m2	**7.53**	Energy Model
Daylighting & Occupancy Controls	kBtu	Daylighting & Occupancy Controls	kBtu	**Daylighting & Occupancy Controls**	Energy Model
Electric Plug Loads	w/sf	1.0	W/m2	**10.76**	Energy Model
HVAC System	kBtu	High Eff. Heat Pump	kBtu	**High Eff. Heat Pump**	Energy Model

Properties	Imperial Units	option	SI Units	option	Used by
Operating Schedule	Seasonal, Annual, School Year, Daily, Weekend	12/6	Seasonal, Annual, School Year, Daily, Weekend	**12/6**	Energy Model
PV – Panel Efficiency	range (16-20.4)	18.6	range (16-20.4)	**18.6**	Energy Model
PV – Payback Limit	range (10-30)	20	range (10-30)	**20**	Energy Model
PV – Surface Coverage	range (0-90)	60	range (0-90)	**60**	Energy Model

Assumptions

The table below is for reference. Some input variables of the generative and evaluation processes become constants based on assumptions (Table 1.4) usually derived from the regulations and best practices.

Table 1.4: General assumptions

Variable	Imperial Units	Option	SI Units	option	Used by
Air Changers Per Hour (Infiltration)	ac/hr	0.6	ac/hr	0.60	Energy Model
Ventilation Rate per Area	cfm/ft2	0.117884972	m3/m2S	0.0006	Energy Model
Ventilation Rate per Person	cfm/ft2	0.982374768	m3/m2S	0.005	Energy Model
HVAC heating set point	°F	64	°C	18.00	Energy Model
HVAC cooling set point	°F	79	°C	26.00	Energy Model
HVAC heating setback set point	°F	73	°C	12.00	Energy Model

Variable	Imperial Units	Option	SI Units	option	Used by
HVAC cooling setback set point	°F	90	°C	32.00	Energy Model
*Wall Reflectance	0-100%	70%	0-100%	0.70	Daylight & Energy
*Ceiling Reflectance	0-100%	70-90%	0-100%	70-90%	Daylight & Energy
*Floor Reflectance	0-100%	20%	0-100%	0.20	Daylight & Energy

(*ASHRAE/IES Advanced Energy Design Guides)

Table 2 Inputs

Using the values from Table 2 to update the tiles from the default settings, notice how the energy performance model updates and shows real-time results, see Figure 1.13.

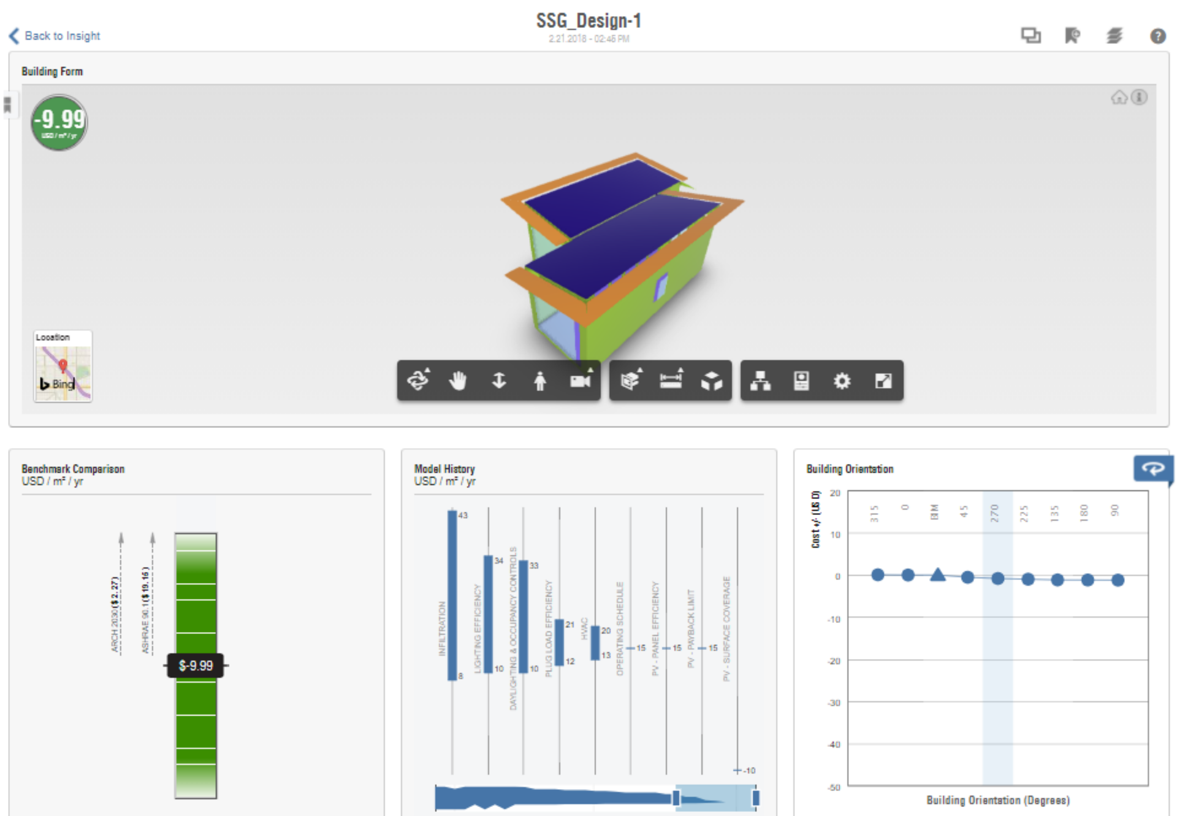


Figure 1.13: Updating tiles to the new values and seeing real-time updates

Create another “Scenario” and called it “Table 2 Inputs”, see Figure 1.14.

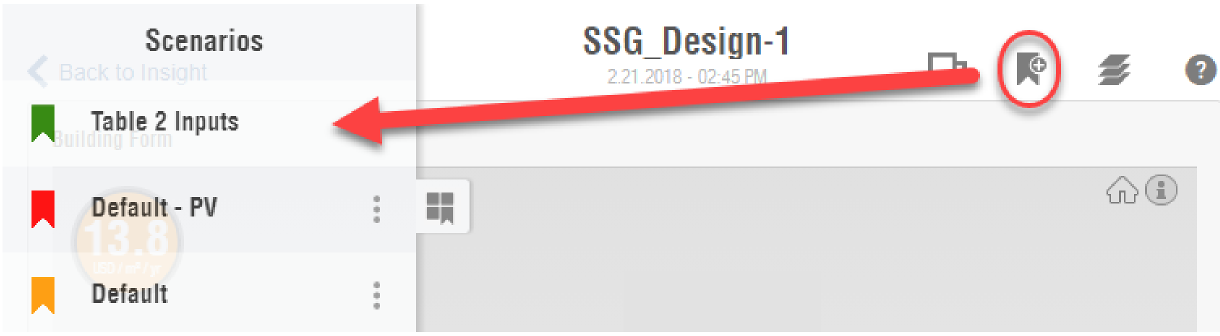


Figure 1.14: New scenario with Table 2 inputs added

Comparing Results

Select scenario “Default” and notice the energy performance = 13.8, see Figure 1.15. Change the scenario to “Default – PV” and notice the energy performance = 23.7. Finally change the scenario to “Table 2 Inputs” and notice the energy performance = -9.99, see Figure 1.16. With these settings we have a “Negative Net Zero” energy building.

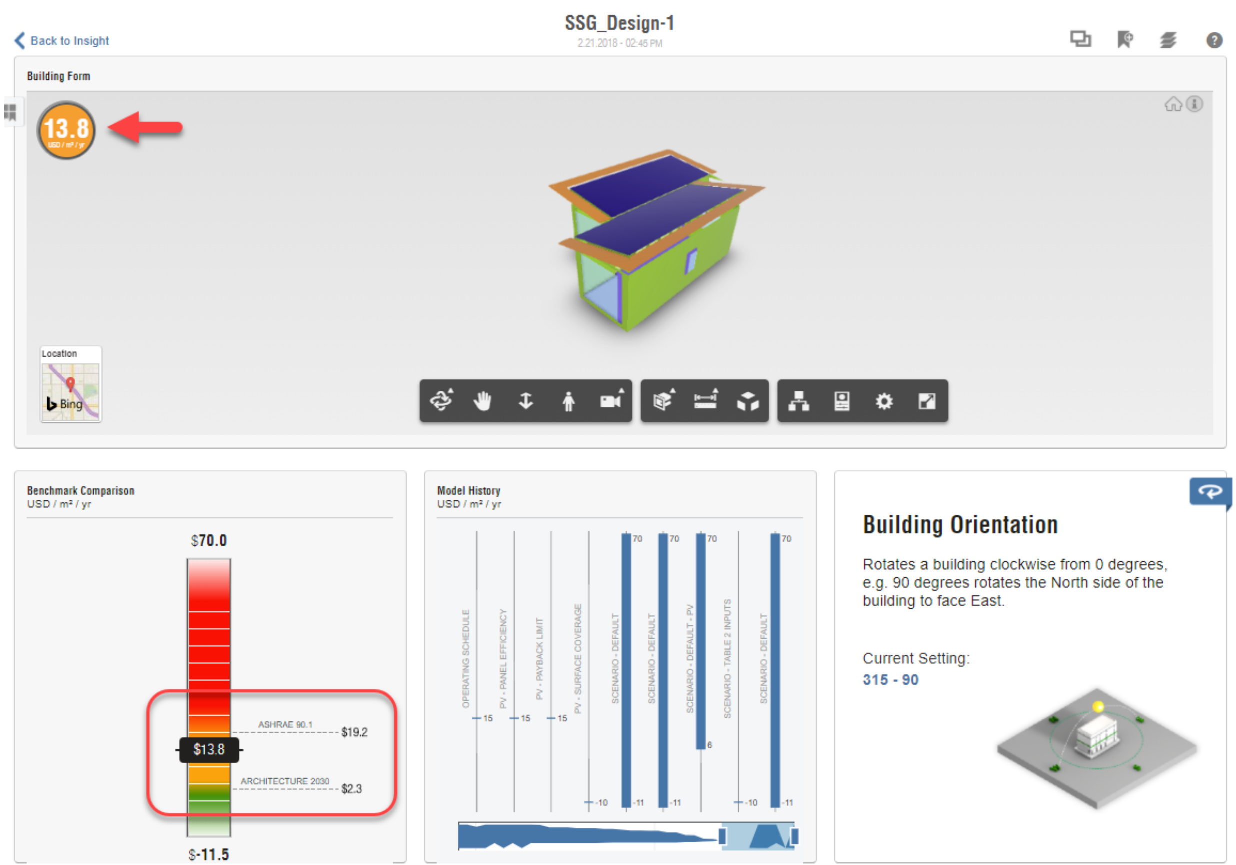


Figure 1.15: Default settings from Revit model (BIM), better than ASHRAE 90.1

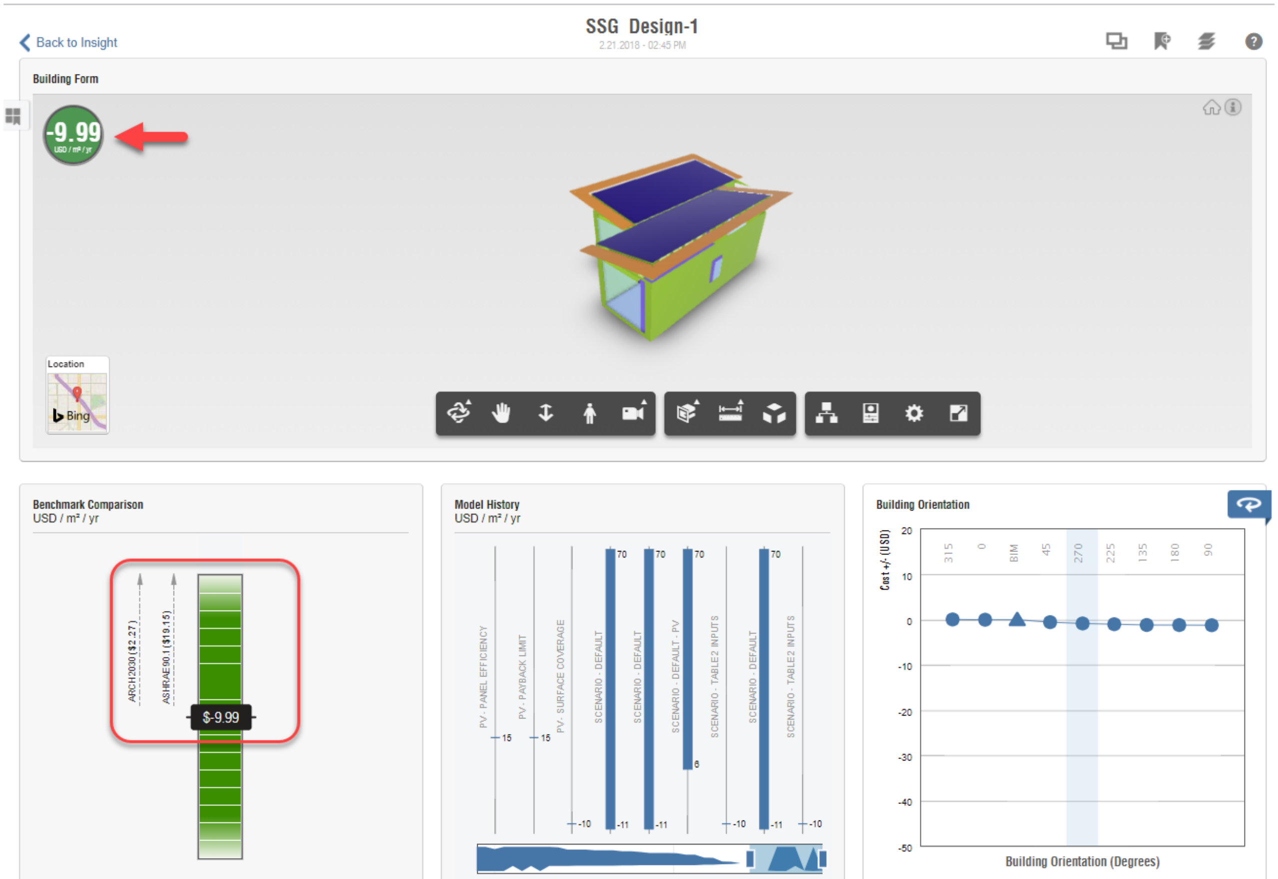


Figure 1.16: Values from [Table 2](#), better than ARCHITECTURE 2030

You can also see and compare the results side-by-side using the “Scenario Compare” tool, see Figure 1.17.

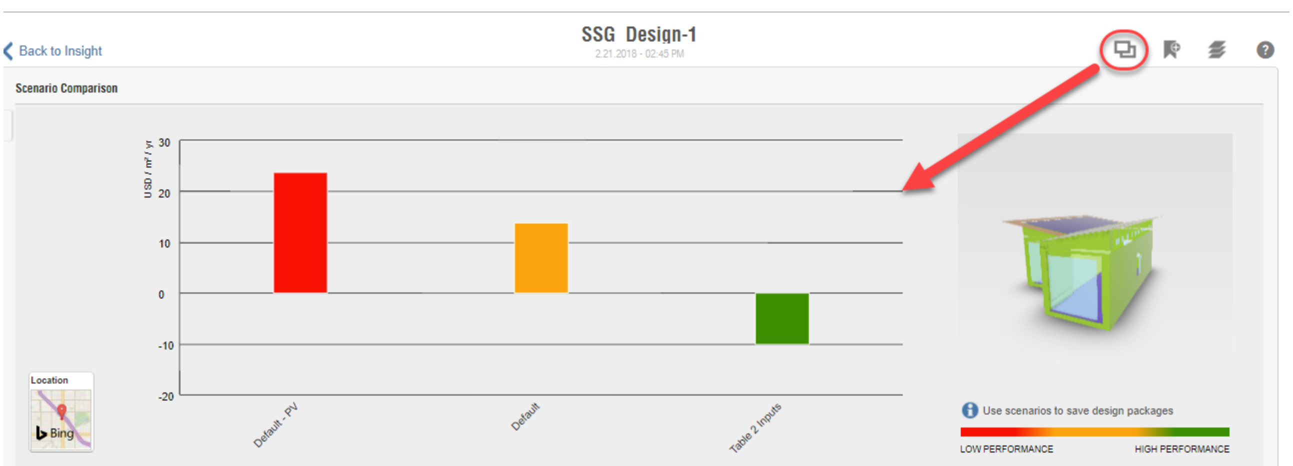


Figure 1.17: Compare results side-by-side

Export Options

By selecting the “Back to Insight” at the top left you can get to these settings, see Figure 1.18.

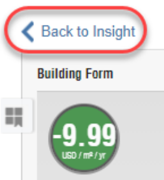


Figure 1.18: Getting to export options

Export Files

From Insight you can “export” multiple different formats of the energy model data, see Figure 1.19. This includes CSV, EnergyPlus, GBXML, DOE-2, and images. Note you can take this data directly into AIA DDx to fill out the reporting forms for the project, see Figure 1.20.

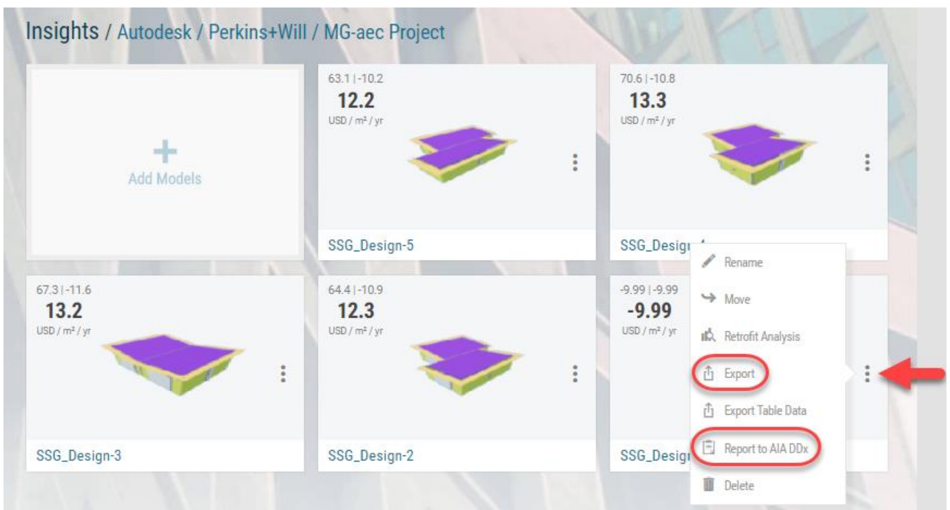


Figure 1.19: Export options from Insight

Using the “Export” brings up an additional dialog box to select multiple different formats, see Figure 1.20.

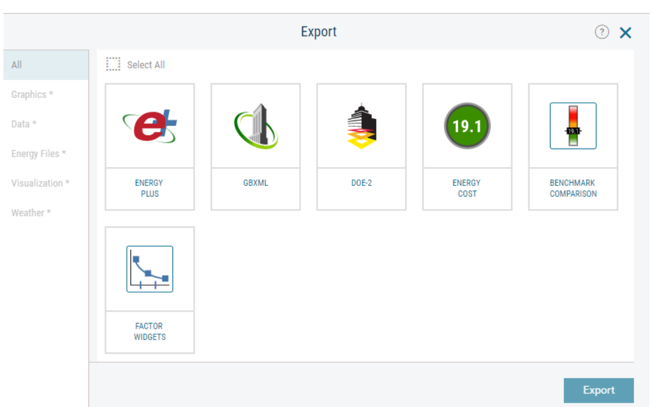


Figure 1.20: Download the other formats

Export AIA DDx

Measuring progress on carbon neutrality is a complex task that can take time away from firm capacity. AIA helped develop the 2030 Design Data Exchange (DDx) to make it easier and faster to record data, get results and advance your firm's performance with actionable information.

The confidential, easy-to-use DDx lets you pinpoint best practices and anonymously compare project performance in your firm and beyond. The research tool allows you to compare projects of similar type, size, climate and a host of other attributes across the 2030 portfolio.

AIA developed the DDx with support from the US Department of Energy and in partnership with Architecture 2030 and the US Environmental Protection Agency—and with guidance from a diverse group of experienced 2030 firm users. Using the "Report to AIA DDx" tool will bring you to the DDX website for reporting, see figure 1.19 / 1.21.

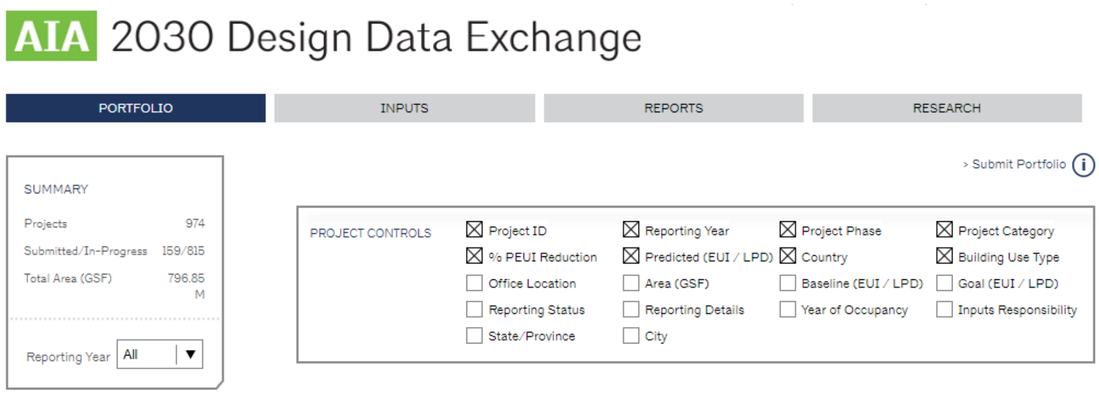


Figure 1.21: Energy data reporting to AIA

Model Comparison

Since you created some Scenarios in the first Design analysis you can use those same settings on the other models for a quick comparison. On the "Model Comparison" palette select the "Scenarios "custom" drop-down, see Figure 1.22.

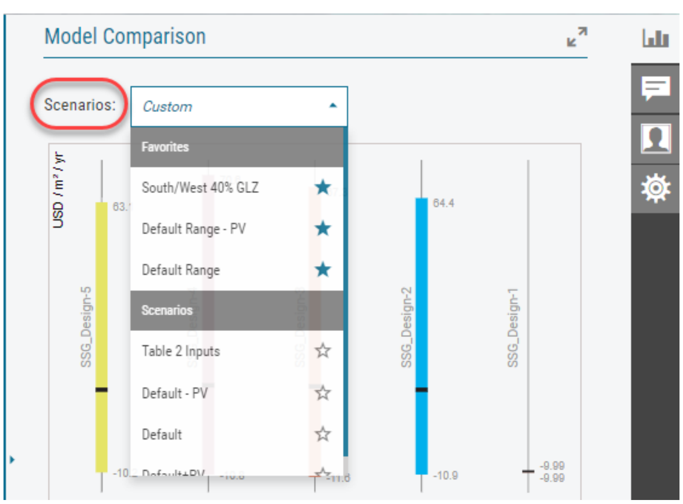


Figure 1.22: Scenario model comparison

Select the “Star” next to the “Table 2 Inputs” to add it as a Favorite, see Figure 1.23.

