H00314985

Produced By:

Hamza Dodhy

Design Software Application
Date: 18/11/2021

Design Software Application – Coursework 3

D19SO

Professor: Dr. Hassam Chaudhry

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1 Introduction

This research aims to reach a conclusion on many aspects relating to building design performance. Using the software *Integrated Environment Solutions for Virtual Environment* , more commonly known as IES VE, the Heriot-Watt Postgraduate Centre, located in Edinburgh, Scotland, was the selected building to be modelled into the software to analyse and evaluate the degree of sensitivity when conducting and modifying various aspects of building design parameters. Implementing given data and altering certain specifications that are required to be changed. the designed model for the building is then compared with the real building data which is evaluated to review the performance gap between them. Taking this knowledge, the final discussion for this report would demonstrate the understanding of the methods to adapt with original building specifications.

The software used to conduct this investigation, IES VE, is a design analysis software which essentially provides an architect and a user with the sustainability performance of a building and can allow a user to modify appropriate aspects of the model to obtain improved results. This benefits a user to save time and cost by modelling the building in a software instead of making the changes first then obtaining the results. For this investigation, the building was modelled and a number of modifications took place in order to achieve the best possible model compared to the building. These alterations include, glazing, adding of zones, assigning new templates etc.

2 Description of case study

As the introduction of the building model was briefly explained in Section 1 of this report and this section will wordily describe the specifications of the building model. The software used to model the building has various aspects which can be modified to obtain certain results hence, it's important to know which aspect requires alterations.

2.1 Missing Zones

Many changes were made to the initial design that was provided beforehand. The first of many was the added of zones. Two areas, the 'Lecture Rooms' and the 'Unheated Space', needed to be added on the left side of the model or the North East side of the building. Identifying the missing of zones is a crucial part when advancing to the procedure of obtaining the results for the energy and carbon emissions of the building as if the model is deemed to be incomplete, the results will vary accordingly, in this case, the readings acquired from the model will be lower than usual as they thermal environment and the usage of the rooms would be essentially neglected. The zones were added with the correct dimensions and alignment with the existing building creating the near perfect replica of the original building. The following images, Fig 2.01-2.02, indicate where the zones were added to the model.

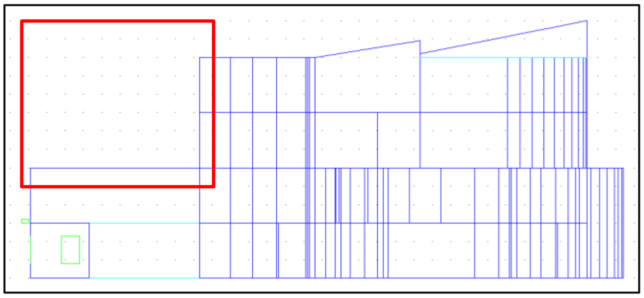


Fig 2.01. The above image is the initial model which clearly shows the zones that are missing

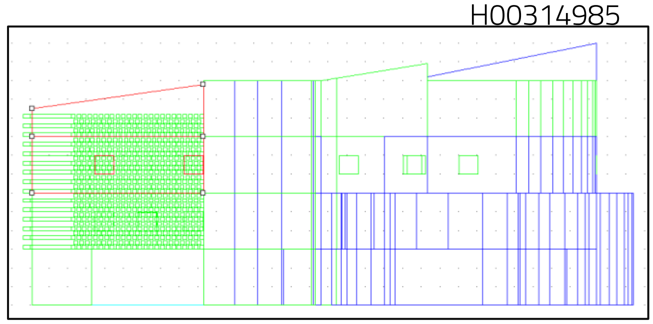


Fig 2.02. The above image is the modified model with the zones added.

2.2 Glazing

The glazing wasn't included in the initial model design for the building and required some attention. As the climate in Edinburgh, Scotland stays cold throughout the year with temperatures reaching 15^{0}C-17^{0}C in prime summer time. The thermal environment of the building should be warmer than usual hence the glazing of the building should be able to retain as much heat within the building with less heat loss occurring. With all the conditions considered, the glazing chosen for this model were double glazed windows with low emission of heat. The images, Fig 2.03-2.06, below demonstrate the glazing implemented to the model which replicates the real building.

