AUTODESK **UNIVERSITY** 2014

# Come to the Light: Revit Lighting and Daylighting Performance Analysis for Everyone

David Scheer - Autodesk

## AB6553

Until recently, daylighting performance modeling was a bespoke skill in the world of building design, requiring tedious and highly technical model setup with specialty analysis software. This class will show how new analysis tools for Revit make it possible for novices and experts to perform simple and repeatable analysis workflows on standard architectural models and to visualize results in-canvas. By moving computationally intensive processes to a fast simulation engine in the cloud, these tools free up computer resources and offer speeds 50 to 1000 times faster than comparable tools.

This class will cover 3 of these new tools: We will do a deep dive into the Lighting Analysis for Revit plugin that helps automate simulation and results management for typical daylighting analyses like LEED 8.1; an introductory look at Rendering Illuminance output that allows flexible and general visualization of illuminance levels for any time, location, or sky condition for any Revit 3D view; and a quick intro to Dynamo Daylighting and Rendering nodes that provide the ultimate in flexibility and automation using the same analysis engine.

### Learning Objectives

At the end of this class you will be able to:

- Apply the essential metrics for evaluating lighting and daylighting performance.
- Set up a Revit software model with effective practices for getting valid lighting-simulation results.
- Perform and prepare a full LEED 2009 IEQc8.1 daylighting credit submission.
- Perform advanced and detailed lighting and daylighting analyses.

### About the Speaker

*David Scheer is a Senior Product manager in Autodesk's Building Performance Analysis group. David is a registered architect with a background in building construction and GIS and as an Alaska float plane pilot. With a Master of Architecture degree from Berkeley, he has focused the last 15 years on building design, building science and energy analysis consulting and software. David is based in the San Francisco office where he works with a variety of teams at Autodesk to coordinate simulation workflows, including daylighting, solar and PV, airflow, and especially whole building energy analysis with the Green Building Studio group.*
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## Introduction

The purpose of these exercises is to provide an understanding of three methods for performing lighting and daylighting analysis in Revit using the Lighting Analysis for Revit (LAR) plugin, the Rendering Illuminance output option, and the Daylighting nodes in the Dynamo plugin for Revit.

**Exercise 1.0:** A step by step tour through the inside workings of the automated analysis process employed on a standard architectural model by the Lighting Analysis for Revit plugin for workflows such as LEED daylighting credits.

**Exercise 2.0:** Two essential workflows using the 360Rendering Illuminance output type: simple camera perspective illuminance, and orthographic view of illuminance on a plane.

**Exercise 3.0:** A quick introduction to the Rendering and Illuminance nodes for Dynamo, which can be used for iterative workflows, or for customized variations of the workflows in exercises 1 and 2.

Over the next few weeks we will continue to publish *Special Section* workflow exercises, including:

**0.1**: Creating a simple and effective glazing library for use with LAR and Rendering Illuminance
**0.2**: Three ways ways to define glazing transparency
**0.3**: Modeling Solatubes for analysis in Revit
**0.4**: Where to get solar variables DNI and DHI for your Revit project location

**1.1**: Config File Settings and the Lighting Analysis Model View
**1.2**: Refining Analysis Scope and Managing Cloud Credit Costs in LAR
**1.3**: Creating a layout and setting up views that update automatically
**1.4**: Using custom analysis times and solar values with LAR
**1.5**: Managing and interpreting point data from the raw grid data export option

## What you'll need

Revit 2014 or 2015

Lighting Analysis for Revit plugin
http://www.autodesk.com/products/lighting-analysis-revit/overview

Dynamo for Revit plugin
http://dynamobim.org/

A subscription-enabled Autodesk 360 account (paid or student)

A Revit model – the 'rac_advanced_sample_project.rvt' project from the 'Samples' folder installed with Revit is used for the following examples. A prepopulated version is also available here:
https://autodesk.box.com/s/h08o5bb0f49u4djgbzmh

## Sign in to Autodesk 360

To access Autodesk Cloud Services, select Sign In from Revit's title bar…

# Exercise 1.0:

**The basic automated analysis process for LEED daylighting credits using Lighting Analysis for Revit on a standard architectural model**

## i. Open the model:

'rac_advanced_sample_project.rvt' from your Samples directory installed with Revit will be used for this exercise. This is usually in C:\Program Files\Autodesk\Revit 2015.

TIP

TIP: To get links to help on the following steps, you can click Run Analysis in the Light Analysis section of the Analyze toolbar to get a quick start window with links, then cancel until you are ready to do your analysis.

## ii. Set Location:

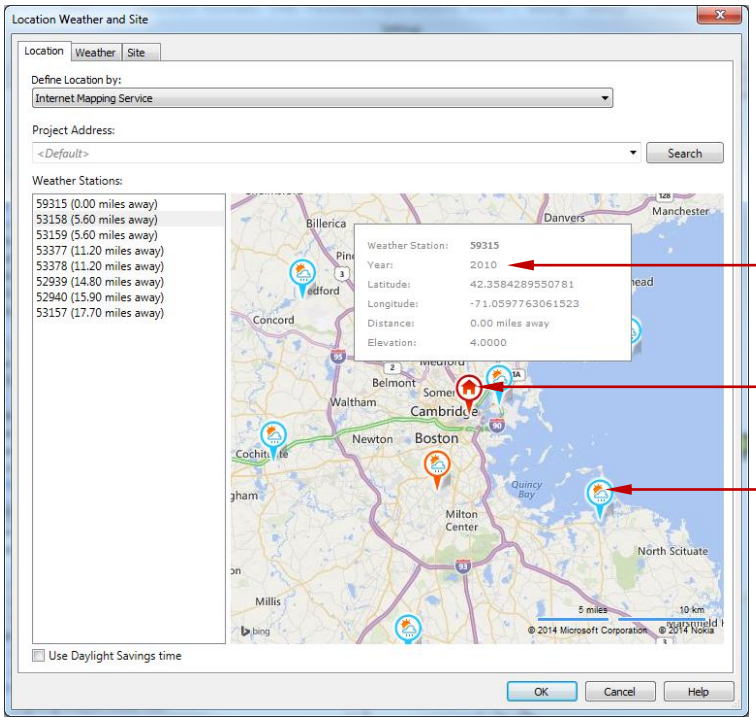
Daylighting analysis uses the specific solar conditions at your project location for the date and time of the analysis. The first step is to define the project location so the analysis will use the correct weather data.

TIP

Autodesk's Climate Server weather data stations are located on an approximately a 14 km grid with modeled weather data covering most of the globe.

- Stations identified as 2004 or 2006 are modeled data based on measured data for those years.
- Stations identified as '2010' are TMY data. More information about TMY data can be found here: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

In the Manage toolbar, Project location section, click 'Location' to bring up the location dialog. In this dialog, the Location tab should be selected.

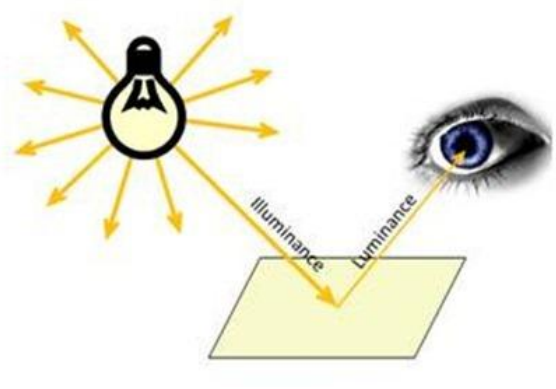



Choose to Define Location by: Internet Mapping Service to see a map with your project address and locations of weather data available nearby from Autodesk's Climate Server data set.

The closest station will be automatically selected. Accept this, or choose another station nearby that may better match the site's microclimate or terrain conditions. Solar data does not vary much by microclimate or site, so the default is a good choice. Click OK, and all analysis done in Revit will use this site's weather.

### iii. Manage 'opaque' surface material properties:

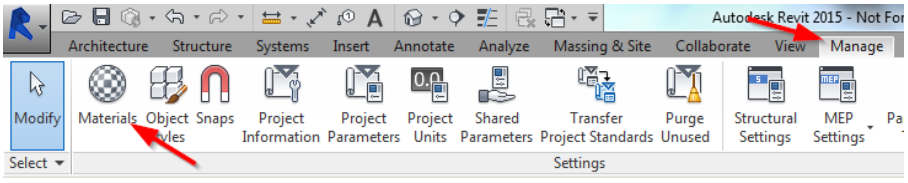
For visual renderings, all visible material properties are needed to render a good representation of reality. For analytical renderings and measurements of visual performance, we are concerned with measuring 'illuminance' and 'luminance', and we only need to know how much visible light the material will reflect, and possibly some information about how the material will distribute that reflected light. For this exercise, we will be concerned with defining material Reflectance.




For the most part, Revit default materials properties, and most materials created for visual renderings, will be close enough to physical reality for use in analysis. Some care has to be taken where materials have been manipulated to get a particular rendered effect for visual renderings, but most of the time the assumption of WYSIWYG (what-you-see-is-what-you-get) will apply well for opaque materials in Revit.

