

# **IES EDUCATION PROJECT ACADEMIC CONSULTANCY REPORT**

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## **COLLABORATORS:**

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FUNDER

**CIC START ONLINE**

## **EXECUTIVE SUMMARY**

The 'IES Education' Project was funded through a £3000 CIC Start Online Academic Consultancy Grant. This enabled researchers from the School of Architecture, University of Edinburgh work with Research Officers at IES Glasgow to develop a version of the IES-VE environmental analysis programme, tailored to the needs of undergraduate Environmental Design teaching.

The CIC grant enabled the researchers to have a series of meetings assess the relevant parts of the existing IES-VE programme dealing with Climate and Location, aspects of Lighting, and Thermal analysis that could be written into a student worksheet for teaching principles of environmental physics and its assessment within building models. It also enabled Dr Uduku, to present the 'beta' student version of the worksheet and relevant parts of the IES-VE programme to Environmental Design Academics at Architecture Schools in Scotland and also in Liverpool.

The 'beta' version of the IES-VE education worksheet was successfully developed, with a number of key conceptual issues related to its use and presentation within an Architectural education identified. This included an accompanying set of pre-designed building models available for student import and use, within the IES-VE programme. General feedback from the Lecturers at Universities visited was positive, and there was also useful feedback with which to improve the further development of the programme.

The beta version of the IES education worksheet, and the IES Gaia package is now being installed in all four Schools of Architecture in Scotland and also at the School of Architecture, University of Liverpool. Feedback is awaited from the students who are currently 'trialing' the programme.

## INTRODUCTION

The IES Education project was set up between Environmental Design Academics at the University of Edinburgh, School of Architecture and IES research staff to investigate the possibility of developing an IES-VE environmental analysis programme, that could be used for teaching environmental design principles, and allowing basic environmental analysis to be performed by Architecture students and for Continuing Professional Development (CPD) for small to medium-sized architectural firms.

It ran over a period of six months, from late June to December 2011, and involved research collaborations, research development, and fieldwork surveys that can be categorized as follows:

### **Research Collaboration – *identifying the task***

For the first two months of the project a number of meetings were set up between researchers at Edinburgh University and Research staff at IES in order to work with the existing IES model and identify the key areas of the model which would be best for using as a teaching demonstration tool to undergraduates being taught the principles of Environmental science for buildings.

The key areas identified were:

- location and climate
- lighting and
- dynamic thermal analysis – with an emphasis on building constructions and natural ventilation as moderating factors.

### *Location and Climate*

The *VE Climate Metrics* and *Climate Energy Index* modules were identified as being most appropriate for the Education model. It allows the use of global climate data from VE default climate database, although many cities had representative weather files from areas located some distance from their actual location, for example climate data for Lagos Nigeria, was sourced from Tripoli (Libya). However, VE allows users to import their own weather files.

The *Climate Metrics* translates the large amount of hourly weather data into a language that can be easily understand and contains climate information such as comfort stress, max /min & when, dry/or wet seasons, solar energy potential, what to look for in design file and etc. The *Climate Energy Index* provides an indication of the consequence of climate with respect to building performance at an accepted standard of comfort at a particular geographic location. It calculates the energy required to condition any weather hourly ordinate to the nearest boundary of a human comfort zone. It can be seen that the *Climate Energy Index* focuses on the use of mechanical energy to ameliorate or positively modify indoor climate and not on passive methods to achieve this. However there is another VE module called *Bioclimatic Analysis*, which is using an understanding of climate to inform building design strategy via passive methods. This module has only been recently developed and is to be included in the future teaching model.

### *Lighting*

The lighting module, VE *FlucsDL* is used to analyze the daylight factor and expected daylighting uniformity. VE *Suncast* is also introduced to allow analysis of sunpath and shadow studies. The visual display and ease of use of these two programmes was considered particularly appropriate for teaching and engaging student input. Also, these programmes could provide statistical data for comparison.

### *Thermal Analysis*

*ApLocate*, *ApacheSim* and *MacroFlo* were chosen within the IES-VE programme as the best tools for students to use on basic models to explore thermal analysis results considering three main variables:

1. Geographical climate location of the building model,
2. Thermal properties of building constructions, and
3. Window opening areas.

### **Research Development – *developing the ‘beta model’***

(to be read in association with Appendix One – worksheet and models)

With the identification of which parts of the IES programme that were considered most relevant to the development of a specific version of the IES programme for educational use, the research collaborators worked to produce a beta model of the programme that could be assessed and test-used by architectural environmental design lecturers and teachers in Scottish Universities.

This involved the development of two specific tools:

The IES student worksheet and

The design of basic building models for use with the Worksheet

The IES student worksheet (appendix 1.0a & b)

Dr Uduku developed this. It incorporated the three identified parts of the IES programme; *Climate Metrics & Climate Energy Index*; *Flucs DL* & *Suncast*, and *ApLocate*, *ApacheSim* & *MacroFlo*, within a simple, step-by-step easy to use student worksheet guide to using IES to test simple building models provided in the IES files of the IES Education ‘Beta’ Programme, that was offered for installation at each institution visited.

Attached to the end of the worksheet, (which was available online as well as in the form of a conventional hard copy) was a ‘*survey monkey*’ basic open-ended response type-questionnaire, which students were encouraged to fill in after

using IES Education, so that the collaborative research team could assess their sent responses.

The IES Test Case Models (appendix 1.0c)

The IES student worksheet, was developed for use with a number of simple pre-designed IES building models. This was considered necessary, as there were identified problems with importing models from Sketch Up™ and using the IES drawing programme, 'modelit', was also difficult for novices. The different conditions that the models covered were as follows:

- Basic model (comprising roof with clerestory lighting, windows at adjacent walls and a door)
- Basic model as before with overhang
- Plain model with obstructing building
- Plain model with windows fully closed
- Plain model with windows at 20% openings
- Plain model with windows at 50% openings
- Pain model with windows 100% open

The worksheet encouraged students to vary wall-cladding materials and glazing lighting transmittance values which would affect thermal and lighting performance respectively..

### **Field Work – *'trialing' the 'beta model' and gaining feedback***

*(see appendix two interview summaries)*

This involved showing the developed 'IES Education beta' comprising; the worksheet and the IES programme with the pre-uploaded test models, to Academics involved in teaching Environmental Design at the four Architecture schools in Scotland. The 'beta' was also demonstrated to Environmental Design academics at the University of Liverpool.

