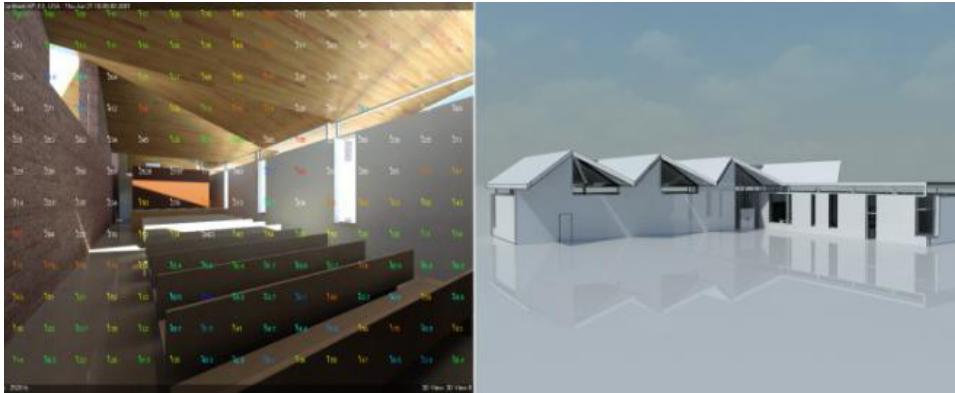


# Daylight Simulation in 3ds Max Design 2009 – Getting Started



Christoph Reinhart / Marion Landry / Pierre-Felix Breton

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## Getting Started with Lighting Analysis in 3ds Max Design 2009

### Summary

This white paper walks the reader through the various principles and workflows for carrying out an accurate daylight analysis in Autodesk® 3ds Max® Design 2009 software with the Exposure™ technology feature. The reader will learn some of the basic principles of daylight simulation and lighting analysis as well as how to build a scene, pick adequate material properties, and set up the render settings for a physically accurate simulation.

Available only within 3ds Max Design, Exposure is a new module for physically based, accurate simulations of complex 3D scenes with daylight and/or electric light sources. The module has been specifically developed for design practitioners with an interest in integrating daylighting with their project. The module predicts interior lighting conditions, under the overcast and clear CIE sky as well as the PEREZ sky, allowing users to evaluate their design according to the US Green Building Council's LEED green building system (under the Indoor Environmental Quality Daylighting Credit 8.1). In addition to light metering functionality with graphical output, Exposure also features a quick-settings dashboard interface and an intelligent user interface for accessing the various aspects of the software used in a light simulation, such as render settings, light settings, and material settings.

*Note: This document is written for 3ds Max Design 2009 Service Pack 1 (or higher). Make sure you have updated your product to the latest Service Pack and Hotfixes. It is also assumed that the program default settings are unchanged and correspond to the “out of the box” installation.*

In addition, a second document entitled “Daylight Simulation in 3ds Max Design 2009—Advanced Concepts” provides tips and tricks as well as more detailed information on the topics covered here. For the best results, be certain to read it too.

### Audience

The reader should be familiar with basic concepts of 3ds Max, such as 3D navigation, material editing, and rendering.

### Model and files used in this document

Although this document is not intended to be a step-by-step tutorial, an AutoCAD® Revit® 2009 software and 3ds Max Design 2009 model has been included as a reference.

The model, courtesy of [BNIM Architects](#), on which the workflow example is built, represents the Greensburg City Hall in Greensburg, Kansas, USA, a project with a strong focus on sustainable design.

The example analysis concentrates on the “Council Chamber,” an important community gathering space for the City of Greensburg. With a seating capacity of roughly 100, the room will accommodate regular meetings of the city council as well as other community and judicial proceedings.

## Introduction to Daylight Simulations

A daylight simulation is a computer-based calculation of the amount of daylight inside or outside of one or several buildings. Common daylight simulation outputs are either luminance distributions, i.e. photorealistic high dynamic range (HDR) images, illuminances at key positions within a scene, or various “daylighting metrics” that have been derived from the earlier two types of data.

An HDR image is similar to a conventional digital picture, however it stores absolute luminance values for each pixel allowing an image to be displayed using different exposure settings. HDR images can be a valuable tool for investigating the appearance of glare in a space.

In a predominantly sunny climate, it can be instructive to test indoor illuminance levels under a clear, sunny sky. For such an analysis, one would usually use the CIE clear sky model. A typical time of interest is, for example, noon during the winter and summer solstice (see section 5.5, Daylighting Metrics, below). The front cover of this document shows a hybrid simulation output generated with 3ds Max Design in which a false color grid of illuminances is overlaid on an HDR image of a space.

An individual interested in using a daylight simulation tool should initially consider the following two questions:

*What daylighting metrics do I want to calculate using the simulation program?*

*Is my simulation tool capable of reliably calculating these metrics?*

These two questions are further discussed in the following sections of the document.

### What daylighting metrics do I want to calculate?

Many users might want to initially “see” a design under key times of the year, such as solar noon on the winter and summer solstice, or other times that are relevant for the particular use of a space. High Dynamic Range HDR images can be used for such an exploratory, qualitative analysis.

As a design progresses, a user might want to further compare certain daylighting characteristics or “metrics” of a space with minimum requirements that are set by applicable standards and/or building rating systems. Traditionally, two common daylighting metrics are the daylight factor and indoor illuminances under a CIE clear sky. Both of these metrics can be calculated using 3ds Max Design 2009 as shown in section 5.5, Daylighting Metrics, of this document.

3ds Max Design 2009 is also capable of loading in an EnergyPlus weather file (\*.EPW), allowing it to automatically generate time series of HDR images and/or illuminances under multiple sky conditions. EnergyPlus weather files contain annual data for typical climatic conditions at a site, including ambient temperature, relative humidity, wind speed and direction, as well as direct and diffuse irradiances. EnergyPlus weather files for over 2000 locations worldwide can be downloaded from [http://www.eere.energy.gov/buildings/energyplus/cfm/weather\\_data.cfm](http://www.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm).

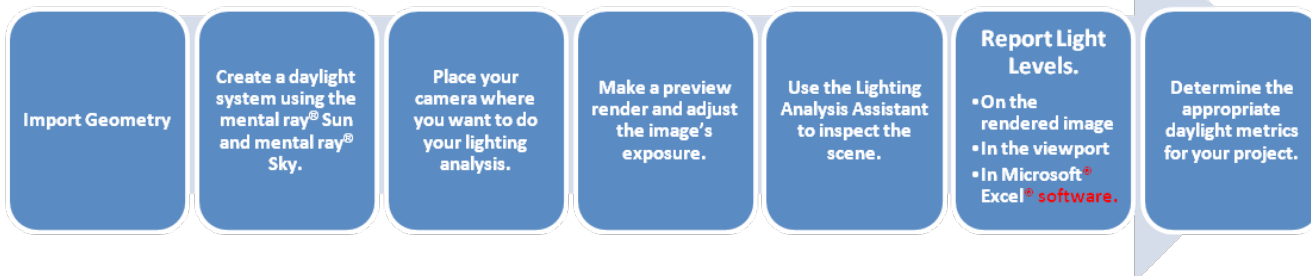
The ability of 3ds Max Design 2009 to generate time series of indoor illuminances is useful for users interested in optimizing a design with respect to local climatic conditions using one of the emerging climate-based daylighting metrics, such as daylight autonomy and useful daylight illuminance. An introduction to these metrics is provided under <http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc48669/>.

### Is the simulation tool capable of reliably calculating these metrics?

The answer to this question is generally difficult to divine partly due to (a) the scarcity of rigorous validation studies that compare daylighting measurements to simulation results, and (b) the fact that no simulation program can currently model any daylight situation. While modeling the daylight factor in a side-lit rectangular space with a clear glazing might be a task that many simulation programs master, tool performances vary dramatically as more complex geometries, or daylighting systems, are investigated.

The following section will show you how to carry out such a simulation analysis.

## Daylight Analysis Workflow



### Import Geometry

#### General modeling concerns

Lighting analysis is a form of 3D rendering where precise definitions of lights and materials are taken into account. Generally speaking, the same principles that apply to “pretty picture” renderings are just as valid for lighting analysis workflows, i.e. your geometric model has to be “clean” (without any holes etc.) and all materials have to be specified accurately.

See the *Guidelines for your scene geometry* in the *Advanced Concepts* document for a list of tips and reminders on the subject.

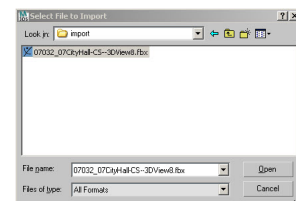
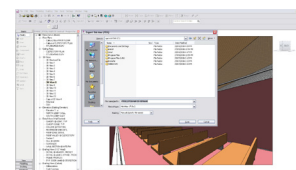
#### If your model was created in Revit 2009

The interoperability between 3ds Max Design 2009 and Revit® 2009 software has improved considerably via the Autodesk® FBX® file format. As this topic is not further described, we encourage you to review the following Autodesk white paper:

*Autodesk FBX-Based Revit Architecture 2009 to Autodesk 3ds Max Design 2009 Workflow* (pdf—2027Kb)

This white paper is for architects, designers, engineers, and visualization specialists who need to move data from Revit Architecture 2009 software to Autodesk 3ds Max Design 2009 software to further explore, validate, or communicate their designs.

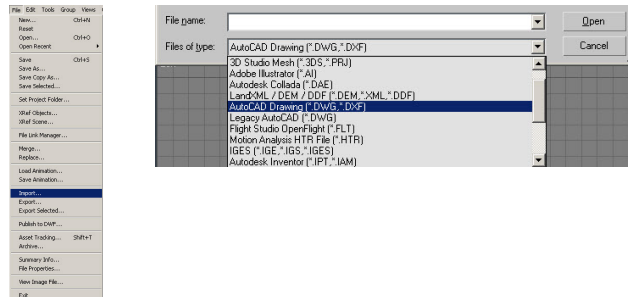
<http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=11360846>



Screen grabs of a Revit 2009 model exported as FBX and imported in 3ds Max Design 2009. This model will be used throughout this document as an example.