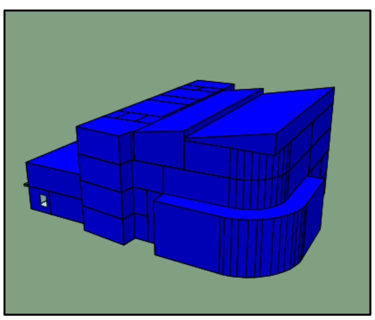


Fig 2.03.

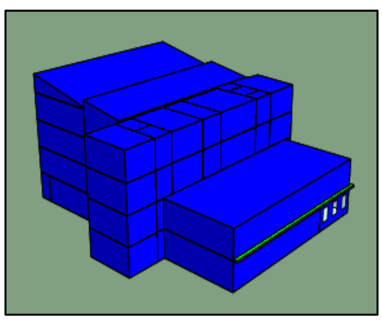


Fig 2.04.

The glazing on the initial model showed on the left presents 4 windows on the lower North East side of the building which is deemed to be false as it misinterprets the building design.

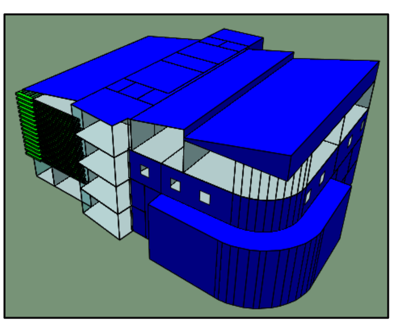


Fig 2.05.

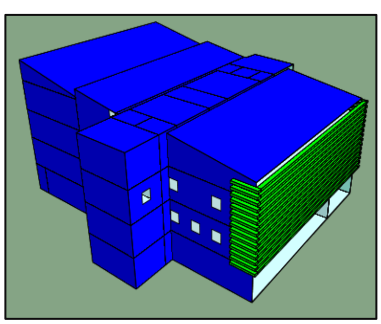


Fig 2.06.

The final model contains a substantial amount of glazing which closely replicates the original building design. All the glazing added are double glazed windows.

2.3 Thermal Templates

Thermal templates are one of the most important aspects that are to be taken into consideration as they define the thermal environment and atmosphere of each and every area of the building. Thermal templates include many features that are sensitive to finding the end results of total electricity used and total natural gas. These features include variation profiles, which determines the system supply air flow of the allocated area with details about the timings of how long the system supply air flow stays connected to power throughout the week. Alongside variation profiles, the HVAC systems with heating and cooling systems can also be set accordingly. Moreover, the internal heat gains can also be set through recognizing the various forms of heat sources located in the area. Lastly for thermal templates, the air exchanges and ventilation can be evaluated through the observing which form of ventilation and infiltration each area of the building is utilizing.

This investigation report contains a majority of provided data that needs to be altered or added to meet either the requirements of the building or the regulations of building design. The first implementation required to meet the building design was to create new thermal templates for the added zones mentioned in Section 2.1. In order to create reliable and correct templates for the design, the default templates that were given were copied to get reasonable readings, and they were altered accordingly. The template of the Lecture Rooms was copied from the template of the Lecture Auditoriums and was altered by changing the variation profiles from 'Weekday7amto9pm' to '9 - 5 weekday working'. The second template that needed to be created was for the 'Crush Areas' of the building design. The template for the 'Office' was copied for this template to be created and the internal heat gains for the computers was changed from 25 W/m^2 to 5W/m^2 due to less computer usage in the Crush Areas. The templates for the rest of the areas stay the same and don't require any substantial changing.

For this report, the variation profiles were set to a standard of being 'off' at night and after constant reassurance with superiors allowed the variation profiles to be 'Weekday7amto9pm'. The following images show the thermal templates created for the 'Lecture Rooms' and the "Crush Area's" in the final model created.

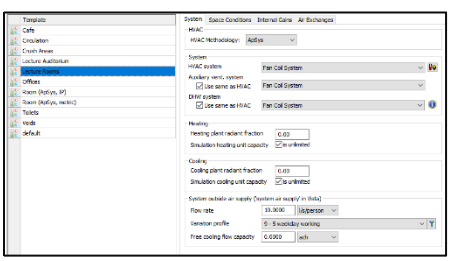


Fig 2.07.

