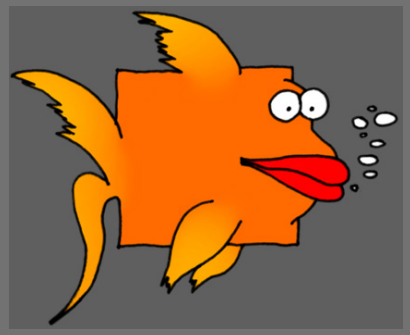
Using RADIANCE for Right-to-Light and Solar Access Studies

3rd International RADIANCE Workshop
Fribourg, 12th October, 2004



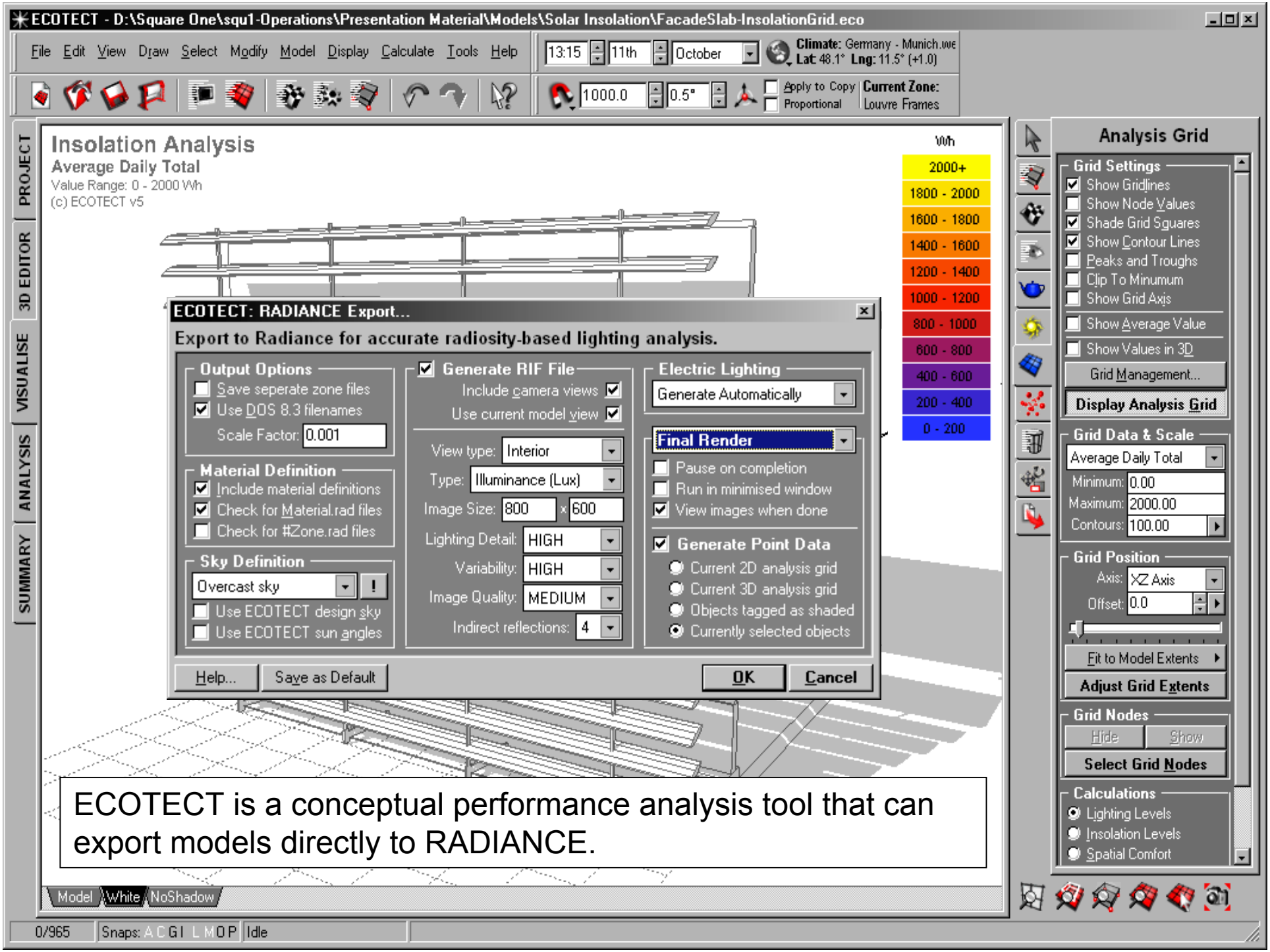
Dr. Andrew Marsh

Research Fellow : Welsh School of Architecture

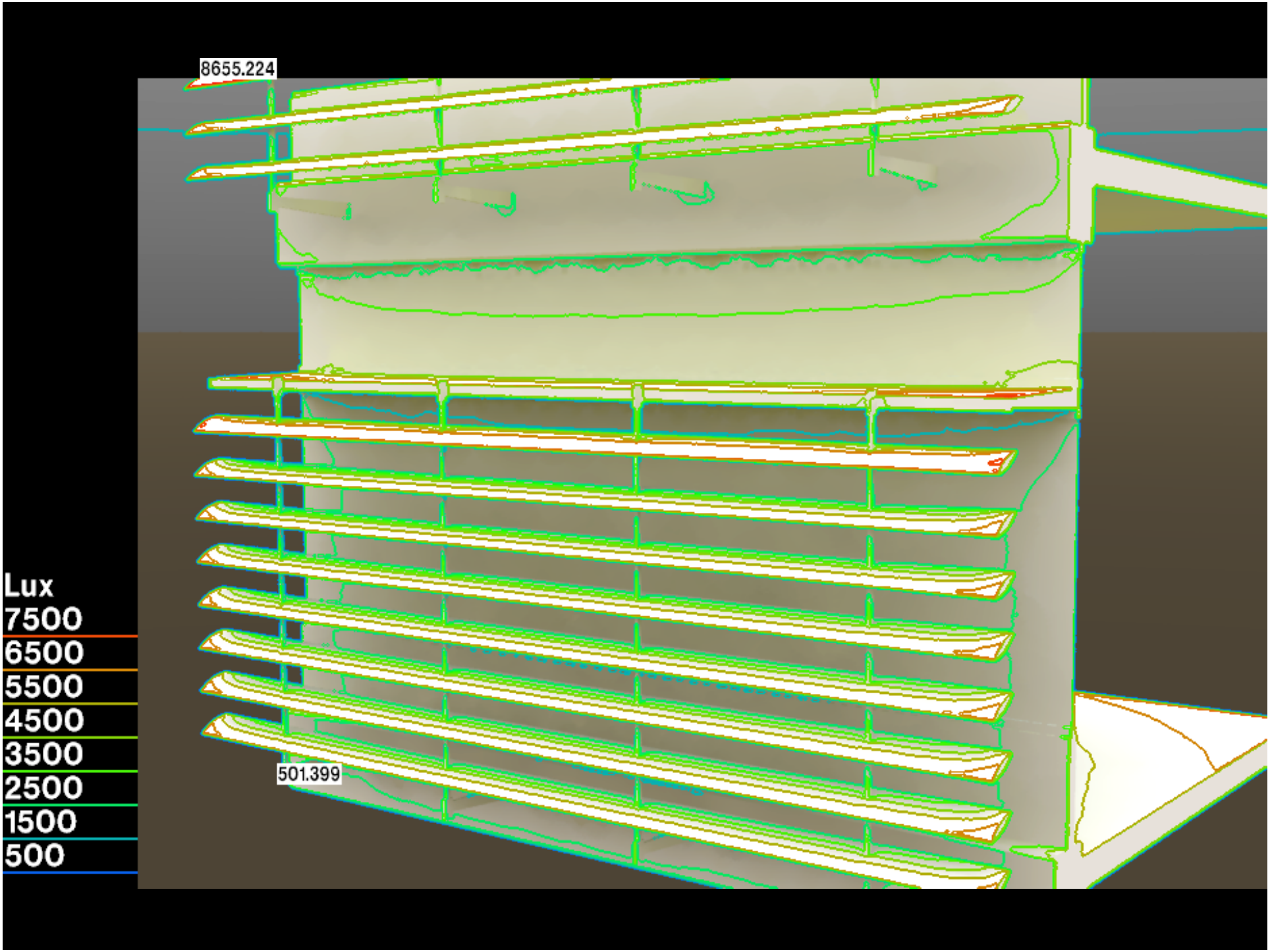
Director : Square One *research* PTY LTD

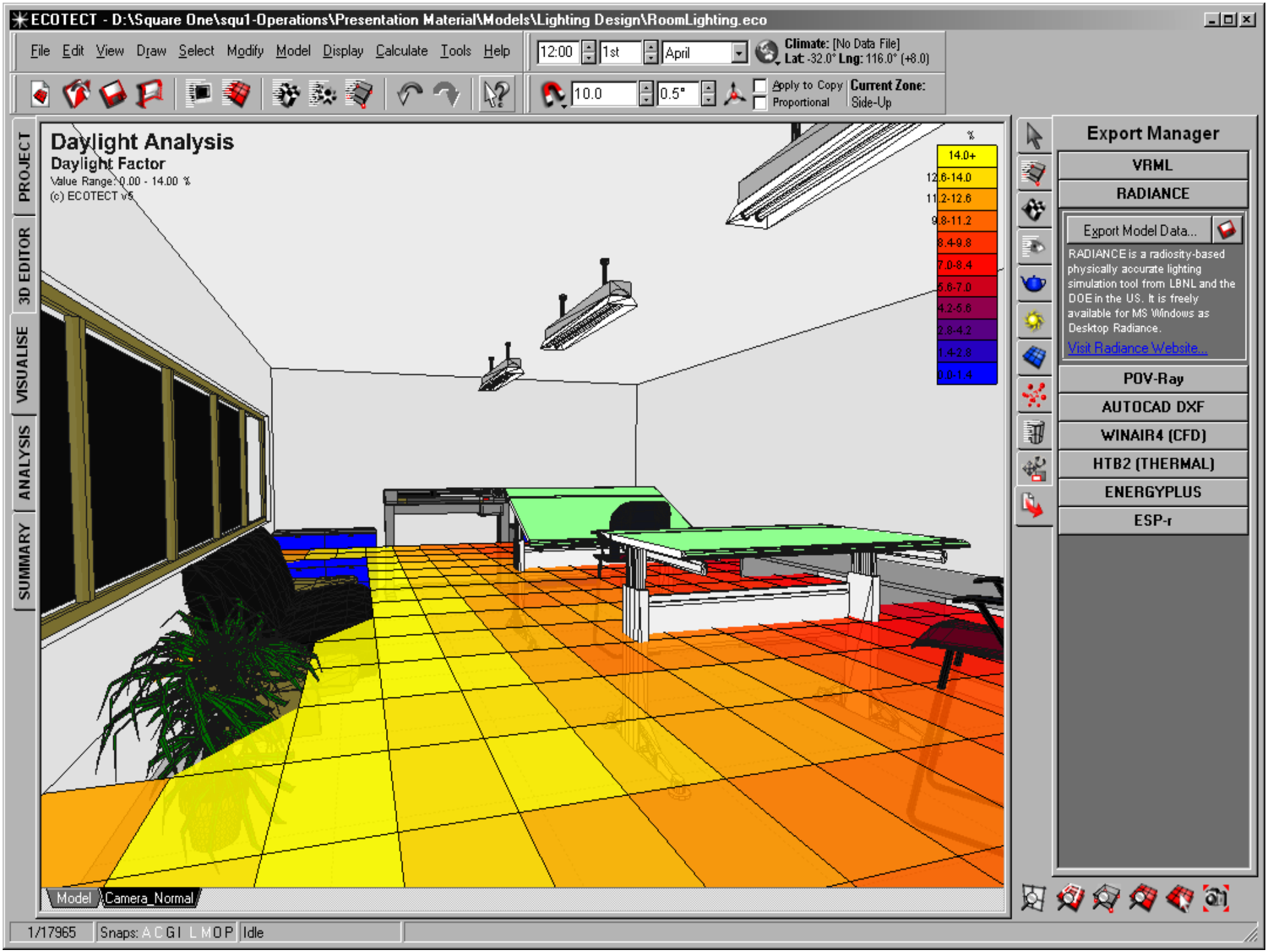
www.squ1.com **www.ecotect.com**

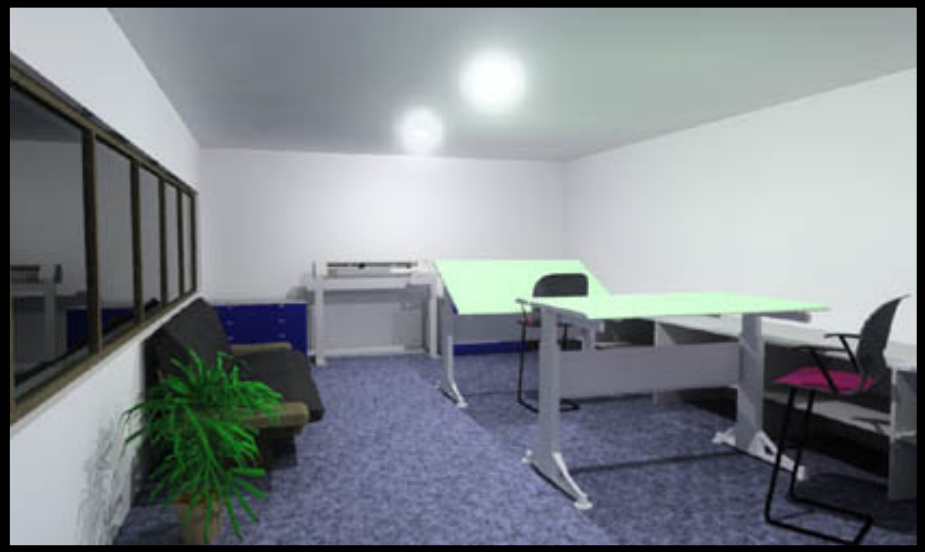
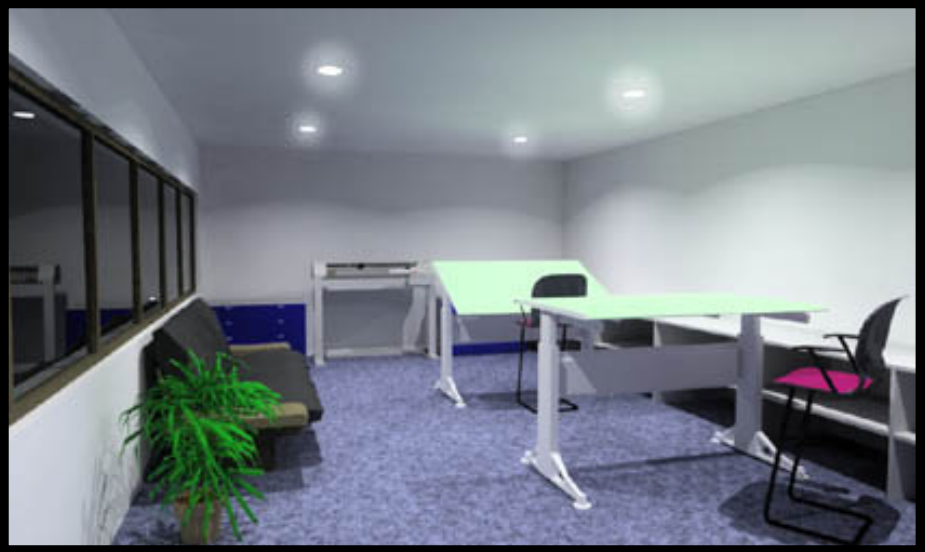
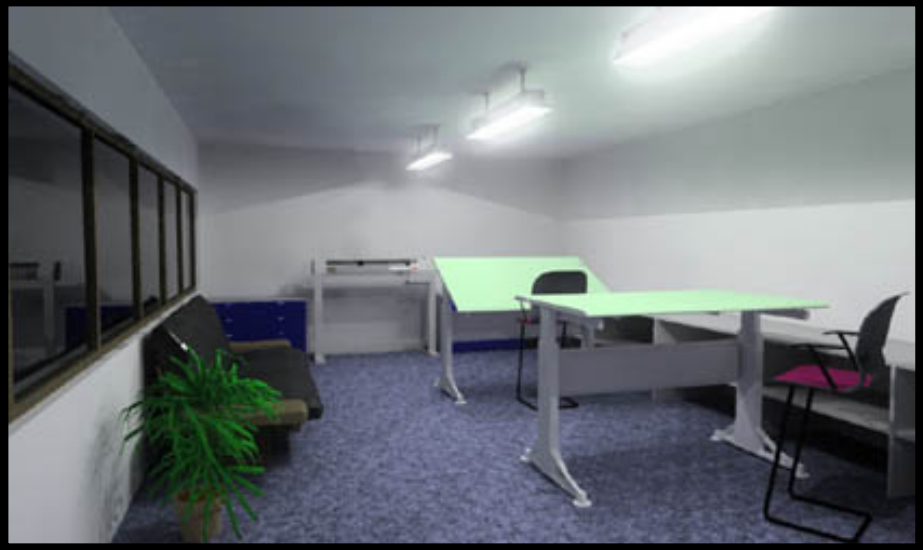
CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

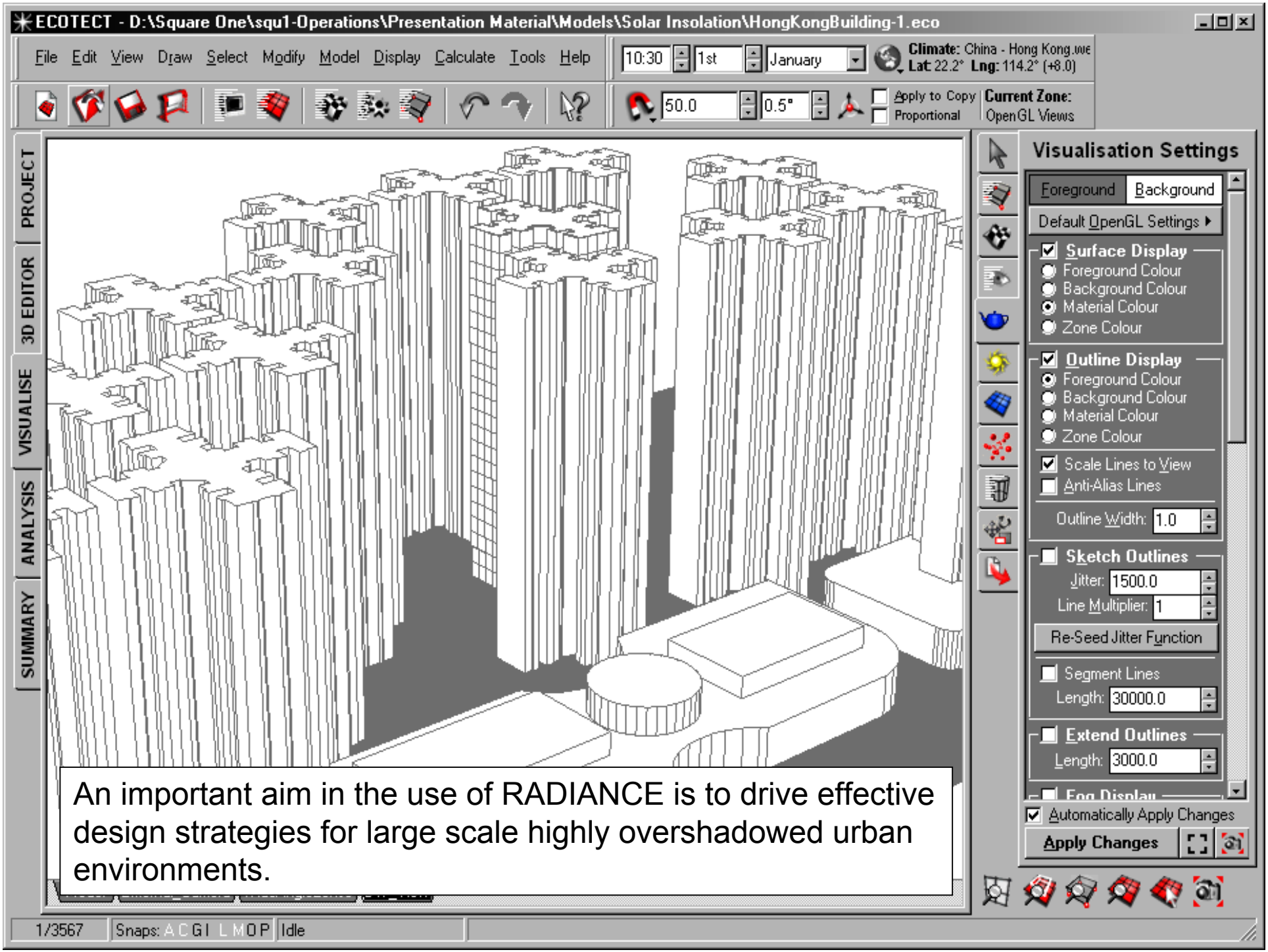


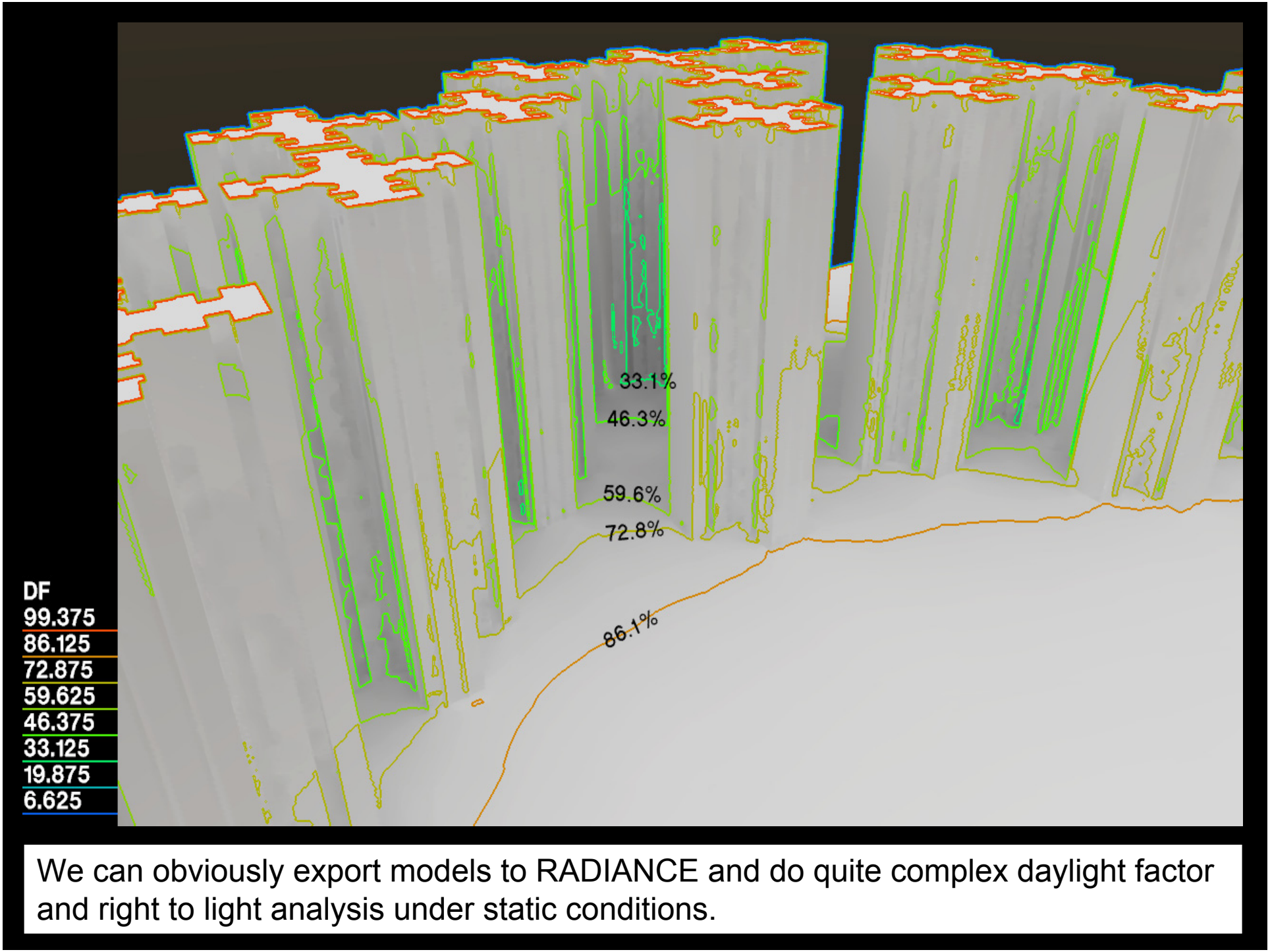
ECOTECT is a conceptual performance analysis tool that can export models directly to RADIANCE.