### If your model was created in AutoCAD / AutoCAD Architecture

AutoCAD® software models can be imported in 3ds Max Design 2009 via File | Import | AutoCAD Drawing (\*.DWG, \*.DXF). Consult the product documentation for more information on this topic.



AutoCAD \*.DWG files can be imported in 3ds Max Design from the File | Import menu.

### Try a few test renderings with a Daylight System

Lighting analysis in 3ds Max Design 2009 is based on the mental ray® rendering engine. In short, if you can get a reasonably looking image (i.e. a “pretty picture”), the lighting levels reported by the lighting analysis tools should be accurate—assuming that your render settings are high enough and that lights and materials were previously defined in a “physically correct” way.

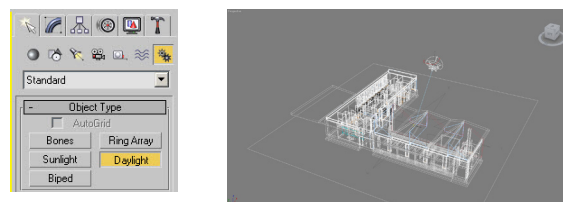
The following section will walk you through the basic steps of achieving a good looking image with mental ray, as a first step to a more advanced lighting analysis.

### Create a daylight system using the mental ray Sun and mental ray Sky

Once your geometry has been properly imported into 3ds Max Design 2009, you have to create a so-called “Daylight System” object. A Daylight System models the orientation and celestial hemisphere under which your scene geometry is placed (i.e. the intensity of the Sunlight and the Skylight).

In 3ds Max Design, direct sunlight is modeled as a “directional” light source that casts strong shadows, whereas diffuse daylight is modeled as an “environmental” light source. The latter is calculated through the Final Gather process of mental ray.

*Note: if you imported a Revit model from Revit 2009 using the FBX file format, you will most likely already have a Daylight System in your scene. Select the object with the Scene Explorer by searching for an object called “Daylight01” and continue as explained below.*



You can create a Daylight System object from the “Systems” panel in the Create tab in 3ds Max Design.

### Exposure Control

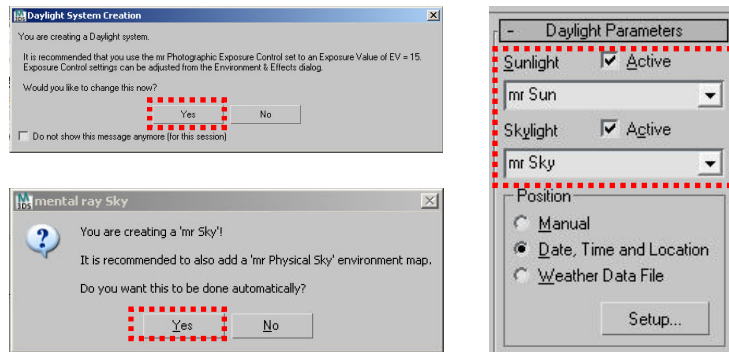
During the creation of the Daylight System object, you will be prompted to enable the Exposure Control system and add a Physical Sky environment map. Click “Yes” to the two prompts.

The Exposure Control system is equivalent to the Shutter and Aperture settings of a digital camera. It is used to control the brightness and contrast of the rendered image. Note, however, that—just like in real life—lighting levels calculated by the renderer remain unchanged by the exposure control setting. An analogy would be the fact that changing the shutter speed on your camera does not dim the lights of in your living room.

For more details on Exposure Control, please refer to the *Advanced Concepts* document under *What is Exposure Control*.

### Environment Map

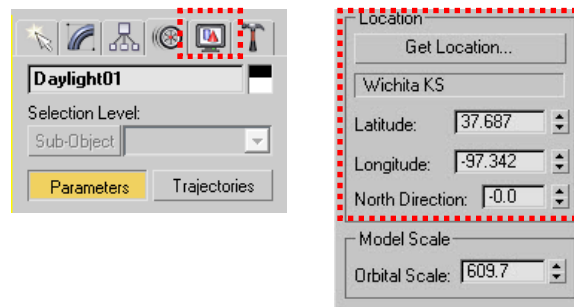
The mental ray (mr) Physical Sky environment map is the sky background map. It is a purely cosmetic effect, filling in the background of your render with a nice shade of blue, representing a physical sky by taking the position of the Sun into account. It does not alter the light levels calculated by the renderer since these are calculated using the Skylight object.



Click “Yes” if you are prompted to assign an Exposure Control to your scene. Click “Yes” if you are prompted to assign a mr Physical Sky as an Environment map. Make sure your Daylight System uses the mr Sun and mr Sky.

### Specify Location and Time

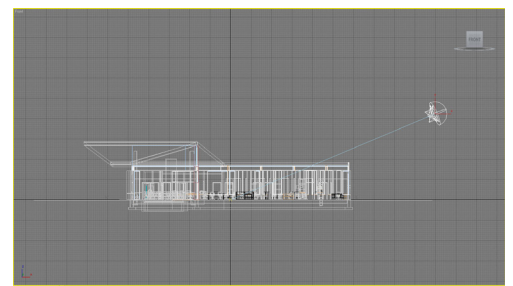
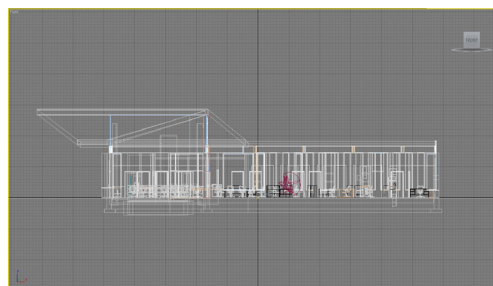
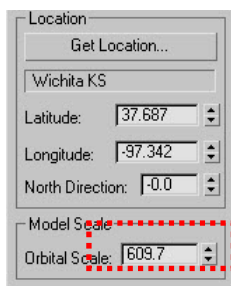
The location and time of the Daylight System is defined in the Motion Panel. Don’t worry about the position of the Sun and Sky objects in the 3D viewport: this is used purely for visual representation. Internally, the Sun and Sky illumination is always computed from the extents of the 3D model, regardless of its size. Feel free to position the Daylight System object anywhere within your scene.



To reach the location and time control of the Daylight System, select the Daylight System and switch to the Motion Panel.

### Daylight System Orbital Scale

Next, adjust the Orbital Scale of the Daylight System object to move the Sun and Sky objects above your model as illustrated. This can be done via the Motion Panel. This does not change the way the scene is rendered or illuminated, it only moves the Sun and Sky lights along their axis for easier selection.



The Orbital Scale parameter controls the height of the Daylight System in the viewports. Note that this does not affect the way the Sun and Sky render: they will always illuminate the scene from outside, even if the object is located inside a room in your viewport.



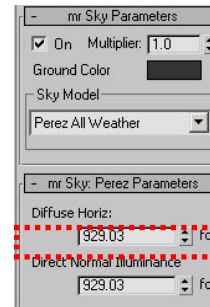
### Aerial Perspective

Turn off the Aerial Perspective option in the mr Sky Advanced Parameters. Aerial Perspective is used to achieve aesthetic affects suitable for exterior renderings. It creates “fog” effects where a distant building vanishes in the horizon and can interfere with the rendered images, especially for interior shots. It is ON by default in 3ds Max Design 2009 and should be OFF for any quantitative lighting analysis.

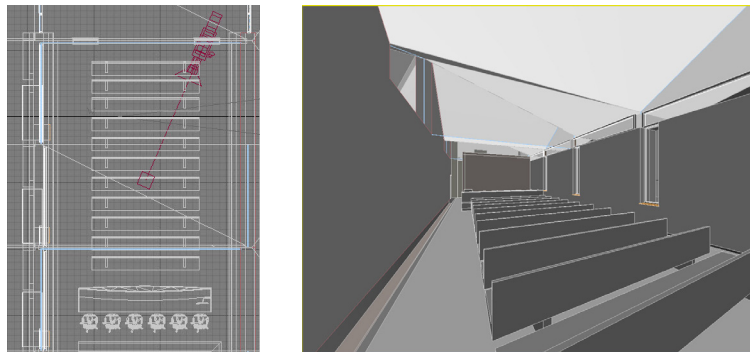
### Place your Camera where you want to do a lighting analysis

At this point, your model should contain all geometry as well as a Daylight System. As a next step, you will need to place a camera to define a point of view on your model. Typically, you may place your camera in a way so that you can see the entire area in which you are interested.

In the example, we are going to analyze light levels in one of the rooms within our model. Accordingly, we place our camera in one of the corners of that room.



Make sure you turn off the Aerial Perspective, as it is a “nice picture” effect only.



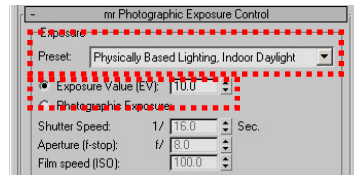
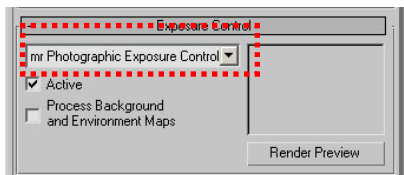
Place your camera in a way so you will be able to see the entire workplane in which you are interested. In the example, we are going to inspect light levels across the entire room at “workplane height” (about 30 inches from the floor). The example camera location has been chosen accordingly to allow us to view the complete workplane area within the space at once.

### Make a preview render and adjust the image exposure

Prior to looking at any illuminance levels in the scene, we recommend that you run a few test renderings to verify whether the model looks “ok.” An initial visual inspection constitutes an important preliminary quality control step that may help you to detect any modeling errors, including holes within the geometry, a wrong material type, or an improperly oriented Daylight System.

Also, as we will be overlaying a grid of illuminance results on the visualization later in the process, it is a good idea to take care of this first step right away.