The Lecture Rooms template with all the necessary changes

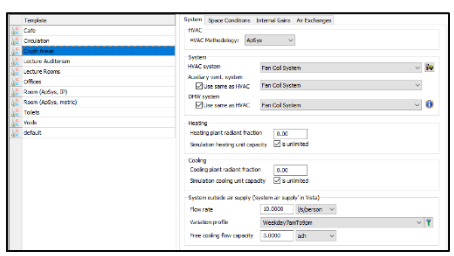


Fig 2.08.

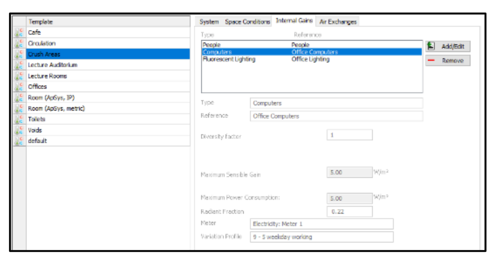


Fig 2.09.

Both the images above indicate the templates for the Crush Areas with the internal heat gains from the computers of 5 W/m^2

2.4 Shading

Generic shading is the last part of the demonstration of this case study. The initial model design for this building lacked the use of shading around the building. For the end results and readings, the shading is another sensitive aspect. If shading isn't done properly with the correct terms and placement, it would essentially mean that the temperature gains and losses will disrupt the final readings as this would have an impact on the total electricity used for the heating or cooling systems. To add shading in the software, it is really important to select the 'Local Shade' option in order to obtain reliable readings. The shading that needed to be added to the model can be indicated visually through the 'green colour' around the model. for the final model, the shading was added on the left side of the model or the South side of the building. The 'mesh-like' formation on the front side of the model is created with smaller shades interconnecting with each other to get the closest replica to the original building. The images below show the shading that was added to initial model.

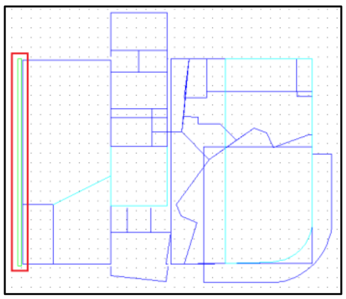


Fig 2.10.

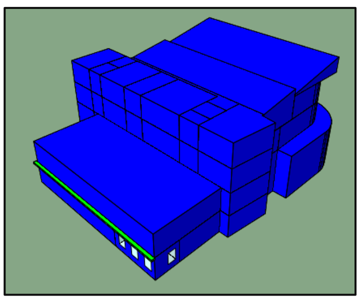


Fig 2.11.

Figures 2.10-2.11 illustrate the shading of the initial modelled building. It only has one shade on the lower left side of the model.

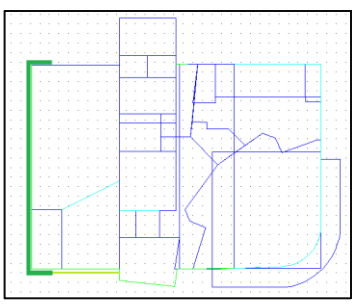


Fig 2.12.

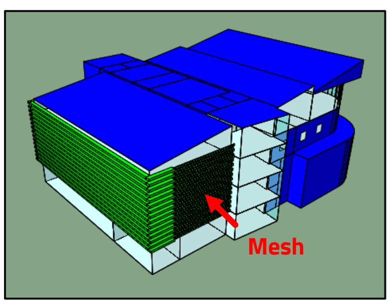


Fig 2.13.

The images on the left show the full shading that needed to be added on the left side of the model. it also shows the 'mesh' like formation of the shade on the front side of the model.

3 Summary of Results

This section will shed on the results obtained after modelling the building in IES VE. As mentioned before, the software provides the total energy and carbon readings of the model. Below are the mentioned results collected from the software and the analysis of the results will be discussed and evaluated in the Section 4.

