

Case Study Design

Advanced Building Services & Environmental Design

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Introduction

This report will detail aspects of the Innovation Matrix building in detail and analyse and critique the ventilation system, small lighting and power facilities and its overall building fabric. The report will include drawings of recommend layouts of each of these tasks. The report will include recommendations on current performance and how it would be better suited to use alternative systems and designs.

Task One – Evaluate options and recommendations for the design and construction of Mechanical Ventilation and HVAC Technologies as well as the installation challenges facing 2 zones of different uses.

A) CAD Drawing for MVHR For Office

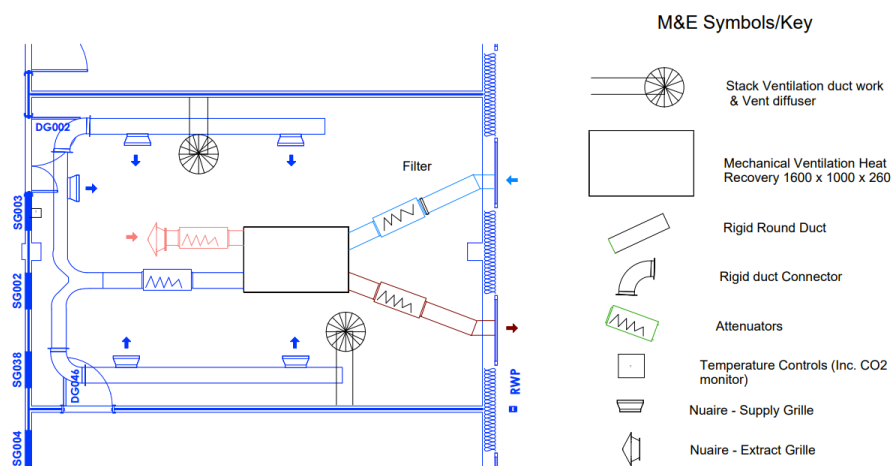
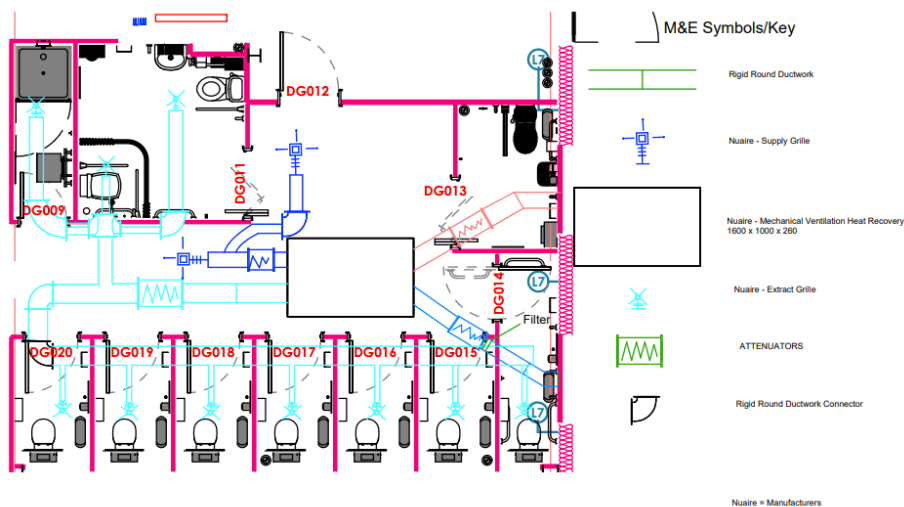


