Dynamic Energy Optimization with Revit® and Insight 360

Daniel Stine, LHB

Class Description

This presentation will cover tools and features needed to do high performance building analysis at various phases within the design process. A lot has changed in recent versions and the options can be a little confusing as they overlap some of the MEP specific options. Plus the new Autodesk Insight 360.

About the Speaker:

Daniel John Stine, CSI, CDT is an author, instructor, BIM manager, and architect with 24 years of experience. Working full-time at LHB, a 250-person multidiscipline firm in Minnesota, Daniel provides training and support for all disciplines of Autodesk® Revit® (Architecture, Structure and MEP), AutoCAD® Civil 3D®, and AutoCAD. He currently teaches Revit to architecture and interior design students at North Dakota State University (NDSU). Leveraging his professional and academic experience, Daniel has also written the following textbooks: Interior Design using Revit 2017, Design Integration using Revit 2017 (Architecture, Structure and MEP), Architectural Commercial Design using Revit 2017, Residential Design using Revit 2017, Residential Design using AutoCAD 2017, Commercial Design using AutoCAD 2013, Chapters in Architectural Drawing; Hand Sketching in a Digital World, Hand Sketching, Adobe Photoshop and Google SketchUp for Interior Designers and SketchUp 2013 for Interior Designers.

High performance design is an important aspect of building design. LHB, the Minnesota based firm I have worked for since 2003, is actively involved in research and development in this area. The firm was involved in the development of the State's B3 Benchmarking program (required program for all Minnesota public buildings) and Regional Indicators Initiative (which collects and analyses performance metrics for entire cities). In Minneapolis, our new office was third in the state to achieve LEED CI Platinum (Commercial Interiors). Additionally, USGBC's Minnesota Chapter is located within our Minneapolis office through donated space. Finally, LHB's trademarked program, Performance Metrics™, tracks the Energy Use Intensity (EUI) of buildings we design and is used for research, validation and marketing to future clients.

Autodesk Revit has several Building Performance Analysis (BPA) tools available to those engaged in the art of building design. This presentation will provide a detailed look at the essentials of running an energy simulation from within Revit. This will include an introduction to the new **3D energy model view** in Revit 2016, the **automatic zoning** feature in Revit 2016 R2 (update for subscription customers) and an overview of **Autodesk Insight 360** cloud service that was announced at Greenbuild 2015. Finally, we will look at what's new in Revit 2017, including the new **AIA 2030 Commitment Design Data Exchange (DDx)** feature which was just announced at the AIA convention this past May in Philadelphia.

Energy Simulations within Revit

The built-in ability to run an energy simulation within Revit represents the most democratized opportunity for design professionals and students – period. If you or your firm have Revit, you have access to this feature. There are no add-ins or additional software costs. This is not to say it is free—Revit has to be on subscription, as the simulation itself is actually run in the Cloud using Autodesk's GBS engine. However, subscription is becoming the norm with Autodesk's new sales model.

Note: *Energy simulations and Insight 360 do not require cloud credits at this time.*

When getting started with the energy simulation features, you may wonder where to begin given all the settings and related commands.

Here is a basic overview of the workflow:

1. Create a Revit model using masses, building elements, or both
2. Energy Settings dialog (**Analysis** tab)
   - Set Location
   - Review *Energy Analytical Model* settings
   - All other settings are optional
3. Create Energy Model
   - *Views created:* 3D Energy Model, Analytical Spaces (Schedule), Analytical Surfaces (Schedule)
   - Use this tool to delete and recreate the Energy Analysis Model (EAM) anytime the Revit model changes
4. Visually Review Energy Model
5. Launch **Insight 360** for interactive project exploration
6. *AIA 2030 Commitment Firms: Upload results to DDx*
7. Optional Settings and Workflows

Following these steps will provide super-fast access to estimated Energy Cost and EUI information at any phase in a project. Next, we will take a detailed look at each of these steps. Understanding *what Revit wants* (subliminal plug for Luke Johnson's blog) will facilitate efficient and accurate use of this tool.

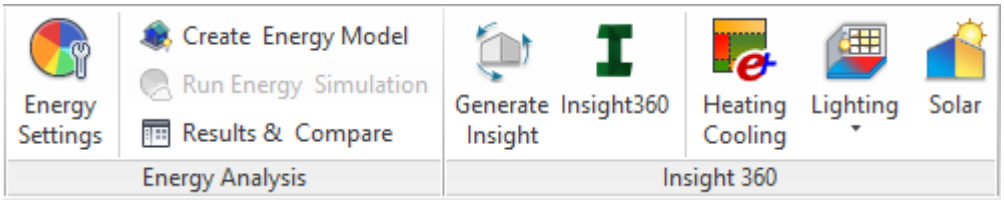


Figure 1. Energy Analysis tools on the Analysis tab in Revit 2016 R2 & 2017, plus the Insight 360 add-in.

1 Creating the Revit Model

The obvious first step is to create the model. The ideal design process would be to start with massing, quickly studying how shape and orientation impact performance. As the project develops, Revit building elements can be added to the mix for known aspects of the design, for example, curtainwall, windows, sunshades, etc. At some point, the mass elements are abandoned in favor of a more detailed model based solely on Revit building elements.

Here are a few things to keep in mind concerning Revit model creation.

Massing

When using masses, be sure to select the mass and specify the floor levels as shown in the image below—using the **Mass Floors** tool. Also, use masses to define external shades such as adjacent buildings, just don't specify a mass floor for them. The Revit project must have at least one mass with mass floors assigned to create a valid Energy Analysis Model (EAM).

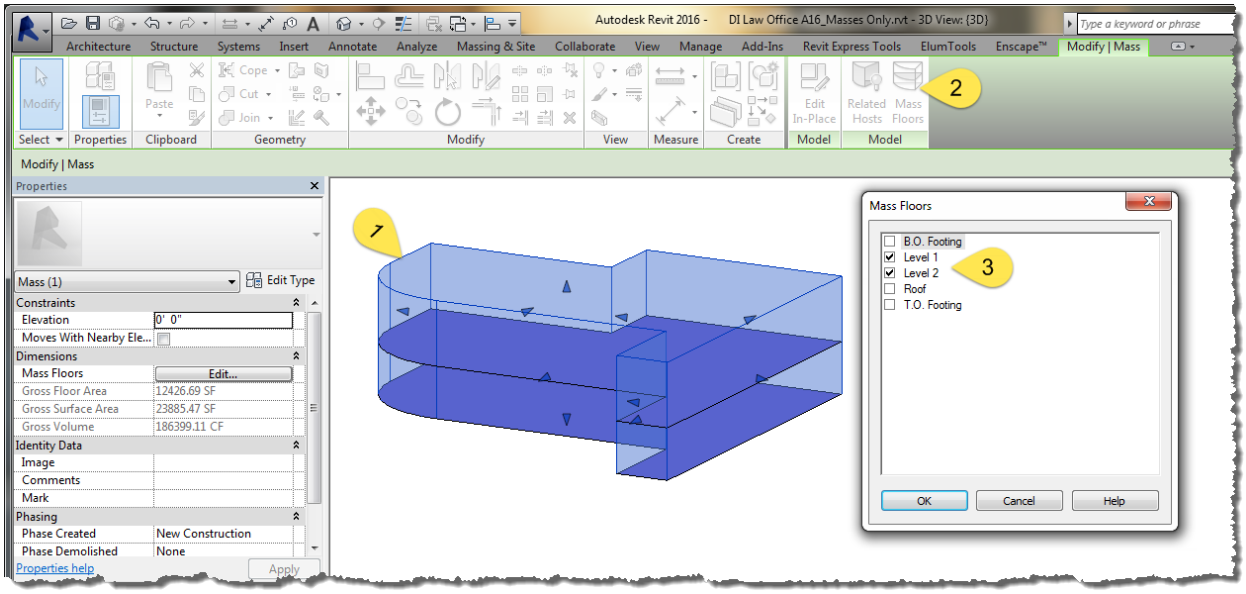


Figure 2. Masses must have 'mass floors' specified to create a valid EAM.

Combined Massing and Building Elements

The image below is an example of using massing and building elements together. This example makes the glazing size and locations explicit rather than being generically based on a percentage of surface area and fixed sill height (Figure 3).

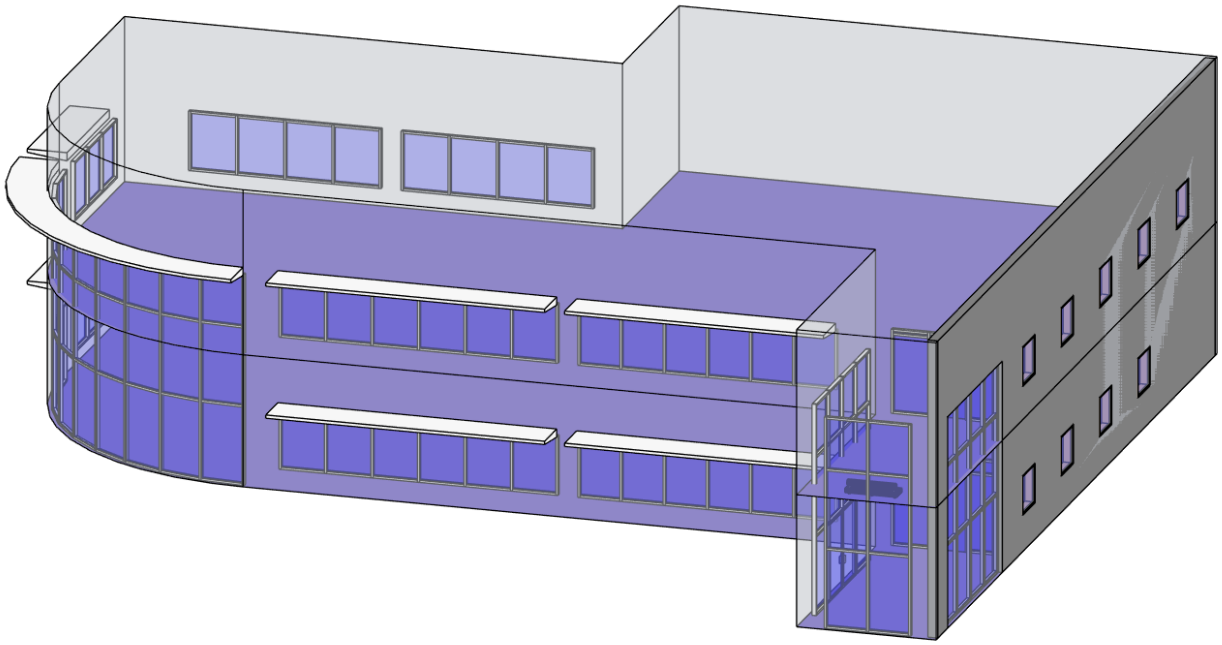


Figure 3. Masses and Building Elements used together in energy analysis.

Another example might be to use masses to study future expansion in the context of an existing Revit model (Figure 4). When you get to the point in the design where you need to add masses to create sloped walls (e.g., using the **Wall by Face** tool), then it is time to stop using masses in the energy analysis. It is not possible to include some masses and exclude others.

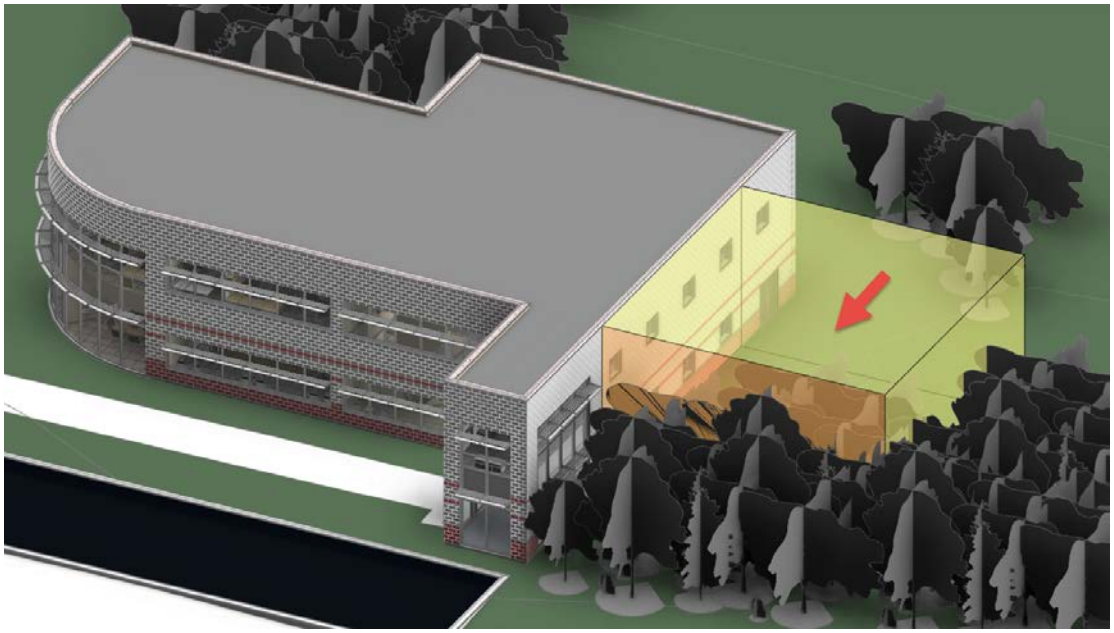
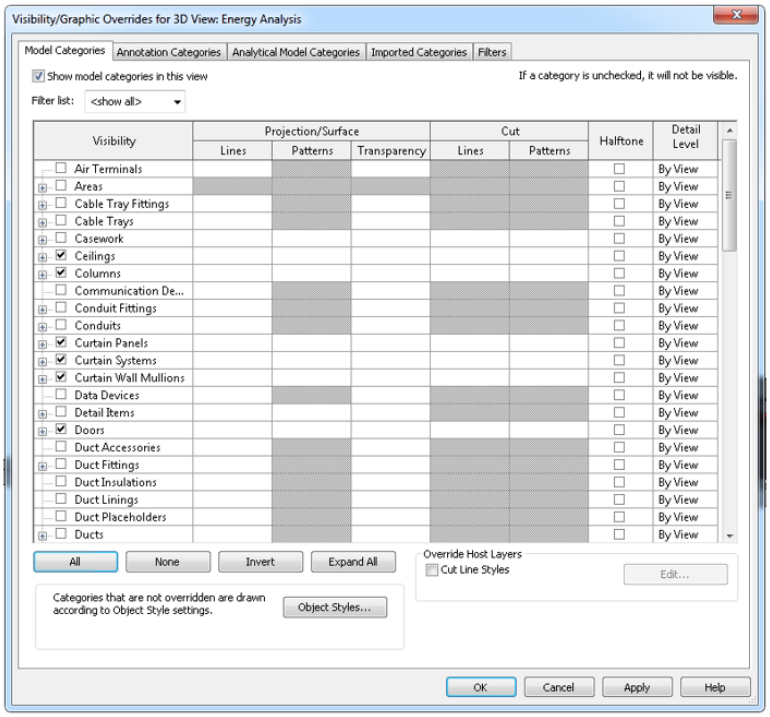


Figure 3. Masses and Building Elements used together in energy analysis.

Building Elements

Most Revit models can be used to create a decent EAM. The elements listed in the image below (Figure 5), when set to **Room Bounding**, are used in the EAM creation.



√ Ceilings
√ Columns
√ Curtain Panels
√ Curtain Systems
√ Curtain Wall Mullions
√ Doors
√ Floors
√ Roofs
- √ Common edges
- X Fascias
- X Gutters
- √ Hidden Lines
- √ Interior Edges
- √ Roof soffits

√ Shaft Openings
√ Site
- X Hidden Lines
- X Landscape
- √ Pads
- X Project Base Point
- X Property Lines
- X Stripe
- X Survey Point
- X Utilities

√ Structural Columns
√ Walls
- √ Common Edges
- √ Hidden Lines
- X Walls Sweeps – Cornice

√ Windows

Figure 5. Building elements used in EAM creation; some sub-categories are not included.

The tricky thing is dealing with aspects like sun shades as they are often modelled as Generic Model. As seen in the list above, this category is not used, as it could contain any number of irrelevant items. Also note that doors are recognized but converted to walls in an effort to simplify the EAM.

The EAM will also include elements, set to **Room Bounding**, contained within *linked models*—as long as the linked model itself is set to Room Bounding in the host model—an **Edit Type** property.

2 Energy Settings

In the **Energy Settings** dialog, which has been streamlined in Revit 2017, there is one critical setting related to running the simulation and a few more that must be considered to generate a valid EAM. To study the real-time impact on overall performance, all other inputs can be adjusted in the cloud later.

The Energy settings essential to a valid Energy Simulation are:

- Location

The Energy settings essential to creating a valid Energy Analysis Model (EAM):

- Analysis Mode
- Ground Plane
- Project Phase
- Analytical Space Resolution
- Analytical Surface Resolution
- If using masses (separately or in conjunction with building elements)
  - Perimeter Zone Depth
  - Perimeter Zone Division

In Revit 2017, these important parameters have been separated from the secondary options. The Energy Settings dialog is now split into two. The first dialog shown, see the image to the right (Fig. 6), presents the more essential parameters, while the Other Options "Edit..." button opens the secondary dialog where optional settings can be adjusted.

Now let's take a look at each of these settings to better understand what they do and why they are important.

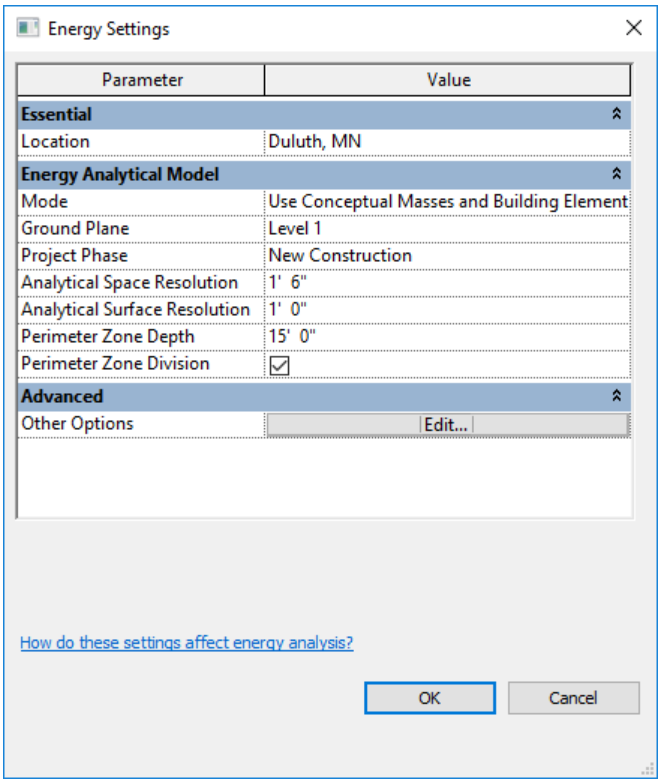


Figure 6. New Energy Settings dialog

Location

The **Location** setting provides *localized weather and utility data* which is vital in creating a legitimate energy simulation. There are two steps involved in accurately specifying location; **Project Address** and **Weather Station**.

Project Address specifies the project location on earth. This can be a city, a specific postal address or Lat/Long values. If the project site does not have an address, enter the City name and then drag the Project Location Pin (red) to the desired location on the map. You can zoom and pan in this map view as well as make the dialog larger.

Once the geographic location has been specified, the **Weather Station** options should be evaluated. Revit will automatically select the closest option, but this may not always be the best selection. Consider the example shown in the image below (Figure 7). In my location, two of the closest stations have an 800 foot elevation difference. Additionally, depending on project location in this area, one of the two buoy-based weather stations may be closest—which would not be ideal (this is the largest freshwater lake in the world).

FYI from Autodesk's help page:
"Weather stations include 'actual year' virtual weather stations and typical year weather stations (TMY2 and other formats) based on 30-year averages of weather data, typically taken from airport locations."

Don't bother to change anything on the **Weather** tab as this data only relates to Revit's built-in, and older, Heating and Cooling Loads feature.