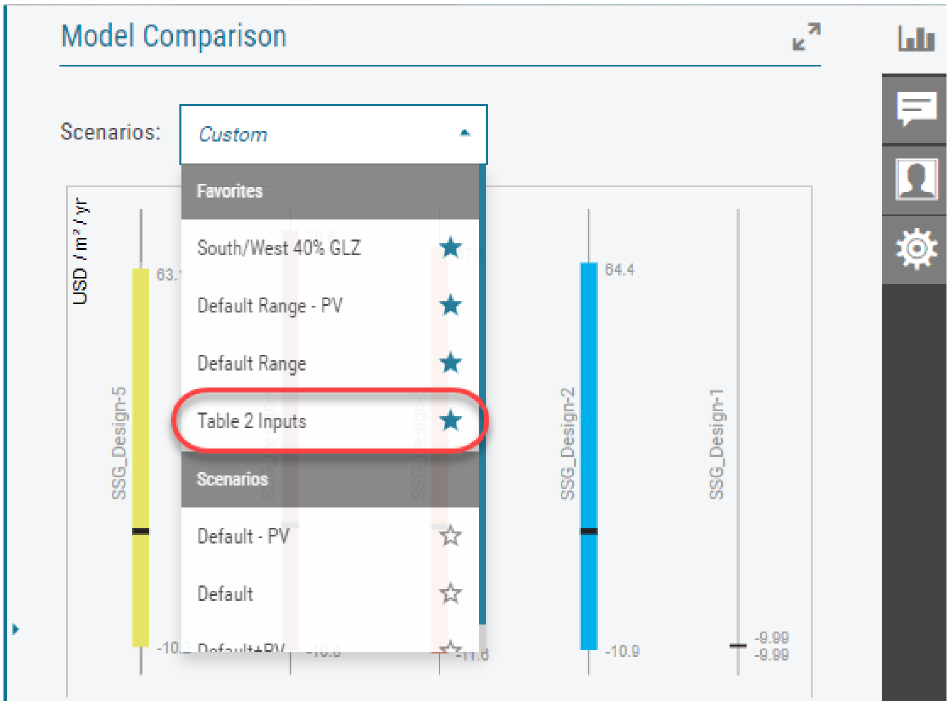


Figure 1.23: Add favorite to scenario model comparison

Now select it to add those settings to all of the design models. Notice all of the design models have been updated with the new settings and show the new energy performance data, see Figure 1.24.

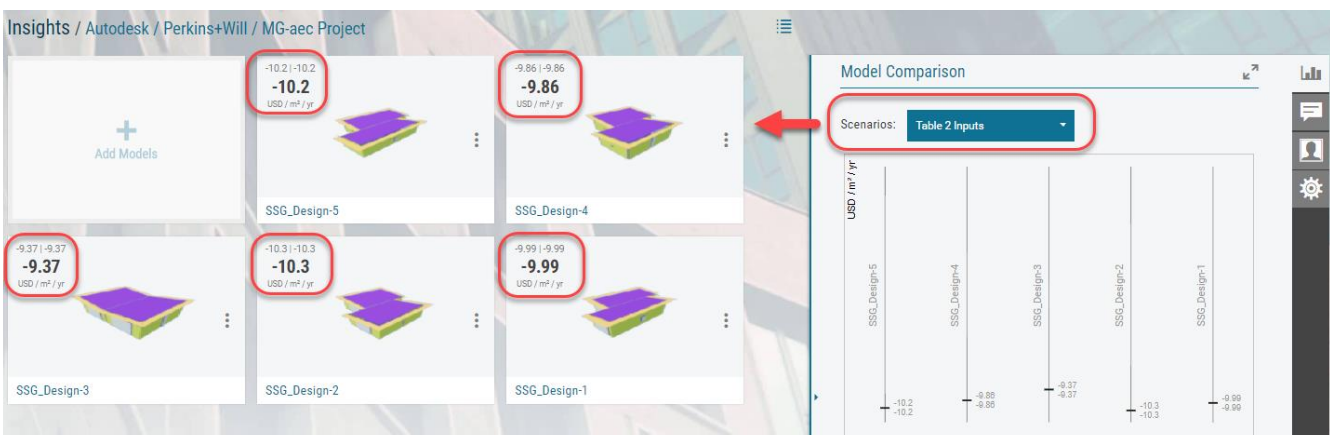


Figure 1.24: Table 2 Inputs applied to all design models for comparison

Optimization for Detailed Architectural Model

For your own projects that are using mass elements, or building elements, or a combination of the two, there are some items to be aware of.

Perform the following steps in the order listed.

1. Isolate elements that will be used in the creation of the energy model.
2. Focus the model to minimize processing time.
3. Identify and resolve issues, such as obvious missing elements and large gaps.
4. Create the energy model and assess the results.
5. Reduce resolution incrementally as needed.

For more detail in this process look here - LINK

Green Building Studio

Autodesk® Green Building Studio (GBS) is a flexible cloud-based service that allows you to run building performance simulations to optimize energy efficiency and to work toward carbon neutrality earlier in the design process. Green Building Studio® will help extend your ability to design high performance buildings at a fraction of the time and cost of conventional methods.

GBS is available as an extension of the Insight analysis and will give additional data and imagery if needed. You can login here using the same Autodesk Account that you used for your Insight analysis: LINK

Daylight Analysis

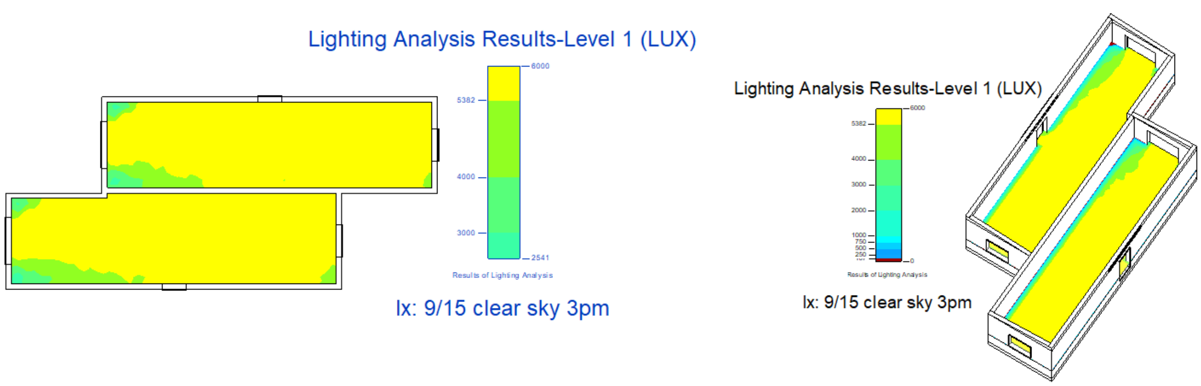


Figure 2.0: Heat map representing the daylight indicator of a design alternative

The daylight simulation calculates the daylighting quantity and quality within the spaces of the building (Figure 2.0). This analysis calculates the Daylight Factor - the ratio between the interior and exterior illuminance levels of natural lighting. This plug-in provides “LEED IEQc8.1 2009” and “LEED v4 EQc7 opt2” results for most models in less than 15 minutes once the analysis is started. The LA/R is specifically designed for architects to be able to use without learning the difference between the Perez or CIE's sky models, direct normal incident, or direct horizontal radiation. Just specify if you want to analyze the whole building, a single, or multiple floors, and kick-off the analysis. If you want more control of those parameters, you can use Revit's existing 360 Rendering Advanced Illuminance feature .

Analysis Type	Description
Illuminance Analysis	Full custom control over date, time, threshold, and analysis plane height
Daylight Autonomy (sDA preview)	Sample calculation for LEED v4 EQc7 opt1 (sDA & ASE) Reduced cost & calculation time
LEED 2009 IEQc8 opt1	Automated settings for LEED 2009 IEQc8 opt1 settings
LEED v4 EQc7 opt1	Automated settings for LEED v4 EQc7 opt1 (sDA & ASE) settings
LEED v4 EQc7 opt2	Automated settings for LEED v4 EQc7 opt2 settings
Solar Access	Customizable hours of sun study

Daylight Simulation and Analysis

Open "SSG_Design-1_Daylight.rvt" or one your Sprout Space building element models in Revit. Note that for lighting analysis studies, you must use one of the converted Revit models since these tools do not work with a conceptual mass model. Also, be sure to login to your Autodesk account within Revit. Lighting analysis consumes Cloud Credits, so Revit will need to be able to access your Autodesk account to complete the analysis.

If you are using the "SSG_Design-1_Daylight.rvt" or one of your earlier models, the location should be set and along with a weather station being selected but make sure they are correct. From the Analyze tab, select Lighting from within the Insight panel, see Figure 2.1.

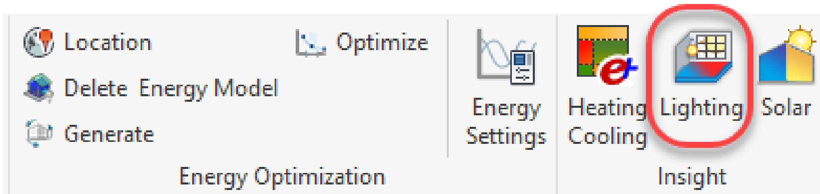


Figure 2.1: Getting started with lighting analysis

The first dialog that appears provides resources and best practices for conducting a lighting analysis study. These best practices are not required, but will help you achieve more accurate results, select Continue, see Figure 2.2.

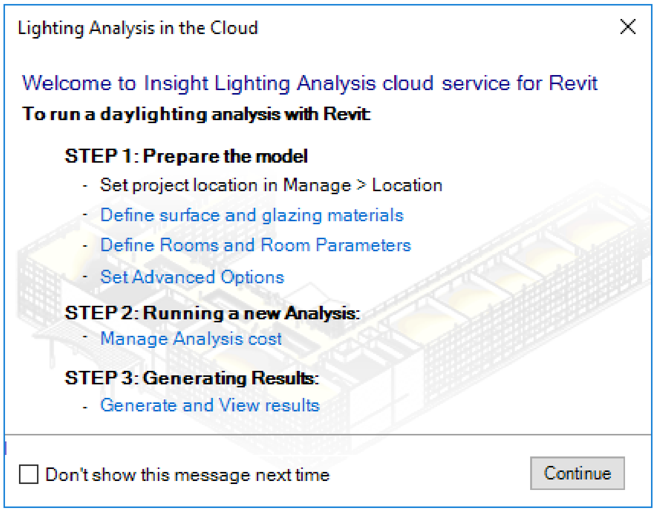


Figure 2.2: Overview of lighting analysis tool

Next, you will have the option to run a new analysis type or recall previously saved results. Select "Run New Analysis" and then pick Go, see Figure 2.3.

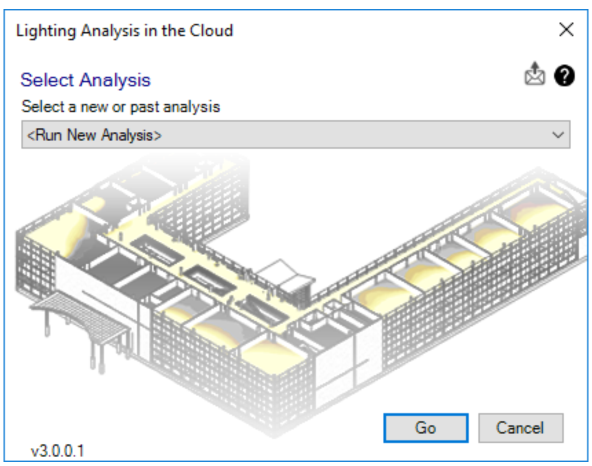


Figure 2.3: Run new analysis

The "Lighting Analysis in the Cloud" dialog box will allow you to control your study settings, see Figure 2.4.

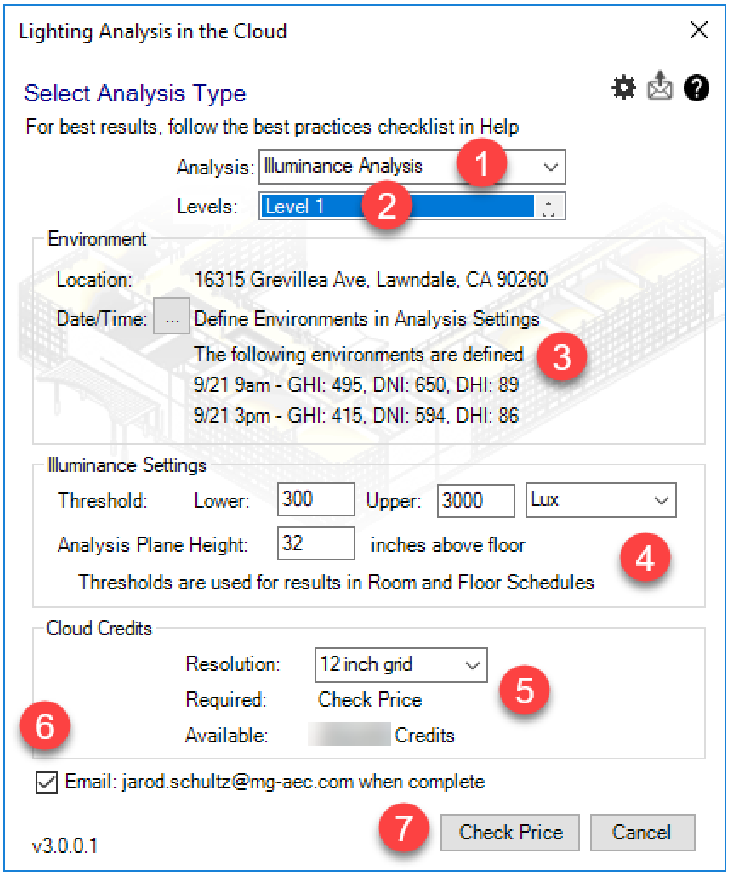


Figure 2.4: Analysis settings

1. "Analysis" allows you to select between different study types including:

Analysis Type	**Description**
Illuminance Analysis	Full custom control over date, time, threshold, and analysis plane height
Daylight Autonomy (sDA preview)	Sample calculation for LEED v4 EQc7 opt1 (sDA & ASE), Reduced cost & calculation time
LEED 2009 IEQc8 opt1	Automated settings for LEED 2009 IEQc8 opt1 settings
LEED v4 EQc7 opt1	Automated settings for LEED v4 EQc7 opt1 (sDA & ASE) settings
LEED v4 EQc7 opt2	Automated settings for LEED v4 EQc7 opt2 settings
Solar Access	Customizable hours of sun study

2. Select which "Levels" you would like to visualize results for using the drop-down menu, and double click on your selection. To select multiple levels, hold down SHIFT to select the levels, then click outside of the drop-down menu.

3. The "Environment" settings include location and analysis time or range. The *location* specified for the Revit project is what will be used for the analysis. The date and time settings are automatically populated for LEED analysis types, however if you select *Illuminance Analysis* or *Solar Access*, you have the ability control to the settings.
4. The "Illuminance Settings" are also automatically populated based on LEED criteria, but can be manually controlled for "Illuminance Analysis" and "Solar Access" studies.
5. The "Resolution" includes two analysis grid sizes; a 72 inch grid and 12 inch grid. For some analysis types, these grid sizes are preset and cannot be edited.
6. Get an email or not when the analysis is done.
7. Select "Check Price" and then "Start Analysis" to begin the simulation.

After selecting "Start Analysis", the model geometry will be uploaded to the cloud rendering engine. Do not close the project or Revit during this process.

NOTE: You will get a dialog box once the model is successfully uploaded to the cloud and to notify you to Save the project. Once that happens it is okay to close the project or continue working in Revit.

NOTE: That any changes you make to the model geometry or material settings will not be reflected in your analysis results, as the model has already been uploaded for analysis.

You can check the progress of the analysis by initiating the plugin again and using the drop-down menu to find in progress analyses, see Figure 2.5.

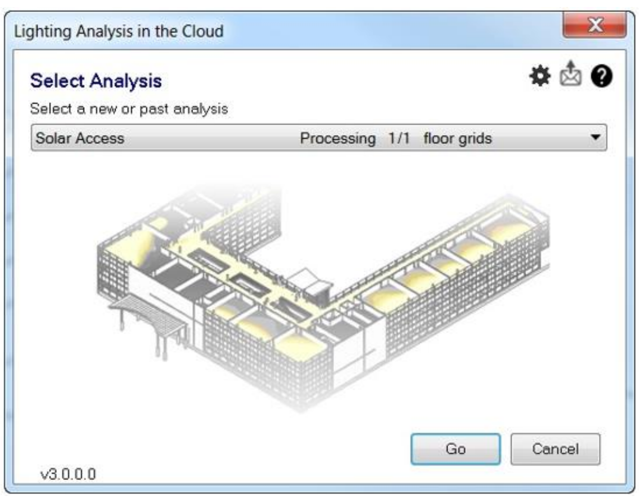


Figure 2.5: Lighting analysis in progress

Revit will notify you once the results are ready. "Accept" or "Decline" the cloud credit charges at this point, see Figure 2.6. It is recommended you also save the project after accepting the charges, so you will be able to recall the lighting analysis results after exiting Revit.

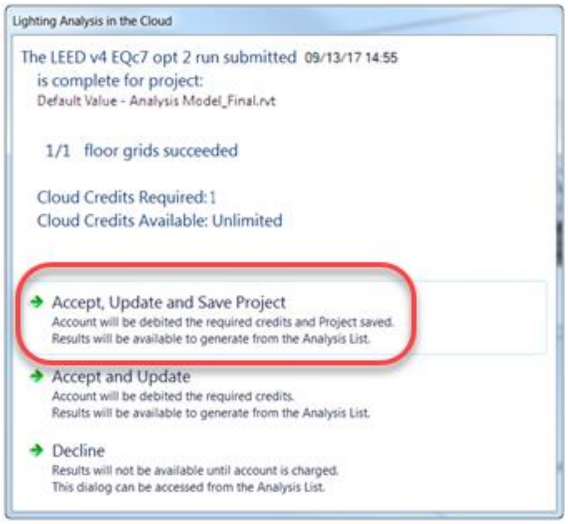


Figure 2.6: Accept lighting analysis results

Visualization

Open the "_Lighting Analysis Model" view under 3D Views, see Figure 2.7. Note that any "*_Lighting…*" views are automatically created to easily access results in plan, 3D, and as a schedule. Analysis results will populate in whatever 3D view is currently active.

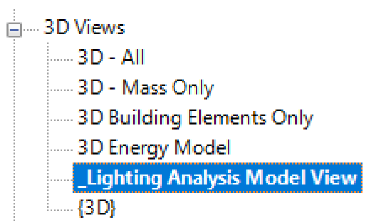


Figure 2.7: Lighting Analysis Model View

From the Insight panel select "Lighting" to access your analysis results. This time, select the results for the analysis that has been completed and select "Go", see Figure 2.8.

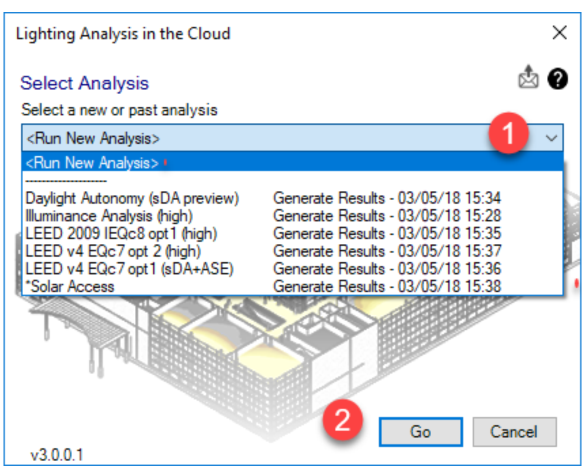


Figure 2.8: Applying Lighting Analysis to the current view

You'll be prompted with a dialog box with a summary of your results. If you are doing a LEED type analysis, then the amount of achievable points will also be included, see Figure 2.9.

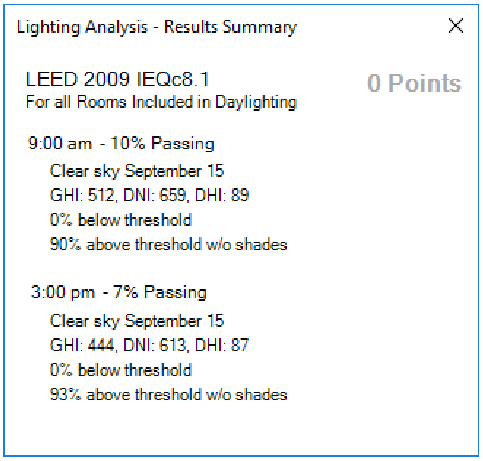


Figure 2.9: The Lighting Analysis results

Within a 3D view, on the Properties palette, you can use the use the "Section Box" tool to view the results or you open the corresponding "*_Lighting Analysis*" floor plan, see 2.10.

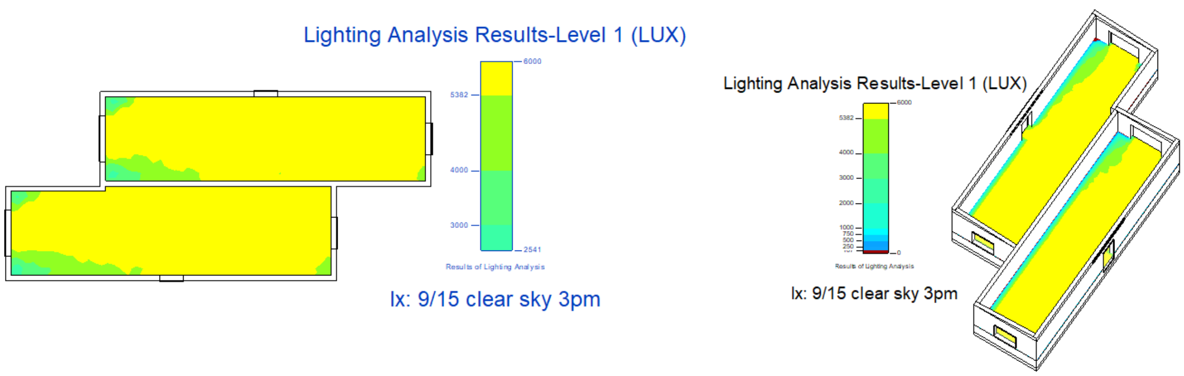


Figure 2.10: Plan view on the left and section box view on the right

The "*_Lighting Analysis*" floor plans are only produced if rooms are placed for the levels, see Figure 2.11.