This demonstration of the IES Education 'beta' programme at different educational institutions was undertaken for two reasons. Firstly, to get feedback from Environmental Design academics involved in teaching the discipline at tertiary level. Secondly the demonstrations were a way to show the use of the model as teaching tool, and to negotiate for the IES-VE model and the teaching worksheet to be installed for test use, and feedback by students in the different institutions. All four Schools of Architecture, Robert Gordon, Aberdeen, Dundee, Strathclyde, and the Mackintosh School were visited, whilst the University of Edinburgh had a pre-test of the *Climate Metrics* and *Climate Energy Index* model during the period of the project. Ultimately these demonstrations were able to enable us work on the development of a fine tuned final beta version of the worksheet and accompanying IES-VE models at the end of the project.

## **RESEARCH FINDINGS**

The research collaboration worked well and produced a number of findings. These are summarized as follows:

### **1.0 The Analysis of the Task and Developing the Beta Model**

The collaboration meetings identified that there were key conceptual differences in the way in which the IES programme would be developed for architects and architectural education, than its development for use for environmental building assessments.

The key conceptual issue was that current Architectural teaching on sustainability focused on the core conceptualisation of the design and analysis of buildings being geared towards the use of 'passive' systems of heating and cooling, and reduced dependence on fully 'active' mechanical solutions.

Also important was the recognition that Architecture students were less likely to be conversant with the use of programmes and the understanding of environmental modeling. Thus the use of IES-VE needed to be made more user-friendly through the simplification of tasks and an emphasis on more user visualization of processes and results;

- both in terms of computing platforms ( for example most Architecture students, and schools used Macintosh computers)
- and also in their engagement with the IES interface, which was currently geared more towards environmental engineering requirements than basic architectural analysis. (the development of the basic step by step worksheet, which initially ensured Architects and students did not get 'lost' in the IES interface was considered crucial
- also the use of pre-prepared models was considered a safer option than getting students to develop their own models for use within IES as the importation of sketch up models could often be tricky.

#### **The Beta Model**

The development and pre-testing of the Beta Model threw up a few glitches. Most were ironed out through the meetings between the IES team and University of Edinburgh staff.

A key issue will be getting a version of IES-VE that works well across computer platforms, and requires limited updating for the duration of an academic year, as few institutions or students are likely to update programmes on more than an annual basis, unless IES adopts an automatic 'cloud' updating service.

Eventually the microclimate and lighting parts of the worksheet worked well, with the final glitches ironed out at the end of the project. The thermal analysis element however remained particularly tricky – it was decided that this would have limited visual display, as there were easier model 'apps' available for students to view ventilation across sectional surfaces, than using the IES model. (For example the Wind Tunnel™Pro app for the iPhone™/iPad™).

Also, due to the complicated routine related to changing building component files, a further set of pre-designed models with preloaded light, medium and heavy weight thermal insulated envelopes would be included in the programme, so students could simply run the model to see the difference in thermal performance attained with these different envelope conditions.

## **2.0 Demonstration feedback from Environmental Design Teaching Academics**

Taking the 'beta-version' of IES education to different Architecture Schools was a successful experience. As stated, the feedback given was generally positive. However all staff highlighted the complex nature of the original IES programme for Undergraduate teaching and agreed with the idea of the development of a simplified version.

In Liverpool and the Mackintosh school, Glasgow, Academics pointed out that the IES programme was used at Masters level and above and not for undergraduates. The development of a simple to follow worksheet and preloaded models was considered a good idea, and both schools were willing to have the 'beta' tested on their students in the forthcoming academic term. There were however a few issues that were highlighted in the feedback sessions had with academics. These included:

### **Sensitivity of Data Used and Produced**

In the climate metrics analysis the easiest default to use within the current IES-VE programme loads climate data from weather stations nearest to city locations stated. However often this data is often an adequate proxy for the city chosen. Thus climate data for Lagos, (Nigeria) is taken from the nearest weather station, Tripoli, Libya.

It was agreed that in the final version of the IES-VE beta, real climate data would be uploaded into the IES Education Beta for the representative climate types, identified by historic Environmental Design texts (, Manual of Tropical Architecture, Koenigsberger, et al, Design with Climate, Olgyay et al, Szokolay, dealt with in environmental analysis namely

Hot humid -	Kuala Lumpur
Hot Dry -	Dubai
Temperate Continental -	Chicago
Cold -	Reykjavik
Island tropical -	Jamaica
Subtropical -	Cape Town
Local European -	Edinburgh, Glasgow, Dundee, London, Liverpool

*(key towns in the UK and Europe, including data for all cities and towns in which architecture schools are located)*

Also highlighted was the "building-centred" focus of IES, the focus being on the environment within the building and not the effect of the ecological and physical

properties of the landscape surrounding the building. This has been addressed by only one of the templates incorporating an obstruction to the building model. The future development of the beta model should incorporate more templates, which help the student analyse the effect of external environmental features such as trees and differences in topography on the building environment.

Also, during the demonstration of the IES-VE Education 'beta' a number of glitches were identified. These have largely been resolved. SunCast, within the lighting programme had its original analysis process changed due to an upgrade of the IES-programme. Once highlighted this was resolved although it meant re-editing the completed student worksheet.

A result of the glitch finding process has been the stipulation that the planned final IES-VE education programme would ideally be developed to have only an annual upgrade over the summer period to enable students have the use of a stable programme for most of the September to June academic year without having to worry about upgrades, unless instant 'cloud' updates become easily implementable.

Finally, the timing of the visit to the schools meant that it was considered best that the student test period would take place at the beginning of the second semester in January/February 2012 – however permission to install the programme at all Schools visited was granted. This would also allow for final fine-tuning of the last identified glitches with the programme during the demonstrations at the different schools.

## KEY CONCLUSIONS – PROSPECTS FOR FURTHER R&D

This initial scoping project for the development of an IES Education programme went well. The key aim of the project, which was to explore the viability of developing a 'stripped down' IES Programme for use in Architectural Education and CPD training. This objective was successful as the IES Education beta worksheet and accompanying programme information was successfully developed over the project period. Furthermore the 'beta' programme was demonstrated and trialed at Architecture schools as planned in the latter half of the project period. The feedback given has been invaluable in the further development of the IES Education programme.

