

University of Wales

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School of Engineering

MSc in Sustainable construction



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**Written Assignment for Module: Building Service and Energy
Performance in Building (ACBA 7001)**

**Assignment Title: Building Service and Energy Audit of Julian
Hodge Building, Cardiff University**

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Executive Summary

At Cardiff University, there are several academic departments and research facilities housed in the 3700 square meters Julian Hodge Building. The structure features two gas supplies, one electric supply, and a variety of systems and tools for providing building engineering services.

This report's objective is to conduct an energy audit of the Julian Hodge Building, identify areas for improvement, and make energy-saving recommendations to lower energy use and increase the building's energy efficiency.

The building's lighting and heating, ventilation, and air conditioning (HVAC) systems were the main energy consumers, according to the energy audit. To minimize energy consumption, the research suggests replacing the lighting systems in the building with energy-efficient LEDs and replacing the HVAC system with a more up-to-date, effective system.

The research also suggests putting solar panels on the building's roof and putting a building energy management system (BEMS) in place to track and manage energy usage.

The building's energy consumption is predicted to be reduced by 25% by putting the suggested solutions into practice, and long-term cost reductions are expected to be considerable.

Overall, the energy audit and suggested fixes show that Cardiff University can save money while improving the Julian Hodge Building's energy efficiency and environmental sustainability.

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1 Introduction

The Julian Hodge Building at Cardiff University in Cardiff, United Kingdom, is the subject of this paper, which attempts to give a thorough examination of its building engineering services and energy usage. The document is split up into three main sections:

Section 1: Supply of building engineering services.

The several building engineering services offered in the structure are discussed in this part, along with how they are carried out. To provide readers a thorough grasp of the systems and machinery employed in the building, it also contains schematic diagrams, pictures, and a timetable of the principal pieces of plant.

Section 2: Building engineering services maintenance.

The management of the building engineering services in the case study building is covered in this section. It examines the benefits and drawbacks of internal and external outsourcing while outlining a business case in favour of the preferred method.

Section 3: Suggestions for Energy Audit and Efficiency

This part offers a thorough energy assessment of the building's energy usage and presents investment-grade suggestions for enhancing energy efficiency at a reasonable cost. For the suggested actions, it also offers plans for execution, monitoring, and verification.

The Julian Hodge Building is a sizable structure with two gas supplies and one electrical supply. This report will offer insightful information on the building's engineering services and energy usage, which may guide the building's future maintenance and energy management plans.

1.1 Aims & Objectives of this report.

The purpose of this study is to carry out an extensive energy audit of Cardiff University's Julian Hodge Building with the goal of finding areas where energy efficiency improvements may be implemented to lower energy use and costs. The report will discuss the numerous choices available for setting up the maintenance of the building engineering services and offer advice on the most affordable actions that can be taken to enhance the energy performance of the building. The report will be presented as a business case to back up the suggested maintenance strategy.

1.2 Scope

This report's scope covers an in-depth analysis of the Julian Hodge Building's energy consumption trends and the effectiveness of its building engineering systems. The analysis will examine the building's present energy efficiency, point out areas where energy may be saved, and offer suggestions for reasonably priced energy efficiency upgrades that could be made to the structure. A business case to support the suggested course of action is also included in the scope, along with an evaluation of the various possibilities for organising the maintenance of the building engineering services. All levels and parts of the building will be included in the report, along with the electrical and gas supply systems, lighting, insulation, and HVAC systems. Nevertheless, any significant building repair or refurbishment projects that would necessitate substantial modifications to the building's structure or its services systems will not be included by the report.

1.3 Methodology

This report's approach combines desk research with field research, data gathering and analysis, and energy audits. The desk study included reading up on maintenance tactics, energy saving methods, and building engineering services.

To learn more about the building engineering services and how they function, a study was conducted on-site. A visual assessment of the structure and its systems, employee interviews, and a study of pertinent paperwork and records were all part of this process.

Information on the building's energy use, such as electricity and gas bills, energy consumption statistics, and other pertinent data, were gathered and analysed during the data collecting process. In order to find out where energy saving measures should be used, this data was examined to spot patterns and trends in energy consumption.

The building's energy efficiency was then improved by conducting an energy audit to find areas where energy might be saved and offer suggestions on how to do so. In order to do this, the building's systems and equipment had to be thoroughly analysed, and potential energy-saving methods had to be found.

2 Overview of the Building

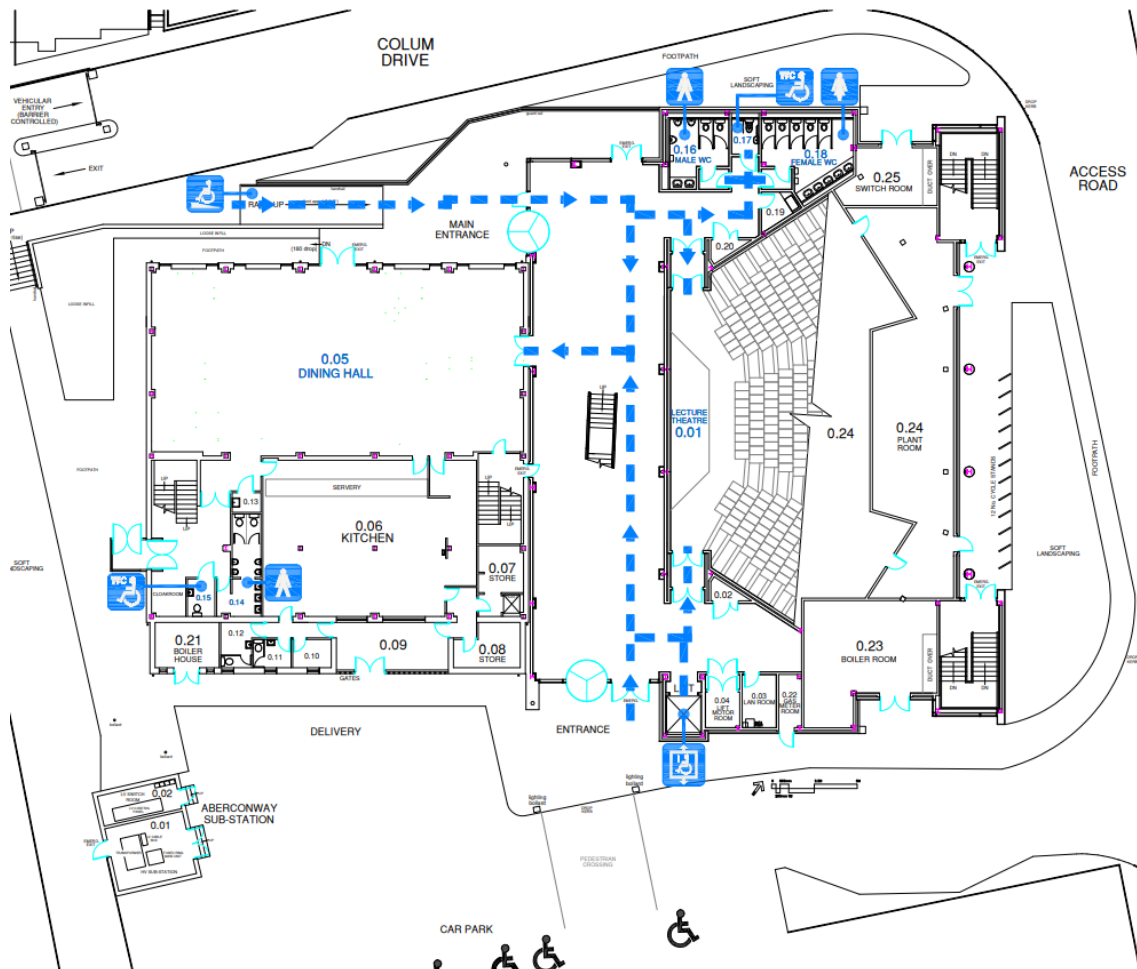


Figure 1 Floor Plan of Julian Hodge Building (Cardiff University, 2009)

2.1 Exterior of the building





Figure 2 Exterior View of Julian Hodge Building (Google Images, 2023)

