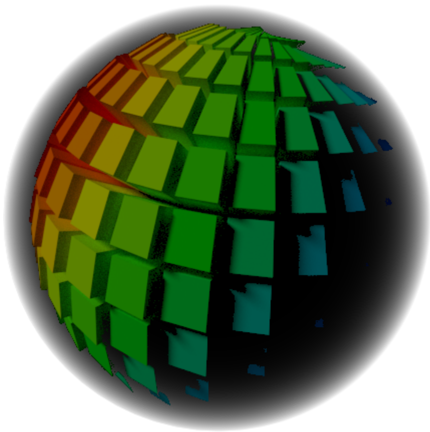
Simulations and Visualisations with the VI-Suite

For VI-Suite Version 0.4



Dr Ryan Southall - School of Art, Design & Media - University of Brighton.

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1 Introduction

The VI-Suite is an open-source add-on to the 3D modelling and animation package Blender that provides a set of tools for the analysis of environmental factors within and around buildings. It uses Blender's node system (figure 1) to provide a user interface that allows quick and custom analyses to be created. As of VI-Suite version 0.4 nodes exist for GIS height map import, sun path analysis, wind rose display, shadow studies, lighting metric prediction, energy performance and advanced airflow network creation. The lighting and energy analyses are achieved with the two main VI-Suite components: LiVi, which acts as a pre/post-processor for the Radiance lighting simulation suite and EnVi, which does the same for the EnergyPlus thermal simulation engine.

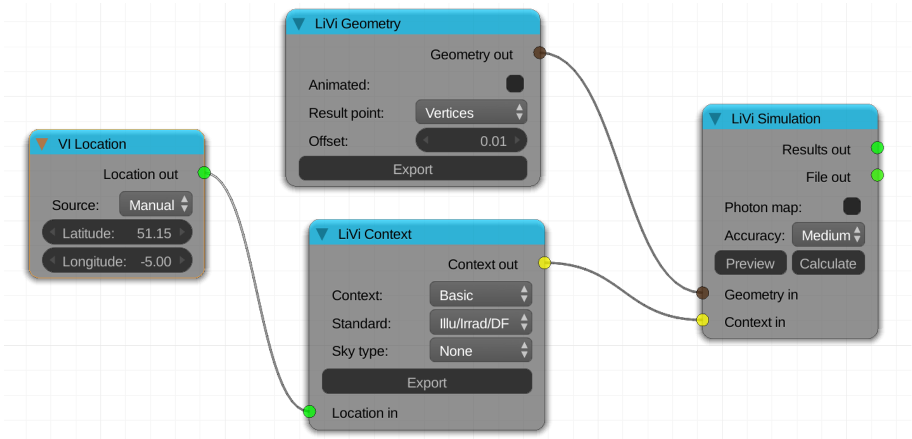


Figure 1: Blender nodes

2 Installation

For full functionality Blender (http://www.blender.org), Radiance v5.0.a.11 (http://www.radiance-online.org/), EnergyPlus v8.6 (http://apps1.eere.energy.gov/buildings/energyplus/), Matplotlib (http://matplotlib.org/), Kivy (https://kivy.org) and the VI-Suite (http://arts.brighton.ac.uk/projects/vi-suite/) installations are required. The VI-Suite website (http://arts.brighton.ac.uk/projects/vi-suite/downloads) contains links to down-loadable zip files that include everything required to run the VI-Suite on OS X 10.9 (64bit) and Windows 7 (64bit). An exception to this is that recent versions of OS X do not come with an X11 display server (needed by LiVi). You may need to download and install XQuartz (http://xquartz.macosforge.org/landing/) if you cannot preview Radiance models with LiVi. The folder within the zip file should be moved to a location on your computer that has no spaces in the name. '/Users/Reginald/Desktop' would for example be fine but '/Users/Reginald/My Desktop' would not. Blender can then be run by clicking on the Blender executable within the folder.

As there are so many different Linux distributions, and the required software installation is relatively simple, no complete packaged file is provided for this platform. The complete VI-Suite zip file, which includes EnergyPlus and Radiance binaries, can however be downloaded from the VI-Suite website.

As the VI-Suite is updated an additional zip file will be available on the website that contains purely the VI-Suite script files. These can replace the existing script files in the addons directory (detailed in the sections below) to update the VI-Suite.

If a manual installation of the separate components is preferred, platform specific installation guidelines can be found below.

2.1 OS X

The VI-Suite has been tested on OS X Version 10.10 (64bit).

First download Blender from http://www.blender.org/download and install. Run Blender once and select "File" - "Save Start Up File" to make sure the Blender configuration directory is created at */Users/user-name/Library/Application*

Support/Blender/blender_version where *user-name* is your username and *blender_version* is the version of Blender downloaded (currently 2.78). Create within this directory a “scripts” directory, and within this an “addons” directory (all lowercase).

The VI-Suite Python files are available as a down-loadable zip file from the VI-Suite website which can be found at (http://arts.brighton.ac.uk/projects/vi-suite/downloads. The vi-suite folder within the zip file should be placed in the *addons* folder created earlier.

Download Radiance from https://github.com/NREL/Radiance/releases/ and run the Radiance installer. The VI-Suite initially assumes Radiance is installed to the folder locations /usr/local/radiance but this can be changed in the VI-Suite settings. A recent version of Radiance (5.0.a.11 or above) is required.

Download and install EnergyPlus v8.6 from https://github.com/NREL/EnergyPlus/releases. The VI-Suite settings can later be used to point the VI-Suite to the directory where EnergyPlus is installed.

Numpy is included with recent versions of Blender but a number of other dependencies, namely pyparsing, six, sip, dateutils, distutils, pylab, cycler and matplotlib itself are required for full matplotlib functionality. Installing all these dependencies is troublesome but the easiest method would appear to be installing a Python 3.5 distribution such as Anaconda https://store.continuum.io/cshop/anaconda/ and copying the relevant files to Blender’s Python folder. If matplotlib still does not work try typing *import matplotlib.pyplot as plt* in Blender’s Python command window. Any error message should say which Python library is missing. In addition Kivy is required for progress windows and cancelling simulations.

It is also advisable to use a three-button mouse, which is set up as a three button mouse in OS X.

2.2 Windows

VI-Suite has been tested on a 64bit Windows 7 system, although the Radiance and Blender binaries are both 32bit and should run on older 32bit Windows versions. First download the Blender zip file from http://www.blender.org/download. The folder within this zip file can be moved to anywhere on your system as long as there are no spaces in the full directory path. The folder is subsequently referred to here as the *blender_folder*. Run Blender once and select ”File” - ”Save Start Up File” to make sure the Blender configuration directory is created at
`C:\Users\`*`user-name`*`\AppData\Roaming\Blender Foundation\Blender\`*`blender_version`* where *user-name* is your user name and *blender_version* is the version number of the downloaded Blender version (2.78 at the time of writing). Create within this directory a “scripts” directory, and within this an “addons” directory (all lowercase). Then download Radiance from https://github.com/NREL/Radiance/releases/ and install. Vi-Suite assumes that Radiance is installed in the C:\Program Files(x86) \Radiance folder for 64bit windows and C:\Program Files\Radiance for 32bit windows. A recent version of Radiance (5.0.a.11 or above) is required.

Download and install EnergyPlus v8.6 from https://github.com/NREL/EnergyPlus/releases. The VI-Suite user settings can later be used to point to the install directory.

From http://arts.brighton.ac.uk/projects/vi-suite/downloads download the VI-Suite Python scripts zip file. Inside the zip file is a folder called vi-suite, which should be moved to the C:\Users*user-name*\ Application Data\Blender Foundation\ Blender*blender_version*\scripts\addons\ folder created earlier.

Numpy is included within Blender’s inbuilt Python installation. Installing matplotlib for plotting capabilities is, however, a little complicated. The best way appears to be to download a Python 3.5 environment like Anaconda and moving the required matplotlib components: PySide, dateutil, six, sip, cycler and pyparsing to the relevant folder in *the blender_folder*\2.78\python directory. If matplotlib still does not work try typing *import matplotlib.pyplot as plt* in Blender’s Python command window. Any error message should say which Python library is missing. In addition the *python35.dll* file in the *blender_folder* must be replaced with the *python35.dll* file from the installed Python distribution e.g. Anaconda.

2.3 Linux

VI-Suite has been tested on a 64bit Arch Linux installation. First install Blender, which is available though most Linux distributions package management system. Run Blender and select ”Save Startup File” from the file menu to create a Blender configuration directory at
`/home/`*`user-name`*`/.config /blender/`*`blender_version`* where *user-name* is your user name and

blender_version is the Blender version number (2.78 at the time of writing). Create within this directory a "scripts" folder and within this an "addons" folder.

The VI-Suite scripts are available as a zip file from the VI-Suite website at (http://arts.brighton.ac.uk/projects/vi-suite/downloads. Inside the zip file is a folder called vi-suite04. This folder should be moved to the `/home/`*`user-name`*`/.config/blender/`*`blender_version`*`/scripts/addons/` folder created earlier.

Download Radiance from https://github.com/NREL/Radiance/releases/ or from the host package management system and install. A recent version of Radiance (5.0.a.11 or above) is required. Download and install EnergyPlus v8.6 from https://github.com/NREL/EnergyPlus/releases. VI-Suite settings can later be used to point to the installed Radiance and EnergyPlus directories.

For full functionality make sure Python, numpy, matplotlib and the Python modules kivy, sip, six, dateutil, pyparsing and PyQt4 are installed via the distribution's package management system, and remove the /usr/share/blender/*2.78*/python folder if it exists to force Blender to see the system Python installation.

2.4 All Platforms

Once the whole VI-Suite has been downloaded and installed, bleeding edge updates of the actual Python VI-Suite scripts can be downloaded checking out the code from the Git repository. Go to https://github.com/rgsouthall/vi-suite.v04 and click on the 'Download ZIP' button on the right. V04 and recent bug fixes can be found in the v04 repository. Bleeding edge code (and I really do mean Bleeding Edge) can be found in the master repository. Once the repository is selected the latest code can be downloaded with the zip link at the top of the page.

3 Configuration

Running Blender launches the main Blender interface, which should look similar to the one shown in figure 2. The main window is the 3D view where the default cube, lamp and camera can be seen. Below this is the animation time-line, on the top right is the project outliner that contains a list of everything in the scene, and bottom right are the properties panels where many of Blender's options and functions reside. At the top of the properties panel window are tabs to control which panel is visible. The main panels used in the VI-Suite are the "Material" and "Object data" panels. Detailed instructions on how to use Blender are beyond the scope of this document, but there are excellent and free beginners tutorials available from https://www.blender.org/support/tutorials/. Good on-line video tutorials are available here and here. In addition, there are a wealth of books [1, 2, 3], websites and You Tube and Vimeo videos dealing with many aspects of Blender's capabilities. The Blender Artists forum at http://blenderartists.org/forum/ is an excellent resource for finding out what other people are doing with Blender, and asking questions of knowledgeable users.

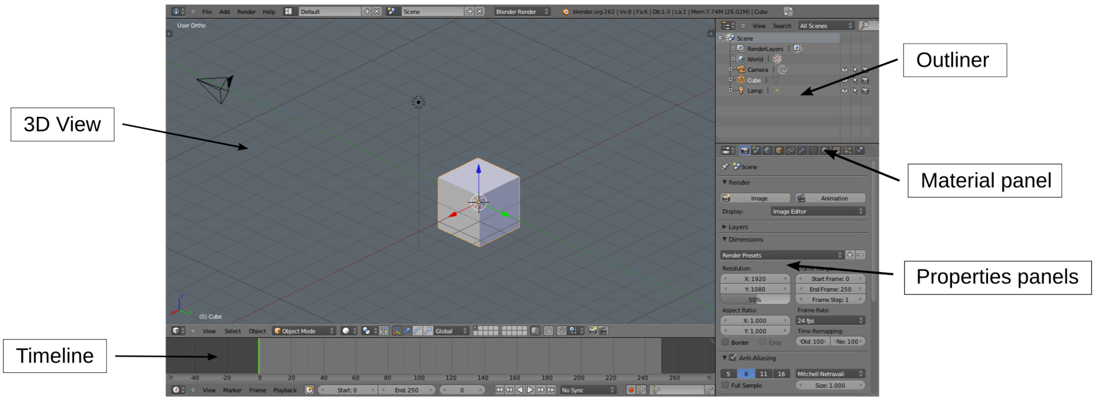


Figure 2: Blender interface

The VI-Suite is an add-on to Blender and will need to be activated on a fresh install. This can be done from Blender's user preferences. Go to "File" menu at the top of the 3D view and from the drop down list select "User Preferences". Along the top of the new preferences window there will be an "Addons" tab. Click on this and from the "Import-Export" list on the left select the VI-Suite. On the left of the Vi-Suite check box is a triangle. Clicking on this will show some information and expose the options to select custom Radiance binary and library directories and EnergyPlus binary and weather directories. If you wish to use your own installed Radiance and Energyplus packages point to their directories with these settings. Changing these settings may require a Blender restart to register. Leaving the entry fields blank will cause the VI-Suite to use it's own built in default directory locations and can be left empty if using the packaged zip files from the VI-Suite website.

There are other settings within the "User Preferences" that can be altered as desired, for example to control how the 3D view is navigated. The resources above contain sections on customising the Blender user interface. By default the 3D view can be rotated with the middle mouse button, zoomed with the mouse wheel and objects are selected with the right mouse button (it is recommended to change this to left mouse button select in the user preferences "Input" tab). Once the VI-Suite addon has been activated, and any other changes have been made, click "Save User Settings" to make these choices permanent.

Once the VI-Suite has been activated it sits within Blender's node editor. The Blender interface is, in general, what's called a non-overlapping interface i.e. interface areas sit side-by-side rather than on top of each other. Any area can be turned into any other area type by selecting the type from the drop-down menu at the left-hand side of the area's header bar, which sits either at the bottom or the top of each area. For example, the time-line can be turned into the node editor by selecting "Node Editor" in the drop-down menu in the very bottom left of the time-line area.