Figure 1 MVHR Layout For Office

B) CAD Drawing for MVHR For Office



C) Drawings for heating in office space & Toilets

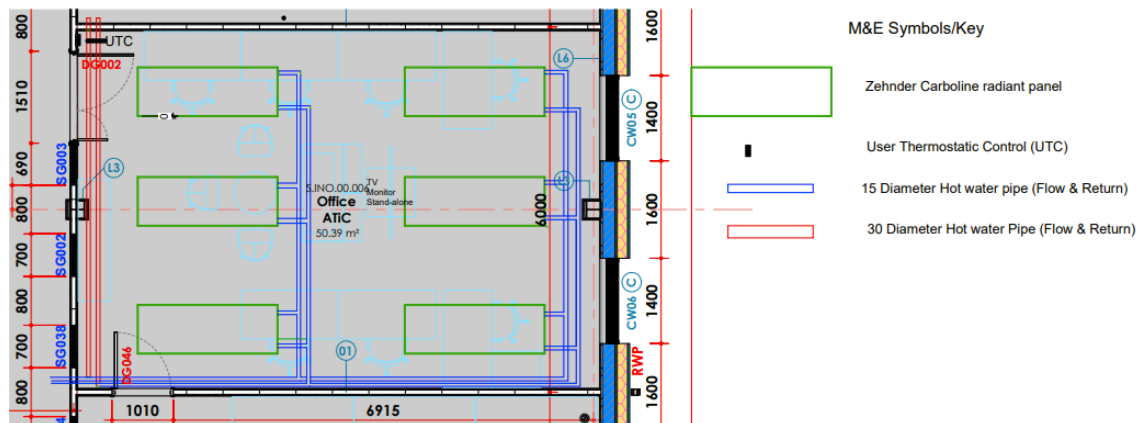


Figure 2 Heating Layout for Office

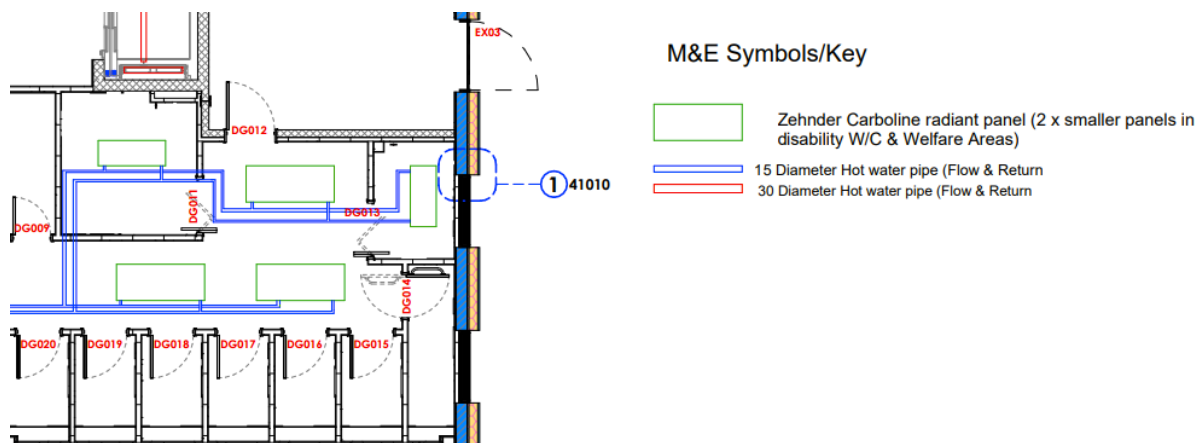


Figure 3 Heating Layout For Toilets

To justify the choices made in relation to the mechanical ventilation and HVAC technology, consideration has been given to the sustainability with targets of net zero and the amount of embodied energy used, the use of the space, whether the space is occupied or unoccupied, levels at which the space is used and how the location of the space can contribute to the design of these technologies. The client's aspirations have been considered when choosing these designs, attention should be given to the client's comfort control and purpose of the building when used by the client. Finally, considerations should be made to the costs of both of these which include the upfront and running costs of these systems.

Sustainability

Sustainability should be considered at all levels of the build and for this project it has been one of the main aspects of design. The use of an air source heat pump located on the roof provides a great space saving addition, this air source heat pump will provide hot water to the building for the welfare rooms showers, kitchen taps and bathroom taps. The air source heat pump also provides heat which is sent to the

underfloor heating and radiant panels. The use of MVHR systems situated in each individual room are used as part of a heat recovery system, although, these MVHR systems are not equipped with air conditioning therefore, as it stands now, the user



Figure 4 Showing underfloor heating installation

will need to use a separate or stand-alone air conditioning systems with user controls or room fans to help reduce overheating during summer months. Natural ventilation is a key aspect of providing a space with fresh air and combating the over usage of high energy intensive forms of machinery. The key to natural ventilation is to ensure that there is a passive effect, for instance fresh air supplied from the top is pushed out through the bottom. Passive stacks have been designed within the Revit drawings above which will be key to providing a flow of ventilation which has no operational costs as well as providing the

clients with an increase in workforce satisfaction due to less sickness and better health and well-being.