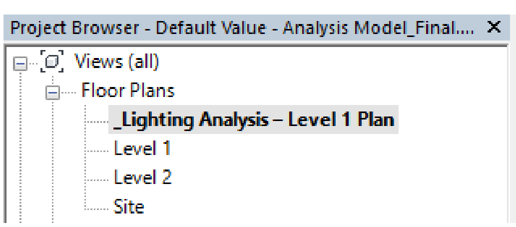


Figure 2.11: Lighting Analysis plan view

For analysis types that represent a single point in time, you can toggle between the two dates and times that were simulated by selecting the analysis plane and changing the "Analysis Configuration" in the "Properties" panel, see Figure 2.12.

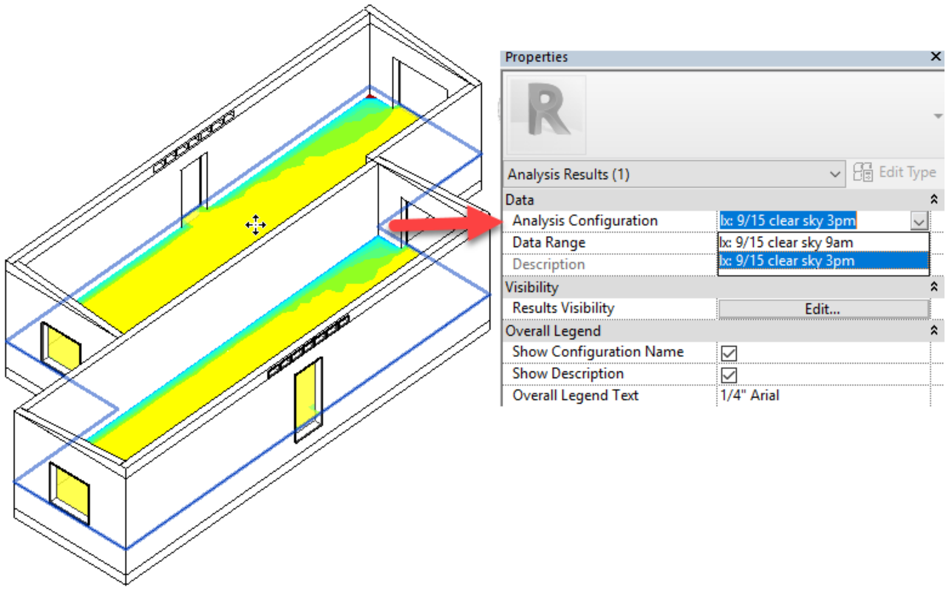


Figure 2.12: Selecting lighting analysis "plane" and changing date

Data

Open "_Lighting Analysis Room Schedule". If you define rooms, those rooms and corresponding analysis values will be populated here, see Figure 2.13.

<_Lighting Analysis Room Schedule>

LEED v4 EQc7 opt2 Whole Building Results: 16315 Grevillea Ave, Lawndale, CA 90260

9am: 1% within & 3pm: 0% within thresholds

Solar Values (W/m2): 9/21 9am GHI: 486, DNI: 641, DHI: 89 & 9/21 3pm GHI: 454, DNI: 619, DHI: 88

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
						9am threshold results						3pm threshold results					
				Include In Daylighting	Automated Shades	within threshold		above threshold		below threshold		within threshold		above threshold		below threshold	
Level	Name	Number	Area			%	Area	%	Area	%	Area	%	Area	%	Area	%	Area
Level 1	Room	1	434 SF	☑	☐	2	7 SF	99	427 SF	0	0 SF	1	2 SF	100	432 SF	0	0 SF
Level 1	Room	2	453 SF	☑	☐	1	5 SF	99	448 SF	0	0 SF	0	2 SF	100	451 SF	0	0 SF

Figure 2.13: LEED v4 schedule in Revit

LEED Studies (Single point in time)

You can use Insight Lighting Analysis to determine your design's progress towards achieving LEED daylighting criteria, specifically LEED 2009 IEQc8 opt1and LEED v4 EQc7 opt2. Both of these credits require specific illuminance levels at the equinoxes.

To conduct either of these studies, follow the steps outlined in the Overview and take note of the following.

When selecting either LEED analysis type, note that the majority of the analysis settings are preset according to the LEED specifications, see Figure 2.14.

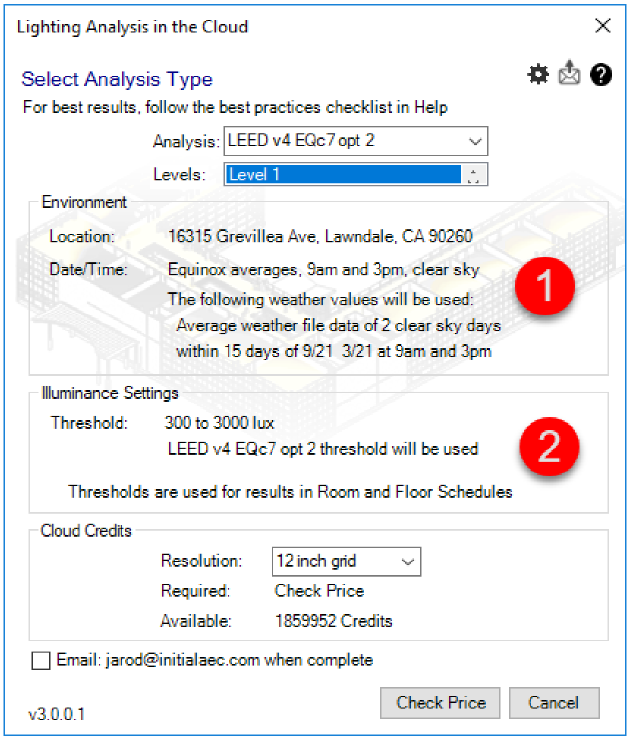


Figure 2.14: LEED v4 settings

Analysis Type	**Description**
LEED 2009 IEQc8 opt1	As defined by USGBC, this simulation requires a clear sky condition within 15 days of September 21 at 9am and 3pm.
LEED v4 EQc7 opt2	As defined by USGBC, this simulation requires a clear sky condition and uses average weather data within 15 days of September 21 and March 21.

1. The *Location* is set based on the Revit project location.

NOTE: LEED single point in time analysis automatically use the Perez Sky model.

2. LEED 2009 and v4 specify different thresholds, so you will see these values change depending on which version of LEED you choose for the analysis type. Additionally, LEED requires the analysis occur at 30 inches above the finished floor. The analysis plane automatically is generated at this height for LEED studies.

When you generate the results in your Revit model, you will also get a summary of percentage of rooms passing and estimated LEED credit points the project is eligible for, see Figure 2.15.

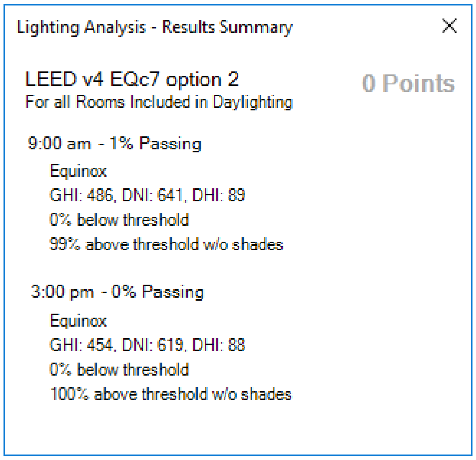


Figure 2.15: LEED v4 results

It is often the case that you will want to exclude rooms that are not regularly occupied from the analysis so not to skew your results. You can control this through the schedule, see Figure 2.16.

"Automated Shades" are also available to include and will extend the acceptance threshold, see Figure 2.16.

A	B	C	D	E	F
Level	Name	Number	Area	Include In Daylighting	Automated Shades
Level 1	Room	1	434 SF	☑	☐
Level 1	Room	2	453 SF	☑	☐

Figure 2.16: LEED v4 schedule to include rooms or automated shades

Any changes made in the schedule do not require you re-run the analysis. To "regenerate results" go to the ribbon, select the Analyze tab, and select "Lighting" again. This will regenerate results and will consider the new information updated in the schedule, see Figure 2.17.

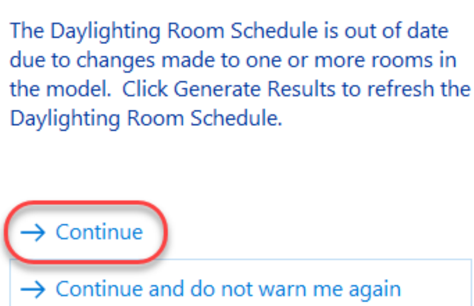


Figure 2.17: LEED schedule updated, and warning shown to regenerate results

LEED sDA & ASE Studies (Annual simulation)

You can use Insight Lighting Analysis to produce sDA and ASE results according to LEED v4 EQc7 opt1. This credit requires annual simulation at an hourly time step.

To conduct these studies, follow the steps outlined in the "Overview" and take note of the following.

Similar to the LEED studies for a single point in time, many of the settings for this analysis type are automatically predefined, see Figure 2.18.

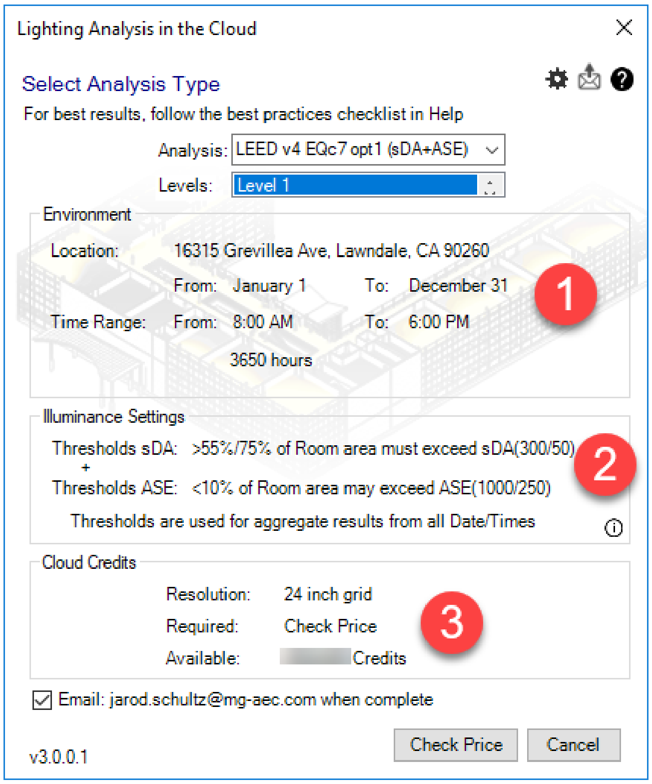


Figure 2.18: LEED v4 settings

1. The time range will be automatically set to a full annual simulation, from 8am to 6pm. LEED sDA and ASE studies automatically use the Perez Sky model.
2. Per the LEED requirements, sDA300/50 for at least 55% or 75% regularly occupied floor area is achieved. Additionally, ASE1000/250 of no more than 10% for the occupied floor area that is daylit per sDA300/50. LEED requires the analysis occur at 30 inches above the finished floor. The analysis plane automatically is generated at this height for LEED studies.
3. sDA and ASE calculations require at 24 inch analysis grid, which is automatically set.

Since the sDA and ASE simulation is more intensive than a single point in time, the analysis will take more time than a single point in time analysis.

Results summaries will provide guidance on how to improve design to achieve LEED requirements as well as more information about the metrics, see Figure 2.19.

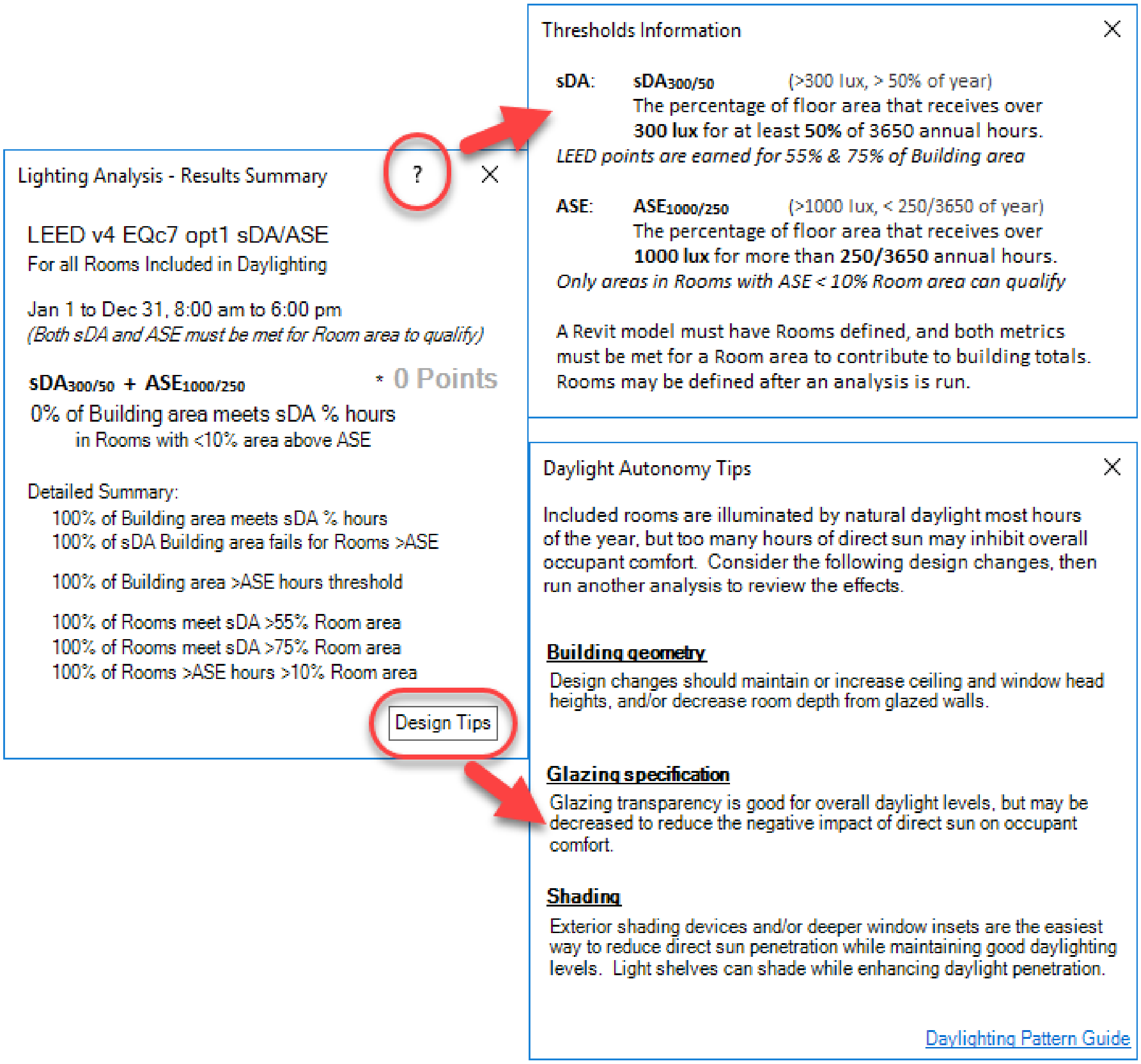


Figure 2.19: LEED v4 sDA/ASE guidance

Visual results and schedule results will present sDA300/50 and ASE1000/250 results, sDA and ASE Annual Hours, as well as combined metric results. Like before if you select the analytic surface you in the Properties palette you change from sDA Annual Hours to ASE Annual Hours, see Figure 2.20.

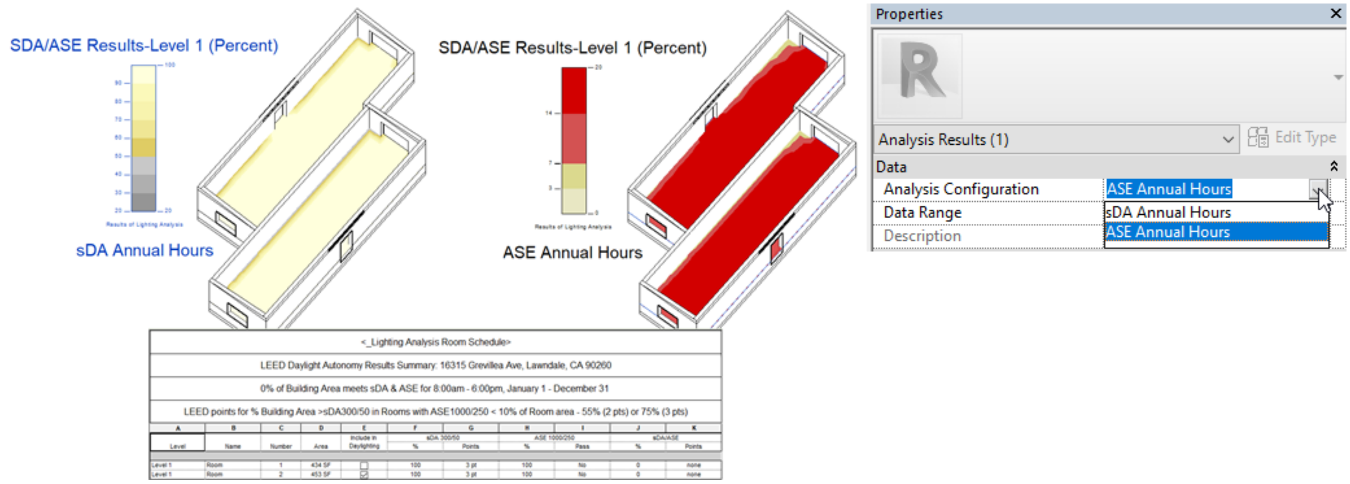


Figure 2.20: LEED v4 sDA/ASE results

Since the sDA and ASE simulations are more computationally intensive than a single point in time analysis, the time will likely be greater than for other analysis types. The "Daylight Autonomy (sDA Preview)" study type will analyze a sampling of the 3650 hours used in the full *LEED v4 EQc7 opt1 (sDA+ASE)* analysis. The "sDA Preview" study type will run faster. Results will be in line with those from the full *LEED v4 EQc7 opt1 (sDA+ASE)* analysis.

Export Data

Any of the lighting analysis can be exported out to XML for additional usage. Open the lighting dialog box and select one of the analysis. Now use the "export" option at the bottom left to create the XML file, see Figure 7.20.

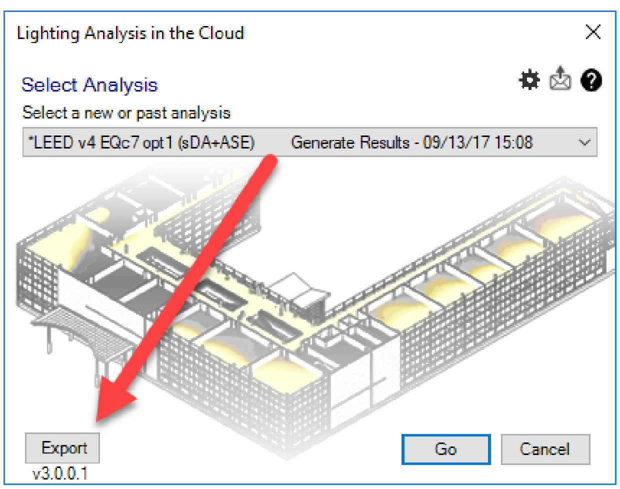


Figure 7.20: Export lighting analysis to XML

The lighting schedule in Revit can be exported as a tab delimited TXT file so the data can be used elsewhere. From the File drop-down use "export" to get to the "report" tool, see Figure 2.22.

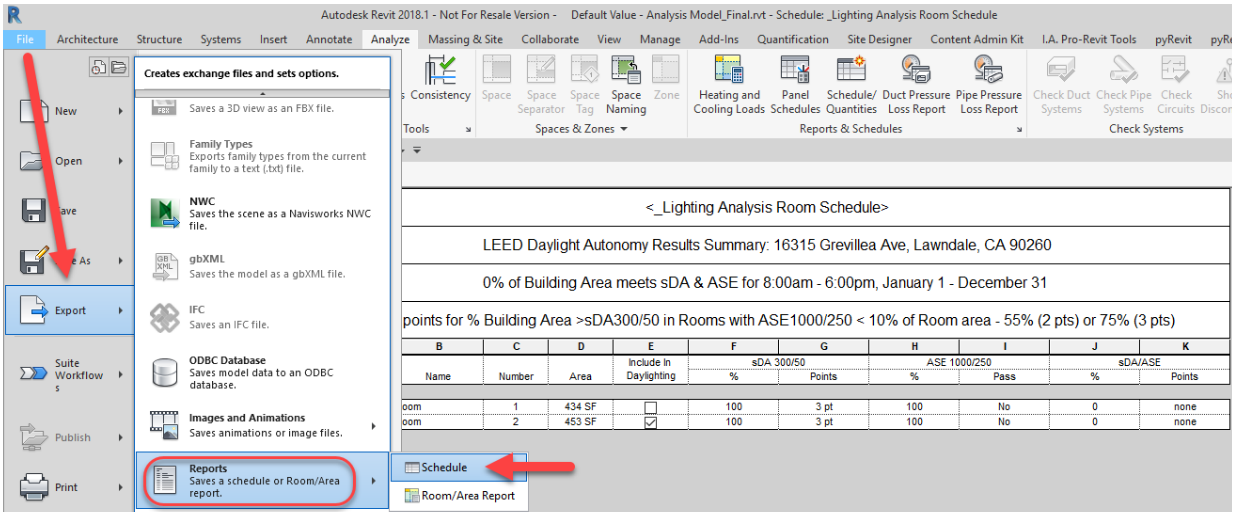


Figure 2.22: Export Revit schedule to tab delimited TXT file

Quality View Analysis

The purpose of View Quality analysis is to assure the connection with the outdoor environment, see Figure 3.0. This analysis entails two indicators: The Direct Line of Sight (DLS) that calculates the percentage of the floor area of the building with exterior view, and the Quality View (QV) that calculates the percentage of the area that allow the view of some relevant elements of the landscape. These two indicators are based on the Chapter Indoor Environmental Quality from the Guide for Building Design and Construction LEED V4 (Updated July 1, 2014).