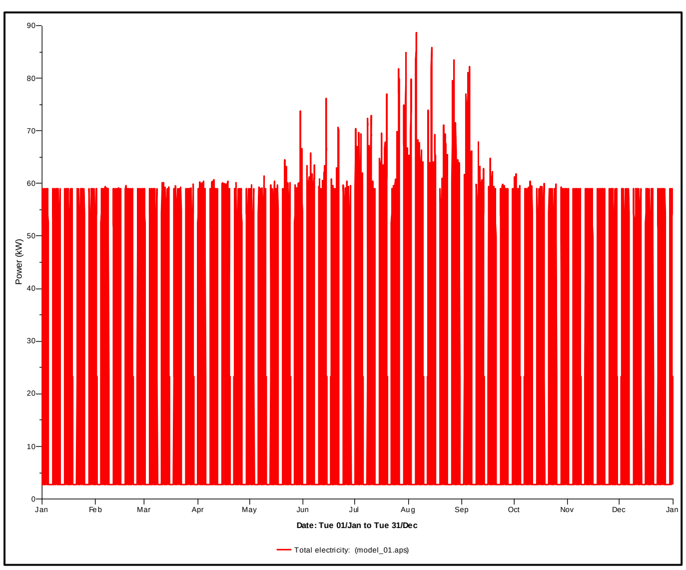
3.1 Energy

Date	Total electricity (MWh)
Jan 01-31	14.4345
Feb 01-28	12.6219
Mar 01-31	13.366
Apr 01-30	13.8925
May 01-31	14.6922
Jun 01-30	13.1983
Jul 01-31	15.8258
Aug 01-31	15.5294
Sep 01-30	13.9329
Oct 01-31	14.4841
Nov 01-30	13.2862
Dec 01-31	13.8917
Summed total	**169.1556**

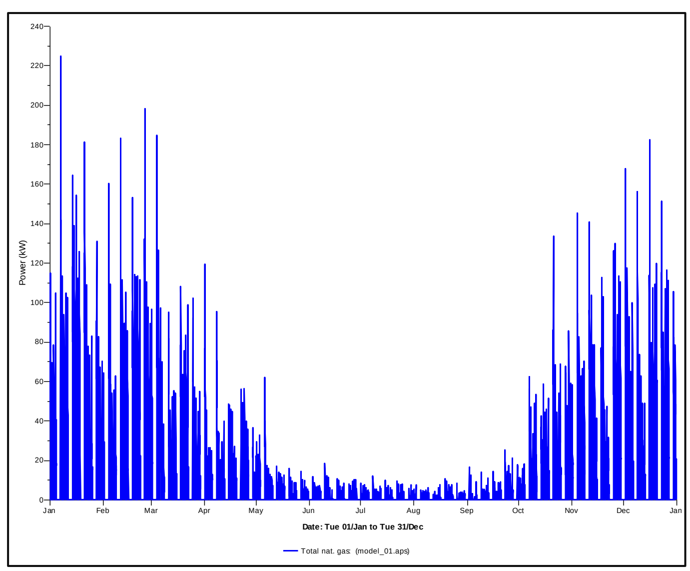
Table 3.01 Total Electricity

Date	Total natural gas (MWh)
Jan 01-31	16.4108
Feb 01-28	13.5457
Mar 01-31	9.4028
Apr 01-30	5.5223
May 01-31	1.7924
Jun 01-30	0.6039
Jul 01-31	0.4214
Aug 01-31	0.3115
Sep 01-30	0.8473
Oct 01-31	6.5312
Nov 01-30	11.619
Dec 01-31	15.3151
Summed total	**82.3233**