A quick way to generate a preview render is to use the Render Preview tool in the Rendering | Environment | Exposure Control rollout. Go ahead and make a render preview in such a way that your Exposure is in the correct range. For more details on Exposure Control, please refer to the *Advanced Concepts* document under *What is Exposure Control*.

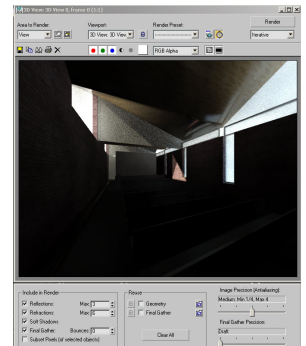
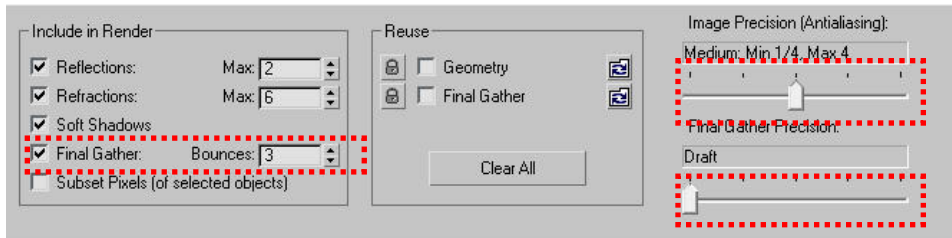


First, perform a quick test render and adjust the Exposure Control in order to get a reasonably good looking image. You can do this from the Exposure Control Preview tool. Use the “Physically Based Lighting Indoor Daylight” preset as a starting point. Adjusting the Exposure Value (EV) will affect the image shown in the preview in real time. Once you are happy with the results, you can go further and make a large render preview.

### Try a higher resolution test image

Once you are satisfied with the results from the preview, you can render a larger image by using the Rendering | Render command. This will bring up a rendering window (known as Frame Buffer in 3ds Max). On the bottom part of the window you will find a few settings that control the speed and quality of your render.

The most important parameters for an accurate daylight simulation are the Image Precision, Final Gather Precision, and Final Gather Bounces. For interior renderings, a Final Gather Bounces of 4 to 7 is recommended. The Final gather precision will reduce the “noise” within an image but will increase render times.



Render window (Frame Buffer) with quality control parameters. A Final Gather Bounces of 4 to 7 is generally preferable for interior spaces.

### Prepare for analysis

Now that you have a reasonably good looking image, you can start extracting light levels at any location within the space. The following four sections will walk you through the steps necessary to accomplish this task by helping you verify that all of your scene settings are in the realm of “physical correctness.”

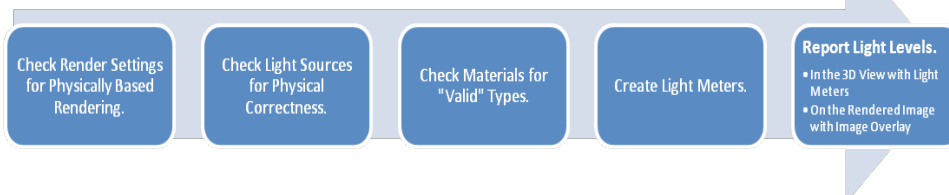
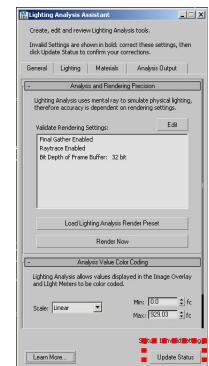
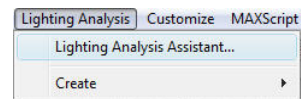
*Note: Although this white paper focuses on Daylight aspects, the lighting analysis features of 3ds Max Design can be used for artificial light sources as well (photometric lights), for example, to plan interior spaces in a concert hall.*

### Use the Lighting Analysis Assistant to inspect the scene

The Lighting Analysis Assistant is designed to guide you through the process of checking the scene and raising flags about potential issues that may be found. For example, you may have a scene that uses “Standard Lights” as opposed to “Photometric Lights.” These light sources would be found by the Lighting Analysis Assistant and flagged as “invalid” to use. For more information, take a look at the Frequently Asked Questions (FAQs) 6.3.2: What are the object types that are valid for lighting analysis in 3ds Max?

*Note: We do not recommend you to initiate the lighting analysis process until all items identified as invalid are resolved.*

Please launch the Lighting Analysis Assistant via the top menu Lighting Analysis | Lighting Analysis Assistant.



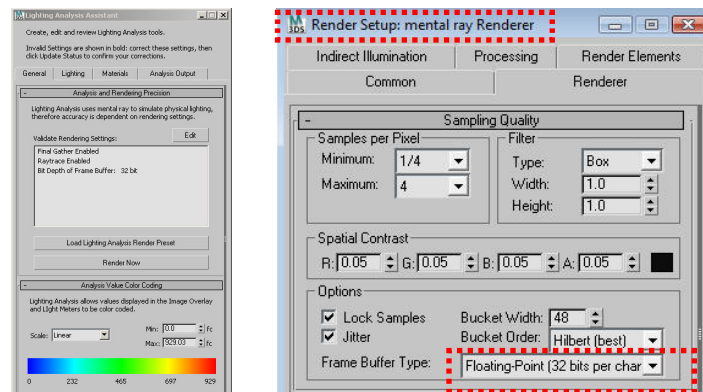
The Lighting Analysis Assistant is a scene analyzer that searches for incorrect rendering settings that may incorrectly alter the results for the lighting simulation. You can launch it from the Lighting Analysis pull-down menu. Click the “Update Status” button to refresh its content.

## Daylight Simulation in Autodesk 3ds Max Design 2009

After launching the Lighting Analysis Assistant from the Lighting Analysis pull-down menu, start with the General Tab.

### General Tab

In the General tab, you can adjust your basic render settings. For a physically based lighting calculation you will have to use the mental ray renderer within 3ds Max Design 2009. Final Gather has to be enabled and the Renderer | Frame Buffer Type set to 32-bit precision. The General Tab also lets you specify maximum and minimum levels for the pseudo color display for the Light Meter objects (see below).



General Tab of the Lighting Analysis Assistant.

### Lighting Tab

The Lighting Tab allows you to find “invalid” light types (such as Standard Lights and Standard Sunlight objects) within your scene and verify that the Daylight System is correctly set up. Shadow settings are also verified—all lights must use shadows that are ray traced to support transparency properly.

### Materials Tab

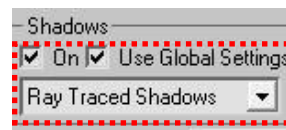
Use the Materials Tab to search for all non-physically based, “invalid” materials in your scene. These materials have to be replaced by physically based materials for a correct lighting analysis. Physically based, “valid” material types are mental ray “Architecture & Design Material” (A&D Mtl) and “ProMaterials™” material types.

You will need to replace all invalid materials with those that are valid. A quick way to do this is to select all invalid objects and assign them a default “flat” finish Material. Keep in mind, however, that the color determines the amount of light reflecting from those materials (reflectance). You can deal with this at a later stage within your project. You also have to pay attention so you do not accidentally replace a window pane with the default opaque material.

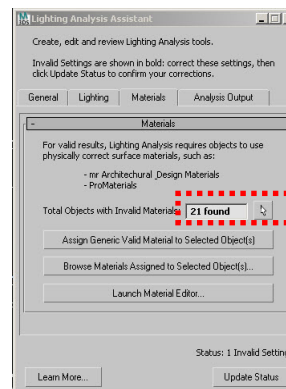
For more information on defining accurate material properties, please refer to the *Advanced Concepts* document under the *Guidelines for creating Materials and Finishes* section.



Lighting Tab of the Lighting Analysis Assistant.



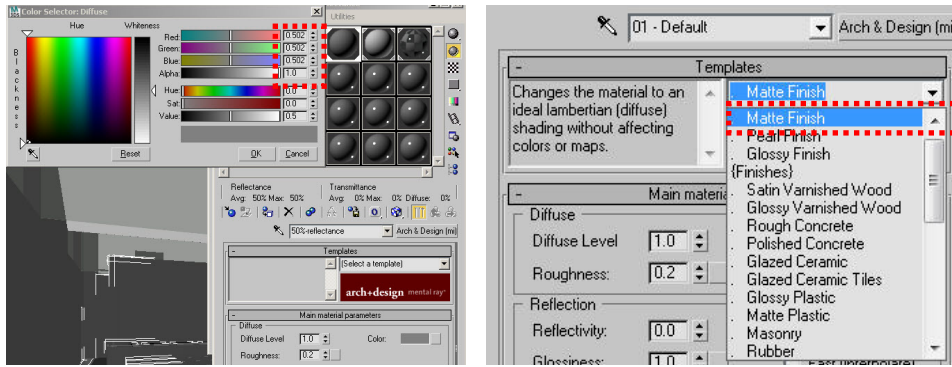
The Lighting Analysis Assistant expects “physically correct” shadow settings for all light sources.



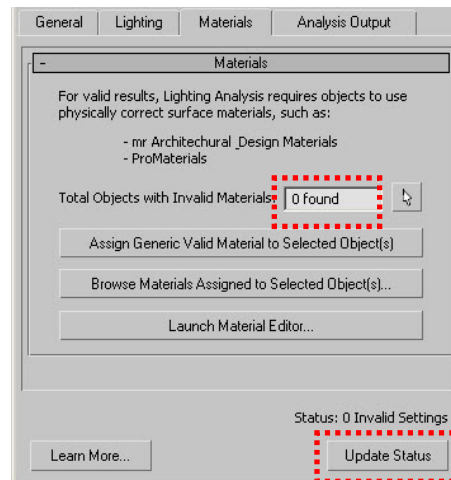
The Materials Tab allows you to search and find non-physically based materials in your scene that are incompatible with lighting analysis workflows. Here we show that this scene has 21 “invalid” materials which will need to be replaced.