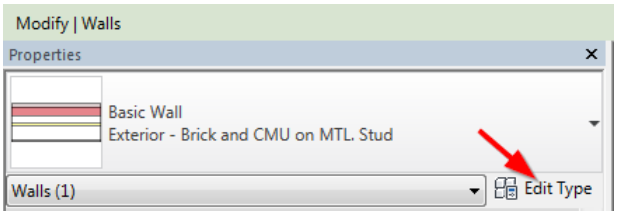
Revit lighting analysis tools currently use the properties of surface layer materials defined in the Appearance tab of the Materials Browser.

To get to this dialog, if you already know the material you wish to edit or want to review all materials, you can go directly to Manage > Materials:

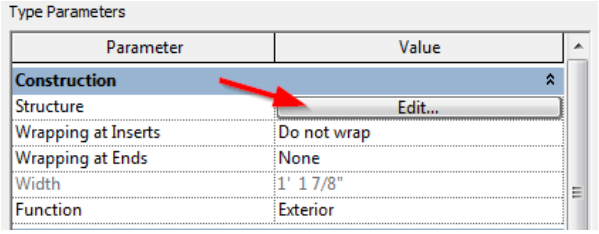



or pick an object in Revit and navigate to the surface layer of its construction with these steps:

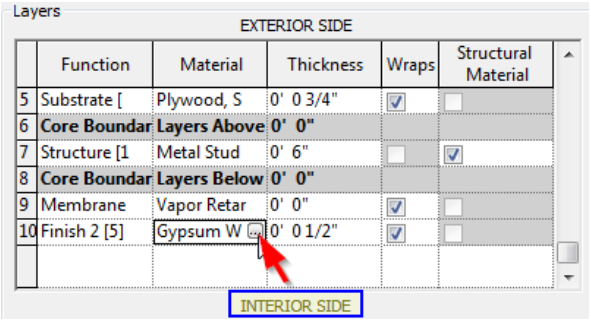
**a. Select the object** (wall, ceiling, floor, etc) and click Edit Type on the Properties bar:



**b. Edit the material layers of the Construction** - In the Type Parameters, select Edit Structure:

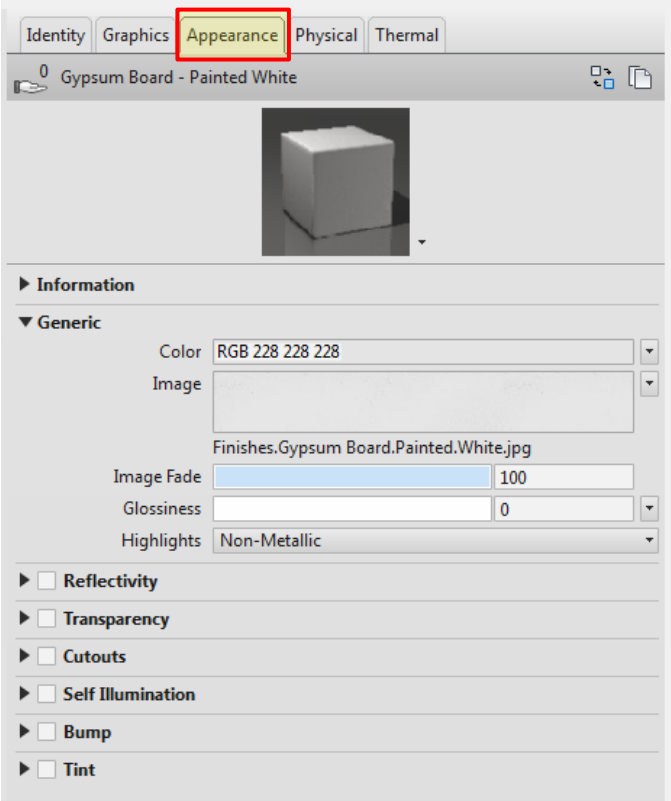



**c. Edit the Finish material** - Choose the Edit button for the Finish material on the Interior and/or Exterior sides of the construction:




**d. Navigate to the Appearance tab** of the Material Browser dialog:

**[Note that ONLY the settings on the Appearance tab of the Material Browser will affect lighting and daylighting analytical simulations. This includes work using Rendering Illuminance and Lighting Analysis. The properties on any of the other tabs are not used.]



**e. Edit the reflectance by defining the RGB color for the material**.

Though all of the properties on the Appearance tab of this dialog are used by the analysis engine to interpret the visual light reflectance behavior of opaque materials. However, we recommend that you keep it simple and only use the RGB color values of generic materials in most cases, or that you follow the rule of WYSIWIG and the checklist at the end of this section.

Used alone, the RGB value is interpreted as the diffuse visible light reflectance property for the surface. The RGB values are a range of 0 – 255, so the percent reflectance of the surface is defined as:

Weighted **RGB / 255** = **Reflectance** (%)

| Reflectivity | R | G | B |
|---|---|---|---|
| 100% | 255 | 255 | 255 |
| 98% | 250 | 250 | 250 |
| 94% | 240 | 240 | 240 |
| 90% | 230 | 230 | 230 |
| 86% | 220 | 220 | 220 |
| 82% | 210 | 210 | 210 |
| 78% | 200 | 200 | 200 |
| 75% | 190 | 190 | 190 |
| 71% | 180 | 180 | 180 |
| 67% | 170 | 170 | 170 |
| 63% | 160 | 160 | 160 |
| 59% | 150 | 150 | 150 |
| 55% | 140 | 140 | 140 |
| 51% | 130 | 130 | 130 |
| 47% | 120 | 120 | 120 |
| 43% | 110 | 110 | 110 |
| 39% | 100 | 100 | 100 |
| 35% | 90 | 90 | 90 |
| 31% | 80 | 80 | 80 |
| 27% | 70 | 70 | 70 |
| 24% | 60 | 60 | 60 |
| 20% | 50 | 50 | 50 |
| 16% | 40 | 40 | 40 |
| 12% | 30 | 30 | 30 |
| 8% | 20 | 20 | 20 |
| 4% | 10 | 10 | 10 |
| 0% | 0 | 0 | 0 |

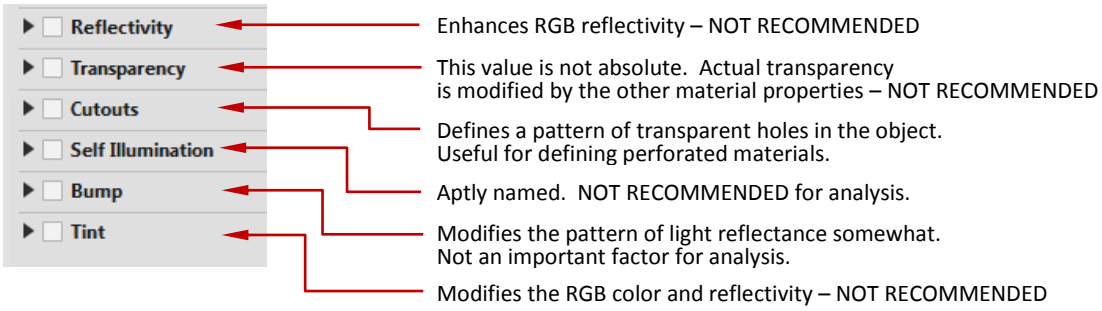
For analytical simulations, only the quantity and distribution of light matters not the quality (color, pattern, etc.), so the greyscale values from the chart above are all we need. However, we normally work with colors in Revit models for many other reasons, including that we may want to create visual renderings from the same model. If the surface material has a color tone, the Weighted RGB and reflectivity can be derived using the following formula weighting the relative importance of red, green and blue:

Weighted **RGB**(R,G,B) = **0.2126 R** + **0.7152 G** + **0.0722 B**

For materials using bitmaps for color distribution and character, like wood flooring, the analysis engine uses the average color of the bitmap to derive surface reflectance RGB. Modifications like 'stain' will further modify the overall RGB. For complex materials like this, it's best to either simplify, or assume WYSIWIG from a visual rendering to interpret the effect of the material properties.


**f. Simplify the material properties**

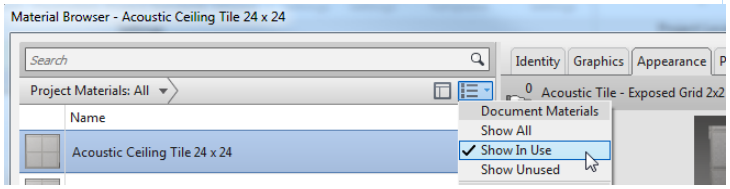
All the other Appearance Property Modifiers will modify this basic reflectance in complex ways. For this reason, we recommend great care when using these other properties or avoiding them altogether.




TIP

***Best Practices for managing materials in a new or existing Revit model**:*

1. Review the materials library in the Materials Browser - Manage > Settings > Materials




2. If preparing an existing Revit model for analysis, focus on the Materials in Use.

3. Simplify all materials as much as possible.
   a. Remove unnecessary appearance properties other than Generic RGB
   b. Use simple Generic appearance materials whenever possible

4. Remove (uncheck) the main problematic material modifiers of Reflectivity and Self-Illumination.

## iv. Manage 'transparent' material properties (ie 'glazing'):

Transparent materials can come in a huge variety of visual and analytical properties. Similar to opaque materials, we are only concerned with quantifying the amount and distribution of light passing through (or reflecting off of) the object. For this exercise, we will be concerned with defining material Transmittance.

