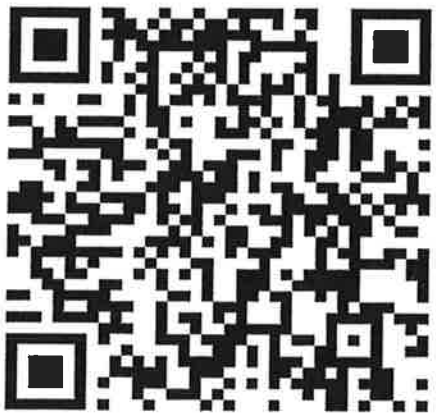
SOLAR MODELING

Please complete the electronic course evaluation form via the URL http://tiny.cc/knzb4x

or the appended QR code.



Organised by: BCA ACADEMY

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Email:bca_academy@bca.gov.sg

Important Notes to Course Participants

On Attendance/Examination/Assessment/Assignment

Please remember to sign on the attendance sheet daily and promptly upon arriving at the class. Course participants are **not allowed** to sign for lesson(s) not attended or for someone else. Participants are to monitor their attendance throughout the whole course.

Participants must achieve at least **75% class attendance for lessons (excluding exam attendance)** to qualify to sit for all the assessment(s). Participants who do not achieve at least 75% class attendance may be debarred from all the assessment(s). In this case, the participant will also not be allowed to sit for the supplementary assessment(s). The participant would be deemed to have failed the course and will not be issued the Certificate of Successful Completion.

Submission of assignment/project report (if any) will have to be made by the given deadline. Failure to do so, will result in incompetency/unsuccessful completion of the course.

Late submission of assignment will not be accepted.

BCA Academy

Solar Modeling

BY ERIKA YUNIARTI
GMP, LEED AP, SCEM, GBI FACILITATOR, GREENSHIP PROFESSIONAL
MANAGING DIRECTOR

Introduction

INTRODUCTION

- Model through computational simulation that analyze outcomes related to solar condition, such as:

✓ shadow,
✓ solar radiation (insolation),
✓ sun reflection,
✓ sun penetration,
✓ heat gain and
✓ daylight



WHY SOLAR MODELING?

- Tools to aid design from the BIM model
  - ✓ Analyze current design
  - ✓ Analyze possible improvements or design variants
  - ✓ Comparison of performance in term of shading, heat gain, daylight, or glare.
  - ✓ Select the optimum design result, especially impact to operational stage.

WHY SOLAR MODELING?

- Analysis beyond manual calculation
  - ✓ Complicated shape will take very long to analyze using manual calculation.
  - ✓ Updated 3D design can be used for a quick analysis for result update.

Basic Knowledge

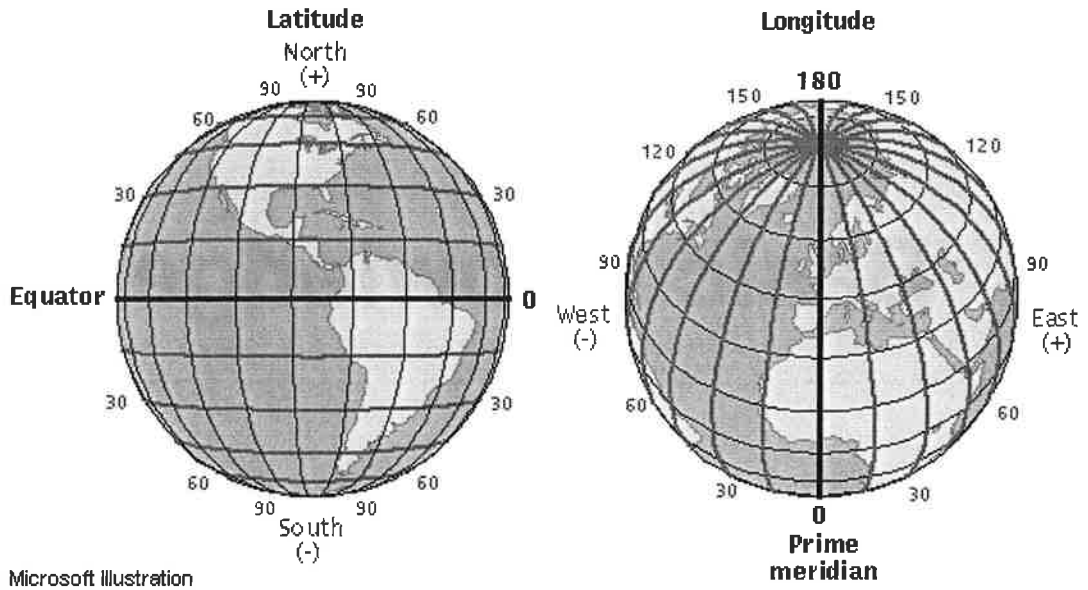
BASIC KNOWLEDGE

SUN POSITION

The position of the Sun in the sky varies continually during the day and also changes seasonally throughout the year. Sun position is also very location-dependent, so it is critical that you know the latitude and longitude of your development site before you begin any calculations.

SG: La 1.3° N
Lo 103.8° E

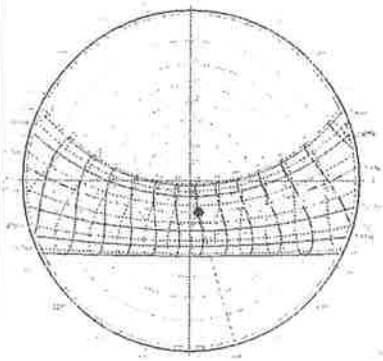
BASIC KNOWLEDGE



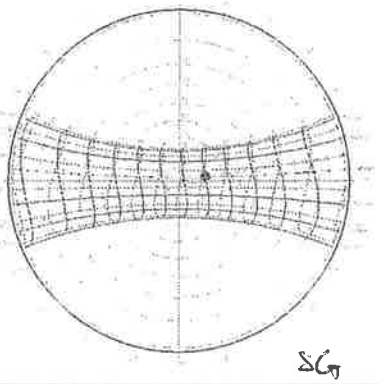
Microsoft Illustration

BASIC KNOWLEDGE

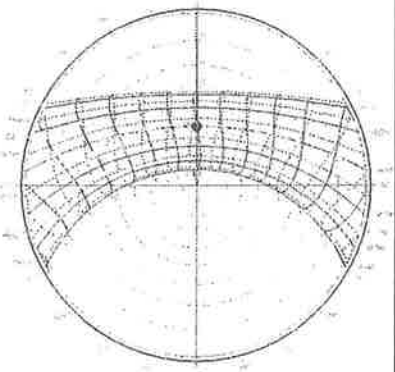
Which one is Sydney, Dubai and Singapore?



Dubai
N to face South



SG



Sydney
N to face North

Luminance level : Lux
Luminance : ← glare
Luminous flux :

Daylight factor = $\frac{\text{Indoor lux}}{\text{Outdoor lux}}$

BASIC KNOWLEDGE

DAYLIGHT FACTORS: AVERAGE

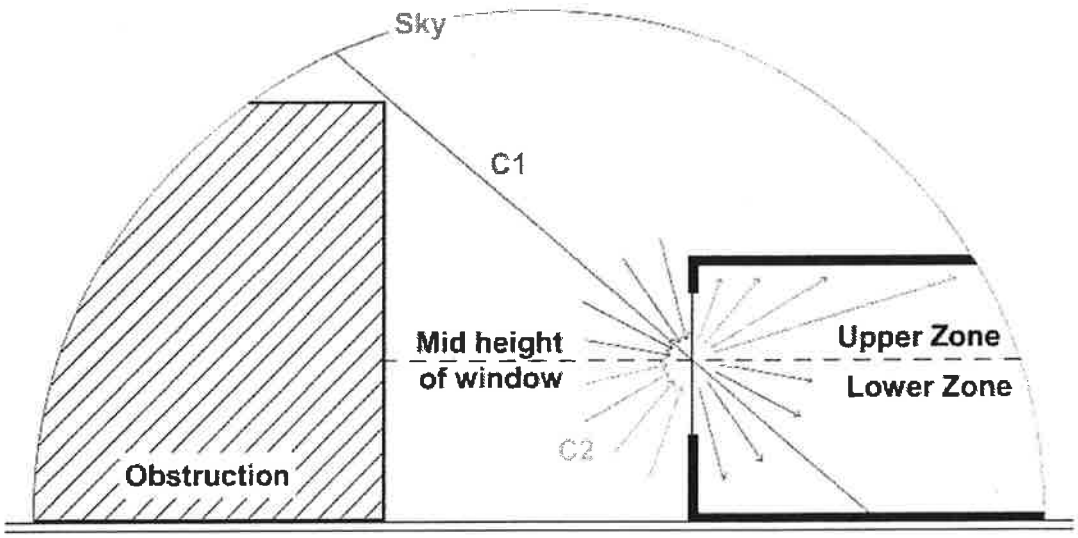
The amount of daylight entering and bouncing around a space is broadly a function of the size of each window aperture, the amount of sky visible from each window and the reflectance of internal surfaces. Whilst the inter-relationships between each element is quite complex, it is possible to simplify and formalize them to yield a single room-averaged daylight value. Though not particularly accurate, especially for deep spaces and those closely surrounded by other buildings or vegetation, it does provide a quick and simple guide to the potential for daylighting.

BASIC KNOWLEDGE

As lighting conditions are continually changing and absolute sky illuminance levels are often hard to find or calculate, it is more useful to design based on the *relative* amount of light entering a space. This way internal light levels can be expressed as a percentage of external levels. Thus, even though the sky may get momentarily darker or brighter, the percentage will remain the same. This means that the percentage value is a property of the building itself, providing an objective measure for the comparison of alternative design options and allowing for direct comparison with other buildings. This percentage value is known as a Daylight Factor.

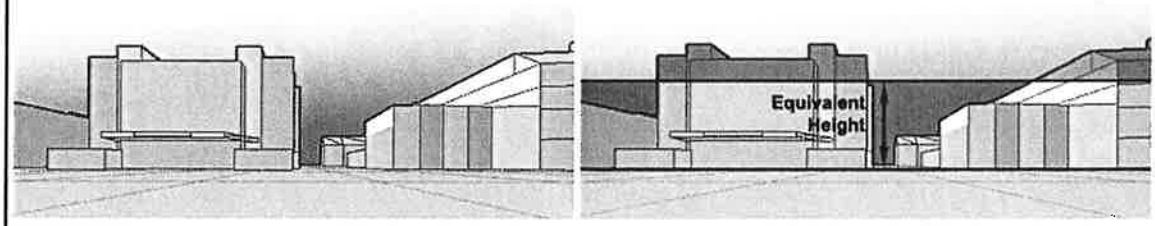
C1 - Direct
C2 - Indirect

BASIC KNOWLEDGE



Sky Vertical Angle

It is often necessary to visually estimate the vertical angle of the sky as seen from the center of a window. This is typically due to variations in either the height of adjacent building / obstructions or shading projections above the window itself. Figure below outlines an empirical method for estimating this angle by simply averaging out the heights. It is also possible to calculate this value directly from a window's shading mask.



View from window — Multiple visible external obstructions. View from window — Equivalent obstruction height, where red area = blue area

Sky Component (SC)

If a traced ray passes through a transparent aperture and travels out towards the unobstructed sky, then that particular ray's solid angle contributes to the Sky Component and is modified by:
the relative sky illuminance in that particular area of solid angle,
the relative angle it makes with a horizontal (or vertical) surface, and
the visible transmittance of each glazing material through which it travels.

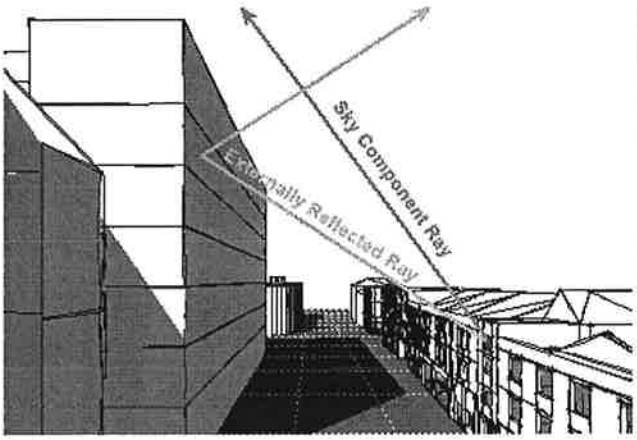
Externally Reflected Component (ERC)

If the ray passes through an aperture and then strikes an external object, it contributes to the Externally Reflected Component and is modified by:
the illuminance of the sky it would have hit,
the external reflectance of the material assigned to the struck external object, and
the relative surface angle and glazing transmittances.

BASIC KNOWLEDGE

Internally Reflected Component (IRC)

If a ray hits an opaque object before passing through an aperture, then it contributes to the Internally Reflected Component. In this case the internal surface reflectance of the object is stored and the altitude angle of the ray is then used to determine which parts of the IRC formula it contributes to.

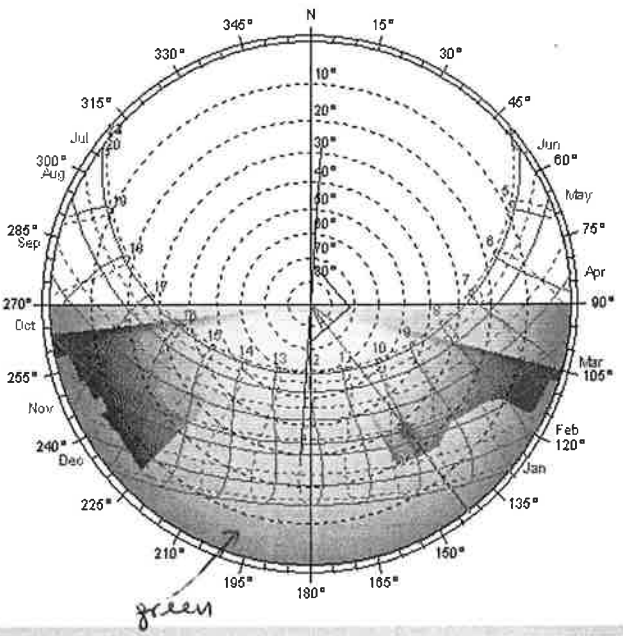


$$D_{fave} = \frac{W_A T \Phi M}{A \times (1 - R_{ave})}$$

W_A – window area
T – glass transmittance
Φ –
M – maintenance factor
R – Reflectance (weighted average)

BASIC KNOWLEDGE

If you look at a Sun-Path Diagram, you can actually see by the overshadowing which bits of the sky dome are obstructed (shown below in GREEN, therefore becoming ERC), which are clear (shown in YELLOW, becoming SC), and which are internal surfaces (shown in DARK GRAY, becoming IRC). The sky colour values in Figure 2 are graded to indicate the sky illuminance distribution, in this case for a CIE Overcast Sky.



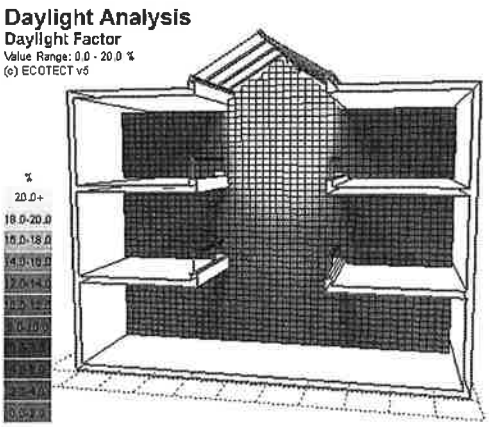
BASIC KNOWLEDGE

As each ray represents an approximately equal solid angle of sky, summing up relative illuminance after modification and comparing it against the total unmodified illuminance gives a percentage value equivalent to the Daylight Factor. If this is done for a large number of points in a space, distributed over an analysis grid, then it is possible to plot Daylight Factor contours over an entire area of work surface.

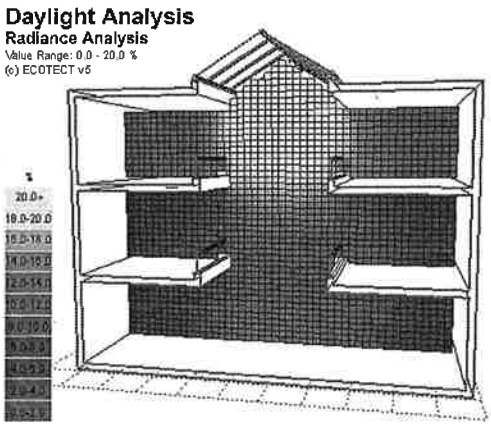
BASIC KNOWLEDGE

The main limitation of the BRE Daylight Factor method is that it uses a relatively simple formula for the effect of internal reflections. To be fully compliant with this method, ECOTECT's ray-tracing cannot consider multiple reflections so the method will **underestimate** the performance of indirect daylight solutions that rely on the reflection of light off multiple surfaces to illuminate a space.

This is clearly illustrated in the next image. As soon as the grid is obstructed by the floor slabs in the lower floors, daylight factor values fall off very quickly, you can almost see them as defined lines. In real buildings the fall off is much more gradual than this, due to diffuse reflections and scattering by other internal surface materials.



An example of BRE Daylight Factors falling off quite quickly when obstructed from direct sky or external reflections



A more realistic spatial distribution of light energy generated by RADANCE using a hybrid reverse ray-trace solution.

Glazing Maintenance Factor

The relative cleanliness of glazing panels within a window can have a significant effect on it's overall visible transmittance. To account for this, Table 1 gives a range of values to be used as the maintenance factor for different glazing angles and environments.

OCATION OF BUILDING	TYPE OF WORK	INCLINATION OF GLAZING	MAINTENANCE FACTOR
Non-industrial / clean industrial	Non-industrial / clean industrial work	vertical	0.9
		sloping	0.8
		horizontal	0.7
	Dirty industrial work	vertical	0.8
		sloping	0.7
		horizontal	0.6
Dirty industrial	Non-industrial / clean industrial work	vertical	0.8
		sloping	0.7
		horizontal	0.6
	Dirty industrial work	vertical	0.7
		sloping	0.6
		horizontal	0.5

BASIC KNOWLEDGE

Absorbed solar radiation ($G_{absorbed}$) is affected by the solar absorption value assigned to a material (F_{abs}), and its transparency value (F_{trans}). The transmitted component is affected by the transparency of the material (F_{trans}) as well as, for windows, their shading coefficient (SC) or solar heat gain coefficient ($SHGC$) and the effects of refraction ($F_{refract}$)

Specularity
Matte surface are rough and reflect light in all directions. Rougher or more matte surface has lower specularity

BASIC KNOWLEDGE

Solar Absorption and Color

The amount of solar radiation that is absorbed by any surface is assumed to be all that isn't reflected or transmitted. For an opaque surface, its reflectivity is really a function of its surface color. A highly gloss surface will reflect just as much solar radiation as a matte surface if their colors are exactly the same - its just that the matte surface will reflect diffusely in all different directions whilst the gloss will reflect the majority of light in a specular direction. The specularity value of a material is therefore not important unless considering the amount of radiation reflected from that surface onto other parts of the model.

Transparency and Shading Coefficient

Another issue sometimes encountered in ECOTECT is the ability to define both a transparency and a solar heat gain coefficient value for a WINDOW material. Traditionally the solar heat gain coefficient is to solar radiation what the transparency value is to light. One difference is that the solar heat gain coefficient can also be used to account for the effects of external and internal shading, but not usually in a dynamic way.

SHGC – amount of light through a glass

SC – used in ETTV = SHGC relative to SHGC of a std 3mm glass

Refractive Index

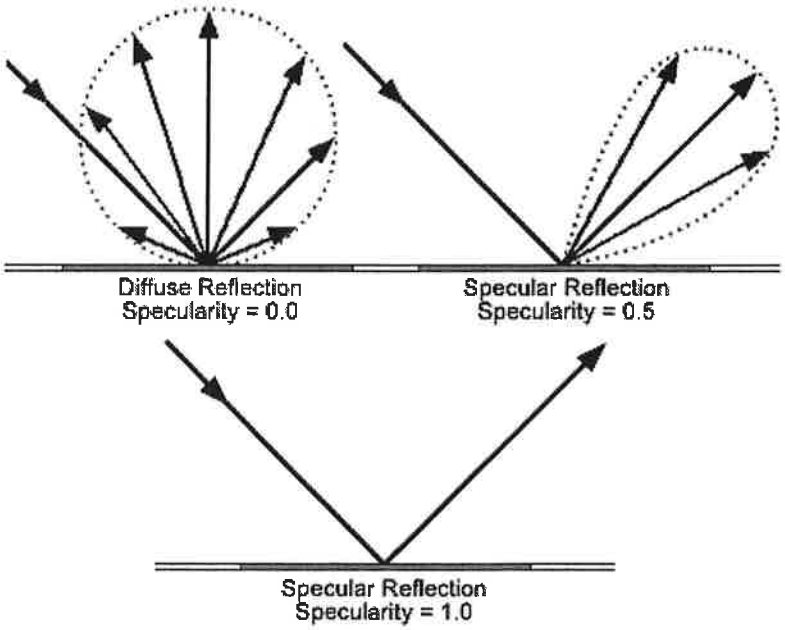
Refraction is an effect that occurs at the interface between transparent materials of different densities, such as air and glass. The bending of light and solar radiation that results from refraction is due to the longer time it takes the waves to move through the denser of the two materials. It is dependent on two factors: the incident angle and the refractive index of each material. The main effect of refraction is to significantly increase the effective surface reflectivity at angles close to grazing incidence.

BASIC KNOWLEDGE

Secularity

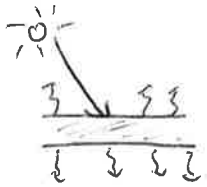
The secularity value of a material is given in the range 0-1 and defines the concentration of reflected light/radiation in the specular direction. A mirror has a very high secularity, which means that the majority of the energy from a focused beam of light would be reflected at an angle equal to the incidence angle on its surface, but mirrored around its surface normal. If that same beam fell on a surface covered with talcum powder, the myriad of tiny individual grains would reflect parts of the beam in all different directions. Being very white the same amount of light would be reflected from the powder surface as from the mirror, but the reflection would be diffuse, spread out at all angles such that the patch of the beam incidence on the surface was visible from anywhere around it not just in the specular reflection angle.

BASIC KNOWLEDGE



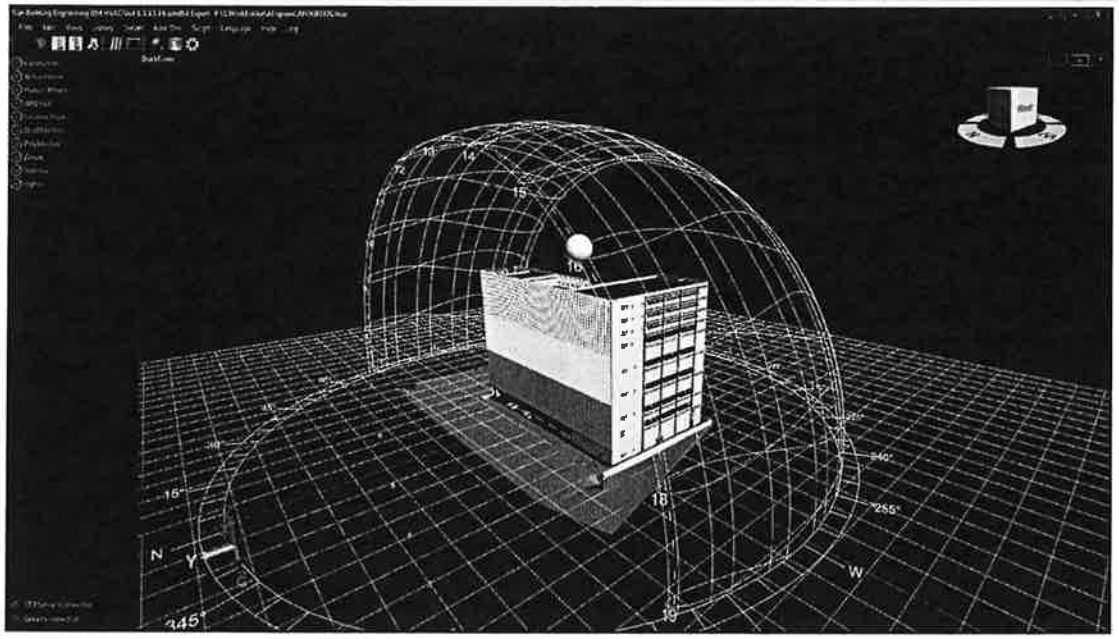
Emissivity

The emissivity value of a material is given in the range 0-1 and describes its ability to absorb and emit long-wave radiation. This occurs at much lower frequencies that light, usually referring to the infra-red radiation from objects at terrestrial temperatures (below 100°C). As a result, emissivity values are important in thermal calculations when considering long-wave radiant exchange between surfaces, but do not play a significant role in ECOTECT solar incidence calculations.



Various Usages

SUNPATH ANALYSIS

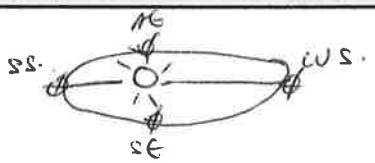


4 design days

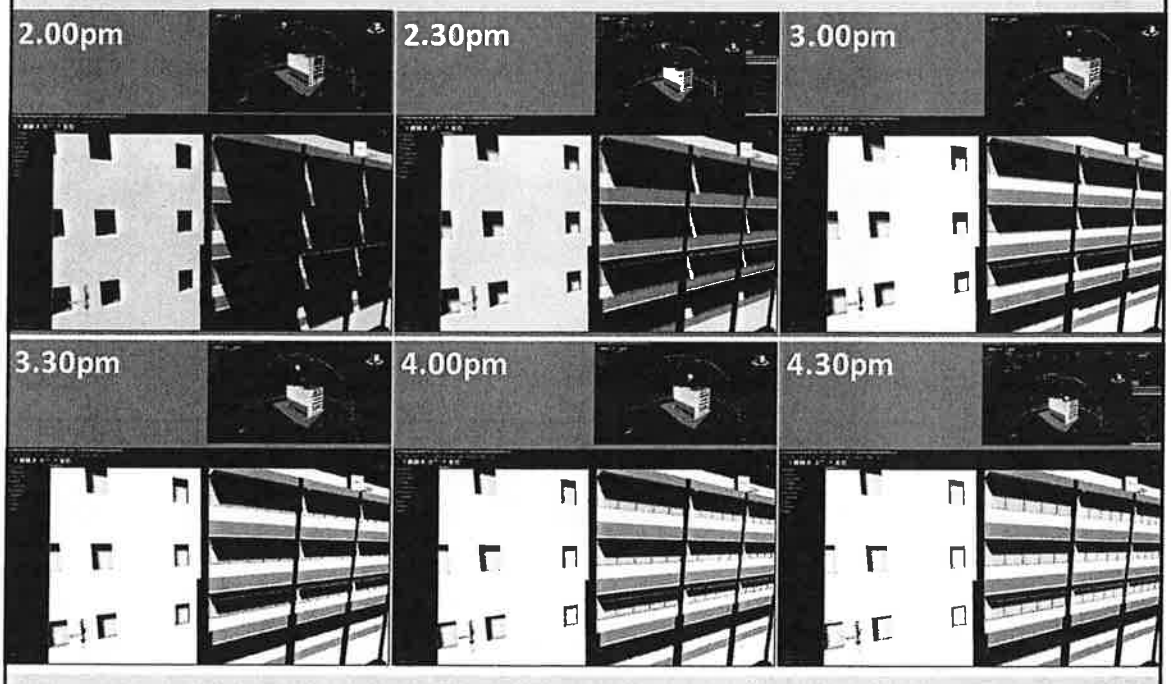
Summer Solstice

Winter Solstice

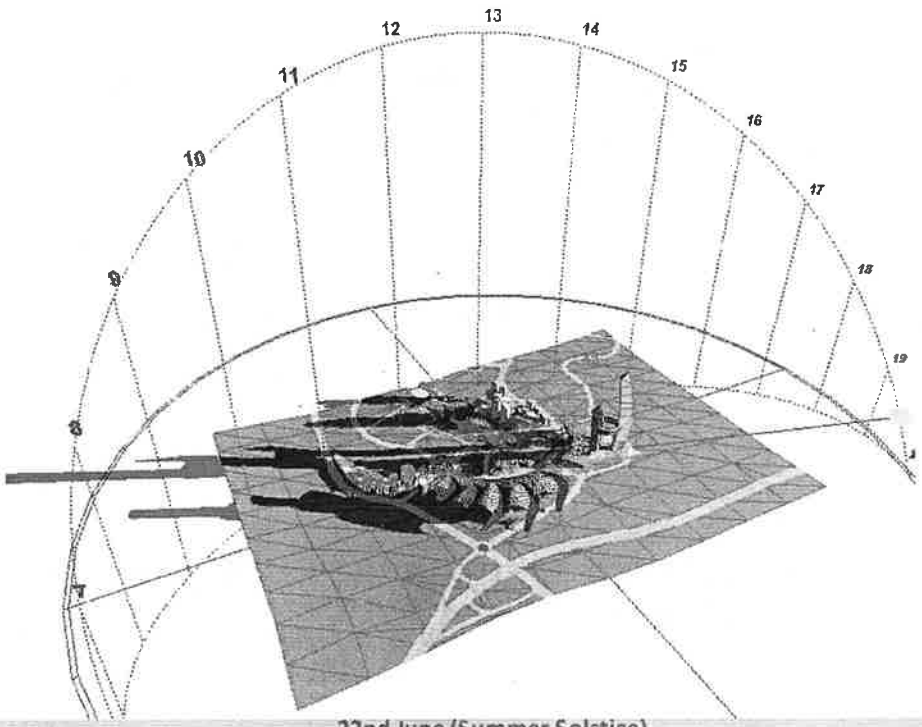
Autumn/Spring Equinox



SUNPATH ANALYSIS



SUNPATH ANALYSIS

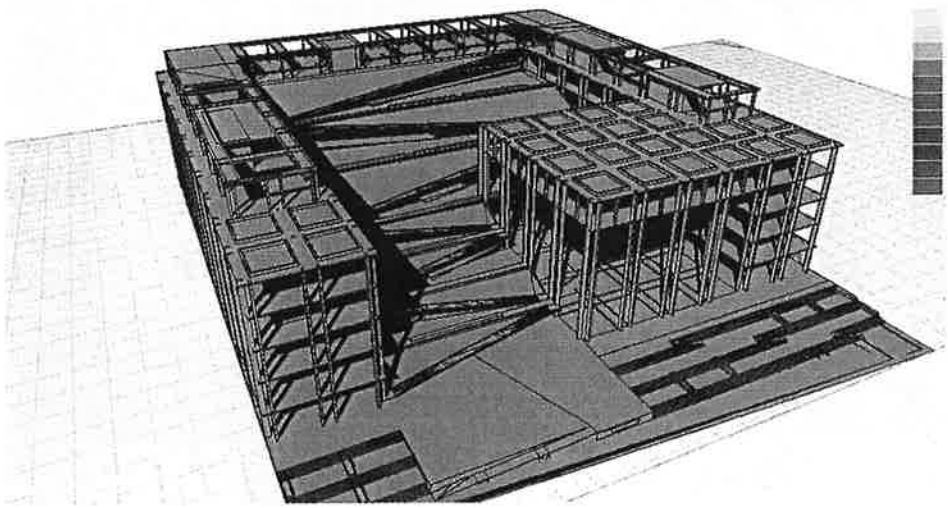


22nd June (Summer Solstice)

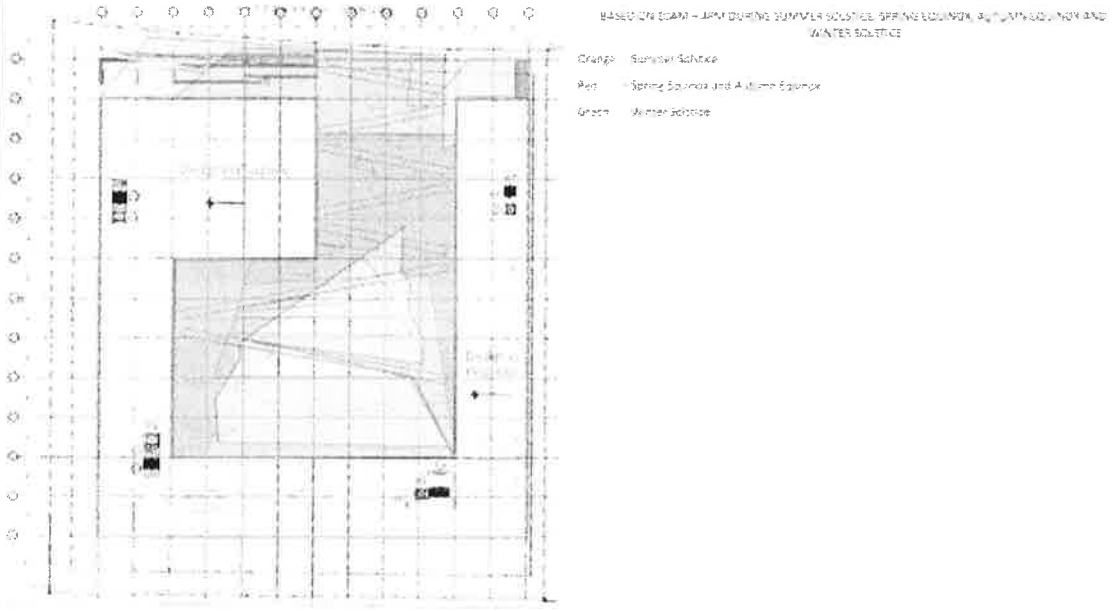
Sunlight required!
1) PV
2) Daylight
3) Vegetation/Landscape

Glare analysis

SUNPATH ANALYSIS



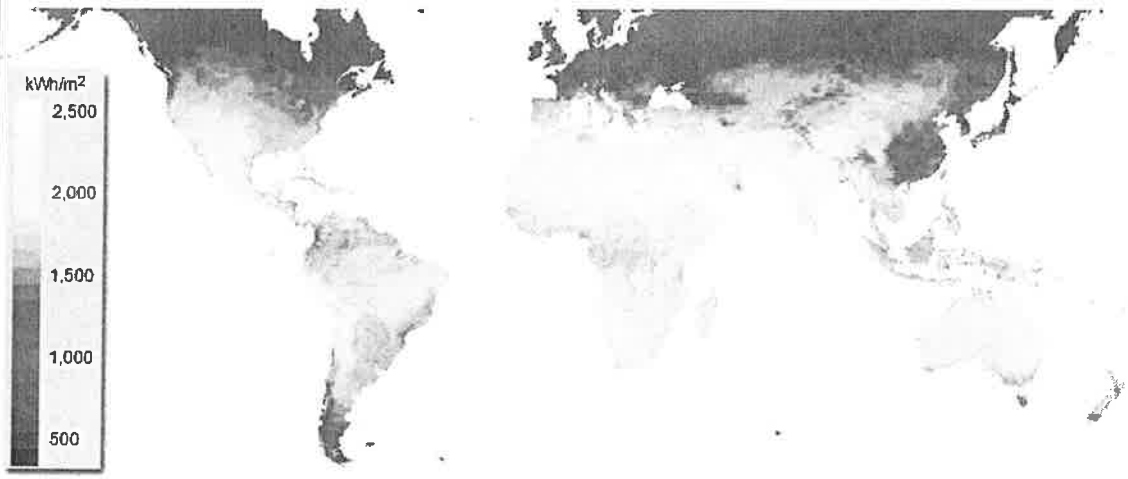
SUNPATH ANALYSIS



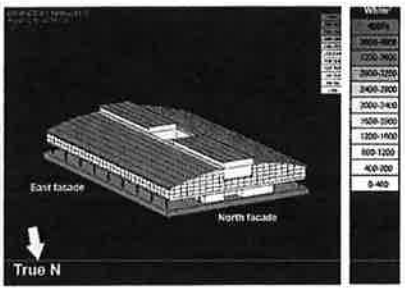
SOLAR

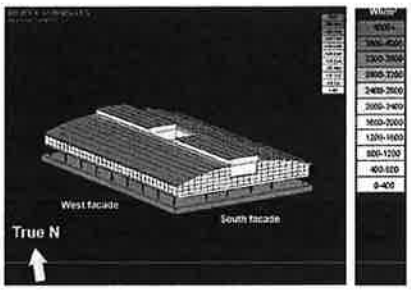
The following maps highlight the differences between direct and global irradiance where "global" includes diffuse light. Areas with a high proportion of diffuse light include Northern Europe, South-East China and the tropical belt around the equator. *(Source: Meteonorm)*