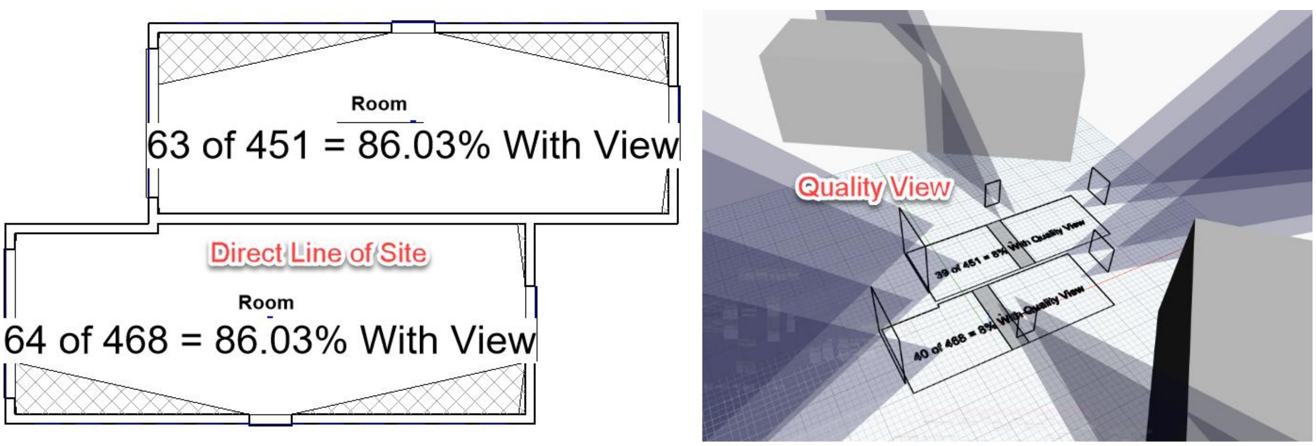


Figure 3.0: View quality (QV) and direct line of sight (DLS) analyses for design 1

There are two Dynamo graphs that will be used for this process. Revit does not have such a feature built-in so hence the reason for the Dynamo graphs. Based on the knowledge learned in section 1 you can go in and see how the graph was built and modify it for your project.

Quality View Analysis Process

This analysis takes the building envelope components as inputs and discriminate between opaque and glazing surfaces to calculate the two-different indicator: DLS and QV, see Figure 3.1.

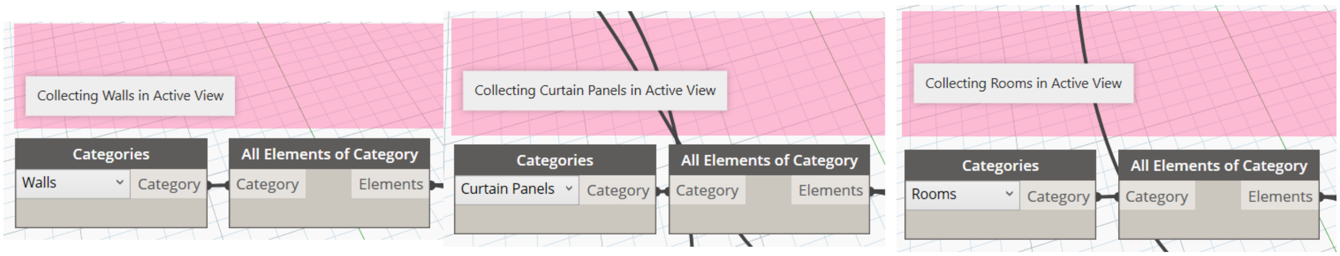


Figure 3.1: Quality view Dynamo graph and main nodes

Glazing and Opaque Areas

The "Curtain Panels" component distills the glazing regions of the envelope that constitute the main input to calculate the DLS and the QV indicators. It takes in the geometry of the envelope, including wall, curtain panel, and interior partition geometry to identify the interior spaces, the plan perimeter, the glazing cells or surfaces, and the opaque walls with and without windows, see Figure 3.2.

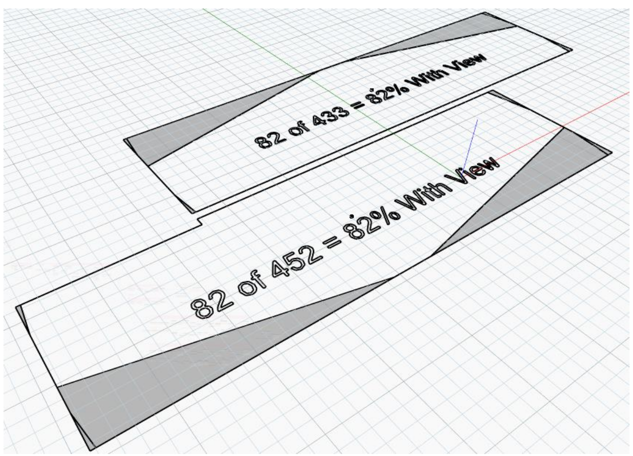


Figure 3.2: Glazing calculation

Direct Line of Sight (DLS) Indicator

The Dark Areas

The extent of glazing, as viewed in plan, is used to determine the 'areas with no views'. This concept is taken from LEED 4.0:

"Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area. View glazing in the contributing area must provide a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance."

The method that calculates the floor area, is taken from LEED 2009 IEQ Credit 8.2 Daylight and views. In this method, the plan view angle through the glazed area considers the actual wall thickness for punched windows. In plan, two diagonal lines are drawn, one connecting the exterior left wall opening corner to the interior right wall opening corner, and the other connecting the exterior right wall opening corner to the interior left wall opening corner. This is done for each glazed opening. These two diagonal lines are extended towards the interior. Wherever diagonal lines of adjacent windows intersect, the area contained within these diagonal lines and the associated wall or walls is regarded as an 'area with no view' or dark area, see Figure 8.3. The DLS indicator of this case study is 0.830265, or 85%, which is above the recommended reference of 75%, see Figure 3.3.

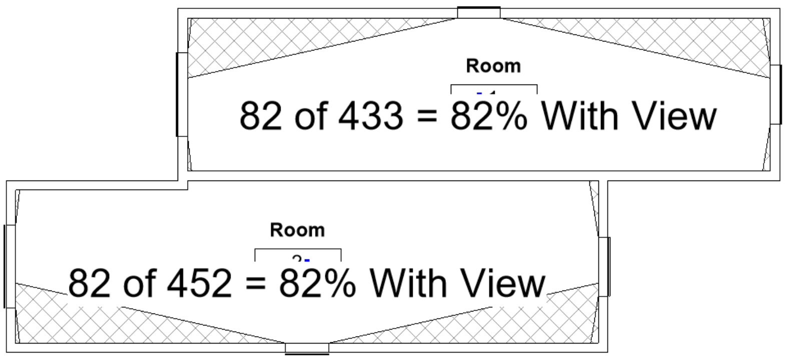


Figure 3.3: Process of computing the dark areas of the building

Duplicate Floor View

To try this workflow, open "SSG_Design-1_Quality View" or one of the earlier Project design files and "duplicate with detail" Level 1 Floor Plan. We want to capture the room and room tag data for this new view. Rename it "Level 1 – Line of Sight", see Figure 3.4.

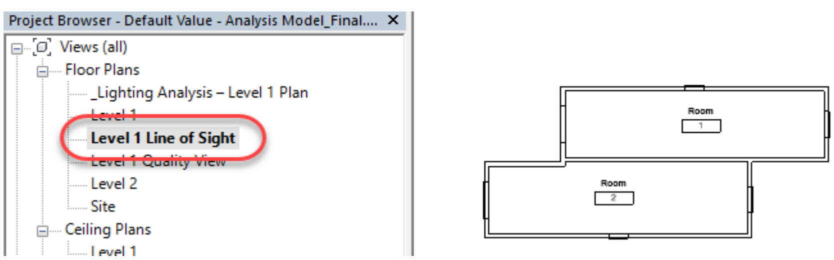


Figure 3.4: "Duplicate with detail" the Level 1 Floor Plan view, rename it

Check View Range

Can you see all of the windows in the floor plan for the DLS? If not, from the "Properties" palette using the "view range" dialog box, you will need to change the "cut plane offset" value, see Figure 3.5.

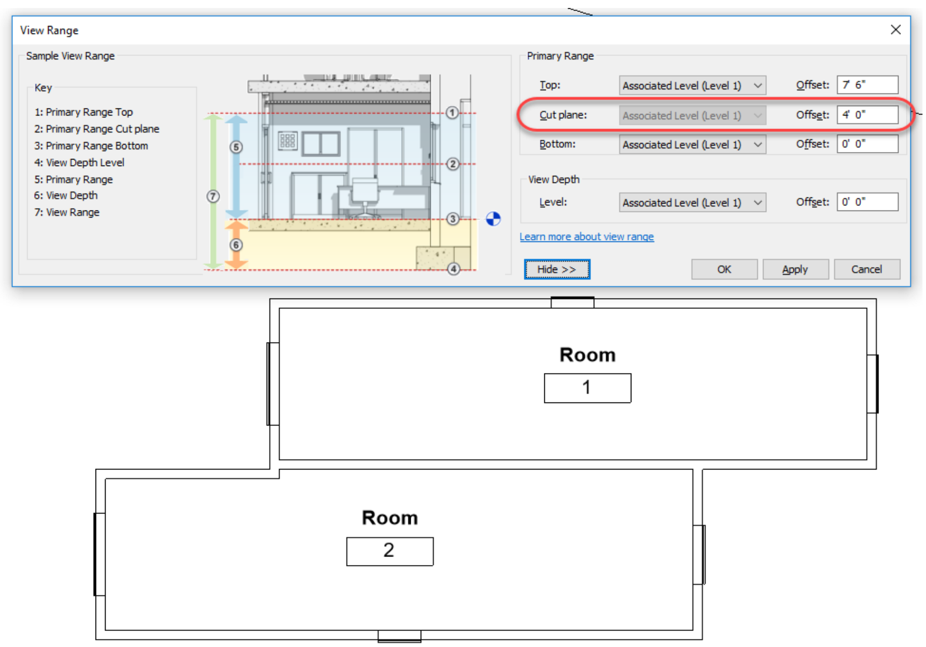


Figure 3.5: Changing the cut plane to see all of the windows

Starting DLS Dynamo Graph

Staying in the “Level 1 – Line of Sight”, on the ribbon go to the Manage tab and start Dynamo for Revit and open the “Direct Line of Sight” Dynamo graph and run it. Dynamo and the Revit view will update with the direct line of sight information, see Figure 3.6.

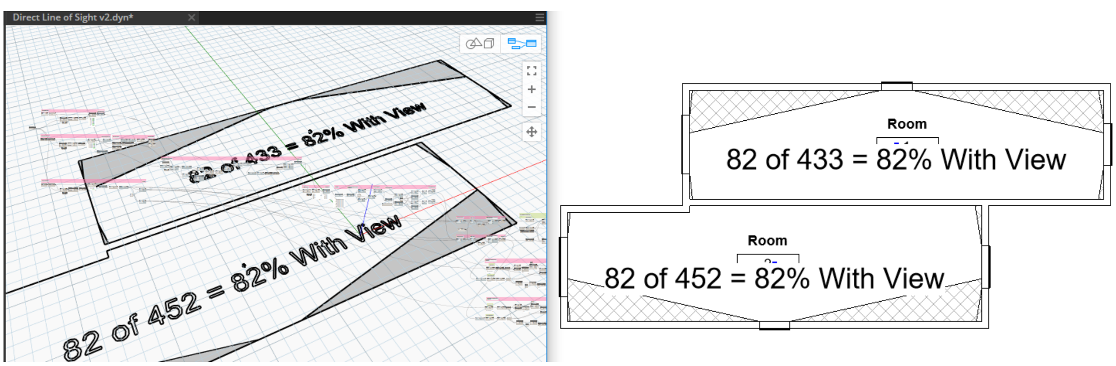


Figure 3.6: Dynamo and Revit showing direct line of sight information

NOTE: If you make changes to the model you will need to re-run the Dynamo graph. Before doing that make sure to delete the “Filled Regions” and “Text”.

Quality View (QV) Indicator

2D Visual Fields

DLS assures people can see out of the building, but this says nothing about the quality of that view. The QV indicator is inspired by the Quality View definition in LEED V4. It is based on a two-dimensional interpretation of the building. It represents a 2D viewing angle from each sampled view point inside the building, as it would be represented in a section, and computes the intersection of these 2D fields with relevant elements of the landscape, see Figure 3.0 / 3.7.

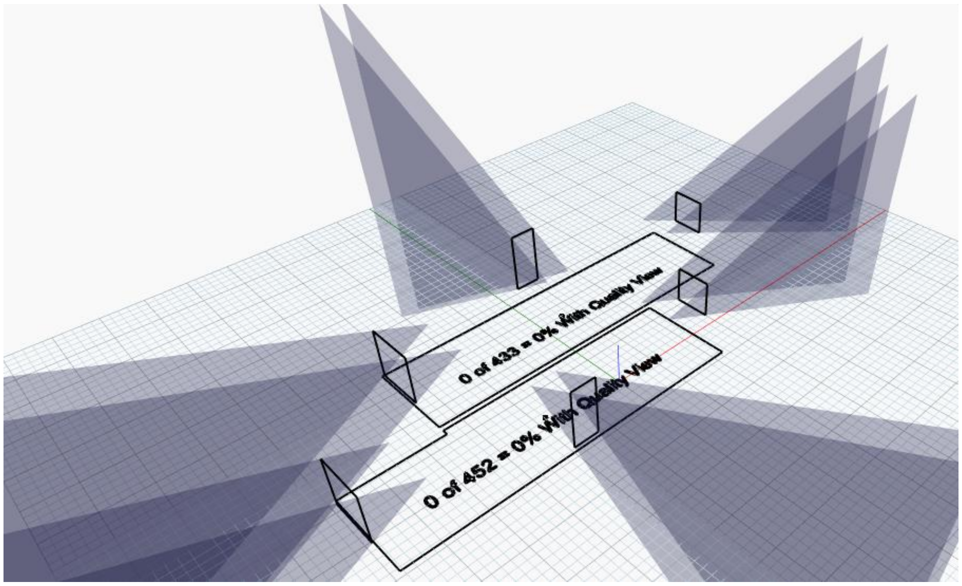


Figure 3.7: Process of computing the 2D viewing angles

Refer to the Guide for Building Design and Construction LEED V4 (Updated July 1, 2014) Chapter: Indoor Environmental Quality EQ Credit Quality Views, and see examples on pages 750-751 for more information.

Landscape Evaluation

For the purpose of this case study, the triangular meshes representing the 2D viewing angles are used to intersect elements in the context model of two buildings masses of visual interest, see Figure 3.8. When an intersection is found, it is counted towards a quality view area, represented as a blue area on the center of the space. This method requires a mesh representation of the relevant elements of the landscape. The QV indicator of this case study is 0.237862 that corresponds to almost 24% of the floor plan area of the building.

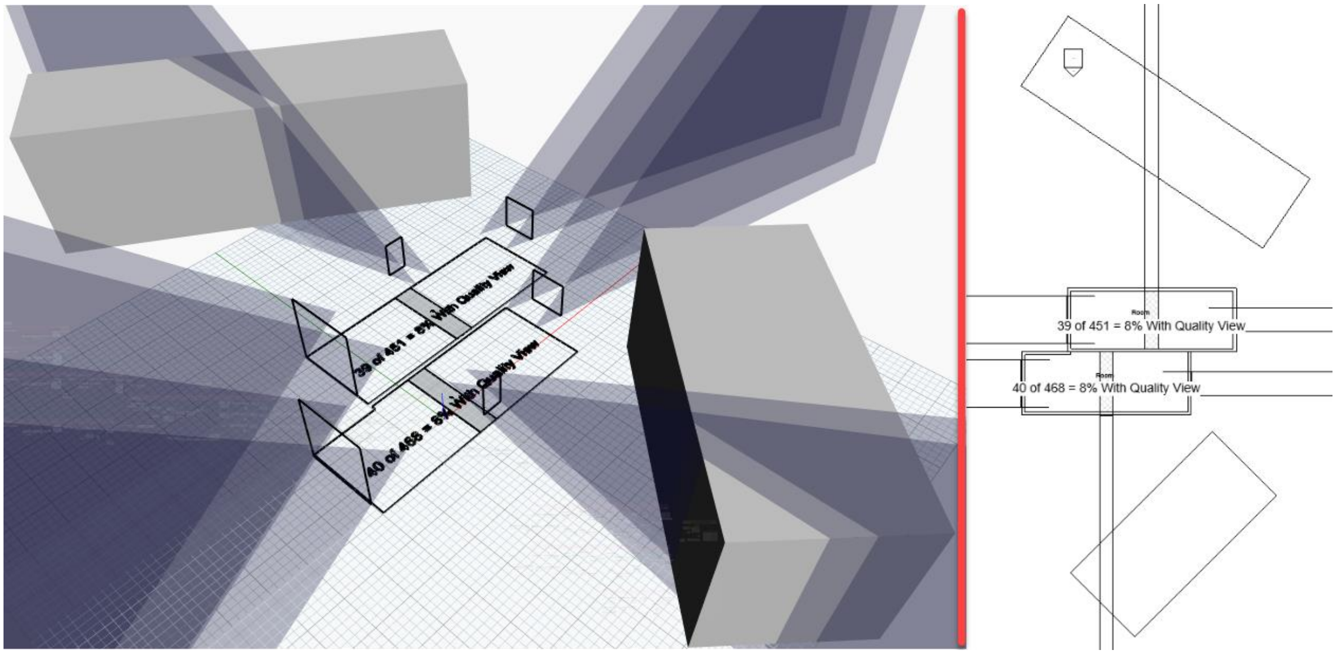


Figure 3.8: Computing and mapping in plan the intersection of the viewing angles with relevant elements of the landscape

Duplicate Floor View

For the Dynamo graph to work properly a view and "mass elements" need to be developed. Open "SSG_Design-1_Quality View " or one of the Project Design files and "duplicate with detail" Level 1 Floor Plan. We want to capture the room and room tag data for this new view. Rename it "Level 1 – Quality", see Figure 3.9.

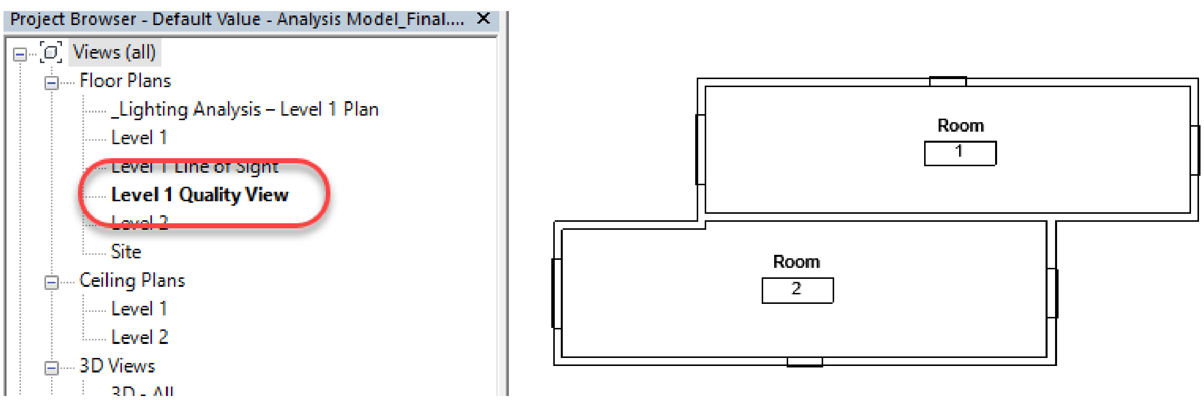


Figure 3.9: "Duplicate with detail" the Level 1 Floor Plan view, rename it

Create Site Elements

On the “Architecture” tab choose the drop-down for “Component -> Model in Place”. Choose “Site” for the category and call it “Mass Site”, see Figure 3.10.

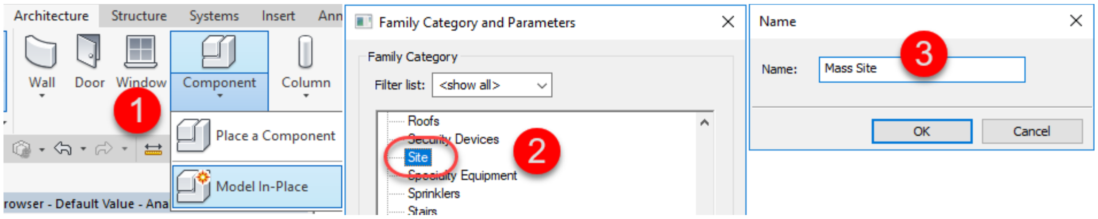


Figure 3.10: Start the process of creating the site mass

Use the “Extrusion” tool to create two masses that are located away from the Sprout Space. Change the “extrusion end” height to be 20ft, see Figure 3.11.

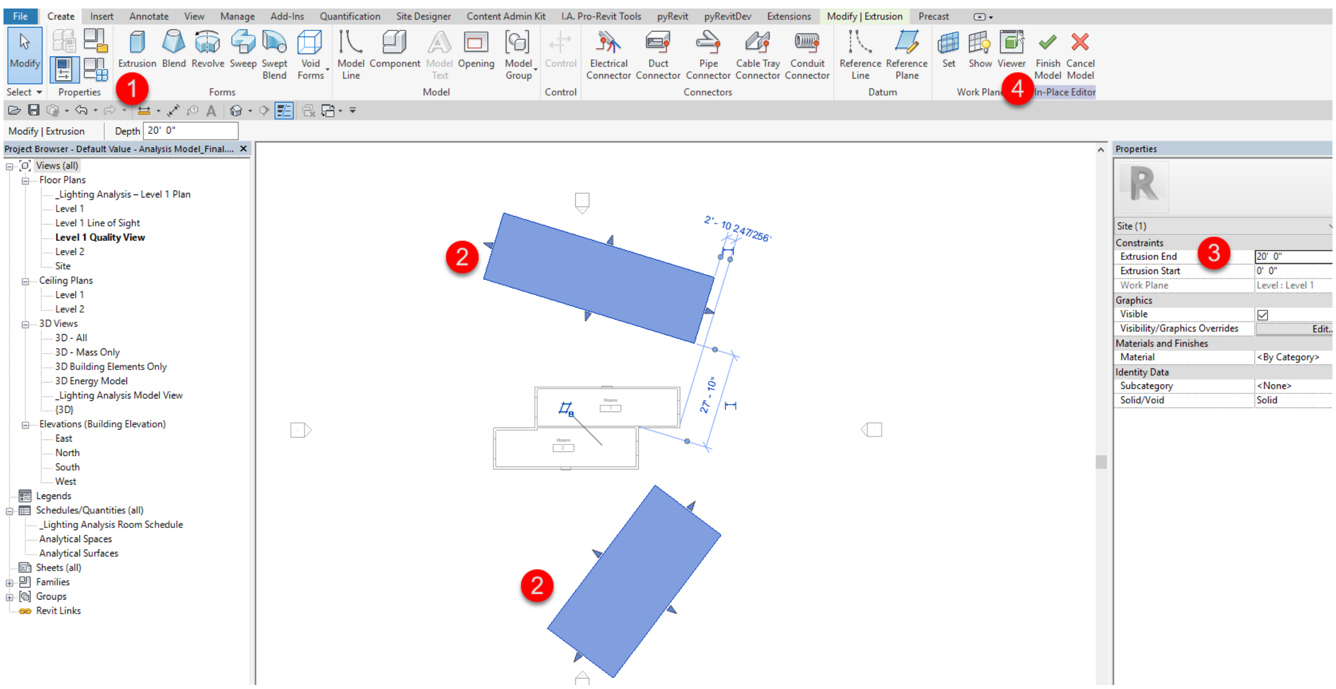


Figure 8.11: Creating site mass with extrusion

Starting QV Dynamo Graph

On the ribbon go to the Manage tab and start Dynamo. Open the “View Quality” Dynamo graph and run it. Dynamo and the Revit view will update with the quality view information, see Figure 3.12.