4 The Vi-Suite Interface

4.1 The Node System

The VI-Suite uses Blender's user customisable node system to provide a flexible user-interface. The node editor view (figure 3) can be panned with the middle mouse button and zoomed with the mouse scroll wheel. Nodes can be added, deleted, moved, re-sized, collapsed, grouped, linked and unlinked. Once a VI-Suite node tree has been created nodes can be added using the "Add" menu item at the bottom of the node editor. There are six node categories:

- Input nodes that import data into the VI-Suite
- Process nodes that export Blender information to a format that can be used for analysis
- Analysis nodes that run analyses
- Generative nodes that specify targets and geometry manipulation for Generative Design (not currently active)
- Display nodes that display the results of analyses.
- Edit nodes that can manipulate data
- Output nodes that can export data for third-party analysis.

Some of these nodes are common to multiple types of analyses.

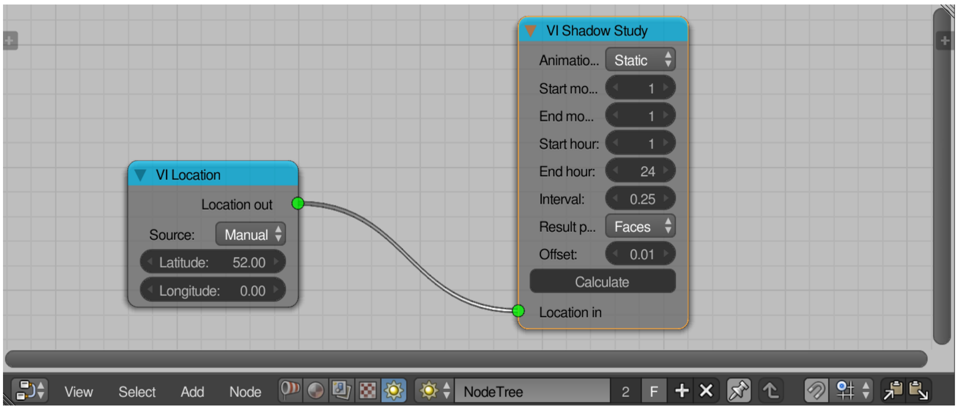


Figure 3: Blender node editor

Before any nodes are created the Blender file should be saved. The VI-Suite project directory will then be created in the same location the Blender file is saved to, with the same name as the Blender file name. For example, if you save the Blender file to the desktop with the name 'FirstProject.blend' then a directory will also be created on the desktop with the name 'FirstProject'. This directory will contain all the intermediary files created by the VI-Suite. Avoid using spaces in either the Blender file name or the directory to which Blender file is saved.

Within the node editor VI-Suite nodes can be connected together to perform analyses. Once the node editor has been selected for an interface area, at the bottom of the node editor area will be a row of menu items and a row of icons (figure 4). The main VI-Suite node tree window is selected by selecting the sun icon in the icon row. Once the sun icon has been clicked press the new button on the right to create a new VI-Suite node tree. The "Add" menu entry allows the creation of nodes within the chosen, created node tree.

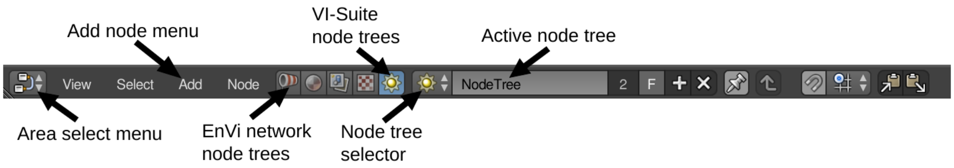


Figure 4: Blender node editor menus

Blender nodes can be scripted with Blender's Python scripting back-end and this allows some user-feedback features to be implemented. Nodes in general will be red if:

- The node contains a operator button which has not yet been pressed
- The options selected within the node are different to the selected options when the operator button was last pressed
- The options selected within the node are invalid within the context of the other nodes the node is connected to.

The node colour will revert to the general Blender theme colour if none of the above conditions are true and the node, in it's current state, is valid as a simulation component.

Links between nodes are also scripted so that only valid links can be made. If a link is attempted between two node sockets the link will immediately disappear if the connection is not valid. Sockets are generally coloured to show which can be connected (red to red, yellow to yellow etc).

In addition to the VI-Suite nodes, visualisation options, when relevant, become available in the 3D view properties panel in the "VI Display" tab (section 4.2).

4.2 Visualisation panel

Control of the visualisation of results within Blender's 3D View is done within 3D view properties panel. This panel can be toggled on and off by pressing the "n" key with the mouse over the 3D view. Alternatively you should see a small "+" sign in the top right of the 3D view. Clicking on this will also open the 3D view properties panel. At the bottom of this panel is the "VI-Suite Display" tab (figure 5), which will get populated with visualisation options as they become available.

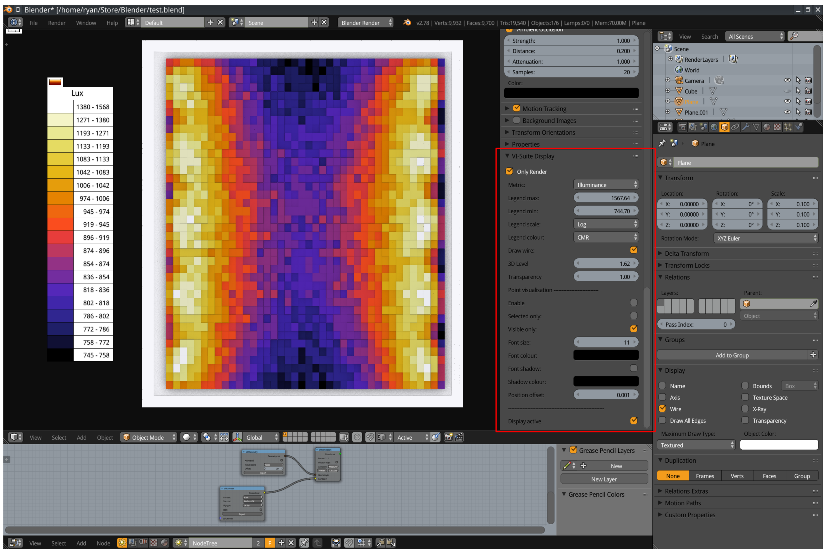
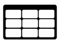


Figure 5: VI-Suite Display tab (red box)

VI-Suite v0.4 has a new display framework that will create icons in the 3D view for the visualisation of analysis results. If these icons are clicked the icon will expand to show the associated data. Clicking and dragging on the icon will move it around the 3D view and once an icon is expanded clicking and dragging the bottom right of the open window will resize it. The full list of icons that can be created is presented below although the actual icons created depend on the analysis context.

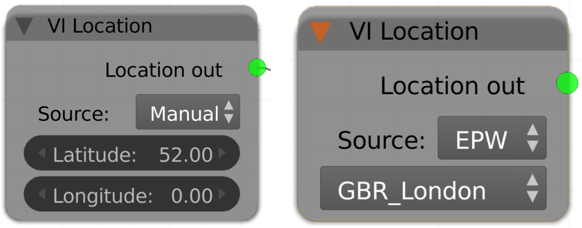
-  Legend display - this will display a colour bar that relates numerical value to colouration within the 3D scene.
-  Table display - this will display tabulated results.
-  Scatter display - this will display a scatter graph of the chosen results (days along the x-axis and hours on the y)
-  Bar chart display - this will display changes in variable across parametric analyses.
-  Compliance display - this will display whether the selected results comply with the chosen standard
-  BSDF display - this will display a tensor tree visualisation of a calculated or loaded BSDF.

At the bottom of the ”VI-Suite Display” tab is a ’Display active’ toggle. It is good practice to turn this off before initiating another simulation or when finished with the display of results.

4.3 Common Nodes

Common nodes are nodes that do not belong to any particular simulation pipeline.

4.3.1 The VI Location node



(a) (b)

Figure 6: VI Location node (a) with manual entry (b) sourcing EPW weather file

A VI Location node can be added from the ”Add” - ”Input nodes” menu entry. The Vi Location node sets the location of the context to be analysed in terms of latitude and longitude and, if required, hourly weather data from an EPW format weather file. This node is a required node for sun-path, solar shading, wind rose, energy and most lighting analyses.

The source of the information provided by this node can either be entered manually by the user (adequate for sun-path, solar shading and some lighting analyses) or generated from an EnergyPlus weather (EPW) file (required for wind rose, energy and CBDM analyses but can be used for any location based analysis type). This choice is made with the node’s first drop-down menu. If the ”Manual” option is chosen here then the user can enter site latitude and longitude (longitude is in the range -180 to 180 degrees with West of the Greenwich meridian having positive values) in the two number dialogues. If ”EPW” is chosen then a new drop-down menu appears with a list of registered EPW files. EPW files are registered by placing them either in the ”EPFiles/Weather” folder within Vi-Suite script folder or the custom directory specified in the VI-Suite addon settings. The EPW files should have a ”.epw” or ”.EPW” extension. A good source of EnergyPlus weather files is http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_about.cfm, but they are a common format and can be found at many sites for a wide variety of locations.

The VI Location node has one output socket, a light green ”Location out” socket, which can connect to any light green ”Location in” socket. If an EPW weather file is selected the ’Location out’ socket can also connect to the green input socket of the VI Chart node for plotting of the weather data.

4.3.2 The ASC Import node

ASCII formatted Esri Grid files are GIS data files which can represent ground elevation data in text file format. These files often have the extension .asc and are referred to as ASC files here. ASC files can be exported by the Edina DigiMaps web service that contain accurate terrain height data for the whole of the UK.

The ASC import node can be added via the ”Input” nodes menu in the node editor. The node contains two toggle options and an operator button. The toggle options are:

- ”single”. If on, only the ASC file selected is imported. If off, all ASC files within the directory of the selected ASC file will be imported.
- ”splitmesh”. If multiple ASC file are imported this option creates separate meshes for each file. ASC files from DigiMaps are separated by the map grid squares selected for export. DigiMaps can also supply images of roads, building locations etc for each of these map grid squares and turning on ”splitmesh” can make mapping these images to the geometry imported into Blender easier.

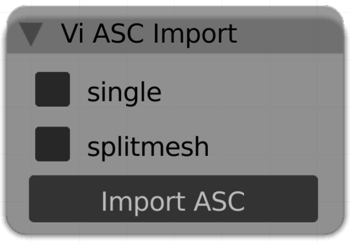


Figure 7: VI ASC import node

The operator button converts the ASC file into Blender co-ordinates and creates a mesh within the scene which accurately represents the ground heights in the ASC file. Once this geometry has been imported it can be subject to further analysis, for example a shadow study (section 4.4.3).

4.3.3 The EnergyPlus Input File node

With this node the user can import an EnergyPlus input file for simulation. The results of the simulation cannot be visualised within the 3D View but can be charted with the VI Chart node. In future versions of the VI-Suite it will be possible to reconstruct geometry and materiality from the input file for visualisation.

The node contains one operator button which, once pressed, opens up a file browser to locate the desired input file. Once a file has been selected a 'Context out' socket should become visible which can be connected to the 'Context in' socket of the EnVi Simulation node.

4.3.4 The EnergyPlus Results File node

The EnVi Results File node (figure 8) allows for the loading of a previously generated results file from an EnVi simulation for plotting. The node contains a file select button which opens up a file selection window to navigate to the desired file, a text box that shows the file name and path of the currently selected file, and a "Process File" button to convert the results file into data stored within the node. Once the "Process File" button has been pressed the "Results out" socket should become visible for connection to a VI chart node.

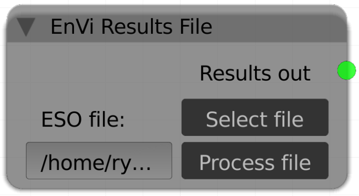


Figure 8: EnVi Results File node

4.3.5 The VI Chart node

The VI Chart node (figure 9) uses Matplotlib http://matplotlib.org/ to provide simple line plotting for certain types of data. As of version 0.4 this chart node can plot climate data from an EPW file selected within a "VI Location" node, results data from an "EnVi Simulation" or "EnVi Results file" node and results from the 'LiVi Simulation' node. Initially only the X-axis socket is exposed. Once this socket is connected a "Y-axis 1" socket is exposed. Once this socket is connected a "Y-axis 2" socket is exposed, which should again be connected to the same "Results out" socket. In total three "Y-axis" sockets can be exposed. It is possible to connect different result source nodes to the input sockets of this node but the result length coming from each source node must be the same or an error will occur.

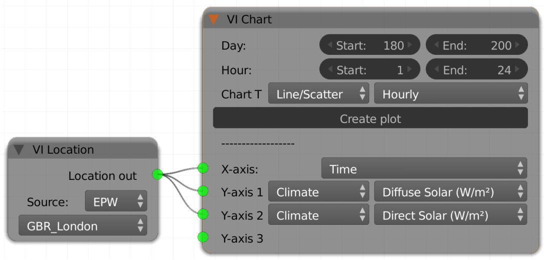


Figure 9: VI Chart node

Next to each connected socket menu items will appear to select the type of data to plot on the axis. This contents of these menu items depends on the contents of the results embedded in the connected node.

A "Create plot" button in the middle of the node creates the Matplotlib plot in a new window. Buttons within this new window allow some manipulation of the chart and export to image file. The options presented by the node are:

- Day - start and end day of the period to be plotted. Defaults to the total day range of the results connected to the sockets.
- Hour - start and end hour of the day period to be plotted.
- Chart type - Line/Scatter for line or scatter plots
- Frequency - Hourly, daily, monthly results plotting

4.3.6 The VI CSV Export node

The VI CSV Export node can take the results from simulation nodes and converts them to CSV format. The CSV formatted data can then saved to a file for third-party visualisation/processing. If the results from the simulation contains parametric data the node will expose one option which toggles whether only the animated parametric data or the complete static data set is exported. The 'Export' button will open up a file save window and the name and the destination of the CSV file can be specified.