Table 3.02 Total Natural Gas

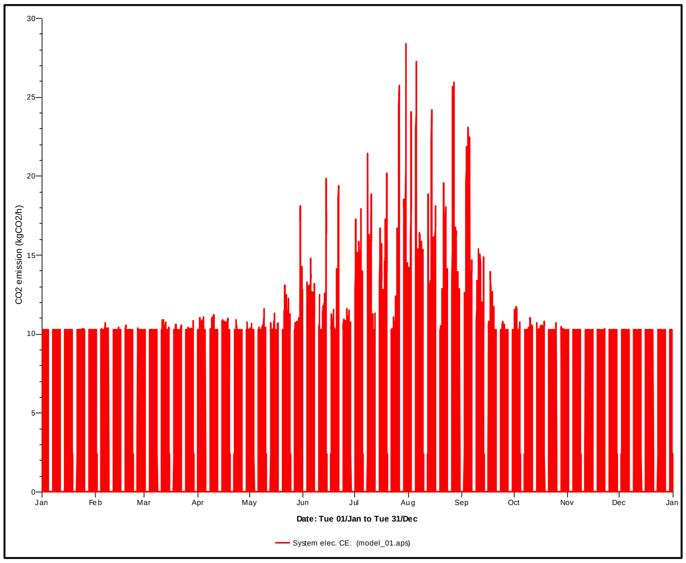


Graph 3.01 Total Electricity

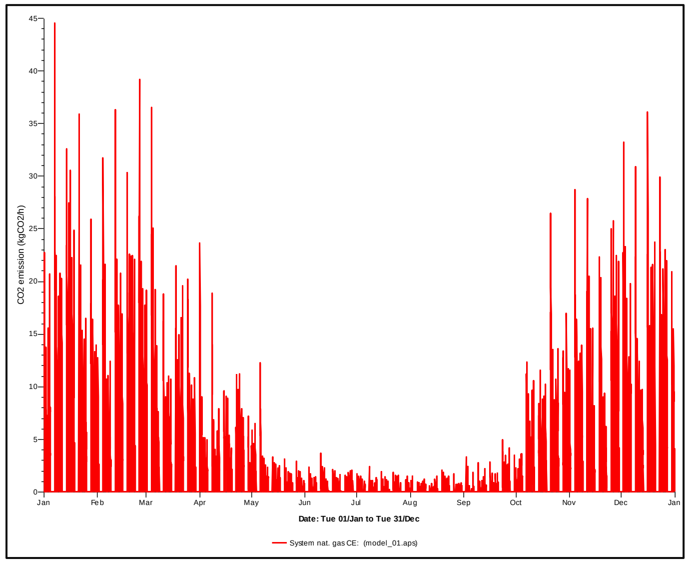


Graph 3.02 Total Natural Gas

3.2 Carbon



Graph 3.03 System Electricity for Carbon Emissions



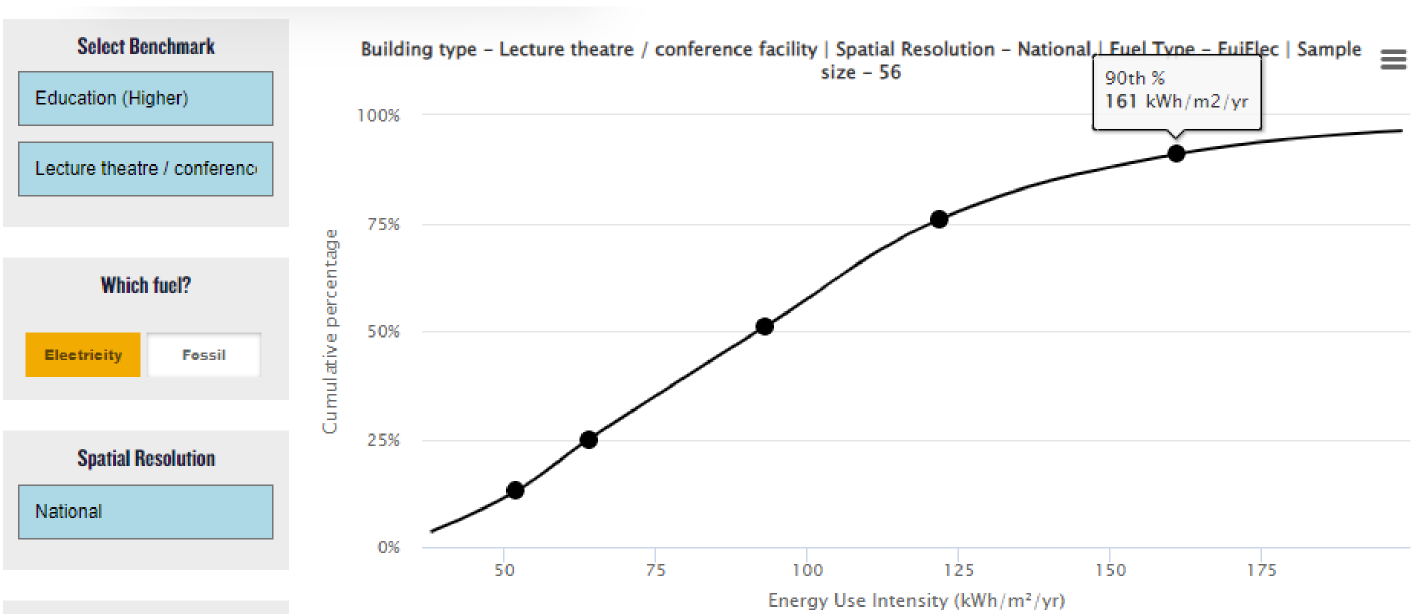
Graph 3.04 System Natural Gas for Carbon Emissions

4 Analysis of results

The results obtained from the software are shown in the previous Section 3. To summarise, the various results that are taken include the total electricity, total natural gas for both annual energy usage and carbon emissions. These outcomes are then compared with 'real' given data of the building and, by using the benchmark tool, compared with CIBSE Standards. The importance of comparing modelled results is that an architect or client will be able to oversee any faults in the building itself and the modelled design. It will help in cost reducing measures and time.