All materials respond to light by either reflecting, absorbing or transmitting light. Adding these 3 values must always equal 1 for the conservation of energy:

**Absorptance** + **Reflectance** + **Transmittance** = **1.0**

…or using our Appearance representation by RGB:

**RGB Absorptance** + **RGB Reflectance** + **RGB Transmittance** = **255**

Opaque materials either absorb or reflect. Transparent materials absorb, reflect and transmit. The color of opaque materials is determined by what wavelengths are reflected (the rest are absorbed). The color of transparent materials is determined by what wavelengths are transmitted (and in very small part also by what is reflected).

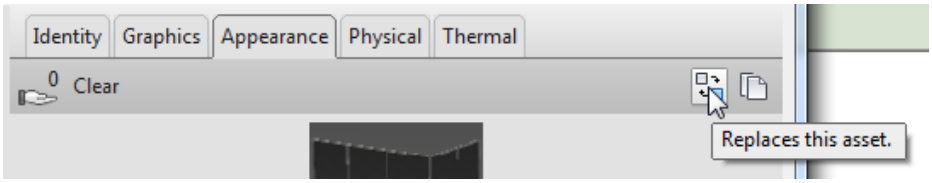
Revit analytical material properties for transparent materials is currently limited to the following:

- ✓ Visible reflectance of glass is currently locked at 4%. This is a good estimation, and modifications to this are rarely needed because reflections from glass are a very small part of the total luminance effect of transparent surfaces.
- ✓ Diffusing properties and non-standard refraction such as translucent or textured panels are not currently supported for transmitted light, and all light passing through a transparent surface is assumed to be specular modified only by the refractive properties of glass.

**a.** **Follow steps (a) through (d) from the section above** on opaque materials to arrive at the Appearance Tab of a transparent material.

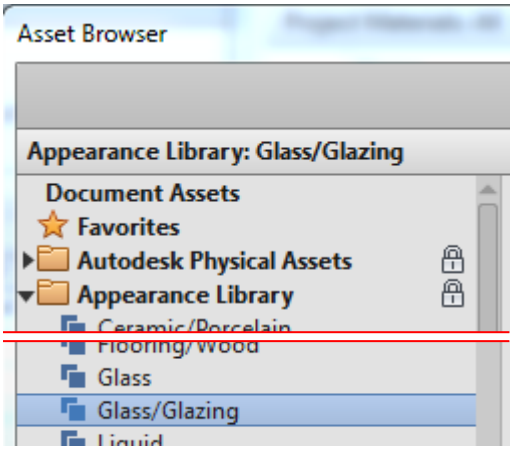
**b.** **Choose a Glazing asset from the Asset Browser**

All transparent objects should be modeled using a Glazing or Glass Appearance Asset.




TIP

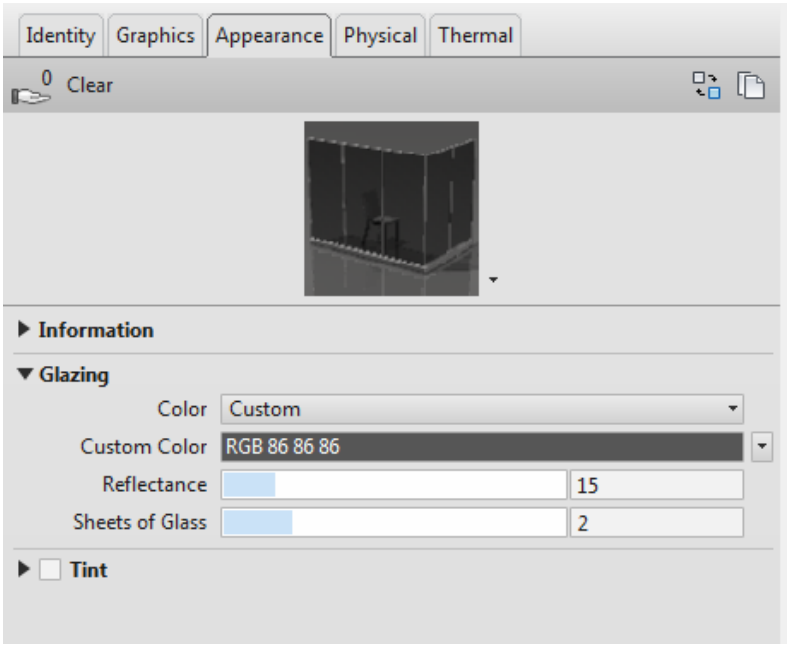
Using a Generic asset with transparency as a simplified method for early design will work as well, but generally the transparency will be reduced, and refractive qualities of glass thickness will not be considered properly. See the special section on ways to define transparent materials for more details.]



Choose a Glazing asset from the Asset Browser and apply to the material:

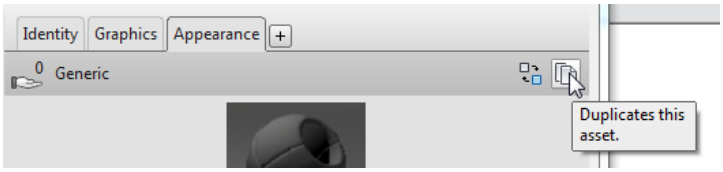

### c. Modify the properties of the Appearance Asset

Now in the Appearance tab you can modify the properties of this Appearance Asset to define the transparency of the material for the object it is applied to:




TIP

Note that any changes to the properties of an Appearance Asset will apply everywhere this asset is used, so be careful that you know where it is used, or that you duplicate the asset before making changes.




### d. Define the desired visible transmittance for the window using RGB values

Refer to standards, defaults, recommendations, or to the specifications of the windows or glazing units used in your design. If references are not available, values between 40% and 70% are typical for most applications. Generally lower transmittance will be used in commercial applications, and higher transmittance in residential buildings.

Glazing material transmittance in Revit is dependent on the following parameters:

- ✓ Window object thickness – this is the modeled thickness in Revit, not the manufacturer specifications. Eg, Typically a glazing unit with specs defining two glass panes of 1/8" and a ¾" air gap as a single 1 inch thick extrusion. The 1 inch value is important as the object thickness.

- ✓ Window object number of panes – This is rare, but in some cases glazing units are modeled similar to the physical IGU. If that is the case, use the actual modeled glass thickness and the number of panes modeled.
- ✓ RGB color

Use the RGB-Transmittance table below or the Excel widget to define the RGB values to use in the Appearance Asset. Using a 'Custom' color, type in the RGB values for the desired visible transmittance for the window. If using the table, enter the same number for each of R, G, and B. If using the Excel tool to define a colored glass, use the values from the 'RGB for desired TVis column.

| # Panes Modeled | Modeled Thickness | 90% | 80% | 70% | 60% | 50% | 40% | 30% | 20% | 10% |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **3.0 mm** | 171 | 24 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **4.0 mm** | 189 | 43 | 8 | 1 | 0 | 0 | 0 | 0 | 0 |
| | **5.0 mm** | 201 | 61 | 16 | 3 | 0 | 0 | 0 | 0 | 0 |
| | **6.0 mm** | 209 | 78 | 25 | 7 | 1 | 0 | 0 | 0 | 0 |
| | **8.0 mm** | 219 | 105 | 45 | 17 | 5 | 1 | 0 | 0 | 0 |
| | **10.0 mm** | 226 | 125 | 64 | 29 | 11 | 3 | 0 | 0 | 0 |
| | **12.7 mm** | 232 | 146 | 86 | 47 | 22 | 9 | 3 | 0 | 0 |
| | **25.4 mm** | 243 | 193 | 148 | 109 | 76 | 49 | 27 | 12 | 3 |
| | **28.6 mm** | 244 | 199 | 157 | 120 | 87 | 59 | 35 | 17 | 5 |
| | **33.3 mm** | 246 | 206 | 168 | 133 | 101 | 72 | 47 | 25 | 9 |

**e. Simplify the glazing material definition.**

Similar to the recommendations for opaque materials, we recommend that only the 'Glazing' property of the Appearance asset be used for managing transparency of the material. 'Tint' will further modify the transparency in a complex way and will offer no value to the analytical results.

*TIP*

RGB is used by the analysis engine to interpret the visible transmittance (or transparency) of the 'glazing' or 'solid glass' material. The formula is not as simple as it is for reflectivity:

RGB(Tvis) = 255 * sqrt(10^((log(T/F^p))/(p*d/100)))

Where:

T = desired Tvis (decimal)
d = pane thickness (mm)
p = number of panes
F = Fresnel transmission of standard glass = 0.9216

…so we created the RGB-Transmittance table and the TVis Excel tool to help you until a more straightforward way of defining glass transmittance is devised for Revit materials.

## v. Manage Rooms

Architects commonly use Revit Room objects to schedule, label and otherwise report on the spaces of a building design. LAR also uses Rooms to inform how analysis results are organized and interpreted.

For the purposes of analysis, you can use the standard Revit methods to define rooms by clicking in bounded areas, defining boundaries or subdividing bounded areas with Room Separators, etc. See Revit Help for more details. There are also a number of plugins to help you automatically assign Rooms to the entire building or to copy Space boundaries to Room objects to coordinate with energy model settings.

Rooms are used by LAR for three things:

**a.** A mechanism for reporting analysis results. Threshold performance percentages are organized and reported in standard Revit schedules by Rooms. Graphical results in Floor Plan views are rendered on a surface derived from the floors of Room objects.

**b.** A way for you to define which rooms are to be used in the overall floor and building threshold performance percentages. In USGBC terminology, to define LEED Regularly Occupied spaces.