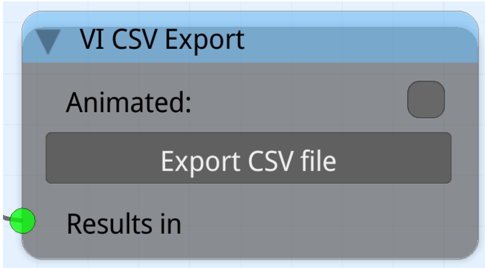


Figure 10: VI CSV Export node

4.3.7 The Text Edit Node

The 'Text Edit' node in the 'Edit Nodes' menu allows for an information pipeline to be interrupted for manual editing within Blender's text editor. This node currently only works with the LiVi simulation pipeline. Once a LiVi Geometry or Context node is connected to the 'Text in' socket the Radiance input text is loaded into Blender's text editor. The name of the text file within the text editor is also shown within the node. If any changes are made to the text in the text editor an 'Update' button appears within the node. When pressed the updated text is loaded into the node and will be presented to any 'LiVi Simulation' node connected to the 'Text out' output socket.

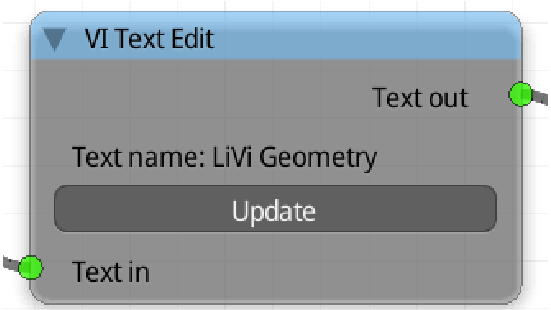


Figure 11: VI Chart node

4.4 Specific Analysis Nodes

Analysis nodes can be found in the "Add" - "Analysis nodes" menu in the VI-Suite node tree. Analysis nodes initiate actual calculations. Some analysis nodes need to be part of a larger node set-up, for example LiVi and EnVi simulation nodes, whereas others represent a complete analysis, for example wind rose and shadow study nodes. These standalone analysis nodes are described here.

4.4.1 The Vi Wind Rose node

The "VI Wind Rose" node takes wind data from an EPW weather file and creates a wind rose plot. The "VI Wind Rose" node has one input "Location in" socket that connects to a VI location node "Location out" socket. As EPW data is required, EPW must be selected as a source of information in the "VI Location" node. Once a valid "Location in" socket connection has been made a drop-down menu specifying the type of wind rose to plot (two types of histogram, and three types of contour, plot are currently available), two numerical input fields to specify the start and end day for the wind rose data, a colour menu to select the colouration of the created wind rose and one "Export" button are exposed. Upon pressing the "Export" buttons a new wind rose object is created within the Blender scene which can be scaled, moved or rotated as desired. Wind rose specific display options are also revealed in the "VI Display" tab (section 4.2).

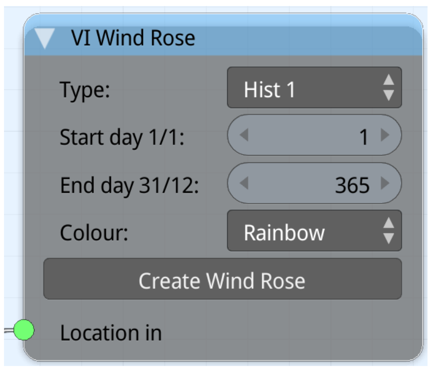


Figure 12: VI Wind Rose node

4.4.2 The Vi Sun Path node

The ”VI Sun Path” node shown in figure 13 creates objects within the Blender scene for sun path visualisation (section 5.1). These objects include the sun-path mesh itself, sun lamp, sun mesh and sky mesh. These objects can be moved around the scene as desired. As the sun path analysis requires latitude and longitude data this node has one input socket ”Location in” which connects to a ”VI Location” node’s ”Location out” socket. As only latitude and longitude data is required either EPW or manual data input can be used in the ”VI Location” node connected to the ”Location in” socket. The node contains no options, simply a button, which is only visible once a valid ”Location in” socket connection has been made, to create the sun-path geometry. Once this button is pressed, and the sun path objects created, options appear in the ”VI-Suite Display” tab (section 4.2) to control the day, time and size of the sun path objects for real time visualisation of sun position.

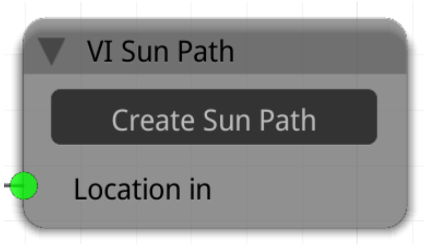


Figure 13: VI Sun Path node

4.4.3 The Vi Shadow Study node

The VI Shadow Study node (figure 14) colours sensing geometry based on the proportion of time the geometry is exposed to direct sunshine assuming clear sky conditions. The calculation is done every specified interval during month and hour range specified if the sun is above the horizon. The node has one input socket; ”Location in” which connects to a VI location node’s ”Location out” socket. The VI Location node can have either manual or EPW specified latitude and longitude. The node also has a ’Results out’ socket for connection to a ’VI Chart’ node for plotting, or a ’CSV’ node for exporting the calculated data to a csv formatted text file. Node options, which are only displayed once a valid socket connection has been made, include:

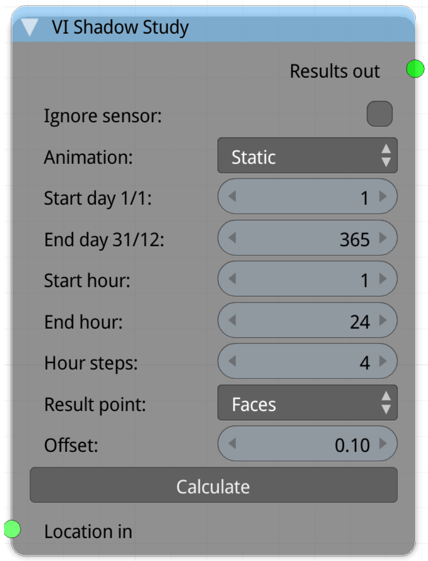


Figure 14: VI Shadow Study node

- Ignore sensor - when turned on shading sensor surfaces do not shadow other shading sensor surfaces.
- Animation - to specify whether geometry is animated or static.
- Start & end day - to specify the day range for analysis.
- Start & end hour - to specify the daily hour range.
- Hour steps - number of steps per hour to calculate.
- Result point - to specify whether the shadow sensing points are positioned at the face centre or vertices of the sensing object
- Offset - to specify the distance of the sensing point from the geometry (this is useful if the sensing mesh has non-planar faces that would place the centre of the face below the face surface). If the results are inexplicably zero for some result points try increasing this number.

4.5 LiVi Nodes

The lighting analysis nodes control and specify a LiVi simulation for the prediction of lighting metrics. Most of the lighting analysis nodes (”LiVi Geometry”, ”LiVi Context”) can be added via the ”Process nodes” menu. ”LiVi Simulation” can be added from the ”Analysis nodes” menu.

4.5.1 The LiVi Geometry Export node

The ’LiVi Geometry’ node (figure 15) exports Blender geometry and materiality to a format that can be understood by the Radiance lighting simulation suite. All unhidden lights, geometry and materials on the current Blender layer are exported and the Radiance description stored within the node. If the animated option is selected a Radiance description for each frame selected with the node’s frame range options is written. A Blender animation covering the selected frames should have been created previously. Subsequent options control the point type on any sensing geometry at which results will be calculated (vertices or faces), and the offset in metres for the sensing point from the actual geometry. This option is useful for non-planar surfaces where the average central point of a face centre is actually below the face surface. If calculated results are inexplicably zero on some faces try increasing this value. The node has one ’Geometry out’ output socket that can connect to a ’Text in’ or ’Geometry in’ socket.

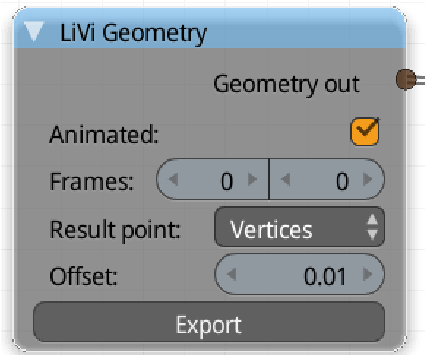
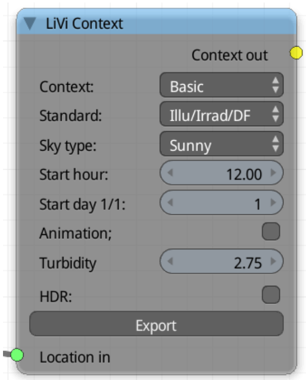


Figure 15: LiVi Geometry node

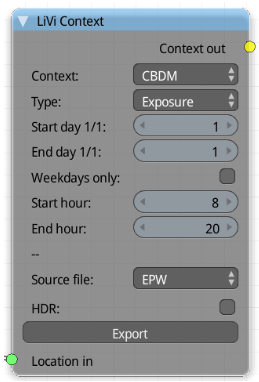
4.5.2 The LiVi Context node

The LiVi Context node (figure 16) controls the export of a lighting simulation context to a text format that Radiance can understand. In terms of a Radiance simulation, context means the type of sky the building is exposed to, the time of day and year and the metric to be calculated. On export the sky context is stored within the node. This node can create three different categories of sky context: ’Basic’, for simple lighting metrics, ’Compliance’ for checking against lighting standards (BREEAM, Code for Sustainable Homes, Green Star and LEED v4 are currently supported), and ’CBDM’ for climate based daylight modelling.



(a) Basic analysis

(b) Compliance analysis



(c) CBDM analysis

Figure 16: LiVi Context node

The node has one input socket and one output socket. The input socket is a ”Location in” socket for connection to a VI location node’s ”Location out” socket. This connection is required to expose the node’s export button. The output socket is a ”Context out” socket for connection to a ’Text in’ socket or a LiVi Simulation ’Context in’ socket.

Node options are dynamic and presented only if appropriate for the type of analysis selected, which is set with the first menu. These first menu options are:

- Analysis type - Basic:
  - Allows calculation of illuminance, irradiance, daylight factor & glare
  - Sky type options - Sunny, partly cloudy, cloudy, daylight factor, HDR & Radiance sky. The latter two allow the selection of an HDR panorama image or a Radiance sky description file respectively.
  - Animation options - Only available if a sunny, partly cloudy or cloudy sky is selected. If animation is chosen Blender animation frames will be created from the selected starting frame option (end frame is calculated automatically depending on the end time specified in the node).
  - Time options - start hour/day (only available if a sunny, partly cloudy or cloudy sky is selected in the sky option) and end hour/day and interval (only available if animation is selected). If a sunny, partly cloudy, or cloudy sky is chosen a sun will be created in Blender's 3D scene. The position of this sun will update according to the hour/day settings. If animation is selected the sun position will be registered for each frame of the frame range range selected.
- Analysis type - Compliance:
  - Allows assessment of compliance against BREEAM, CfSH, Green Star and LEED v4 standards.
  - Building type options - sets the type of building for compliance analysis.
  - If LEED compliance is selected options are presented similar to the CBDM analysis options detailed below with the exception of lux level and day range as these are set by the compliance specification.
- Analysis type - CBDM:
  - Allows calculation of:
    - Lighting and radiation exposure.
    - Daylight availability, useful daylight illuminance, spatial daylight autonomy, annual sunlight exposure.
    - Hourly irradiation.
  - Time options - set the day range and daily hour range for the simulation.
  - Lux levels options - defines the lighting benchmark levels for the chosen metrics.
  - Source options - defines the type of climate data used to create the sky context.
    - Either 'EPW' from the connected 'VI Location' node or 'VEC' for a previously processed epw file. This vec file with the extension '.mtx' is stored automatically in the VI-Suite project directory whenever an EPW file is processed. Choosing the pre-processed vec file is slightly quicker when exporting.
- HDR: Exports an HDR panorama of the sky.

If valid socket input connections have been made an 'Export' button will appear at the bottom of the node. Clicking this will export the context to Radiance format and stores it within the node.

4.5.3 The LiVi Simulation node

The LiVi Simulation node (figure 17) calls the rtrace component of Radiance to calculate the chosen metric on the sensing geometry. The exception to this is if glare analysis has been selected, in which case images will be generated from Blender's camera view-point with glare metrics incorporated and stored in Blender's image editor.

The node has two input sockets: ”Context in”, which accepts connections from a ”Context out” socket of a “LiVi Context” node and ”Geometry in” for connection to the ”Geometry out” socket of a ”LiVi Geometry” node. Once valid socket connections have been made the node options are exposed. This node shows the current range of frames for which a Radiance simulation will be conducted which is a combination of the frame range from the connected geometry and context nodes. The ”Accuracy” menu controls the simulation accuracy, with more accurate values leading to longer simulation times. The options presented in this menu depend on the type of analysis being conducted: a LiVi Basic analysis presents ”Low”, ”Medium”, “High” and ”Custom” options. LiVi Compliance and CBDM analyses give rise to ”Initial”, ”Final” and ”Custom” options. A ”Custom” selection allows for the input of Radiance command line options into the exposed text box.

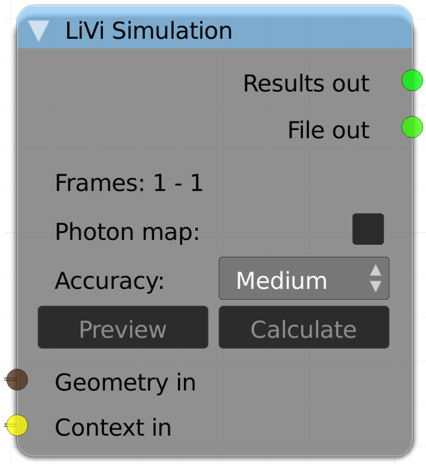


Figure 17: LiVi Simulation node

The node also contains options for Radiance’s new Photon Mapping capability. At least version 5 of Radiance is required to use Photon Mapping. Photon mapping options include the number of global and caustic photons emitted. Refer to the Radiance photon mapping manual for more information about these options.