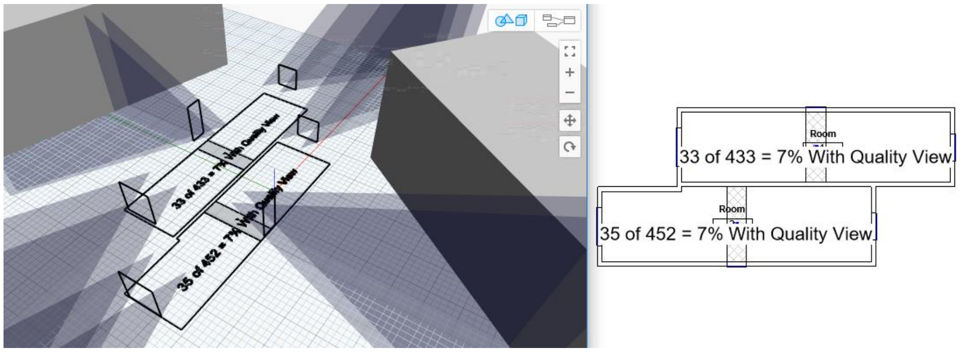


Figure 3.12: Dynamo and Revit showing view quality information

3D View

The 2D viewing angles are converted and shown in Revit. Change from the floor plan view to a 3D view to see them in your Revit model. Change the “visual style” from “hidden” to “shaded” for a better visual (Figure 3.13). You can delete or hide them at any time when not needed.

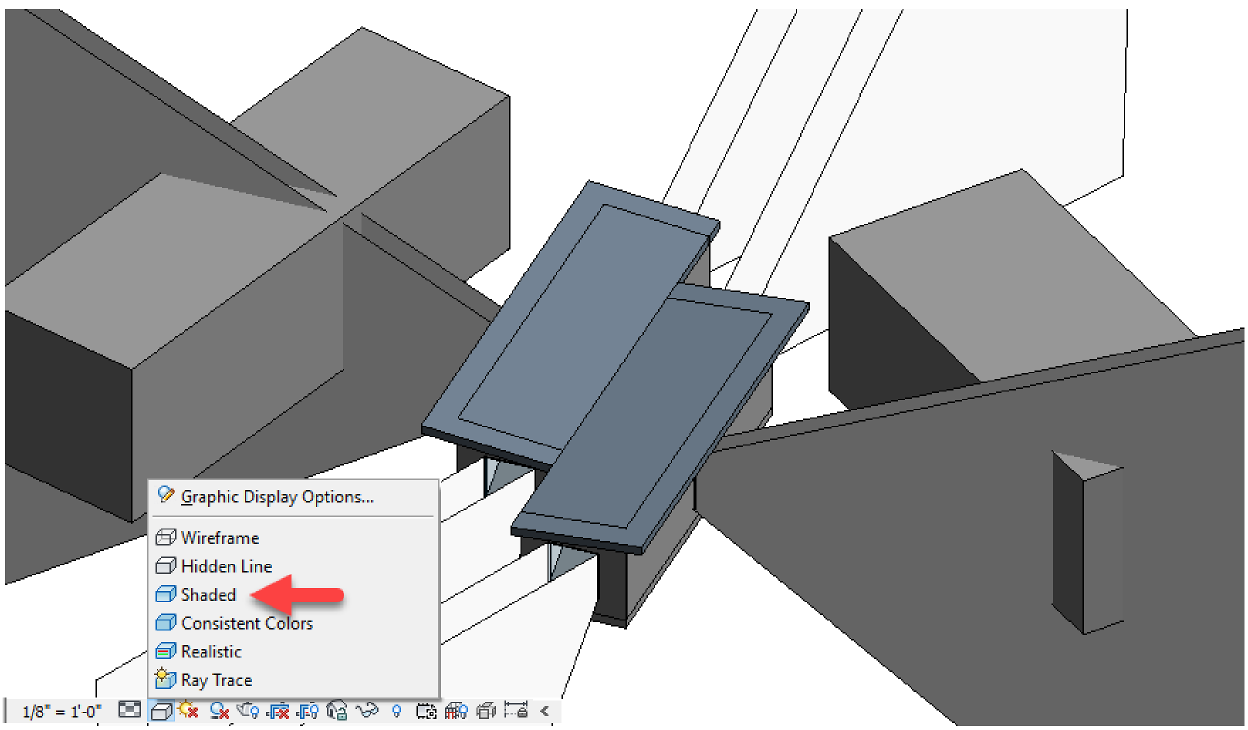


Figure 3.13: 2D viewing angles shown in Revit

Change Dynamo Settings

Back in the “View Quality” Dynamo graph you can change the “Eye Elevation” and “View Depth” if the 2D viewing angles need to be higher, shorter, or longer so it intersects the mass site elements (Figure 3.14).

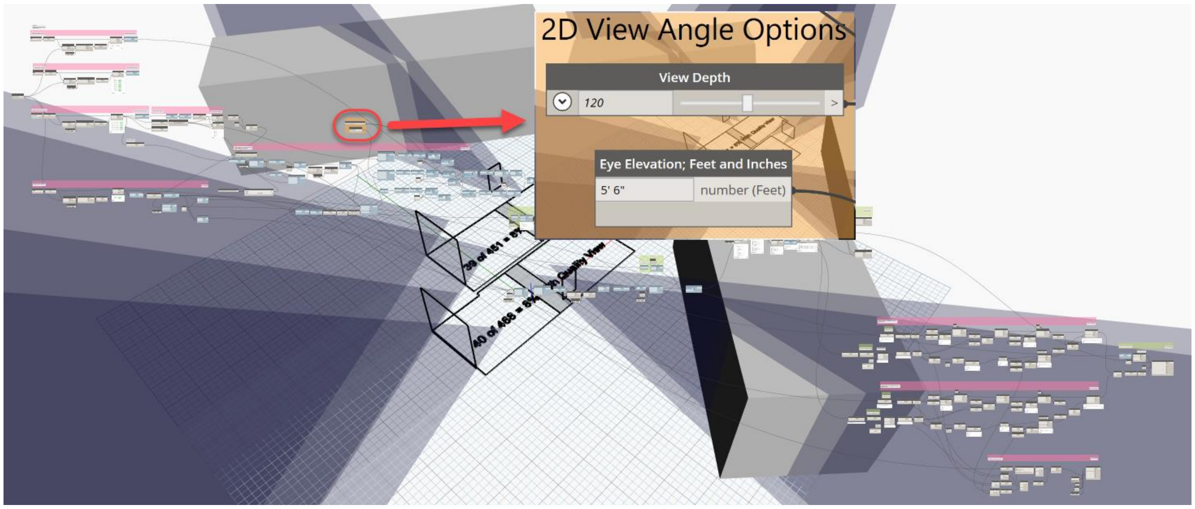


Figure 3.14: Change eye elevation or view depth of 2D viewing angles

Data Export

Both Dynamo graphs create excel spread sheets and place them in the same folder from where you opened the graph, see Figure 3.15.

Direct Line of Sight Data

	A	B	C	D	E
1					
2		Room	Dark Area	Room Area	Percentage with View
3		Room 1	81.24487918	433.7777778	82
4		Room 2	81.63543519	452.8888889	82

Quality of View Data

	A	B	C	D	E
1					
2		Room	Area with View	Room Area	Percentage with Quality View
3		Room 1	32	433.7777778	7
4		Room 2	34	452.8888889	7
5					

Figure 3.15: Data from Direct Line of Sight and Quality of View

Solar Analysis

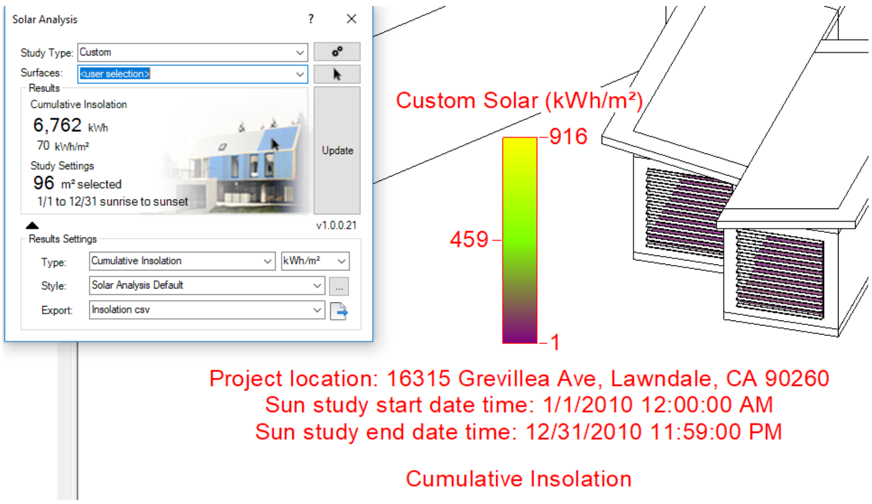
Overview

Insight Solar Analysis 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. The following analysis types are currently available:

Analysis Type	**Description**
Solar Energy – Annual PV	Annual simulation for determining PV energy production estimates
Custom	Customizable simulation for general solar insolation studies

Insight Solar Analysis with Revit uses the Perez Solar Model, a calculation method that occurs locally within Revit.

NOTE: For solar analysis studies you can use a conceptual mass, detailed building element model, or even a hybrid of the two.



Validation

Insight Solar Analysis with Revit uses the Perez solar model to calculate results. This model is used by the National Renewable Energy Lab (NREL) and their PVWatts® tool. Results from Insight Solar Analysis have been validated directly by NREL and findings conclude that differences between the results were less than 1% for surfaces oriented horizontal, east facing vertical, and south facing with latitude tilt angle.

You can test solar analysis results yourself by analyzing a surface with specified tilt and orientation in PVWatts® for a TMY station and comparing results with Insight Solar Analysis with Revit for a location with the same TMY station.

It's important to note that Revit uses a variety of weather data for analysis, not just TMY data. Read more about the Revit Internet Mapping Service. When comparing Insight Solar Analysis results to those from other tools, consider weather data sources and varying calculation methods when comparing results.

Getting Stated

Open the "SSG_Design-1_Solar Analysis.rvt" file or open one of the Project Design files. Make that the "Location" is set before starting the Solar analysis. On the ribbon go to the Manage tab and select Location, see Figure 4.1.

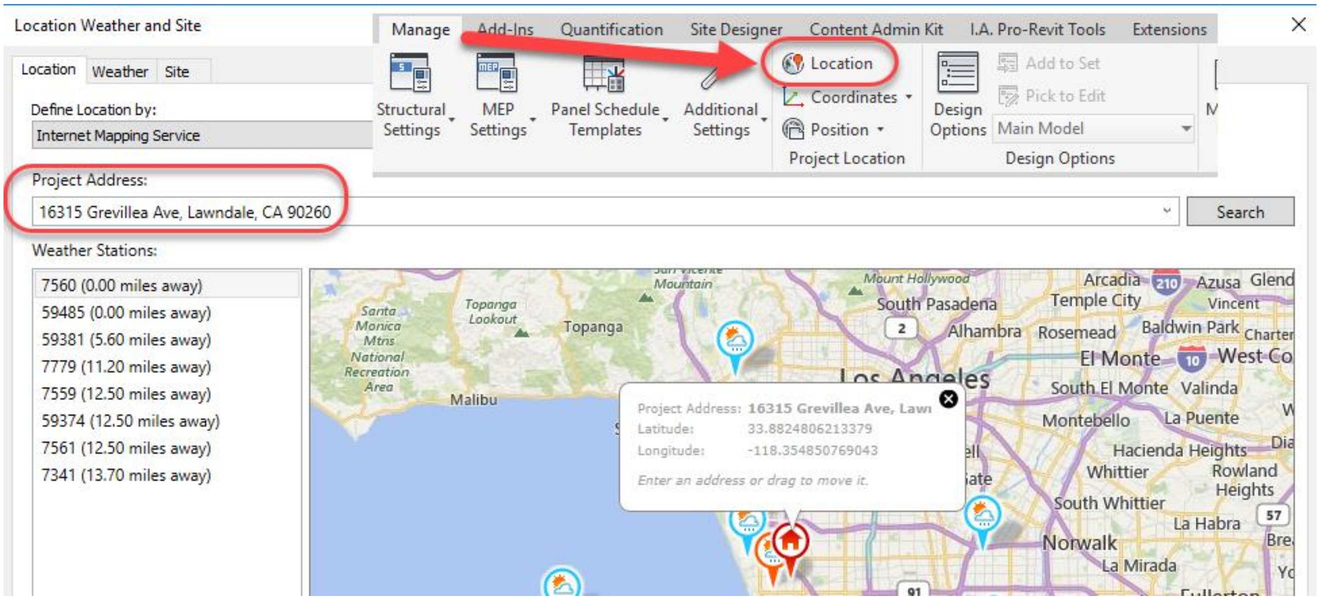


Figure 4.1: Set location for solar analysis

Start Solar Analysis

On the ribbon go to the Analyze tab, select Solar from within the Insight panel, see Figure 4.1. The Solar command is a separate plugin you can download from here.

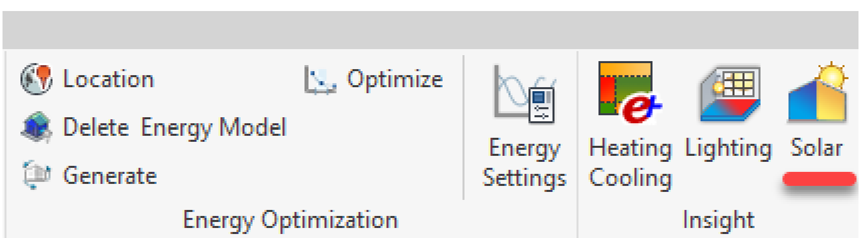


Figure 4.2: Start the solar analysis

The Solar Analysis dialog box will appear. This is where you can control your study settings, see Figure 4.3.

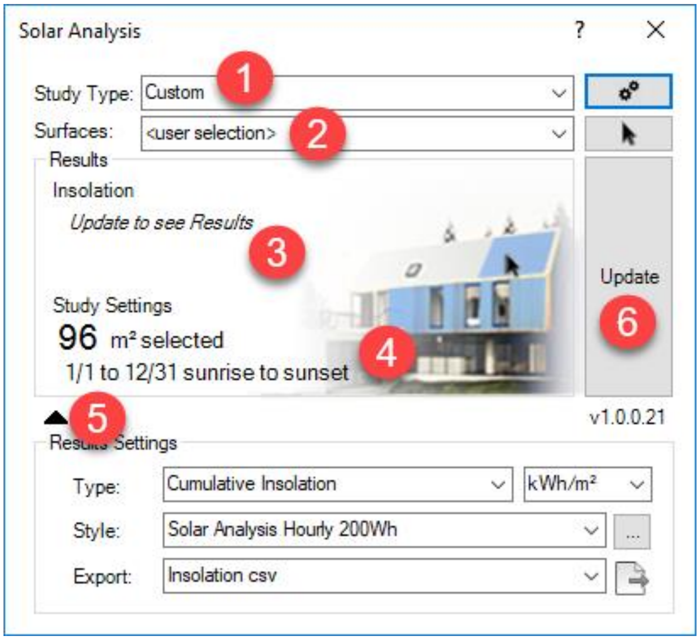


Figure 4.3: Solar analysis interface

Options

1. "Analysis" allows you to select between different study types including:

Analysis Type	**Description**
Solar Energy – Annual PV	Annual simulation for determining PV energy production estimates
Custom	Customizable simulation for general solar insolation studies

2. Select which "Surfaces" you would like to visualize results for. There are two preselection options, and one customizable option.

Surface Selection	**Description**
All Roof Exterior Surfaces	When selected for a model with building elements, this option automatically selects all Roof elements
All Mass Surfaces	When selected for a model with conceptual masses, this option automatically selects all mass faces
User selection	This option allows you to select your own mass and building element surfaces for analysis

3. The “Results” dialog provides a summary of PV Energy Production or Insolation results; whichever study type is selected. These results become available once the analysis is complete.
4. Study Settings summarize the area and time range selected for your analysis. To change the date and time range, edit the Sun Settings for the 3D view you have active, see Figure 4.4.

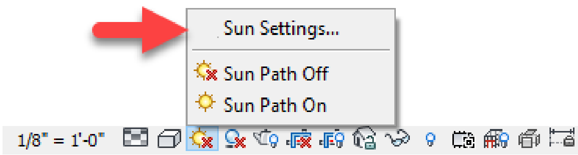
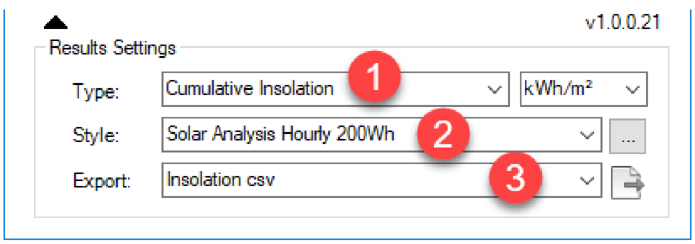


Figure 4.3: Solar analysis interface

5. You can expand *Results Settings* to define additional settings for analysis.



   1. The “Type” allows you to select between different analysis types:
      - Cumulative Insolation
      - Average Insolation
      - Peak Insolation

   You can also specify which units you would like to use for results:
      - Wh/m2
      - Wh/m2
      - BTU/ft2
   2. The “Style” controls the color scale and legend settings. Use the drop-down menu to select a different style or select the […] to create your own style.
   3. “Export” allows you to export results as a CSV. This option will be enabled once the analysis is complete.
6. Once all settings are defined, you can select “Update” and the analysis will begin. The analysis happens locally (within Revit), and you will see a status bar indicating analysis progress.

Results

Once the analysis is complete, the “Solar Analysis” dialog will update with a results summary and results will appear in your active 3D view, see Figure 4.4.

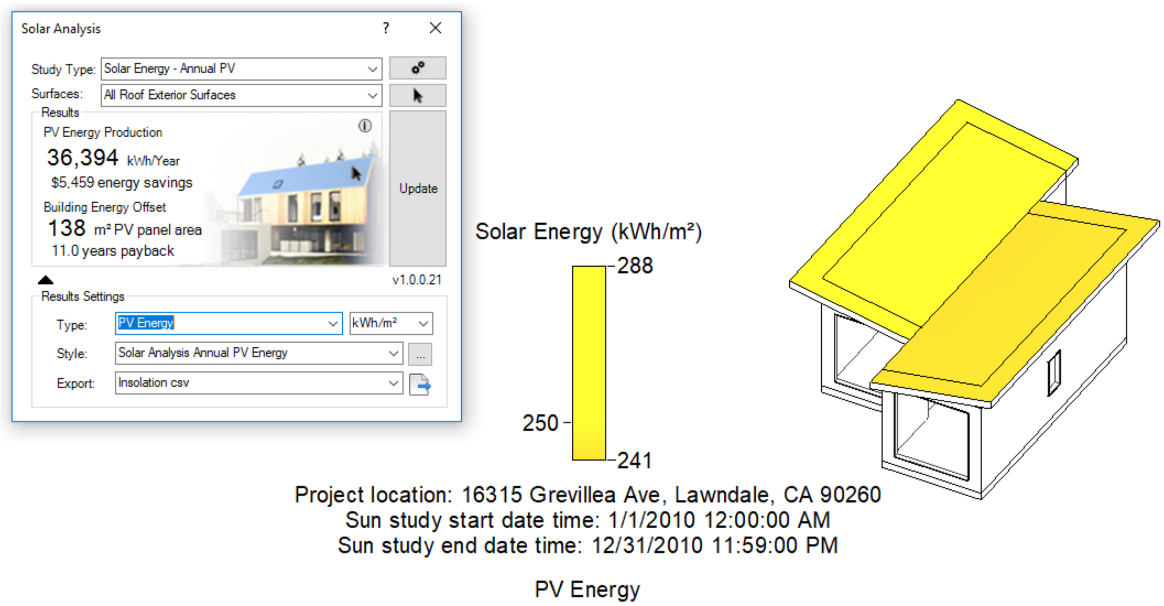


Figure 4.4: Solar analysis results

To make any changes to the analysis settings, or select new surfaces for analysis, simply edit the settings or selections, and press “Update again”. New results will override previous results.

NOTE: Solar analysis results cannot be saved with the Revit model. If you like certain settings take note of what those settings were for future analysis.

Louver Analysis

You can use Solar Analysis to create your own custom analysis types, specifying your own date and time range, surface selection, and result types, and visualization style. In this example we are going to look at how to use Solar analysis for louver design.

Currently some firms use curtain mullions to represent shade devices but if you are wanting to see how the solar analysis is affecting the interior surfaces this process won’t work. Hopefully a future release will fix this but for today we will need to use a “Model In-Place” component to represent the shade device.

When using the “user selection” option to select only the surface you want to use for the solar analysis a warning will display about the limitation of certain building elements in Revit, see Figure 4.5.

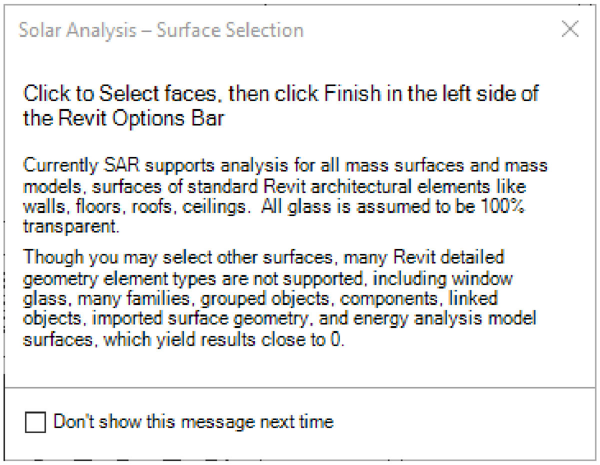


Figure 4.5: User selection for Solar analysis results

Below is an example of using the “user selection” option to select the inside floor surface to see how the “Model In-Place” shade device is affecting that surface, see Figure 4.6. This is comparing two shade devices vs a single shade device.