All of the above are crucial aspects of a buildings pathway to becoming net zero and lowering the overall operational energy of the building. The key design concern of using passive stack ventilation systems, is to utilise wind power, in this case, the wind power will hopefully still be of adequate power during summer months as it is in winter due to the location of being right of the seafront and orientation of the IM. In the winter months it would be necessary to include volume dampers onto the stack ventilation to ensure that the rooms do not get over ventilated and become noisy with the force of the wind hitting the ducts. There must be a consideration with the chosen ground floor room on installing passive stack ventilation although it may be more tasking to install and inspect, there could be an option to use a vent at the top of the window or alternatively run the duct work within the false ceilings, through a void in the cavity and up on to the roof.

Use of space & Client Aspirations

With the IM building becoming a space in which will entice local businesses to hold either meetings or use as a base for its day to day running, it is important to consider the use of the spaces and the overall client aspirations. The use of space can differ from client to client, the same with comfort levels, room uses and the purpose of this space. To utilise each space, it should be down to the client to decide on comfort controls, ventilation requirements and heating. The individual spaces need to be set up on schedules with updates from the client in terms of occupancy levels for that working week, as to whether the space should be heated or the need to adjust the ventilation requirements due to the rooms being at maximum capacity for example. There would also be a benefit to having a user-controlled thermostat enabling the room comfort levels to be set by the client, however, there could be a downfall to this, including deliberate tampering with the device and therefore a further issue of unnecessary energy outputs for the building to cope with. To further combat this

issue of unnecessary energy outputs being used, a smart building control overall should be utilized to ensure these failures do not happen.

Further considerations are required in terms of where the room is located on the ground level or first floor and the orientation of the space as to whether it is located on the south side or north side. The south facing side will be prone to large amounts of solar energy input throughout the whole year but mainly around summertime and as indicated by (Everest, 2022) who suggest that large glass panes facing south provide a problem due to solar gain. Reducing the size of windows and panes that are exposed to direct sunlight is the main goal of the Part O regulations and advice should be sort from Building Regulations Part O.

Considering this potential prone to overheating, clients need to be advised as to whether they have taken this into consideration or what the intended purpose of the room is going to be. If the room on the south side is due to be largely used by technology such as monitors or consoles, these items of equipment give off a large amounts of internal heat energy which will endeavour to increase the temperature in the room, just like the solar gains from the glazing and so for this, further requirement and attention into ventilation is a must have necessity.

The IM building has been designed with a colossal Central Atrium with large, glazed windows on both north and south sides, this atrium can be cleverly used to operate a passive effect where the atrium becomes the ventilation chamber for the building, it can also be used to transport heat to and from each individual working space avoiding the use of energy consumption by ventilation and cooling strategies. The use of purge ventilation would be recommended for the IM building as suggested by Part F Building Regulations (Welsh Government , 2010) where this is used during the evening hours just as the temperature becomes cooler allowing the whole building to regulate its temperature as a 'reset' for the next working day.

Costs

The current design of the IM building poses great concern for overheating therefore higher aspirations for ventilation and cooling will need to be considered as per the designs accompanied. The use of natural ventilation from windows that can only open at a slight angle are not quite sufficient enough therefore the designs incorporate the use of a passive stack ventilation which is located at the roof of the building and uses cleverly designed ducting to reach the desired room. Using this technique will create a passive movement of air, accompanied by the use of an air-cooling system which runs alongside the MVHR using a fan coil unit, if required for an additional quicker cooling facility.

With the original running costs, it can only be imagined that the cost of cooling the building in the summer months would be a considerable costly sum and that further consideration to airtightness and building fabric should have been sought. The IM building should have been designed with futureproofing in mind and should have taken in concerns regarding overheating and building fabric. At this point where the building is in the process of being built with no further adaptations in the pipeline, consideration into a higher upfront cost should have factored.