## Daylight Simulation in Autodesk 3ds Max Design 2009



If you need to quickly create a material with a default “flat” finish, we recommend that you use an Arch & Design Material assigned to a grey color of RGB 0.5 0.5 0.5 and use the “Matte Finish” template. This will be considered as a perfectly diffuse material that reflects 50% of the incoming light back into the scene.

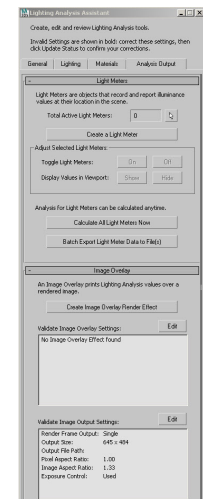


The process of checking materials is complete when the Lighting Analysis Assistant shows that no materials are found with invalid settings. Note: You have to click on the Update Status button in order to refresh the user interface of the Lighting Analysis Assistant.

### Analysis Output Tab

The Analysis Output Tab of the Lighting Analysis Assistant regroups most functionality required to create light metering tools to extract light levels from your scene. It offers two modes of data reporting: Light Meters which are 3D objects located in space and Image Overlay which will overlay illuminance values projected from the screen on top of the rendered image.

The former type of data corresponds to one or several illuminance sensors located at key positions within a space, such as the “work plane.” The latter output format helps a user interpret simulation output in relation to the space. The next section describes how to enable those output options. The subsequent section (5.5 Daylighting Metrics) will discuss various ways to calculate and interpret the simulation results.

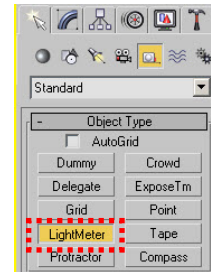
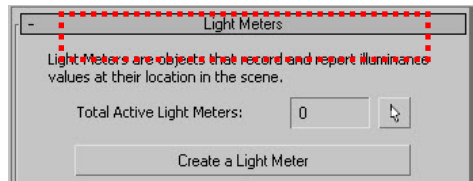


The Analysis Output Tab of the Lighting Analysis Assistant.

### Report Light Levels

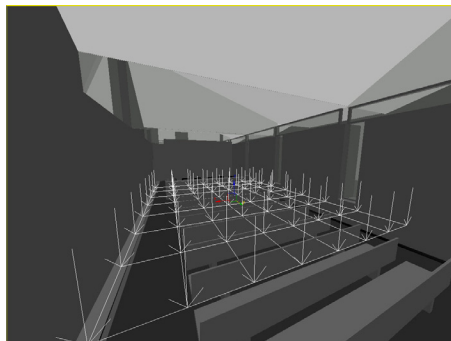
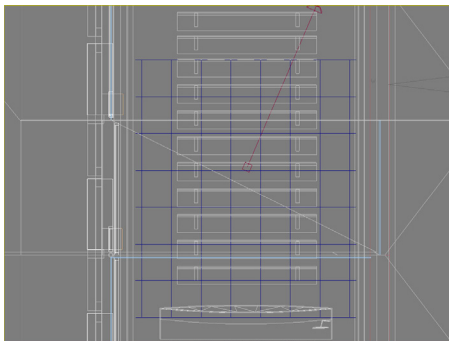
#### Light Meter Objects

Light Meters allow you to report incident lighting (illuminance) falling onto any point within a scene. You can create them as three dimensional “grids” and correctly position them within your scene using the 3ds Max Design transform tools. Lighting grids can be animated as well and showing, for example, changing indoor illuminance patterns over the course of a day or year.



You can create a Light Meter object from the Analysis Tab of the Lighting Analysis Assistant or from the Create | Helper Panel.

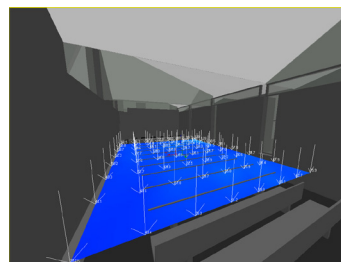
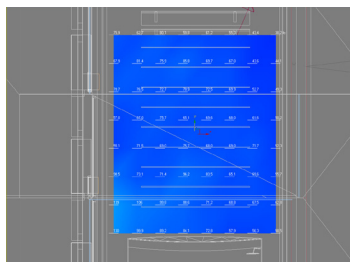
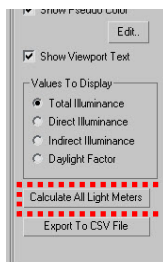
Light meters do not affect the scene (they do not block or bounce light) so they can cover any area. Each subdivision represents a point at which incident illuminance normal to the grid will be measured (calculated). As a consequence, the denser the subdivisions, the longer a simulation will take. Typical grid resolutions are in the order of 1ft x 1 ft or 0.5 m x 0.5 m.



A Light Meter object has been created in the 3D space, at the workplane position, or 30 inches above the floor. It covers the entire room area and has a relatively coarse subdivision. Light levels will be reported at each intersection.

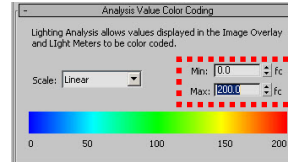
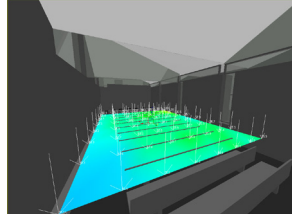
Once all Light Meters have been created—and you have successfully gone through all the steps described in the previous sections of this document—you can hit the “Calculate All Light Meters” button. This will initiate a lighting calculation process for the Light Meters only. At the end of the process, the calculated Illuminance values will be displayed on the Light Meters in the 3D viewport.

*Note: Keep in mind that the Light Meter calculation uses the rendering parameter defined in the Rendering Settings dialog. For example, if Indirect Illumination calculation is turned off, the Light Meters will ignore indirect lighting.*



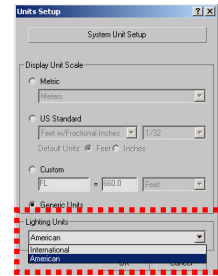
A Light Meter object has been created in the 3D space, at the workplane position 30 inches above the floor. It covers the entire room area and has a relatively coarse subdivision. Light levels will be reported at each intersection.

To change the color range of the Pseudo Color display of the Light Meters, go in the Lighting Analysis Assistant | General tab and set the Min / Max ranges. Note that this does not affect the calculated values. It only affects the color on the Light Meters and not the light levels themselves.



Pseudo Color range is adjusted for the Light Meters in the Lighting Analysis Assistant | General tab.

Once the data has been calculated, you can export it to a \*.CSV file (format readable by Microsoft® Excel® software) for further analysis. The generated data contains Illuminance values for each calculated point for every frame of your animation. Depending on the complexity of your project, you may want to consider using a database system such as Microsoft® Access® software to run custom queries and formulas as the dataset may be cumbersome to deal with otherwise.

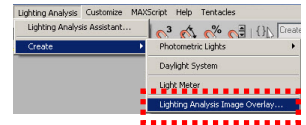


The Lighting Units (lux or foot candles) can be changed in the Customize | Units dialog.

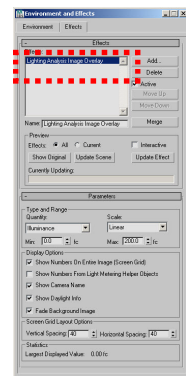
Exporting to \*.CSV files is useful for performing a climate-based-daylighting analysis as explained in section 5.5, Daylighting Metrics.

### Rendered Image Overlay

For presentation purposes, it is useful to overlay light levels on top of the rendered image (on top of the “pretty picture”). This helps putting the results into context. To help you with this task, another method is available to you, which is called the “Lighting Analysis Image Overlay.”

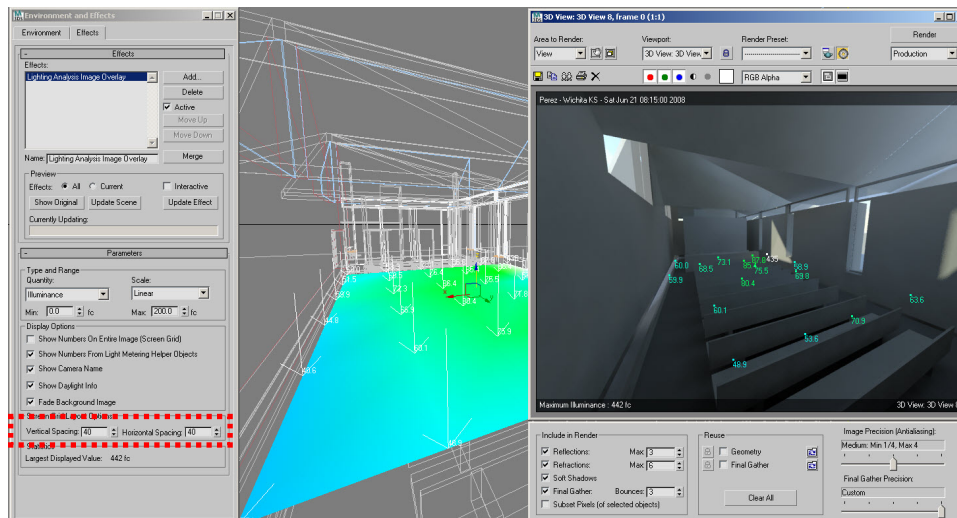


In 3ds Max Design terms, this is implemented as a “Render Effect.” This tool will basically print numbers in pseudo color form on top of the rendered image. You can enable this feature from the Lighting Analysis Assistant or from the Lighting Analysis | Create | Lighting Analysis Image Overlay.



### Showing light levels from Light Meters overlaid on the rendered image

To show numbers calculated from the Light Meters on your rendered image, use the “Show Numbers from Light Metering Helper Objects” option in the Lighting Analysis Image Overlay Render Effect.