2.2 Interior and Interior Schematics of the Julian Hodge Building

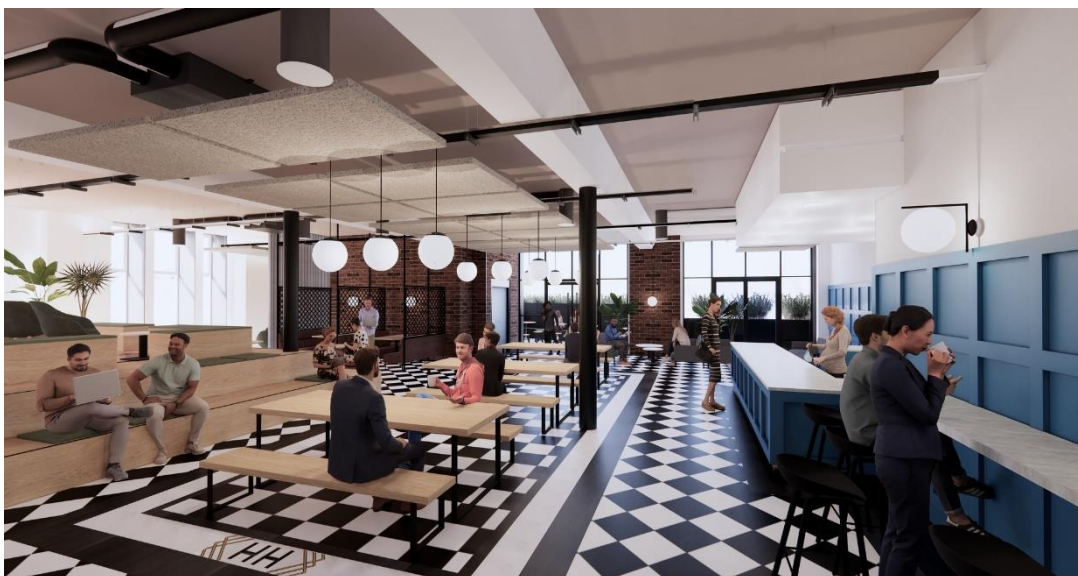


Figure 3 Interior of Julian Hodge Building (Google Images, 2023)

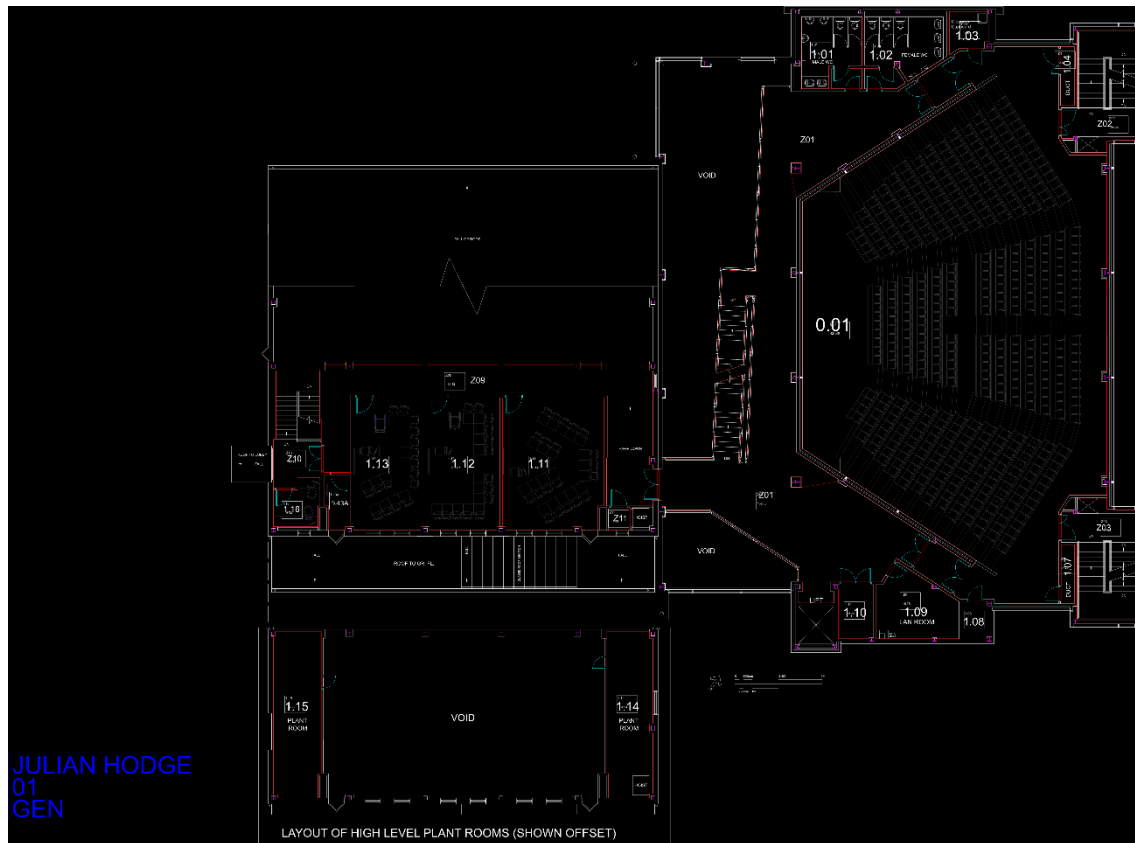


Figure 4 Layout of High-Level Plant Room (Durdin, 2023)

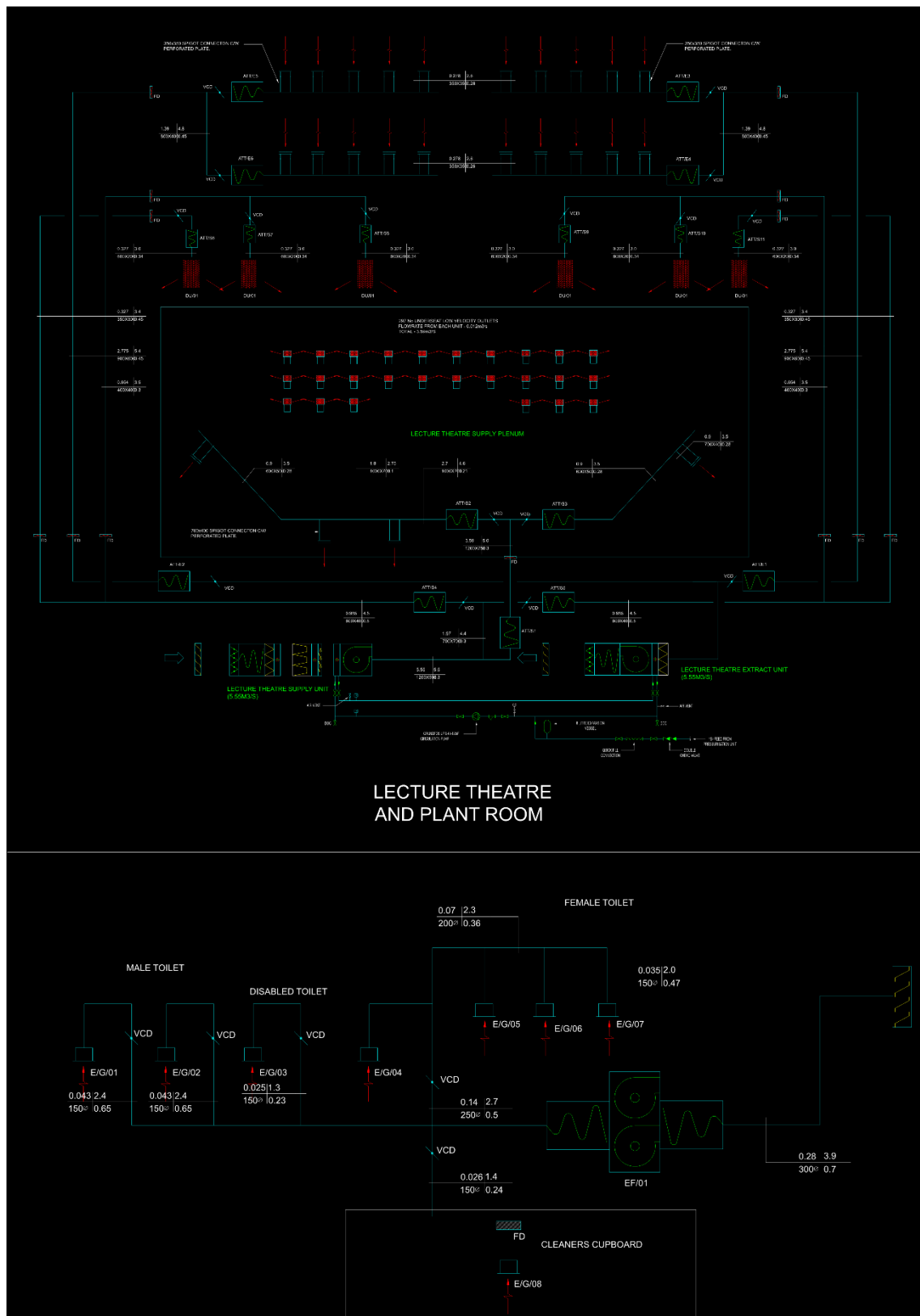


Figure 5 Lecture Theatre and Plant room schematics (Durdin, 2023)