8655.224
501.399
Lux
7500
6500
5500
4500
3500
2500
1500
500

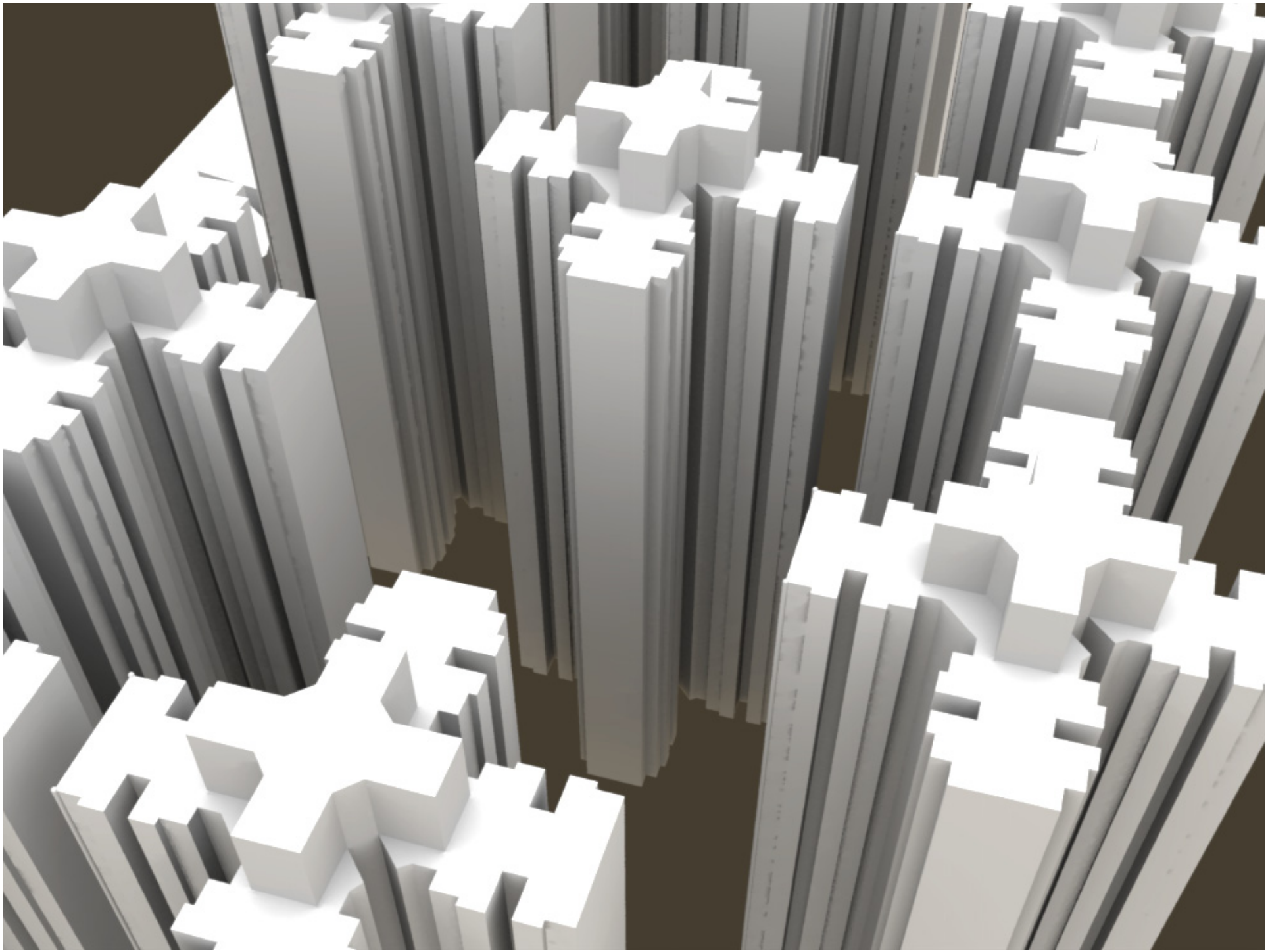

ECOTECT - D:\Square One\squ1-Operations\Presentation Material\Models\Lighting Design\RoomLighting.eco
File Edit View Draw Select Modify Model Display Calculate Tools Help
12:00
1st
April
Climate: [No Data File]
Lat: -32.0° Lng: 116.0° (+8.0)
10.0
0.5°
Apply to Copy
Proportional
Current Zone:
Side-Up
PROJECT
3D EDITOR
VISUALISE
ANALYSIS
SUMMARY
Daylight Analysis
Daylight Factor
Value Range: 0.00 - 14.00 %
(c) ECOTECT v5
%
14.0+
12.6-14.0
11.2-12.6
9.8-11.2
8.4-9.8
7.0-8.4
5.6-7.0
4.2-5.6
2.8-4.2
1.4-2.8
0.0-1.4
Model
Camera_Normal
Export Manager
VRML
RADIANCE
Export Model Data...
RADIANCE is a radiosity-based physically accurate lighting simulation tool from LBNL and the DOE in the US. It is freely available for MS Windows as Desktop Radiance.
Visit Radiance Website...
POV-Ray
AUTOCAD DXF
WINAIR4 (CFD)
HTB2 (THERMAL)
ENERGYPLUS
ESP-r
1/17965
Snaps: A C G I L M O P
Idle

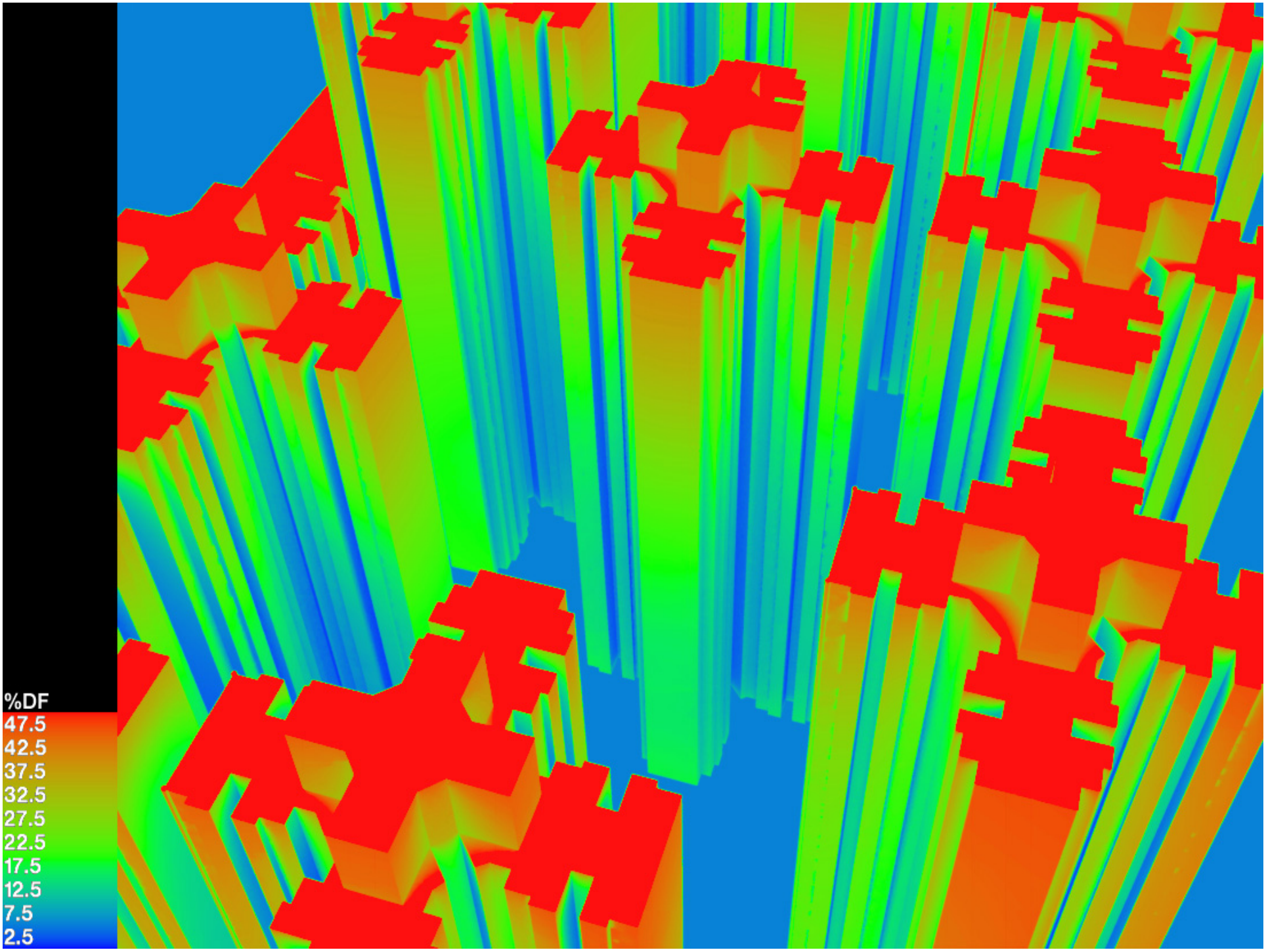




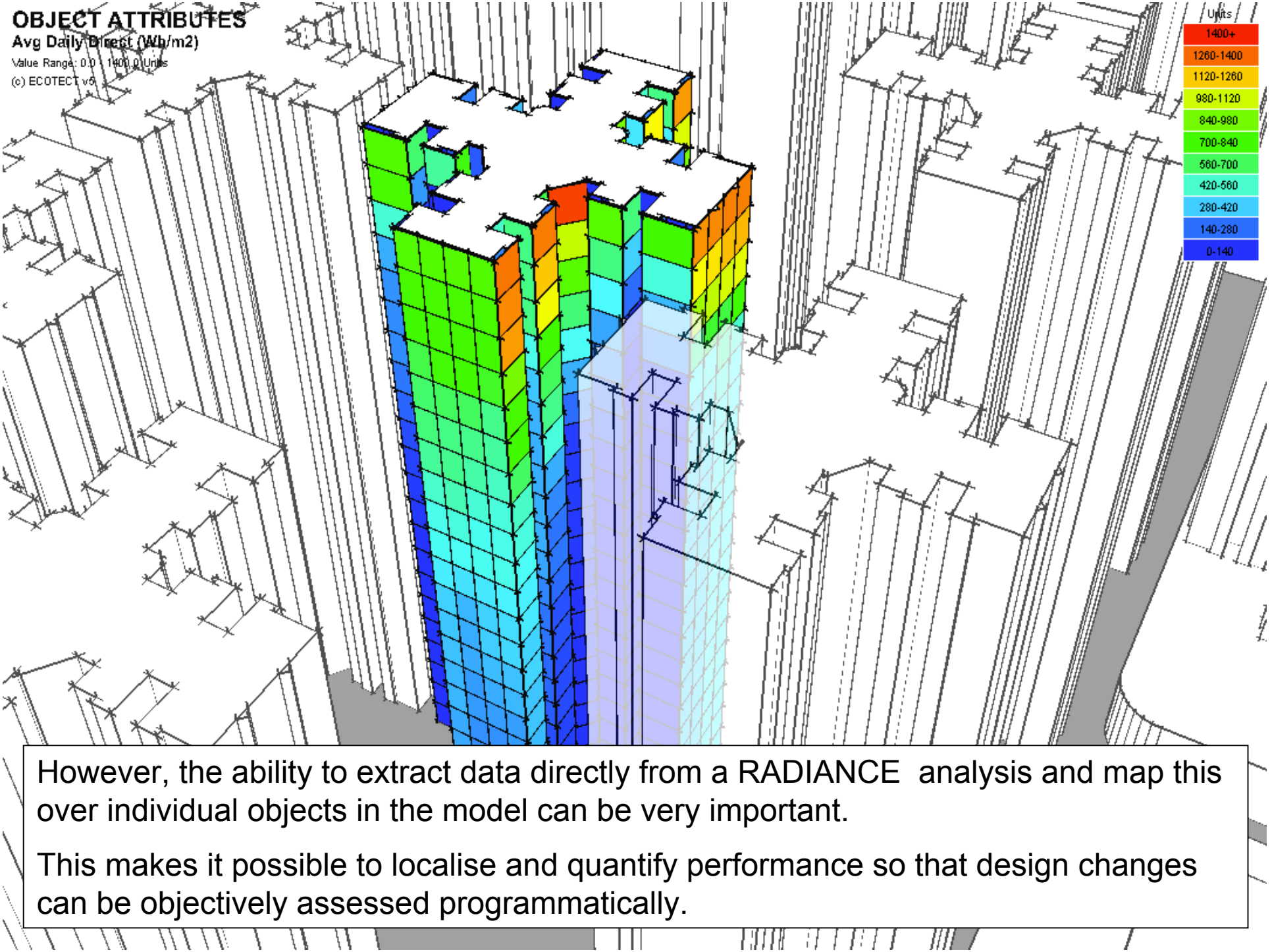


ECOTECT - D:\Square One\squ1-Operations\Presentation Material\Models\Solar Insolation\HongKongBuilding-1.eco
File Edit View Draw Select Modify Model Display Calculate Tools Help
10:30
1st
January
Climate: China - Hong Kong.we
Lat: 22.2° Lng: 114.2° (+8.0)
50.0
0.5°
Apply to Copy
Proportional
Current Zone:
OpenGL Views
PROJECT
3D EDITOR
VISUALISE
ANALYSIS
SUMMARY
Visualisation Settings
Foreground
Background
Default OpenGL Settings
Surface Display
Foreground Colour
Background Colour
Material Colour
Zone Colour
Outline Display
Foreground Colour
Background Colour
Material Colour
Zone Colour
Scale Lines to View
Anti-Alias Lines
Outline Width: 1.0
Sketch Outlines
Jitter: 1500.0
Line Multiplier: 1
Re-Seed Jitter Function
Segment Lines
Length: 30000.0
Extend Outlines
Length: 3000.0
Automatically Apply Changes
Apply Changes
An important aim in the use of RADIANCE is to drive effective design strategies for large scale highly overshadowed urban environments.
1/3567
Snaps: A C G I L M O P
Idle



We can obviously export models to RADIANCE and do quite complex daylight factor and right to light analysis under static conditions.

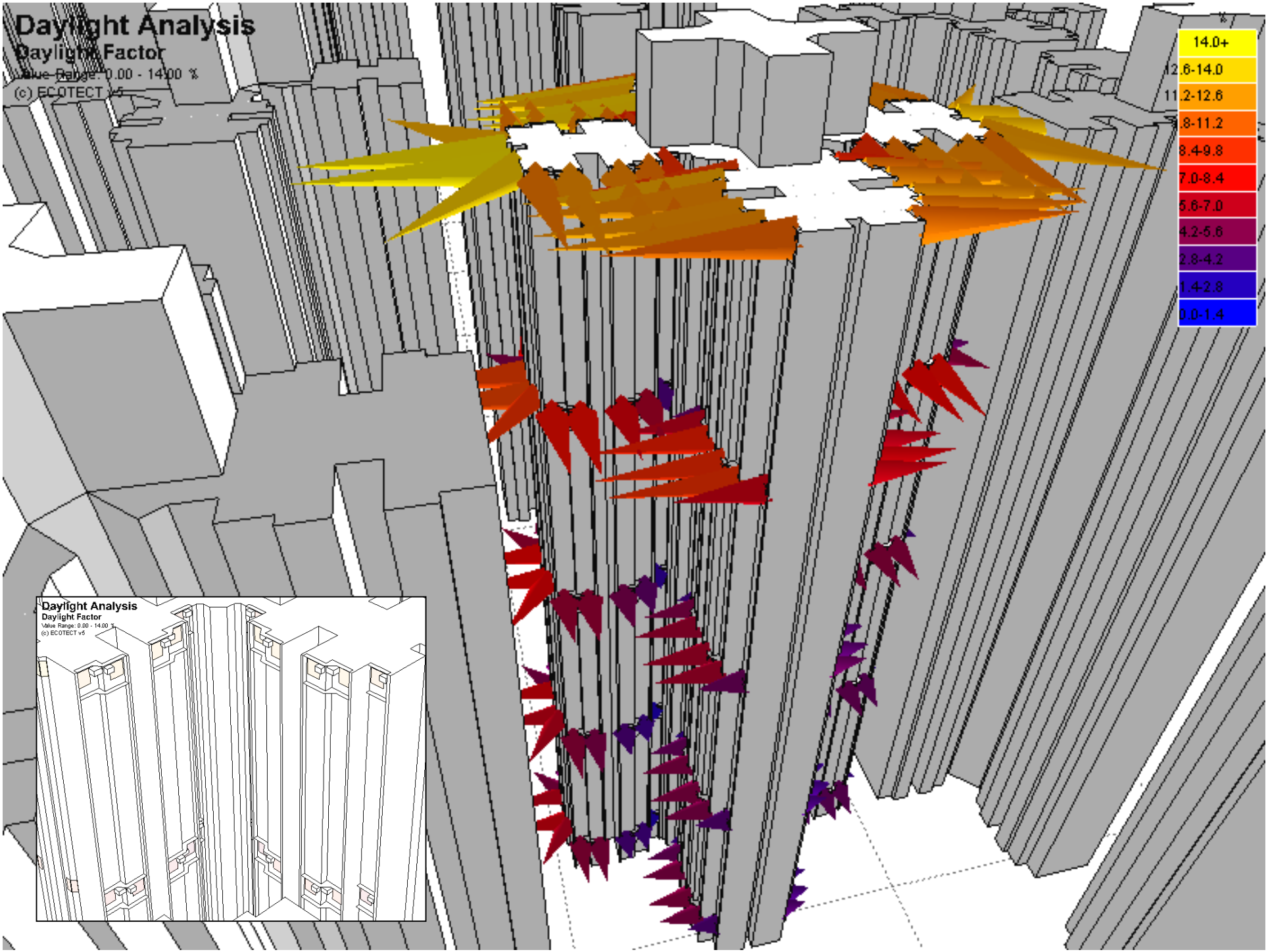


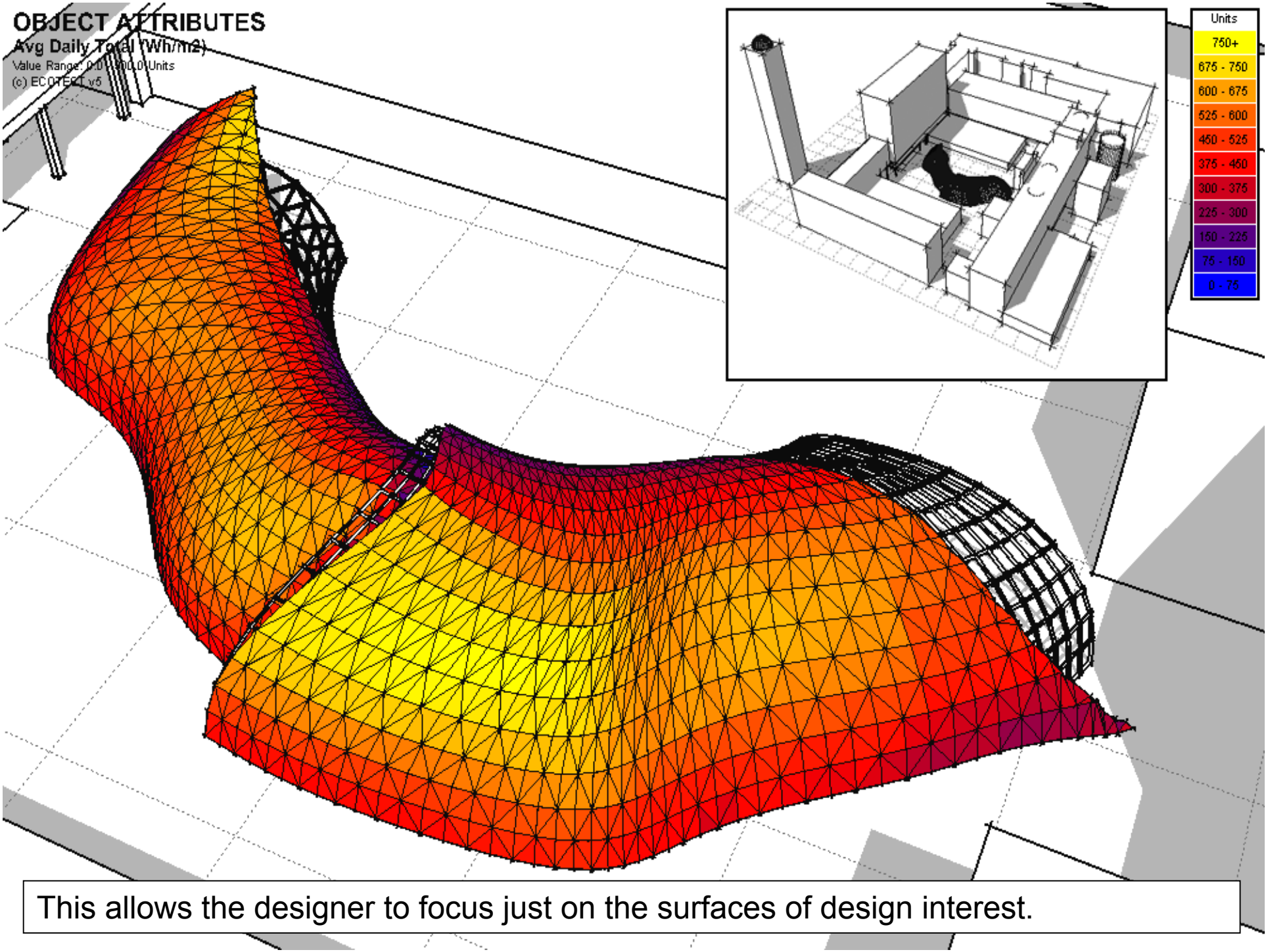

%DF
47.5
42.5
37.5
32.5
27.5
22.5
17.5
12.5
7.5
2.5



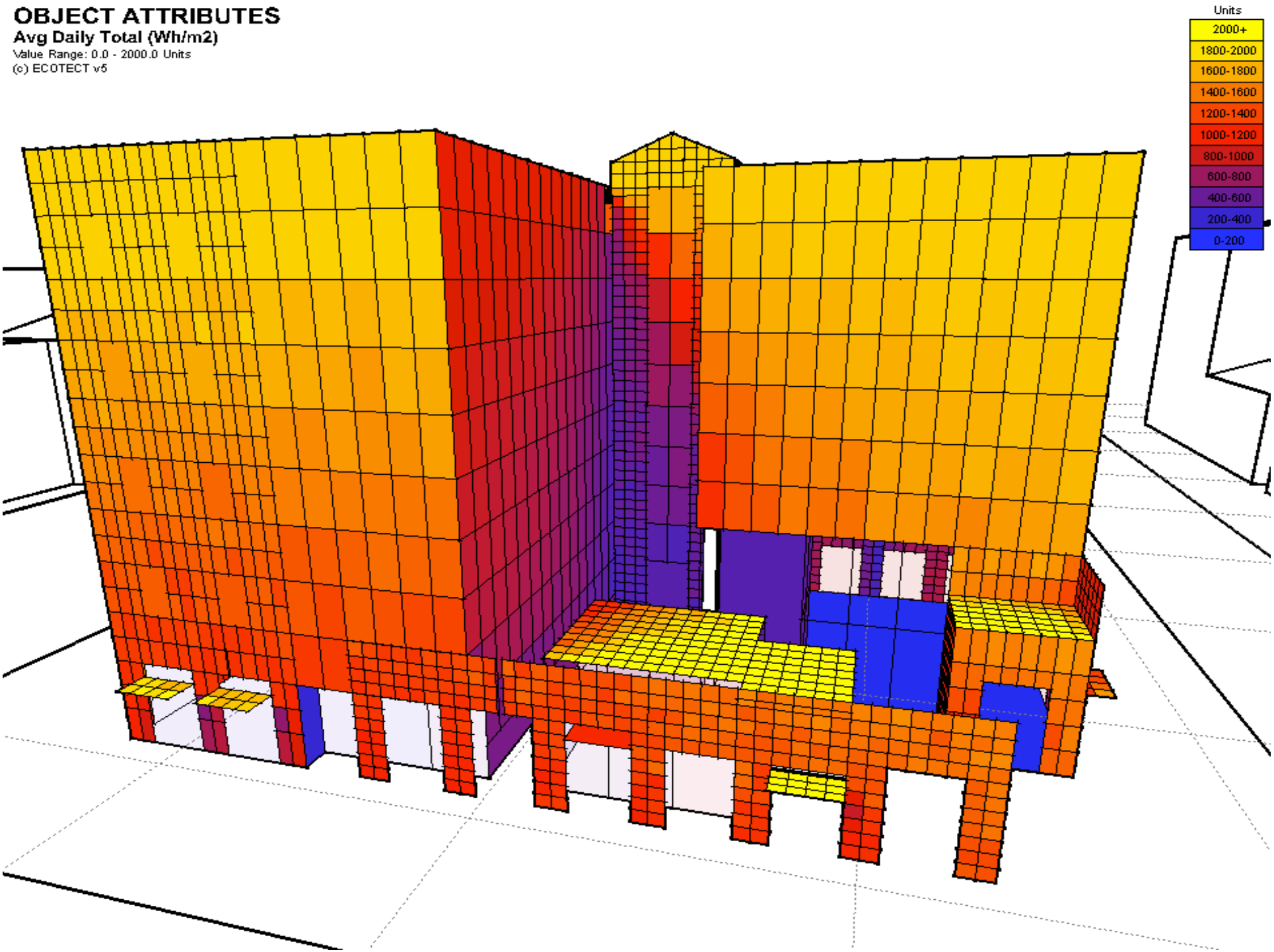
However, the ability to extract data directly from a RADIANCE analysis and map this over individual objects in the model can be very important.