There are two buttons in this node: A “Preview” and a “Calculate” button. The ”Preview” button brings up a Radiance rvu window and renders the scene, from the point of view of Blender’s camera, and the ”Calculate” button initiates the rtrace or glare simulation. When the ”Calculate” button is pressed the Blender interface will lock up during the simulation but a kivy window will appear that shows an estimate of simulation duration and presents a cancel button to terminate the simulation.

4.6 EnVi Nodes

4.6.1 The EnVi Geometry node

The EnVi Export node (figure 18) exports Blender scene geometry and materiality into a form more suitable for EnergyPlus analysis, which requires a very different geometry format than that typically used within Blender. The node contains one ”Export” operator button. Upon pressing the ”Export” button the node converts all unhidden geometry, designated as EnergyPlus geometry, on Blender’s layer 1 and places it on layer 2 where it is coloured according to the construction type: Green for roof, grey for walls, brown for floor, yellow for ceiling, turquoise for windows and red for shading geometry. After changes are made to any geometry on layer 1 the ”Export” button should be re-pressed to convert and copy the new geometry to layer 2. Layer 2 should be checked before simulation to confirm the correct geometry and construction designation. The node has one output socket, ”Geometry out” for connection to an “EnVi Export” node’s ”Geometry in” socket

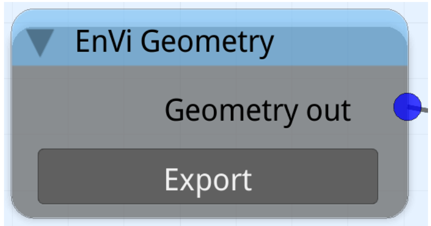


Figure 18: EnVi Geometry node

4.6.2 The EnVi Export node

The “EnVi Export” node converts the modified Blender geometry and materiality on layer 2 into a valid EnergyPlus text description and combines it with the weather data specification in the connected location node, the context and the desired simulation metrics presented within this node to create a complete EnergyPlus text input file. The input file created is called in.idf and is stored in the project directory. It is also registered within Blender’s text editor, and can be edited before eventual simulation if required. The node has two input sockets: ”Geometry in” for connection to an EnVi geometry node’s ”Geometry out” socket and ”Location in” to connect to a VI location node’s ”Locaton out” socket, and one output socket ”Context out”, for connection to an EnVi simulation node’s ”Context in” socket. The connected ”VI Location” node must have ”EPW” selected as its information source. If valid input socket connections are made an ”Export” button will appear at the bottom of the node.

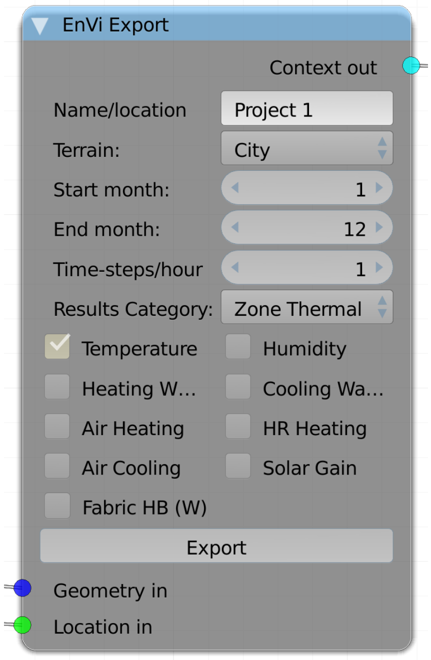


Figure 19: EnVi Export node

Options include:

- Name/location - provides a text box for the optional entry of an EnergyPlus project name
- Terrain - specifies the type of terrain the building sits in.
- Start/end day - specifies the beginning and end day for the simulation.
- Time steps - specifies the number of simulation time steps per hour
- Results category - chooses the class of metrics to be calculated. Options are ”Zone Thermal”, ”Comfort”, ”Zone Ventilation”, ”Ventilation Link”.
- Individual tick boxes for specific metrics within the chosen results category class.

Upon pressing the “Export” button the in.idf file is created in the project directory and the ”Context out” socket will become visible.

4.6.3 The EnVi Simulation node

The EnVi Simulation node (figure 20) initiates an EnergyPlus simulation. The EnVi Simulation node has two sockets: ”Context in” for connection to another node’s ”Context out” node, and ”Results out” for connection to a ”VI Chart” node or a ”VI CSV Export” node. The node contains a text box into which the name of the EnergyPlus results file (default is ”results”) can be specified. This file, with the extension .eso, is saved in the project directory. Once a valid socket connection has been made to the ”Context in” socket a ”Calculate” button appears, which when pressed initiates the EnergyPlus simulation. The node will then turn red and will monitor the EnergyPlus simulation and give a prediction of simulation progress. The Blender interface should remain interactive during simulation and a kivy window is presented to estimate simulation time and to cancel the simulation. No changes to the Blender scene should be made while the simulation is running.

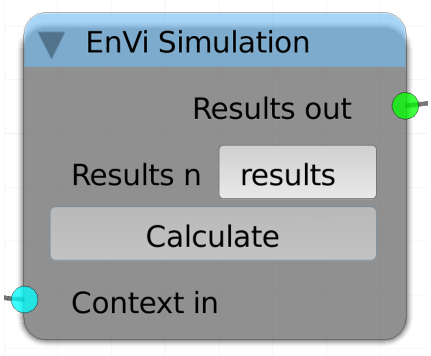


Figure 20: EnVi Simulation node

4.7 EnVi Network Nodes

EnVi Network Nodes are used within the EnVi Network node tree to specify zone schedules and natural ventilation networks.

4.7.1 The EnVi Zone nodes

EnVi zone nodes are created automatically in the ”EnVi Network” node tree during EnVi geometry conversion. Input sockets are created for HVAC, occupancy, equipment and air infiltration schedules. If a Blender object's material has the airflow surface or boundary surface option turned on sockets are also created for these surfaces. These sockets are coloured brown if representing a boundary surface, green if representing a sub-surface flow component associated with opening surfaces like windows or doors, and red for a surface flow associated non-opening surfaces such as walls, floors and roofs. These sockets are created on both sides of the node for easier arrangement of connections within the node editor.

The example in figure 21 shows a zone with one sub-surface flow material associated with a window, and a surface flow material associated with a wall. These two flow components express themselves as two input sockets and two output sockets with socket names derived from the name of the material associated with the surface, the index number of the Blender face and at the end of the socket name an ”s” denotes a surface flow and ”ss” denotes a sub surface flow. A ”b” at the end of the socket name would denote a boundary surface. For example, en_window_1_ss denotes that Blender material en_window is associated with a face with an index of 1 that represents a sub-surface flow. The VI-Suite itself does not by default visualise face index number but the VI-Suite will automatically turn on index visualisation for any object on layer 2 that is in 'Edit' mode. Selected face indices can then be visualised by selecting the 'Indices' option in the 'Mesh Display' section of the 3D View properties panel.

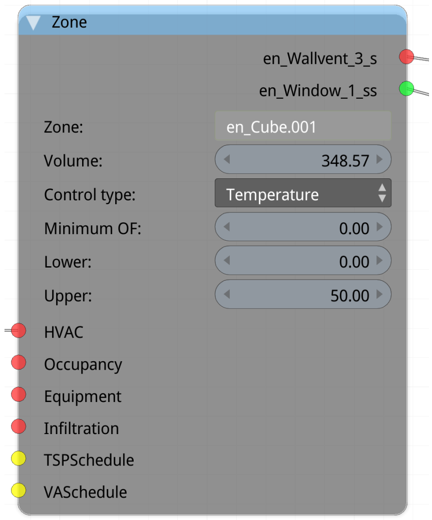


Figure 21: EnVi Zone node

Boundary sockets must be connected to another boundary socket on another zone node. The VI-Suite then assumes that the connected boundary surface sockets sit on the boundary between these two zones.

Surface and sub-surface flow sockets must be connected to an 'EnVi Surface flow' node or an 'EnVi Sub-surface flow' node respectively.

An additional input socket ”VASchedule” is optional and allows the specification of a venting availability schedule for the zone.

If an airflow or boundary socket on one side of the node is connected the socket with the same name on the other side of the node will disappear. When all airflow/boundary sockets are connected the node becomes valid and will turn the default colour. It should be noted that any EnVi zone must have at least two airflow surfaces specified within it during geometry creation, and at least two sets of flow sockets should appear in the node.

The node also displays the name of the Blender object/EnergyPlus zone, the calculated volume of the node and the ventilation control type. Control types are ”None”, ”Constant” and ”Temperature”. If ”Temperature” is selected a new input socket ”TSPSchedule” must be connected to an EnVi schedule node. This schedule will set thermostat temperature set-points above which the openable zone airflow connections will all considered to be fully open. Some extra options are then also displayed:

- Minimum OF - the minimum opening factor
- Lower - the lower temperature difference threshold
- Upper - the upper temperature difference threshold

See the EnergyPlus input/output reference file for details on these options.

4.7.2 The EnVi HVAC node

The EnVi HVAC node specifies heating and cooling levels for a connected EnVi Zone node by creating an EnergyPlus IdealLoadSystem. EnergyPlus was developed in the United States where the heating and cooling of buildings with air is common and many of the EnergyPlus options pertaining to the supply of heating and cooling reflect this.

- HVAC Template - whether an HVAC template should be used (as of v0.4 only an ideal load air system has been implemented and this option therefore only duplicates the action of this node).
- Heating limit:
  - None: No heating.
  - No limit: Heating is unlimited in terms of the air flow rate that can be supplied or the capacity to heat the air.
  - LimitFlowRateAndCapacity: Limit the overall capacity and the airflow rate of the heating system.
  - LimitCapacity: Limit only the overall capacity of the heating system.
  - LimitFlowRate: Limit only the airflow rate of the heating system.
- Heating temp: Temperature of the heating airflow.
- Heating airflow: Maximum air flow rate (m^3/s) if air flow is limited.
- Heating capacity: Maximum heating capacity (Watts) if capacity is limited.
- Thermostat level: Thermostat set-point for heating.
- Heat recovery: Turns on sensible heat recovery.
  - HR eff.: Sets the heat recovery efficiency

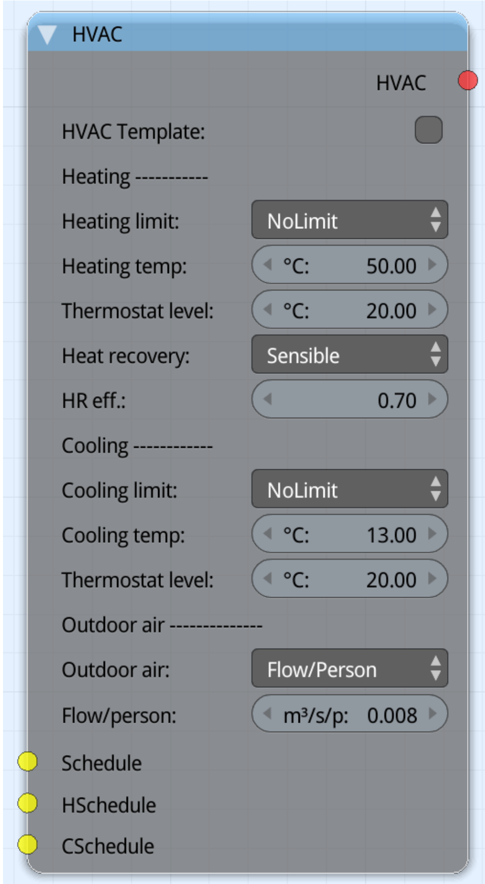


Figure 22: EnVi HVAC node

Most of these options have their corollary in the cooling section of the node. The level of outdoor air supplied by the heating/cooling system can also be specified. If the outdoor air flow level is higher than the flow supplied by the heating/cooling system the latter is supplied. See the EnergyPlus Input Output reference document for details of the outside air supply options.

In addition, the node has three input sockets:

- Schedule - for the connection of a schedule node to determine when the heating/cooling system available (schedule values: 0 or 1).
- HSchedule - for the connection of a schedule node to provide time varying heating thermostat set point temperatures (schedule values: temperature).
- CSchedule - for the connection of a schedule node to provide time varying cooling thermostat set point temperatures (schedule values: temperature).

4.7.3 The EnVi Occupancy node

The EnVi Occupancy node specifies the type and nature of any occupancy within a connected EnVi zone node. Occupancy is set as a maximum occupancy level within this node and an attached schedule node can set the fractional schedule of this maximum level. The options within the node control:

- Type of occupancy:
  - None: No occupancy.
  - Occupants: Occupancy in terms of number of people.
  - Persons/m^2: Number of people per square meter of floor area.
  - m^2/person: Square meter of floor area per person.
- Max level: Maximum occupancy in terms of the previously selected occupancy type.
- Activity level: Watts per persons metabolic rate.
- Comfort calc: Turn on thermal comfort calculations
  - Work efficiency: Proportion of the metabolic rate expended in useful work.
  - Air velocity: Average air velocity for comfort calculation.
  - Clothing: Clothing level of the occupants in clo.
  - CO_2: Turn on the calculation of internal CO_2 levels.

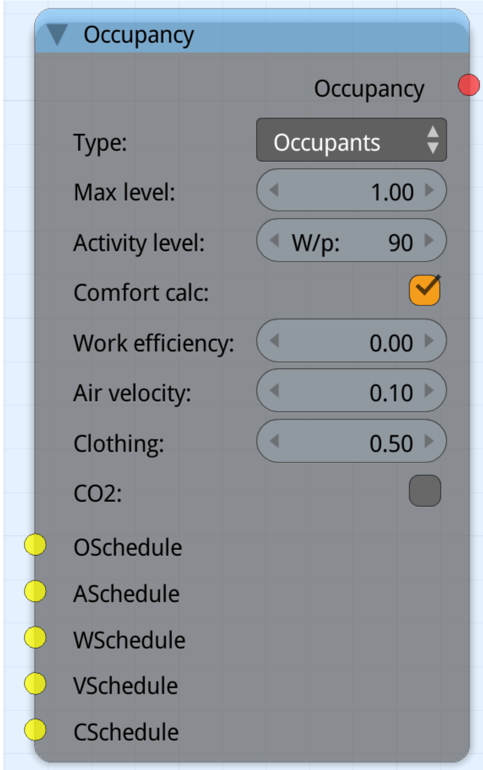


Figure 23: EnVi Occupancy node

The node also contains sockets for the connection of schedule nodes: OSchedule socket is for the scheduling of occupancy level as a proportion of the maximum specified occupancy; ASchedule socket for the schedule of the absolute metabolic rate; WSchedule for the scheduling of the absolute level of the work efficiency; VSchedule for the scheduling of absolute air velocity in m/s; CSchedule for the scheduling of absolute clothing level.