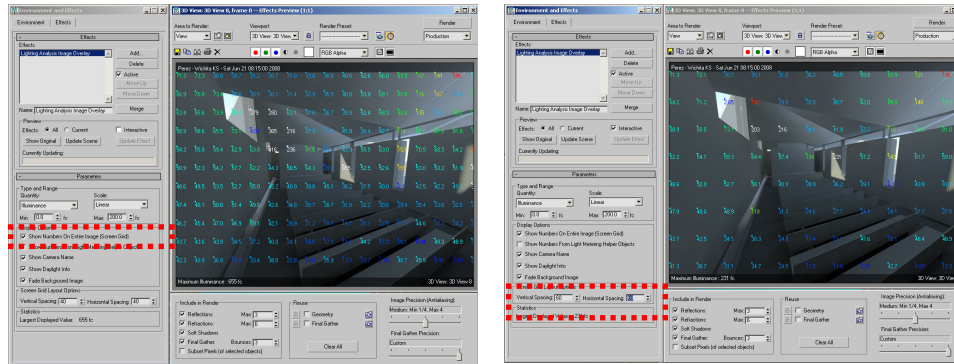
The Lighting Analysis Image Overlay render effect must be added in the Effects panel to be enabled.

Lighting Analysis Image Overlay showing numbers from Light Meter Objects.

### Showing light levels projected from the Camera overlaid on the rendered image

Another approach is to report numbers on the image as if a grid was projected from the camera. This is convenient when statistical analysis is less important but presenting an idea of the light levels in a complex space is needed.

*Note: Keep in mind that this type of projection is view dependent and numbers correspond to the intersection of a ray projected from the Camera into the scene. As a result, they will be a mix of points on the floor, ceiling, walls, and furniture.*



“Show Numers on Entire Image (Screen Grid)” option in the Lighting Analysis Image Overlay Render Effect is now used. The Screen Grid layout Options manages the density of the grid on screen.

Now that you know how to access and use the various analysis tools in 3ds Max Design 2009, the next section will provide you with some suggestions of what you might want to calculate and how to analyze your results.

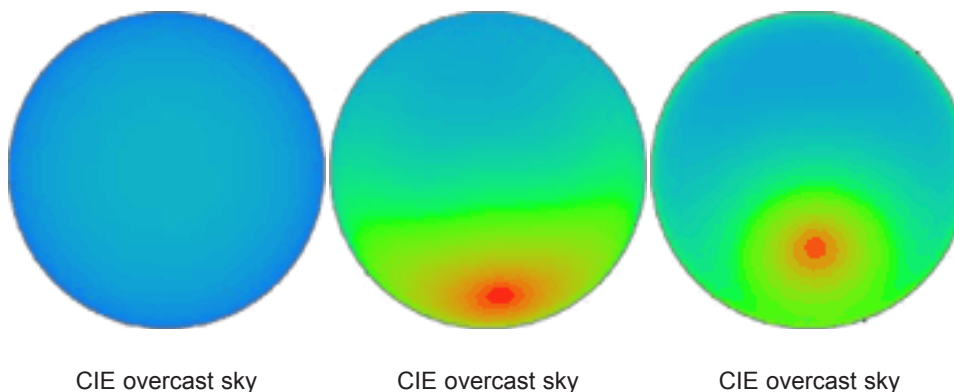
### Daylighting Metrics

In this section, three different daylighting metrics and related simulation workflows are discussed. Some very basic directions are provided to determine which of these metrics might be most adequate for your particular project. The three metrics are daylight factor, CIE clear sky illuminances, and climate-based metrics.

#### Daylight Factor

The daylight factor is defined as the ratio of the internal illuminance at a point in a building relative to the unshaded, external horizontal illuminance under a CIE overcast sky. The CIE overcast sky is a standardized description of a completely overcast sky, meaning that the cloud cover is continuous and no “blue” sky is visible. In contrast, a sky with partial cloud cover is often referred to as an “intermediate” CIE sky. A “clear” CIE sky has no clouds.

The CIE (International Commission on Illumination) has defined standard sky luminance distributions for all three types (see Figure below). More recently, the CIE diversified into a larger number of intermediate, standardized skies. 3ds Max Design 2009 supports the two extreme CIE sky conditions, overcast and clear. For intermediate skies, the “Perez All Weather” sky model has been implemented (see below).



Visualisation of the sky luminous distribution of the standard CIE overcast, intermediate, and clear skies.



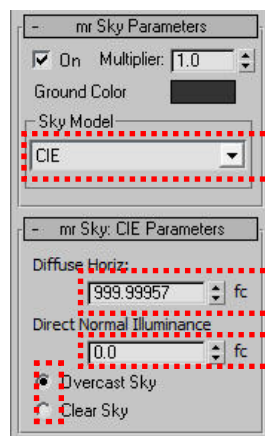
### Calculating the Daylight Factor

The CIE overcast sky is accessible in the mr Sky interface, under the “Sky Model” drop down as illustrated below. It will automatically control the balance between the illumination coming from the Sunlight and the Sky dome (mr Sun and mr Sky) based on the Diffuse and Direct Illuminance parameters. To obtain a fully overcast sky, set the Direct Normal Illuminance to zero (meaning that you have no light coming directly from the Sun).

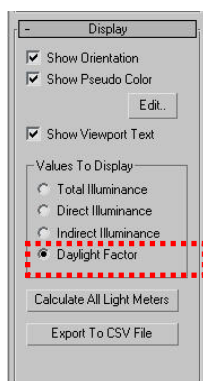
Once you have run a lighting simulation under a CIE overcast sky, daylight factor results are accessible for all Light Meter objects. All you need to do is to set the “Values to Display” radio button to “Daylight Factor” as illustrated below. The Light Meters will calculate illuminances at each point as usual, but the values will be reported in percentage (%) values corresponding to the Daylight Factor. I.e. simulated illuminances are divided by the horizontal outside illuminance that was specified earlier under the mr Sky interface.

Please note that the daylight factor is independent of the outside horizontal illuminance, whereas total and diffuse illuminances are daylight factor-dependent.

*Note: This option is only available when the CIE sky model is used.*



The mr Sky set to use the CIE Overcast Sky model.



G	H	I	J	K	L	M
direct	Total	Illum. Un	Daylight Factor	Pos X	Pos Y	Pos Z
898	898	fc	89.76	63.92	-61.93	
846	846	fc	84.62	76.53	-61.93	
741	741	fc	74.13	89.14	-61.93	
673	673	fc	67.31	101.75	-61.93	
527	527	fc	52.75	114.36	-61.93	
365	365	fc	36.46	126.97	-61.93	
244	244	fc	24.41	139.58	-61.93	
178	178	fc	17.84	152.19	-61.93	
170	170	fc	16.97	164.8	-61.93	
148	148	fc	14.81	177.42	-61.93	
126	126	fc	12.65	190.03	-61.93	
112	112	fc	11.18	202.64	-61.93	
111	111	fc	11.13	215.25	-61.93	
115	115	fc	11.46	227.86	-61.93	
87.3	87.3	fc	8.73	240.47	-61.93	

Change the Values to Display to the Daylight Factor mode on Light Meter Objects. When exported to \*.CSV files, Light Meters also report the Daylight Factor in a dedicated column.

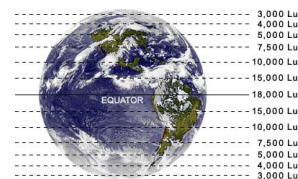
### Design Sky

One obvious question to ask yourself is; to what level you should set the outside horizontal illuminance. Ideally, that would be a level that corresponds to “typical” outside illuminance levels for your particular site. One quantity that you could use for this purpose is the “design sky.”

According to the Square One WIKI, the design sky represents “the horizontal illuminance value that is exceeded 85% of the time between the hours of 9am and 5pm throughout the working year” ([http://squ1.org/wiki/Design\\_Sky](http://squ1.org/wiki/Design_Sky)). In other words, it constitutes a typical, lower threshold level for outside illuminances.

The figure below shows different design sky values for different latitudes based on a formula by Peter Tregenza. For a more accurate estimate, based on your particular building's latitude, the Square One WIKI also provides an online design sky calculator.

Once you set your outside horizontal illuminance to the design sky value, you can actually interpret the illuminances subsequently calculated by 3ds Max Design 2009 as representative indoor illuminance levels for your particular site. Note, however, that the concept of the daylight factor and overcast CIE sky only apply to skies without direct sunlight. The metric is therefore only relevant in either a climate with primarily overcast sky conditions, or for a site in a sunnier climate that is so heavily obstructed by neighbouring buildings or landscape that incidental direct sunlight is negligible over the course of the year.



Estimate of design sky levels for different latitudes.



### Using the Daylight Factor as a design metric

This section discusses the value of the daylight factor as a design metric. Portions of the text were taken from (<http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc48669/>). The daylight factor is the oldest daylighting metric, going back at least as far as 1909 when Waldram published a measurement technique based on ratios rather than absolute values in order to deal with “frequent and often severe fluctuations in the intensity of daylight.”

As explained earlier, the daylight factor is based on the CIE overcast sky and therefore only applies to overcast sky conditions. Since the CIE overcast sky is “rotational invariant” (identical for different facade orientations), the daylight factor for a particular point in a building is independent of the building’s orientation, and even the climate. In other words, the daylight factor for a south-facing office in Miami, Florida is the same as for a north-facing classroom in Anchorage, Alaska—if both spaces have identical geometry and material properties.

As a design metric, the daylight factor functions mainly as a way to proportion window and skylight openings, as well as interior space dimensions, so that there is sufficient daylight available within a space under overcast sky conditions. A daylight factor analysis may inform decisions related to building geometry, surrounding landscape and buildings, as well as surface properties (color, diffuseness, specularity, transmittance, and reflectance). Design variables—apart from building orientation and climate—that are not considered by a daylight factor analysis are movable shading devices, occupancy patterns, and glare.

On a practical level, the daylight factor offers the advantage of predictions being intuitive and easy to communicate within a design team. A number of calculation methods exist for the daylight factor, ranging from simple spreadsheet calculations to advanced calculation techniques based on radiosity and/or raytracing. 3ds Max Design 2009 is based on a backward raytracing method.