Justification for designs on Toilets/welfare area

The justification on the designs for the toilet area/welfare area (005) located on the ground floor, adjacent to atrium. These toilets contain six standard cubicles, one standard disabled cubical and one wheelchair disability accessible shower room with toilet. This area also contains a sole wheelchair accessible WC and a shower room. As shown in the designs, each toilet cubical and both shower facilities will contain an extract grille and a volume control damper to allow stagnant air to be removed from the rooms, these rooms are important to ventilate efficiently due to the amount of humidity that these shower facilities can give off. The common areas will be supplied with two supply grills for ventilation, these will ensure that fresh air is circulated. The use of an MVHR in this area will be the main point of extraction and supply as ventilation as well as the distribution of fresh air and the removal of any dead air. Toilets/welfare areas are required to have more than 5 ACH as per (The Chartered Institution of Building Services Engineers, 2015) with shower rooms needing around 6 ACH per hours.

Within the toilets, as per the designs above show three radiant panels within the circulation area of the toilets and two radiant panels in the disabled W/C's welfare areas and so that in the winter months, the toilets will still be heated to a comfortable temperature for all of its users.

Justification for designs on Office Space

The designs detailed for the use of office space (006) utilises passive ventilation by a modified stack, and the use of ceiling diffuser fan which will push the air around the room during the day. The office space will still have use of windows and doors to ensure the occupiers are able to keep the room at an adequate level for comfort. During the nighttime hours, to allow for the building to be adequately ventilated, it would be advisable to conduct a nightly purge of the building, forcefully opening all windows and doors allowing any stale and stagnant to be removed and replaced by fresh air ready for the next morning, the ultimate benefit of this is that fresh air can be easier to heat without any pollutants or particular matters, this way of ventilating has been proven by a test conducted by (CIM, 2022) and vouch for its effectiveness.

The heating will be used as little as possible and will rely on ensuing the use of solar energy and heat gains from the large, glazed windows in the atrium, corridors, and the room itself, although it will not be practical for clients to keep individual room doors open, as during certain times the noise levels may rise however, the design of using openable vents in the walls to aid ventilation and heating between the office and the atrium without much disruption, also designed into the rooms is the use of six radiant panels ceiling fitted which can be used at the clients disposal when required or during the winter. Each of the radiant panels will have a hot water flow and return to ensure that the panels are continuously heated at a constant temperature.

The challenges facing this zone is that the requirement for the supply rate of air is around $10^{[2]} \text{ L.s}^{-1}$ per person that is why the use of both a MVHR and a passive ventilation stack can adequately ensure that the office room is equipped with the