4.7.4 The EnVi Equipment node

The EnVi Equipment node specifies the level of mechanical and electrical internal heat gains. The options within this menu include:

- Type: Sets the type of equipment gain.
  - None: No gains
  - EquipmentLevel: sets the total Watts of internal gains for the zone.
  - Watts/area sets the internal gains in Watts per square metre of floor area.
  - Watts/person sets the Watts per occupant.

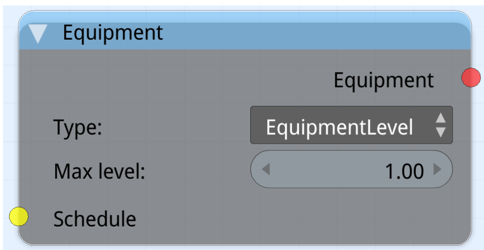


Figure 24: EnVi Equipment node

- Max level: Sets the maximum gain based on the previously selected gain type.

The node also contains an input socket for the connection of a schedule node to set a absolute scheduled value for the specified heat gain.

4.7.5 The EnVi Infiltration node

The EnVi Infiltration node sets a constant or scheduled level of fresh air infiltration into a zone. If an air-flow network is specified this node and the settings within it will be ignored. The node sets two options:

- Type: Sets the type of infiltration
  - None: No infiltration
  - Flow/Zone: Total flow for the whole zone in m^3/s.
  - Flow/Area: Flow per square metre floor area in $m^3/s{\cdot}m^2$.
  - Flow/ExteriorArea: Flow per square metre of exterior surface area in $m^3/s{\cdot}m^2$.
  - Flow/ExteriorWallArea: Flow per square metre floor of exterior wall area in $m^3/s{\cdot}m^2$.
  - ACH: Total flow in ACH.
- Level: Sets the level for the previously selected infiltration type.

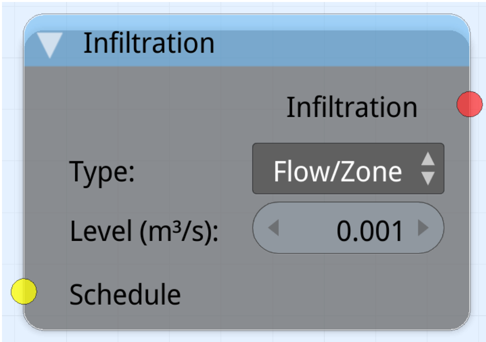


Figure 25: EnVi Infiltration node

The node contains 1 input socket for the connection of a schedule node to specify a fractional infiltration rate.

4.7.6 The EnVi Schedule node

The EnVi Schedule node can be found in the "Add" - "Schedule nodes" menu in the "EnVi Network" node tree. A schedule node creates an EnergyPlus schedule, which is used to control an input's time dependence e.g when windows are open. All EnVi schedules basically operate over defined periods of a year, for defined days within that period, and defined hours of those days. The node options reflect the specification of these three layers of time data. The node is initially red and will only become the default colour when the options below are given valid values. The options are:

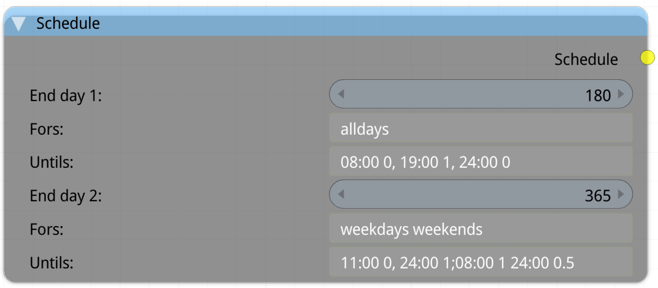


Figure 26: EnVi Schedule node

- "End day 1" - sets the end day of the first scheduled year period. This defaults to 365, the last day of the year.
- "Fors" - sets the day types (valid day types are: Alldays, Weekdays, Weekends, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday and AllOtherDays) for the above year period in a space separated list. *weekdays weekends* would for example set two day types for the next "Untils" option.

- ”Untils” - sets the schedule values with space separated end hour/value pairs, comma separated for each period within a day type and semi-colon separated for each day type. *12:00 1, 24:00 0; 24:00 1* would, for example, mean on the first day type (weekdays) the schedule value is 1 up to midday, and 0 up to midnight, and for the second day type (weekends) the schedule value is 1 up to midnight. A whole day period must be covered so 24:00 should always be the last time specified.

If the first end day is less than 365 the three options above are repeated for the next year period. Up to four year periods can be set.

In figure 26 for example for the first period up to day 180, for all days within that period the node sets a schedule value of 0 up to 08:00 in the morning then 1 until 19:00 and then 0 again until 24:00 (midnight). For the next period from day 180 to the end of the year (day 365) weekdays within this period have a schedule value of 0 until 11:00 in the morning and then 1 until 24:00. For weekends within this period the schedule values are 1 up to 08:00 in the morning and 0.5 until 24:00. The node presented in figure 26 represents a fraction schedule where the schedule values are the fraction of a maximum value e.g. maximum occupancy where 0 would represent no occupancy, 1 maximum occupancy and 0.5 half the maximum occupancy. Sometimes however schedules specify actual values e.g a changing thermostat set-point temperature. Refer to the EnergyPlus user manual for clarification of what schedule type is required to control which parameter.

4.7.7 The EnVi Surface Flow node

The ”EnVi Surface flow” node creates a flow component within a solid building construction such as a wall, floor or roof. It contains two input sockets ”Node 1” and ”Node 2”, and two output sockets ”Node 1” and ”Node 2”. Having sockets on both sides of the node makes node connections within the node tree more flexible but only one needs to be connected so if a node socket on one side of the node is connected, the similarly named socket on the other side of the node will disappear. All of these sockets are for connection to the surface flow sockets of ”EnVi Zone” nodes.

If both ”Node 1” socket and ”Node 2” sockets are connected to two different EnVi zones the surface flow node is assumed to specify a flow component between the two zones. If only one socket is connected to an EnVi zone node the surface flow is assumed to sit on the external boundary of the zone and control airflow between the zone and the outside air. If ”Input” is selected for the ”WPC type” in the EnVi network control node, an ”EnVi External” node must then be connected to the other socket to represent outside conditions.

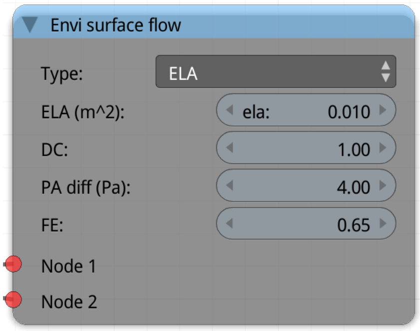


Figure 27: EnVi Surface flow node

Options in this node include:

- Type - the type of flow component (effective leakage area (ELA) or crack)
- If “ELA” is chosen the next option sets the area of the leakage area. This maximum value for this option is auto calculated from the area of the geometric face it is associated. Subsequent options control the parameters of the leakage component type. Refer to the EnergyPlus input/output reference file for further details.
- If “Crack” is chosen the flow coefficient and flow exponent can be specified. Refer to the EnergyPlus input/output reference file for further details.

4.7.8 The EnVi Sub-surface Flow node

The EnVi Sub-surface Flow node creates a flow component within an opening building construction such as a window or door. It contains two input sockets ”Node 1” and ”Node 2”, and two output sockets ”Node 1” and ”Node 2”. All of these sockets are for connection to the sub-surface flow sockets of EnVi Zone nodes. If a node socket on one side of the node is connected the similarly named socket on the other side of the node will disappear. This makes node connections within the node tree more flexible. If both ”Node 1” socket and ”Node 2” socket are connected to two different EnVi zones the subsurface flow is assumed to control airflow between the two zones. If only one socket is connected to an EnVi zone node the surface flow is assumed to sit on the external boundary of the zone and control airflow between inside and outside.

An additional socket is the ”VASchedule” socket which allows for the specification of a venting availability schedule for the component.

The ”Control type” option sets the criteria for the opening and closing of the component. ’None’ means the windows doors are always closed, ’Zone’ means they open/close according to the ventilation control of the parent ’EnVi Zone’ node, “Constant” sets opening/closing according to the schedule attached to the “VASchedule” socket and ”Temperature” sets opening/closing based on a temperature thermostat schedule attached to the exposed “TSPSchedule” socket.

Options in this node include:

- Type - the type of flow component (simple opening, detailed opening, horizontal opening, effective leakage area or crack)
- Subsequent options control the parameters of the selected component type. Refer to the EnergyPlus input/output reference file for further details.

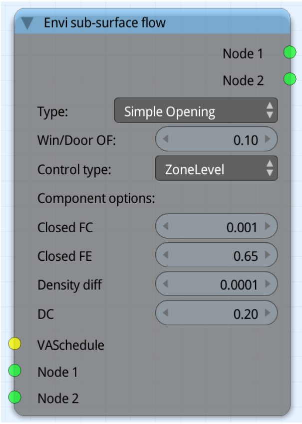


Figure 28: EnVi Sub-surface flow node

4.7.9 The EnVi External node

The EnVi External node provides wind pressure coefficients for the outside surfaces of the building. These nodes are only required if the ”WPC type” option in the EnVi control node is set to ”Input”. The node has sub-surface flow and a surface flow sockets as both inputs and outputs. Joining these sockets to a flow component specifies the building wind pressure coefficients for the angles specified by a WPC Array node. A WPC Array is therefore required to be connected to the EnVi control node for these nodes to be valid.

4.7.10 The EnVi Reference Crack Conditions node

This optional node sets the reference temperature, pressure and humidity for any ventilation cracks specified within the network. If not created, EnVi will assume standard values for these parameters, which are the same as the default values presented when this node is created.

4.7.11 EnVi Program Node

Certain parameters within EnergyPlus can be controlled with the Energy Management System (EMS) control language, which offers more flexibility in controlling the relationship between different elements of the model and the data it produces than the standard EnergyPlus input syntax. Details of the EMS syntax can be found in the EnergyPlus EMS Applications document. There is a single option within the node to select the Blender text file that contains the EMS program logic. There are also two sockets: a ’Sensor’ socket that can be connected 1 or more ’EMS Zone’ sensor sockets, and an actuator socket that can be connected to 1 or more ’EMS Zone’ actuator sockets. It is the name of the sockets in the connected EMS zones that defines the variable names to be used in the EMS program text.

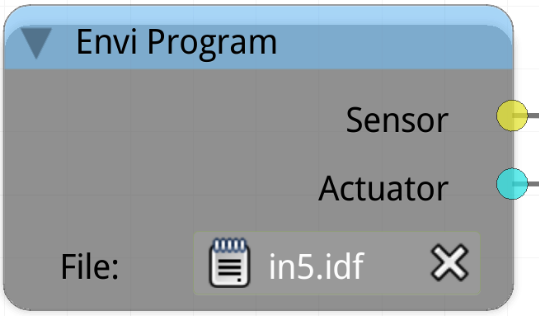


Figure 29: EnVi Program node

4.7.12 EMS Zone node

The ’EMS Zone’ node identifies the sensors and actuators to be controlled by the EMS program node. Once the case-sensitive name of an EnVi Zone on Blender’s layer 2 has been entered in the ’Zone’ text box, options for the sensed variable and actuated variable within the zone are presented. The sensed variable might for example be the zone temperature or occupancy level. The actuated variable might be the temperature of the air supply or the opening factor of any windows or doors. Once these have been selected the names of the input sockets will reflect the names required to address these variables in the EMS program text.

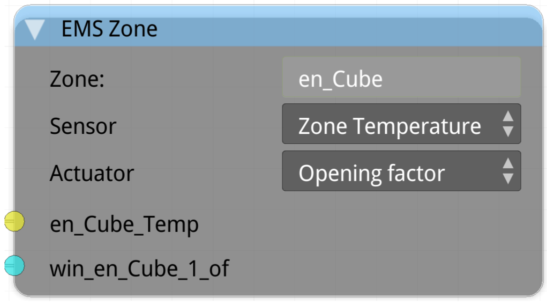


Figure 30: EMS Zone node

4.7.13 The EnVi Control node

The EnVi control node is created automatically within the EnVi network node tree during EnVi geometry conversion if a Blender object/EnergyPlus zone contains air flow surfaces. The EnVi control node specifies the high level options for the ventilation network. For more details of these options refer to the EnergyPlus input/output reference document. An important option here is ”WPC type”, which if set to ”Input” requires an array of wind pressure coefficients to be specified. The wind angles for these values are specified with a WPC Array node attached to the WPC Array socket of the control node. EnVi External nodes attached EnVi Surface flow and EnVi Sub-surface nodes then specify the wind pressure coefficient values for these angles for particular surfaces.

4.7.14 The EnVi WPC Array node

The WPC Array node attaches to the EnVi Control node via the Control node’s ”WPC Array” socket node and specifies the angles of the wind from North that wind pressure coefficient values are specified for in the ”EnVi External” nodes.

5 Using the VI-Suite

5.1 Sun Path Projection

Projecting a sun-path analysis into the Blender scene requires a VI Location node to be created to provide the latitude and longitude co-ordinates of the scene. The VI Location node can either take the latitude and longitude values from an EPW file, or they can be entered manually. The start and end month options of the location node are not exposed when doing a sun path analysis as a whole year is always considered. Once the location node has been set-up a Sun Path node can be created and the ”Location out” socket of the location node dragged to the ”Location in” socket of the Sun Path node. A typical node set-up is shown in figure 31.