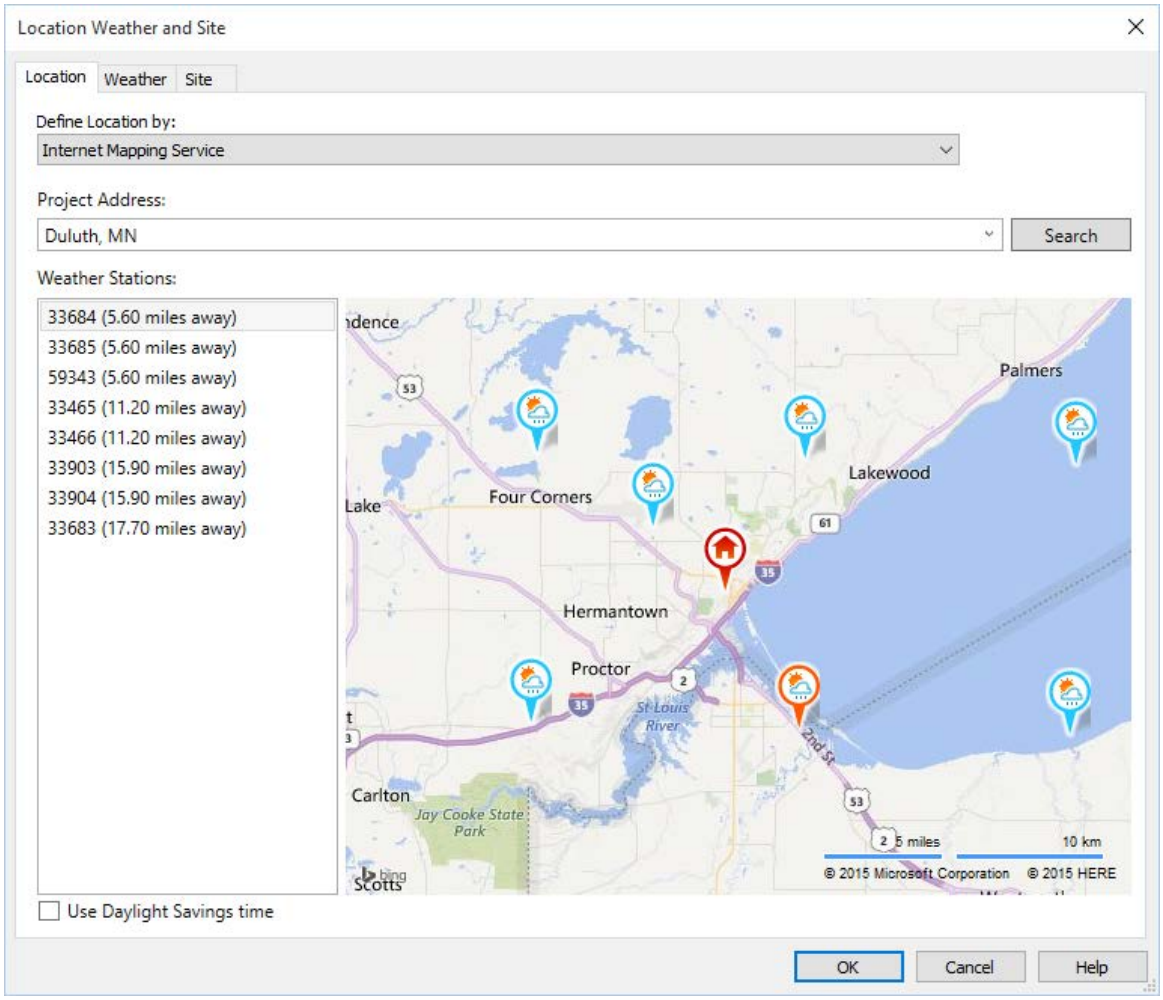


Figure 7. The Location Weather and Site dialog.

Analysis Mode

Analysis Mode determines if Revit should use Masses, Building Elements, or both to create the EAM.

The Analysis Mode options are:

- Use Conceptual Masses (never select this option!)
- Use Building Elements
- Use Conceptual Masses and Building Elements (new in Revit 2016)

As it turns out, the "Use Conceptual Masses" only option uses an older internal algorithm, so don't use that one. Rather, use the combined option which will work on mass-only models.

Ground Plane

Properly setting the Ground Plane parameter ensures that spaces which occur below this level are understood to be below grade by the cloud-based GBS calculation engine. For masses, the EAM will not generate glazing below the ground plane and a different construction can be selected for underground exterior walls. Keep in mind, when using Building Elements the toposurface elements are NOT used.

Project Phase

For projects with phasing—e.g., existing, new construction, phase demolished—be sure this is set correctly. The phase settings for the 3D Energy Model view have no impact on the EAM created.

EAM Creation Level of Detail

These two properties control the accuracy of the EAM when it is created:

- **Analytical Space Resolution** (default: 1'-6")
  This allows small gaps to exist in the model—both exterior and interior. Remember, Revit ignores elements in several categories such as Generic Model and In-Place families, so gaps are not uncommon.
- **Analytical Surface Resolution** (default: 1'-0")
  This setting works in conjunction with the Analytical Space Resolution setting to control the accuracy of the surface boundaries.

If portions of the Revit model are complex and not coming out right in the EAM, these values can be lowered. It is recommended that both of these values be adjusted proportionally. Lowering these values will result in a more accurate EAM but will take longer to create—the simulations will take more time to process as well. Large projects may require these values to be increased.

Automatic Thermal Zoning Settings

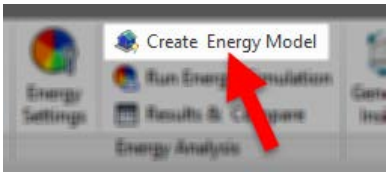
These two properties control the inclusion of space sub-divisions in the EAM:

- **Core Depth** (or Perimeter Zone Depth)
  The distance to measure inward from the exterior walls to define the core zone.
- **Divide Perimeter Zones** (or Perimeter Zone Division)
  Check this box to divide the perimeter into multiple zones.

These settings are used to divide large spaces into smaller subdivisions for more accurate simulations. These settings used to only work on masses, but, new to Revit 2016 R2, they now also apply to large spaces defined by building elements. For example, we recently worked on a 200,000sf office and warehouse building. The large warehouse space would have benefited from this subdivision feature. When creating the EAM for building elements, the interior walls are typically sufficient to naturally 'zone' the model. In these situations, set the Core Depth to zero and uncheck the divide option.

> **TIP:** For Building Element-based analysis, set the Core Depth to zero and uncheck the divide option.

3 Create/Delete Energy Model



Clicking this tool creates the analytical model, resulting in three related views created in the Revit model:

- 3D Energy Model
- Analytical Spaces (schedule)
- Analytical Surfaces (schedule)

This is a new feature added back in Revit 2016 and, as covered in the next section, allows the designer to visually validate model fidelity prior to running a simulation.

As mentioned, the analytical energy model is created from Room Bounding elements within the Revit model. The result is a simplified model consisting of surfaces somewhat analogous to a SketchUp model. By selecting surfaces and adjusting the 3D Energy Model view's visibility, the designer can make sure there are no anomalies before starting a simulation. For example, we had a project where precast panels were modelled separately and then **Edit Profile** was used, as shown in the image below (Figure 8), for an overhead door. This created a problem in the EAM as the opening was hosted by one precast panel and the adjacent voids represented significant leaks in the space—larger than the Analytical Space Resolution value.

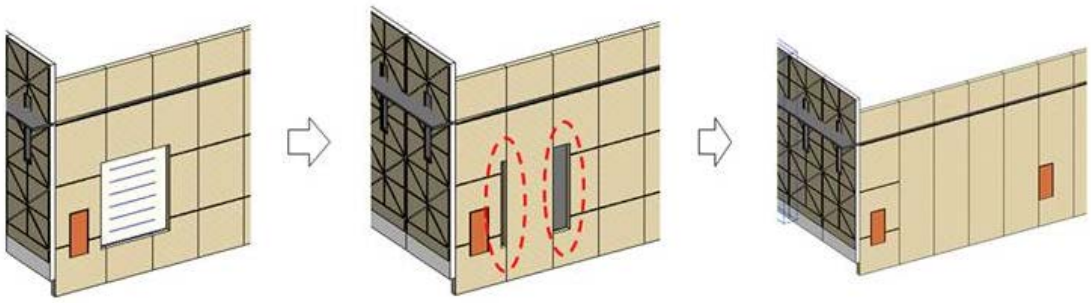


Figure 8. Problems in Energy Analysis Model due to use of Edit Profile on walls.

The next image (Figure 9) shows the categories and sub-categories in the **Analytical Model Categories** tab of the **Visibility/Graphics Overrides** dialog, automatically turned on in the 3D Energy Model view. All other categories on this tab are related to structural analysis and can be ignored.

As more analysis tools like this become available, it is important that models are created correctly. For example, ceilings should not be used for floors or floors for countertops. If thin floors are used for finishes on top of a structural floor, they should have **Room Bounding** unchecked.

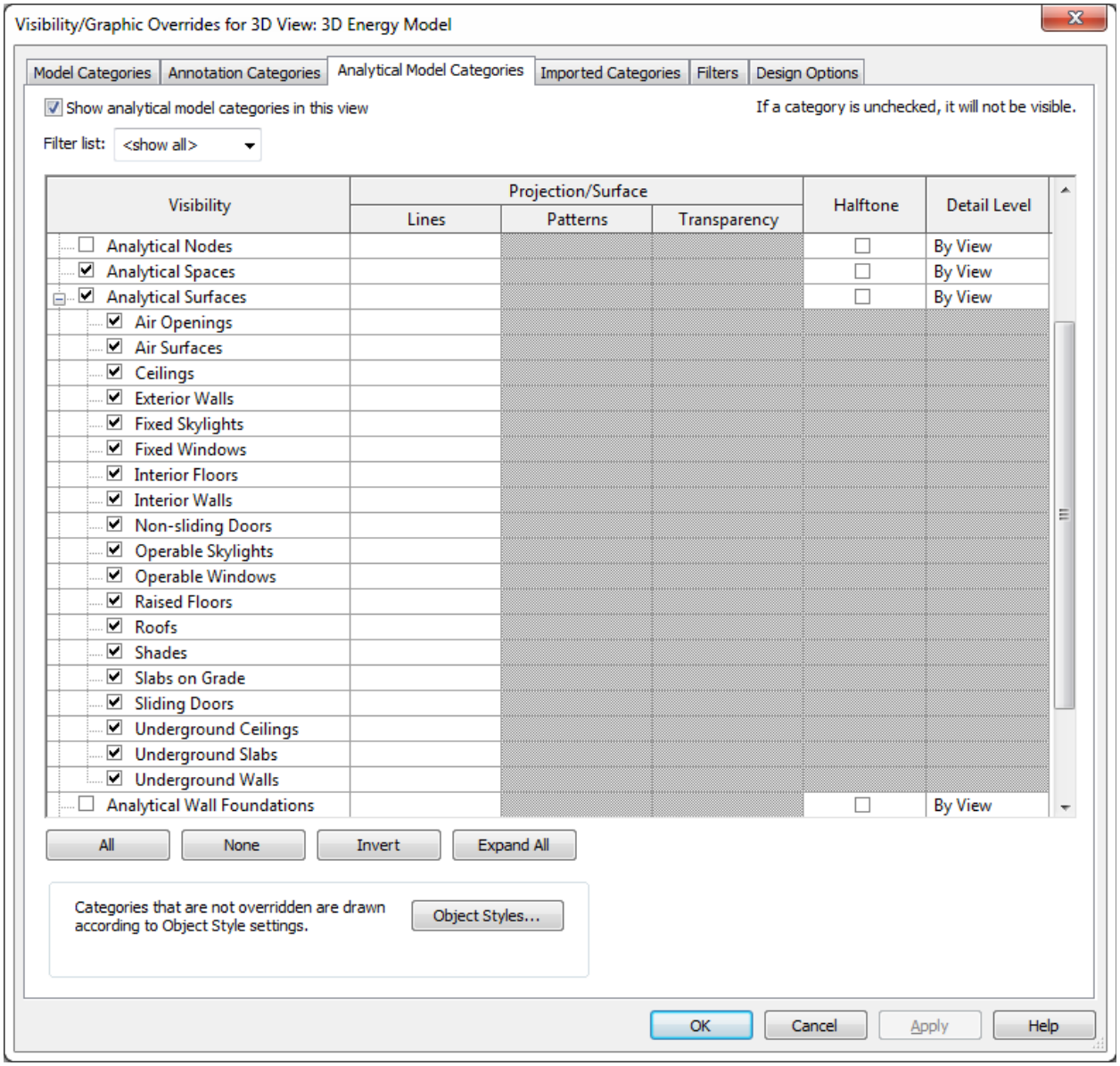


Figure 9. Analytical Spaces and Surfaces in Visibility/Graphic Overrides dialog for 3D Energy Model view.

The analytical model can actually be seen in any view by adjusting the **Visibility/Graphic Overrides**. However, the 3D Energy View provides dedicated and instant access. The **Hide/Show Analytical Model** toggle on the View Control Bar, in the lower left corner of each view, will toggle the Analytical Model Categories on or off for the current view.

Note: *This tab used to be exclusively for structural analytical visibility control.*

It is important to understand that the analytical surfaces do not update automatically as the model changes. When the Revit model changes, the EAM must be deleted and recreated.

A few of the Analytical Surfaces sub-categories may be confusing. Revit Windows are translated to an analytical surface called **Operable Windows** even though they may not actually be operable, and Curtainwall walls are all called **Fixed Windows**.

4 Visually Review Energy Model

It is important to visually validate the Energy Model prior to running a simulation to ensure valid results. If there are problem areas, the Revit model needs to be adjusted and the EAM recreated. The analytical surfaces cannot be modified directly in any way.

In the **3D Energy Model** view, some of the Model Categories are turned on (and set to be partially transparent). It may be helpful to turn these off to clean up the view.

Two things to look for are missing spaces and excessive shades. In the 3D Energy Model view, the sub-categories can be adjusted to isolate these items; or the **Hide/Isolate** feature can also be used. The image below (Fig. 10) shows just the **Analytical Spaces**; both occupiable spaces and plenum spaces (i.e., above ceilings). There are no large missing spaces within the building so all is well. Remember, the **Analytical Space Resolution** aims to simplify model complexity and, as such, some smaller spaces may be omitted.

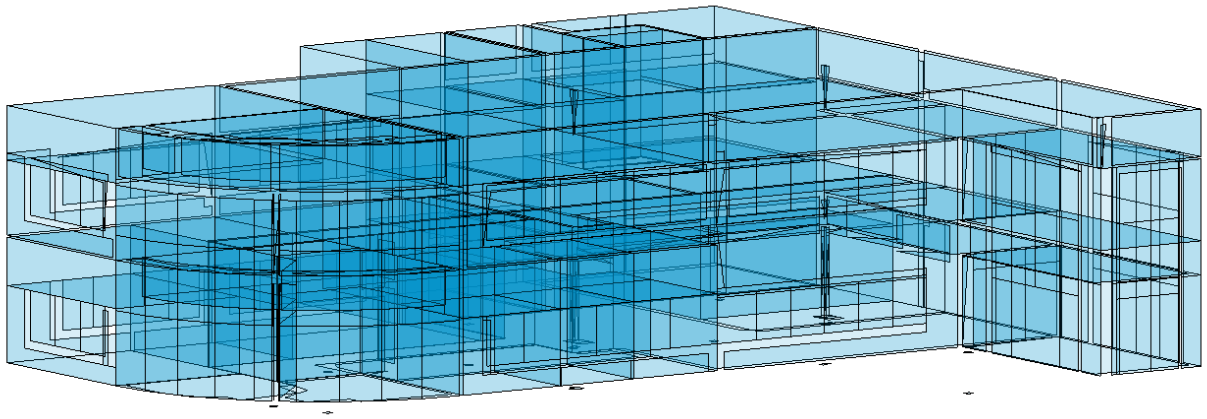


Figure 10. 3D Energy Model view adjusted to show only Analytical Spaces.

The next image (Fig. 11) shows just the Exterior Walls, Fixed Windows and Operable Windows analytical surfaces. The **Function** setting (i.e., Interior vs. Exterior) for walls does not matter as the EAM algorithm automatically determines this. Notice that three interior curtainwall Walls appear due to their close proximity to the exterior.

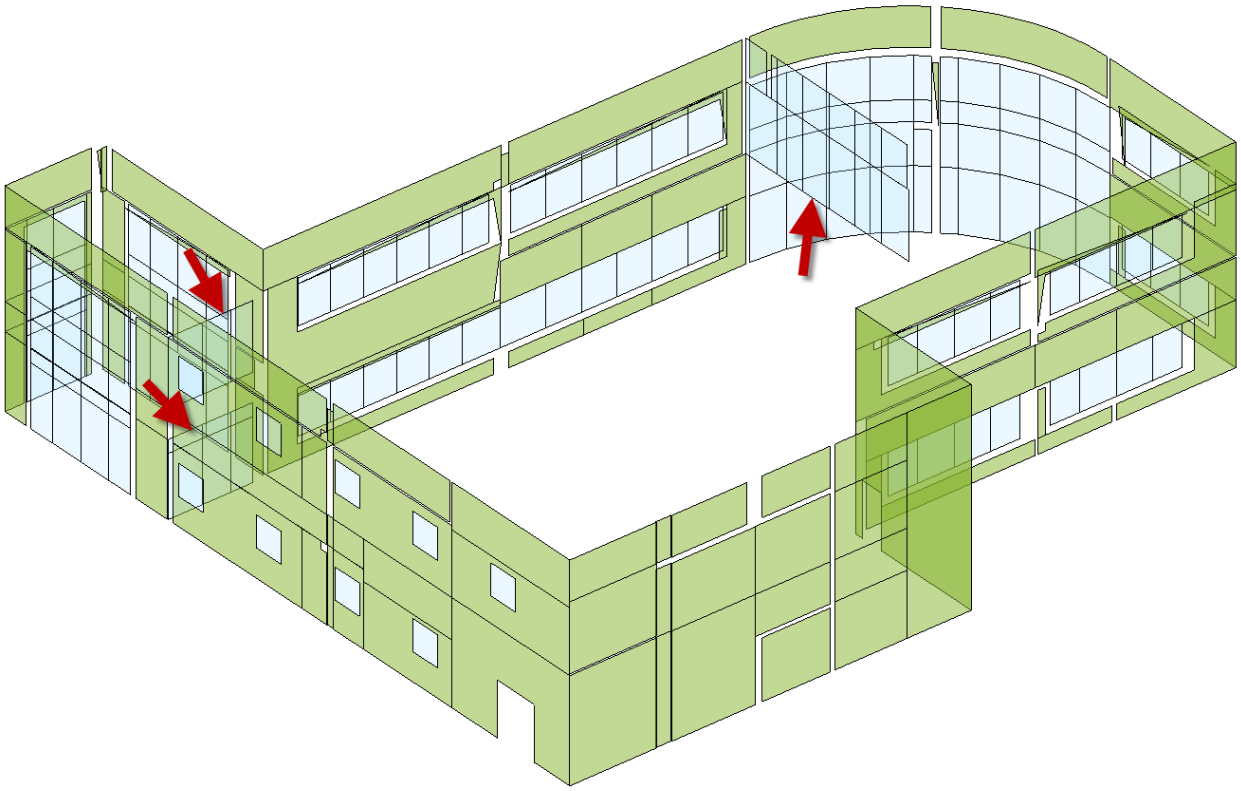


Figure 11. 3D Energy Model view adjusted to show only Exterior Walls and Windows analytical surfaces.

Review the **Analytical Surfaces schedule** to verify the right mix of surface types (Figure 12). If there are only shades and/or no windows, that would be a "red flag."

<Analytical Surfaces>

A	B	C	D
Area	Count	Opening Type	Surface Type
3446 SF	157	Fixed Window	
551 SF	24	Non-sliding Door	
144 SF	9	Operable Window	
9602 SF	29		Ceiling
6614 SF	98		Exterior Wall
4823 SF	30		Interior Floor
8412 SF	153		Interior Wall
5635 SF	14		Roof
2628 SF	59		Shade
5578 SF	22		Slab on Grade
10 SF	15		Underground Wall
47442 SF			

Figure 12. Analytical Surfaces Schedule showing surface types.

The **Analytical Spaces schedule** can be used to verify rooms and areas (Figure 13). The rows without a room name are void/shaft and plenum spaces. Splitting the screen to show both the Analytical Space schedule and the 3D Energy Model view facilitates highlighting a space in the 3D view by selecting a row in the schedule.

Due to the voids and plenum spaces, don't expect the total square footage (SF) to match the total in a room schedule.

<Analytical Spaces>

A	B	C	D
Area	Count	Room Name	Volume
322 SF	1	ASSOCIATES OFFICE 106	2229 CF
322 SF	1		1159 CF
535 SF	1	PARALEGAL 208	3791 CF
539 SF	1		2181 CF
354 SF	1	CONF ROOM 104	2492 CF
157 SF	1	BREAK RM 105	1061 CF
354 SF	1		1328 CF
157 SF	1		572 CF
1449 SF	1	LAW LIBRARY 207	10015 CF
3094 SF	1		12912 CF
190 SF	1	STAIR #1	3415 CF
465 SF	1	MECH - ELEC ROOM 100	5489 CF
169 SF	1	MENS 101	1211 CF
132 SF	1	WOMENS 102	1202 CF
177 SF	1		643 CF
180 SF	1		659 CF
254 SF	1	FILE STORAGE 203	2138 CF
163 SF	1	MENS 205	1186 CF
180 SF	1	WOMENS 206	1235 CF
247 SF	1		1341 CF

Figure 13. Analytical Spaces Schedule showing rooms and areas.

These two schedules are based on the Analytical Surfaces and Analytical Spaces categories. Don't get confused by the title **Analytical Spaces**—the term "Spaces" does not relate to Room versus Space elements.

