Bristol Beacon

Post Occupancy Evaluation Report

February 2025

MAX FORDHAM

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Issue History

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Issue	Date	Description
01	12/02/2025	Issue
02	18/02/2025	Update

Contents

Summary of Findings

The points on the following 2 pages provide a high-level summary of some of the key findings which could improve the environmental and sustainability performance of the building. More detail can be found within the body of the report. Some findings are recommendations that BMT could potentially implement immediately, others are items require more involved works to change operation/controls. Lessons learnt from feedback from BMT can be found in a specific section within the report.

1. Energy benchmarking calculations could not verify accurate readings for electricity imported from the grid. This requires clarification and further review with the utility company to ensure accuracy of data.
2. Gas consumption (heating and hot water) benchmarking shows this is typical for a building of this type, broadly aligning with benchmarks from Julies Bicycle. Opportunities for a reduction in gas consumption are explored in order to save energy.
3. Energy meter labelling on the BMS should ensure it is clear what each meter is measuring. Some meters found to be not logging accurately.
4. Generally, keep each Hall AHUs off as much as possible to save energy. Restrict time schedules to show times only. The manual controllers could be modified or include an additional switch to turn each Hall AHU on/off if this is the FM preference, rather than using the time scheduling on the BMS.
5. It is not clear when the Hall AHUs are placed in 'seated mode' whether this ramps the fans up or down on temperature and CO_2 control. The assumption is that the fans will turn down to a minimum and if so, this will help save energy. If this isn't the case, an additional control setting could be added as 'comfort mode' which maintains space conditions outside of show times. However, note that the fans will still use a significant amount of energy even when turned down to their minimum.
6. Generally, use the Auto-standing setting for typical shows as this will modulate the fans, keeping them on a lower setting for longer and help to save energy.
7. AHU Kitchen - the air supply setpoint is relatively high (19°C). Experience has shown that kitchens can often operate satisfactory at 16°C supply air temperature in winter, so long as the space isn't be over ventilated.
8. Review CO_2 ppm setpoint of AHU 09A & 09B to reduce fan speeds and save energy.
9. Look at options to increase the flow of air in Hall 1 during busy shows to improve air quality. It is not clear what the purge setting does in terms of air flow rates. This should be considered along with acoustics and energy consumption.
10. There appeared to be negative pressure in Hall 2 leading to increased draughts from air being pulled in from gaps in the fabric. It is suggested to review the supply and extract flow rates of the air handing unit to ensure these are balanced. This might require some recommissioning of the air handling unit and volume control balancing dampers. Rectifying would also decrease gas consumption.
11. Intake temperature reading on AHU 02 appears high compared to the outdoor temperature (17.4°C compared to 9.6°C at the time). It is suggested to check this sensor is reading correctly as it might be impacting the AHU's control of the thermal wheel to provide heat exchange, leading to more gas consumption.
12. AHU 04 was found to be in cooling mode, which would not be expected given the time of the visit. This should be investigated.

Summary of Findings

13. Split out the LTHW time schedule so that there are separate time schedules for heating and hot water to allow them to be controlled independently.
14. Reduce the hot water time schedule to only be on when the building is operational. This might be possible via the controller on the gas fired calorifiers.
15. It would generally be expected that no heating would be required during the summer months and the system could be kept off for longer, therefore a suggestion is to reduce the summer off temperature within the BMS and monitor the effectiveness of this.
16. Suggest including increased control over communal area heating controls. Identify zones which have different usage profiles and install 2 port control valves with time schedules editable on the BMS. This will help reduce heating energy consumption.
17. Review the commissioning of the heating system to increase the difference (ΔT) between the flow and return temperatures. This will improve the efficiency of the system by reducing the system losses, decreasing the pump speeds, and improving the condensing ability of the boilers making them more efficient at turning gas to heat, as well as longer term make it more compatible with a district heating system.

Section 1.0

Introduction

1.1 Post Occupancy Evaluation

This report goes through the findings of a number of different items regarding the buildings' post occupancy performance. The evaluation has been conducted 1 year after handover and has been undertaken in line with the criteria and guidance to satisfy the BREEAM Man 05 'Aftercare' - #3 'Post occupancy evaluation (POE)' credit. Its purpose is to gain in-use performance feedback, with the aim to highlight any improvements or interventions that could be made to the environmental and sustainability performance.

This report includes:

- A review of key project aspirations for the building relating to sustainability, energy, operational carbon emissions, and occupant comfort.
- Feedback from key members of the facilities management and operations team within Bristol Music Trust (the building occupants) at Bristol Beacon.
- Analysis of energy and water consumption and comparing the results to design stage project targets as well as industry benchmarks.
- A review of the mechanical and electrical systems, which provide heating, cooling, hot water and ventilation, together with a review of the on-site Building Management System (BMS) and analysis of available sub-metered and environmental sensor data.

The findings within the report use information provided from Arcadis from available design stage information and as-built information from the O&M manual. Energy data was provided by BMT.

1.2 Project Overview

Project Summary

Bristol Beacon (formerly known as Colston Hall) is a historic building which is Grade II Listed. The Bristol Beacon Phase 2 redevelopment is a refurbishment project which consisted of:

- Restoring the original Victorian building.
- Restoring the main hall (Hall 1), second hall (The Lantern) and providing a new cellar music space (Hall 3).
- Proving spaces for music education, a restaurant, refurbished backstage areas and an improved entrance/foyer area.

The building is owned and supported by Bristol City Council and run by Bristol Music Trust (BMT), a registered charity established by the Council in May 2011 to develop the Bristol Beacon's artistic programme and promote music and music making in Bristol.

Bristol Beacon officially opened to the public on 30th November 2023, however, it should be noted that the building was only partially completed at this stage.

Sustainability Aspirations of the Project

An important objective of Bristol Beacon was to be an exemplar of environmental sustainability and accessibility within a listed building as well as to refresh, reimagine, preserve and offer a new life to this significant heritage asset.

Bristol Beacon targeted a BREEAM rating of 'Very Good', being the most consistent with the constraints of the existing site and buildings. The main roof has been provided with an array of PV panels, and all new services and lighting were designed to be minimise energy use.

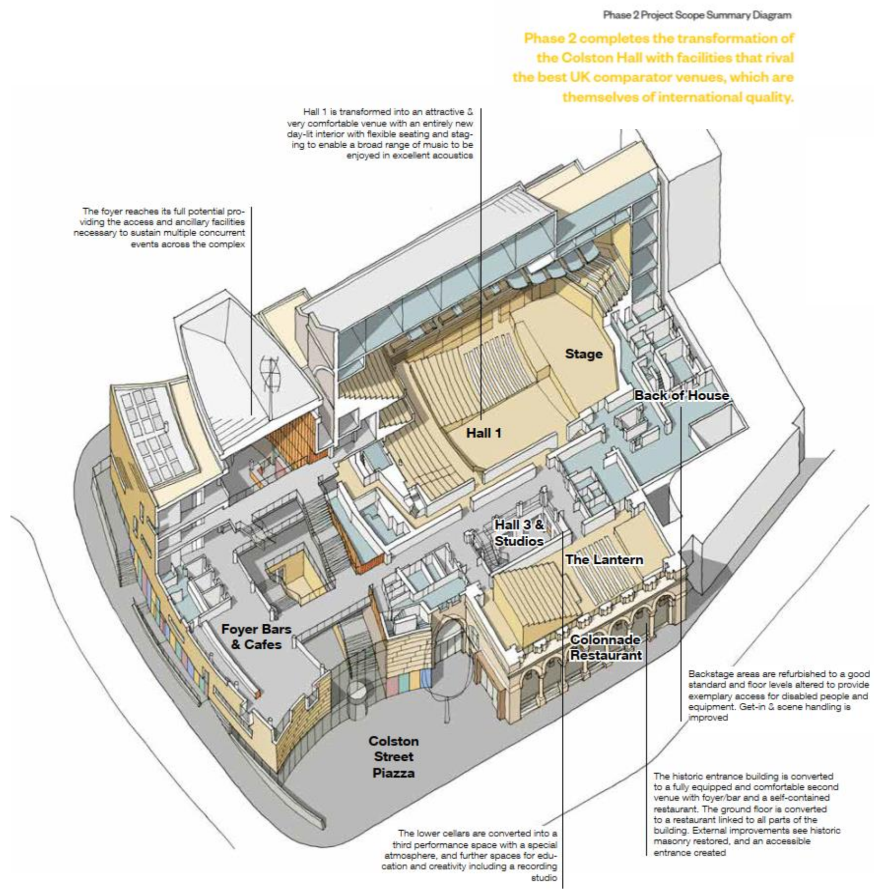


Image from Levitt Bernstein Stage 3 Report.

Section 2.0

Sustainable Energy & Design Strategy

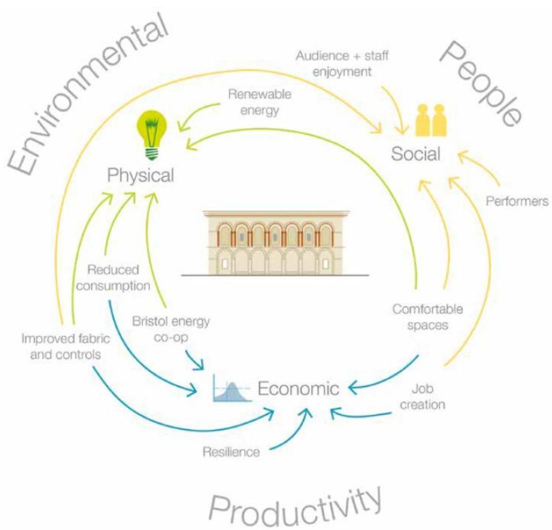
2.1 Sustainability Design Overview

As per the Stage 3 Project Report, the sustainable design enhancements for Phase 2 of Bristol Beacon set out to include:

- Developing the design in consultation with audiences, staff and performers
- Improving access and enjoyment for visitors and staff
- Improving the energy efficiency of the building fabric in key locations such as additional insulation in the roof and replacement windows
- Maximising the use of the existing building by bringing all areas of the building into beneficial use
- Providing new energy efficient, controllable heating, lighting and ventilation
- Significantly improved thermal comfort and acoustics for hall 1 with efficient ventilation systems and improved seating layout
- Providing natural light to the colonnade restaurant, foyers, halls 1 and 2 and other smaller backstage spaces
- Installing low flow water efficient fixtures and fittings where water equipment is replaced to reduce unnecessary water consumption
- Permitting more efficient operation and future maintenance
- Inclusion of roof mounted photovoltaic panels to offset energy consumption
- Designing for future-proofing through maintainability and durability
- Further increasing audience capacity and income from ticket sales
- Increasing business efficiency by enabling more performances to be held

Other sustainable actions included:

- Working with Julie's Bicycle – the project followed the principles outlined in their publication 'Fit for the Future Guide: Investing in Environmentally Sustainable Buildings', a guide for directors and managers of arts organisations developing capital projects.
- Working closely with the Energy Management Unit in Bristol City Council to ensure its' environmental impacts are monitored and managed.
- Commitment from BMT to reduce the negative environmental impacts of its activities; particularly relating to the business premises (energy use, water use and waste), business travel and staff commuting, communications material (posters, flyers etc.), events and office equipment.
- Targeting a BREEAM rating of 'Very Good' in line with Refurbishment and Fit Out 2014



2.2 Sustainable Energy Design Strategy

This section provides an overview of the building services and environmental design strategies. This is based on the energy modelling carried out in accordance with Bristol City Councils policy BCS 14. This involved creating a baseline energy model of the existing building, which is then compared to a proposed model incorporating the measures which aim to reduce the energy and carbon emissions. The existing services were based on site inspection from the modelling team (ARUP) and Building Regulations EPC convention guidance. Results of the modelling are presented at the end of this section

Heating (LTHW)

The existing gas boilers were assumed to have an efficiency of 65%. These were replaced with gas fired condensing boilers with an assumed seasonal efficiency of 95%.

The gas boilers are designed to feed a constant temperature (CT) circuit, operating at 80°C/50°C. This circuit feeds all the air handing units, radiators and overdoor heaters. Zones are controlled through thermostatic radiator valves.

There is an allowance for a future connection to the district heating network. Time frames are uncertain for possible connection.

Centralised air source heat pumps were investigated but due to the existing heat emitter sizing, it was deemed unfeasible to replace the existing high temperature system with a low temperature system. Space constraints also meant finding space for the external condensers was difficult, and therefore not cost effective.

Hot Water

Hot water is provided by gas fired water heaters (Calorifiers). The system recirculates water around the building for use in basins, showers etc.

2.2 Sustainable Energy Design Strategy

Cooling (CHW)

Existing cooling systems with an estimated Seasonal Energy Efficiency Ratio (SEER) of 2.2 were replaced with a new central chiller system (with an assumed SEER of 4.1).

The roof mounted air-cooled chillers run are designed to run at a constant flow/return water temperature of 6/14°C. This serves the air handing units (01A, 01B, 02, 03, 04, 05, 08) and fan coil units.

Ventilation / Air Handling

The design of the performance halls is providing ventilation through air handling units with air heated or cooled accordingly from the LTHW and CHW systems, with air supplied from a displacement system at low level.

The assumed specific fan power (SFP) of existing equipment of 3W/(l/s) replaced with high efficiency units with SFP of 1.8W/(l/s) and heat recovery of 75%, with the ability for demand control of fresh air.

Lighting

LED lighting was designed to be better than the lighting used by the Part L Notional Building (80lm/W) and controlled with occupancy and/or daylight sensors where appropriate.

The existing lighting was a mixture of low frequency ballast T8 fluorescents, compact fluorescents, some LED, high pressure mercury lamps and tungsten halogen lamps.

Building Fabric

It was assumed that the building had an air permeability pre-refurb of 25m^3/m^2.h @ 50 Pa, which was reduced to an avergae across new and existing elements of 19.5m^3/m^2.h @ 50 Pa. Table 1 below outlines the targetted U-values for the building in comparrison to the Building Regulations 'Notional Building'.

Table 1: *U-values for the building in comparison to the Building Regulations notional building.*

Element	Building Target	Part L Requirement	Notional Building
Wall New (W/m^2.K)	0.26	0.35	0.26
Wall Existing (W/m^2.K)	1.4	N/A	0.26
Ground Floor Existing (W/m^2.K)	1.2	N/A	0.22
Ground Floor New (W/m^2.K)	0.25	0.25	0.22
Roof New (W/m^2.K)	0.18	0.25	0.18
Roof Existing (W/m^2.K)	2.0	N/A	0.18
External Glazing New (W/m^2.K)	2.00	2.20	1.60
External Glazing Existing (W/m^2.K)	5.60	N/A	1.60
Air permeability (m^3/m^2.h @ 50 Pa)	19.5	N/A	3

Photovoltaics

A PV array was proposed at design stage with annual yield of 27,500kWh. The installed array based on the commissioning certificates will generate an increased amount, estimated at 116,387kWh (127kWp).

2.2 Sustainable Energy Design Strategy

Energy Modelling

The building was modelled in IES during the design stage with the results presented in a report titled "*Response to BCS14 Sustainable Energy*".

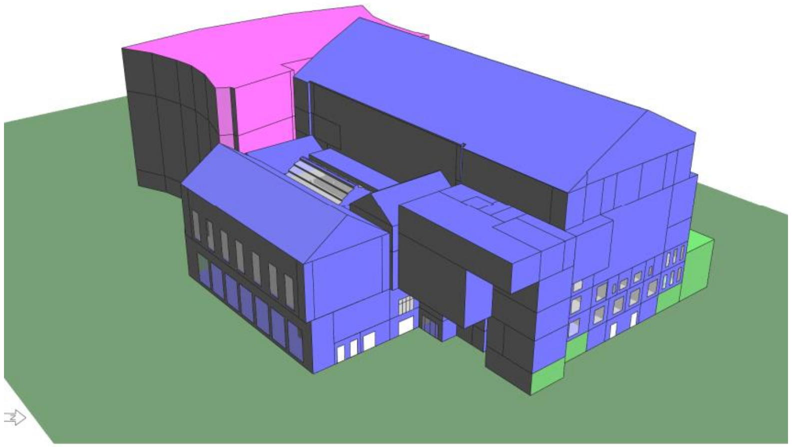
This presented the results of the current/existing building against the proposed scheme post refurb. The results are summarised and presented below in Table 2.

It should be noted that these figures are based on calculations used with the Building Regulations compliance modelling and so make a number of standardised assumptions about how the building is operated in order to provide a comparison.

Table 2: *Summarised results of the existing building against the proposed scheme post refurb.*

	Energy demand		Energy saving
	kWh/yr*	kWh/m²/yr**	
Pre-refurb Installation modelling	2,132,410	289	
Modelled scheme after energy efficiency measures (excluding PV)	978,390	132	54.1%

***Figures from *Response to BCS14 Sustainable Energy, 2017*.**
****Floor area of 7386m^2 used within as built EPC modelling.**



Colston Hall Phase 2 IES Energy & Thermal Dynamic Model

It should be noted that a Display Energy Certificate (DEC) was available for the building pre refurb, published in 2018, however this used a floor area significantly above what was expected and so it's not clear how this relates to the building or whether it is accurate. Certificate can be found here:

Display energy certificate (DEC) – Find an energy certificate – GOV.UK

The as built EPC certificate can be found here:

Energy performance certificate (EPC) – Find an energy certificate – GOV.UK

Section 3.0

Feedback from Building Users

3.1 BREEAM Requirements and Introduction

The BREEAM (Refurbishment and Fit Out 2014) requirements for feedback includes:

Feedback from a range of building users including facilities management on the design and environmental conditions of the building covering:

- *i. Internal environmental conditions (light, noise, temperature, air quality)*
- *ii. Control, operation and maintenance*
- *iii. Facilities and amenities*
- *iv. Access and layout*
- *v. Other relevant issues.*

Key building users were interviewed on the above topics with the discussion being led by Max Fordham. The interviewees were:

- Clare Jack (COO, Bristol Music Trust)
- Joe Allotey (Facilities Manager, Bristol Music Trust)

It was decided by BMT that the above were sufficient to gain building user feedback for the purpose of the POE exercise.

It was pointed out that BMT were only lightly involved in the design process; they went to meetings; however, Bristol City Council were who made the important decisions.

Bristol Beacon was due to open to the public in October 2023, but this was postponed to 30th November 2023. Although the building was still only partially completed at this point, due to confirmed performance commitments, Bristol Beacon had to open. This blurred the lines for the different stages of handover.

Project Team

Role	Company
Project Manager	Bristol City Council & Mace
Lead Consultant and Architect	Levitt Bernstein
Acoustician	Sound Space Vision
Theatre Consultant	Charcoalblue
Access Consultant	Attitude is Everything
Quantity Surveyor	AECOM
Structural Engineer	Arup
MEP Engineer	Arup
Lighting Designer	Arup
Fire Engineer	Arup
Catering Consultant	Kendrick Hobbs
Principal Designer	AECOM
BREEAM Assessor	Levitt Bernstein
Planning Consultant	Stride Treglown
Heritage Consultant	Alan Baxter
Consultation Consultant	Avril Baker Consultancy
Contractor	Willmott Dixon
MEP Sub-Contractor	TClarke
BMS Installer and Maintenance Team	ATS
End-User Client	Bristol Music Trust (BMT)

3.2 Facilities and Amenities

Feedback is generally positive regarding facilities and amenities, noting that the design meets the building's requirements despite constraints due to its Listed status.

However, there was a few issues noted regarding specific facilities. The loading and unloading area for performance equipment does not feature a dipped curve, which has caused problems with transporting the equipment to the lift. Also, this lift that connects the external access to the interior is a critical point of operation, and any failure could jeopardise a show. It was noted that this heavy reliance was not fully considered during the design phase. The garage doors in the loading and unloading area initially posed a safety issue, as they would not stop closing when obstructed, but these have since been replaced.

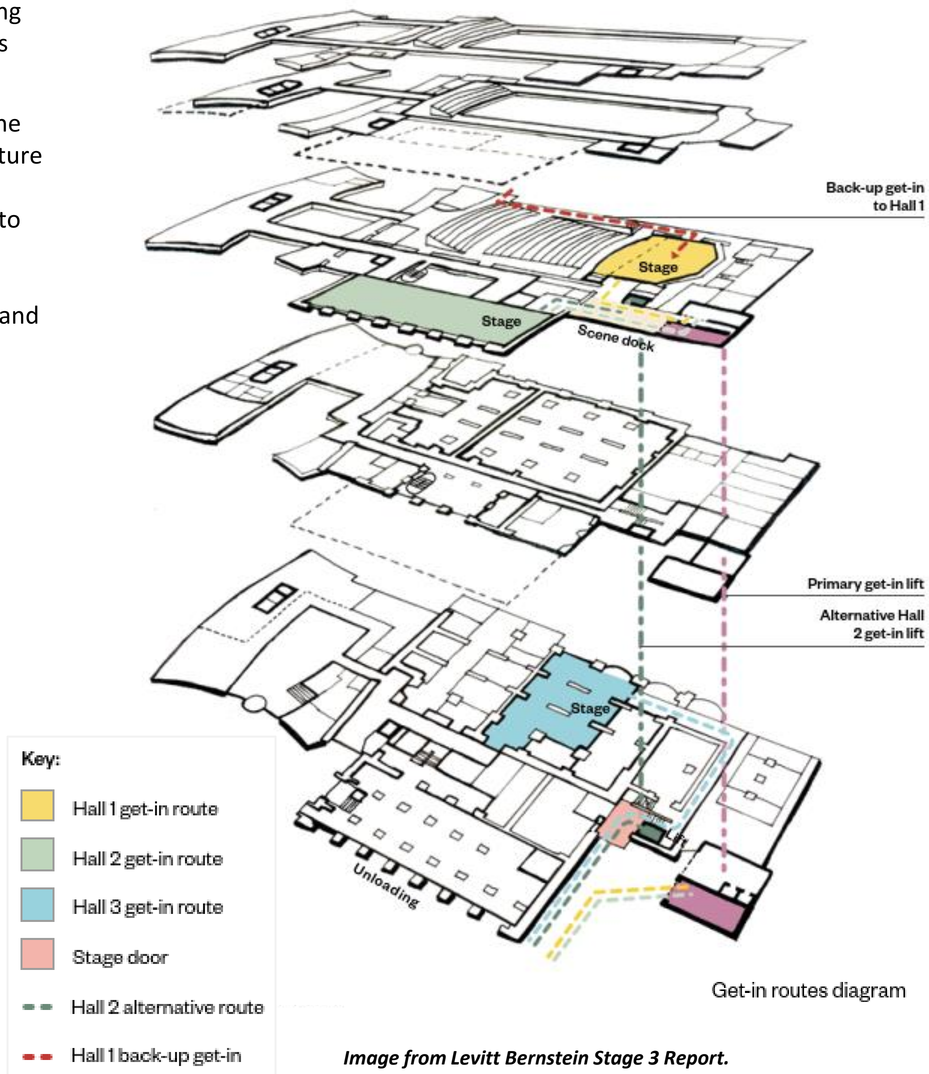


Image from Levitt Bernstein Stage 3 Report.

3.3 Internal Environmental Conditions

Temperature and Air Quality

Feedback highlighted several aspects regarding temperature and air quality management within the building. It was noted that achieving satisfactory temperature and air flow conditions for all building users took roughly six months. This extended adjustment period was largely due to the large variety of performances and events hosted in the building, each requiring different environmental settings. These adjustments involved frequent tweaks to the temperature and air flow settings in the BMS based on different user feedback.

Issues included a draught in Hall 2 (Lantern Hall) near the entrance doors, which was traced to a hole in the ceiling and addressed by the contractors (circled in yellow in image), however the issue has not fully been rectified. This is discussed in later sections. However, overall, temperature and air quality in the three main halls are now effectively managed through the BMS. Each hall is currently maintained at approximately 20.5°C, though adjustments between 20 and 21°C are occasionally required to meet user preferences due to variations in thermostat readings at different levels.

It was noted that in communal spaces, the temperature controls are less manageable. These spaces are connected through a single heating (LTHW) circuit, requiring manual adjustments within the spaces/rooms. It was expressed that it would be preferable for these controls to be integrated into the BMS for greater usability and efficiency. Since the communal space radiators need manual operation, the responsibility is left with the user of that room to remember to turn them down at the end of the day.

Additionally, it was noted that while CO_2 sensors are installed in the halls, such sensors are not present in other areas, which could be an area for future improvement to demand control the ventilation in these areas.

Noise

Noise levels from the air handling units (AHUs) are satisfactory, with no significant complaints. The building's purpose necessitated thorough testing for noise bleed between spaces, which has generally been well-managed. A minor issue was noted with noise bleed between Hall 1 and Hall 3 (Cellar Hall), which was slightly more pronounced than expected but is being actively managed. No noise bleed issues were reported between Hall 1 and Hall 2. Overall, the acoustics have been carefully considered and are functioning well in line with the building’s requirements.

3.4 Control, Operation and Maintenance

Control

BMT attended seasonal commissioning meetings with ATS so that they could clarify specific requirements for control and access in the BMS. While the system overall allows for some effective management, the BMS still requires further improvement – such as labelling meters within the system to easily identify which meter relates to which part of the building.

A challenge that arose in the earlier stages of developing the BMS was the transition from the installer team to the maintenance team, although both teams were within ATS. Better communication between teams could have reduced this issue.

Another challenge highlighted was around the integration of the BMS from Phase 1 of the project with the new system installed during Phase 2. In retrospect, further consideration should have been considered around the integration of the separate BMS systems especially since it involved combining refurbished and new building sections.

Note that additional comments on the control of temperature and air quality are detailed in the previous section.

Operation

BMT are now contracted with a new maintenance provider following the end of the defects period on 30th November 2024. Prior to this, maintenance was handled under the contract by TClarke. BMT were scheduled to receive a comprehensive BMS report from ATS during the week commencing 9th December 2024.

Maintenance

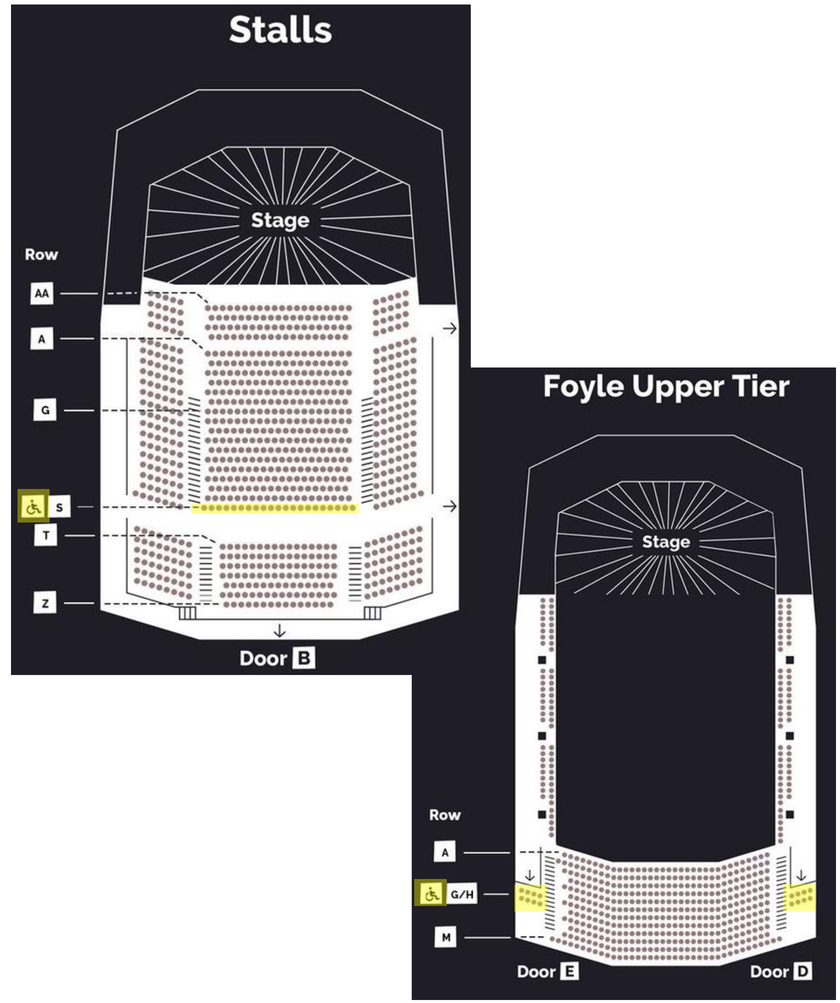
Physical access to plant equipment is generally straightforward, though some specific units, such as AHUs 09A and 09B, as well as certain ceiling dampers, can be challenging. Addressing these accessibility issues could improve the efficiency of routine maintenance and troubleshooting efforts, however it has been noted that these are not a significant barrier to maintenance thus far.

3.5 Access and Layout

While sufficient wheelchair spaces were provided, their placement and access to getting to the spaces could have been better thought out. Complaints have been received regarding concerts where other audience members stand up from their seats obstructing the view for those using wheelchairs. Additionally, wheelchair users currently lack the option to choose their seating location (see photos showing the seating layout in Hall 1), having the option between being at the front or back of the hall would have been more inclusive and provided greater flexibility for personal preference.

Accessibility-related equipment, such as lifts, frequently requires maintenance. Investing more in higher-quality systems initially could have reduced long-term costs.

BMT is currently targeting the Access is Everything “Gold standard” for accessibility facilities.

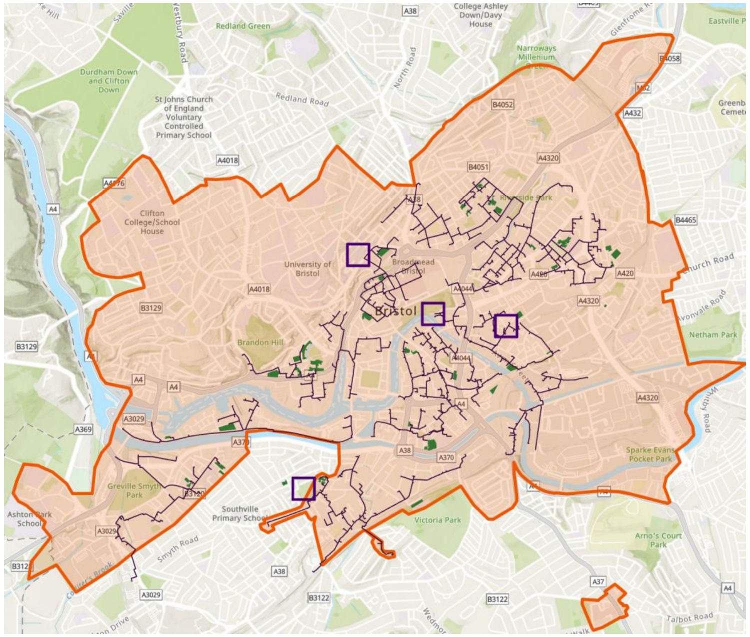


3.6 Energy and Water Consumption

BMT find gas metering straightforward for the entire building, with sub-metering available for the restaurant for tenant billing. However, the meters on the BMS, for both gas and electricity, need clearer labelling so that it easier to identify which meter is related to which part of the building (see screenshot form the BMS).

During the first year, BMT discovered they were paying a maximum electrical capacity charge based on a peak electrical load estimate of 1,600kVa, while actual usage was only 22kVa, resulting in a reported overpayment of £90,000 during the first year. This overestimation of the peak electrical demand would have been likely calculated based on the high power capacity of the building which was not close to be being realised in operation. It was also noted that another reason the power demand is significantly lower than the building's agreed power capacity, is due to performers often use low-energy equipment compared to what was likely assumed during the maximum capacity calculations.

A district heat network is due to be installed nearby, and the building has the ability to be connected to this which is part of the long-term energy plan (as shown on the site map showing the red highlighted potential heat zones). Feedback was positive regarding this.



3.7 Other Relevant Issues

Handover Process

Bristol Beacon was initially scheduled to open in October 2023, allowing BMT a planned three-month transition period to settle in and train staff before opening to the public. However, the project was only partially completed by November 2023, forcing BMT to develop their own training plan while the building remained under construction. On opening night, the fire system was not operational, presenting a major concern.

Handover responsibilities were included in the initial contract with Willmott Dixon, and relevant information was expected within six weeks of partial completion. It was noted that BMT only received the building user guide in late November 2024 with no notice and delivered via USB stick.

Obtaining essential documents, such as warranties and spares lists, also required significant effort from BMT. As operators, BMT could not proceed without this information and had to invest additional time and resources to bridge the gaps.

Value for Money and Business Objective

BMT has managed to operate effectively, despite operational challenges, the building has received substantial positive feedback from both the general public and performers.

Offices

Feedback on the office spaces was generally positive, and it was noted that the cooling seems to work well.
Some suggestions by BMT of things that could improve the spaces are; more natural lighting and more consideration around the desk arrangements and socket locations.

Sustainability

The PV panels were installed by Bristol Energy Cooperative and BMT buy the energy from them at a fixed rate. Currently BMT is exploring whether adding a small battery would help with optimising energy usage, however due to the relatively high constant building base load this may not be beneficial in terms of payback.

The building's design itself is highly sustainable, repurposing an existing structure.

BMT is working toward becoming operationally carbon neutral by 2030, with support from Hope Solutions. Initiatives include a green champions group, sustainable catering practices, and the use of green gas and electricity tariffs through SSE. One key challenge remains encouraging staff and visitors to opt for public transport instead of driving, and pilot programs like token incentives for greener travel are being trialled.

3.8 Lessons Learnt (Based on Feedback)

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The key lessons learnt based on the feedback from the building users included:

1. More involvement (as well as earlier involvement) from the building users so that building can fully meet their expectations and requirements.
2. Temperature and air quality management in a building this complex will take time. Seasonal commissioning is vital.
3. All spaces should ideally be controlled through the BMS, not just the main areas. This would need increased heating system zone control to allow the BMS to turn zones on/off when needed.
4. CO_2 sensors and demand-controlled ventilation should be installed in all spaces, not just the main areas.
5. Be wary of noise bleeding between spaces above and below each other (not just spaces next to each other).
6. Meters need to fully commissioned and clearly labelled in the BMS
7. For projects that are split into separate stages/phases/buildings with separate BMS systems, careful consideration on how to integrate these separate systems into one central BMS and how this can be done relatively easily is important and should be done at an early stage.
8. Consider ease of accessibility for all plant equipment (including ceiling dampers).
9. Provide alternatives for critical points of operation - e.g., for Bristol Beacon, there is only one lift which can transport performance equipment from the loading and unloading area, if this lift fails, the equipment cannot be transported to the required stage/hall and so the show cannot go ahead.
10. Consider the size and location of catering spaces in relation to the spaces in which the food is being made for.
11. Provide seating options for wheelchair users, such as so they can decide between being at the front or back of the hall.
12. Invest in higher quality accessibility equipment, this reduces maintenance costs in the long run.
13. Maximum electrical demand calculation need to be carefully carried out considering the equipment being installed and the diversity of the usage. It should also be noted that underestimating can be very problematic, and so the calculation needs to build in some tolerance to avoid this.
14. Consider power socket arrangements in relation to the desk layout in office spaces – it is common to have desks facing each other, so providing sockets only at the walls can require the use of a lot of extender sockets.

Section 4.0

Energy Consumption Analysis

4.1 Electricity Import

Data was taken from the electricity utility bills for the first full year that Bristol Beacon has been open to the public (December 2023 – November 2024) as well as from the BMS (total from the main switch board) and is displayed in Table 3.

This data provides the electricity imported from the national grid.

Bristol Music Trust were informed by their electricity supplier in December 2024 that the electricity metering has not been working correctly for the past year. Supposedly, issues with the meters have now been resolved, and so more accurate readings can be taken from now on.

It is believed that December 2024 reading is a reconciliation, but this reconciliation period is unclear. Because of this, accurate and reliable conclusions for yearly electrical energy consumption cannot be drawn from this electricity data provided.

Total electricity consumption on the main switch board (MSB) taken from the BMS shows higher consumption levels to the utility bills.

Extrapolated over a full year implies an annual import from the electricity grid to be roughly 9kWh/m^2/yr using the gross internal area provided by Arcadis of 8,362m^2. This is unrealistically low and doesn't align with the sub –metering (see section 4.3).

Note that in order to get a figure for the total energy use intensity the grid import value is added to the PV generation, as presented on the following page.

Table 3: *Data on electricity imported from the national grid collected from the monthly utility bills and downloaded from the BMS.*

Date	Per Utility Bills	Per BMS (MSB)	Difference
Dec-23	4,864	N/A	-
Jan-24	5,243	N/A	-
Feb-24	4,827	N/A	-
Mar-24	5,905	N/A	-
Apr-24	5,761	6,324	563
May-24	5,003	5,728	725
Jun-24	5,654	6,425	771
Jul-24	5,228	5,744	516
Aug-24	5,797	6,313	516
Sep-24	5,224	5,759	535
Oct-24	5,361	5,911	550
Nov-24	4,699	5,212	513
Dec-24	54,888	N/A	-

4.2 Electricity Generation (Solar PV)

Total annual PV generation is extrapolated based off the following two meter readings provided by Bristol Music Trust in Table 4.

Table 4: *Meter readings of the electricity generated from PV.*

Date	PV Generation (kWh)
28/11/2023	2,175
04/07/2024	61,1927

This gives an estimated annual generation of 119,504kWh/yr. This compares to the estimated PV generation of 116,387kWh.

It is worth noting that this 6-month period covers more of winter-time, so this calculation is likely an underestimation.

It could also be argued that the PV generation applies to the whole building, and so it shouldn't only be apportioned to Phase 2.

4.3 Gas Consumption

Data has been taken from the gas utility bills for the first full year of operation (December 2023 – November 2024) and is displayed Figure 1 below.

Highest consumption was in January and lowest was in August likely due to heating demand. January corresponded to the coldest month.

There is a noticeable difference between July and August. This could be down to the summer/winter switch which appeared to begin working at the end of July to shut off the heating system. See Section 5.10 Heating (LTHW).

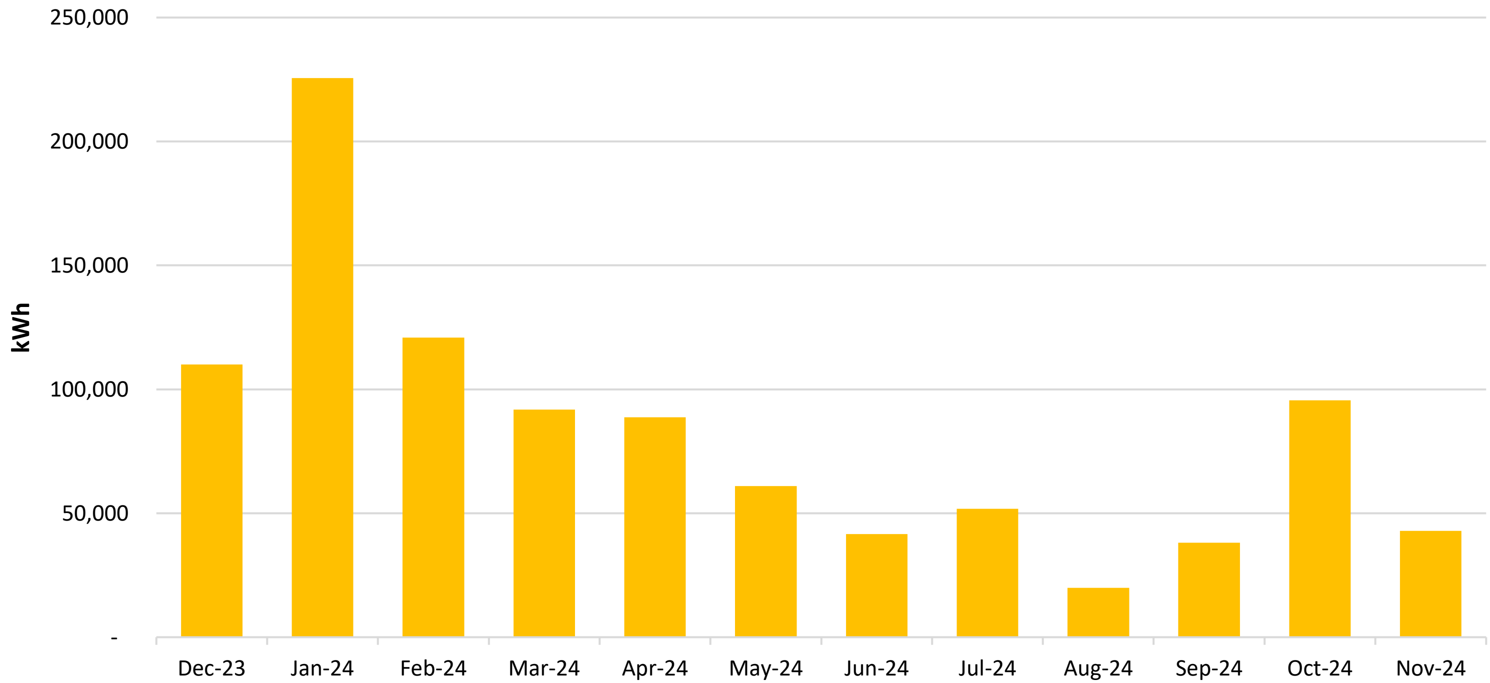

Figure 1: *Gas consumption per the utility bills at Bristol Beacon from December 2023 to November 2024.*

4.4 Energy Consumption Benchmark Comparison

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The available metered energy consumption has been compared to the design stage modelling and other building benchmarks and is displayed in Figure 2.

It should be noted that the electricity imported from the electricity grid is lower than we would expect for this building type, so backs up the suggestion that the data may be inaccurate. This if further backed up a calculation of the mechanical distribution boards presented on the following page.

Modelled energy demand is taken from the IES Energy & Thermal Dynamic Model done during the design stage. This is typically an underestimate due to the modelling assumptions used within the calculation software.

Julie's Bicycle takes data from 111 Performing Arts buildings measured between 2012 and 2014.

DEC benchmark is the 'Entertainment halls' energy data taken from TM46 Energy Benchmarks published in 2008. This benchmark broadly corresponds to a DEC D rating. A DEC A rating is a 75% improvement on this so the equivalent of around 143kWh/m²/yr.

Note: Bristol Beacon measured calculation is based on 8,362m² floor area provided by Arcadis.

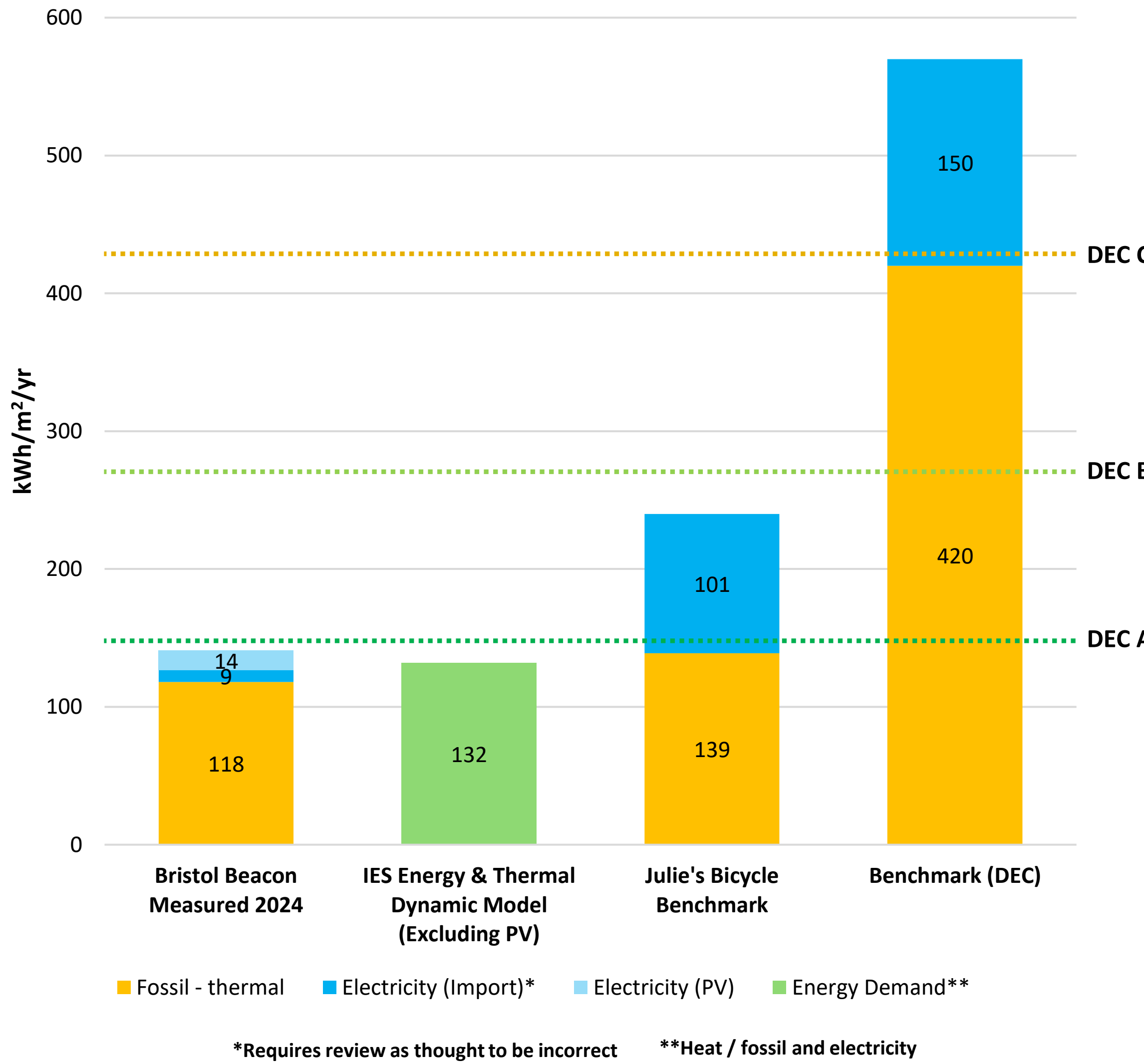


Figure 2: *Total measured energy consumption for Bristol Beacon compared to design stage modelling and other building benchmarks.*

4.5 Mechanical Electricity Consumption

Electricity consumption per mechanical distribution board were downloaded from the BMS. It was not possible to ascertain what plant is connected to each distribution board as the distribution board schedules were not within the O&M information. It is expected that the plant on these boards include as a minimum:

- Air handing units
- Chillers
- Fans and Pumps

Note that the data looks incorrect up to 18/04/24 where there is a sudden surge in power around the middle of the day – it is assumed that this value is the total energy consumption up to this date. Only data from 19/04/24 onwards has been analysed.

Table 5 shows the calculated average energy consumption per day per distribution board.

DB-Mech1-06 has the highest average energy consumption per day, this is due to high energy loads in the evening/midnight over different days. This is likely due to the load from AHU 01A & 01B and chillers.

This leads to a total energy consumption of **17kWh/m²/yr** for the mechanical distribution boards.

Compared to the assumed total energy consumption of 23kWh/m²/yr (electricity consumption and PV generation combined), this is a large proportion which further implies inaccuracy in the electricity data available.

Table 5: *Average daily electricity consumption per mechanical distribution board. Data downloaded from the BMS.*

Distribution Board Reference	Average Energy Consumption Per Day (kWh)
DB-Mech1-01	7
DB-Mech1-06	224
DM-Mech1	11
DB-Mech2-01	22
DB-Mech2-05	81
DB-Mech-B1	33

4.6 Water Consumption

Data has been taken from the water utility bills for the first full year that Bristol Beacon has been open to the public (December 2023 – November 2024) and is displayed in Table 6.

Note that the December to February 2024 water consumption is an average based off a total of 2,258m^3 from a water bill which covers the period 07/09/24 to 28/02/24. This leads to the average water consumption per month being roughly 376m^3.

Water consumption is much higher in August which is likely due to underestimated water consumption between the two last actual meter reading on 06/03/24 and 15/08/24.

Table 6: *Average daily electricity consumption per mechanical distribution board. Data downloaded from the BMS.*

Bill Month	Total Used (m^3)	Last Actual Reading
Dec-23	376	06/09/2023
Jan-24	376	-
Feb-24	376	28/02/2024
Mar-24	279	06/03/2024
Apr-24	417	Estimated
May-24	430	Estimated
Jun-24	484	Estimated
Jul-24	499	Estimated
Aug-24	1108	15/08/2024
Sep-24	516	Estimated
Oct-24	565	Estimated
Nov-24	522	Estimated

Section 5.0

Mechanical & Electrical Review

5.1 Air Handing Units (AHUs)

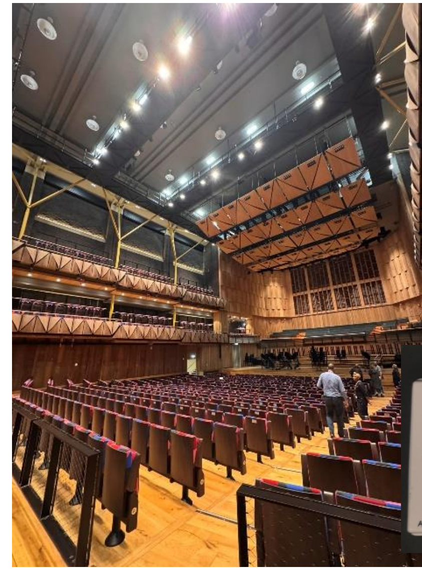
The following sections focus on the review of the operation of the main air handling units . Particular focus was paid to the AHU operation/control in Halls 1 and 2.

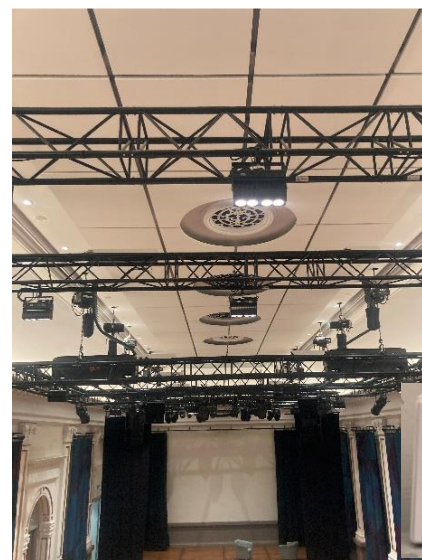
The general recommendation to help save energy is to keep the air handling units off for as long as possible, only having them on when a show is happening. This will require the time schedules to be regularly altered.

The controls of the AHUs could be changed so that the BMS has more control over the fan settings. This will require changing the controllers to digital devices which have a two-way control signal to the BMS allowing the BMS to over-right the manual control. This would allow remote control of the AHUs regardless of the manual control settings. There could also be a manual on/off switch added making it easier to keep the AHUs off, without constantly changing the time schedules. In addition, an “Environmental mode” could be included which maintains space temperature conditions whilst running the fans at their lowest fan speeds. Instructions could be printed next to each controller.

Generally, for shows, keep the controls set in ‘Auto Standing’ so that they ramp up and down automatically helping to save energy whilst ensuring optimal space conditions are achieved. Avoid using the ‘Standing’ setting where possible as this will use the most energy. Note that the AHU was in standing mode during the site visit walkaround.

More detail is provided in the following sections.





5.2 AHU Hall 1 (Main Hall)

Hall 1 is mechanically ventilated, utilising a displacement strategy whereby the tempered supply air is provided at low level, utilising the voids below the raked seating used as plenums and extracted at high level above the stage.

Hall 1 is served by a pair of dedicated variable-speed air handling units (AHU 01A & 01B) with re-circulation, heat recovery and free-cooling capability to meet the ventilation, temperature and acoustic criteria. The tempered air is cooled or warmed as necessary to achieve space conditions of 21°C (min) in winter.

Ventilation and Fan Speed Control

- The brief asks for a standing capacity of 2,174 people. It was noted in the brief that the fresh air would be designed on the basis of 10l/s/p, with a purge and cooling rate of 16l/s/p. This equates to 21,740 (21.73 m³/s) – 34,780 l/s (34.78 m³/s)
- Within the des ops / as built drawings the fan speeds are adjusted through a three-position switch for Seated (10.89 m³/s), Auto Standing (10.89 – 13.2 m³/s), Standing (13.2 m³/s), as well as a switch to Purge.
- It's worth noting that the brief does not align with the as built information. There are many reasons why this difference has occurred, included spatial and acoustic issues.
- In Auto Standing, fan speed modulates to maintain CO_2 levels below 1000ppm, monitored by a duct-mounted CO_2 sensor, and/or follows the time schedule on the BMS.

Hall 1 (AHU 01A & 01B) Fan Speed Controls.

Hall 1 - three ventilation modes:

1. **Seating –** normal mode: The AHUs operate at a reduced constant to maintain the temperature and CO_2 within the space. [10.89 m³/s]
2. **Standing –** boost mode: The AHUs operate at an increased constant volume. [13.2 m³/s]
3. **Auto standing –** the AHU modulates from 'seated' volume to 'standing' volume, once the CO_2 and temperature set points are exceeded [10.89 – 13.2 m³/s]

As well as a **Purge** switch which boosts the fans to maximum speed. It is not clear what this commissioned speed is.

5.2 AHU Hall 1 (Main Hall)

The current time schedule for Hall 1 (as pictured):

True (AHU on) 8:30am – 12am

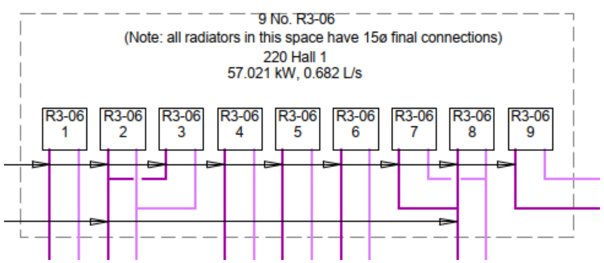
False (AHU off) 12am – 8:30am

It would be recommended to generally keep the AHU off for as much time as possible to save energy and only turn it on when a show is happening.

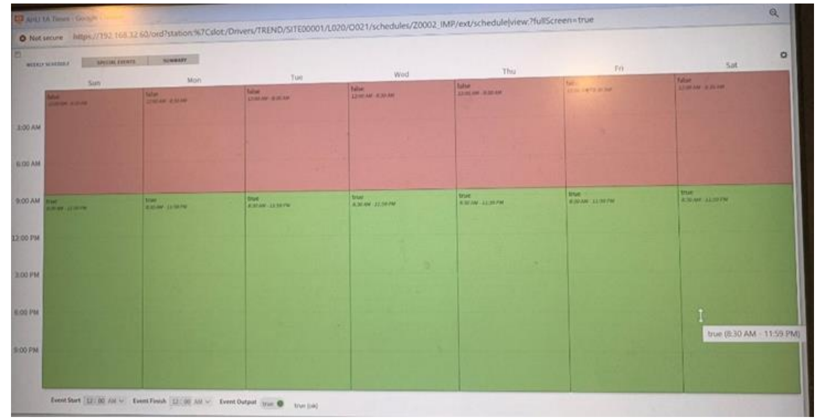
To illustrate the energy consumption, if the AHU is left on for 15.5hrs in seated mode the fans alone will use around 100,000kWh/year costing approximately £25,000/year. There will also be additional energy used for heating/cooling not accounted within this calculation.

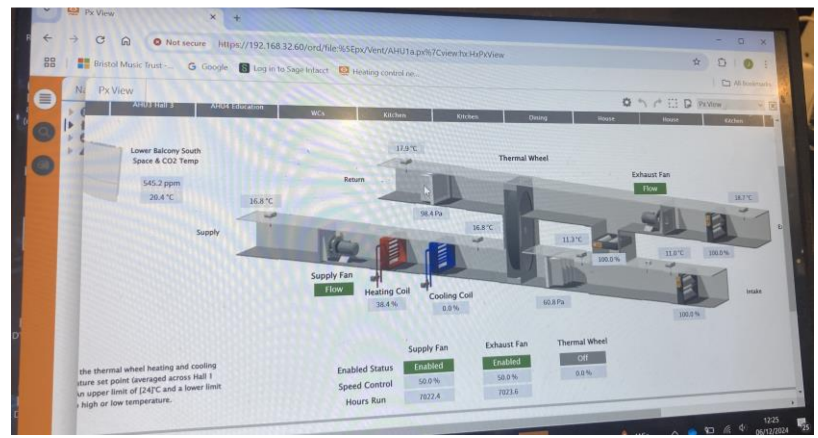
It is not clear whether when in 'seated mode' the AHUs are controlled on temperature and CO_2. If this is the case, the fans should ramp down to a minimum. However, the minimum speed will still be relatively energy intensive (~30% of the peak design rate).

It is understood from the heating schematic that there are also radiators in the space. These were not observed during the site visit. These could be used for space heating, rather than relying on the AHU to provide heat however there is no central control of these. A general recommendation is to look at some zone control of the heating system which is mentioned elsewhere in the report (See Section 5.10).



A button could be added to the manual control to switch it on/off, rather than relying on the time schedule. Otherwise keep the time schedule off when a show isn't happening.





5.2 AHU Hall 1 (Main Hall)
Internal Conditions and AHU 01A

Figure 3 shows the internal conditions and AHU 01A supply and extract air temperatures during the time of a performance to review how the system performs in operation.

The example performance used is when Interpol performed on 7th November 2024, at these times (as per Interpol | Bristol Beacon):

Doors: 19.00
Dust: 19.45
Interval: 20.30
Interpol: 21.00
Finish: 22.30

From around 8pm CO_2 levels gradually rose up to 1900ppm. CO_2 levels above 1000ppm will begin to indicate that the space feels stuffy.

The temperature was well controlled by the cooling via the supply air temperature supplied by the AHU.

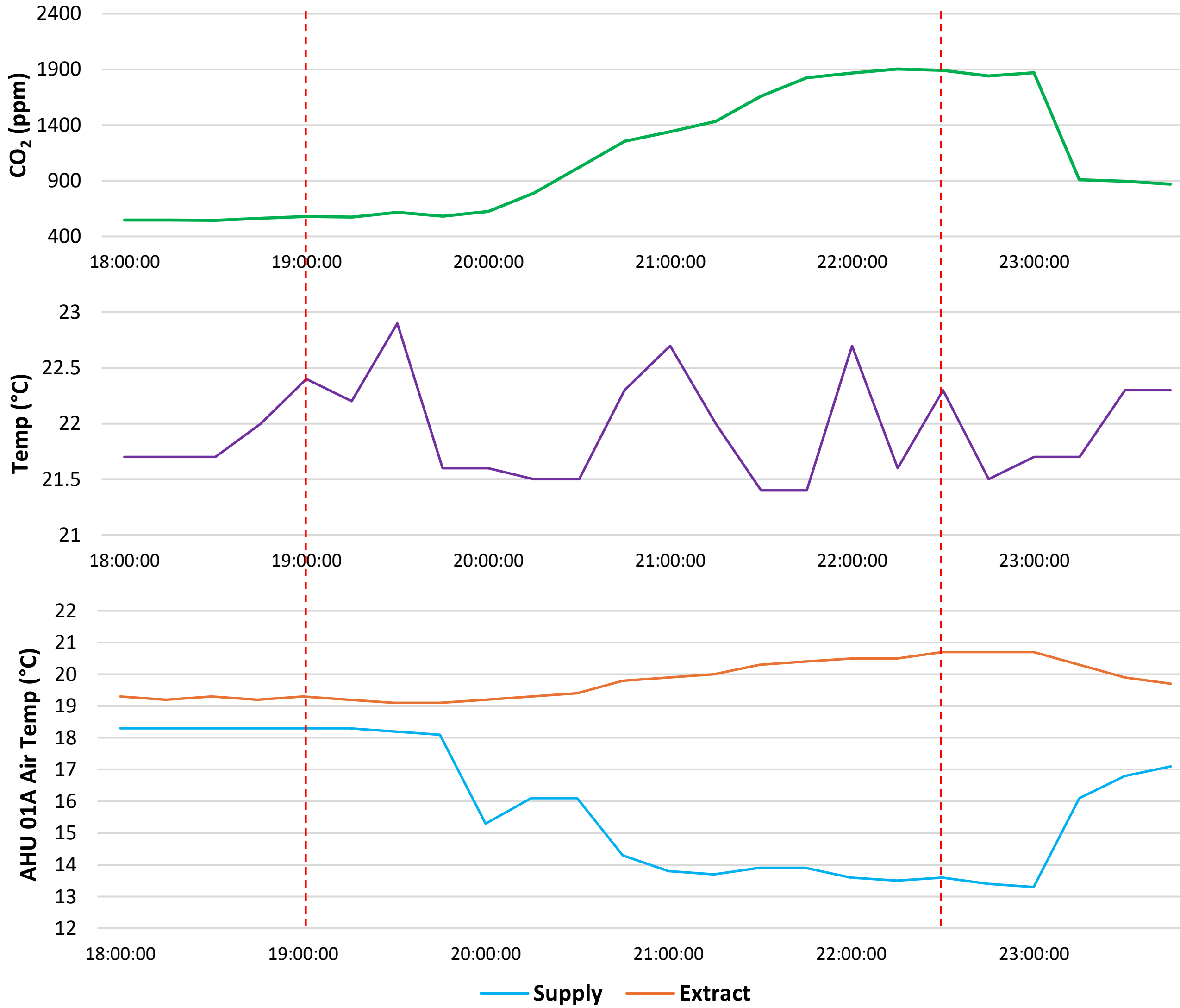


***Figure 3:** The internal conditions and AHU 01A supply and extract air temperatures during a performance in Hall 1 (Interpol, 7th November 2024).*

5.3 AHU Hall 2 (Lantern Hall)

Hall 2 is mechanically ventilated utilising a displacement strategy whereby the tempered supply air is provided at low level, utilising the void behind the retractable seating (either extended or retracted) as a displacement plenum and extracted at high level from the ceiling via the existing and new roses. The tempered air is cooled or warmed as necessary to achieve space conditions of 21°C (min) in winter.

Temperature and CO_2 levels are controlled via a combined sensor located within the Hall.

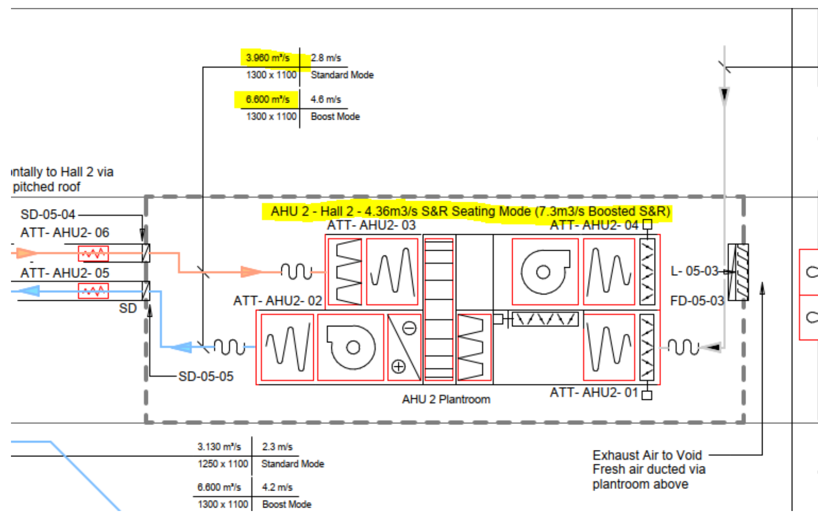
Hall 2 (AHU 02) Fan Speed Controls. Current setting was 'Standing'.

Hall 2 has three ventilation modes:

1. **Seating –** normal mode: The AHUs operate at a reduced constant to maintain the temperature and CO_2 within the space. [4.36 m³/s]
2. **Standing –** boost mode: The AHUs operate at an increased constant volume. [7.3 m³/s]
3. **Auto standing –** the AHU modulates from 'seated' volume to 'standing' volume, once the CO_2 and temperature set points are exceeded [4.36 – 7.3 m³/s]

As well as a **Purge** switch which boosts the fans to maximum speed.

The speed setting on the BMS des ops (above, do not appear to match those on the ventilation as built drawings).

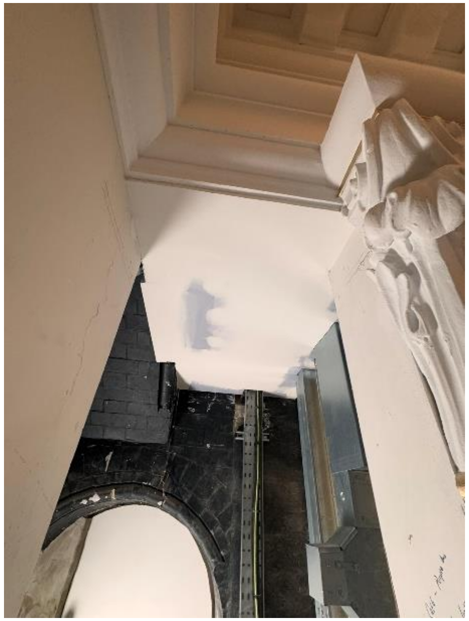


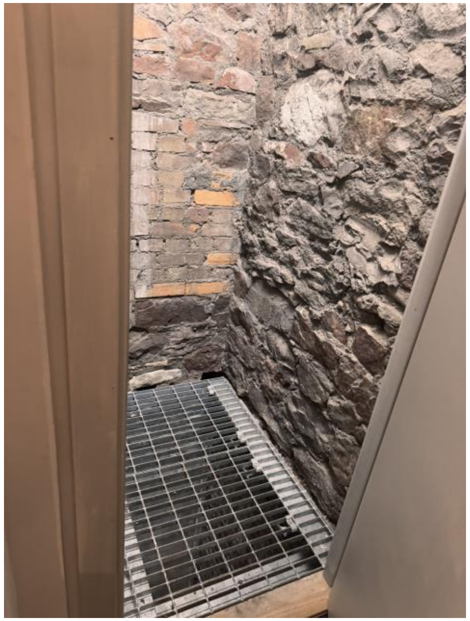
5.3 AHU Hall 2 (Lantern Hall)

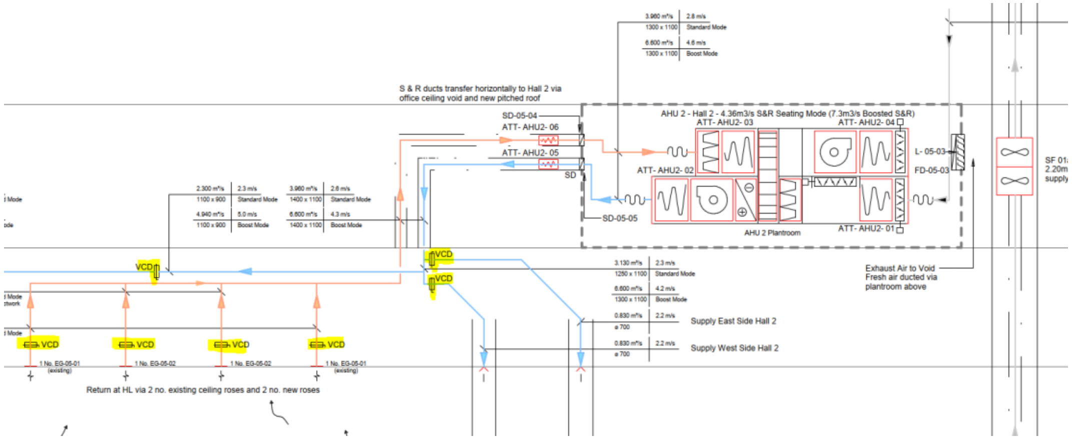
Draughts have been noticed by building users when entering Hall 2 – this was thought to be due to a hole in the ceiling, which was pointed out to, and subsequently filled in by, the contractors (image left).

There was also a noticeable pressure difference when opening the doors. This suggests that there is a pressure imbalance in the air handling unit which is causing a negative pressure created through higher extract flow rates compared to supply. This is sucking in air from the outside through gaps in the fabric causing draughts and excess cold air.

The commissioning certificates should be reviewed and testing carried out to ensure balanced airflows of the supply and extract at the different control settings. This may require an inspection and testing of the Volume Control Dampers (VCDs) (highlighted in yellow. Access could be difficult.







5.3 AHU Hall 2 (Lantern Hall)

The current time schedule for Hall 2 (pictured):

Sunday – Friday

True (AHU on) 8:00am – 1:30am

False (AHU off) 1:30am – 8am

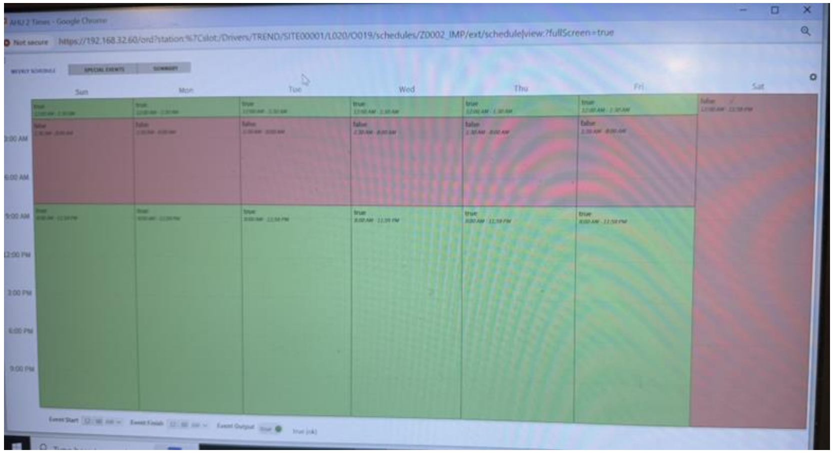
Saturday

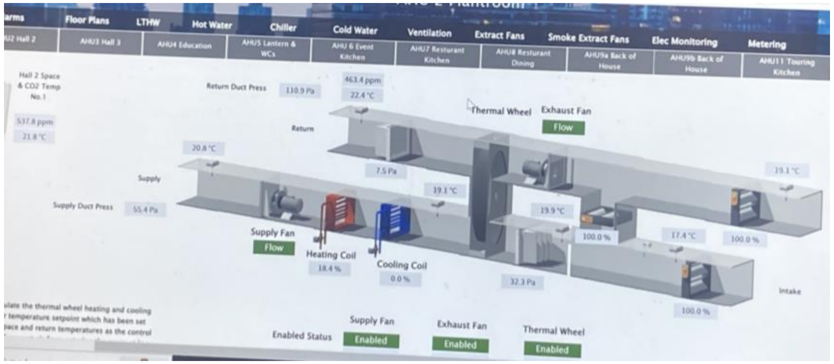
False (AHU off) all day

As with Hall 1 it would be recommended to generally keep the AHU off for as much time as possible to save energy and only turn it on when a show is happening. As with Hall 1 the AHU running will use a lot of energy.

It is not clear whether when in ‘seated mode’ the AHUs are controlled on temperature and CO_2. If they are the fans should ramp down to a minimum. However, the minimum speed will still be relatively energy intensive (~30% of the peak design rate). Avoid using the ‘standing mode’ unless needed.

Intake temperature reading appears high compared to the outdoor temperature (17.4°C compared to 9.6°C at the time). It is suggested to check this sensor is reading correctly as it might be impacting the AHU’s control of the thermal wheel to provide heat exchange, leading to more gas consumption.





5.3 AHU Hall 2 (Lantern Hall)
Internal Conditions

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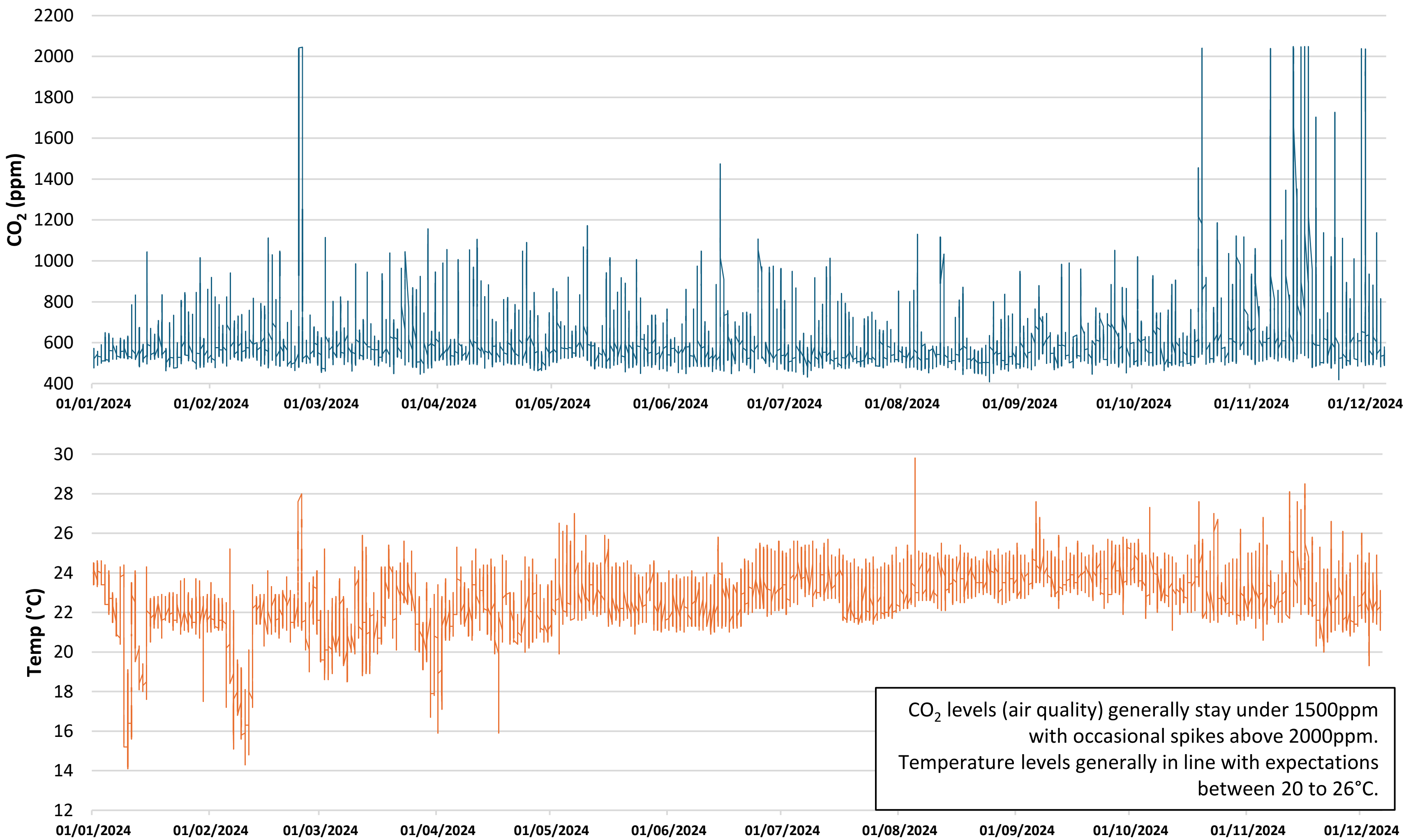


Figure 4: *The internal conditions in Hall 2 from January 2024 to end of November 2024.*

5.4 AHU Hall 3 (Cellar Bar)

Hall 3 is mechanically ventilated utilising a hybrid sideways-displacement ventilation strategy whereby the tempered supply air is supplied from the three end-walls of the longitudinal vaults (the audience end) and extracted at high level via the bar (the stage end). Hall 3 is located in an arched cellar with no opportunity to run large services via the lower cross-arches due to limited headroom. A new trench system through the lower cellar floor was created to route ductwork to each individual longitudinal arch with local risers serving each of the end- wall plenums. The tempered air is chilled or heated as necessary to achieve space conditions of 21°C (min) in winter.

Hall 3 is served by a dedicated variable-speed air handling unit (AHU 03) with recirculation, heat recovery and free- cooling capability to meet the ventilation, temperature and acoustic criteria.

Ventilation and Fan Control

- Fan speeds are adjusted through a four-position switch for Seated, Auto Standing, Standing and Recording, as well as a switch to Purge. In Auto Standing, fan speed modulates to maintain CO_2 levels below 1000 PPM and/or follow the time schedule on the BMS. In Recording, noise is minimal during noise-critical performances.
- The dampers adjust between 20% and 100% based on CO_2 levels. If CO_2 exceeds 1000 PPM, damper positions open for increased fresh air intake.

Hall 3 (AHU 03) Fan Speed Controls

Hall 3 has four ventilation modes:

1. **Seating –** normal mode [2.4 m³/s]
2. **Standing –** boost mode [3.4 m³/s]
3. **Auto standing –** modulating mode [2.4 – 3.4 m³/s]
4. **Recording** – whisper mode: the AHUs operate at a further-reduced constant volume. [1.7 m³/s]

As well as a **Purge** switch which boosts the fans to maximum speed. It is not clear what this commissioned speed is.

5.4 AHU Hall 3 (Cellar Bar)

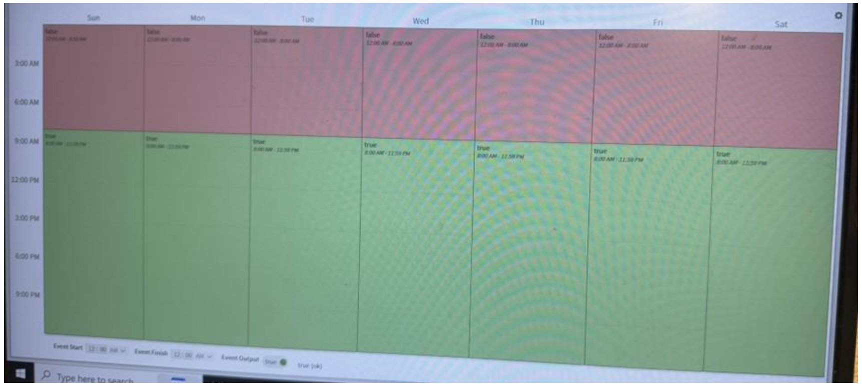
The current time schedule for Hall 3:

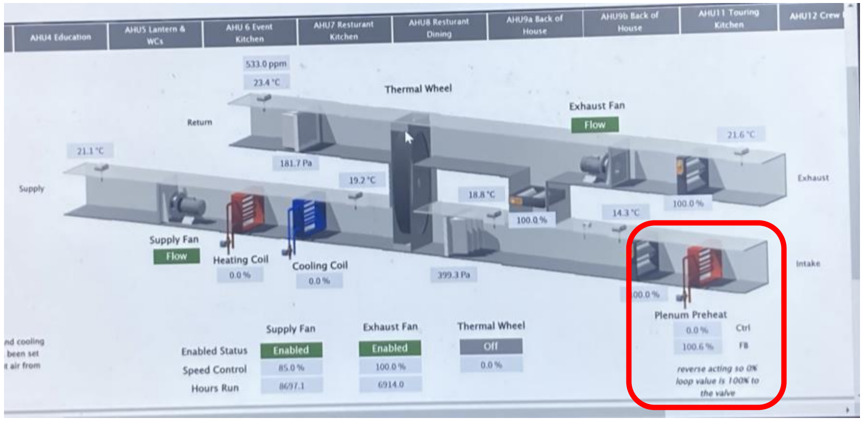
True (AHU on) 8:00am – 12:00am

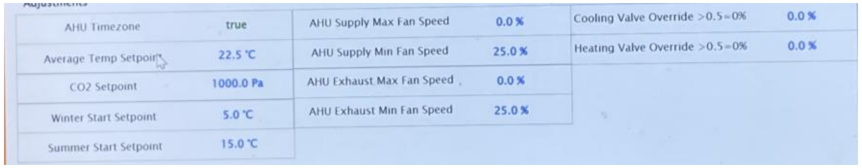
False (AHU off) 12:00am – 8:00am

The time schedule might have the potential to be reduced down to help reduce energy consumption as generally spaces connected to this AHU might not need to be operational during the day.

The plenum pre-heat (highlighted in red) should be checked to ensure this isn't operating unnecessarily as it will take away the effectiveness of the thermal wheel to provide high efficiency heat exchange and lead to increased gas consumption if it is used. This does not seem to be on the heating schematic drawing and it's not clear why it is needed.





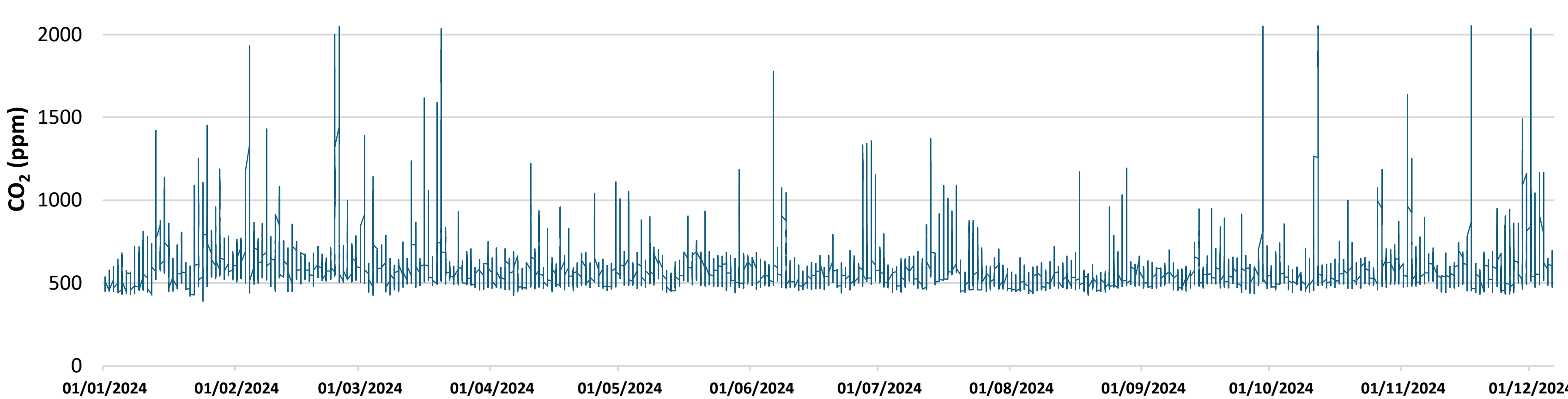


AHU Timezone	true	AHU Supply Max Fan Speed	0.0 %	Cooling Valve Override >0.5=0%	0.0 %
Average Temp Setpoint	22.5 °C	AHU Supply Min Fan Speed	25.0 %	Heating Valve Override >0.5=0%	0.0 %
CO2 Setpoint	1000.0 Pa	AHU Exhaust Max Fan Speed	0.0 %		
Winter Start Setpoint	5.0 °C	AHU Exhaust Min Fan Speed	25.0 %		
Summer Start Setpoint	15.0 °C				

5.4 AHU Hall 3 (Cellar Bar)
Internal Conditions

CO_2 levels generally stay under 1500ppm.

Temperature levels generally stable, in line with expectations between 20 to 25°C.



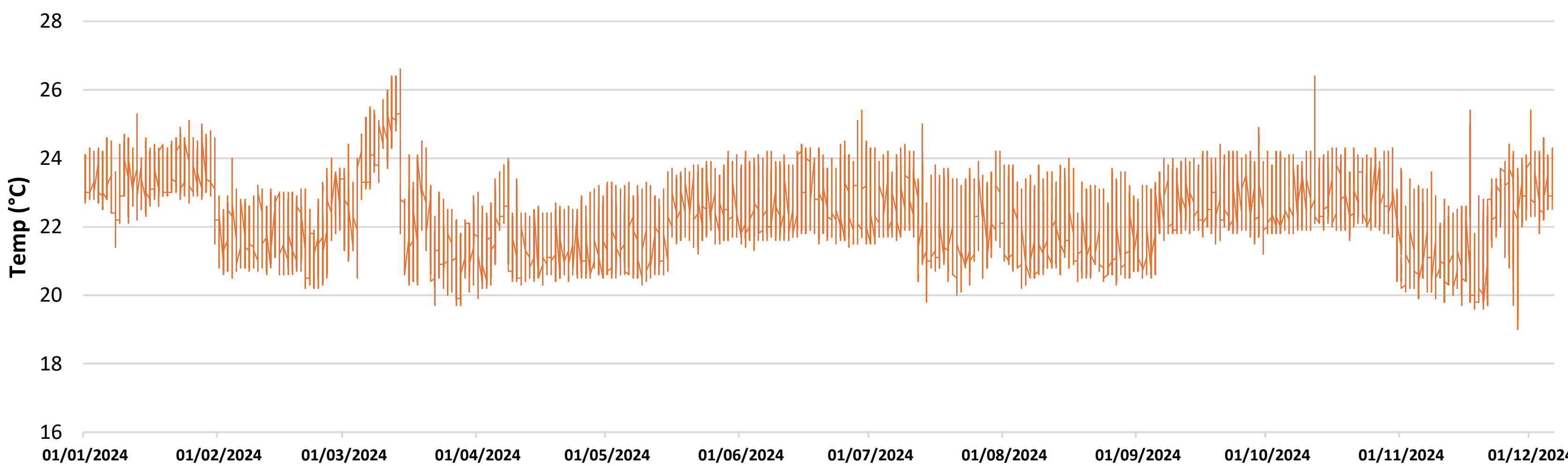


Figure 5: *The internal conditions in Hall 3 from January 2024 to end of November 2024.*

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5.5 AHU Education Spaces

The current time schedule for the education spaces:

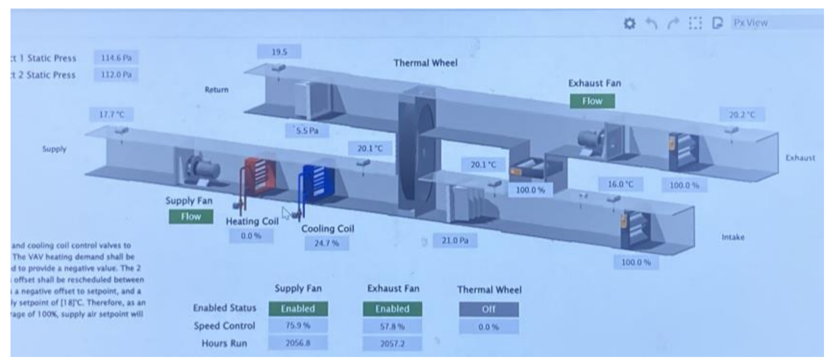
True (AHU on) 8:00am – 12:00am

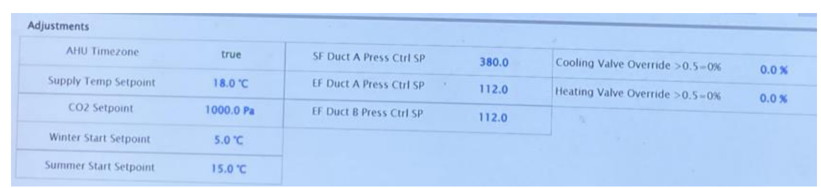
False (AHU off) 12:00am – 8:00am

This time schedule might have the potential to be reduced down to help reduce energy consumption as generally spaces connected to this AHU might not need to be operational late at night.

The intake temperature is high, with the AHU in cooling mode. This would not be expected in the winter season and will be resulting in a situation where the Ahu supply air is being cooled, and then the spaces heated back up through the radiators.

It's suggested to investigate the intake supply temperature sensor for accuracy and ensure that during winter the AHU is not going into cooling mode unnecessarily. For the majority of the time the unit should operate in free cooling to achieve the supply air temperature set point.



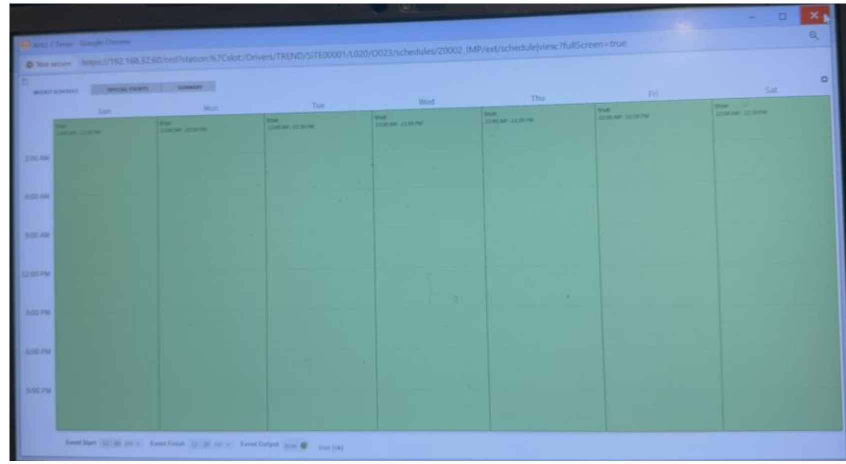


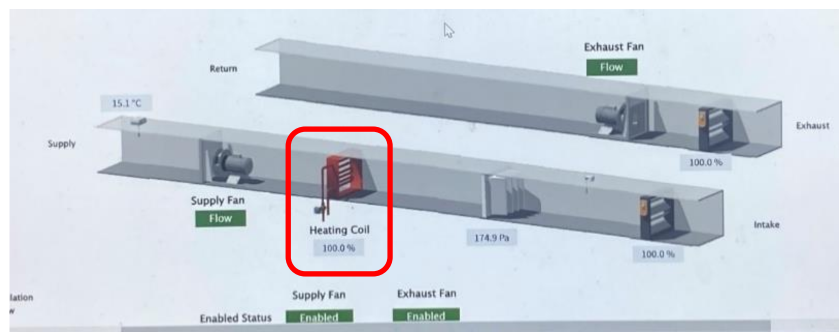
5.6 AHU Restaurant Kitchen

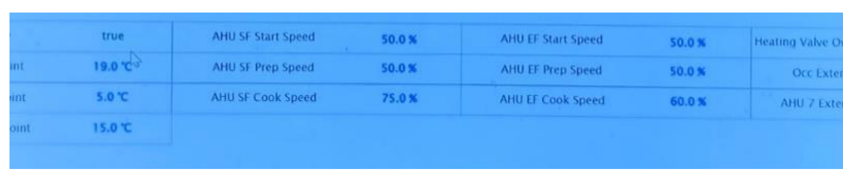
The time schedule is set 24/7. It's suggested to review this with the kitchen staff and how they use the local controls. Ensuring the fans are not on out of hours would reduce energy.

The air supply setpoint is relatively high (19°C). Experience has shown that kitchens can often operate satisfactory at 16°C supply air temperature in winter, so long as the space isn't be over ventilated. This would also help to reduce overheating in other seasons. This setpoint should be turned down in the summer to avoid pre heating the kitchen.

The kitchen air handling does not have heat recovery so pre heating the supply air too much will use a significant amount of energy.







5.7 AHU Restaurant Dining

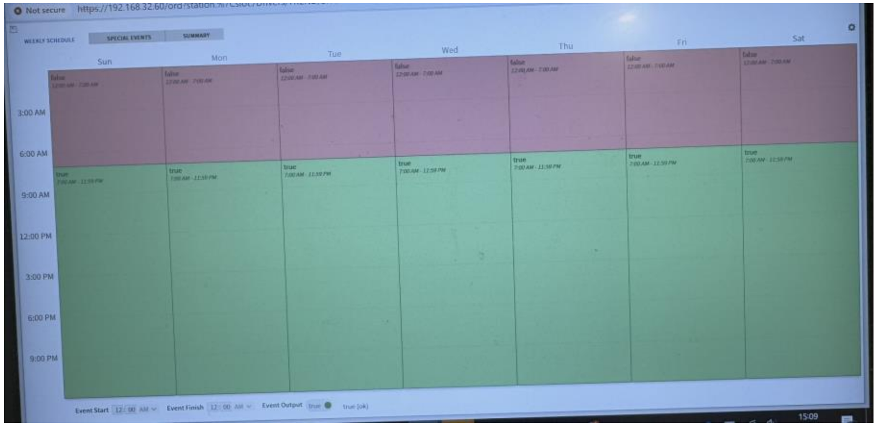
The current time schedule for the restaurant:

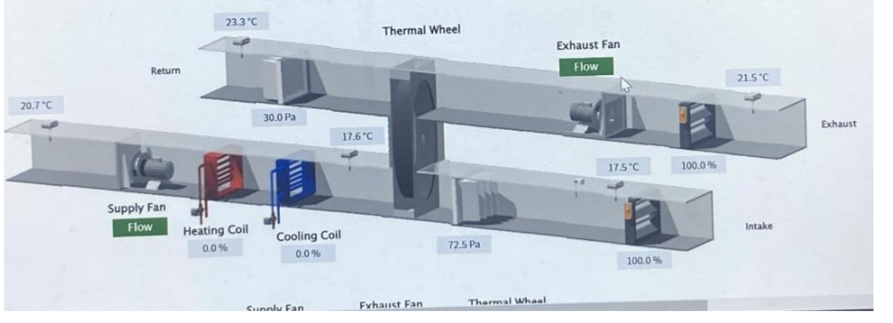
True (AHU on) 7:00am – 12:00am

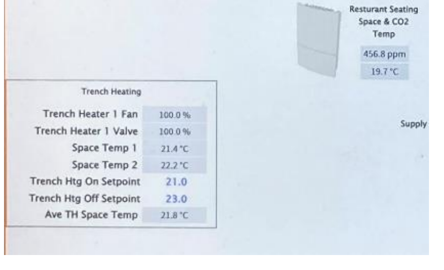
False (AHU off) 12:00am – 8:00am

This time schedule might have the potential to be reduced down to help reduce energy consumption as generally spaces connected to this AHU might not need to be operational in the morning.

The trench heating set points should be reviewed in summer to prevent simultaneous heating and cooling when the AHU is trying to cool the space down.







5.8 AHU Back of House Area

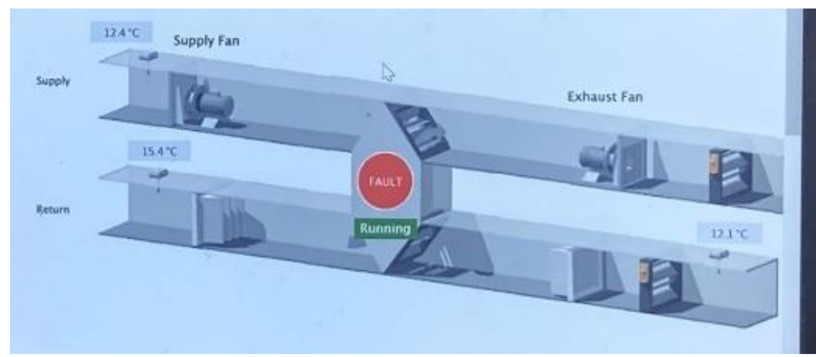
The current time schedule for the restaurant:

True (AHU on) 9:00am – 11:00pm

False (AHU off) 11:00pm – 9:00am

There was a fault on the AHU which might be on the heat exchanger. This should be investigated. The unit also appeared to be running in boost mode which might not be appropriate.

The CO_2 setpoint is relatively low (650ppm). This could be increased to save fan power so ~1000ppm.



AHU Timezone	true	Boost Override	false
Night Cool Timezone	false	Summer Night Free Cool Active	false
Temp Setpoint	20.0 °C	Alarm Reset	false
CO2 Setpoint	650.0		
ost Temp Setpoint	4.0 °C		
Press Setpoint	200.0 Pa		

5.9 AHU Additional Observations

- AHU 09B running in boost mode. Check this is required.
- AHU 09B CO_2 setpoint at 650ppm. This could be increased.
- AHU 11 BMS schedule is labelled incorrectly.
- AHU 12 out of auto. Required rectifying.
- AHU 13 in cooling mode in winter. Low supply air temperature with potential conflict with heating system leading to simultaneous heating and cooling

5.10 Heating (LTHW)

The heating and hot water seems to be based off the same LTHW time schedule set to 24/7.

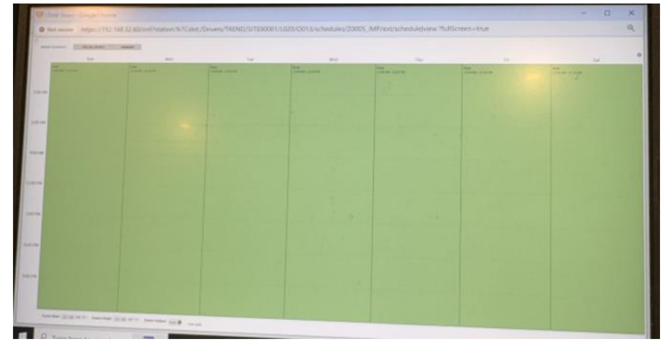
We can also see from the graph on the following page that the boilers are running 24/7.

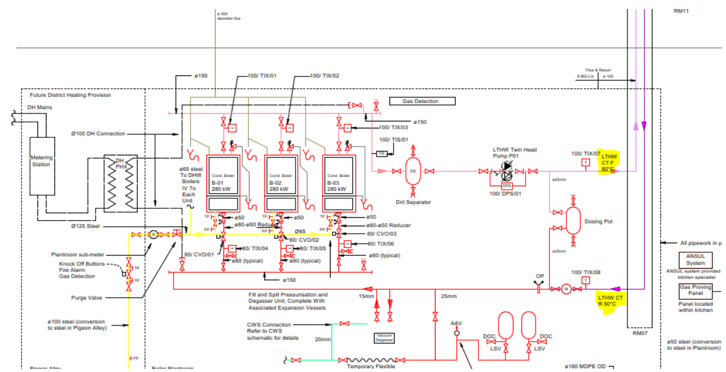
It is suggested that a separate time schedule is setup on the BMS for the heating and hot water to allow each to be controlled separately.

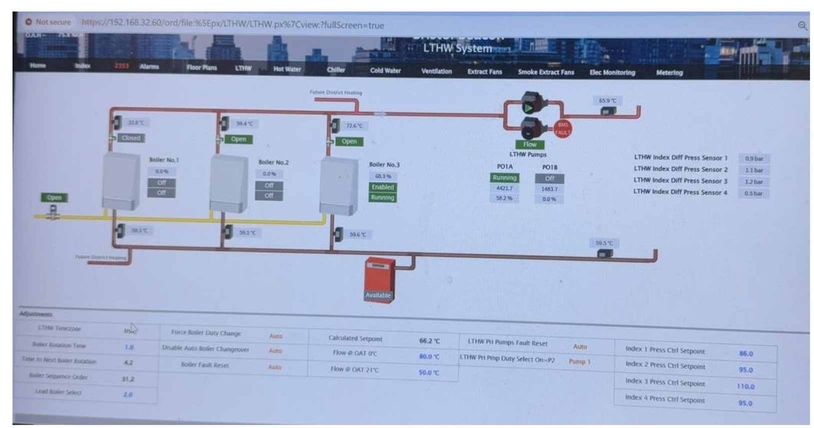
The heating time schedule could be reduced out of hours so that boilers and pumps don’t run 24/7.

The design appeared to be for a Constant Temperature “CT”, which is also shown on the as-built schematics (highlighted in yellow). However, what has been installed is a variable temperature system, where the water flow temperature varies with outdoor air. This is good for energy saving as the boilers will run more efficiency at lower temperatures and there will be reduced heat losses, however, it might mean that when the system water temperature drops, some heat emitters might struggle to achieve the desired temperature. The overdoor heaters could be an example of this, where they might have been designed for a constant high temperature and the output will be reduced when the water temperature in the system reduces.

The graph on the following page shows that the difference (ΔT) between the flow and return temperatures are relatively small. This suggests that the pumps are generally running at too higher speeds. It is suggested that the pump commissioning is reviewed to increase the Δ T to improve the efficiency of the boilers and reduce heat losses. This will be a requirement if the building connects to a district heat network which will typically require return temperatures to be lower (below ~50°C).







5.10 Heating (LTHW)
Flow & Return and Outdoor Temperature

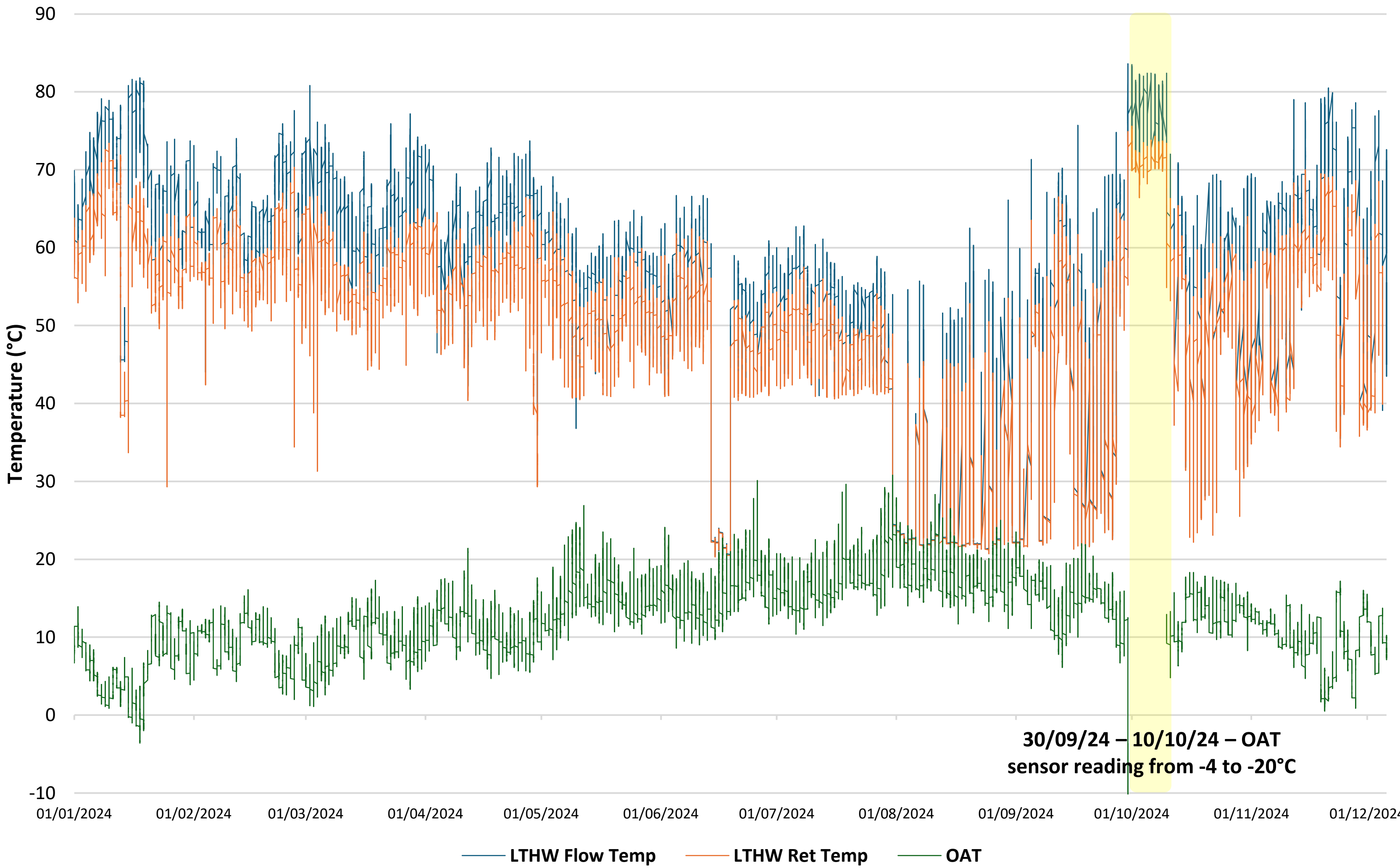


Figure 6: *The LTHW flow and return temperature alongside the outdoor air temperature.*

5.10 Heating (LTHW)

During the summer, the heating appeared to be consistently running until the end of July when the summer mode appeared to begin to operate to restrict the heating coming on in accordance with the des ops (section 1.2.6 and shown in **Figure 7**). It would generally be expected that no heating would be required during the summer months and the system could be kept off for longer, therefore a suggestion is to reduce the summer off temperature to help save energy.

The gas consumption would have been relatively high until the end of July with high heat losses from the pipework and pumping energy circulating water.

BMS Des Ops:

1.2.6. Summer Hold-Off

During the warmer months the heating system will not be required. If the outside air temperature exceeds the summer hold-off temperature setpoint of [17]˚C for [1200] seconds then the heating pumps will be held off, regardless of any demands from the supply systems or heating zones (pump & valve exercise can still enable plant).

The summer hold will be deactivated once the outside air temperature drops [2]˚C below the summer hold-off temp setpoint.

A software knob allows the users to force the system into summer hold-off mode for test or maintenance purposes, or force the heating system to run by generating a 'dummy' heating demand.

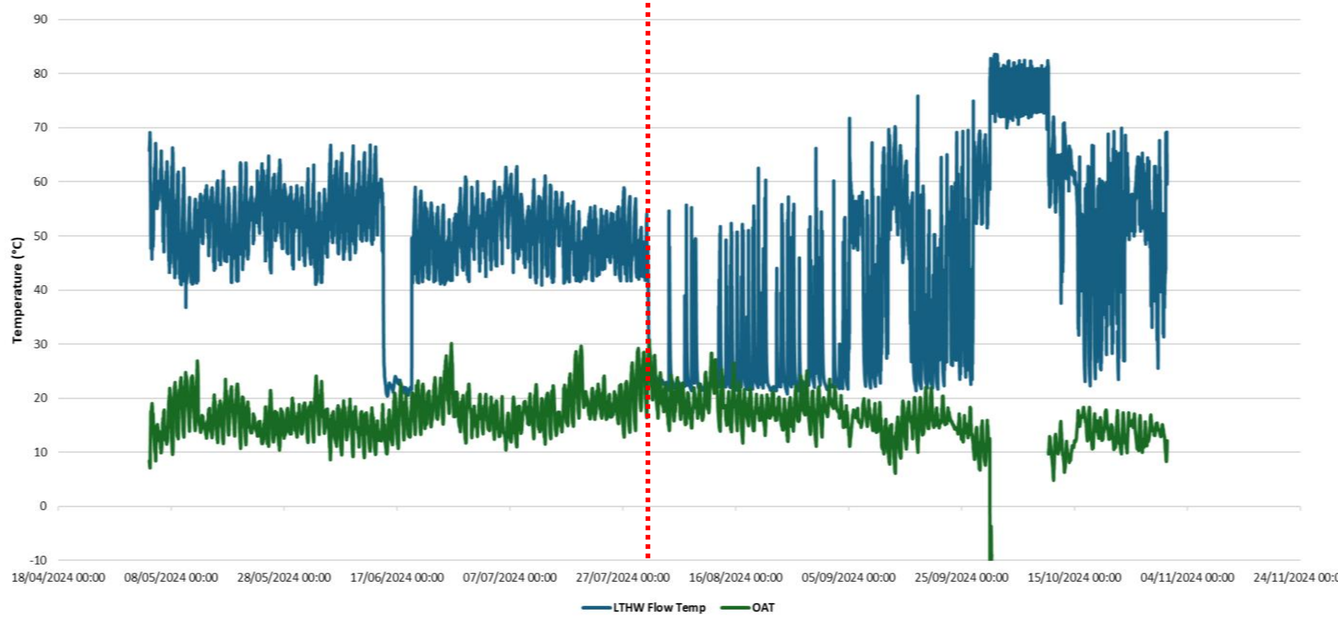


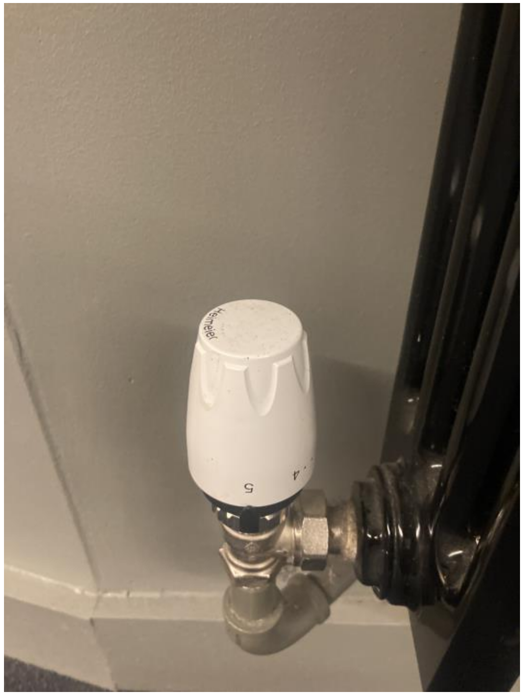
Figure 7: *The LTHW flow temperature alongside the outdoor air temperature.*

5.10 Heating (LTHW)
Controls

Many rooms and zones are controlled through thermostatic radiator valves. The heating schematic shows that there is very little zoning using additional 2 port valves, and because the heating is running 24/7, radiators will tun on/off based on the position of the TRV. If at setting 5 (as pictured), they will generally always be on as this corresponds to a space temperature of approx. 28°C.

It’s generally suggested that most TRV settings should be set at 3, which corresponds to approximately 21°C. Lockable TRV’s would decrease tampering.

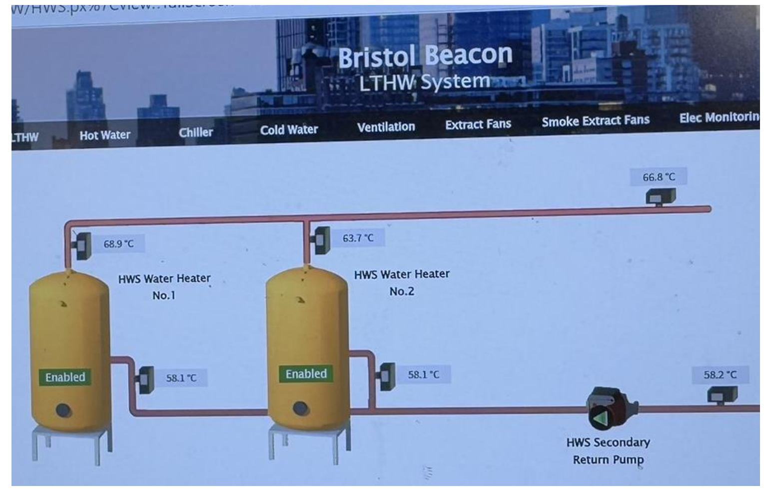
Zones which require independent control could be fitted with 2 port valves in the pipework serving that zone, connected back to the BMS to allow the whole area to be shut down. This will improve control. The control on the BMS could be based on a temperature set point from the inclusion of a space temperature sensor and/or have a dedicated time schedule with control still via the TRVs.



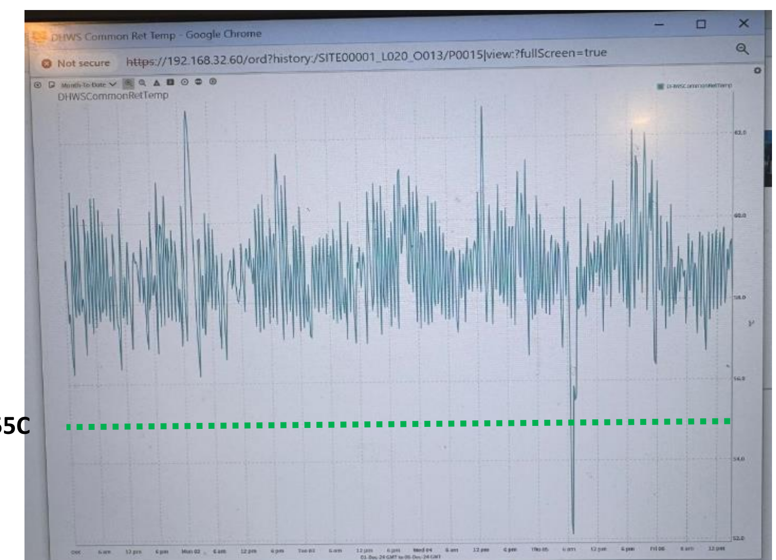
5.11 Hot Water

The heating and hot water seems to be controlled on the same LTHW time schedule as the heating, however this requires further investigation. The system is currently running 24/7, which could be reviewed and reduced to when the building is open and there is a hot water demand. This might be possible via on the onboard controls of the water heaters. This will help save energy by reducing pumping energy and hot water pipework losses so decrease the gas consumption.

The return water temperature should be around 55°C when in operation. The graph demonstrates that the return temperature is generally above this suggesting that the water flow setpoint could be reduced. This will help reduce system heat losses and reduce gas consumption.



55C



5.12 Cooling

Cooling water for the AHUs and fan coil units is generated by two air-cooled chillers at level 7 in the plant tower above the “get in” yard.

Each chiller also incorporates a matched hydraulic pack and duplicate pumps, which circulate chilled water to the plant tower's buffer vessel at level 5.

There is a fault with chiller 1 according to the BMS and a BMS fault with one of the CHW pumps. Both require investigating. However, it appeared from the on-board controller on chiller 1 that it was working, so the fault could be due to the BMS communications.