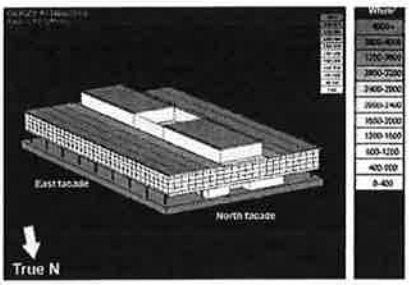
Yearly sum of global irradiance

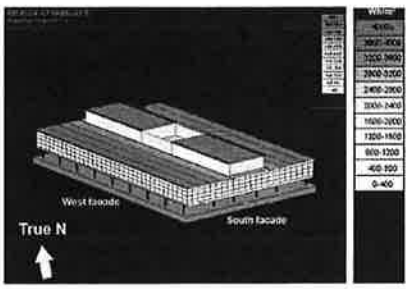


SOLAR



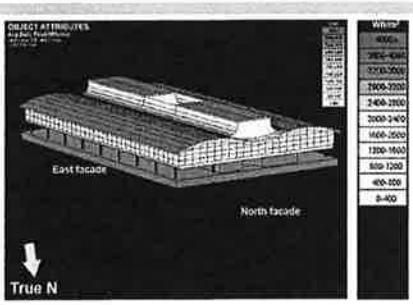


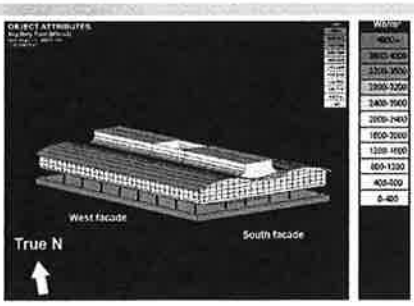


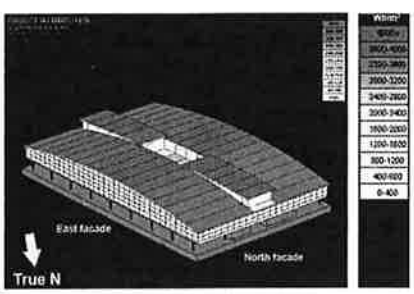


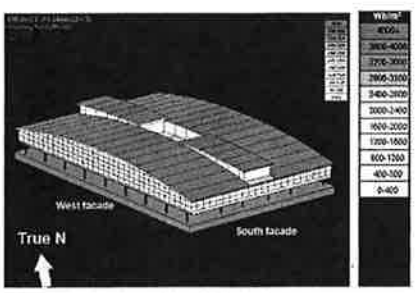
Insolation

SOLAR

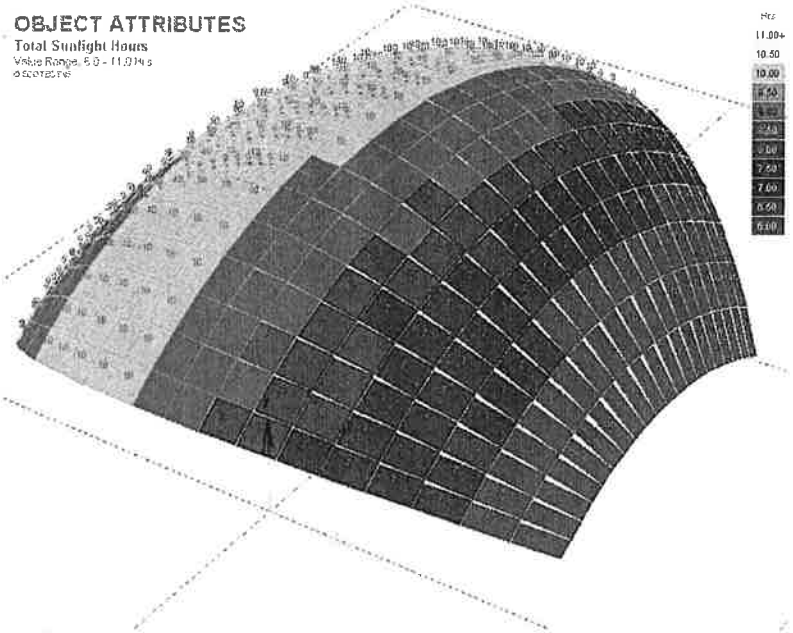




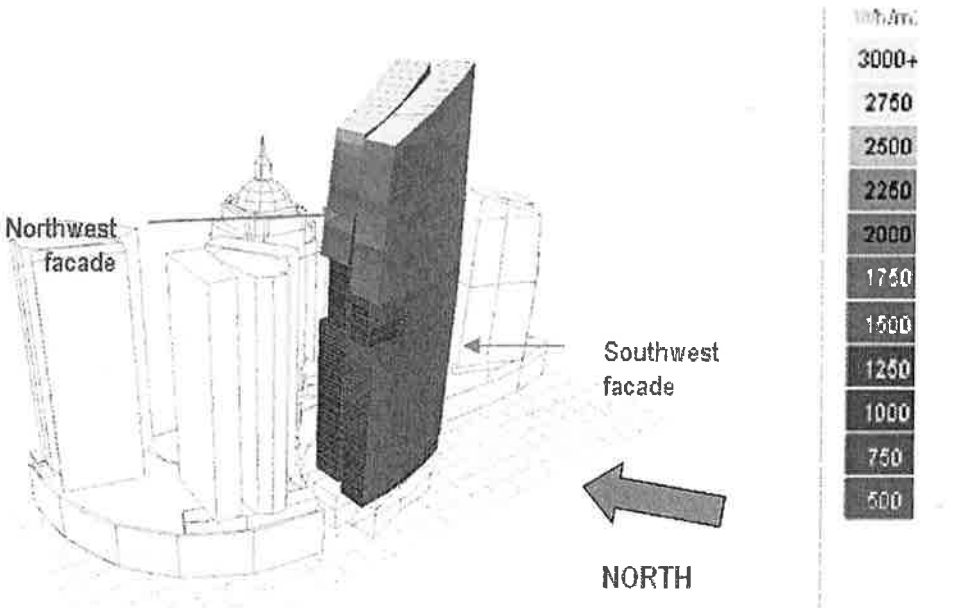




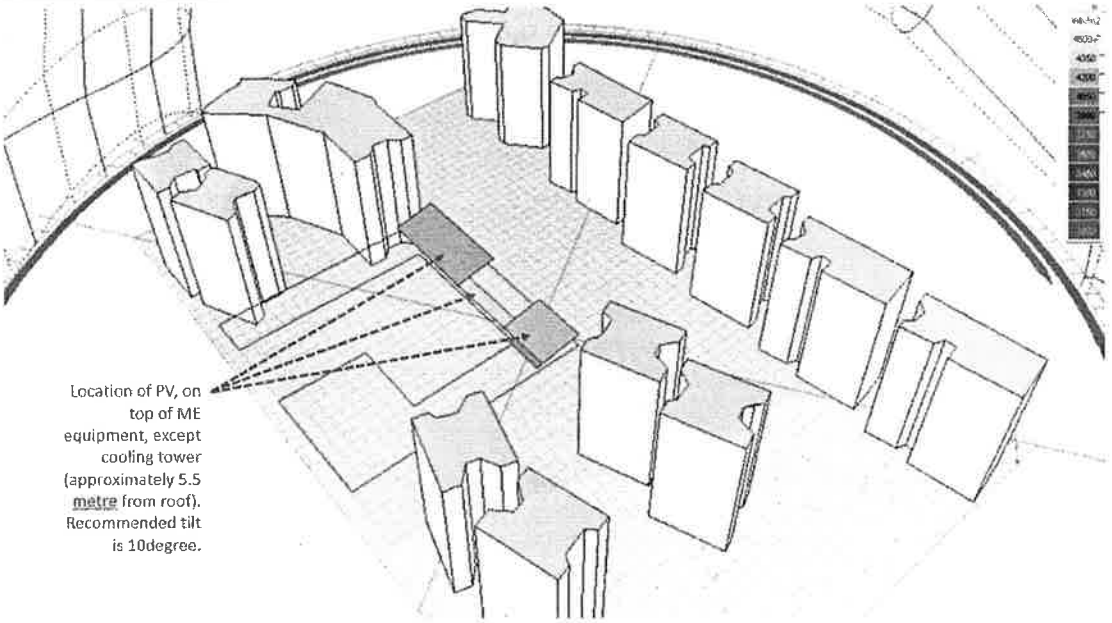
SOLAR


OBJECT ATTRIBUTES
Total Sunlight Hours
11.00+
10.50
10.00

SOLAR

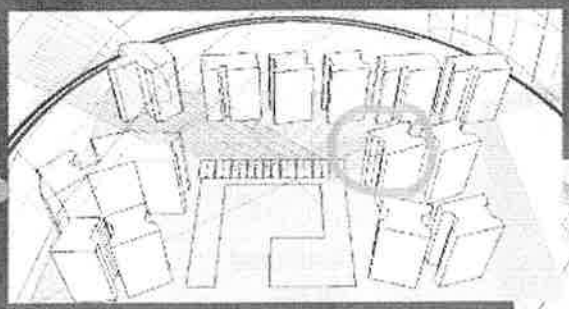

Northwest facade
Southwest facade
NORTH
3000+
2750
2500
2250
2000
1750
1500
1250
1000
750
500

SOLAR

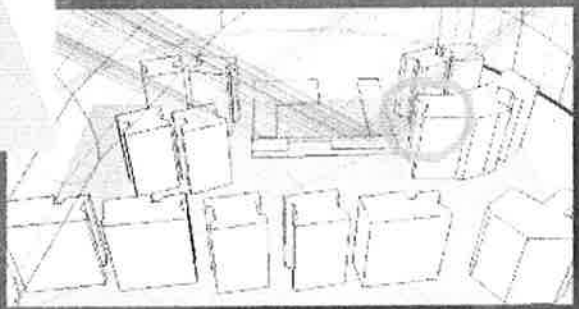


Location of PV, on top of ME equipment, except cooling tower (approximately 5.5 metre from roof). Recommended tilt is 10degree.

SOLAR

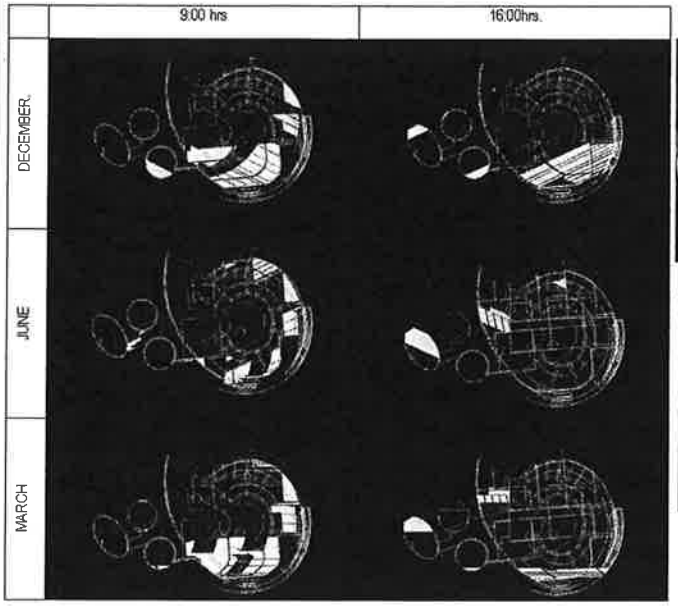


Panel inclination to SE and NW



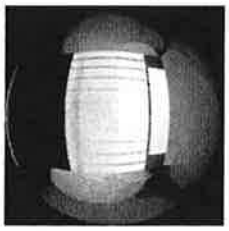
Panel inclination to NE

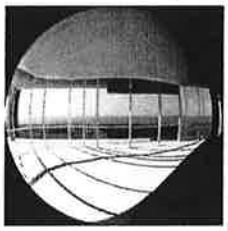
DAYLIGHT



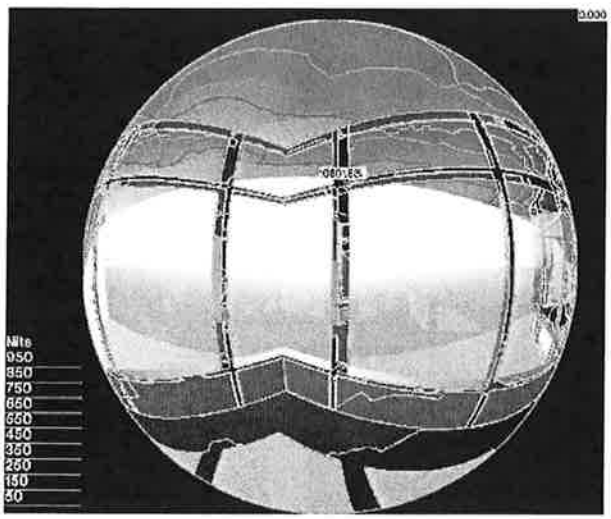

View 1 towards East from Bedroom


View 2 towards East from Living room

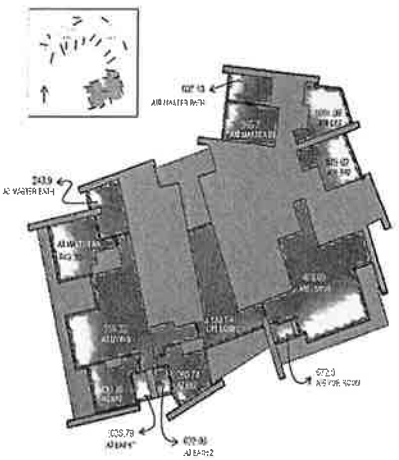

View 3 towards West from Kitchen

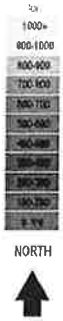

View 4 towards South from Living room

DAYLIGHT

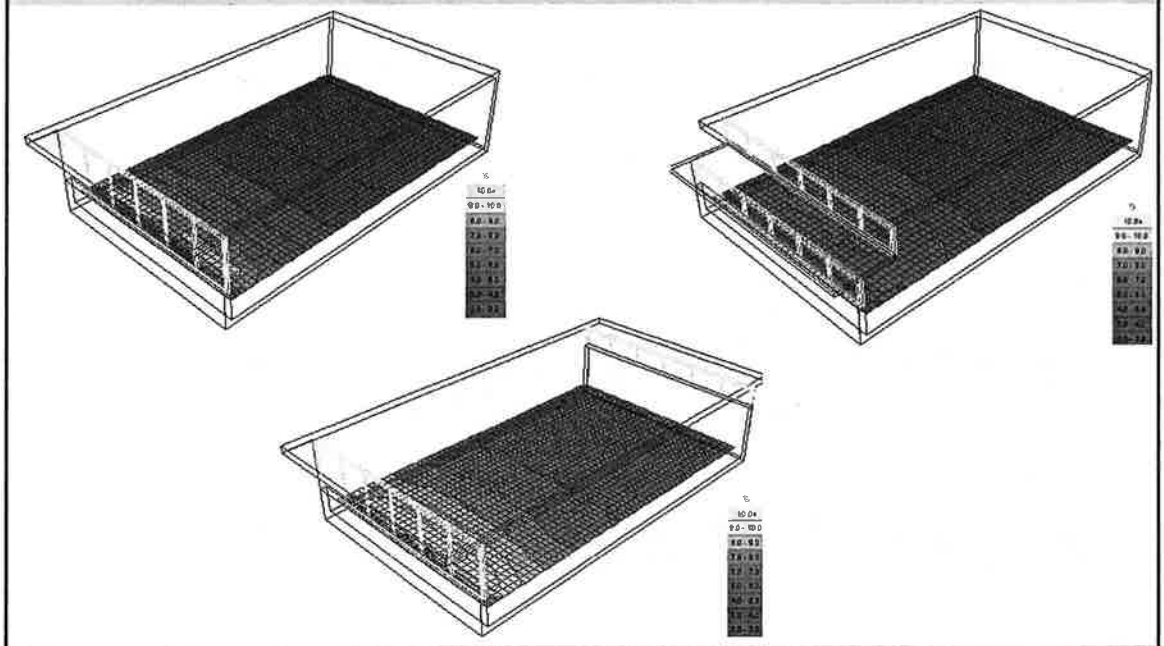


a. Tower A

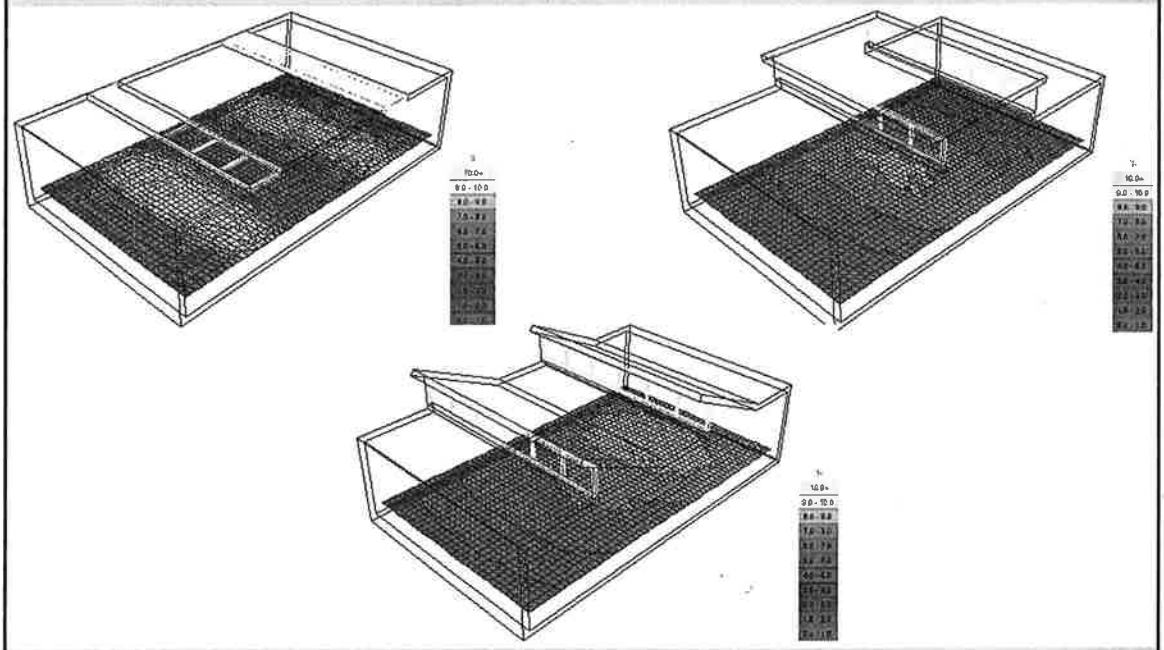




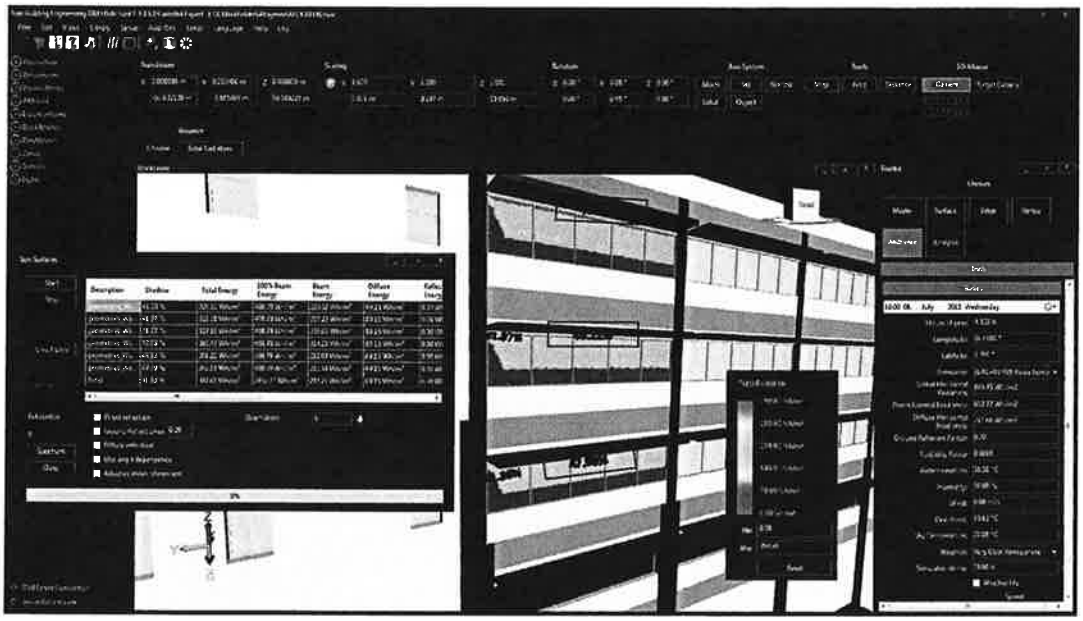
DAYLIGHT



DAYLIGHT



SHADING COEFFICIENT FOR ETTV



$$SC_y = \frac{G \times I_D + I_\theta}{I_T}$$

SHADING COEFFICIENT FOR ETTV

$$Percentage\ Difference = 100\% * \frac{0.6674 - 0.6623}{0.6674} = 0.77\%$$

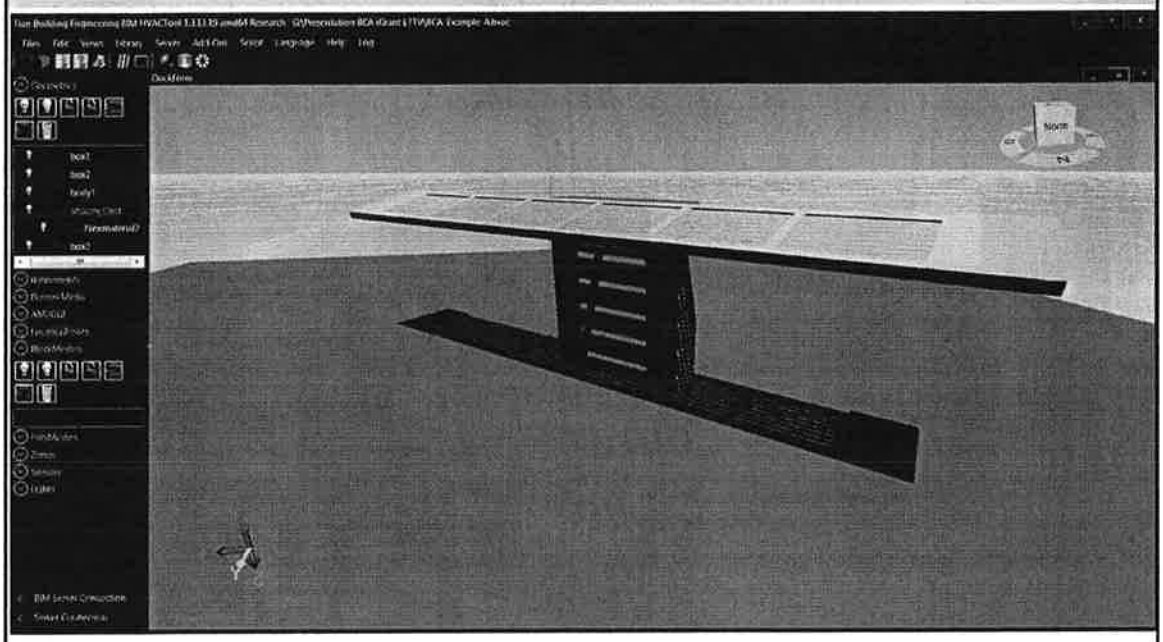
BCA RETV Guide 2008

North East	Mar-21					Jun-22					Sep-23					Dec-22				
Time	θ_1	(1-G)	I_D	I_θ	Q	θ_1	(1-G)	I_D	I_θ	Q	θ_1	(1-G)	I_D	I_θ	Q	θ_1	(1-G)	I_D	I_θ	Q
7.00 AM	6	0.18	94	23	100.08	6	0.18	159	33	163.38	6	0.18	94	23	100.08	15	0.26	52	20	50.48
8.00 AM	26	0.365	293	76	262.06	21	0.315	387	86	351.1	26	0.365	293	76	262.06	46	0.63	111	63	104.07
9.00 AM	44	0.6	336	106	240.4	34	0.455	462	116	367.79	44	0.6	336	106	240.4	67	1	87	83	83
10.00 AM	59	0.933	278	126	144.63	47	0.647	435	133	286.56	59	0.933	278	126	144.63	81	1	28	98	98
11.00 AM	72	1	154	136	136	58	0.902	345	141	174.81	72	1	154	136	136	-	1	0	109	109
12.00 PM	83	1	31	136	136	68	1	216	141	141	83	1	31	136	136	-	1	0	116	116
1.00 PM	-	1	0	133	133	78	1	98	110	110	-	1	0	133	133	-	1	0	116	116
2.00 PM	-	1	0	123	123	88	1	29	116	116	-	1	0	123	123	-	1	0	108	108
3.00 PM	-	1	0	104	104	-	1	0	93	93	-	1	0	104	104	-	1	0	93	93
4.00 PM	-	1	0	85	85	-	1	0	76	76	-	1	0	85	85	-	1	0	73	73
5.00 PM	-	1	0	60	60	-	1	0	53	53	-	1	0	60	60	-	1	0	50	50
6.00 PM	-	1	0	28	28	-	1	0	22	22	-	1	0	28	28	-	1	0	20	20
$\Sigma Q = \Sigma(\theta_1 \times I_D + I_\theta)$				1552.161					1955.63					1552.161					1028.55	6088.5
$\Sigma I_T = \Sigma(I_D + I_\theta)$				2322					3252					2322					1227	9123
SC (Day)				0.668458656					0.601362239					0.668458656					0.838264059	
Effective SC (Annual) = $(\Sigma(Q)_{Mar-21}) / (\Sigma(I_T)_{Mar-21})$																				0.6674

BEM HVACTool

North East	Mar-21					Jun-22					Sep-23					Dec-22				
Time	θ_1	(1-G)	I_D	I_θ	Q	θ_1	(1-G)	I_D	I_θ	Q	θ_1	(1-G)	I_D	I_θ	Q	θ_1	(1-G)	I_D	I_θ	Q
7.00 AM	6	1	0	0	0	6	1	0	0	0	6	0.9178	94	23	30.727	15	1	0	0	0
8.00 AM	26	0.3864	293	76	255.78	21	0.3667	387	86	331.09	26	0.4225	293	76	245.21	46	0.5156	111	63	116.77
9.00 AM	44	0.557	336	106	254.85	34	0.475	462	116	358.55	44	0.6063	336	106	238.28	67	0.9114	87	83	90.708
10.00 AM	59	0.7933	278	126	183.46	47	0.6091	435	133	303.04	59	0.8667	278	126	162.5	81	1	28	98	98
11.00 AM	72	1	154	136	136	58	0.79	345	141	213.45	72	1	154	136	136	-	1	0	109	109
12.00 PM	83	1	31	136	136	68	1	216	141	141	83	1	31	136	136	-	1	0	116	116
1.00 PM	-	1	0	133	133	78	1	98	110	110	-	1	0	133	133	-	1	0	116	116
2.00 PM	-	1	0	123	123	88	1	29	116	116	-	1	0	123	123	-	1	0	108	108
3.00 PM	-	1	0	104	104	-	1	0	93	93	-	1	0	104	104	-	1	0	93	93
4.00 PM	-	1	0	85	85	-	1	0	76	76	-	1	0	85	85	-	1	0	73	73
5.00 PM	-	1	0	60	60	-	1	0	53	53	-	1	0	60	60	-	1	0	50	50
6.00 PM	-	1	0	28	28	-	1	0	22	22	-	1	0	28	28	-	1	0	20	20
$\Sigma Q = \Sigma(G \times I_D + I_\theta)$				1499.0954					1818.1286					1401.7169					990.4766	5709.4
$\Sigma I_T = \Sigma(I_D + I_\theta)$				2205					3060					2322					1155	8742
SC (Day)				0.679861859					0.594159673					0.630121835					0.857555498	
Effective SC (Annual) = $(\Sigma(Q)_{Mar-21}) / (\Sigma(I_T)_{Mar-21})$																				0.6623

SHADING COEFFICIENT FOR ETTV

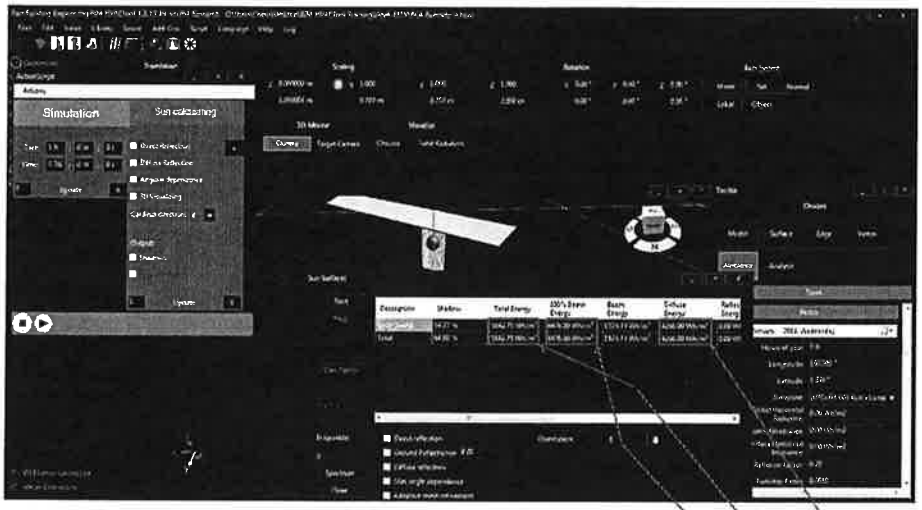


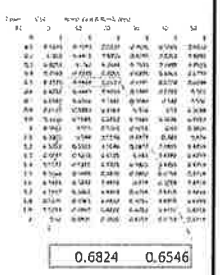
SHADING COEFFICIENT FOR ETTV



SHADING COEFFICIENT FOR ETTV

Automatic SC2 Calculation for March 21st, June 22nd, September 23rd, and December 22nd

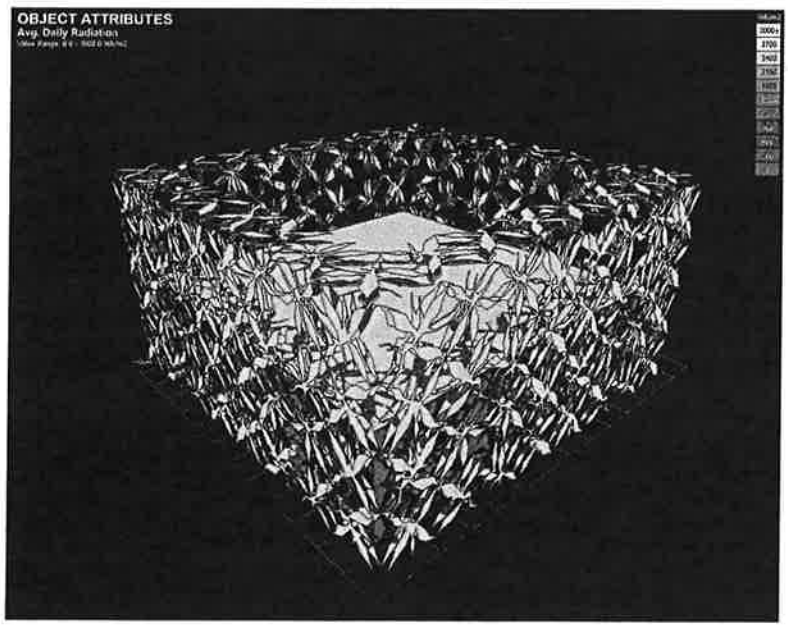




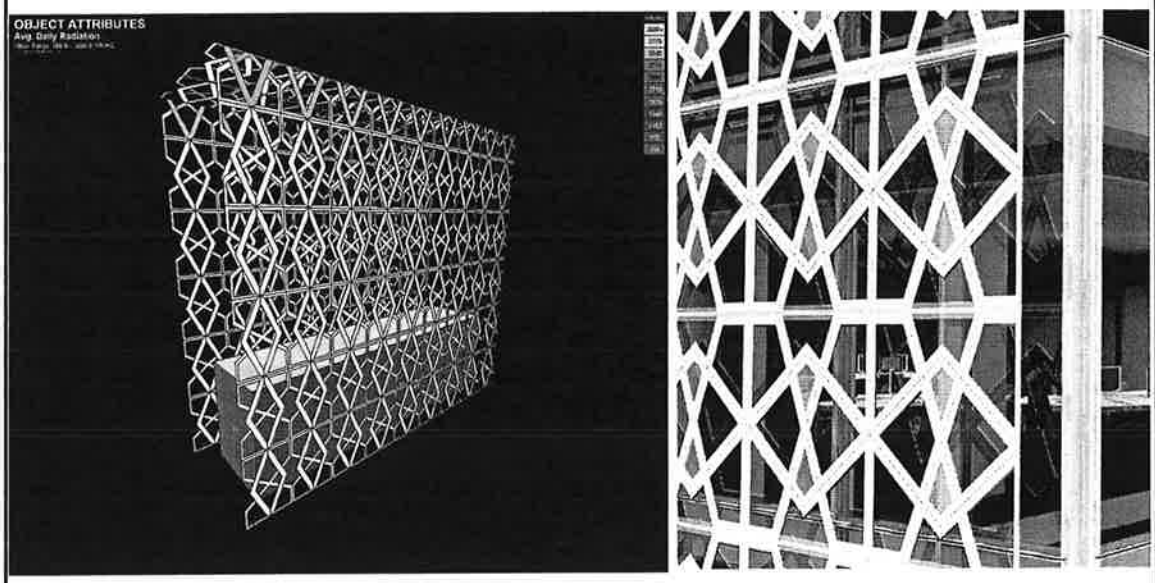
SC2 from Manual Interpolation From Table C14
= (0.6824 + 0.6546)/2
= 0.6685

$$Annual\ SC2 = \frac{Total\ Energy}{100\%\ Beam\ Energy + Diffuse\ Energy} = \frac{5842.75}{4476 + 4266} = 0.6684$$

SHADING COEFFICIENT FOR ETTV



SHADING COEFFICIENT FOR ETTV



Shortcuts

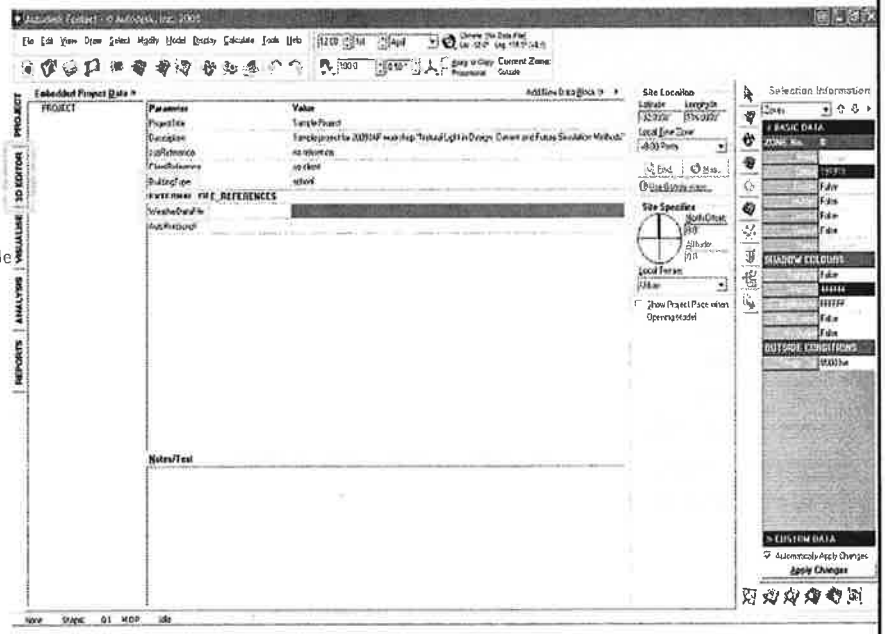
SHORTCUTS

Left Click – Select
Right Click – Rotate
Scroll Wheel – Zoom
Hold Scroll Wheel – Pan
F2 – Repeat Last
F3 or Double Click Nodes On/Off
F4 – Isolate selected Zone
F5 – Plan
F6 – Side
F7 – Front
F8 – Axonometric
Insert – Insert Child Object(Door, Window, Void)
Ctrl – Hold to Move Cursor in Z direction instead of X, Y

To Generate Model

TO GENERATE MODEL

1. Open up Ecotect
2. Create a Project Title
3. Choose your building type
4. Define location
5. Define North angel
6. Choose your Weather Data File
7. Navigate to 3D EDITOR

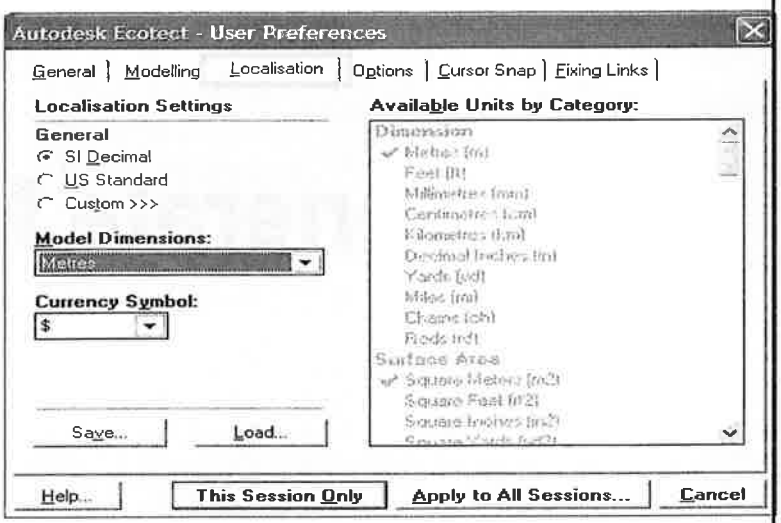


TO GENERATE MODEL

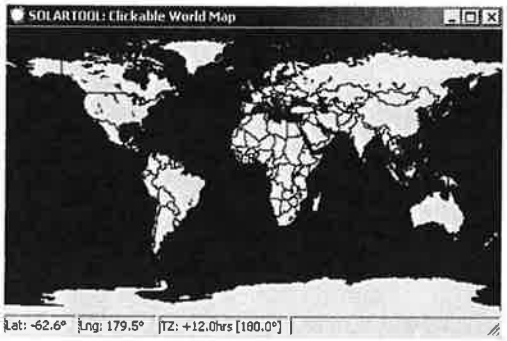
1) Go to User Preference

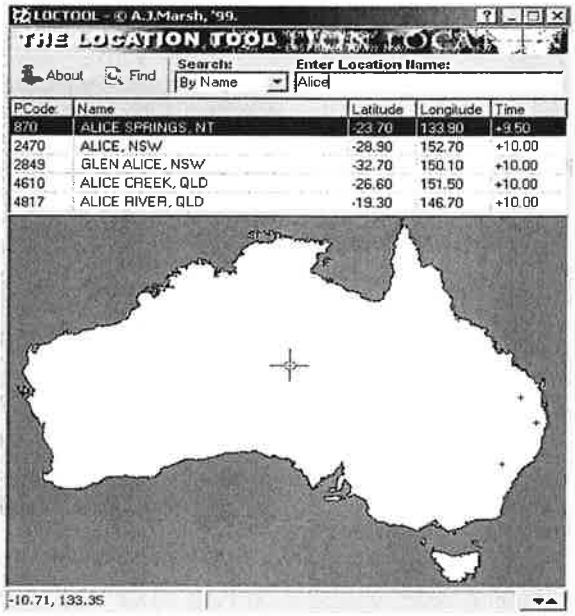


On the **Localisation** tab to edit units for the model.