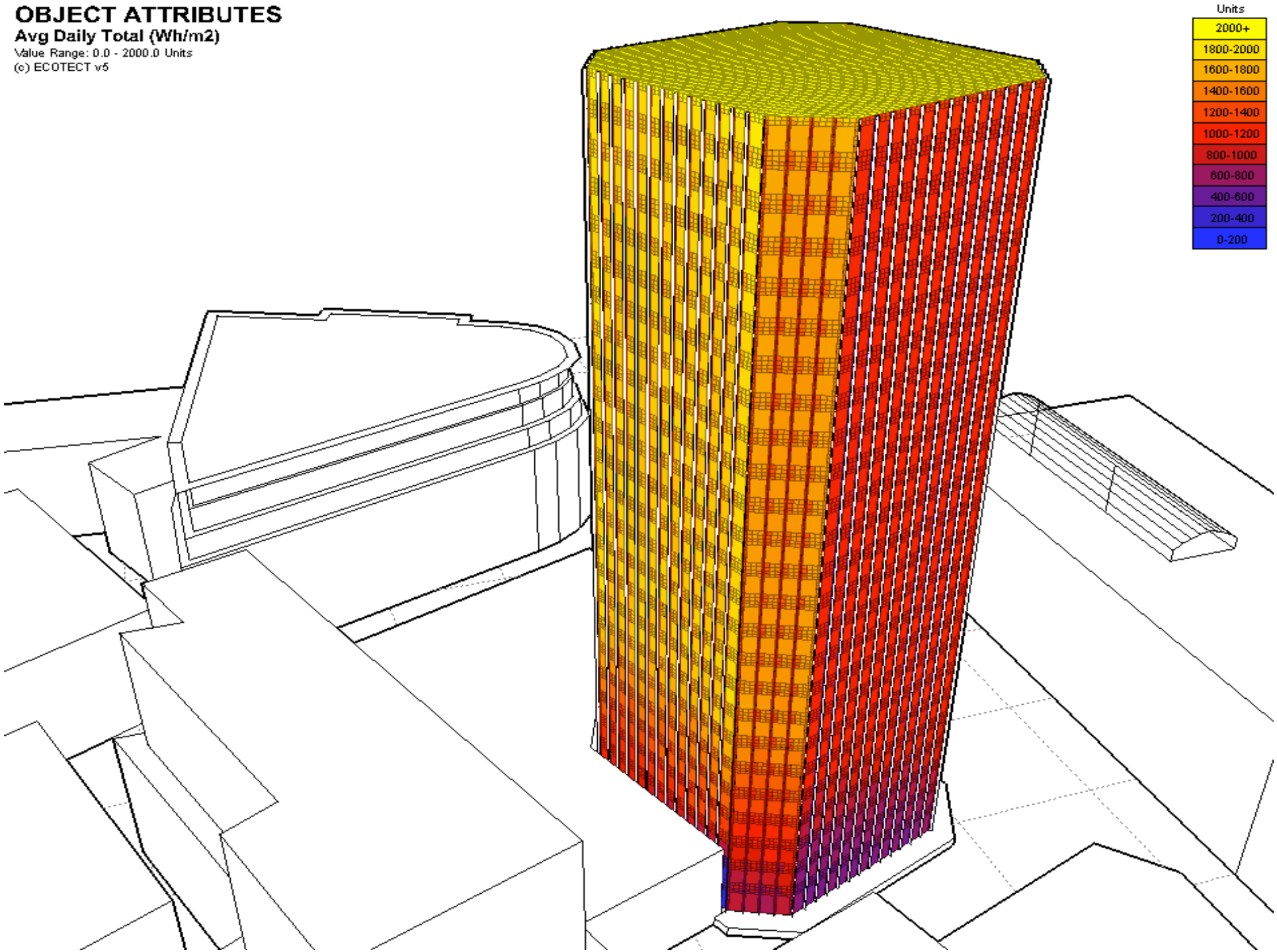
This makes it possible to localise and quantify performance so that design changes can be objectively assessed programmatically.

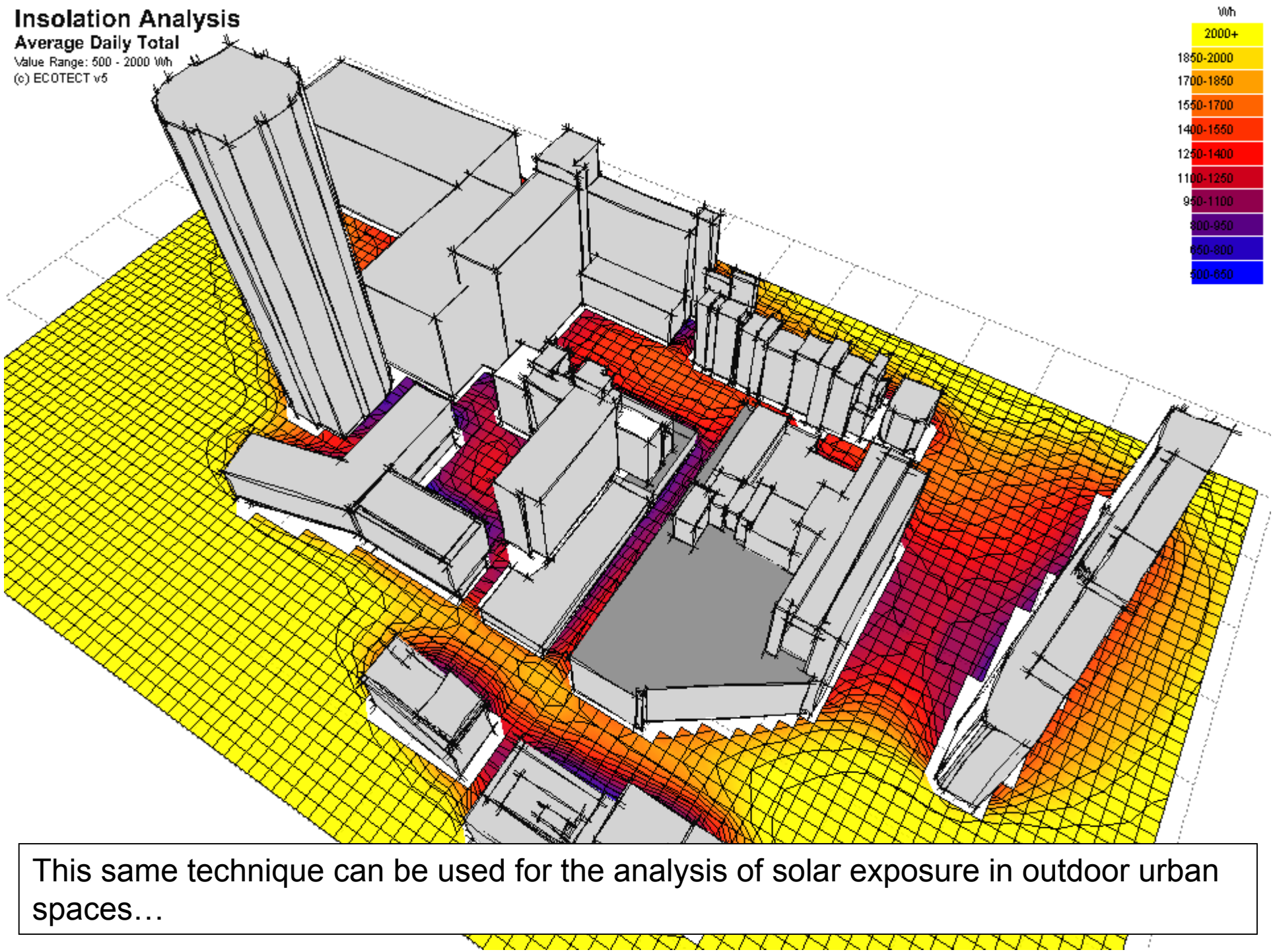

Daylight Analysis
Daylight Factor
Value Range: 0.00 - 14.00 %
(c) ECOTECT v5
14.0+
12.6-14.0
11.2-12.6
9.8-11.2
8.4-9.8
7.0-8.4
5.6-7.0
4.2-5.6
2.8-4.2
1.4-2.8
0.0-1.4
Daylight Analysis
Daylight Factor
Value Range: 0.00 - 14.00 %
(c) ECOTECT v5



This allows the designer to focus just on the surfaces of design interest.


OBJECT ATTRIBUTES
Avg Daily Total (Wh/m2)
Value Range: 0.0 - 2000.0 Units
(c) ECOTECT v5
Units
2000+
1800-2000
1600-1800
1400-1600
1200-1400
1000-1200
800-1000
600-800
400-600
200-400
0-200


OBJECT ATTRIBUTES
Avg Daily Total (Wh/m2)
Value Range: 0.0 - 2000.0 Units
(c) ECOTECT v5
Units
2000+
1800-2000
1600-1800
1400-1600
1200-1400
1000-1200
800-1000
600-800
400-600
200-400
0-200



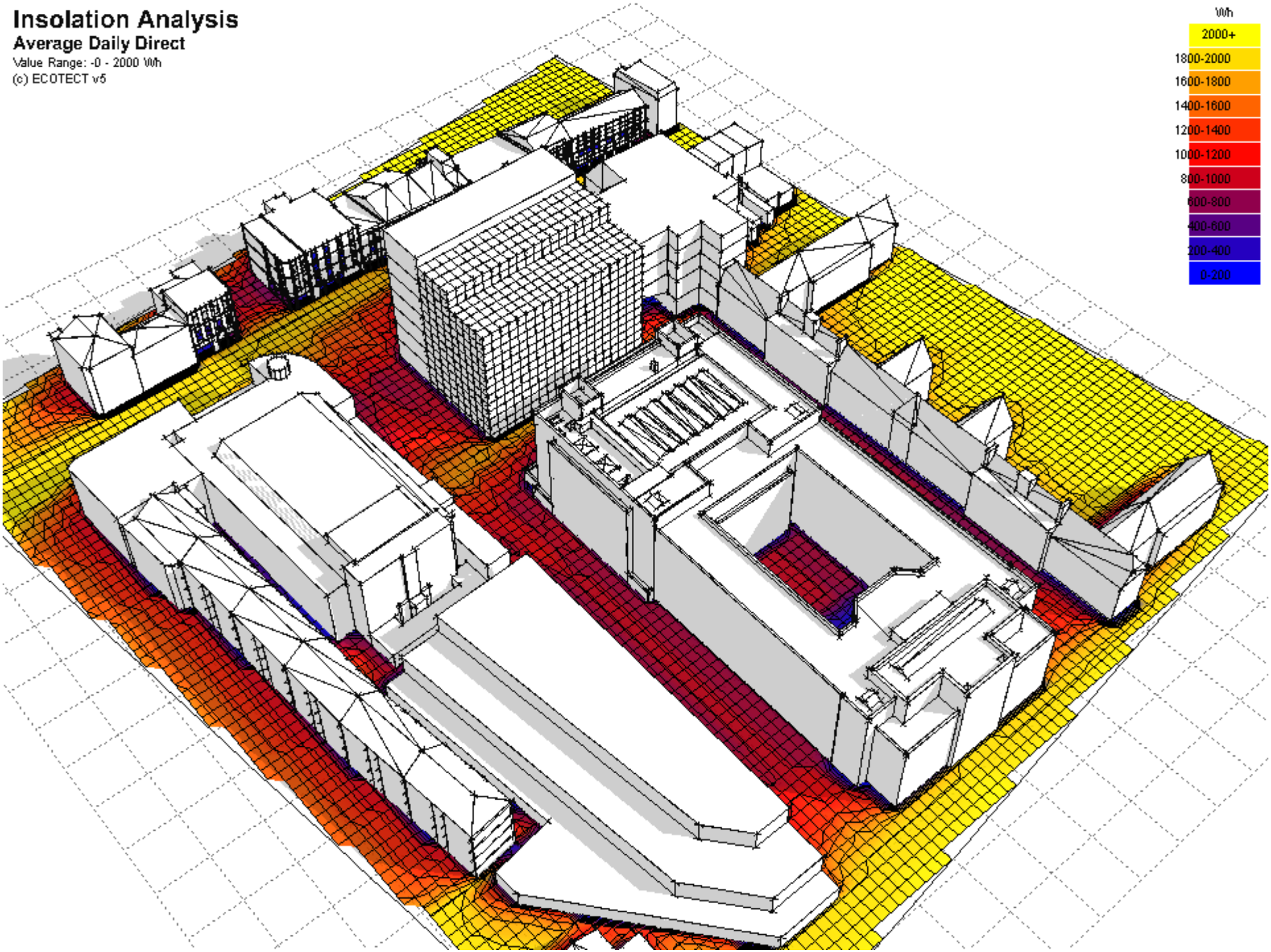
This same technique can be used for the analysis of solar exposure in outdoor urban spaces…

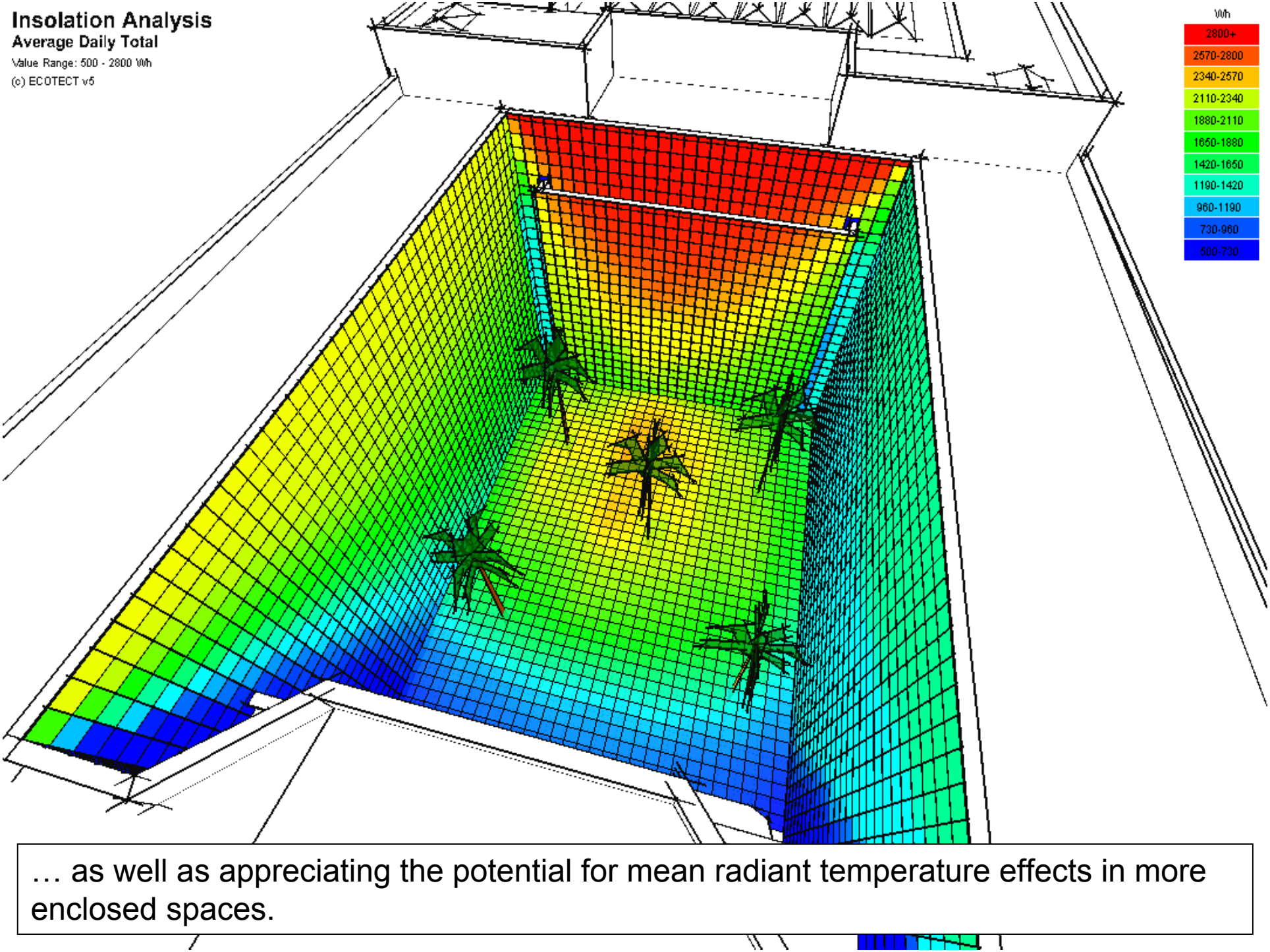
Insolation Analysis

Average Daily Direct

Value Range: -0 - 2000 Wh

(c) ECOTECT v5



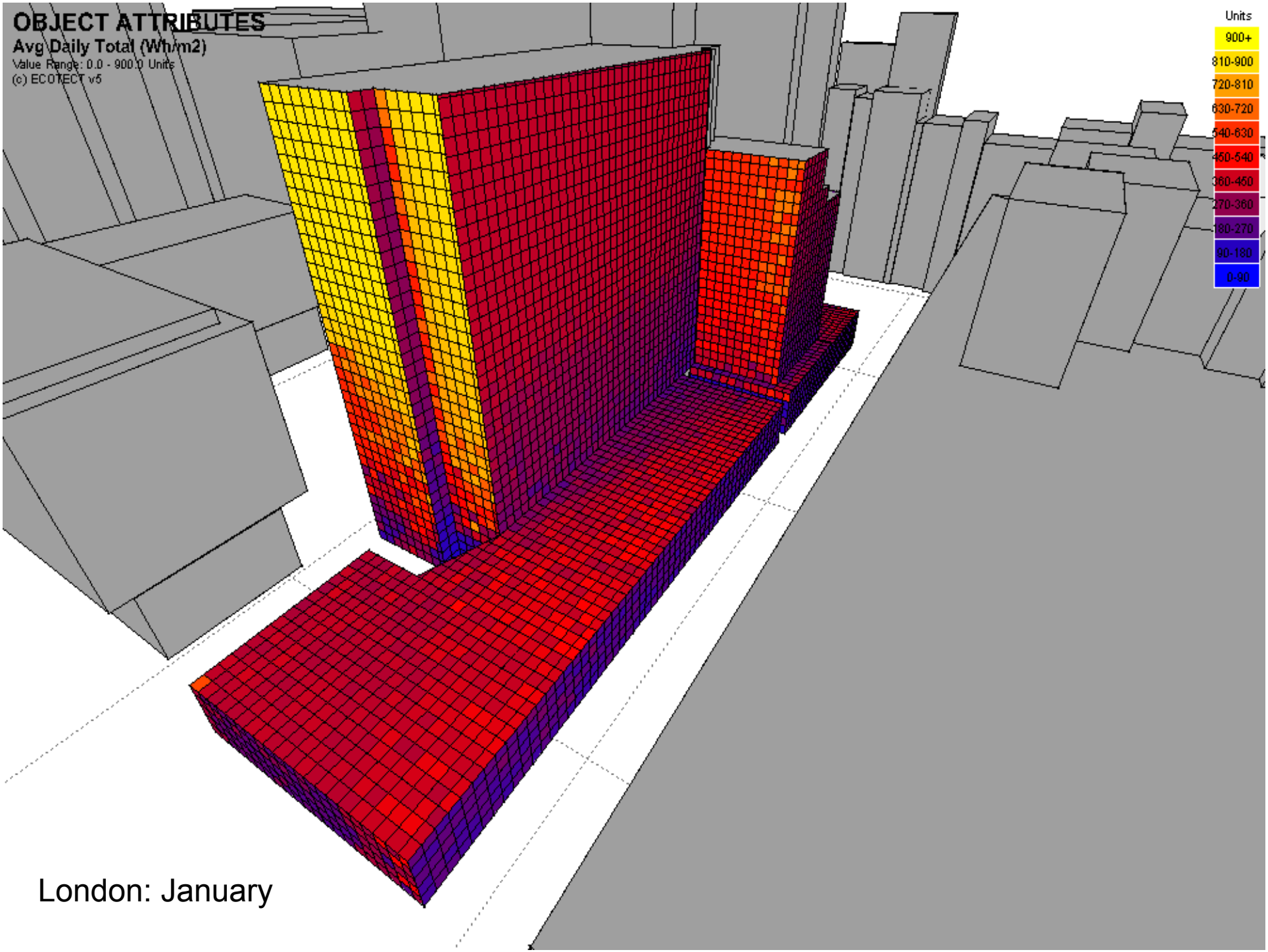


… as well as appreciating the potential for mean radiant temperature effects in more enclosed spaces.