4.1 Analysis of the results of Energy Consumption

For electricity, a visual observation can be overseen by reviewing Graph 3.01. During the time of July till September, the electricity consumption increases. this is justified in Table 3.01 with the values increasing by 2.63 MWh. The peak electricity consumption occurs in early August with electricity jumping up to more than 85 kW per day. It can be assumed that this increase in electricity could mean the building occupies more people during these times. By comparing the total electricity consumption to the benchmark tool of the CIBSE Standards, we can evaluate that the modelled results are lower than the standards which creates a performance gap. The total electricity for this project is 169.1556 kWh/m^2/yr and the CIBSE Standard, mentioned below, is above 180 kWh/m^2/yr .



The table and graphs for the total natural gas for this project are very different from that f total electricity. A clearer observation can be seen as the values decrease drastically from the months of May till October. The natural gas values fluctuate variously from values hitting a peak of 16.4108 MWh and a low of 0.3115 MWh. There is a major difference in values in the middle of the year and it can be assumed that the building uses less equipment that use gas in these stages such as heating systems which require natural gas in Scotland.

4.2 Analysis of the results of Carbon Emissions

Evaluating carbon emissions in a building is very essential as analysing the carbon footprint to reduce carbon emissions can play a huge role of cost reducing measures and health and safety of the users. For this project, the carbon emissions are broken down into two aspects, total electricity and total natural gas, similar to the Energy consumption. It is examined that the Graphs 3.01 and 3.03 and Graphs 3.02 and 3.04 are very similar. This is an indication that the modelled design is accurate enough as the relation between carbon emissions and energy consumption is directly proportional.

The electricity for this modelled design also plays a role in the carbon emissions of the building and is quite similar to that of energy consumptions as it also peaks during the middle of the year. The peak of total electricity occurs at the end of July and hits 28.4 kgC02/h. electricity also stays stable for one half of a year and fluctuates the other, this could mean that the building occupies more users during the middle part of the year.

Carbon emissions can be impacted from natural gas. In this case the natural gases have an impact on the carbon emissions earlier in the year than usual as in the beginning of January, the natural gases reach a peak of 44.5 kgC02/h. This indicates that the relation between the electricity and natural gases for carbon is inversely proportional. Hence stating that the readings obtained from the model can be assumed as near accurate.

5 Performance Gap

Performance gap can be defined as the difference between the results and readings between real life models compared with computerized models. A performance gap can occur due to many reasons including, inaccurate computerized designs, misguided readings, lack of software knowledge, not reviewing the project and ill-mannered designs.