**c.** A way for you to define which rooms have automated shading devices on the windows. This is a programmatic definition, not a behavior that is actually simulated.

TIP

When you Run Analysis on a Revit model, the Room and Room Parameter settings do not affect the scope of the analysis, only the presentation of the analysis results. You can define rooms either before or after Run Analysis.

TIP

When a project has no Rooms defined at all, the entire building is assumed to be Included in Daylighting for the purposes of the Schedules and Floor Plan views. It is not necessary to define Rooms before running an analysis.

### vi. Manage Room Parameters

LAR uses two Room Parameters to define how to interpret the analysis results in the schedules and on the Floor Plan results views.

**a. Include in Daylighting:**

If this is checked, the results for this room are used in the roll-up floor and building threshold performance percentages. This is also equivalent to LEED Regularly Occupied. Also if this is checked, the graphical results for this area will be shown in the _Lighting Analysis Floor Plan views. If this is not checked, results will not be shown for this area of the floor.

The LEED IEQ Space Matrix defines what space/room types are regularly occupied and should be marked 'Include in Daylighting.'

**b. Automated Shades:**

If this is checked, the room is assumed to have shades that are automatically lowered to block high levels of direct solar and raised when not needed. For the analysis results for LEED, this means that the area above the upper threshold can be assumed to be included instead in the Areas Within Threshold and increase the LEED performance percentage.

TIP

In a new Revit project that has never run a LAR analysis, the LAR Room Parameters will not be available until you click Run Analysis. To pre-populate your Rooms with these parameters, click Run Analysis, then cancel the analysis to create the LAR parameters in your Shared Parameters file. For Rooms that are defined, the new parameters will be populated with Include in Analysis ON and Automated Shades OFF. If you created rooms after these parameters are created, you will have to set the flags manually.

TIP

After running an analysis and generating results, you can change the Room parameters and regenerate Results without running a new analysis. You can use this method to experiment with the effectiveness of automated shades or update Room types or areas to LEED Regularly Occupied or not.

Other parameters for organizing results in the schedules for Rooms and Floors/Levels are written to the users Parameters file during analysis and results processing for LAR. See the Help documentation for a list of these parameters, what they are used for, and the naming convention used in the schedules.

### vii. Manage analysis grids (ie Floors)

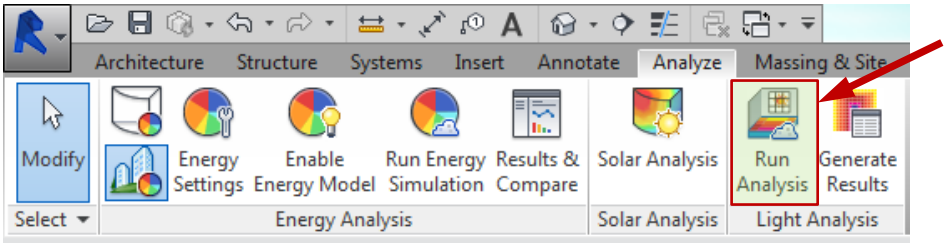
LAR defines analysis grids at 30 inches above each Floor object on all Levels that are selected for analysis in the Run Analysis dialog.

Since Floor objects are often used for things other than interior occupiable floors, it's good practice to associate Floors that are either outside the building or are otherwise not actual occupiable floor area (like shading devices) with a separate Layer so it can be excluded from the analysis in the Run Analysis dialog. See the *Special Section* on Refining Analysis Scope and Managing Cloud Credit Costs for more details.

### viii. Set Advanced Options

Advanced options include a variety of settings in the configuration file to allow you analyze tubular skylight devices, turn on an off object types in the "_Lighting Analysis Model View," or even define custom analysis times, dates and solar data. These advanced options are covered below in the *Special Section* topic on Config Settings and Advanced Options.

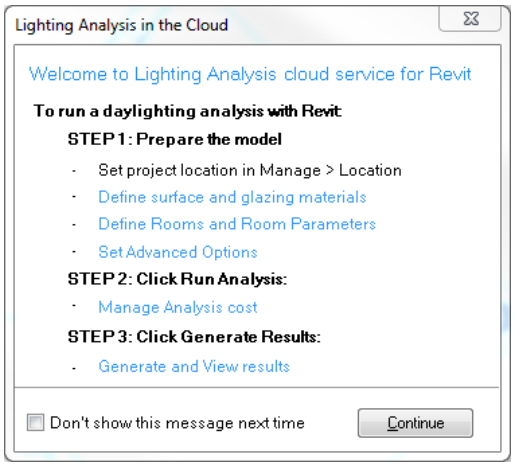
### ix. Run Analysis




To start the analysis process, click the Run Analysis button on the Analyize toolbar. This sets off a series of events that help to automate the process of lighting and daylighting analysis as much as possible. At the simplest level, this button brings up the Analysis dialog where you can select the Analysis Type, the Levels to be included in the analysis, and the Resolution of the analysis grid. Behind the scenes, the following are taking place:

- The "_Lighting Analysis Model View" is created.
  This view contains all the geometry and settings that will be used in the actual analysis. Though this view is managed automatically, you can manage the configuration manually as well by setting overrides in the configuration file. These settings include such things as different design options, visibility of furniture and other objects, use of electric lighting, etc. For more on how to override the automated settings, see the *Special Section* topic on Config Settings and Advanced Options.
- Furniture and other non-permanent objects are turned off in the Model View.
- Section Box is turned off in the Model View, the 'Show Complete for Lighting' Phase Filter is created and set current, and the New Construction phase is selected.
- The LAR Room and Floor/Level parameters are created and populated to your Parameters file as needed. See the section vi above for more information.
- Solar data is downloaded from Autodesk Climate Server for the project Location.
- Flags are checked to see if there is an analysis already running or complete on the server so you can download the results before running a new analysis.

After clicking Run Analysis, the quick start tips window pops up:



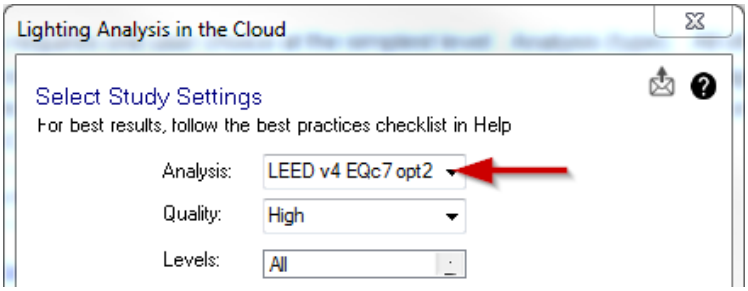

This window is a quick list containing an overview of most of what we are talking about here with links to online Help documents that go into more depth. You can dismiss that window or select 'don't show next time' and the window will not reappear again for the current Revit session.

Click Continue to move to the Run Analysis dialog.

*TIP*

If you want to review and/or customize the "Lighting Analysis Model View," this is the time to do it. This view is created the first time you Run Analysis on a project. If this is the first Run, Cancel the process now and review the Model View. You can review the contents of the model in this view to define what is included in the lighting/daylighting analysis model export. Refer to the *Special Section* on Configuration Settings and the Model View to see how to turn on or off the automatic overrides.

The first time you run LAR on a project, this process takes a few seconds while your project is configured, the "_Lighting Analysis Model View" is created and set up, and weather data is downloaded for the project site. Subsequent iterations will be much faster.




The Run Analysis dialog only requires one user choice at the simplest level: Analysis (type). All other options are provided to help control analysis scope, cloud credit cost, and amount of data to manage. We will describe those options here briefly, and you can refer to the *Special Section* or Help topic on Refining Analysis Scope and Controlling Cloud Credit Costs for more detailed information.

Refer to the Run Analysis dialog image below for the following descriptions.

**a.** **Analysis**: Currently we offer two types of automated Analyses in LAR, plus the Custom option that can be configured through the Configuration file (see the *Special Section* on Custom Analysis for more details about that option.).

- LEED v4 EQ credit 7 option 2 – This is the point-in-time simulation option for LEED version 4. Selecting this option will automatically select the dates, times and solar values from the weather data

specified for that simulation option by USGBC. Those values are displayed in the Environment and Threshold sections for review.

- LEED 2009 IEQ credit 8.1 option 1 – This is the simulation option for LEED version 3/2009, which is also based on a point-in-time simulation. The USGBC requirements for this simulation are automatically selected and shown in the Environment and Threshold sections.
- <Custom> - Not available as a selection in the dropdown. This will be shown if you have set the custom options in the configuration file to run special times and solar values (see the *Special Section* on Config File customization for more details). The date/times and solar values from the config file will be shown in the Environment section. Thresholds are not currently customizable, and the 300 to 3000 lux range will be used.

**b. Quality**: Quality allows you to select from two point grid resolutions to control processing time and cloud credit costs. High resolution point grid is a 1 foot point spacing, and Low resolution is a 6 foot point spacing. After you change the Quality option, the Start Analysis button changes to a Check Price button. Click that button to check the price of your new option.

- Speed – Results processing is generally fast, but for very large models, parsing high resolution analysis results for many floors and rooms can take up to a few minutes. Selecting Low resolution will cut the number of points that are processed by 16x.

*TIP*

Quality and Levels options are intended to provide you a way to access FREE analysis jobs when configuring your model or trying out LAR. You can do this by selecting options that process a number of analysis points that is below the paid threshold.