Some key research findings have been highlighted over the project duration these are summarized as follows:

There is a conceptual difference in the way in which the IES programme will be developed as a teaching /research tool in Architectural education to the way in which it is used in the commercial workplace.

The IES programme does lend itself to modification or 'stripping down' for use by an Architecturally trained user group. It is likely though that there will be a

trade off between interactivity at basic level and demonstration due to the complicated nature of working within a programme for the novice user.

There are smartphone 'apps' that are more successful in visually communicating airflow analysis to students than is currently the case within the IES model. The clarity of the visual interface is particularly important for teaching principles of building physics to students.

There is currently a 'gap' in the environmental analysis market caused by the buy out of the ecotect programme by the larger company Autodesk. This is significant as IES could potentially fill this gap with a successful custom-built targeted project for the education market that focuses on cross-platform simplicity in use and good back up support.

Our IES collaborators have also recently been approached by an Architectural Practice, Archial, which is interested in the development of an architect friendly version of the programme.

#### *Areas for further Research*

The IES and UoE research team intend to apply for a larger research development grant in order to develop the proposed IES Education programme further for Architects and Architectural Education. Dr Uduku will also be seeking University Funding to finance a research position to develop the programme further taking into account student needs and teaching pedagogy in Environmental Design.

We wish to thank CIC for the award of the £3000 Academic Consultancy Grant that funded this project. We also acknowledge the time, help and support of the project by all Research members and computer support staff at IES Glasgow and at Edinburgh University.

Dr Ola Uduku , 12<sup>th</sup> January, 2011 Architecture ECA, University of Edinburgh

#### **Select References**

Koenigsberger, O., et al. (1974). Manual for tropical housing and building. London: Longman.

Szokolay, S. 2007, Introduction to Architectural Science, London: Elsevier / Architectural Press

Thomas, R. 2003, Environmental Design: An Introduction for Architects and Engineers, London: Spon.

ESALA T&E Syllabus Years 1 & 2, DRPS College of Humanities and Social Sciences (CHSS) University of Edinburgh

ARB Revised Criteria for the Prescription of Qualifications, *specifically Parts 1 & 2, Technology and Environment* [http://www.arb.org.uk/qualifications/arb\\_criteria/default.php](http://www.arb.org.uk/qualifications/arb_criteria/default.php)

RIBA Procedures for Validation and Validation Criteria for UK and international courses and examinations in Architecture. *Specifically The General Criteria at RIBA part 1 and RIBA part 2, GC2 & GC5.*



## **Appendices**

IES Worksheet

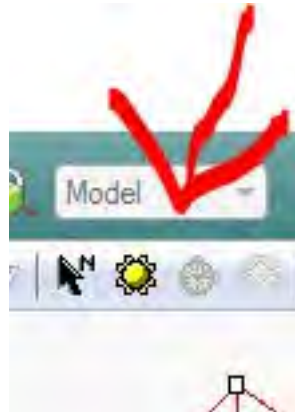
IES Programme models

IES Meeting Summarys Universities of Liverpool, Strathclyde, Glasgow, Aberdeen, Dundee

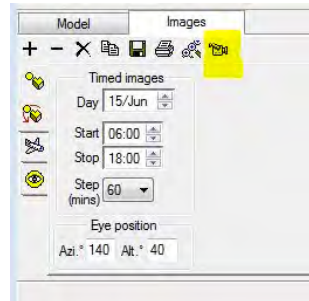
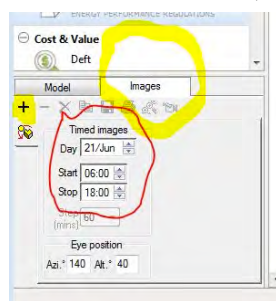
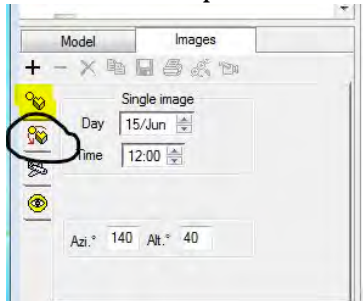
## LIGHTING ANALYSIS

### USING SUNCAST

1. Go to the top menu applications tab
2. Click on **Solar**
3. Click on '**suncast**'



4. Click on **view** and ensure the **browser** tab is ticked (screen shot)
5. Click on sunpath diagram (screen shot)
6. View the sunpath diagram for your location
7. In the split screen in the left bar below,



- click the "single images" tab (screen shot)
8. Choose a day, that is either a solstice or an equinox (Dec 21, June 21, or March 21, September 21) (screen shot)
9. Use the tabs to the left to:
10.
  - A: create one image\* (as above)
  - B: create a timed image\*\* (second box down – see screen shot)
  - C: create a video – after creating timed image (screen shot)

\*Set time at 12 noon

\*\*Choose a 12 hour cycle, 0600 – 1800hrs

NB The model will temporarily 'disappear' whilst you set up the information relating to the image or timed image, click the (+) tab to create the image

(screen shot)

Compare these images with the earlier images

11. Repeat the whole exercise with the other climate file you have chosen.  
(i.e. you should have results for Bangalore and Helsinki)
12. Compare the differences
13. **Import the model with an obstruction**, and compare the difference in shading – you only need to use one climate location

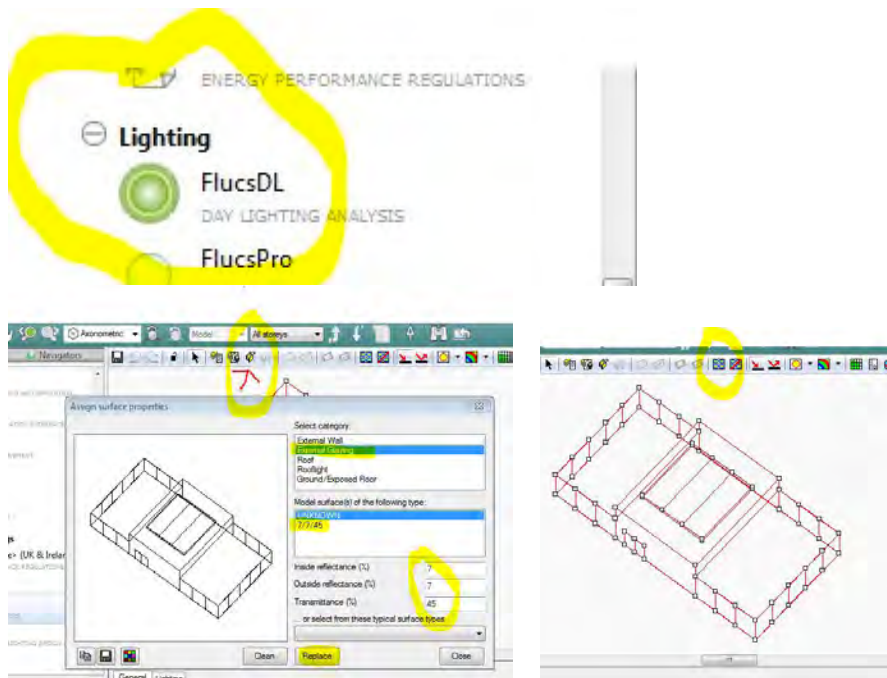
## D: USING FlucsDL

For daylight factor calculations

Go to **Applications**

Go to **Lighting Module** (left hand side) (screen shot)