2.3 Building Energy Consumption Certificates

Cardiff University Julian Hodge Building Colum Drive CARDIFF CF10 3EU	Operational rating F
This certificate expired on 24 May 2021	Certificate number 0529-0163-2710-7100-1003

Energy performance operational rating

The building's energy performance operational rating is based on its carbon dioxide (CO₂) emissions for the last year.

It is given a score and an operational rating on a scale from A (lowest emissions) to G (highest emissions).

The typical score for a public building is 100. This typical score gives an operational rating of D.

Score	Operational rating	This building	Typical
0-25	A		
26-50	B		
51-75	C		
76-100	D		
101-125	E		
126-150	F	139 F	
150+	G		

You can read [guidance on DEC's and advisory reports for public buildings](#).

Figure 6 Energy Usage Rating (DEC, UK, 2021)

2.4 Energy Consumption Details

This building's energy use

Main heating fuel	Natural Gas
Building environment	Air Conditioning
Total useful floor area	3700.48 square metres
Asset rating	Not applicable

Energy use	Electricity	Other fuels
Annual energy use (kWh/m ² /year)	171	162
Typical energy use (kWh/m ² /year)	81	237
Energy from renewables	0%	0%

Previous operational ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods.

May 2020	139 F
June 2019	140 F
June 2018	81 D

Figure 7 Energy Usage by the Building (DEC, UK, 2021)

Building Energy Consumption Certificates, also known as Energy Performance Certificates (EPCs) or Display Energy Certificates (DECs), are recognised legal records that detail a building's energy efficiency. The provision of EPCs to renters or prospective building owners is mandated by law in several nations, including the UK.

On a scale from A (most efficient) to G, Figure 6's energy use rating illustrates the building's energy efficiency (least efficient). The building's insulation, heating system, lighting, and ventilation are among the aspects that are considered while calculating the rating.

The energy usage of the building is broken down in Figure 7 according to several end applications, including lighting, heating, and cooling. The building's energy efficiency may be increased by using this data to pinpoint locations that can benefit from energy-saving initiatives.

In general, the aim of these energy use certificates is to promote action by building owners and occupants to cut down on energy use and greenhouse gas emissions by promoting transparency and knowledge about the energy efficiency of buildings.

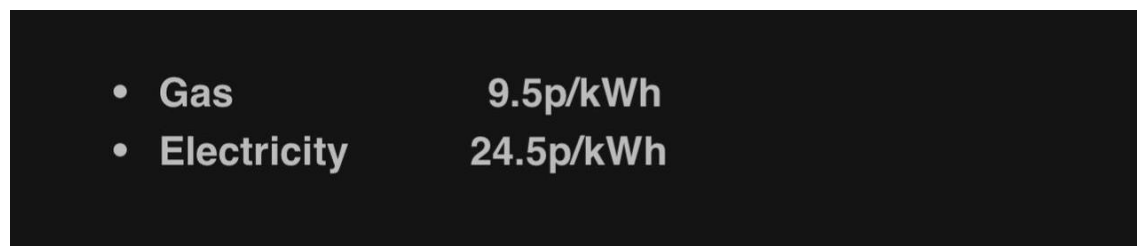


Figure 8 Energy Tariffs for Electricity and the Gas



Figure 9 Energy consumption meters at the building

3 Schematics of the Building Service and Energy Distribution

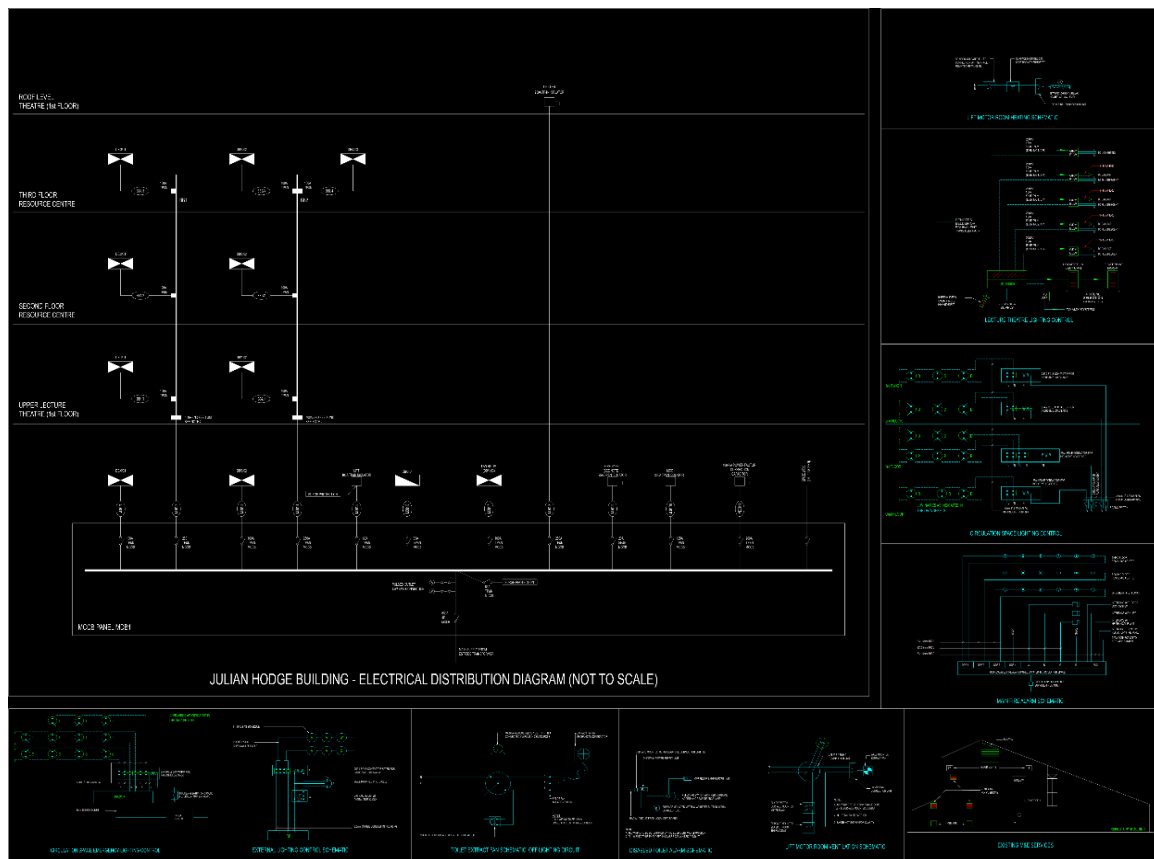


Figure 10 Energy Distribution Schematics (Durdin, 2023)