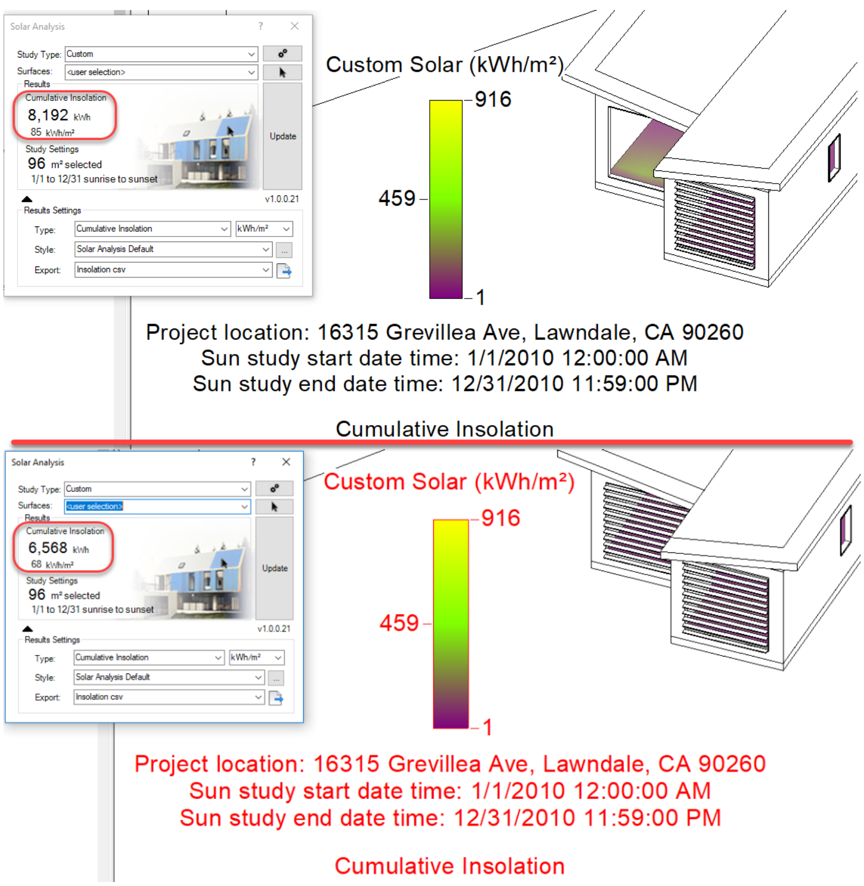


Figure 4.6: Solar analysis results showing how the shade device is affecting the interior floor surface

Create Shade Device

We will go through the process of developing the shade device for a solar analysis. Open “Floor Plans – Level 1” on the project browser. Generate a section going through one of the rooms, name it “Shade Device”, see Figure 4.7.

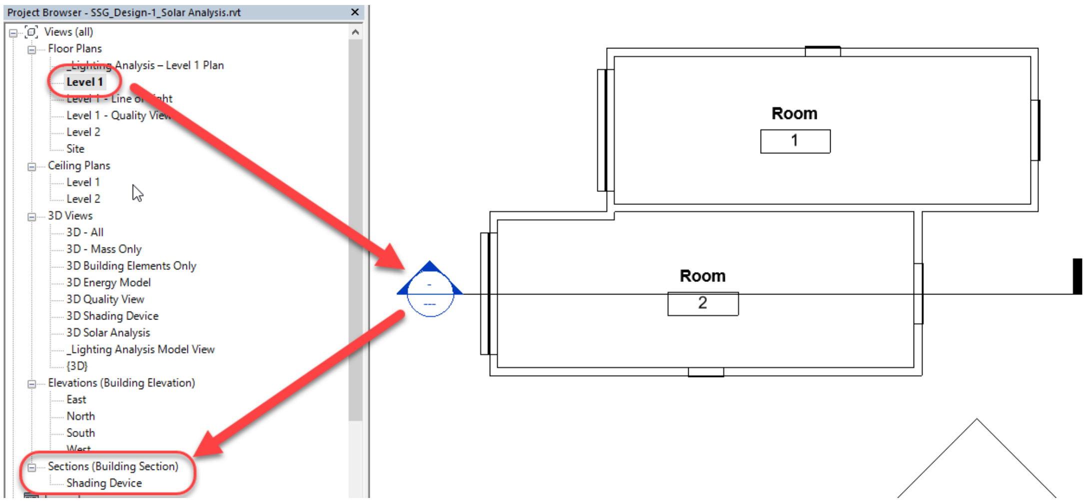


Figure 4.7: Create section in Level 1 view and name it

Model In-Place

On the ribbon go to the Architecture tab and select the “Component” drop-down, select “Model In-Place”. Scroll down and select the “Windows” category and select Ok, name it “Shade Device”, and select Ok, see Figure 4.8.

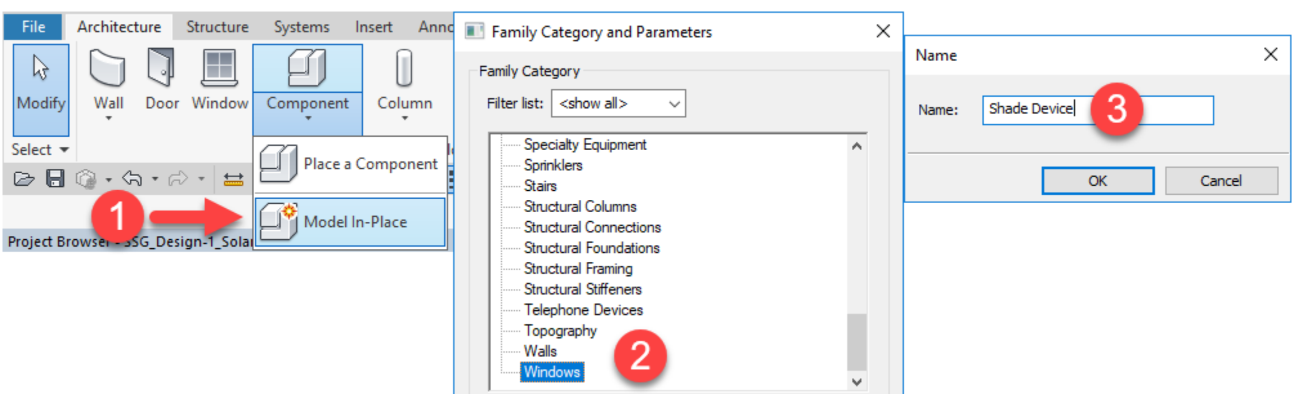


Figure 4.8: Create model in-place

Reference Plane

Staying in the “Level 1” view, on the “Create” tab select “Reference Plane” draw it along the edge of the window, name it “Shade Device 1”, see Figure 4.9.

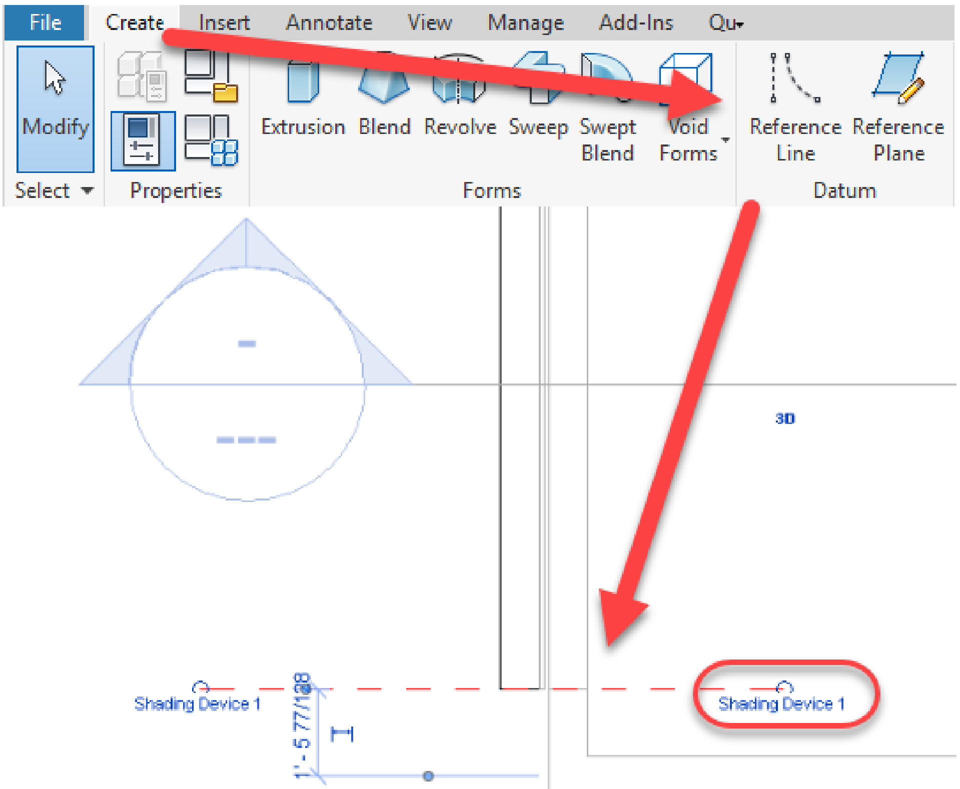


Figure 4.9: Create reference plane

Create Shape

Open the section that you created earlier called "Shade Device". On the "Create" tab select "Extrusion", select "Set" so the "Reference Plane: Shading Device 1" is current, now draw a 8" x 1" rectangle for the shade device. Once done, on the ribbon select the "Finish Edit Mode" check mark, see Figure 4.10.

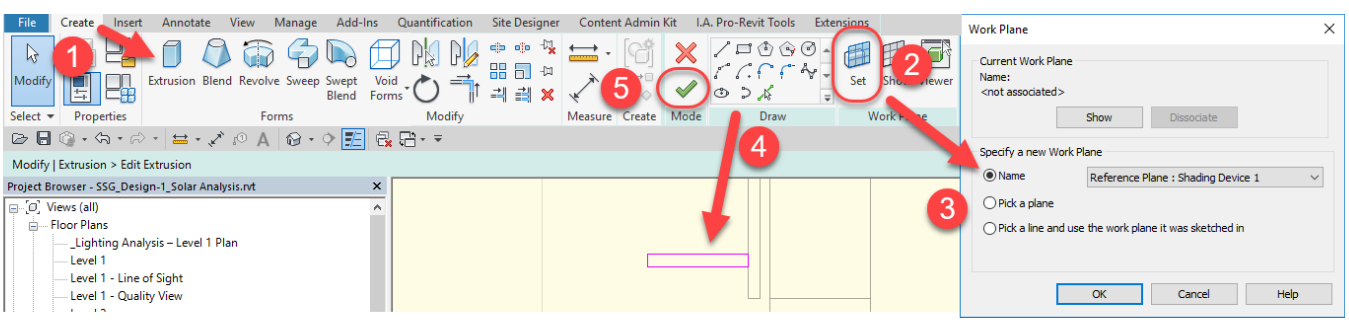


Figure 4.11: Create shade device shape using extrusion

Modify Extrusion

Open the "Default 3D" view and notice the extrusion is not fitting the window. You can either use the "Align" tool to align the edges or you can select the extrusion and use the Properties palette to change the length, see Figure 4.12.

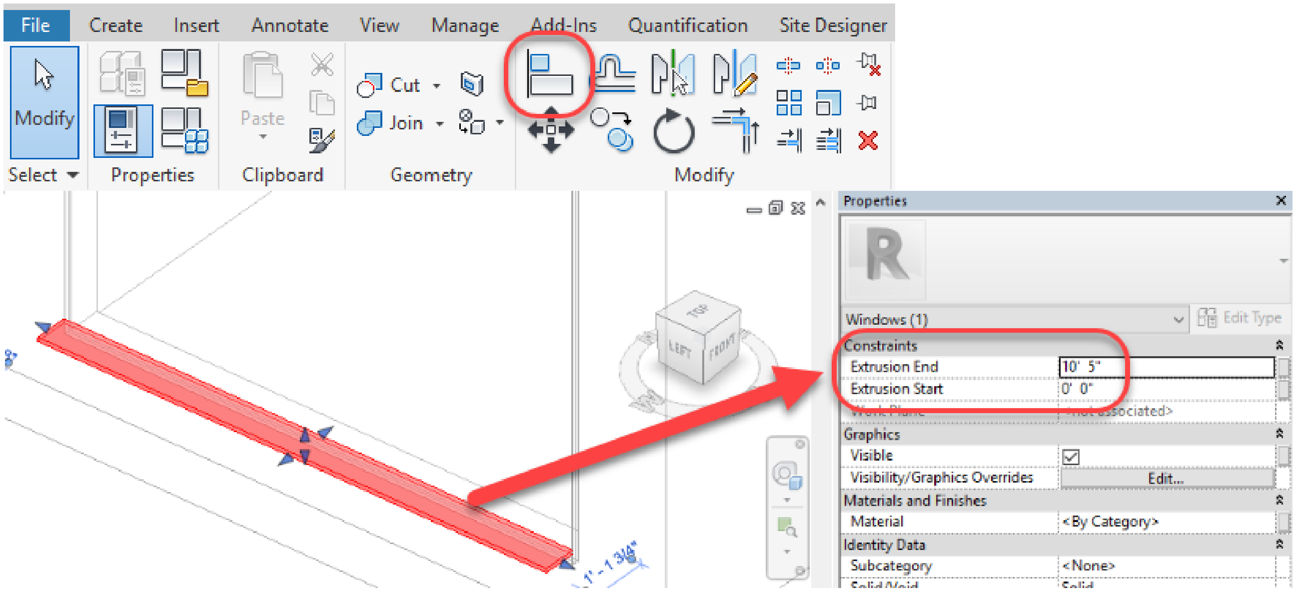


Figure 4.12: Modify extrusion to better fit the window width

Array Extrusion

This last step is using the “Array” to create multiple copies of the extrusion. The benefit of doing this is you can go back to one of the extrusions, change the shape, and all of them will update.

Go back to the “Shading Device” section view. Select the extrusion and on the ribbon select the “Array” tool. On the “Option Bar” change the number to “12” and switch the “Move To:” to the option of “Last”, see Figure 4.13.

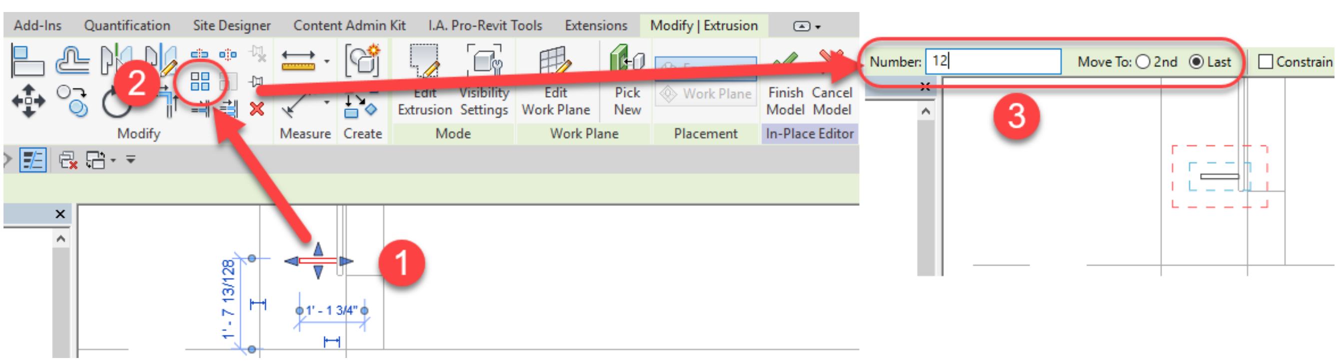


Figure 4.13: Starting the array tool and defining the settings

Select a point near the first extrusion edge, now select a point near the top of the window. Notice you now have “12” extrusions to represent the shading devices. You can change the number any time to update the array. On the ribbon select “Finish Model” and go to the “Default 3D” view, see figure 4.14.

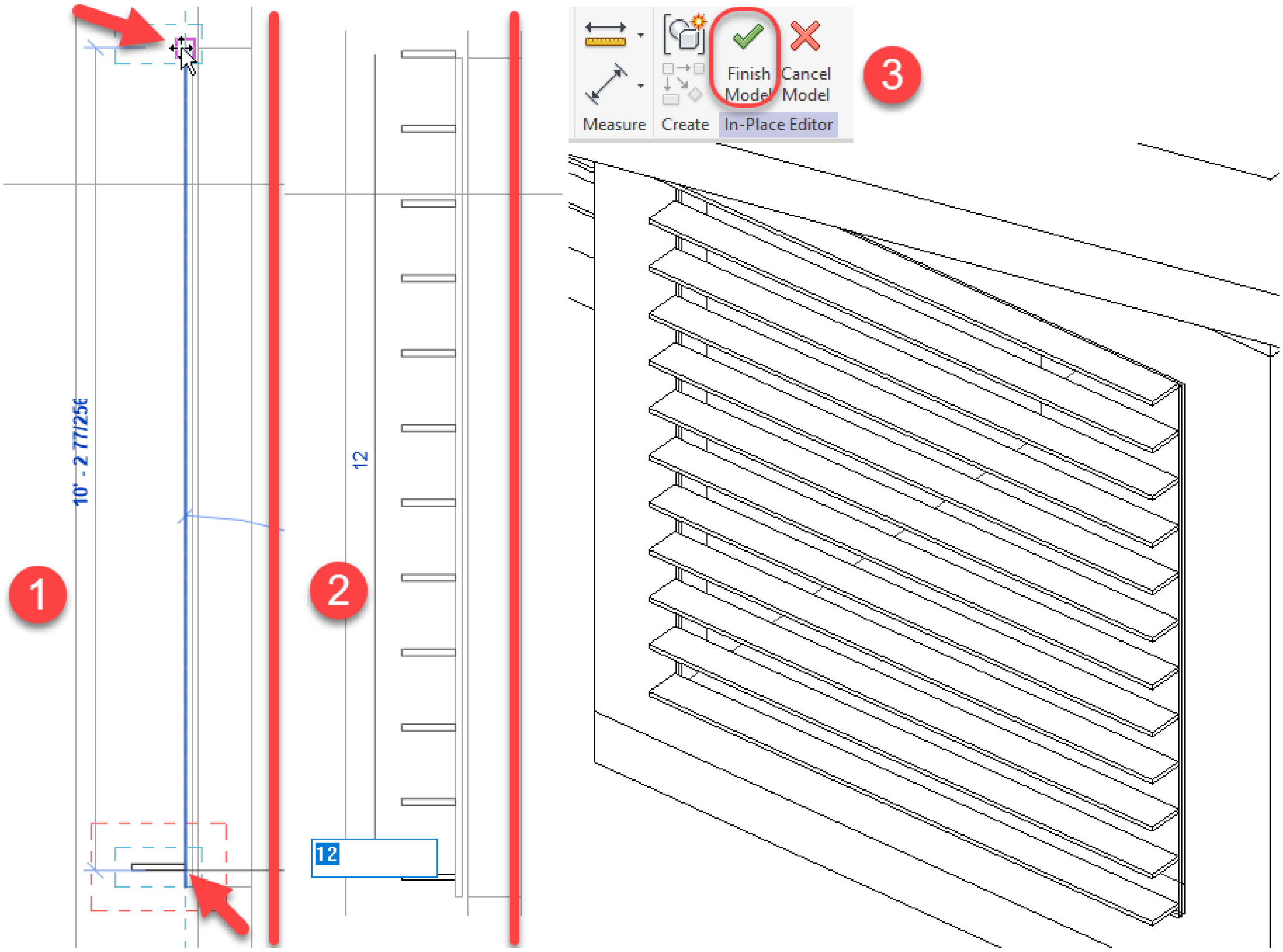


Figure 4.14: Defining the two points and finishing the array tool

Modify the Shade Device

If you ever need to redefine the shape or how many extrusions just select the array and, on the ribbon, select “Edit in-Place”. Now you can select one of the extrusions to change how many or on the ribbon select “Edit Group” to modify the extrusion, see Figure 4.15.

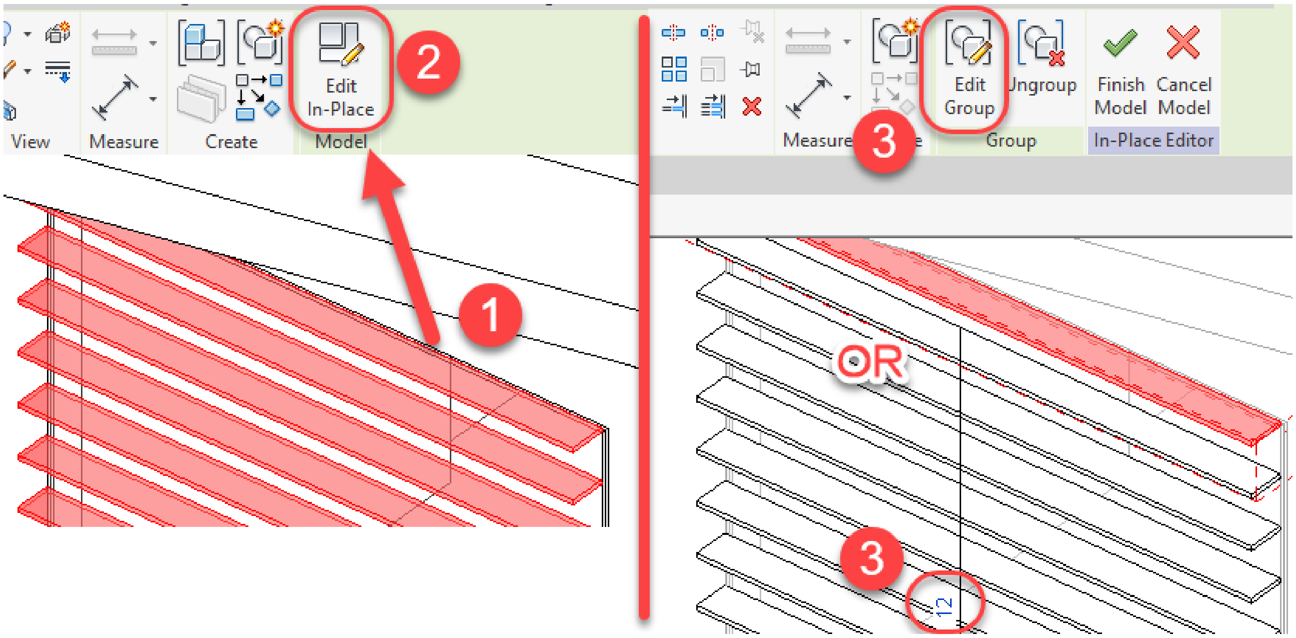


Figure 4.15: Modify the array

Shade Device Solar Analysis

Open the "Default 3D" view, if you want to run a before and after analysis with the shade devices, select the shade devices and on the "View Bar" select the "Temporary Hide/Isolate" and select "Hide Element", see Figure 4.16.