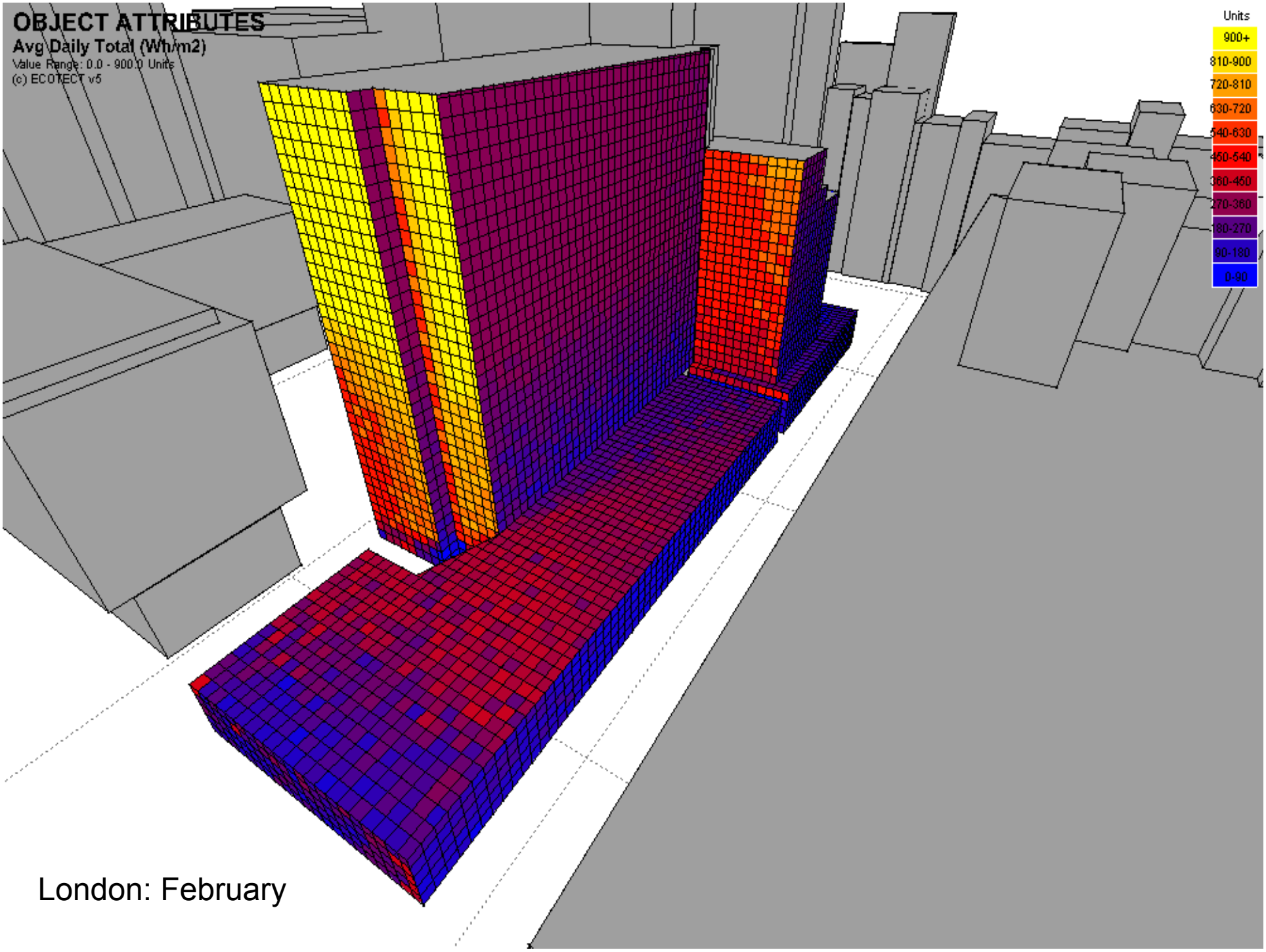
The issue here is basically the consideration of **dynamic conditions**.

As seen from the previous presentation, this can be solved in RADIANCE with the use of **cumulative skies**.

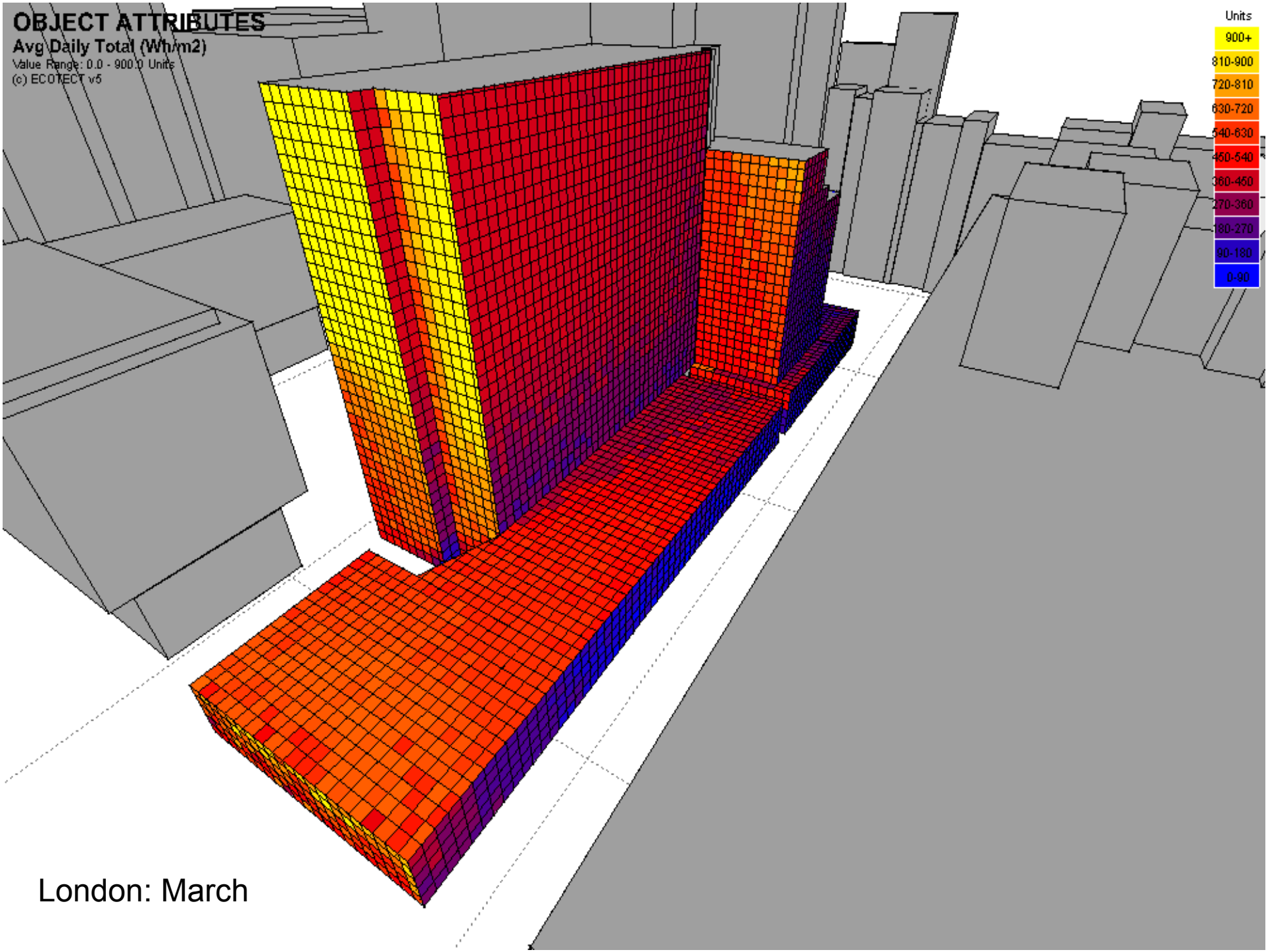
This is important, as shown in the following example using cumulative solar insolation, because these dynamic changes can be significant.



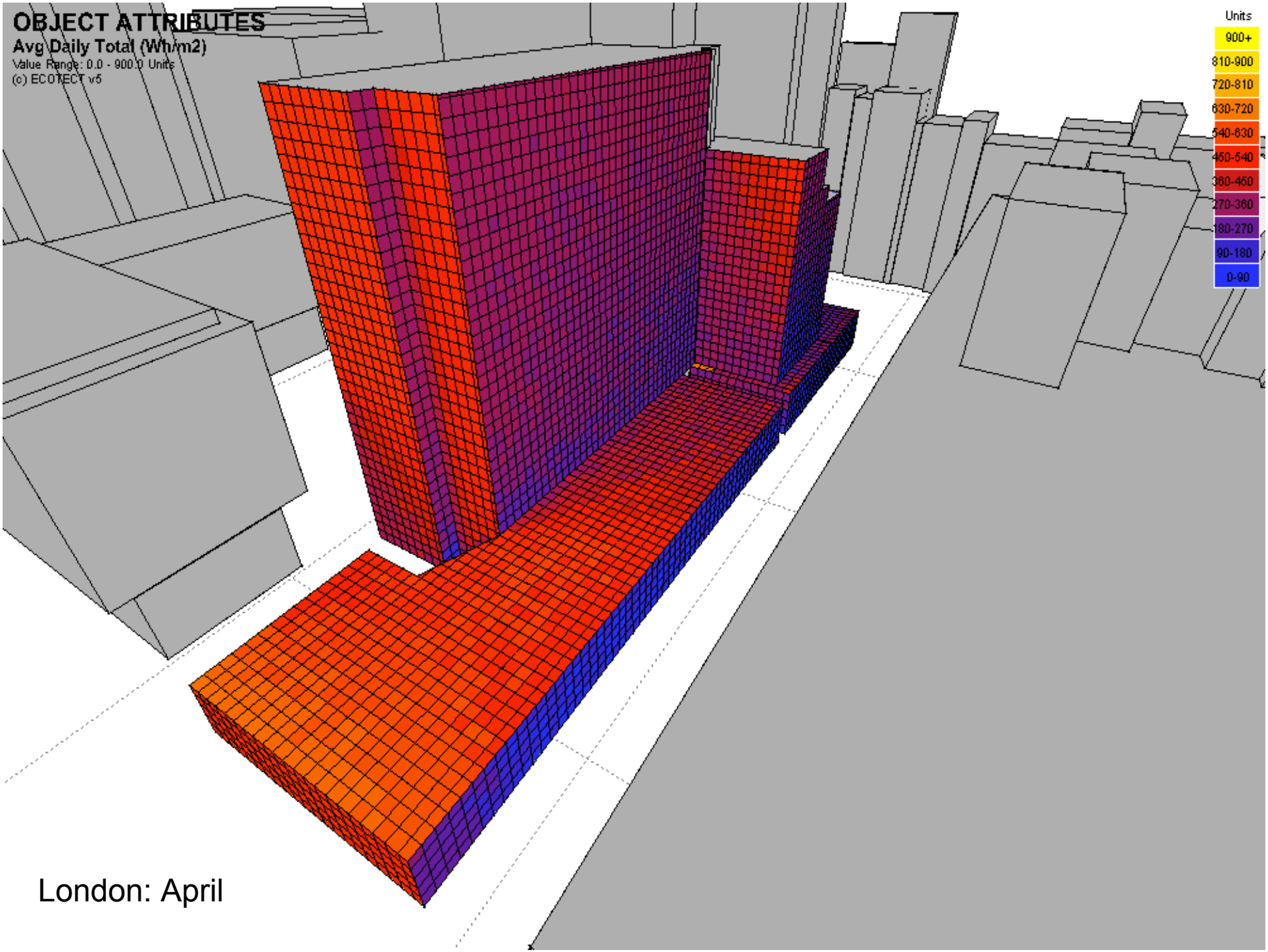
London: January



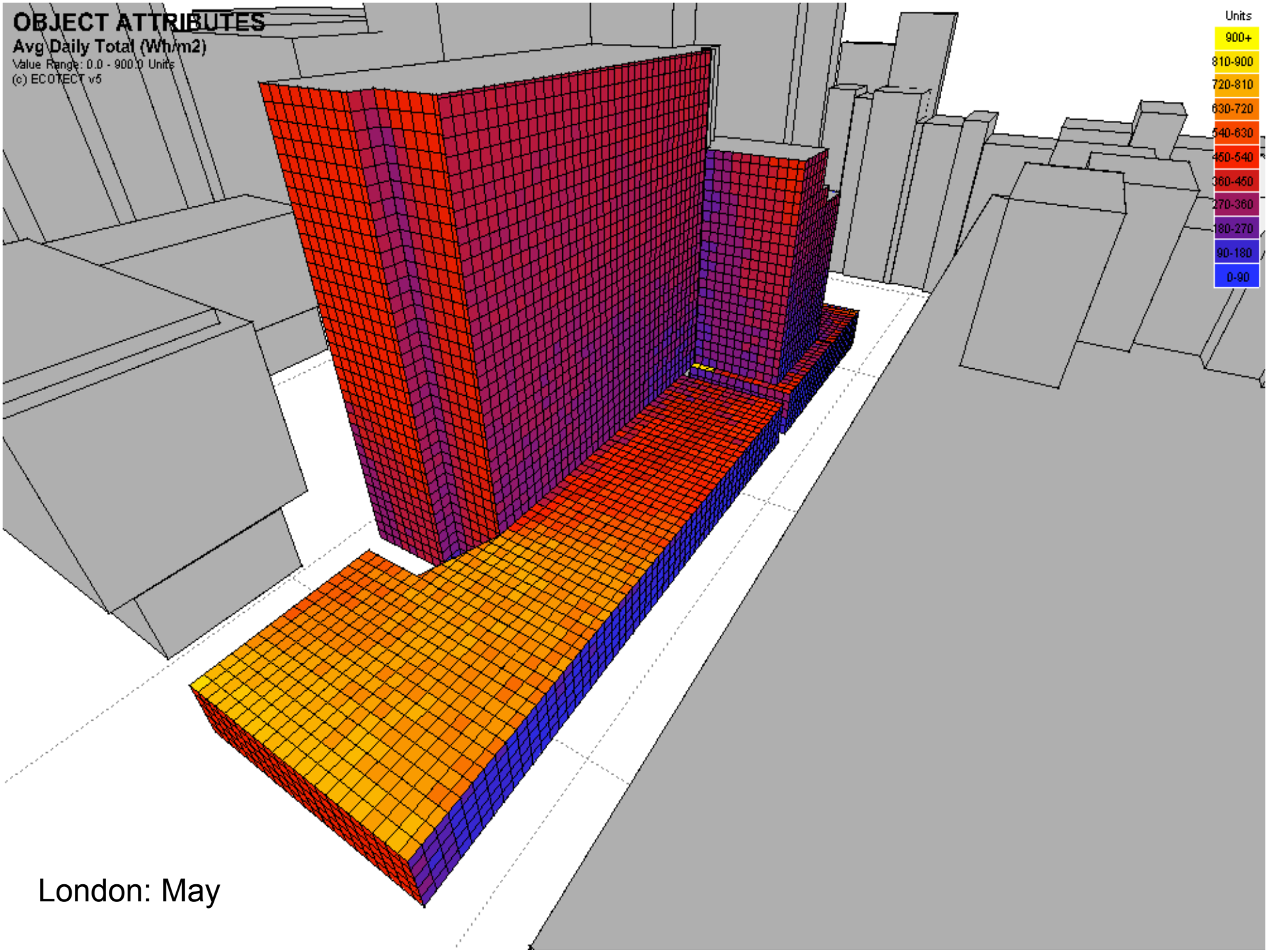
London: February



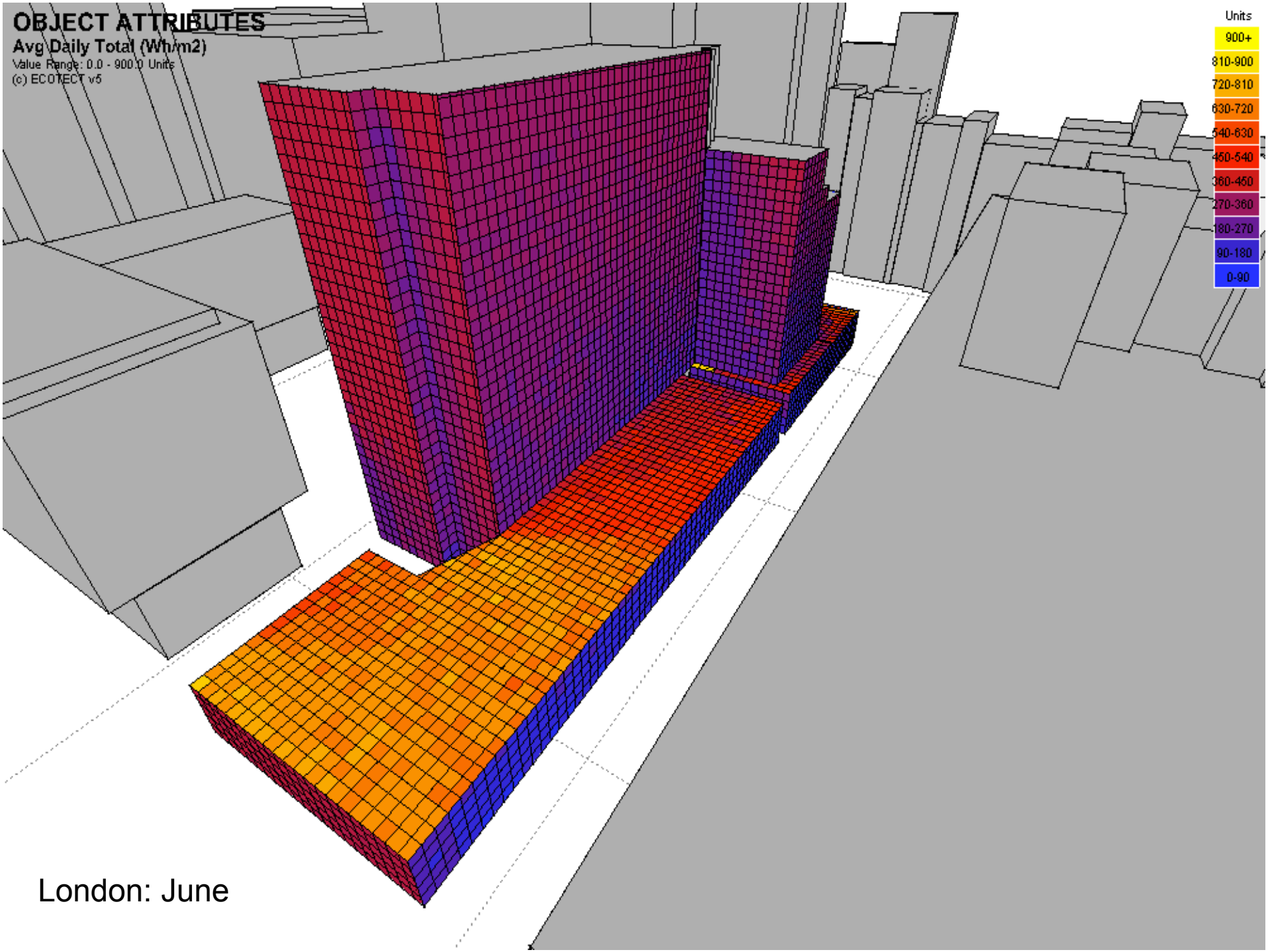
London: March



London: April


OBJECT ATTRIBUTES
Avg Daily Total (Wh/m2)
Value Range: 0.0 - 900.0 Units
(c) ECOTECT v5
Units
900+
810-900
720-810
630-720
540-630
450-540
360-450
270-360
180-270
90-180
0-90

London: May


OBJECT ATTRIBUTES
Avg Daily Total (Wh/m2)
Value Range: 0.0 - 900.0 Units
(c) ECOTECT v5
Units
900+
810-900
720-810
630-720
540-630
450-540
360-450
270-360
180-270
90-180
0-90

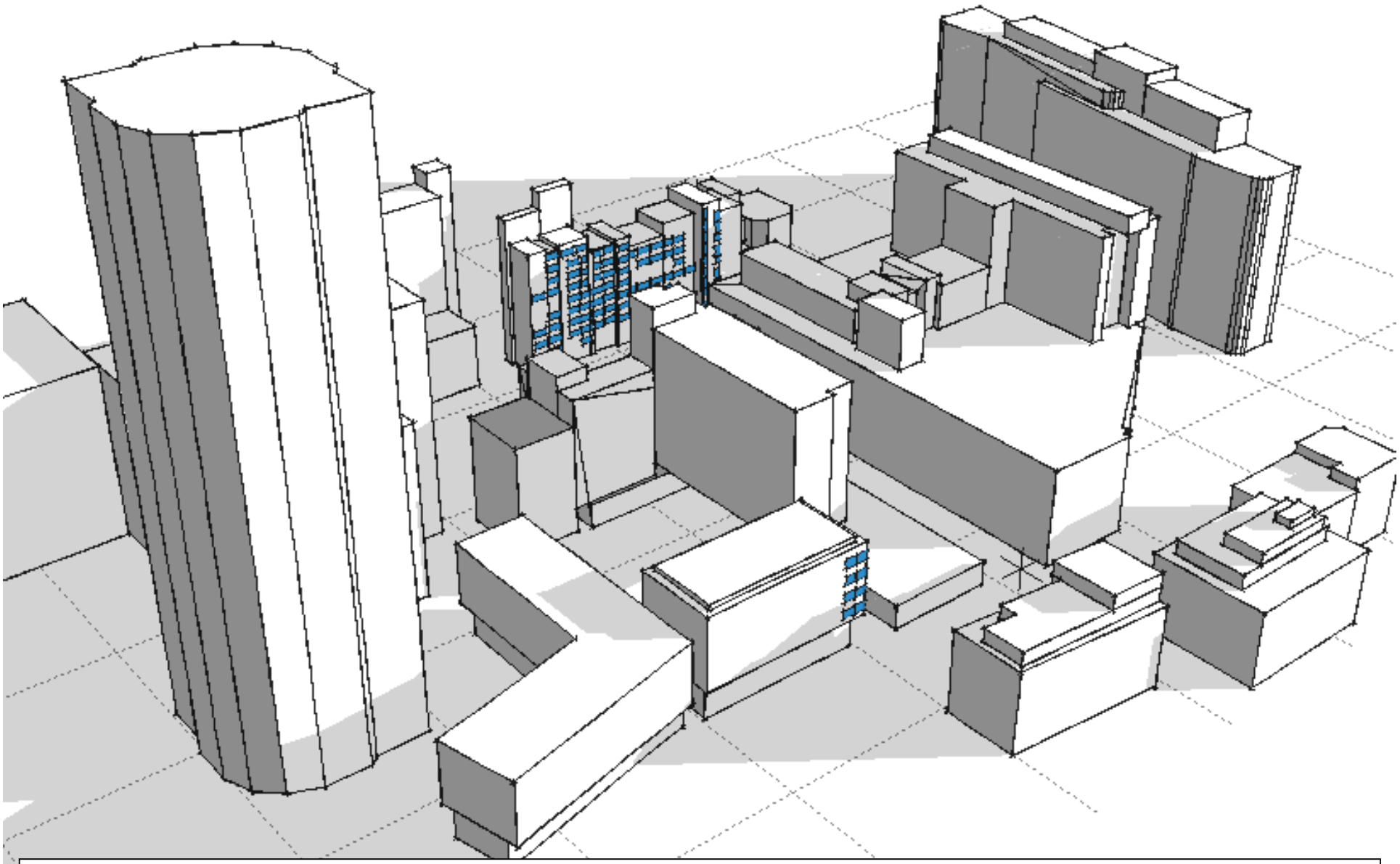
London: June

ECOTECT already calculates cumulative insolation levels over any surface based on measured **hourly solar radiation** values.