Go to FlucsDL



Click **Assign surface types** (screen shot)

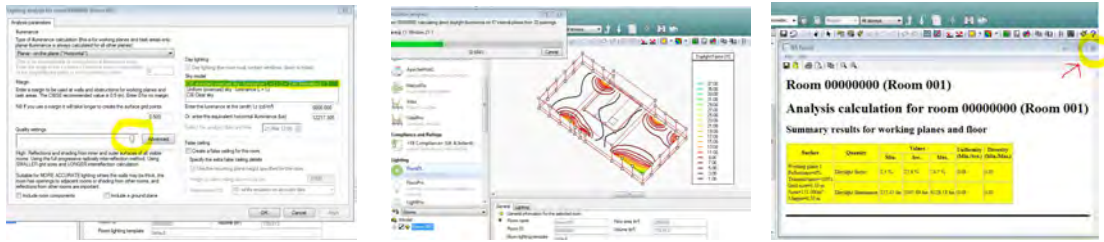
Click **external glazing**

Check properties of inside reflectance, outside reflectance and transmittance value

**Change the category (7/7/70)**

**Ie inside reflectance 7, outside reflectance 7 and transmittance value 70**

**Click replace**



**L**

**leave all other surface specifications**

Select model (it will turn red)

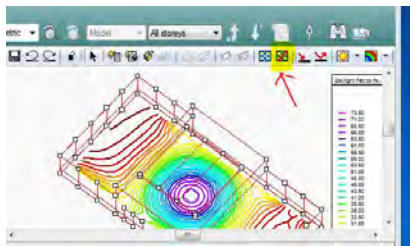
choose **analysis calculations** (screen shot)

click OK

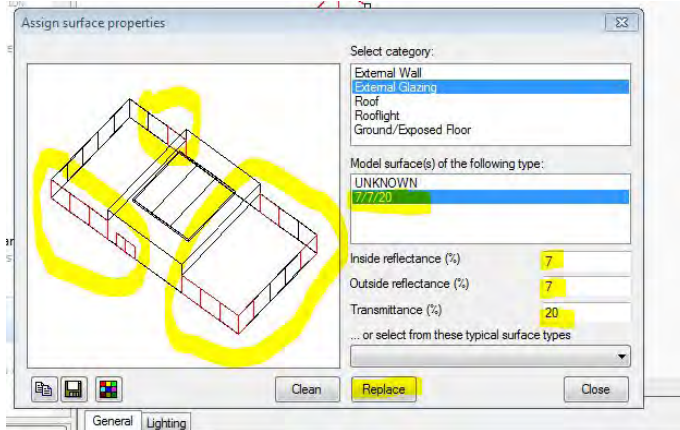
An analysis **report** will be printed.

The **Report** will show summary, illuminance and daylight factor levels.

If you click on the X to the right of the box you will go back to the illustration.



**click undo edit surface types**



Repeat the process but using the **assign surface types** tab, leave the internal and external reflectance values at 7%, but change the glazing transmittance value to **70%**.

Re-run the simulation

Then repeat the process again changing the glazing transmittance value to **25%**

**Change floor surface to white paper (select from tab below – see screen shot)**

Change rooflight to 7/7/0

Note the slight differences to the shading levels.

Once you have completed the exercise clear the analysis and go back to the main **applications** menu



## IES THERMAL ANALYSIS GUIDE

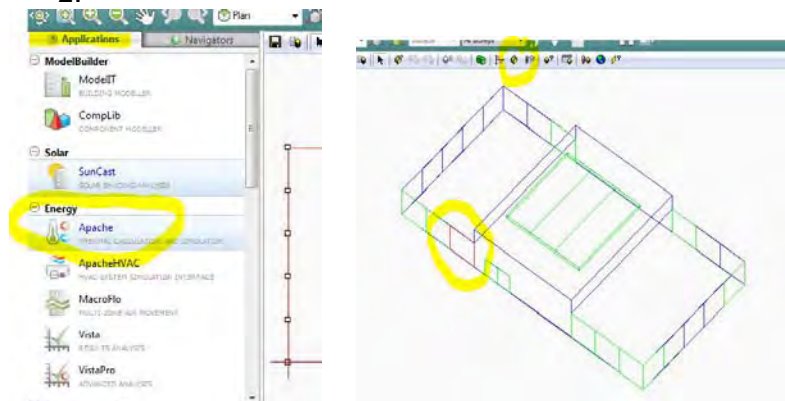
(Sequencing: *APACHE – VISTA – MACROFLO - APACHE (update) - VISTA PRO*)

Ensure that you have closed the last programme you were working with (ie suncast/flucs dl etc)

Ensure model is in axonometric view

Go back to the Applications tab,

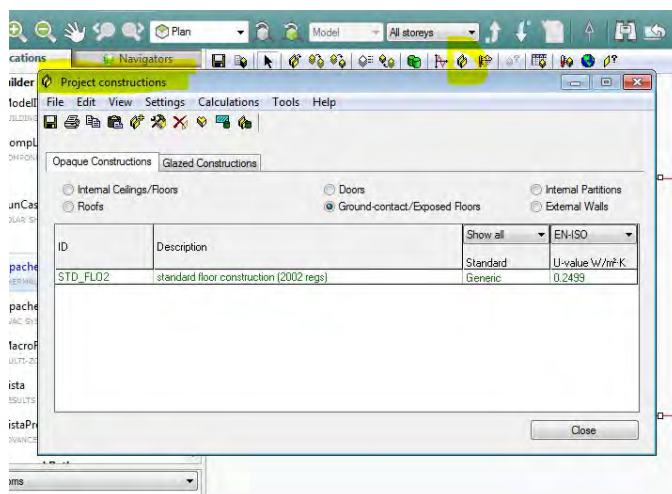
1. Choose **Apache** (screen shot)
- 2.