As a general guide, **FREE** analyses are (for area of Floor objects on selected Levels):

**High Resolution** – Less than 6,000 square feet of Floor area on selected Levels
**Low Resolution** – Less than 25,000 square feet of Floor area on selected Levels

(Refer to the *Special Section* on Controlling Cloud Credit costs for more details.)

- Cloud Credit Cost - Pricing for analysis iterations are by the number of analysis points. Low resolution Quality has a lower pricing rate.

**c. Levels**:
The Levels dropdown allows you to select from all, just one, or multiple Levels to include in the analysis, so you can control processing time and cloud credit costs. This also allows you to exclude Levels that contain Floor objects that are outside the building or your analysis scope, such as sidewalks, courtyards, roads, shading devices, etc. See the section vii above for more information.

Select All, or select one Level, or select more than one Level by clicking while holding CTRL or SHIFT. After you change the Level selection, the *Start Analysis* button changes to a *Check Price* button. Click to check the price of your new settings before you Start Analysis.

**d. Environment:**
*Location* is the project Location that you set in Manage > Location. If your Location says <Default> like the image below, you probably have not set your project location, and you will be running the analysis for the default location of Boston, MA and you will ne get results appropriate for your project location (unless you are a neighbor of the Waltham office of Autodesk).

*Date/Time* shows the parameters required for the Analysis type chosen, or your Custom settings. Two date/times are analyzed for each analysis type. Also shown here are the weather data values for GHI (global horizontal irradiance), DHI (diffuse horizontal irradiance), and DNI (diffuse normal irradiance)

automatically selected from the weather file for clear days within the specified limits of the analysis type chosen. Alternatively, your custom values from the configuration file are shown here.

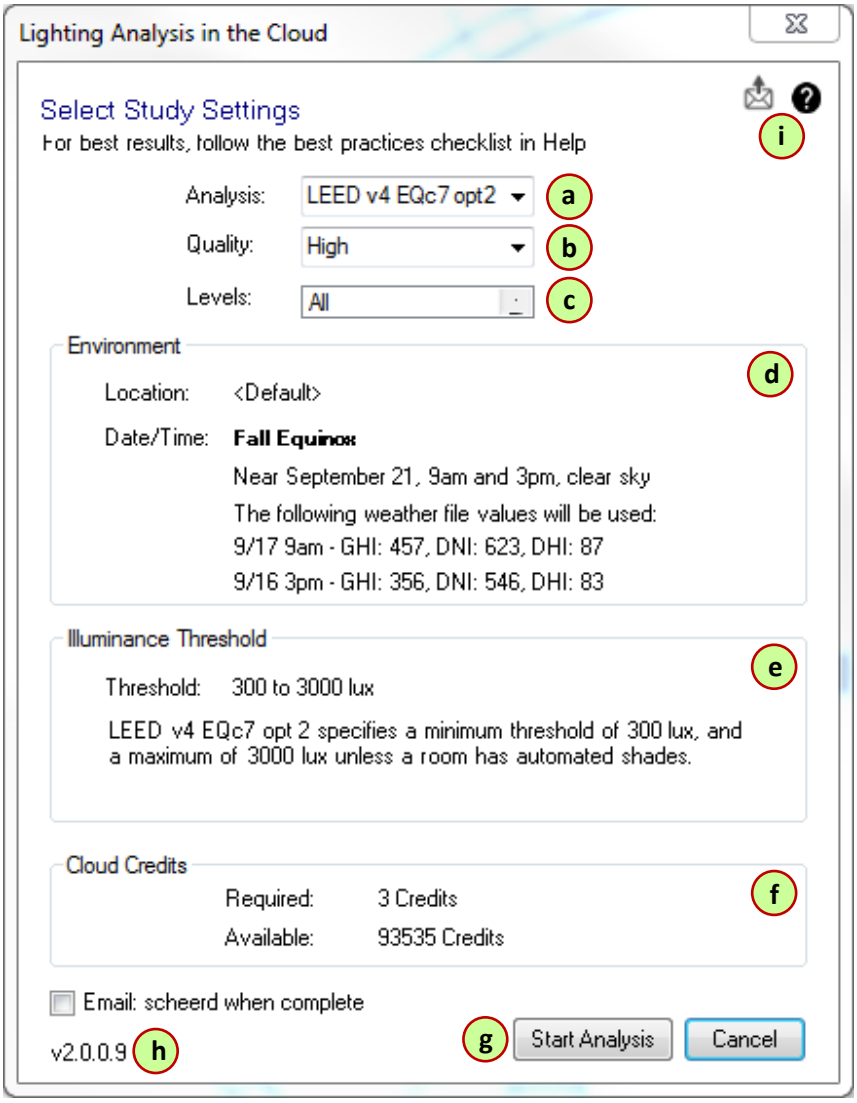
e. **Illuminance Threshold** specifies the threshold values required for results processing for the selected Analysis type. Illuminance is the amount of light available to the particular point. LEED for example requires a high and a low threshold, and passing points fall between these thresholds. Thresholds are set automatically as required for the selected analysis type and are not currently customizable. These values are only used during results processing, and do not affect the analysis process.

f. **Cloud Credits** reports the cost of the current analysis and the credits you have available in your account. Note that when you make a change to the Quality or Levels section, you need to click 'Check Price' button (see section g below) to update the cost of the current analysis. Note that you will not be charged until the analysis is complete and downloaded to your model See below for more details. For more information on cloud services and controlling costs, see online Help or the *Special Section* on cloud credits.

g. **Check Price** or **Start Analysis** buttons.
When you make a change to the Analysis, Quality or Levels selection, the Start Analysis button will become a 'Check Price' button. Click this to update the quoted cost (section f above) of the current analysis settings. When the Cloud Credits cost section is up to date, the button is used to Start Analysis. Note that you will not be changed until the analysis has completed successfully and the results have been downloaded to your project. You will have another opportunity to review the fees before accepting the completed analysis.

h. **Version**. This is the version of the current plugin. Please include this when communicating with us about bugs or questions.

i. **Help** and **Contact** buttons.
The Help button accesses the online help documentation through your default web browser. The Email/Contact button will initiate an email to us using your default email client. We encourage you to communicate about anything that is on your mind about the plugin, daylighting, your wish list, etc. Please feel free to click this button whenever you have an idea or question or complaint, we check this inbox often. We also encourage you to submit questions through the BPA Forum, where you will get even faster and broader support from the whole Revit analysis community.
The **BPA Forum** can be accessed here:
http://forums.autodesk.com/t5/lighting-and-daylighting/bd-p/19




## x. The Simulation Process

After you click Run Analysis, the Revit model version shown in the "_Lighting Analysis Model View" is translated and uploaded to the 360 Rendering engine cloud service with the settings you requested, the analysis process is begun and a reference to the process is passed to your computer.

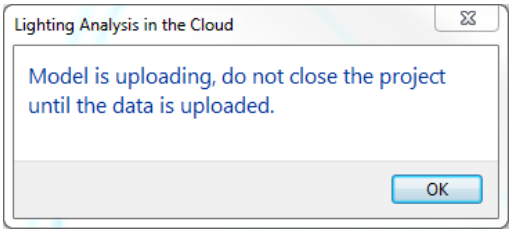
TIP

What is a '**grid**'?

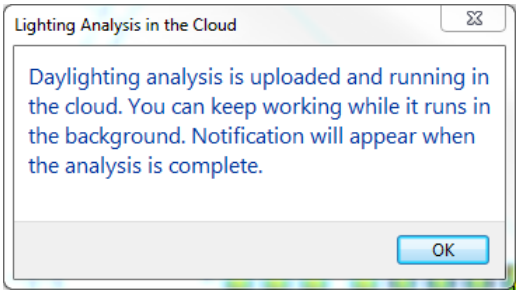
The analysis job is divided into parts based on floor objects and time/date settings to help parallelize the simulation. When you see the word 'grid' in the processing dialogs, these are simply parts of the building simulation. We report the status of the simulation by grids so you can see how much is done and how much is left to do.

If any grid fails (this is very rare), the analysis completed on the successful grids I still valid. Since a grid is basically a floor object, this means any failed grids will be equivalent to missing floors in the analysis results.

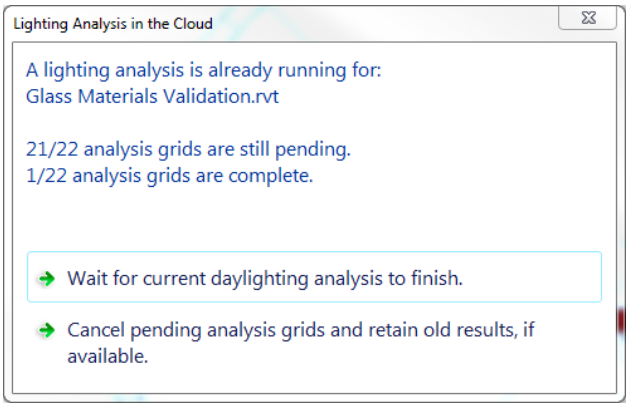
- **Upload**: You will get a message that the model is uploading; This usually only takes a few seconds. While this is happening, you can continue working in Revit or other applications, but you should not close your model or you will lose connection to the analysis job and will have to start again.