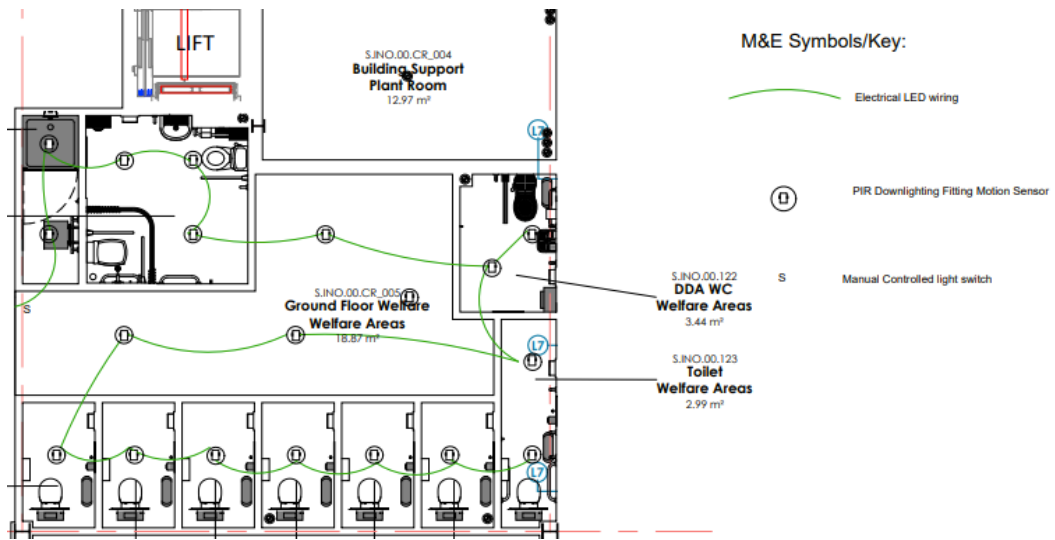


Figure 6 Toilet Lighting

B) Drawing for Small Power in Office

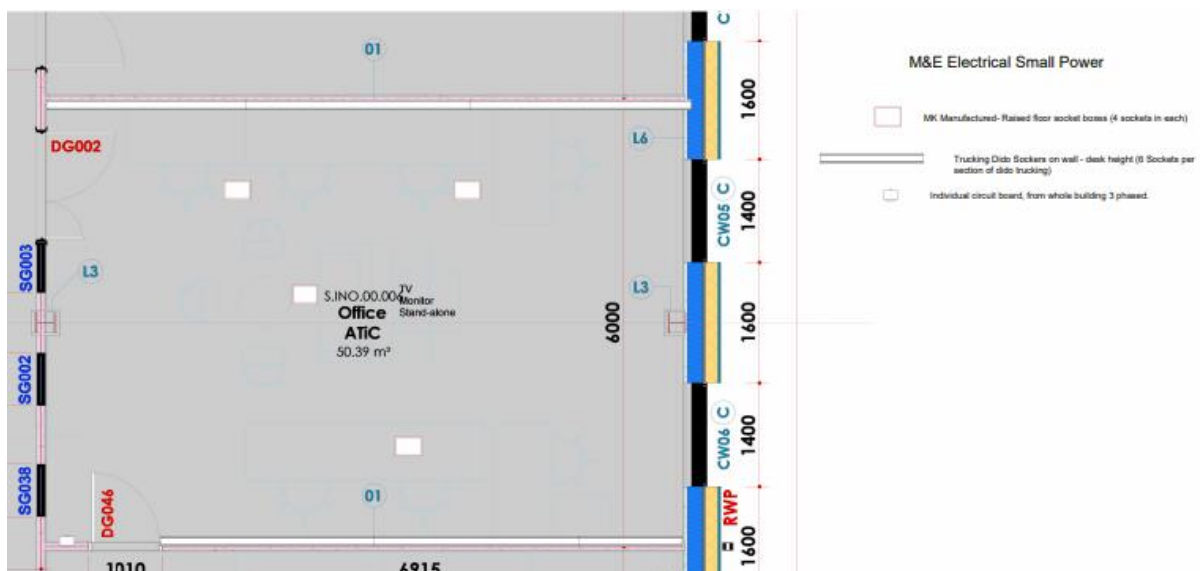


Figure 7 Small Power layout in office

To justify the designs accompanying this document in relation to energy usage, principles for natural and emergency lighting and the small power output for the individual zones. It should be highlighted that as we progress into the future, sustainability, and net zero needs to be at the forefront of any design, this counts for ensuring that the building has considered the maximum utilization of natural lighting and clever use of artificial lighting. This consideration can be used to the benefit the client, in terms of cost saving and better working conditions. The office room will have the benefit of the large atrium that runs through the middle of the building as a way of incorporating its natural light.

Natural lighting as seen from the designs utilizes the multiple small windows for each space to enhance the room lighting. However, the designs suggest using artificial

lighting in the form of ‘Wave LED” luminaire. The artificial lighting will work with both a capacity room sensor and a movement sensor, this will ensure that when the room is unoccupied by the office workers or business then the lighting will remain off and not in use. The vital aspect of using artificial lighting which is suspended from the ceiling or incorporated into a false ceiling dependant on the clients requirements and designs is that any maintenance or repairs required, these luminaires and lamps can be replaced or fixed without much disruption.