If using Design Options, note that only elements in the **Main Model** and the **Primary Options** are used in the EAM. If you want to use **Design Options**, the desired design must be set as **Primary** before creating the EAM. This should be fine early in the design process, but later (e.g., bid alternates), changing the primary designation can mess up construction document views.

5 Insight 360 – The Revit Add-in

Autodesk has recently released this new tool which also combines separate add-ins and formalizes Autodesk Labs and Vasari tools! The installer can be found via this link: https://insight360.autodesk.com. This can only be added to Revit 2016 and up. Once installed, the new tools can be found on the **Analyze** tab in Revit (Figure 14).

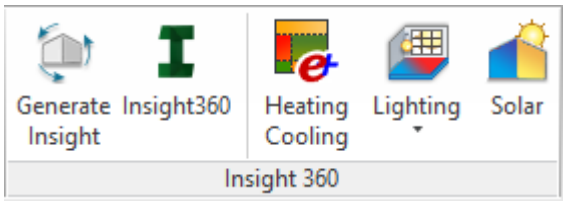


Figure 14. Insight 360 tools on the Analyze tab in Revit

The five different Insight 360 add-in for Revit tools are discussed below:

Generate Insight

This tool will send the energy analysis model (EAM) to the Autodesk A360 cloud for simulation. Although not required, the EAM should be created and reviewed prior to selecting this option. If this tool is selected prior to creating and validating the EAM, the **Generate Insight** command will create one and send it to the A360 cloud; however, in this case, the EAM will not be visible within Revit. If the EAM does exist, it will automatically be updated when the Generate Insight command is selected.

> ***Tip:*** *Prior to selecting this command, select* ***Location****, specify* ***Energy Settings*** *and* ***Create/Validate*** *the energy model.*

An email will be sent indicating that the analysis process has started (Fig. 15).

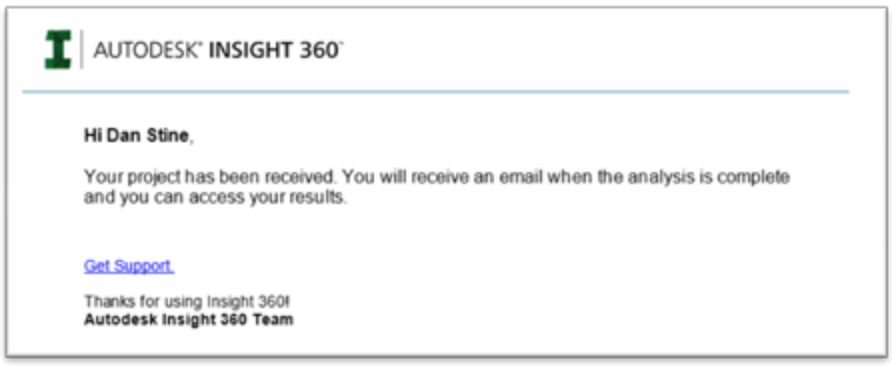


Figure 15. Email from Autodesk indicating the Insight project has been received.

Insight 360 automatically varies building design inputs resulting in high and low possible annual energy costs with approximately +/- 10% accuracy. Inputs can then be adjusted, e.g., glazing properties, to see instant feedback on performance impacts.

Once the simulation is complete, another email will be sent with a link to the project (Figure 16). You must sign in to Autodesk A360 to access the information.

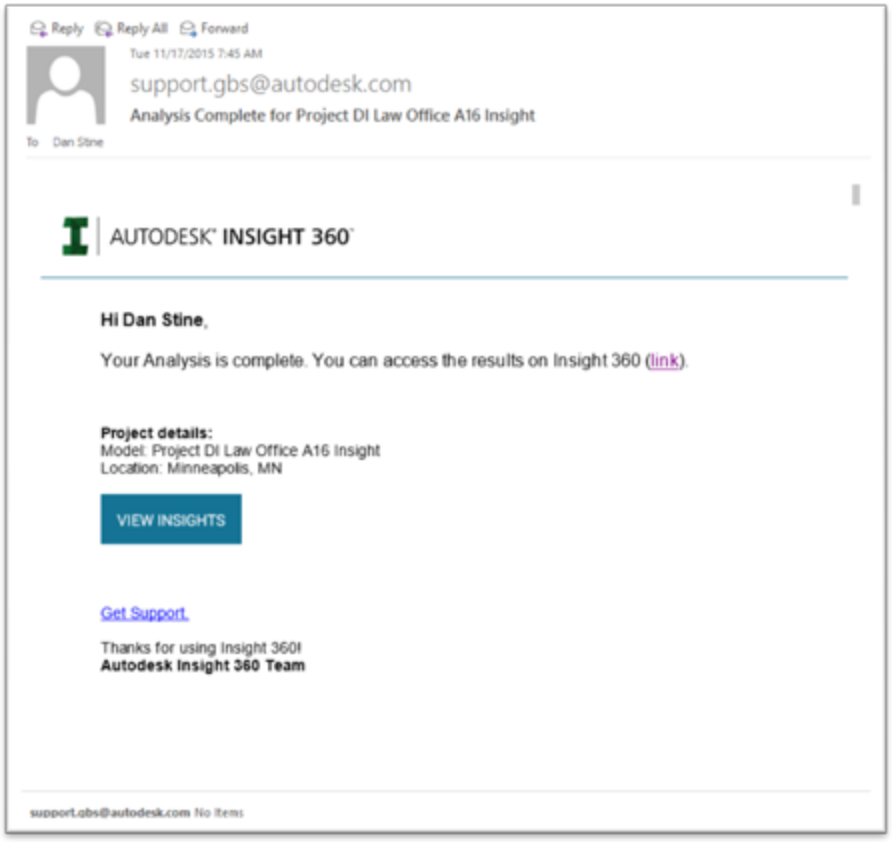


Figure 16. Email from Autodesk indicating the Insight project simulation is complete.

Insight 360

Once an analysis has been performed, the results can be seen by clicking the link in the email or selecting the **Insight 360** tool within Revit. This is similar to the way the *Results and Compare* command works. More on this part after this overview section. Finally, results from an analysis can be pushed out the **AIA DDx** by firms participating in the AIA 2030 Commitment.

Heating and Cooling

This Heating and Cooling (H/C) feature does not quite replace a tool like *Trane Trace,* but it might someday. Think of this as Version 2 of current built-in H/C tool which requires an insane number of hoops be jumped through in terms of modelling Spaces. This tool uses the same Energy Model discussed above using **EnergyPlus** hourly simulation for design days.

Lighting

This tool allows for daylighting calculations in Revit based on location, sky conditions, surface reflectance and glazing visual transmittance. Previously, this tool was hard-wired to only validate LEED credit compliance. This new version included with the Insight 360 tools allows for custom environment settings as seen below (Figure 17).

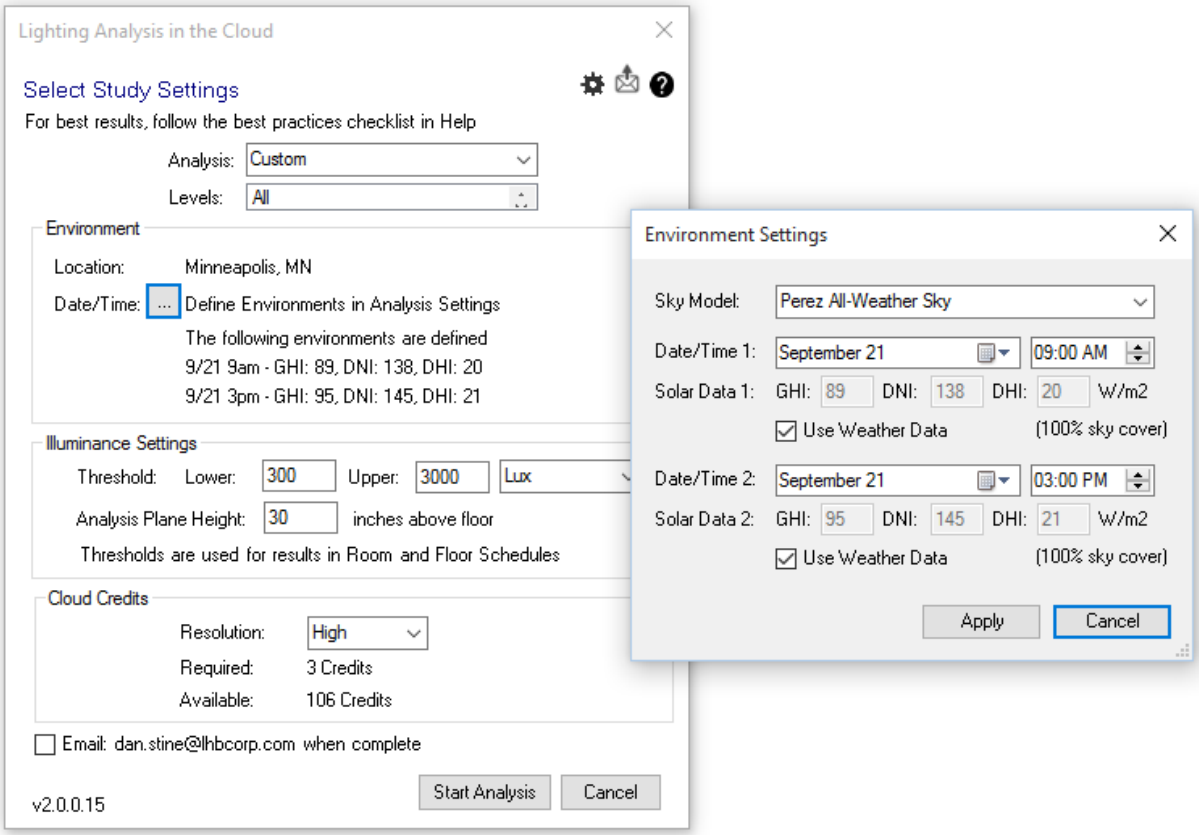


Figure 17. Specifying custom environment settings in the new lighting analysis tool for Revit.

Solar

This tool is used to analyze solar radiation on surfaces based on a building's location, orientation and form. This new version, included with the Insight 360 tools, has been enhanced to automatically select all roof elements. Several settings can be adjusted as seen in the next image (Figure 18).

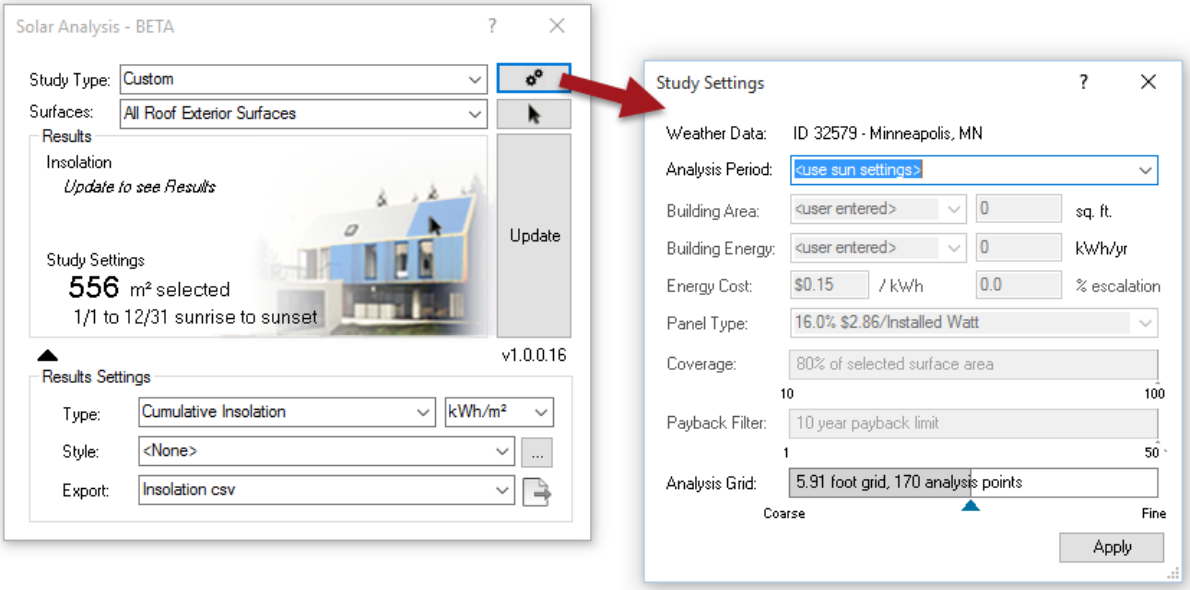


Figure 18. Updated solar analysis tool provided with Insight 360.

Insight 360 – The Cloud-based Tool

Let's take a closer look at what we can do with Insight 360. When the EAM is ready, simply click the **Generate Insight** command in Revit. Once the analysis is complete, the results can be accessed in the cloud in one of two ways: clicking the Insight360 tool within Revit or browsing to the website per the URL mentioned above (Chrome, Firefox or Safari browsers only). The browser option allows the window to be resized and will not close if Revit is closed.

The next image is the initial view of the project in Insight 360 (shown in Chrome). Right away, we see the energy cost in the upper left (red circle). This value will change as we adjust inputs. Speaking of inputs, they have all been varied across all possible values. Thus, looking at the **Benchmark Comparison** tile, we see the high and low possible cost range—this means the best and worst possible scenarios based on energy usage.

Let's take a minute to look at the User Interface (UI). There are several interesting aspects of the UI that should be understood to fully leverage this new tool. They are marked in the image below (Figure 19) and discussed subsequently.

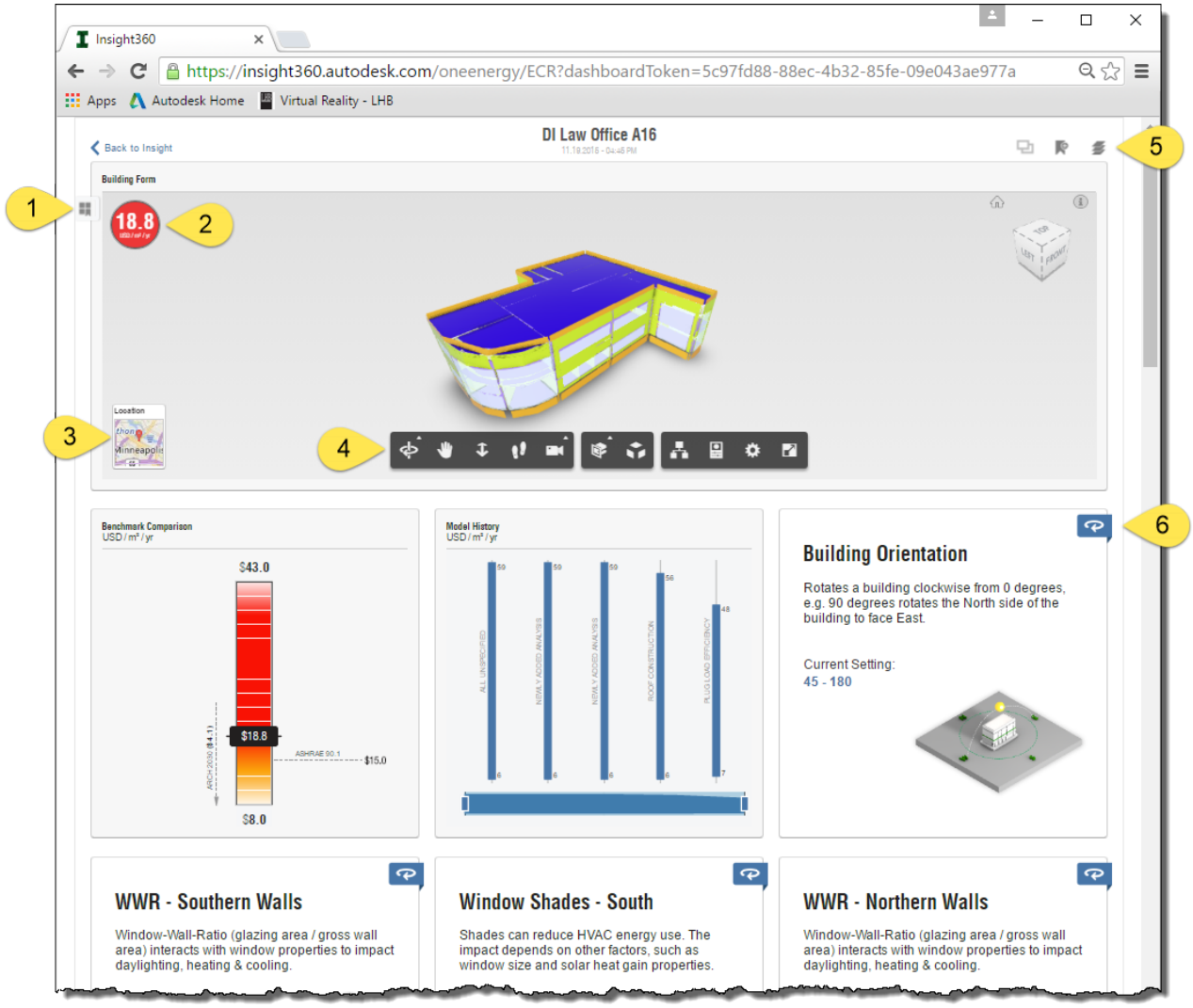


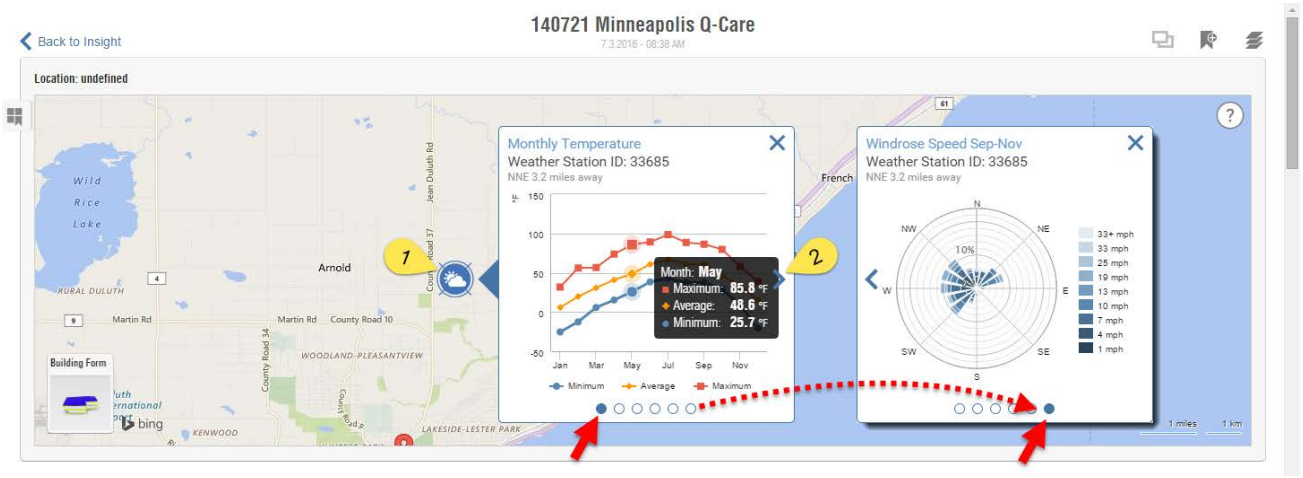
Figure 19. Initial project view in Insight 360.

1. **Saved Scenarios Slide-out Panel**
   View saved scenarios in this slide-out panel. A saved scenario is a snapshot of a specific arrangement of input settings. This allows for quick comparison between specific or combined variations.

2. **Energy Cost**
   Lists the current annual energy cost per m^2 or ft^2. Adjusting the inputs will instantly change this value. You can click this graphic to toggle between

energy cost **$/m²/yr** or EUI **kBtu/ft²/yr**.

3. **Location**
   Clicking here will toggle the EAM preview to a location map. Click the weather station icon to see historical weather data graphs.



4. **EAM Toolbar**
   The basic navigation tools on the left are generally self-explanatory. The center tools facilitate applying a section cut to the model and exploding the elements to better visualize complex conditions in the EAM. The tools on the right provide access to element information and general settings. See some examples in the next few images.

   Tip: *By default, drag with Left mouse button to orbit and right button to pan. Spin the mouse wheel to zoom.*

5. **Scenario Creation and Comparison**
   Use these icons to save and compare scenarios. The **Visualize** tool provides access to solar, lighting and H/C analysis tools from within Insight 360.

6. **Input Adjustment Tiles**
   Each tile represents a specific design element. The initial view shows a generic image and the current (default) range. For example, the **Daylighting and Occupancy Controls** tile ranges from “none” to “Daylighting and Occupancy Controls” (aka worst to best). Clicking this tile allows the designer to refine the range, or even select something very specific if known. More on this in a moment.