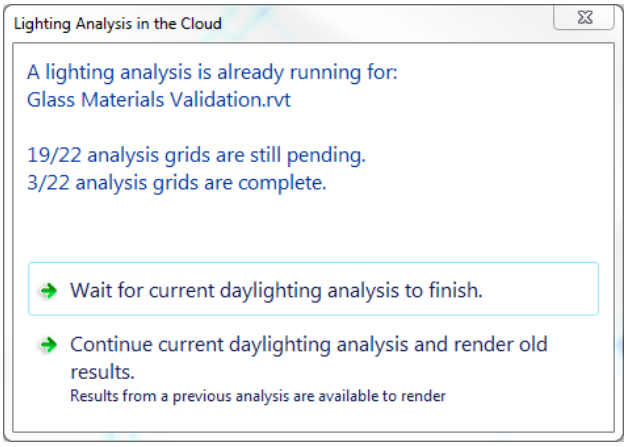



- **Processing**: In a few seconds you will get a message that the upload is complete and is processing. Once the model is uploaded, your Revit project knows where to go to get the results when they are complete, so you can continue working or close Revit and it will reconnect when you open the project and click the Generate Results button. Note that most analyses take less than 10 minutes, so there is usually no need to wait a long time for results. The longest analysis I have seen took about 2 hours on an extremely large model.



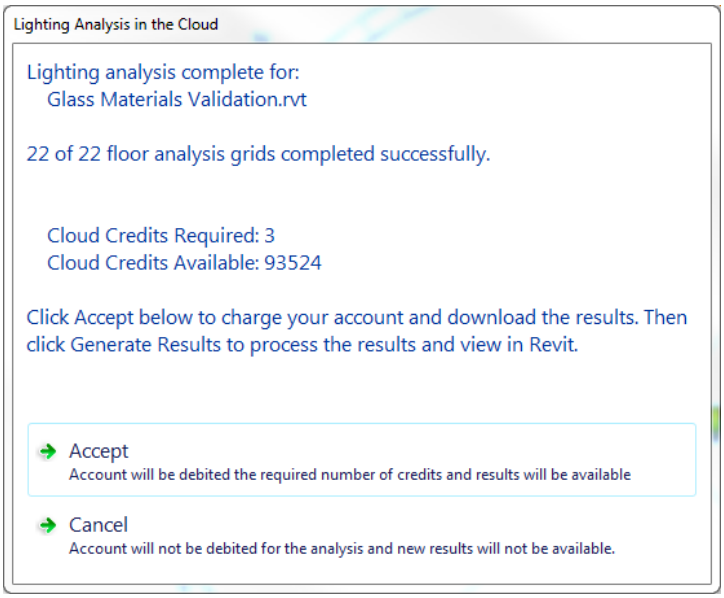

- **Review status**: While the analysis is running, you can review the process by clicking on Run Analysis or Generate Results again to see the status of jobs in queue, complete or failed. You can also choose to cancel the running analysis, run a new analysis, or generate results from existing data on your project while the new results are being processed.






## xi. When the Simulation is Complete:

When your analysis is complete, you will get a window like the one below:

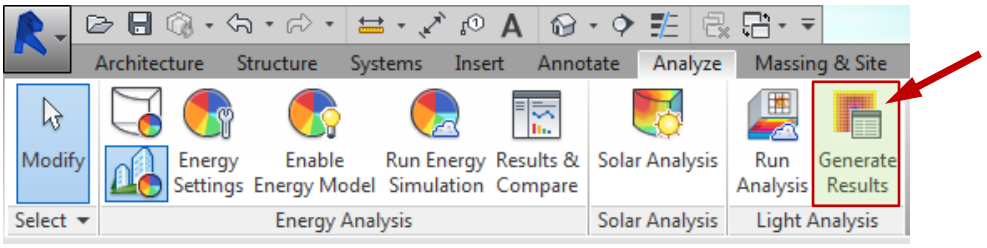



- RVT filename: Since you may be working on more than one project at a time, the notification contains the name of the RVT file that the analysis notification refers to.
- Grids completed: How many of the grids submitted were successful or failed.
- Cloud Credit cost: Report of the cost for the analysis on the successful grids.
- Accept or Cancel:

  If you Accept the results, your account will be debited this number of credits and the results will be downloaded to your project and stored in extensible storage for use by Generate Results process. If you Cancel, you will not be debited, and the results will be lost in the cloud.

  After you Accept the results, you should save your Revit project so the point grid results data in Revit extensible storage that you may have paid for (if not FREE) are safe.

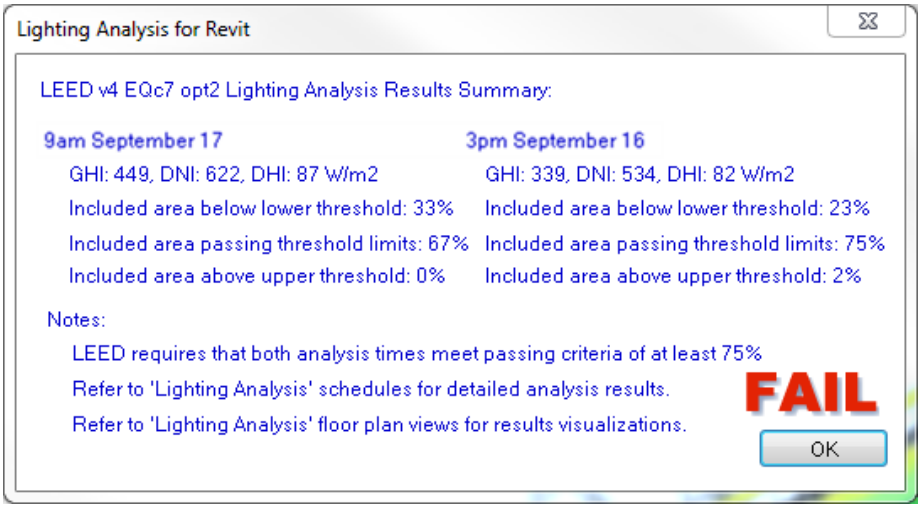
## xii. Generate Results:




To process results that were downloaded and stored in Revit extensible storage, click the Generate Results button on the Analysis toolbar. This sets off a series of processes that parse the raw grid point results data to generate the 4 categories of results output artifacts: Building Summary results, Floor and Room Schedules, Floor Plan photometric views, and 3d photometric views.

**a. Building summary results**:

The building summary results window shows performance of the areas of the entire building that are in Rooms that are Included in Daylighting. The thresholds follow the rules of the Analysis type chosen in the Run Analysis dialog, which is shown at the top of the window. In this case "LEED v4 EQc7 opt2" which has thresholds of 300-3000 lux.




The actual time/date pairs that were analyzed are shown, along with the solar data used. This information is usually required to be included in things like the LEED submittal, and is also a good review for you or your daylighting consultant.

TIP

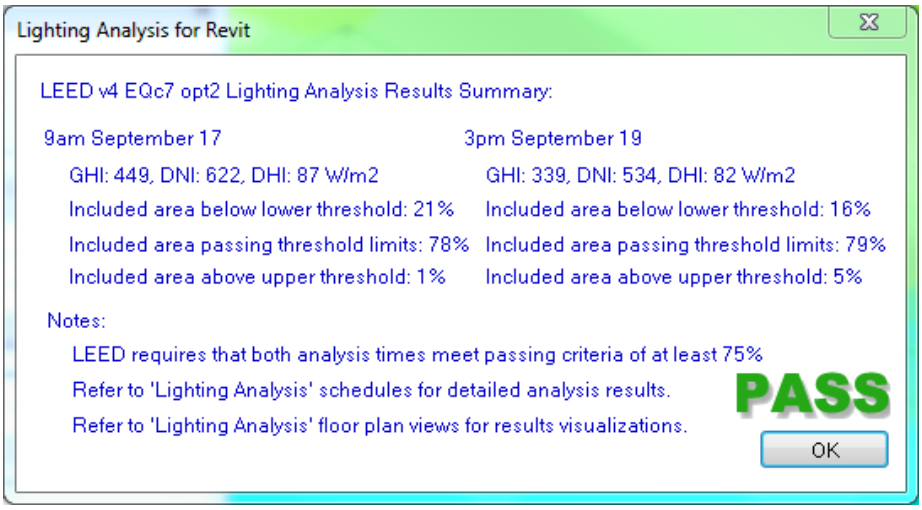
The percentage 'above' can be used to help you decide if automated shades would be useful for this building, or if glare is likely to be a problem. If the values in that section are high, or perhaps just enough to allow the building to pass when added to the 'passing' section, automated shades may be the difference between pass and fail, or between occupant comfort or occupant dissatisfaction.

Use the Floor Plan views or 3d views to review the areas where light levels are too high (yellow).

Use the Room schedule to identify rooms where automated shades would be useful.

Summary building performance is shown in three parts, below, above and within/passing the thresholds for the chosen Analysis type. The percentage 'passing' is the key value for LEED, for example.

PASS/FAIL indicator. This label tells you whether your building currently passes or fails the requirements of the Analysis type chosen. In the case above the building just barely fails due to only 67% of the area within passing thresholds for the 9am analysis time. To improve this you could review the detailed results for 9am in the Schedules, Floor Plan and 3d views to decide what design revisions could be made to improve performance. After making those changes, you would Run Analysis again on the whole building or just those areas where design revisions are made. Below are the results after we modified the glazing to have a higher percentage transmittance.