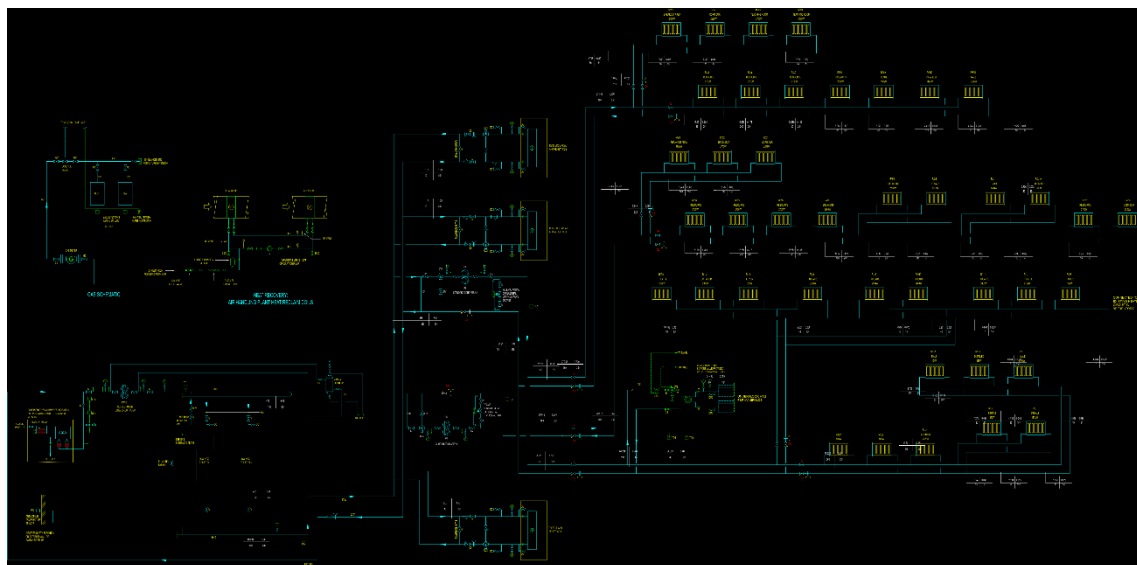


Figure 11 Heating Schematics

3.1 Engineering Services Schematics

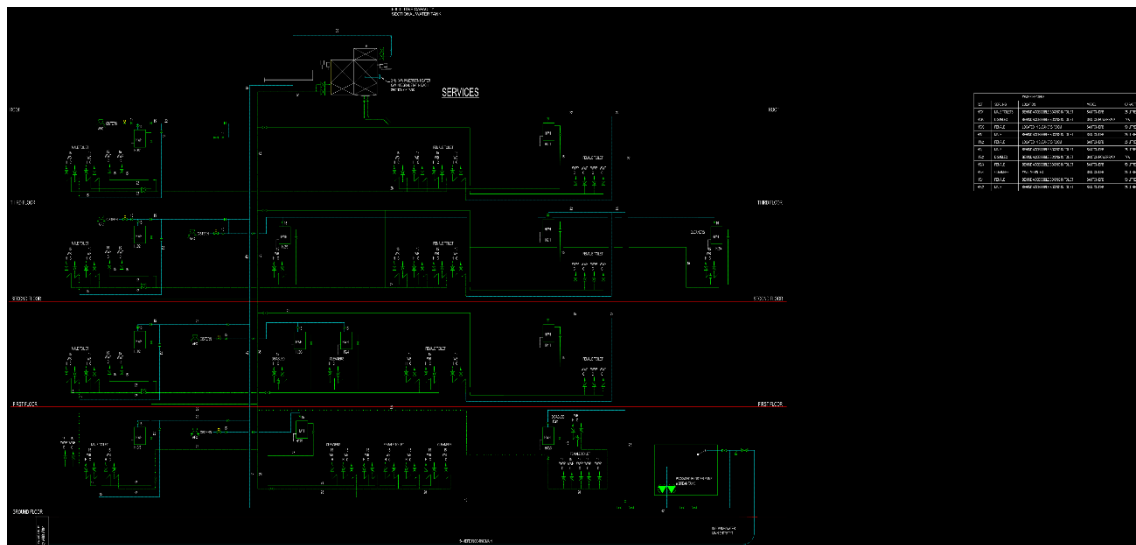


Figure 12 Water Distribution Schematics (Durdin, 2023)

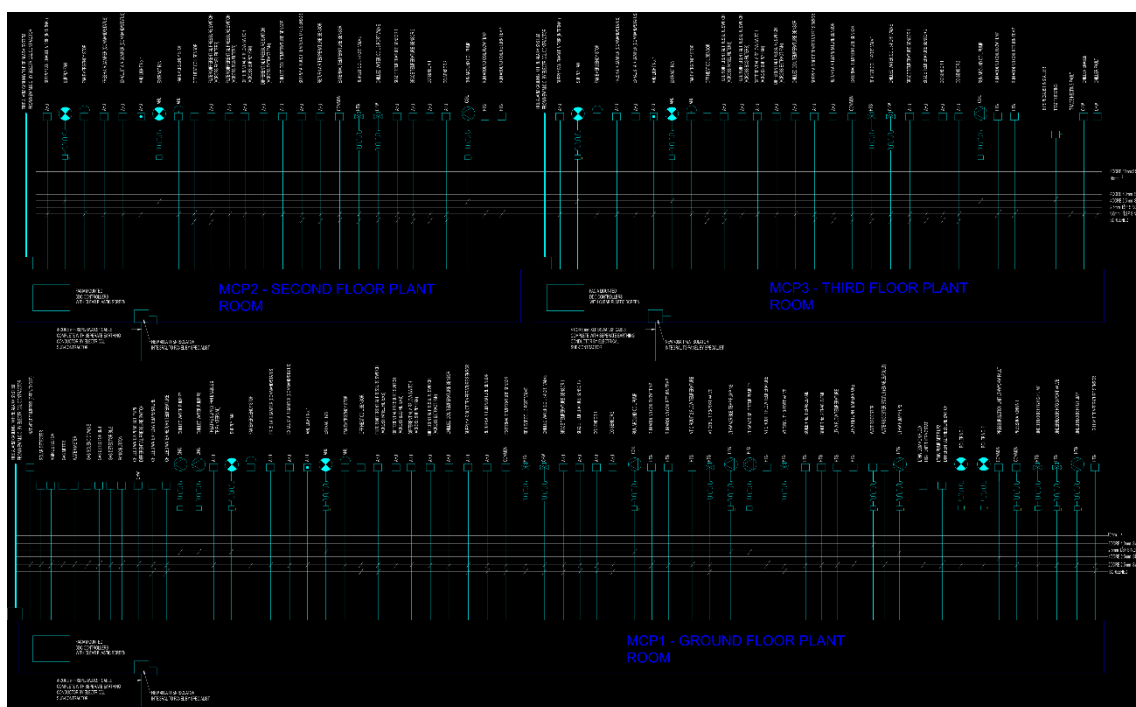


Figure 13 MCP (Mechanical Control Panel) of 1, 2 and 3 Floor's Plant Rooms (Durdin, 2023)

Assignment Title: Building Service and Energy Audit Schematics of the Building Service and Energy Distribution