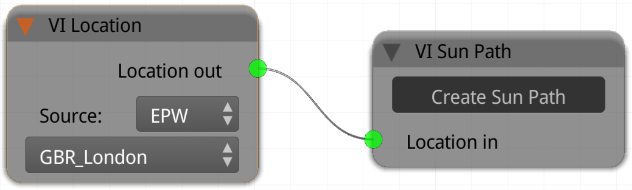


Figure 31: Sun Path node set-up

The Sun Path node itself has no options, only a button to be clicked to create the sun-path. Along with a sun-path mesh, a sun lamp, a spherical mesh to represent the sun and a sphere are created to represent the sky. The sun path object has materials associated with it and these can be changed to alter the appearance of the sun path. Once a sun-path has been created a number of options are presented with the 3D view properties panel in the ”VI-Suite Display” tab (section 4.2). The sun path options display options available are shown in figure 32. The first and second options control the day of year and time of day for the position of the sun lamp and the sun mesh. The third option controls the display of the hour numbers on the sun-path and the fourth toggles the display of the time, date and altitude and azimuth of the sun. The final options controls the text display of the hours and sun time. The sun path mesh can be moved, scaled and rotated as desired. Day of year and time of day options can be animated within Blender and the sun will move accordingly to create animations of sun position.

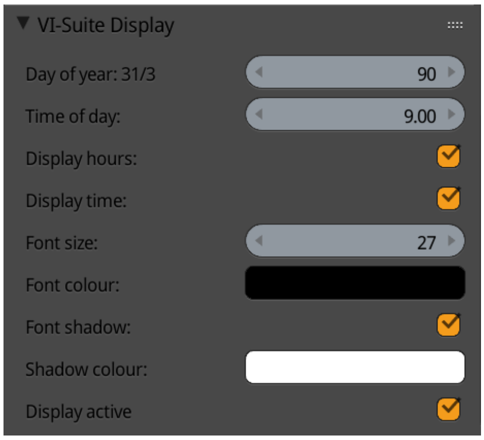


Figure 32: Sun Path visualisation options

If using the Cycles rendering engine the illumination of the scene will correspond to the sun position and a couple more capabilities are enabled. If the Hosek/Wilkie sky is selected as the sky texture in the world background settings the sun orientation within the sky texture will update to correspond to the sun-path sun position. In addition, if the sun and sun mesh are given an emissive material, with a black-body temperature colour, the black-body colour will also change according to the position of the sun in the sky; orange/red near the horizon, white near noon.

As the sky background is much further away from the 3D viewpoint than the sun and the sun path mesh, then if the viewpoint is not near the centre of the sun path mesh there will be a misalignment between the sun and the brightness of the sky background. To rectify this a ”SkyMesh” is also created, but is hidden be default. This sky mesh is a sphere, the surface of which sits just outside sun path mesh. If in ”Cycles” rendering mode unhide the sky mesh and select ”Emission” as the surface for the ”SkyMesh” material, select ”Sky Texture” for colour and select ”Texture Coordinate - Normal” for the vector setting. When the 3D viewpoint is now inside this sky mesh sphere, the sky texture will be projected onto the inside of the sphere in accordance with the sun position, and will line up more closely with the sun-path mesh itself.

5.2 Wind Rose Projection

Projecting a wind rose into the scene also requires a VI Location node. In this case however the location node provides wind speed and direction data for the wind rose analysis and therefore an EPW file must be chosen as the source of information within the location node. A typical node set-up is shown in figure 33.

The options within the wind rose node control the type of wind rose plot to create (two types of histogram and three types of contour plot are available), the start and end days of the year to plot and the colour scale to use for the plot . Examples of a histogram and contour plot are shown in figure 34.

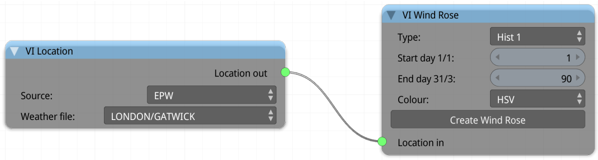


Figure 33: Wind Rose node set-up

Once the button to create a wind rose is pressed a wind rose object is created at the centre of the scene. This object, like any Blender object, can be moved, scaled and re-sized as desired. Each time the wind rose button is pressed a new object is created.

When a wind rose object has been created a button is exposed in the ”VI-Suite Display” tab (section 4.2) of the 3D view properties panel. The wind rose analysis uses the new VI-Suite display framework so once this button is pressed 3 icons will appear in the 3D view: A ”Legend” icon to display the wind speed colouration of the wind rose, a “Table” icon to display tabulated wind speed and direction data and a “Scatter icon” to display a scatter graph of the hourly wind speed or direction data. Some display options are also presented in the 3D view properties panel. These are “Wind metric” to control whether the scatter graph displays speed or direction data and “Colour” to select the colour scale of the scatter graph.

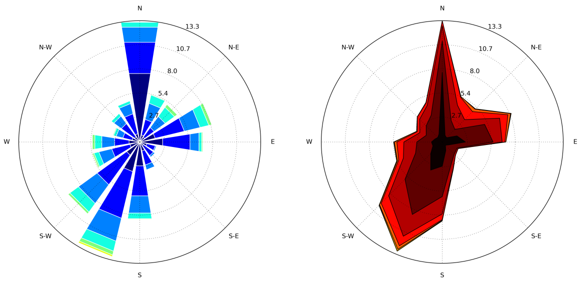


Figure 34: Histogram and contour wind roses

5.3 Shadow Study

The shadow study node also requires a VI Location node to provide latitude and longitude co-ordinates so either an EPW file or manual entry can supply this data. A typical node set-up is shown in figure 35.

A shadow study analysis requires sensing geometry to be specified. This geometry is specified via its material designation. Once a Blender object has a material associated with it (and this material can only be associated with specific faces of an object if desired) then in the Blender material panel in ”Vi-Suite Material” tab there is an drop-down menu called ”Material type”. Within this menu the option ”Shadow sensor” should be selected. An analysis will then plot on this sensing geometry a grey-scale colouration signifying how often that point receives direct sunlight, when the sun is above the horizon, for the specified simulation period.

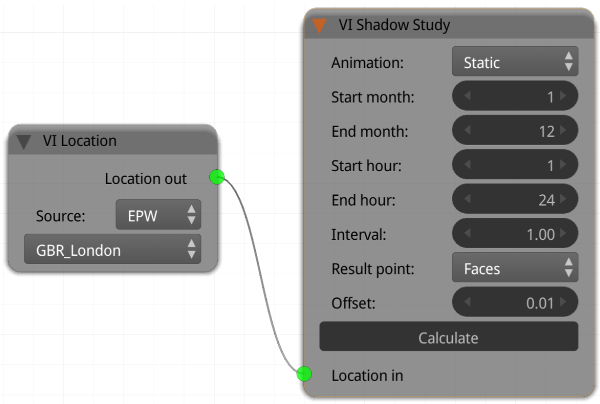


Figure 35: Shadow Study node set-up

The year period for the simulation is set within the Shadow Study node with the start month and end month options. The period of each day to be simulated is set with the start hour and end hour options. The ”Interval” option sets the hourly time step for the simulation. A value of 1 will do a calculation once per hour, and a value of 0.25 will do one every 15 minutes. The ”Animation” option allows either a static analysis or one based on a geometry animation. If ”Static” is selected then results are valid for the current selected frame. If ”Animated” is selected results will be generated for each frame of the created animation.

In the 3D properties panel (section 4.2) the ”VI-Suite Display” tab will present a shadow study display button and once this is pressed will also show options relevant to the shadow study. The display panel options are shown in figure 36.

The options in the display panel are:

- VI 3D Display - If selected before the display button is pressed the results can be extruded to provide 3D result visualisation.
- Shadow Display button - When clicked will initiate display and expose further display options.
- Only Render - Removes some interface elements from the 3D view
- Legend - Turns on the legend display in the top left of the 3D view
- 3D Level - If VI 3D Display was selected this number will extrude the results plane for 3D results visualisation.

In the Point Visualisation section:

- Enable - Turns on per-point numerical visualisation of the results
- Selected only - Only the currently selected object will display numerical results
- Visible only - Only points not obscured in the 3D view show numerical results
- Font size, font colour, font shadow - changes the colour and size of the point numerics.

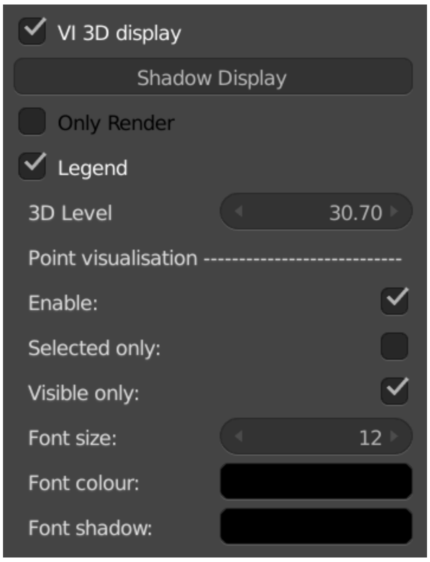


Figure 36: Shadow study display options

Figure 37 shows a shadow study analysis of the terrain around Mount Snowdon.

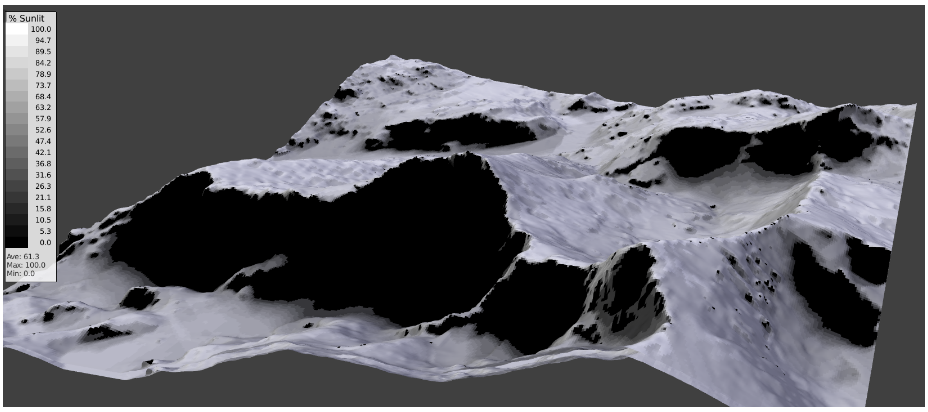


Figure 37: Shadow study analysis of Mount Snowdon

5.4 LiVi Lighting Analysis

Lighting analysis is conducted with the LiVi component of the VI-Suite, which acts as a pre/post processor for the Radiance software simulation suite. A valid Radiance installation is therefore required on the host machine. Details of the installation process can be found in section 2.

There are three main LiVi nodes: LiVi Geometry, LiVi Context and LiVi Simulation. All are detailed in section 4.5. A LiVi analysis will require all 3 nodes.

A numerical LiVi lighting analysis, like a shadow study, requires geometry within the scene to be identified as sensing geometry. This is done in the material panel within the ”Vi-Suite Material” section where the option ”Light Sensor” should be selected in the ”Material type” drop-down list. All geometry to which this material is associated will now act as a sensing plane. Sensing surfaces are not required for glare studies, or if only a preview of the Radiance scene is to be conducted. The sensing geometry senses in the direction of the Blender sensing face or vertex normals.

5.4.1 LiVi Geometry

The LiVi Geometry node, which can be found in the ”Add” - ”Process Nodes” menu of the Vi-Suite node editor, controls the export of the of the Blender scene geometry and materiality to the Radiance text file format. Only geometry on the current Blender layer is exported meaning that a number of different scene scenarios can be set up on different Blender layers. Within a layer, any geometry that is not hidden, and has at least one material associated with it, will be exported.

Upon pressing the node’s ”Export” button the node first converts Blender materials to Radiance material descriptions. Specification of the Radiance material type for a particular Blender material is done within Blender’s material panel. At the bottom of the material panel a section called ”VI Material Type” presents a drop down menu called ”LiVi Radiance type” that allows the designation of the Radiance material type for the selected Blender material. Options include ”Plastic”, ”Metal”, Glass” etc. Options to further specify the Radiance material are then presented.

Next, suitable geometry is exported as obj files to the ”obj” folder created in the project directory. The obj files are then automatically converted to Radiance mesh files, with Radiance’s obj2mesh program, and referenced within the Radiance input text. Actual object vertex co-ordinates are instead written out to the Radiance input if a Blender object’s geometry is non-manifold i.e. not physically realisable (e.g. an edge without faces), or if a ”Mirror” or an ”Emission” material is associated with an object as Radiance meshes cannot have these material attached.

Next Blender lights are exported to Radiance format. There are two ways to set-up lights for Radiance export: Creating standard Blender lamps, or creating a plane at each face of which a lamp is automatically specified. If using the first method then selecting a lamp within Blender will display a ”LiVi IES File” section at the bottom of the Lamp properties panel. In this section it is possible to specify an IES file to associate with the Blender lamp. IES files are released by luminaire and lamp manufacturers, and describe the brightness of a luminaire or lamp from multiple directions. The desired IES can be picked with the ”Select IES File” button. Three additional options are also presented:

- IES Dimension - specifies the distance unit for the geometry described in the file
- IES Strength - which allows the light to be dimmed (can be animated)
- IES Colour - sets the colour of the lamp (can also be animated).

The second method allows any selected mesh object to have an IES file associated with it via the ”LiVi IES file” section of the ”Object data” panel. Any IES file selected here will now be applied in the Radiance scene at each face centre of the mesh object. This is useful for quickly setting up arrays of lights. Simple rotations of the light array object will be reflected in the positioning and direction of the lights in the Radiance scene, although more complex rotations may not be correctly reported to Radiance. In general keep IES object rotations to a single axis rotation.

If undertaking an animated, parametric analysis LiVi will export a Radiance scene for each frame from start frame to end frame as specified within the geometry node interface. How to set up animations in Blender is beyond the scope of this document so please refer to on-line information for this but in short pressing the ’i’ key with the cursor over the value in the interface to be animated will register that value for the current animation frame selected.