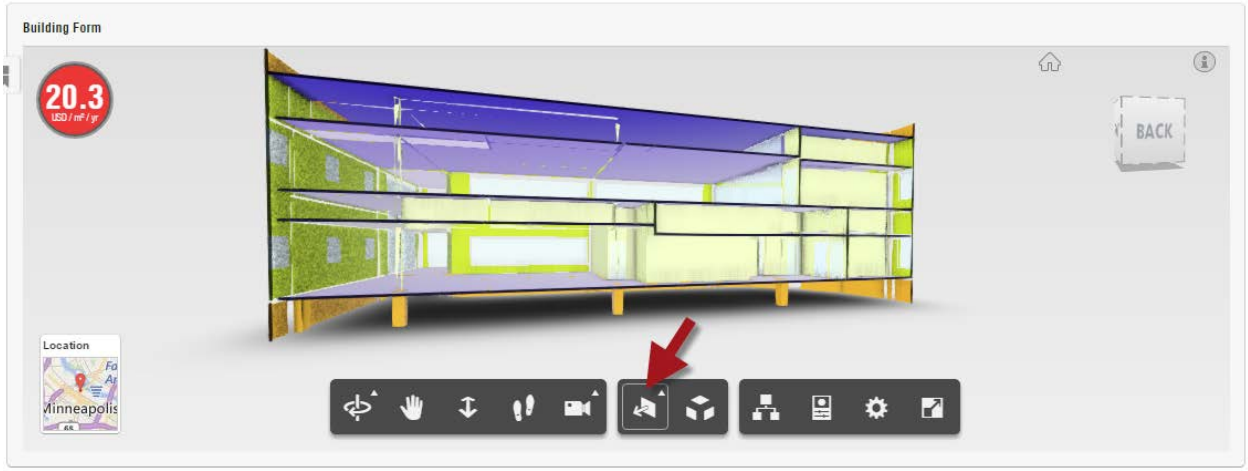


Figure 20. EAM view shown with section cut applied.

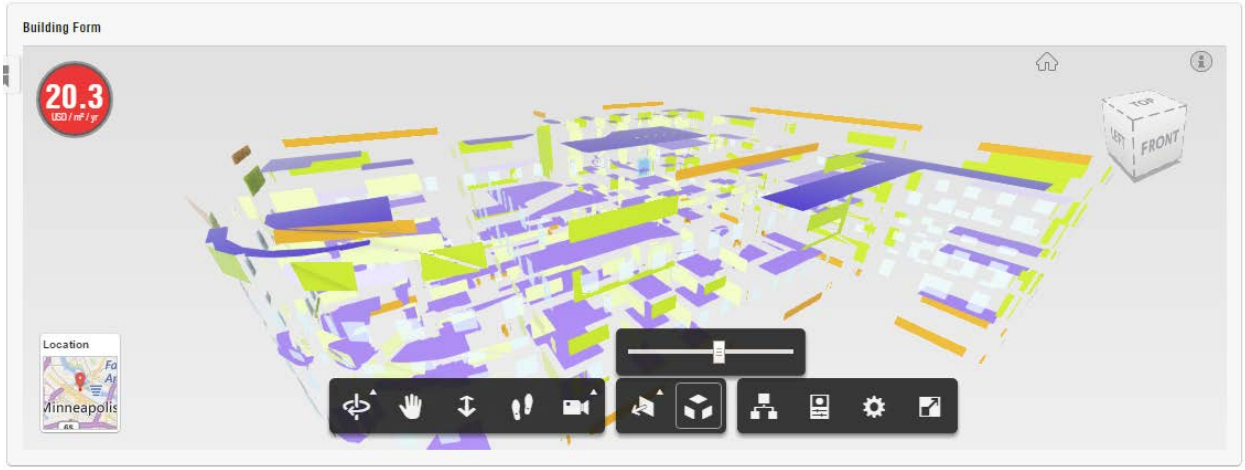


Figure 21. EAM shown exploded.

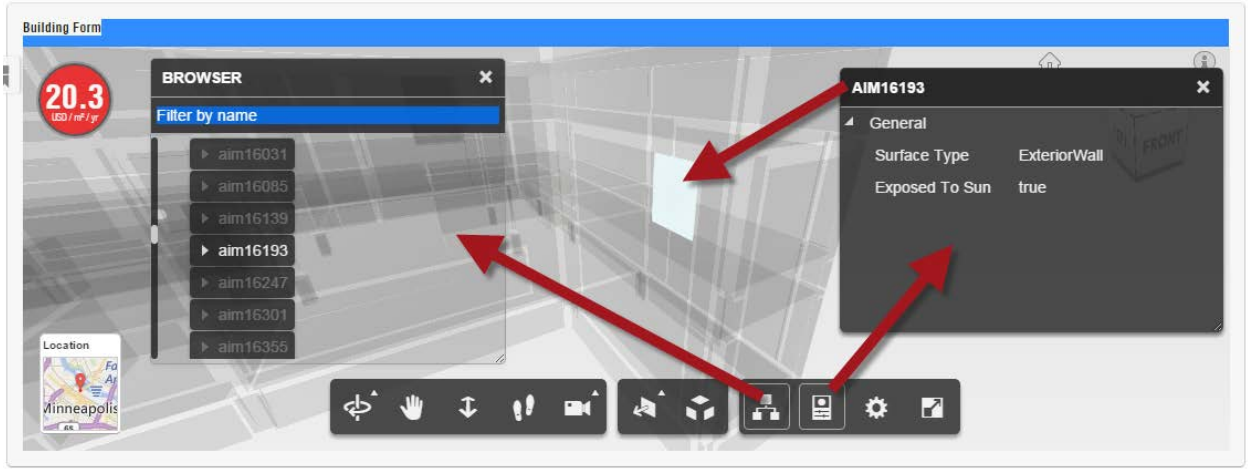


Figure 22. The Object Browser and Properties Palette provide a look “under the hood.”

Now let's take a look at the most significant feature: insight into your design and the interrelated results based on making various adjustments. This is analogous to a mixing board in a music recording studio—the combination of several adjustments produces a unique result.

First, we can see that adjusting some aspects of the design, such as orientation and location in this case, have minimal impact on overall performance (see image below – Figure 23). Clicking the **Building Orientation** tile reveals the relatively flat graph shown below. If the building orientation will not change, the range can still be adjusted to reflect this known bit of information. Note that the "0" position relates to the current orientation in the Revit model.

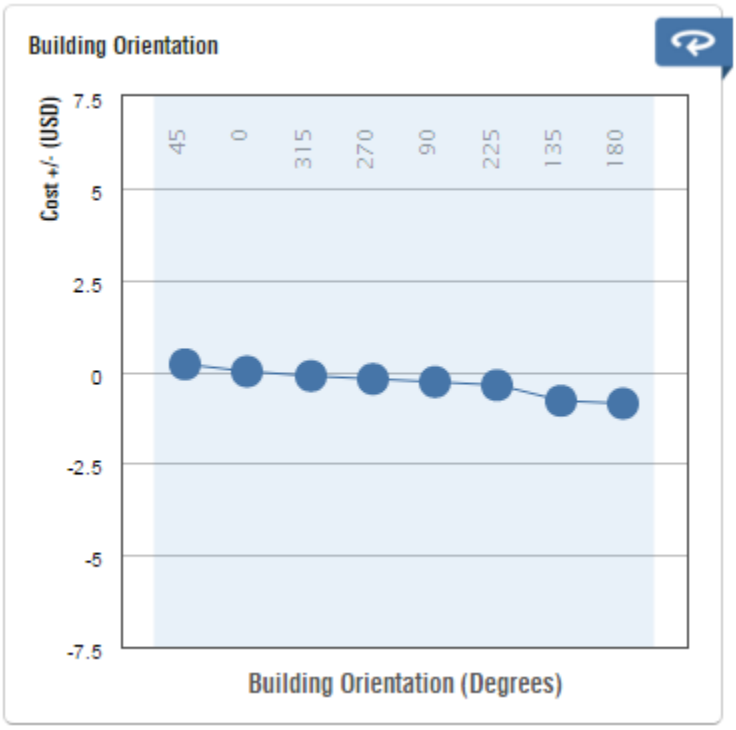


Figure 23. Cost range based on building orientation.

When we contrast the **Building Orientation** with another metric such as **Lighting Efficiency**, we see a more significant opportunity to affect the overall building performance, as shown below (Figure 24).

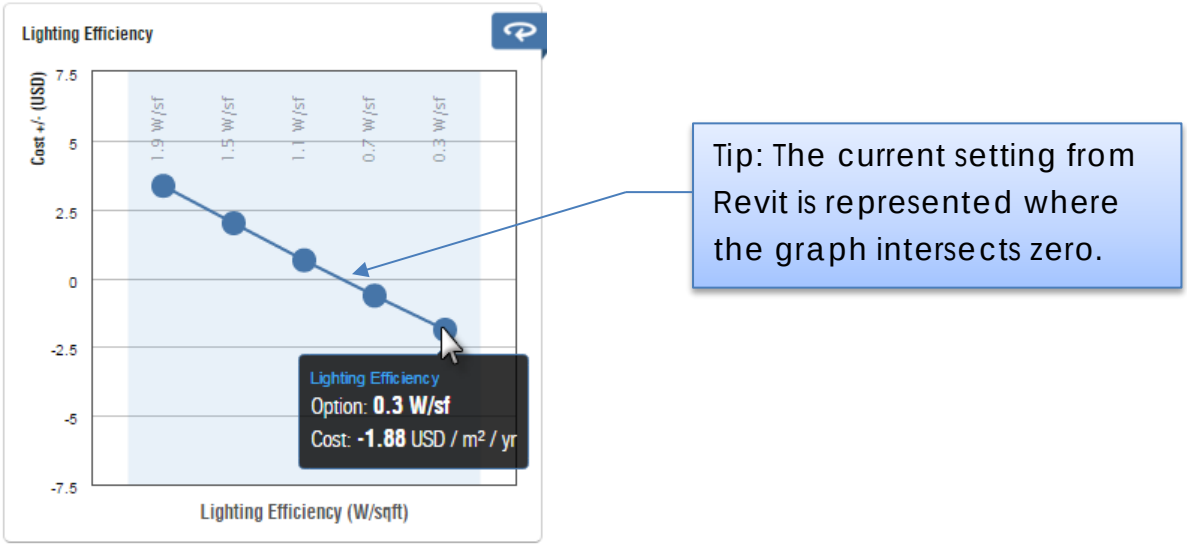


Figure 24. Cost range based on lighting efficiency.

Clicking on the graph opens the cost range view. If we want to see the relative change to the **Energy Cost Mean** by designing to the upper 1/3 range, we see about a ten percent change. Similar to the building's orientation, if we get to the point where we know exactly what the lighting efficiency is, we can adjust the sliders to select a specific input. You can hover your cursor over the graph for additional information as shown in Figure 25.

As the inputs are adjusted, the **Energy Cost Mean** value continues to update. While the performance is below the ASHRAE 90.1 threshold, the circle is colored red as seen in all images previously. Once in the "middle" range, the color changes to orange. Once the Architecture 2030 benchmark has been reached, the circle turns green as shown in the image below (Figure 26).

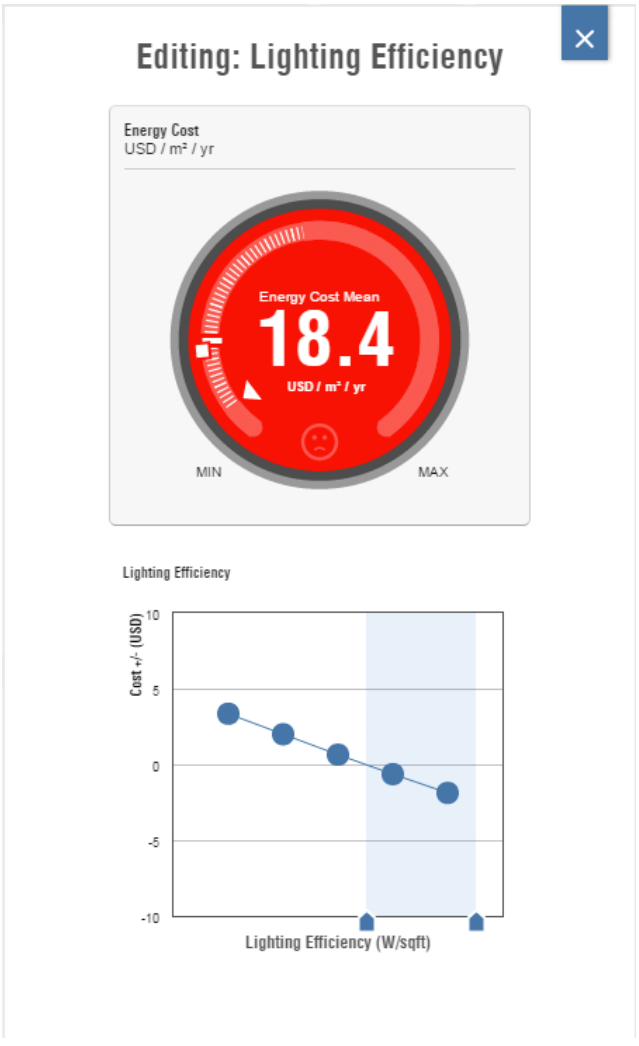


Figure 25. Cost range adjustment for lighting efficiency.

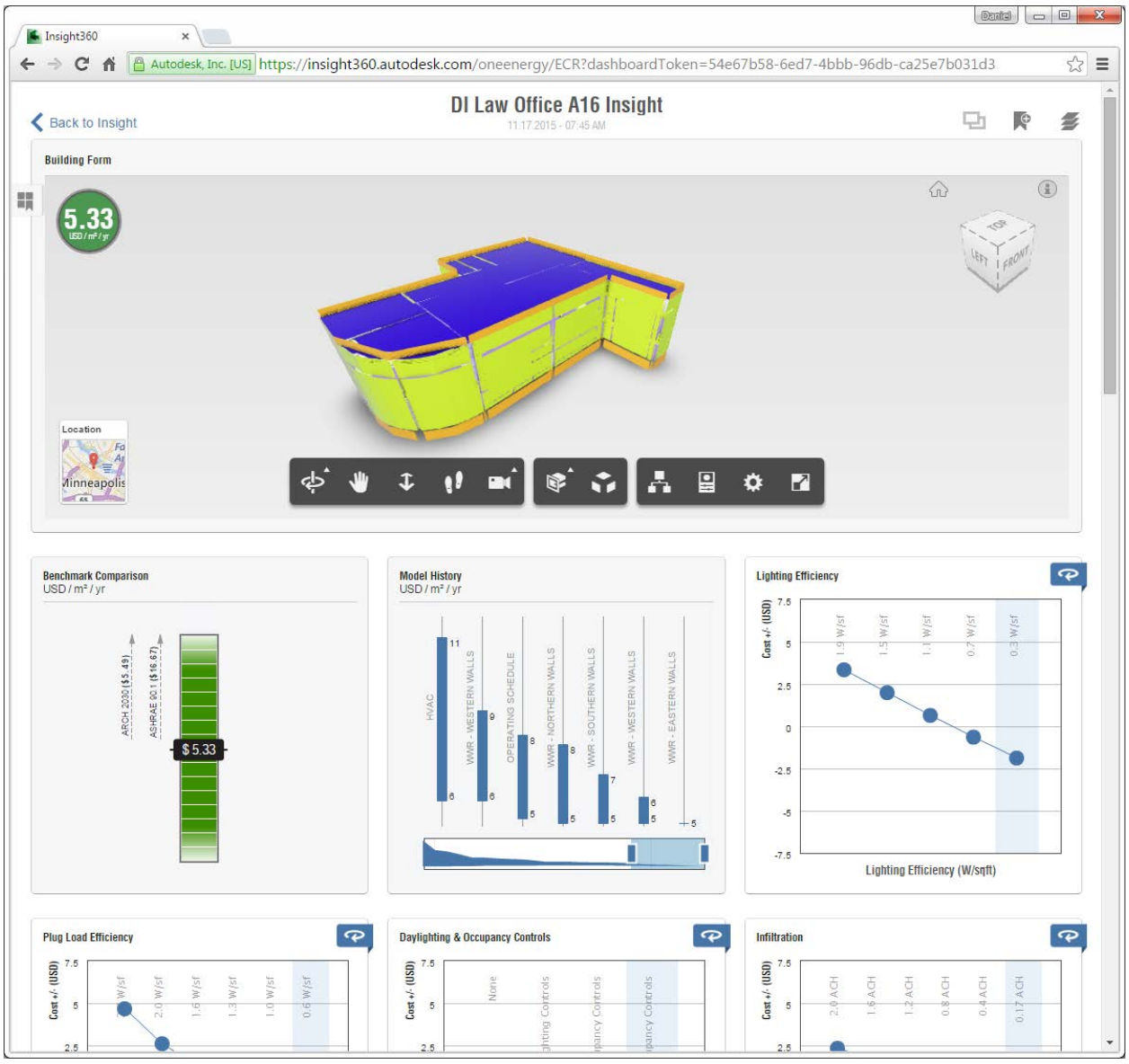


Figure 26. Insight with several high performance selections made, resulting in a "green" circle.

To save scenarios, make changes to the cost range values and then click the **Add Scenario** icon in the upper right. These can then be used to compare the various effects of multiple sets of input adjustments. The example below (Figure 27) shows a comparison between a medium and high performance scenario.

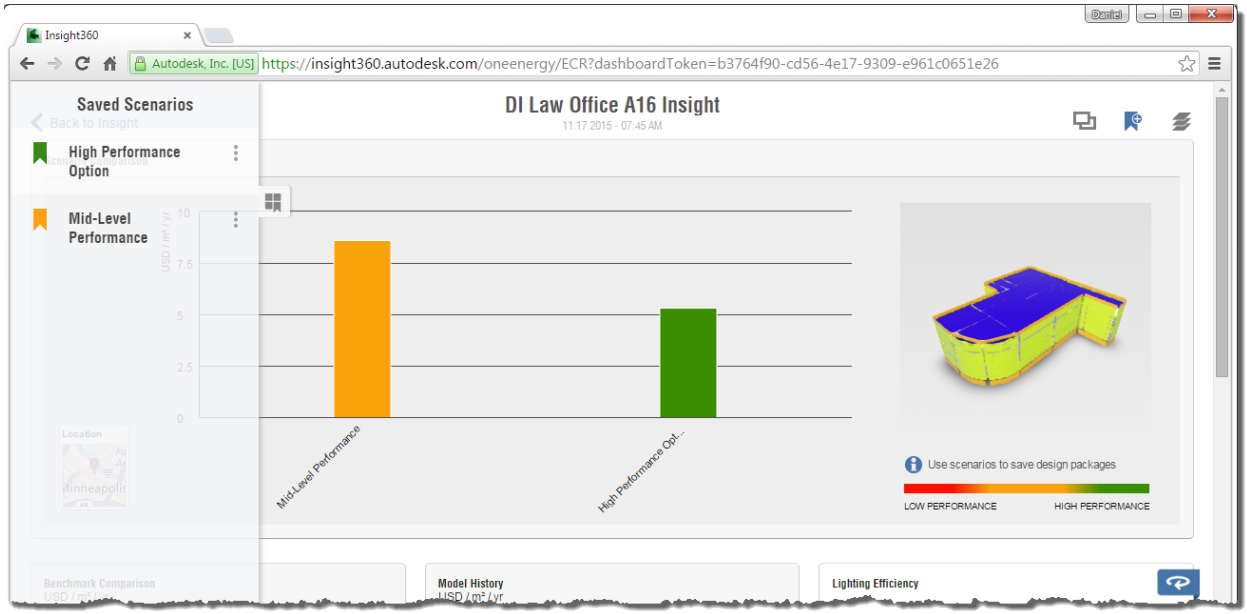


Figure 27. Comparing saved scenarios.

Insight Collaboration

The Insight 360 project can now be saved with other Autodesk A360 users! Not only that, but when two people are looking at the same project they both see any changes in real-time via their browser.

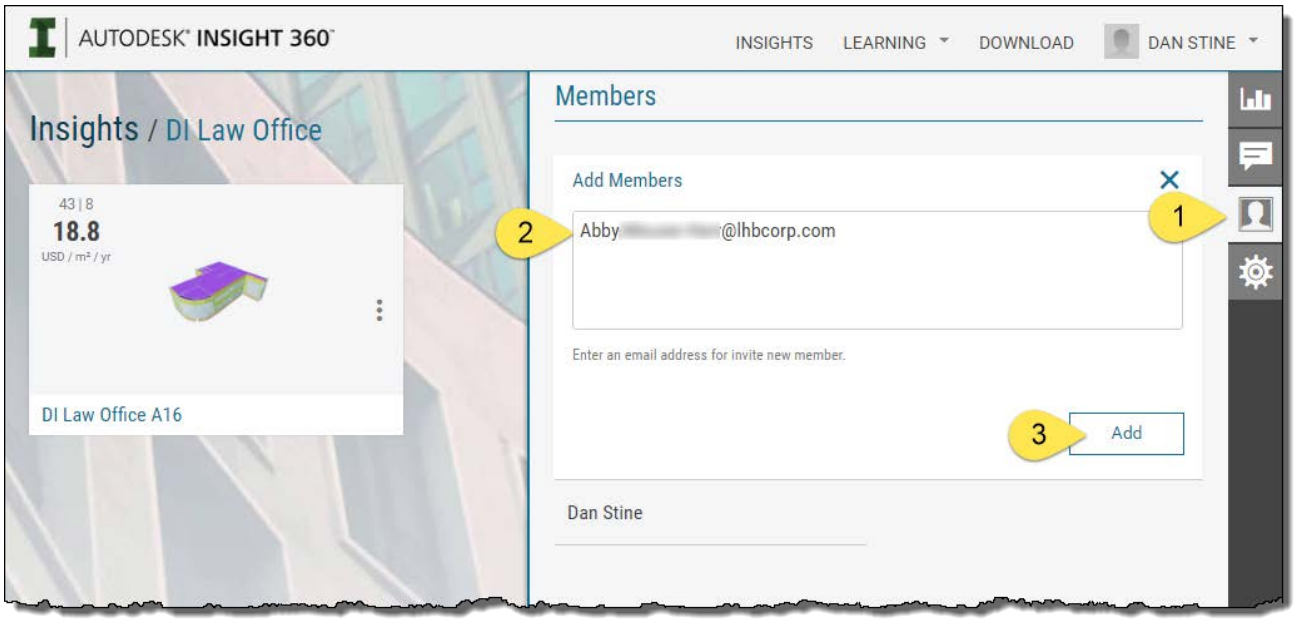


Figure 28. Sharing an Insight project with another user

The Insight home screen has an indicator to remind you that the project is shared with others. Right now there are no user rights controls. On a related note, notice the project image can be customized (Figure 29).