**Set up the construction**

Click the model and the panel clicked twice will turn red

Click **Assign Constructions** to view the different constructions possible for the panel



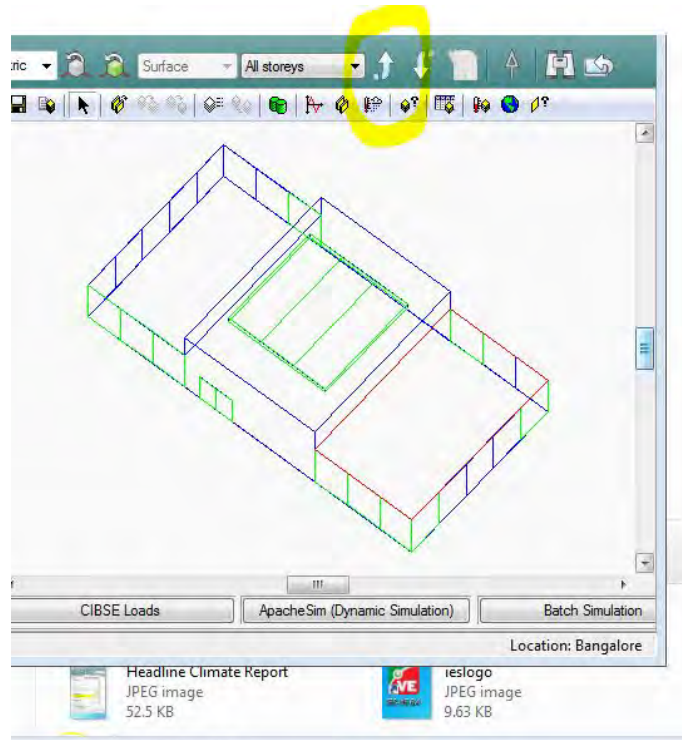
Click the APcdb button (screen shot)

To show possible replacement construction materials

For **model one** change the external wall panels construction from (2002 regs) to sheet aluminium

(double click wall panel in axonometric then click assign constructions)  
select construction material chosen –it will turn green, then click replace then save the changes. **(screen shot)**

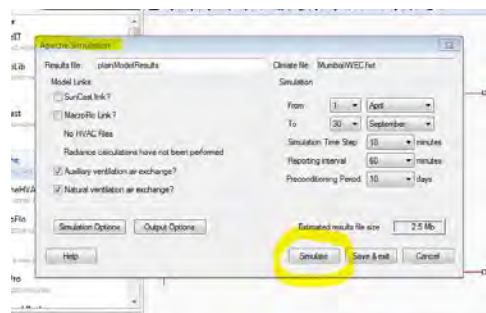
**Use the navigation arrow to go back up to the axonometric model (screen shot)**



For model one, it assumes all windows are closed and simply expects the room to remain in a closed state throughout the analysis.

**From the Apache screen :**

Click Apache Sim, dynamic simulation **(screen shot)**



The first analysis will assume the building has all windows closed and therefore no ventilation.

Ensure the following:



- You name the results file (e.g. plainModelResults)
- You check the correct climate file is loaded
- The suncast box is unchecked
- The auxiliary and natural ventilation are unchecked
- Check you have the correct nearest climate file loaded  
 check the simulation runs from 1 Jan – 31 December  
 simulation time step 6mins  
 reporting interval 60mins  
 preconditioning period 10days

Then run the systems simulation

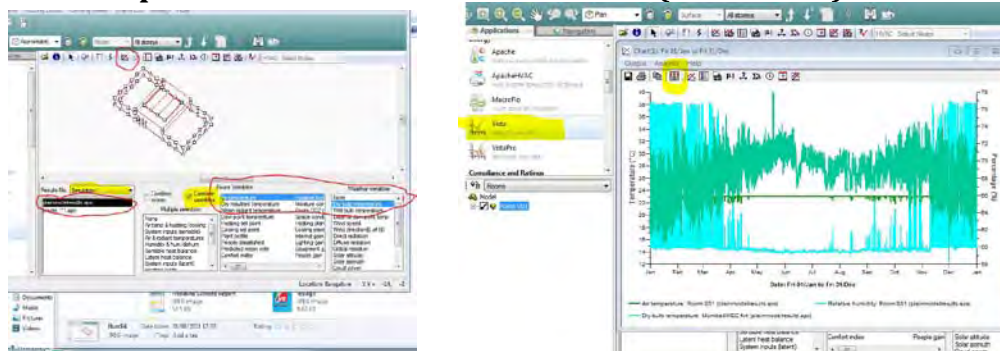
**Go to Vista**

Click **the results file for the named simulation**

Click **combine variables**

Highlight air temperature and dbt (use control key to toggle across)  
 (use table below main panel which shows results)

**Select air temperature and relative humidity from room variables, and dry bulb temperature from weather variables (screenshot)**