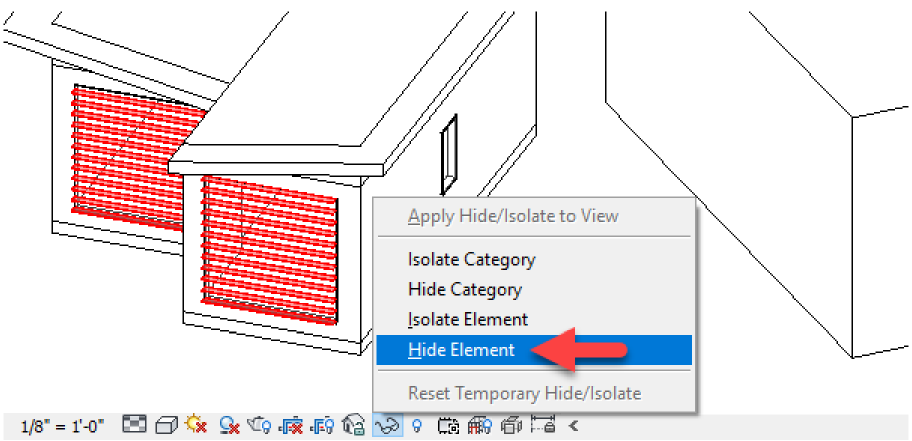


Figure 4.16: Hide shade device for solar analysis

Select Surface

On the ribbon select the "Analyze" tab, select the "Solar" tool. Change "Study Type" to "Custom", change "Surfaces" to "User Selection", and select the "Arrow" icon. A dialog box will appear telling you what can used for surfaces, select the "X" in the top right corner. Select the interior floor surface and select "Finish" on the "Options Bar", see Figure 4.17.

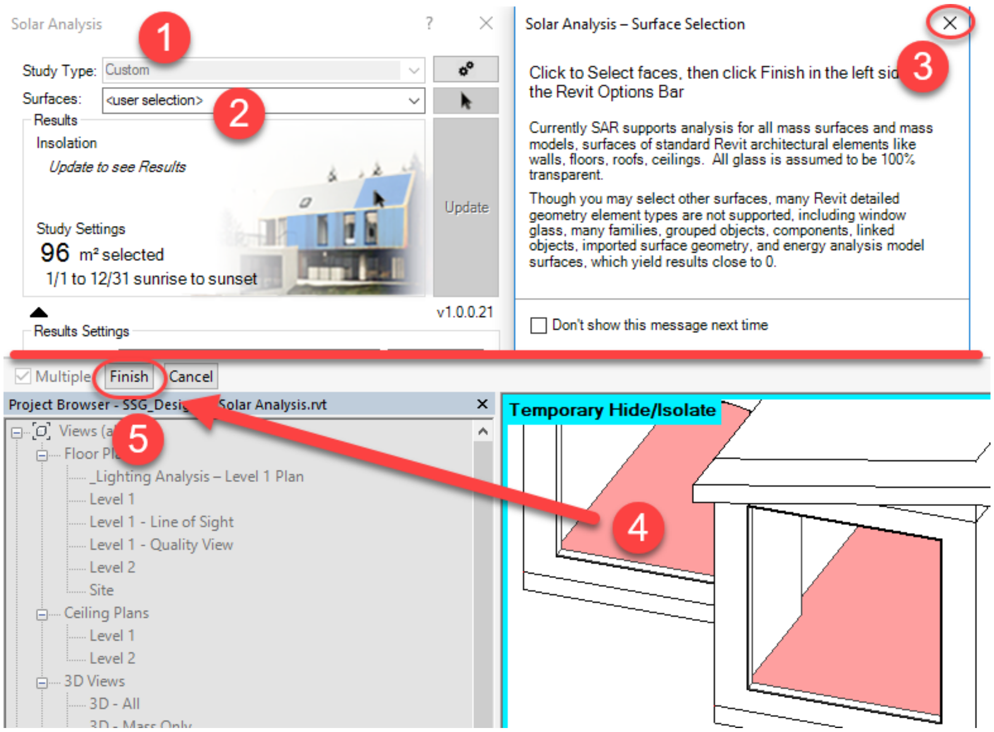


Figure 4.17: Changing the settings and selecting the inter floor surface

No Shade Device Results

For the “Result Settings’ change the “Type” to “Cumulative Insolation” along with the “Style” to “Solar Analysis Default”. Now select the “Update” button to see the results, see Figure 4.18.

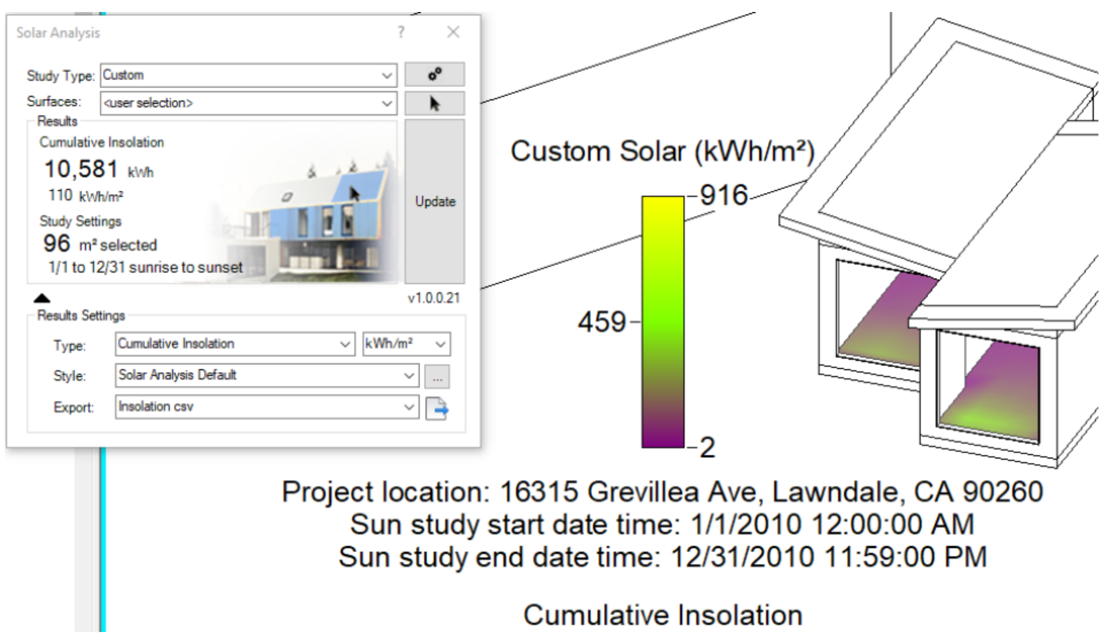


Figure 4.18: Results with no shade device

Shade Device Results

On the "View Bar" select "Temporary Hide/Isolate" and select "Reset Temporary Hide/Isolate" so the shade devices are shown again. If the previous analysis is still shown select the edge of the interior floor and use "Delete" to start over, see Figure 4.19.

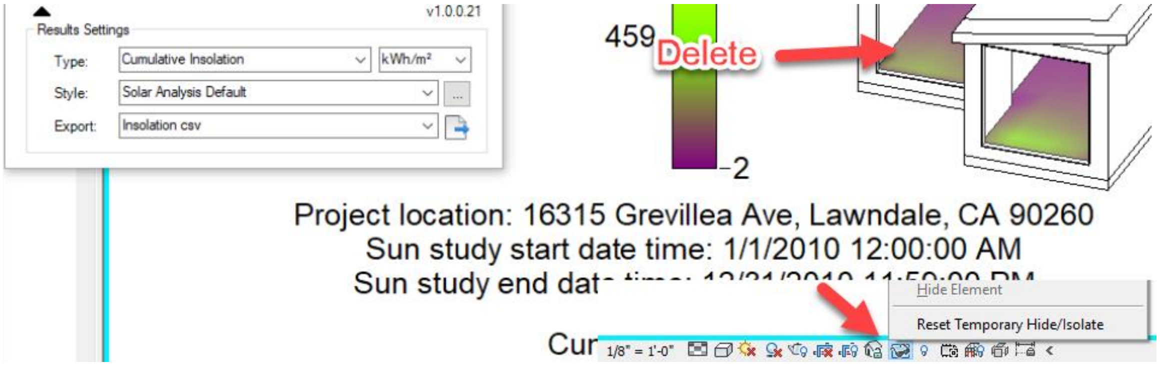


Figure 4.19: Reset isolate to see shade device and delete the old analysis

Repeat the same process as before using the same settings and use the "Update" button to see the new results with the shade device as part of the analysis, see Figure 4.20. This shows the difference between the two designs with and without the shade devices.

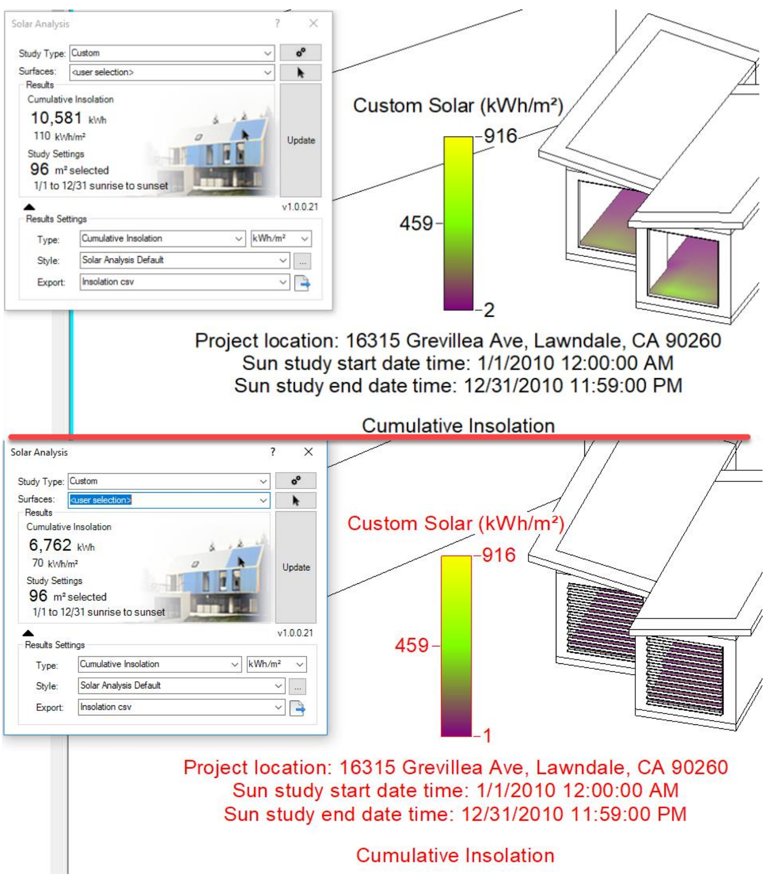


Figure 4.20: Comparison between with and without shade devices

Managing Results

Insight Solar Analysis results are visible in 3D views only and are not saved with the Revit file. To access results after closing a model, it is suggested to set up 3D views with the preferred dates and times preset, so you can quickly generate results for studies.

Customizing Analysis Visual Styles

For all analysis types, default analysis display styles are used to visualize results. The steps below will allow you to modify these or create your own. In a view that has visible analysis results, on the “Properties” palette, select the […] for “Default Analysis Display Style”.

The styles on the left are all default styles. Select any one of these to see change the visualization style in the current view. To create your own style, select “New” and give it a name, for solar analysis results, “Colored surface” and “Markers with text” are the styles that should be used, see Figure 4.21.

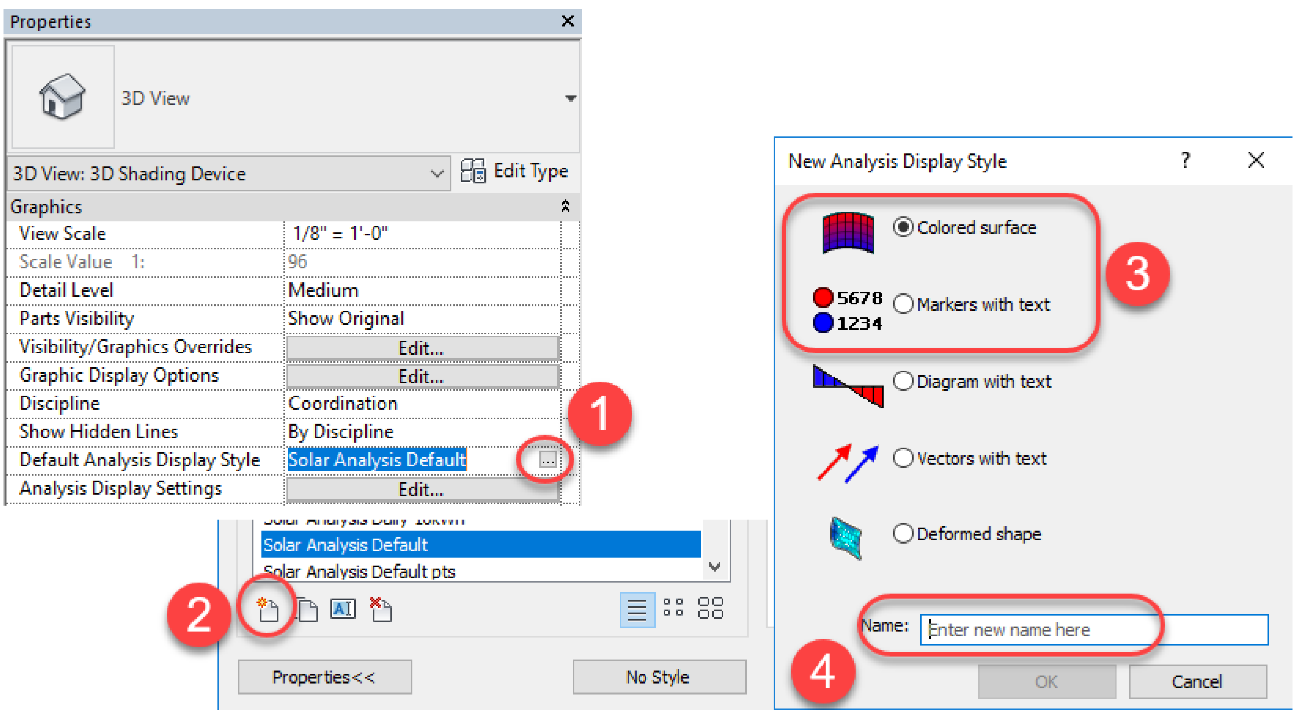


Figure 4.21: Create new display style

Control the “Settings”, “Color”, and “Legend” in the respective tabs. Adding values associated with specific colors will allow you to highlight specific thresholds, see Figure 4.22.

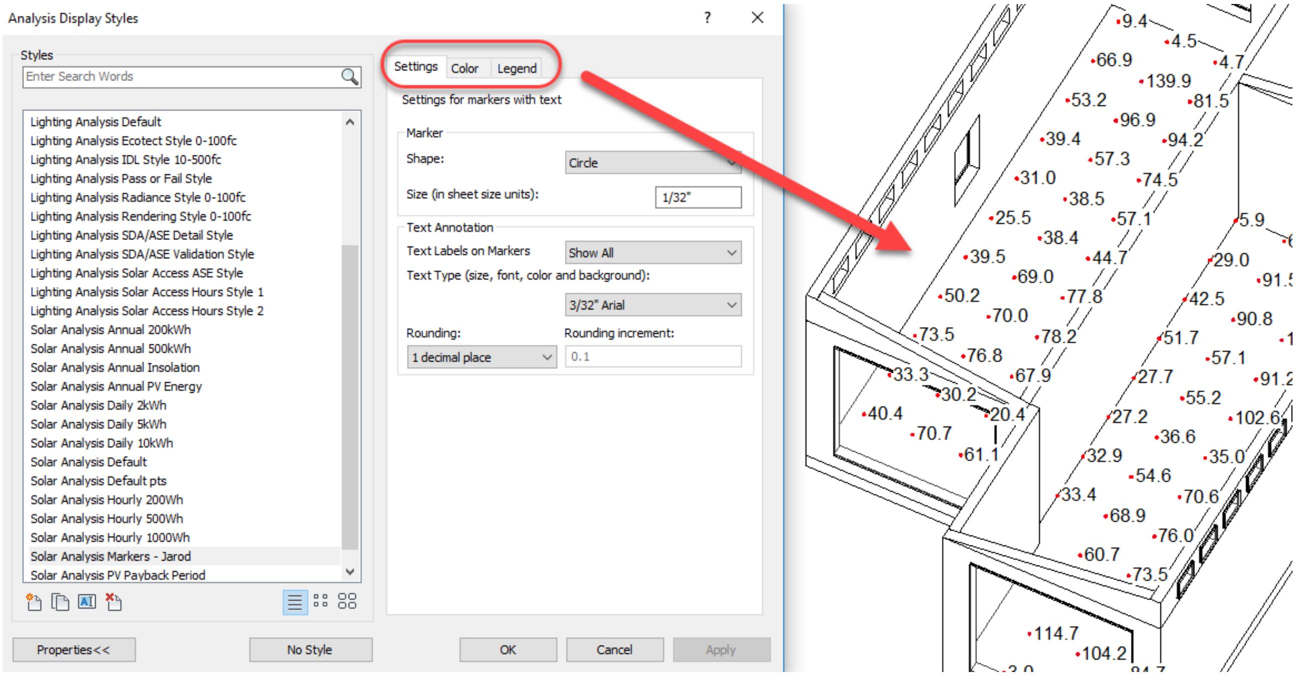


Figure 4.22: New display style applied to analysis

Exporting Results

Once results have been generated in your 3D view, you can export analysis point location and associated data as a CSV. Selecting "Export" will prompt you to name the CSV and specify a file destination. The resulting CSV will produce a summary of the simulation and list values of individual analysis points and their location in the model, see Figure 4.23.

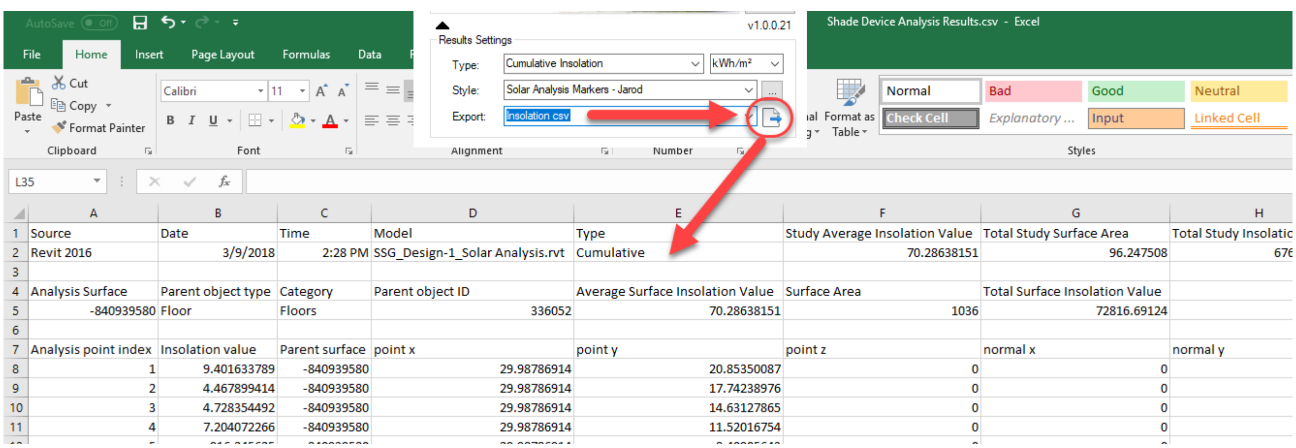
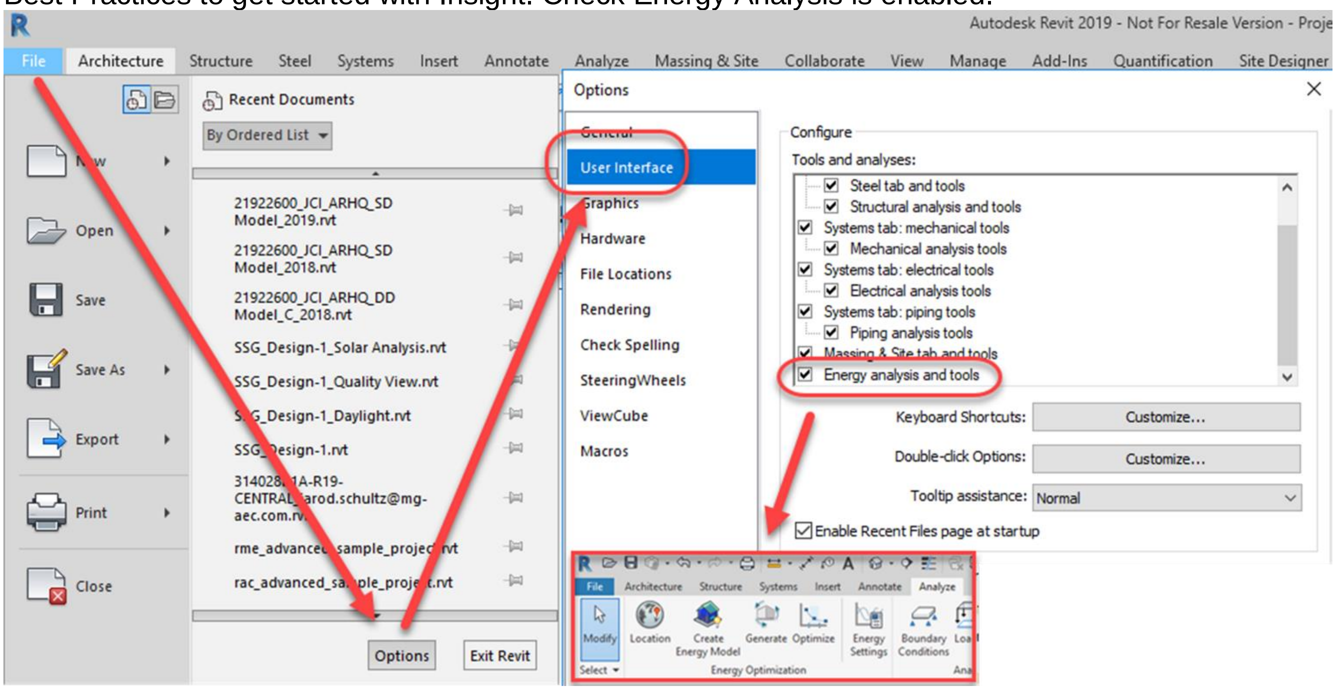


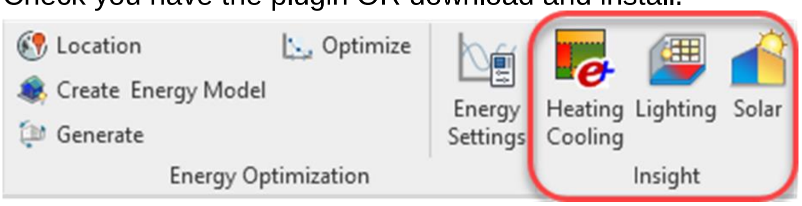
Figure 4.22: Exported results to an Excel spread sheet

How to Get Started

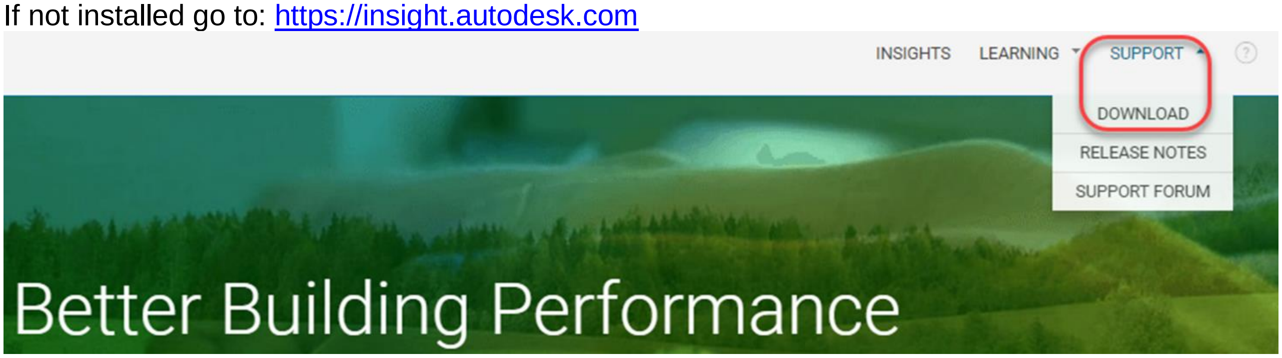
Best Practices to get started with Insight. Check Energy Analysis is enabled.