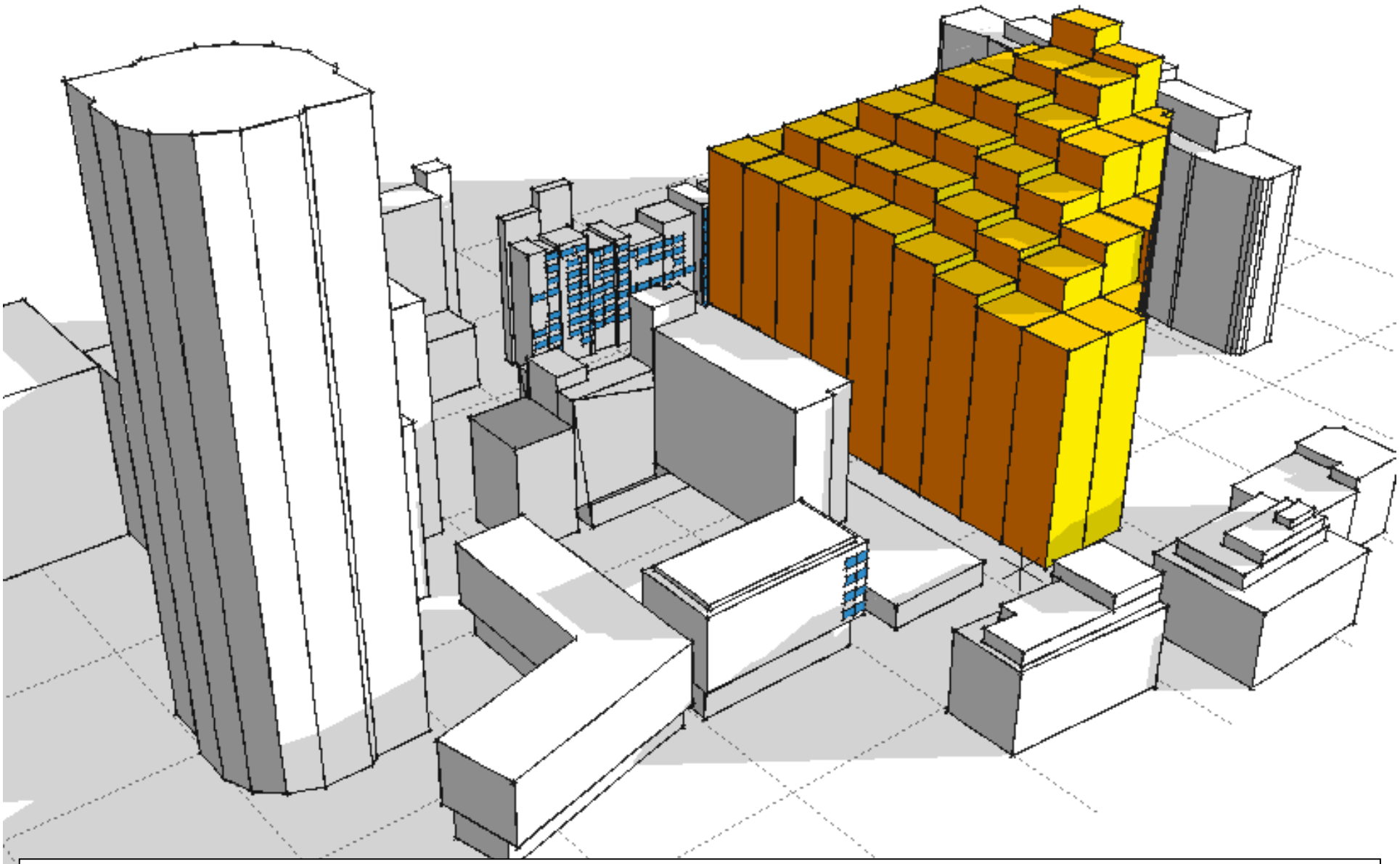
However, it's calculation method does not fully account for diffuse inter-reflections anywhere near as well as the **radiosity approach** used in RADIANCE.

If the same information is extracted from a RADIANCE analysis, it can be **visualised** interactively and even **analysed further** by user defined scripts.

Linking this with the ability of a script to generate/modify geometry means that a **generative approach** to issues such as right to light can be taken.



<<Show interactive demonstration>>

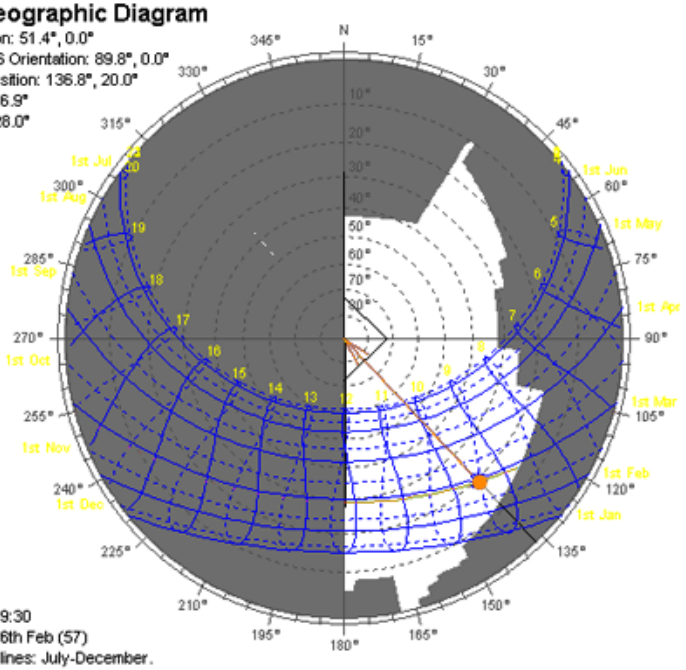


<<Show simpler, goal seeking demonstration>>

The mechanics of ECOTECT's calculation – showing how similar and easy it is to implement and automate using RADIANCE...

Stereographic Diagram

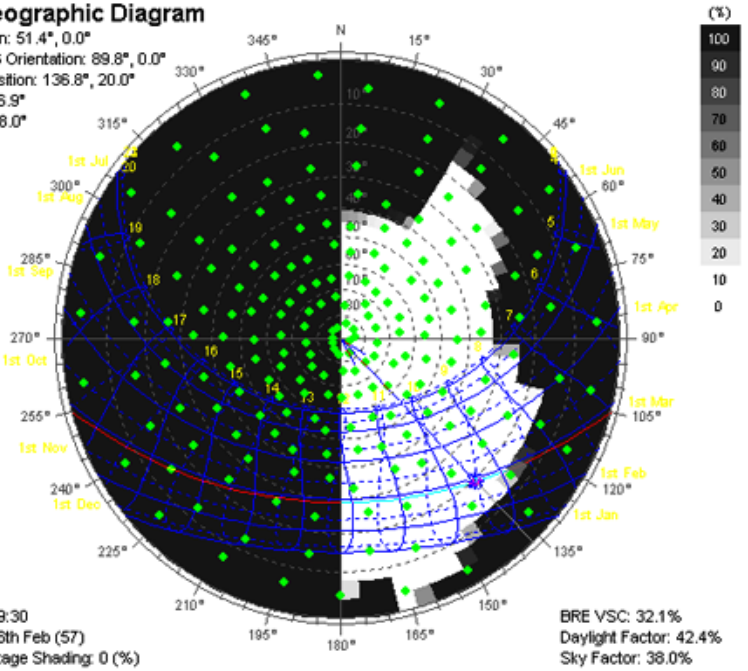
Location: 51.4°, 0.0°
Obj 376 Orientation: 89.8°, 0.0°
Sun Position: 136.8°, 20.0°
HSA: 46.9°
VSA: 28.0°



Time: 09:30
Date: 26th Feb (57)
Dotted lines: July-December.

Stereographic Diagram

Location: 51.4°, 0.0°
Obj 376 Orientation: 89.8°, 0.0°
Sun Position: 136.8°, 20.0°
HSA: 46.9°
VSA: 28.0°

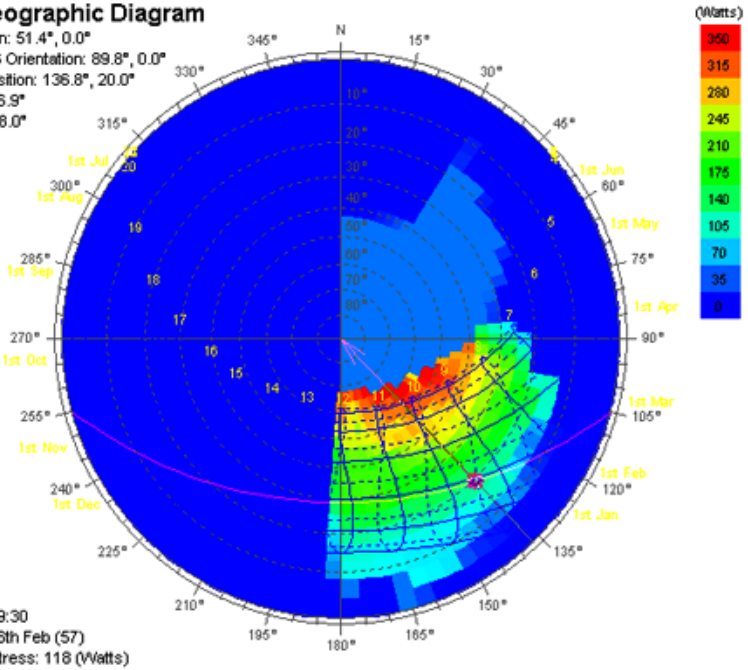


Time: 09:30
Date: 26th Feb (57)
Percentage Shading: 0 (%)

BRE VSC: 32.1%
Daylight Factor: 42.4%
Sky Factor: 38.0%

Stereographic Diagram

Location: 51.4°, 0.0°
Obj 376 Orientation: 89.8°, 0.0°
Sun Position: 136.8°, 20.0°
HSA: 46.9°
VSA: 28.0°

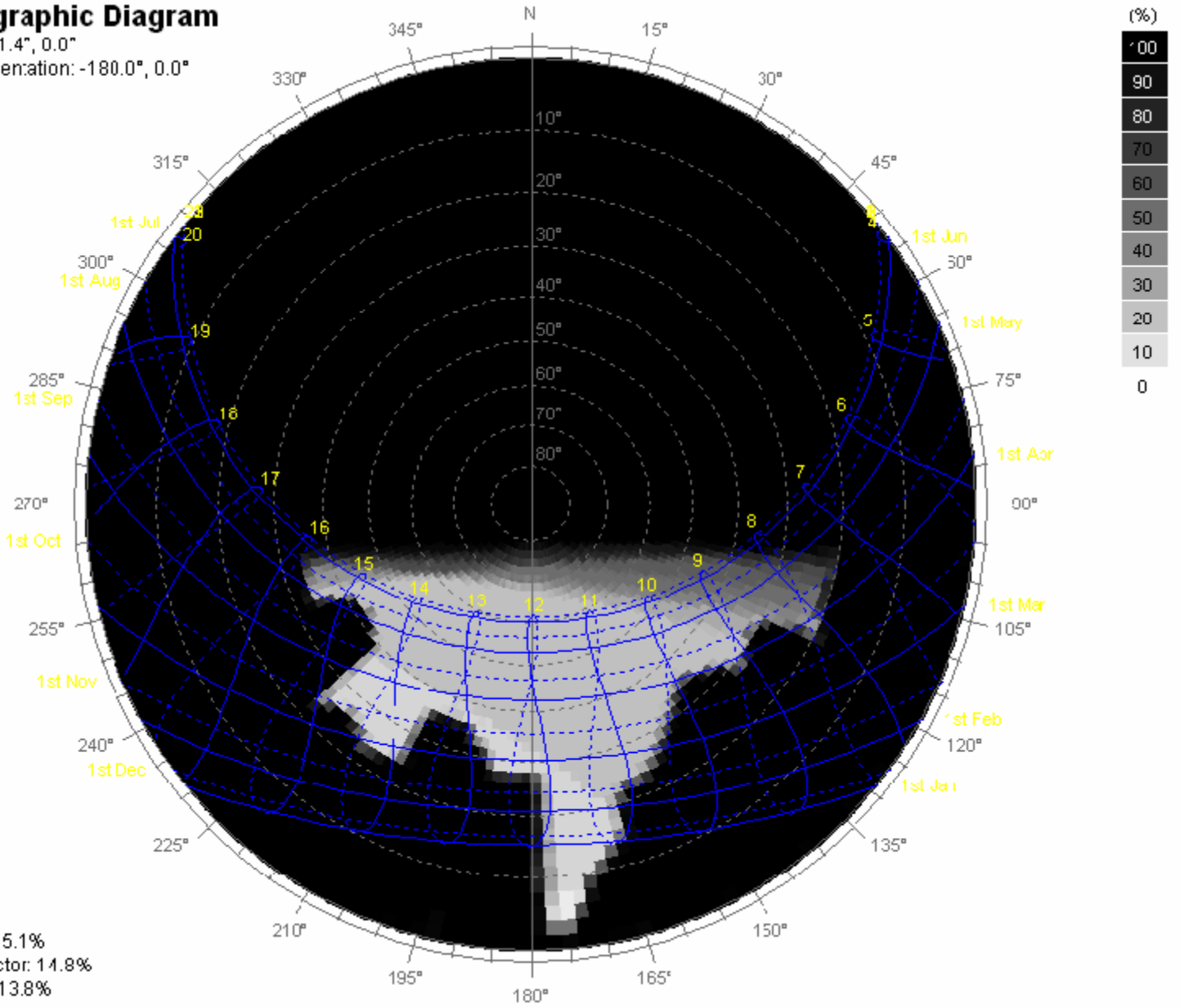


Time: 09:30
Date: 26th Feb (57)
Solar Stress: 118 (Watts)

Stereographic Diagram

Location: 51.4°, 0.0°

Obj 456 Orientation: -180.0°, 0.0°



(%)