**b. Schedules**:

Two schedules are generated automatically. Both schedules have headers that show the building-scale summary performance data and the analysis settings used in the simulation:

<_Lighting Analysis Room Schedule>

LEED v4 EQc7 opt2Whole Building Results - 9am: 67% within, 3pm 75% within

9/17 8am GHI: 449, DNI: 622, DHI: 87 W/m2

9/19 2pm GHI: 339, DNI: 534, DHI: 82 W/m2

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 9am threshold results | | | | | | 3pm threshold results | | | | | |
| | | | | | | within threshold | | above threshold | | below threshold | | within threshold | | above threshold | | below threshold | |
| Level | Name | Number | Area | Include In Daylighting | Automated Shades | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area |
| 01 - Entry Level | Admin | 126 | 169 SF | ☑ | ☐ | 0 | 0 SF | 0 | 0 SF | 100 | 169 SF | 0 | 0 SF | 0 | 0 SF | 100 | 169 SF |
| 01 - Entry Level | Cafeteria | 121 | 1582 SF | ☑ | ☐ | 87 | 1375 SF | 0 | 0 SF | 13 | 207 SF | 61 | 961 SF | 4 | 68 SF | 35 | 553 SF |
| 01 - Entry Level | Conference | 103 | 508 SF | ☑ | ☑ | 97 | 494 SF | 0 | 0 SF | 3 | 14 SF | 100 | 508 SF | 0 | 0 SF | 0 | 0 SF |
| 01 - Entry Level | Conference | 116 | 340 SF | ☑ | ☐ | 33 | 113 SF | 0 | 0 SF | 67 | 227 SF | 86 | 293 SF | 13 | 45 SF | 1 | 2 SF |
| 01 - Entry Level | Conference | 123 | 447 SF | ☑ | ☐ | 17 | 76 SF | 0 | 0 SF | 83 | 371 SF | 14 | 61 SF | 0 | 0 SF | 86 | 386 SF |
| 01 - Entry Level | Corridor | 107 | 1480 SF | ☐ | ☐ | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF |
| 01 - Entry Level | Corridor | 131 | 588 SF | ☐ | ☐ | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF |
| 01 - Entry Level | Dry Storage | 124 | 91 SF | ☐ | ☐ | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF |
| 01 - Entry Level | Electrical | 112 | 76 SF | ☐ | ☐ | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF | 0 | 0 SF |

- _Lighting Analysis Floor (or Level) Schedule shows summary threshold results similar to the building summary, but summarized at the scale of building Levels. Results here include all the Rooms that are marked as Include in Daylighting that are associated with the particular Level.

  This schedule is useful for narrowing down the parts of the building that need further review.

  If no Rooms are created in the Project, this schedule assumes that all Floors associated with this Level are Included in Daylighting results.

- _Lighting Analysis Room Schedule shows the threshold results summarized at the scale of Rooms. Only points that are within the bounds of the Room object are included in the percentage calculations.

This schedule is useful for narrowing down the parts of the building that need further review, for identifying Rooms where Automated Shades would be useful, and is the fastest way to mark Rooms as Include in Daylighting or not.

TIP

Include in Daylighting (eg LEED Regularly Occupied)

Using the Room Schedule and referencing the LEED IEQ Space Matrix spreadsheet available from USGBC is the fastest way to mark Rooms as Include in Daylighting or not. Sort or Filter the Schedule by Room type or name to isolate rooms that are not included, and uncheck them in two clicks.

TIP

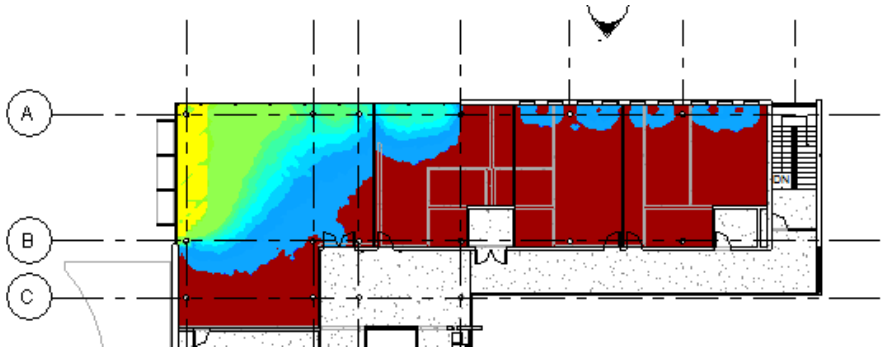
No need to Run Analysis again after making changes to Rooms or Room Parameters.

The status of the Rooms and the Room parameters is only used during the Generate Results process, not when running an analysis. The raw points data created during the analysis can be processed again and again for different configurations of Rooms and different Room parameter settings, like Automated Shades or Include in Daylighting.

Example: To see whether Automated Shades will help pass LEED, after selecting some Rooms to have Automated Shades, simply click Generate Results again to process new summary Building, Floor/Level and Room schedule results for FREE.

Note that the Room parameters also show up in the Properties panel when the Room object is selected in other views so you can review the threshold performance and/or set the results parameters of Automated Shades or Include in Daylighting.

c. **_Lighting Analysis floor plan photometric views** are automatically created for any level that has at least one Room with Include in Daylighting set to On. If you don't see a floor plan that you expect to see, the reason is probably because it has no Rooms or Rooms are associated with a different level.

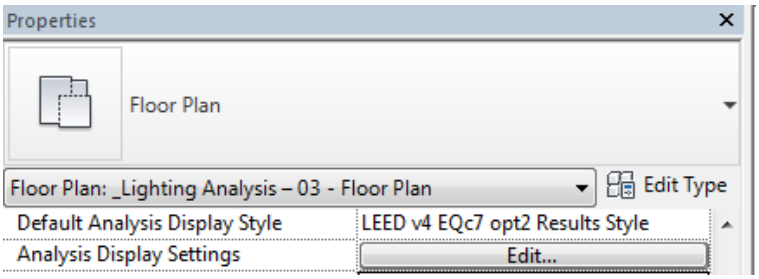



The _Lighting Analysis floor plans will be named with the Level name and a prefix of "_Lighting Analysis."

TIP

LAR will regenerate results automatically for all floor plan views that contain the string "_Lighting". If you want to create a custom floor plan view, for instance for a layout sheet, that you want to show analysis results, just add the prefix of "_Lighting" to the name of the view and LAR will update the results each time Generate Results is clicked.

The Illuminance values for all of the grid points in included Rooms are shown in these views using the Revit AVF (analysis visualization framework) tool. This is a powerful in canvas visualization tool that allows you to control which results are shown and how the results are formatted. You can also use AVF create your own graphical styles for viewing the LAR results. Extensive documentation for AVF is included in the standard Revit Help.

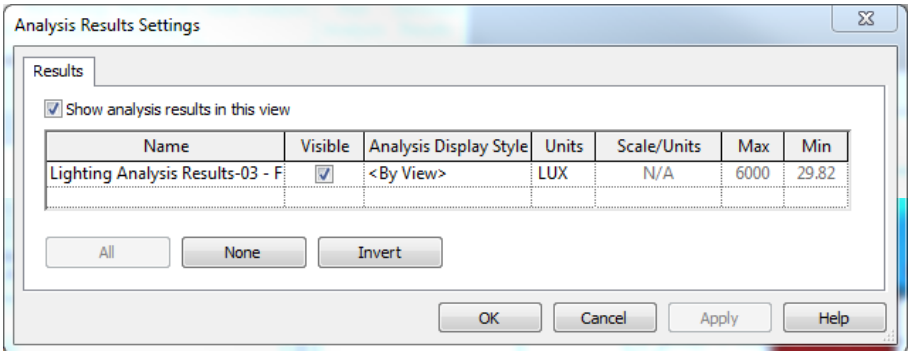



LAR is installed with a number of AVF visual styles. A default option appropriate to the thresholds used in the selected Analysis type is set when the view is generated. You can change this by selecting a different Default Analysis Display Style or by selecting other options in the Analysis Display Settings in the Properties panel of the View.