Typical daylight factor levels to aim for are 2% in offices, 3% for classrooms and higher end retail spaces, and 1% for circulation areas.

### CIE Clear Sky Illuminances

The daylight factor becomes an obsolete metric for a site which receives a lot of direct sunlight. At this point it is important to stress that one cannot multiply the daylight factor with the outside horizontal illuminance under a clear or intermediate sky, since the presence of direct sunlight obviously means that most of the natural light comes from a very small portion of the sky. The diameter of the opening cone of the sun is only 0.5 degrees, whereas the overall circumsolar region (area around which most of the direct sunlight is forward scattered) is about 5 degrees. Under such climatic conditions it is therefore advisable to concentrate the daylighting analysis on sunny skies using the CIE clear sky.

### Enabling the CIE Clear Sky model

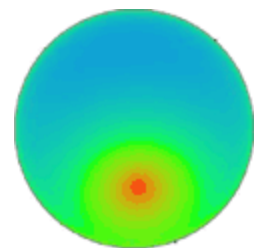
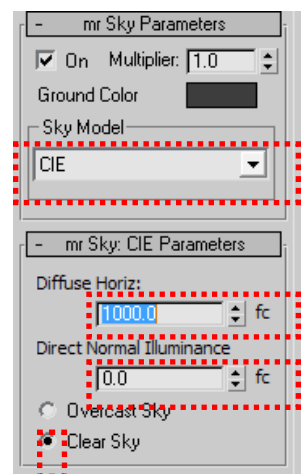
The CIE Clear Sky is accessible in the mr Sky interface, under the “Sky Model” drop down, similarly to the CIE Overcast Sky. The user needs to provide the latitude and longitude of the scene’s site as well as direct and diffuse outside horizontal illuminances.

### Using CIE Clear Sky illuminances as a design metric

Since the CIE clear sky varies with sun position at different times of the year, the obvious question to consider is on which times of the year to concentrate. A common choice, promoted by the US Green Building Council’s LEED 2.2 green building rating system, is to first calculate indoor illuminances under a clear sky on an equinox day at noon (March 21 or September 21) and then aim for indoor illuminances over 250 lux ([www.usgbc.org/leed/](http://www.usgbc.org/leed/)).

In the authors’ opinion this approach is too narrow, since neither daily nor annual variations are considered. So, as a minimum, we recommend looking at illuminance conditions at 9 a.m., noon, and 3 p.m. under CIE clear sky conditions on solar solstice and equinox days (December 21, March 21, and June 21).

The resulting matrix of nine illuminance patterns provides at least some indication of typical illuminance conditions within a space under clear sky conditions. In order to further evaluate a space based on its actual usage pattern, one might further investigate other key times of the years. For example, for a space of Christian worship one might look at daylighting levels on Easter Morning and Christmas Day.



The mr Sky set to use the CIE Overcast Sky model.

### Towards Climate-Based Metrics

As explained above, the daylight factor for mainly overcast climates—and CIE clear sky illuminances for mostly sunny climates— provide you with some meaningful ways to optimize your daylighting design. For a more variable climate, you have to work with both metrics to make sure that your design “works” under both types of skies. This approach will lead to reasonable daylighting designs.

An emerging, more holistic way of analyzing the daylighting within a space is to use so called “climate-based” metrics. These metrics are based on a very large number of sky conditions, typically all hourly or even sub-hourly sky conditions within a given year. In practice these sky conditions can be generated using a “weather file” for your particular building site.

Annual weather files contain typical environmental conditions for a particular site based on several years of measured data. A common file format is the US Department of Energy’s EnergyPlus weather data format (\*.EPW). Several thousand EPW files are available free-of-charge from

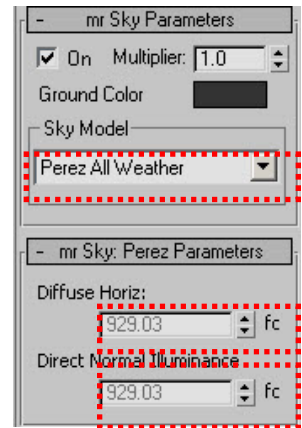
[http://www.eere.energy.gov/buildings/energyplus/cfm/weather\\_data.cfm](http://www.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm).

3ds Max Design 2009 can read EPW files and combine them with the Perez All Weather sky model, allowing the software to model daylighting conditions during all hours of the year.

### Enabling the Perez Sky Model and loading an EPW File

In order to use the Perez sky model in combination with an EPW file you have to select ‘Perez All Weather’ under the mr Sky Parameters and provide diffuse and direct outside horizontal illuminances.

First, download the EPW file of your choice from the Energy Plus website. You can browse by region and city in the Weather Data section of the website.

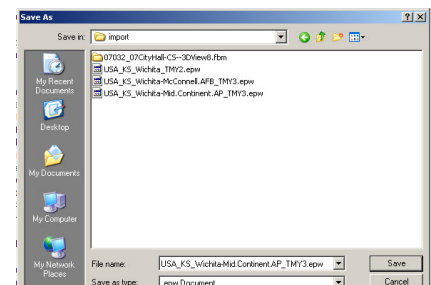
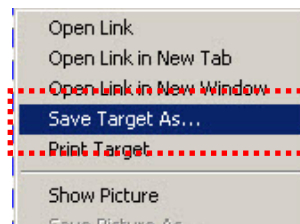


The mr Sky set to Perez All Weather model. Select this sky type if you desire to do lighting analysis with weather data files.



The Energy Plus website allows you to browse by regions for weather data files.

<b>Kansas</b>		
Chanute-Martin Johnson AP (TMY3)	EPW	STAT
Concordia-Blosser Muni AP (TMY3)	EPW	STAT
Dodge City Rgnl AP (TMY3)	EPW	STAT
Emporia Muni AP (TMY3)	EPW	STAT
Fort Riley-Marshall AAF (TMY3)	EPW	STAT
Garden City Muni AP (TMY3)	EPW	STAT
Goodland-Renner Field (TMY3)	EPW	STAT
Great Bend AWOS (TMY3)	EPW	STAT
Hayes Muni AWOS (TMY3)	EPW	STAT
Hill City Muni AP (TMY3)	EPW	STAT
Hutchinson Muni AP (TMY3)	EPW	STAT
Liberal Muni AP (TMY3)	EPW	STAT
Marshalltown Rgnl AP (TMY3)	EPW	STAT
Newton AWOS (TMY3)	EPW	STAT
Olathe-Johnson County Executive AP (TMY3)	EPW	STAT
Olathe-Johnson County Industrial AP (TMY3)	EPW	STAT
Russell Muni AP (TMY3)	EPW	STAT
Salina Muni AP (TMY3)	EPW	STAT
Topeka-Forbes AFB (TMY3)	EPW	STAT
Topeka-Phillip Billard Muni AP (TMY3)	EPW	STAT
Wichita-Col. Jabara Field (TMY3)	EPW	STAT
Wichita-McConnell AFB (TMY3)	EPW	STAT
Wichita-Mid Continent AP (TMY3)	EPW	STAT



Locate the EPW symbol matching the region of your choice and “Save Target As.”

## Daylight Simulation in Autodesk 3ds Max Design 2009

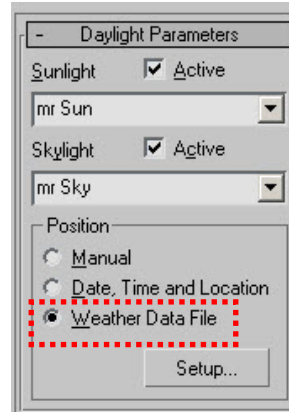
Once the EPW file has been saved on your disk, load it in the Daylight System of your 3ds Max Design project.

*Tip: Use the Scene Explorer to locate and select the Daylight System from a list view as opposed to selecting by picking in the scene.*

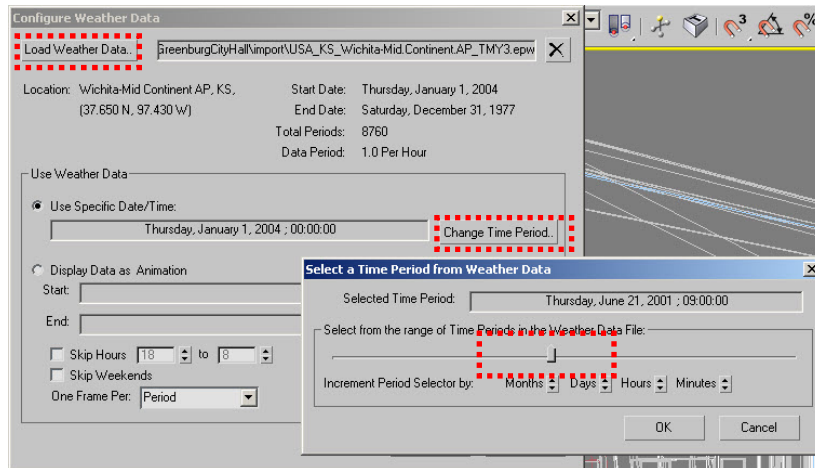
When you load an EPW file into 3ds Max Design 2009, the software resets the azimuth and altitude of the Daylight System according to the information provided in the EPW file. Depending on the date and time you select, the software also resets the direct and diffuse outside illuminance used by the Perez All Weather sky model.

### Setting the Animation Range of your simulation

The Weather Data File configuration dialog allows you to select the EPW file of your choice and determine the range of data (time period) you will want to use to perform your calculations. You can configure it to use a specific entry in the file (a single Date/Time), or you can set a starting point and an ending point in the Weather Data File to perform an animation.