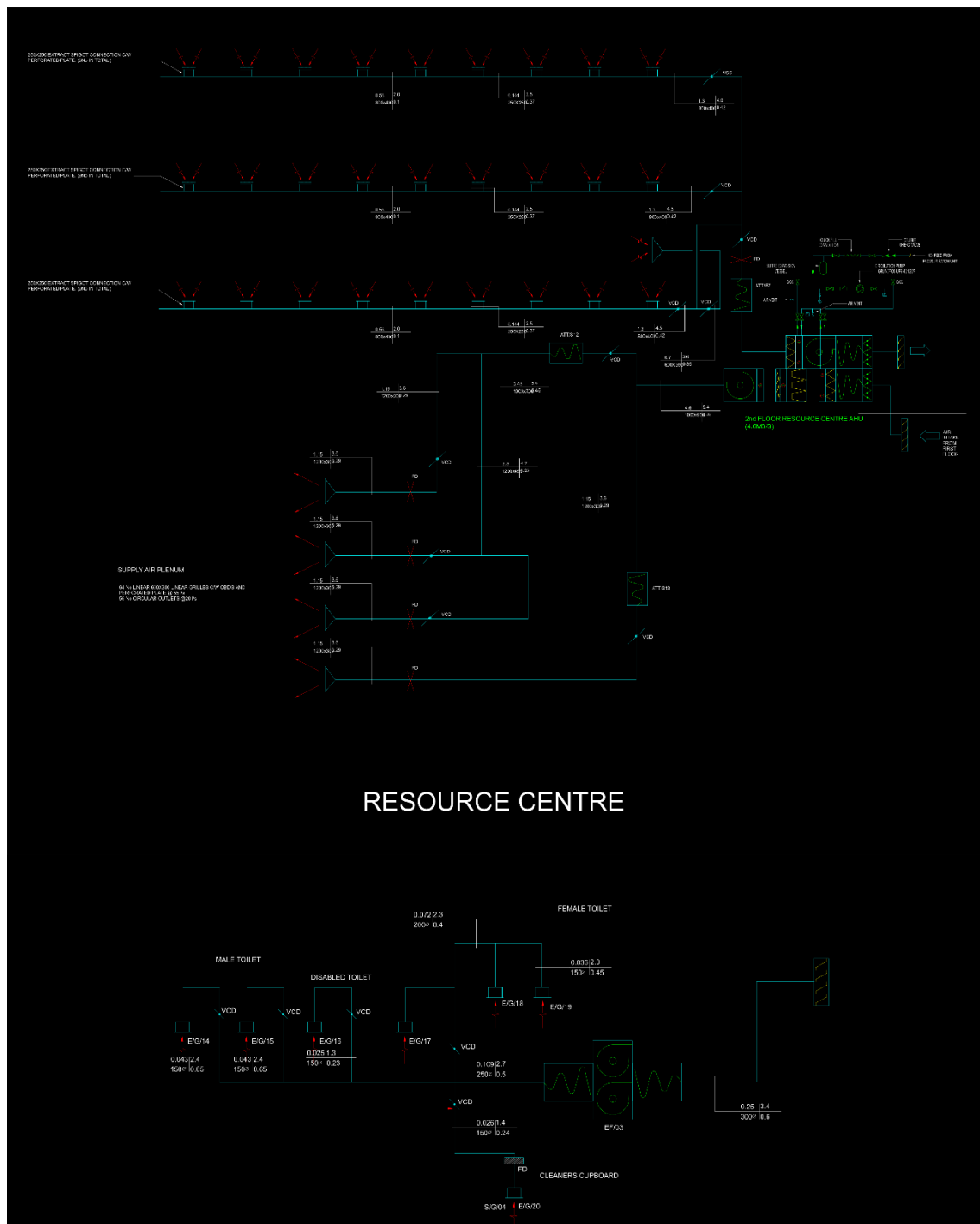


Figure 14 Resource Centre and Supply Air Planum (Durdin, 2023)

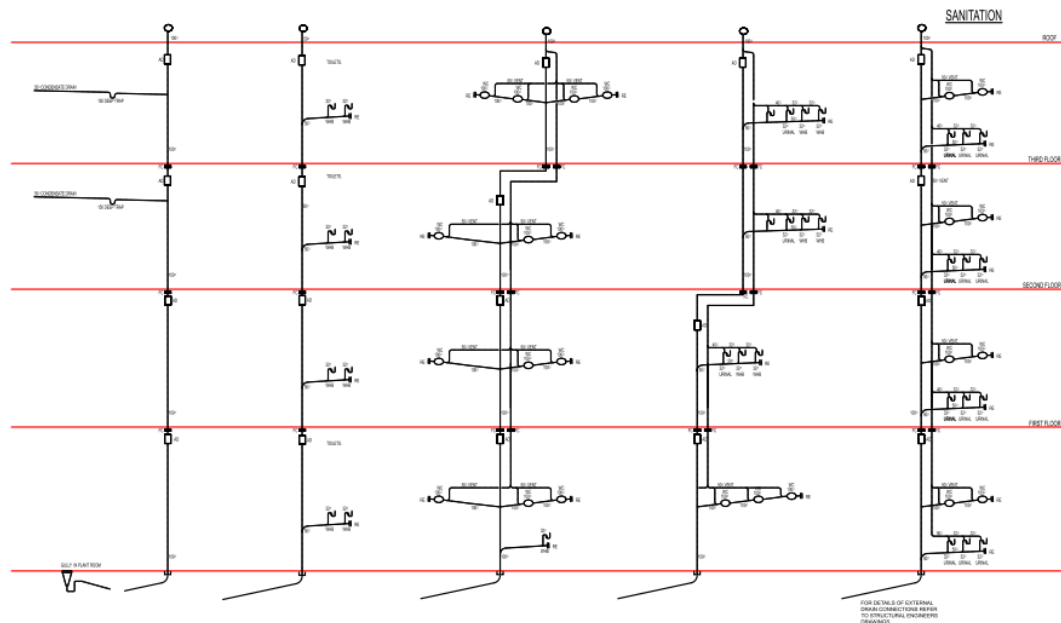


Figure 15 Foul Drainage Schematics (Durdin, 2023)

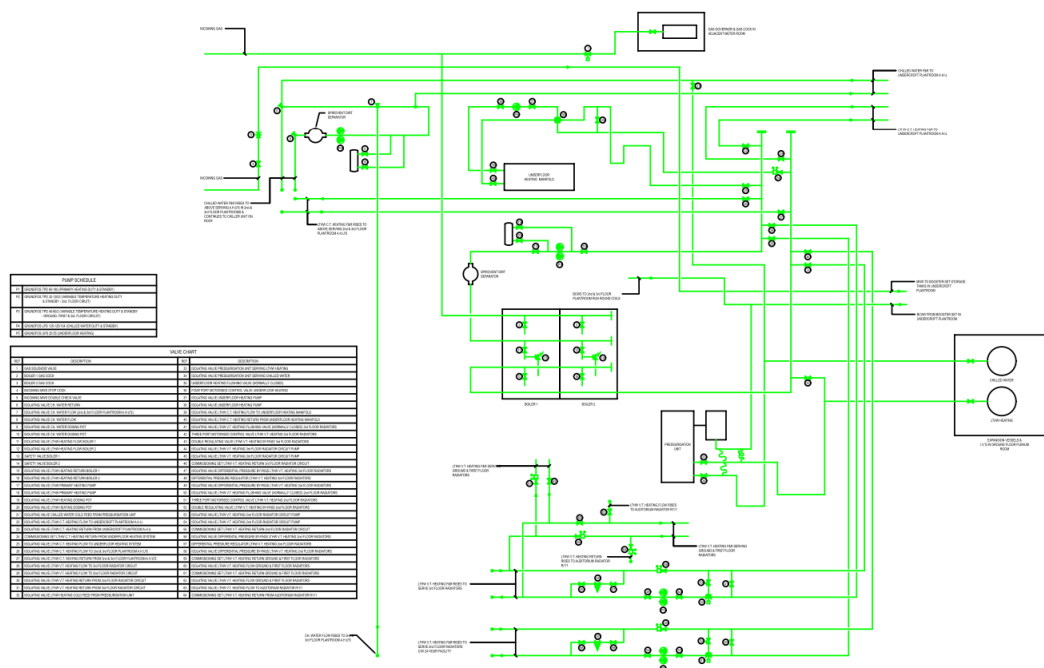


Figure 16 Ground Floor Under Croft Valve Chart (Durdin, 2023)

