Energy simulation,
Building and Urban scale

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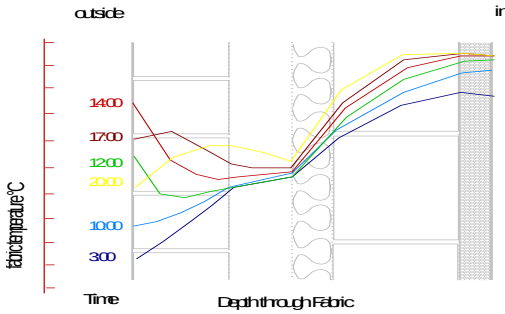
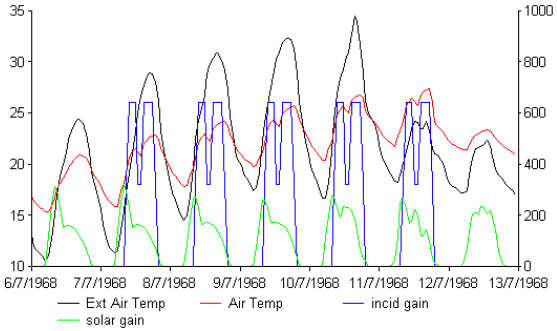
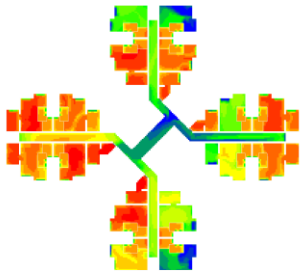
Modelling Background

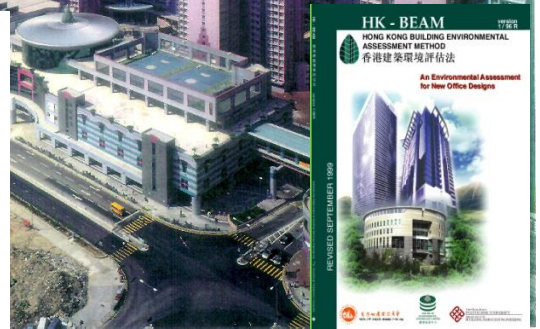


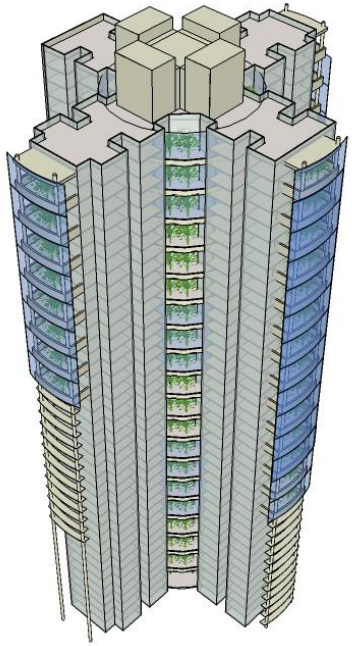
Dynamic energy modelling of buildings: Detail model of the building fabric and energy use, includes;

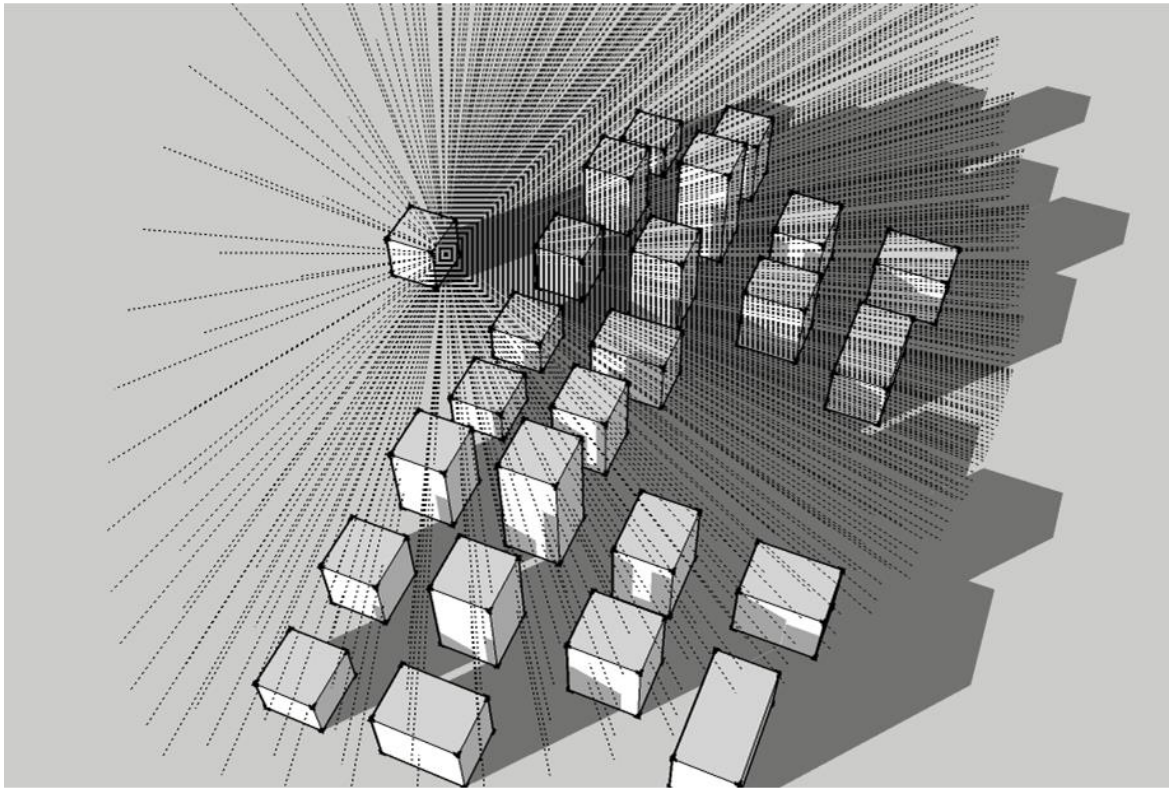
- **Hourly data**
- **Local weather files**
- **Occupancy models**
- **Thermal mass**
- **Radiative transfer**



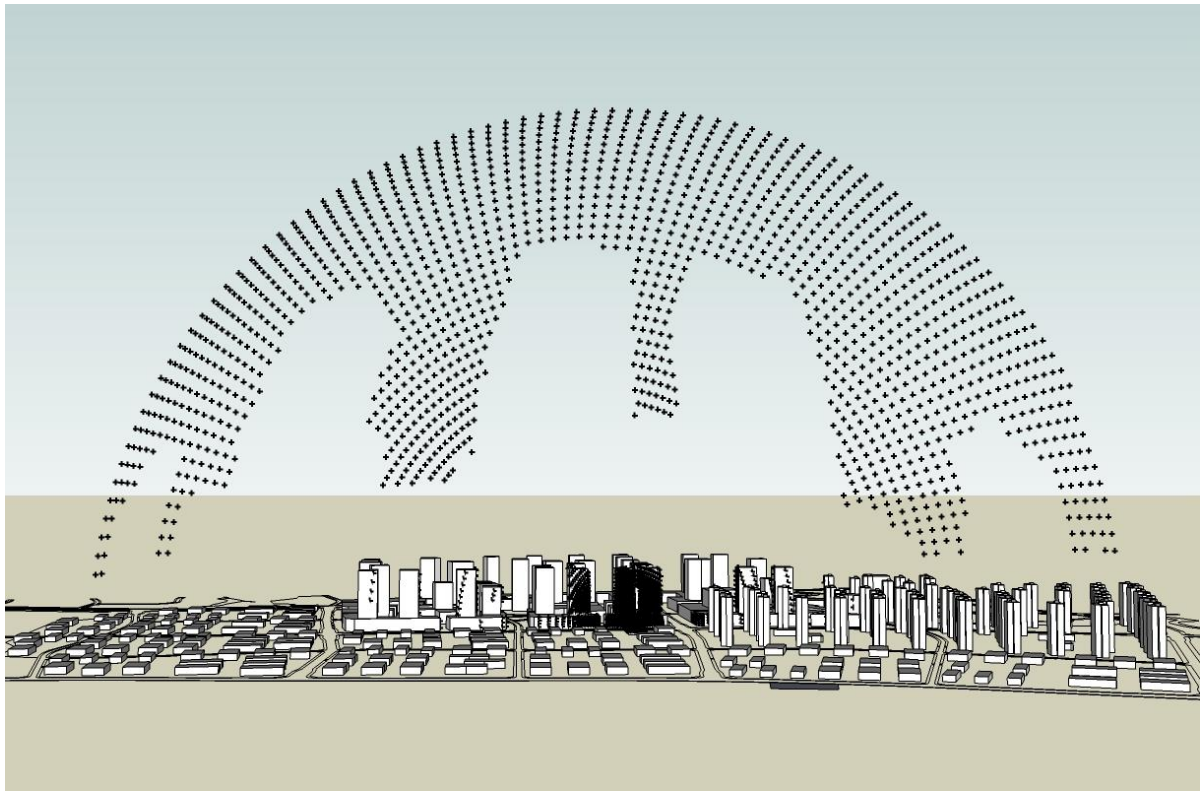








SketchUp Model : The VirVil Plugin
Uses dynamic simulation at an early stage with simple input data to reduce complication