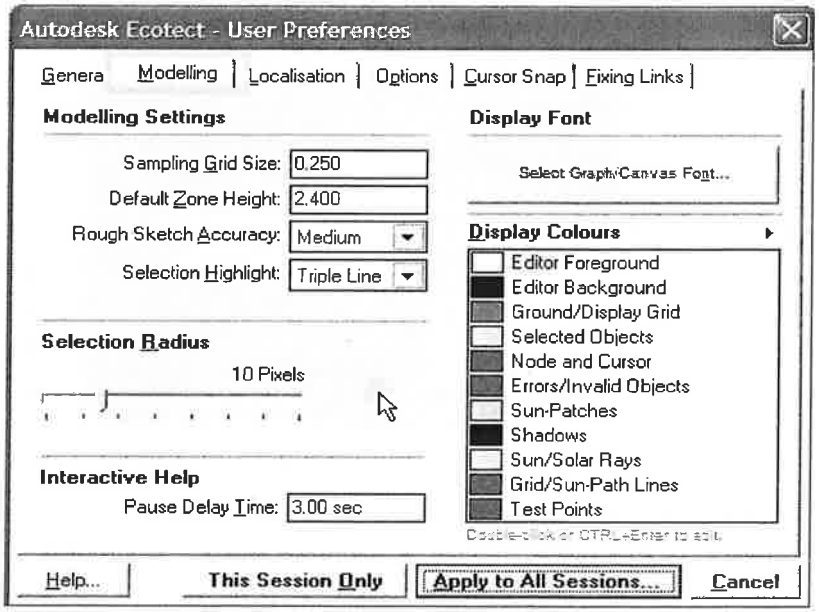
TO GENERATE MODEL





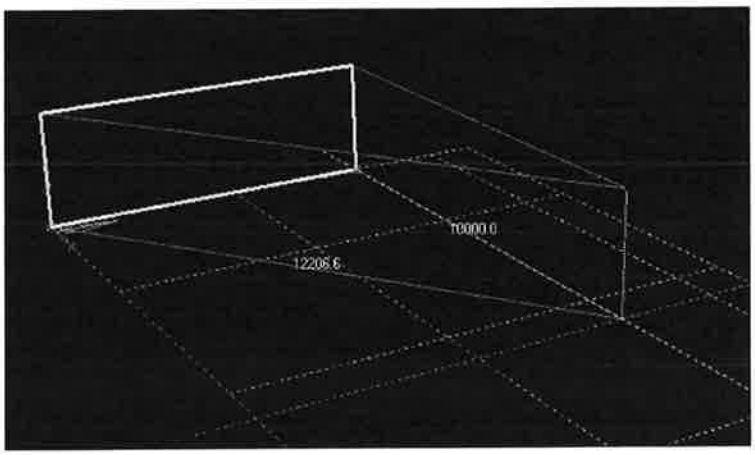
TO GENERATE MODEL

On the **Modeling** tab to edits **Default Zone Height** (Ceiling Height)



TO GENERATE MODEL

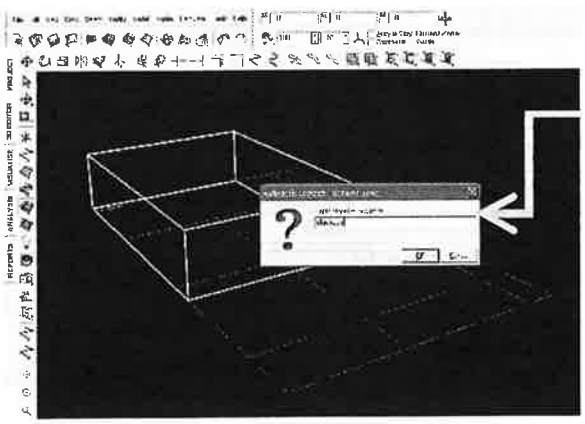
Click on the ground to place each corner



TO GENERATE MODEL



Click to create a **ZONE**



Once done press **ESC** and will see this pop up asking you to name your zone.

VISUALISE

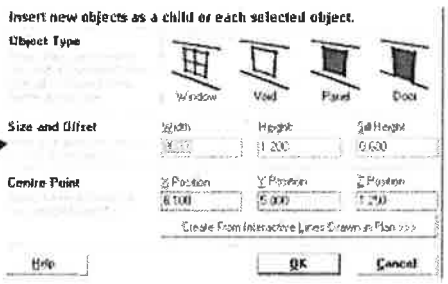
Once done can click on **VISUALISE** to see your 3D model comes to life.

TO ADD WINDOW

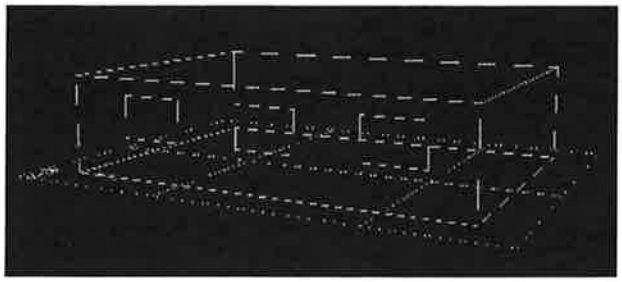


1) Go to toolbar click on the highlighted icon or press **Insert**

2) Next this will pop up you can create a window on your existing model



3) You can create multiple exact window by clicking on it next by pressing Ctrl + C then Ctrl + V it will paste the window.



4) Click ✥ to move your window to your liking.

85
85
35

TO GENERATE MODEL

TASK 1:

Generate model of buildings as shown in the example

POINT OBJECT

1. POINTS are mainly used for geometric testing purposes, such as the focus of a SunPath Diagram or as a lighting sensor point.

2. POINTS can be assigned a radius as part of their material properties to form a sphere. ECOTECT does not use the radius other than when exporting it to VRML, RADIANCE of POVRay.
To hide or show the POINT radius in the model, use the Element Detail items in the Display menu.

3. When positioning a POINT object or node the Control key can be used to move in the Z axis. Releasing the Control key sets the new POINT in the Z plane, allowing movement again in the X and Y axis.

POINT OBJECT

Select the Point tool, and in the 3D Editor window, create a point The created point appears as a small 3D crosshair at the insertion location, and remains selected after it has been created.

To move the point to the vertical position of 3.6m above the surface of the pitch, use the Z key on the keyboard to nudge the point in a positive direction along the z axis.

To see how far the selected point has been nudged, look down at the bar located below the 3D Editor window you
will see the distance the point has from its original location. If you move the point too far, hold down Shift and press the Z key to move the point in the negative direction along the z axis.

POINT OBJECT

To alter the nudge increment distance, go to the *Grid Snap* field located in the *Snap* toolbar located above the 3D Editor window.

Alternative method for moving a POINT

1. Select the point, and then activate the *Move* tool. The *Zone/Cursor* toolbar above changes into 3 input boxes for specifying X, Y and Z coordinates.

2. If you don't see the input boxes for X, Y and Z coordinates, this may be because the *Zone/Cursor* toolbar has been switch to *Polar* coordinate mode. Click the *Cartesian/Polar coordinates* button to toggle between these two different coordinate input modes.

POINT OBJECT

Checking the location of a POINT

1. To confirm if the point has been positioned correctly, select the *Measure* tool from the toolbar. Click on the Point (the cursor should snap onto it), and then hover the move over the nearest corner of the stadium pitch (ie. the location where the point was first inserted).
In the *Zone/Cursor* toolbar above, you will see displayed the X, Y and Z distances for the point in relation to the corner of the stadium
pitch.

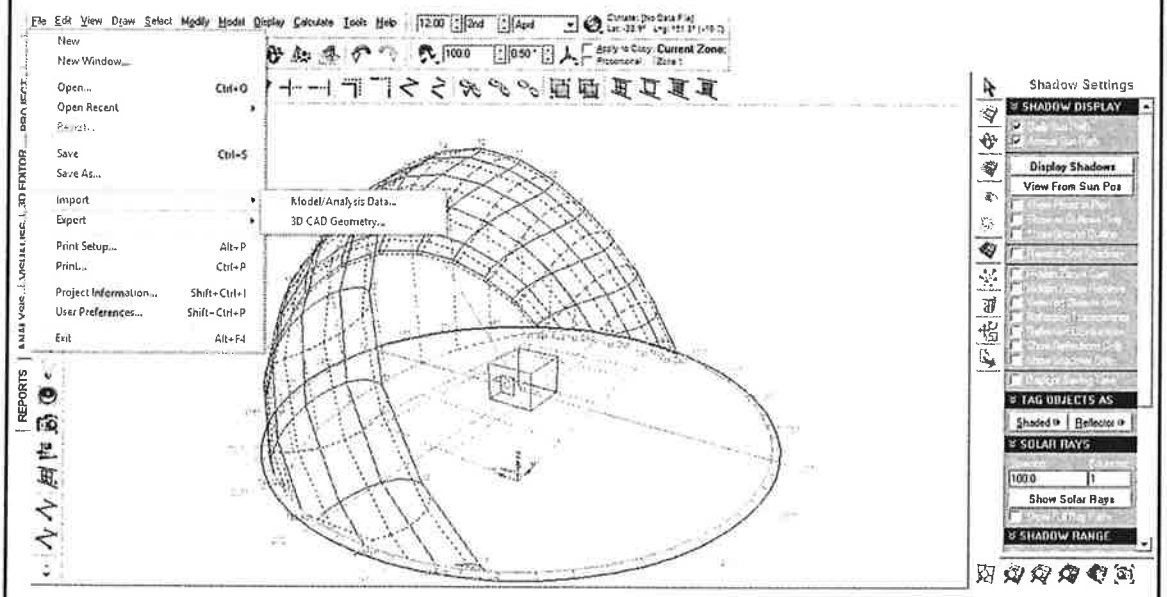
POINT OBJECT

TASK 2:

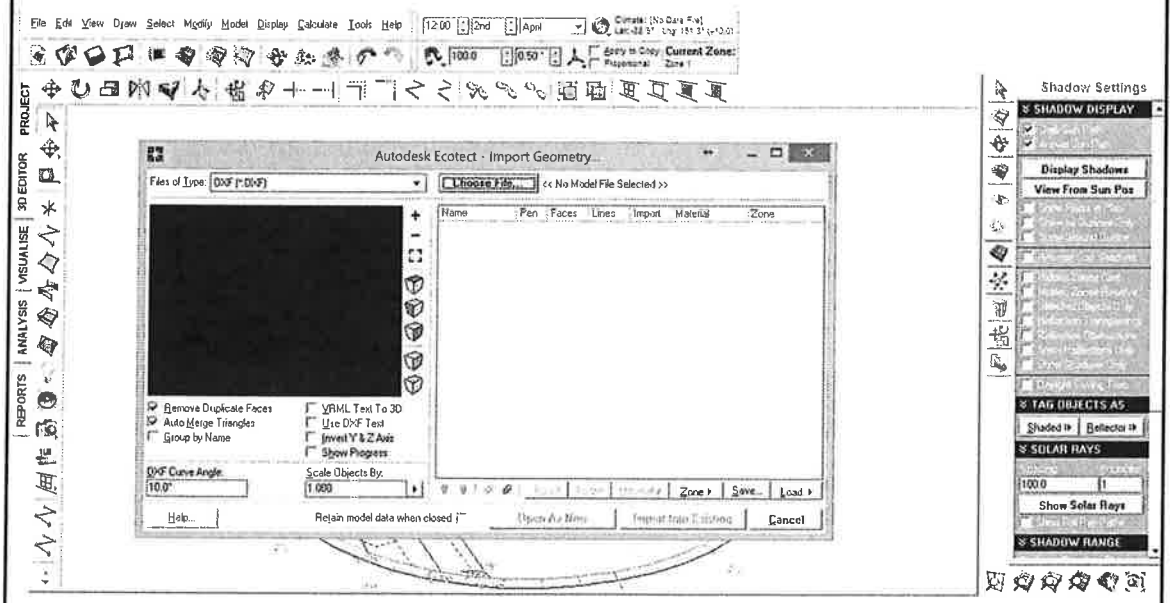
Create a point object at the center of the buildings created in task 1

Import Model

IMPORT MODEL



IMPORT MODEL



IMPORT MODEL

DXF files are good for 2D geometry and only very simple solids, not full 3D or ACIS geometry.

3DS files are good for 3D geometry but not at all for 2D geometry.

ECOTECT locates objects using real world coordinates. If geometry that is being imported is positioned using very large negative coordinates, ECOTECT will have trouble rotating/viewing the geometry. That is, rightclicking and dragging to rotate the view in one direction may result in the view moving in the opposite direction.

In addition, very large coordinate values for the location of geometry may result in ECOTECT being unable to fit the grid canvas correctly. This will often result in what looks like very tiny objects way off in the distance and an oversized grid.
To avoid these issues, it is recommended that you locate the geometry as close to 0,0,0 as is possible.

IMPORT MODEL

It is important to remember that the DXF & 3DS file formats can be written differently by different CAD programs, therefore different results may occur depending on the program and it's export settings. If the desired result is not achieved in ECOTECT it is recommended that you attempt all the options available when exporting from your CAD package, as significantly different results can be achieved with different settings.

IMPORT MODEL

2D Import DXF Files

ECOTECT will not read blocked or referenced objects. Therefore it is important that you explode any block or group objects before exporting as a DXF.
ECOTECT will also not understand very well change in UCS made to create objects. Objects created with an altered UCS may import out of alignment and orientation.
If exporting from AutoCAD, type use dxf entered at the command line and in the SaveAs DXF dialog box, choose the Options button, then the DXF Options tab and make sure the Select Objects checkbox is ticked. It is important to only export the drawing objects, otherwise the DXF file will include all the linestyle tables and redundant layers etc.

IMPORT MODEL

1. To import a 3DS file, choose the Import item from the File menu.
Open the 3D Model.3ds file in the Tutorial Files directory in the ECOTECT installation directory. You will need to make sure the Files of Type list has 3D Studio Files chosen.

2. There are no options for 3DS file import, therefore the objects should be displayed in the drawing canvas immediately after loading.

3. Notice that the geometry is triangulated.
This is characteristic of a 3DS file, and occurs when the geometry is exported by the CAD program, not by ECOTECT when it imports the geometry.

4. If you don't want the geometry to be triangulated, select the objects just loaded and choose the Merge Coincident Triangles item from the Modify menu.
This function may not work with all triangles and can occasionally get a bit confused with some geometry, like the base plane in the example model shown above. In these instances it may be appropriate to manually correct some of the resulting geometry.

IMPORT MODEL

5. You may also notice that the imported geometry is also grouped together. This is because most geometry from a 3DS file is quite complex, and it was thought that grouping the geometry on import would make it easier to handle.

To ungroup the objects, hit Shift+Ctrl+U or choose the Ungroup item from the Edit menu.

IMPORT MODEL

TASK 3:

Create new file
Import dxf file (sample given) into ecotect.

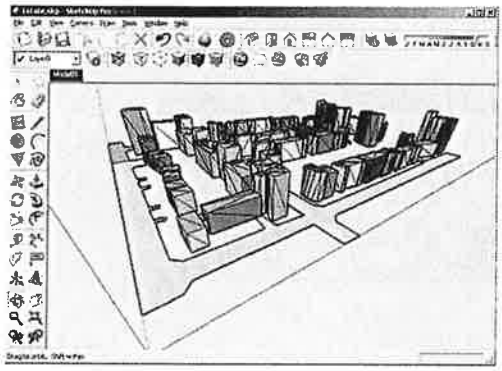
IMPORT MODEL

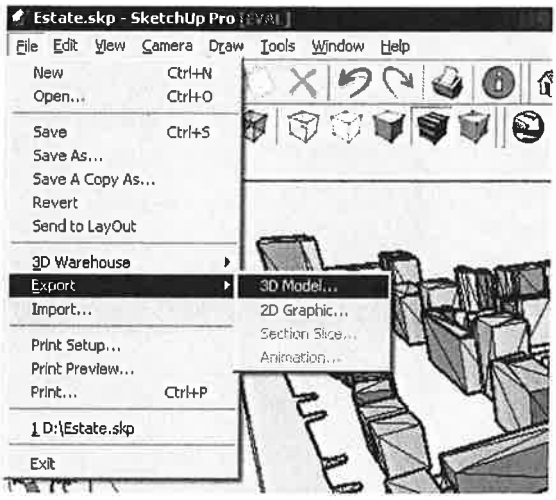
ECOTECT allows you to run analyses on models imported from SketchUp. If you use the right format (explained below), ECOTECT will maintain all your SketchUp material assignments, allowing you to autoconvert them to elements in its own library.

1. *open SketchUp and load the model* you wish to convert.

2. Choose the Export » 3D Model... item in the File menu. *First load your model in SketchUp.*

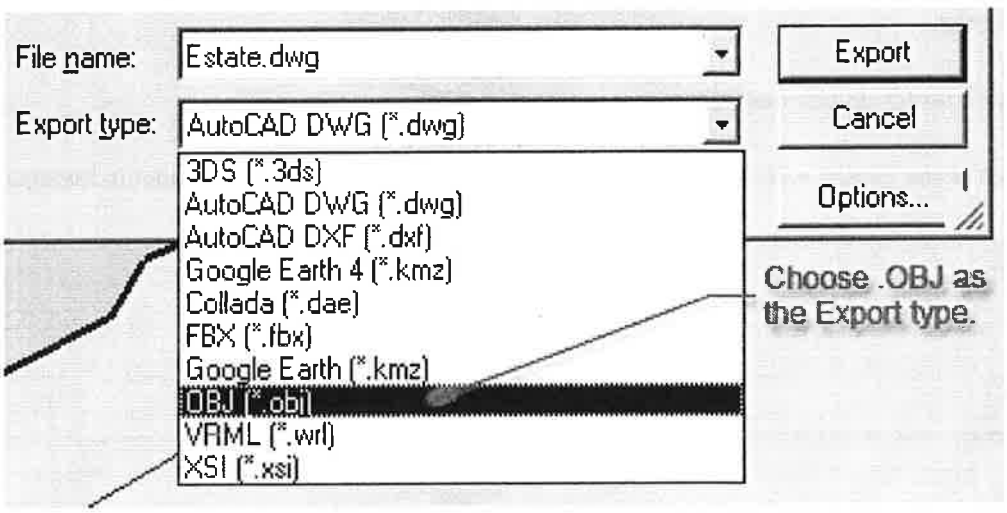
IMPORT MODEL





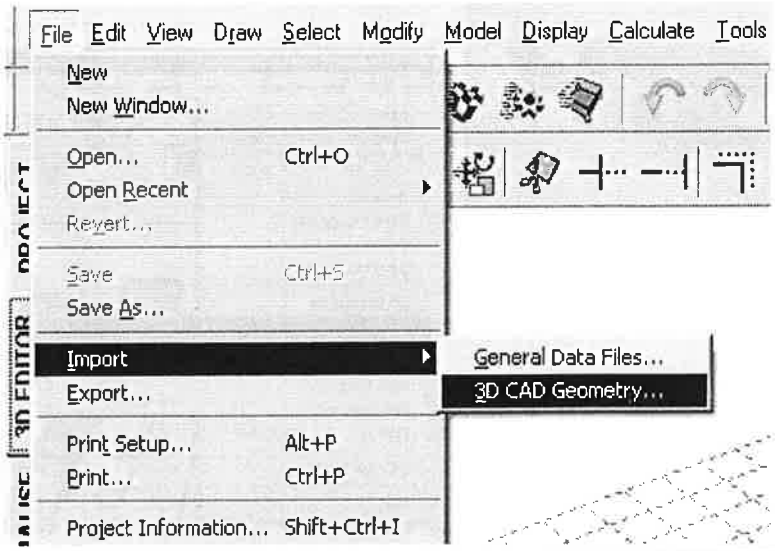
IMPORT MODEL

3. When the Windows *File Save As...* dialog appears, make sure you select the OBJ (*.obj) item in the *Export type*.



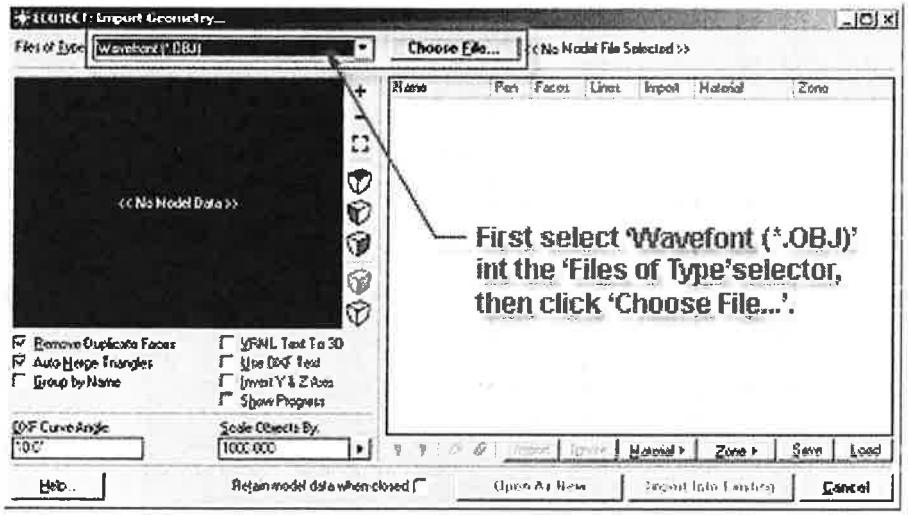
IMPORT MODEL

4. Open up ECOTECT and select the Import » 3D CAD Geometry... item in the File menu. *Export model to disk.*



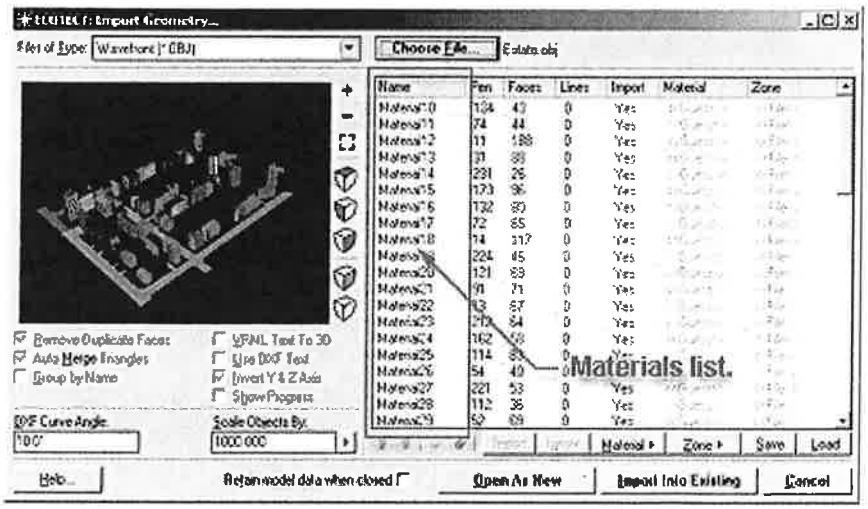
IMPORT MODEL

5. Once the *Import Geometry...* dialog is displayed, choose the Wavefront (*.obj) item in the *Files of Type:* selector, then click the Choose File... button to locate the .OBJ file you just saved from SketchUp.

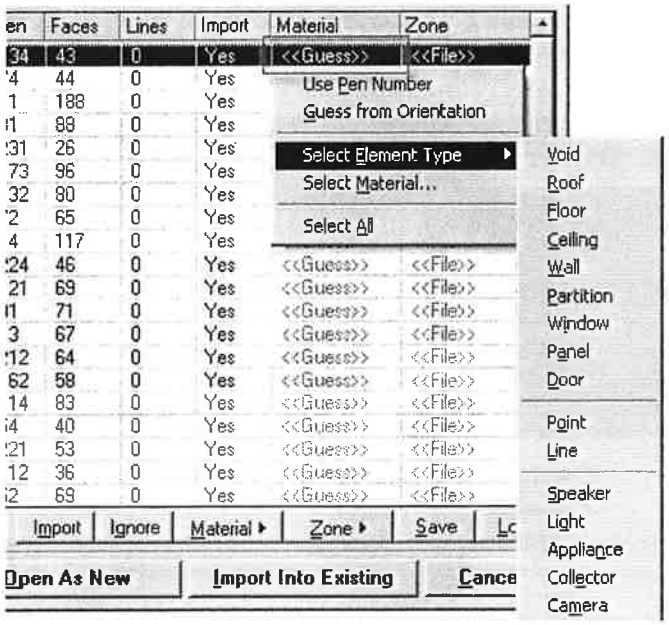


IMPORT MODEL

6. You should now see a preview of the model on the left and a list of all the materials assigned to objects within it on the right. *Prepare to import the newly created file in ECOTECT. Select the right format and locate newly created file.*

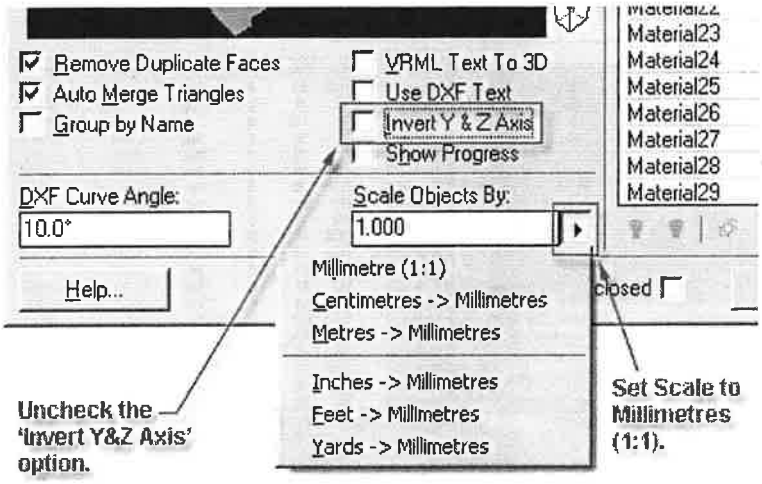


IMPORT MODEL



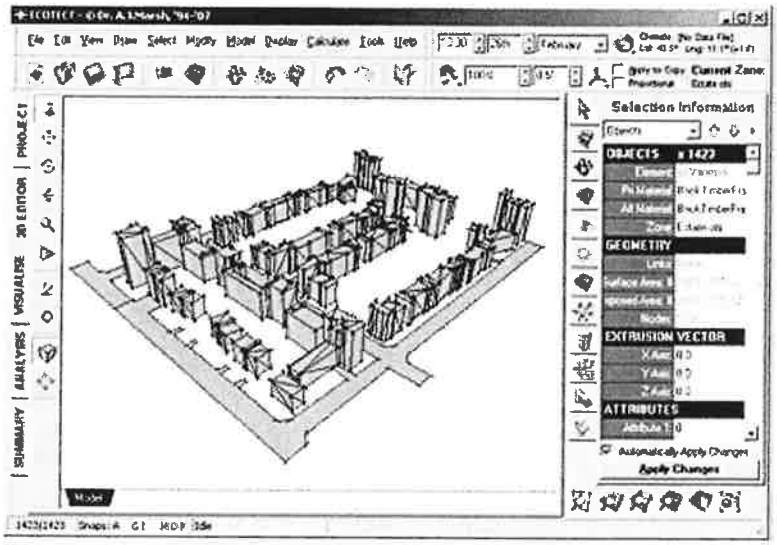
IMPORT MODEL

7. Next, make sure you '*Uncheck* the Invert Y&Z Axis option and set the appropriate scale. In this case, the model was originally drawn in millimetres, so we want to select Millimetre (1:1) in the scale menu. The scale value should now show '1.000'.



IMPORT MODEL

7. Finally, click **Open as new**



IMPORT MODEL

TASK 4:

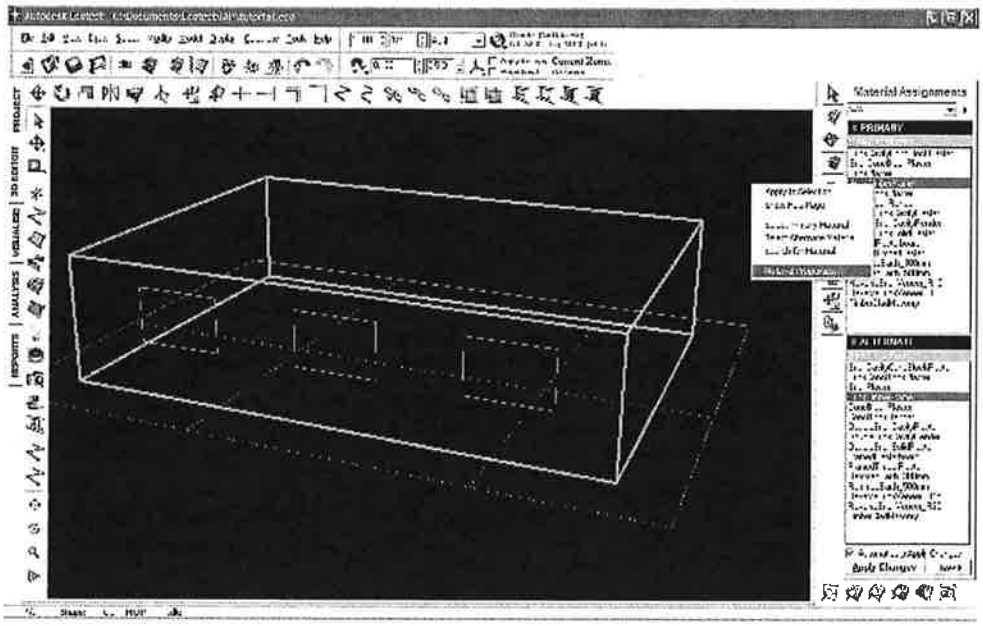
Create new file
Import sketch up file (sample given) into ecotect.

Material

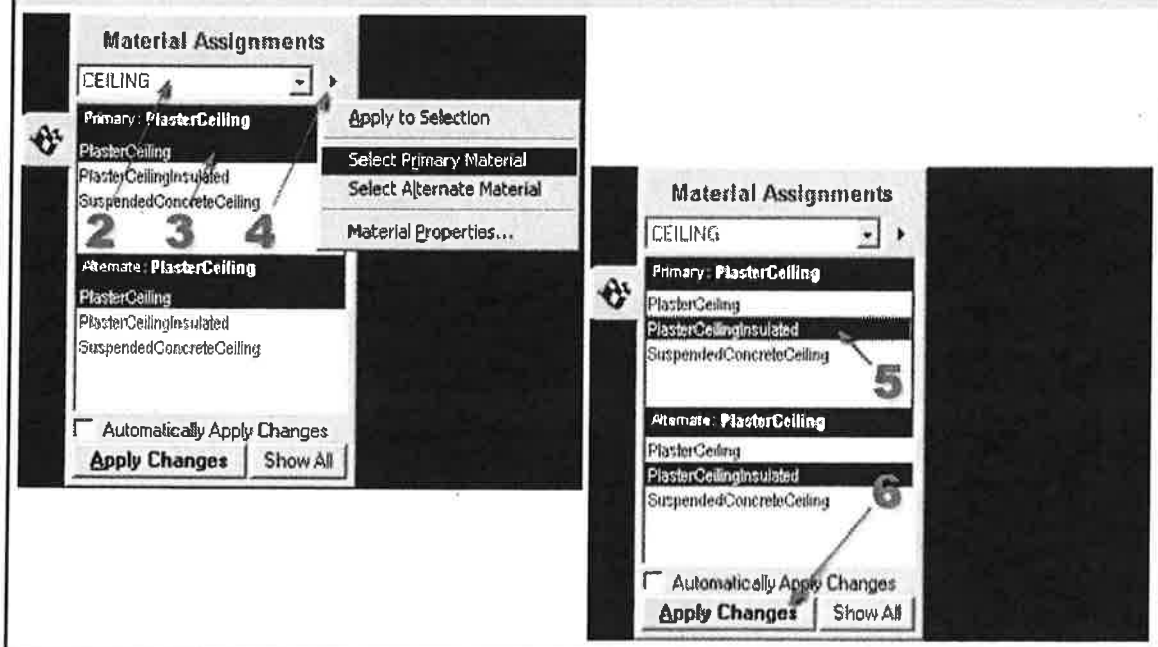
ADD MATERIAL

1) Click on  to open material library it is located at right toolbar
2) Right click on any material, click **Select Primary Material**. The model will be selected with this material.
3) Right click on any material, click Material Properties. A box will pop up

ADD MATERIAL



ADD MATERIAL



ADD MATERIAL

TASK 5:

Open the file created in task 2
Apply material for each element.