100
90
80
70
60
50
40
30
20
10
0

BRE VSC: 15.1%

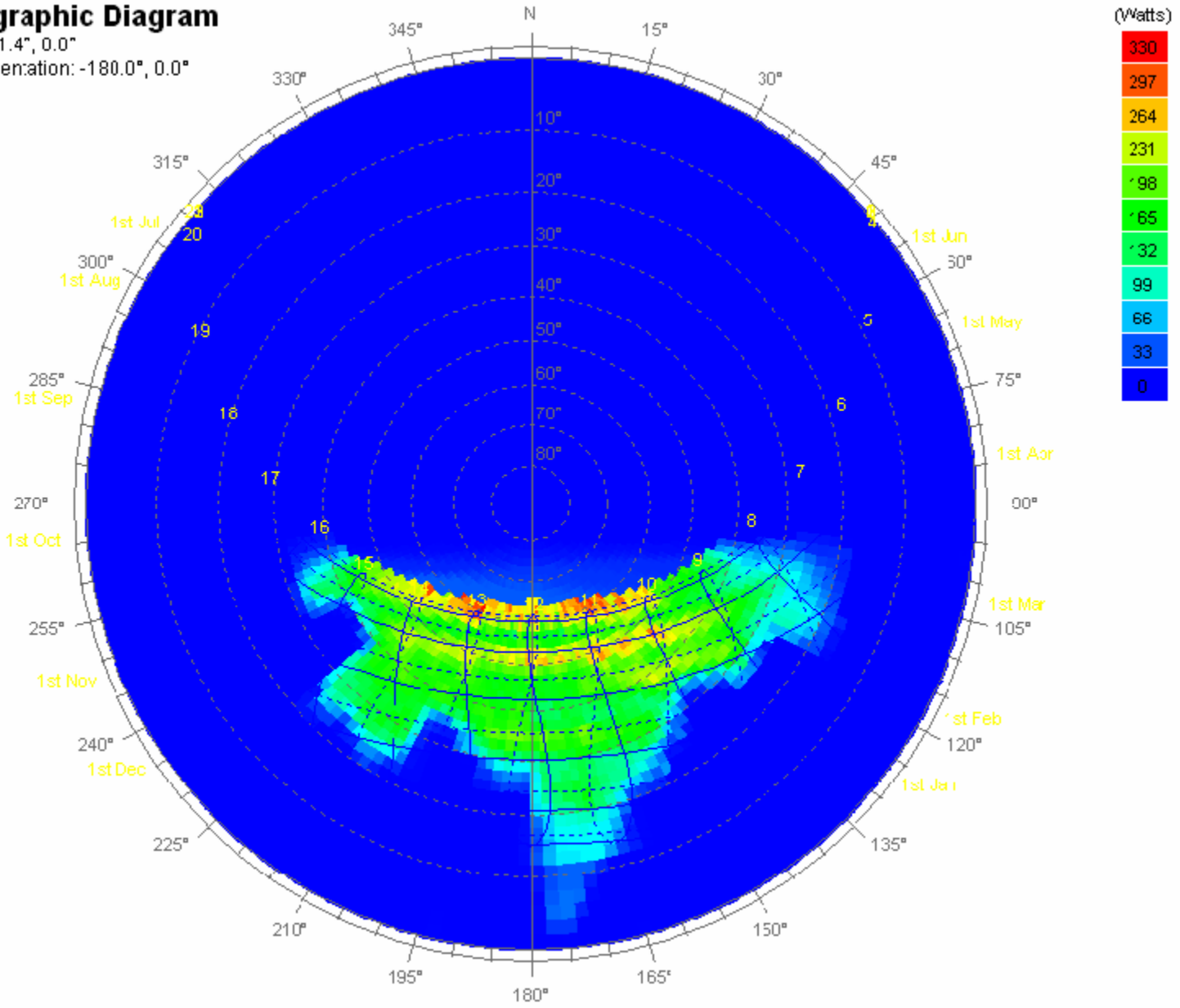
Daylight Factor: 14.8%

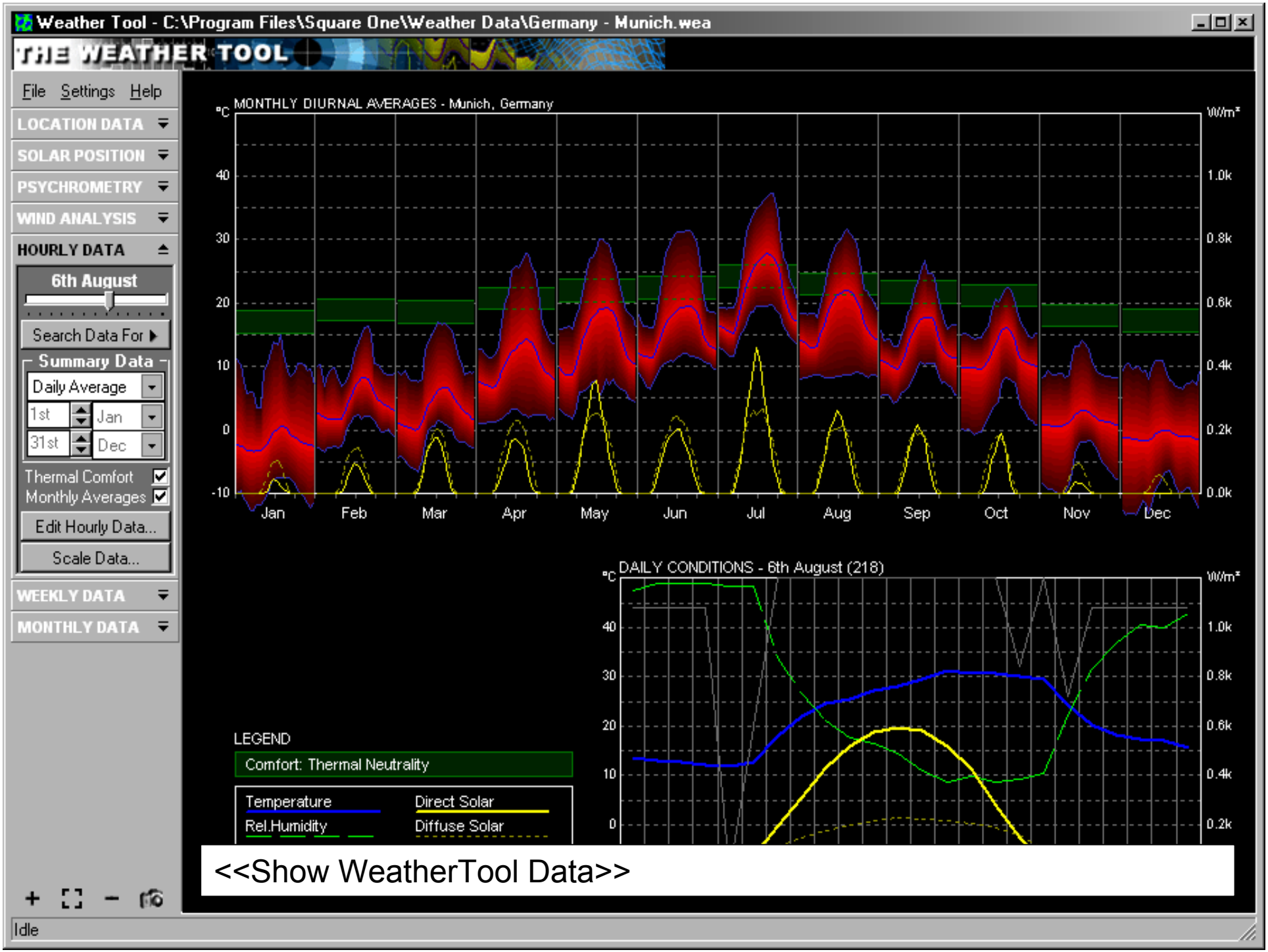
Sky Factor: 13.8%

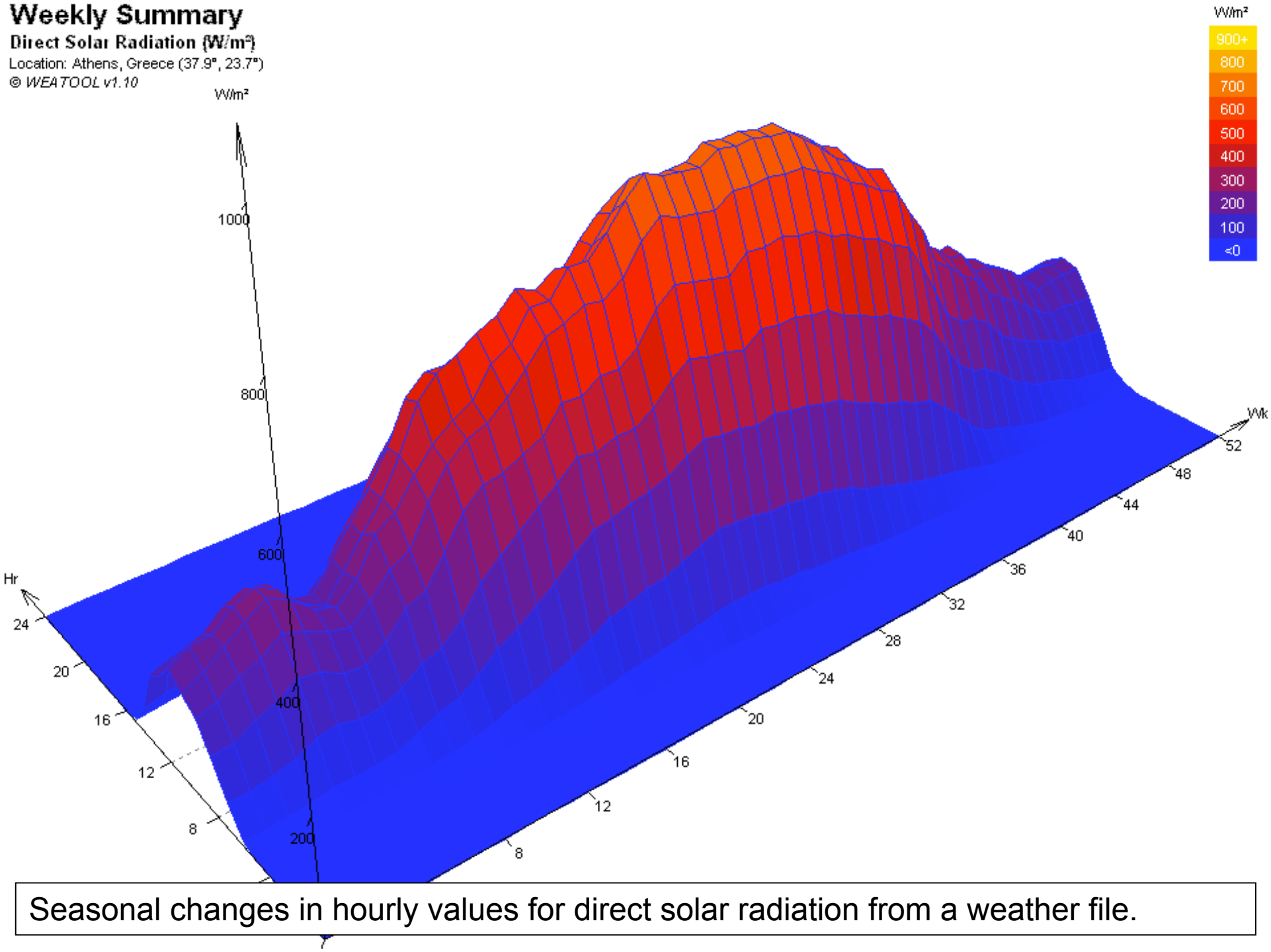
Stereographic Diagram

Location: 51.4°, 0.0°

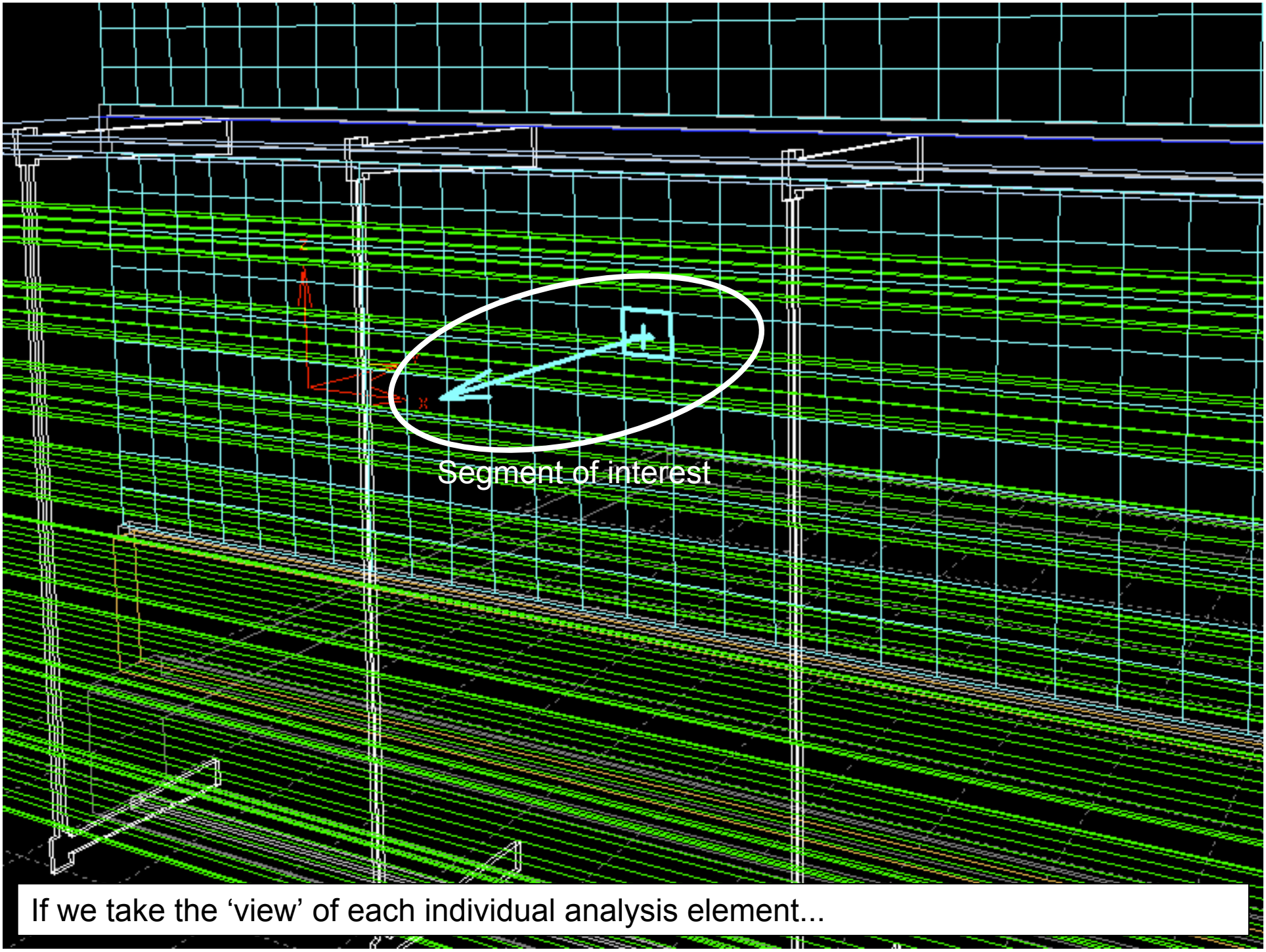
Obj 456 Orientation: -180.0°, 0.0°



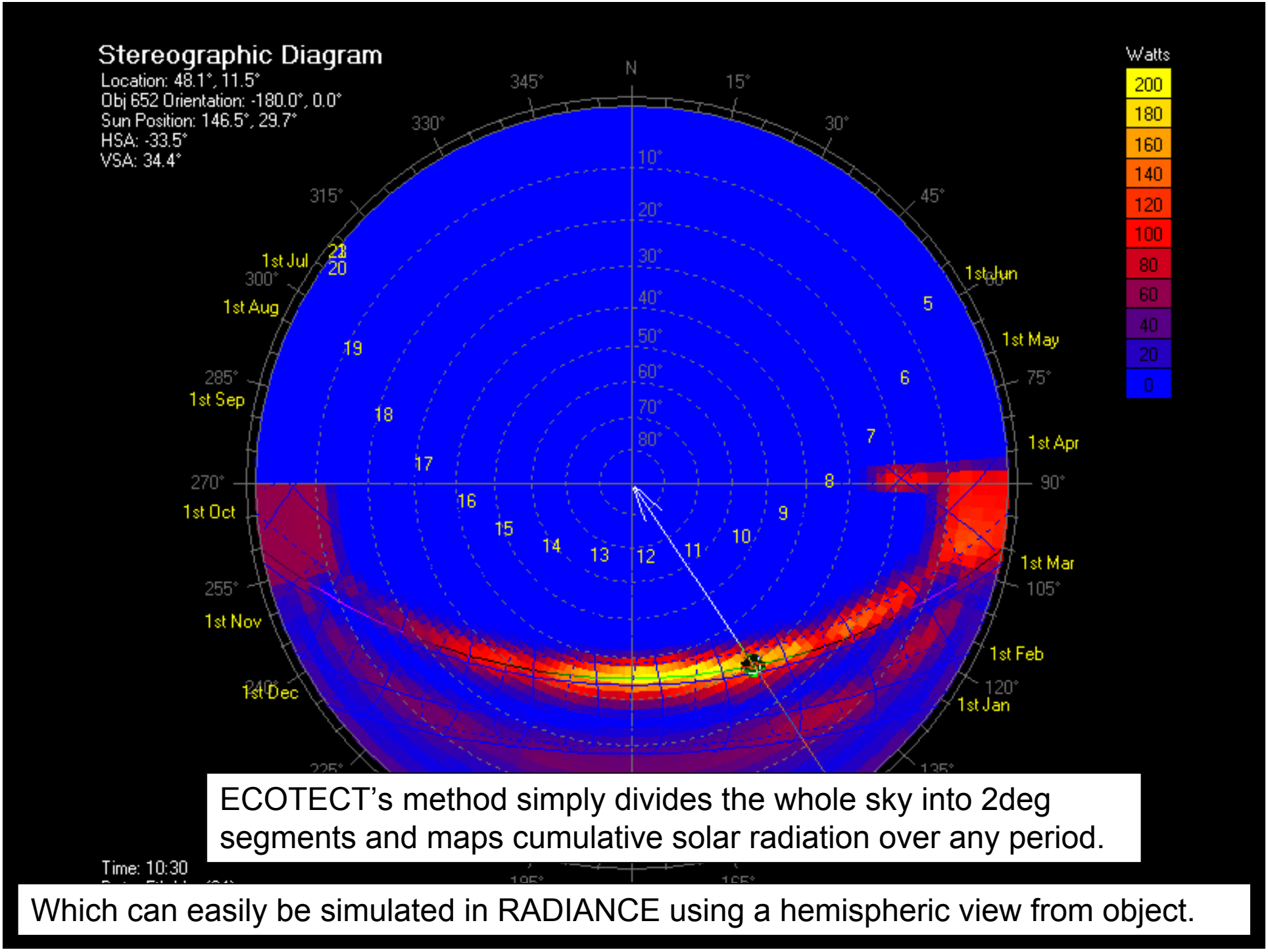

Weather Tool - C:\Program Files\Square One\Weather Data\Germany - Munich.wea
THE WEATHER TOOL
File Settings Help
LOCATION DATA
SOLAR POSITION
PSYCHROMETRY
WIND ANALYSIS
HOURLY DATA
6th August
Search Data For
Summary Data
Daily Average
1st Jan
31st Dec
Thermal Comfort
Monthly Averages
Edit Hourly Data...
Scale Data...
WEEKLY DATA
MONTHLY DATA
MONTHLY DIURNAL AVERAGES - Munich, Germany
°C
W/m²
40
30
20
10
0
-10
1.0k
0.8k
0.6k
0.4k
0.2k
0.0k
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
DAILY CONDITIONS - 6th August (218)
LEGEND
Comfort: Thermal Neutrality
Temperature
Rel.Humidity
Direct Solar
Diffuse Solar
<<Show WeatherTool Data>>
Idle

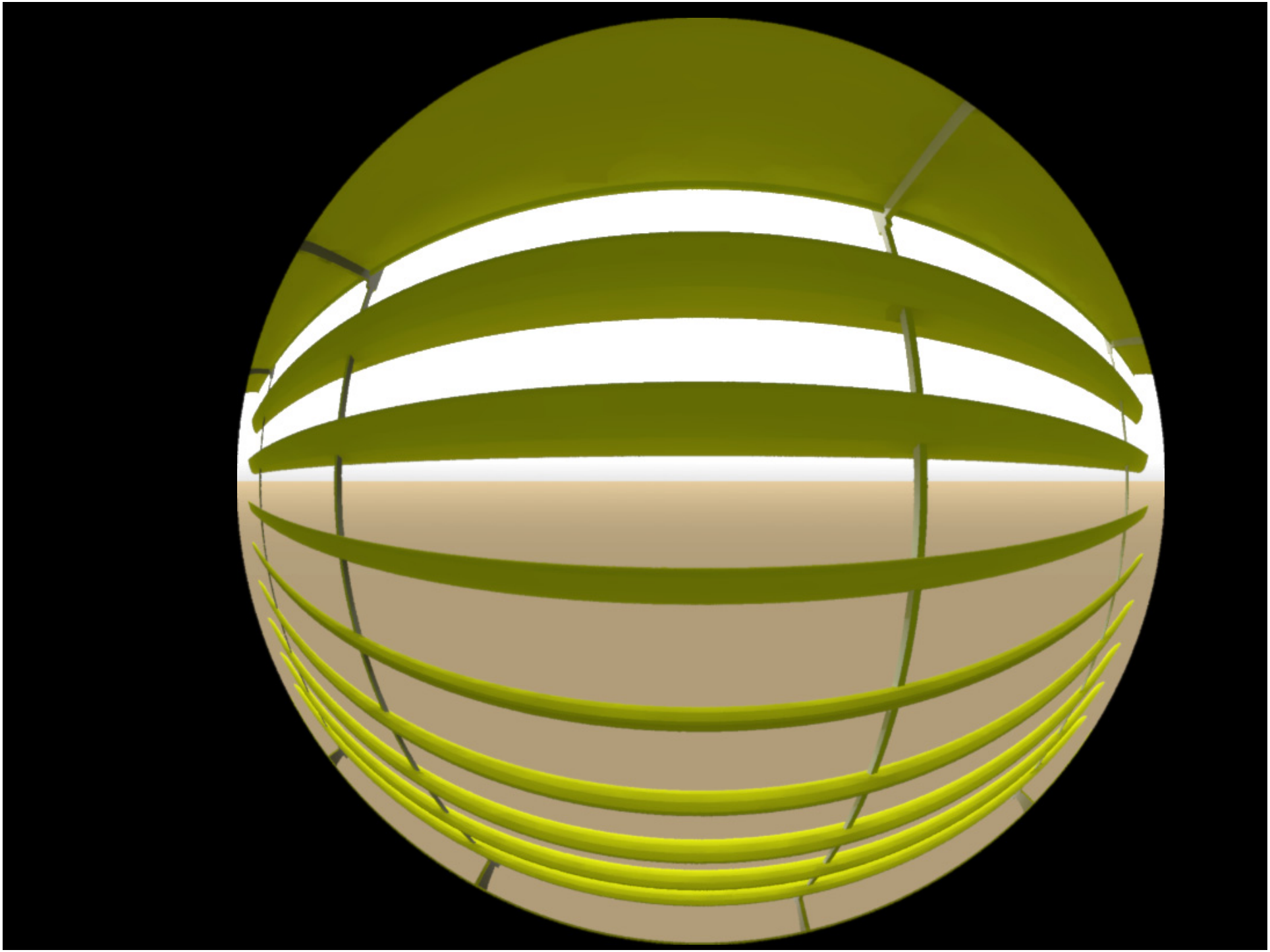


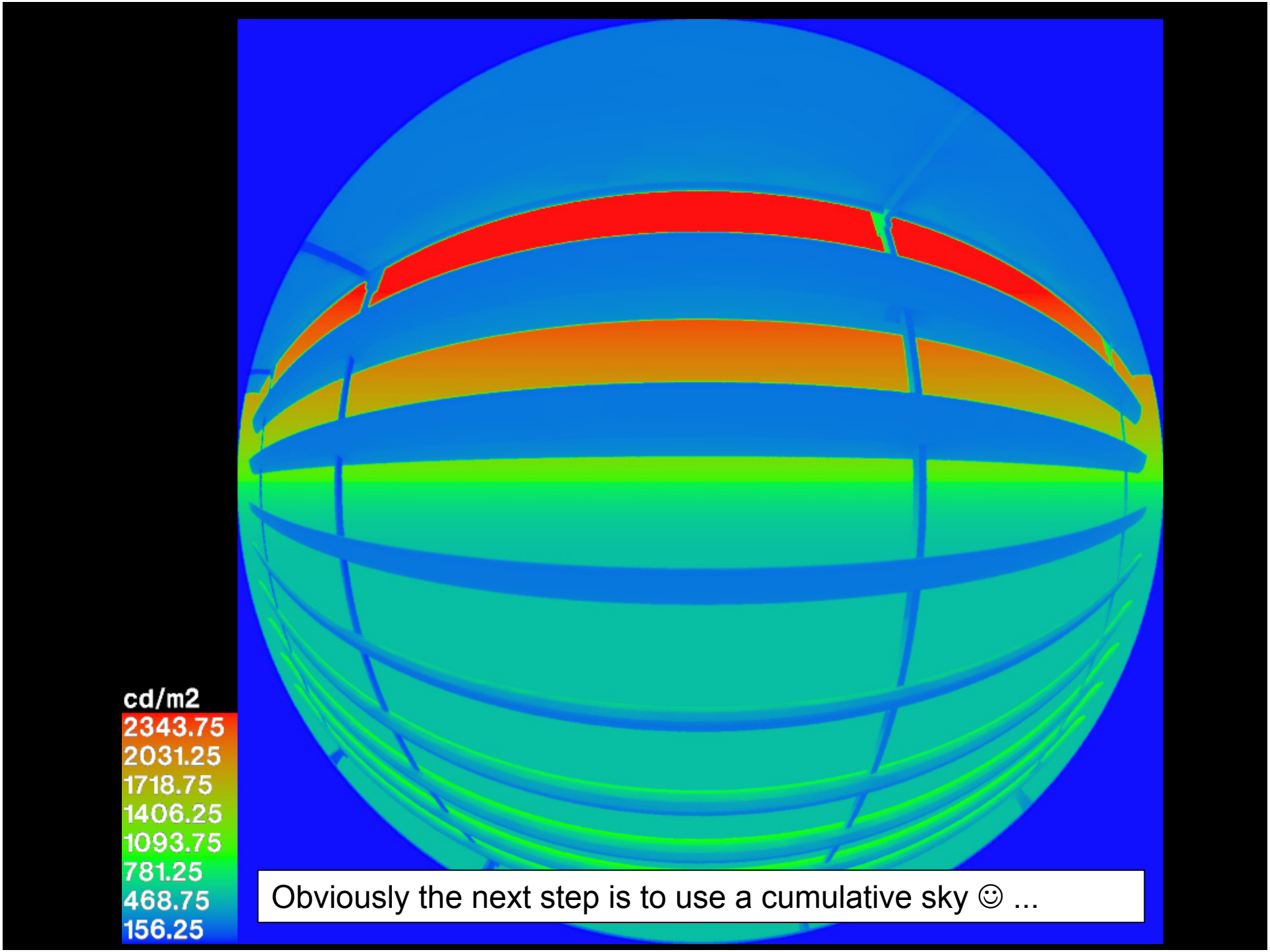
Seasonal changes in hourly values for direct solar radiation from a weather file.



If we take the ‘view’ of each individual analysis element...

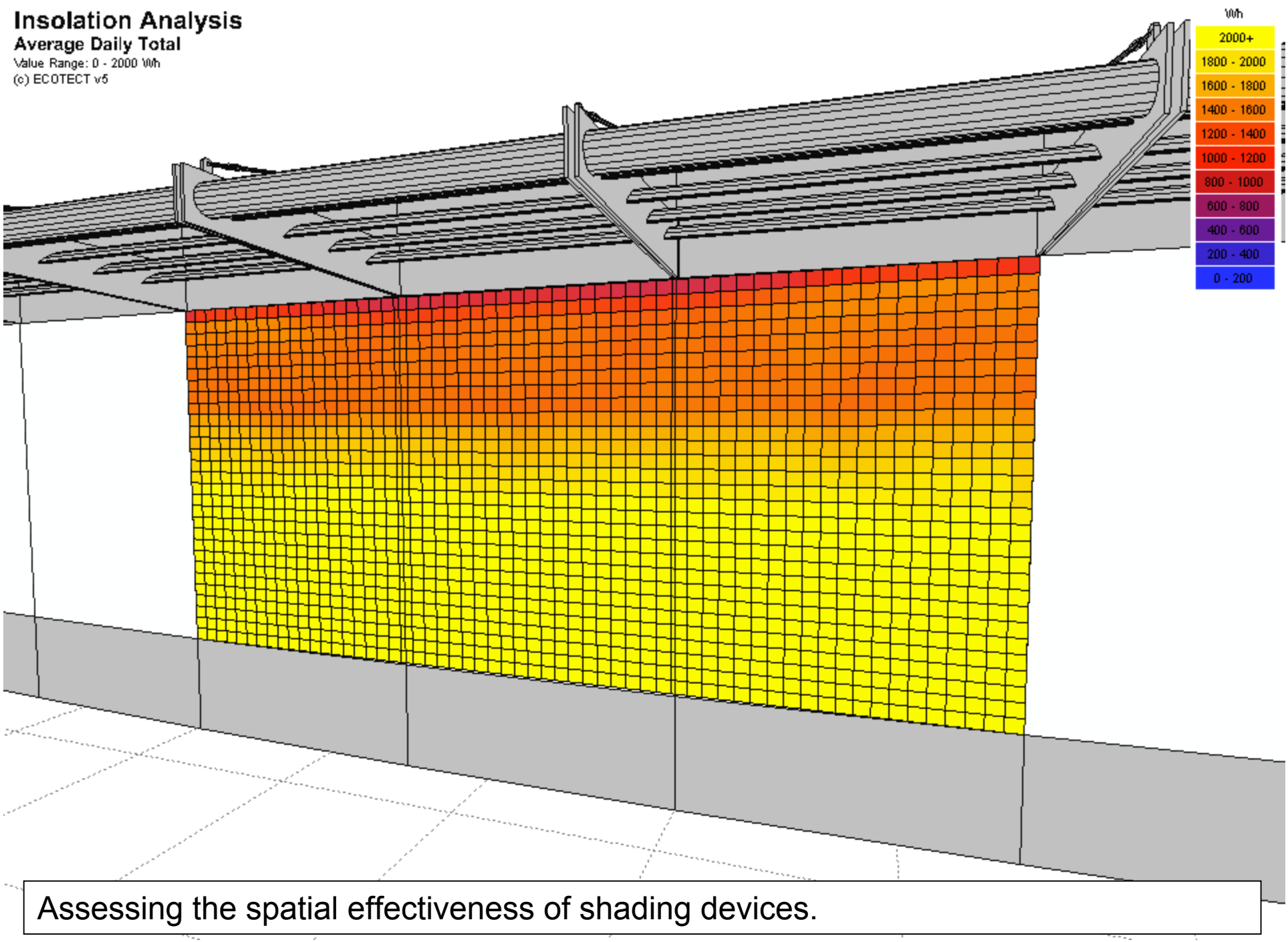

Stereographic Diagram
Location: 48.1°, 11.5°
Obj 652 Orientation: -180.0°, 0.0°
Sun Position: 146.5°, 29.7°
HSA: -33.5°
VSA: 34.4°
Watts
200
180
160
140
120
100
80
60
40
20
0
N
15°
30°
45°
1st May
75°
1st Apr
90°
105°
1st Mar
1st Feb
120°
1st Jan
1st Dec
255°
1st Nov
270°
1st Oct
285°
1st Sep
1st Aug
300°
1st Jul
315°
330°
345°
10°
20°
30°
40°
50°
60°
70°
80°
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
Time: 10:30
ECOTECT's method simply divides the whole sky into 2deg segments and maps cumulative solar radiation over any period.
Which can easily be simulated in RADIANCE using a hemispheric view from object.