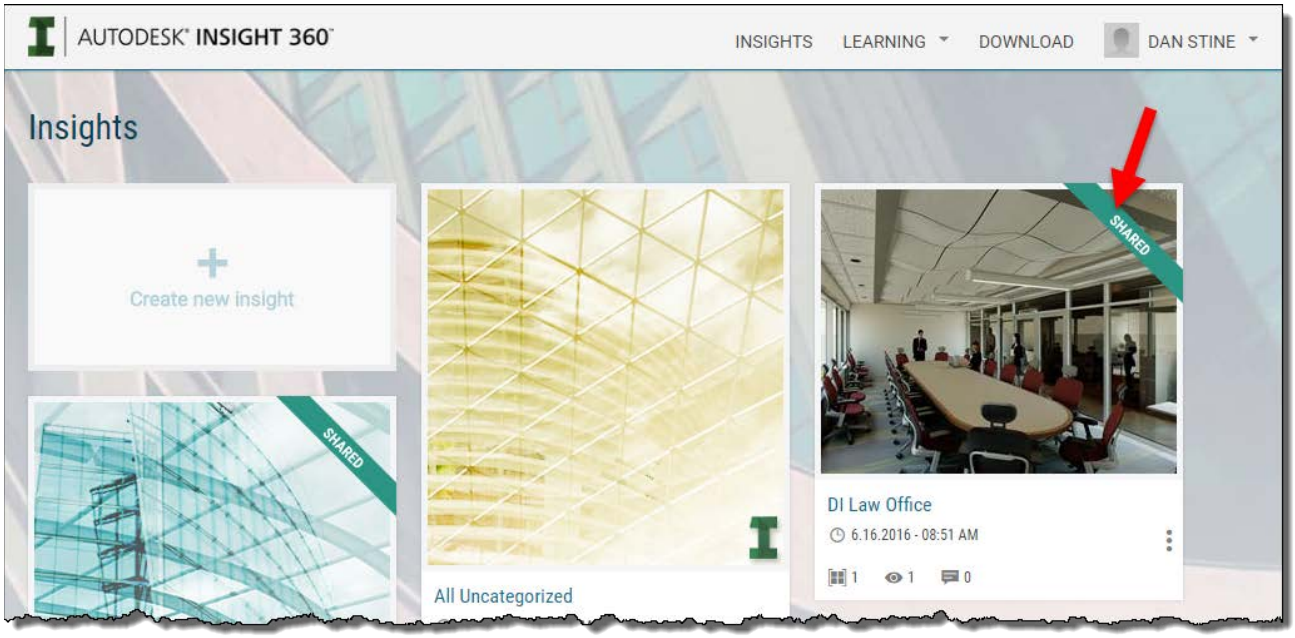


Figure 29. Indication that a project has been shared with others

Saved scenarios can now be applied to all models within a project as shown in the next image. This allows for super-fast comparison of various massing configurations. Additionally, when scenarios are made a favorite that scenario can be accessed from any project – just click the start.

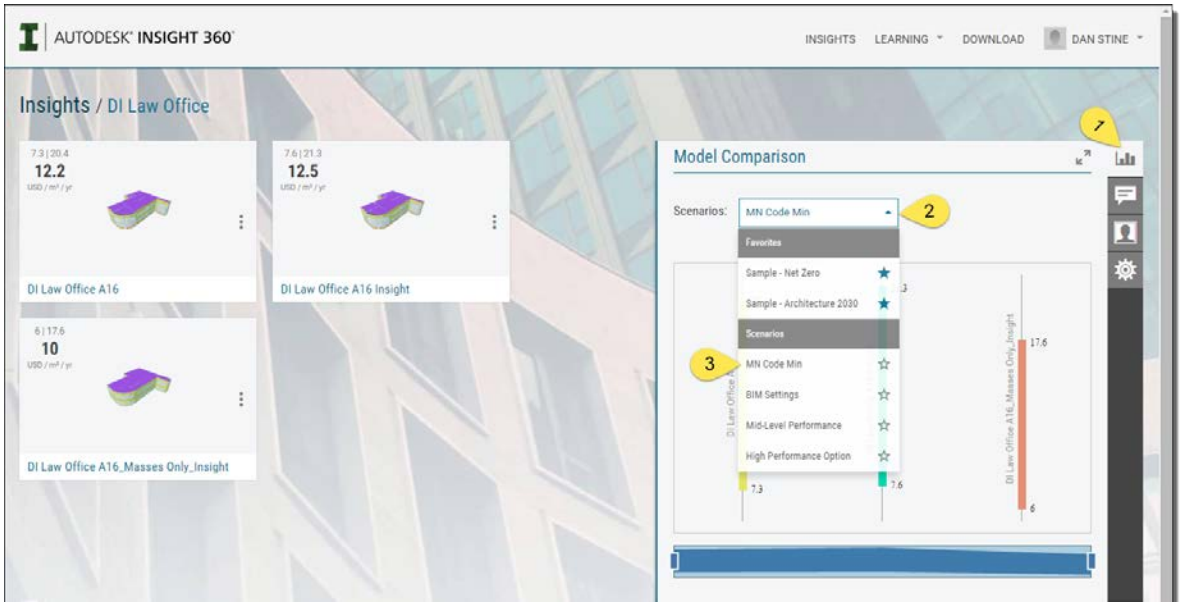


Figure 30. Saved Scenarios can be applied to multiple projects within the same Insight

Glazing Properties used in Insight

This question has come up a number of time so I am sure this will be helpful to those who want to understand what is going on under the hood; here are the factors used relative to the glazing options in Insight.

Name	Glazing Type-Northern, Southern, Eastern, Western Walls	U-Value W/m^2K	U-value BTU/hr-ft2-F	SHGC	VLT
No Change	No change	No change		No change	No change
Sgl Clr	Single Clear 6mm	6.17	1.09	0.81	0.88
Dbl Clr	Dbl Clear 6/13 Air	2.74	0.48	0.7	0.78
Dbl LoE	Dbl Low-E (e3=0.2)Clear 3/13 Air	1.99	0.35	0.73	0.74
Trp LoE	Trpl Low-E (e2=e5=0.1) Clr 3mm/6mm Air	1.55	0.27	0.47	0.66
Quad LoE	Quadruple LoE Films (88) 3mm/8mm Krypton	0.66	0.12	0.45	0.62

Settings

These options are self-explanatory…

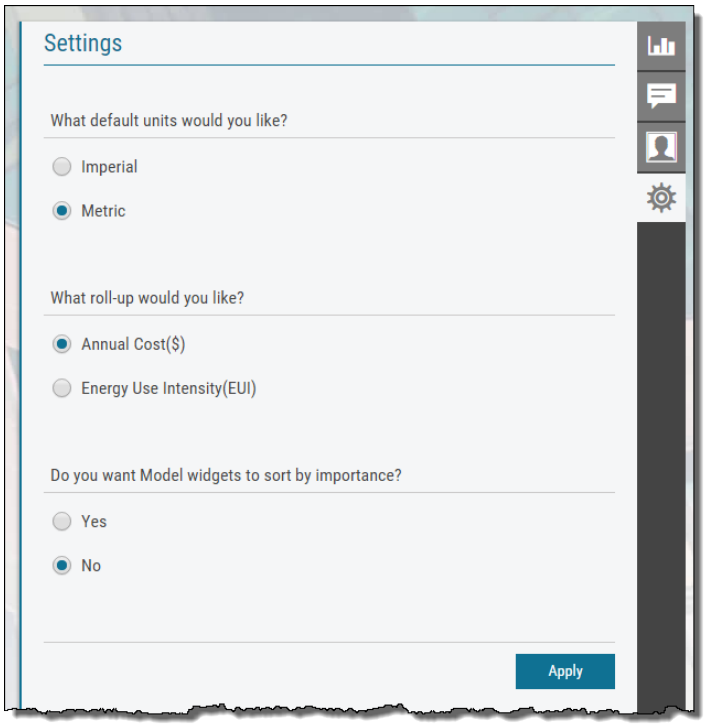
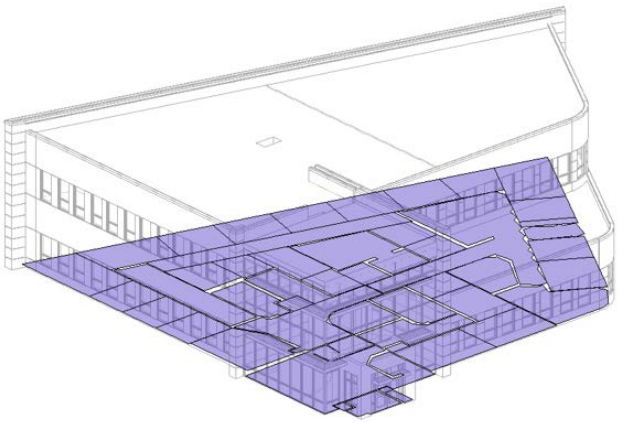


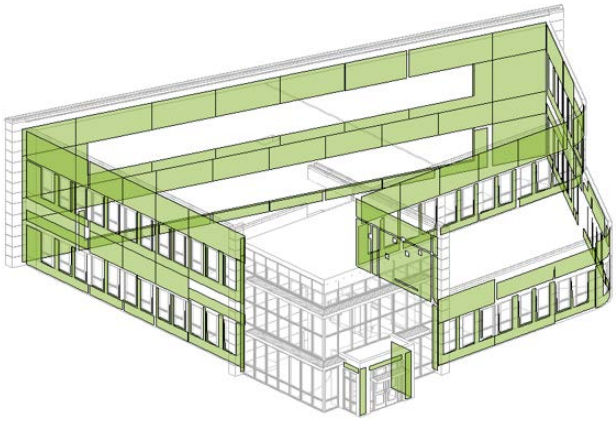
Figure 33. Insight settings panel

Additional EAM Validation

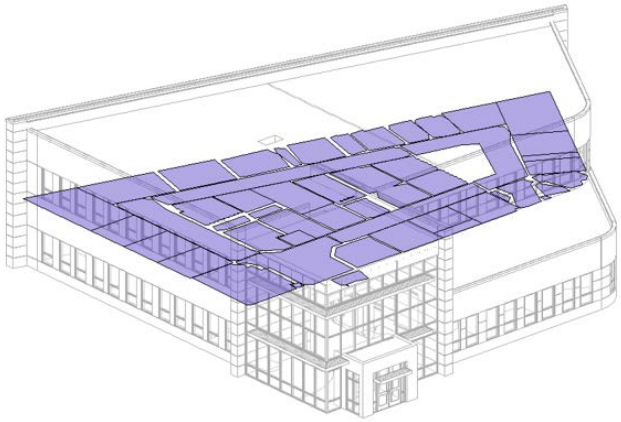
The next several images show how one might use the EAM 3D view to filter the analytical categories for visual validation.



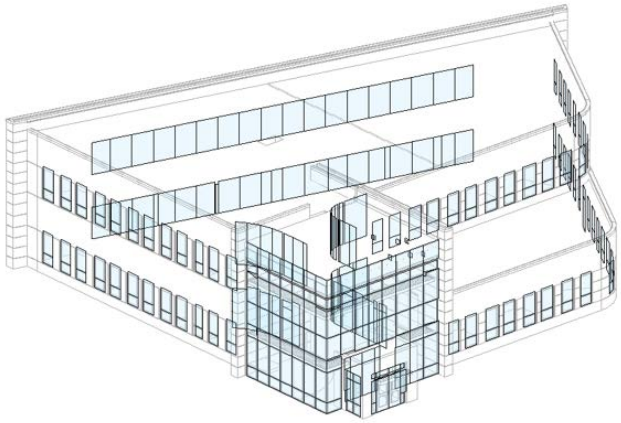
Analytical Surfaces – Slab on Grade



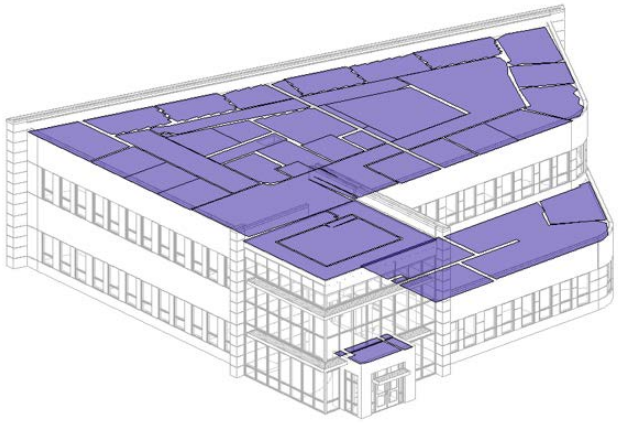
Analytical Surfaces – Exterior Walls



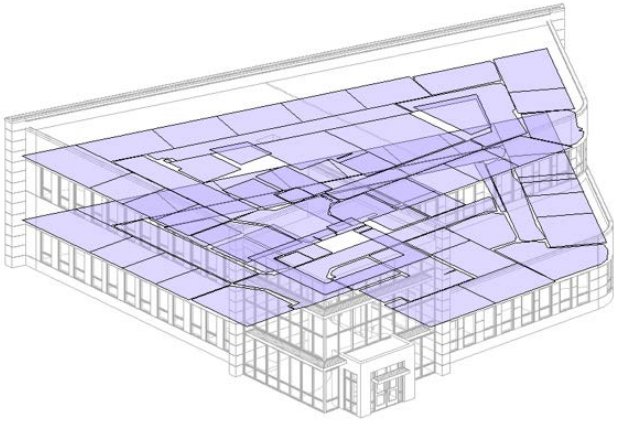
Analytical Surfaces – Interior Floors



Analytical Surfaces – Windows



Analytical Surfaces – Roofs



Analytical Surfaces – Ceilings

Insight Heating and Cooling Loads - EnergyPlus

Running the Heating and Cooling loads, from within Revit, can be helpful as it provides additional information, such as **peak heating and cooling loads**, and uses EnergyPlus (rather than DOE2). The image to the right (Figure 34a) shows a partial view of the results—the building summary and the first room. This tool is not meant to be used to size HVAC equipment at this time.

Running H&C from with Insight 360 provides a more graphical result as shown below (Figure 34b). Selecting a room in the model preview provides loads.

Load calculation summary report

Summary of heating and cooling loads for spaces

Project summary

Location and Weather	
Project	DC LAW OFFICES
Location	Minneapolis St Paul IntL Arp MN USA TMY3 WMO#=726580
Latitude	44.88
Longitude	-93.2

Building summary

Inputs	
Area (SF)	9158.89
Volume (CF)	87322.41
Calculated Results	
Peak Cooling Total Load(Btu/h)	228866.39
Peak Cooling Month and Hour	7/21 11:30:00
Peak Cooling Sensible Load(Btu/h)	220562.12
Peak Cooling Latent Load(Btu/h)	8304.18
Peak Heating Load(Btu/h)	-160135.39
Checksums	
Cooling Load Density (Btu/(h·ft²))	24.99
Heating Load Density (Btu/(h·ft²))	-17.48

Space Summary "ASSOCIATES_OFFICE_106"

Inputs	
Area (SF)	187.51
Volume (CF)	1303.10

Figure 34a. Results from EnegyPlus heating and cooling analysis

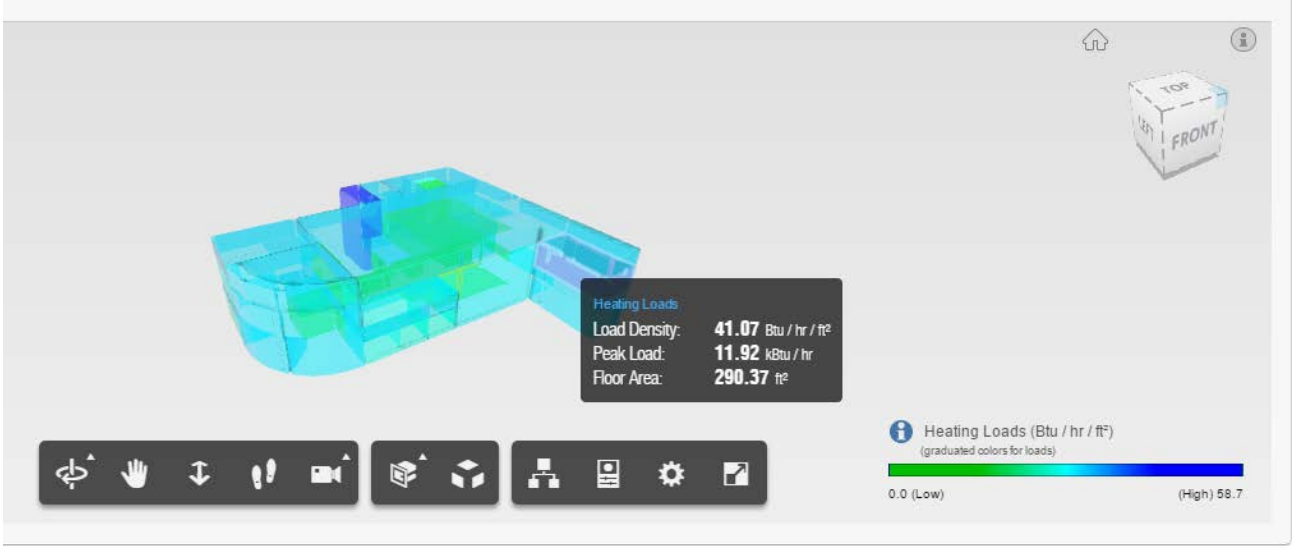


Figure 34b. Results from EnegyPlus heating and cooling analysis within Insight 360

6 AIA 2030 Commitment Firms; upload to DDx

Firms participating in the AIA 2030 commitment are now able to push data from Insight directly into the AIA 2030 Design Data Exchange (DDx).

What is the AIA 2030 Commitment (from the AIA website)?

> The AIA 2030 Commitment is a growing national initiative that provides a consistent, national framework with simple metrics and a standardized reporting format to help firms evaluate the impact design decisions have on an individual project's energy performance.