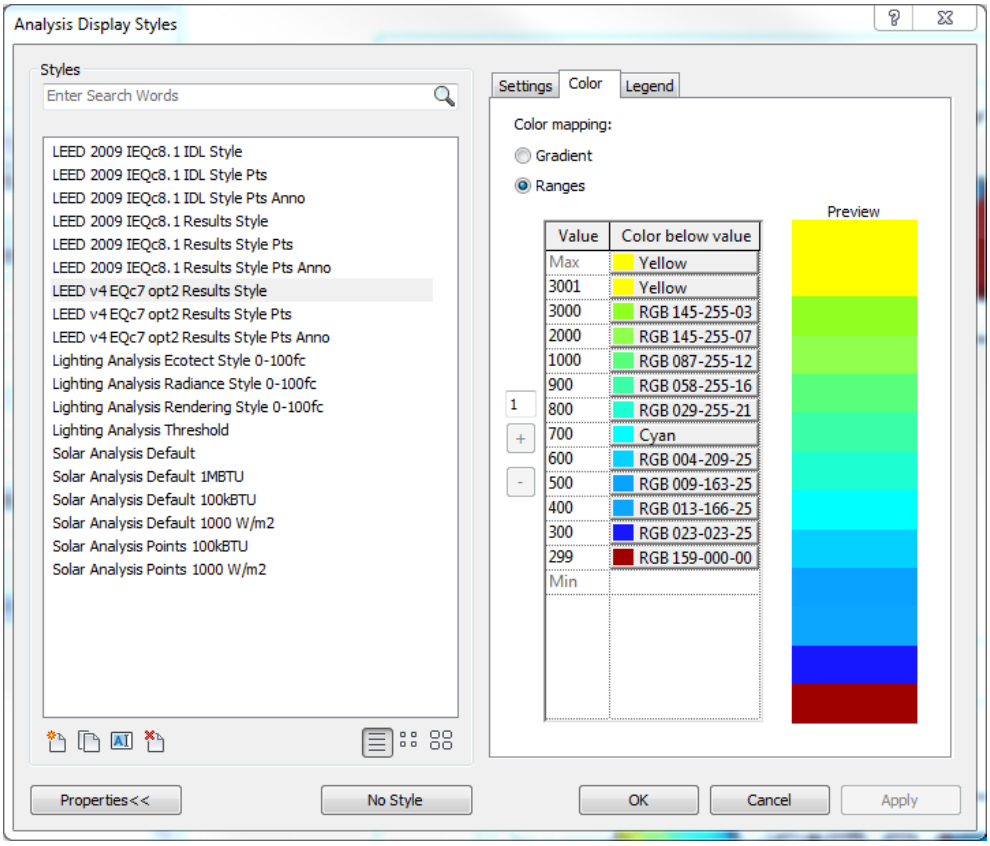
TIP

The results in Floor Plan Views are shown only for areas of the floor plan that are in Rooms that have Include in Daylighting set to On. This is to help you visualize the areas that are actually affecting your Analysis performance percentages, as well as to create the required artifacts for things like the LEED credit submission.

In the Analysis Display Settings, you can choose to show or hide the data with the 'Visible' check box, choose a different style for each data set in the view, or change the units displayed in the AVF data legend.

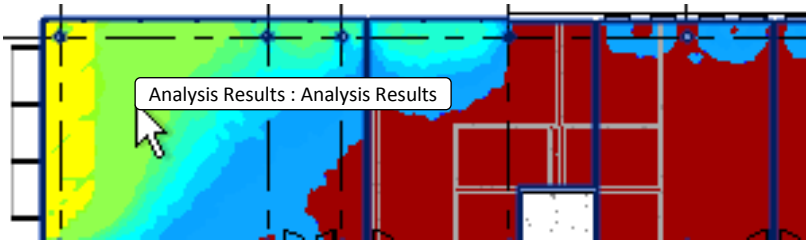



By default, the point grid data is shown as a surface countour style with a range selected for the Thresholds used in the Analysis type chosen. You can select any of a number of stock styles, including points views and annotated points views (be careful with these, as they take a long time to render), different color combinations and ranges, etc. Or you can create your own style. See Revit AVF Help for more details on styles.

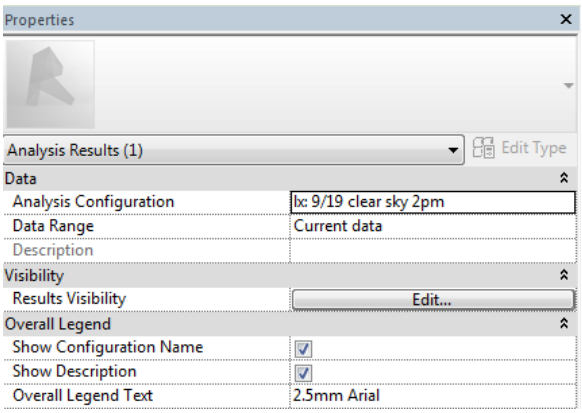



Note that one characteristic of AVF is that the results rendering does not persist between Revit sessions. However, LAR saves all of the view settings, so simply click Generate Results again, and the views will be regenerated as they were before you closed the project.

Two points in time are simulated for each analysis. To view each of these, select the AVF object (click and Tab if you have trouble selecting it),




then select one of the analysis times from the Analysis Configuration in the Properties panel for the object. Here you can also modify other options for the AVF data display object, like style and Legend configuration.




### d. General 3d photometric views:

TIP

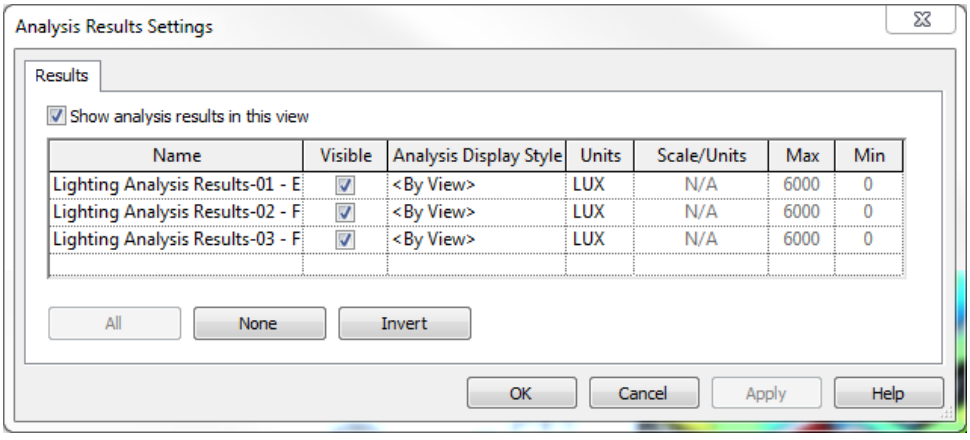
The 3d view is the designer's analysis view:

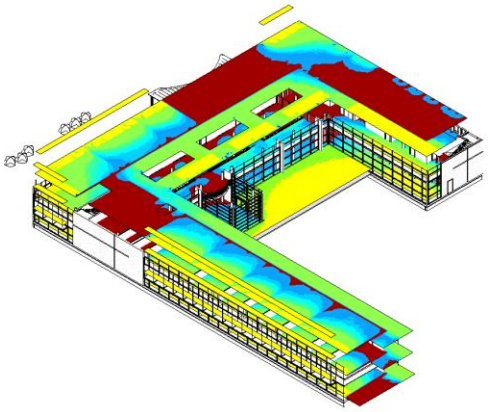
In 3d views, all data points for all Floors that were analyzed are rendered in the view, whether they are in a Room that is Include in Daylighting or not. This means the 3d view with AVF LAR results is very useful as a design tool to review overall building performance, to see synergies and related effects of geometry in any area of the building, to help discover where program area modifications might improve daylighting performance, or to see how particular window or shading geometry affects daylight levels, to discover what shading modifications might block direct sun, etc.

Results data is shown in 3d views using the AVF feature as well.

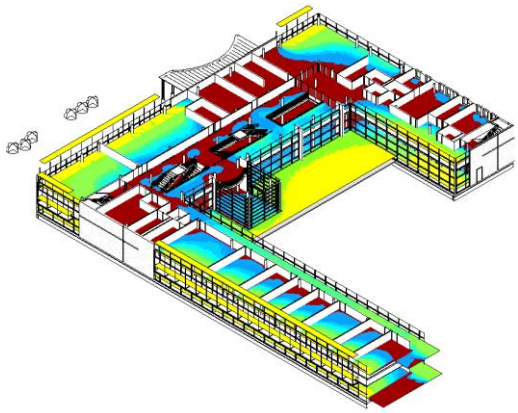
- ✓ AVF data can be displayed only in non-perspective 3d views.
- ✓ LAR generates photometric data only for the 3d view that is active when Generate Results is clicked.

All the rules and tips described for floor plan views above also apply to 3d views for formatting AVF display styles, viewing data for different times, and making analysis results visible or not visible. One difference is that in 3d views, you may see more than one result set. For LAR there will be one result set for each building level. You may also see result sets from other analysis tools like Solar Analysis.





Lighting Analysis Results-03 Visible



Lighting Analysis Results-03 not Visible

TIP

A very useful technique for reviewing in-canvas daylighting results is to generate results in a 3d view, then cut a section of the building to view the results in the context of the building geometry. When doing this, some floor levels may obscure levels below. Results are organized by Level, so you can use the Analysis Results Settings to turn Visibility off for levels that are in the way.

## xiii. Summary of Exercise 1.0:

At a high level, the process of running an analysis with LAR is very simple:

1. **Prepare the model** – Set/Review opaque and transparent materials, create Rooms
2. **Run Analysis** – click the button and choose the Analysis type
3. **Generate Results** – Fully automatic, 4 output types

Our intention is to provide a tool that is very simple, that automates as many of the processes of preparing an analysis as possible. We do this so that novice users can generate valid results, and so results will be consistent no matter the modeler, and so that expert consultants can spend more time consulting and less building models.

But for a tool to be useful for collaboration between professional architects and designers, and expert consultants and engineers, we offer this deeper explanation of the automated methods, as well as access to the layers of information underneath the automation. We have covered only some of the details of those layers here.

Deeper dives into the analysis results and engine capabilities are possible through customization using the LightThresholds.dll.config file, through 360 Rendering Illumination, by doing custom analyses using Dynamo, and using the raw data export capabilities. Keep an eye out for continuing updates on these special capabilities through the *Special Section* exercises.

But all of that is optional. The first goal is to create great daylighted buildings for satisfied occupants

We welcome your feedback.
Enjoy and Create!