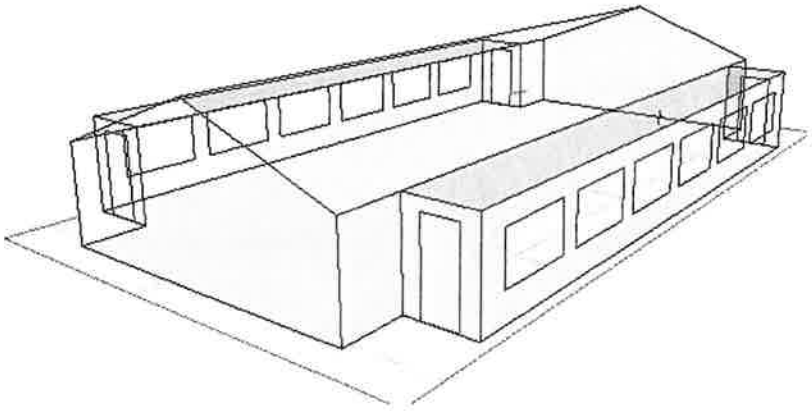
Visulaization

VISUALIZATION

1) Go to Visualize

2) Go to Visualization Setting and check **Make Transparent**

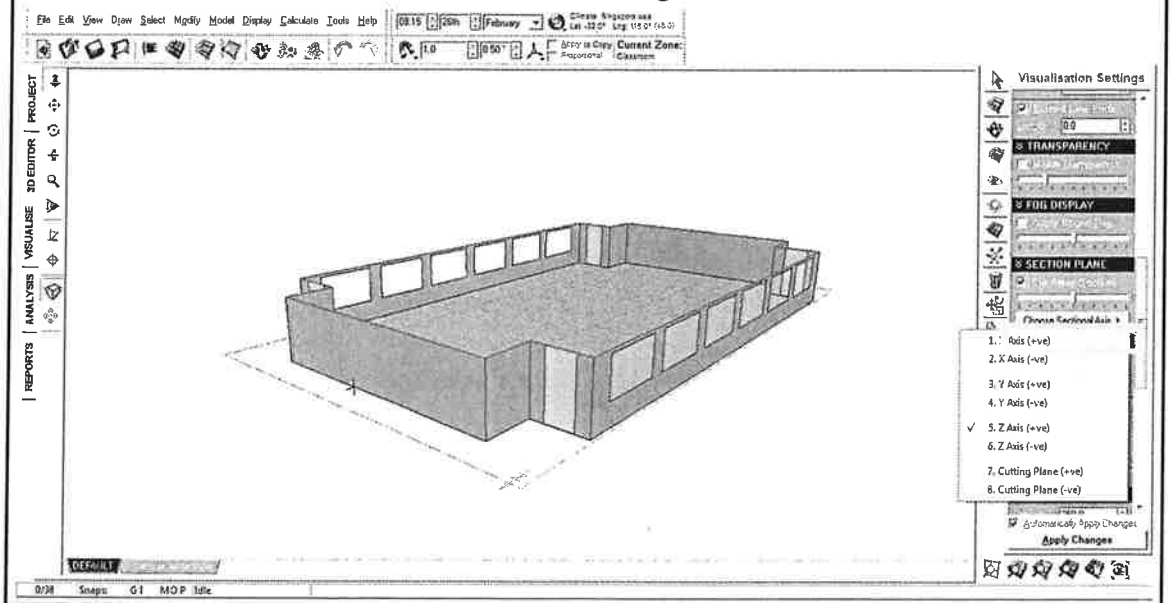
3) Control the transparency of the building by dragging the slider.





VISUALIZATION

Cut Away Section can be found at Visualization Setting to create a Section Plane



VISUALIZATION

1. Click on the Visualise display tab, followed by the Visualisation Settings panel tab. This displays all of the controls that can be used to adjust the Visualise display settings.

2. The *Basic Settings* section of the panel allows you to adjust the foreground and background colour, as well as use predefined display styles.

Click on the Foreground or Background buttons to change the display colour, or the Default OpenGL Sets button to choose from one of a number of default display styles.

Activate the Visualise display tab and then click on the Visualisation Settings panel.

VISUALIZATION

Surface Display

1. The *Surface Display* section can be used to determine how surfaces in the model are displayed. Select/Deselect the Display Surfaces checkbox to turn on/off the surface display, and then select from one of the four options to set how the surface is displayed.

2. The Disable Depth Buffer and Front-Face Culling checkboxes provide advanced surface display options. *Use the Basic Settings to change the foreground or background colour, or to select one of the default OpenGL styles.*

Visualise display configured with dark background and the pencil sketch display style.

VISUALIZATION

Outline Display

1. The *Outline Display* section can be used to control how edges are displayed in the model. Select/Deselect the Display Outlines checkbox to turn on/off the outline display, and then select from one of the four options to set how the edges is displayed.

2. The Scale Lines to View and Anti-Alias Lines checkboxes provide advanced edge display options.

3. Use the Outline Width field to set the thickness of the edge lines.

VISUALIZATION

Sketchiness

The *Sketchiness* section can be used to simulate the appearance of sketchy, handdrawn lines in the model.

1. Select the Sketchy Lines checkbox to display the model with sketchy lines.

2. The Jitter and Line Multiplier fields can be used to manipulate the sketchiness of the lines. Click the ReSeed

Jitter Function

to reset the line sketchiness.

Surfaces turned on, displayed by zone colour.

Edges turned on, displayed using foreground colour with an outline thickness of 2.0.

3. Segment Lines and Extend End Lines provide additional sketchiness controls.

VISUALIZATION

Transparency
1. The Make Transparent checkbox allows surfaces in the model to be displayed with transparency. Use the slider to adjust the level of
transparency applied.

Fog Display
1. Select the Apply Backgnd Fog checkbox to turn on Fog Display; this simulates the appearance of depth in the image by greying out the background of the model view. Use the slider to adjust the amount of fog displayed.
Sketchy Lines turned on, with Jitter set to 200 and Line Multiplier set to 6. Transparent surfaces turned on.

VISUALIZATION

Camera Views
1. The *Camera Views* section allows you to manually adjust camera settings. The Pnt Size spin box can be used to adjust the display of POINT objects in relation to incremental adjustments of the camera view.
Increase this value for large, urbanscale models, and decrease this value for small models and interior
views.

2. The *Near Clip* and *Far Clip* spin boxes can be used to adjust the minimum and maximum clipping planes, which determines the visibility of objects in relation to the camera position.

3. For more detailed information on all of the settings available under the *Camera Views* section, please refer to the ECOTECT Help file.

VISUALIZATION

Interactivity

1. The Full Interactive Redraw checkbox forces ECOTECT to redraw the model when adjusting the model view (eg. zooming, panning, orbiting), rather than reverting to a wireframe display.
2. The AutoOptimise Depth checkbox, if selected, automatically calculates the near and far clipping planes, to ensure that the perspective view of the model is correct.
3. Click the Straighten Current View button to align the view of the model so that all vertical edges are parallel.

Shading Effects are used to control the display of shadows and shading in the model. Original View.

4. For more detailed information on all of the settings available under the *Interactivity* section, please refer to the ECOTECT Help file.

VISUALIZATION

Display Default

1. To save the current display settings as the default values to use, click the Save Default Settings button. A dialogue box prompt will appear confirming that you wish to proceed.
2. If the Visualise display window becomes corrupted, or the various visualization settings controls do not respond, click the Reset OpenGL Display to reinitialize the display settings.

VISUALIZATION

TASK 6:

Show the model created in Task 2 :

1. Section crossing through x direction at the center of the building
2. Section crossing through y direction at the center of the building
3. Section crossing through z direction at the center of the building

Shadow

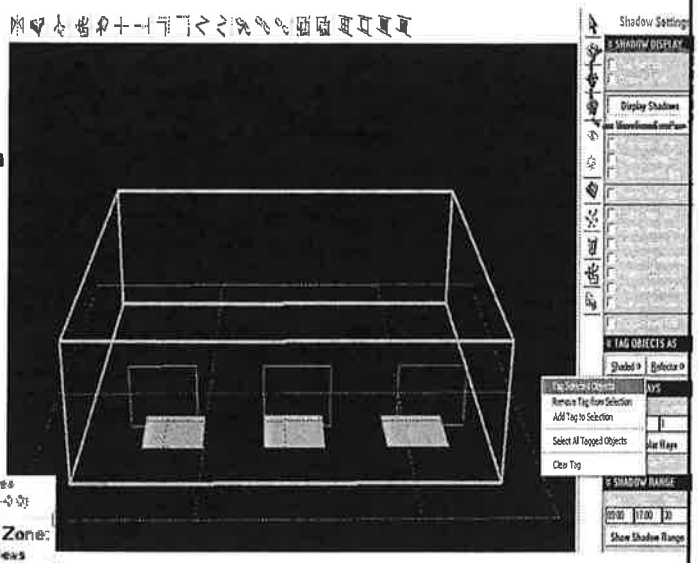
SHADOW

1) Go to **Shadow Settings** located at right hand side

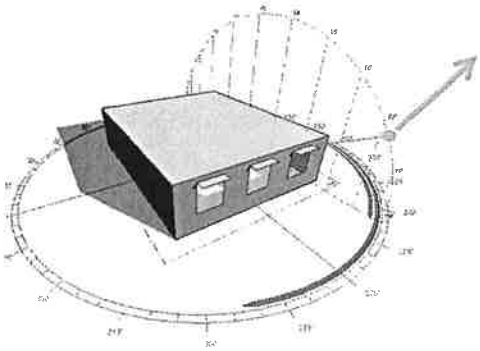
2) Press **Display Shadow** and **Daily Sun Path** and/or **Annual Sun Path**

Choose your timing throughout the year in order to see how the shadow and the sun path look like.

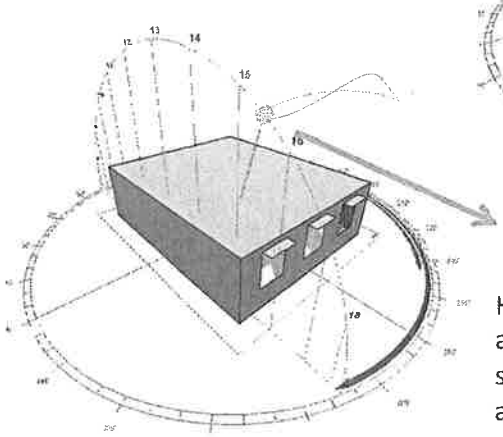




SHADOW

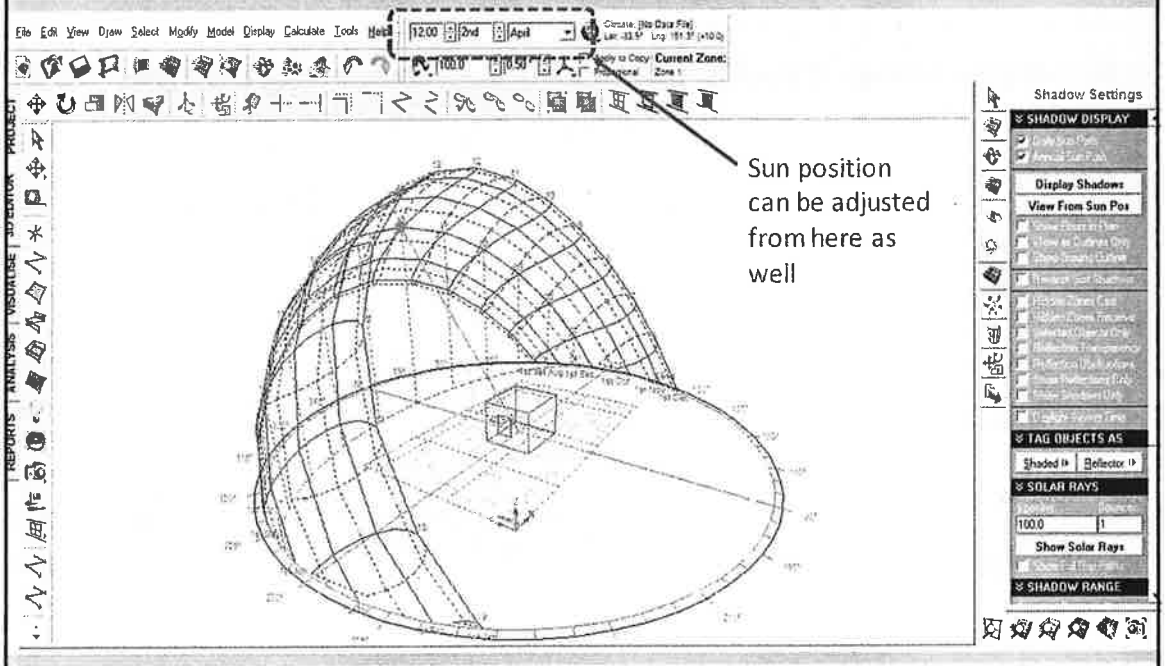


Hold the sun and shift side by side to adjust timing of the day



Hold down **Shift** and move side by side to adjust Date and Year

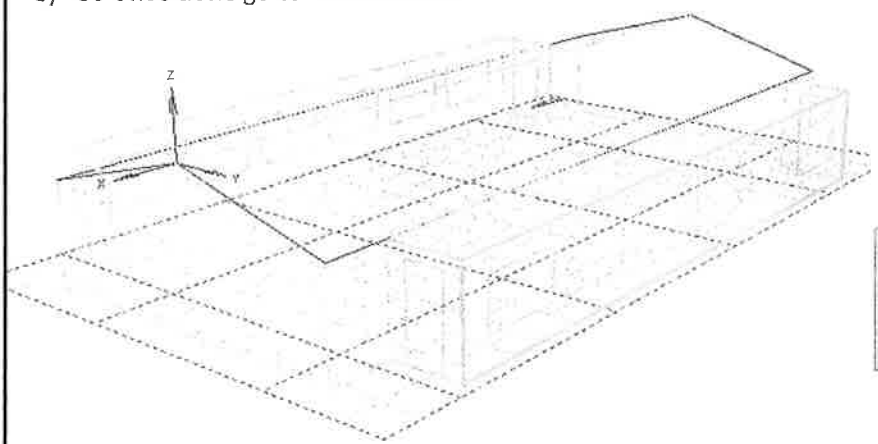
SHADOW

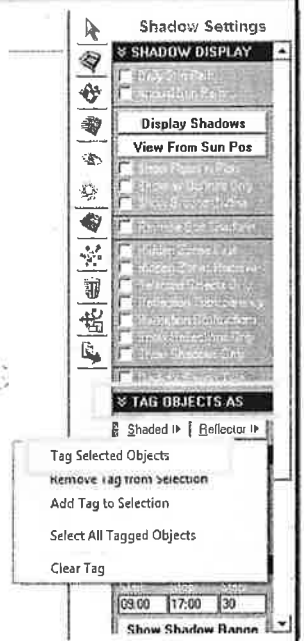


SHADOW

Displaying reflection or shadow for a particular object or surface

1) Highlight the surface you want
2) Go to **Shadow Setting → Reflector → Add Tag to Selection.** Do the same for **Shaded** as well
3) So once done go to **Visualize** tab

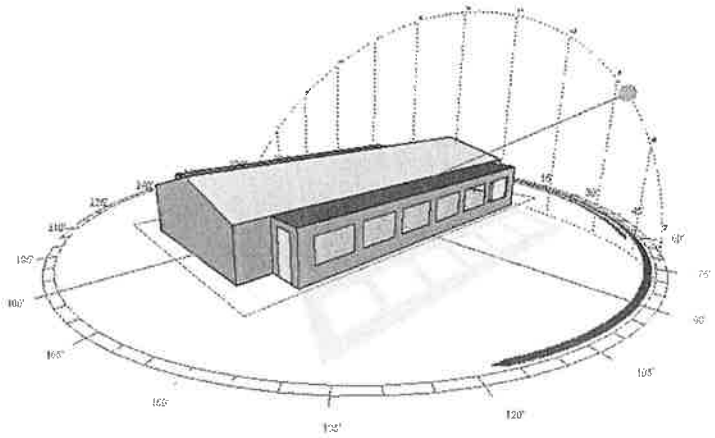


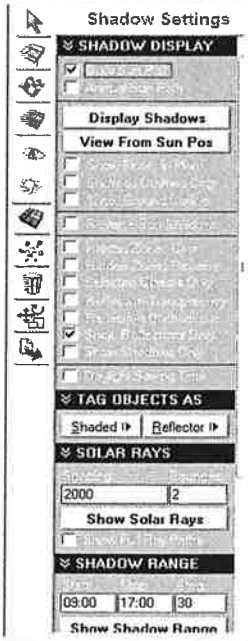


SHADOW

1)Check on **Show Reflection Only** under **Shadow Setting.**

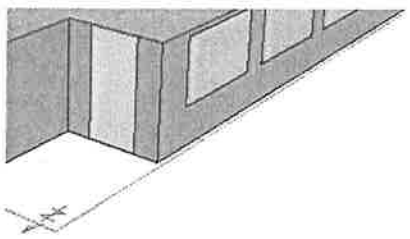
If you do not see your reflection it maybe your sun position is not facing at your reflector

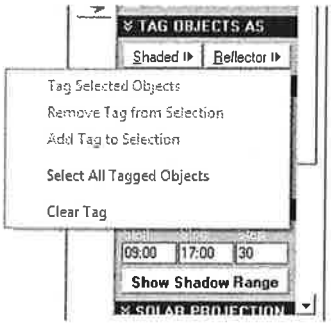




SHADOW

To reset the shadows/reflector display back to normal, click on the **Shaded/Reflector** button again and then select the **Clear Tag.**





Animation

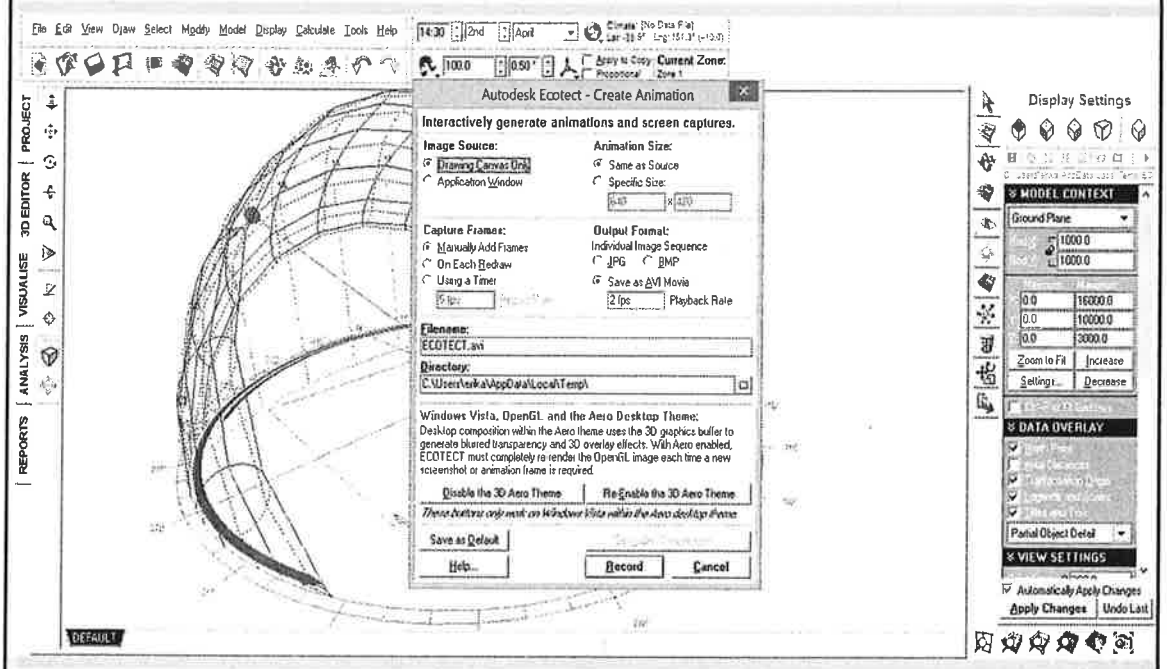
ANIMATION

The shadow can be moved from hour to hour and from day to day and be recorded into an animation.

The view can also be rotated to show different façade of the building. This can be captured as a series of view and be made as animation.

The smoothness of animation depends on the amount of image per second. The more image (transition of movement), the smoother it is.

ANIMATION

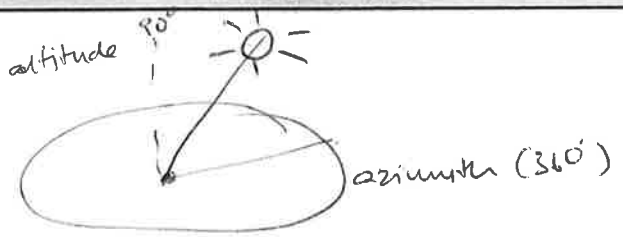


ANIMATION

TASK 7:

Select location of building to be in Singapore
Generate hourly shadow for 4 design days (summer solstice, winter solstice, spring equinox, autumn equinox)
Capture in a video through ecotect animation

Sunpath Diagram



SUNPATH DIAGRAM

Whilst there are many different types of sun-path diagram, there are only really two types of projection system used; Polar and Cartesian.

Polar Projections

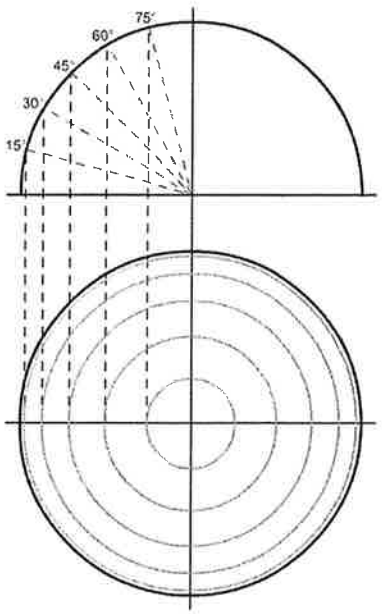
Polar projections produce circle-shaped diagrams in which each data point is represented by an*angle around* and *distance from* the centre. In the case of a polar sun-path diagram, the solar azimuth is plotted as an angle from North (0-360) whilst the solar altitude is given as the distance from the centre (0-90).

A simple linear projection of altitude lines around the sky dome straight down onto a flat surface would make angles near the horizon very close together and those near the zenith quite far apart. If you were interested in the effect of an overhead shading device, this would be entirely appropriate. However, in many architectural situations the bulk of overshadowing from surrounding buildings and vegetation occurs when the Sun is much nearer the horizon. Thus, alternate projections are necessary in order to increase the level of accuracy and detail for angles nearer the horizontal.

SUNPATH DIAGRAM

Spherical Projections

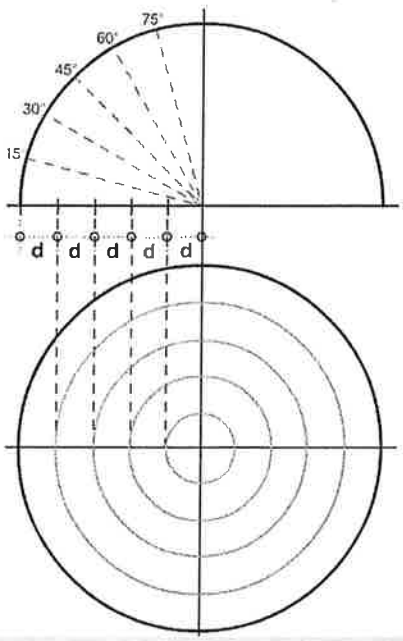
In this method, the radial distance from the centre is simply the cosine of the altitude angle. As shown above, the relative change in radius between 75° and 90° is very much greater than between 75° and 90°. This makes such diagrams very good for considering overhead shading or very tall surrounding buildings.



SUNPATH DIAGRAM

Equidistant Projections

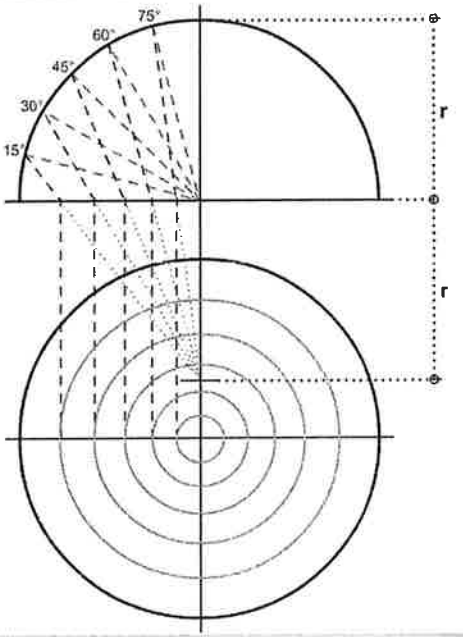
Using this method the radial distance is simply a linear factor of the altitude angle. Thus the relative change in radius between all angles is the same, so there is no bias towards either the zenith or the horizon.



SUNPATH DIAGRAM

Stereographic Projections

This is a more complex projection in which azimuth lines are first projected back to a reference point located a distance of 1 radius beneath the circle centre. The point where each of these lines intersects the zero axis gives the radial distance. The primary advantage of this method is that it increases the resolution of the diagram at low solar altitudes making it more suitable for the majority of surrounding building overshadowing situations.



SUNPATH DIAGRAM

Cartesian Projection

The Cartesian coordinate system is used to uniquely determine any point in a plane through two numbers, usually called the x-coordinate and the y-coordinate of the point. Each coordinate is given relative to a universal origin point and measured along two perpendicular axis. This typically results in a rectangular-shaped diagram with solar azimuth along the horizontal axis and solar altitude along the vertical axis.

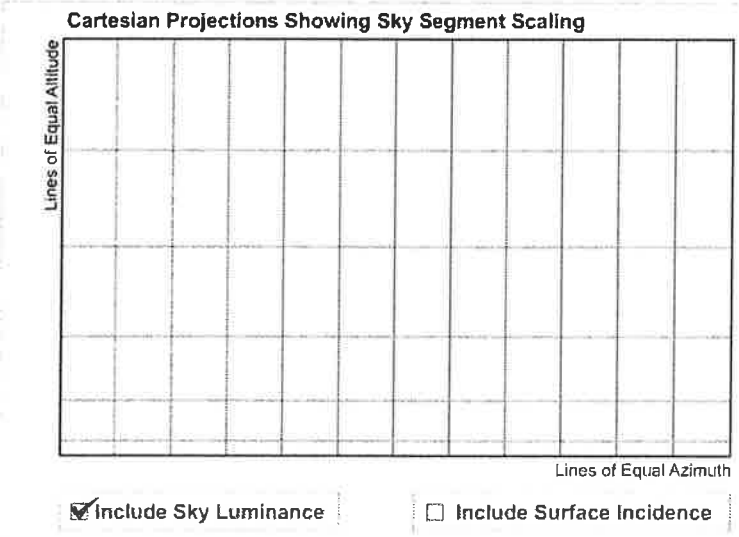
SUNPATH DIAGRAM

Axial Scaling

Not all parts of the sky contribute equally to the daylight that arrives at a surface or passes through a window. Different sky conditions can result in variations in the distribution of luminance over the sky dome, with some areas brigher or darker than others. For a flat surface or a window, light from some parts of the sky will arrive at normal incidence whilst others will arrive at almost grazing incidence, with the cosine law determining their relative contribution.

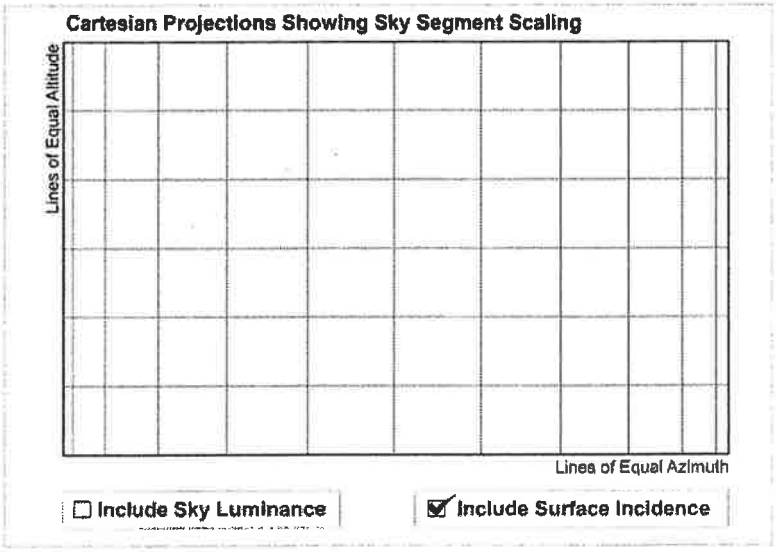
These effects can be accommodated within cartesian sun-path diagrams by applying non-linear scales to one or both of the axis, as shown in the interactive animation immediately below. This can be done solely for visualisation purposes or, with the addition of distributed points or a grid of squares, used as a basis for manually taking off measurements for daylighting potential or overshadowing effect.

SUNPATH DIAGRAM



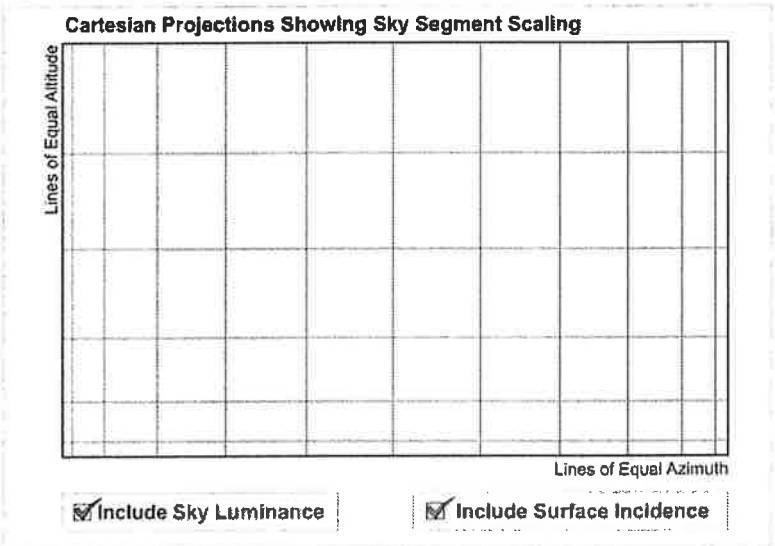
Cartesian projection showing the scaling effects of sky illuminance distribution and surface incidence.

SUNPATH DIAGRAM



Cartesian projection showing the scaling effects of sky illuminance distribution and surface incidence.

SUNPATH DIAGRAM



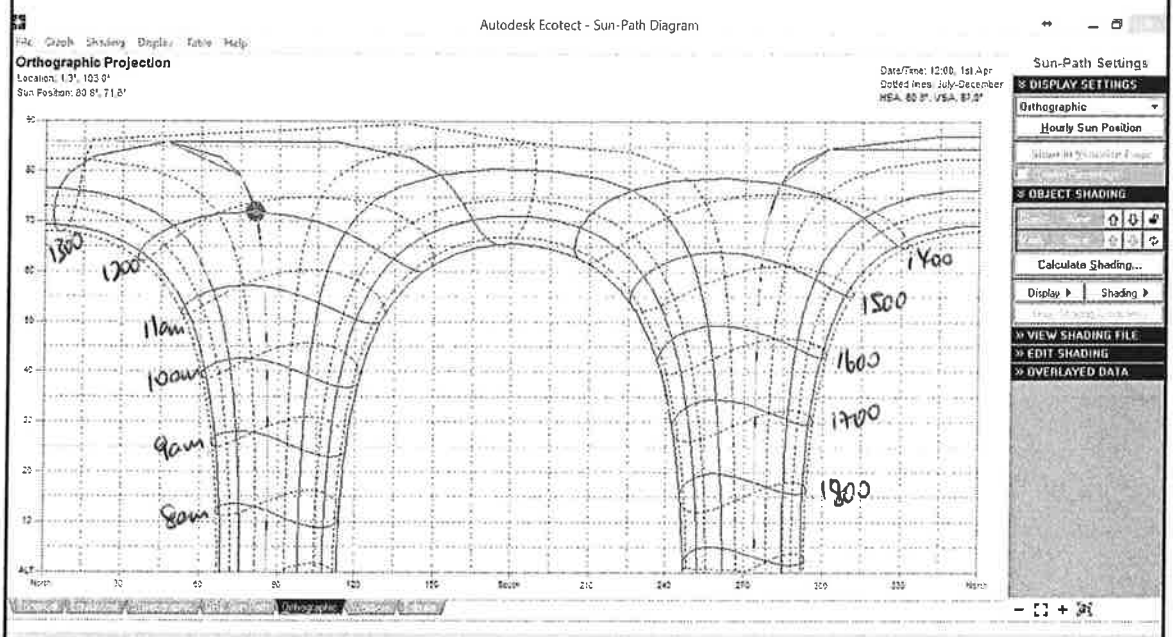
Cartesian projection showing the scaling effects of sky illuminance distribution and surface incidence.

SUNPATH DIAGRAM

Orthographic Projection

This refers to a straight mapping of azimuth and altitude angles onto the X and Y axis (respectively) of a cartesian graph. The key to an orthographic projection is that, much like plan view or elevation of a 3D object, the data on each axis is mapped linearly, with no attempt to include modifiers for surface incidence or sky luminance.

SUNPATH DIAGRAM



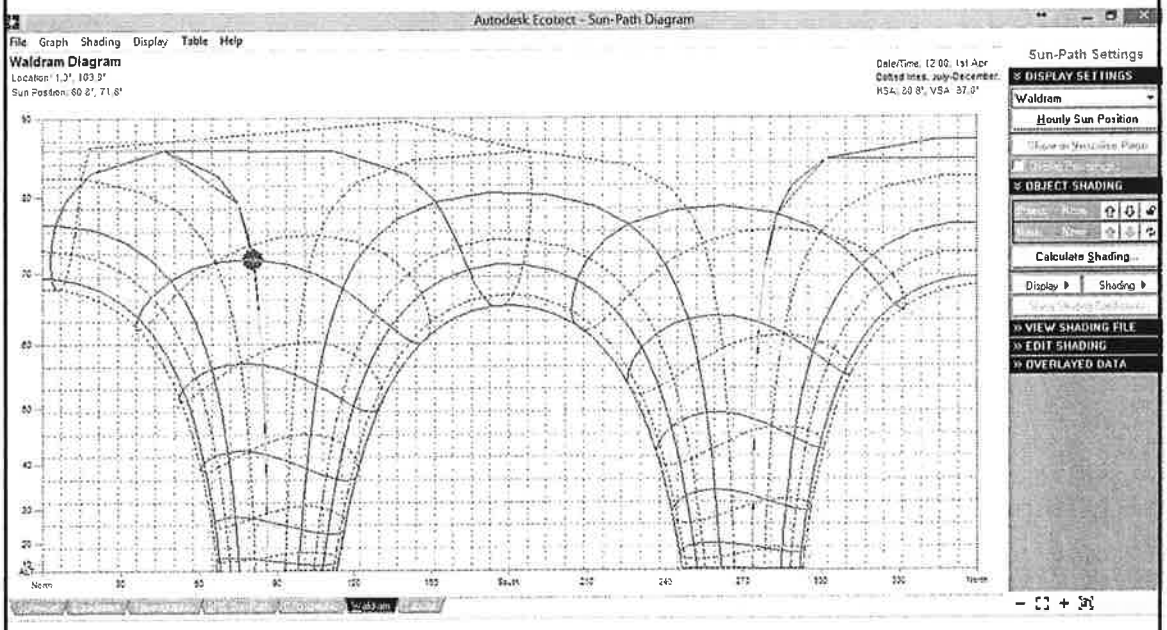
SUNPATH DIAGRAM

Waldram Diagram

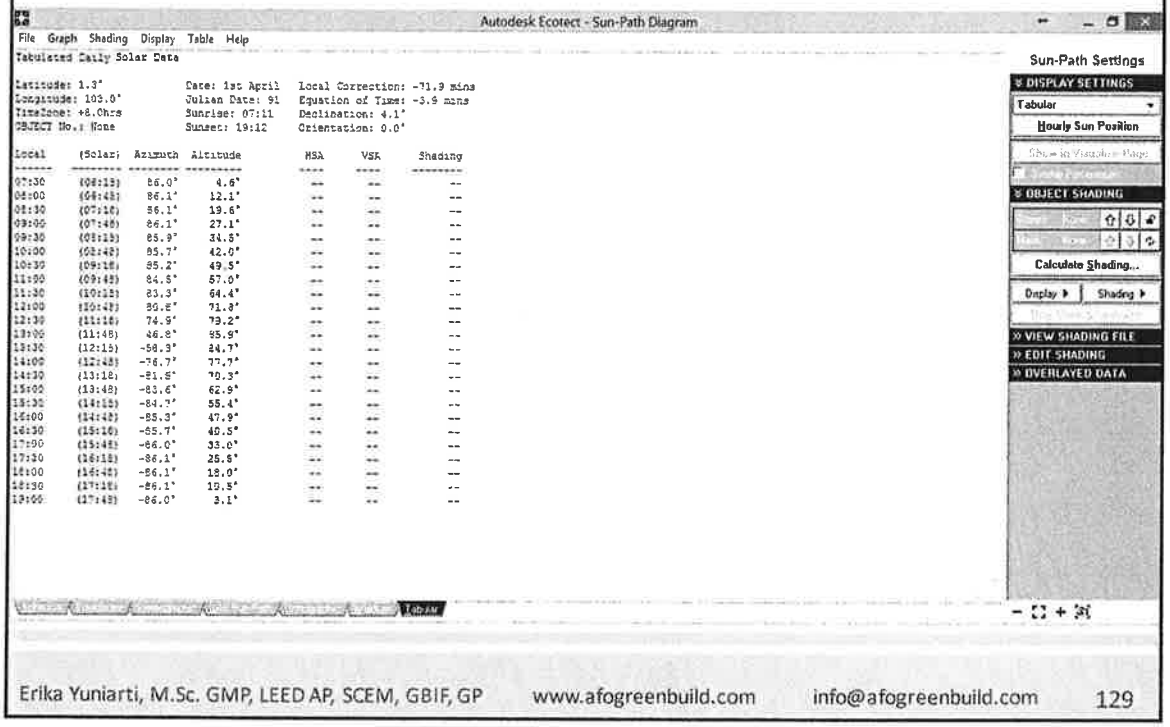
Waldram Diagrams are intended for use in the manual calculation of potential daylight levels in buildings. As such, the scale in the altitude axis needs to consider important effects such as sky luminance distribution, surface incidence and sometimes even corrections for angular variations in transmission through the glass.

Daylight design is typically driven by worst-case conditions, that being a dark overcast sky in winter. The CIE-Overcast-Sky model defines the zenith as being 3 times as bright as the horizon. This means that the equivalent angular difference in altitude in these two parts of the sky dome should result in squares with areas differing by a factor of 3

SUNPATH DIAGRAM



SUNPATH DIAGRAM



SUNPATH DIAGRAM

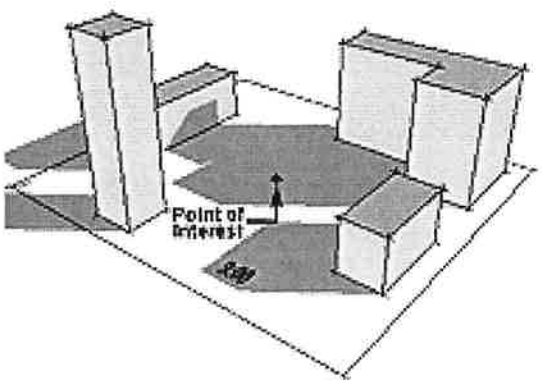
TASK 8 :

Compare sunpath diagram of Singapore, Toronto and Otago in term of stereographic, equidistant and tabular

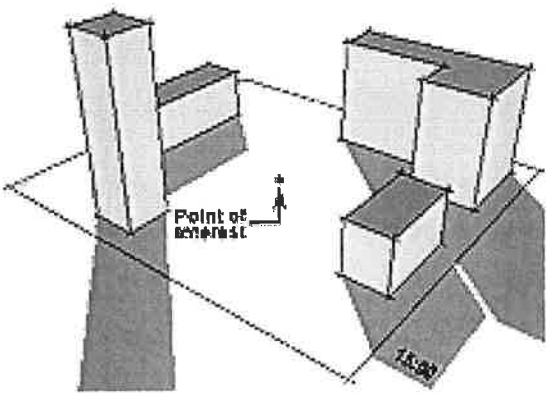
Overshadowing

OVERSHADOWING

The aim of most overshadowing analysis is to determine when a particular point in a model is exposed to direct sunlight



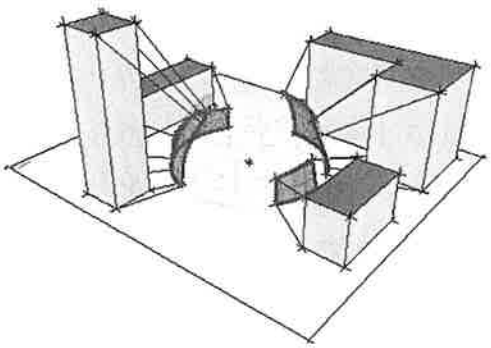
Shadows at 9am



Shadows at 3pm

OVERSHADOWING

If the annual path of the sun is overlaid on the diagram, it is possible in the one image to display the overshadowing for the whole year for a single point in space. Moreover, the diagram also shows the relative area of the sky that is obstructed at that point, thus providing information on the availability of diffuse radiation as well.

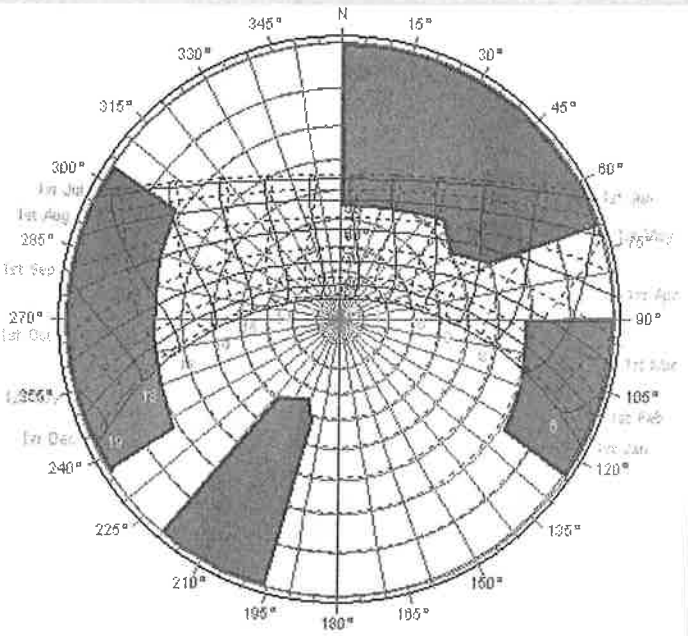


Site obstructions projected back onto an imaginary hemisphere centered at the point of interest.

OVERSHADOWING

When generated and projected this way, it is possible to derive a series of individual transformed polygons

Projected site obstructions shown in a sun-path diagram centered at the point of interest.



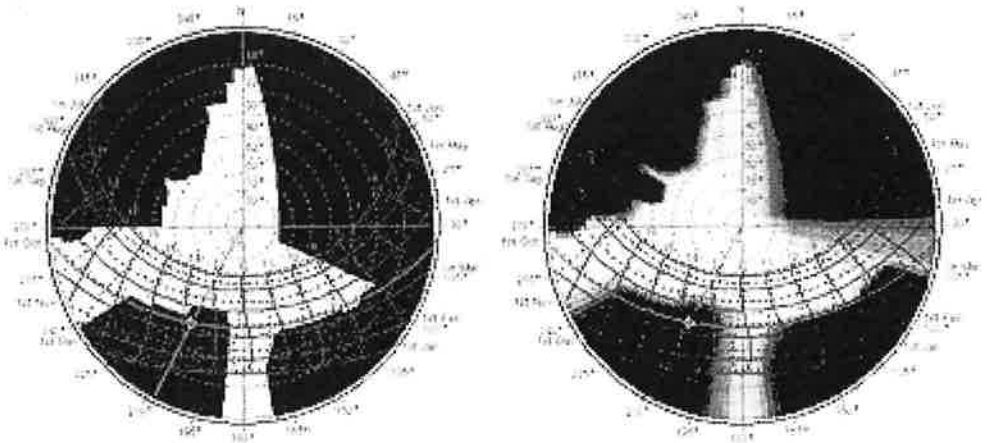
OVERSHADOWING

The benefit of using the segmented sky approach is that the resulting data is easy to access and immediately useful in a whole range of numerical analysis. Determining if the point is in shadow at any time simply requires the altitude and azimuth of the sun, from which the specific sky segment can be determined and the appropriate shading value referenced. Similarly, the fraction of unobstructed sky can be quickly found by simply summing the shading values for each segment and dividing by the total number of segments.

OVERSHADOWING

Partial Shading Effects

As shown in the subdivided sky, the shading mask for a single point is hard edged - it is either in shade at a particular time. The shading mask for a planar surface however is more often soft-edged as only a portion of the surface may be in shade at certain times.



Point *Surface*

OVERSHADOWING

Incidence Angle Effects

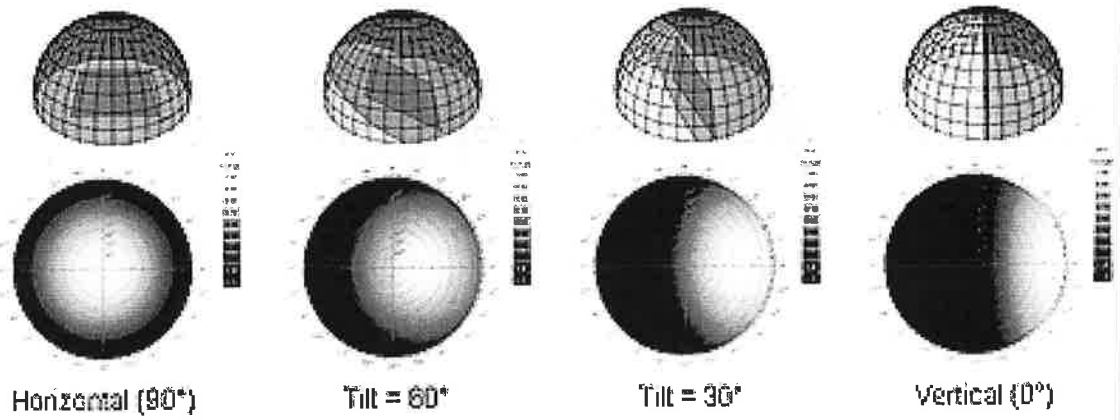
Once the sky has been subdivided, the orientation and inclination angle of the surface can be used to determine which parts of the sky it is actually exposed to. For example a vertical surface, no matter which way it faces, will only ever 'see' at best one half of the sky dome - meaning that it will only ever receive a maximum of one half of the available diffuse component. A horizontal surface that faces upwards, on the other hand, could see it all.

OVERSHADOWING

However for a horizontal surface, any light from the zenith of the sky arrives normal to that surface whilst light from the horizon arrives at grazing incidence. For a vertical surface the reverse is true light from the zenith arrives at grazing incidence whilst light from the horizon arrives along its normal. This means that the area of the sky that contributes most to any surface depends greatly on its inclination angle.

OVERSHADOWING

Images below shows a surface at different inclinations and its corresponding surface incidence effect mapped over a mask. This is simply the cosine of the incidence angle the geometric centre of each sky segment makes with the surface normal.



OVERSHADOWING

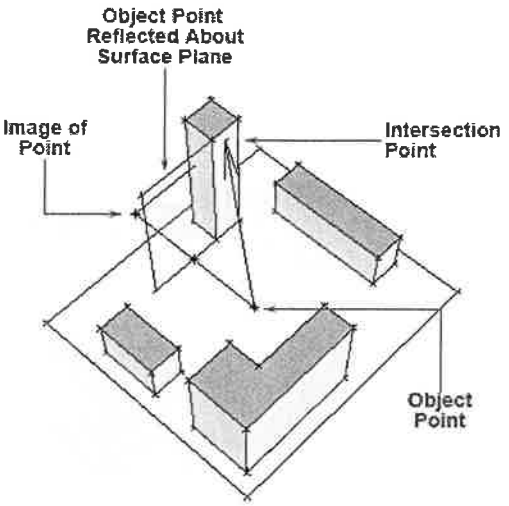
To consider this effect, an extra layer is added to the shading mask of all surfaces. Each segment in this layer is assigned the cosine of the angle that its' center point makes with the surface's normal. To calculate the relative contribution of any sky segment, its fractional exposure (1 - overshadowing) and incidence value are multiplied together and converted back to a shading percentage. When done for each segment in the mask, the total effect can then be displayed, as shown in figure below.



OVERSHADOWING

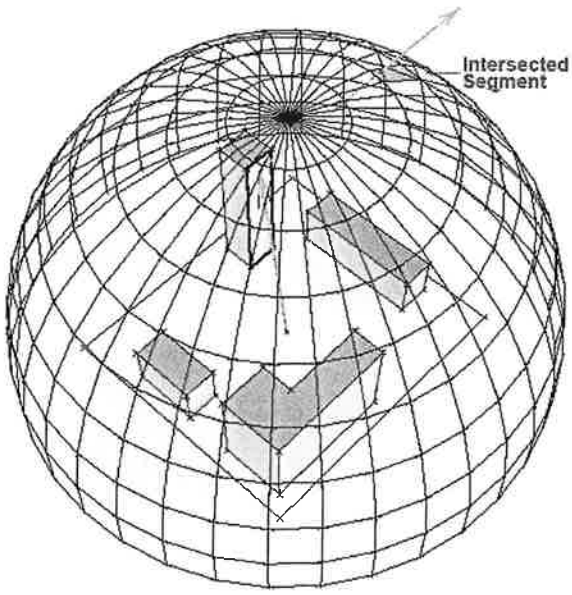
Reflected Solar Radiation

Using shading masks it is also possible to accommodate the effects of transparent and reflective surfaces. Basic ray-tracing techniques can be used to continue tracing rays through any number of transparent surfaces, with each surface reducing the total contribution of the ray. If the ray hits a reflective surface, it can be forked to produce a reflected ray which is then traced in the same way as the original ray. The direction of this spawned ray is determined by mirroring the origin of the first ray about the plane of the reflective surface, as show in this figure.



OVERSHADOWING

Once reflected, the closest sky segment in the direction of the new ray is determined. If the reflected ray is not obstructed before hitting this sky segment, then it contributes an additional fraction to this segment equal to the original ray fractional value when striking the reflective surface multiplied by both the reflectivity and specularity of its assigned material.



OVERSHADOWING

TASK 9 :

Open the file created in Task 2
Generate overshadowing for this file

Optimize Shading

OPTIMIZE SHADING

1.Go to the **Calculate** menu, and select the **Shading Design Wizard** menu item. The calculation wizard appears on screen. Choose the **Generate Optimised Shading Device** radio option and then click **Next**.

2.In order for the wizard to work properly, you need to select a window. Click the **Select Objects or Set Date/Time...** to return to the 3D editor and select the window. Press the **F2** to return to the wizard. Ignore the error message that still appears, and then click **Next**.

3.An optimized shading device can be designed to work for specific dates and/or times. For this tutorial, we are going to design a device that completely shades the window for Spring, from 9am to 5pm. Select these values using the drop down lists and input fields, and then click **Next**.

OPTIMIZE SHADING

4. Select the type of shading device you would like Ecotect to generate. For this tutorial, select radio option **No 3 - Optimised for Selected Dates**. Click **Next**.

5.Ecotect now displays a summary of all the options you have selected using the wizard. However, these will all be wrong, so re-enter all of the options and settings you specified previously, and then click **Ok** to proceed with generating the shading device.

6. Ecotect generates a shading device using the settings specified. To see if it is working properly, try displaying shadows for a date and time that falls within the selected range - the window should be completely in shade.

OPTIMIZE SHADING

TASK 10:

Open file in task 2
Generate optimize shading

Projecting Solar Profile

SOLAR PROFILE

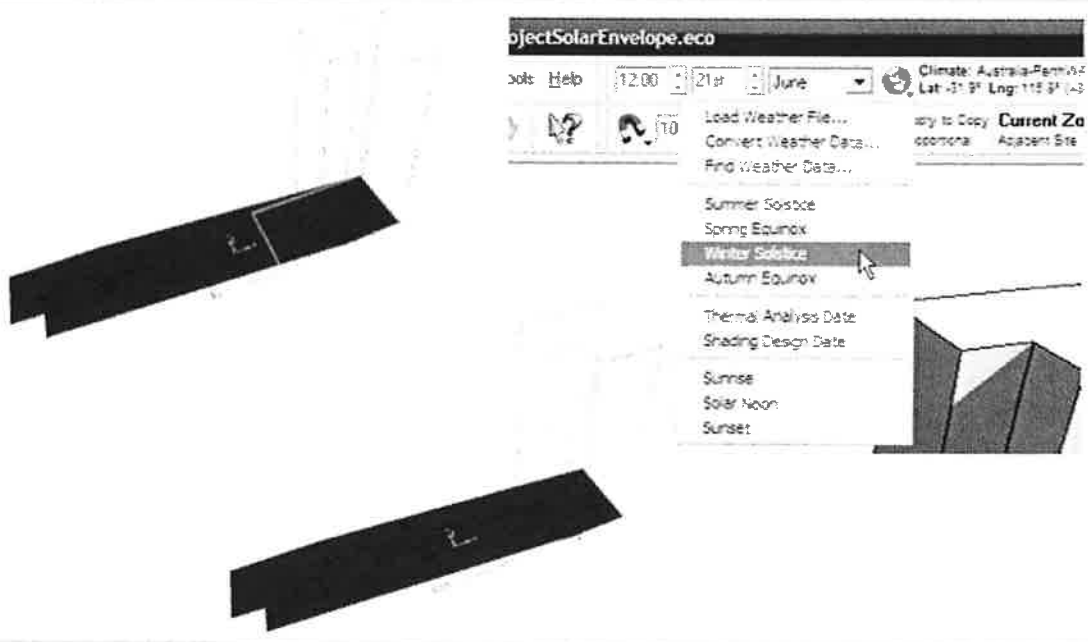
For certain types of development, there may be restrictions placed on the height of a proposed building so as not to overshadow adjacent sites or buildings. This is known as the maximum solar envelope.

Set the date to use for projecting the solar profile.

Select the proposed building, and make *Proposed Building* the current zone.

Go to the Calculate»Shading & Shadows»Project Transformation Origin»Follow Hourly SunPath menu item. Using the settings you have specified,ECOTECT projects the solar profile as a line upon the selected building. This line represents the maximum building height so as not to overshadow the transformation origin for the selected date.

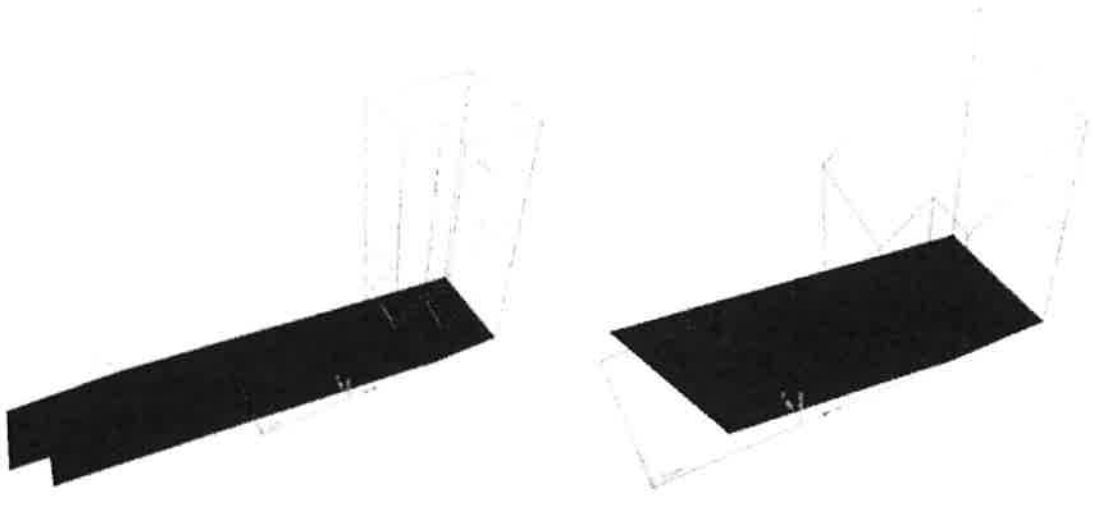
SOLAR PROFILE



SOLAR PROFILE

Of course, this profile is for a single point only on the adjacent site. To determine a spectrum of solar profiles, different transformation
origin points should be used. For example, use the button and the option to reposition the transformation origin to the northwest
corner of the adjacent site. *Select the date you wish to use for projecting the solar profile.*
Repeat the solar profile projection note how the profile is at a different height to the previous one. Create a series of solar profile
projections, one for each corner of the site. To track the profiles, you may wish to place them on individual zones, so that you know
which profile corresponds with each point.
Now that you have a series of solar profiles, you can use these to determine the optimum building height, based on which points of the
site are allowed to be overshadowed. You can then edit the nodes of the proposed building envelope to adjust its overall height.

SOLAR PROFILE



SOLAR PROFILE

TASK 11:

Open file created in task 2.
The 10m x 10m space in the center of the building complex shall not be shaded from 4 pm onward.
Generate the solar profile of these buildings.
Do not override file in task 2, but save as task 11

Solar Tool

SOLAR TOOL

1. Select the Open item from the File menu.
Open your file and make sure the shadow button is on.
2.On the left hand side of the screen, locate and click the Sun Path rollout to open the Sun Path settings.





SOLAR TOOL

Fully Shaded - Represents the times and dates when the window is in 100% shade only.

Percentage Shade Creates a greyscale diagram displaying the proportion of shade at various times. This is indicated by steps of 10% (from 0 to 100) shown at the top right corner of the Sun Path canvas.

Centre Point Dark grey sections show when the center point of the window is in shade; lighter grey indicates a fully shaded window.

None No shadows are cast
Choose the **Fully Shaded option** to continue

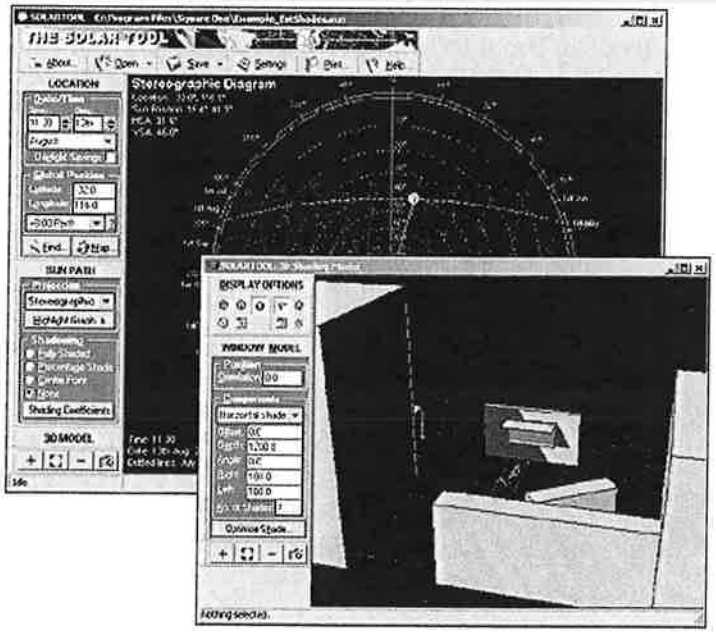
SOLAR TOOL

Locate and click the 3D Model rollout which can be found below the Sun Path rollout (or hit the F9 key).



A new window will open containing a 3D model of the scene represented in the Sun Path diagram you were previously looking at. This 3D model is directly linked to the Sun Path diagram, so any changes that are made in one window will also be seen in the other. Because of this it is recommended that you arrange the two Solar Tool application windows next to each other on your desktop, so that you can see these changes in real time.

SOLAR TOOL



SOLAR TOOL

Daylight Savings ☑

When this box is checked, one hour will be subtracted from on the Sun Path diagram, while the Time input field remains the same. In this way daylight savings time [summer time] can be incorporated into your model.

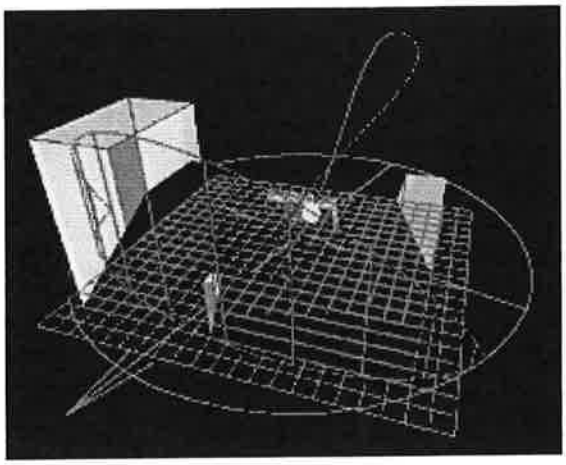
Position the cursor over the sun (a small hand icon will appear), then left click and drag the mouse.

You should notice that dragging the cursor changes the position of the sun. While in 3D view, the movement of the sun is constrained in order to represent the Sun Path on a given day with shadows updated in real time.

As the sun changes position in the 3D Model, the time and date settings also update in all the relevant areas

SOLAR TOOL

Whilst continuing to drag the sun with the cursor press and hold the Shift key down.



This constrains the movement of the sun to the current hour of the day, but allows you to interactively change the day of the year (represented by the red line). Date settings will update in the Sun Path diagram window as your cursor changes position in the 3D Model window.

Useful Note:

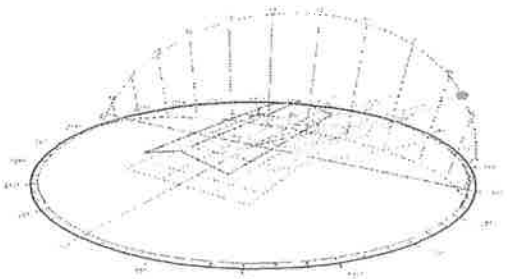
This red line shown in the 3D Shading Model is known as the analemma. The analemma is essentially caused by two characteristics of the earth orbit within the solar system; firstly, the earth is tilted on its axis 23.5Ã‚Â° in relation to the plane of its orbit around the sun, and secondly, the earth orbits the sun in an elliptical path (not a circular path).

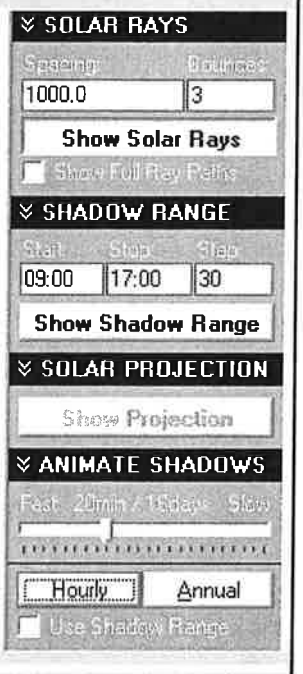
Solar Ray

SOLAR RAY

Creating Solar rays

1) Highlight the surface you want the solar rays to be reflected. Eg Floor
2) Choose your **Spacing** and **Bounce** to indicate rays spacing and how many bounces you want.
3) Click on **Show Solar Rays** with your **Daily Sun Path** on so to change your sun rays angle
4) You may want to add a **Camera** in to your model
5) So once done move on to **Visualise**



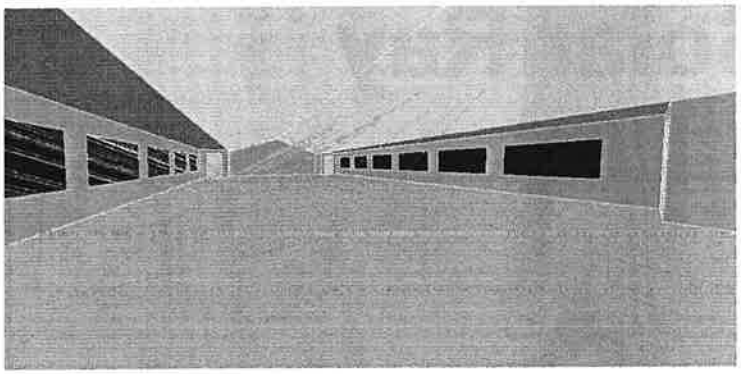


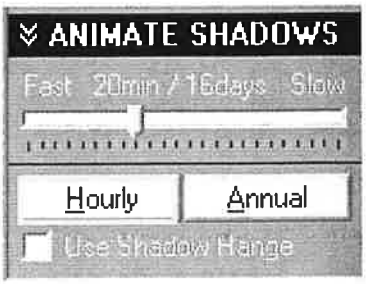
SOLAR RAY

When you are in **Visualize** you will get to see this at bottom of your screen 

Click the **Camera** tab and you will see a view of the internal model with your sun rays penetrate in.

Click on the **Hourly** it will simulate an animated sun rays movement through out the days.





SOLAR RAY

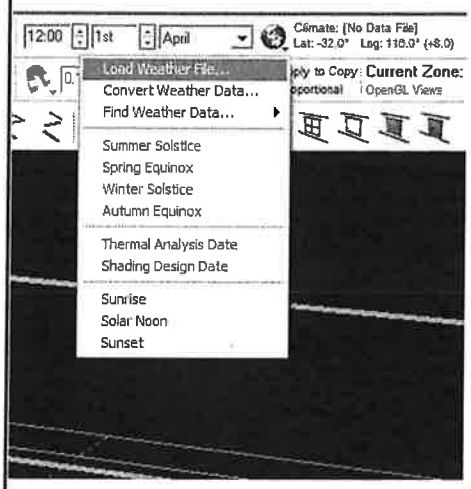
TASK 12:

Open file in Task 2 (before solar profile change)
The owner of the lowest building is considering implementation of solar panel on the roof. He wants to avoid glare disturbance to his neighbors.
Check the potential glare by simulating solar ray.
Check which pv orientation is the best (minimum glare).

Weather Tool

WEATHER DATA

Click on next click on **Load Weather File**



Weather Data folder will open up, choose from any .WEA files that come with Ecotect.

If the city you are finding is not in then navigate your mouse to **Find Weather Data→ US Department of Energy**
Eg. (Singapore)
Southwest Pacific → Download the ZIP → Run the Weather Tool → Import the .EPW file → Save as .WEA → Click on **Load Weather File** and load the .WEA file that had saved.

WEATHER DATA

How to convert TMY or EPW weather data into WEA format for Ecotect Analysis

The easiest work flow for getting weather data into .wea format for Ecotect Analysis is to convert the TMY3 format to .EPW (this is the format used by EnergyPlus which is a US government's energy simulation engine). Alternatively, there are many TMY3 and other file formats that have already been converted to .EPW format on the US Department of Energy's web site:
http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_sources.cfm

To convert a .EPW file into .WEA format, simply open the Weather Tool in Ecotect Analysis, and drag and drop a weather file onto the Weather Tool screen, click the "Import File" button on the bottom right of the import dialog, and then choose Save As .WEA in the Weather Tool.
It is also possible to convert TMY3 to TMY2 using Ecotect can using an NREL utility:
http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/#software

WEATHER DATA

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Weather Data Sources

The weather data provided in EnergyPlus weather format on this website are derived from 20 sources:

- CTZ2 California Climate Zones 2
- CWEC Canadian Weather for Energy Calculations
- CIBSE Chartered Institution of Building Services Engineers'
- CityUHK City University of Hong Kong
- CSWD Chinese Standard Weather Data
- CTYW Chinese Typical Year Weather
- ETMY Egyptian Typical Meteorological Year
- IGDG Italian Climatic data collection "Gianni De Giorgio"
- IMGW Instytutu Meteorologii i Gospodarki Wodnej
- IMS Weather Data for Israel
- INETI Synthetic data for Portugal
- ISHRAE Indian Weather Data from the Indian Society of Heating, Refrigerating and Air-Conditioning Engineers
- ITMY Iranian Typical Meteorological Year
- IWEC International Weather for Energy Calculations
- KISR Kuwait Weather Data from Kuwait Institute of Scientific Research
- NIWA New Zealand Data from NIWA
- RMY Australia Representative Meteorological Years
- SWEC Spanish Weather for Energy Calculations
- SWERA Solar and Wind Energy Resource Assessment
- TMY Typical Meteorological Year
- TMY2 Typical Meteorological Year 2

WEATHER DATA

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

EERE Home

Weather Data

Weather data for Singapore are available below. The original source data are described on the Weather Data Sources page.
Learn more about the weather files.

All Regions : Southwest Pacific WMO Region 5 : Singapore

Singapore 486980 (IWEC) ZIP

File Information

Each file is named using the ISO standard three-letter country abbreviation (i.e. CUB for Cuba), followed by the location name, World Meteorological Organization designation (WMO) and the source format (CTZ2, CWEC, CityUHK, CSWD, CTYW, ETMY, IGDG, IMGW, IMS, INETI, ISHRAE, ITMY, IWEC, KISR, NIWA, RMY, SWEC, SWERA, or TMY3). Thus,

CUB_Havana.782240_IWEC.zip — is the ASHRAE International Weather for Energy Calculations (IWEC) data for Havana, Cuba, WMO 782240.

The compressed file (ZIP) which contains the following files for the location:

- EnergyPlus weather files (EPW)
- A summary report on the data (STAT)
- An ASHRAE Design Conditions Design Day Data file (DDY).

WEATHER DATA

Why EPW weather files show 1000s of mm of rainfall a month (not likely in the desert).

The EPW weather files that are published by the US Department of Energy are compatible with Ecotect Analysis. These files can just be dragged-and-dropped onto the Weather Tool interface and they will be converted to the correct format.

No known weather files contain rainfall data. What shows up in the weathertool is called "precipitable water", which is water contained in a column of air, 1m, from the top of ground to top of atmosphere. It is not precipitation however. The data in the weathertool needs to be re-adjusted. In all cases, the data is only used to define the type of climate in the passive design strategies.

WEATHER DATA

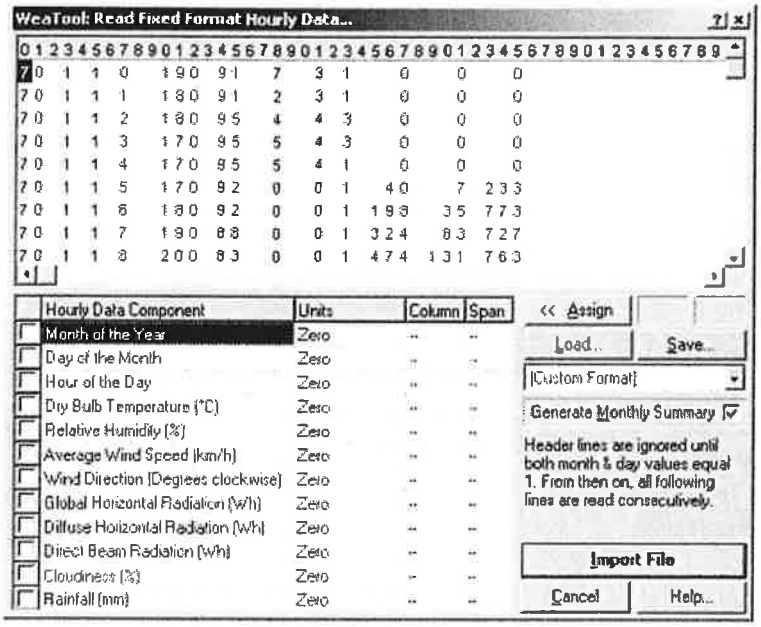
For weather data to be useful in the analysis routines in ECOTECT, you really need a full year worth of hourly weather data. This cannot be monthly averages or even daily ranges, but actual data recordings for every hour of the day. The data required includes:

- Air Temperature
- Relative Humidity
- Global or Direct Solar Radiation
- Diffuse Horizontal Solar Radiation
- Wind speed
- It is also desirable but not essential to include:
- Wind direction
- Cloudiness
- Rainfall

WEATHER DATA

1. To begin, open the Weather Data Fixed Format ReadMe.txt file by simply doubleclicking it in Windows Explorer.
You will usually get either a text file like this one included with any custom weather data to explain what the values in the file are and their units.
2. With this file still open, run The Weather Tool .
3. Click the Open button.
In the Open Data File dialog box, change the Files of Type to Fixed Format Weather Files, then open the Weather Data Fixed Format.dat file. The following dialog box will be displayed.

WEATHER DATA



WEATHER DATA

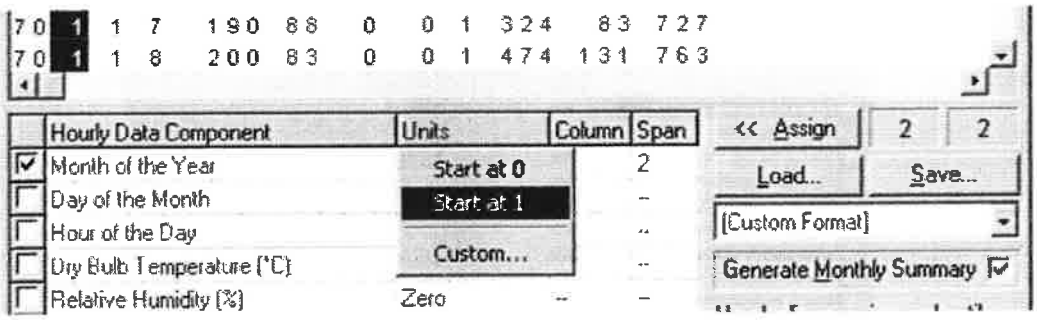
The reason for choosing Fixed Format Weather Files is because the format of the data is determined by a fixed set of columns. That is, each value (regardless of whether the data is complete or not) will always start in a fixed column.

4. With the dialog box shown above open, you now need to go through each set of values and specify what they are and their units. This is where the "Weather Data Fixed Format ReadMe.txt" file comes in, as you will need to refer to it for whateach set of values are.

5. Starting with the Month of the Year, make sure it's checkbox is ticked then left click and drag acrosscolumns 2 and 3 in the table above.
As the columns in The Weather Tool begin at 0 instead of 1, you have to consciously subtract 1 from thecharacter indexes in the description.
You should also notice that the entire 2nd and 3rd columns become highlighted when you release the mouse button. With these selected click the Assign button, to assign the 2nd and 3rd columns to the Month of the Year field.
Continue doing this for each successive data component.

6. You can see that the first month value in the file is '1'. Thus you need to leftclick in the Units column and select the 'Start at 1' option.

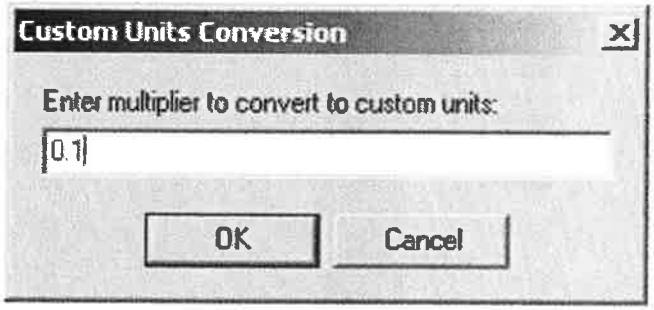
7. When you get to Dry Bulb Temperature, you will notice that the text file states the columns run from 9 to 13, but there is only numbers in 10 to 12.



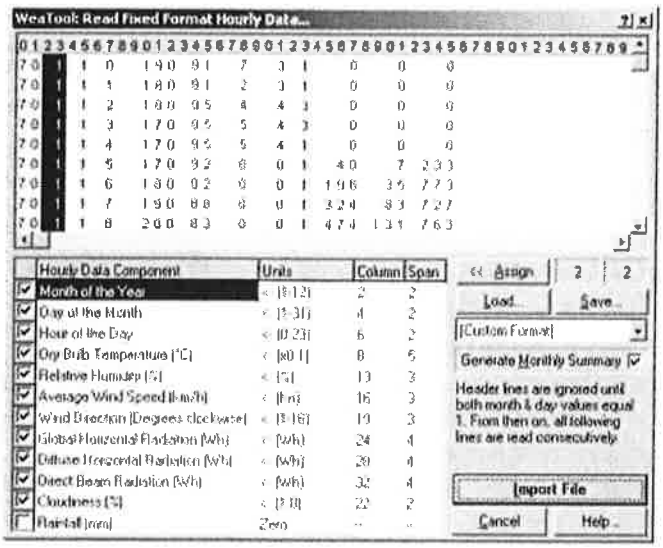
Quite often data will be slightly mismatched or inconsistent. If this is the case you will need to exercise a bit of judgement as to which is correct (this may involve several attempts at importing). In this instance choose columns 10 to 12 anyway.

8. Once the columns have been assigned it is important to specify the correct units. In this instance the value for Dry Bulb Temperature has three characters/components and the "Readme.txt" file says their units are in °C.
The Weather Tool uses SI unit, therefore the Celsius is ok, we just need to reduce the value by one decimal point. You can always tell what units The Weather Tool is going to convert to as they are written next to the name of each component, in this case (°C).

9. To change the scale for Dry Bulb Temperature, left click the units cell next to Dry Bulb Temperature.
Then choose the Custom... item from the list.
In the Custom Units Conversion dialog box, type in a value of 0.1
This specifies that the Dry Bulb Temperature component must be multiplied by a value of 0.1 to give in degrees, resulting in a temperature of 19.0°C rather than 190°C for example.

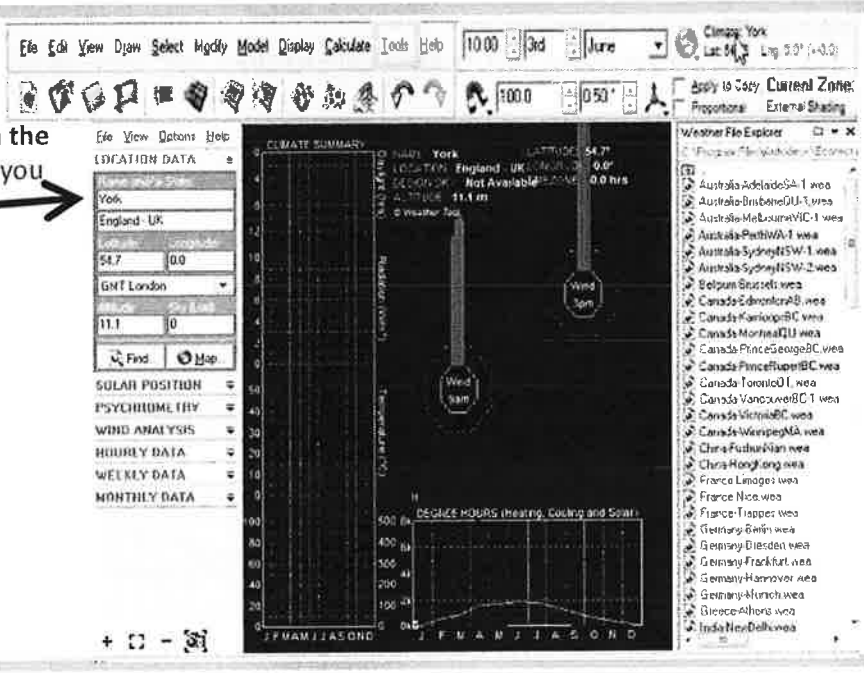


10. Continue specifying columns for each of the data components based on the information in the "Weather Data Fixed Format ReadMe.txt" file.
The dialog box should eventually look similar to the image below.
You will notice in this set of data there is no rainfall component. When a particular component doesn't exist in the data then you just need to make sure that it's check box is not ticked.



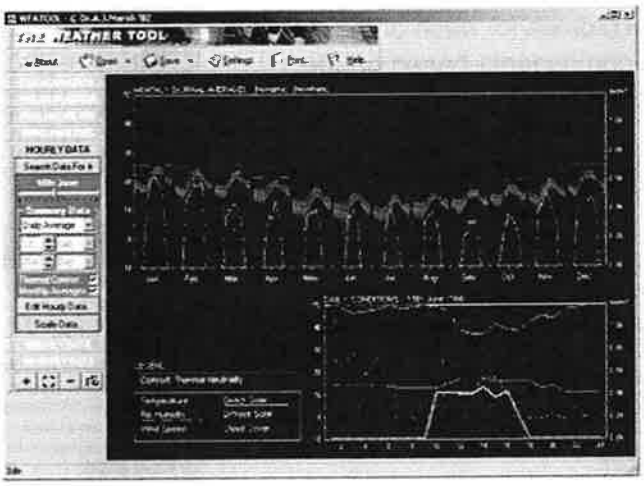
WEATHER DATA

1) Go to **Tools → Run the Weather Tool** and you will see this



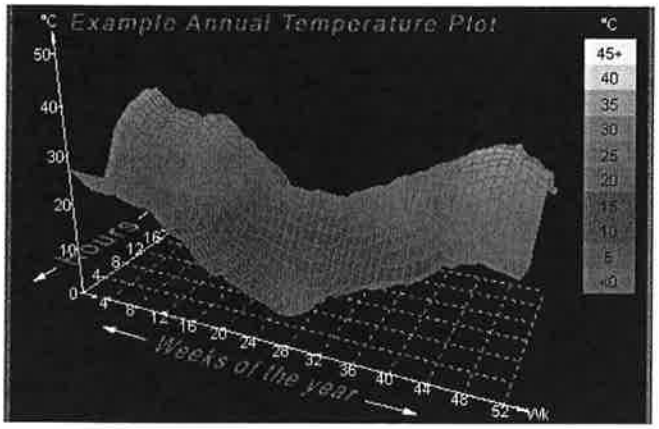
WEATHER DATA

11. Once all the columns and units have been defined, click the Import File button. Once imported, select the Hourly Data button on the left of the left panels. This should display something similar to the following: You can now save this data as a WEA file and load it into ECOTECT for use in the thermal and solar analysis of your models. You can also use the data analysis and visualisation features of The Weather Tool to gain a real understanding of what is going on in that climate.



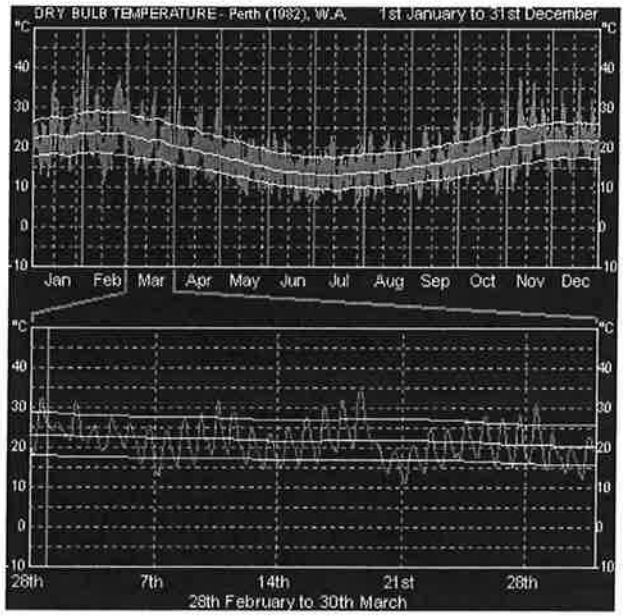
WEATHER DATA

Weather data can be displayed by graphing weeks of the year in one direction, in this case the X axis, and hours of the day along the adjacent Y axis. Variations in level within the selected data is then displayed using a colour intensity and, in the case of the three-dimensional graphs used here, as a displacement in the Z axis.



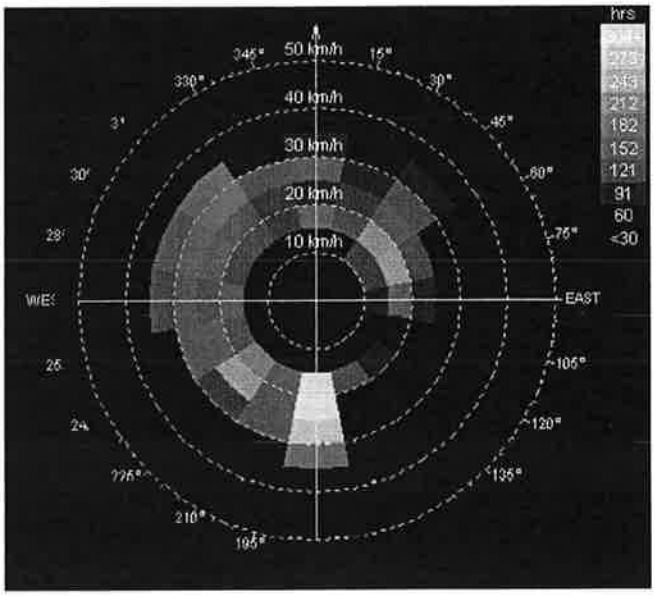
WEATHER DATA

The same data as displayed above can also be plotted as a 2D linear graph. Whilst this form shows the range of diurnal variation, it does not illustrate the diurnal patterns present in the data in the same way the 3D graph does.



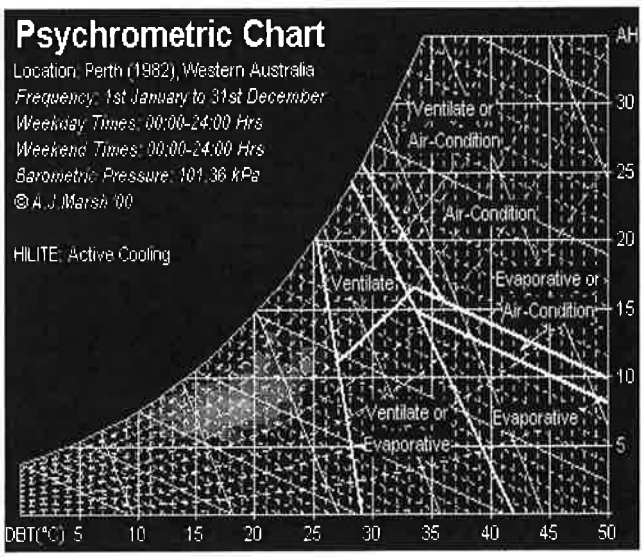
WEATHER DATA

Hourly wind direction can also be displayed, if it is present in the data.



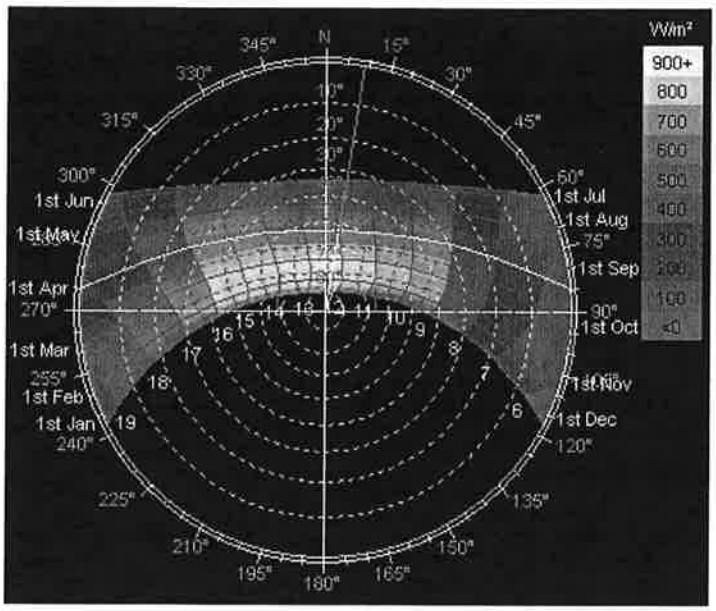
WEATHER DATA

Given hourly values for temperature and relative humidity, it is possible to plot their distribution on the Psychrometric Chart. This is very useful as it clearly shows the range of conditions to be accommodated within that climate. Once plotted, a range of information can be overlayed on the chart. The chart below, for example, shows the areas most suitable for different cooling strategies.



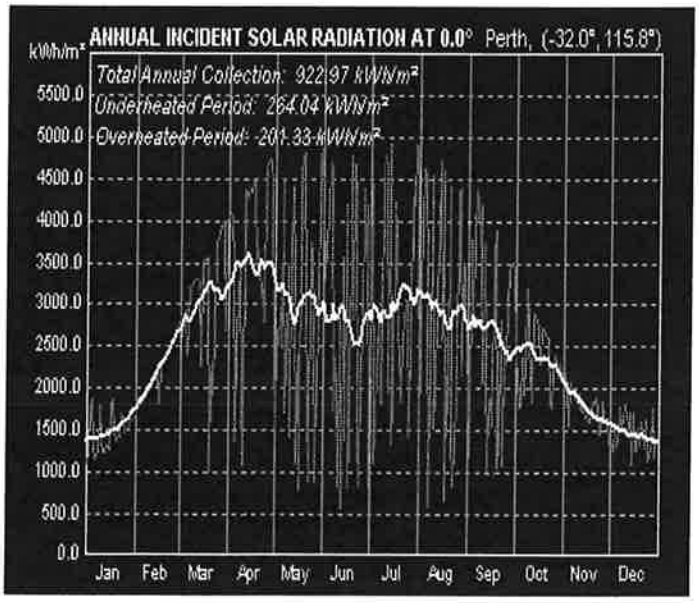
WEATHER DATA

It is always useful to see the variation in Sun position throughout the year in order to appreciate the need for shading. A sun-path diagram can be generated for any location from its latitude, longitude and time-zone. Of more importance, however, is the ability to relate aspects of the climate data to the position of the Sun, to see where the Sun is when it is the hottest or during the strongest winds, etc.



WEATHER DATA

Additionally, the effects of orientation on incident solar radiation are also very important at a pre-design phase. Given hourly data for both direct and indirect solar radiation, it is a relatively simply matter to determine total annual solar collection. However, the design aim is slightly more complex as in most climates it is desirable to minimize solar collection during summer, when it is usually too hot anyway, and maximize it in winter to provide additional heating. To do this effectively, the seasonal variation in incident solar radiation must be visualized.



Optimum Orientation

OPTIMUM ORIENTATION

Three values are stored for each angle, the average daily radiation taken over the whole year, over the coldest 3 months and over the warmest 3 months. These three values can then be plotted on a polar graph where the radius of any point from the centre represents the incident radiation value.

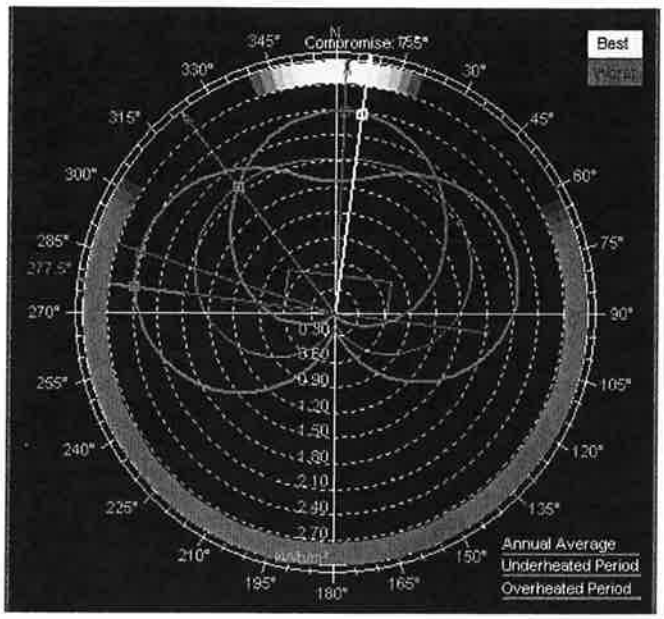
The most favourable orientations occur where the amount of incident radiation in winter is greater than that incident in summer, where the blue line extends out beyond the red line. However, it is also desirable to provide as much protection from the maximum summer radiation as possible. Hence the **optimum orientation** provides maximum winter collection with maximum summer protection which, assuming the building is roughly orthogonal, involves a trade off between the two based on the relative amounts of heating and cooling stress in the climate. Thus, in the graph above, the compromise angle is not exactly at the point of maximum winter collection, but slightly to the east in order to 'turn away' slightly from the hot afternoon sun in summer.

This calculation is available in the Weather Tool by clicking the **Best Orientation...** button in the **Solar Position** panel. You should try a few different climates, especially Kuala Lumpur in Malaysia as its solar radiation distribution is markedly asymmetrical.

OPTIMUM ORIENTATION

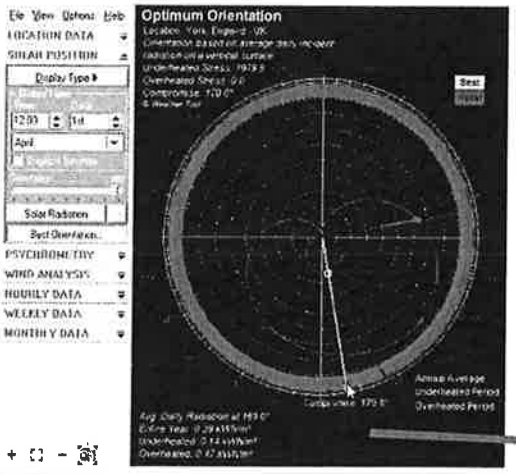
Another important aspect that affects building performance is orientation. An effective passive solar heating design assumes that the building is orientated to receive as much solar radiation as possible in winter, when heating is required, whilst rejecting as much as possible in summer when it is not.

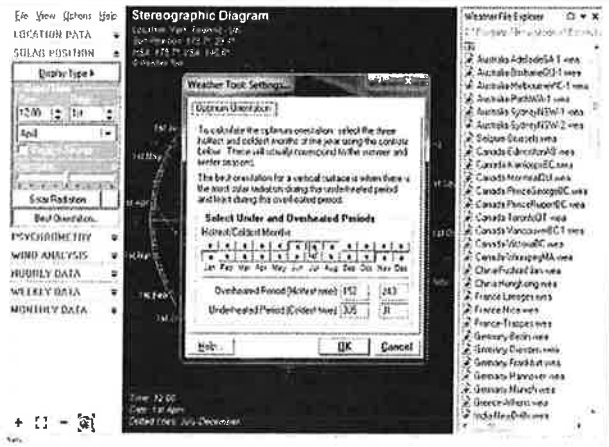
To derive the most effective orientation, the Weather Tool calculates the amount of solar radiation incident on a 1m² vertical surface for each 5° of orientation angle.



OPTIMUM ORIENTATION

You will get to see this pop up after you clicked **Best Orientation.** →





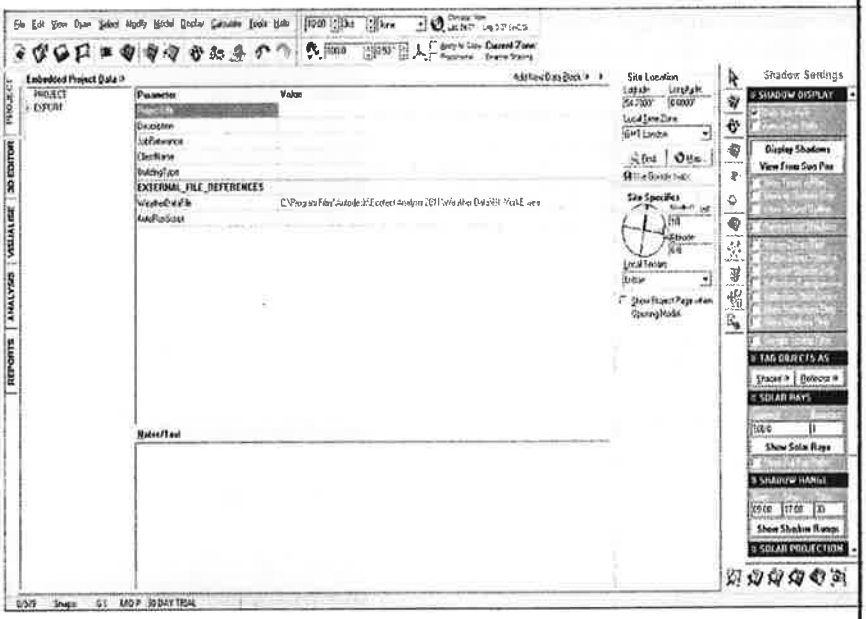
Click **OK** and you will need to wait for about few seconds. You will get to see the best orientation.



170 degree from North
10 degree from South

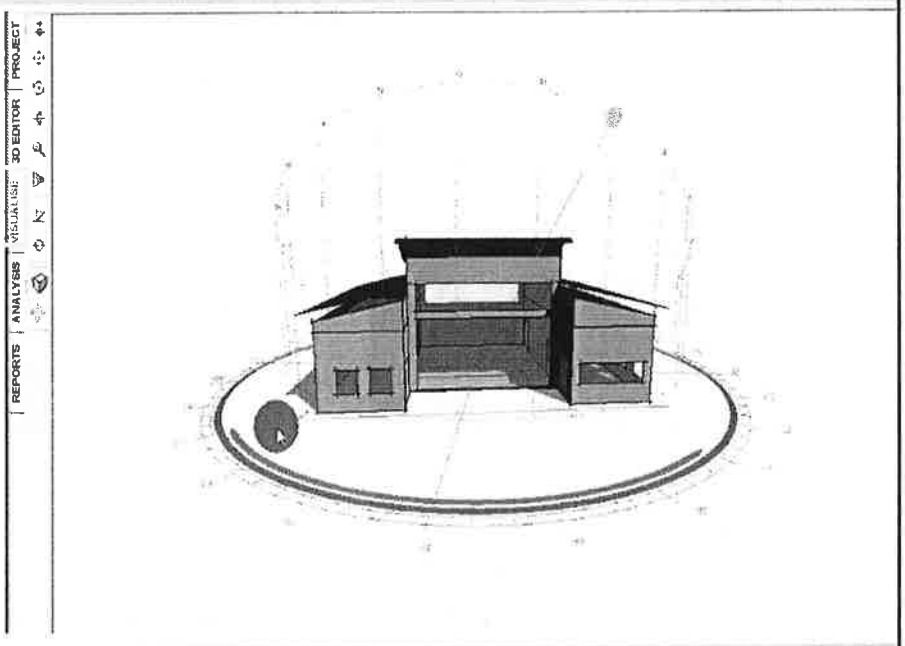
OPTIMUM ORIENTATION

Go to **PROJECT** tab and change the **Site Specific North Offset** to 10



OPTIMUM ORIENTATION

Go to Visualize and you should see your building had changed orientation.



OPTIMUM ORIENTATION

TASK 13:

Find out the optimum orientation for task 2.

Solar Radiation

SOLAR RADIATION

1. Turn on the display of the analysis grid it is currently configured to cover the entirety of your building.
Go to the Calculate menu, and select the *Solar Access Analysis...* menu item.

2. The following wizard dialogue box appears, presenting a series of options on how solar availability can be analysed. Any of these options will provide some kind of information on solar availability, such as number of daylight hours, watt hours, megajoules per square metre, or as percentage values. Select the *Shading, Overshadowing and Sunlight Hours* radio option and then click Next.

3. Specify the calculation period for the solar availability this can be for a specific date and time, the current day (as set in the model), or for a particular time period.

SOLAR RADIATION

4. The analysis values for the period can be displayed in a number of ways, such as cumulative, average or peak values. When calculating solar availability, read carefully how each of period based values are calculated, and then select the most appropriate option for your needs. For this tutorial, select the *Cumulative Values* radio option, and then click Next.

5. The next wizard dialogue box screen determines whether model object or the analysis grid is used for the solar availability analysis. As this is meant to be a tutorial about calculating solar availability over the analysis grid, select the *Analysis Grid* radio option. Click Next to continue.

SOLAR RADIATION

6. Overshadowing will obviously have an impact on the level of solar availability. ECOTECT can calculate overshadowing in one of two ways using existing shading masks calculated as part of the interzonal adjacency checking process, or 'onthefly' as part of the solar access analysis calculation. As we are using an analysis grid to display the results, only the second option applies. Use the slider and dropdown box to specify the level of accuracy for the shading calculation, and then click Next.

7. The final wizard screen summarises the selections made. Make any adjustments if necessary, and then click Ok to commence the solar availability analysis.

SOLAR RADIATION

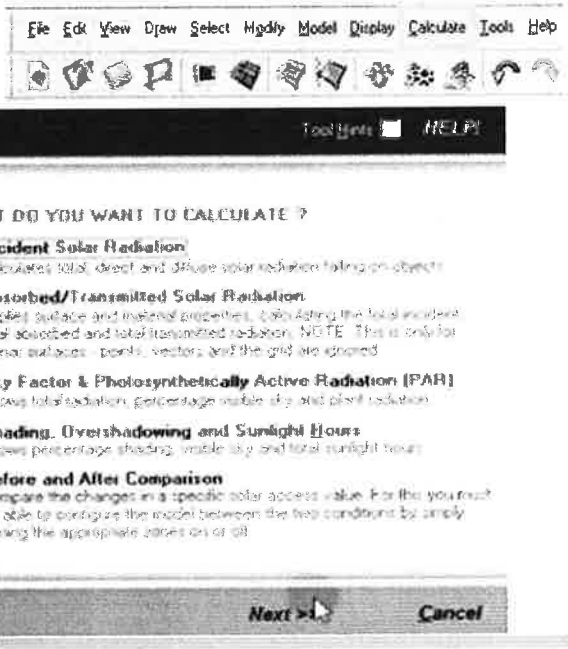
8. ECOTECT commences the analysis process, which should take a few minutes. When complete, the results are displayed across the analysis grid according to the settings you specified in the wizard.

Useful Tips

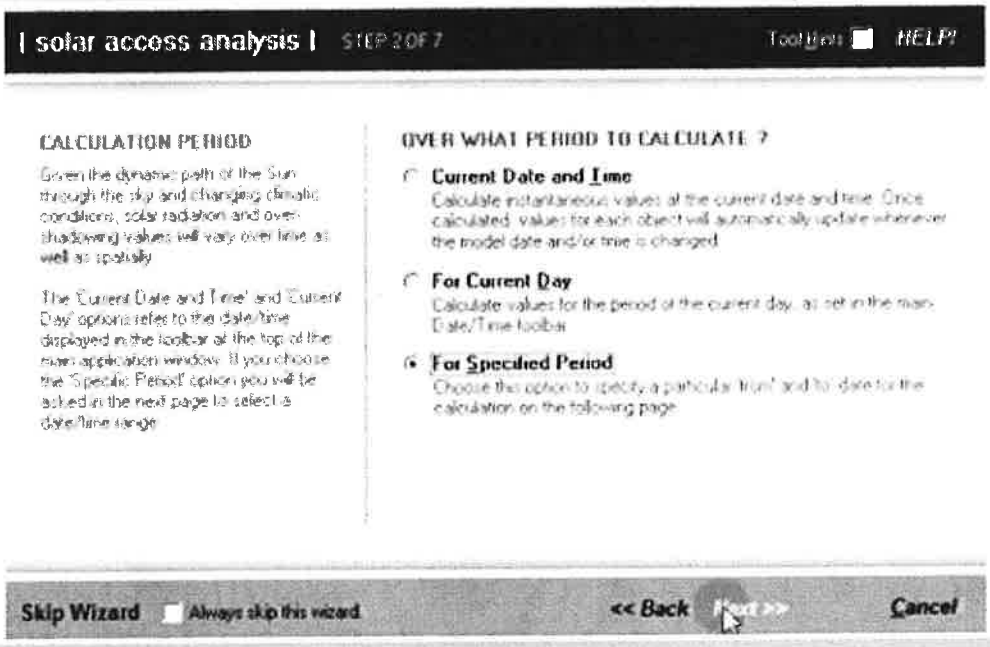
When selecting the analysis grid option in the wizard, there is a suboption *use full 3d extents of analysis grid.* If checked, this calculates the results of the analysis grid in three dimensions, showing multiple levels of data. This can be useful for examining changes in solar availability at different heights, for example. Note, however, that not all types of data can be displayed on a 3D analysis grid, such as direct and diffuse radiation.

SOLAR RADIATION

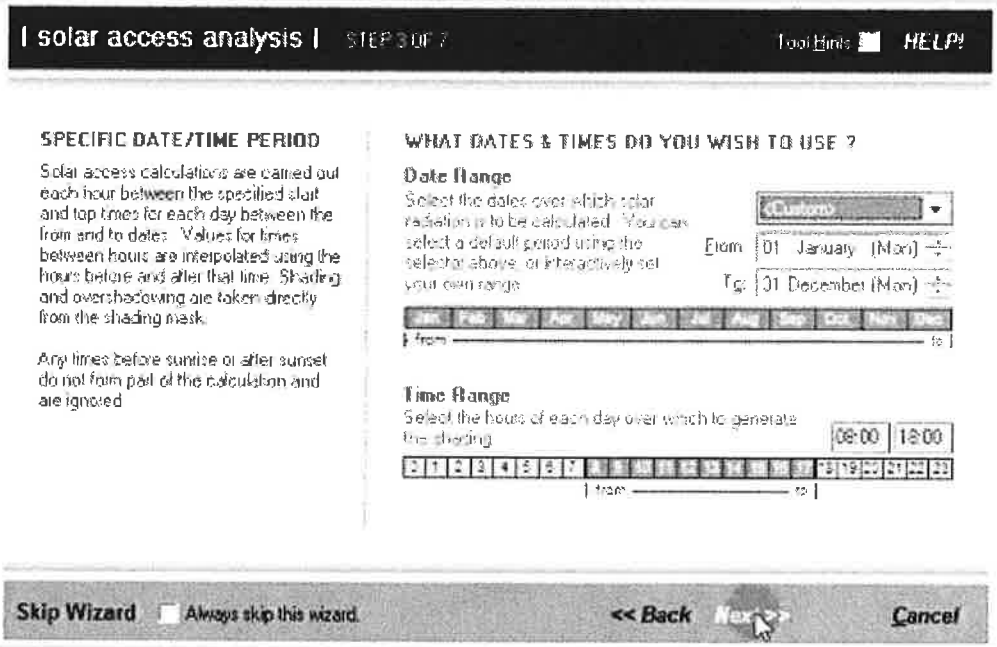
Go to **Calculate → Solar Access Analysis**



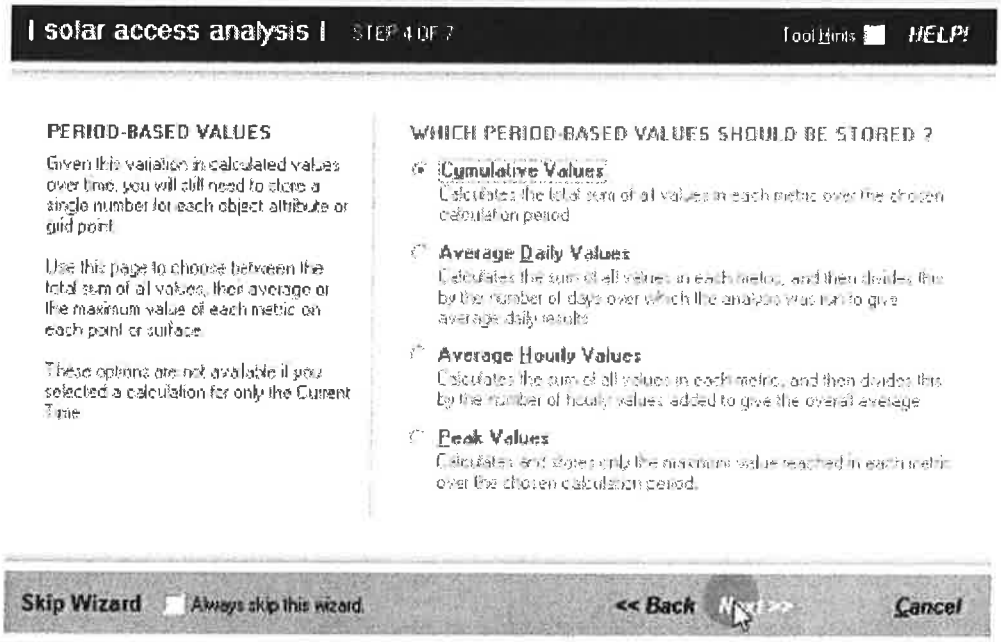
SOLAR RADIATION



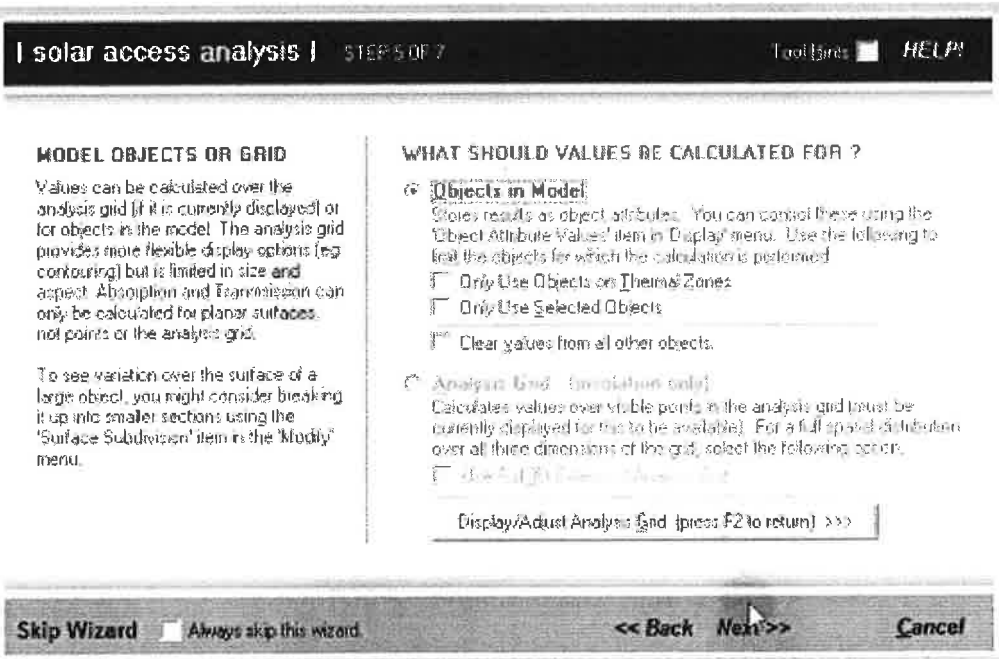
SOLAR RADIATION



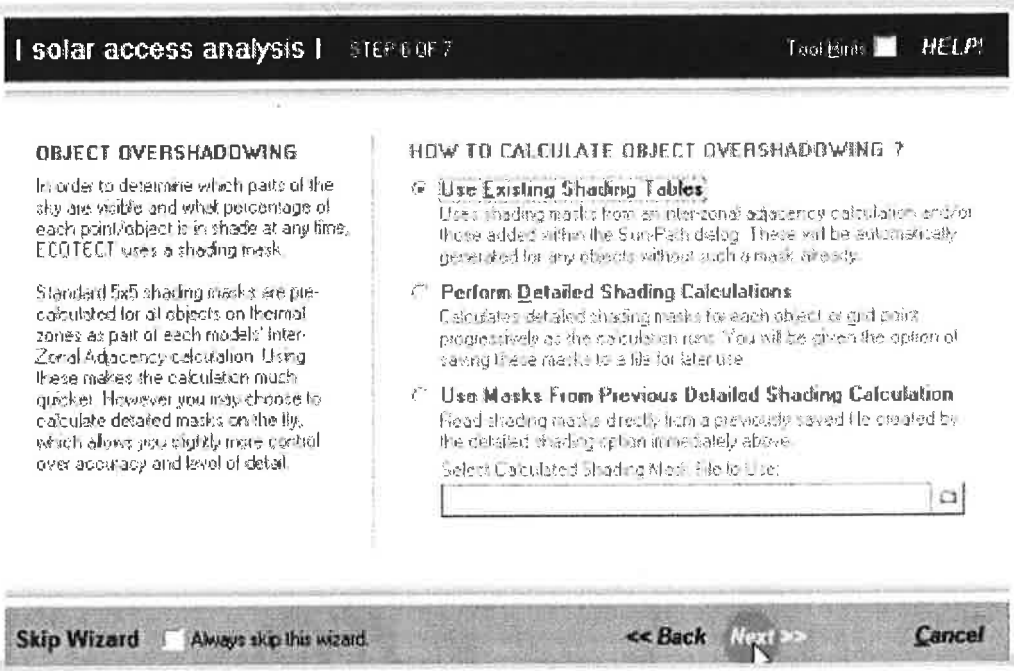
SOLAR RADIATION



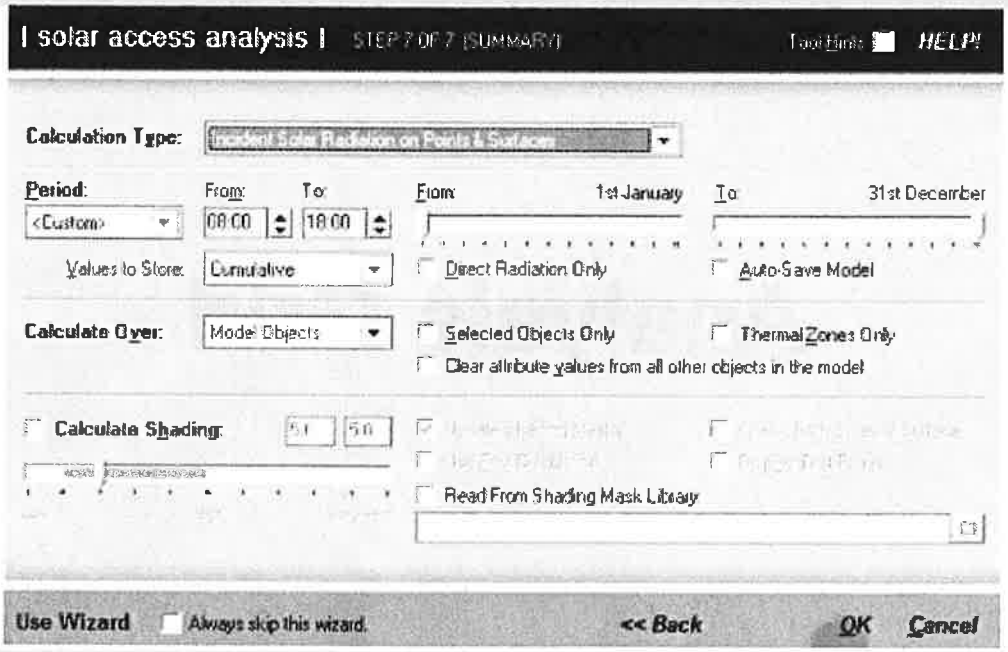
SOLAR RADIATION



SOLAR RADIATION

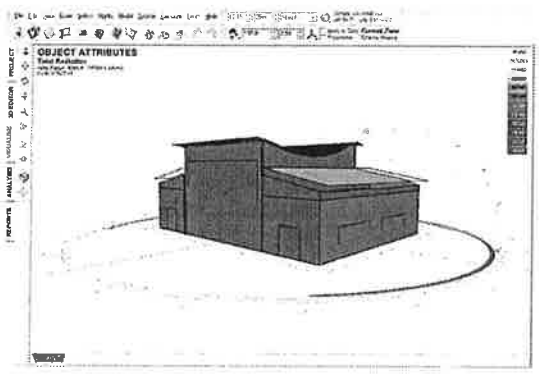


SOLAR RADIATION

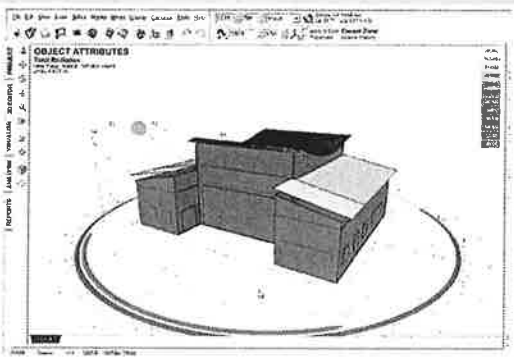


SOLAR RADIATION

The building for the front is a lot warmer then the back. By identifying the color and countercheck with the Wh/m² that stated at the right side.



Back



Front

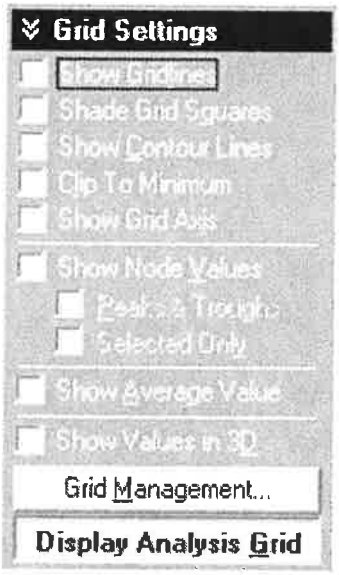
Next we will be finding the best orientation for this building to reduce the Wh/m².

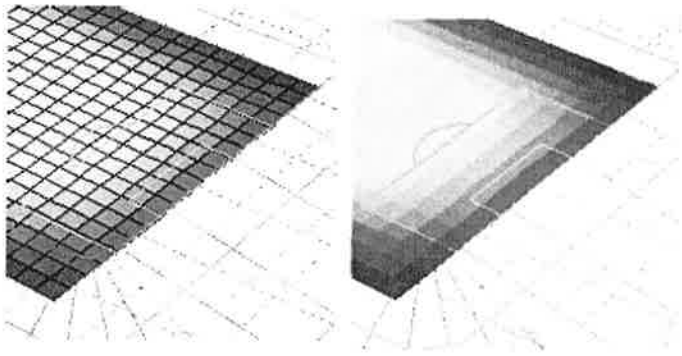
Analysis Grid

ANALYSIS GRID

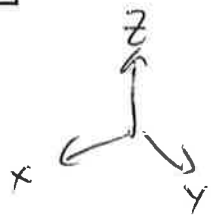
1. in the Analysis Grid panel, click on the Display Analysis Grid button.
2. Most of the basic settings that control the display of the analysis grid can be found under the *GridSettings* section of the panel. Let's examine these one by one to see what impact t hey have on the analysis grid display.
3. The *Show Gridlines* checkbox toggles the display of the lines between each grid cell.
4. The *Shade Grid Squares* checkbox toggles the display of each grid cell as a colourfilled block. The colour corresponds to the scale shown in the topright of the 3D Editor canvas.

ANALYSIS GRID





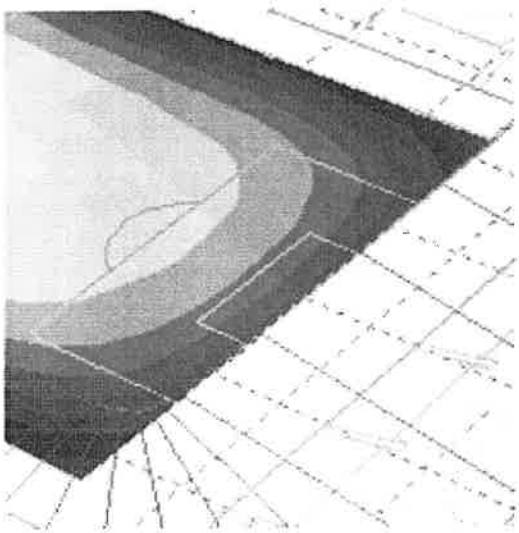
Gridlines on. Gridlines off



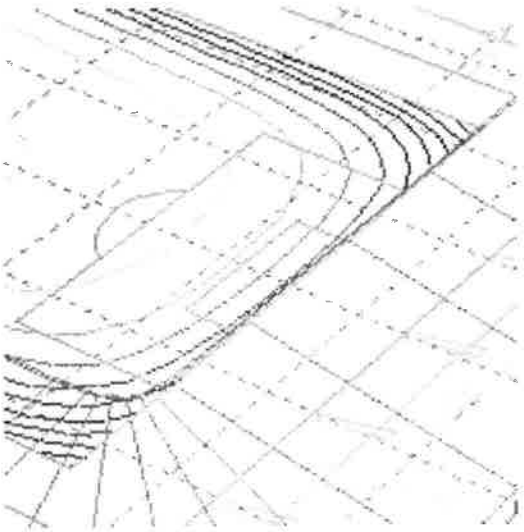
ANALYSIS GRID

5. *Show Contour Lines* displays values as a series of contours over the grid. The range and increment of contours can be specified under the *Grid Data_Scale* section of the panel. If *Shade Grid Squares* option is also checked, the contours are shown as coloured bands instead of lines. Contour bands provide a smoother visualization of the analysis grid values, as opposed to the fixed size of the grid cells.

ANALYSIS GRID



With Shade Grid Values On.

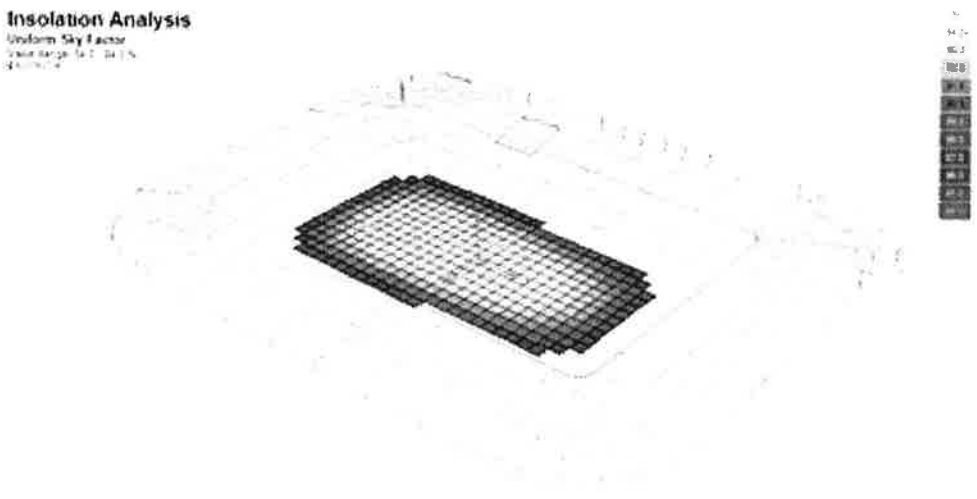


With Shade Grid Values Off.

ANALYSIS GRID

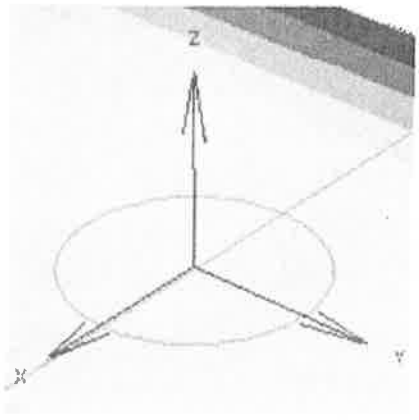
6. The *Clip to Minimum* checkbox is used in conjunction with the *Minimum* value field under the *Grid Data_Scale* section of the panel. When checked, values below the specified minimum value are not displayed on the analysis grid. Click the *Fit scale to values* button to reset the minimum and maximum values for the analysis grid.

ANALYSIS GRID

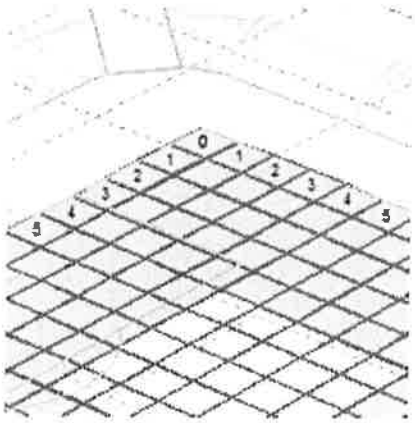


ANALYSIS GRID

7. *Show Grid Axis* displays a 3D axis around the grid with units. If neither the *Show Gridlines* or *Shade Grid Squares* options are selected, the axis shows the actual cell indexes in each direction.



Grid Axis visible.

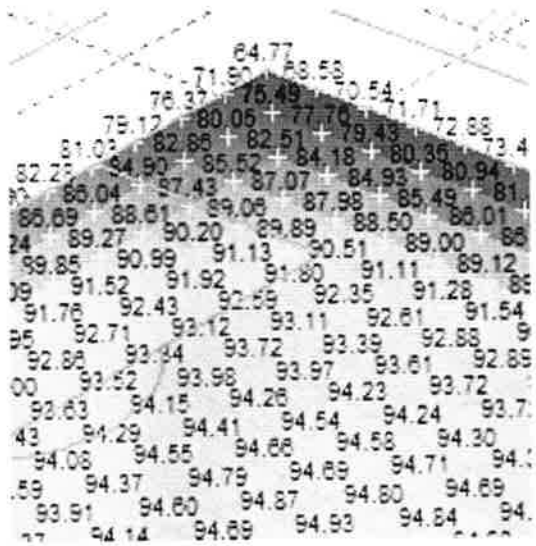


Cell index.

ANALYSIS GRID

8. The *Show Node Values* checkbox option displays the numeric value currently stored at each grid node. also has two suboptions.
Peaks & Troughs displays the value at a grid node when all surrounding points are either higher or lower (on a relatively smooth grid this usually gives a clearer view than showing all node values).
Selected Only displays values only at grid points that are currently Selected.
Clip to Minimum hides values below the specified minimum from being displayed on the analysis grid.

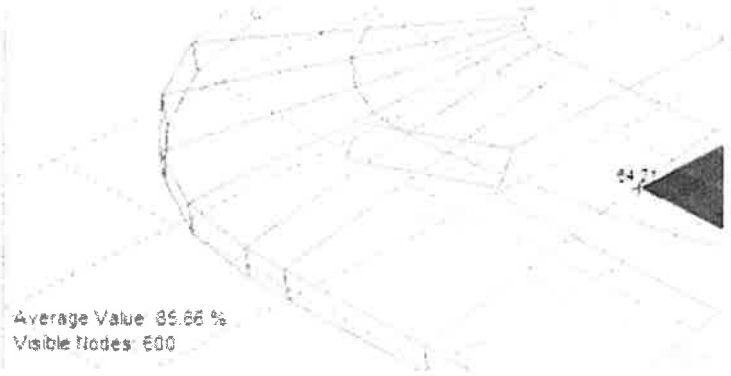
ANALYSIS GRID



Show Node Values. *Peaks*

ANALYSIS GRID

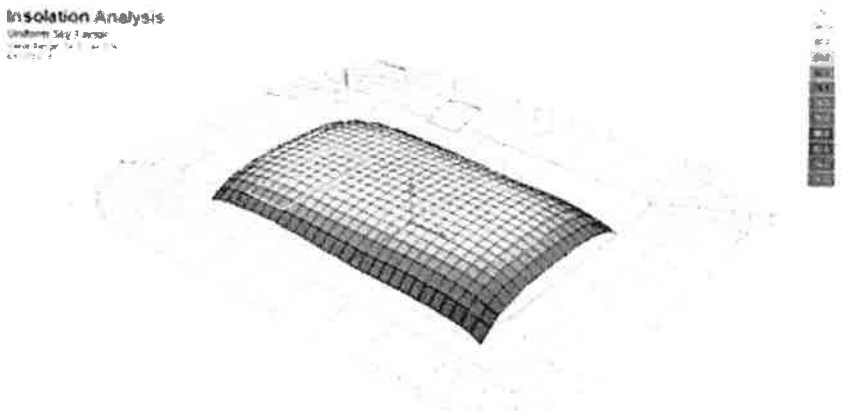
9. When the *Show Average Value* is checked, the average grid value is displayed in the bottom left corner of the *3D Editor* canvas. This is simply the sum of all visible node values divided by the number of nodes summed.



Show Average Value

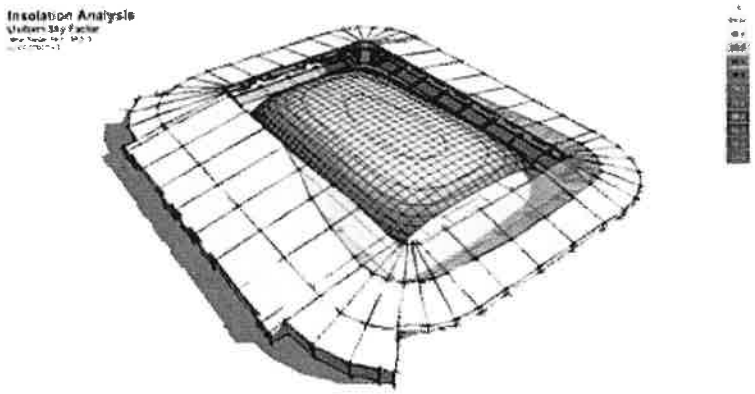
ANALYSIS GRID

10. *Show Values in 3D* displays each point value with an offset based on its value and the current scale. This produces an undulating grid surface as opposed to a flat plane, and assists in providing more visual emphasis to the values of the analysis grid.



ANALYSIS GRID

11. Lastly, many of the analysis grid display options are also visible under the *Visualize* tab. Combined with OpenGL rendering capabilities, compelling images can be created in conjunction with the analysis grid.



ANALYSIS GRID

TASK 14:

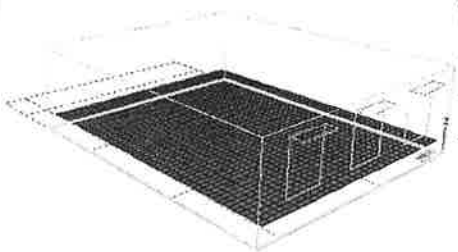
Generate analysis grid for Task 2

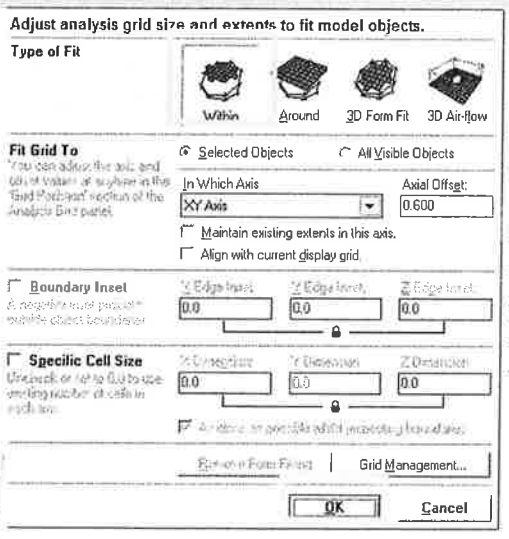
Run solar radiation check on all of building facades

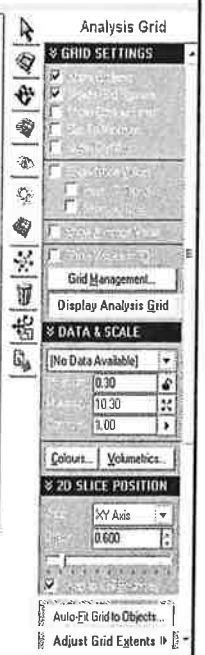
Daylight Analysis

DAYLIGHT ANALYSIS

1) Go to create a **Analysis Grid**
2) Click on **Display Analysis Grid** a default grid will appear in your model.
3) Highlight your floor plane and click **Auto Fit Grid to Objects** choose option **Within** and click **OK**.

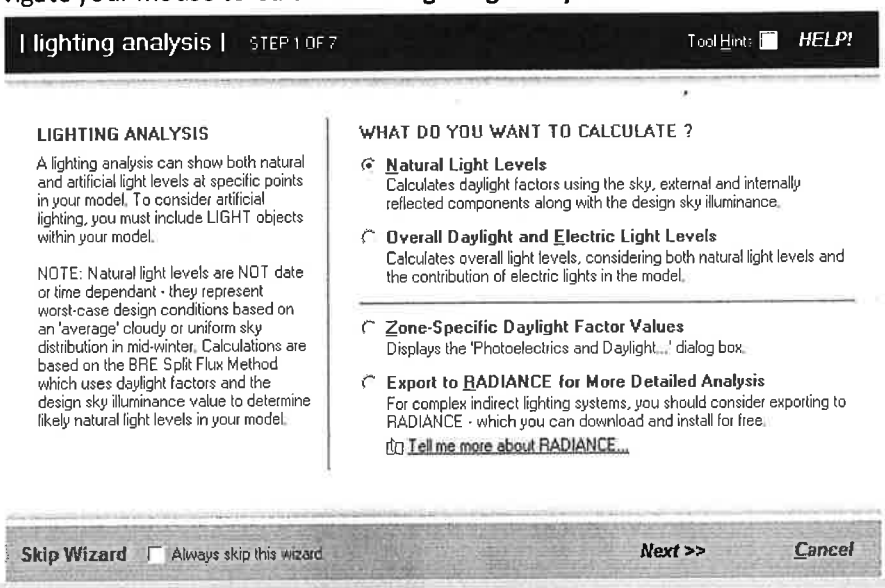




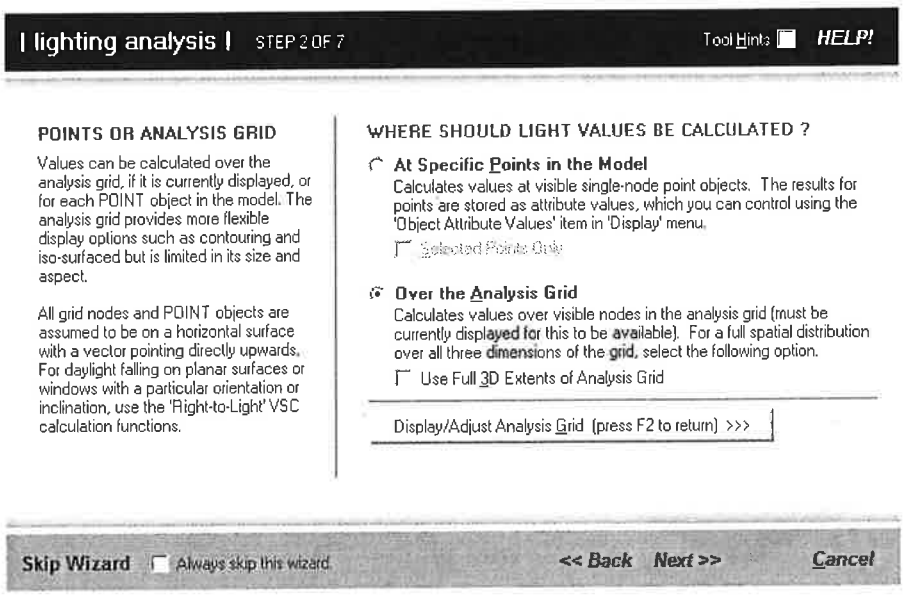


DAYLIGHT ANALYSIS

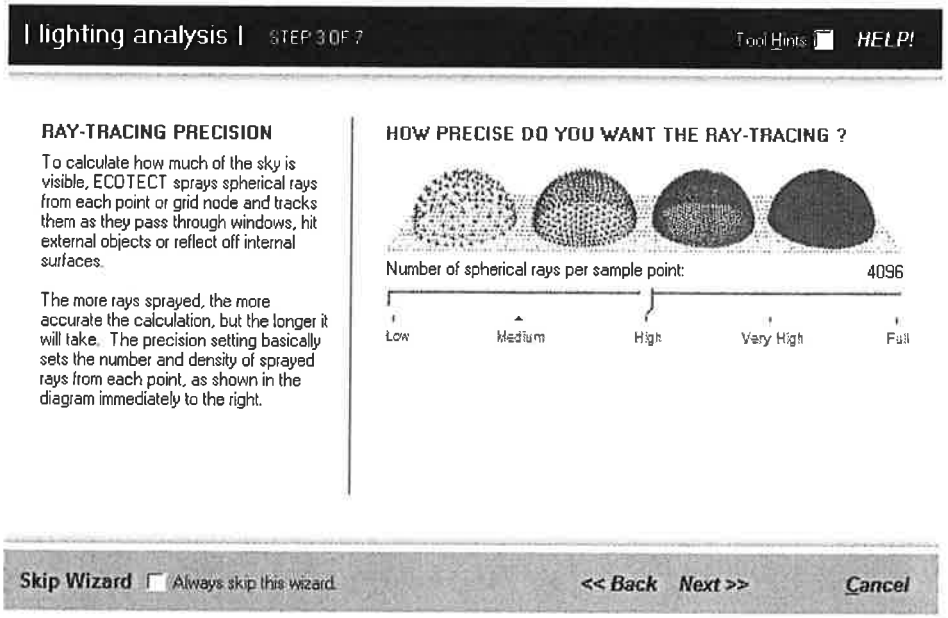
1) Navigate your mouse to **Calculate → Lighting Analysis**



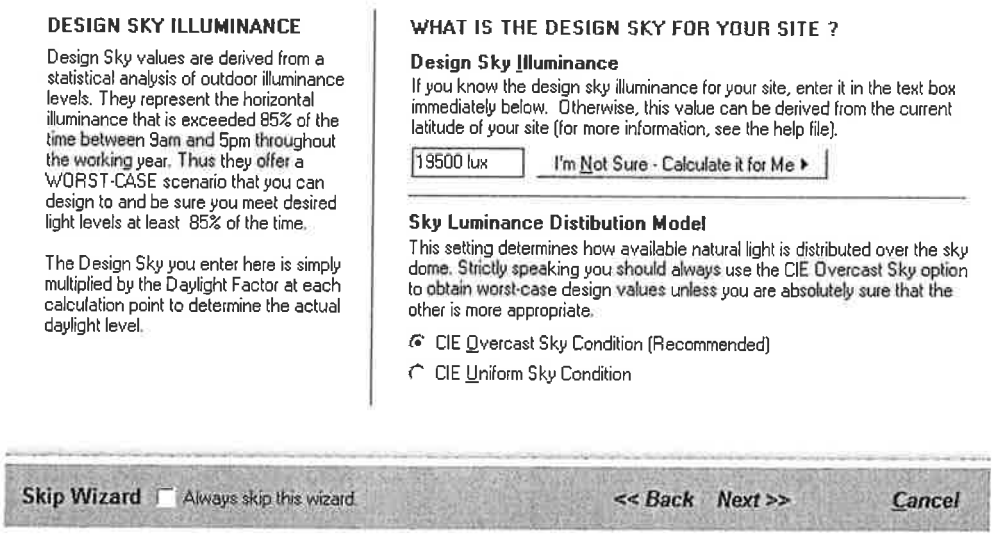
DAYLIGHT ANALYSIS



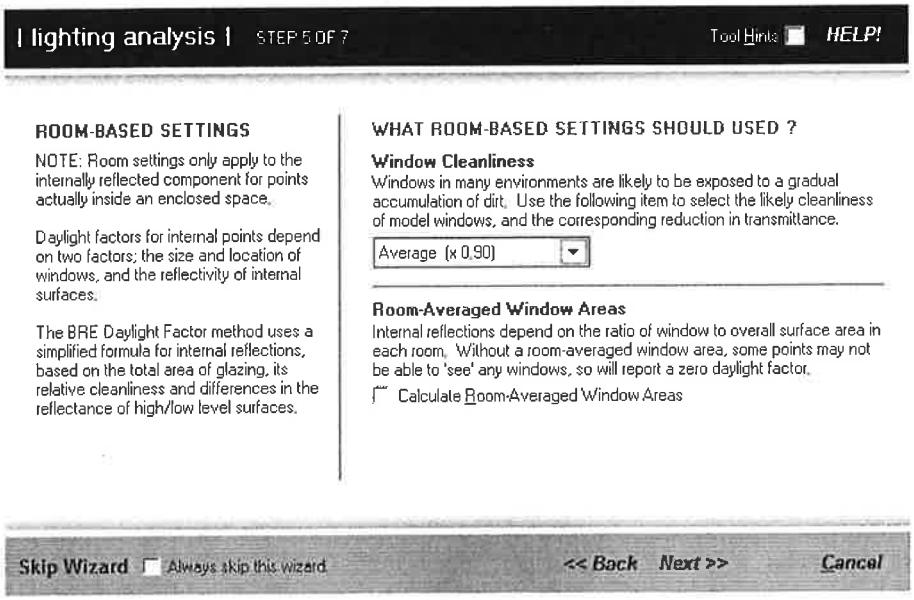
DAYLIGHT ANALYSIS



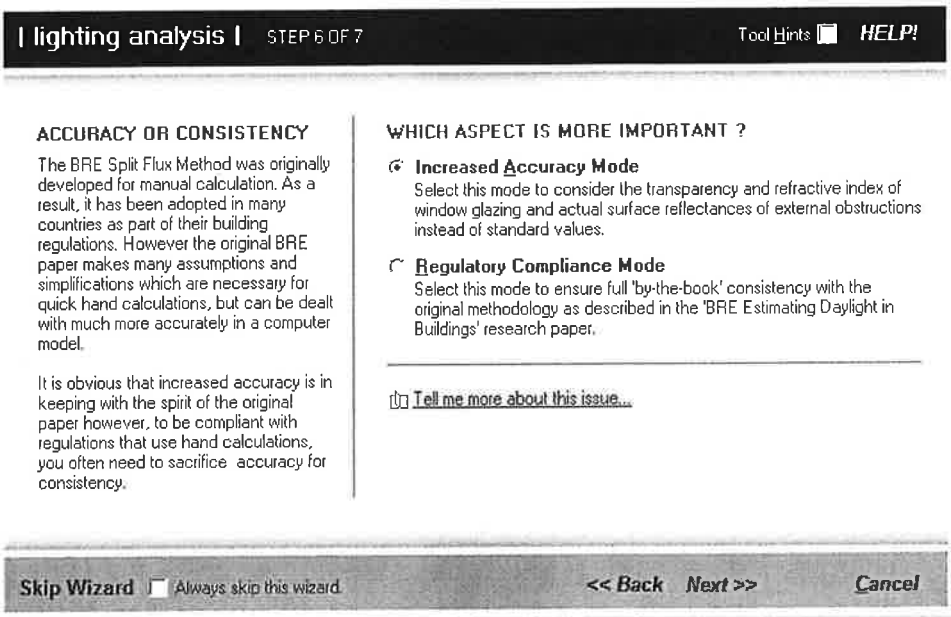
DAYLIGHT ANALYSIS



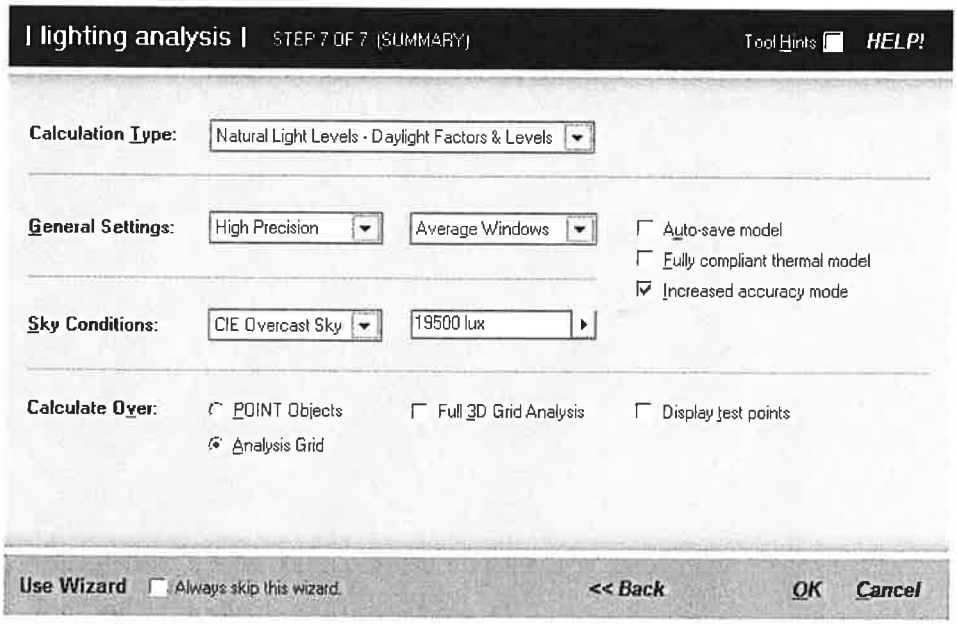
DAYLIGHT ANALYSIS



DAYLIGHT ANALYSIS



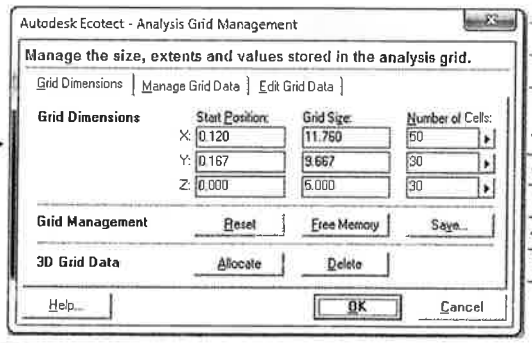
DAYLIGHT ANALYSIS

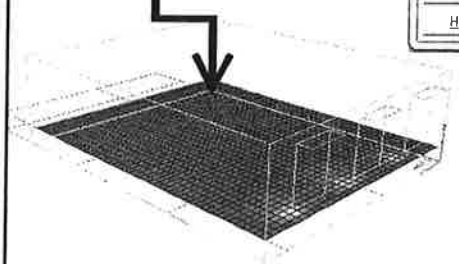


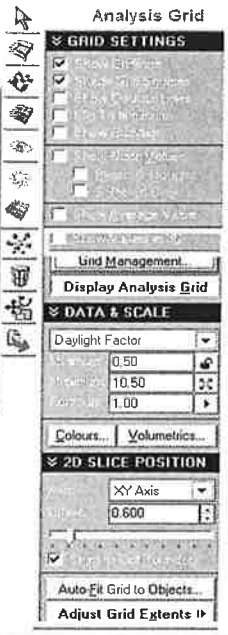
DAYLIGHT ANALYSIS

You may change the cells in the grid by going to **Grid Management** in order to have much detail analysis you will see this pop up

After everything is done you will be seeing something like this.







DAYLIGHT ANALYSIS

TASK 15:

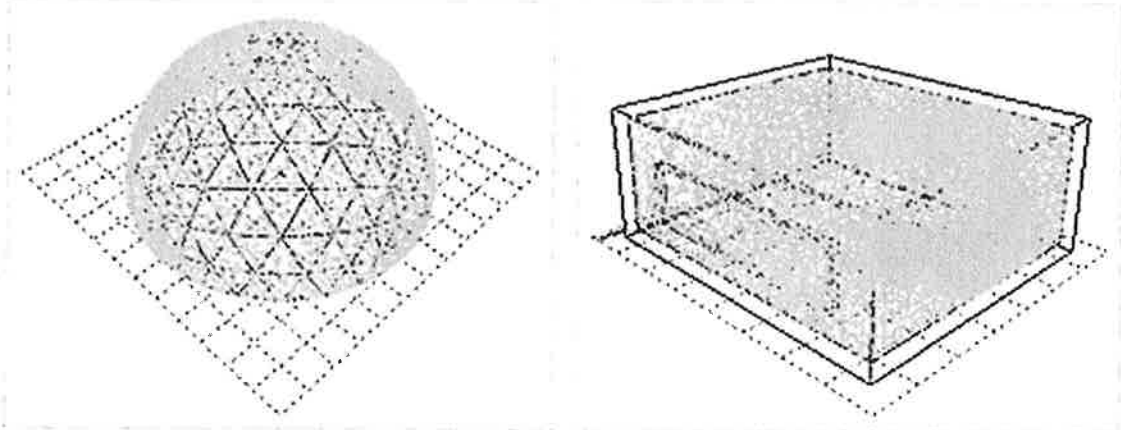
Generate daylight (illuminance level) level on working plan for the first floor of the lowest building

Daylight Factor

DAYLIGHT FACTOR

ECOTECT uses a geometric version of the Split Flux Method as outlined by the UK Building Research Establishment (BRE). This method has it limitations as it is essentially based on a manual method (as explained later) however it is an internationally recognised technique, is quick to calculate and is suitable for most types of conceptual design analysis. For more detailed analysis, ECOTECT allows you to export your model to RADIANCEfor more complex and physically accurate daylight simulation.
ECOTECT's implementation of the Split Flux Method involves spraying a large number of imaginary light rays from each point of interest within the building. These points of interest can be spread out over an analysis grid or created individually as POINT objects within the model. Rays are generated pseudo-randomly but in an even distribution over the sky dome such that they each represent an approximately equal 3D solid angle. The green dots in the next figure each represent a ray intersection point, in this case with a geodesic dome object centred on the analysis point to show the evenness of the distribution, and also within a simple enclosure.

DAYLIGHT FACTOR



The pseudo-random test rays generated spherically during a daylight factor calculation, shown over a hemisphere and within a simple room.

DAYLIGHT FACTOR

TASK 16:

Open file in Task 2
Check the daylight factor at the center of the rooms in the first floor at working plane level

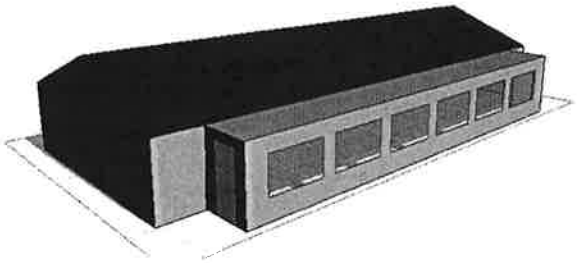
Thermal Analysis

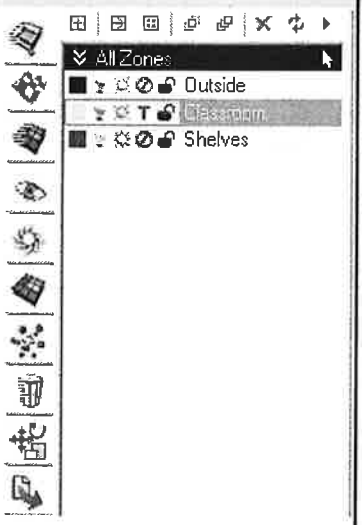
THERMAL ANALYSIS

In order to proceed we need to check each thermal zone display in **Zone Management.**

Make sure those zones that are being occupied in Thermal Zone.

Non Thermal Zones like external shading devices and object do not form a thermal zone





THERMAL ANALYSIS

To determine thermal zones, display the Zone Management panel on the right side of the main window. The images alongside each zone indicate its current state, whether it is hidden/displayed, on/off, locked/unlocked, thermal/nonthermaland its colour.

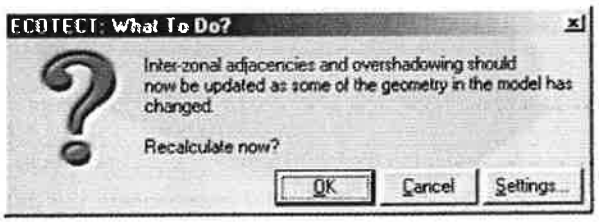
The red T indicates that each zone is thermal. If any zones in your model (other than the Outside zone) is set as nonthermal, simply click the Left Mouse button on the thermal indicator to turn it on.
To make some of the thermal graphs clearer, each zone is assigned a different color.

THERMAL ANALYSIS

Calculating Internal Temperatures

1. From the Calculate menu, select the Thermal Performance... item. Before thermal calculations can be performed, some preprocessing needs to be done on the model to determine interzonal adjacencies and overshadowing tables. These are stored to disk as .ADJ and .SHD files with the same name as the model. If the geometry of the model has changed, ECOTECT will prompt you to recalculate these with the following message box.

2. Click the OK button to recalculate interzonal adjacencies and overshadowing.

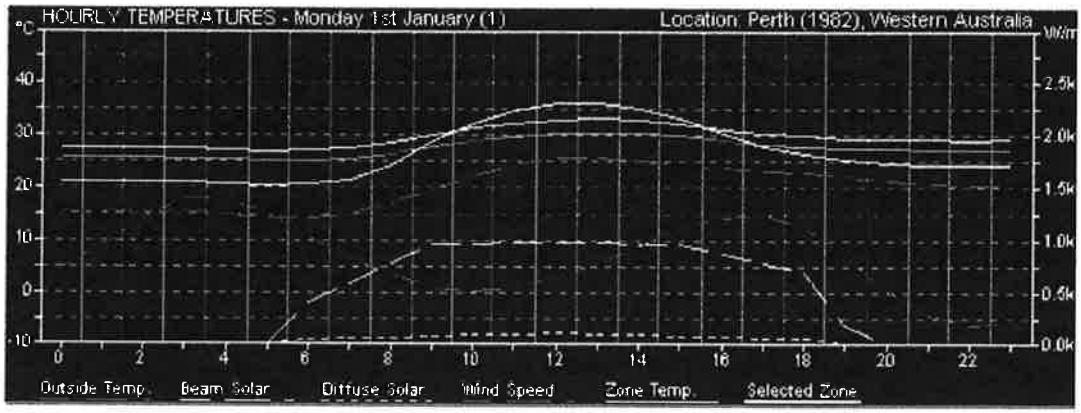


THERMAL ANALYSIS

During this calculation, objects in successive zones will highlight and small dots will appear within some of these. These dots indicate that the object is overlapped by another object on a different zone, an interzonal adjacency. ECOTECT uses the resulting values to determine heat flow between zones at different temperatures and hourly shading during incident radiation calculations.

When these calculations have finished, a graph will be displayed.

THERMAL ANALYSIS



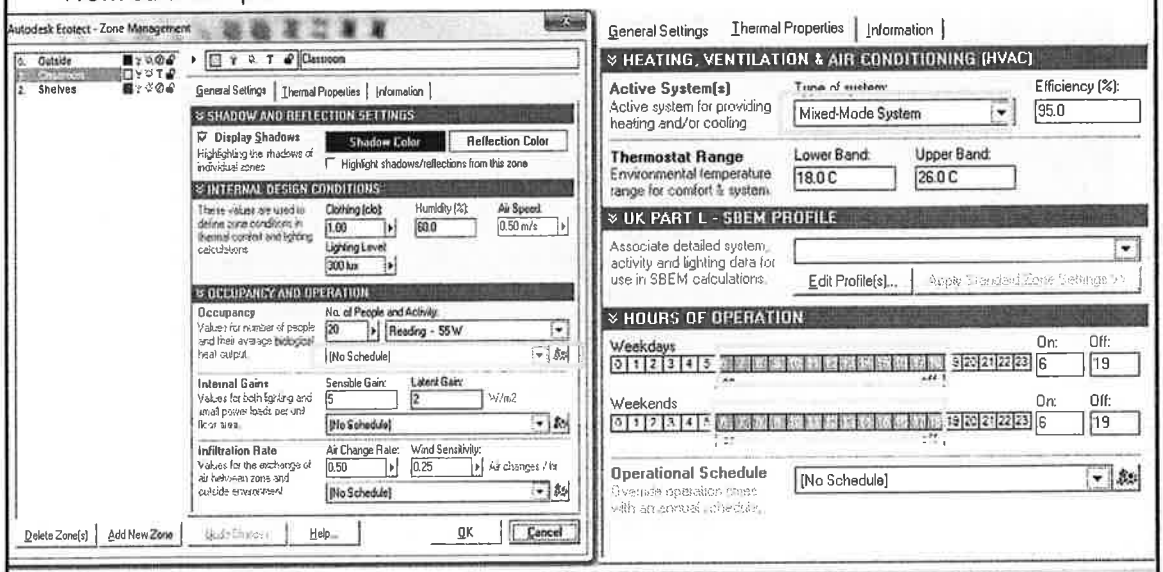
This graph displays the hourly temperature within each zone at the current date (Monday the 1st of January).
The dotted and dashed lines represent the climate data on that day, as shown in the legend immediately below
the graph, whilst the solid colored lines show internal environment temperatures.

THERMAL ANALYSIS

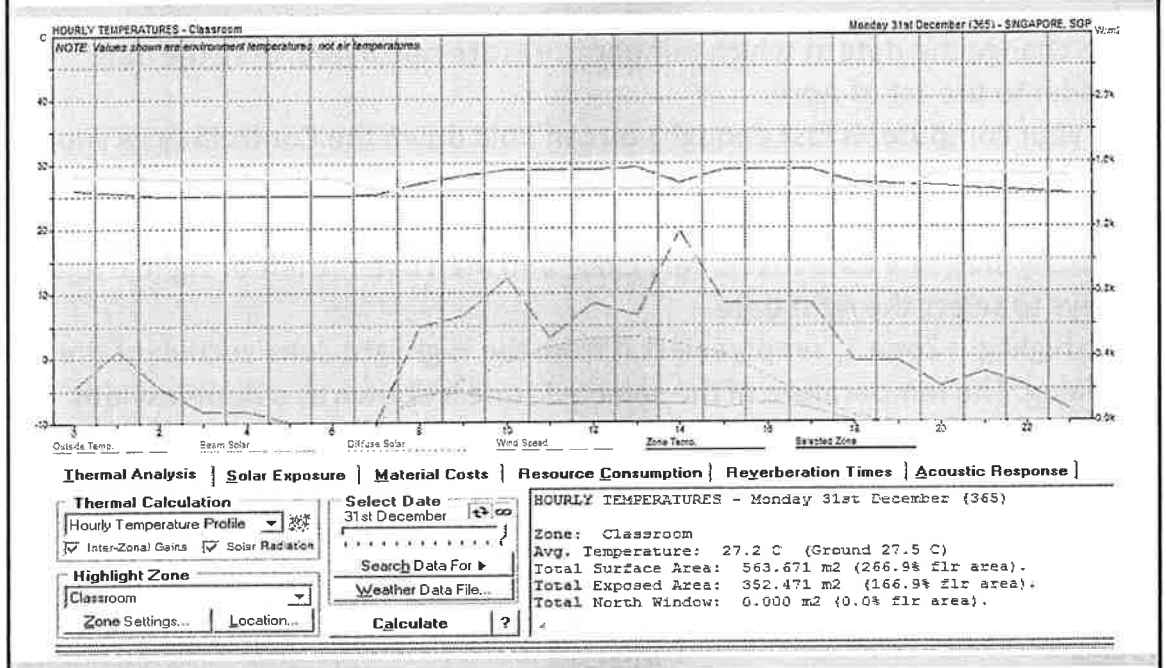
To change the date at which temperatures are calculated, drag the date slider to the 1st of April.
If your computer is fast enough you can hold down the Control key as you drag the slider to automatically update the graph. The size of the slider means that you may not be able to drag directly to the 1st of April. If not, simply drag to a date that is very close and then use the left or right arrow keys to select the right date.
To highlight Zone 1, simply select it from the Highlight Zone section of the dialog. The temperature of the selected zone is shown as a double width line. The red and blue gradients in the graph indicate when the temperature of the zone is above or below its designated comfort range. You can set comfort band values for each zone in the Zone Management dialog box.

THERMAL ANALYSIS

A classroom of 20 people
From 6am till 7pm

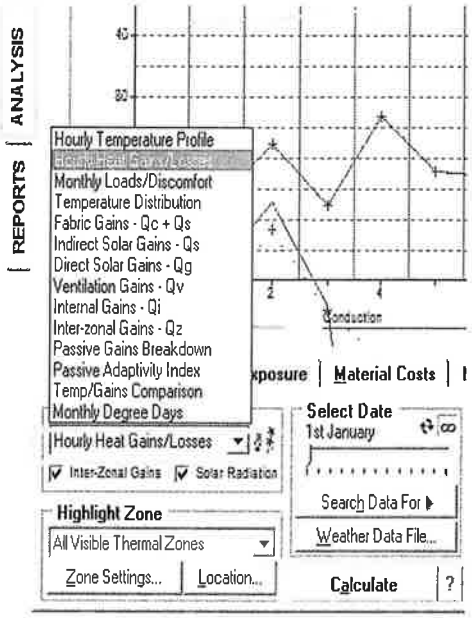


THERMAL ANALYSIS

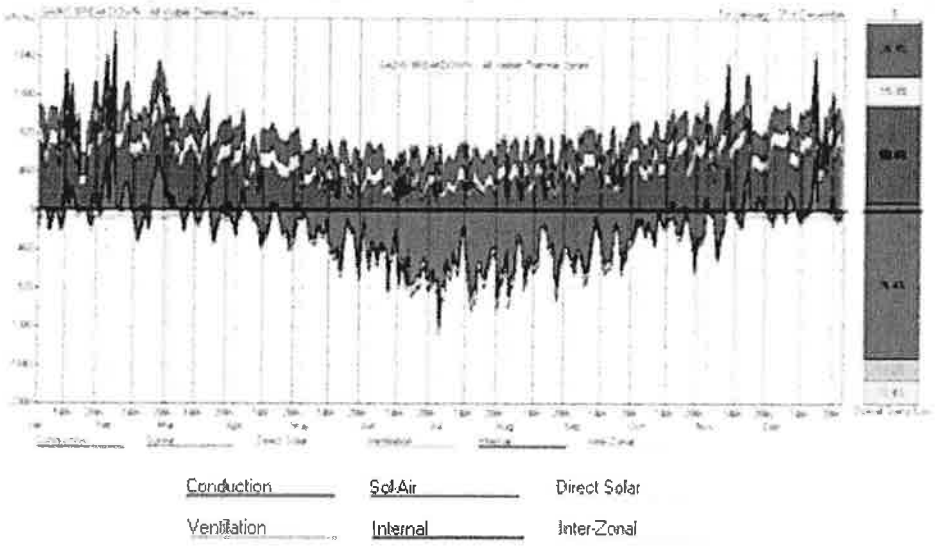


THERMAL ANALYSIS

Analysis Tab → Thermal Analysis→ Thermal Calculation→ Hour Heat Gain/Losses→ Calculate

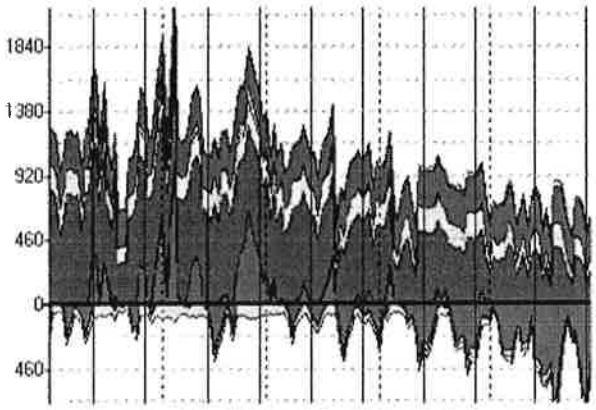


THERMAL ANALYSIS



The passive gains breakdown graph consists of the six heat transfer mechanisms that can occur in a zone.

THERMAL ANALYSIS

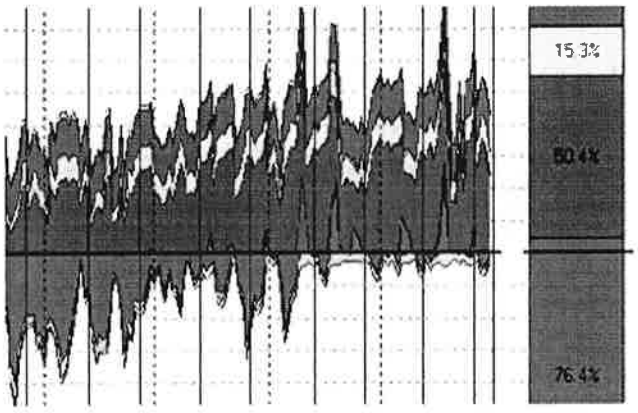


The gains breakdown is measured in Watts per hour per square metre

Conduction | Sol-Air | Direct Solar
Ventilation | Internal | Inter-Zonal

The passive gains breakdown graph consists of the six heat transfer mechanisms that can occur in a zone.

THERMAL ANALYSIS



The gains breakdown is also shown as a series of percentage values, proportional to the overall gains and losses.

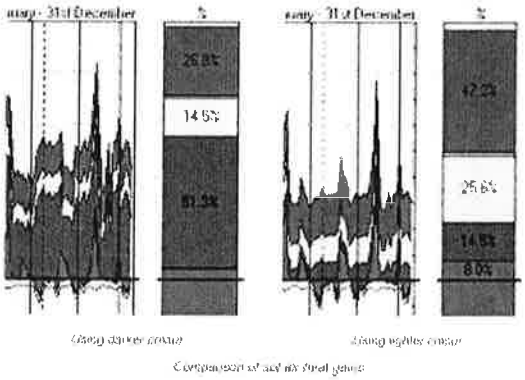
Conduction | Sol-Air | Direct Solar
Ventilation | Internal | Inter-Zonal

The passive gains breakdown graph consists of the six heat transfer mechanisms that can occur in a zone.

THERMAL ANALYSIS

The passive gain breakdown graph shown indicates that the majority of heat gains occur via Sol-air heat transfer, or indirect solar gain. This suggests that changing color of the walls and roof to be lighter should reduce the sol-air gains.

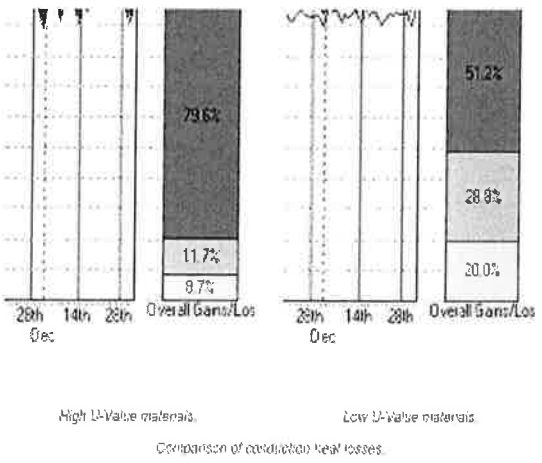
Change the color of the wall and roof elements to white and then recalculate the passive gains breakdown graph. Note how heat gains vial sol-air have reduced from around 50% to around 14%.



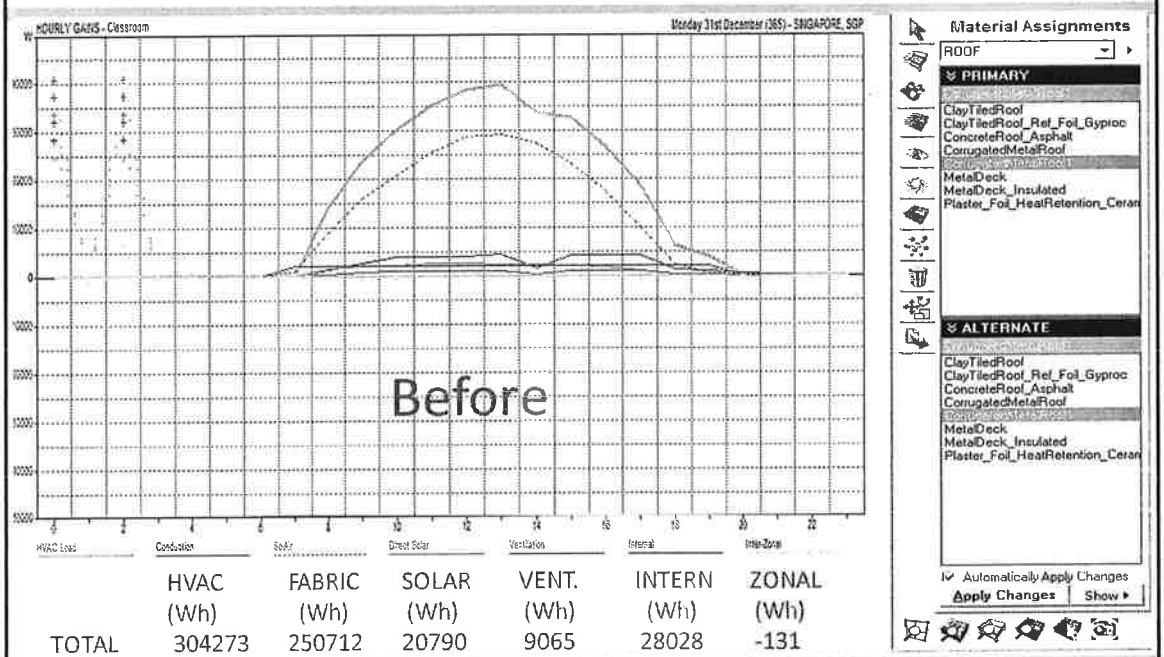
THERMAL ANALYSIS

Majority of heat losses in this example occur via conduction heat transfer, or through the building fabric. This suggests that changing the walls and roof to use materials with low U-Values should reduce these gains.

By changing the wall material, the conduction heat losses are reduced from around 78% to around 51%.

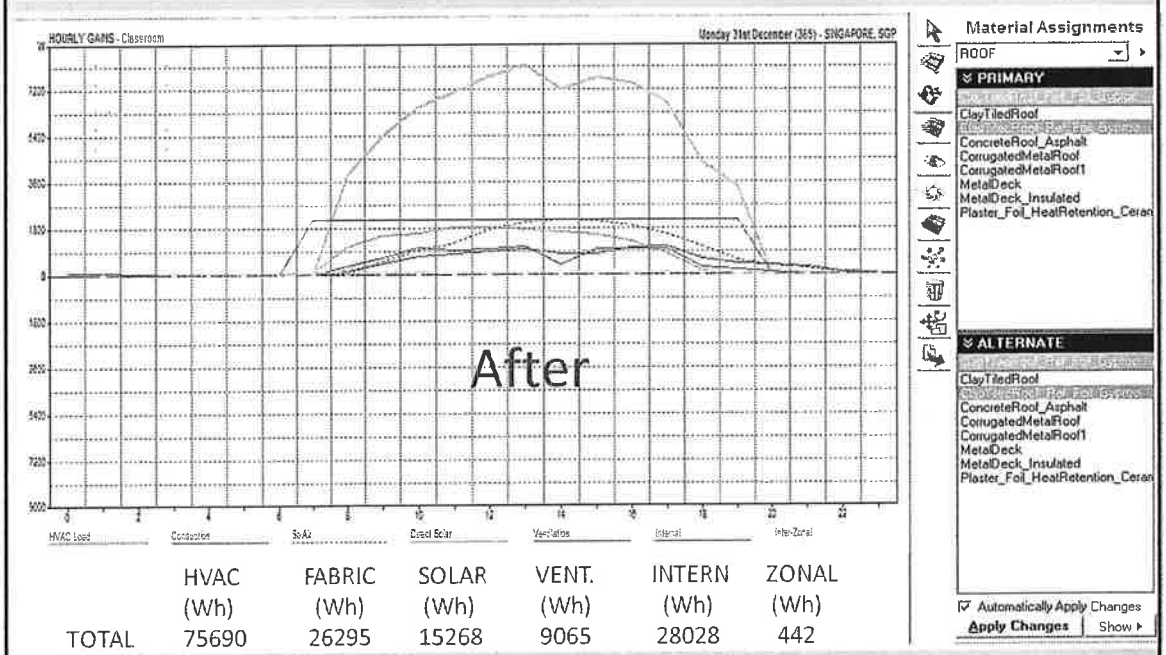


THERMAL ANALYSIS



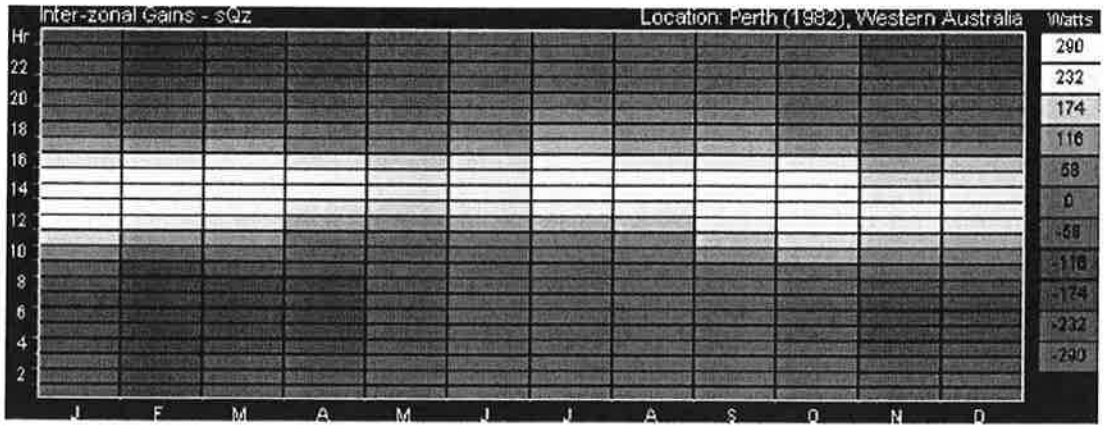
	HVAC (Wh)	FABRIC (Wh)	SOLAR (Wh)	VENT. (Wh)	INTERN (Wh)	ZONAL (Wh)
TOTAL	304273	250712	20790	9065	28028	-131

THERMAL ANALYSIS



	HVAC (Wh)	FABRIC (Wh)	SOLAR (Wh)	VENT. (Wh)	INTERN (Wh)	ZONAL (Wh)
TOTAL	75690	26295	15268	9065	28028	442

THERMAL ANALYSIS



THERMAL ANALYSIS

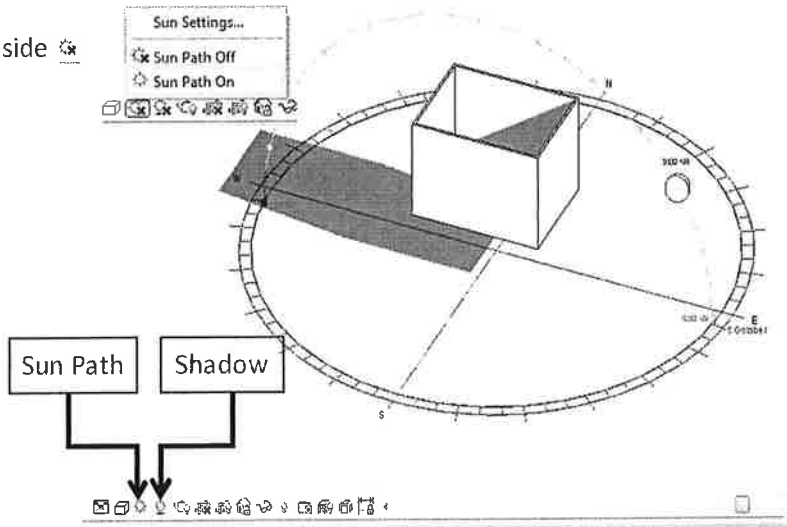
TASK 17:

Open Task 2
Generate thermal analysis
Improve the design to reduce thermal gain by 15% or more.

Integration in Revit

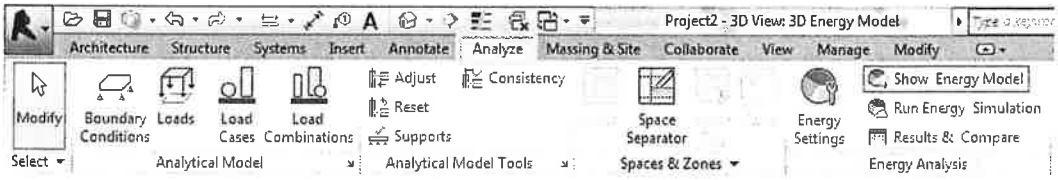
SUN AND SHADOW STUDY

1) Open a model in **Revit**
2) Look for **Sun Path** located at bottom left
3) Click on **Sun Path on**
4) Turn on **Shadow** ☼ beside ☼



ENERGY ANALYSIS

1) Open up Revit
2) Go to **Analysis** tab
3) You will be able to locate **Energy Analysis**



DAYLIGHT

1)Click on the below link
https://apps.autodesk.com/RVT/en/List/Search?searchboxstore=RVT&facet=&collection=&sort=&query=Lighting+Analysis (Figure 1)
2) Go to **Lighting Analysis** and download (Figure 2)
3) Install the Plugin
4) Open your **Revit** and go **Analyze** tab you will see





Figure 1

Figure 2

SOLAR ANALYSIS

1)Click on the below link
https://beta.autodesk.com/callout/?callid=A85F5FB11247411E985ED97605743273 (Figure 1)
2) Click on **JOIN NOW** (You will be ask to sign in or create account)
3) After everything is done you will get to see (Figure 2)
4) Scroll down and go to **Download**
5) Install and run **Revit**

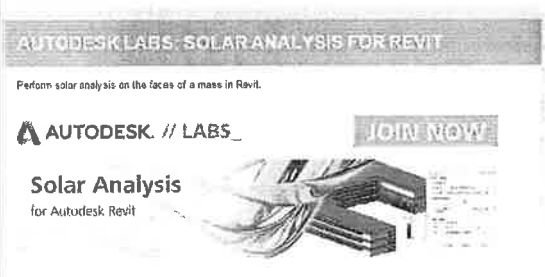


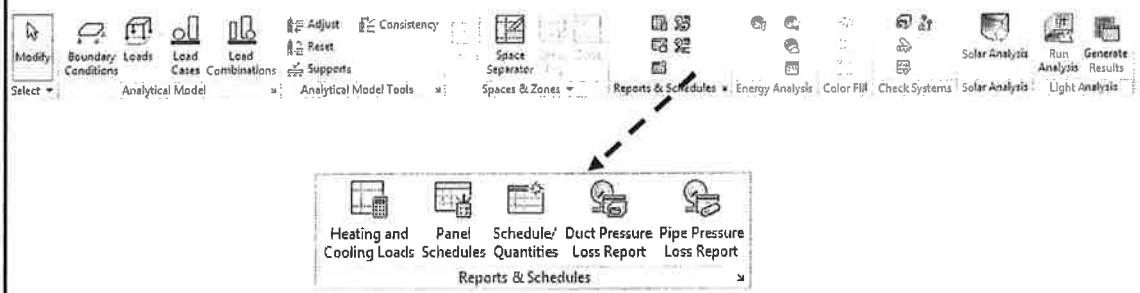
Figure 1



Figure 2

THERMAL PERFORMANCE

1) Go to **Analyze** tab
2) Look for **Reports & Schedules**
3) You will get to see **Heating and Cooling Loads**
4) If Panels are full Click and drag out **Report & Schedules** and you will get to see the individual panel of it



WEATHER DATA

1) Go to **Manage** tab (Figure 1)
2) Click on under **Project Location** (Figure 1)
3) Figure 2 will pop up choose between **Default City List** or **Internet Mapping Service**
4) As **Default City List** let you choose the country you want while **Internet Mapping Service** shows your current location.

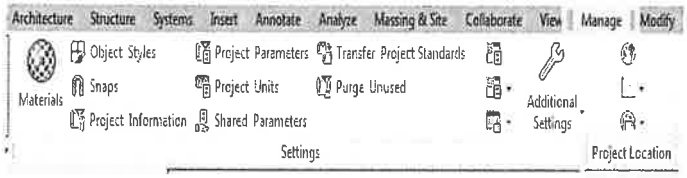


Figure 1



Figure 2

9K358067

Thank You !

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