For more information on this AIA initiative:
http://www.aia.org/practicing/2030Commitment/

The next for images describe the process from within Insight:

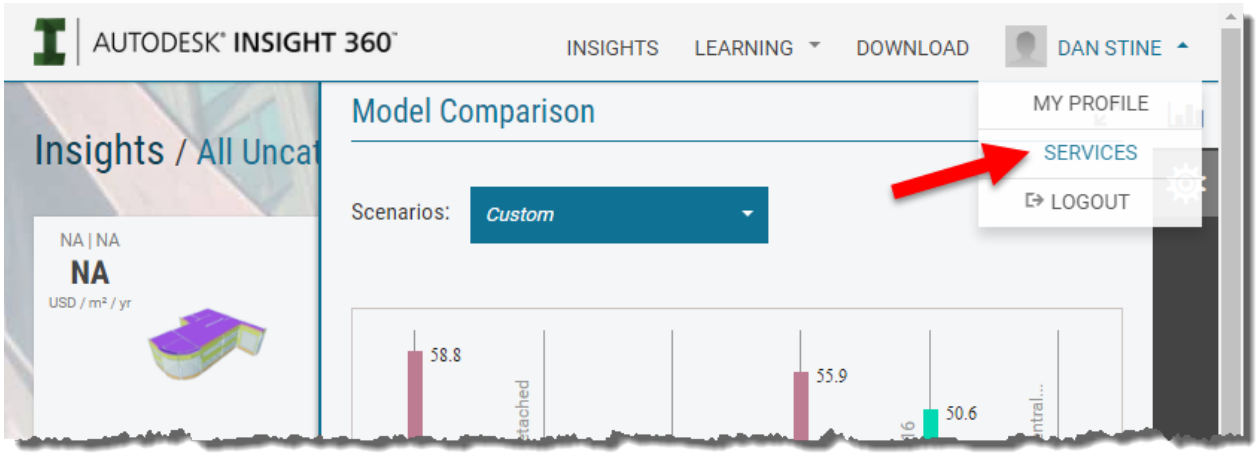


Figure 35. Verify AIA DDx service is turned on

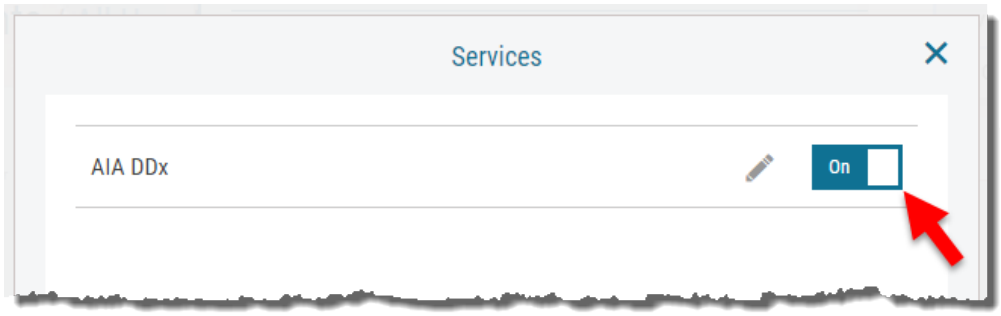


Figure 36. Turn AIA 2030 DDx service off and then on to get login dialog (see next image)

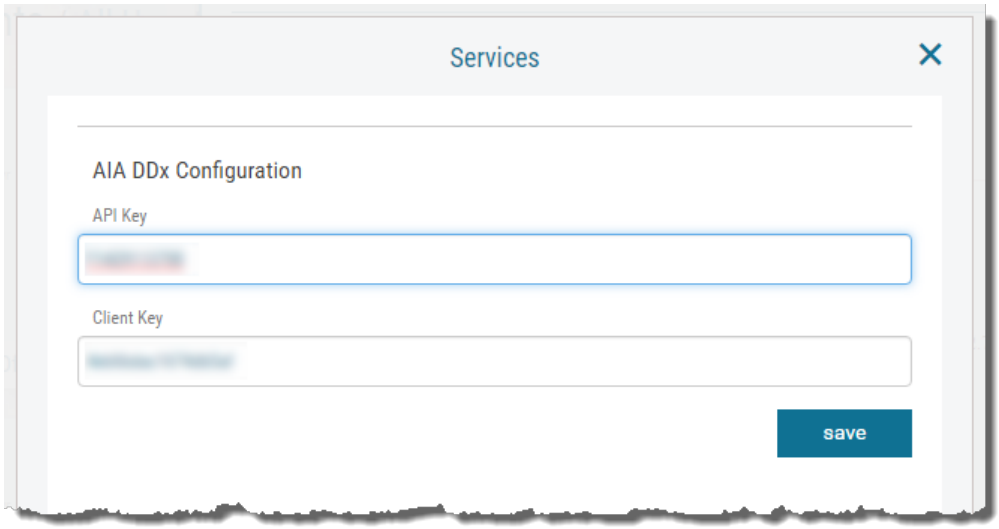


Figure 37. Insight dialog to enter AIA firm and user id numbers

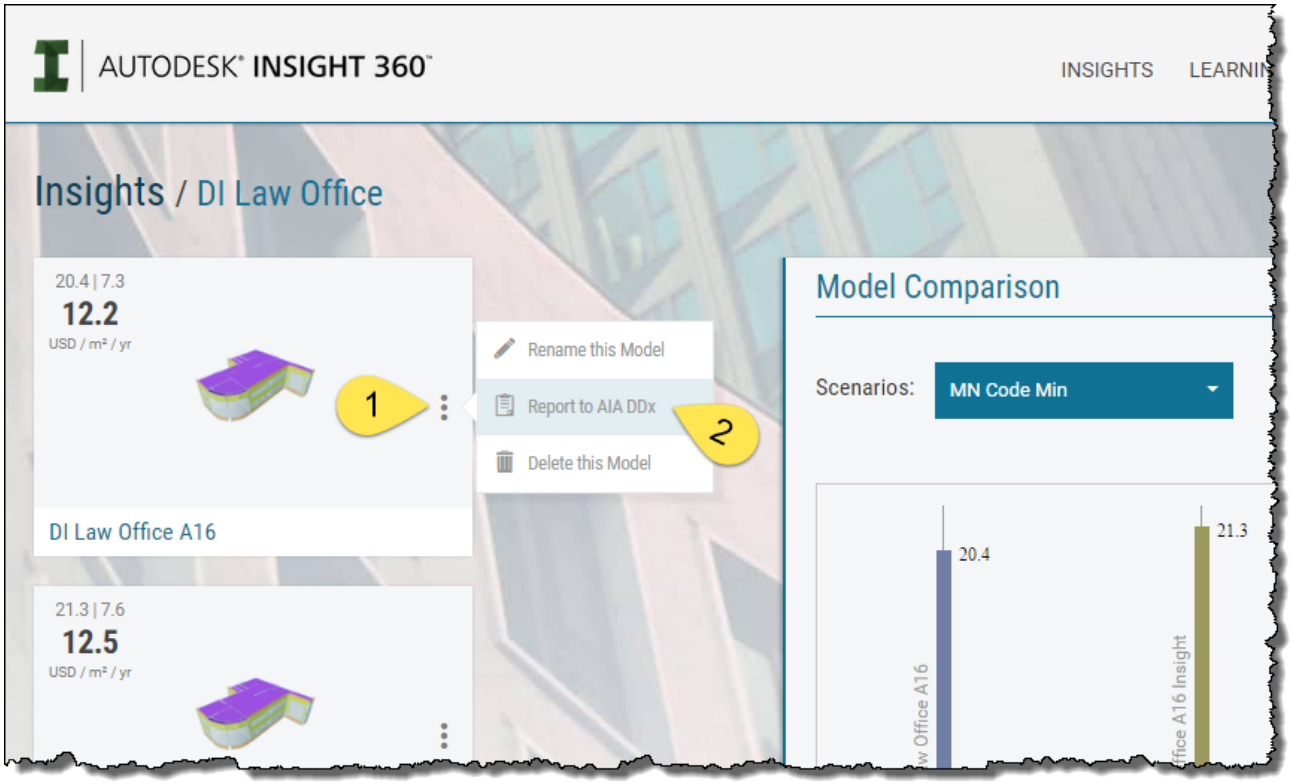


Figure 38. Push current energy analysis data to AIA 2030 DDx

The following image (Figure 39) shows the exact information that will be sent to the AIA site. Notice the inputs with drop-down arrows allow information to be changed prior to clicking “send”.

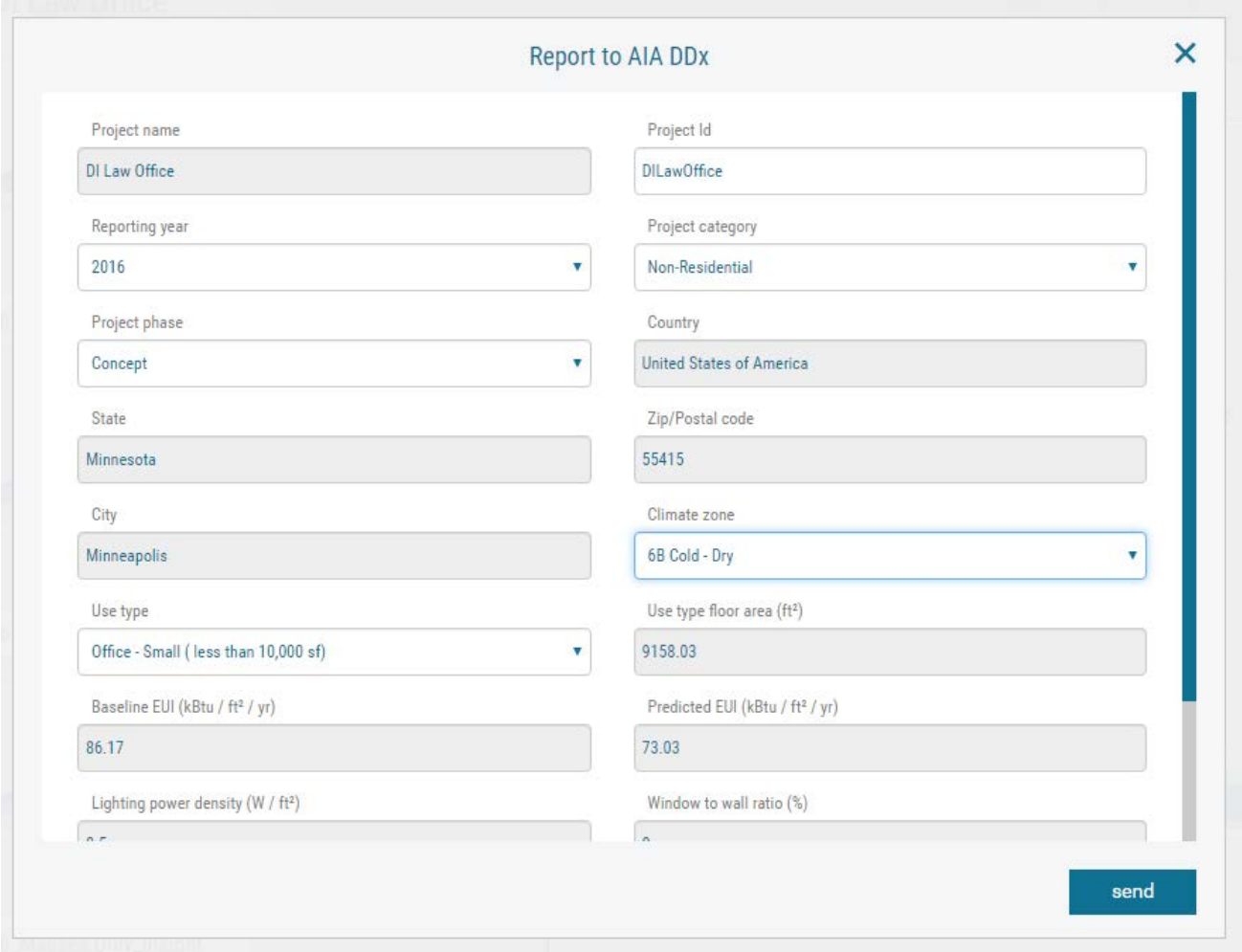


Figure 39. Review Insight data to be pushed to AIA 2030 DDX

The last image in this section (Figure 40) shows the results as seen when logged into the AIA site. Most of these inputs can be modified here as well if needed.

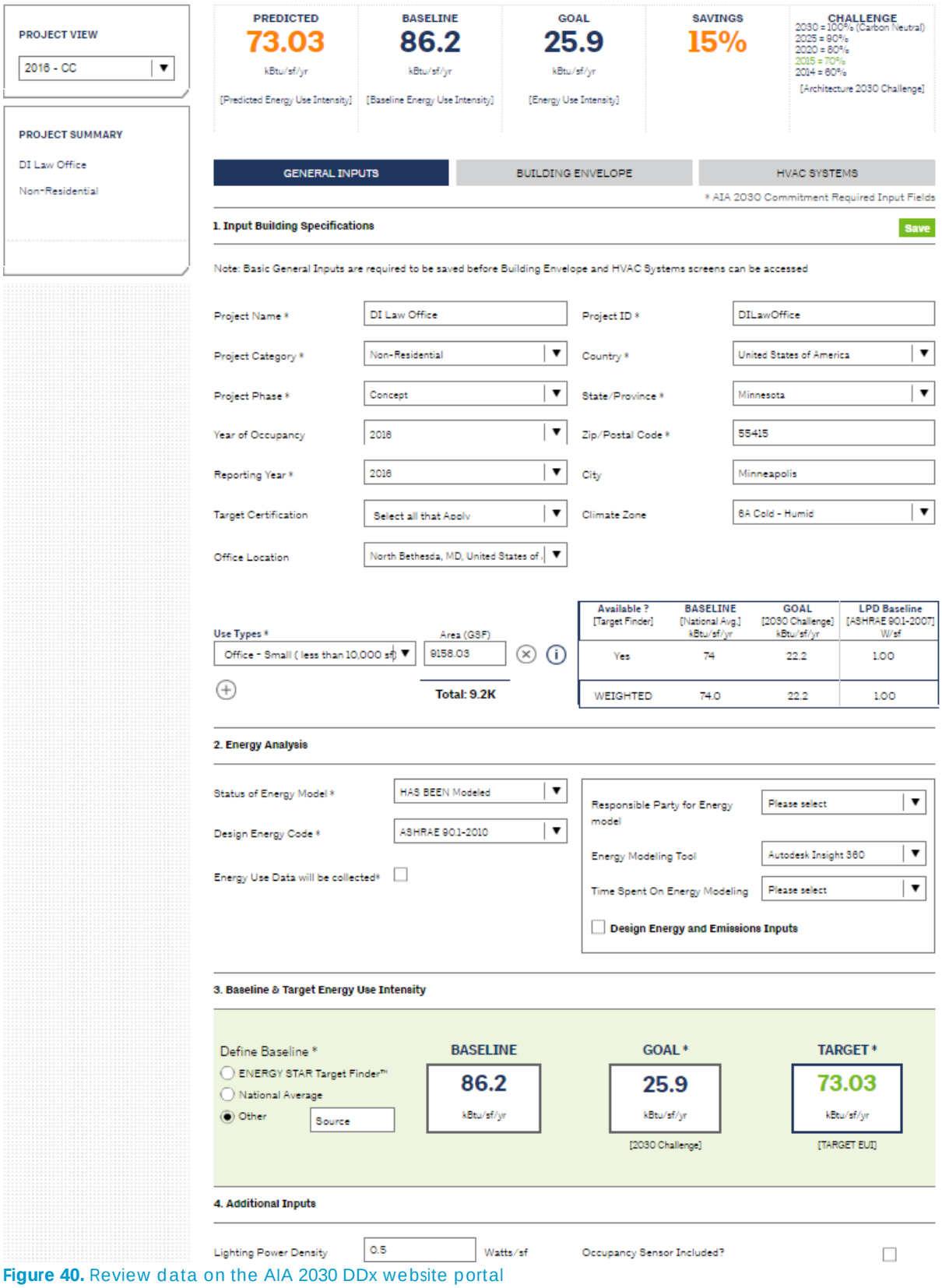


Figure 40. Review data on the AIA 2030 DDx website portal

7 Optional Settings and Workflows

The remainder of this handout will cover optional settings and workflows related to energy simulation in Revit.

Advanced Energy Settings

All other settings, in the Energy Settings dialog (Figure 41), not mentioned yet do not have to be set prior to creating the EAM or running a simulation. These inputs are all automatically varied over the possible ranges and can be adjusted in **Insight 360** to see instant feedback on performance impact.

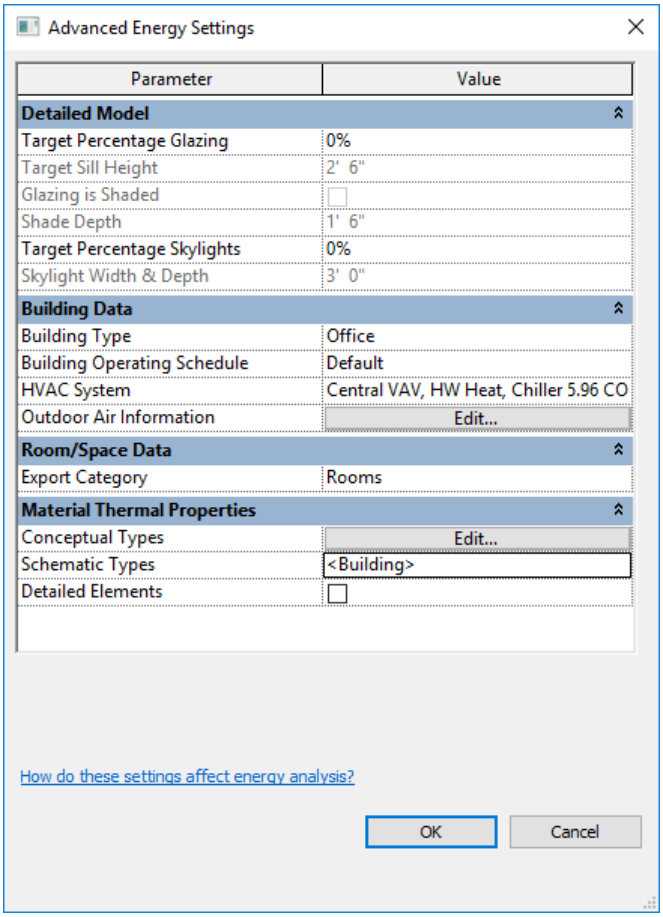


Figure 41. Advanced Energy Settings dialog

Rooms or Spaces are not required, but when they are present some additional information is used (more on this later).

Revit 2017 changes the way Thermal Properties data is prioritized and used in the energy analysis. The order they are listed here relates to priority; Conceptual Types (lowest) to Detailed Elements (highest). If Detailed Elements is checked, the thermal properties saved in the building elements (e.g. walls, floors, etc.) will be used. If no thermal properties existing then any Schematic Type overrides are used, and if no overrides, the Conceptual Types settings are used.

> **Tip:** For combined mass and building elements where the building elements define all glazing (like the combined example shown previously in Figure 3), set **the Target Percentage Glazing** to 0%.

The **Conceptual Types** dialog shown below (Figure 42) defines the construction defaults, assuming vertical surfaces are walls, top horizontal surfaces are roofs, etc. Again, it is no longer important to adjust these prior to running a simulation.

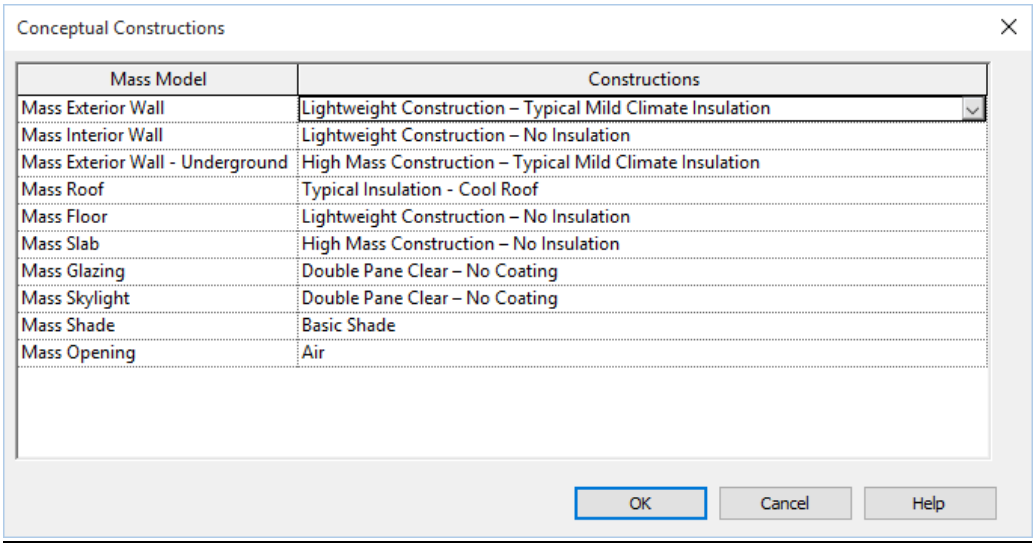


Figure 42. Define generic constrictions.

The **Schmatic Types** dialog shown below (Figure 43) has more detailed options form which to choose. When a category is checked, the defaults selected in the Conceptual Constructions dialog are overridden. Again, it is no longer important to adjust these prior to running a simulation.