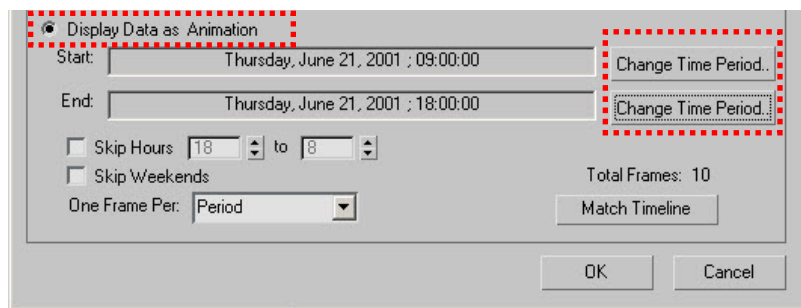


The Daylight System can be driven from a weather file. Use the Weather Data File option and click Setup to enable this functionality.

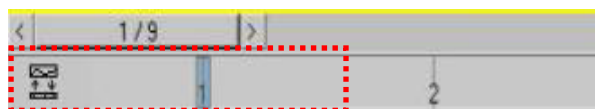


A Weather Data File has been loaded and a fixed period from the file has been selected. A period corresponds to an entry in the Weather Data File (row).

If you want to perform a lighting analysis study as an animation, you must specify a Start and End point in the Weather Data File configuration dialog. By matching the 3ds Max Design timeline you will end up with an animation corresponding to exactly one rendered frame per entry in the Weather Data File.



Specify an animation by identifying a Start and End point in the Weather Data File.



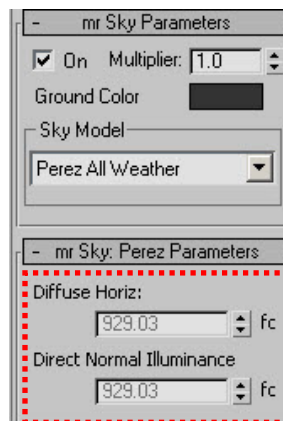
Match Timeline will change the 3ds Max Design animation ranges to fit the selected Start and End points.

Once a Weather Data File has been selected and configured, the Daylight System orientation and illuminances will be controlled from the file. As you scrub the timeline, you will see the values changing.

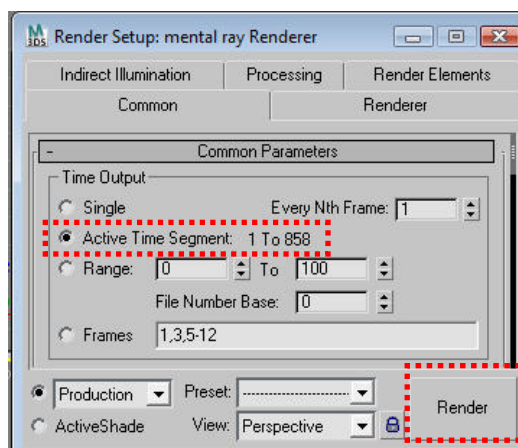
### Reporting light levels over a period of time

After having set your Daylight System to pull data from a Weather Data File over a period of time via the 3ds Max Design animation system (timeline), you can now create Light Meters and run the calculation for the entire animation range using the *Render Setup* dialog.

Once the simulation is completed you can export simulation results for every frame (time step) and Light Meter into a (\*.CSV) file. Be aware that the resulting output files can be very large and that you might have to analyze the data using Macros or a database system.



Once a Weather Data File has been loaded in the Daylight System, you can confirm that the Illuminances values are read from the file. The controls will be greyed out in the user interface but their values will change from frame to frame in real time.



Light Meters collect light levels for every rendered frame. At the end of the process, you can export to a CSV file and inspect the data for every Light Meter point, at every frame. The number of frames depend on the length of your animation, which can be set by matching the timeline in the Weather Data File configuration dialog.

### Using climate-based daylighting metrics for design

Using the workflow described above will enable you to generate time series of images or illuminance grids. For example, you can use the image series to visualize how the lighting in a space changes over the course of a day (equinox, solstice etc.) and refine your analysis from the previous section.

You can also run a simulation for a grid of illuminances for a whole year and load the results into Excel. Once you have the information available within Excel (8760 lines for each hour of the year times as many columns as you have grid points) you will have to reduce this abundance of data into something that is useful for design. How to do this is an ongoing area of research, the current state of which is described under <http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc48669/>.

If you want to calculate the daylight autonomy for your space, you have to limit your analysis to the hours of occupancy during the year (say weekdays from 8 am to 6 pm for an office). Then you have to count how many hours of the year your daylight illuminance is above your target illuminance for that space (say 500 lux for an office). The ratio of hours above the target level divided by all hours of occupancy corresponds to your daylight autonomy for that particular grid point. In a similar fashion, you can extract useful daylight illuminances and other climate-based metrics.

## FAQs

### Analysis Output

#### **How can I switch between lux and foot candles?**

Lighting units can be changed from the Customize | Units dialog. You will be able to set your display as foot candles (Imperial) or lux (SI) units.

#### **Can I export animation data in Microsoft Excel?**

Yes. If you performed a lighting analysis calculation per frame (typically with Daylight running through the course of a day, month, or year), exporting the data collected by Light Meters to a CSV file will let you load it into a spreadsheet program such as Microsoft Excel. Be aware that the resulting output files can be very large and that you might have to analyze the data using Macros or a database system such as Microsoft Access.

#### **Microsoft Excel opens exported CSV files as a single blob of text, what to do?**

Usually, Microsoft Excel imports CSV files correctly (i.e. with columns and rows well separated). However, in some cases, it may load the CSV file exported from Light Meter objects as a single “blob” of text. If this happens, you will have to manually open the CSV file with the File | Open command and make sure you specify the “Text File (\*.pm, \*.txt, \*.CSV)” option. This should launch a wizard that allows you to load the incoming data to specific rows and columns into a new spreadsheet.

#### **Can I do lighting analysis with Photometric Lights? Do I need daylighting for it to work?**

Many people need lighting analysis tools for artificial lighting conditions (museums, theaters, schools etc.). This is a supported workflow with 3ds Max Design 2009, and you can do a lighting analysis without specifying a Daylight System. The workflow is identical except for that you have to specify Photometric Lights.

#### **Why are my Light Meters all white in the viewport after the calculation has been completed?**

Typically, this is caused by an incorrect range of illuminance values in the Pseudo Color display; adjust them in the Lighting Analysis Assistant, in the General Tab.

#### **Can I create curved Light Meters?**

Not at the moment. Light Meters are constrained to rectangular shapes in 3ds Max Design 2009.



## Materials and Finishes

### I imported my scene from Revit 2009. Are my materials accurate?

Not necessarily. While materials imported from Revit 2009 via FBX are of a valid type (ProMaterials) for analysis, nothing guarantees that their color (reflectance) matches the physical properties that are determined by your project.

In many cases, we have seen that Revit users select an overly bright color or use un-calibrated texture maps which introduce incorrect reflectance values in the model.

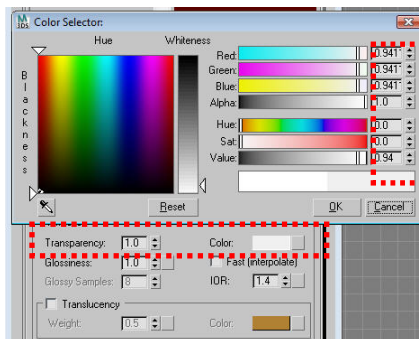
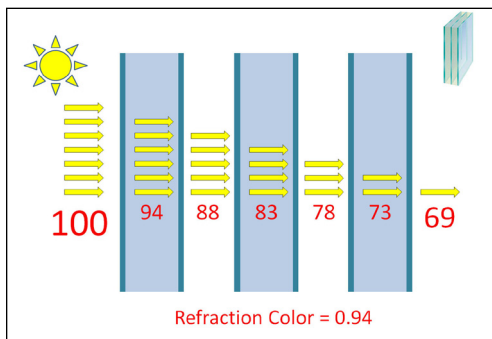
We always recommend that you verify whether the materials used by the simulation are set to plausible reflectance values. In other words, verify the results from the Revit user who handed off a “nicely renderable” model. A correct visual appearance does not guarantee that glazing and walls properties have been set accurately.

### How should I model windows? How can I specify glazing transmittance?

The short answer is that the transparency color of your material (typically the Architecture and Design A&D material or ProMaterials Glazing) will attenuate light rays for each polygon that is traversed.

For example, if you modeled a triple glazing system where the thickness of the glass panes is physically represented, you would have six polygons to traverse (i.e. three sheets of glass represented by solid boxes represents a total of six polygons for a light ray to traverse).

By assigning a Refraction color of 0.94, the total glass transmissivity would then be  $0.94 * 0.94 * 0.94 * 0.94 * 0.94 = 69\%$ , as the light gets attenuated by 6% each time it traverses a polygon.



Each polygon traversed by a ray of light loses 6% of the initial energy, for a total of 69% energy left on the other side of the glazing assembly.

For the long answer (and more details), please consult the Advanced Concepts document under the topic entitled *Glass and Glazing in the Guidelines for creating Materials and Finishes* section.

### Can I import Radiance Materials (\*.rad files) exported from the Optics 5 software?

No, but you can manually extract the information provided by these files and convert them into a physically correct 3ds Max material. Please consult the *Advanced Concepts* document under the topic entitled *Glass and Glazing in the Guidelines for Creating Materials and Finishes* section for a description of the process.

### Can I use texture maps on my materials for accurate analysis?

Yes, but this will require several calibration steps and is not recommended for beginners. If you are not in a calibrated environment where image gamma and color calibration have been taken into account, your lighting analysis results will be incorrect. Avoid textures and colors on your surfaces if you are not familiar with the relevant conversion processes and use grey shades instead.

Please see the *Advanced Concepts* document under section *Diffuse Color vs. Diffuse Reflectance* for more details on the topic.

### Rendering, Precision, and Algorithms

#### Can I use a rendering engine other than mental ray?

No. The lighting analysis features in 3ds Max Design 2009 are based on core mental ray features and cannot be used with other renderers such as the Default Scanline Renderer or other third party renderers.