To utilize artificial lighting to its peak usage, as suggested by (Chadderton, 2007) the colours rendered by objects on the working plane should match the colours under daylight and a number of factors can affect the need for a certain number of lumens. These include the accuracy and speed of the task required, the age of the occupier, the type of room in which this certain task will be performed and the length of time the task will take. It is also important to consider the surroundings when choosing the correct artificial lighting to use. To correctly light an office working environment, as indicated by (The Chartered Institution Of Building Service Engineers , 2012) the lighting should use a lamp type of Fluorescent with a colour rendering index of 80-90 R_a with a task luminance/lux of between 300 – 750 depending on the task. Considerations need to be taken, in terms of any other accompanying matters such as screens or projectors. The lighting for an office space should include a lighting efficacy percentage of not less than 55 luminaire lumens per circuit watt.

The same concept has been designed for the toilets where the artificial lighting will switch on from a movement sensor. The designs, consider the LUX levels for a toilet within an educational building as 200 Lux. It is important to note that toilets are not for spending long periods of time in, therefore, the lux levels can be lower than in the main areas used for tasking jobs like office spaces. This particular area due to the fact that it contains two separate shower rooms, the use of a PIR humidity stat would be beneficial, all controlled from a central location. The lighting design includes movement sensors which all work individually, the sensors have been designed so that in cases where there may only be one person in the toilet and no movement has been detected, the luminaires will remain on until all sensors can no longer sense movement. These designs and operational measures benefit in terms of repairs and faults as if one were to fail at the least the others would continue to work until there is a replacement sourced.

To briefly consider the lighting levels required for the main atrium of the IM building, it



Figure 8 Showing Large Glazed Windows

would be safe say that the only artificial light that would need to be placed into this area would be to provide light for later hours of the day where daylight is narrowing, and the space is still in use by occupants. The main factors of the large, glazed units at the north or south face are to provide a maximum amount of natural lighting with smaller glazed units along the east and west face at eaves height to provide that additional lighting throughout the large atrium. The recommended lux level is around 100 lumens for circulation areas, this is a lower lux level to the original office space as these areas tend to have fewer intensive tasks involved and are only used to manoeuvre around the building as detailed by (BRE, 2001).

Emergency lighting is required as part of (The British Standards Institution, 2016) emergency lighting part one, where it is deemed necessary for person, employers and businesses to carry out risk assessments to ensure that there is a “safe means of escape, including emergency escape routes and exits, together with, where necessary, signs indicating them”. Emergency lighting should not be overlooked, and guidance can be followed from BS 5266 and (Advanced, 2021):

- “On escape routes up to 2m wide – 2 lux minimum on the centre line”.
- “On escape routes that may be used by the young, elderly, physically impaired or partially sighted – a minimum of 1 lux on the centre line”.

With stairways a consistent light distribution along the escape path should be present with lighting fixtures positioned close to staircases so that every step gets direct light. It is also necessary to illuminate any other level alterations that could present a hazard for tripping in low light.

Small power systems can come in the form of many outlets such as desktops that contain computer systems and devices to small, unfixed equipment that requires a power source. Small power outlets are vital within an office environment however not quite as essential in a welfare area or toilets. As per the designs, the small power has been designed as a raised floor with multiple supply zones sockets in the floor space to allow for a flexible workspace. These multi zone sockets within the floor area mean that small power items can be moved freely with the minor inconvenience or move the power source to an alternative supply zone without much fuss. It has also been detailed within the office to have dado wall trunking which contains small power sockets, the advantages to have this wall dado which circles around the room is to allow even more flexibility, as with the raised floor sockets, dado trunking allows for swapping and changing of plug sockets easily and efficiently, this trunking can also come in use when small cables are present which do not have enough extension to allow for power too far away, hence the wall dado becoming a better alternative to just individual wall sockets.

The use of asset management conducts itself well with the small power and building services, it is important to note that as we progress forward technology is advancing and therefore for equipment is available to ensure that areas which are in use twenty-four-seven, are equipped with the correct technology which can improve the health and productivity of workers. The use of asset management and their systems can use vast amount of technology to control all or parts of new buildings with the use of controls and smart systems.

Task Three – Describe the building fabric and potential services equipment choices for both the design and installation practice. Referencing sustainable futures, low carbon, and financial cost savings

The IM building is a new development that comprises of a two-storey steel framed building that will hold new businesses and appear as a collaboration centre for the university. The overall concept of the design is to achieve an EPC rating of an A+ with four credits contributing to a BREEAM excellence rating.