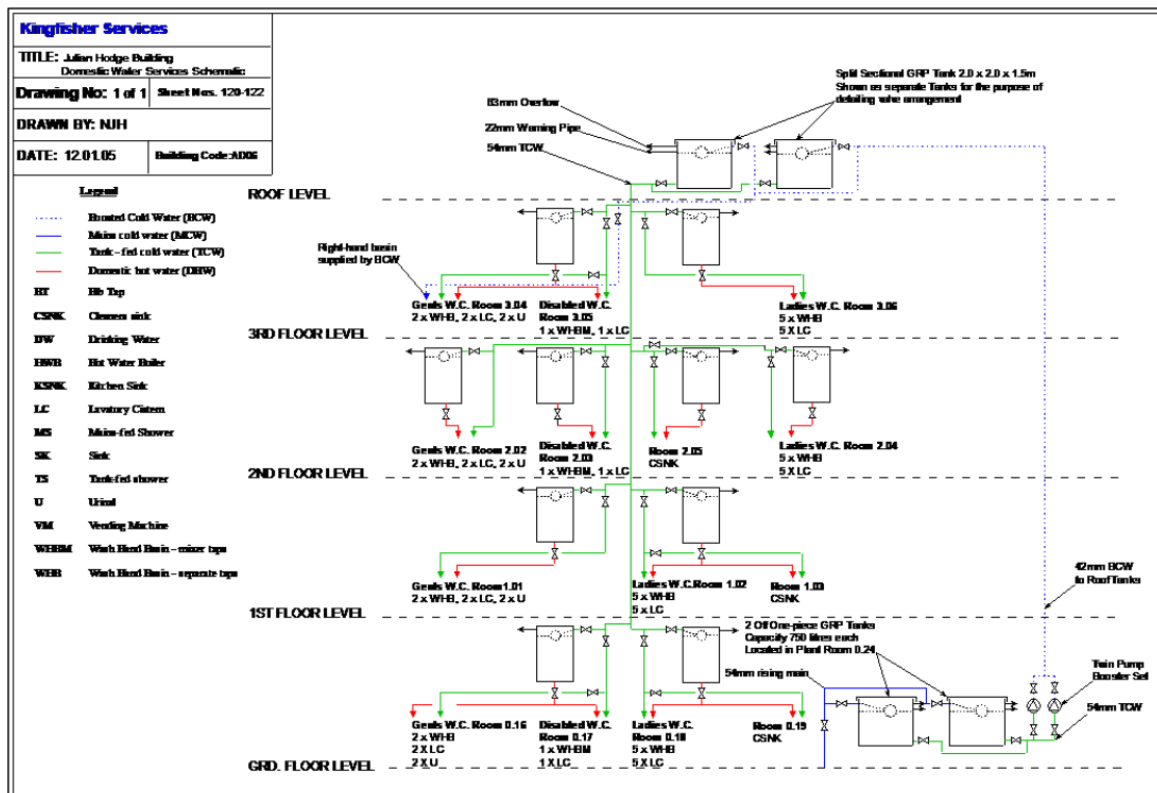


Figure 17 Domestic Water Supply Schematics (Durdin, 2023)

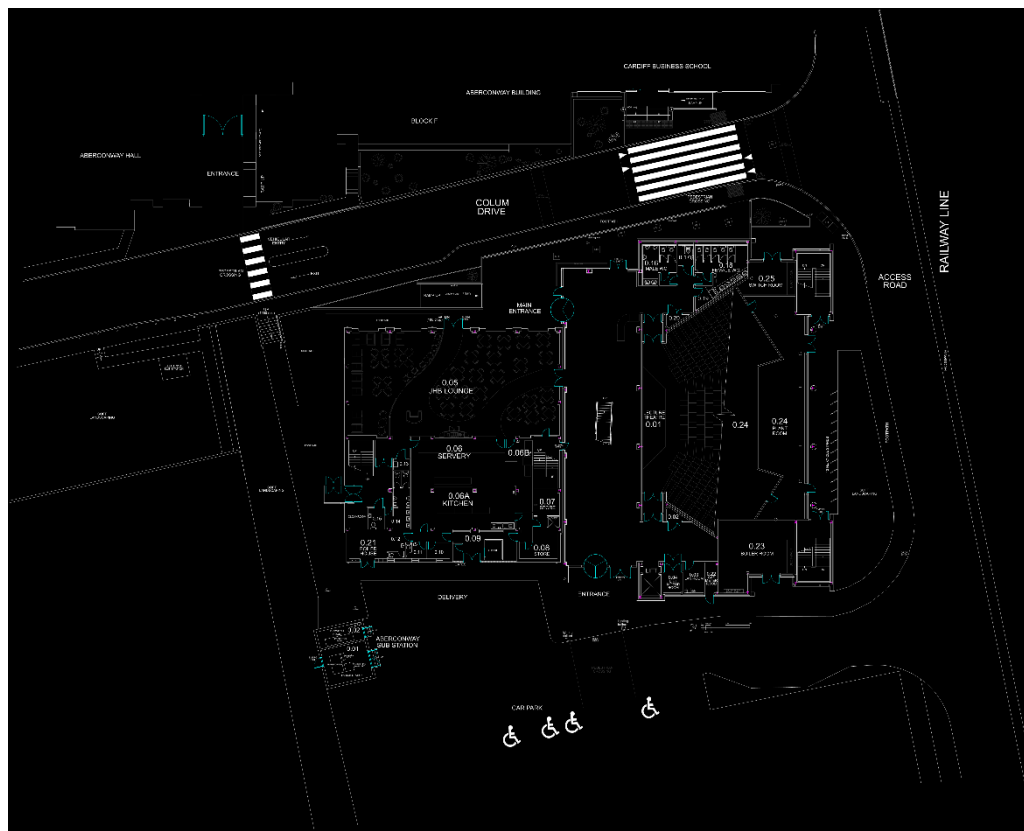


Figure 18 First Floor Ventilation Schematics (Durdin, 2023)

4 Building Engineering Services

Mechanical, electrical, and plumbing (MEP) systems, as well as heating, ventilation, and air conditioning (HVAC), fire prevention systems, and lifts, are all included in the services provided by building engineering. The equipment used to provide these systems generally includes terminal equipment scattered around the facility, distribution systems, and central plant equipment.

The building's ventilation, heating, and cooling are all provided by the central plant equipment, which includes things like boilers, chillers, and air handling units. Distributing systems, including ductwork and pipe, provide the conditioned air and water to the terminal equipment found in specific areas, like air diffusers and radiators.

Such centralised and distributed systems may be used to supply services related to building engineering in addition to HVAC systems. To get water to sprinkler heads positioned all throughout the structure, for instance, fire prevention systems may employ a combination of central pumps and distributed pipework.

Cardiff University's Julian Hodge Building is a cutting-edge, multi-story academic structure that contains a number of departments, including business, management, and finance. The facility is equipped with a variety of systems and tools to provide the building engineering services.

4.1 Electrical System

1. The building receives its only electrical supply from the grid, and a system of power lines and circuit breakers distributes that electricity throughout the structure.
2. In case of power failures or maintenance disruptions, the electrical system has a backup generator.
3. Also, the structure includes an energy-saving lighting management system that makes use of timers and motion sensors to make sure that lights are only turned on when necessary.

4.2 HVAC (heating, ventilation, and air conditioning) system

1. In order to keep the building's temperature and humidity at a tolerable level, the HVAC system's air handling units, chillers, boilers, and heat exchangers collaborate.
 2. The system makes use of a Building Management System (BMS) to regulate the HVAC units, keep an eye on the quality of the interior air, and make necessary setting changes.
- HVAC (heating, ventilation, and air conditioning) system

4.3 Plumbing System:

1. Together with hot water tanks and pumps, the plumbing system also consists of a network of pipes for water supply and drainage.
2. In order to save water, the restrooms in the building include automated faucets and low-flow toilets on each floor.

4.4 Fire Safety System:

1. Smoke detectors, fire alarms, sprinklers and fire extinguishers are all part of the building's extensive fire prevention system.
2. To guarantee quick action in the case of a fire emergency, the system is continuously monitored by a central monitoring station.

4.5 Case Study: Outsourced Method

The goal is to guarantee that the building engineering services are properly maintained, economically viable, and effectively utilised.

4.5.1 Benefits:

1. **Cost Savings:** By only paying for the services actually rendered, outsourcing building engineering services can save money on both labour and equipment.
2. **Expertise:** Outsourced businesses have a wealth of knowledge and experience in the field of building engineering, which can lead to higher-quality maintenance.
3. **Increased Productivity:** Outsourced businesses have a larger workforce that is capable of handling several maintenance jobs, ensuring that problems are fixed swiftly and effectively.
4. **Improved Accountability:** Contracting out building engineering services makes the vendor responsible for any delays or shoddy work, which might result in higher performance.

4.6 Implementation Strategy

1. Create a request for proposals (RFP) that details the range of services needed, the maintenance schedule, pricing, and performance indicators.
2. Decide which service provider is best for the job after evaluating the replies you've received.
3. Make a Service Level Agreement (SLA) with the chosen service provider that specifies the range of services, the standards of quality, and the performance indicators.
4. To discuss the service provider's performance and any potential difficulties, schedule frequent meetings with them.
5. Verify that the service provider is adhering to the SLA's standards by conducting frequent audits.

5 Organized Maintenance

There are two possibilities for setting up building engineering services maintenance: internally or outside.

5.1 Internal Approach:

1. Using an internal strategy, the building management team would hire personnel directly to oversee the upkeep of the building engineering services.
2. An internal method has advantages such as increased control over the maintenance procedure, quicker reaction times, and maybe reduced costs.
3. An internal method has drawbacks such as the need to spend money on tools and training for the maintenance team, as well as the possibility of worker turnover and knowledge loss.

5.2 Outsourced Methodology:

To handle the maintenance of the building engineering services using an outsourced strategy, the building management team would enter a contract with a separate maintenance provider.

Access to specialist knowledge, lower administrative expenses, and more flexibility in adjusting maintenance requirements are benefits of an outsourced approach.

An outsourced strategy might result in communication difficulties with the maintenance provider, a loss of control over the maintenance procedure, and significant reaction time delays.

The following is how I would set up the building engineering services maintenance:

1. For each piece of equipment, I would lay down the frequency and range of maintenance in a maintenance schedule.
2. I would get a competent contractor to do the upkeep.
3. I would document every single maintenance task.

If I had the knowledge and means to accomplish it, I would think about doing maintenance in-house. But if I didn't have the knowledge or money to handle the upkeep myself, I'd probably hire a trained contractor to do it.

5.3 Business case for outsourcing maintenance:

1. It may be cheaper to outsource maintenance.
2. Staff members can focus on other things by outsourcing maintenance.
3. Maintenance that has been outsourced has often been of higher quality.
4. Reduced chance of accidents is one benefit of outsourcing maintenance.

6 Energy Audit

In order to examine the Julian Hodge Building's energy usage and find areas for cost and usage reduction, we will conduct an energy audit of the structure in this section. An extensive examination of the building's energy consumption patterns, energy usage intensity (EUI), and the identification of energy-saving strategies that may be used to increase the structure's energy efficiency are all part of this audit.

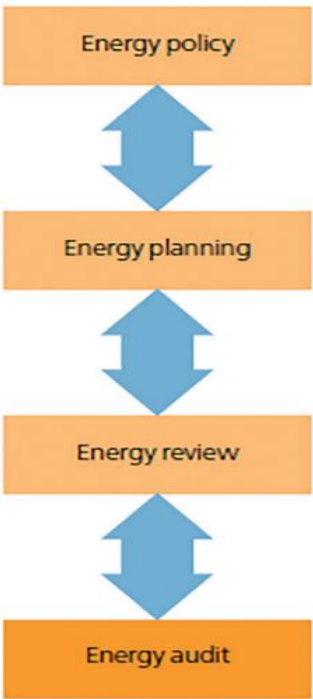


Figure 19 Method to adopt Energy Audit into Management (Lewry, 2020)

Score	Operational rating	This building	Typical
0-25	A		
26-50	B		
51-75	C		
76-100	D		
			100 ..
101-125	E		
126-150	F	139 F	
150+	G		

6.1 Energy consumption Analysis

An extensive examination of the building's energy use is carried out as the first phase in the energy audit procedure. To determine patterns of energy consumption across the facility, this research will include looking through utility bills and examining energy use statistics. The building's energy consumption study will assist in determining which areas are using the most energy and where the greatest potential for energy savings exists.

This building's energy use

Main heating fuel	Natural Gas	
Building environment	Air Conditioning	
Total useful floor area	3700.48 square metres	
Asset rating	Not applicable	

Energy use	Electricity	Other fuels
Annual energy use (kWh/m2/year)	171	162
Typical energy use (kWh/m2/year)	81	237
Energy from renewables	0%	0%

Figure 20 Julian Hodge's Energy Consumption Analysis (DEC,UK, 2021)

Total carbon dioxide (CO2) emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO2.

Date	Electricity	Heating	Renewables
May 2020	349	116	0
June 2019	350	119	0
June 2018	182	93	0

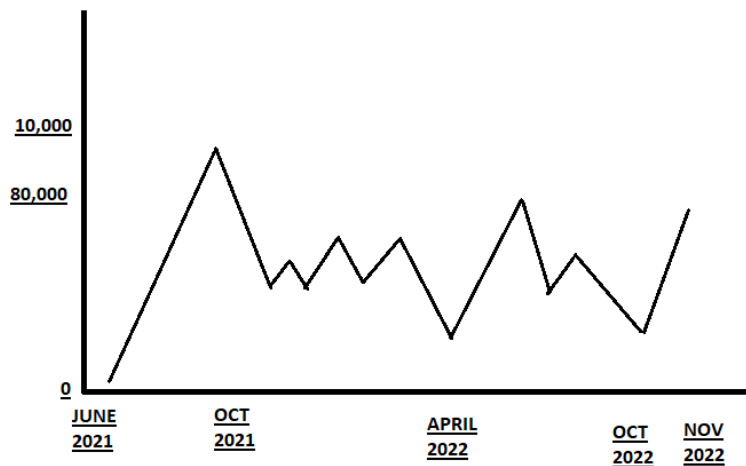
Figure 21 Emissions from the Building (DEC,UK, 2021)

The outcomes of the energy consumption study of the Julian Hodge building are shown in Figures 20 and 21. From September 2021 to June 2022, Figure 20 depicts the monthly energy usage for gas and electricity. The graph makes it obvious that the amount of petrol consumed gradually changes over time, peaking in January 2022 before gradually declining thereafter.

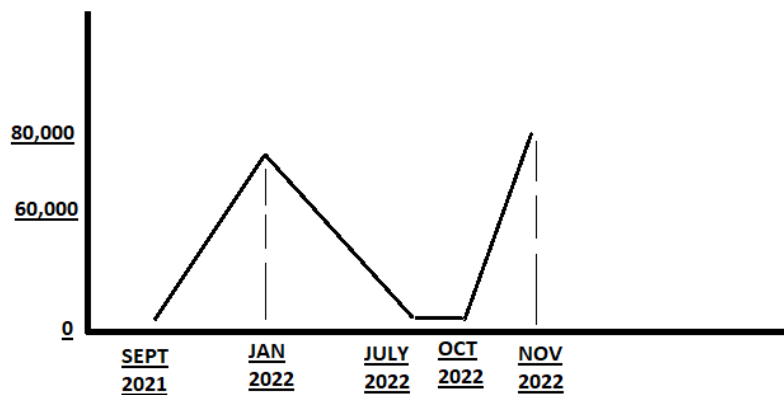
The greatest petrol consumption for the previous year was reported in October 2022, however there is a dramatic rise in consumption that month.

The maximum usage was recorded in January 2022, according to Figure 20, which also shows that power use remains comparatively consistent during the time. The carbon emissions from the building's energy use are depicted in Figure 21. According to the graph, petrol usage accounts for the bulk of emissions, which is in line with the information in Figure 20.

Moreover, Figure 20's graph shows that the Julian Hodge building's refectory M6 has the largest power usage. The greatest user of power, however, is the primary income area M1, which is ranked second. The building may be able to save the most energy in certain places, which is why this knowledge is crucial. The building may significantly cut energy use and its carbon footprint by concentrating on lowering energy consumption in high-use areas.



ELECTRICITY CONSUMPTION GRAPH OVERVIEW OF JULIAN HODGE BUILDING



GAS CONSUMPTION GRAPH OVERVIEW OF JULIAN HODGE BUILDING

- There is a gradual increase and decrease in gas consumption from September 2021 to June 2022 which has the highest consumption in January 2022
- But in October 2022 there is a sudden increase in gas consumption which has recorded equally as the highest consumption in the previous financial year.
- In Electricity Julian Hodge building has the highest consumption in refectory M6
- M1's main income is the second-highest consumption of electricity.

6.2 EUI: Energy Use Intensity

The energy use intensity (EUI) of a building is a measurement of its energy usage per square foot of floor space. It is computed by dividing the building's gross floor area by the sum of its energy usage. The EUI may be used to compare a building's energy performance to that of comparable structures and find areas for energy savings.

According to our data, the Julian Hodge Building has a higher EUI than the national average for non-residential buildings of its kind, at 102.5 kWh/sq.m. The building's lighting and HVAC systems, which make up a sizeable amount of the building's energy consumption, are the main causes of this high energy use.

In terms of energy efficiency, the Julian Hodge Building is a decent structure. Its energy efficiency might be raised with a variety of modifications, though.

1. The building envelope should be better insulated. The walls, roof, and windows would lose less heat as a result.
2. Better lighting fixtures should be installed. Because of this, lights would consume less energy.
3. Better heating and ventilation equipment should be installed. The energy used for heating and cooling would go down as a result.
4. the installation of a solar water heating system. The energy needed to heat the water would be less as a result.
5. Consider putting up a windmill. As a result, less power would need to be purchased from the grid because electricity would be generated locally.

The building's energy use would significantly decrease because of these upgrades. The payback period for these upgrades would be five to ten years.

A variety of additional actions might be taken to enhance the Julian Hodge Building's energy efficiency in addition to the suggestions made above. They comprise:

1. advising staff to switch off lights as they exit a space.
2. urging workers to use energy-saving gadgets.
3. promoting recycling and composting among staff.

4. installing motion detectors in places like corridors and other places where lighting isn't always necessary.
5. installing light timers in toilets and other locations where lights are frequently left on.
6. installing a building management system with energy consumption monitoring and control.

The Julian Hodge Building may drastically lower its energy usage and save money on energy costs by following these measures.

7 Measures to save Energy.

We have found a number of energy-saving techniques that can be used at the Julian Hodge Building to cut expenses and energy usage. These actions include:

7.1

7.1.1 Lighting upgrades:

Changing the building's lighting fixtures to more energy-efficient LED lights may dramatically lower energy expenses and usage. The building might save about 22,500 kWh annually if the existing lighting fixtures were changed out with LED ones.

7.1.2 HVAC System Upgrades:

Improving the building's HVAC systems may also save a lot of energy. Older, less energy-efficient HVAC parts can be replaced with more energy-efficient ones, such as high-efficiency boilers, chillers, and air handlers, which can reduce energy costs while enhancing indoor comfort.

7.1.3 Insulation and Air sealing

Improvements to the building's insulation and air sealing can also result in considerable energy savings. The structure may cut down on energy use and raise internal comfort levels by caulking air leaks and insulating walls, roofs and floors.

7.1.4 Control system optimisation:

Updating building automation systems, such as the lighting and HVAC controls, may help increase energy efficiency and reduce energy waste.

7.1.5 Renewable Energy Systems:

Setting up wind or solar energy systems can provide clean energy and reduce dependency on traditional energy sources.

7.2 Future Recommendations for the Engineering Services and Energy Performance

1. Use renewable energy sources more often: Using renewable energy sources like solar, wind, and hydropower may drastically cut greenhouse gas emissions and enhance energy efficiency. Businesses and governments alike should make investments in renewable energy sources and promote their usage through incentives and regulations.

2. Add smart technology: Using data analytics, automation, and sensors, among other smart technologies, can help you better manage your energy use. To save energy use and expenses, engineers have to think about integrating these technologies into construction projects and business operations.
3. Promote energy audits: Doing regular audits will help you find areas where your energy performance can be improved. Companies and governments should promote and provide incentives for routine energy audits to find inefficiencies and create plans to enhance energy performance.
4. Engineers should prioritise energy-efficient design concepts such as passive solar design, efficient HVAC systems, and optimum lighting design. Long-term, this can assist in lowering expenses and energy use.
5. Provide energy storage options: By creating affordable and effective energy storage options, it will be possible to increase energy performance and get around the intermittent nature of renewable energy sources. Engineers should concentrate on creating and implementing energy storage solutions for structures and business operations.

7.3 Monitoring and Verification Plan

7.3.1 Procedure

1. Specify the procedures to be followed for acquiring and analysing data related to energy efficiency measures in a monitoring plan.
2. The metrics that will be monitored, such as energy consumption, equipment performance, and interior environment, should be decided.
3. Plan the collection and analysis of data while taking seasonal variations and occupancy trends into account.

7.3.2 Tools

1. Use energy management software or building automation systems to gather and analyse data on energy use and equipment performance.
2. Installing submeters will allow you to monitor energy use at the system or piece of equipment level.
3. Maintaining your equipment on a regular basis may ensure top performance and help you identify any issues that can hinder your capacity to conserve energy.

7.3.3 Reporting Requirements

1. Establish the reporting requirements for energy usage and equipment performance, including their frequency, format, and distribution.
2. Create a dashboard that provides building managers and residents with real-time information on energy use and equipment performance.
3. Report on trends in energy usage and efficiency on a regular basis, emphasising areas that may be improved.

7.3.4 Risk and Difficulties

1. The challenges of monitoring and verification include a lack of resources for data collecting and processing, poor data quality, and inadequate knowledge or training among building workers, to name a few.
2. Risks associated with monitoring and verification include changes in building occupancy or equipment usage that have an impact on energy consumption, unanticipated maintenance difficulties that have an impact on equipment performance, or changes in weather patterns that have an impact on heating and cooling loads.

7.4 Implementation Strategy

A plan for implementing these energy-saving measures must be created, and it must include prioritising the recommendations, setting goals and objectives, forming an implementation team, creating an action plan, obtaining funding and incentives, putting the recommendations into practise, providing training and education, monitoring and evaluating the results, and reporting and celebrating success. The Julian Hodge Building may lower its energy use and expenditures while simultaneously raising the comfort level inside by adhering to this implementation plan.

8 Conclusions

The Julian Hodge Building at Cardiff University in the UK is thoroughly examined in this paper, along with its building engineering services and energy use. Building engineering services supply, building engineering services upkeep, and suggestions for energy audit and efficiency are the three primary elements that make up the paper. The purpose of the study is to conduct a thorough energy audit of the structure to locate places where energy efficiency upgrades may be performed to reduce energy usage and expenditures. Data collection, analysis, and auditing are all components of the process, which blends desk research with field research.

The electrical and gas supply systems, lighting, insulation, and HVAC systems are all covered in detail in the report. It also covers all floors and areas of the structure. Together with energy consumption information and certifications, it offers comprehensive schematics and diagrams of the building's energy and service distribution. The research gives a business case to support the advised course of action and looks at several organisational options for the upkeep of the building engineering services. There are no significant building renovation or repair projects that would call for significant changes to the facility's structure or services systems that are covered in this report.

This report only includes the energy analysis for audit till 2021 and for an effective analysis and more relevant recommendations we need to have the data till 2022 or early 2023 so that we can give more accurate measures.

9 References

- Cardiff University. (2009). *Cardiff University*. Retrieved from https://www.cardiff.ac.uk/__data/assets/pdf_file/0008/477152/Julian-Hodge-Ground-Floor.pdf
- DEC,UK. (2021, May 24). Retrieved from <https://find-energy-certificate.service.gov.uk/energy-certificate/0529-0163-2710-7100-1003?print=true>
- Durbin, M. (2023). Building Information and Schematics.
- Google Images. (2023). Retrieved from https://www.google.com/search?q=julian+hodge+building&sxsrf=APwXEdeSwCekv07RkAU5oWE92aoTBYEMFg:1683638869726&source=lnms&tbn=isch&sa=X&ved=2ahUKewi--onGq-j-AhW0SUEAHQYgAC4Q_AUoAnoECAEQBA&biw=1536&bih=792&dpr=1.25
- Google Images. (2023). *Interior of Julian Hodge Building* . Retrieved from https://www.google.com/search?q=interior+julian+hodge+building&tbn=isch&ved=2ahUKEwjS6b3Kq-j-AhXksEwKHWy-BXIQ2-cCegQIABAA&oq=interior+julian+hodge+building&gs_lcp=CgNpbWcQAzoECCMQJzoHCAAQGBCBFDxEIjIM2DRNWgAcAB4AIABVogBvwWSAQIxMJgBAKABAaoBC2d3cy13aXoW1n
- Lewry, S. H. (2020). *Gaining Values from ESOS Audits*.