#### What are the object types that are valid for lighting analysis in 3ds Max Design?

Lighting analysis results can only be guaranteed to be within physical correctness when you use a special subset of light sources and materials in 3ds Max Design.

Those are: mental ray renderer, A&D Material, ProMaterials, Photometric Lights, and mrSun+Sky using the Perez or CIE sky model. Using any other type of material or light source may not prevent the lighting analysis data from being reported, but we cannot predict how accurate those numbers will be.

As for geometry, the type of geometry does not matter. It can be Editable Meshes, Polygons, Patches, or NURBS, as long as they are renderable by mental ray.

#### What controls the precision of light meters?

Light Meters are collecting illuminance at each point based on your mental ray Final Gather and Global Illumination settings. The more accurate your “pretty picture” renderings get, the more precise the illuminance is going to be.

However, there is some tolerance built into this. Internally, Light Meters will cast eight times as many rays than what is set in the Final Gather settings. This means that even if the “pretty picture” you get is not totally noise free, the Light Meters’ numbers will be somewhat more accurate.

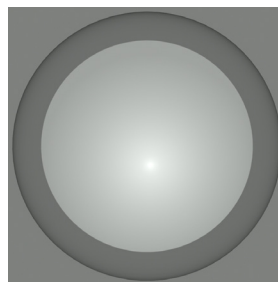
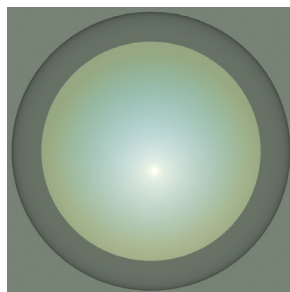
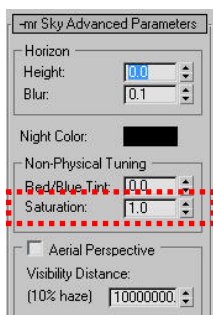
Note that this feature does not protect you from mistakes such as wrong material reflectance, incorrect glazing definition, and non-physically based effects such as lights that may not cast shadows or attenuate. We hope that this document gives you enough information on this topic and proves to be helpful.

#### Can I use the IES sun and IES sky plug-ins?

Although they are supported by mental ray, we do not recommend that you to use them since they have not been validated. Additionally, the mr Sun and mr Sky plug-ins have internal optimizations that will make your renderings faster under certain circumstances.

#### My sky is greenish, how can I solve this?

While our test confirms that the light levels are unchanged by the Saturation parameter, the CIE sky has the tendency to create greenish images. If your goal is to create pretty pictures with overlaid light levels, you may want to reduce the Saturation of the mr Sky to 0.0 in order to get a grey image with the CIE sky.



Reducing the mr Sky Saturation to 0.0 will remove the green tint you may see in the rendered image. Note that this green tint does not affect the light levels reported by the Light Meters.

#### What are the best Final Gather settings to use?

The answer to this question depends on the complexity of your scene. Generally speaking, if you are satisfied with the way the image looks, the results should be pretty accurate. The image quality (thus lighting computation accuracy) is greatly influenced by the type of scene with which you are dealing.

## Daylight Simulation in Autodesk 3ds Max Design 2009

If your interior is a large atrium where the sky is visible from almost any location in space, chances are that this will be easily solved by a few bounces of light with a few rays per Final Gather FG sample. If you have a closed interior that has small windows, chances are that the requirements for light bounces and rays per FG points will need to be a lot higher.

### Do I need to use Global Illumination / Photons with mental ray?

No. In fact, we recommend that inexperienced users stick to Final Gather only. Photons can be tricky to use, especially with Caustics. If you want to opt for Photons (they are definitely very fast to compute) keep in mind that, by the nature of Photon Density requirements (if you plan to report light levels through Caustics), a receiving surface must be very close to the Light Meter. For example, you will not be able to measure light levels from Caustics effects with a Light Meter “floating” in the air.

*Note: We have not validated the physical correctness of Photons yet, so, if you validate them, please let us know.*

### Can I use sky portals?

From our validation tests, sky portals are physically correct but there is a certain offset when using them which is more pronounced especially from dawn until noon. However, when during certain days there are some highlight peaks, sky portals seem to simulate these conditions better than default render settings.

The results of our validation tests can be found here: [link to NRC report on 3ds Max Design 2009 comparison](#)

### I used an overcast sky model and I still see the sun disk in the background and in reflections.

This is “normal” in a sense—in 3ds Max Design, illumination is separated from reflections and backgrounds. The reason you see the sun disk is that the Environment Map (mr Physical Sky map) always display it. To eliminate this, you can set its size to zero. Note that although the Sun may be visible in reflections and the background, the lighting values reported by the Light Meters are not affected. The illumination comes from the mr Sun and mr Sky lights (wrapped inside the Daylight System).

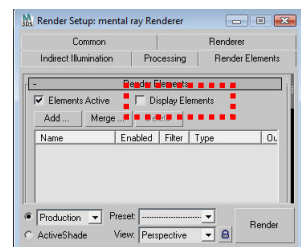
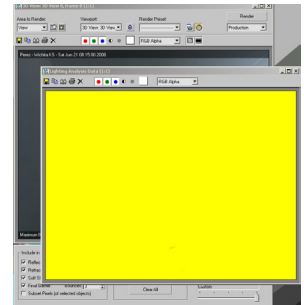
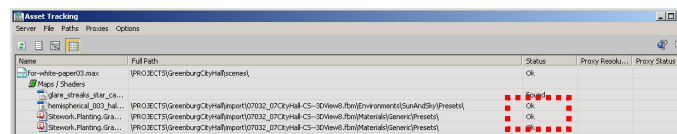
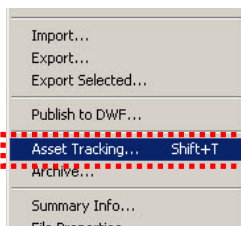
### A yellow image pops up after using the Lighting Analysis Image Overlay.

#### Do I need it?

If you see a yellow image pop up after rendering, this is caused by the Lighting Analysis Image Overlay. This image is a temporary data buffer where luminance and illuminance are recorded for every pixel. You can close this dialog if you wish.

### Where can I fix “missing files” messages?

If you open a 3ds Max file and you get an error message stating that some files are missing (textures, weather files, photometric files, etc.), you can remap them to a valid path from the File | Asset Tracking dialog.



The yellow image is temporary data buffer that is used by the Lighting Analysis Overlay render effect. You can dismiss this dialog or prevent it from showing up by disabling the “Display Elements” from the Render Elements Tab.

The Asset Tracking dialog of 3ds Max allows you to identify and repath externally referenced files from your scene.

## Daylight Simulation in 3ds Max Design 2009—Advanced Concepts

A second document entitled “*Daylight Simulation in 3ds Max Design 2009—Advanced Concepts*” provides tips and tricks as well as more detailed information on the topics covered here.

[LINK TO ADVANCED CONCEPTS DOCUMENT HERE](#)

## External Links

Autodesk: Ecotect Wiki

<http://squ1.org/wiki/>

Energy Plus: Weather Data Files

[http://www.eere.energy.gov/buildings/energyplus/cfm/weather\\_data.cfm](http://www.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm)

Autodesk: 3ds Max Design White Papers

<http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=11360846>

National Research Council of Canada: Introduction to dynamic daylight metrics

<http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc48669/>

X-Rite: GretagMacBeth Color Chart

[http://www.xrite.com/product\\_overview.aspx?ID=820](http://www.xrite.com/product_overview.aspx?ID=820)

Windows Group, Lawrence Berkeley National Lab

<http://windows.lbl.gov/>

Radiance Material Definition

<http://radsite.lbl.gov/radiance/refer/ray.html#glass>

## About the Authors

### **Christoph Reinhart**

Christoph Reinhart is an Associate Professor of Architectural Technology at Harvard University. Before joining Harvard in 2008, Christoph worked for over a decade as a staff scientist at the National Research Council of Canada and the Fraunhofer Institute for Solar Energy Systems in Germany.

His expertise is in daylighting, passive cooling concepts, and the influence of occupant behaviour on building energy use. He is the main developer of Daysim, an advanced Radiance-based daylighting design tool. Following a series validation studies of the Radiance daylight simulation engine, he recently developed a more general suite of daylight simulation test cases that were used to benchmark Autodesk mental ray and Autodesk 3ds Max against measured illuminances.

Christoph is on the editorial board of the Journal of Building Performance Simulation and served as a guest editor for a special issue on "Daylighting Buildings" in the Energy and Buildings journal. Between 2005 and 2007 he was also a member of the Technical Advisory Group for LEED-Canada.

### **Marion Landry**

Marion Landry has over ten years experience in Architecture Visualization, working with a wide range of software including Autodesk 3ds Max and Autodesk Maya. She has worked on numerous projects from concept design to high-end pre-visualization.

Among her recent projects have been the innovative Ritz Carlton Residence Vancouver (Arthur Ericson designed tower), and the Hyatt Hotel, Vancouver. She contributed high-end animation packages to the Four Seasons Hotel, Whistler, and to a number of Intrawest Resorts. She has participated in a range of sustainable building projects, including the LEED-certified Vancouver Convention Centre, built for the 2010 winter Olympics, and the Abbotsford Regional Hospital and Cancer Centre.

As a Technical Marketing Specialist for Autodesk Media & Entertainment, she is now focusing on the creation of different demonstrations for an AEC-wide audience as well as being involved in the development of Autodesk 3ds Max and Autodesk 3ds Max Design products.

### **Pierre-Felix Breton**

Pierre-Felix Breton is senior software designer and lighting consultant, specializing in the field of physically based and artistic lighting simulation. His professional background includes electrical engineering, computer programming, and theatrical lighting.

Currently employed by Autodesk Media & Entertainment, he helps design products such as Autodesk 3ds Max and Revit where he focuses on the integration of the mental ray rendering engine as well as daylight simulation technologies.

Pierre-Felix also consults regularly on various architectural lighting design projects as a designer, technical coordinator, and simulation specialist where he is involved in the entire lighting design and specification process.



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