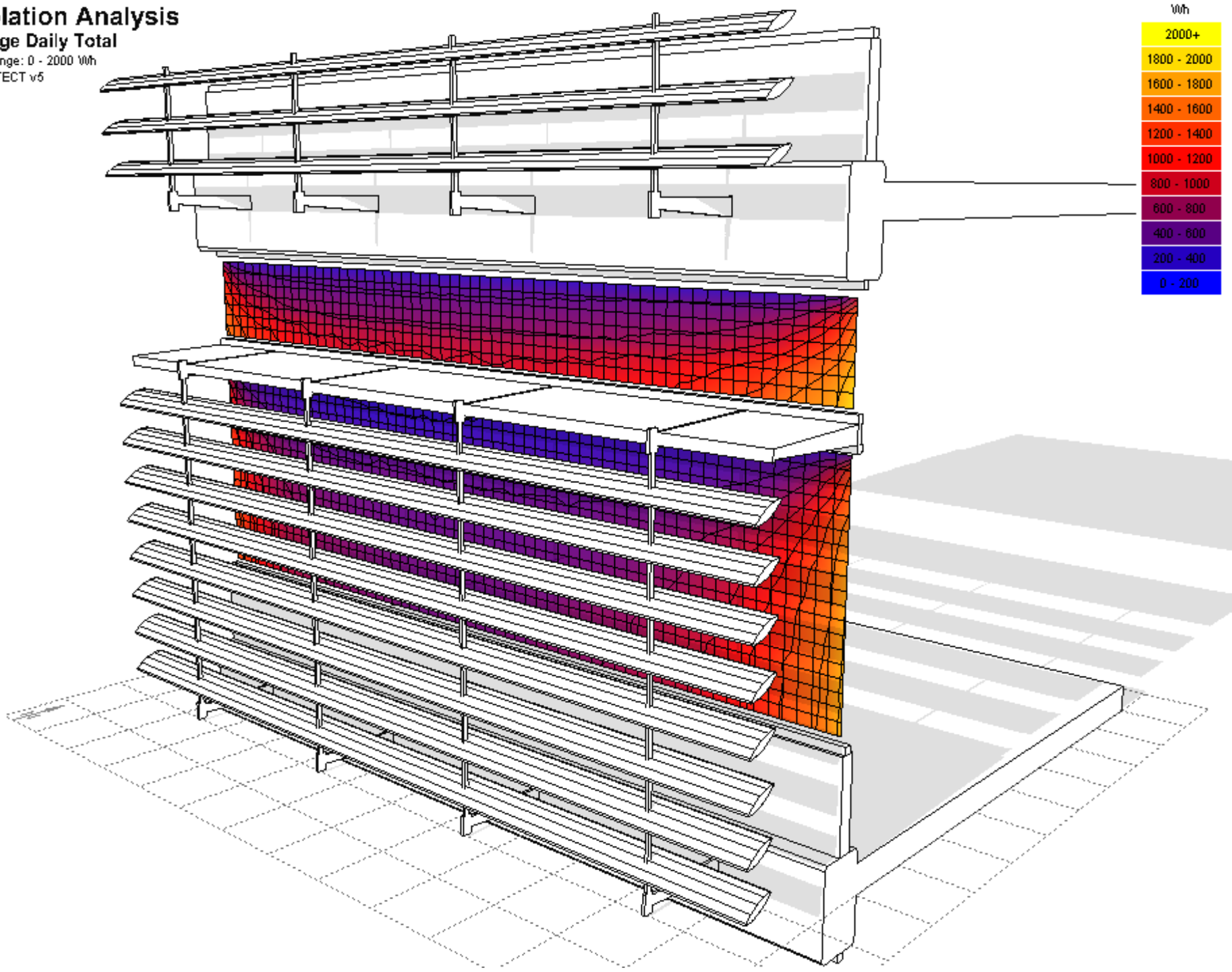


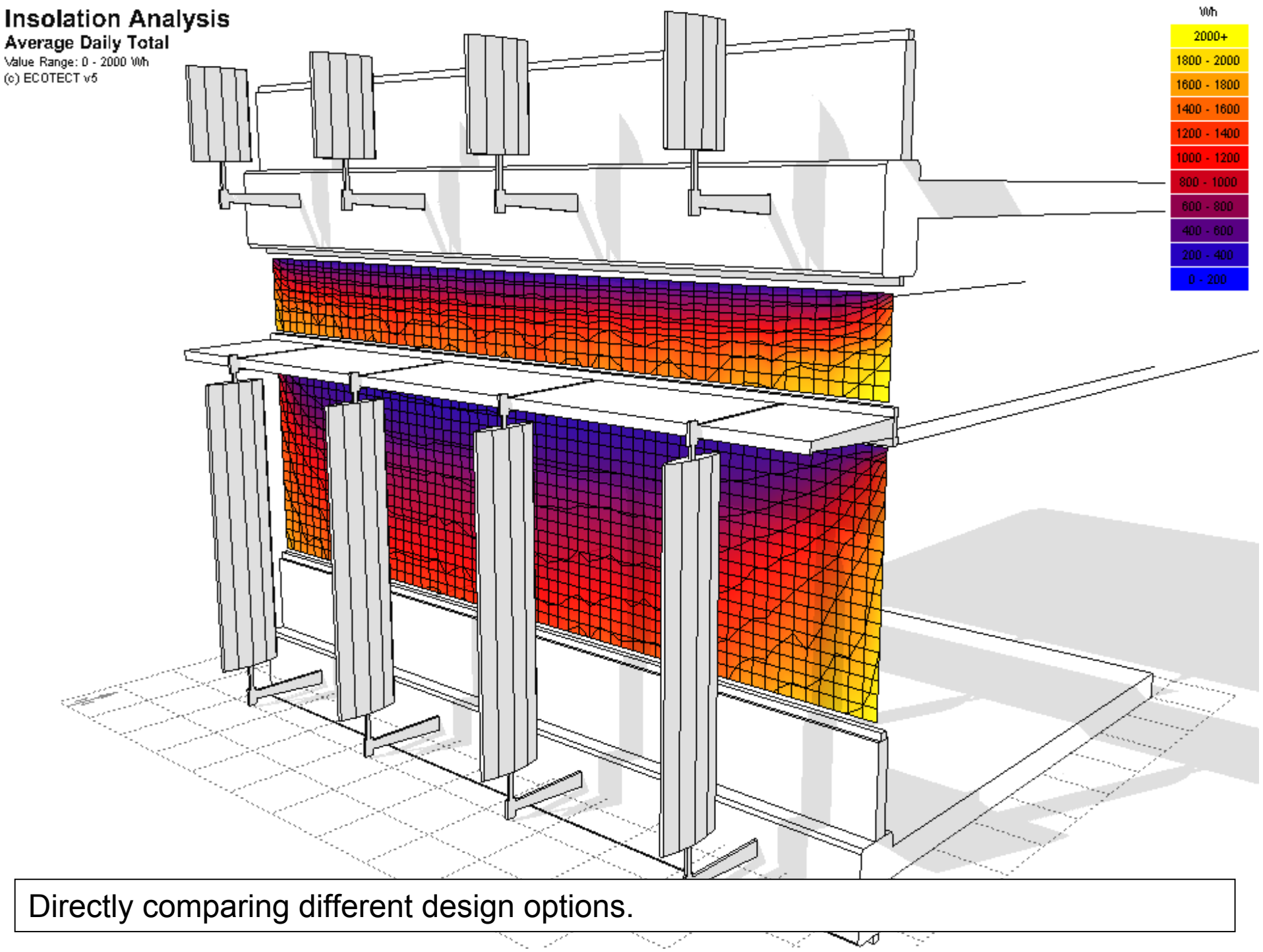
Obviously the next step is to use a cumulative sky ☺ ...

Once extracted and mapped for each element of interest, the information can be used to objectively inform many different early design decisions.



Assessing the spatial effectiveness of shading devices.


Insolation Analysis
Average Daily Total
Value Range: 0 - 2000 Wh
(c) ECOTECT v5
Wh
2000+
1800 - 2000
1600 - 1800
1400 - 1600
1200 - 1400
1000 - 1200
800 - 1000
600 - 800
400 - 600
200 - 400
0 - 200



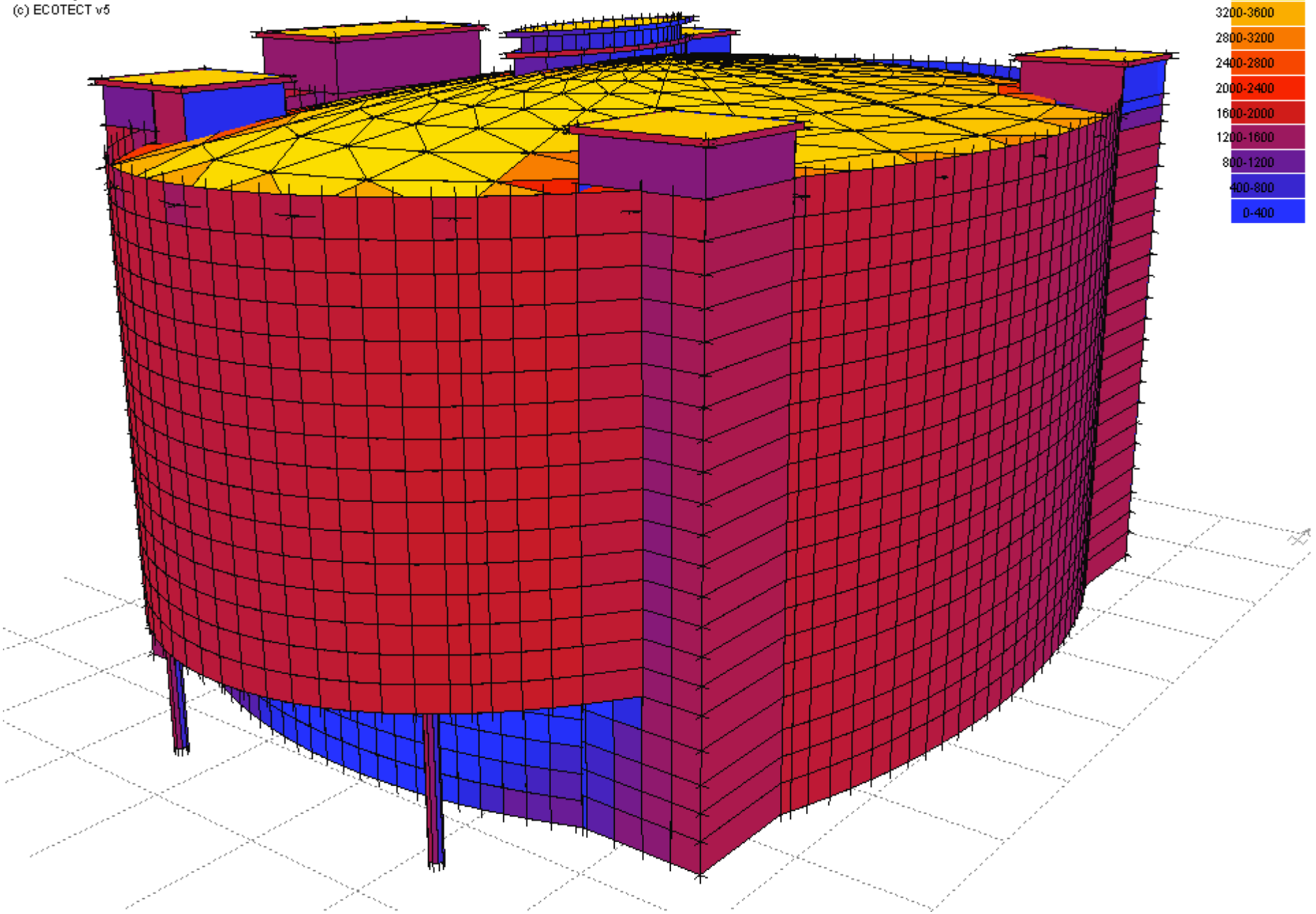
Directly comparing different design options.

OBJECT ATTRIBUTES

Avg Daily Direct (Wh/m2)

Value Range: 0.0 - 4000.0 Units

(c) ECOTECT v5

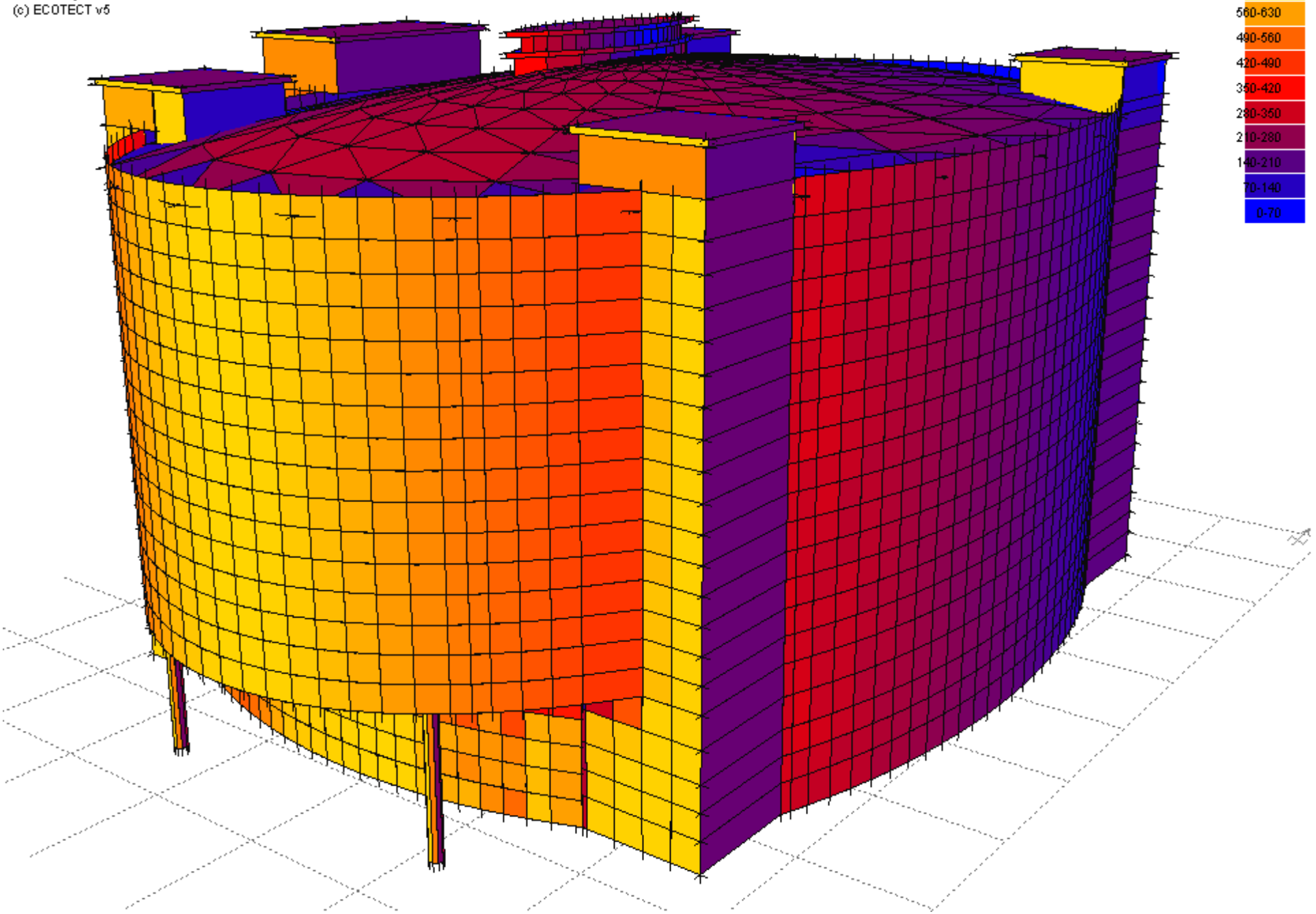


OBJECT ATTRIBUTES

Avg Daily Direct (Wh/m2)

Value Range: 0.0 - 700.0 Units

(c) ECOTECT v5

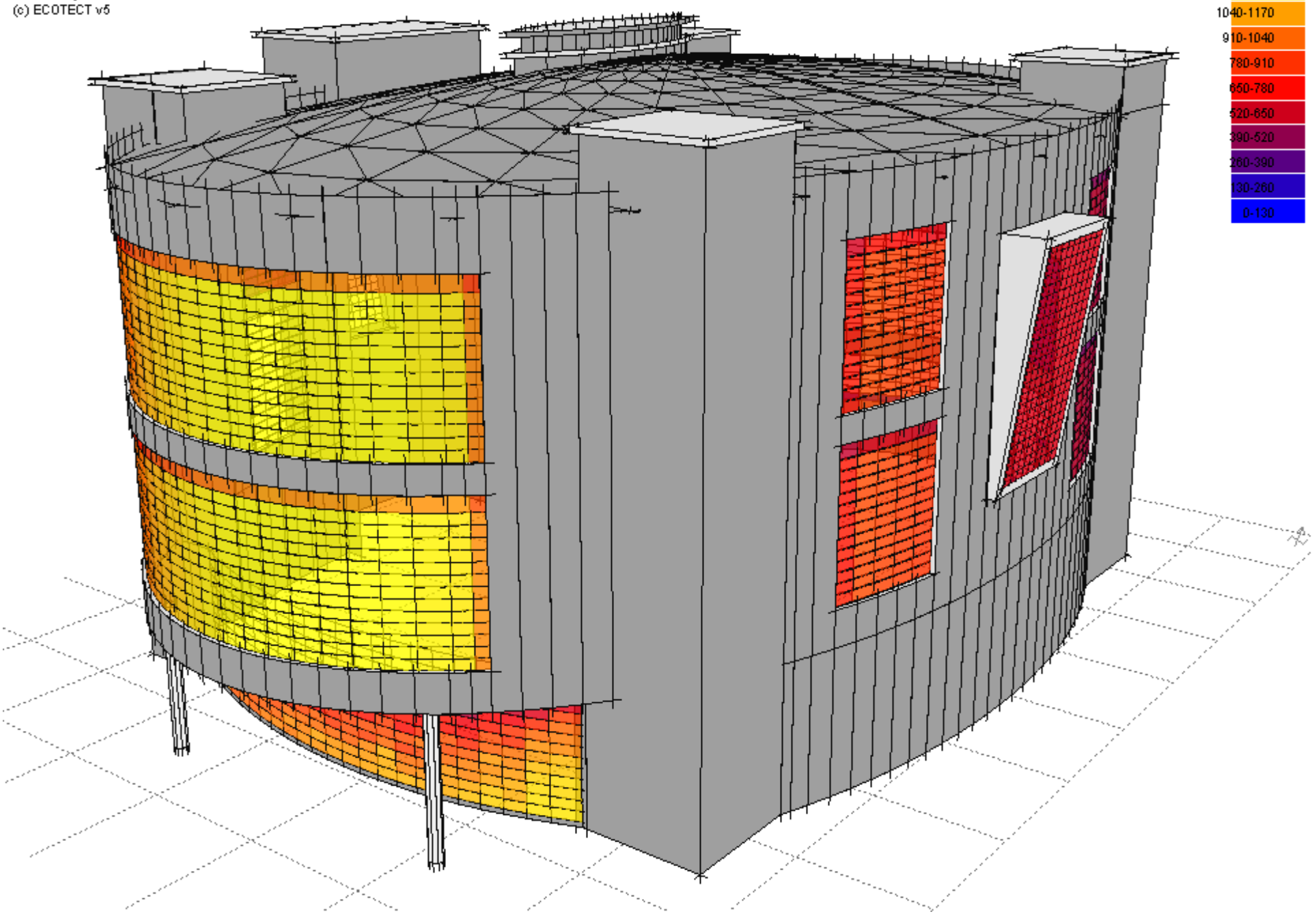


OBJECT ATTRIBUTES

Avg Daily Direct (Wh/m2)

Value Range: 0.0 - 1300.0 Units

(c) ECOTECT v5

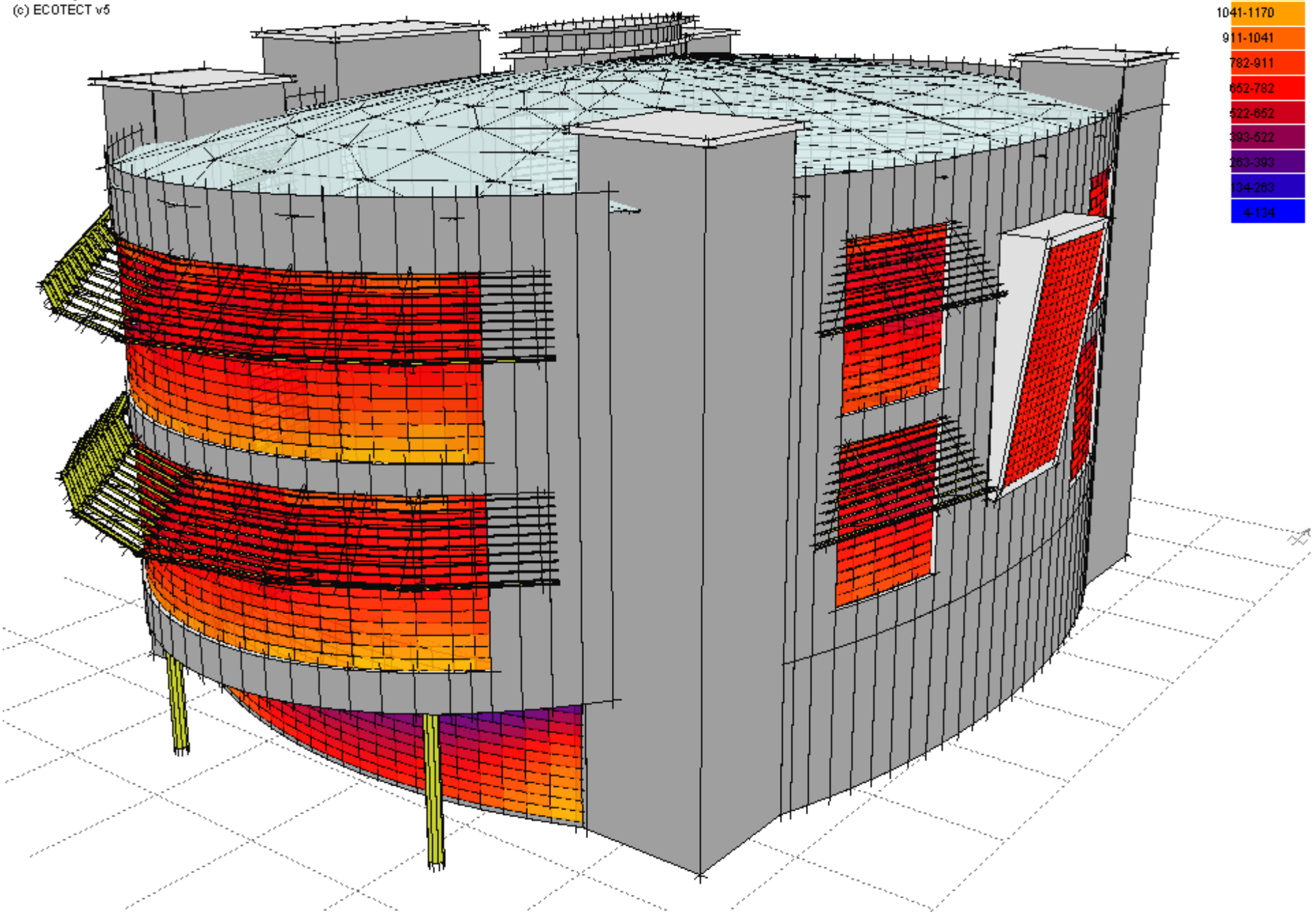


OBJECT ATTRIBUTES

Avg Daily Direct (Wh/m2)