Analysing the building fabric, starts with consideration to its overall structure and construction materials. The IM building is a steel frame building with insulated steel sheathing coloured in a moderate brown colour. The front of the building is fitted with a double-glazed curtain wall to both the north and south sides. The building is accompanied by small, glazed units along the east and west sides and the roof of the IM incorporates a steel sheathing with insulation and square glazed unit at the top of the sides. The smaller square glazed units are set on mechanical operation systems to control the airflow and ventilation. The internal layout and materials within the building are a concrete floor topped with screed equipped with underfloor heating controlled by manifolds which are separated out into two sections, the north and south entrance and meeting in the centre of the atrium. The building has a number of offices, laboratories, research centres, social spaces, printer, and storage rooms, as well as stairwells, a café and two plant /building support rooms which are situated either side of the building. The plant rooms are located in the centre of the building to provide each side with mechanical and electrical supplies. The building itself does not contain any form of gas and runs entirely from electric, including an electric boiler to power the hot water systems and in turn using hot water to heat the radiant panels within each individual office space, lab, and social space which, in contrast to conventional heating systems, warms the people and things in the room not just the air.



Figure 9 Showing External Building Fabric



Figure 10 Showing Metal Carry Trays for M&E

The mechanical and electrical services have been designed to run along the building using metal trays with exposed pipework and ductwork giving the building the industrial feel. Using the industrial feel of the carry trays with mechanical and electrical services, provides an easy access aspect when it comes to repair and maintenance. Although, the concept of the underfloor heating is a great cost effective way of emitting heat, it may pose difficulty when it comes to accessing any part of the underflooring heating especially when it experiences any issues and a repair or maintenance is required, as stated above the floor is covered in an in situ concrete with levelling screed, this could become a costly mistake if there are any future issues as the floor will need to be dug up in order to fix any issues.

To critique and provide the IM building with improvement suggestions in terms of its building fabric design and overall building performance. Firstly, it is important to note that overheating will be a prominent factor in the IM's building once it is up and running. It would be highly recommended to use an alternative building fabric for its overall use and aesthetic appearance, the brown sheathing external fabric which could have been designed with locally sourced bricks to both better the heating performance and kept the building in design with the surrounding structures. The large amounts of glazed units contained within the building will heat the building to uncomfortable state during certain periods of the year therefore, the designs could have incorporated reflective glazing or large overhangs providing the windows with enough shading to prevent this. The overall layout of the office and rooms within the building have been laid out in a suitable state apart from the kitchen which again is south facing with a glazed curtain wall, the café and kitchen will be producing enough heat gain with operating not considering the solar gains that will be produced from the atrium itself and the glazed curtain wall surrounding this area, this room could have been placed at a different location within the building.

The ventilation strategy could have also been improved; the current strategy is from MVHR units which are a fair efficient choice however these units are not equipped with air condition facilities which is a vast concern to its already stated overheating issue, although as per BREEAM Certification, the scoring list has the highest points on energy and for the building to obtain air conditioning, this may pose an issue and risk to the overall score as detailed by (ongreenin, 2024), therefore natural ventilation would be the most suitable choice, with the addition of night purging to allow the building to cool to its natural state.

The current heating strategy of radiant panels is an effective use of energy. These panels create a warming environment by heating physical elements within a room such as person instead of old systems which would heat the air within an environment which would then help heat an individual, by using these infrared panels, it manages to cut of an unnecessary part of the heating process and sends the heat directly to the user.

Airtightness can be an important aspect of a new building which relies on technology and design aspects to naturally heat and ventilate a building. The IM currently has an airtightness result of 2.5 (m³/hr/m²) once completed. Airtightness is accomplished by sealing a structure to lessen infiltration, also known as uncontrolled ventilation. The amount of air that enters or leaves a building at a pressure of 50 Pascals is used to determine how airtight a structure is. For a building as new as the IM, it would have been beneficial to increase the airtightness of this building to prevent the use of over working mechanical systems which will be used to get rooms up to comfortable temperatures and have adequate ventilation rates, also airtightness will become of benefit in the future as climate change becomes more of a prominent factor. Air tightness can also affect how much cool air is exhausted from the building as well as how much warm air is able to be absorbed by the building, this is why airtightness can be an important aspect of designs. If the IM building had been built with better airtightness, there could be an argument as to whether there would have been the amount of overheating there is currently, and with this being an educational building, spending more costs on airtightness and better ventilation techniques could have had a long term cost saving as not much money would be spent to heat a room and to keep ventilation at its correct and adequate comfort levels.