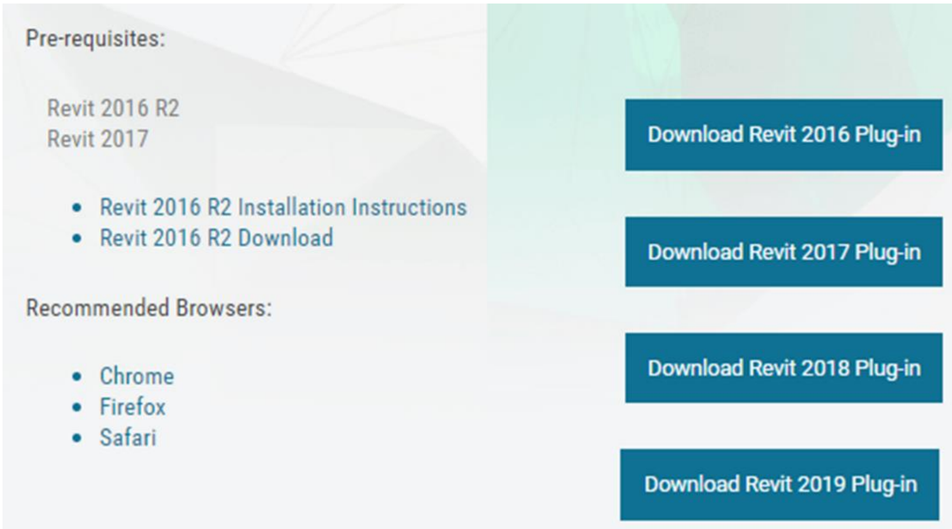


Check you have the plugin OR download and install.

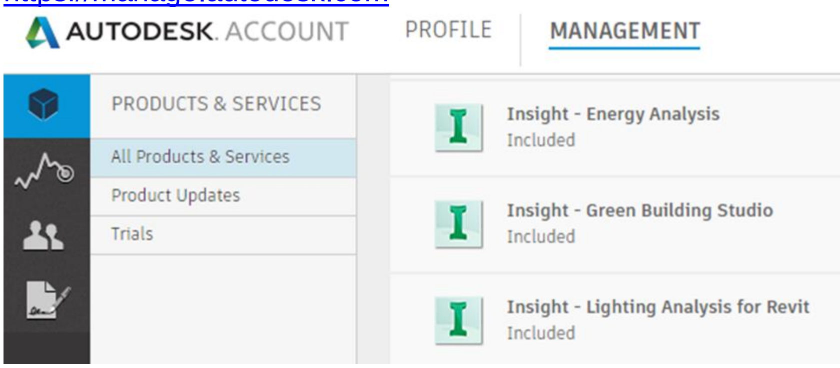


If not installed go to: https://insight.autodesk.com

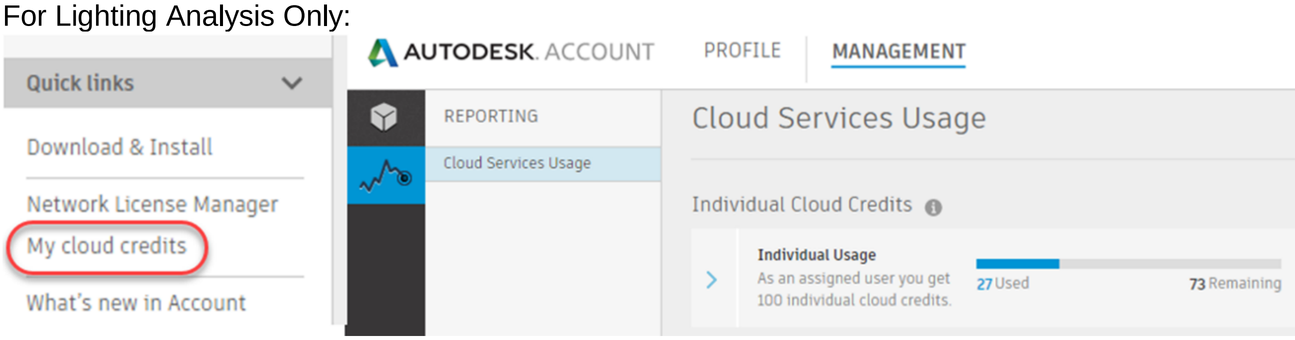




Check if you have entitlements (and cloud credits for Lighting Analysis). Go to: https://manage.autodesk.com



For Lighting Analysis Only:

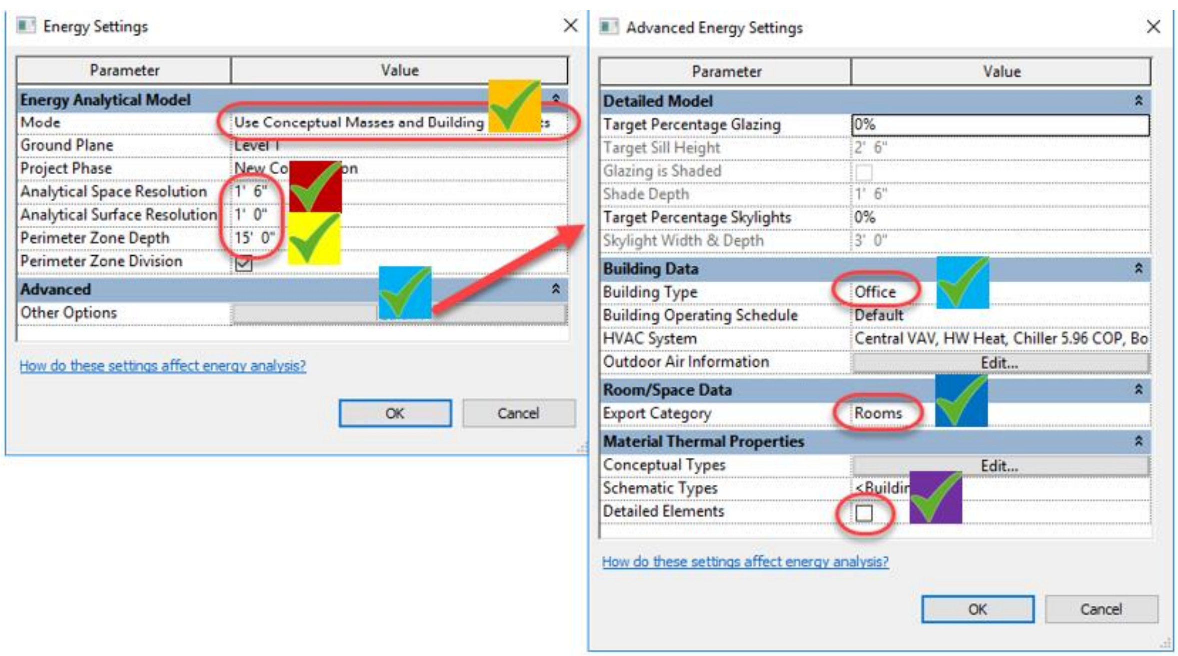


1. ALWAYS set model to 'Use Conceptual Masses and Building Elements'
2. Start with the default Analytical Space and Surface Resolution
3. Set Perimeter Zone Depth Y/N?
4. 'Advanced' Options:

a) Set Building Type

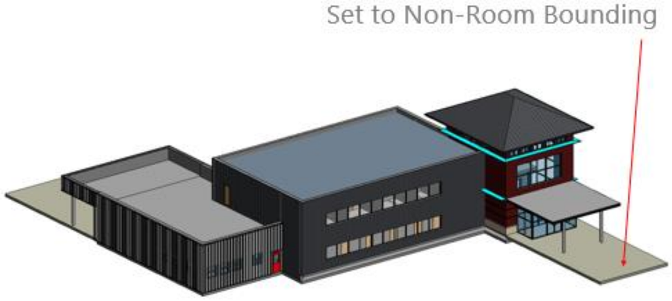
b) Room/Space Data

c) Disable Detailed Element Material Thermal Properties



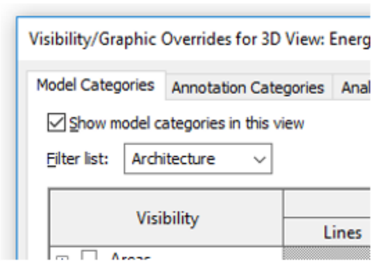
Create a new 3D view and isolate key architectural elements used.

Set to Non-Room Bounding



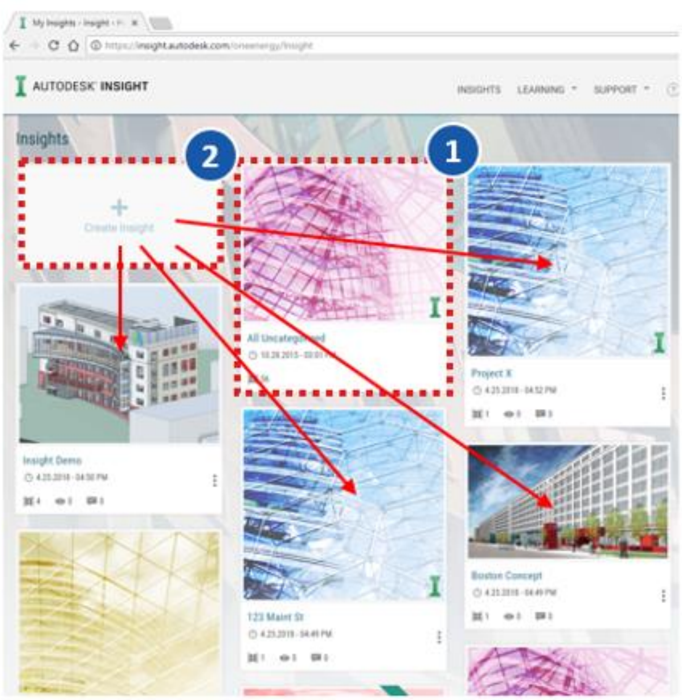
The purpose of the view is to enable a visual check.

Disable unnecessary elements (optional but faster processing). [LINK]



- ✓ Ceilings
- ✓ Columns
- ✓ Curtain Panels
- ✓ Curtain Wall Mullions
- ✓ Doors
- ✓ Floors
- ✓ Mass
- ✓ Roofs
- ✓ Shaft Openings
- ✓ Site: Pads
- ✓ Structural Columns
- ✓ Walls
- ✓ Windows

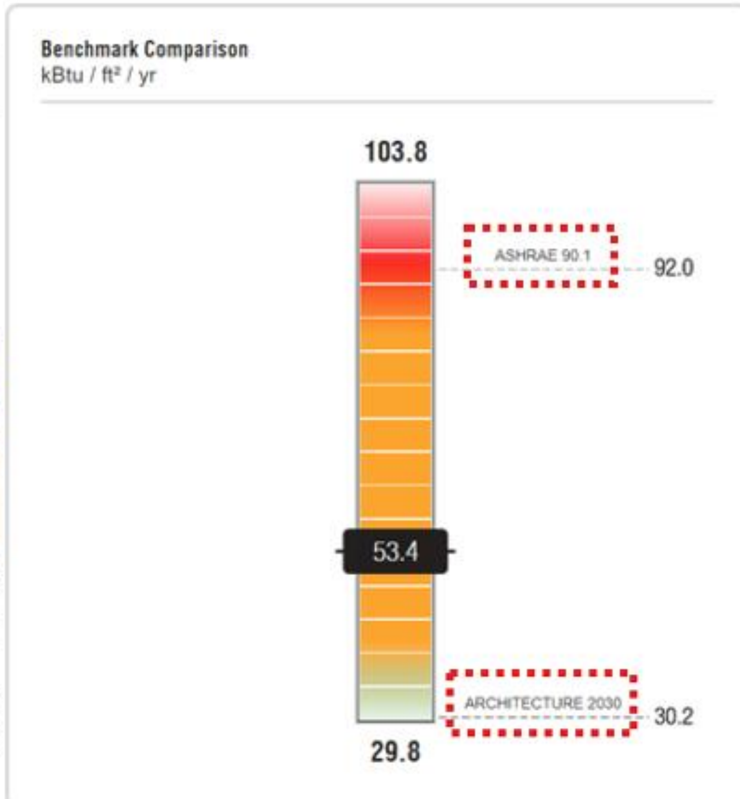
- 'Uncategorized' vs 'New Insight' ✓
- Model Menu → Rename, Move etc. ✓



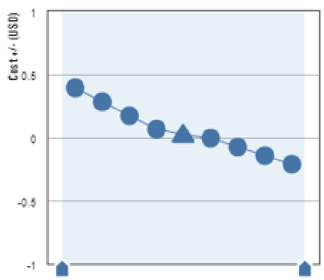
1 New Models go to 'Uncategorized' by Default

2 Use 'New Insight' to Store as Required e.g. by Project or Design Stage

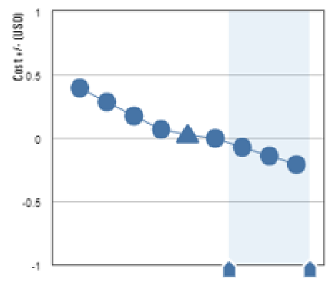
- Use Energy Cost or Energy Use (EUI)? ✓
- Benchmark Comparison ✓



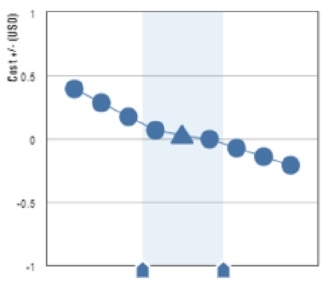
- The 'BIM' Setting and Energy Range Paradigm ✓
- Explore Opportunity & Embrace Uncertainty! ✓



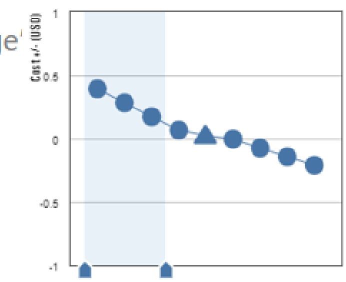
'Full Range / Unknown'



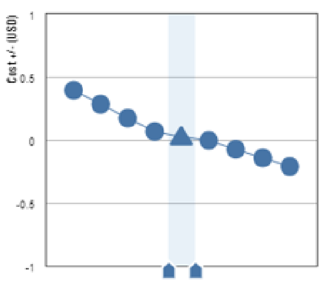
'High Performance Range'



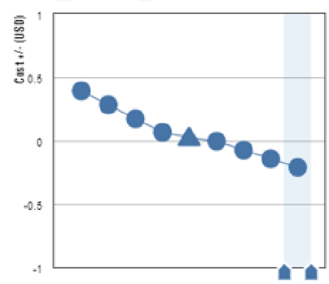
'Mid Performance Range'



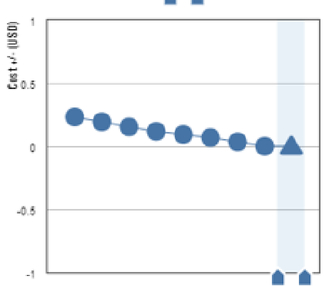
'Low Performance Range'



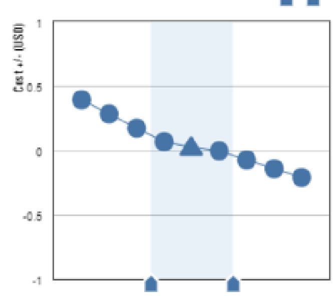
The 'BIM Setting'



Other Single Point



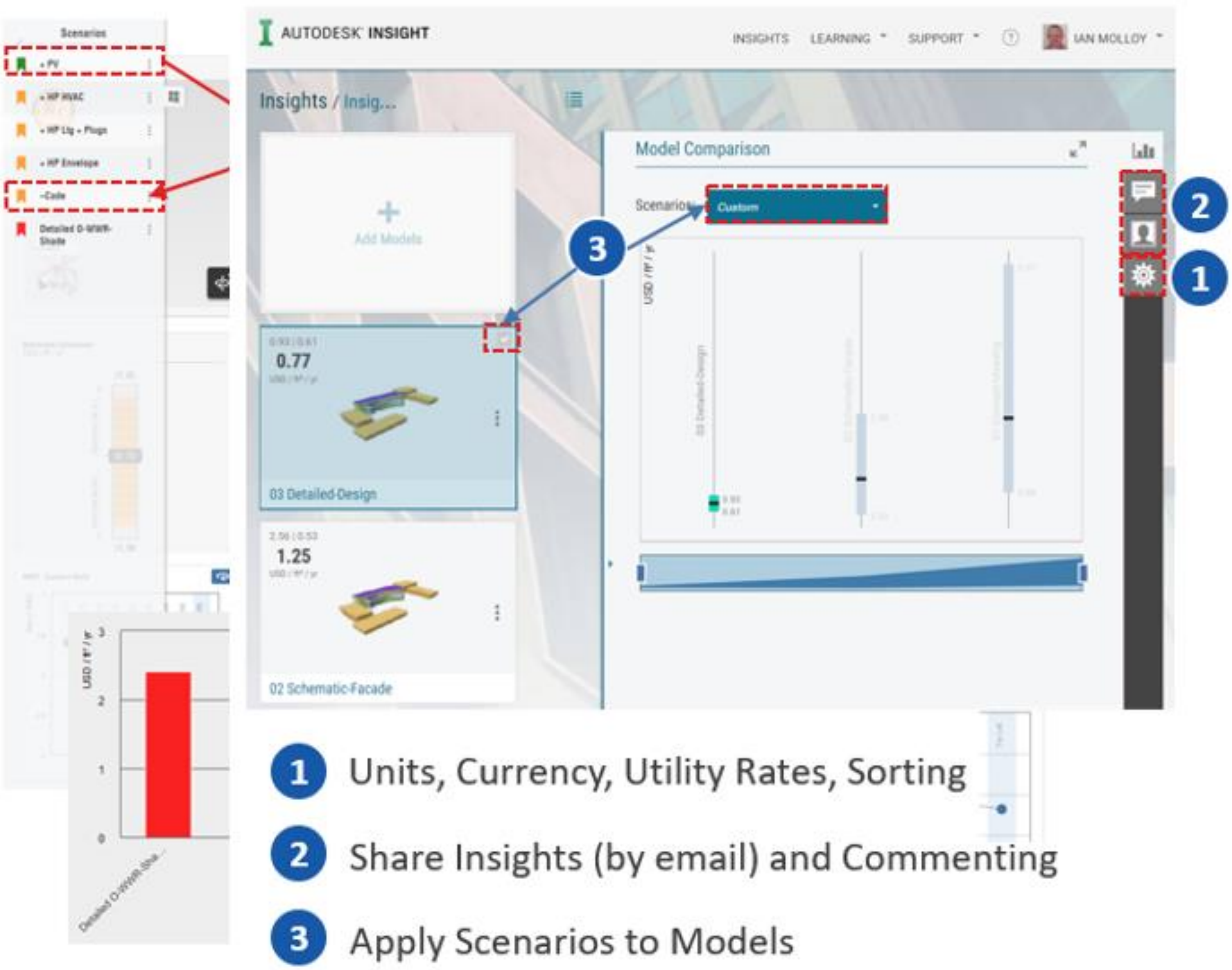
New 'BIM'



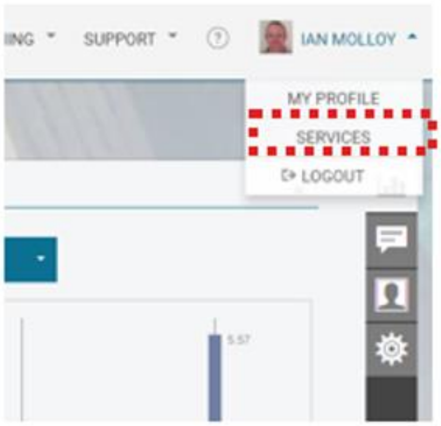
If in Doubt...
Use a Range

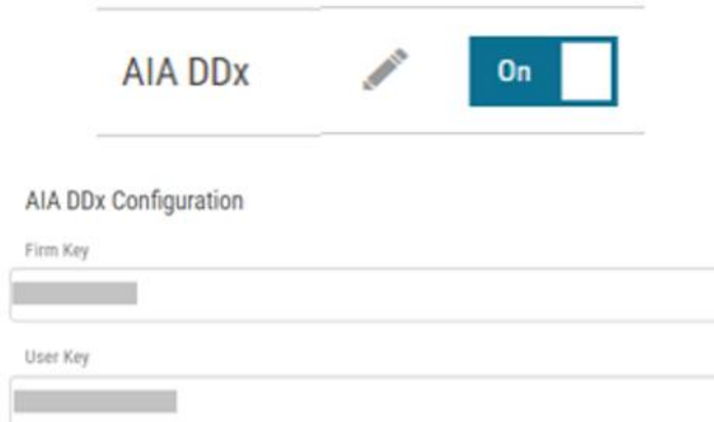
- Use Scenarios and Scenario Compare ✓
- Use Model Compare – Settings, Members, Comments & Scenarios ✓

A 'Scenario' is a Saved Combination of Factor Settings



- Export options incl. AIA 2030 DDx ✓





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for your firms key (free)