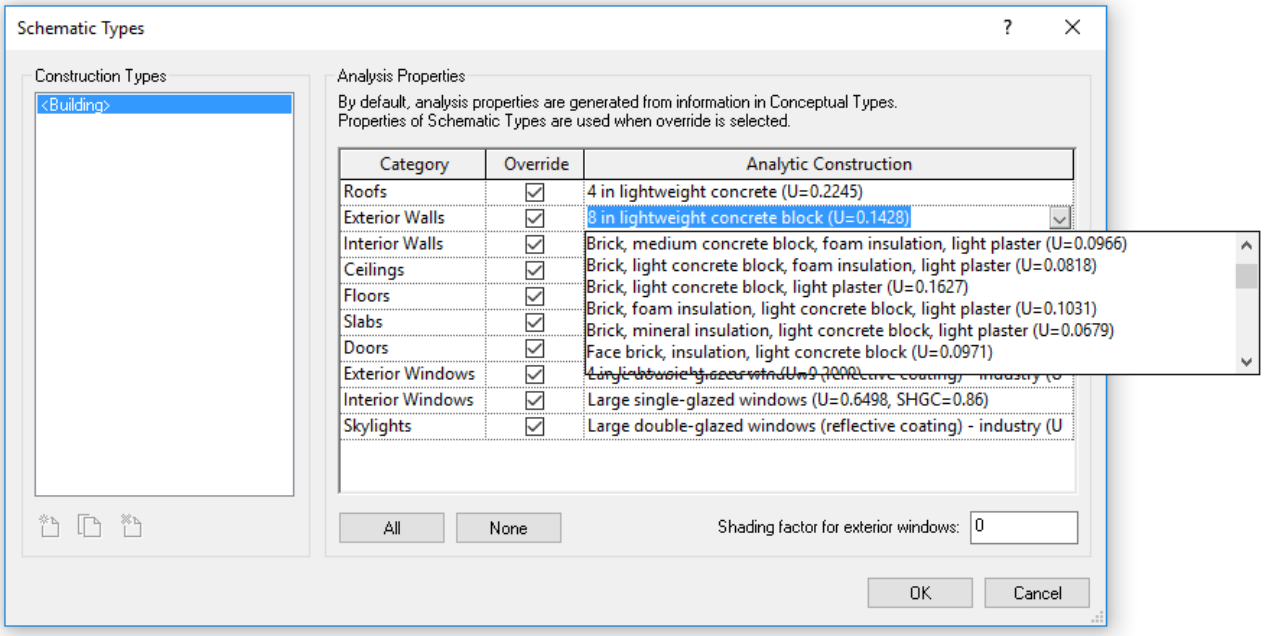
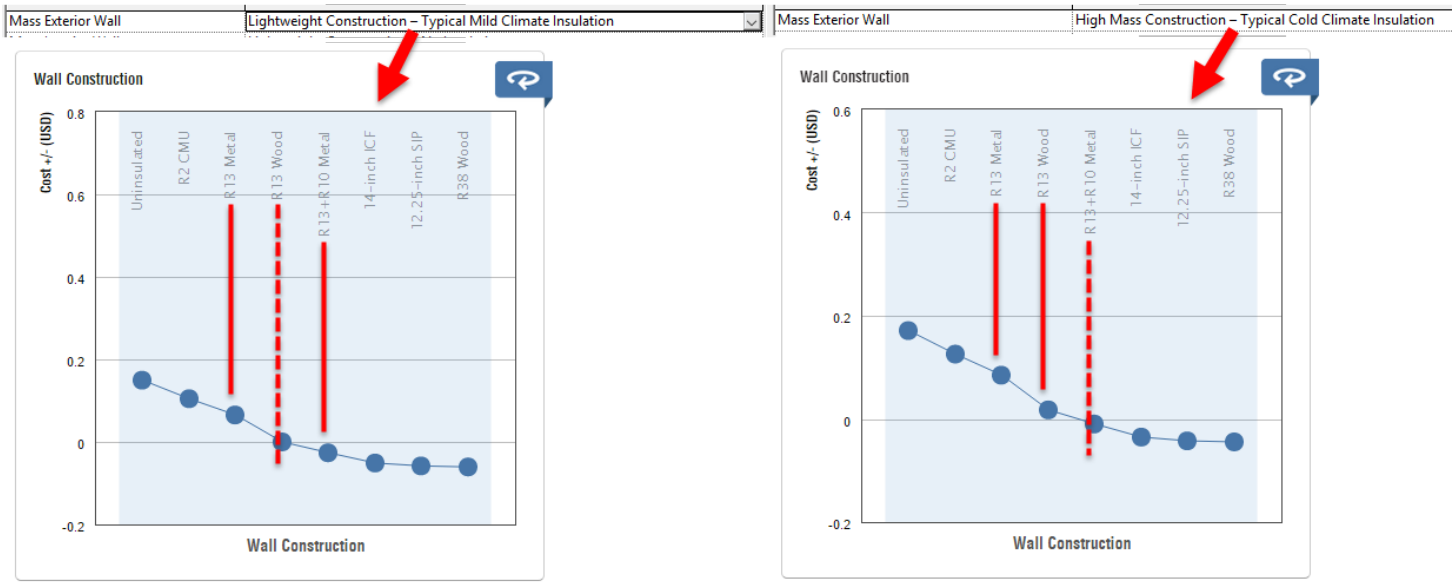
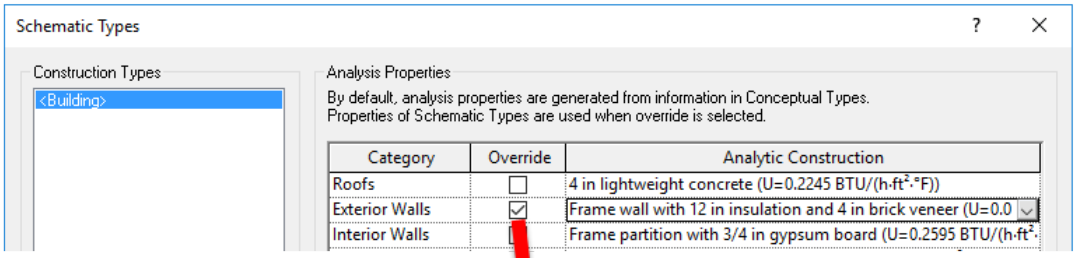
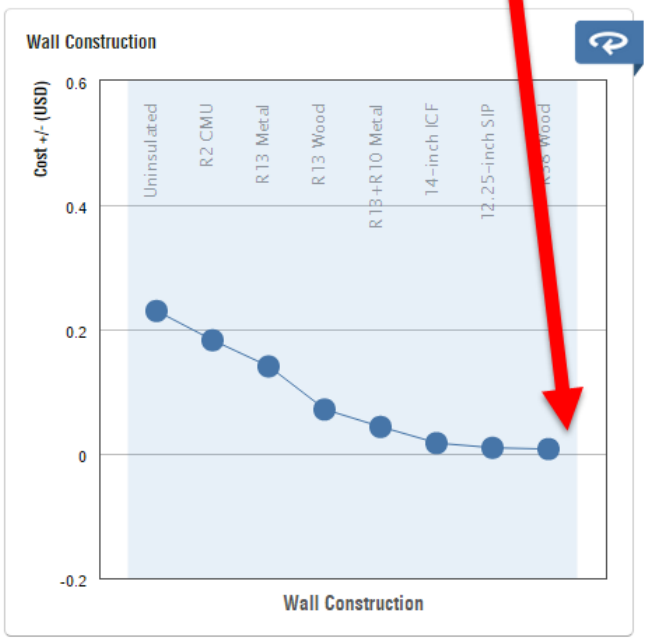


Figure 43. Use generic overrides based on element category.



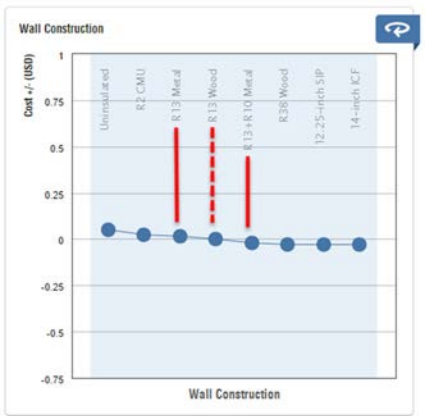
The image above, for a Minnesota project site, shows how changes to the Conceptual Constructions affect the results with Insight; remember the graph intersects "0" at the BIM setting. The image below shows we can override just the walls, in this example, with a super insulated wall.





Notice how the graph changes for a different project site:

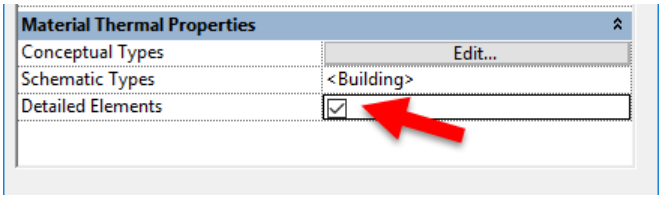
Scottsdale, Arizona



TIP: Edit the Conceptual Constructions in your firm template to align with your states minimum energy code requirements.

One final comment about building elements is that their **Thermal Properties**, assigned via materials, can be used in the energy simulation. For *layered* system families, such as walls, floors and roofs, the thermal properties are calculated for all layers (e.g., brick, air space, insulation, etc.). Notice highlighted **Resistance (R)** and **Thermal Mass** properties for the selected wall in the image below (Figure 44). However, applying and/or using building element thermal properties is not required. Generic assembly overrides can be applied, as just discussed, which is great as this would be putting the "cart before the horse." We are using this process, partly, to determine what the thermal properties should be!

As the model develops to the point where building elements in Revit have the correct thermal properties, check the Detailed Elements in the Energy Settings dialog.



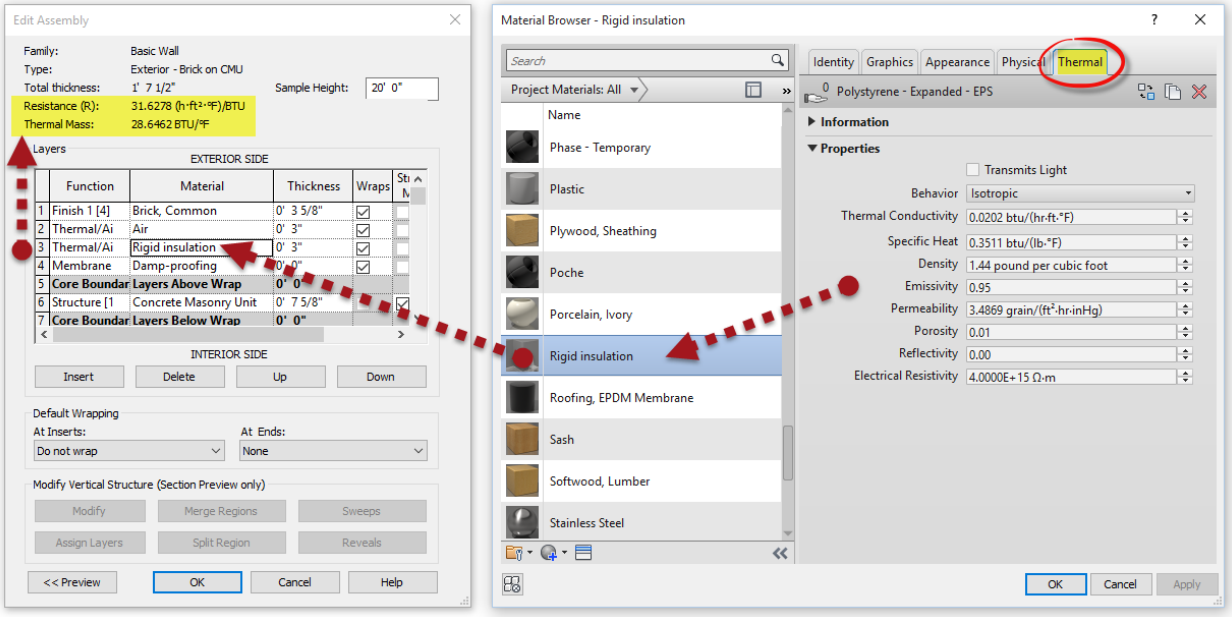


Figure 44. Thermal properties associated with building elements can be used in the energy simulation.

Irrelevant Settings

Some settings have no impact on the Energy Simulation. Revit 2017 removed these irrelevant settings from the Energy Settings dialog. The image to the right, Figure 45, shows the Revit 2016 dialog with all the omitted parameters highlighted. Helpful information if you are still using Revit 2016.

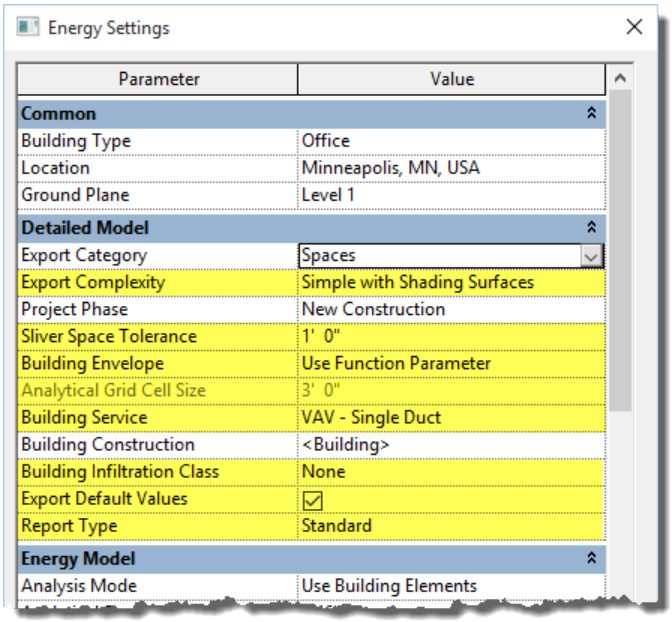


Figure 45. Parameters not used at all in Energy Simulation.

These omitted settings are specific to the old room/space based gbXML export and heating/cooling loads and they are still present in those dialogs.

Design Options

Revit's **Design Options** feature *partially* works for energy modeling in the preliminary design phase. The EAM is defined by elements in the **Main Model** and the **Primary** design option. To study another option, use the **Make Primary** command in the **Design Options** dialog, and recreate the EAM. If using design options for construction documents, e.g., a deduct alternate, it is not possible to change the primary options as annotations will get messed up.

Don't make a copy of your project and work in a separate file—it is not very BIM-like. There are always exceptions, but the energy analysis workflow is designed to work within the context of an active project.

Rooms and Spaces Not Required

It is helpful to understand that **Rooms** or **Spaces** *are not required* when using the **Use Building Elements** analysis mode. If they exist, some information is used. However, the EAM is generated from **Room Bounding** elements. Additionally, **Area and Volume Computations** does not have to be set to calculate volumes.

Just in case these two terms are not clear, understand that **Rooms** are typically placed by Architects and Interior Designers, while **Spaces** are placed by MEP designers. These two elements are placed and look the same in the model, but Rooms contains parameters like *Department* and *Wall Finish* while Spaces have engineering data such as *Electric Loads* and *Heating/Cooling Loads* (Figure 46). Also, when a Space exists within the same enclosed area as a Room (even when the Room is in a linked model), it has the ability to read the Room Name and Number.

When Rooms/Spaces exist, these are the parameters used:

- **Rooms**
    1. Room Name and Number
- **Spaces**
    1. Space Name and Number
    2. Occupancy; number of people
    3. Lighting and Equipment Loads
    4. Plus
        1. Building Construction (via Energy Settings dialog)
        2. Zones (i.e. collections of Spaces w/ set points)

***Tip:** Use the **Space Renaming Tool** add-in to make the Space names match the Room names (subscription benefit).*

Selecting and then using Spaces does allow for more detailed inputs, as just seen in the list above. Additionally, when **Energy Settings** > **Export Categories** is set to **Spaces**, the **Building Construction** option becomes available (see next section for more on this). Just remember, Rooms or Spaces are not required to start getting useful information on the performance potential of a design.

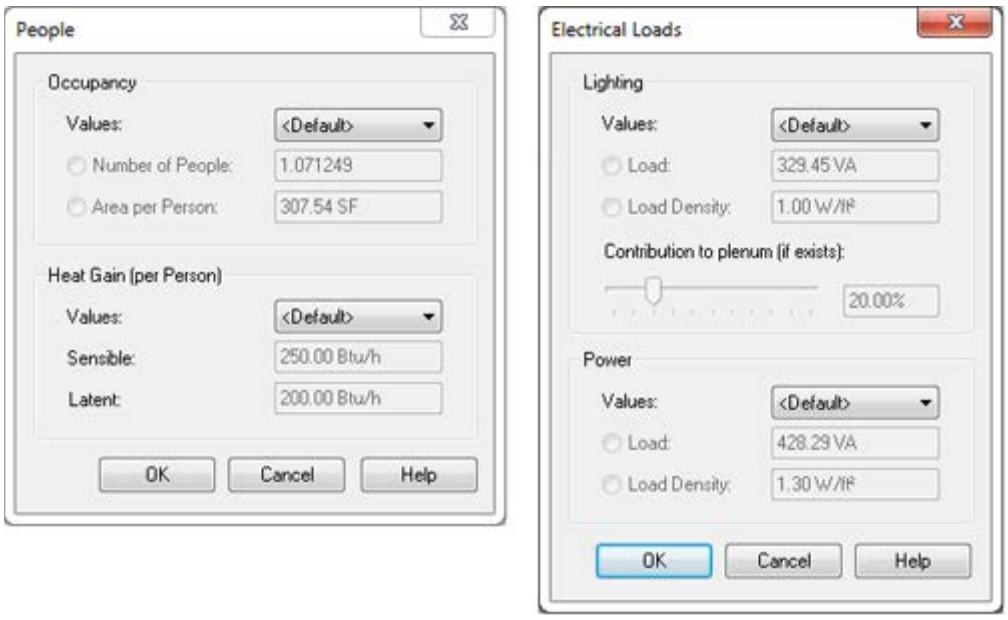


Figure 46. Additional properties embodied in EAM when Spaces are used.

Spaces also have the ability to be grouped into **Zones**. These allow things like **Outdoor Air Information** and **Heating / Cooling** set-points to be entered as shown below (Figure 47).

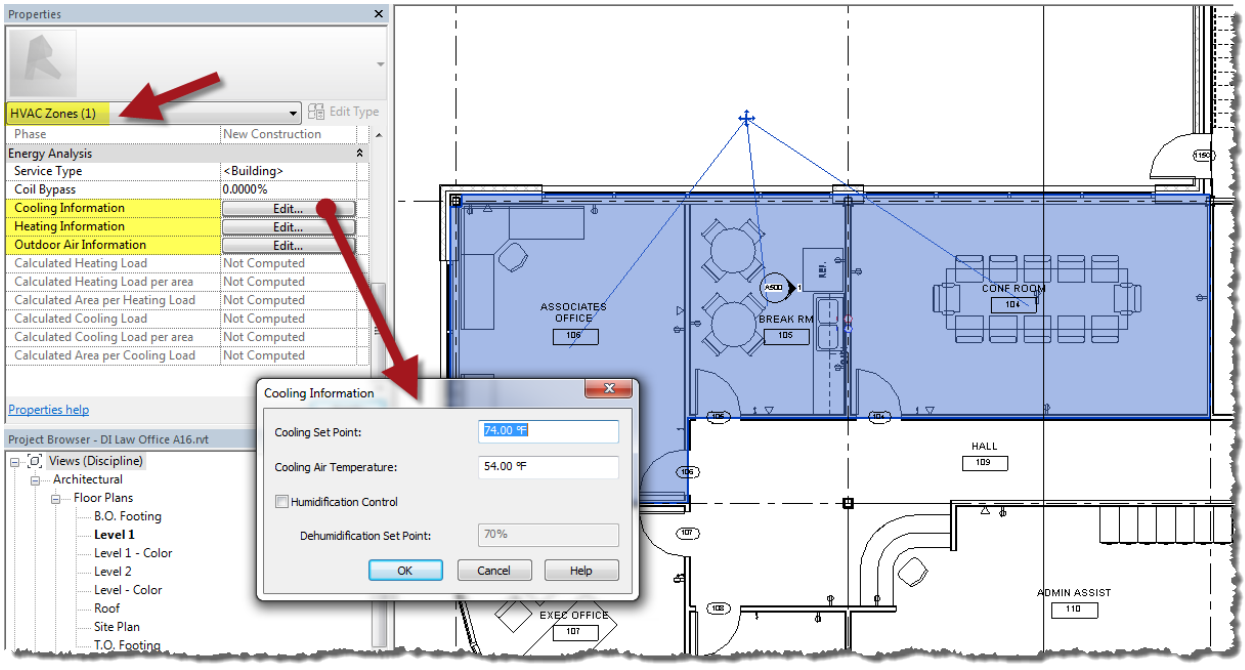


Figure 47. Additional properties embodied in EAM when Spaces and Zones are used.

Run Energy Simulation (old workflow)

Tip: *This step is part of the built-in Revit tools. When using the new Insight 360 feature set, this step can be skipped.*

Before running an Energy Simulation, make sure the EAM is up to date—simply delete and recreate it. Revit will provide a prompt if the EAM appears to be out of date.

The **Run Energy Simulation** dialog requires a **Project Name** and a **Run Name**. For the first run, be sure to specify a meaningful name. For subsequent runs, make sure the existing project name is selected and provide a new Run Name. Multiple runs may be compared—a feature which will be covered later.

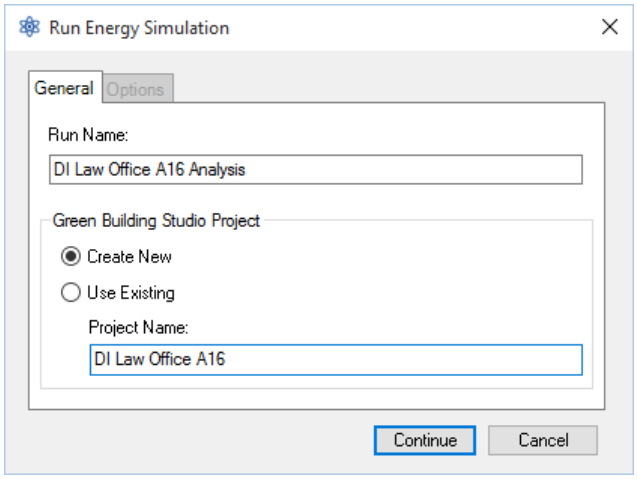


Figure 48. The Run Energy Simulation dialog.