5.4.2 LiVi Basic analysis

A basic analysis allows for the prediction of illuminance (lux), irradiance (W/m^2), Daylight Factor (%) and glare. The first three metrics are plotted onto sensing planes, in a similar manner to the shadow study analysis, using the ”rtrace” component of Radiance, and can be visualised by pressing the ”Radiance Display” button in the ”VI Display” section of the 3D view properties panel after simulation. The glare analysis is assessed via the creation of fish-eye point-of-view images that highlight the glare sources within a scene. A typical node set-up is shown in figure 38.

A ”VI Location” node, ”LiVi Geometry” node, ”LiVi Context” node and a ”LiVi Simulation” node are required for this type of analysis and the node connections should replicate the connections shown in figure 38. A basic LiVi analysis can be selected in the first menu of the context node.

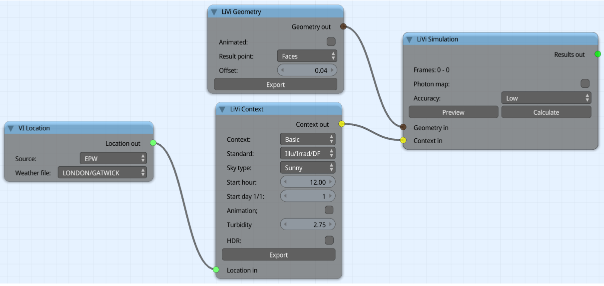


Figure 38: Typical LiVi Basic node set-up

The LiVi Geometry and Context nodes can be exported independent of other node connections and store their respective Radiance text file descriptions within themselves. This means that different geometry and context nodes can be swapped in and out of the analysis node network without needing to be re-exported. Once all nodes have been exported, connected, and the ”Calculate” button has been pressed on the simulation node the Radiance simulation is run. A kivy window should then appear giving an estimate of simulation time and presenting a button to cancel the simulation. When completed the Radiance results are stored within the meshes of the sensing geometry for visualisation. Options in the ”VI Display” panel detailed in section 5.4.5 control visualisation of these results unless a glare analysis has been selected. Glare analysis has a different visualisation process also detailed in section 5.4.5.

5.4.3 LiVi Compliance

A ”LiVi Geometry” node, ”LiVi Context” node and a ”LiVi Simulation” node are also required for a compliance analysis. For a compliance analysis ’Compliance’ should be selected in the first menu of the context node. A LiVi compliance analysis checks lighting performance against internationally recognised standards. As of VI-Suite version 0.4 compliance with BREEAM HEA1, Code for Sustainable Homes, Green Star and LEED v4 can be assessed. Options will appear within the node to specify the compliance standard and building type. If LEED v4 compliance has been selected additional options will be exposed. These additional options control the daily start and end hour for the compliance period, whether only weekdays are simulated, and the source of the hourly data required for this type of compliance simulation.

Once a compliance context has been exported a compliance specific drop-down menu is exposed within the ”VI-Suite Material” tab of the material panel to define the type of space a particular sensing material is associated with. For a BREEAM residential property, for example, this option can select a Kitchen, Living/Dining/Study or Communal space.

Once the Calculate button is pressed the Radiance simulation is initialised, and when finished, display options appear in the VI Display section of the 3D view properties panel. These display options are detailed in section 5.4.5. Upon pressing the display button an additional compliance icon will be drawn on the 3D view which will show a compliance table when clicked.

5.4.4 LiVi CBDM

A Climate Based Daylight Modelling (CBDM) analysis also requires a VI Location node, LiVi Geometry, LiVi Context and LiVi Simulation node and for the first menu in the context node to be set to ’CBDM’. A CBDM analysis allows the lighting performance of a building over longer periods of time to be analysed. The information for the environmental lighting conditions is provided (at least initially) by a location node, taking an EPW file as its source of information.

When the simulation node's calculate button has been pressed the Radiance simulation is initialised a kivy window will appear and the Blender interface will lock up until completion. If an hourly calculation metric has been selected the simulation can take some time. Once completed, display options will appear in the VI Display tab and detailed in section 5.4.5.

5.4.5 LiVi Display

Apart for a LiVi Basic glare analysis LiVi display options are presented within the "VI Display" section of the 3D View's properties panel (toggled with the "n" key over the 3D display). A basic VI Display" section is shown in figure 39.

Initially only the "VI 3D display" toggle and the "Radiance Display" button are shown. The "VI 3D display" toggle controls whether a 3D display of the results metric is desired. Once the "Radiance Display" button is pressed new Blender objects will be created and coloured according to the Radiance results, icons to display data graphics will appear in the 3D view and further options are presented. These options include:

- Only Render - toggles the display of the 3D cursor, axis, wire-frames and object manipulators
- Legend max/min - controls the range of the displayed legend and the associated sensor mesh colours in the 3D view.
- Legend scale - legend and result display can be set to linear or logarithmic.
- Legend colour - sets the colour map for the legend and mesh sensors
- Draw wire - toggles the display of a wire-frame for the selected object. May need to be selected twice to turn on the wire-frame.
- 3D Level (only appears if VI 3D display option was chosen) - controls the level of 3D extrusion of the results geometry
- Transparency - set the transparency level of the result geometry

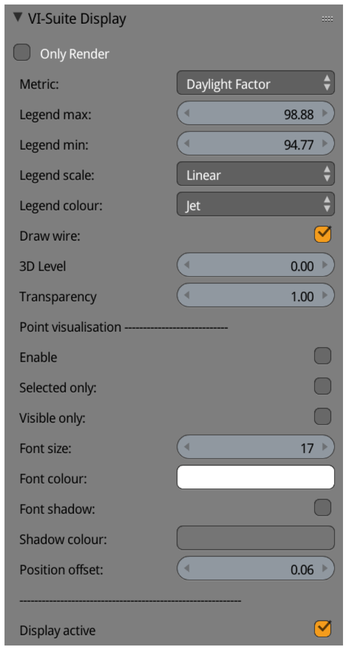


Figure 39: "VI Display" options

The next section controls the display of numerical result values for each point of the sensing geometry. Options in this section include:

- Enable - toggles numeric display
- Selected only - display numerical results only on the selected geometry
- Visible only - only the sensing geometry points visible within the 3D view display numerical values (orientating the view to the selected object may be required to correctly calculate which points are visible)
- Font size, colour, shadow controls the number display
- Position offset - controls the offset point for the numerical display (in general should be set to the same value as the offset value in the "LiVi Geometry" node

The ”Display active” option at the bottom turns off result display. This should be turned off when results display is no longer required.

If a compliance analysis was undertaken an extra icon in the 3D display is created to display the compliance table. The VI-Suite is released as free and open-source code and comes with no warranty. If using the compliance analysis for consultancy work it is the responsibility of the user to ensure that the results are valid.

Standard: BREEAM HEA1
Space type: School

Standard requirements:	Target	Result	Pass/Fail
% area with DF > 2	80	95.1	Pass
Ratio of minimum to average DF	0.4	0.5	Pass
Minimum DF	0.8	1.7	Pass
% area with sky view	80	88.9	Pass

Exemplary requirements:			
% area with DF > 4	80	3.6	Fail
Minimum DF	1.6	1.7	Pass

Build type: School	Standard credits: 1	Exemplary credits: 1

Figure 40: LiVi Compliance panel

Glare analysis differs from other LiVi analyses in that once a simulation is finished, no visualisation options appear in the VI Display Panel. Instead grey-scale fish-eye images, from the point of view of the Blender camera are created, with coloured areas showing glare risk. These images are saved in the project directory with the name glare-*frame_number*.hdr, and also registered within Blender’s image database and can therefore be viewed by opening up a Blender UV/Image editor window. LiVi also writes out the glare metrics calculated from the image on the right hand side of the image, along with the data and time specified in the LiVi Context node.

5.5 EnVi Energy Analysis

The EnVi component of the VI-Suite is a pre/post processor for the EnergyPlus simulation engine (http://apps1.eere.energy.gov/buildings/energyplus/). An EnVi analysis requires a "VI Location" node to provide an EnergyPlus weather file for the simulation, an EnVi Geometry node to pre-process the full Blender geometry into the sub-set of the geometry that will be used in the EnergyPlus simulation, an EnVi Export node to convert the sub-set of the Blender geometry and the building context to the EnergyPlus text format, and finally an EnVi Simulation node to run the simulation. Optionally, a VI-Suite chart node can be used to plot out the simulation results. A typical node layout is shown in figure 41.

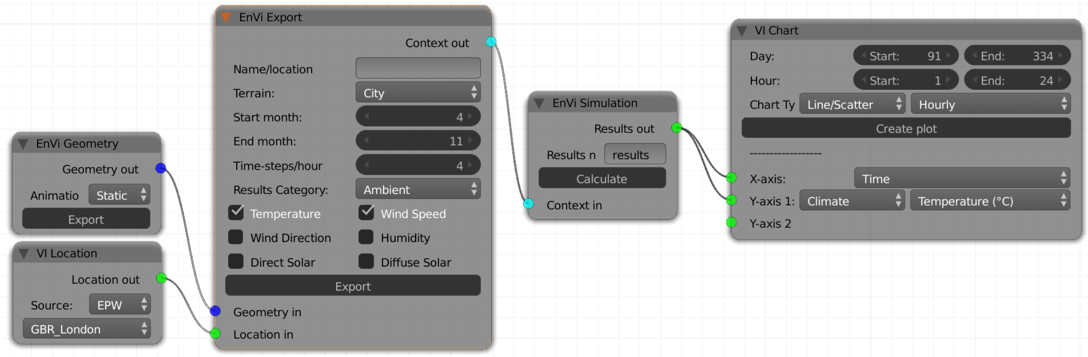


Figure 41: Typical EnVi node set-up

An object in Blender, in terms of EnergyPlus, can either represent nothing, a thermal zone or shading geometry. This selection is made in the "Object Data" panel within the "VI-Suite Object Definition" tab. If 'EnVi Zone' and then either 'Thermal' or 'Shading' are chosen the geometry will be considered as part of an EnergyPlus simulation. A shading object will be used in its entirety in the EnergyPlus simulation with all mesh faces specified as shading faces. A thermal object requires EnergyPlus specified materials applied to the object mesh to define the building construction. Blender materials can be applied to the object mesh as usual in Blender. As EnergyPlus only needs planar geometry then if the building is modelled in Blender with a wall thickness only the interior faces of the walls should have an EnergyPlus material applied. In the material panel for the material applied the tab 'VI-Suite Material' has a section 'EnVi construction type'. The first menu defines the construction type, which can be:

- Wall - Typical external and party wall constructions
- Window - Typical glazing constructions
- Floor - Typical ground and upper storey floor constructions
- Roof - Typical roof constructions
- Door - External and internal door constructions
- Shading - External shading surfaces
- None - No EnVi construction type

Once the type has been selected options are presented to define if the mesh faces the material is associated with sit on a boundary between two zones, whether they allow air-flow or whether the faces will act simply as thermal mass with no heat flow passing through the mesh faces. The specific construction make-up can then be selected by selecting either a pre-set construction or by defining up to 5 layers. If choosing a pre-set construction the user only needs to input the thickness of each construction element (suggested default are thicknesses are presented to the right of the thickness entry dialog). If choosing to buildup a construction with layers then for each layer a material from the VI-Suite database can be selected or a custom material specified. If custom is specified the user must input the detailed thermo-physical data for the material.

Once a Blender object, which has been designated as a an EnVi thermal zone or shading construction, has been fully materially defined, the geometry can be stripped down to only that geometry required by EnergyPlus for simulation. EnergyPlus, like many whole-building energy modelling systems, only requires geometry comprising of simple planes with construction attributes then associated with them. An EnVi Geometry conversion is therefore first required by pressing the 'Export' button in the 'EnVi Geometry' node to turn possibly complex Blender geometry into simplified geometry suitable for energy analysis. During the conversion process only the faces of Blender objects on layer 1 with a valid EnVi construction material are copied and moved to Blender's layer 2. Layer 2 should then be checked to make sure that all desired geometry has been exported. For easy checking the geometry created on layer 2 is coloured according to construction type:

- Roof - green
- Walls - grey
- Windows - light blue
- Floor - brown
- Ceiling/party floor - yellow

An further changes to the geometry should be made on layer 1 and layer 2 used only for checking. After any material changes the geometry will also have to be re-converted.

Once a valid geometry conversion has been completed, nodes representing each zone will be created in the 'EnVi Network' node tree, selected with the wind sock icon at the bottom of the node editor. It is here that the user can specify EnergyPlus zone characteristics. Sockets are also created within these nodes to allow for the specification of the zone characteristics. These sockets are:

- HVAC - for the specification of heating and cooling with a connected HVAC node (section 4.7.2)
- Occupancy - for the specification of occupancy with a connected Occupancy node (section 4.7.3)
- Equipment - for the specification of equipment gains with an Equipment node (section 4.7.4)
- Infiltration - for the specification of air infiltration with an Infiltration node (4.7.5)

Each of these connected nodes can in turn have a schedule node attached for time dependent specification.

An example complete EnVi zone specification is shown in figure 42.