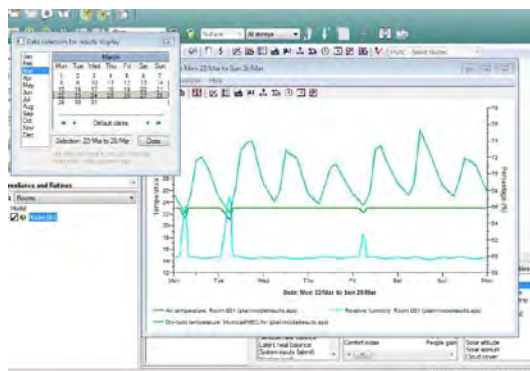


Click the graph symbol

This will show 12 month data **(screen shot)**

**Set dates** to show what is happening left [mouse] click at start /right click at end

**Use an equinox or solstice day/week (screen shot)**

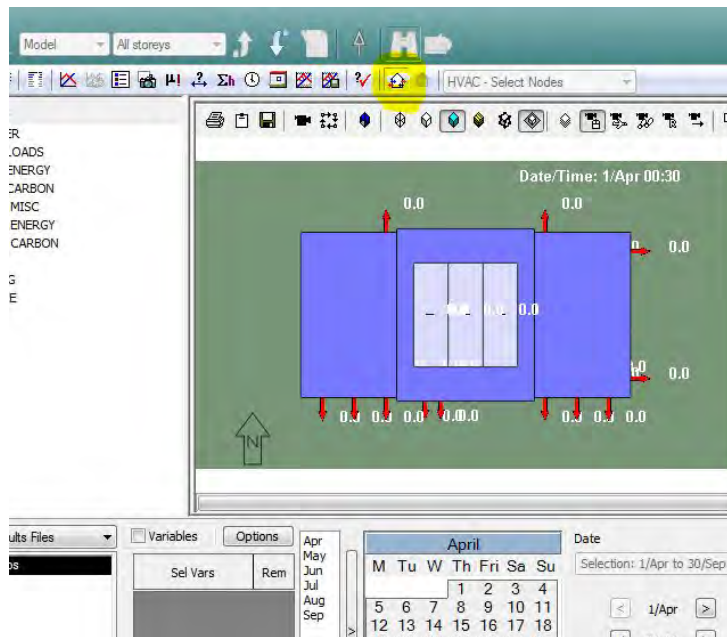


**THERMAL FLOW ANALYSIS**

For the first model there will be no thermal flow, as the windows are all closed. However perform the analysis so it is the base case (no airflow windows closed)

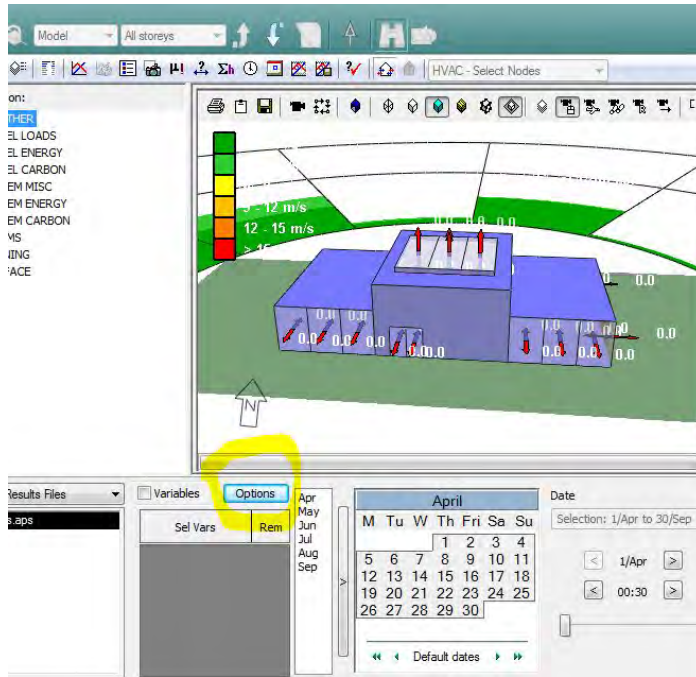
Close the Vista analysis box and Go to **vista pro**

Select model and click **house icon** with arrow  
The **3d air/ventilation model** (screen shot)



Make sure the time is set properly and see wind speed change by month and time

For the Wind rose view – click options and ensure the wind rose graphics is ticked as on, you can alter their appearance. (screen shot)

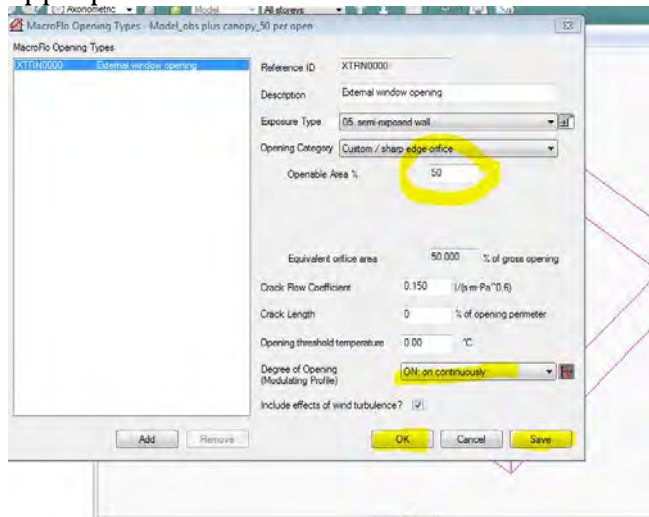


## Thermal Simulation Two

In the applications panel go to the **Apache Macro flow icon**

Click on the **Assign opening types** button.

In the dialogue box type **50** (to designate window 50% openings) in the appropriate box.



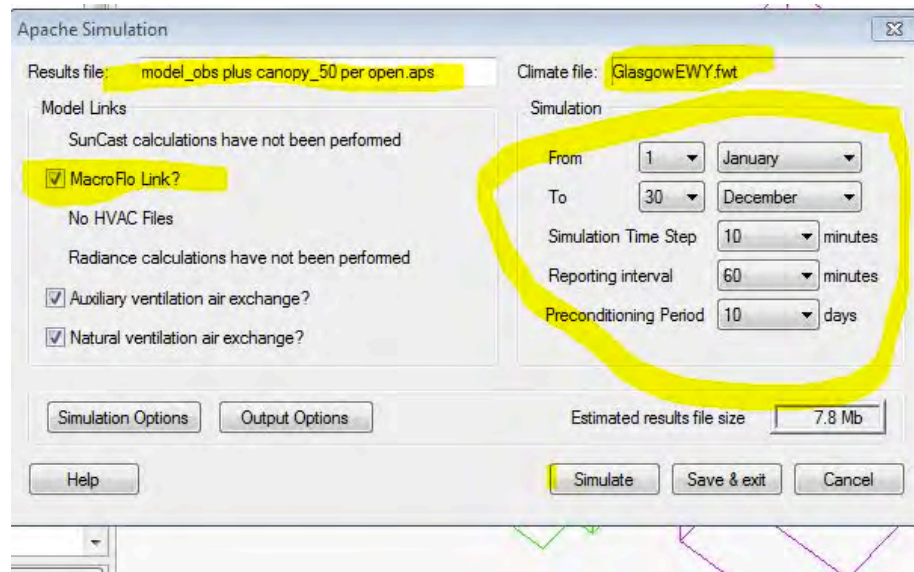
Leave all other boxes unchecked

Ensure opening is left continuously on

Save the change.