Once **Continue** is selected, the EAM is uploaded to the cloud and processed by the GBS engine. A brief pop-up message will appear when the simulation is complete.

Review Results (old workflow)

Tip: *This step is part of the built-in Revit tools. When using the new Insight 360 feature set, this step can be skipped.*

When the simulation is complete, click the **Results and Compare** button within Revit. This opens the dialog shown next (Figure 49). Notice the **Project Name** and **Run Name** are listed on the left (right-click them for options).

Be sure to double-check the floor area and location for good measure. Notice that a **Total EUI** in **kBtu/sf/yr** is provided for each run. This number, and others listed, can be used to compare runs. However, in the early design stages, there are still several inputs to be explored. So don't take these numbers to the bank just yet. In fact, it is good practice to inform the client that all results from energy modelling are not perfect and should mainly be used in a comparative fashion—i.e. 'this form' performs XX% better 'than that form.'

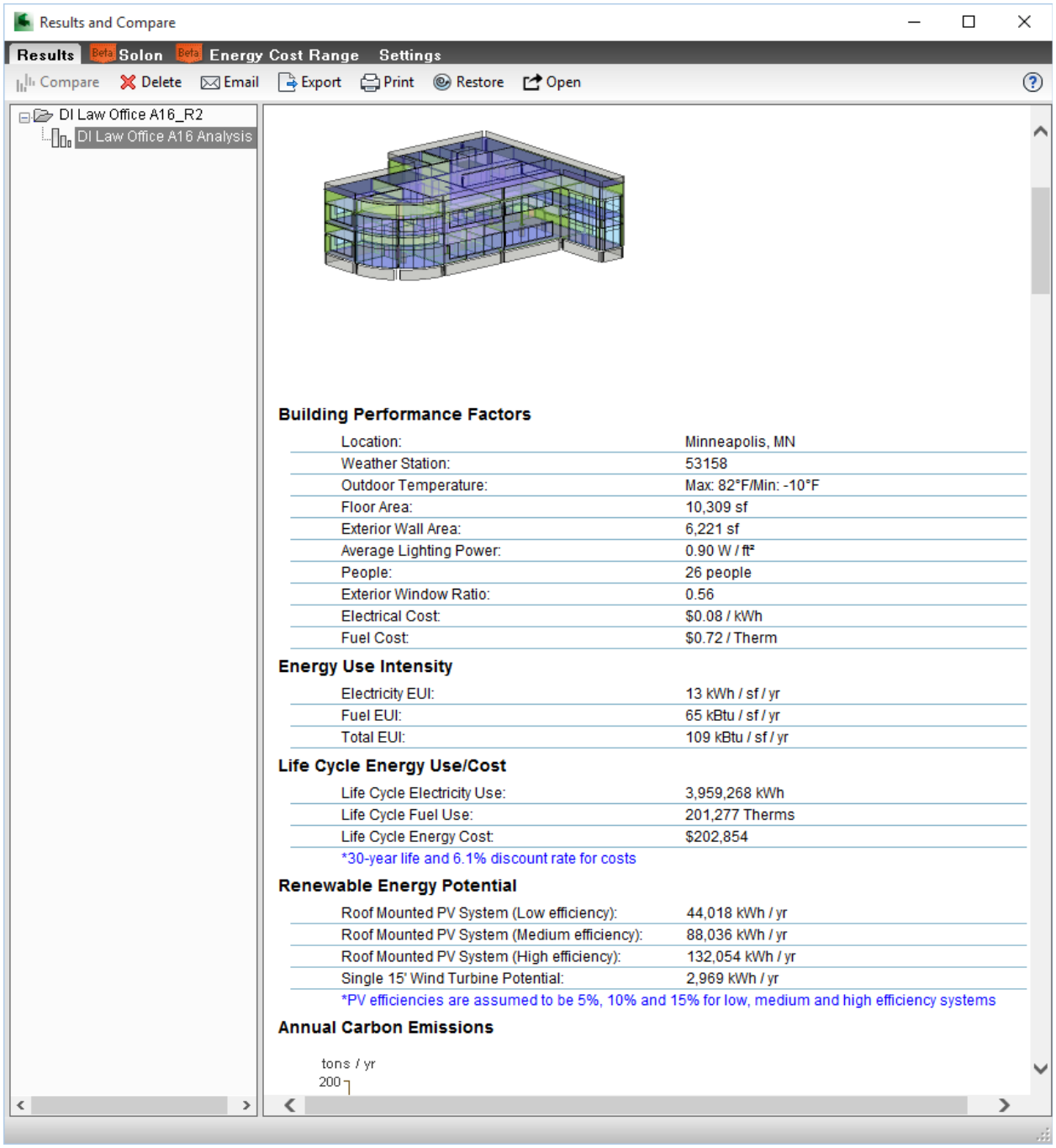


Figure 49. The Results and Compare dialog.

Scrolling down in the dialog, one can see various graphs which help tell the story about how the building performs based on the current location, form and inputs. To highlight the possible variation in results, compare the next two images which contrast the same project/inputs in Minnesota and Arizona (note the mBtu value scale on the left). Looking at the **Monthly Cooling Load** graph for both locations, it is also apparent that the building elements having the most impact on performance vary. This highlights specific areas in which adjustments to the design can have the biggest impact. In this example, the **Window Solar** and **Misc Equipment** consume more resources in Minnesota, whereas **Window Conductive** is the largest driver in Arizona for our building example (Figure 50).

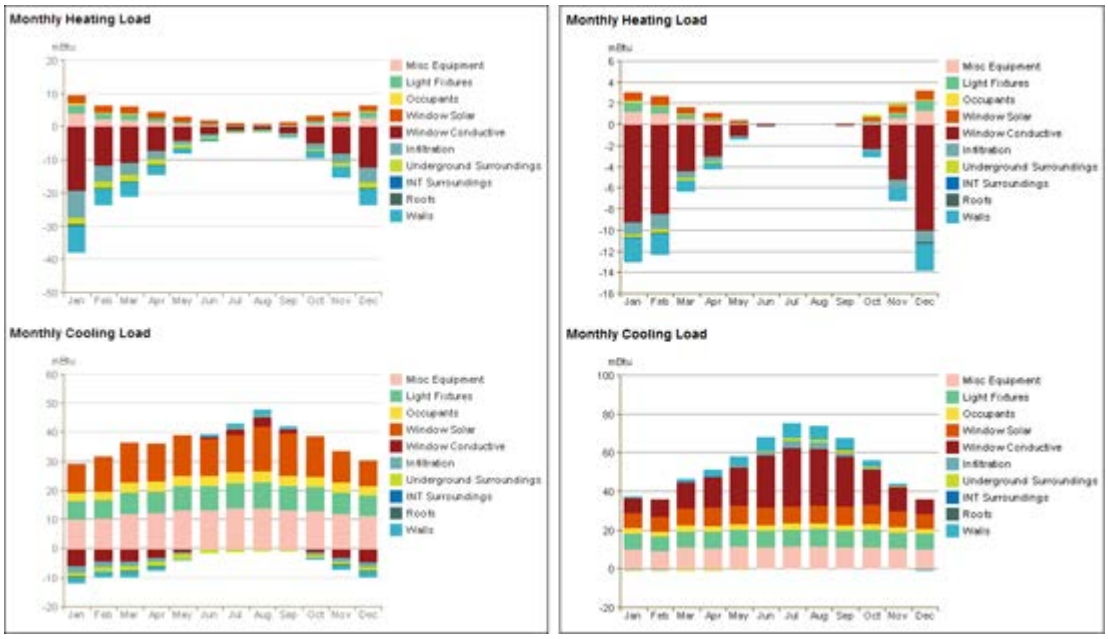


Figure 50. Comparing the Heating and Cooling Loads for the same project in Minneapolis, Minnesota, versus Phoenix, Arizona.

Going Further

Green Building Studio (GBS) is the web service that runs DOE 2.2 and EnergyPlus simulations used by Revit's *Energy Simulation* tool and by *Insight 360*. Use GBS to define custom settings for the analysis, such as currency, unit costs for electricity and natural gas, and the utility bill history with historical weather data.

Once a Revit Energy Simulation has been run, it can be opened in GBS as seen below (Figure 51 & 52). GBS allows multiple users to access the information.

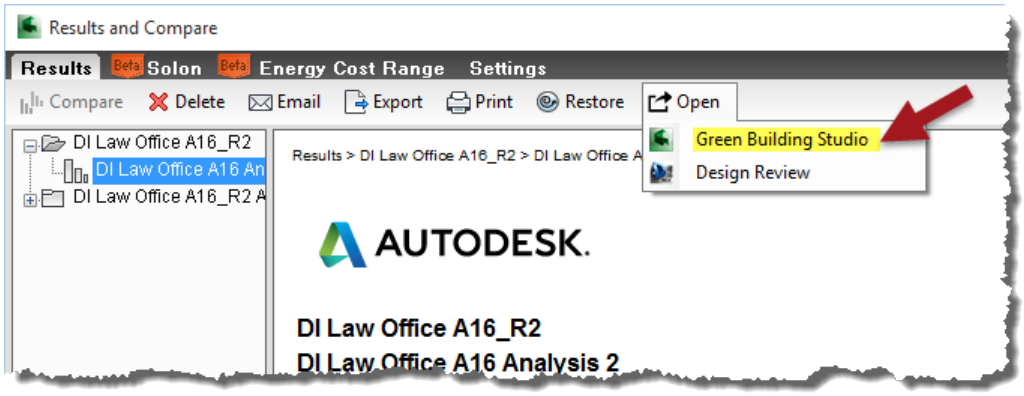


Figure 51. Opening a Revit Energy Simulation in Green Building Studio.

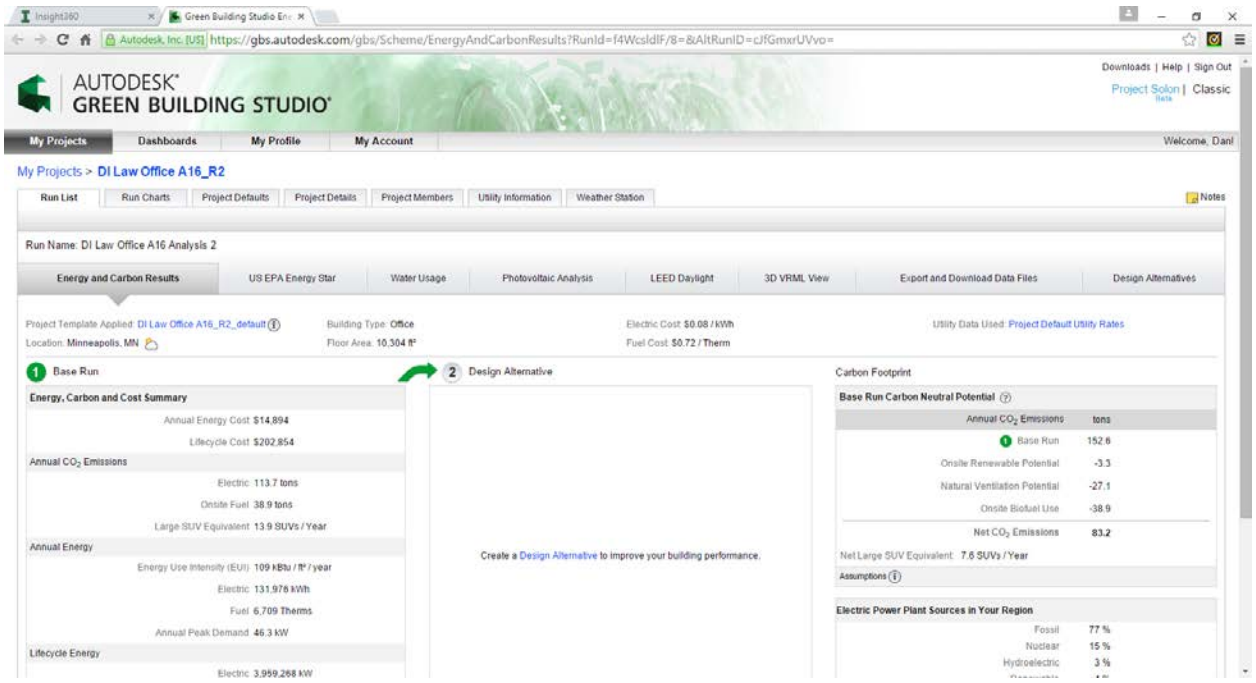


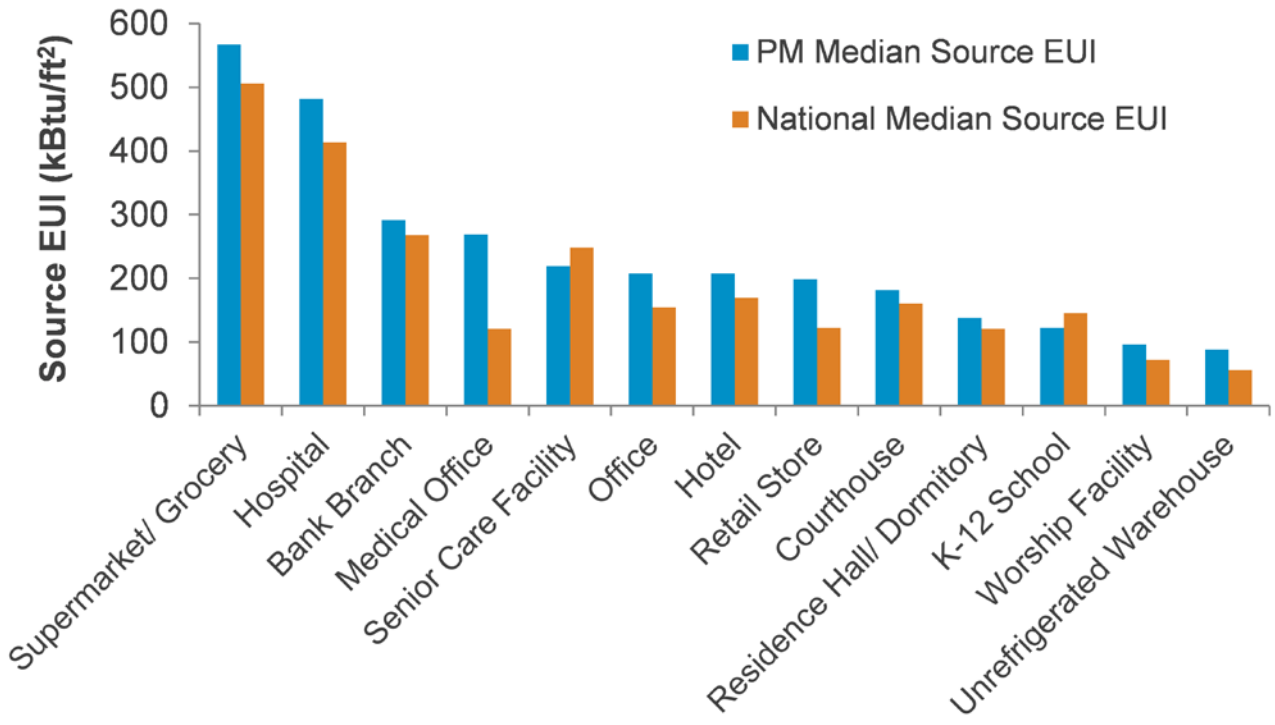
Figure 52. An example of the GBS cloud service.

8 Reference Material

When it comes to energy modelling, it is important to understand the required inputs and desired outputs, or results. The following information may be helpful to those just getting started in the art of energy modelling.

Results

Autodesk Insight 360 provides the primary results in either EUI or Cost. Having a feel for the actual EUI of existing buildings can be helpful. The graph below is based on research EPA conducted on more than 100,000 buildings. We obviously want to do better than these numbers...



Some building types excluded due to inadequate data and/or EUI values beyond this range

Source: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/what-energy

Insight 360 Inputs and Comments

		Firm specific comments for staff reference (not official)
Building Orientation		Rotates a building clockwise from 0 degrees, e.g. 90 degrees rotates the North side of the building to face East.
	45 degree increments	*0 degrees equals True North position in Revit*
Wall Window Ratio (for N, E, S, W)		Window-Wall-Ratio (glazing area / gross wall area) interacts with window properties to impact daylighting, heating & cooling.
	0% 15% 30% 40% 50% 65% 80% 95%	*In the Energy Settings dialog, 'Target percentage glazing' is set to 0% as Insight 360 will vary for all options. Once windows or curtainwall are added, the Revit setting will be the point where the graph crosses 0 in Insight for Window-Wall-Ratio for each direction.*
Window Shades		Shades can reduce HVAC energy use. The impacts depends on other factors, such as window size and soar heat gain properties.
	No Change 1/6 Win Height 1/4 Win Height 1/3 Win Height 1/2 Win Height 2/3 Win Height	*Can also model sun shades in Revit. Use floor element in secondary Design Option. Set to Primary prior to generating Energy Analysis Model (EAM) in Revit. Switch back to secondary right after EAM creation. FYI: Revit ignores the Generic Model category.*
Window Glass		Glass properties control the amount of daylight, heat transfer & solar heat gain into the building, along with other factors.
	Sgl Clr * Dbl Clr Trp LoE Dbl LoE Quad LoE	*Zone 6 (non-residential): U .55, curtainwall U .45* *Zone 7 (non-residential): U .45, curtainwall U .40*
Wall Construction		Represents the overall ability of wall constructions to resist heat losses and gains.
	Uninsulated R2 CMU R13 Metal R13 Wood R13 + R10 Metal 14-inch ICF	*http://www.dli.mn.gov/CCLD/codes15.asp* *Reference: 2015 MN Energy Code --> ASHRAE 90.1 --> 5. Building Envelope --> Tables 5.5-1 thru 5.5-8 (depending on climate zone)* *Zone 6 (non-residential): R13*

	12.25-inch SIP *(approx. R40)*	*Zone 7 (non-residential): R15.2*
	R38 Wood	
Roof Construction		Represents the overall ability of roof constructions to resist heat losses and gains.
	Uninsulated	*http://www.dli.mn.gov/CCLD/codes15.asp*
	R10	*Reference: 2015 MN Energy Code --> ASHRAE 90.1 --> 5. Building Envelope --> Tables 5.5-1 thru 5.5-8 (depending on climate zone)*
	R15	
*	R19	*Zone 6 & 7 (non-residential): R20*
	10.25-inch SIP	
	R38	
	R60	
Infiltration		The unintentional leaking of air into or out of conditioned spaces; often due to gaps in the building envelope.
	2.0 ACH	*If building pressurized (values from Trane Trace defaults):*
	1.6 ACH	*0.3 Average construction (LHB typical)*
	1.2 ACH	*0.5 Poor construction*
	0.8 ACH	*If not pressurized (neutral):*
	0.4 ACH	*0.6 Average*
	0.17 ACH	*1.0 Poor*
		2.5 Loose
Lighting Efficiency		Represents the average internal heat gain and power consumption of electric lighting per unit floor area.
	1.9 W/sf	*ASHRAE 90.1 (2010), Table 9.5.1*
	1.5 W/sf *Retail*	*Office 0.9 W/sf*
	1.1 W/sf *Mfr Facility*	
	0.7 W/sf *Dormatory*	
	0.3 W/sf *Parking Garage*	
Daylighting & Occupancy Controls		Represents typical daylight dimming and occupancy sensor systems.
	None	
	Daylighting Controls	
	Occupancy Controls	
*	Daylighting & Occ Ctrls	
Plug Load Efficiency		The power used by equipment i.e. computers and small appliances; excludes lighting or heating and cooling equipment.
	2.6 W/sf	*Varies widely based on building type and use.*
	2.0 W/sf	
	1.6 W/sf	
	1.3 W/sf	
	1.0 W/sf	

0.6 W/sf

HVAC	Represents a range of HVAC system efficiency which will vary based on location and building size.
ASHRAE Package Terminal Heat Pump	** = Typical options for education projects*
ASHRAE VAV	
ASHRAE Heat Pump	
High Eff. Heat Pump *	
High Eff. VAV *	
ASHRAE Package System *	
High Eff. Package System	
High Eff. Package Terminal AC	

Operating Schedule	The typical hours of use by building occupants.
24/7	
12/7	
12/6	
12/5	

PV - Panel Efficiency	The percentage of the sun's energy that will be converted to AC energy. Higher efficiency panels cost more, but produce more energy for the same surface area.
16%	*We typically spec Suniva OPT250 which has 15.4 to 16.33 eff*
18.60%	
20.40%	

PV - Payback Limit	Use the payback period to define which surfaces will be used for the PV system. Surfaces with shading or poor solar orientation may be excluded.
10 yr	
20 yr	
* 30 yr	

PV - Surface Coverage	Defines how much roof area can be used for PV panels, assuming area for maintenance access, rooftop equipment and system infrastructure.
0%	
60%	
75%	
90%	

Conclusion

It should be clear that Autodesk is investing significant resources in the advancement of its performance design tools. It is definitely worth spending some time learning to use these tools. Hopefully this document will serve as a reference for those who are ready to jump in and get started!