The IM building was constructed with respect to sustainability, carbon aspects, financial cost, embodied energy and overall contribution to net zero, and for these it can be seen as an educational building with great potential.

The IM is currently aiming for a BREEAM excellence with an EPC rating of an A+ and this is considered a great step towards its futureproofing, overall performance, and the effects on the environment.

To summarise the IM building in relation to sustainability and net zero, it must be given that the building currently hosts no facility for gas and instead runs the whole building from electric sources, these come in the forms of an air source heat pump located on the roof which uses the outside air and boosts it to a high temperature, this is to be adequately used in high insulated properties, although the IM building is insulated to a satisfactory level, it may have been beneficial to better insulate with not only a better quality insulation but with a more sustainable, low embodied material such as strawbale or wood fibre which can be locally sourced.

In terms of the materials used for the IM building and the buildings overall embodied carbon, it should be noted that materials could be locally sourced with the lowest embodied carbon and energy possible, this way of construction with sustainable materials requires a lot more thought and research which can help impact a building in a better positive way. To consider the materials that have been used in contrast to what could have been used for a lower embodied carbon effect, we should first look at the external cladding, where we could have used a natural Welsh stone or bricks or alternative locally sourced timber, although given the location of the IM and the saltwater emitting from the port this would require a lot of maintenance and protection throughout its lifecycle. To consider the internal materials used and what could have been used instead, a different form of insulation such as strawbale or cellulose which is recycled paper, further consideration during the design process

could have helped obtain a lower embodied energy and carbon. The IM building is currently anticipated to vastly overheat especially during the summer months therefore, more consideration should have been sought in relation to this, overheating is not something that will be reduced as we progress into the future and this should have been on the forefront of the designs and how the building can be altered to prevent the cases of overheating in such a momentous building, referring to (Cibse, 2015) to prevent overheating, the building should be designed with external shading and internal shading which can be altered by the user. The overheating will be a cause of the large, glazed windows situated on the southside of the building along with the large amounts of glazed units all over the building and the lack of air conditioning within each of the individual rooms. The consumers of these rooms will evidently struggle to work at a comfortable temperature throughout the summer months within these rooms and will no doubt request for additional air conditioning. Along with the lack of air conditioning and large amounts of glazing all supposedly combated by restricted opening windows and a MVHR units, these units will likely become overrun and overused during certain times of the year, leading to financial costs being spent on repair and maintenance of these items as well as additional costings on smaller air conditioning units running from small power supplies leading to more financial outgoings on electricity. As suggested in the ventilation section, the use of a nighttime purge will help in reducing unwanted financial outgoings while there is little to no one present in the building and provide the MVHR units a few hours of reduced working time.

To evaluate the building within the current year, the IM could have been constructed to a better standard using either the BREEAM Outstanding award or Passivhaus Standard. The BREEAM Outstanding award consists of reaching 85% environmental performance, as detailed by (Encon Associates, 2024). This is the best possible BREEAM rating achievable, it requires a project to fulfil the "outstanding" requirements and shows innovative and ground-breaking techniques that raise the bar for sustainability in the sector. In relation to the IM building becoming of Passivhaus Standard it would have needed to meet the following strict criteria:

- Space Heating Energy Demand is not to exceed 15 kWh
- Renewable Primary Energy Demand
- Airtightness of ≤ 0.6 ACH @ 50 Pa.
- Thermal comfort

To have the IM building meet either of these standards would have been a greater short term financial outgoing with lower long-term cost especially in these unpredicted times of soaring energy bills and greater concerns for health and wellbeing within buildings, although there is a strong argument that if this building had been designed with increased thought into its purpose and design, it could have been up to Passivhaus standard, it could have also been recognised for its design in this matter and bought far more interest and publicity to the site and University.

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