Go back to Apache

Click the Apache simulation box

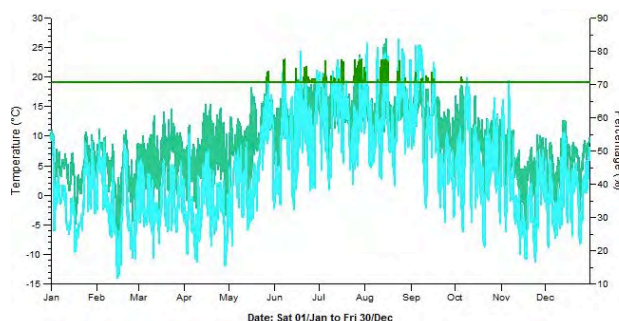


Name your new simulation  
Ensure you have the correct location  
Tick the macroflow analysis box  
Ensure the timing is as before

Perform the apache simulation  
Perform the same analysis and  
Compare the results with the previous results when all openings were closed

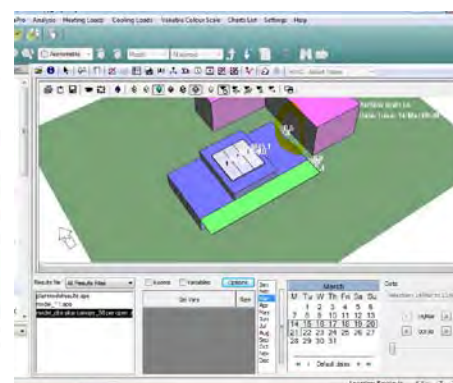
Go to Vista pro and run the air flow analysis again.  
Note you will now have recognisable air speeds from the 50% open windows  
and other openings.

**END**



**Yearly thermal simulation**

**Reykjavik Iceland**



**Airflow for Reykjavik-located building with obstruction 15<sup>th</sup> -22<sup>nd</sup> March**

## **Further Work**

### ***Load a new model***

(there are two others one with a canopy and an obstruction & the other

### ***Perform the same set of analyses.***

What does the analysis tell you about the effects of the following on the building model?:

Shading

Climate

Building materials

Orientation

Re-run the simulation and select the same combined variables analysis as before  
Note the difference with the windows at 50% open specification

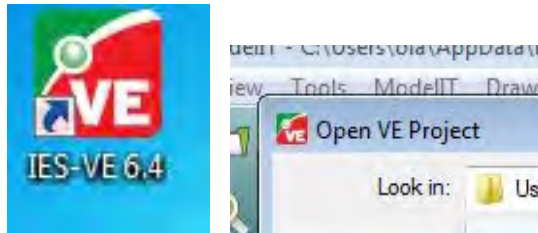
Repeat the entire process for differently prepared models, as they have different opening details, and notice the difference, (the model will show different air speeds).

## IES SELF – GUIDED TUTORIAL PART ONE CLIMATE REPORT

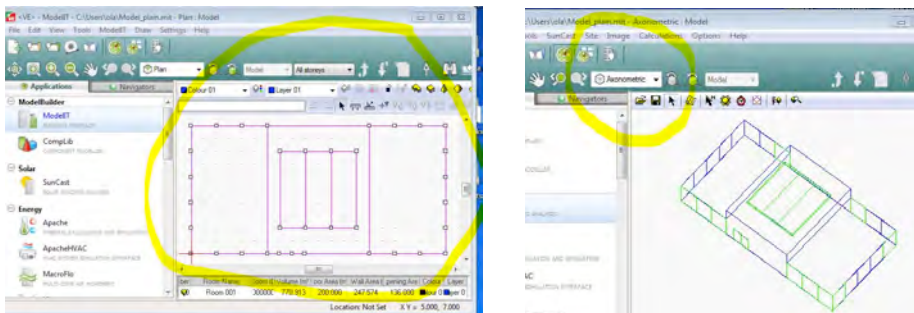
### 1. Bringing in the prepared models into the IES analysis Environment

*For this exercise a number of models have been prepared for you, you need only bring these models into IES to perform the tasks on this sheet.*

- On the PC desktop, open the **IES 6.4.0.5** programme



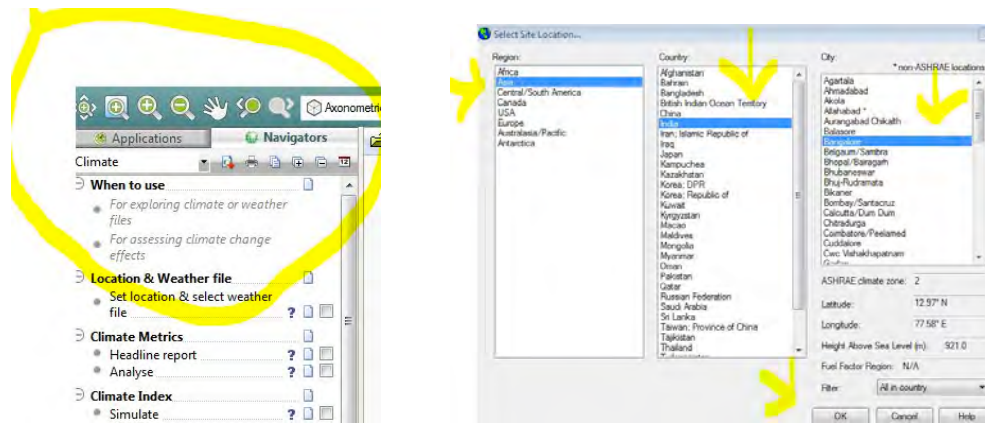
- Go to the **“File”** symbol and scroll down to **“open project”** and search for **TEST MODEL 1**
- Double click on the icon to open the model – ignore the warnings and follow through until you see a plan displayed in the main window of the screen.
- go to the **fourth toolbar down and scroll to the axonometric view.** You should now see the model building in axonometric view



## SETTING THE CLIMATIC LOCATION AND PERFORMING A BASIC CLIMATIC ANALYSIS

(This is part of the IES VE 'Gaia' Programme)

Go to the **'navigators'** bar and scroll the left tab to **climate**



Follow the workflow – you will notice there are tick boxes and spaces for comments as you work through each task:

*First*

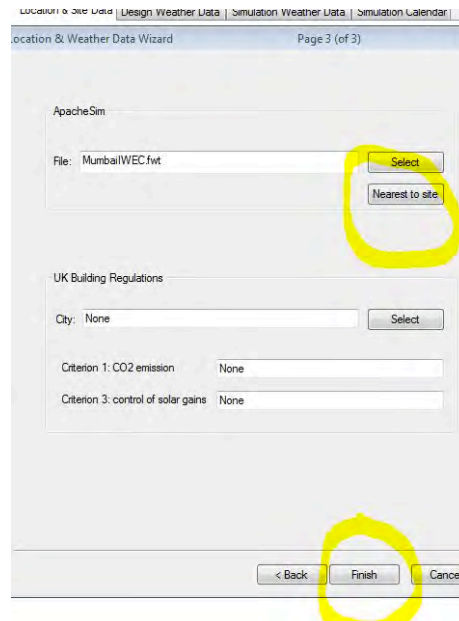
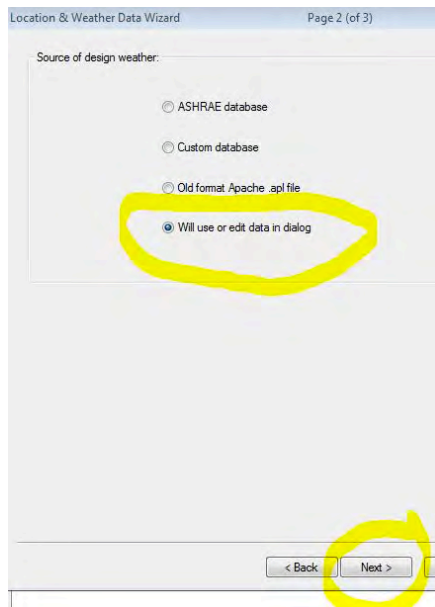
Click the **set location and select weather** file and click **selection wizard**

*Task*

Select a tropical location (for example Asia, India Bangalore) and click **OK**

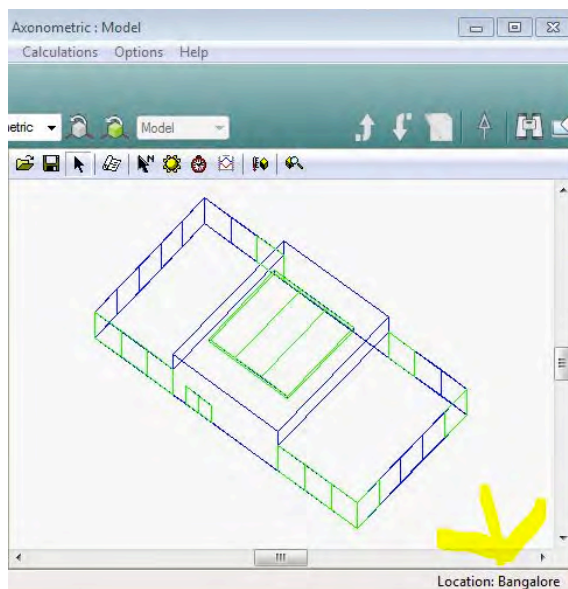
This will take you to the next screen , click **Next**

In the next screen, “**source of design weather**” – click **will use or edit data in dialog** and then click “**next**”



In the **next** box –click the **nearest to site** tab , this will update the weather reading station, to a location that is nearest to the location that you chose in the last screen. Click **finish** to save this.  
(image)

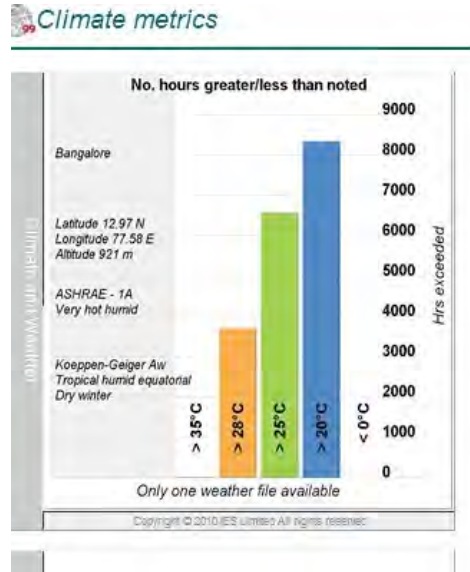
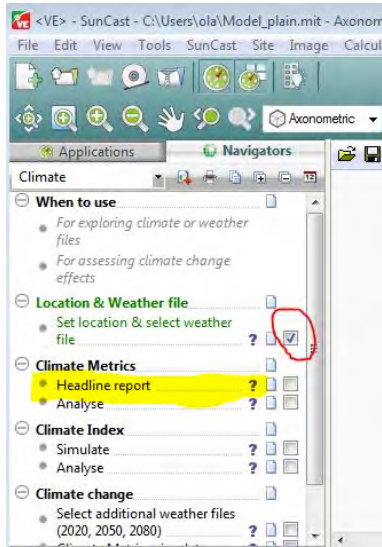
As you click the save this box you will be asked to save the current weather file click yes and then you will see that the new climate location has been saved in the main screen.



### Climate Headline Report and Simulation/Contextual Analysis

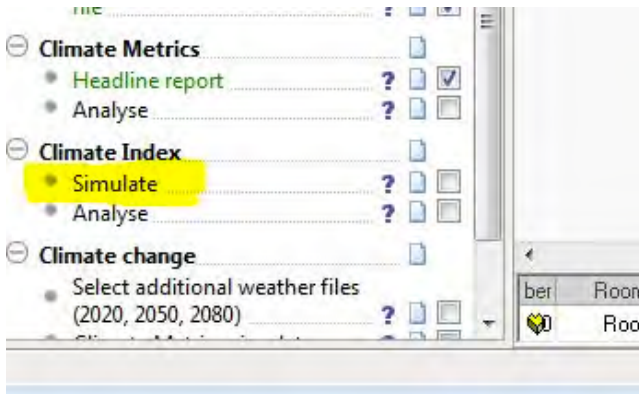
Tick the check box to the right of the location and weather bar (to show you have completed this task) then click climate report below the climate metrics header





The report will be produced on the main screen and can be printed out. If you click on the different graphs and data they will be enlarged for closer analysis.

Tick the check box for the climate metrics and then click the Climate Index "Simulate" hypertext, you will get a screen report out that you can either print out or analyse online. As with the previous climate report you can click on the data graphs to enlarge them.



### Task

Repeat the analysis using Reykjavik, (Iceland) as the climate location and compare the results.