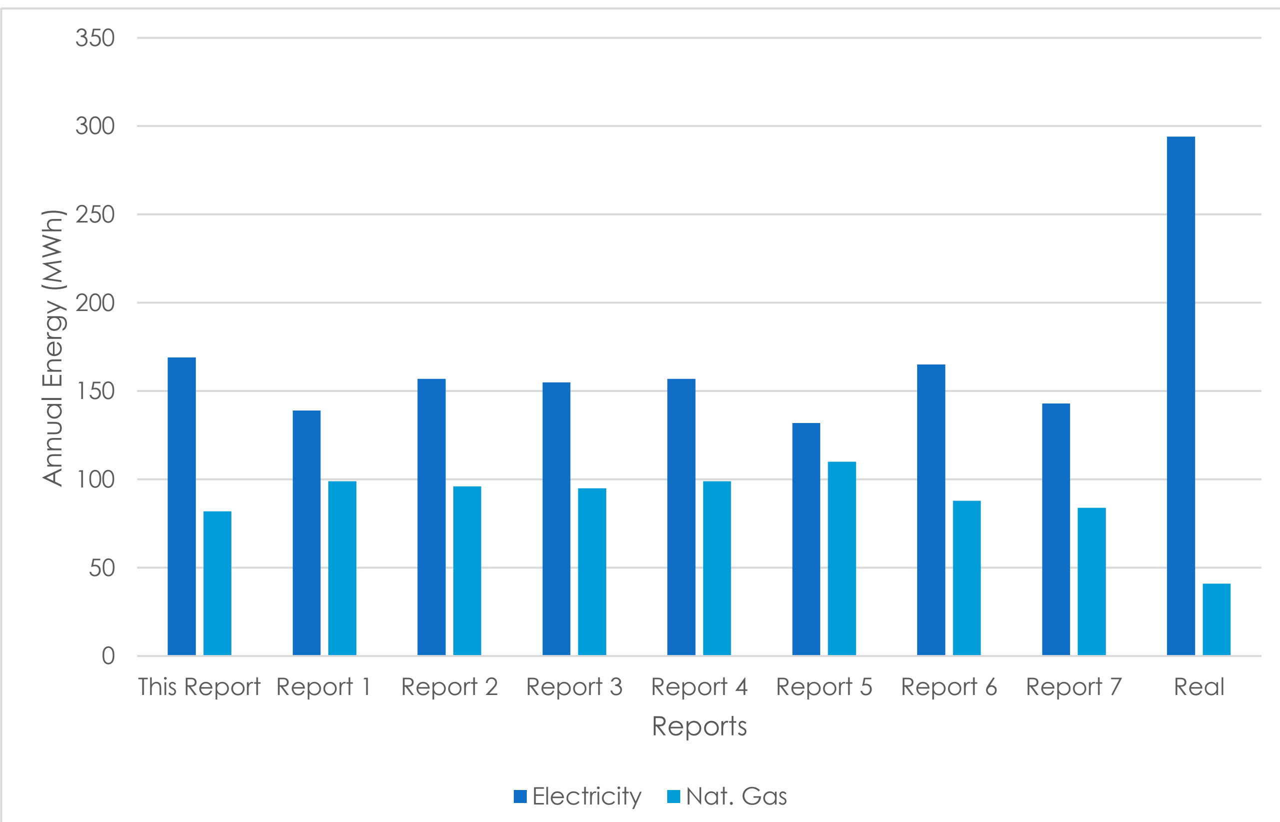
After explaining and evaluating this project thoroughly, a small conclusion can be made that this project can contain a substantial performance gap. Hence, this section will indicate whether or not there is a performance gap in this investigation.

Looking at the basics, the project was to model the Heriot Watt Postgraduate Centre located in Scotland on IES VE to obtain results for annual energy consumption and carbon emission through total electricity and natural gases. However, the details for the model weren't given very accurately and was more based on visuals. That is a reason that leads to a performance gap later on when obtaining the readings.

Another factor that can affect the readings are the templates which aren't accurate enough. The variation profile indicated that 'nothing is to be left on at night' however, some of the profiles contained selection which stated that the usage of objects was left 'on' till 9pm which in reality can be deemed incorrect as the building wouldn't accommodate users to leave something on till 9pm hence creating a performance gap.

Lastly a performance gap can be seen in the results. By obtaining results from various investigations and comparing with the real data shows a clear performance gap as the above factors come into place to create the gap. The below table and graph can be analysed to oversee the performance gap by just observing the values. They portray the values for the annual energy consumption for the building.

	Electricity	**Nat. Gas**
This Report	169	82
Report 1	139	99
Report 2	157	96
Report 3	155	95
Report 4	157	99
Report 5	132	110
Report 6	165	88
Report 7	143	84
Real	**294**	**41**



There is a clear difference between the reports and the real building, concluding that there is a definite performance gap in this report and in general when modelling a building design.

6 Conclusion

To conclude this lengthy report, it can be stated that the model was designed with accurate readings that obtained substantial results. From navigating the software to analysing the final readings, the design was implemented with given data and standard knowledge. The design was carried on with visual from the help of Google Maps and Google Earth to gain the knowledge of the details of the building.

Making additional thermal templates for new zones that were created at the start of the design with changes according to the annotations. The thermal templates then assigned to get the most accurate results from the model.

After running the dynamic simulation to get the annual energy consumptions and carbon emissions for the building, the electricity and natural gases usage was determined for each of the factors. The results were then put together to get a clear understanding that energy consumption and carbon emission are directly proportional whereas the electricity values and natural gases are inversely proportional. Comparing the graphs of the two factors indicated that the design was accurate to make assumptions.

The performance gap was then identified through the means of different reports and evidence from the results form IES VE.