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

![Graph showing temperature changes through fabric depth over time.](image)
SketchUp Model : The VirVil Plugin
Uses dynamic simulation at an early stage with simple input data to reduce complication
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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
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.
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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

<table>
<thead>
<tr>
<th>Operating energy</th>
<th>Total Operating Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (Gwh/month) Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec</td>
<td></td>
</tr>
<tr>
<td>heating 6387.74 5485.37 4301.16 2317.42 337.14 72.31 20.29 2.30 96.94 1485.14 3283.62 5108.48</td>
<td></td>
</tr>
<tr>
<td>cooling 0 0 0 0 20.10 134.33 621.03 289.70 1.25 0 0 0</td>
<td></td>
</tr>
</tbody>
</table>
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Impact of shape and form on energy performance

Case studies comparing different urban layouts

<table>
<thead>
<tr>
<th></th>
<th>Total Floor Area (m²)</th>
<th>Total Exposed Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-rise</td>
<td>6,076</td>
<td>8,456</td>
</tr>
<tr>
<td>Mid-rise</td>
<td>6,030</td>
<td>6,027</td>
</tr>
<tr>
<td>Low-rise</td>
<td>6,063</td>
<td>12,338</td>
</tr>
</tbody>
</table>
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
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Impact of terrain

Case Study: Houses, New Tredegar, Wales
Impact of terrain
Case Study: Houses, New Tredegar, Wales

<table>
<thead>
<tr>
<th>Direction</th>
<th>Solar radiation No Terrain (kWh/m²·a)</th>
<th>Solar radiation Terrain (kWh/m²·a)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>South-West</td>
<td>1056</td>
<td>847</td>
<td>- 25%</td>
</tr>
<tr>
<td>South-East</td>
<td>1023</td>
<td>932</td>
<td>- 10%</td>
</tr>
</tbody>
</table>
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Impact of surrounding buildings
Overshadowing and orientation

100m

40m

20m

Shading Masks: for example 20m gap
A modelled building and surrounding plots

The modelled building result 187 kWh/m²
A modelled building height reduced

The modelled building result 181 kWh/m^2
The modelled building result 178 kWh/m²
The modelled building result 174 kWh/m²
A modelled building surrounding plots closer

The modelled building result 172 kWh/m\(^2\)
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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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