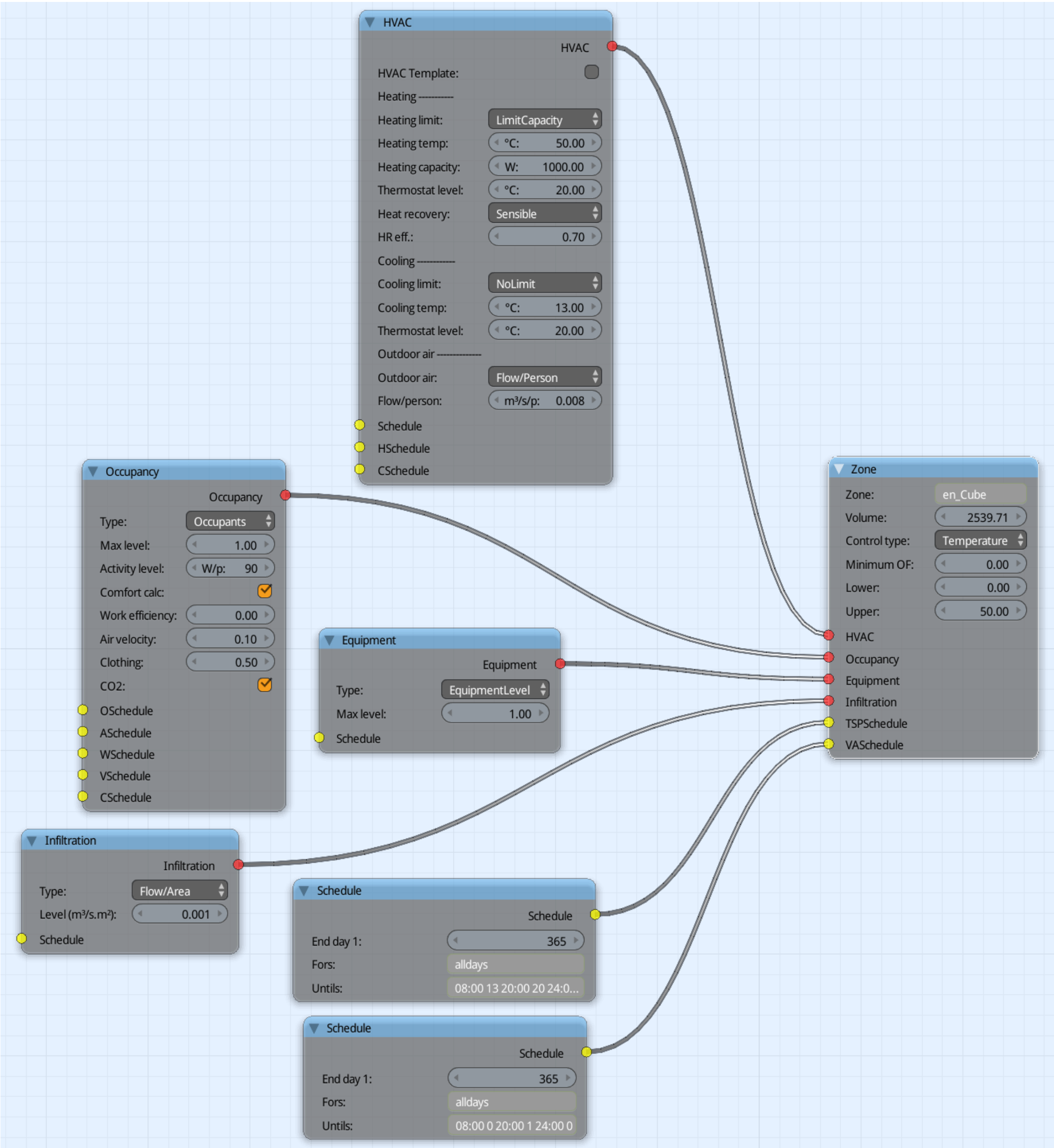


Figure 42: EnVi Zone specification

Object surfaces specified as being an intra-zone boundary or an air-flow surface via their material designation generate extra sockets within their associated EnVi Zone nodes. These sockets should be connected to specify the nature of air-flow apertures and the zones between which boundaries sit before exporting the EnVi Context. Figure 43 shows an example node network.

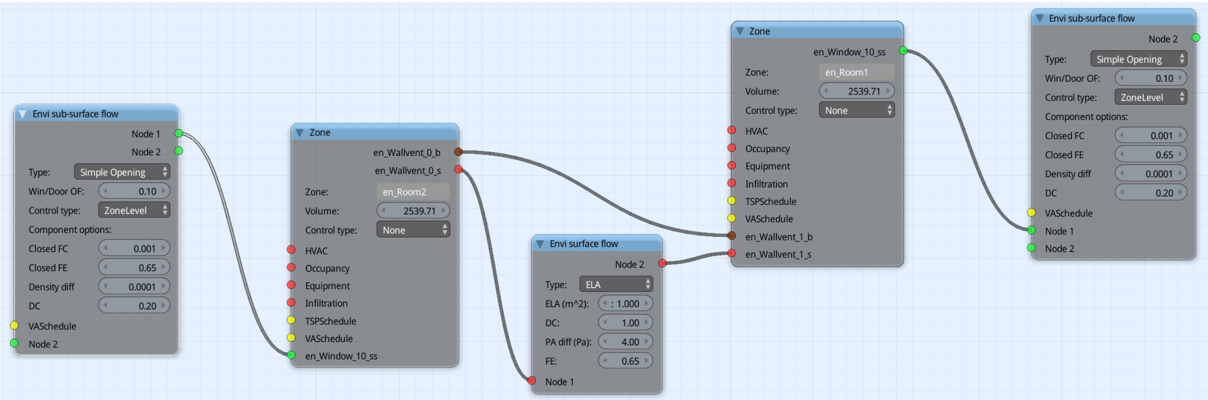


Figure 43: EnVi Network connections

The brown boundary sockets in each zone node are connected to each other as these boundary surfaces sit on the boundary between the two zones and as these boundary surfaces have also been specified as an air-flow surface, the red surface flow sockets are also connected via a surface flow node to specify the nature of the air-flow aperture. The two zones also each have a openable window specified as an airflow surface, but as these windows sit at an external boundary they are connected to sub-surface flow nodes which do not need another connection.

Once required network connections have been made all nodes should turn the default colour and the EnVi context can be exported. Any remaining red nodes in the EnVi Network node tree will prevent export.

Exporting the EnVi context will generate an input file for EnergyPlus for each relevant frame. After export the input files will be registered with Blender's text editor and they can be edited and saved before simulation if required. Changes will however be overwritten every time the context is exported.

Once exported the EnVi Context node can be connected to the EnVi Simulation node and the simulation initiated. A kivy window should then appear to estimate remaining simulation time and to display a cancel button.

Once the simulation has finished results are available for 2D plotting by connecting the EnVi Simulation node to the VI Chart node, or can be exported by connecting to a VI CSV node.

5.5.1 EnVi Display

Once the EnVi Simulation has finished EnVi display options appear in the VI-Suite Display tab (figure 44). The first option controls whether static or parametric results from an animated simulation should be displayed. If static is selected, and the simulation was not animated, the next options selects the day range for the visualisation. If the simulation was animated an option to set the desired frame for visualisation is also shown.

In the 'Ambient' section the display of ambient parameters such as humidity, temperature, wind speed and direction can be turned on as well as solar display. In the 'Zone' section the simulated zone results can be selected for visualisation. These options are however experimental and may not function as expected.

Without any of the 'Ambient' or 'Zone' options selected pressing the 'EnVi Display' button will display visualisation icons in the 3D view and will bring up a new set of options (figure 45).

If the object selected in Blender is on layer 1 and the object was exported as an EnVi zone these icons, when clicked, will display tabular and scatter result data for the selected object. The scatter data set plotted is controlled by the first of the new options and the colour scale is controlled by the second. Subsequent options control the range of the scatter graph and the min and max threshold values for the tabular display for each result parameter.

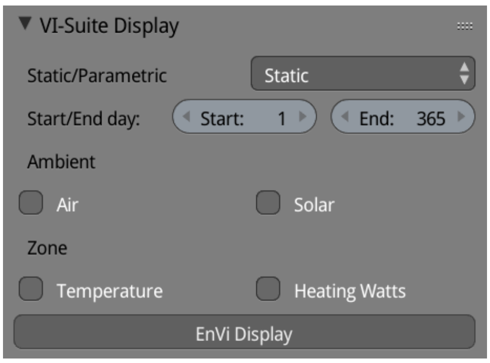


Figure 44: EnVi Display options

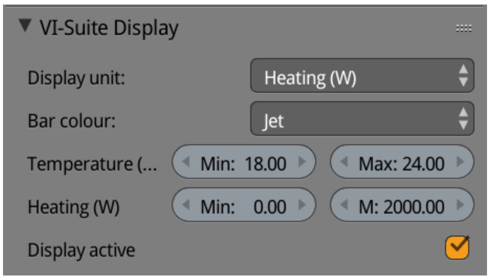


Figure 45: EnVi Display

If any of the ambient or zone options were selected the Blender frame range is set to encompass the hour range of the selected days. If air was selected a panel is displayed on the top right of the 3D view and changing the current frame will display ambient metrics for that frame. If solar was selected a sun is created in the 3D scene and an animation is created to update the sun position when the frame is changed. If zone metrics were selected an object is created at the centre of each zone in the 3D scene which will represent the chosen metric and it's value at each frame.

If a parametric display was selected initial display options will allow specification of the range of the animation. Once the EnVi Display button has been pressed icons will also appear in the 3D view offering tabulated parametric results and a bar graph to compare a metric across all the simulated frames. New options select the bar graph metric, colourmap and the colour range of the bar graph.

5.5.2 Storing EnVi custom constructions

Within the VI-Suite scripts directory is a file called envi_mat.py, that contains all the built-in material and construction specifications accessible by EnVi. Before changing this file it is a good idea to make a back-up copy. At the beginning of the file is a class called "envi_materials" which contains lists of material specifications in different material categories (metal, brick, cladding, concrete, wood, stone, gas (opaque construction cavity), wgas (window construction cavity), glass, insulation). If adding a material that falls under the metal category the self.metal_datd should, for example, be edited. Each list is encompassed with curly brackets, and contains a comma separated set of material specifications. A material specification within the metal list may look like

```
"Lead": ("Smooth", "35.3", "11340", "128.00", "0.05", "0.05", "0.05", "5")
```

The first word is the name of the material, the first word within brackets is the surface roughness, and the following numbers are thermal conductivity (W/m-K), density (kg/m^3), specific heat (J/kg-K), thermal absorbtance, solar absorbtance, visible absorbtance, default thickness (mm).

A material in the glass catagory may look like

```
"Clear 6mm": ("Glazing", "SpectralAverage", "", "0.006", "0.775", "0.071",
    "0.071", "0.881", "0.080", "0.080", "0.0", "0.84", "0.84", "0.9")
```

Only the numbers within the brackets generally need to be changed and they represent: default thickness (m), solar transmittance at normal incidence, front side solar reflectance at normal incidence, back side solar reflectance at normal incidence, visible transmittance at normal incidence, front side visible reflectance at normal incidence, back side visible reflectance at normal incidence, IR transmittance at normal incidence, front side IR hemispherical emissivity, back side IR hemispherical emissivity and thermal conductivity (W/m-K).

5.6 Importing GIS building heights

For certain kinds of contextual analysis it can be very useful to import GIS building heights and terrain data. The following guide works with data produced by Edina Digimaps via an application called Qgis. Qgis is a flexible GIS application that can import data from many different sources so it is likely that any GIS building height data can be imported for analysis with the VI-Suite with a modification to the workflow below.

There are at least two types of data you will require from Digimaps: Digital Terrain Map (DTM) data and building height data. The DTM can be imported directly into the VI-Suite with the ASC import node, but to match up the buildings with the terrain it is recommended that both types of data are processed with the methodology below.

Once you have logged in to your Edina Digimaps account select the 'Download for GIS and CAD' link. From here you can zoom in on the part of the UK that you wish to have data for and select the specific area you want.

In the 'OS Mastermap' link on the left you can select building heights and from the 'Land and Height Data' link you can select the OS terrain 5 DTM. Once these have been selected you can press the order button which will

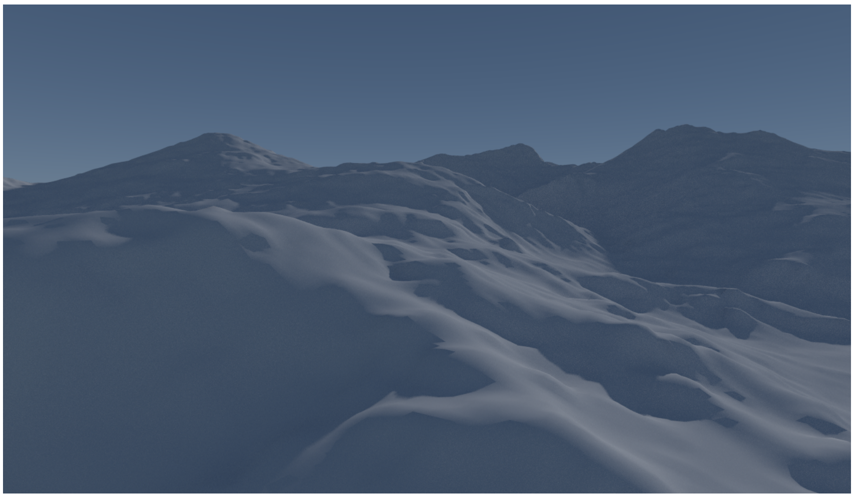


Figure 46: Render of ASC imported terrain height around Mount Snowdon.

list the files you have requested. You will need to set the file format of the building height data to Geodatabase. Add a name for the data and press 'Request Download'. Once the files are ready you will be sent an email with a link to download the data zip file.

Extract this zip file to your computer and inside you should see two folders: one for the DTM and one for the building heights. There may be multiple sets of data as Edina provides data for grid map reference squares and if the area you pick straddles these grid map squares multiple data sets will be in the download.

Open up QGIS and select New Raster layer from layer menu at the top and navigate to the asc file in the DTM directory .. to be continued.

A render of the terrain around Mount Snowdon in Wales is shown in figure 46.

6 Known issues

- When conducting a sun path study after an animated LiVi analysis that uses an animated Hosek/Wilkie sky background the animation key frames have to be removed manually from the sky background.
- If simulating heating with EnVi each zone must have faces designated as a floor with a floor material.
- If using shape keys to animate an object for a LiVi analysis then these shape keys will be lost if a sensing surface is also part of the object.
- On OS X the Kivy window does not appear in front of the Blender window. Check the desktop for this window when running a simulation.

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- Thanks go to the Blender Foundation for the creation, distribution and constant improvement of Blender.
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- Thanks go to the Matplotlib Development Team for Matpltlib - Copyright (c) 2012-2013 Matplotlib Development Team; All Rights Reserved

- Thanks to Continuum Analytics for producing Anaconda, which provides certain Python components for OS X and Windows platforms.
- This product includes Radiance software (http://radsite.lbl.gov/) developed by the Lawrence Berkeley National Laboratory (http://www.lbl.gov/)
- Thanks to Tony Graham for his feedback on this manual.

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