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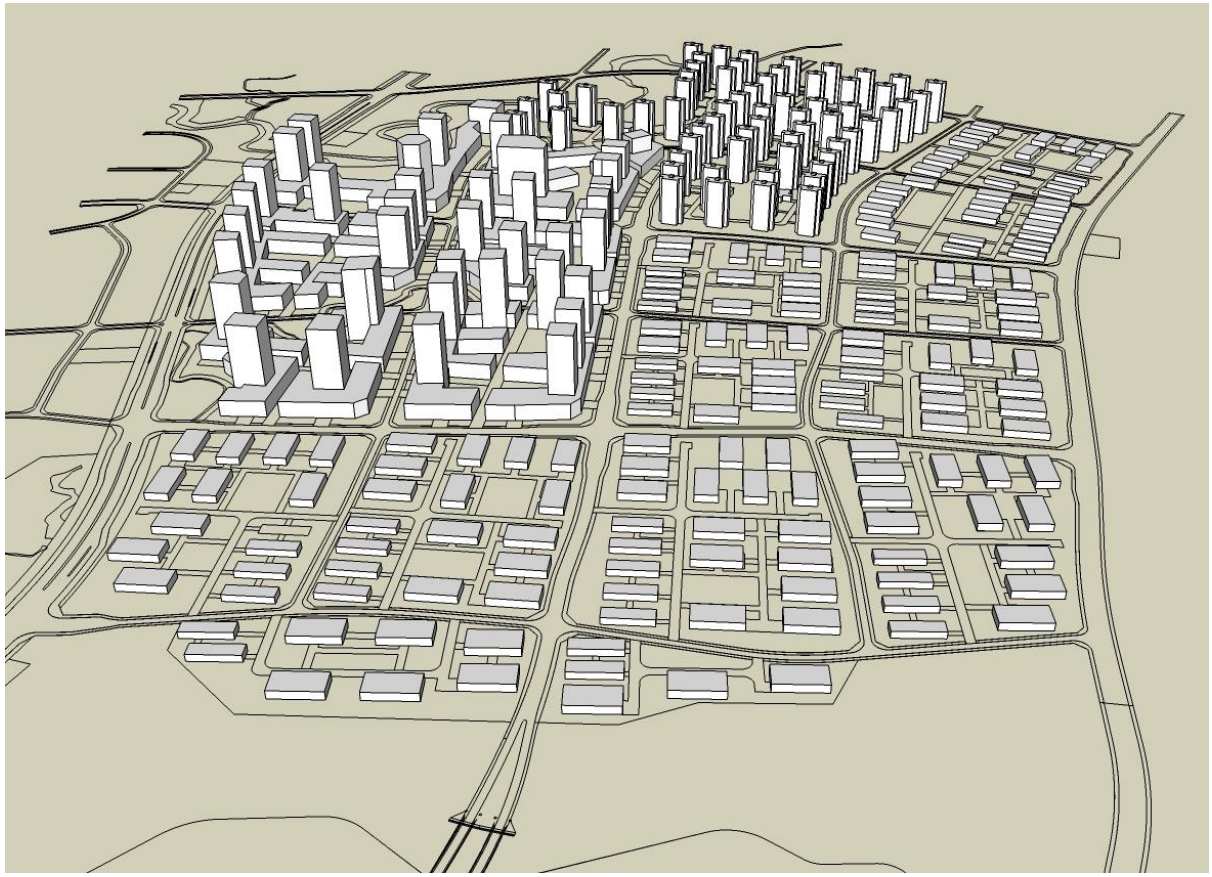

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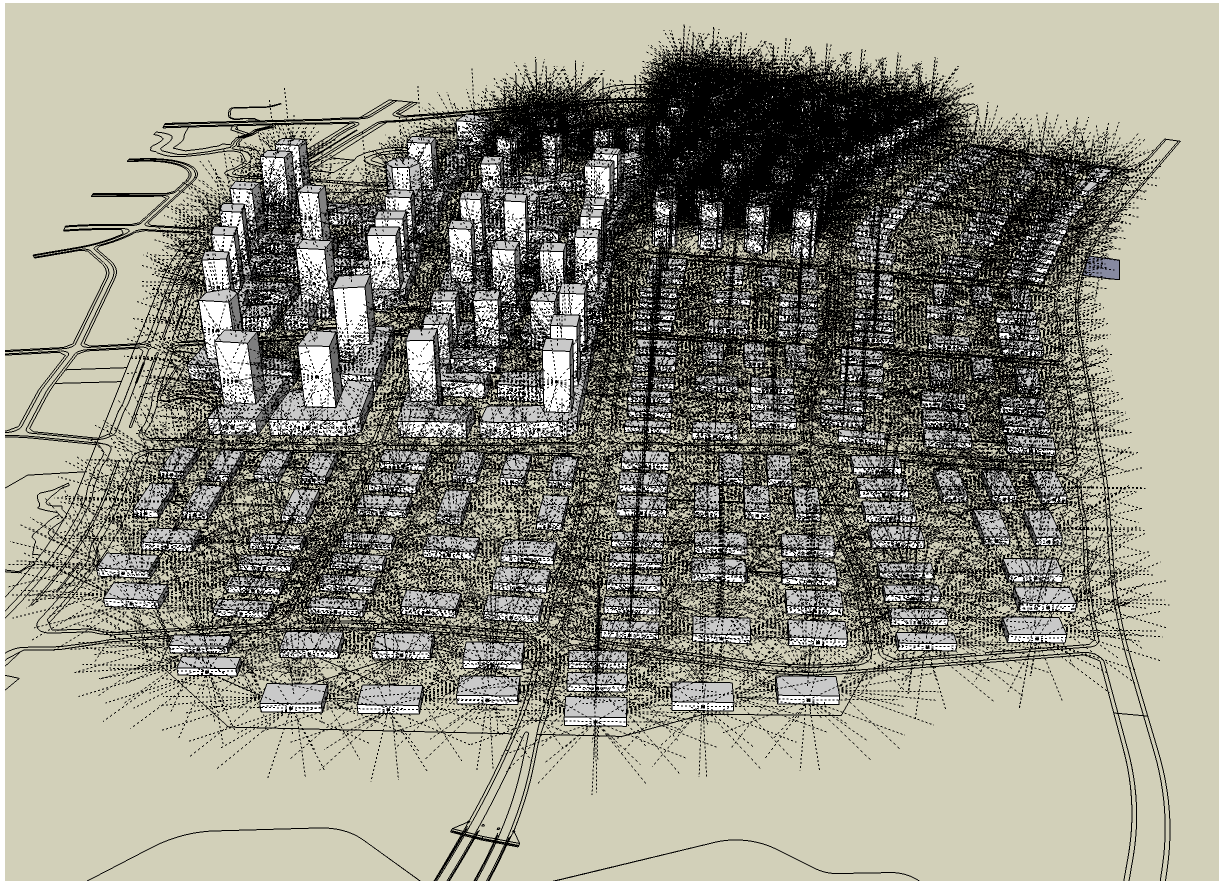
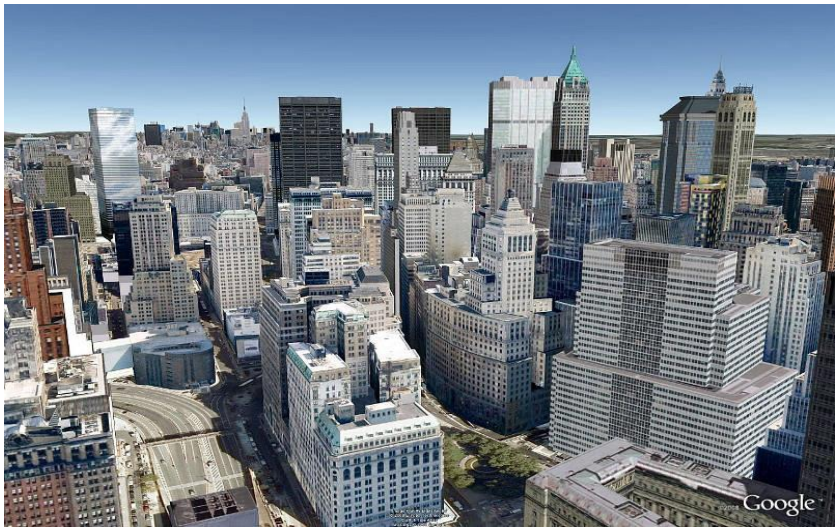
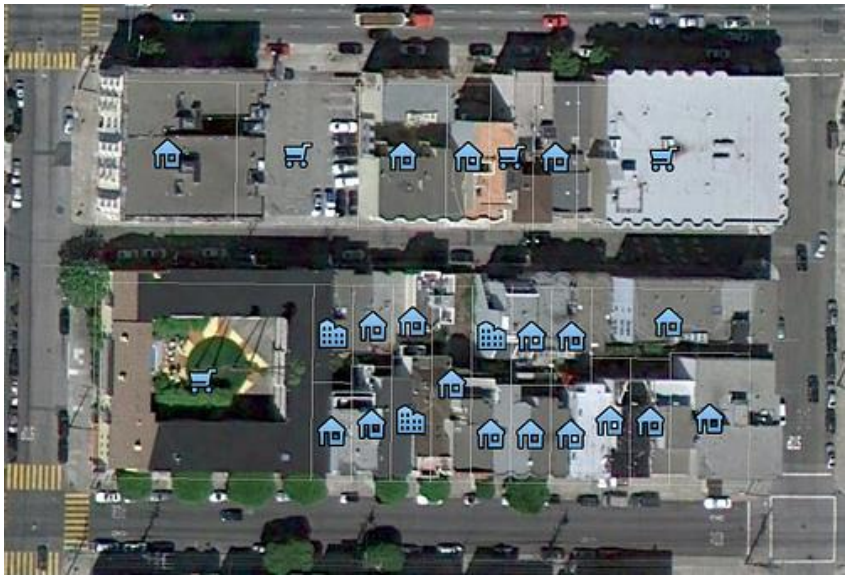


SketchUp Model : The VirVil Plugin
Uses dynamic simulation at an early stage with simple input data to reduce complication

Why SketchUp?

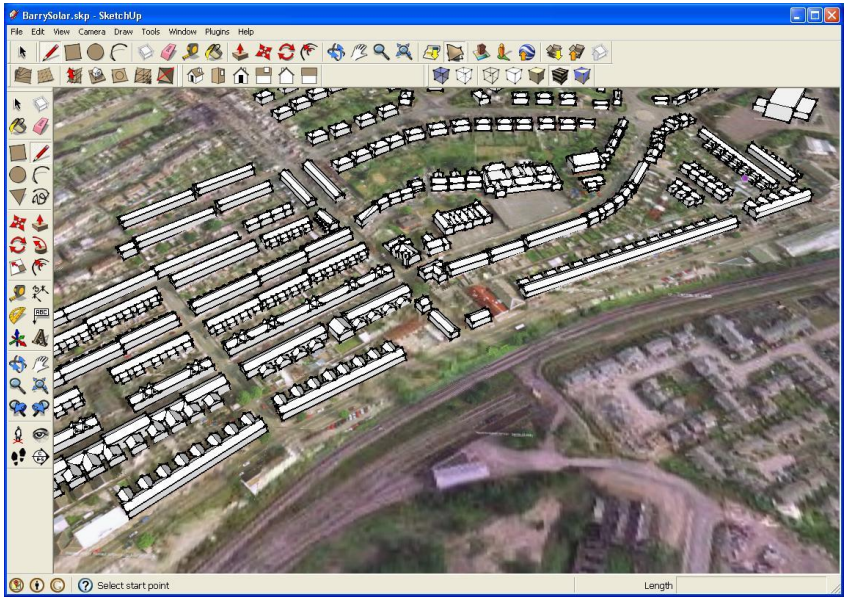
- Very popular as a design tool in 2012 over 30 million activations
- User Interface
- Great symmetry with HTB2
- Existing models and terrain

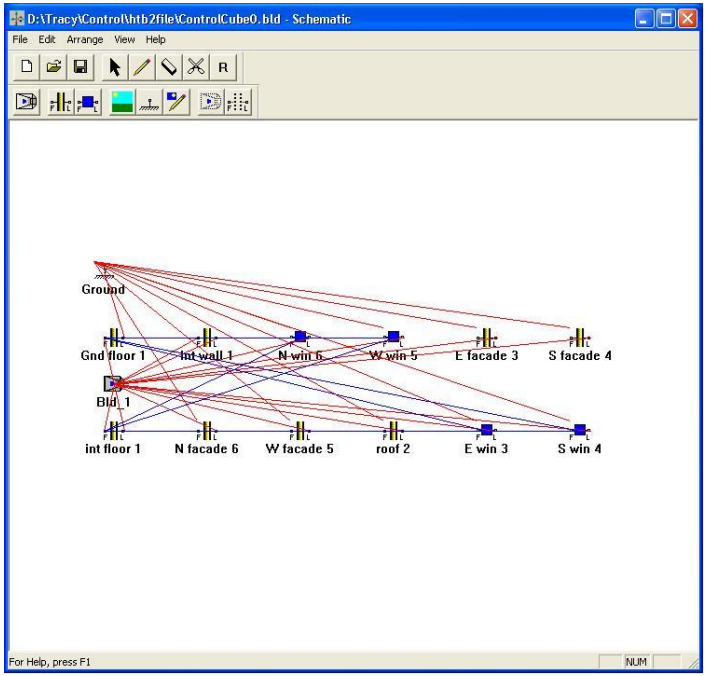


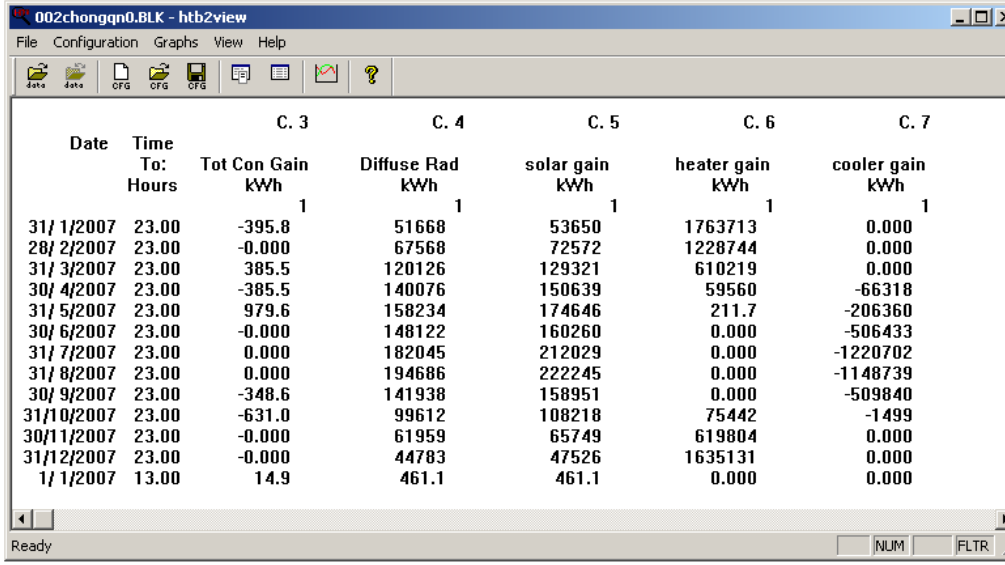


VirVil Extension

- Produces HTB2 input files automatically
- Runs the HTB2 model
- Displays results within a design tool
- Retains the detail of the full simulation







Date	Time To: Hours	C. 3 Tot Con Gain kWh	C. 4 Diffuse Rad kWh	C. 5 solar gain kWh	C. 6 heater gain kWh	C. 7 cooler gain kWh
		1	1	1	1	1
31/ 1/2007	23.00	-395.8	51668	53650	1763713	0.000
28/ 2/2007	23.00	-0.000	67568	72572	1228744	0.000
31/ 3/2007	23.00	385.5	120126	129321	610219	0.000
30/ 4/2007	23.00	-385.5	140076	150639	59560	-66318
31/ 5/2007	23.00	979.6	158234	174646	211.7	-206360
30/ 6/2007	23.00	-0.000	148122	160260	0.000	-506433
31/ 7/2007	23.00	0.000	182045	212029	0.000	-1220702
31/ 8/2007	23.00	0.000	194686	222245	0.000	-1148739
30/ 9/2007	23.00	-348.6	141938	158951	0.000	-509840
31/10/2007	23.00	-631.0	99612	108218	75442	-1499
30/11/2007	23.00	-0.000	61959	65749	619804	0.000
31/12/2007	23.00	-0.000	44783	47526	1635131	0.000
1/ 1/2007	13.00	14.9	461.1	461.1	0.000	0.000

Energy simulation: VirVil SketchUp Extension

What it predicts

- Solar radiation falling on a face
- Heating and Cooling Energy demand

What it can test

- Impact of shape and form on energy performance
- Impact of terrain
- Impact of surrounding buildings
- Impact of shading devices

Energy simulation: VirVil SketchUp Extension

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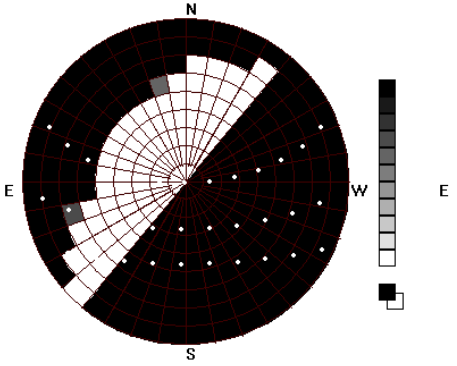
Solar radiation

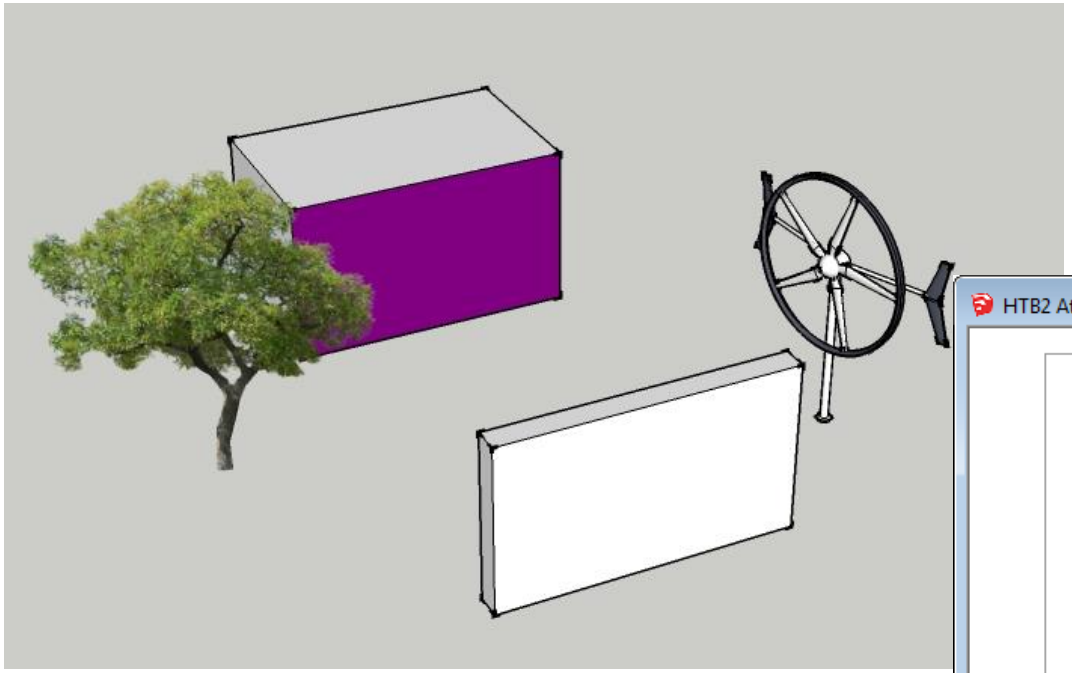
HTB2 calculates the Solar radiation falling on each external surface of the model.

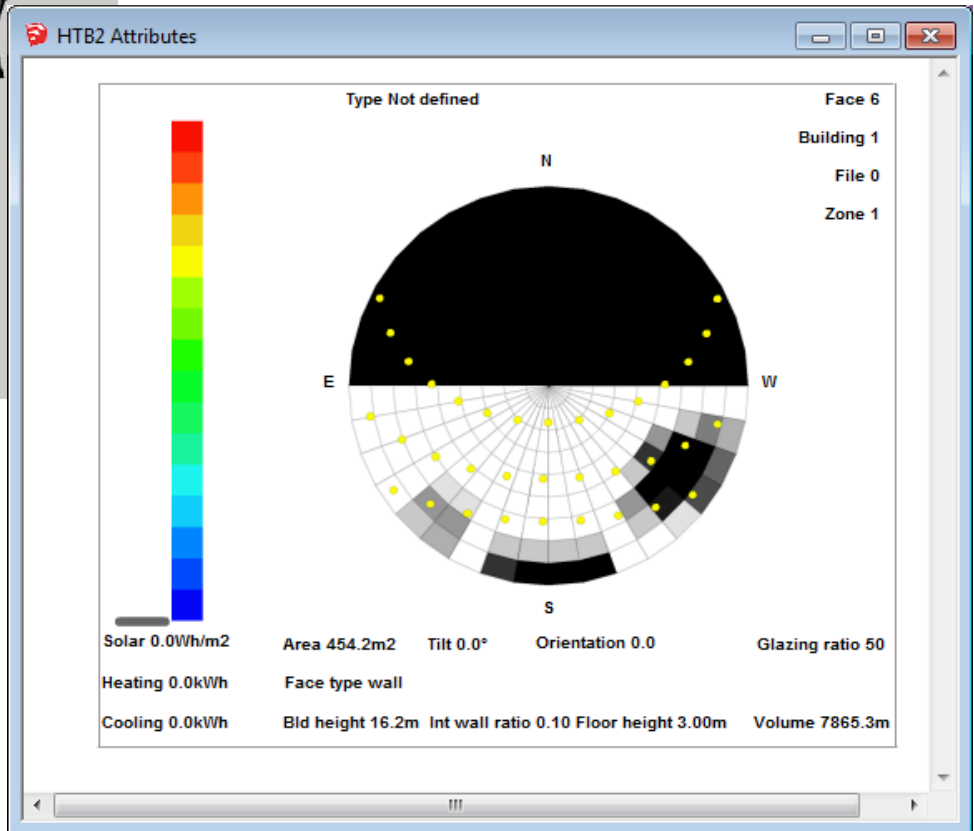
- HTB2 uses the direct, diffuse and direct normal solar radiation to calculate the solar radiation falling on an external surface.
- Considers the orientation and tilt of the surface
- If the surface is transparent it models the transmission of solar radiation onto the buildings internal surfaces
- The surround site can be considered using a shading mask, which breaks the sky above the external surface into 324 blocks of 10 by 10 degrees.
- The black blocks are obscured and no direct radiation will pass through it
- The white blocks are clear and the sky can be seen through these.



Shading mask

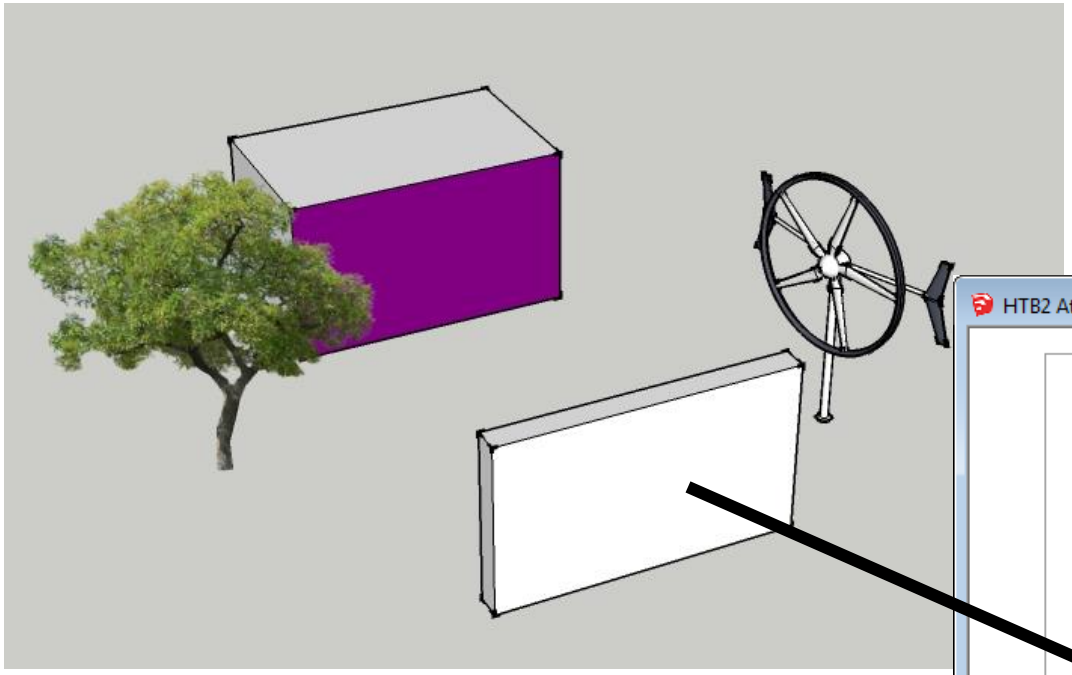
An example of a shading mask is shown below, the sky view from the purple wall

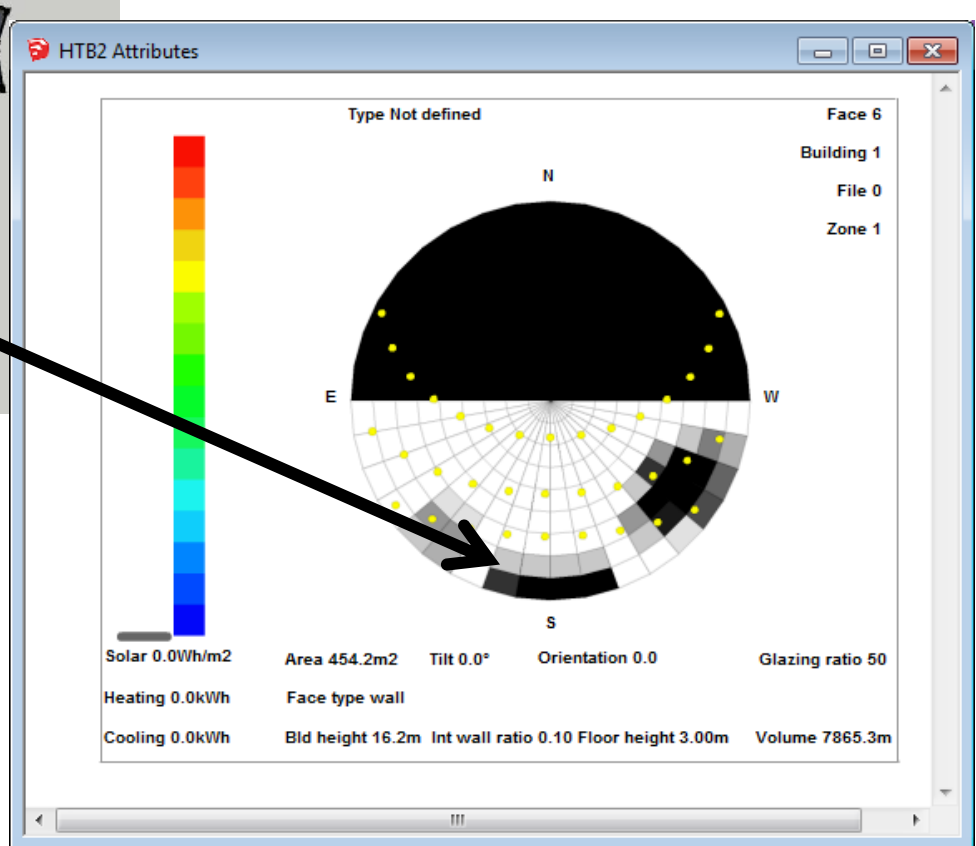




Shading mask – opposite wall

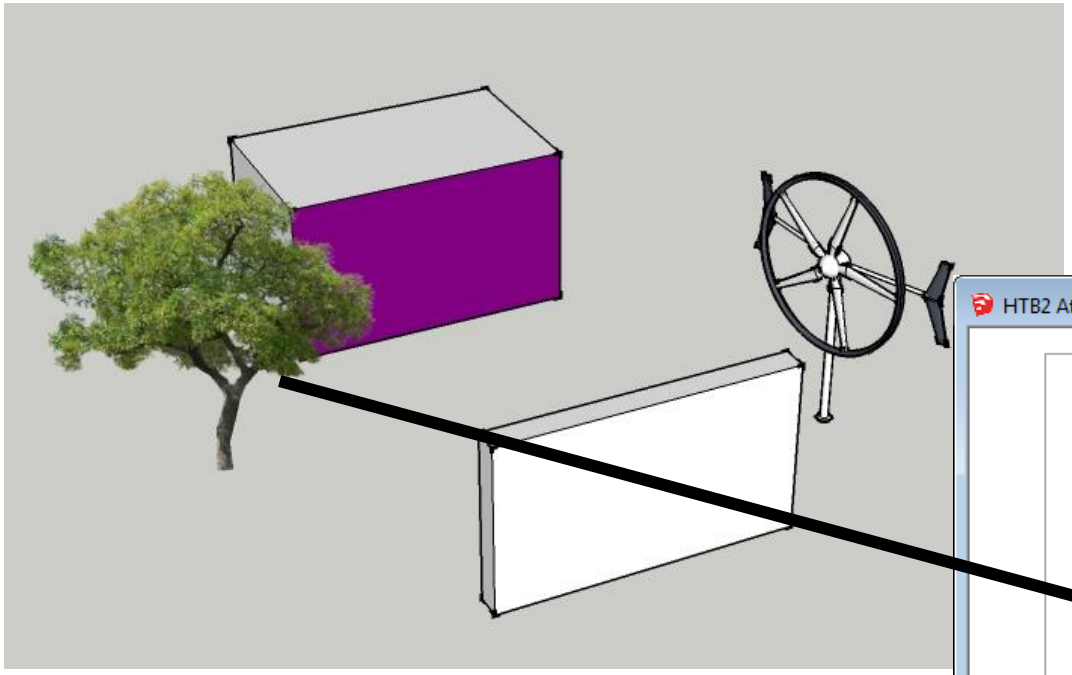
The opposite wall is the black and grey patch at the bottom.

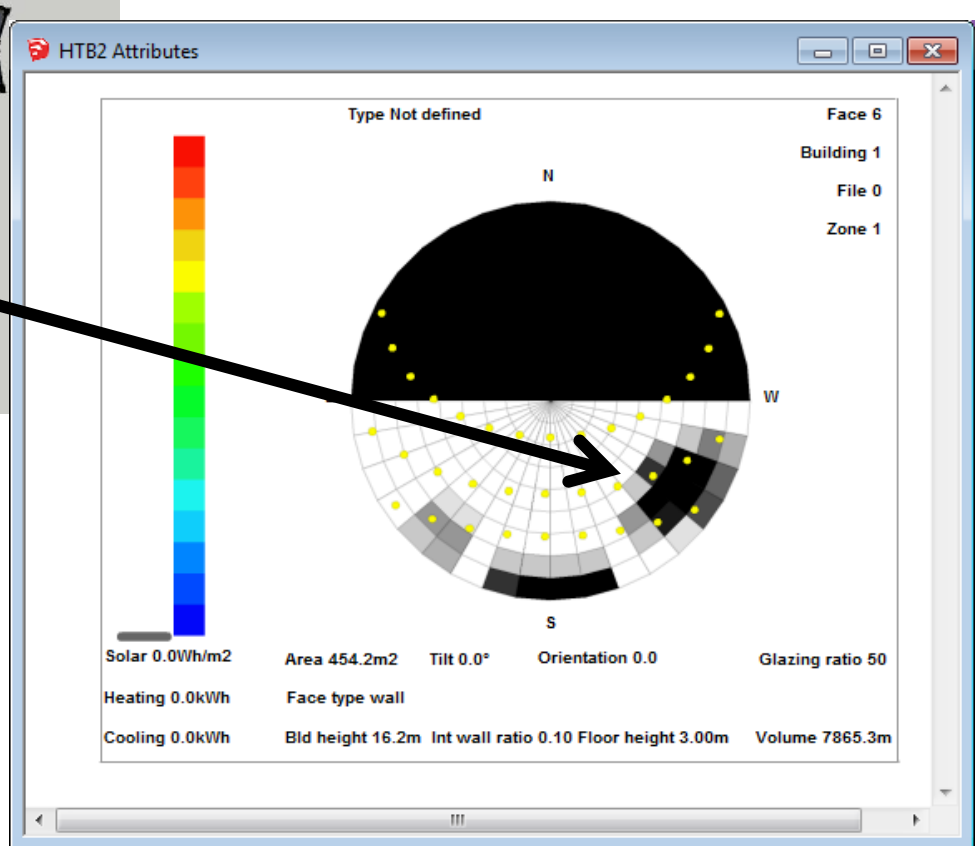




Shading mask - tree

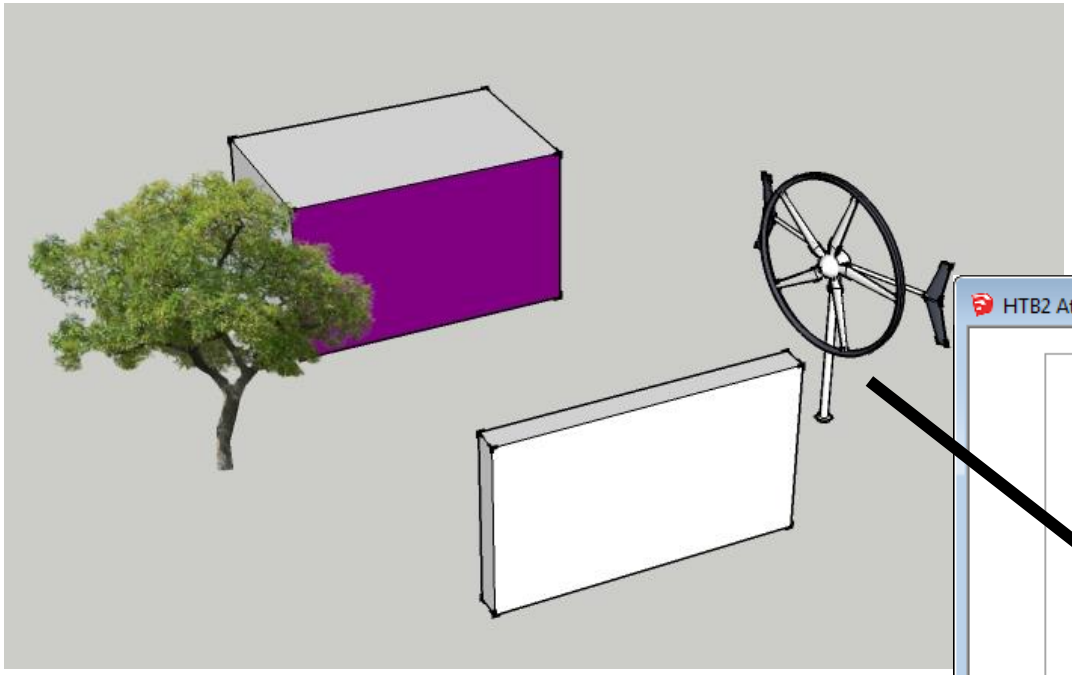
The tree is the large black and grey patch to the bottom left.

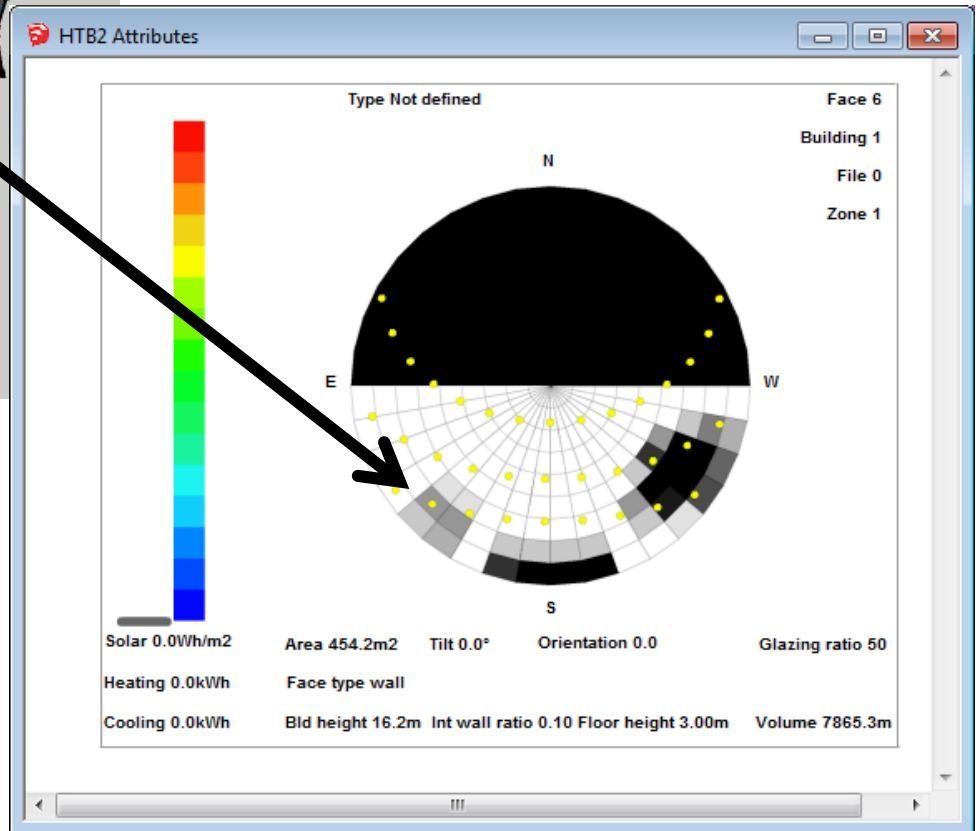




Shading mask - wind turbine

The wind turbine is the small grey patch to the bottom left.





Energy simulation: VirVil SketchUp Extension

What it predicts

- Solar radiation falling on a face
- **Heating and Cooling Energy demand**

What it can test

- Impact of shape and form on energy performance
- Impact of terrain
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Heating and Cooling Energy demand

HTB2 calculates the heating and cooling demand for each zone within a model.

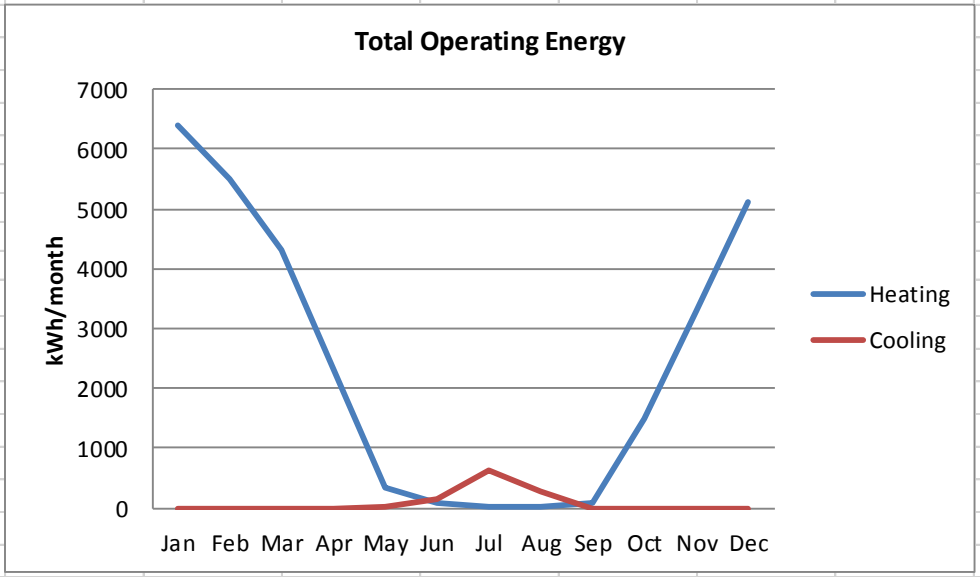
- HTB2 considers the internal, ventilation, solar and fabric gains.
- If the heating system is considered it will attempt to condition the spaces to a simple set point for example 21 Degree C for heating. The demand required by the heating system is calculated as a heat balance od the gains to the space.
- The VirVil SketchUp Extension makes each building a zone, and considers the building as a simple representation of all the spaces combined.
- The results from this calculation can be used to predict the annual heating demand for a building.

Heating and Cooling Energy demand

HTB2 calculates the heating and cooling demand for each zone within a model.

- The data can be combined to give monthly data

Operating energy



E (Gwh/mor	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
heating	6387.74	5485.37	4301.16	2317.42	337.146	72.311	20.299	2.306	96.936	1485.14	3283.62	5108.48
cooling	0	0	0	0	20.101	134.33	621.033	289.705	1.256	0	0	0

Energy simulation: VirVil SketchUp Extension

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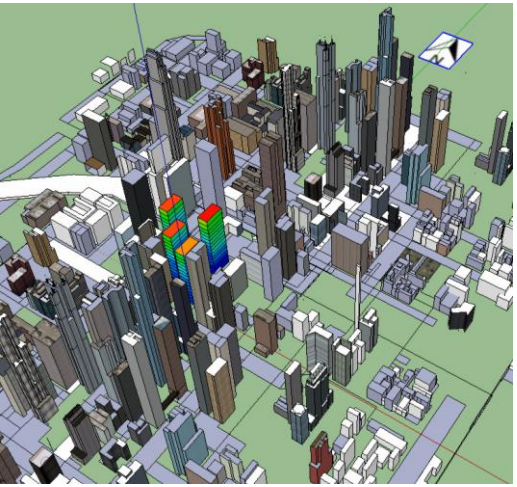
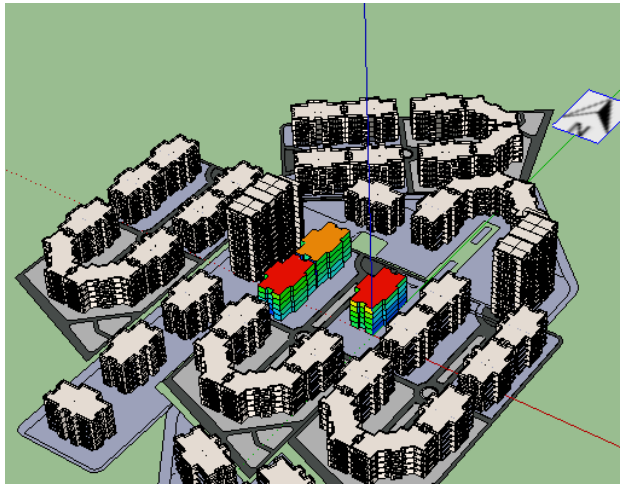
Impact of shape and form on energy performance

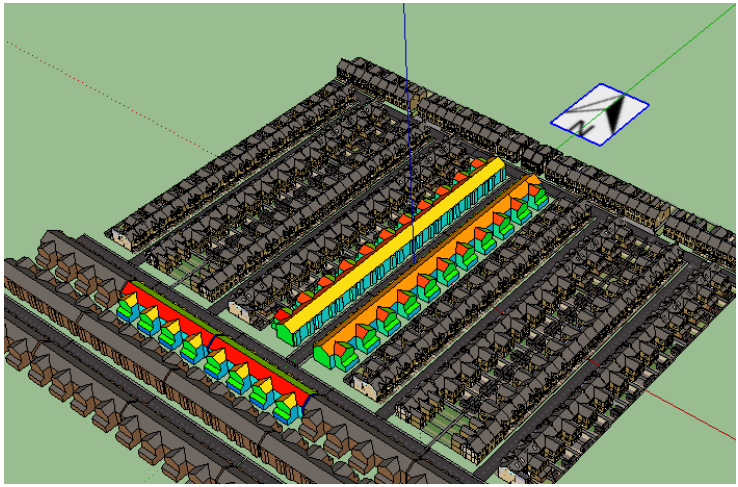
Case studies comparing different urban layouts



High-rise buildings



Mid-rise buildings

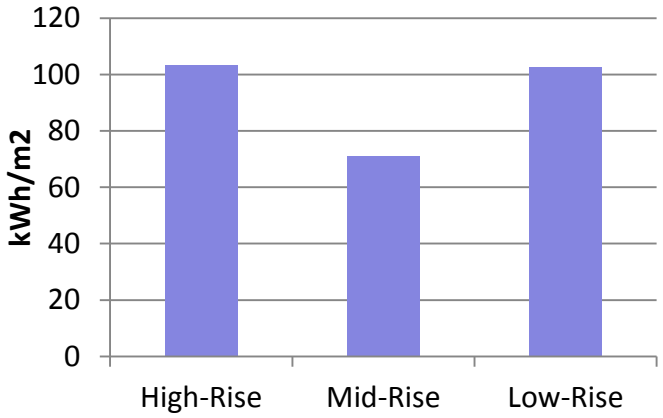


Low-rise buildings

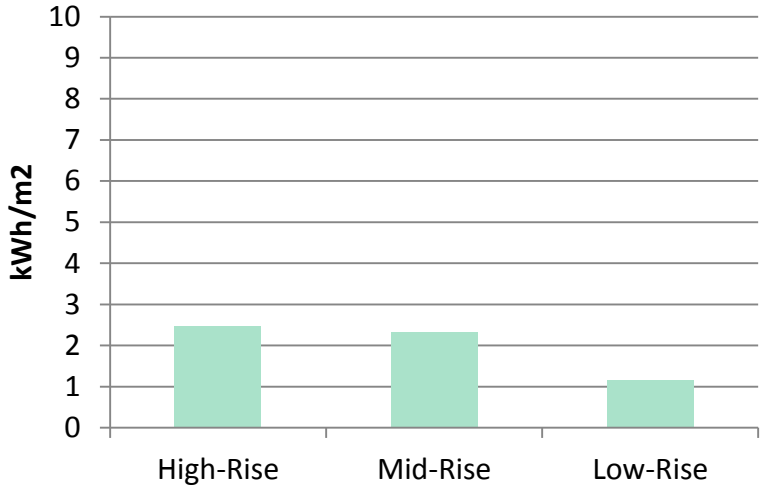
	Total Floor Area (m^2)	Total Exposed Area (m^2)
High-rise	6,076	8,456
Mid-rise	6,030	6,027
Low-rise	6,063	12,338

Impact of shape and form on energy performance

Case studies comparing different urban layouts



Normalised data of the annual energy use for Heating kWh/m2



Normalised data of the annual energy use for Cooling kWh/m2

Energy simulation: VirVil SketchUp Extension

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- **Impact of terrain**
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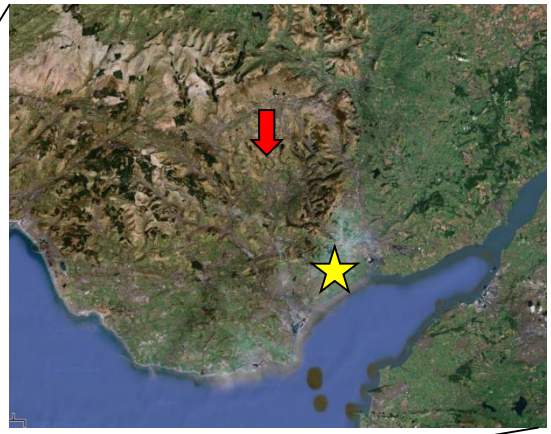
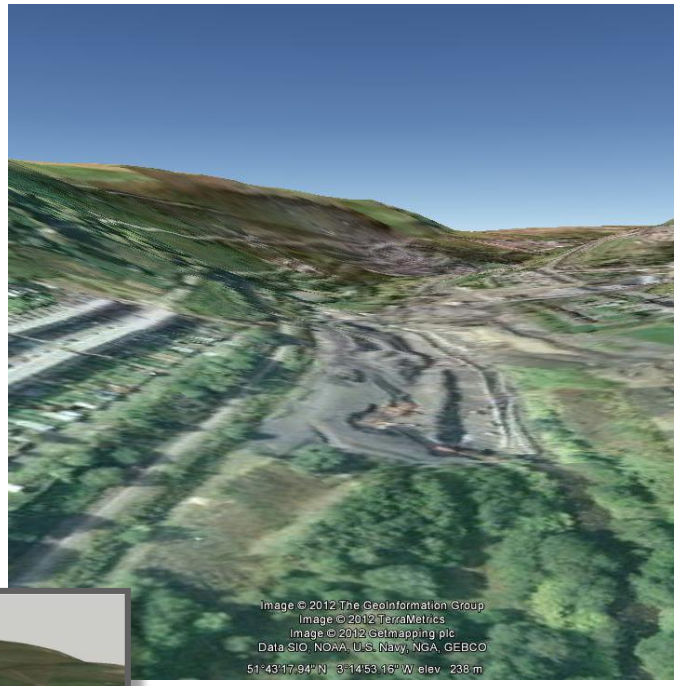
Impact of terrain

Case Study : Houses, New Tredegar, Wales

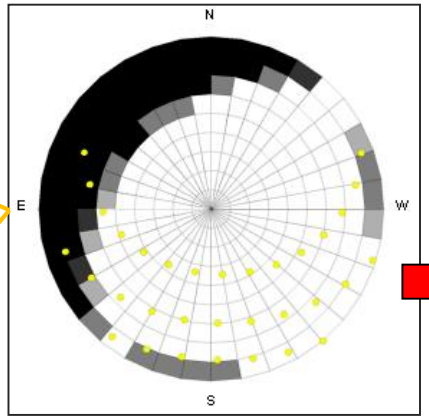


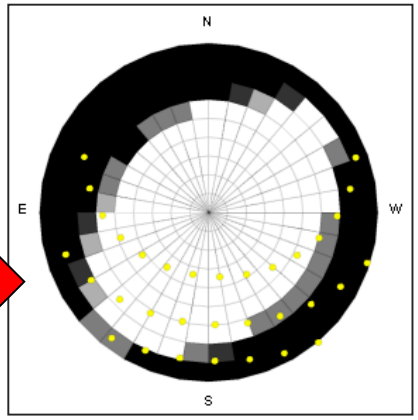


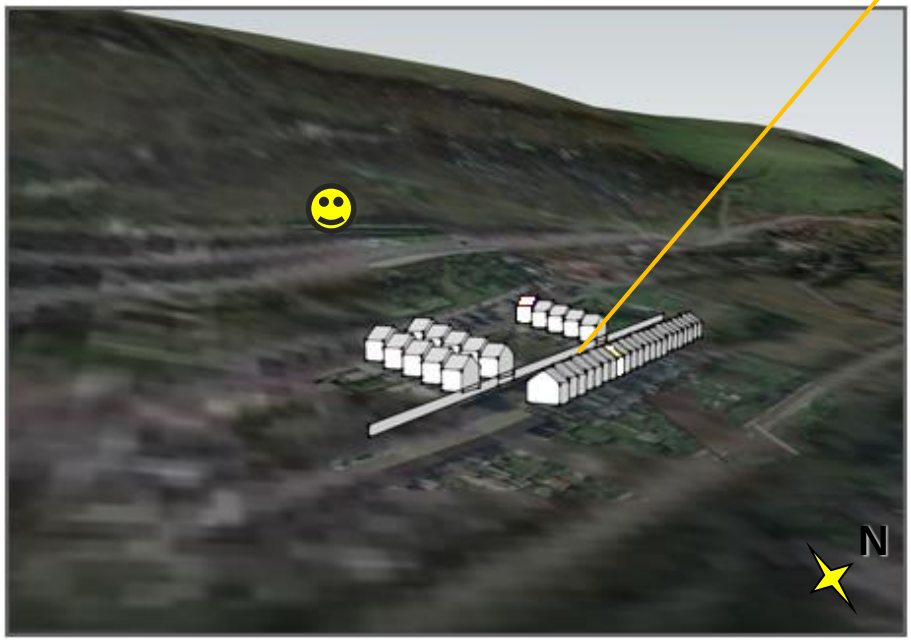
Impact of terrain

Case Study : Houses, New Tredegar, Wales

= vantage point of photo







	Solar radiation No Terrain (kWh/m²·a)	Solar radiation Terrain (kWh/m²·a)	Change
South-West	1056	847	**- 25%**
South-East	1023	932	**- 10%**

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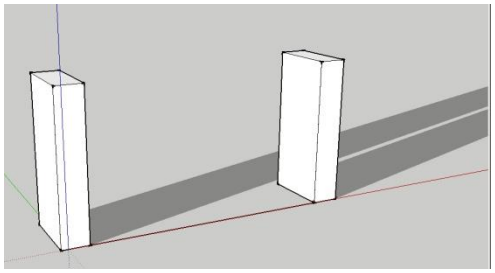
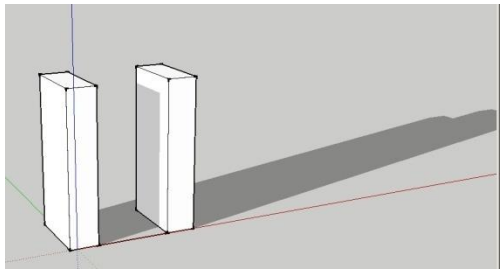
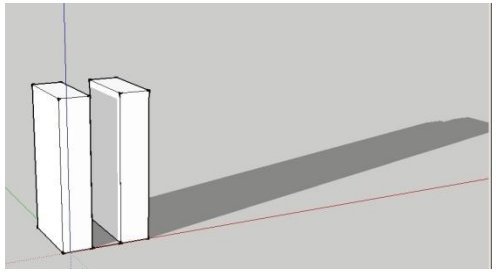
Impact of surrounding buildings

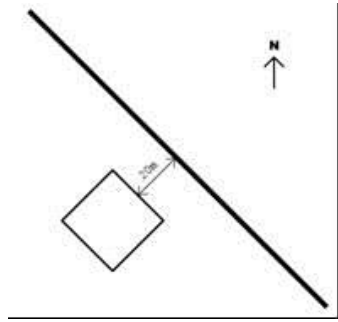
Overshadowing and orientation

100m **40m** **20m**

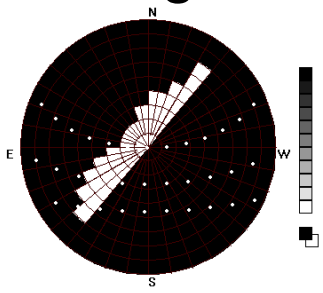




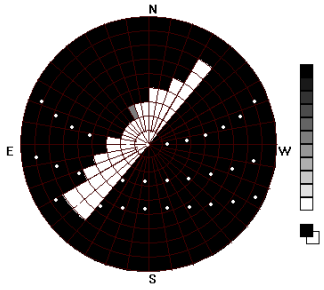




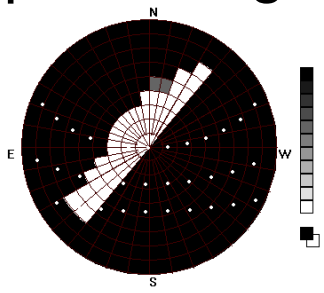
Shading Masks: for example 20m gap



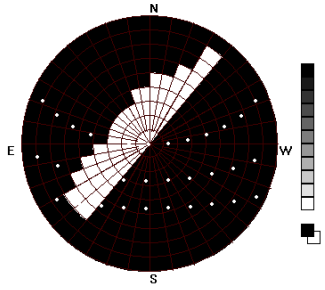
Ground Floor



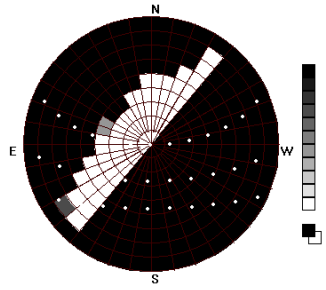
2nd Floor



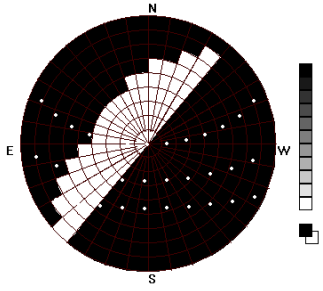
4th Floor



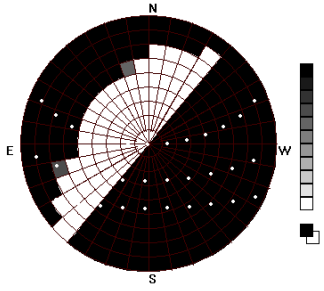
6th Floor



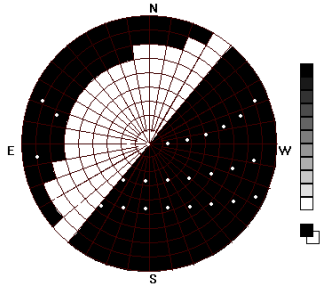
8th Floor



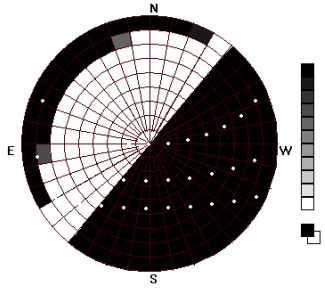
10th Floor



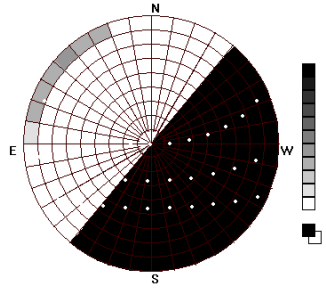
12th Floor



14th Floor

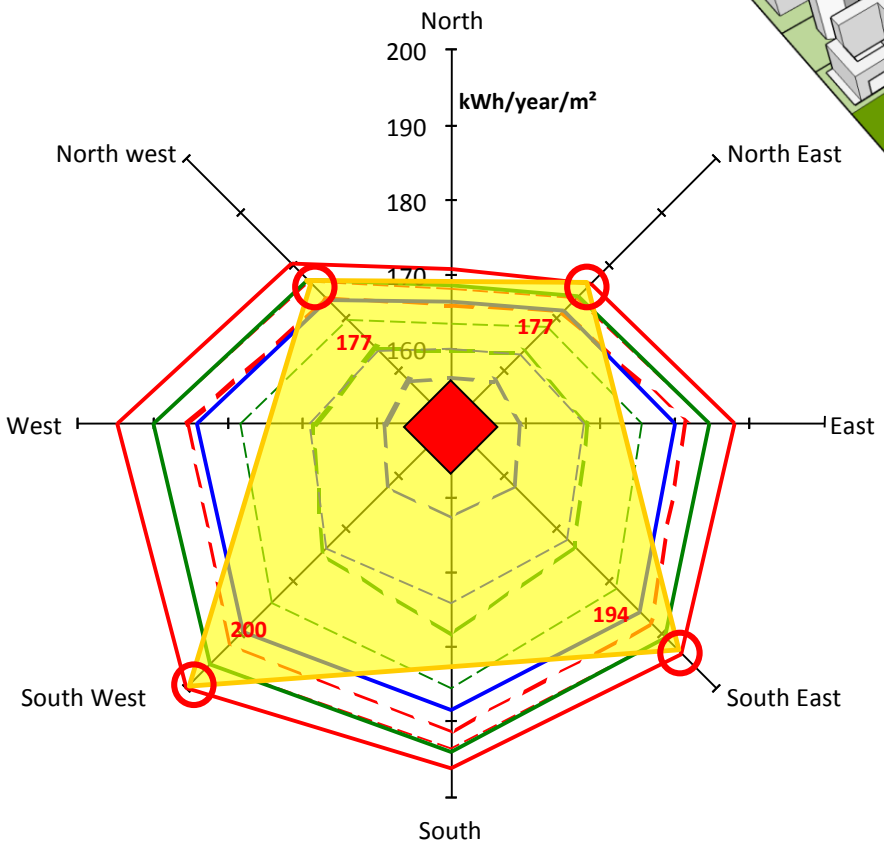


16th Floor



18th Floor

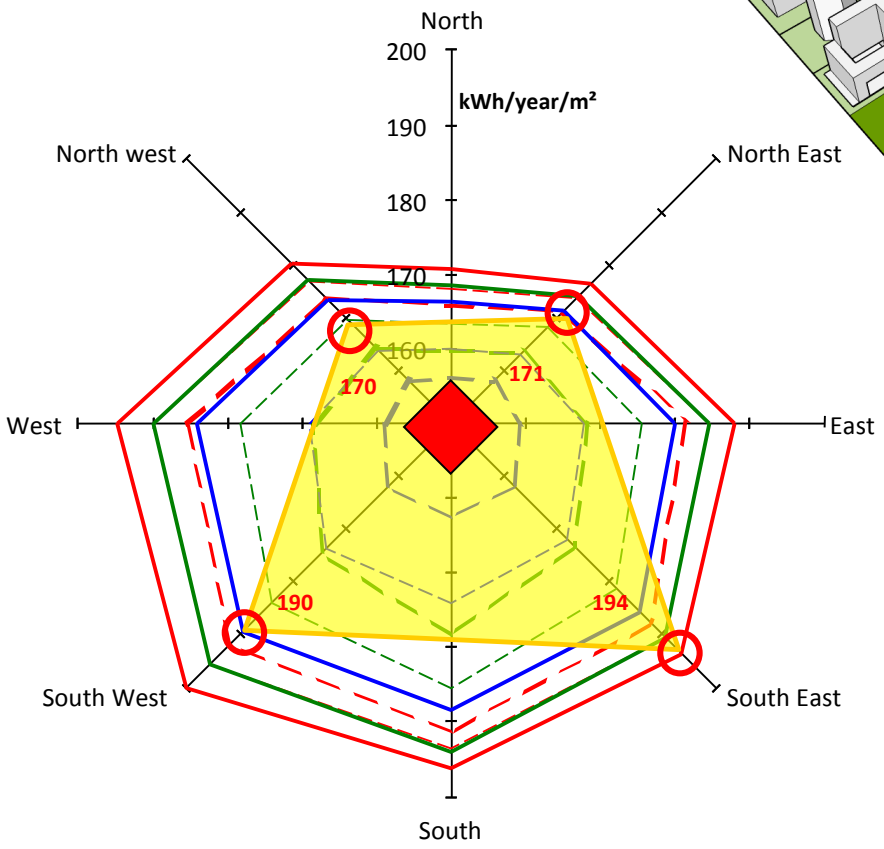
A modelled building and surrounding plots



100m overshadow, next building half height
100m Same height
100m overshadow, next building twice height
40m overshadow, next building half height
40m Same height
40m overshadow, next building twice height
25m overshadow, next building half height
25m Same height
25m overshadow, next building twice height
Building

The modelled building result 187 kwh/m^2

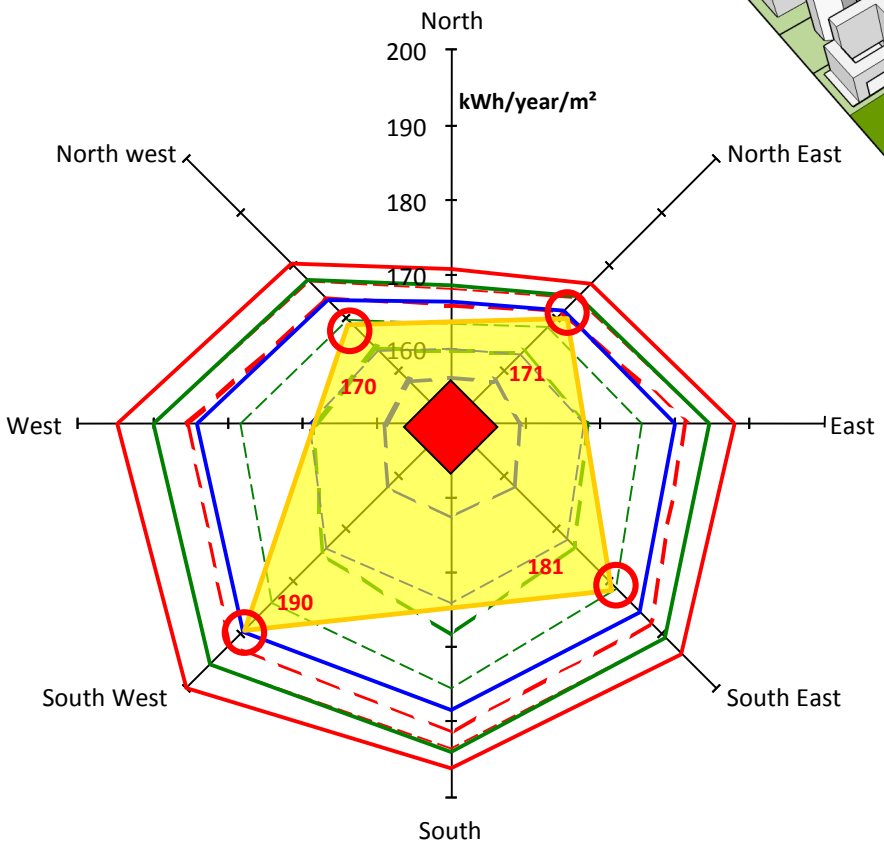
A modelled building height reduced



100m overshadow, next building half height
100m Same height
100m overshadow, next building twice height
40m overshadow, next building half height
40m Same height
40m overshadow, next building twice height
25m overshadow, next building half height
25m Same height
25m overshadow, next building twice height
Building

The modelled building result 181 kwh/m²

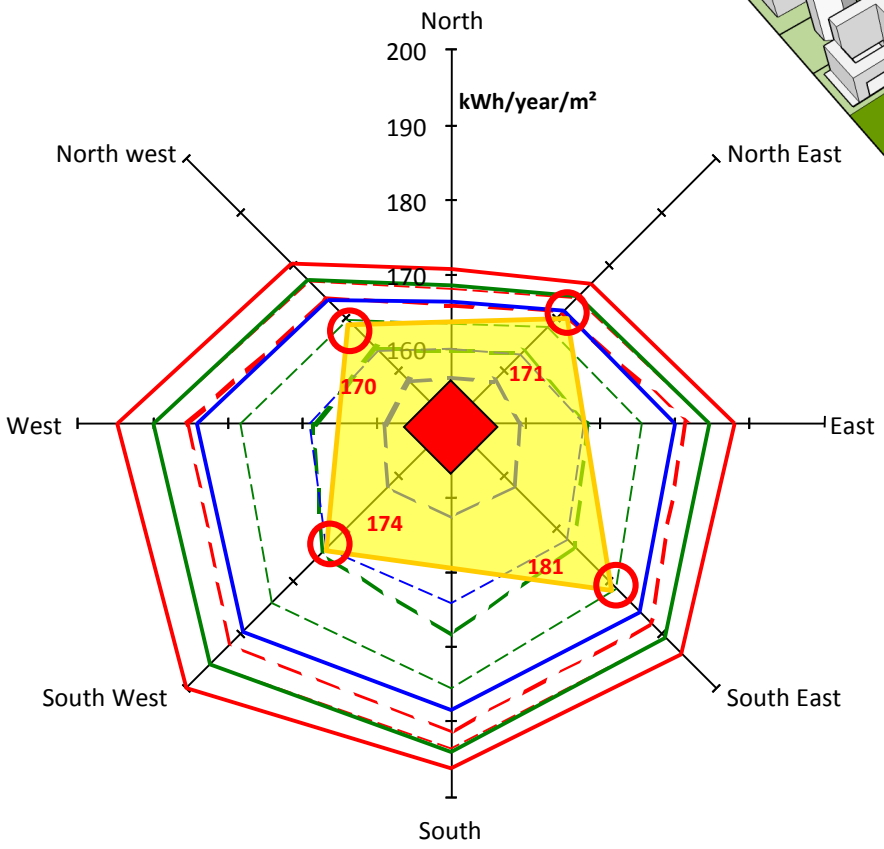
A modelled building change surrounding plots

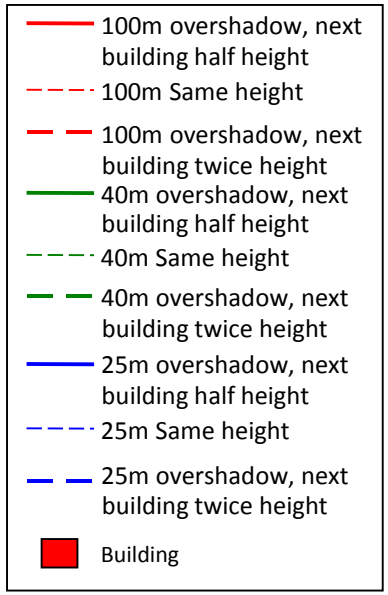


The modelled building result 178 kwh/m²

100m overshadow, next building half height
100m Same height
100m overshadow, next building twice height
40m overshadow, next building half height
40m Same height
40m overshadow, next building twice height
25m overshadow, next building half height
25m Same height
25m overshadow, next building twice height
Building

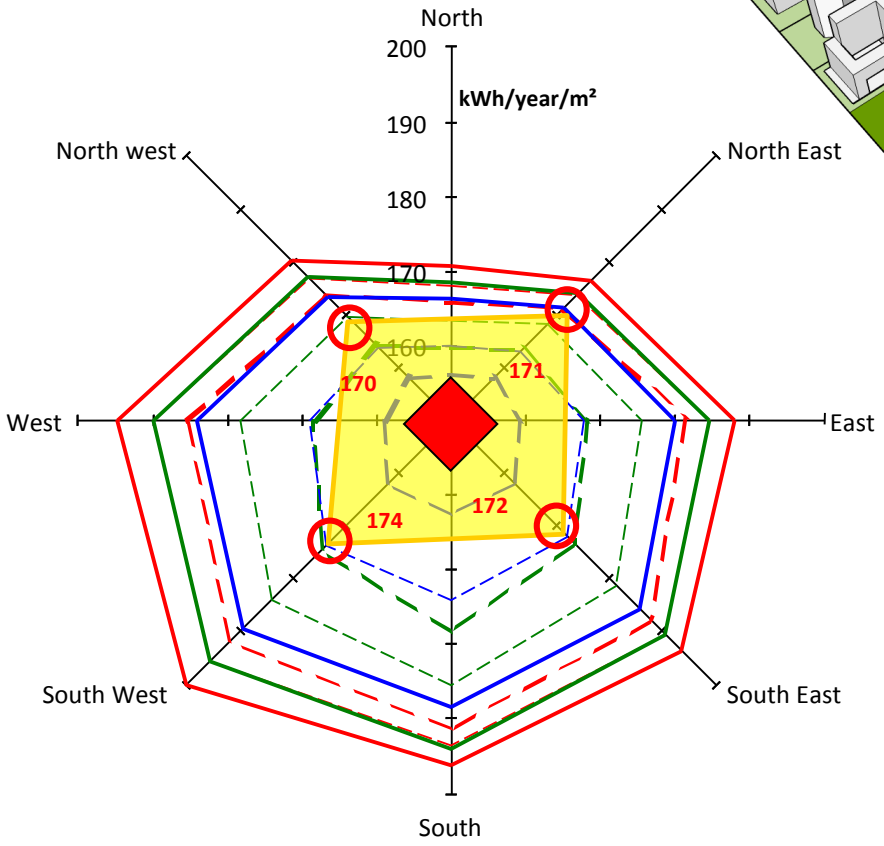
A modelled building change surrounding plots





The modelled building result 174 kwh/m²

A modelled building surrounding plots closer



The modelled building result 172 kwh/m²

- 100m overshadow, next building half height
- 100m Same height
- 100m overshadow, next building twice height
- 40m overshadow, next building half height
- 40m Same height
- 40m overshadow, next building twice height
- 25m overshadow, next building half height
- 25m Same height
- 25m overshadow, next building twice height
- Building

Energy simulation: VirVil SketchUp Extension

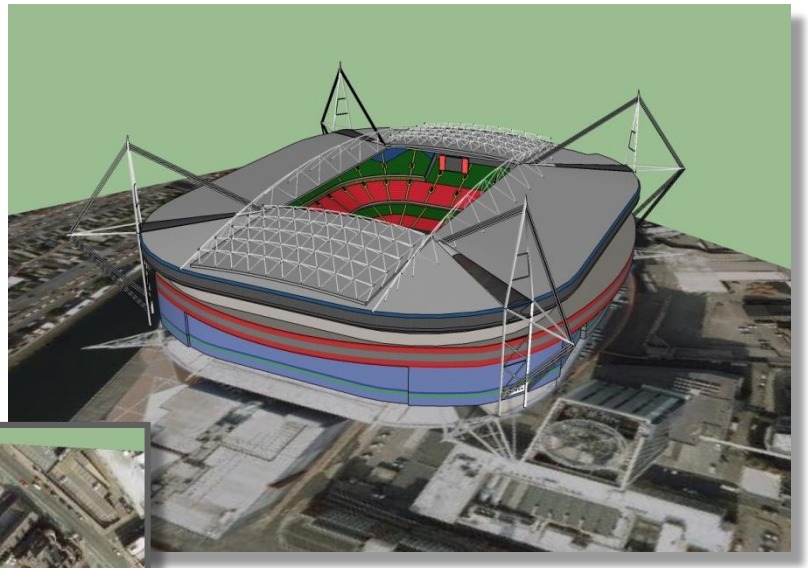
What it predicts

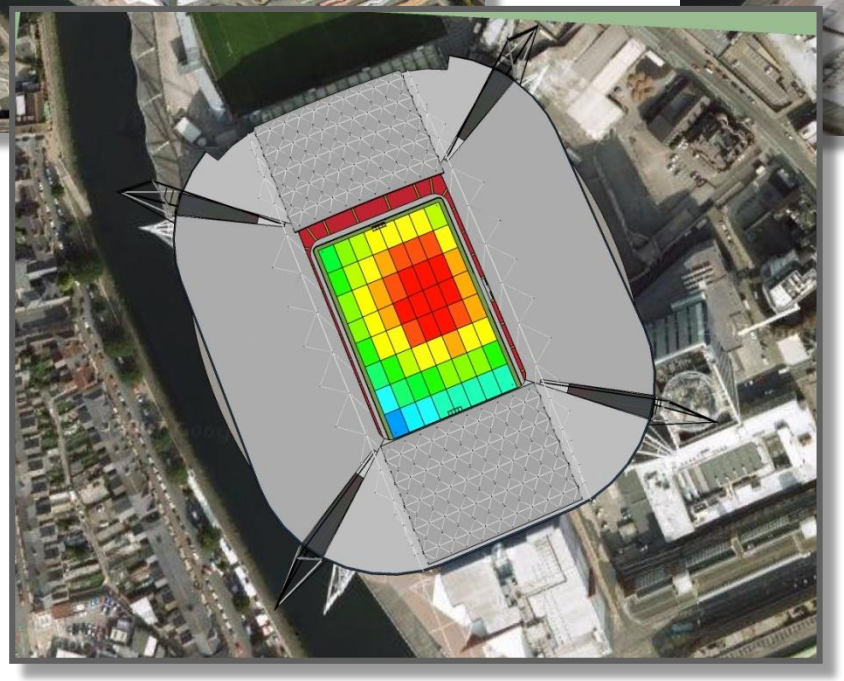
- Solar radiation falling on a face
- Heating and Cooling Energy demand

What it can test

- Impact of shape and form on energy performance
- Impact of terrain
- Impact of surrounding buildings
- **Impact of shading devices**

Impact of shading devices





Playing pitch study
Cardiff Millennium Stadium
Cardiff, UK

Collaborative exploration of solar access to playing grass of local stadium using SketchUp and 3D Warehouse

Thank you

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