Value Range: 4.0 - 1300.0 Units

(c) ECOTECT v5

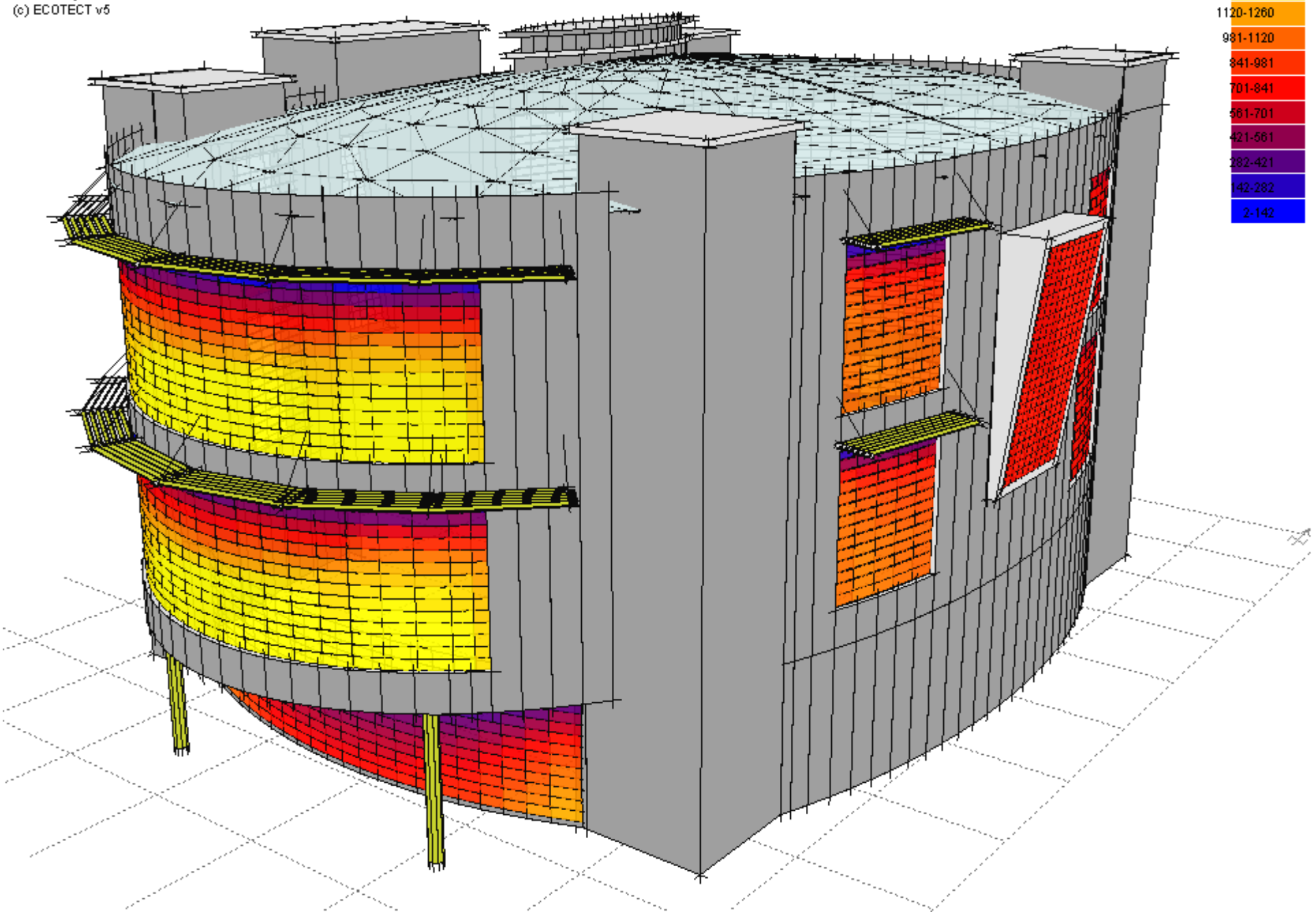


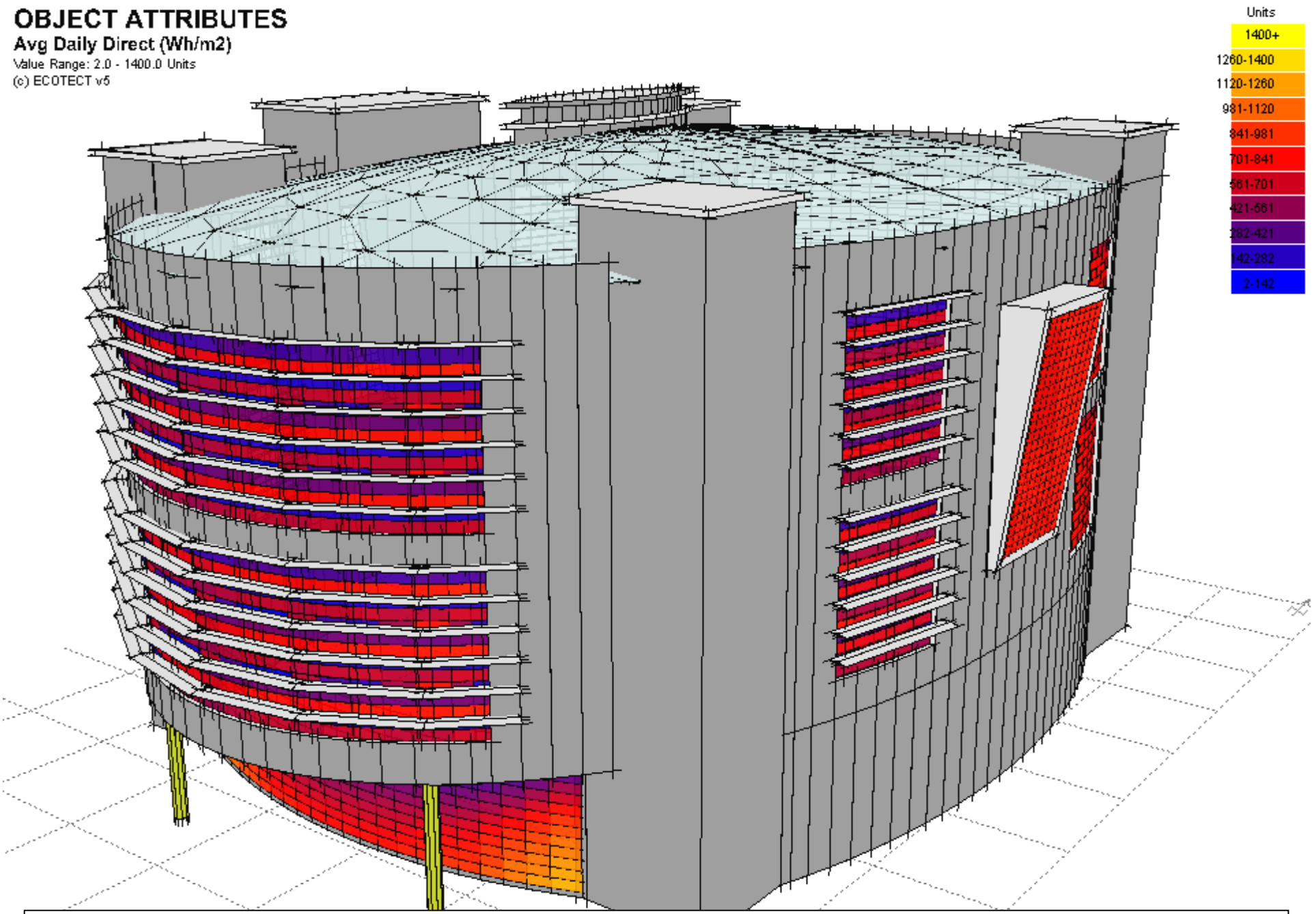
OBJECT ATTRIBUTES

Avg Daily Direct (Wh/m2)

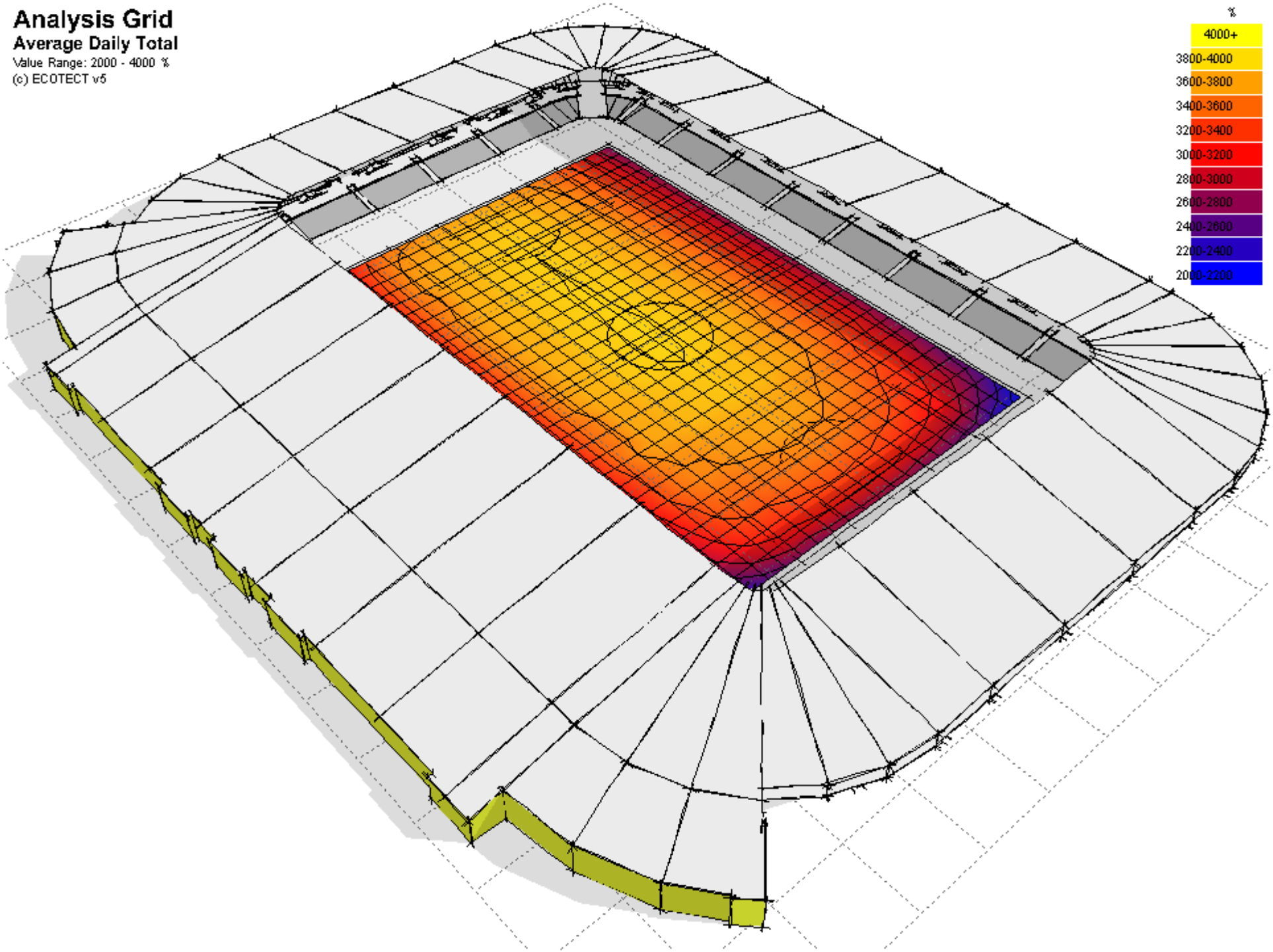
Value Range: 2.0 - 1400.0 Units

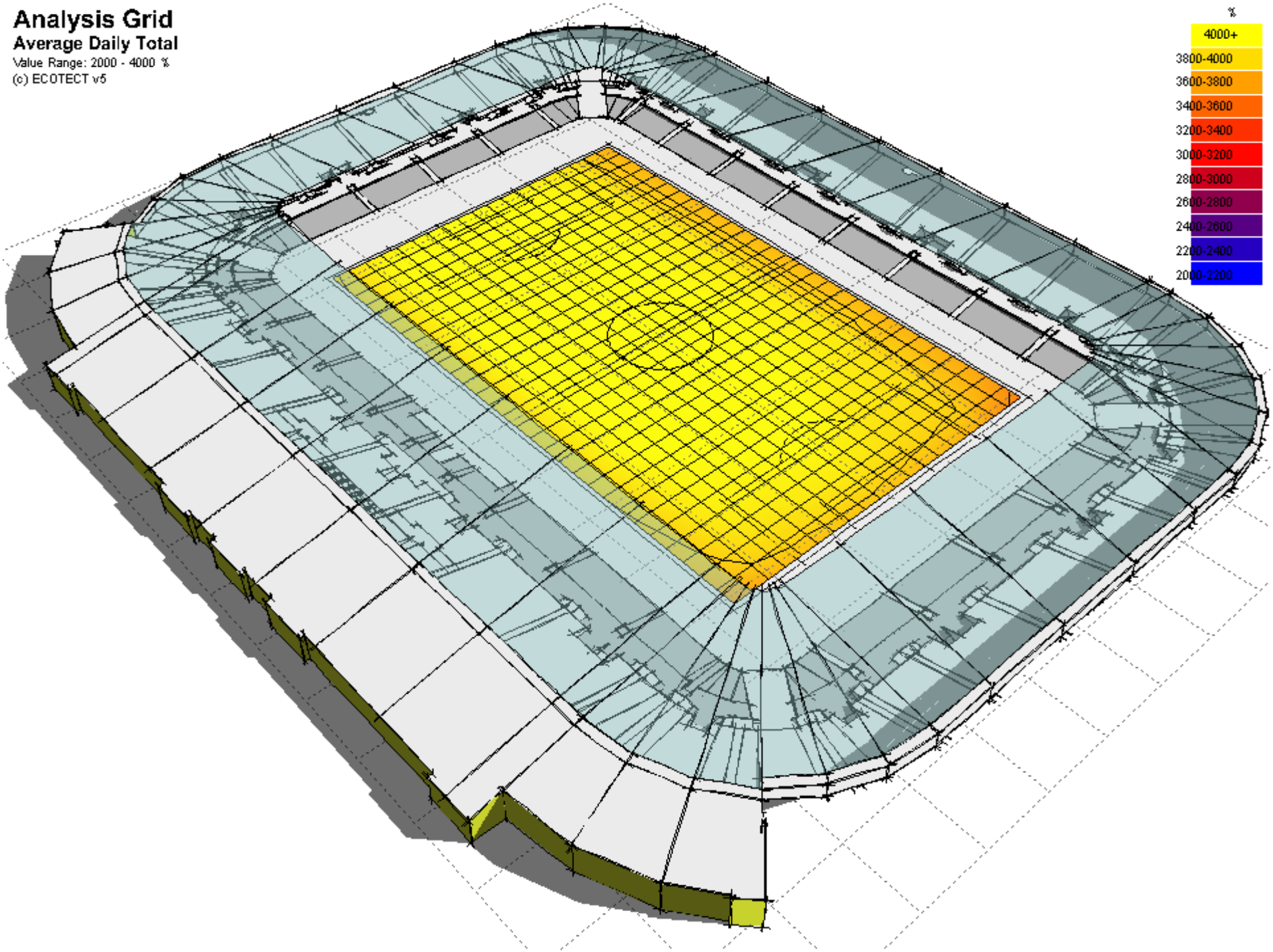
(c) ECOTECT v5

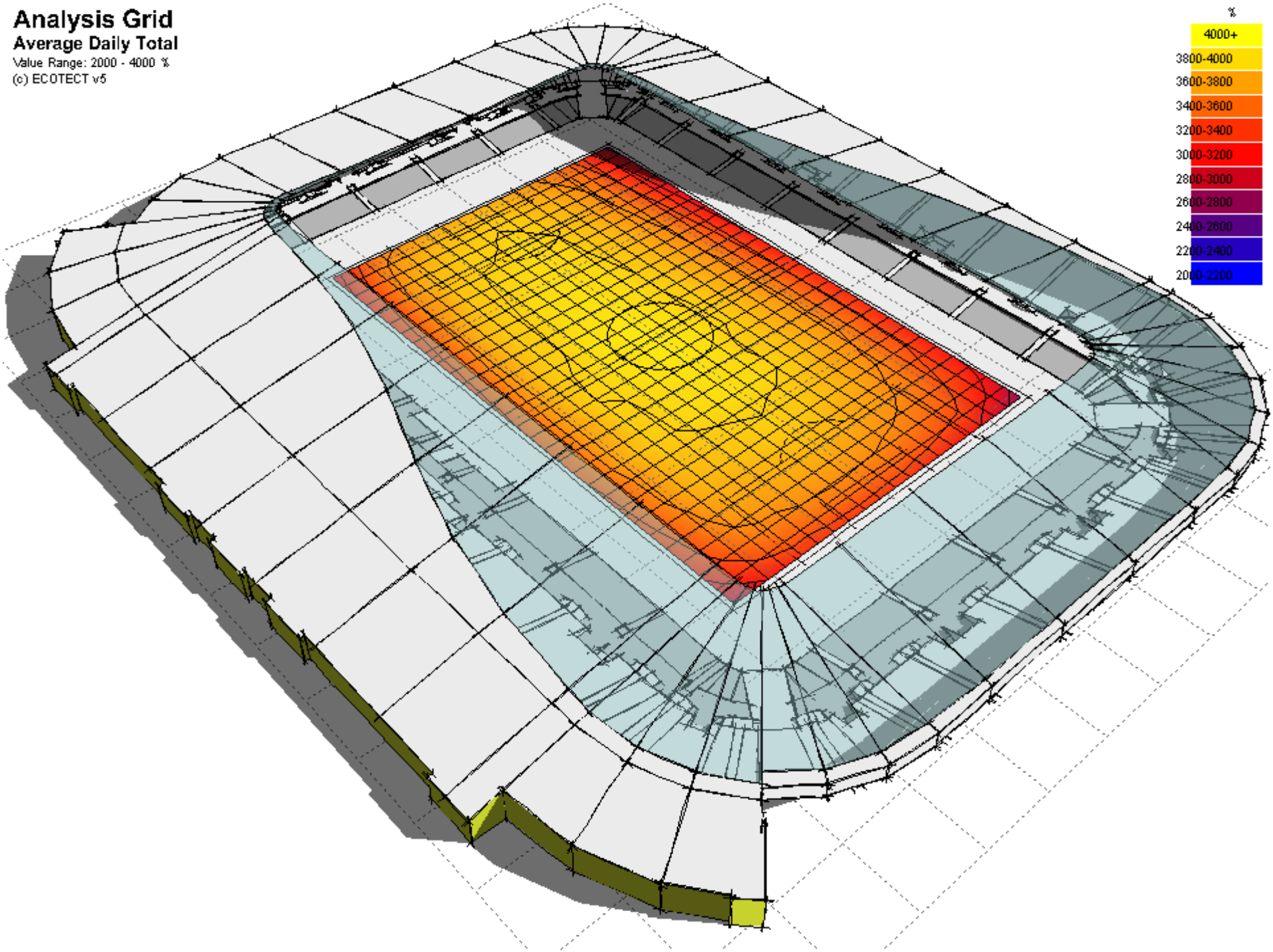


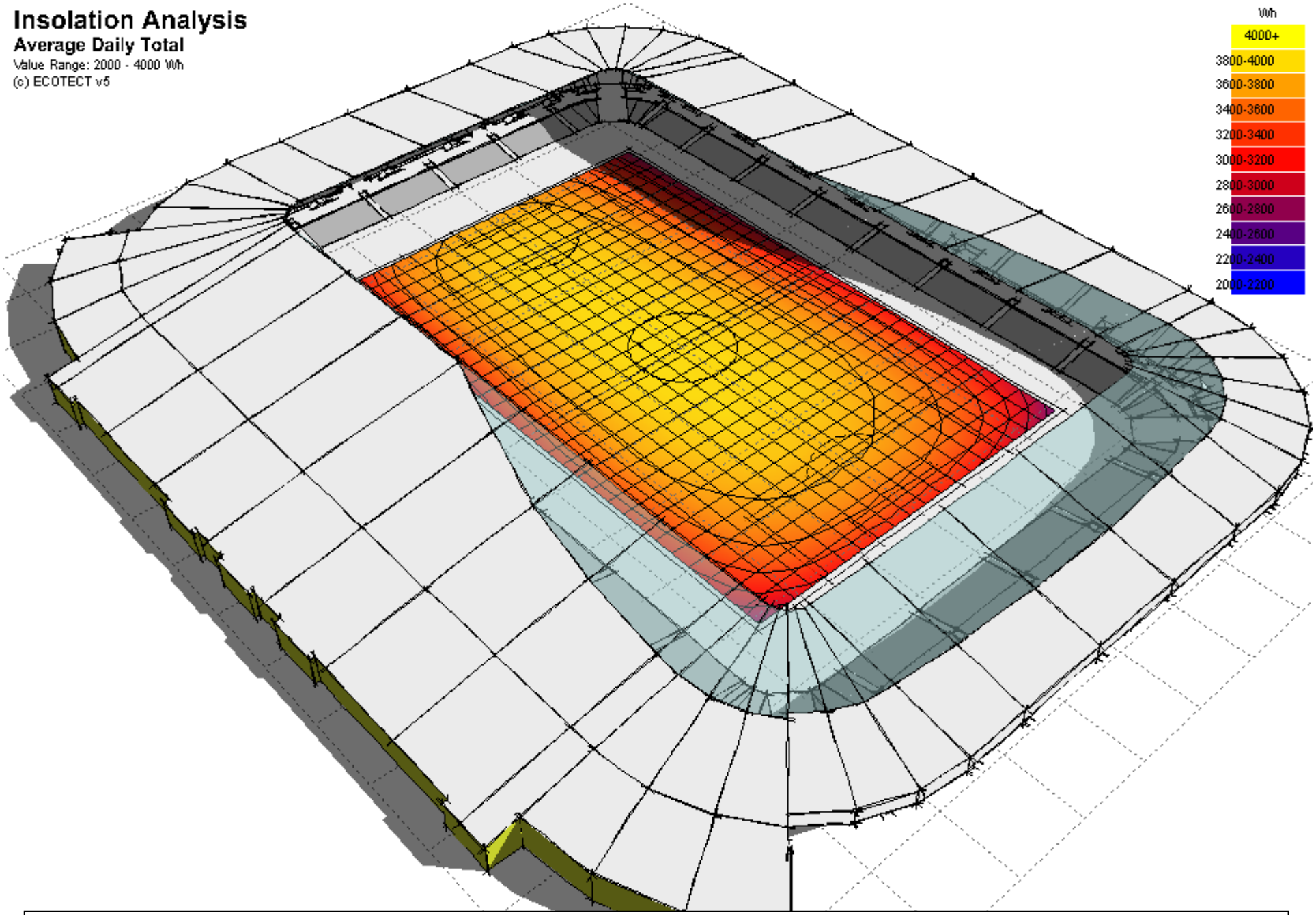


Deciding where to locate windows and how to effectively shade them.


Analysis Grid
Average Daily Total
Value Range: 2000 - 4000 %
(c) ECOTECT v5
%
4000+
3800-4000
3600-3800
3400-3600
3200-3400
3000-3200
2800-3000
2600-2800
2400-2600
2200-2400
2000-2200


Analysis Grid
Average Daily Total
Value Range: 2000 - 4000 %
(c) ECOTECT v5
%
4000+
3800-4000
3600-3800
3400-3600
3200-3400
3000-3200
2800-3000
2600-2800
2400-2600
2200-2400
2000-2200


Analysis Grid
Average Daily Total
Value Range: 2000 - 4000 %
(c) ECOTECT v5
%
4000+
3800-4000
3600-3800
3400-3600
3200-3400
3000-3200
2800-3000
2600-2800
2400-2600
2200-2400
2000-2200



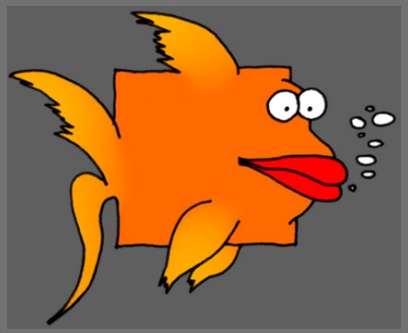
Or even where best to locate the glazing in a stadium roof.

Summary

- The ability to spatially map calculated values over the original geometry (or even for specific objects in a model) has been shown to have significant potential in the area of generative design solutions - allowing iterative analysis and modification to the design parameters.

- In high-density environments, such as deep urban canyons, inter-reflected light is a significant component of overall availability.

- The use of cumulative skies in RADIANCE, as described by the previous speaker, means that these design issues can be approached with full consideration of inter-reflection.



www.squ1.com **www.ecotect.com**

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD