LONDON

TUNNELS

The London Tunnels

22. Energy Statement and Overheating Assessment

PROJECT NO. 70087403
REF NO. TLT-WSP-XX-XX-RP-ES-00001

30 November 2023

The London Tunnels Public Limited Company

THE LONDON TUNNELS

Energy Statement & Overheating Assessment

TYPE OF DOCUMENT (VERSION) PUBLIC

PROJECT NO. 70106185

OUR REF. NO. TLT-WSP-XX-XX-RP-ES-00001

DATE: NOVEMBER 2023

WSP

WSP House
70 Chancery Lane
London
WC2A 1AF

Phone: +44 20 7314 5000

WSP.com

QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2	Revision 3
Remarks	Draft	Final draft for legal review	Final Report for planning submission	
Date	27th October 2023	10th November 2023	30th November 2023	
Prepared by	Jesus Avila	Jesus Avila	Jesus Avila/ Silke Mason	
Signature				
Checked by	Silke Mason	Silke Mason	Michela Martini	
Signature				
Authorised by	Michela Martini	Michela Martini	Dimitri Avakian/ John Parker	
Signature				
Project number	70106185	70106185	70106185	
Report number		TLT-WSP-XX-XX-RP-ST-0000_P01	TLT-WSP-XX-XX-RP-ST-0000_P01	
File reference				

CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

WSP has been commissioned by The London Tunnels PLC (the Applicant) to develop and prepare an Energy Statement to support the full planning permission and demolition in conservation area for development at 38-39 and 40-41 Furnival Street, EC4A 1JQ & 31-33 High Holborn WC1V 6AX (hereafter referred to as the 'Site'), which is located within the City of London (CoL) and the London Borough of Camden (LBC). The development of the energy strategy has followed the GLA policy and maximised performance in terms of carbon reduction over the notional building for full compliance.

Planning permission is being sought for:

"Change of use of existing deep level tunnels (Sui Generis) to visitor and cultural attraction, including bar (F1); demolition and reconstruction of existing building at 38-39 Furnival Street; redevelopment of 40-41 Furnival Street, for the principle visitor attraction pedestrian entrance at ground floor, with retail at first and second floor levels and ancillary offices at third and fourth levels and excavation of additional basement levels; creation of new, pedestrian entrance at 31-33 High Holborn, to provide secondary visitor attraction entrance (including principle bar entrance); provision of ancillary cycle parking, substation, servicing and plant, and other associated works."

ENERGY AND CARBON POLICY SUMMARY

The relevant targets for the Proposed Development can be summarised as follows:

- All developments must meet the prevailing Building Regulations requirements. Specifically, with regards to energy and carbon compliance, all buildings must meet the Building Regulations Part L 'Target Emission Rate' (TER) requirements for the Part L revision which is current at the time of initial construction works for each particular developmental phase;
- The Proposed Development will be assessed against Approved Document L2 relating to new build non-residential buildings;
- As required by LB Camden and City of London, the Proposed Development must demonstrate how the zero-carbon targets will be met, with at least a 35%* on-Site reduction beyond Part L 2021 and proposals for making up the shortfall to achieve zero carbon, where required. For the purposes of calculating carbon reductions for planning the proposed SAP10.2 emission factors will be used;
    - **Major developments should demonstrate how the net zero carbon target will be met, with a target of 35% on-Site reduction beyond Part L 2021 and proposals for making up the shortfall to achieve net zero carbon, where required. However, further to this, the GLA have recognised that non-residential developments may find it challenging to achieve significant on-Site carbon reductions beyond Part L 2021 to meet both the energy efficiency target and the minimum 35% improvement. Therefore, the GLA will be looking to ensure planning applicants have followed the energy hierarchy and maximised carbon savings as far as possible, assessing each application on a case by case basis.*
- Non-domestic developments should aim to achieve 15% improvement on Building Regulations from energy efficiency;
- Developments will be required to connect to or demonstrate a potential connection to a decentralised energy system unless it can be demonstrated that it is not feasible or viable and evaluate the feasibility of communal heating systems;
- Major developments should provide a reduction in expected CO_2 emissions through the use of on-Site renewable energy generation, where feasible to do so;
- Dynamic modelling for overheating risk analysis in line with the guidance and data sets in CIBSE TM52 should be undertaken;
- All new non-residential development and non-self-contained residential accommodation over 500 square metres floorspace (gross) are expected to meet or exceed BREEAM 'Excellent' rating;
- The Energy Statement must include information of how the building's actual energy performance will be monitored post-construction and produce all relevant documentation as outlined in the "Be Seen – Energy Monitoring Guidance"; and
- All major developments are required to calculate and reduce the whole life-cycle carbon (WLC) emissions to fully capture the development's carbon impact. In line with CoL's guidance, an Optioneering Study has been carried out to determine the best suited project solution for the Site.

ENERGY STRATEGY SUMMARY

The energy strategy has been structured in accordance with GLA's energy hierarchy: Be Lean, Be Clean, Be Green and Be Seen. The Proposed Development has been developed to achieve an energy an efficient and sustainable development.

The Proposed Development will be designed to achieve optimum energy performance, and will incorporate the following design features:

Be Lean

- During design development, significant consideration has been given to how the building fabric will respond to its environment in order that the energy consumption of the building is reduced as far as possible through passive means.
- The vast majority of the project makes use of existing structures. The project has some design constraints due to its heritage and bespoke nature.
- The Tunnels have a high level of insulation and thermal mass as result of the surrounding soil which encapsulates all external surfaces of the Tunnels.
- Passive design measures will be incorporated into the design to reduce energy demand and the risk of overheating in the above ground buildings;
- A high-performance building services solution is proposed for the Proposed Development;

Be Clean

- WSP has been in contact with the local heat network provider regarding a proposed District Heat Network. It has been determined that at the time of the submission it is not possible to connect to a planned District Heat Network. Conversations with the nearby DHN provider are ongoing;
- Subject to future legal and technical agreements, the plant space will be designed to be adaptable for future connection into the district heating network;

Be Green

- Terminal units are designed to achieve a specific fan power in operation lower than the Part L 2021 limiting SFP;

- All spaces will include 100% low energy lighting. Lighting controls will be specified as appropriate across the development; and
- Heat recovery heat pumps will allow for simultaneous heating and cooling through an all-electric low-carbon hot water.
- A high level of heat recovery is present in the design with heat recovery chillers.
- Highly efficient water-cooled chillers will provide cooling.

Be Seen

- A detailed TM54 operational energy analysis has been carried out based on four different use scenarios.
-

RESULTS

WSP utilised a dynamic simulation software package, the Virtual Environment (VE) suite from Integrated Environmental Solutions (IES).

The Tunnels and the existing above ground building at 31-33 High Holborn have been assessed as existing buildings in line with the GLA Energy Assessment Guidance. New construction assessment guidance has been applied for 38-39 and 40-41 Furnival Street due to the nature of the redevelopment at this building.

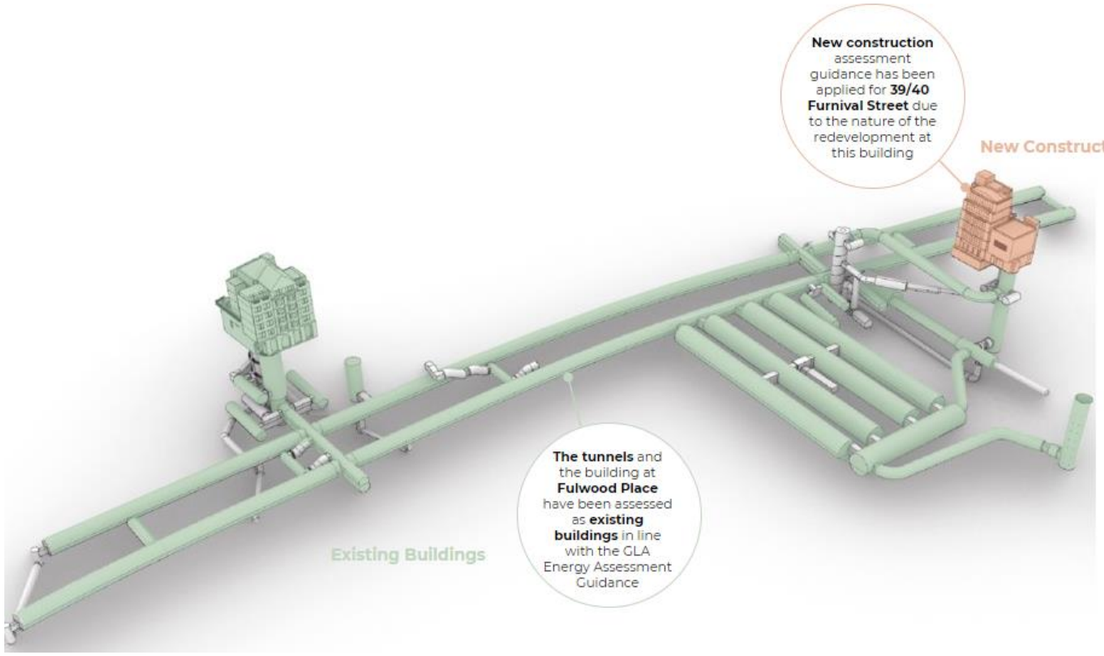


Figure 1 – Site Wide Axonometric Showing Part L Approach

The SAP 10.2 carbon factors have been used for all further calculations using version 2.0 of the GLA Carbon Emission Reporting Spreadsheet.

The results of the analysis for the development are shown in Table 1**.**

Table 1 - Carbon Emissions After Providing Renewable Energy – Site Wide

	Furnival Street (New Build)	31-33 High Holborn (Existing Build)	Kingsway Tunnels (Existing Build)	Site Wide		
Total	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Unregulated Emissions (Tonnes)**	**% Reduction in Regulated Carbon Emissions**
Baseline emissions (Tonnes CO_2)	1.1	3.8	69.4	74.2	22.8	-
Be Lean: Emissions after energy demand reduction (Tonnes CO_2)*	1.0	3.9	69.1	74.0	22.8	0.3%
Be Clean: Emissions after energy efficient supply (Tonnes CO_2)*	1.0	3.9	69.1	74.0	22.8	0.3%
Be Green: Emissions after renewable energy (Tonnes CO_2)	0.5	3.6	39.4	43.5	22.8	41.4%

**The energy efficiency savings have been calculated on the basis that the buildings are served by a central heating system served by ASHPs with a seasonal efficiency of 264% for space heating and 286% for DHW.*

Major developments should demonstrate how the net zero carbon target will be met, with a target of 35% on-Site reduction beyond Part L 2021 and proposals for making up the shortfall to achieve net zero carbon, where required. However, further to this, the GLA have recognised that non-residential developments may find it challenging to achieve significant on-Site carbon reductions beyond Part L 2021 to meet both the energy efficiency target and the minimum 35% improvement. Therefore, the GLA will be looking to ensure planning applicants have followed the energy hierarchy and maximised carbon savings as far as possible, assessing each application on a case-by-case basis.

The carbon emission reduction of the Proposed Development has been maximised to achieve the largest improvement possible on Site. While the development falls short of the 35% reduction, all buildings (including Tunnels) achieve Building Regulations Part L compliance, see Figure 2.

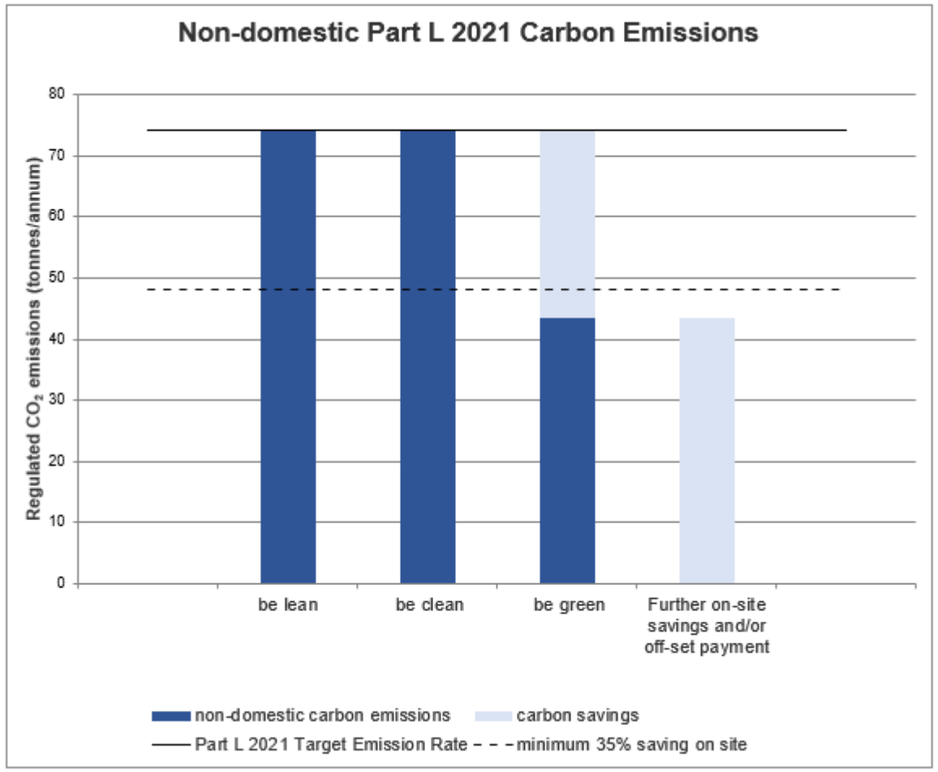


Figure 2 - Carbon emissions savings bar chart

1 PROJECT BACKGROUND

The project is centred around the refurbishment and improvement of the Tunnels below High Holborn (see Figure 1-1), with the intention of creating a unique, high quality visitor attraction. The Tunnels were previously known as the Kingsway Exchange Tunnels because they were used as a telephone exchange. They were originally constructed as a bomb shelter and command centre.

The Tunnels are connected to ground level via shafts in 31-33 High Holborn, 38-39 and 40-41 Furnival Street and Took's Court. The project includes:

- 31-33 High Holborn – Refurbishment of the existing building and amendments to base of existing shaft. The current shaft has two smaller diameter shafts at its base. These will be removed to enable the extension to the larger diameter shaft which extends from ground level, with connecting Tunnels formed at the base to link to tunnel network at this level.
- 38-39 Furnival Street – Demolition of the existing building to enable construction of a new four storey building with a 4-storey basement. The basement will connect into the upper existing Tunnels and will replace the existing shaft. The shaft diameter will be increased below the new basement to the lower-level Tunnels. The connecting Tunnels at the base of the shaft will be modified to increase clear width/diameter.
- 40-41 Furnival Street – Major building redevelopment in combination with the construction at 38-39 Furnival Street.
- The Took's Court shaft is below an existing building and does not feature in the Scheme. However, this shaft will be sealed to ensure no air permeability into the Tunnels. This approach was agreed with the Building Control Officer during RIBA Stage 2.

The Kingsway Tunnels are subdivided in different elements:

- The Streets – these are thought to be part of the original construction. They are 5.2m in diameter and its structures varies between cast iron rings and precast concrete rings. A closer inspection suggest that part of the structure was altered in the early 50's. The current finish floor level is provided by a concrete slab supported by a secondary steel frame. There is limited information about the existing build-up below the finish floor structure.
- The Avenues - the avenues are part of the second stage of construction and believed to be part of the works undertaken by BT when they took possession of the Tunnels. As per the streets, the structure varies between cast iron ring panels and precast concrete panels. The finish floor levels are similar as per the streets.
- The "Dog Leg": the secondary tunnel connecting Furnival Street shaft to a construction shaft is located half way between ground level and Tunnels level. This appears to be part of the second construction stage and built as a construction tunnel. This tunnel connects Furnival Street shaft to the disused construction shaft 2.
- The Ventilation Tunnels - there is a secondary network of smaller Tunnels providing ventilation routes between adjacent Tunnels. These are too narrow for public use but provide opportunities for services distribution.
- The Disused shafts - the Tunnels include a number of shafts and vertical connections that have been blocked or made unusable due to more recent developments. These include:
  - Chancery Lane tube station connection shaft
  - Took's Court Shaft
  - Staples Inn shaft
- The Access Shafts - these include both shafts at 31-33 High Holborn and the Goods Shaft at Furnival Street. The Scheme relies in these connections to provide safe access and evacuation to the Tunnels

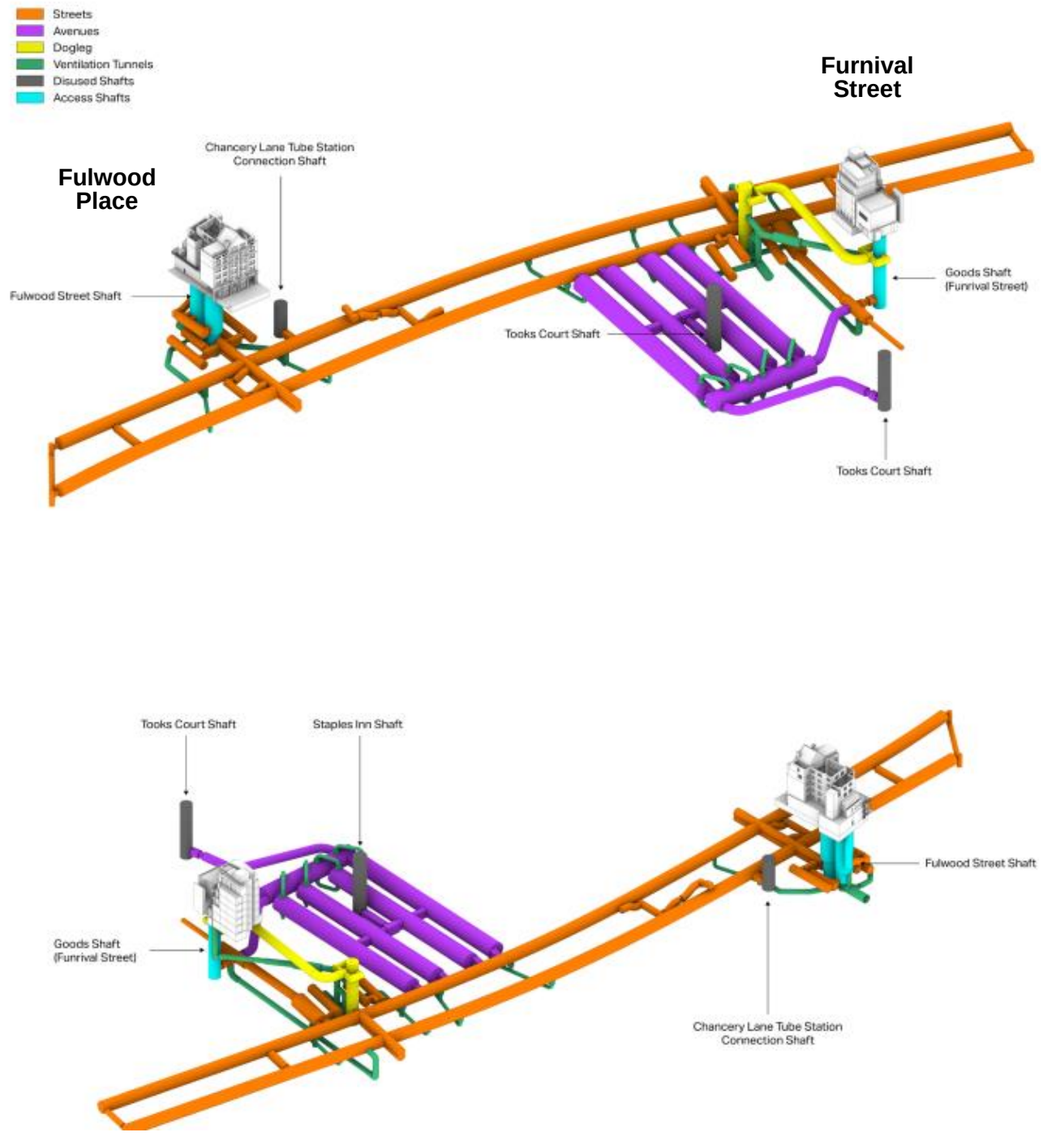


Figure 1-1 – The London Tunnels - Main Features

1.1 THE PROPOSED DEVELOPMENT

Planning permission is being sought for:

"Change of use of existing deep level tunnels (Sui Generis) to visitor and cultural attraction, including bar (F1); demolition and reconstruction of existing building at 38-39 Furnival Street; redevelopment of 40-41 Furnival Street, for the principle visitor attraction pedestrian entrance at ground floor, with retail at first and second floor levels and ancillary offices at third and fourth levels and excavation of additional basement levels; creation of new, pedestrian entrance at 31-33 High Holborn, to provide secondary visitor attraction entrance (including principle bar entrance); provision of ancillary cycle parking, substation, servicing and plant, and other associated works."

The floorspace of Proposed Development will be distributed as shown in Table 1-1.

Table 1-1 – Proposed Floorspace

Proposed Use	Location	Floorspace (GIA)
Class F1	38-39 and 40-41 Furnival Street	2,467 m^2
Class F1	Tunnels	7,829 m^2
Class F1	31-33 High Holborn	329 m^2
Total Floorspace		**10,625 m^2**

2 POLICY CONTEXT

2.1 NATIONAL PLANNING POLICY

The National Planning Policy Framework (NPPF) was updated in July 2021 and replaces the previous versions. Plans and decisions should apply a presumption in favour of sustainable development.

The National Planning Policy Framework (NPPF) sets the planning context for sustainable design and construction. It is this that Local Planning Policies are based on and adapted to account for regionally specific requirements.

The NPPF identifies three dimensions to sustainable development - economic, social, and environmental – which should be applied jointly and simultaneously:

- **Economic objective** – to help build a strong, responsive and competitive economy, by ensuring that sufficient land of the right types is available in the right places and at the right time to support growth, innovation and improved productivity; and by identifying and coordinating the provision of infrastructure;
- **Social objective** – to support strong, vibrant and healthy communities, by ensuring that a sufficient number and range of homes can be provided to meet the needs of present and future generations; and by fostering a well-designed and safe built environment, with accessible services and open spaces that reflect current and future needs and support communities' health, social and cultural well-being; and
- **Environmental objective** – to contribute to protecting and enhancing our natural, built, and historic environment; including making effective use of land, helping to improve biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy.

The NPPF promotes the pursuit of sustainable development by seeking positive improvements to the built and natural environment, and to people's quality of life. The NPPF includes the following key themes:

- Delivering a sufficient supply of homes.
- Building a strong, competitive economy;
- Ensuring the vitality of town centres;
- Promoting healthy and safe communities;
- Promoting sustainable transport;
- Supporting high quality communications;
- Making effective use of land;
- Achieving well-designed places;
- Protecting green belt land;
- Meeting the challenge of climate change, flooding and coastal change;
- Conserving and enhancing the natural environment;
- Conserving and enhancing the historic environment; and
- Facilitating the sustainable use of materials.

2.2 REGIONAL POLICY - THE LONDON PLAN MARCH 2021

The New London Plan was adopted in March 2021 and is the Spatial Development Strategy for Greater London. It sets out a plan for how London will be developed over the next 20-25 years.

An overview of the energy policy is provided in Table 2-1:

Table 2-1 – Summary of Key Policies in the London Plan 2021

Policy Title	Summary of Policy
Policy SI1: Improving Air Quality	Development should not lead to further deterioration of existing poor air quality, create any new areas that exceed air quality limits and create unacceptable risk of high levels of exposure to poor air quality. Major development must be at least air quality neutral and should use design solutions to prevent or minimise increased exposure to existing air pollution and make provision to address local problems of air quality in preference to post-design or retrofitted mitigation measures. Major development must be submitted with an Air Quality Assessment. To reduce the impact on air quality during the construction and demolition phase development proposals must demonstrate how they plan to comply with the Non-Road Mobile Machinery Low Emission Zone and reduce emissions from the demolition and construction of buildings following best practice guidance.
Policy SI2: Minimising Greenhouse Gas Emissions	Major development should be net zero-carbon. Reducing greenhouse gas emissions in operation and minimising both annual and peak energy demand in accordance with the energy hierarchy: Be Lean – Be Clean – Be Green – Be Seen. Major development proposals should include a detailed energy strategy to demonstrate how the zero-carbon target will be met and achieve a minimum on-Site reduction of at least 35% beyond Building Regulations. Residential development should achieve 10% and non-residential should achieve 15% through energy efficiency measures. Where it is clearly demonstrated that the zero-carbon target cannot be fully achieved on-Site, any shortfall should be provided, in agreement with the borough, either: 1) through a cash in lieu contribution to the borough's carbon offset fund, or 2) off-Site provided that an alternative proposal is identified, and delivery is certain. Major development should calculate and minimise carbon emissions from any other part of the development, including plant or equipment (Unregulated emissions). Development (referable to the Mayor) should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions.
Policy SI3 Energy Infrastructure	Boroughs and developers should engage at an early stage with relevant energy companies and bodies to establish the future energy and infrastructure requirements arising from large-scale development proposals such as Opportunity Areas, Town Centres, other growth areas or clusters of significant new development.
Policy SI4 Managing Heat Risk	Development should minimise adverse impacts on the urban heat island through design, layout, orientation, materials, and the incorporation of green infrastructure. Through an energy strategy, development should demonstrate how they will reduce internal overheating and reliance on air conditioning systems in accordance with the cooling hierarchy.

2.3 REGIONAL POLICY – SUPPLEMENTARY PLANNING GUIDANCE

2.3.1 ENERGY ASSESSMENT GUIDANCE (JUNE 2022)

The Mayor Energy Assessment Guidance sets out guidance on preparing energy assessments as part of planning applications. The document sets out the requirements to minimise CO_2 emissions through the application of the energy hierarchy:

1. **Be lean**: use less energy;
2. **Be clean**: supply energy efficiently;
3. **Be green**: use renewable energy; and
4. **Be seen**: monitor performance.

Over the last 2 to 3 years, the quantum of coal in the electricity mix in the UK has substantially decreased and the quantum of low and zero carbon technologies (including PV, wind, and nuclear energy) has increased; as a result, the carbon content of grid supplied electricity has reduced. This decarbonisation will accelerate; suggesting a push towards an increasingly electric future rather than the gas fuelled MEP solutions that we see today.

The Mayor strives to improve the air quality in London and a movement towards an all-electric solution also provides air quality benefits both local to the development and across the city.

Under the 2021 Building Regulations, applicants are to use the current Building Regulations methodology for estimating energy performance against Part L (2021) requirements, which are in relation to the SAP 10.2 carbon factors.

Table 2-2 – Summary Part L Carbon Factors –SAP 10 and SAP 10.2

Fuel Type	SAP 10.0 ($kg.CO_2/kWh$)	SAP 10.2 ($kg.CO_2/kWh$)
Grid Supplied Electricity	0.233	0.136
Natural Gas	0.210	0.210

2.4 LONDON BOROUGH (LB) LOCAL PLANS

The Site boundary is located within the City of London (CoL) and the London Borough of Camden (LBC). Both Local Plans have been considered in the development of the Energy Strategy for the Proposed Development.

2.4.1 CAMDEN LOCAL PLAN

LB Camden Local Plan was adopted in July 2017. The most relevant policies for this development are as follows:

Table 2-3 – Camden Local Plan Policy Summary

Policy Title	Summary of Policy
D1 Design	The Council will seek to secure high quality design in development. The Council will require that development Development must: 1. respects local context and character 2. is sustainable in design and construction, incorporating best practice in resource management and climate change mitigation and adaptation; 3. is of sustainable and durable construction and adaptable to different activities and land uses 4. comprises details and materials that are of high quality and complement the local character 5. promotes health; 6. responds to natural features and preserves gardens and other open space; 7. incorporates high quality landscape design (including public art, where appropriate) and maximises opportunities for greening for example through planting of trees and other soft landscaping, 8. incorporates outdoor amenity space;
CC1 Climate change mitigation	The Council will require all development to minimise the effects of climate change and encourage all developments to meet the highest feasible environmental standards that are financially viable during construction and occupation. Development will: 1. promote zero carbon development and require all development to reduce carbon dioxide emissions 2. demonstrate how London Plan targets for carbon dioxide emissions have been met; 3. ensure that the location of development and mix of land uses minimise the need to travel by car 4. support and encourage sensitive energy efficiency improvements to existing buildings; 5. involve substantial demolition to demonstrate that it is not possible to retain and improve the existing building 6. work with local organisations and developers to implement decentralised energy networks in the parts of Camden most likely to support them; 7. assess the feasibility of connecting to an existing decentralised energy network, or where this is not possible establishing a new network.
CC2 Adapting to climate change	The Council will require development to be resilient to climate change. All development should adopt appropriate climate change adaptation measures such as: 1. the protection of existing green spaces and promoting new appropriate green infrastructure; 2. incorporating bio-diverse roofs, combination green and blue roofs and green walls where appropriate; 3. .measures to reduce the impact of urban and dwelling overheating, including application of the cooling hierarchy. 4. ensuring development Schemes demonstrate how adaptation measures and sustainable development principles have been incorporated into the design and proposed implementation; 5. encourage new build residential development to use the Home Quality Mark and Passivhaus design standards; 6. expecting non-domestic developments of 500 sqm of floorspace or above to achieve “excellent” in BREEAM assessments and encouraging zero carbon in new development from 2019

2.4.2 CITY OF LONDON LOCAL PLAN

The City of London Local Plan was adopted in 2015 and sets out the vision for the Square Mile up until 2026. The most relevant policies for this development are as follows:

Table 2-4 – City of London Local Plan Policy Summary

Policy Title	Summary of Policy
S8 Design	The City Corporation will promote innovative, sustainable and inclusive high-quality buildings, streets and spaces, seeking design solutions that make effective use of limited land and contribute towards a zero emission City , through development which: 1. Optimises pedestrian movement by maximising permeability, providing external and internal pedestrian routes which are inclusive, welcoming, convenient, comfortable and attractive 2. Is pedestrian-focused, reducing conflict between pedestrian and vehicular traffic, 3. Delivering public space at the upper levels of buildings by maximising the amount of accessible and free to enter roof terraces and spaces 4. Delivering world class sustainable buildings which are mixed-use, resilient, adaptable and contribute towards a zero emission, zero carbon and climate resilient City 5. Optimises the amount of green infrastructure and amenity space designed as integral to the architecture, enhancing public access to nature and biodiversity through maximising the amount provision of green roofs, walls and trees; 6. Delivers high quality sustainable architecture of a height, bulk, massing, scale, urban grain, material, quality and depth of modelling and detail 7. Incorporates sustainability measures and other plant and building services into a coherent architectural design;
D1: Sustainability Standards	All development must demonstrate the highest feasible and viable sustainability standards in the design, construction, operation and “end of life” phases of development. Proposals for major development will be required to: 1. Achieve a BREEAM rating of “excellent” or “outstanding” against the current, relevant BREEAM criteria at the time of application, obtaining maximum credits 2. demonstrate that London Plan carbon emission and air quality requirements have been met on Site 3. Incorporate collective infrastructure such as heating and cooling networks, smart grids and collective battery storage wherever possible, to contribute to a zero-emissions, zero-waste, climate resilient City.
CR1: Overheating and Urban Heat Island Effect	Developers will be required to demonstrate that their developments have been designed to reduce the risk of overheating through: 1. solar shading to prevent solar gain, particularly on glazed facades; 2. urban greening to improve evaporative cooling; 3. passive ventilation and heat recovery; 4. use of thermal mass to moderate temperature fluctuations; 5. minimal reliance on energy intensive cooling systems. Building designs should minimise any contribution to the urban heat island effect.

2.5 PART L1 OF THE BUILDING REGULATIONS (2021)

All new buildings constructed in the UK must meet the minimum requirements of the UK Building Regulations. Specifically, with regards to energy and carbon compliance, all buildings must meet the Building Regulations Part L ‘Target Emission Rate’ (TER) requirements for the Part L revision which is current at the time of initial construction works for each particular developmental phase.

This is illustrated by the production of a BRUKL (Building Regulations United Kingdom Part L) document outputs which list details of the Part L calculation and proposed fabric and building services. The BRUKL documents can be found as an appendix in this report. The results in terms of carbon emission have been included in the report text. The tables in the report show that the carbon emission of the actual building is lower than the notional building.

3 BASELINE

The first stage of the energy assessment is to establish the baseline Site energy demand and CO_2 emissions based on dynamic energy modelling software for the whole Proposed Development.

Detailed energy modelling was undertaken based on the methodology from Part L1 of the Building Regulations (2021) in order to establish the baseline carbon emissions for the Proposed Development.

WSP utilised a dynamic simulation software package, the Virtual Environment (VE) suite from Integrated Environmental Solutions (IES). A render of the model can be seen in Figure 3-2.

This process enabled the identification of optimum fabric and building services specification required to meet City of London, LB Camden and the GLA's planning targets. The analysis has followed the energy hierarchy as shown in Figure 3-1.

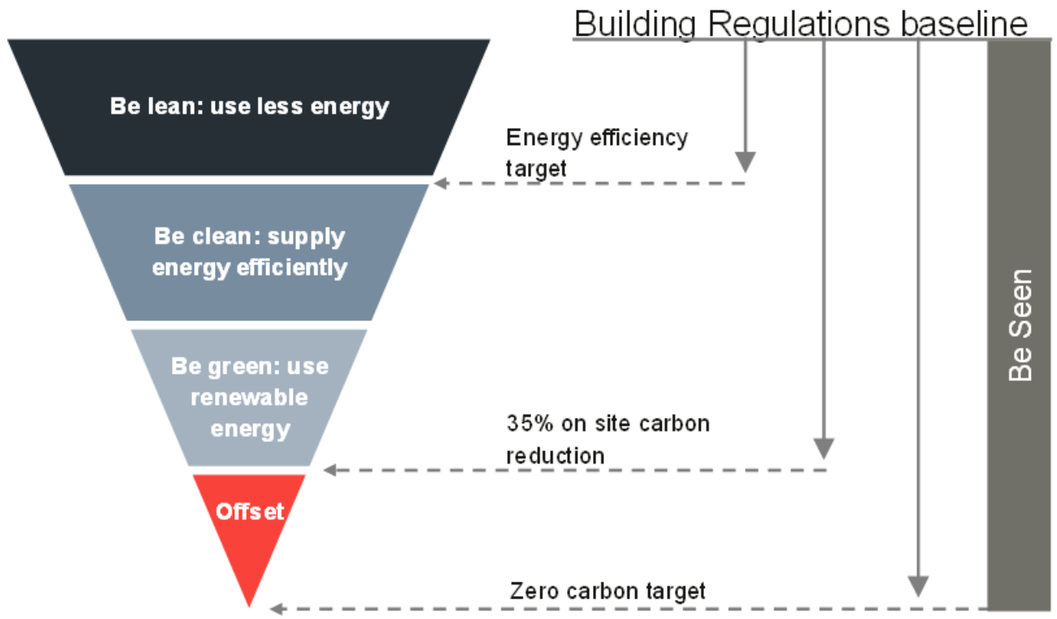


Figure 3-1 – GLA Energy Hierarchy

Table 3-2 summarises the baseline carbon emissions split by type and for the whole Proposed Development. The SAP10.2 carbon factors have been used for all calculations using version 2.0 of the GLA Carbon Emission Reporting Spreadsheet.

The Tunnels and the existing above ground building at 31-33 High Holborn have been assessed as existing buildings in line with the GLA Energy Assessment Guidance. New construction assessment guidance has been applied for 38-39 and 40-41 Furnival Street due to the nature of the redevelopment at this building. The existing systems have been assigned based on the Energy Assessment Guidance table 11 and the Part L2 for Existing Buildings, see Table 3-1. This assessment approach was agreed with the Building Control Officer during RIBA Stage 2.

Table 3-1 – Baseline HVAC input for existing buildings

	Efficiency	Notes
Domestic hot water efficiency	2	*Efficiencies to match the applicable notional values for existing buildings (see tables 6.2, 6.4, 6.5 & 6.8 in Approved Document L2)*
Space heating efficiency	2.5	
Cooling	6	*As per final building specification. Seasonal energy efficiency ratio (SEER) to match the applicable notional values for existing buildings (see table 6.9 in Approved Document L2)*
Central SFP	2.6 W/l/s	*Specific fan power to match the applicable notional values for existing buildings (see table 6.9 in Approved Document L2)*
Terminal SFP	0.4 W/l/s	
Heat recovery	70%	*Energy Assessment Guidance Table 11*
Lighting	60 Lm/Watt	*Energy Assessment Guidance Table 11*

Table 3-2 – Baseline Carbon Emission

	Furnival Street (New Build)	31-33 High Holborn (Existing Build)	Kingsway Tunnels (Existing Build)	Site Wide		
Total	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Unregulated Emissions (Tonnes)**	**% Reduction in Regulated Carbon Emissions**
Baseline emissions (Tonnes CO_2)	1.1	3.8	69.4	74.2	22.8	-

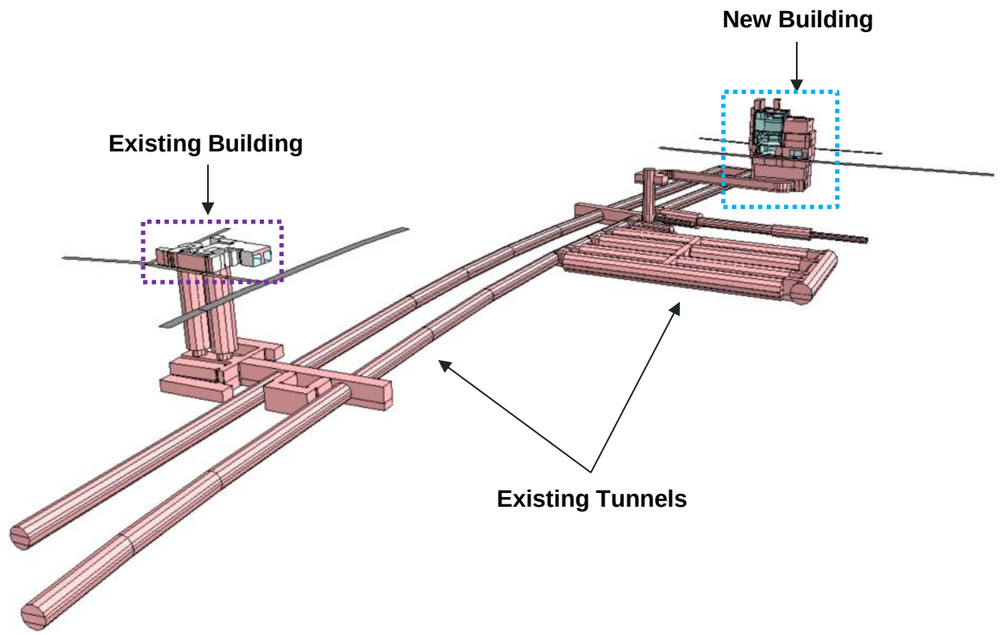


Figure 3-2 – IES VE Model

4 BE LEAN

The first step to achieving Building Regulations compliance and the targets outlined previously is to reduce energy demand. The measures associated with reducing demand can be termed as ‘Energy Efficiency Measures.’

4.1 BUILDING FABRIC

The project poses a unique mix of refurbished buildings, new build elements and existing below ground infrastructure.

4.1.1 ABOVE GROUND

38-39 and 40-41 Furnival Street will partially demolished and rebuilt to ensure the best use of space for lobby, retail, plant space, and office. The façade will feature a glass brick curtain wall to the retail floors and a glass brick double skin façade to the plant and office floor. Between the glass brick façade and the thermal line wall of the upper floors, there will be a void which is open to the external environment, which will bring air into the plant room, see Figure 4-1 and Figure 4-2. Where possible, existing brick will be reused to minimise carbon and support the circular economy strategy of the building.

Figure 4-1 – Furnival Street Facade

Figure 4-2 – Furnival Street Render

There will be minimal change at the 31-33 High Holborn, however work to ensure the building is in good condition and can properly serve the attraction will be carried out. This will include replacement of the glazing and draught proofing of the building.

4.1.2 BELOW GROUND

The tunnel network was constructed in the 1940s. It is approximately 30m below ground level and the and is predominantly built from cast iron and concrete. The thermal model has been developed by applying the ground contact to all surfaces of the Tunnels, as well as setting the adjacent temperature condition to the IES-VE default ground temperature. The build-up of all surfaces has included a layer of London clay to ensure the heat sink and thermal mass provided by the clay is considered, see Figure 4-3. Please see Figure 4-4

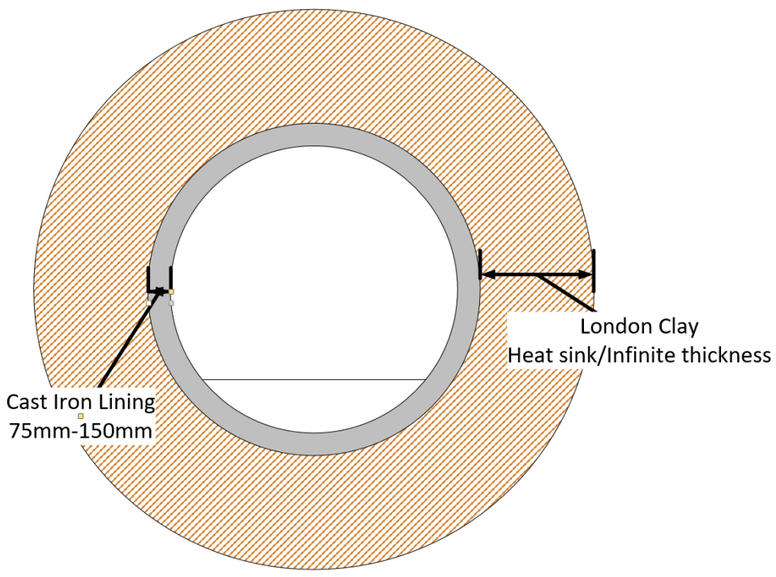


Figure 4-3 – Tunnel Build-up

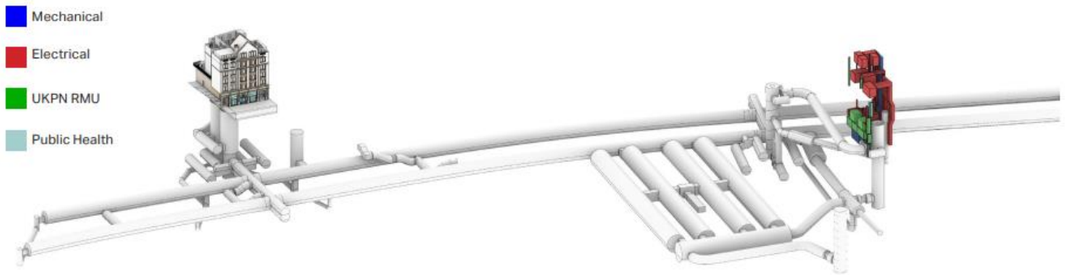
Figure 4-4 – South West Street – Existing Tunnel

Table 4-1 – Fabric Performance Targets

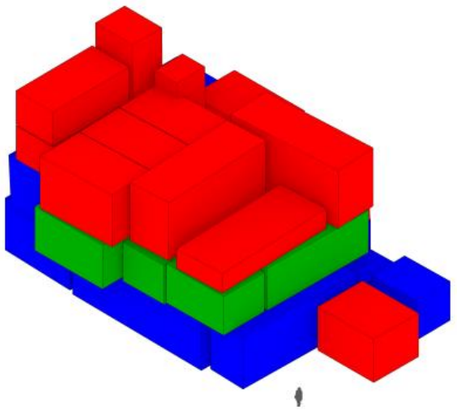
Element	31-33 High Holborn	Furnival St	Tunnels	Part L 2021 New Elements in new buildings	Part L 2021 New elements in existing buildings	Part L 2021 Existing elements in existing buildings
Exposed Floor U-value	0.25 W/m²K	0.13 W/m²K	0.14 W/m²K	0.18 W/m²K	0.25 W/m²K	0.18 W/m²K
Roof U-value	-	0.13 W/m²K	0.15 W/m²K	0.16 W/m²K	0.16 W/m²K	0.15W/m²K
External Wall U-value	0.30 W/m²K	0.13 W/m²K	0.12 W/m²K	0.26 W/m²K	0.30 W/m²K	0.18 W/m²K
Glazing U-value (double)	1.2 W/m²K	1.2 W/m²K	-	1.6 W/m²K	-	1.2 W/m²K
Curtain Wall U-value	-	1.6 W/m²K	-	1.6 W/m²K	-	-
Glazing g-value	0.35	0.30	-	-	-	-
Thermal Bridging	25% of associated U-value	25% of associated U-value	-	-	-	-
Air Permeability	3 m³/(h.m²) @50Pa	3 m³/(h.m²) @50Pa	-	8 m³/(h.m²) @50Pa	10 m³/(h.m²) @50Pa	10 m³/(h.m²) @50Pa

4.2 THE BUILDING SERVICES

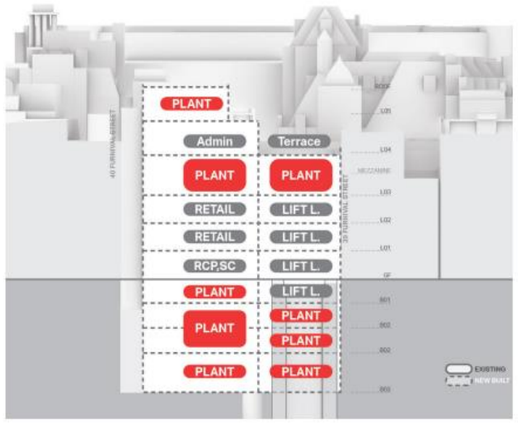
All major equipment for the Tunnels operation will be located above ground for ease of maintenance, upgrading and replacement. This strategy allows for an optimised MEP selection, smoke management and stair pressurisation strategy which will the adequate visitors capacity to receive up to 2 million people per year.



Isometric diagram and scale comparison of the indicative plant equipment required at Furnival Street to service the Tunnels.



Indicative MEP plant equipment scale comparison.



Schematic cross section showing the spatial distribution for the required plant equipment at Furnival Street.

Figure 4-5 - 3D view of the MEP strategy with MEP plant located above ground

The Building Services have been carefully selected to ensure an efficient strategy is in place, which will minimise the carbon emissions, see Figure 4-6 for general overview and location. The general strategy is as follows:

- Avenues and Streets supplied with minimum fresh air via combined general ventilation and smoke control ductwork;
- Duct sizes minimised to the smoke requirement to save material and embodied carbon;
- CO_2 control in AHUs and Avenue zones to minimise energy consumption;
- Downflow units and displacement vent, in each fire compartment cooling very efficiently due to stratification in space;
- Chilled panels used in high load area to cool at ceiling level as well as for nighttime cooling;
- Air handling plant combined with smoke system at both 38-39 and 40-41 Furnival St and 31-33 High Holborn;
- Chillers, cooling towers and a heat-recovery heat pump for simultaneous heating and cooling located at Furnival St.

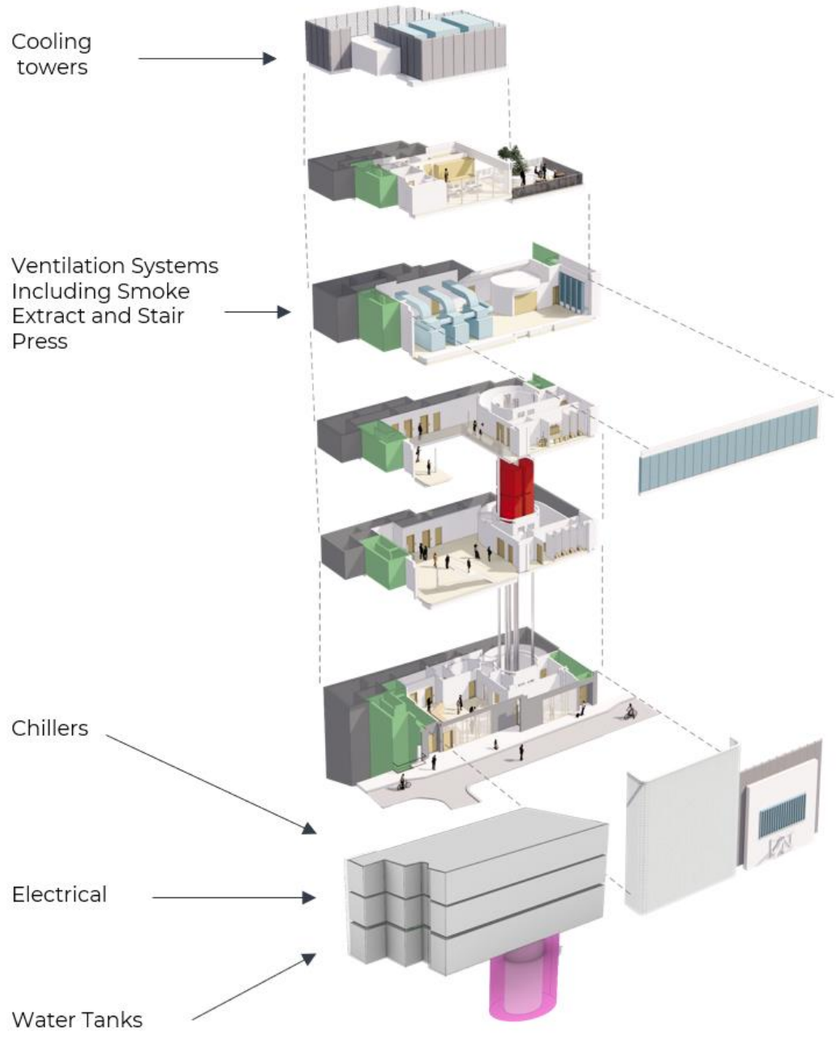


Figure 4-6 - MEP level overview

The general intake and exhaust strategy at Furnival Street can be seen Figure 4-7.

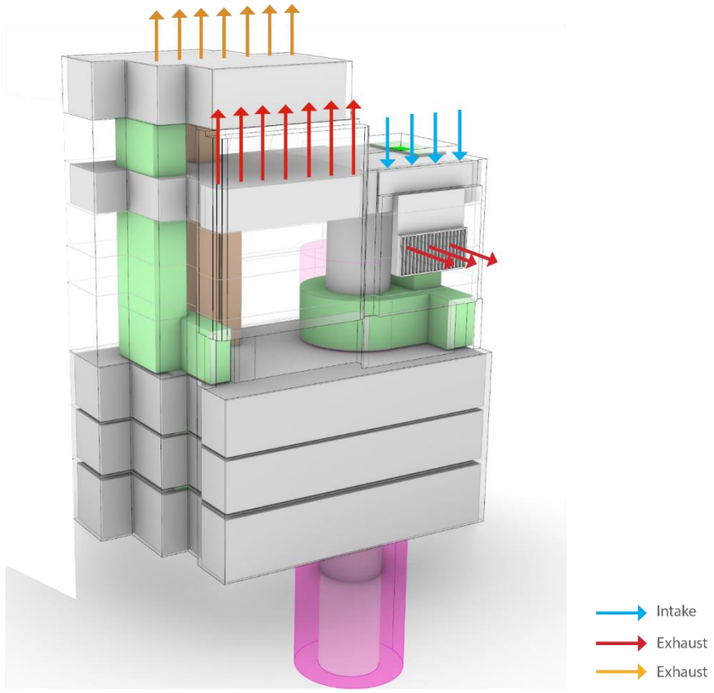


Figure 4-7 - Ventilation intake/ extract

4.2.1 COOLING PEAK CONDITIONS

Peak loads on the chillers and cooling towers will only occur when peak occupancy coincides with peak audio-visual loads (some types of events) and peak outdoor, summer temperatures.

- System sized to meet this peak condition using the cooling tower capacity within the acoustic limits.
- In peak conditions cooling is achieved through combination of systems:
  - ~10% of provided by fresh air system.
  - ~50% provided by the downflow displacement vent.
  - ~40% of provided by chilled panels and fan coil units.
- Hot water requirements in peak conditions delivered using the heat pump that provides simultaneous heating and cooling.

4.2.2 COOLING MID-SEASON/WINTER

When outdoor temperatures are lower than the internal tunnel temperatures the energy efficiency of the cooling is greatly improved.

- Systems operate at lower capacity, dynamically responding to changes in occupancy based on CO2 control, and cooling demand which varies based on the type of event set up (LED vs Projectors).
- In the mid-season in typical conditions:
  - ~20% of provided by fresh air system.
  - ~40% provided by the downflow displacement vent.
  - ~40% of provided by chilled panels.
- In the winter in typical conditions:
  - ~50% of provided by fresh air system.
  - ~0% provided by the downflow displacement vent.
  - ~50% of provided by chilled panels connected directly to cooling towers.

4.2.3 PERFORMANCE SPECIFICATION

Table 4-2 lists the general design rationale and proposed specification for the MEP building services.

Table 4-2 – Performance Specification

Total	Regulated Emissions (Tonnes)
Air Handling Plant	Ventilation proposed to be through local mechanical ventilation units complete with heat recovery. The MVHR will be provided to achieve a specific fan power (SFP) of • **2 W/l/s** or lower for the Tunnels • **1.79 W/l/s for Furnival Street** Supply and exhaust ventilation will be designed to comply with the minimum performance criteria outlined in the Building Regulations Part L.
Energy Recovery	Where appropriate, air handling systems will incorporate heat recovery systems. These transfer waste heat from the exhaust air stream to the supply air stream via a heat exchanger. The AHUs will incorporate thermal wheels with a minimum heat recovery efficiency of **76%.**
Space Heating	A heat recovery heat pump (ASHP) will produce the heating for the project. The SCOP of the ASHP will be **3.2.**
Domestic Hot Water	DHW will be supplied by the WSHPs. The overall DHW efficiency will be 2.86.
Cooling	Cooling will be supplied at an efficiency of 7 from a water-cooled chiller.
Terminal Units	In the retail and office space, heating and cooling is to be provided by FCUs with an SFP of **0.20 W/l/s** or lower. In the Tunnels, downflow units will be in place
Lighting Technology	Detailed lighting proposals will be developed during the subsequent design phases. High efficiency lighting will be provided throughout to significantly exceed the minimum requirements of the Non-Domestic Building Services Compliance Guide. This includes the use of high efficiency fluorescent and/or LED luminaries

Total	Regulated Emissions (Tonnes)
	throughout. Lighting to achieve a lighting power density of **1.8 W/m²/(100 lux)** in the all areas below ground, in the office spaces a lighting power density of **1.2 W/m²/(100 lux)** is designed for.
Lighting Control	Occupancy and daylight sensing will be specified to an appropriate level throughout the different areas of the Proposed Development. This assists in reducing the use of artificial lighting when areas are not occupied. Light dimming and PIRs are specified where applicable. Time switch on lighting controls is specified to avoid night-time parasitic power.

4.3 CARBON EMISSION REDUCTION

Based upon the energy efficiency measures outlined and excluding the contribution of the efficient project specific ASHP and chiller systems the following total carbon emissions are calculated in Table 4-3. The SAP 10.2 carbon factors have been used for all further calculations using version 2.0 of the GLA Carbon Emission Reporting Spreadsheet.

The carbon emissions from the development are shown to be lower than the minimum requirements of the Building Regulations by energy efficiency measures alone. This is achieved via the use of the energy efficiency measures proposed (including a highly efficient building fabric, 100% low energy lighting and centralised ventilation with heat recovery systems) which far exceed the minimum requirements of the Regulations.

The Tunnels and the existing above ground building at 31-33 High Holborn have been assessed as existing buildings in line with the GLA Energy Assessment Guidance. New construction assessment guidance has been applied for 38-39 and 40-41 Furnival Street due to the nature of the redevelopment at this building.

Table 4-3 – Be Lean: Carbon Emissions After Providing Renewable Energy

	Furnival Street (New Build)	31-33 High Holborn (Existing Build)	Kingsway Tunnels (Existing Build)	Site Wide		
Total	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Unregulated Emissions (Tonnes)**	**% Reduction in Regulated Carbon Emissions**
Baseline emissions (Tonnes CO_2)	1.1	3.8	69.4	74.2	22.8	-
Be Lean: Emissions after energy demand reduction (Tonnes CO_2)*	1.0	3.9	69.1	74.0	22.8	0.3%

**The energy efficiency savings have been calculated on the basis that the buildings are served by a central heating system served by ASHPs with a seasonal efficiency of 264% for space heating and 286% for DHW.*

While the results shown in Table 4-3 fall short of the aspiration 15% GLA target, it should be noted that this target was put in place under the 2013 Building Regulations. Due to the existing heritage of the projects, has not been possible to update the material in the actual Tunnels. Furthermore, the Tunnels already benefit from the insulation provided by the soil surrounding the structure. However slight improvements are available across the project to ensure a reduction compared to the Notional building.

Table 4-4 shows the cooling demand of the development. While the above ground buildings slightly exceed the notional cooling demand, the Proposed Development as a whole shows a lower total cooling demand when compared to the notional value.

Table 4-4 – Cooling demand

Building		Area weighted cooling demand (MJ/m²)	Total cooling demand (MJ/year)
Tunnels	Proposed	18	139.834.8
	Notional	18.7	145,272.8
Furnival Street	Proposed	18.9	14,454.7
	Notional	14.8	11,319.04
31-33 High Holborn	Proposed	29.1	4,976.1
	Notional	22.2	3,796.2
Total	Proposed		159,265.6
	Notional		160,387.8

5 OVERHEATING ANALYSIS

Overheating and reliance on air conditioning systems have been considered in accordance with the following cooling hierarchy:

- Minimise internal heat generation through energy efficient design;
- Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls;
- Manage the heat within the building through exposed internal thermal mass and high ceilings;
- Passive ventilation;
- Mechanical ventilation; and
- Active cooling systems (ensuring they are the lowest carbon options).

Dynamic thermal models were built in IES VE to verify the internal conditions of the non-residential elements of the development. All occupied spaces have been analysed against the criteria within TM52. A stepped approach was utilised following the cooling hierarchy. Measures were incorporated into the models and building design until internal conditions became acceptable.

The following weather files have been used in the analysis following the GLA guidance for overheating assessments:

- London_LWC_DSY1_2020High50 (a moderately warm summer);
- London_LWC_DSY2_2020High50 (a year with a very intense single warm spell); and
- London_LWC_DSY3_2020High50 (a year with a prolonged period of sustained warmth).

Due to the tunnel being under ground, the weather files do not directly impact the Tunnels in the same way as buildings with direct connection to the outside air. The assessment has been run in line with TM52 methodology, however it is acknowledged that this presents a limitation in terms of what can be done in IES VE. For this reason, a more advanced tunnel model will be developed in the next stage of assessment. This model will allow a detailed overheating study to be carried out, similar to assessments that are done for underground train stations, where the rising temperature of the soil can be more accurately captured.

5.1 CIBSE TM52 OVERHEATING CRITERIA

CIBSE TM52 sets out criteria based on an adaptive approach to thermal comfort. The ‘adaptive’ approach to thermal comfort shows that the temperature at which the majority of people are comfortable ‘tracks’ the mean indoor temperature because of the correlation between indoor and outdoor temperature in naturally ventilated (free-running) buildings.

The following three criteria, taken together, provide a robust yet balanced assessment of the risk of overheating of buildings in the UK and Europe. A room or building that fails any two of the three criteria is classed as overheating.

- The first criterion states the number of hours (He) during which ΔT (the difference between the actual operative temperature in a room and the limiting maximum acceptable air temperature) is greater than or equal to one degree (K) during the period May to September inclusive shall not be more than 3% of occupied hours.
- The second criterion deals with the severity of overheating within any one day, which can be as important as its frequency, the level of which is a function of both temperatures rise and its duration. This criterion sets a daily limit for acceptability. To allow for the severity of overheating the weighted exceedance (We) shall be less than or equal to 6.
- The third criterion sets an absolute maximum daily temperature for a room, beyond which the level of overheating is unacceptable. The value of ΔT shall not exceed 4K.

5.2 OVERHEATING ANALYSIS

For the purposes of this analysis the following key assumptions have been made based on CIBSE TM52 guidance:

5.2.1 INTERNAL GAINS

- The use of high efficiency fluorescent and/or LED luminaries is specified throughout. It is expected that the internal gains will be significantly lower than the specified in this analysis, however this will be designed in the detailed design stage; and
- An infiltration rate of 0.15 ACH in all spaces where it is applicable.

The following gains were used in the analysis:

Table 5-1 – Occupancy Gains

Area	Maximum Sensible Gain	Maximum Latent Gain	Occupancy Density
Office	75	55	1 person per 10 m^2
Attraction/Retail	75	55	1 person per 5 m^2

Table 5-2 – Internal Equipment Gains for Conditioned Areas

Area	Lighting*	Equipment
Office	10 W/m^2	10 W/m^2
Attraction/Retail	10 W/m^2	10 W/m^2

*The lighting design will target significant lower values compared to these. However, these values are used a worst case scenario.

- NABERS equipment and occupancy profiles were used for all offices.

Table 5-3 – Comfort Criteria for Conditioned Areas

Area	MET	CLO Winter	CLO Summer	Heat. Setpoint	Cool. Setpoint
Office - Tunnels	1.0	0.8	0.8	20	24
Office – Furnival St	1.2	1.0	0.7	21	23
Bar – Tunnels	1.0	0.6	0.6	20	24
Retail – Furnival St	1.4	1.0	0.5	19	23
Exhibition - Tunnels	0.9	0.7	0.4	20	23

5.2.2 VENTILATION

The following auxiliary ventilation rates have been specified in the analysis:

Table 5-4 – Ventilation Rates

Area	Ventilation Rates
Office	10 l/s/person
Attraction/Retail	10 l/s/person

Auxiliary ventilation is considering operating all times in all spaces where it has been specified. The summer ventilation supply temperature has been adjusted in the analysis to consider the use of heat recovery in all main spaces.

5.3 RESULTS

The table below summarises the performance of the project during occupied hours after each step of the cooling hierarchy is introduced.

Table 5-5 – Cooling Hierarchy, Project Measures and Project Performance/Simulation Results for Occupied Zones

Description	Project Measures	DSY 1 2020high50	DSY 2 2020high50	DSY 3 2020high50
		THERMAL COMFORT PERFORMANCE		
1.Minimise internal heat generation through energy efficient design	100% low energy LED lighting will be provided to reduce internal heat gains.	0% zones pass	0% zones pass	0% zones pass
2.Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls	The proposal for the façade include solar control glass and high thermal performance specification where possible; helping to reduce solar gain.	0% zones pass	0% zones pass	0% zones pass
3.Manage the heat within the building through exposed internal thermal mass and high ceilings	N/A due to geometry/constraints	N/A	N/A	N/A
4.Passive ventilation	N/A due to geometry/constraints	N/A	N/A	N/A
5.Mechanical ventilation	Mechanical ventilation providing 10l/person/second.	85% zones pass	3% zones pass	2% zones pass
6.Active cooling systems (ensuring they are the lowest carbon options)*	An efficient water cooled system allows mitigation of overheating spaces. As the cooling strategy is electrically based it is the most carbon efficient solution. This is due to high efficiencies and the carbon emissions associated to it will continually decrease with the decarbonisation of the grid.	100% zones pass	100% zones pass	100% zones pass

* Rooms compliance for simulation when active cooling system and mechanical ventilation are incorporated are assessed against TM52 minimum criteria for mechanically cooled buildings.

As seen in Table 5-5, the passive measures including the openable windows have a positive impact on the thermal comfort results. It should however also be noted that in order to future proof the building for future climate conditions, it is necessary to install an active cooling system. This system is of high efficiency and will ensure thermal comfort of the building users.

5.4 BS EN ISO 7730 – PREDICTED MEAN VOTE (PMV) AND PERCENTAGE OF PEOPLE DISSATISFIED (PPD) INDICES FOR AIR-CONDITIONED BUILDINGS

Thermal comfort can be difficult to measure because it is highly subjective. It depends on the air temperature, humidity, radiant temperature, air speeds, activity rates, and clothing levels. However, each individual experiences these sensations differently based on his or her physiology and state. TM52 recommends carrying out predicted mean vote and predicted percentage dissatisfied for airconditioned spaces.

5.4.1 PREDICTED MEAN VOTE (PMV)

The PMV is an index that predicts the mean votes of a large group of persons on the seven-point thermal sensation scale based on the heat balance of the human body. Thermal balance is obtained when the internal heat production in the body is equal to the loss of heat to the environment. Values are measured on the following 7-point thermal sensation scale, see Figure 5-1.

5.4.2 PREDICTED PERCENTAGE DISSATISFIED (PPD)

The PPD is an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people who feel too cool or too warm. For the purposes of ISO 7730[6], thermally dissatisfied people are those who will feel hot, warm, cool or cold, see Figure 5-1.

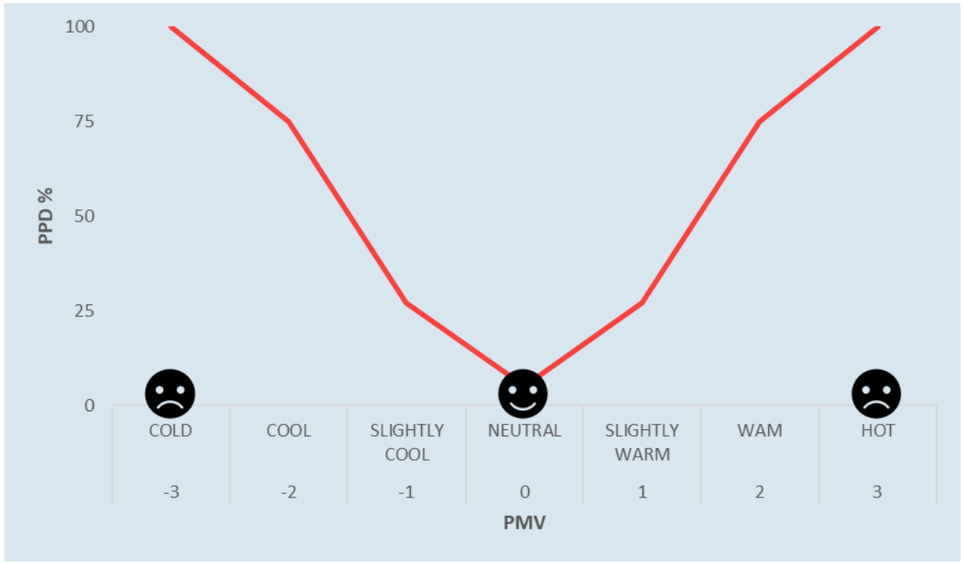


Figure 5-1 – PPD/PMV 7-Point Thermal Scale

Zero is the ideal value, representing thermal neutrality, and the comfort zone is defined by the combinations of the six parameters for which the PMV is within the recommended limits (-0.5 < PMV < +0.5).

Percentage of people dissatisfied (PPD) predicts the percentage of people who would be dissatisfied, taken as those who would vote >+1 or <–1 on the sensation scale. The PPD is a function of the predicted mean vote (PMV). It applies to a large group of people in the same thermal environment and with identical clothing and activity level.

PPD assumes that everyone has the same metabolic rate and the same clothing insulation, while people are free to choose their clothing for comfort and their activities vary. The actual percentage dissatisfied may therefore differ substantially from that predicted by the PPD equation; in general, having a free choice of attire would tend to reduce the actual percentage dissatisfied while variation in activity level within a space would tend to increase the actual percentage dissatisfied.

The CIBSE Guide A operative temperature ranges correspond to a PMV of +/- 0.25 which sits between the Category A and Category B requirements listed in Annex A, Table A.1 of EN ISO 7730 as shown on Table 5-6 below. Compliance with the CIBSE Guide A criteria will therefore effectively also demonstrate compliance with the Category B requirements set out in EN ISO 7730.

Table 5-6 – Annex A, Table A.1 of EN ISO 7730

Category		Thermal State of the Body as a Whole	
		Allowable Predicted Percentage or People Dissatisfied (PPD) %	Allowable Predicted Mean Vote (PMV)
A	Recommended for spaces occupied by very sensitive and fragile persons with special requirements (very young children, elderly, ill)	<6	-0.2 < PMV < +0.2
B	Recommended for most new buildings and renovations	<10	-0.5 < PMV < +0.5
C	Recommended for existing buildings	<15	-0.7 < PMV < +0.7

5.5 WELL STANDARD

The WELL Standard set out the percentage of occupied hours and the percentage of occupied spaces, which should meet the PMV ranges, see Table 5-7.

Table 5-7 – WELL Standard PMV Criteria

PMV Range	Percentage of Occupied Hours	Percentage of Regularly Occupied Spaces
+/- 0.5	For at least 90%	At least 90%
+/- 1.0	For at least 98%	At least 95%

5.6 RESULTS

Table 5-8 – PMV and PPD indices for Current London DSY1 2020High50

Space Type	% Occupied Hours Complying with pmv at -/+0.5 /PPD at 10% Criteria (Worst Performing Space)		
	DSY1 2020High50	DSY2 2020High50	DSY3 2020High50
Office tunnel	99.1%	98.5%	99.1%
Office Above ground	100%	99.9%	100%
Bar	100%	99.3/%	100%
Retail	100%	98.1%	98.4%
Attraction Tunnels	99.9%	99.7%	99.7%

As seen in Table 5-7, all offices perform in line with the TM52 and WELL Standard and it is therefore anticipated that these will provide thermal comfort to the occupants. It is acknowledged that specialised tunnel software should be used in the next stage of the project to ensure that the uniqueness of the space is accurately captured. The model will allow a detailed overheating study to

be carried out, similar to assessments that are done for underground train stations, where the rising temperature of the soil can be more accurately captured.

6 BE CLEAN

After consumption has been reduced through the application of energy efficiency measures, the next step is to consider low carbon technologies in order to provide further reduction in carbon dioxide emissions.

An appraisal of 'efficient supply' technologies was undertaken in the Be Green section. The GLA states that in order to comply with London Plan Policy SI3, developments in Heat Network Priority Areas (HNPAs) should have a communal low-temperature heating system and select a heat source in accordance with the heating hierarchy which favours heat networks and zero-emission heat sources.

6.1 CONNECTION TO AN AREA WIDE HEAT NETWORK

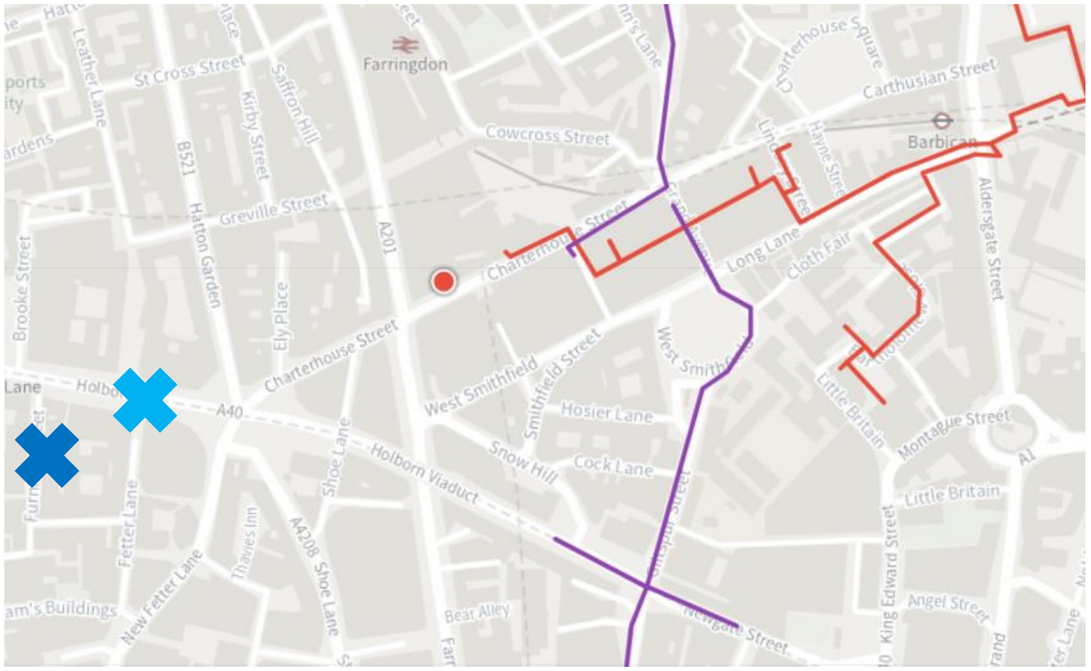


Figure 6-1 – Excerpt from the London Heat Map Showing and Existing (Red) /Proposed (Orange) District Heating Networks, Nearest Site Point (Light Blue) and Site Plant Room (Dark Blue)

Based on the London Heat Map as shown in Figure 6-1 above, the District Heat Network (DHN) provider for the nearest networks have been contacted. WSP has been in contact with E.ON to discuss the possibility to connect to the Citigen heat network. Due to the potential of exporting waste heat from the development, the conversation with E.ON is still ongoing, see communication in the appendix.

During a meeting with E.ON it was discussed that the infrastructure in terms of pipework is currently not installed by the Tunnels. Some constraints are currently in place however future expansion towards the Site area could be viable.

6.2 FUTURE DHN CONNECTION

In accordance with the GLA's Guidance on Preparing Energy Statements the low temperature hot water system has been designed to facilitate connection to the network should such connection become viable. Energy Statements should:

"Commit to a Site wide heat network to allow connection to existing or planned district heating networks identified in the area"[1]

In accordance with the London Plan and planning policy, space provision has been made for a future connection to a local heat network. To accommodate the connection, one of the chillers will be removed to provide space for the plate heat exchanger. Future DHN connection has been located within the B1 plantroom at Furnival Street, see Figure 6-2.

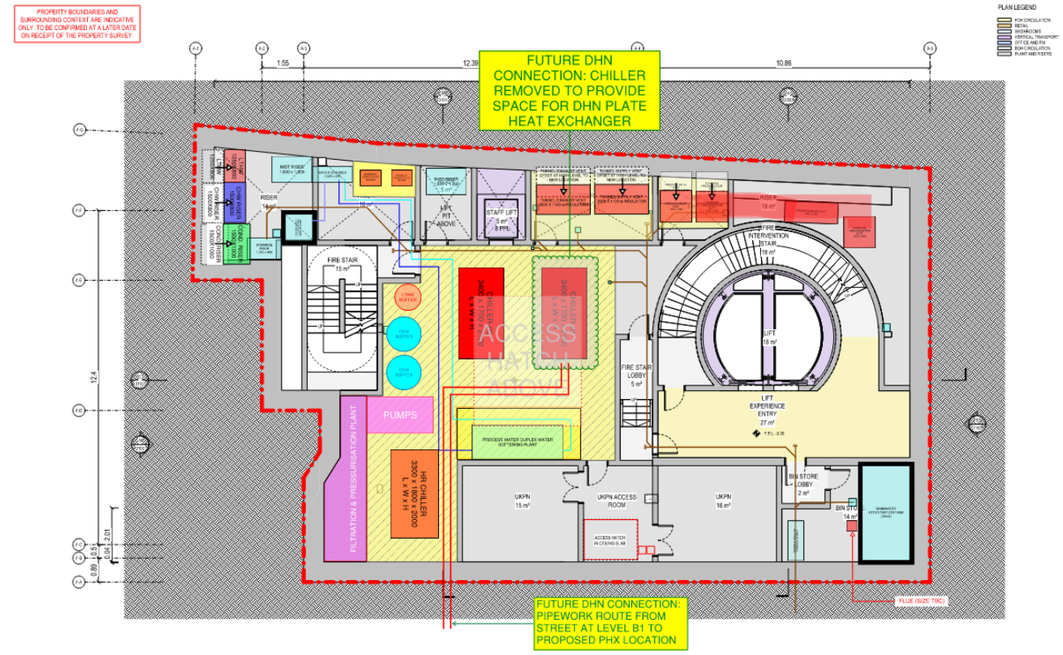


Figure 6-2 – DHN Allowance

[1] GLA's Guidance on Preparing Energy Statements – Section 1.5

The future provision shall be complete with a dedicated plant provision for connection to extension of the local district heat network. In the future, the building via plate heat exchangers and a 3-port valve arrangement, mixing the network temperature to suit the in-building regime. The overall carbon emissions for the development are shown in Table 6-1. Due to no current options for DHN connection, the results have not changed from the Be Lean stage.

The Tunnels and the existing above ground building at 31-33 High Holborn have been assessed as existing buildings in line with the GLA Energy Assessment Guidance. New construction assessment guidance has been applied for 39/40 Furnival Street due to the nature of the redevelopment at this building.

The SAP 10.2 carbon factors have been used for all further calculations using version 2.0 of the GLA Carbon Emission Reporting Spreadsheet.

Table 6-1 – Be Clean: Carbon Emissions After the Application of Be Clean Measures

	Furnival Street (New Build)	31-33 High Holborn (Existing Build)	Kingsway Tunnels (Existing Build)	Site Wide		
Total	Regulated Emissions (Tonnes)	Regulated Emissions (Tonnes)	Regulated Emissions (Tonnes)	Regulated Emissions (Tonnes)	Unregulated Emissions (Tonnes)	% Reduction in Regulated Carbon Emissions
Baseline emissions (Tonnes CO_2)	1.1	3.8	69.4	74.2	22.8	-
Be Lean: Emissions after energy demand reduction (Tonnes CO_2)*	1.0	3.9	69.1	74.0	22.8	0.3%
Be Clean: Emissions after energy efficient supply (Tonnes CO_2) *	1.0	3.9	69.1	74.0	22.8	0.3%

**The energy efficiency savings have been calculated on the basis that the buildings are served by a central heating system served by ASHPs with a seasonal efficiency of 264% for space heating and 286% for DHW.*

7 BE GREEN

Renewable energy technologies can provide a source of energy on-Site that is not primarily based on the consumption of fossil fuels or grid electricity and/or utilises a heat source that is renewable such as ground source and solar thermal systems.

In accordance with the requirements of the London Plan policy, we have evaluated a number of renewable energy technologies and outlined how they may be applied to the Proposed Development.

7.1 WIND POWER

Harnessing the kinetic energy of wind can provide a renewable source of onSite electricity generation. Wind turbines need to be positioned where a frequent and steady source of wind is available that is not too turbulent or uneven in direction. Typically, wind turbines are positioned on the roof of buildings that are significantly higher than their surroundings and or located in open areas where there is minimum disruption to prevailing winds.

The Proposed Development is located within an urban environment with near-by buildings providing turbulent wind conditions unsuitable for wind power generation. In addition, it is not considered appropriate in townscape, architectural and aviation safeguarding terms to provide wind turbines on top of buildings. Due to the urban location, there is limited space to generate a significant amount of power and reinforcing the roof be strong enough the sustain a wind turbine is likely to be very costly. On that basis they are not proposed for the Proposed Development.

7.2 BIOMASS HEATING

Biomass heating has embodied environmental impacts from transport and fuel combustion which makes it less desirable in Air Quality Management Areas (AQMAs), such as where the application Site of the Proposed Development is located. A review of the potential impact on air quality from increased wood fuelled biomass use in London has been conducted by AEA Energy & Environment and was published in December 2007. The assessment indicates that potentially increasing the contribution from small-scale wood fuelled biomass combustion may lead to a substantial increase in nitrogen dioxide and particulate matter concentrations.

Further to this, solid biomass relies on a reliable fuel supply which must be delivered and stored on Site. The application Site therefore requires good access routes and space for fuel storage and plant, which could not feasibly be incorporated within the proposed Scheme. It also has relatively high maintenance requirements and fuel costs.

This technology is therefore deemed to be unsuitable for the Proposed Development.

7.3 GROUND SOURCE HEATING AND/OR COOLING

Ground source heating and/or cooling may be incorporated to make use of the thermal storage and ground temperature to provide heating and/or cooling to a building. Ground source heating is an effective renewable energy source when used to provide space heating via low grade heating system such as underfloor heating. Furthermore, a ground source heating system is not complementary to the councils' and the GLA's requirement to support and develop district heating networks; therefore, it is not considered feasible for the Proposed Development.

7.4 SOLAR THERMAL HOT WATER HEATING

Solar thermal hot water (STHW) generation involves capturing solar radiant heat to preheat or heat domestic hot water. Correctly located and orientated, solar thermal systems can meet a proportion of a building's domestic hot water dependent on the expected demand profile and available space for locating STHW panels. Due to the limited amount of available space which will be used for solar photovoltaic panels, a STHW system is not proposed for the development. They would also conflict/compete with the air-/water-source heat pumps described below.

7.5 AIR SOURCE HEAT PUMPS

Air source heat pumps (ASHPs) are capable of providing heating and/or cooling utilising air temperatures. The use of ASHPs are an effective LZC technology as they have high efficiencies for both heating and cooling.

With the decarbonising grid due to an increase in renewable energy generation and a reduction in coal power generation, the operational impact of electrically led systems is reduced. Therefore, the benefit of heat pump technologies will improve through the lifetime of the Proposed Development.

7.6 WATER SOURCE HEATING AND OR COOLING

Bodies of water can be used to extract or reject heat as long as there is an adequate water flow. However, there is minimal flow in a canal and utilising this as a source to extract/reject heat is not feasible.

WSHPs have a significantly higher coefficient of performance (COP) than ASHPs due to the higher temperature of the heat source which is constant throughout the year. A highly efficient building fabric combined provide an ideal method of providing space heating to the development. Low flow temperatures from the WSHPs further reduce the energy consumption and carbon emissions for the Proposed Development.

WSHPs are powered by grid supplied electricity. As mentioned in the ASHP section above, the National Grid is increasingly decarbonising due to an increase in renewable energy generation and a reduction in coal power generation. This leads to a long-term low carbon solution. Due to the high level of heat recovery from the chillers, water source heat pumps are not currently proposed in the Scheme.

7.7 PHOTOVOLTAIC PANELS

The feasibility of providing PV panels has been assessed based upon estimated energy production (kWh) from the installed location along with manufacturers cost data to enable a life cycle cost analysis to be undertaken. Panels correctly oriented, maintained and not obscured by shading can be expected to provide in the region of 120kWh/m^2/year in London.

The roof areas of the project are located at 38-39 and 40-41 Furnival Street, see Figure 7-1.

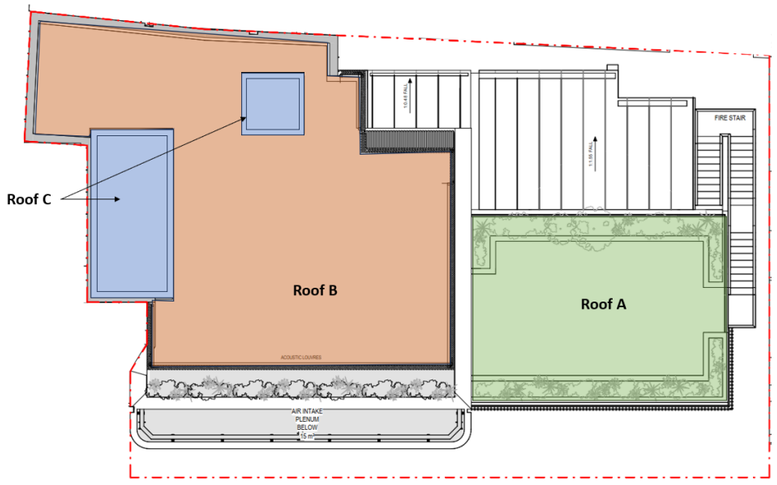


Figure 7-1 - Roof areas

Due to very constrained area on the roof, the roof area is at a premium and the usage has been identified in Table 7-1.

Table 7-1 – Roof use

Roof type	Area (m^2)	Use
A	91.5	Terrace
B	132.4	Plant area
C	23.2	Stairs/lift overrun

The limited available roof area accessible from the office (Roof A) will be used as amenity space for the staff. This will also create more visual value to the residential properties behind the Site. Furthermore, due to the limited above ground space, the terrace will be only of the only spaces that can be used to support the urban greening factor.

The largest roof area will be used to accommodate the servicing plant of the building. As seen in Figure 7-2, roof B will be fully utilized for mechanical equipment which has specific ventilation requirements and therefore the airflow should be hindered by PV. Furthermore, the PV cannot be placed on top of mechanical equipment for health and safety reasons relating to access.

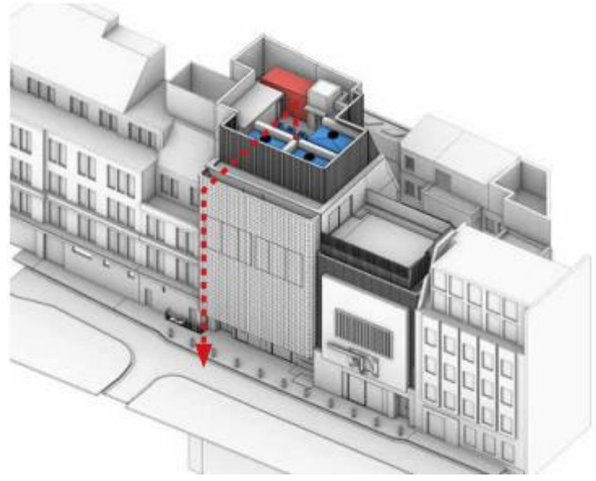


Figure 7-2 - Mechanical equipment over roof type B

A solar exposure analysis was carried out on roof type B which shows that the roof will be overshadowed due to the perimeter balustrade, therefore it can be concluded that this roof is not suitable for photovoltaic panels. Figure 7-3 shows the annual solar exposure over the roof type B.

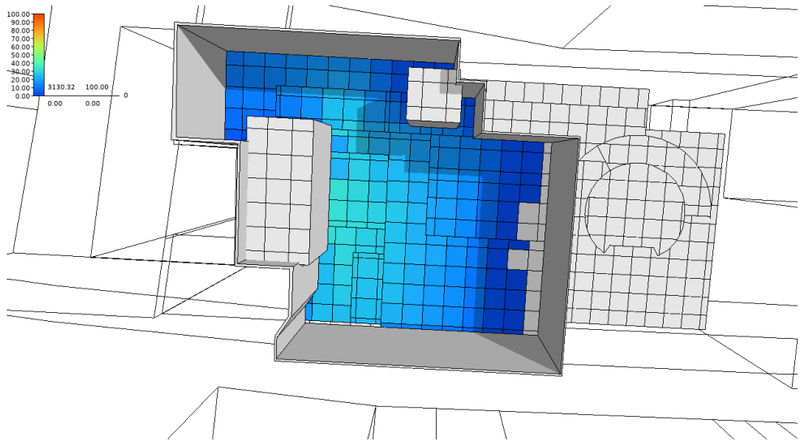


Figure 7-3 - Solar exposure over roof type B

Finally, the very limited area available of roof type C will be used to further maximise the urban greening factor. Due to the levels change from roof type B, the access to the roof would be a health and safety risk and at the same time take away from the fully utilised plant area of roof type B.

Based on the above analysis, PV will not be incorporated into the Proposed Development.

7.8 FEASIBILITY OF EXPORTING HEAT/ELECTRICITY FROM THE SYSTEM

If the district heat network connection becomes possible in future, further assessment will be undertaken to investigate whether exporting waste heat/cool from the project.

7.9 SYSTEM MONITOR OF PERFORMANCE

The Proposed Development will be provided with Building Management System. This will control and monitor the building systems and services throughout the development, provide feedback of plant, system performance and energy usage of the system. The BMS will analyse this data to enable optimum use of the engineering facilities within the development with minimum of human intervention, and maximum energy efficiency.

7.10 CARBON EMISSIONS REDUCTION

All renewable energy technologies which may be considered feasible for the Proposed Development have been assessed, the outcomes of which are summarised above. Savings from renewable energy are shown in the below tables.

The Tunnels and the existing above ground building at 31-33 High Holborn have been assessed as existing buildings in line with the GLA Energy Assessment Guidance. New construction assessment guidance has been applied for 38-39 and 40-41 Furnival Street due to the nature of the redevelopment at this building.

Table 7-22 – Carbon Emissions After Providing Renewable Energy

	Furnival Street (New Build)	31-33 High Holborn (Existing Build)	Kingsway Tunnels (Existing Build)	Site Wide		
Total	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Regulated Emissions (Tonnes)**	**Unregulated Emissions (Tonnes)**	**% Reduction in Regulated Carbon Emissions**
Baseline emissions (Tonnes CO_2)	1.1	3.8	69.4	74.2	22.8	-
Be Lean: Emissions after energy demand reduction (Tonnes CO_2)*	1.0	3.9	69.1	74.0	22.8	0.3%
Be Clean: Emissions after energy efficient supply (Tonnes CO_2) *	1.0	3.9	69.1	74.0	22.8	0.3%
Be Green: Emissions after renewable energy (Tonnes CO_2)	0.5	3.6	39.4	43.5	22.8	41.4%

**The energy efficiency savings have been calculated on the basis that the buildings are served by a central heating system served by ASHPs with a seasonal efficiency of 264% for space heating and 286% for DHW.*

8 RESULTS

The three principal steps taken; Be Lean (Use Less Energy), Be Clean (Supply Energy Efficiently) and finally Be Green (Renewable Technology Measures) are summarised below. The target (Building Regulations compliant) carbon emissions for the Proposed Development are calculated to be 43.5 tonnes CO2 per annum. Any percentages refer to the reduction of carbon emissions from this baseline, see Figure 8-1.

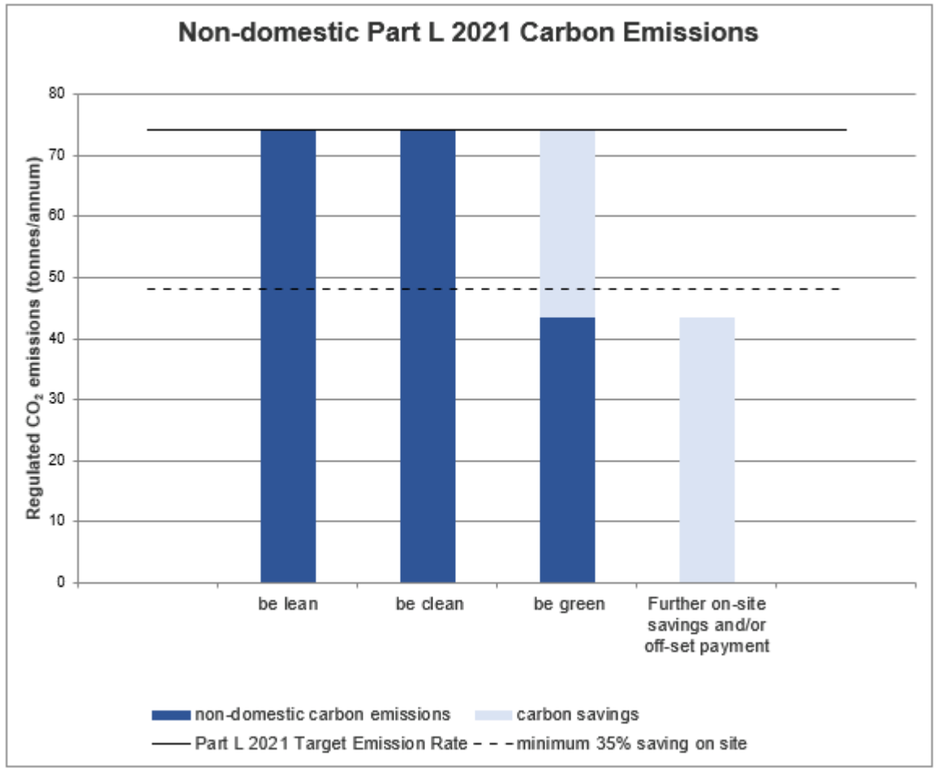


Figure 8-1 - Carbon emissions savings bar chart

8.1 DEMAND REDUCTION (BE LEAN)

The application of the measures identified in the report provides an overall reduction of **0.3%** in carbon emissions from the Proposed Development and a total carbon reduction of **0.2** tonnes CO_2 per annum from the baseline carbon emissions. After this stage of the energy hierarchy the total regulated carbon emissions from the Proposed Development is shown to be **74** tonnes CO_2 per annum.

8.2 HEATING INFRASTRUCTURE (BE CLEAN)

It is not yet possible to connect to a DHN. Therefore, the results are the same as for the Be Lean stage.

8.3 RENEWABLE ENERGY (BE GREEN)

The feasibility of a range of renewable technologies has been assessed in the context of the London Plan. It was concluded that ASHPs are suitable for the development.

The renewable technology provides an overall reduction of **41%** in carbon emissions from the Proposed Development and a total carbon reduction of **30.7** tonnes CO_2 per annum from the baseline carbon emissions compliant development. After this stage of the energy hierarchy, the total regulated carbon emissions from the Proposed Development are shown to be **43.5** tonnes CO_2 per annum.

8.4 GLA GUIDANCE ON PREPARING ENERGY ASSESSMENTS

In direct response to the information outlined within the Greater London Authority (GLA) Guidance on Preparing Energy Assessments (June 2022), the results outlined previously are summarised in the tables below, with the results presented against the overall carbon reduction target.

The proposals for the Proposed Development outlined within this energy strategy are considered to maximise the potential carbon savings which can be achieved on the application Site through the provision of:

- A highly efficient building fabric;
- Efficient building services plant, including providing high efficiency air handling plant with heat recovery;
- 100% low energy lighting and maximised use of LED and low energy fixtures; and
- ASHPs and water-cooled chillers supplying a downflow unit system.

Overall, the Proposed Development maximises the reduction of carbon emission over the notional building as required by GLA. The building fabric, air tightness, thermal bridging and g-value specifications have all been maximised to provide the maximum carbon reductions. High performing efficient building services plant, including providing high efficiency air handling plant with heat recovery have been considered.

8.5 PART L CARBON DIOXIDE EMISSIONS

The following tables provide a summary of the performance of the Proposed Development. The performance of development is provided in Table 8-1 summarises the overall Site performance.

Table 8-1 – Regulated Carbon Dioxide Savings from Each Stage of the Energy Hierarchy

	Regulated Carbon Dioxide Emissions Savings (Tonnes CO_2 per Annum)	Regulated Carbon Dioxide Emissions Savings (%)
Be lean: savings from energy demand reduction	0.3	0%
Be clean: savings from heat network	0.0	0%
Be green: savings from renewable energy	30.5	41%
Total Cumulative Savings	**30.7**	**41%**
Annual savings from off-set payment	43.5	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**1,305**	
Cash in-lieu contribution (£)	**£123,951**	

9 FLEXIBILITY AND PEAK DEMAND

In line with Policy SI2 and SI3 of the London Plan, the possibility for including measures for reducing peak energy loadings has been considered in detail.

Load and peak demand calculations have been undertaken for the whole development and appropriate system capacity has been provided.

9.1 COOLING DEMAND

The peak cooling load for the Proposed Development has been estimated as approximately 1.8MW. There are 3 Cooling Towers at roof level on the 38-39 and 40-41 Furnival Street building, supplying to 2 chillers of 800kW cooling capacity each and a heat recovery chiller with a cooling load of 468kW. The significant thermal mass of the tunnel walls can be used to facilitate peak shifting of the cooling demand.

Table 9-1 – Cooling Load and Capacity

	Heat
Peak Cooling Load (MW)	1.8MW
Available Capacity (MW)	2MW

9.2 HEATING DEMAND

The peak heating load for the Proposed Development has been estimated as approximately 395kW. Therefore, 1 Heat Recovery chiller with a maximum capacity of 400kW has been proposed to provide 254kW fresh air heating and 141kW domestic hot water.

Table 9-2 – Heat Load and Capacity

	Heat
Peak Heating Load (MW)	395kW
Available Capacity (MW)	400kW

9.2.1 HEAT NETWORK CONECTION

Connection to the City 2 district heat network is not possible at this time. However, in accordance with the GLA's guidance, the London Plan and planning policy, the low temperature hot water system has been designed to facilitate connection to the network, should such connection become viable.

9.2.2 HOT WATER ENERGY STORAGE AND HEAT RECOVERY

LTHW and CHW thermal stores will be located in the basement level 1. These are not designed for system resilience, as the building is expected to mainly operate at peak loads throughout the year. During down time periods where demand is decreased the chillers would reduce the capacity to meet the demand. The primary purpose of the stores will be to provide sufficient thermal mass during the defrost cycle, as well as to increase system efficiency and prevent the units from cycling.

1 no. 2500 litre LTHW and 2 no. 3750 litre CHW thermal store will be connected in series on the return of the pipework from the building. The thermal stores shall not be installed in parallel.

The distribution loss has been calculated as follows in Table 9-3. This will be revaluated as design progresses.

Table 9-3 – Distribution Loss

Distribution loss		
Primary network (buried pipe)	Total pipe length (m)	N/A – no buried pipework
	Average heat loss rate (W/m)	N/A – no buried pipework
Secondary network (buried pipe)	Total pipe length (m)	N/A – no buried pipework
	Average heat loss rate (W/m)	N/A – no buried pipework
Total losses (MWh/year)		N/A – no buried pipework

9.3 ELECTRICAL DEMAND

As per design criteria detailed in MEP Stage 2 report, it has been estimated that the power requirements for the new development will be as follows.

Table 9-4 – Electrical Load Assessment

	KVA	Allowance (include for, Small Power, Lighting & Mechanical Loadings)
Exhibition Avenue	400	
Exhibition Street	400	
Café Spaces	205	
Bar	150	
Lift Lobbies and Reception	40	
Retail	240	
Function Rooms	150	
Ancillary Spaces/Shop	240	
Kitchens	200	
Office Areas	70	
WCs	10	
Circulation and Staircases	10	
AV/IT/Server Rooms	1500	

Plant Areas	200	
Total	**3815**	**Additional 10% allowance to be included for future capacity**

On Site, 2No. new 33kV UKPN Intake rooms will need to be established consisting of 3-panel 33kV switchboard (2 x incomers; 1 x feeder circuit breaker) each along with the associated auxiliary and ancillary equipment.

2No. 33KV intake rooms to be supplied at 38-39 and 40-41 Furnival Street to supply equipment associated with

The building will utilise 4No.33/0.4kV transformers each of which will be housed in a separate room in order to increase the resilience of the system. The secondary side of each 33/0.4kV transformer will supply the Main Distribution LV switchboards, which will be located in dedicated LV switch rooms.

An alternative supply is proposed to emanate from a 550KVA enclosed generator set located on the roof of 38-39 and 40-41 Furnival Street which is then distributed to provide dedicated secondary supplies to the life safety systems.

9.3.1 AV SYSTEM SMART CONTROLS

Smart control on the AV systems in event spaces will be used to facilitate a reduction in standby loading, and demand side response as far as possible within the constraints of the events being held.

9.3.2 ELECTRICAL ENERGY STORAGE

Battery storage has not been included due to a lack of renewable energy generation and space considerations. However, as battery technology improves, the potential for this to be included will be investigated for future phases of the development.

9.4 FLEXIBILITY INTERVENTIONS

Table 9-5 – Summary of Interventions for Achieving Flexibility

Flexibility Achieved Through	Yes/No	Details
Electrical Energy Storage (kWh) capacity	No	Battery storage has not been included due to a lack of renewable energy generation and space considerations
Heat Energy Storage (kWh) capacity	Yes	3750 l (Chilled water), 2500 l (LTHW) of thermal storage has been included to help reduce peak heat demand. However, this is not sized with the intention to shift peak demand but to allow improved control and operation of the heat pumps and chillers avoiding 1) chillers running reduced load and short cycling.
Renewable Energy Generation (load matching)	No	No renewable energy generation proposed.
Gateway to enable automated demand response	No	Not proposed
Smart systems integration	No	Not proposed

Table 9-6 – Summary of Site-Wide Peak Demand, Capacity and Flexibility Potential

	Electrical	Heat
Estimate Peak Demand (MW)	4,000 kW	411 kW
Available Capacity (MW)	TBC at next stage	TBC at next stage
Flexibility Potential (MW)	TBC at next stage	TBC at next stage
Revised Peak Demand (MW)	TBC at next stage	TBC at next stage
Percentage flexibility predicted (%)	TBC at next stage	TBC at next stage

10 BE SEEN

The ‘Be Seen’ – Energy Monitoring Guidance’ consultation ended in early 2021. Therefore, meeting the ‘Be Seen’ stage has become a requirement. In light of this, the Proposed Development has sought to and is committed to comply with the requirements described in the guidance for the “Planning Stage”, “As-Built Stage” and “In-Use Stage”.

For compliance with “Planning Stage” requirements, the following has been completed for the Proposed Development:

- Completion of the GLA’s ‘be seen’ spreadsheet with performance indicators including contextual data, building energy use and carbon emissions for the entire development as a whole;
- Confirm target dates for all subsequent ‘Be Seen’ stages’;
- Report the energy consumption (kWh/m^2) and carbon emissions (tonnes CO_2/m^2) estimates following Part L (2021) compliant methodology using SAP assessments as per the ‘Be Seen’ guidance;
- Production of a TM54 analysis in line with the minimum requirements of the ‘Be Seen’ energy monitoring guidance (June 2022); and
- Contribution of operational carbon performance for Module B6 of the separate Whole Life-Cycle Carbon assessment using the findings of the TM54 analysis.

See Table 10-1 and Table 10-2 for project performance indicators and contextual data.

Table 10-1 – Performance Indicator

Performance Indicator	
Total Site Carbon Emissions (regulated) (tCO2e)	1,305
Total Site cash-in-lieu (£)	123,951

Table 10-2 – Planning Stage Contextual Data

Contextual data	Part L Calculation
Location/Address	38-39 and 40-41 Furnival Street, Kingsway Tunnels, 31-33 High Holborn
Site Plan	Please refer to WEA’s drawing pack
Typology/Planning Use Classes	F1
GIA per Typology/Planning Use Classes	11,147 m^2
Anticipated Reporting Stage	Stage 2

10.1 PART L 2021

As the building stretches across two London boroughs Camden and The City of London, the energy analysis for Part L of the building regulations has been split into 3 sections. 38-39 and 40-41 Furnival Street, Kingsway Tunnels and 31-33 High Holborn.

Table 10-3 – 31-33 High Holborn Part L (2021)

Performance Indicator	Part L (2021) Calculation
Annual Electricity Use – Regulated (kWh/m2yr)	18.84
Annual Electricity Use – Unregulated (kWh/m2yr)	10.25
Annual Gas Use (kWh/yr)	0
Other Fuel Use (kWh/yr)	0
Elec Generation, Gross (kWh/yr)	0
Predicted Annual Carbon Emissions (kgCO_2/m^2)	2.67

Table 10-4 – Kingsway Tunnels Part L (2021)

Performance Indicator	Part L (2021) Calculation
Annual Electricity Use – Regulated (kWh/m2yr)	37.59
Annual Electricity Use – Unregulated (kWh/m2yr)	38.34
Annual Gas Use (kWh/yr)	0
Other Fuel Use (kWh/yr)	0
Elec Generation, Gross (kWh/yr)	0
Predicted Annual Carbon Emissions (kgCO_2/m^2)	5.07

Table 10-5 – Furnival Street Part L (2021)

Performance Indicator	Part L (2021) Calculation
Annual Electricity Use – Regulated (kWh/m2yr)	33.8
Annual Electricity Use – Unregulated (kWh/m2yr)	13.36
Annual Gas Use (kWh/yr)	0
Other Fuel Use (kWh/yr)	0
Elec Generation, Gross (kWh/yr)	0
Predicted Annual Carbon Emissions (kgCO_2/m^2)	4.98

10.2 OFFSET

Table 10-6 – Application Carbon Offset

Performance Indicator	
Total Site Carbon Emissions (regulated) [tCO2e]	1,305
Total Site cash-in-lieu contribution [£]	123,951

Table 10-7 – Planning Stage Performance indicators (TM54)

	TM54 Analysis (Likely)
Annual Electricity Use (kWh/m^2_{GIA})	127
Annual Electricity Use (MWh/yr)	1,415
Other Fuel Use (kWh/yr)	0
Elec Generation, Gross (kWh/yr)	0
Predicted Annual Carbon Emissions (tCO_2/yr)	65.8

The CIBSE TM54 analysis results above have been used to represent the regulated and unregulated energy requirements for Module B6 within the accompanying Whole Life-Cycle Carbon (WLC) report. Please refer to the CIBSE TM54 analysis in the appendices and the separate WLC for further details.

The building's actual energy performance will be monitored post-construction. The Proposed Development will be provided with Building Management System. This will control and monitor the building systems and services throughout the development, provide feedback of plant, system performance and energy usage of the system. The BMS will analyse this data to enable optimum use of the engineering facilities within the development with minimum of human intervention, and maximum energy efficiency.

The landlord services fall under the category of sub metering as the main supplies will be bulk metered as part of the building switch rooms. Both small power and lighting are to be sub metered in distribution boards in compliance with TM39:2009. This is achieved via in line meters in the distribution boards. All metering information can be collected and distributed to the BMS via the landlords unified network.

10.3 DETAILED OPERATIONAL ENERGY ANALYSIS: DESIGN FOR PERFORMANCE

The CIBSE TM54: 2022 'Evaluating Operational Energy Performance of Buildings at the Design Stage' methodology has been used to evaluate the predicted operational energy use of the development. For each step of the methodology, the design parameters, together with assumptions regarding levels of occupancy and operation, have been used to predict the energy consumption for: lighting, lifts, small power, AV equipment, catering, servers, domestic hot water, space heating, cooling, fans and pumps.

While every attempt has been made to make a realistic model with conservative estimates, it is always an idealised case, and the actual operation of a building will have faults, unexpected events, and unpredictable tenant behaviour. A further set of simulations have been undertaken to assess the sensitivity of the building. At this stage this has focused on the predicted occupancy and opening times of the building along with the impact of the audio-visual equipment on the overall energy consumption. These parameters have been selected as they are some of the largest unknowns at this stage in design and will have a very significant impact on overall energy use, as this analysis documents. It will be especially important to carefully monitor the construction, commissioning and operation of the building to ensure the predicted energy consumption is achieved. The following three scenarios have been considered:

- Low Scenario: the low scenario represents the base building CAT A design where building operates with anticipated occupancy and opening hours but there is no energy intensive audio-visual equipment installed.
- Medium Scenario: the medium scenario is based on anticipated occupancy and opening hours, also taking into account the proposed HVAC efficiencies for the project. The AV system in this case is assumed to be mostly projectors with some screens, equivalent to roughly 50% AV coverage of the high scenario.
- High Scenario: the high scenario consumption is based on anticipated occupancy and opening hours, also taking into account the proposed HVAC efficiencies for the project. The AV system in this case is assumed to be mostly LED screens with some projectors.

Two of the key assumptions within the analysis are the power consumption of the building and the expected running hours of the building. The results have clearly demonstrated that the operational energy performance of the building is dependent on the level of occupancy and operation of the building, extending the opening hours means that lighting, equipment, and HVAC system will be running for longer and subsequently consume more energy.

The results show that by far the most significant source of energy consumption of the building is the audio-visual equipment that is chosen for the project. Compared with the base building adding projectors across the Avenues, Streets and Entrance Hall leads to an increase in annual energy consumption of 188% from 67 kWh/m^2 to 126 kWh/m^2, see Table 10-8. This shift also increases the cooling demand by over 700% increasing the size of cooling system required and overall embodied carbon of the HVAC system.

As the cooling demand is one of the largest loads in the building, several steps have been undertaken to ensure that cooling can be delivered as efficiently as possible. Heat is rejected by highly efficient cooling towers and water source chillers, circulating chilled water. Heat recovery has been implemented wherever possible to reduce the amount of heat rejected and improve system efficiencies. The air handling units incorporate high efficiency thermal wheels, which will be able to pre-heat air to heat above ground areas of the building using rejected heat from the Tunnels. Hot water can also be generated from rejected heat of the cooling system.

Fan energy consumption is also high as a result of the restricted special requirements and long duct runs leading to higher than usual pressure drop across the ventilation system. Care must be taken at

the next stage of design to ensure that the central air system is designed appropriately with reduced energy consumption in mind. The SFP of the central air handling system has been assumed to be 2.00 W/l/s. However, steps should be taken to reduce this at the next stage in design.

The annual building energy and carbon intensity, see Table 10-9 for each scenario are as follows:

Table 10-8 – Comparison of Annual Energy Intensity

	Low Scenario	**Medium Scenario**	**High Scenario**
Whole building Energy Intensity (MWh)	745	1415	2131
Whole building Energy Intensity (kWh/m^2 GIA)	67	126	191

Table 10-9 – Comparison of Annual Carbon – SAP 10.2 Factors

	Low Scenario	**Medium Scenario**	**High Scenario**
Total Carbon Intensity (TonneCO_2)	101	192	290

The Medium Scenario EUI of 126 kWh/m^2/yr means that the building will be above the industry best practice EUI benchmark for commercial buildings such as the 2020-2025 UKGBC NZC target for offices. However these benchmarks were not designed to apply for museums or unique project such as this one which aims to deliver a unique immersive experience to visitors in the heart of London.

11 CONCLUSION

In conclusion, the Proposed Development has been assessed in line with the GLA Energy hierarchy:

- Be Lean
- Be Clean
- Be Green
- Be Seen.

The Proposed Development has been designed to include high efficiency fabric and passive design measures. Active measures such as high efficiency heat pumps and heat recovery and connection to local heating and cooling networks, have also been included in the design to ensure the building is all-electric and supports the UK's decarbonisation goal. In accordance with the GLA's Guidance on Preparing Energy Statements the low temperature hot water system has been designed to facilitate connection to the network should such connection become viable. If a connection is not possible, the building is designed such that a connection point is available if a DHN connection is available in future.

The reductions under the GLA Energy Hierarchy have been maximised against the Part L 2021 notional building performance. The notional building is already a very energy efficient building but through collaborative engineering and design, the proposed building has incorporated solutions that results in a 41% reduction in regulated energy compared to the notional building.

A TM54 and Design for Performance study has also been carried out to more accurately predict the operational energy consumption of the building.

Appendix A

BRUKL - BE LEAN

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

London Tunnels

As designed

Date: Mon Oct 23 14:55:07 2023

Administrative information

Building Details

Address: Address 1, London, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.22

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.22

BRUKL compliance module version: v6.1.e.1

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m^2]: 84.98

The CO_2 emission and primary energy rates of the building must not exceed the targets

The building does not comply with England Building Regulations Part L 2021

Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	4.98	
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	5.07	
Target primary energy rate (TPER), kWh_{PE}/m^2.annum	52.91	
Building primary energy rate (BPER), kWh_{PE}/m^2.annum	53.63	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER > TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.28	1.19	B200000A:Surf[8]
Floors	0.18	0.26	0.75	GF000009:Surf[5]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.13	0.13	2F000000:Surf[10]
Windows** and roof windows	1.6	1.5	1.61	2F000000:Surf[3]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.36	1.4	DB000000:Surf[0]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Furnival St Fan Coil

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	2.64	7	0	1.79	0.76
Standard value	2.5*	6.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for water-to-water chillers >=1500 kW. For chillers 400-1499 kW, limiting SEER is 6. For chillers <400 kW, limiting SEER is 5.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	**System type in the Approved Documents**
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	**SFP [W/(l/s)]**									**HR efficiency**	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	**Zone**	**Standard**
2F_Retail	-	-	-	-	-	-	-	0.2	-	-	N/A
B1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_lift lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B1_Lift lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
B1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_lift lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_WC	-	-	-	-	-	-	-	0.2	-	-	N/A
4F_Tea Point	-	-	-	-	-	-	-	0.2	-	-	N/A
Office	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Lift Lobby	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_WC	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Circulation	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Circulation	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Lift Lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Circulation	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Lift Lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G5_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
GF_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
GF_Corridor	-	-	-	-	-	-	-	0.2	-	-	N/A
Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
Retail	-	-	-	-	-	-	-	0.2	-	-	N/A
WC	-	-	-	-	-	-	-	0.2	-	-	N/A
Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m^2]
Standard value	95	80	0.3
2F_Retail	178	-	-
B1_Stairs	333	-	-
B2_lift lobby	324	-	-
B2_Stairs	389	-	-
B1_Lift lobby	243	-	-
B1_Stairs	248	-	-
B2_lift lobby	361	-	-
B2_Stairs	346	-	-
B2_Stairs	441	-	-
B2_Stairs	312	-	-
B2_WC	504	-	-
4F_Tea Point	88	-	-
Office	87	-	-
G1_Lift Lobby	264	-	-
G1_Stairs	504	-	-
G1_Stairs	211	-	-
G1_WC	281	-	-
G1_Stairs	211	-	-
G1_Circulation	235	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
G1_Circulation	361	-	-
G1_Stairs	305	-	-
G1_Stairs	279	-	-
G1_Lift Lobby	209	-	-
G1_Circulation	267	-	-
G1_Lift Lobby	205	-	-
G1_Stairs	279	-	-
G5_Stairs	262	-	-
GF_Stairs	223	-	-
GF_Corridor	366	-	-
Stairs	218	-	-
Stairs	222	-	-
Retail	167	-	-
WC	234	-	-
Stairs	283	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
2F_Retail	NO (-43.7%)	NO
B1_Stairs	N/A	N/A
B2_lift lobby	N/A	N/A
B2_Stairs	N/A	N/A
B1_Lift lobby	N/A	N/A
B1_Stairs	N/A	N/A
B2_lift lobby	N/A	N/A
B2_Stairs	N/A	N/A
B2_Stairs	N/A	N/A
B2_Stairs	N/A	N/A
B2_WC	N/A	N/A
4F_Tea Point	NO (-11%)	NO
Office	YES (+57.3%)	NO
G1_Lift Lobby	N/A	N/A
G1_Stairs	NO (-100%)	NO
G1_Stairs	NO (-99.9%)	NO
G1_WC	N/A	N/A
G1_Stairs	N/A	N/A
G1_Circulation	N/A	N/A
G1_Circulation	N/A	N/A
G1_Stairs	N/A	N/A
G1_Stairs	N/A	N/A
G1_Lift Lobby	N/A	N/A
G1_Circulation	N/A	N/A
G1_Lift Lobby	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
G1_Stairs	N/A	N/A
G5_Stairs	N/A	N/A
GF_Stairs	NO (-94.8%)	NO
GF_Corridor	N/A	N/A
Stairs	NO (-100%)	NO
Stairs	NO (-99.4%)	NO
Retail	NO (-40.5%)	NO
WC	N/A	N/A
Stairs	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m^2]	764.8	764.8
External area [m^2]	3308.1	3723.5
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	819.67	901.35
Average U-value [W/m^2K]	0.25	0.24
Alpha value* [%]	16.18	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
34	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
66	**Non-residential Institutions: Libraries, Museums, and Galleries**
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	16.45	13.82
Cooling	1.1	0.89
Auxiliary	10.89	11.5
Lighting	5.37	8.99
Hot water	1.97	0.18
Equipment*	13.36	13.36
TOTAL**	**35.78**	**35.38**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	167.9	153.05
Primary energy [kWh_{PE}/m^2]	53.63	52.91
Total emissions [kg/m^2]	5.07	4.98

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	146	21.9	16.5	1.1	10.3	2.47	5.52	2.64	7
	Notional	138.2	14.8	13.8	0.9	11.5	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

London Tunnels

As designed

Date: Tue Oct 24 09:50:55 2023

Administrative information

Building Details

Address: Address 1, London, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.22

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.22

BRUKL compliance module version: v6.1.e.1

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m^2]: 2641.93

The CO_2 emission and primary energy rates of the building must not exceed the targets

The building does not comply with England Building Regulations Part L 2021

Target CO_2 emission rate (TER), $kgCO_2/m^2$annum	5.17	
Building CO_2 emission rate (BER), $kgCO_2/m^2$annum	8.93	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	56.51	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	97.72	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER > TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.12	0.13	CR000006:Surf[2]
Floors	0.18	0.14	0.14	1S000001:Surf[1]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	-	-	No flat roofs in building
Windows** and roof windows	1.6	-	-	No windows, galzed doors, or roof windows in building
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	10

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Tunnel

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	2.5	6	0	2.6	0.7
Standard value	2.5*	6.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for water-to-water chillers >=1500 kW. For chillers 400-1499 kW, limiting SEER is 6. For chillers <400 kW, limiting SEER is 5.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	**SFP [W/(l/s)]**									**HR efficiency**	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	**Zone**	**Standard**
1st to 2nd Av Bridge	-	-	-	-	-	-	-	0.4	-	-	N/A
2nd to 3th Av Bridge	-	-	-	-	-	-	-	0.4	-	-	N/A
3th to 4th Av Bridge	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
First Avenue	-	-	-	-	-	-	-	0.4	-	-	N/A
Fourth Avenue	-	-	-	-	-	-	-	0.4	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.4	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.4	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.4	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.4	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.4	-	-	N/A
GF_Acess tunnel	-	-	-	-	-	-	-	0.4	-	-	N/A
North Street West	-	-	-	-	-	-	-	0.4	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
North Street East	-	-	-	-	-	-	-	0.4	-	-	N/A
Second Avenue	-	-	-	-	-	-	-	0.4	-	-	N/A
Service Avenue	-	-	-	-	-	-	-	0.4	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.4	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.4	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street West	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street West	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street West	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.4	-	-	N/A
South Street East	-	-	-	-	-	-	-	0.4	-	-	N/A
Third Avenue	-	-	-	-	-	-	-	0.4	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.4	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
1st to 2nd Av Bridge	60	-	-
2nd to 3th Av Bridge	60	-	-
3th to 4th Av Bridge	60	-	-
Circulation	60	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
Circulation	60	-	-
Circulation	60	-	-
Circulation	60	-	-
Circulation	60	-	-
Circulation	60	-	-
Circulation	60	-	-
Circulation	60	-	-
Circulation	60	120	1.32
Circulation	60	-	-
Circulation	60	-	-
First Avenue	60	120	1.32
Fourth Avenue	60	120	1.32
Goods Alley	60	-	-
Goods Alley	60	-	-
Goods Alley	60	-	-
Goods Alley	60	-	-
Goods Alley	60	-	-
GF_Acess tunnel	60	-	-
North Street West	30	-	-
North Street Centre	60	120	1.32
North Street Centre	60	120	1.32
North Street Centre	60	120	1.32
North Street Centre	60	120	1.32
North Street Centre	60	120	1.32
North Street East	60	120	1.32
Second Avenue	60	120	1.32
Service Avenue	60	120	1.32
Toilets	60	-	-
Toilets	60	-	-
Goods Alley	60	-	-
Goods Alley	60	-	-
Circulation	60	-	-
South Street West	60	-	-
South Street West	60	-	-
South Street West	60	-	-
South Street Centre	60	120	1.32
South Street Centre	60	120	1.32
South Street Centre	60	120	1.32
South Street Centre	60	120	1.32
South Street East	60	120	1.32
Third Avenue	60	120	1.32
Toilets	60	-	-
Toilets	60	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
Toilets	60	-	-
Toilets	60	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1st to 2nd Av Bridge	N/A	N/A
2nd to 3th Av Bridge	N/A	N/A
3th to 4th Av Bridge	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
First Avenue	N/A	N/A
Fourth Avenue	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
GF_Acess tunnel	N/A	N/A
North Street West	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street East	N/A	N/A
Second Avenue	N/A	N/A
Service Avenue	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Circulation	N/A	N/A
South Street West	N/A	N/A
South Street West	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
South Street West	N/A	N/A
South Street Centre	N/A	N/A
South Street Centre	N/A	N/A
South Street Centre	N/A	N/A
South Street Centre	N/A	N/A
South Street East	N/A	N/A
Third Avenue	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m^2]	7768.6	7768.6
External area [m^2]	31046	31046
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	4266.7	5046.31
Average U-value [W/m^2K]	0.14	0.16
Alpha value* [%]	23.82	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
100	**Non-residential Institutions: Libraries, Museums, and Galleries**
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	0.5	0.64
Cooling	2.72	1.12
Auxiliary	18.89	13.93
Lighting	38.59	18.08
Hot water	5.66	4.57
Equipment*	20.08	20.08
TOTAL**	**66.36**	**38.34**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	47.98	25.12
Primary energy [kWh_{PE}/m^2]	97.72	56.51
Total emissions [kg/m^2]	8.93	5.17

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	4.4	43.6	0.5	2.7	18.5	2.45	4.46	2.5	6
	Notional	6.4	18.7	0.6	1.1	13.6	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

London Tunnels

As designed

Date: Tue Oct 24 09:31:42 2023

Administrative information

Building Details

Address: Address 1, London, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.22

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.22

BRUKL compliance module version: v6.1.e.1

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m^2]: 171.03

The CO_2 emission and primary energy rates of the building must not exceed the targets

The building does not comply with England Building Regulations Part L 2021

Target CO_2 emission rate (TER), $kgCO_2/m^2$annum	4.09	
Building CO_2 emission rate (BER), $kgCO_2/m^2$annum	6.18	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	42.93	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	66.44	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER > TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.29	1.4	FR00000F:Surf[5]
Floors	0.18	0.25	0.25	FR00000F:Surf[0]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	-	-	No flat roofs in building
Windows** and roof windows	1.6	1.41	1.41	FS000002:Surf[2]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]

$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check.

*** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	10

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Fulwood Pl DX/VRF

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	2.5	6	0	-	0.7
Standard value	2.5*	1.6	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.					

"No HWS in project, or hot water is provided by HVAC system"

"No zones in project where local mechanical ventilation, exhaust, or terminal unit is applicable"

General lighting and display lighting	**General luminaire**	**Display light source**	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
FS_Lift Lobby	60	-	-
FS_Stairs	60	-	-
FS_Circulation	60	-	-
FS_Entrance	60	-	-
FS_Fire Escape Corridor	60	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
FS_Lift Lobby	N/A	N/A
FS_Stairs	N/A	N/A
FS_Circulation	N/A	N/A
FS_Entrance	NO (-8%)	NO
FS_Fire Escape Corridor	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m^2]	171	171
External area [m^2]	263.5	228.8
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	91.07	79.43
Average U-value [W/m^2K]	0.35	0.35
Alpha value* [%]	26.32	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
100	**Non-residential Institutions: Libraries, Museums, and Galleries**
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	11.38	16.52
Cooling	3.08	1.33
Auxiliary	0	0
Lighting	30.26	10.66
Hot water	0	0
Equipment*	10.25	10.25
TOTAL**	**44.72**	**28.51**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	150.25	187.53
Primary energy [kWh_{PE}/m^2]	66.44	42.93
Total emissions [kg/m^2]	6.18	4.09

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	100.5	49.8	11.4	3.1	0	2.45	4.48	2.5	6
	Notional	165.3	22.2	16.5	1.3	0	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

Appendix B

BRUKL - BE GREEN

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

London Tunnels

As designed

Date: Mon Oct 23 16:15:08 2023

Administrative information

Building Details

Address: Address 1, London, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.22

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.22

BRUKL compliance module version: v6.1.e.1

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m^2]: 171.03

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2$annum	4.09	
Building CO_2 emission rate (BER), $kgCO_2/m^2$annum	2.67	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	42.93	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	28.25	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.29	1.4	FR00000F:Surf[5]
Floors	0.18	0.25	0.25	FR00000F:Surf[0]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	-	-	No flat roofs in building
Windows** and roof windows	1.6	1.2	1.2	FS000002:Surf[2]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Fulwood Pl DX/VRF

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	7	0	-	0.76
Standard value	2.5*	1.6	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.					

"No HWS in project, or hot water is provided by HVAC system"

"No zones in project where local mechanical ventilation, exhaust, or terminal unit is applicable"

General lighting and display lighting	**General luminaire**	**Display light source**	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
FS_Lift Lobby	241	-	-
FS_Stairs	258	-	-
FS_Circulation	504	-	-
FS_Entrance	208	-	-
FS_Fire Escape Corridor	394	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
FS_Lift Lobby	N/A	N/A
FS_Stairs	N/A	N/A
FS_Circulation	N/A	N/A
FS_Entrance	NO (-7.1%)	NO
FS_Fire Escape Corridor	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m^2]	171	171
External area [m^2]	263.5	228.8
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	87.82	79.43
Average U-value [W/m^2K]	0.33	0.35
Alpha value* [%]	26.14	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
100	**Non-residential Institutions: Libraries, Museums, and Galleries**
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	9.76	16.52
Cooling	1.54	1.33
Auxiliary	0	0
Lighting	7.53	10.66
Hot water	0	0
Equipment*	10.25	10.25
TOTAL**	**18.84**	**28.51**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	149.75	187.53
Primary energy [kWh_{PE}/m^2]	28.25	42.93
Total emissions [kg/m^2]	2.67	4.09

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	120.7	29.1	9.8	1.5	0	3.43	5.23	3.5	7
	Notional	165.3	22.2	16.5	1.3	0	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

London Tunnels

As designed

Date: Wed Oct 11 15:50:29 2023

Administrative information

Building Details

Address: Address 1, London, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.22

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.22

BRUKL compliance module version: v6.1.e.1

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m^2]: 2641.93

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	5.17	
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	5.07	
Target primary energy rate (TPER), kWh_{PE}/m^2.annum	56.51	
Building primary energy rate (BPER), kWh_{PE}/m^2.annum	55.4	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.12	0.13	CR000006:Surf[2]
Floors	0.18	0.14	0.14	1S000001:Surf[1]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	-	-	No flat roofs in building
Windows** and roof windows	1.6	-	-	No windows, galzed doors, or roof windows in building
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Tunnel

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.2	7	0	2	0.76
Standard value	2.5*	6.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for water-to-water chillers >=1500 kW. For chillers 400-1499 kW, limiting SEER is 6. For chillers <400 kW, limiting SEER is 5.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	**Zone**	**Standard**
1st to 2nd Av Bridge	-	-	-	-	-	-	-	0.3	-	-	N/A
2nd to 3th Av Bridge	-	-	-	-	-	-	-	0.3	-	-	N/A
3th to 4th Av Bridge	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
First Avenue	-	-	-	-	-	-	-	0.3	-	-	N/A
Fourth Avenue	-	-	-	-	-	-	-	0.3	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.3	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.3	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.3	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.3	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.3	-	-	N/A
GF_Acess tunnel	-	-	-	-	-	-	-	0.3	-	-	N/A
North Street West	-	-	-	-	-	-	-	0.3	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
North Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
North Street East	-	-	-	-	-	-	-	0.3	-	-	N/A
Second Avenue	-	-	-	-	-	-	-	0.3	-	-	N/A
Service Avenue	-	-	-	-	-	-	-	0.3	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.3	-	-	N/A
Goods Alley	-	-	-	-	-	-	-	0.3	-	-	N/A
Circulation	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street West	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street West	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street West	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street Centre	-	-	-	-	-	-	-	0.3	-	-	N/A
South Street East	-	-	-	-	-	-	-	0.3	-	-	N/A
Third Avenue	-	-	-	-	-	-	-	0.3	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A
Toilets	-	-	-	-	-	-	-	0.3	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
1st to 2nd Av Bridge	271	-	-
2nd to 3th Av Bridge	250	-	-
3th to 4th Av Bridge	270	-	-
Circulation	374	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
Circulation	186	-	-
Circulation	209	-	-
Circulation	204	-	-
Circulation	374	-	-
Circulation	374	-	-
Circulation	374	-	-
Circulation	196	-	-
Circulation	204	120	1.32
Circulation	204	-	-
Circulation	187	-	-
First Avenue	163	120	1.32
Fourth Avenue	163	120	1.32
Goods Alley	169	-	-
Goods Alley	168	-	-
Goods Alley	173	-	-
Goods Alley	170	-	-
Goods Alley	185	-	-
GF_Acess tunnel	183	-	-
North Street West	83	-	-
North Street Centre	166	120	1.32
North Street Centre	166	120	1.32
North Street Centre	165	120	1.32
North Street Centre	165	120	1.32
North Street Centre	165	120	1.32
North Street East	165	120	1.32
Second Avenue	163	120	1.32
Service Avenue	163	120	1.32
Toilets	184	-	-
Toilets	184	-	-
Goods Alley	168	-	-
Goods Alley	168	-	-
Circulation	293	-	-
South Street West	166	-	-
South Street West	166	-	-
South Street West	166	-	-
South Street Centre	166	120	1.32
South Street Centre	165	120	1.32
South Street Centre	165	120	1.32
South Street Centre	164	120	1.32
South Street East	165	120	1.32
Third Avenue	163	120	1.32
Toilets	170	-	-
Toilets	171	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
Toilets	175	-	-
Toilets	238	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1st to 2nd Av Bridge	N/A	N/A
2nd to 3th Av Bridge	N/A	N/A
3th to 4th Av Bridge	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
Circulation	N/A	N/A
First Avenue	N/A	N/A
Fourth Avenue	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
GF_Acess tunnel	N/A	N/A
North Street West	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street Centre	N/A	N/A
North Street East	N/A	N/A
Second Avenue	N/A	N/A
Service Avenue	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A
Goods Alley	N/A	N/A
Goods Alley	N/A	N/A
Circulation	N/A	N/A
South Street West	N/A	N/A
South Street West	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
South Street West	N/A	N/A
South Street Centre	N/A	N/A
South Street Centre	N/A	N/A
South Street Centre	N/A	N/A
South Street Centre	N/A	N/A
South Street East	N/A	N/A
Third Avenue	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A
Toilets	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m^2]	7768.6	7768.6
External area [m^2]	31046	31046
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	4266.7	5046.31
Average U-value [W/m^2K]	0.14	0.16
Alpha value* [%]	23.82	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
100	**Non-residential Institutions: Libraries, Museums, and Galleries**
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	0.39	0.64
Cooling	0.92	1.12
Auxiliary	15.1	13.93
Lighting	15.83	18.08
Hot water	5.34	4.57
Equipment*	20.08	20.08
TOTAL**	**37.59**	**38.34**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	22.32	25.12
Primary energy [kWh_{PE}/m^2]	55.4	56.51
Total emissions [kg/m^2]	5.07	5.17

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	4.3	18	0.4	0.9	14.7	3.03	5.44	3.2	7
	Notional	6.4	18.7	0.6	1.1	13.6	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

London Tunnels

As designed

Date: Wed Oct 11 15:43:21 2023

Administrative information

Building Details

Address: Address 1, London, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.22

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.22

BRUKL compliance module version: v6.1.e.1

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m^2]: 84.98

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2$annum	4.98	
Building CO_2 emission rate (BER), $kgCO_2/m^2$annum	4.77	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	52.91	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	50.6	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.28	1.19	B200000A:Surf[8]
Floors	0.18	0.26	0.75	GF000009:Surf[5]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.13	0.13	2F000000:Surf[10]
Windows** and roof windows	1.6	1.5	1.61	2F000000:Surf[3]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1.36	1.4	DB000000:Surf[0]
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]

$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check.

*** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- Furnival St Fan Coil

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	7	0	1.79	0.76
Standard value	2.5*	6.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for water-to-water chillers >=1500 kW. For chillers 400-1499 kW, limiting SEER is 6. For chillers <400 kW, limiting SEER is 5.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
2F_Retail	-	-	-	-	-	-	-	0.2	-	-	N/A
B1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_lift lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B1_Lift lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
B1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_lift lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
B2_WC	-	-	-	-	-	-	-	0.2	-	-	N/A
4F_Tea Point	-	-	-	-	-	-	-	0.2	-	-	N/A
Office	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Lift Lobby	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_WC	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Circulation	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Circulation	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Lift Lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Circulation	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Lift Lobby	-	-	-	-	-	-	-	0.2	-	-	N/A
G1_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
G5_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
GF_Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
GF_Corridor	-	-	-	-	-	-	-	0.2	-	-	N/A
Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A
Retail	-	-	-	-	-	-	-	0.2	-	-	N/A
WC	-	-	-	-	-	-	-	0.2	-	-	N/A
Stairs	-	-	-	-	-	-	-	0.2	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m^2]
Standard value	95	80	0.3
2F_Retail	178	-	-
B1_Stairs	333	-	-
B2_lift lobby	324	-	-
B2_Stairs	389	-	-
B1_Lift lobby	243	-	-
B1_Stairs	248	-	-
B2_lift lobby	361	-	-
B2_Stairs	346	-	-
B2_Stairs	441	-	-
B2_Stairs	312	-	-
B2_WC	504	-	-
4F_Tea Point	88	-	-
Office	87	-	-
G1_Lift Lobby	264	-	-
G1_Stairs	504	-	-
G1_Stairs	211	-	-
G1_WC	281	-	-
G1_Stairs	211	-	-
G1_Circulation	235	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
G1_Circulation	361	-	-
G1_Stairs	305	-	-
G1_Stairs	279	-	-
G1_Lift Lobby	209	-	-
G1_Circulation	267	-	-
G1_Lift Lobby	205	-	-
G1_Stairs	279	-	-
G5_Stairs	262	-	-
GF_Stairs	223	-	-
GF_Corridor	366	-	-
Stairs	218	-	-
Stairs	222	-	-
Retail	167	-	-
WC	234	-	-
Stairs	283	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
2F_Retail	NO (-43.7%)	NO
B1_Stairs	N/A	N/A
B2_lift lobby	N/A	N/A
B2_Stairs	N/A	N/A
B1_Lift lobby	N/A	N/A
B1_Stairs	N/A	N/A
B2_lift lobby	N/A	N/A
B2_Stairs	N/A	N/A
B2_Stairs	N/A	N/A
B2_Stairs	N/A	N/A
B2_WC	N/A	N/A
4F_Tea Point	NO (-11%)	NO
Office	YES (+57.3%)	NO
G1_Lift Lobby	N/A	N/A
G1_Stairs	NO (-100%)	NO
G1_Stairs	NO (-99.9%)	NO
G1_WC	N/A	N/A
G1_Stairs	N/A	N/A
G1_Circulation	N/A	N/A
G1_Circulation	N/A	N/A
G1_Stairs	N/A	N/A
G1_Stairs	N/A	N/A
G1_Lift Lobby	N/A	N/A
G1_Circulation	N/A	N/A
G1_Lift Lobby	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
G1_Stairs	N/A	N/A
G5_Stairs	N/A	N/A
GF_Stairs	NO (-94.8%)	NO
GF_Corridor	N/A	N/A
Stairs	NO (-100%)	NO
Stairs	NO (-99.4%)	NO
Retail	NO (-40.5%)	NO
WC	N/A	N/A
Stairs	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m^2]	764.8	764.8
External area [m^2]	3308.1	3723.5
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	819.67	901.35
Average U-value [W/m^2K]	0.25	0.24
Alpha value* [%]	16.18	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
34	**Offices and Workshop Businesses**
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
66	**Non-residential Institutions: Libraries, Museums, and Galleries**
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	14.63	13.82
Cooling	0.95	0.89
Auxiliary	10.89	11.5
Lighting	5.37	8.99
Hot water	1.97	0.18
Equipment*	13.36	13.36
TOTAL**	**33.8**	**35.38**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	190.94	153.05
Primary energy [kWh_{PE}/m^2]	50.6	52.91
Total emissions [kg/m^2]	4.77	4.98

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	172.1	18.9	14.6	0.9	10.3	3.27	5.52	3.5	7
	Notional	138.2	14.8	13.8	0.9	11.5	2.78	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

Appendix C

GLA SPREADSHEET TABLES

Non-residential

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-residential buildings

	Carbon Dioxide Emissions for non-residential buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2021 of the Building Regulations Compliant Development	74.2	22.8
After energy demand reduction (be lean)	74.0	22.8
After heat network connection (be clean)	74.0	22.8
After renewable energy (be green)	43.5	22.8

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-residential buildings

	Regulated non-residential carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Be lean: savings from energy demand reduction	0.3	0%
Be clean: savings from heat network	0.0	0%
Be green: savings from renewable energy	30.5	41%
Total Cumulative Savings	**30.7**	**41%**
Annual savings from off-set payment	43.5	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**1,305**	-
Cash in-lieu contribution (£)	**123,951**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development Information' tab

Appendix D

DHN COMMUNICATION

From: Martini, Michela
Sent: 30 October 2023 14:17
To: Melas, Apostolos
Cc: Avakian, Dimitri; Mason, Silke; Bradbury, Sam; Orme, Shane; Jones, Dwain; Trousdell, Michael
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby [Filed 30 Oct 2023 14:18]
Attachments: 231026 Furnival St Future DHN Connection_.pdf; TLT NDA.pdf

Categories: Filed by Mail Manager

Hi Apostolos,

Hope you are keeping well.

Thanks for coming back to us on the potential connection to the EON DHN.

See the attached drawings showing the location of the tunnel and the proposed provision for the DHN connection in the plan area at 39-40 Furnival Street.
The current proposed construction programme is considering the connection date to be 2029 and our peak loads are as follows:

- **Peak Cooling Load:** 1,155 kW
- **Peak Heating Load:** 411 kW
- **Peak Electrical Load:** 4,000 kW

Please let us know if you need further data from us. In the meantime would you be able to sign and return the NDA I sent you in my previous email? Reattached for reference.

We are looking forward to receiving further information from you.

Regards,

Michela Martini
Associate Director – Building Performance Group
MSc Eng-Arch, CEng MCIBSE, ARB
OCDEA, APM PMQ, Certified Passive House Consultant

T+ 44 (0)20 3116 5971
M+ 44(0)7554791186

WSP UK Limited
WSP House
70 Chancery Lane
London
WC2A 1AF

wsp.com

From: Melas, Apostolos <apostolos.melas@eonenergy.com>
Sent: Thursday, October 12, 2023 10:21 AM
To: Martini, Michela <Michela.Martini@wsp.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>; Jones, Dwain <Dwain.Jones@eonenergy.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Hello Michela,

Sorry for the long delay to respond but I was extremely busy with a big contract and I was a bit derailed on the initial-stage projects.

Are there any drawings with this to show where the tunnels are and potential plant space? We believe the cooling loads are considerable so we can look into a connection to our cooling network.

We need to know the date of connection and heat and cooling on

Also there is no annual loads in your RFI, so can you please provide these as well?

Kind regards

Apostolos Melas

Apostolos Melas
Sales Manager
E.ON City Energy Solutions
M: +44 (0) 7977 526170
Email: apostolos.melas@eonenergy.com

www.eon.com | Facebook | Instagram | LinkedIn | Twitter | Youtube

E.ON UK Solutions
47-53 Charterhouse Street
London
EC1M 6PB

From: Martini, Michela <Michela.Martini@wsp.com>
Sent: Wednesday, September 6, 2023 10:15 AM
To: Melas, Apostolos <apostolos.melas@eonenergy.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Morning Apostolos,

I hope you had a nice holiday.

I was wondering if there is any update from your team regarding a potential connection of our scheme to the Citigen network as per our conversation back in August?

Regards,

Michela Martini
Associate Director – Building Performance Group
MSc Eng-Arch, CEng MCIBSE, ARB
OCDEA, APM PMQ, Certified Passive House Consultant

T+ 44 (0)20 3116 5971
M+ 44(0)7554791186

WSP UK Limited
WSP House
70 Chancery Lane
London
WC2A 1AF

wsp.com

From: Martini, Michela
Sent: Monday, August 14, 2023 4:38 PM
To: Melas, Apostolos <apostolos.melas@eonenergy.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Hi Apostolos,

Thank you very much for your time last week. It was really interesting to understand in more details how the Citigen network operates and discuss a potential connection with the scheme we are working on.

You mentioned that the network is currently operating in the area and is considering future expansion. There are currently some constraints on site but a feasibility study could be undertaken to understand if these can be addressed and pipework extended to the East of the network towards Chancery Lane area. The proposed scheme we are working on would provide the right opportunity to investigate this further.

We understand that your team will be reviewing whether a connection would be feasible and come ack to us on this. Can you confirm when you would be able to provide us with some initial comments? This is a very critical item for our energy strategy and, if a connection is possible, we would like to review design implications asap.
As discussed, we would also be interested in receiving some data on your current and expected carbon factors to review if these are aligned with our energy strategy.

Finally, once it has been confirmed that a connection could be feasible we would be very interested in engaging with your support team to talk more about potentially rejecting heat back into the network and its design implications in our MEP design.

I am also attaching our NDA, the project is confidential and would be great if you could sign it.

Regards,

Michela Martini
Associate Director – Building Performance Group
MSc Eng-Arch, CEng MCIBSE, ARB
OCDEA, APM PMQ, Certified Passive House Consultant

T+ 44 (0)20 3116 5971
M+ 44(0)7554791186
Working days Monday-Thursday

WSP UK Limited
WSP House
70 Chancery Lane
London
WC2A 1AF

wsp.com

From: Melas, Apostolos <apostolos.melas@eonenergy.com>
Sent: Thursday, August 3, 2023 9:21 AM
To: Martini, Michela <Michela.Martini@wsp.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Hello Michela,

I am in Greece these days, so perhaps there is a problem with my network here.

Sure, I can do Thursday morning, I will send the updated invitation

Kind regards

Apostolos Melas

Apostolos Melas
Sales Manager
E.ON City Energy Solutions
M: +44 (0) 7977 526170
Email: apostolos.melas@eonenergy.com

www.eon.com | Facebook | Instagram | LinkedIn | Twitter | Youtube

E.ON UK Solutions
47-53 Charterhouse Street
London
EC1M 6PB

From: Martini, Michela <Michela.Martini@wsp.com>
Sent: Thursday, August 3, 2023 11:17 AM
To: Melas, Apostolos <apostolos.melas@eonenergy.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Good Morning Apostolos,

I have tried to call with no luck.

I am really sorry but my colleague that was going to lead the conversation is no longer available on Monday. Would you have availability on Wednesday afternoon 09/08 or Thursday morning after 10 AM?

Regards,

Michela Martini
Associate Director – Building Performance Group
MSc Eng-Arch, CEng MCIBSE, ARB
OCDEA, APM PMQ, Certified Passive House Consultant

T+ 44 (0)20 3116 5971
M+ 44(0)7554791186
Working days Monday-Thursday

WSP UK Limited
WSP House
70 Chancery Lane
London
WC2A 1AF

wsp.com

From: Martini, Michela <Michela.Martini@wsp.com>
Sent: Wednesday, August 2, 2023 9:45 AM
To: Melas, Apostolos <apostolos.melas@eonenergy.com>

Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: Re: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Morning Apostolos,

Monday is fine. My colleagues will cover.

Thanks for sending the meeting invite.

Regards,

Michela Martini

T+ 44 (0)20 3116 5971

M+ 44(0)7554791186

Working days Monday-Thursday

From: Melas, Apostolos <apostolos.melas@eonenergy.com>
Sent: Wednesday, August 2, 2023 6:54:29 AM
To: Martini, Michela <Michela.Martini@wsp.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Hello Michela,

Unfortunately I have my weekly team call ending at 10.30am, so I would prefer we keep our 11am, or we can go for another day if you prefer.

Kind regards

Apostolos Melas

Apostolos Melas
Sales Manager
E.ON City Energy Solutions
M: +44 (0) 7977 526170
Email: apostolos.melas@eonenergy.com

www.eon.com | Facebook | Instagram | LinkedIn | Twitter | Youtube

E.ON UK Solutions
47-53 Charterhouse Street
London
EC1M 6PB

From: Martini, Michela <Michela.Martini@wsp.com>
Sent: Tuesday, August 1, 2023 6:54 PM
To: Melas, Apostolos <apostolos.melas@eonenergy.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Hi Apostolos,

Apologies I just had something dropped in my calendar for 11AM on Monday. Could you do 10 AM? If not let's pin 11AM and will join for the introduction and let my colleagues leading the conversation.

Regards,

Michela Martini
Associate Director – Building Performance Group
MSc Eng-Arch, CEng MCIBSE, ARB
OCDEA, APM PMQ, Certified Passive House Consultant

T+ 44 (0)20 3116 5971
M+ 44(0)7554791186
Working days Monday-Thursday

WSP UK Limited
WSP House
70 Chancery Lane
London
WC2A 1AF

wsp.com

From: Melas, Apostolos <apostolos.melas@eonenergy.com>
Sent: Tuesday, August 1, 2023 4:39 PM
To: Martini, Michela <Michela.Martini@wsp.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Hello Michela,

For me it is better to have a call on Monday morning, around 11am. Please let me know if this works for you as well.

Kind regards

Apostolos Melas

Apostolos Melas
Sales Manager
E.ON City Energy Solutions
M: +44 (0) 7977 526170
Email: apostolos.melas@eonenergy.com

www.eon.com | Facebook | Instagram | LinkedIn | Twitter | Youtube

E.ON UK Solutions
47-53 Charterhouse Street
London
EC1M 6PB

From: Martini, Michela <Michela.Martini@wsp.com>
Sent: Tuesday, August 1, 2023 2:57 PM
To: Melas, Apostolos <apostolos.melas@eonenergy.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Bradbury, Sam <Sam.Bradbury@wsp.com>; Orme, Shane <Shane.Orme@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Morning Apostolos,

Thanks for coming back to us so promptly.

I have double checked with my colleagues but we can only do Thursday after 3PM this week. Otherwise Monday any time except between 3PM to 4PM. Would any of these slots work for you?

I have also attached the RFI as requested.

Regards,

Michela Martini
Associate Director – Building Performance Group
MSc Eng-Arch, CEng MCIBSE, ARB
OCDEA, APM PMQ, Certified Passive House Consultant

T+ 44 (0)20 3116 5971
M+ 44(0)7554791186
Working days Monday-Thursday

WSP UK Limited

WSP House
70 Chancery Lane
London
WC2A 1AF

wsp.com

From: Melas, Apostolos <apostolos.melas@eonenergy.com>
Sent: Monday, July 31, 2023 12:24 PM
To: Martini, Michela <Michela.Martini@wsp.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Smith, Sam <Samuel.Smith@wsp.com>
Subject: RE: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

Hello Michela,

Thank you for contacting me, I am available for a call, please send an invitation. This week Wednesday to Friday morning seems better at the minute.

Please see attached our request for information document, which we would like to ask you to fill and share with us. This helps the engineering team to assess the project.

Kind regards

Apostolos Melas

Apostolos Melas
Sales Manager
E.ON City Energy Solutions
M: +44 (0) 7977 526170
Email: apostolos.melas@eonenergy.com

www.eon.com | Facebook | Instagram | LinkedIn | Twitter | Youtube

E.ON UK Solutions
47-53 Charterhouse Street
London
EC1M 6PB

From: Martini, Michela <Michela.Martini@wsp.com>
Sent: Monday, July 31, 2023 1:53 PM
To: Melas, Apostolos <apostolos.melas@eonenergy.com>
Cc: Avakian, Dimitri <Dimitri.Avakian@wsp.com>; Mason, Silke <Silke.Mason@wsp.com>; Smith, Sam <Samuel.Smith@wsp.com>

Subject: Citigen DHN - Request for a quick call to discuss potential connection for a new project nearby

> You don't often get email from michela.martini@wsp.com. Learn why this is important

Dear Apostolos,

I am part of the London Energy & Sustainability team of WSP and I am contacting you as our team is working on large scale project in close proximity to the Citigen DHN in the City of London.

We would be very interested in discussing with you options for a potential connection to the DHN and were wondering if you have any availability for a call in the upcoming weeks.

I look forward to hearing from you.

Regards,

Michela Martini
Associate Director – Building Performance Group
MSc Eng-Arch, CEng MCIBSE, ARB
OCDEA, APM PMQ, Certified Passive House Consultant

T+ 44 (0)20 3116 5971
M+ 44(0)7554791186
Working days Monday-Thursday

WSP UK Limited
WSP House
70 Chancery Lane
London
WC2A 1AF

wsp.com

our prior permission is prohibited.

Internet communications are not always secure and therefore the
E.ON Group does not accept legal responsibility for this message.
The recipient is responsible for verifying its authenticity before
acting on the contents. Any views or opinions presented are solely
those of the author and do not necessarily
represent those of the E.ON Group.

E.ON UK plc : Registered in England & Wales No. 2366970

E.ON Energy Solutions Limited : Registered in England and Wales No. 3407430

Registered Address : Westwood Way, Westwood Business Park, Coventry, CV4 8LG.
Telephone +44 (0) 2476 192000
Fax +44 (0) 2476 42 5432
_____ Disclaimer Notice _____
This message and any attachments are confidential and should only
be read by those to whom they are addressed. If you are not the
intended recipient, please contact us, delete the message from your
computer and destroy any copies. Any distribution or copying without
our prior permission is prohibited.

Internet communications are not always secure and therefore the
E.ON Group does not accept legal responsibility for this message.
The recipient is responsible for verifying its authenticity before
acting on the contents. Any views or opinions presented are solely
those of the author and do not necessarily
represent those of the E.ON Group.

E.ON UK plc : Registered in England & Wales No. 2366970

E.ON Energy Solutions Limited : Registered in England and Wales No. 3407430

Registered Address : Westwood Way, Westwood Business Park, Coventry, CV4 8LG.
Telephone +44 (0) 2476 192000
Fax +44 (0) 2476 42 5432
_____ Disclaimer Notice _____
This message and any attachments are confidential and should only
be read by those to whom they are addressed. If you are not the
intended recipient, please contact us, delete the message from your
computer and destroy any copies. Any distribution or copying without
our prior permission is prohibited.

Internet communications are not always secure and therefore the
E.ON Group does not accept legal responsibility for this message.
The recipient is responsible for verifying its authenticity before
acting on the contents. Any views or opinions presented are solely
those of the author and do not necessarily
represent those of the E.ON Group.

E.ON UK plc : Registered in England & Wales No. 2366970

E.ON Energy Solutions Limited : Registered in England and Wales No. 3407430

Registered Address : Westwood Way, Westwood Business Park, Coventry, CV4 8LG.
Telephone +44 (0) 2476 192000
Fax +44 (0) 2476 42 5432
_____ Disclaimer Notice _____
This message and any attachments are confidential and should only
be read by those to whom they are addressed. If you are not the
intended recipient, please contact us, delete the message from your
computer and destroy any copies. Any distribution or copying without
our prior permission is prohibited.

Internet communications are not always secure and therefore the
E.ON Group does not accept legal responsibility for this message.
The recipient is responsible for verifying its authenticity before
acting on the contents. Any views or opinions presented are solely
those of the author and do not necessarily
represent those of the E.ON Group.

E.ON UK plc : Registered in England & Wales No. 2366970

E.ON Energy Solutions Limited : Registered in England and Wales No. 3407430

Registered Address : Westwood Way, Westwood Business Park, Coventry, CV4 8LG.
Telephone +44 (0) 2476 192000
Fax +44 (0) 2476 42 5432

Appendix E

PLANT SPECIFICATION EXAMPLES

TECHNICAL SPECIFICATION SHEET

Ventilation Equipment Ltd

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**	
Unit Reference	ADQ12316-01-A			
Model Reference	Non-standard			

AHU Details				
Design Supply Air Volume	11	m^3/s		
External Static Pressure	500	Pa		
Unit Velocity	1.67	m/s		
Design Extract Air Volume	11	m^3/s		
External Static Pressure	500	Pa		
Unit Velocity	1.67	m/s		

Energy Use				
	Supply on Clean Filters	Extract on Clean Filters	Overall	
Specific Fan Power	1.14	0.96	2.00	$kW/(m^3/s)$

AHU Construction		**Construction**	
Framework\Profile	56mm Anodized Post	Unit Location	Internal
Panel Depth	45 mm	Weather Roof	None
External Panel Finish	Mica Coated steel 0.90mm	Baseframe	200 x 75 PFC
Internal Panel Finish	Galv Sheet 0.9mm	Casing performance (EN 1886 Standard)	
Insulation	Mineral Wool 45mm	Leakage Class	L1
		Casing strength	D1
		Thermal Transmittance	T3
		Thermal Bridge	TB3

Overall Unit Dimensions				
	Length	Width	Height	Weight (Per Unit)
	5656 mm	3800 mm	4000 mm	5871 kg

Section Weights and Dimensions				
Section No.	Length	Width	Height	Weight Approx +/-5%
A	1732 mm	3800 mm	1900 mm	1327 kg
B	850 mm	3800 mm	3800 mm	1415 kg
C	1450 mm	3800 mm	1900 mm	880 kg
D	1624 mm	3800 mm	1900 mm	1076 kg
E	978 mm	3800 mm	1900 mm	365 kg
F	1732 mm	3800 mm	1900 mm	808 kg

Inlet Section			**Construction**	
Component	Damper		Casing	Aluminium - Class 2
Air Pressure Drop	2.00	Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.

Heating Coil			**Construction**	
Air On / Off	-5.00/5.0	°C/°C	Casing Material	FeZn 1.5 mm
Duty	134.02	kW	Tube Material	CU
Water(Inlet)/(Outlet)	82.00/71.00	°C/°C	Fin Material	AL-0.11
Water PD	7.53	kPa	Connection Size	1 x 2"(F) / 1 x 2"(R)
Water Flow Rate	2.99	L/s		
Air Pressure Drop	11.00	Pa		
Internal Volume	37.90	l		

Accessories

Valve and actuator to be supplied and fitted by others
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**
Unit Reference	ADQ12316-01-A		
Model Reference	Non-standard		

Panel and Bag Filter			**Construction**	
Panel Clean PD	51	Pa	Panel Grade	Coarse 85%(ISO16890)
Panel Mean	85	Pa	Panel Media	Card Frame-Cotton/Synthetic Media
Panel Recommended Dirty	120	Pa	Panel Size 1 / Qty	12 x 594 x 594 x 45 mm
			Panel Size 2 / Qty	6 x 594 x 394 x 45 mm
Bag Clean PD	66	Pa	Bag Grade	ePM1 60%(ISO16890)
Bag Mean	128	Pa	Bag Media	25mm Galv Frame/Glass Fibre
Bag Recommended dirty	190	Pa	Bag Size 1 / Qty	12 x 595 x 595 x 635mm
			Bag Size 2 / Qty	6 x 592 x 392 x 635mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted Dwyer Minihelic gauge (Range 0-500 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Heat Wheel Section				**Construction**
	Winter	**Summer**		
Supply Air On (db/RH)	5.00/90.0	30.00/50.0	°C/%	Matrix Type A: Condensation
Supply Air Off (db/RH)	16.60/44.10	25.40/65.80	°C/%	Product Type
Exhaust Air On (db/RH)	20.00/50.0	24.00/50.0	°C/%	1: Condensation rotor (ST)
Exhaust Air Off (db/RH)	8.40/99.00	28.60/37.90	°C/%	
Heat Recovery	166.30	63.30	kW	
Efficiency	77.40	77.40	%	
Supply Pressure Drop	125.00	137.00	Pa	
Exhaust Pressure Drop	132.00	134.00	Pa	

Accessories

Condensation Rotor for sensible heat recovery
Heat exchanger selection compliant to ERP2018 (Ecodesign directive 1253/2014)
Variable speed drive_factory fitted & wired (Internally to Heat Wheel section) for integration into the control system (Requires 0-10v input signals)
Factory fitted IP54 external terminal box c/w wiring to Heat Wheel Controller
Segmented thermal wheel

Supply Fan - Fan Array 3 x 1			**Construction**	
Design Air Volume	11	m³/s	Impeller	Backward Curve
Total Fan Resistance	970	Pa	Internal Isolation	
Fan Speed	1741	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	8.75	Volts		
Maximum Fan Speed	1910	r/min		
Efficiency	76.53	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	9.00	Amps	Type	EC
Total Input Power	4.65	kW	Rating	IE4
Motor Power	5.85	kW		
Motor Speed	1741	r/min		
Electrical Supply	400/3/50.00			

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**
Unit Reference	ADQ12316-01-A		
Model Reference	Non-standard		

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Over temperature protection thermister (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

Chilled Water Coil			**Construction**	
Air On (db/wb)	30.00/20.00	°C/°C	Casing Material	FeZn 1.5 mm
Air Off (db/wb)	20.0/16.4	°C/°C	Tube Material	CU
Duty	73.42	kW	Fin Material	AL-0.11
Water(Inlet)/(Outlet)	6.00/12.00	°C/°C	Connection Size	1 x 1 1/2"(F) / 1 x 1 1/2"(R)
Water PD	23.52	kPa	Eliminators	No
Water Flow Rate	2.91	L/s	Drain Tray	Sloped 304 1.5
Face Velocity	1.94	m/s		
Air Pressure Drop	33.00	Pa		
Internal Volume	36.10	l		

Accessories

Traffolyte label - Drain Trap Instruction
Valve and actuator to be supplied and fitted by others
Split Coil - Extended pipework by others

Access Section		
Length	500	mm
Access Side	Right	

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Heating Coil			**Construction**	
Air On / Off	5.00/21.0	°C/°C	Casing Material	FeZn 1.5 mm
Duty	106.65	kW	Tube Material	CU
Water(Inlet)/(Outlet)	82.00/71.00	°C/°C	Fin Material	AL-0.11
Water PD	13.86	kPa	Connection Size	1 x 1 1/2"(F) / 1 x 1 1/2"(R)
Water Flow Rate	2.38	L/s		
Air Pressure Drop	13.00	Pa		
Internal Volume	20.90	l		

Accessories

Valve and actuator to be supplied and fitted by others
Traffolyte Component label
Split Coil - Extended pipework by others

Outlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

Inlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**	
Unit Reference	ADQ12316-01-A			
Model Reference	Non-standard			

Panel Filter			**Construction**	
Clean PD	51	Pa	Grade	Coarse 85%(ISO16890)
Mean	85	Pa	Media	Card Frame-Cotton/Synthetic Media
Recommended dirty	120	Pa	Withdrawal	Front
			Size 1 / Qty	12 x 594 x 594 x 45 mm
			Size 2 / Qty	6 x 594 x 394 x 45 mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Exhaust Fan - Fan Array 3 x 1			**Construction**	
Design Air Volume	11	m³/s	Impeller	Backward Curve
Total Fan Resistance	748	Pa	Internal Isolation	
Fan Speed	1592	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	8.00	Volts		
Maximum Fan Speed	1910	r/min		
Efficiency	77.76	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	9.00	Amps	Type	EC
Total Input Power	3.53	kW	Rating	IE4
Motor Power	5.85	kW		
Motor Speed	1593	r/min		
Electrical Supply	400/3/50.00			

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Fan Healthy Contacts (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

Outlet Section			**Construction**	
Component	Damper		Casing	Aluminium - Class 2
Air Pressure Drop	2.00	Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**
Unit Reference	ADQ12316-01-A		
Model Reference	Non-standard		

AHU Acoustic Data:

Acoustic Data (Supply AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Supply AHU Inlet Lw (dB)	74	77	76	75	70	64	54	45
Supply AHU Outlet Lw (dB)	80	85	82	88	85	78	66	60

Acoustic Data (Extract AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Extract AHU Inlet Lw (dB)	77	77	80	80	77	75	72	63
Extract AHU Outlet Lw (dB)	83	87	85	91	89	87	85	78

Resultant AHU Breakout

Frequency (Hz)	63	125	250	500	1K	2K	4K	8K
Supply Lw (dB)	82	84	78	68	67	62	61	54
Extract Lw (dB)	81	81	77	68	65	61	60	52
AHU Spectrum Lw (dB)	85	86	81	71	69	64	63	56
Resultant AHU Level @ 3m	64	65	60	50	49	44	43	35
Overall AHU “A” weighted Breakout @ 3m	56							

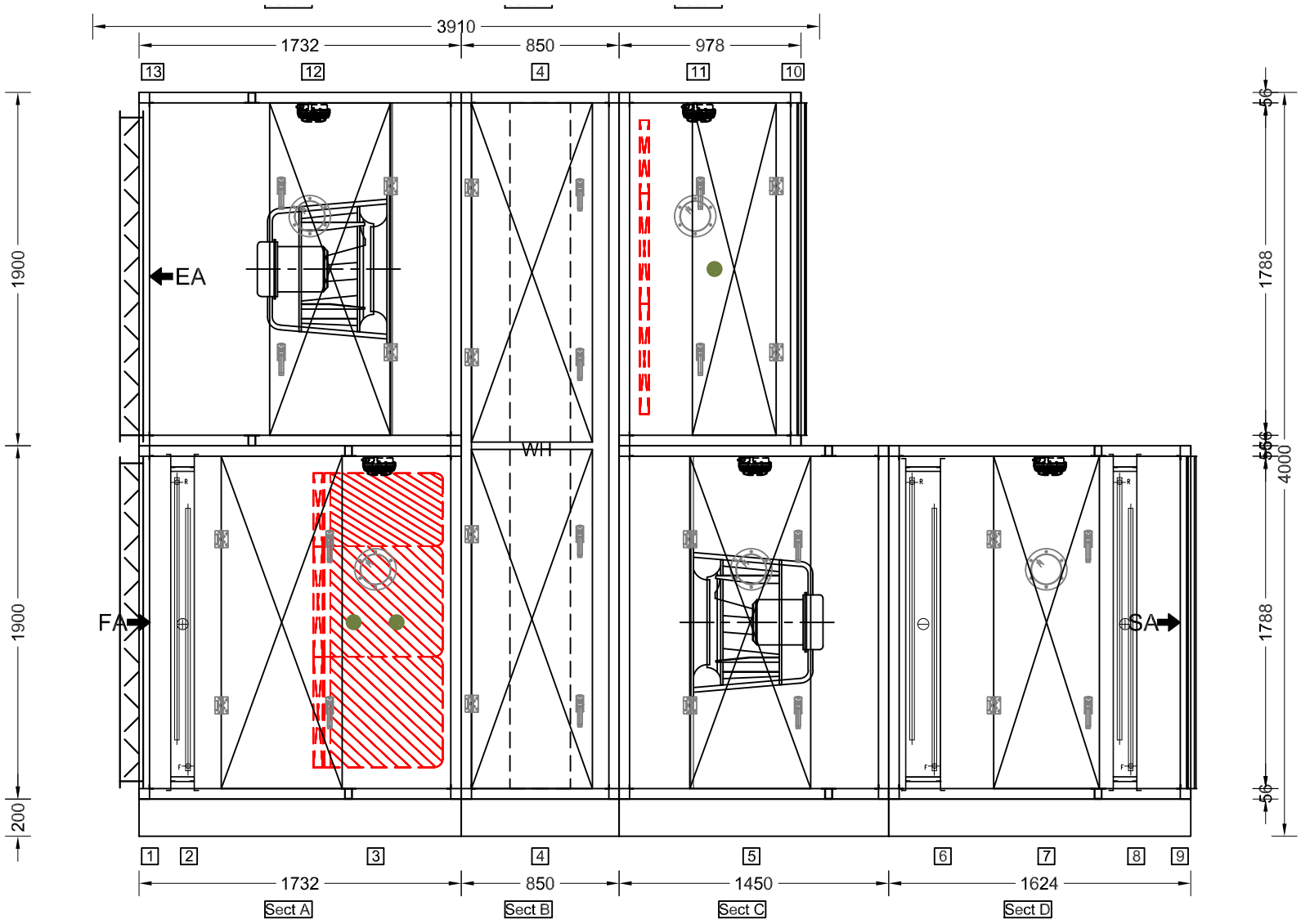
IMPORTANT NOTES

Sound Power levels subject to a correction of +6 dB should be applied across all octave bands for unit casing adjustment

The In-duct Sound Power Level Spectra are in dB re-1pW.

The overall A-weighted sound pressure level is at a distance of 3m with spherical free-field propagation. It is expressed in dB re-20 µPa and is presented for comparative purposes only.

Resultant sound pressure includes all selected AHU component losses within the above calculation.



Unit Height including base 4000mm

Unit Width 3800mm

Section A: Weight = 1327Kgs
Components
1 Inlet
2 Water Heating Coil
3 Panel & Bag Filter
Section B: Weight = 1415Kgs
Components
4 Rotary Heat Exchanger
Section C: Weight = 880Kgs
Components
5 FANARRAY
Section D: Weight = 1076Kgs
Components
6 Water Cooling Coil
7 Access
8 Water Heating Coil
9 Outlet
Section E: Weight = 365Kgs
Components
10 Inlet
11 Panel Filter
Section F: Weight = 808Kgs
Components
12 FANARRAY
13 Outlet

ELEVATION

M&Y Ventilation Equipment Limited
First Floor Offices,
104 Franklynn Road, Haywards Heath,
West Sussex RH16 4DN

T: 0844 756 0202
F: 0844 756 0203
Email: sales@myventilation.co.uk
Web: www.airhandlingunits.co.uk

Project	:	Tunnels London	Project ref	:	12316-1-A	Date	: 28 Sep 2023
Unit reference	:	AHU-Tunnel-01	Unit number	:	12316	Title	:
Number off	:	1	Revision	:	A	Not to scale	

Item 1.1 Quantum oil-free water cooled chiller W0695-T2K00-0404 (R-1234ze)

Certified in accordance with the AHRI Water-Cooled Water-Chilling and Heat Pump Water-Heating Packages Certification Program, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI). Certified units may be found in the AHRI Directory at www.ahridirectory.org.

Technical data:

created with Selectum version 2.94.127, database 26.07.2023 and CPREngine 2825, valid per chiller

Profile	**Design point Refrigerating machine operation**	
Cooling capacity	%	100
Cooling capacity Qo	**kW**	**600**
Thermal output Qc	kW	698
Electrical power consumption	kW	97,6
EER		6,15
SEER		9,89
Space cooling annual consumption index ηs,c		392,60
SEPR HT		9,87
Maximum refrigeration capacity Qo	kW	660
Evaporator		
Chilled medium / Concentration		Water
Volume flow	m³/h	85,8
Chilled medium inlet temperature	**°C**	**12,00**
Chilled medium outlet temperature	**°C**	**6,00**
Pressure drop total	bar	0,29
Fouling factor	m²K/W	0,000018
Number of passes		2
Condenser		
Cooling medium / Concentration		Water
Volume flow	m³/h	120,9
Cooling medium inlet temperature	**°C**	**29,00**
Cooling medium outlet temperature	**°C**	**34,00**
Pressure drop total	bar	0,37
Fouling factor	m²K/W	0,000044
Number of passes		2
Number	Item	2

Profile	**Decreasing (1,9K/10%) condenser inlet temperature**					
Cooling capacity	%	100	75	50	25	20 [Min]
Cooling capacity Qo	kW	600	450	300	150	120
Thermal output Qc	kW	698	505	328	160	127
Electrical power consumption	kW	97,6	54,7	27,8	9,6	7,4
EER		6,15	8,23	10,79	15,70	16,23
Maximum refrigeration capacity Qo	kW	660				
Evaporator						
Chilled medium / Concentration		Water				
Volume flow	m³/h	85,8				
Chilled medium inlet temperature	°C	12,00	10,50	9,00	7,50	7,20
Chilled medium outlet temperature	°C	6,00	6,00	6,00	6,00	6,00
Pressure drop total	bar	0,29				
Fouling factor	m²K/W	0,000018				
Number of passes		2				
Condenser						
Cooling medium / Concentration		Water				
Volume flow	m³/h	120,9				
Cooling medium inlet temperature	°C	29,00	24,25	19,50	14,75	13,80
Cooling medium outlet temperature	°C	34,00	27,86	21,84	15,89	14,71
Pressure drop total	bar	0,37				
Fouling factor	m²K/W	0,000044				
Number of passes		2				
Compressor						
Type		Oil-free turbocompressor				
Number	Item	2				

Profile	**SEER: Ordinance (EU) 2016/2281 for comfort coolers**				
Cooling capacity	%	100	74	47	21
Cooling capacity Qo	kW	678	502	319	142
Thermal output Qc	kW	793	565	349	152
Electrical power consumption	kW	115,1	63,0	31,3	10,5
EER		5,89	7,97	10,19	13,54
Space cooling annual consumption index η		393			
Eco-Design-Directive: minimum value		from 01.01.2021: η = 252			
Yearly power consumption	kWh/a	71622			
Capacity control		variable			
Reduction coefficient for devices with fixed and graduated capacity		-			
SEER		9,89			
Maximum refrigeration capacity Qo	kW	678			
Evaporator					
Chilled medium / Concentration		Water			
Volume flow	m³/h	116,3			
Chilled medium inlet temperature	°C	12,00	10,70	9,35	8,05
Chilled medium outlet temperature	°C	7,00	7,00	7,00	7,00
Pressure drop total	bar	0,45			
Fouling factor	m²K/W	0,000000			
Number of passes		2			
Condenser					
Cooling medium / Concentration		Water			
Volume flow	m³/h	137,4			
Cooling medium inlet temperature	°C	30,00	26,00	22,00	18,00
Cooling medium outlet temperature	°C	35,00	29,56	24,19	18,95
Pressure drop total	bar	0,46			
Fouling factor	m²K/W	0,000000			
Number of passes		2			
Compressor					
Number	Item	2			

Dimensions, weights and fill quantities		
L x W x H*	mm	3213 x 1612 x 2002
Transport weight	kg	2700
Operating weight	kg	2900
Refrigerant R-1234ze	kg	115
Chilled medium content in evaporator	l	150
Cooling medium content in condenser	l	160
**) These are maximum specifications. For exact specifications please refer to the dimension sheet. Options may increase the total weight.*		
Variable flow rate control		
Minimum flow rate evaporator	m^3/h	36,4
Maximum flow rate evaporator	m^3/h	174,5
Minimum flow rate condenser	m^3/h	39,2
Maximum flow rate condenser	m^3/h	187,9
A change of the flow rate set point has influence on performance values.		
Electrical data		
Voltage/frequency	V/Hz	400V/50Hz
Compressor switch-on method	-	Direct (integrated VSD)
Max electrical power consumption	kW	199,0
Max current consumption	A	303
Optional: Max. electrical power consumption incl. pumps **	kW	225,0
Optional: Max. current consumption incl. pumps **	A	355
Start-up current per compressor	A	< 5
Active factor (cos φ) ***	-	> 0,95
Motor cooling	-	refrigerant cooled
Voltage supply control	V DC	24
Control cabinet / power choke protection class	-	IP 54
Supply line cross section ****	mm^2	3 x 150/70 mm^2
Supply line cross section incl. pumps****	mm^2	3 x 240/120 mm^2
Supply line fuse protection ****	A	max. 315
Supply line fuse protection incl. pumps****	A	max. 400
Power element short-circuit current capability	kA	38
) refers to the maximum current and electrical power consumption incl. on-site pumps that can be optionally supplied by the Quantum control cabinet (see options for evaporator and condenser pump version* *) Measured with artificial mains network* *****)Supply line cross sections and fuse protection should be adapted to local situations, if required, and should also b controlled by the executing company.* *Cable glands are to be selected according to the supply line cross-sections and are not part of the delivery.* *Options may increase the total current consumption. You will find the design of the final and total power consumption the circuit diagram. Lightning protection and planning of electrical grounding are in the responsibility of the customer.*		

Sound data (without sound-reducing measures)			
Sound power level in accordance with DIN EN ISO 3744	dB(A)	92	
Medium sound pressure level of measurement surface in 1m distance in open air above a reflecting surface in accordance with DIN EN ISO 3744	dB(A)	74	
At 100% design point at 600 kW cooling capacity (698 kW heating capacity), in the "Low noise" version, the sound power level is reduced by 3 dB (A)			
Colours			
Frame		RAL 9007 (Grey aluminium)	
Condenser		RAL 9007 (Grey aluminium)	
Control cabinet		RAL 7035 (Light grey)	
Economizer		RAL 5015 (Sky blue) or RAL 6018 (Yellow-green)	
Assembly conditions		Minimum	Maximum
Installation altitude	m	1	1000 above sea level
Ambient temperature (Design Day Max)	°C	1	40
Usage limitations		Minimum	Maximum
Evaporator outflow temperature:	°C	3	12
Evaporator inflow temperature:	°C	4	32
Condenser outflow temperature:	°C	20	57
Condenser inflow temperature:	°C	12	53
An adjustment of the operating conditions (media flow and return temperatures) compared to the technical data from the offer by the operator requires inspection and approval by the manufacturer. This also applies in particular if these changed operating conditions continue to lie within the general operating limits.			
GWP (Global Warming Potential) and CO2 equivalent			
GWP as per IPCC (AR4) and regulation (EC) no. 517/2014			7
CO2 equivalent (AR4) (1000kg)			0,805
GWP as per IPCC (AR5)			< 1
CO2 equivalent (AR5) (1000kg)			0,115

ThermoKey
Heat Exchange Solutions
Via dell'industria 1
33061 Rivarotta di Rivignano di Teor (UD) - ITALY
Tel.: +39/0432772300 Fax.: +39/0432779734

Company	WSP	Date	3/10/2023
Attention of	Arnold Mukuvare	Sw Version	230718
City		Offer	Offerta
Telephone		Reference	Q7880
Fax		Position	

TECHNICAL DATA

DRY COOLER (5) SJGH2690.DN5/04 Q2EIAF(EC)(EPSELV)S

Number of circuits **140**

PERFORMANCE (SINGLE UNIT)

Real Capacity **698.00**kW

TUBE SIDE

Fluid (10)	**ETHYLENE GLYCOL 25%**		
Inlet Fluid Temp.	**34.0**°C	Outlet Fluid Temp.	**29.0**°C
Fluid flow rate	**126.42**m³/h	Fluid Velocity	**1.3**m/s
Massic Fluid Flow	**129868**kg/h	Pressure drops	**47**kPa

AIR SIDE

Inlet Air Temp [MAX]	**35.0**°C	Outlet Air Temp.	**32.3**°C
Inlet relative hum.	**35.0**%	Outlet relative hum.	**54.0**%
Inlet Air Temp. [SWITCHING]	**24.8**°C	Altitude	**0**m
Inlet relative hum.	**83.1**%	ESP	**0.0**Pa
Water flow Adiab.	**2097**lt/h	Flow Direction	**N/A**
Air Flow	**278737**m³/h	Air Velocity	**2.29**m/s

FANS TECHNICAL DATA

ERP	**Yes**	UL	**Yes**
Fan Number	**12**N°	Fan Diameter	**900**mm
Phases-Voltage-Frequency	**3-400-50**N°/Volt/Hz	Fan type	**34050H91ECB2C_GN2**
Rpm [Nominal data]	**1100**Rpm	Link	**EC**
Power x 1 [Nominal data]	**3200**Watt	Current x 1 [Nominal data] (1)	**5.00**A
Rpm [Working point]	**1063**Rpm	Rpm rate [working point / nominal]	**97**%
Power x 1 [Working point]	**2592**Watt	Current x 1 [Working point] (1)	**3.95**A
Total Power x n° [Working point]/ [Nominal data]	**31104/38400**Watt	Total Current x n° [Working point]/ [Nominal data]	**47.40/60.00**A
Efficiency Energy Class:nominal calculation Water 40-35°C/Air 25°C	**D**	Efficiency Energy Class:calculation on the working point	**E**

FANS NOISE DATA (7)

Sound Pressure Level (4) [Working	**66**dB(A)	Sound Power Level (4) [Working point]	**98**dB(A)
At the distance of	**10**m	in accordance with EN 13487/EN ISO 3744 (7)	

HEAT EXCHANGER DATA (3)

Fin Material (2)	**AFS fin Turbo**	Tubes Material	**Copper**
Fin Spacing	**1.8**mm	Internal Volume	**857.0**dm³
Fin Thickness	**0.1**mm	Casing material	**Galvanized steel painted**
Surface	**6090.0**m²	Number of passes	**4**
Inlet Connection	**4x4"**		
Outlet Connection	**4x4"**	Connections	**Same side**
Max Pressure Design	**10 bar**	Fluid Category	**Group 2**

DIMENSIONS AND WEIGHT (3)

Length	**7646**mm	Weight (3)	**4280**kg
Width (24)	**2420**mm	Number of fixing point	**14**
Height (24)	**2918**mm	LDM (Approximate data)	**7.71**m

SOUND POWER LEVEL

	Tot.	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Δ [dB(A)]	83	60	66	74	77	79	76	73	66

Data refers to one fan. IMPORTANT: the tolerance in any single octave band is +/-5dB. The tolerance in the overall dB(A) level is +/- 2dB.

In case of AC fans working point is defined by fan supplier in nominal curve (delta or star). In case of EC fans is simulated on working point of unit.

ThermoKey
Heat Exchange Solutions
Via dell'industria 1
33061 Rivarotta di Rivignano di Teor (UD) - ITALY
Tel.: +39/0432772300 Fax.: +39/0432779734

Company		Date	3/10/2023
Attention of		Sw Version	230718
City		Offer	Offerta
Telephone		Reference	
Fax		Position	

DRY COOLER (5) SJGH2690.DN5/04 Q2EIAF(EC)(EPSELV)S

ACCESSORIES

CODE	DESCRIPTION
PA-AFS	AFS fin Turbo
PAS	Special fin spacing
CBLQ2E	Wiring with electrical panel + ECM 'Q2E'
INTSERV	3 pole repair switch 'I'
EPSELV	Complete vertical system
QEPS	EPS control panel
EPS_MOU	Eps mounted in factory
FAI	AISI 304 Flanges (one pair) 'F'
AMM_JUMB	Shock absorbers Jumbo 'A'
VENT_EC_S2	Fan EC 02

WARNING

The delivery time of some fans may be long: please contact Thermokey for availability.

W002: Non-standard fin spacing. Please ask Thermokey for delivery time
W004: Non-standard fin material.Please ask Thermokey for delivery time.
An inverter different from the one proposed by Thermokey must have omni polar sinusoidal filters, between phase and phase and phase and ground.

For any support please contact our Sales Department

Gross Unit Price	€ (EUR)
Accessories Price	€ (EUR)
Total Gross Price	€ (EUR)
Discount	%
Net price of the unit	€ (EUR)
Net price of the accessories	€ (EUR)
Total Net Price	€ (EUR)
Number of units	
Total Net Price	€ (EUR)

Offer validity	**15 Days**
Lead time (9)	**to be defined**

Thermokey sales conditions are available on the website www.thermokey.com

ThermoKey
Heat Exchange Solutions
Via dell'industria 1
33061 Rivarotta di Rivignano di Teor (UD) - ITALY
Tel.: +39/0432772300 Fax.: +39/0432779734

Company		Date	3/10/2023
Attention of		Sw Version	230718
City		Offer	Offerta
Telephone		Reference	
Fax		Position	

DRY COOLER (5) SJGH2690.DN5/04 Q2EIAF(EC)(EPSELV)S

(1) The voltage is referred to the supplier's nominal data: fans consumption may vary with the air temperature and voltage system.

(2) The unit may not be suitable for very corrosive atmosphere. For special applications contact Thermokey. If a special fin material is selected(copper,coating),all the other materials of the unit remain standard(for detailed information please check the Technical description of the unit).

(3) Dimensions and weight are not valid for all possible options! The overall dimensions on the data sheet relate to the units without controls /electrical panels (For more detailed information please refer to the Electrical Box Manual). In the case of horizontal air flow units the standard position of the connections is on the left looking at the finned pack.

(4) Any noise caused by control systems, adiabatic system and so on, is not considered in the fan noise declaration. Actual values can also be subject to changes depending on the conditions of the installation.

(5) The manual consists of 4 parts; IG = General instructions for safe use, IM = Instructions for handling and unpacking, TC = Instructions and technical specifications , IS = Specific use and maintenance instructions. If not expressly requested at the pre-Purchase Order stage, the TC and IS instructions must be downloaded by the user from www.thermokey.com as they will not be provided in paper format.
The installer is required to follow the instructions of the above manuals and of all the main electrical components' manuals (e.g. fans, pumps, regulators).

(6) The unit is equipped with fans that follow the efficiency requirements of ERP directive 2009/125/EC

(7) In accordance with EN 13487 the declared sound pressure level for this unit has been calculated in free-field conditions over a reflecting plane with a parallelepiped surface. With reference to ISO 3744, when the difference of measurement of the unit in on and off stage is < = 6 dB (A) , the the sound measurement does not reach the accuracy as required by the Directive. Background noise values lower than 30dB (A) are typical of indoor and silent environments. The declaration of the sound pressure of the unit, stated on the Thermokey data sheets, considers the background noise negligible.

(8) S x x x x : id serial number of the combination of the standand options available on Archimede (listed and described in the ACCESSORIES section) and special on request. The code appears on the order confirmation (as a part of the model code description) and on the data plate of the unit . Note : For each range the available options are listed in the catalogue on the Table Options and Accessories . The register of combinations of options associated with the code S x x x x is available on request .

(9) Delivery time for standard unit is considered ex works. For any special terms and conditions (ex. Large quantities,special items..) please contact Sales dept.

(10) The standard unit is not self-draining: the choice of fluid (water / glycol) is closely related to the freezing point of the same and to the actual operating period of the unit. For a self-draining construction, please contact Thermokey for a special offer.

(12) The dimensioning is made through a simulation of the selection program which does not take into account the influence of the installation conditions.

(13) For the selection of the maximum operating pressure, the pressure related to the condensation temperature (i.e. middle point) is taken into account

(14) For fan units with microchannel cores, it is mandatory to respect the procedures available on ThermoKey website (Indications for the use of Tk micro cores)

(15) Fluid Group related to Directive 2014/68 / CE.

(16) The data on the fan label do not represent the worst absorption conditions.

(17) The declared performances are suitable for HVAC applications with air flow in a free field on both coil and fan sides (e.g. avoid recirculation or any element that reduces airflow) and with uniform inlet temperatures to the coil (e.g. avoid conditions on which adjacent elements cause temperature variations at the unit inlet). For other critical applications (e.g. industrial, power) please contact Thermokey.

(18) Thermokey reserves the right to change the technical data, drawings and prices of the Archimede software at any time and without prior notice. Please refer to the software release and EULA of the software in Section "?".

(19) The Archimede software is based on latest libraries of oils, refrigerants and mixtures of VDI-Wärmeatlas,Refprop and IIR.Data updates may result in different performances of the units than those of previous releases of Archimede.

(20) Pay attention that the overall dimensions and weight of the unit equipped with EPS system, indicated in the technical sheet, refer to the model without electrical part and mounted evaporative panels, for variation of the possible option combinations please refer back to the following indications!
Take into consideration that the evaporative modules mounted on the side of the model protrude of 440mm all together on the width of the model footprint, whereas they do not affect the length and height dimensions of the model, moreover the discharging tubes mounted on the models protrude of extra 320mm all together on the width of the model. Take into consideration that the control panels and connection piping protrude depending on the selected and requested combinations of 400mm from the extremities of the model. Consider as 60 kilos each module (per fan) the operative weight of the evaporative modules mounted with wet panels. Pay attention that in the case of non optimal maintenance of the discharging drip-trays or of the discharging line, you should consider a possible store of water in the tray and of the sole discharging pipes of EPS system of about 30 kilos per module (per fan). Consider the pre-mounted connection piping of EPS system to water supply network on the model of about 25 kilos per unit. Consider weight of the possible pre-mounted control electrical panel of the EPS system on the model of about 35 kilos per unit.

(21)In case of electric defrosting the external surfaces of the heating elements can exceed 600 °C (with static air of 20 °C). The compliance with EN378 is the responsibility of the designer/ installer, depending on the type of refrigerant.
In case the difference between the refrigerant self-ignition temperature and Hot surface temperature is <100 K, it is mandatory to install devices that allow the unit cooler to work in any condition of use of the installed units.

(22) System design and installation should also, where applicable, follow information presented in accepted industry guides such as the ASHRAE Handbooks. The manufacturer assumes no responsibility for equipment installed in violation of any code or regulation.

(23) When personnel external to Thermokey is lifting units during loading, unloading and installation phases, it is necessary to refer back to the criteria present in the norm UNI EN 13001.

(24) The width of the unit in case of horizontal flow and the height of unit in case of Vertical flow can be influenced by height of fan plate and height of fan motor.The Overall width in Horizontal flow and height in vertical flow are the indicative quote of fan-fanplate in worst condition. Take care that in case of special fans as IEC,Atex,ZAPLUS,Axitop..etc the overall dimensions can be higher.The final unit-drawing of the order can modify indicative values of the selection software.

(25) For units equipped with evaporative panels EPS : do not expose the evaporative cooling panel to high temperature or sparks or other sources which may ignite the paper.
Do not grind or weld arround the unit.

ThermoKey
Heat Exchange Solutions
Via dell'industria 1
33061 Rivarotta di Rivignano di Teor (UD) - ITALY
Tel.: +39/0432772300 Fax.: +39/0432779734

Company		Date	3/10/2023
Attention of		Sw Version	230718
City		Offer	Offerta
Telephone		Reference	
Fax		Position	

DRY COOLER (5) SJGH2690.DN5/04 Q2EIAF(EC)(EPSELV)S

SPECIFICATIONS

Pressure line MAX	**2 - 6**bar	Water flow Adiab. (12)	**2097**lt/h
		Nozzle Tolerance	**1.515**
Type	**Jumbo - SUPER**	Num PADS	**12**
Configuration	**Vertical**		
Panel type	**Pad 01**	Press/flow (for PAD)	**2.9/175**bar/lt-h
Velocity calculation	**2.29**m/s	Water flow adiab. purge(12)	**4320**lt/h

EPS

The water used for the adiabatic system with EPS evaporative panel does not require specific treatments.

However for a long life and a more effective functioning of the evaporative panel and for a reduction of maintenance hours, it is possible to use water with the characteristic indicated in the chart.

Furthermore, the following parameters are defined:

Position	Parameter	Unit	Limits
1	El. Conductivity	µS/cm	< 1000
2	PH-value		6,5 – 8,2
3	Total hardness	°dH	14,0
4	Chlorides	mg/l	< 200
5	Sulfates	mg/l	< 300
6	Nitrates	mg/l	< 50
7	Iron dissolved	mg/l	< 0,1
8	Silicon	mg/l	< 20
9	Colony forming units	KBE/ml(20°C)	< 1000
10	Legionella	CFU/ 100 ml	< 100
11	SAC 254 (spectral absorption coefficient)*	1/m	< 20
12	Water pressure line	bar	1-6
13	Temperatures of parameters	°C	< 20,0

* Indicated in the case of use of UV lamp

• The installer must guarantee that the chemical substances added to respect those parameters do not provoke any corrosion and stress on the materials used on the unit or in anyway damage them

Maintenance:

- It is possible to use the water shared with the public water supply network or water coming from other water supplies, if possible adequately treated with the expectations of durability of the material and cost of treatment. However all measurements have to be done for all chemical and microbiological parameters directly correlated to health compliant to the in force legislation and to directive 2020/2184/CE. Accordingly to what indicated in the use and maintenance manual, Thermokey's evaporative adiabatic system is compliant to VDI 2047-2 requirements.

- The feed water should never go below the minimum PH level of 5 and go above the maximum PH level of 9, in order to avoid chemical aggression problems to the panels. Water hardness should never go above 250 ppmCaCO3. In the case the system is sot to recirculate water, the discharging cycles have to be done in order to avoid that salinity levels exceed the acceptable limits.

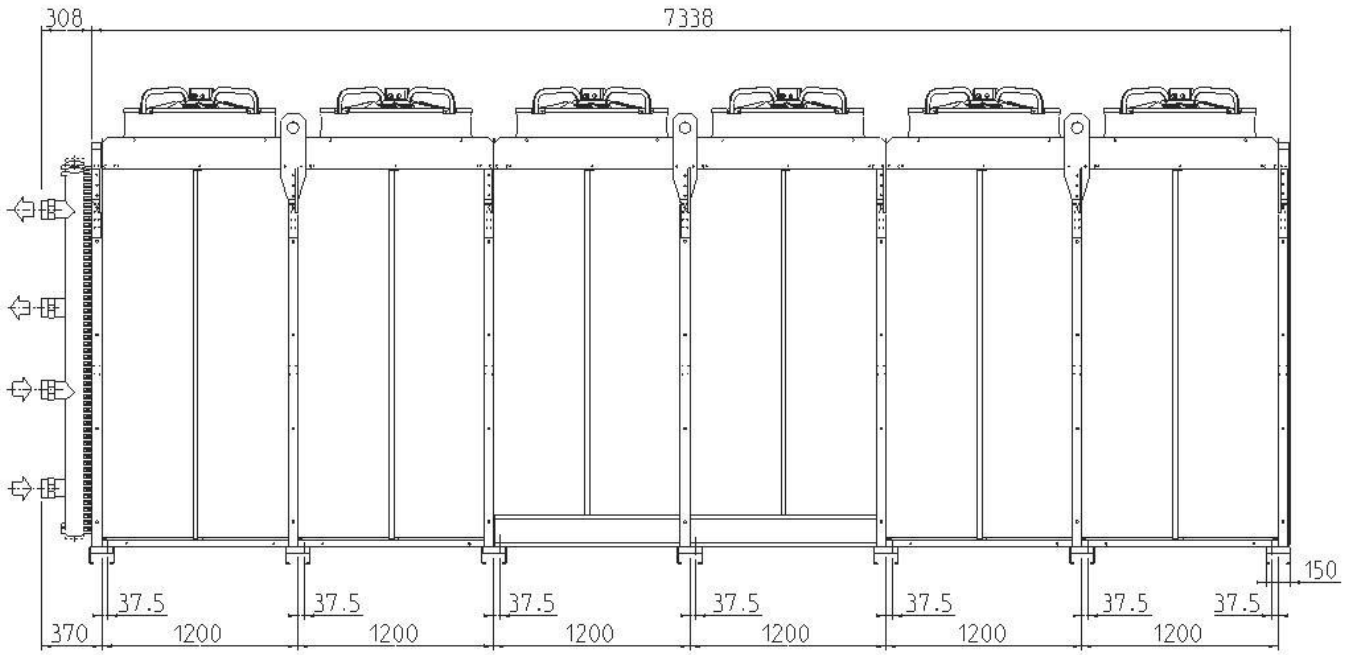
- Do not regularly add oxidising agents to fuelling water since it can create problem to the cellulose sheet of the panel. If they are necessary, use them only in minimum quantities: max 1 ppm in the case of continuous treatment, or max 5 ppm in the case of one-time treatments.

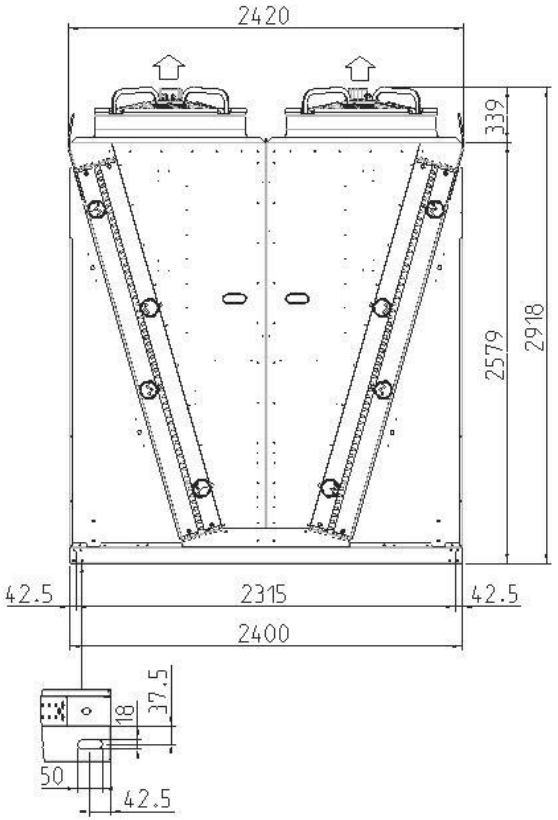
- Water values have to be tested during the start-up of the adiabatic system by qualified personnel and subsequently verified following in force norms, the previewed frequency for the specific application and also the measured values.

- In order to guarantee a safe and efficient functioning of the devices, we recommend the following measures on the system:
  - Prepare a risk analysis of the entire system
  - Documentation of relevant works based on inspection and maintenance planning (inspection, cleaning, … compliant to VDI 2047 prt 2)
  - Discharging of the adiabatic system water supply line using a fuelling valve on the installation site with a switching-off and discharging cycle maximum every 7 days.

NOTES:
(*)Hardness conversion
• 1 °dH (°dH) German hardness: Ca and/or Mg salt, which is equivalent to 1 °dH=17.85 mg/l calcium carbonate (CaCO3) or 1 °dH=10 mg/l calcium oxide (CaO), is dissolved in 1 litre of water.
• German Degrees (dH) =1,78 X French Degreed (°F)=1,24 X English Degreed (°E)
(**)Electrical Conductivity
• The treated water must be balanced: to prevent spontaneous corrosion and / or fouling formation the Langelier Saturation Index (LSI) and Ryznar Stability Index (RI) should be in the following range :-1<=LSI<=+ 1 ; 5.5<=RI<=6.6
• The cooling water must be in any case conditioned by the addition of suitable inhibitors of corrosion / fouling . With the appropriate conditioning it is possible to accept treated water even with characteristics not complying with the ideal ones indicated above .

Model: SJGH2690.DN5/04 Q2EIAF(EC)(EPSELV)S





Attention: Drawing and dimensions not valid for all accessory options!

The overall dimensions on the datasheet refer only to the unit without regulation(For more detailed information refer to Electrical box Manual). In the units with horizontal air flow the standard position of the connections is left looking at the finned pack (right looking at the fans).

ThermoKey
Heat Exchange Solutions
Via dell'industria 1
33061 Rivarotta di Rivignano di Teor (UD) - ITALY
Tel.: +39/0432772300 Fax.: +39/0432779734

Company		Date	3/10/2023
Attention of		Sw Version	230718
City		Offer	- Rev. 00
Telephone		Reference	
Fax		Position	

DRY COOLER (5) SJGH2690.DN5/04 Q2EIAF(EC)(EPSELV)S

LIQUID COOLERS:

Quality standard ISO 9001
Applied Directives:
2014/68/EU Pressure Equipment Directive (PED)
2014/35/EU Low Voltage Directive (LVD)
2014/30/EU Electromagnetic Compatibility Directive (EMC)
2006/42/EC Machinery Directive (MD)
2011/65/UE Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipments (RoHS)

FINNED PACK HEAT EXCHANGER

Optimised geometries for use with mixtures of water or water-glycol and pure, made with tube and fin materials designed to achieve the best performances. The coil is tested at a pressure of 17 bar. For test purposes all circuits are supplied with vent valves and drain valves.Coverplates and side plates made with customised material and painting depending on heat exchanger application. Fin spacing from 1.8 to 4 mm based on materials/applications (2.1 mm by default). Upon request, the whole finned pack can undergo different types of treatments/coatings depending on the application.

Triangular geometry (42 x 36.4 mm) with backflow air-refrigerant circuits in order to optimise the thermodynamic capacity. Heat exchange tubes in smooth copper (Ø 16 mm - 5/8").

Louvered fins with prepainted blue hydrophobic coating: this treatment is ideal for adiabatic industrial systems and it is characterised by a coat of blue polyurethane painting, excellent resistance to UV rays, excellent resistance to corrosion (1000 h test in salt fog ASTM B117 5% NaCl at 35°C, pH 6.5 to 7.2).

CASING

The frame is manufactured with elements in galvanized steel FE ZN275 and in galvanized steel FE ZN275 painted with epoxy-polyester powders RAL 7035 which guarantee a great resistance to corrosion for the main applications. The painting of the components is done subsequently to any manufacturing procedure in order to guarantee a protection against corrosion on all parts. All components in view not painted are manufactured in materials with resistance to corrosion equal or higher to the painted frame. Frame suitable to corrosion class C4L (following norm UNI EN ISO 12944).
The units have been projected with high modularity. The internal construction allows great air distribution using any type of regulation thanks to internal dividing walls which make independent the air flow of each fan.
On request we can manufacture frames following specific paintings, RAL and in stainless steel following the characteristics of the application.

PACKAGING

Protective film packaging. Upon request, the units can be provided with dedicated packaging for special shipments (e.g. container with dedicated slides, barrier bags, etc.).

FANS

All fan units manufactured by Thermokey are fit with axial type fans featuring a motor with an external rotor directly built-in the axial propeller to create a compact, maintenance-free fan.Optimised efficiency and minimised noise level thanks to the fan blades aerodynamic design.Protective grids in compliance with EN 294.All the fans have to meet the requirements of balance quality grade Q 6.3 as prescribed in DIN ISO 1940.Motor protection class IP54.Windings in thermodynamic capacity class F, pursuant to DIN EN 60 034-1. The noise levels in use are those declared by the fan manufacturer according to DIN24166, precision grade 3, measured according to DIN 45635.The sound pressure level declared for this unit has been calculated in free field conditions on a parallelepiped reflecting reference surface in compliance with standard EN 13487.Upon request, fans with special features can be supplied (voltage, frequency, corrosion category, etc.).

High efficiency and long durability EC fans (brushless) supplied with integrated control electronics: ideal for ongoing control of the rotation speed with a 0 to 10V signal or, alternatively, MODBUS RS485.They are the ideal design solution for high aeraulic efficiencies, the modulation of the number of speeds, self electric protection, monitoring/modification of the operating parameters of each individual fan.Three-phase motor(s) 380-480V-3ph+PE-50/60 Hz. Temperature range between -20.0 °C and 60.0 °C (average value depending on type of fan and fan power supply). Alarms are available in the terminal board to warn about motor faults.

HYDRAULIC CONNECTIONS

Copper headers. Flanged connections with stainless steel (AISI 304) slip-on flange PN16 UNI2278 and copper flare fitting.All dry coolers with flanged connections are supplied with a pre-assembled pressure gauge to check the heat exchanger pre-charge pressure (pre-charged with nitrogen to a pressure of 1,5-1,9 bar).

ACCESSORIES

A – SHOCK ABSORBERS

Shock absorbing elastic bases for industrial machineries having a galvanised steel body and NBR elastomer element.

I - 3-POLE SERVICE SWITCH

220V-690V, 50-60Hz.Voltage rating = 20A, 3 poles.Rotary switch installed on each fan / Red handle (black only in presence of mainswitch).Can be padlocked in stop position (padlock not included).Working temperature: -25°C/+40°C.Protection class IP65.Plastic box with 4 inlets for M20 cables.Switches installed and wired on the fans (one switch per fan).

Q2E - THREE-PHASE ELECTRICAL PANEL FOR 400V-3-50HZ EC FANS

Short description: electrical panel for EC fans with paint coated metal casing, controller mounted inside the box, protected by automatic switches (circuit breakers) connected to groups of fans, fan regulation control MODBUS RS485.Description:
metal box painted RAL7035, 120 micron thickness, suitable for outdoor installation.Protection class IP65.Electrical cables suitable for outdoor installation (connection of power and signals).Working temperatures: -20°C/40°C.Power supply: 3~ 400V / 50Hz +PE.Main switch.Protected by automatic switches (circuit breakers) connected to groups of fans.Controller mounted inside the box.Fan speed regulation controlled by MODBUS.Free contact for unit powered indicator.Free general fan alarm contact.Warning light to signal system is powered.General alarm warning light.Quick power connectors for fans directly on panel (4-pole connectors made of plastic, protection class IP68, temperature -50°C/+110°C).Quick signal connector for fans directly on panel (6-pole connector made of plastic, protection class IP68, temperature -50°C/+110°C).Execution in compliance with CE regulations..Panel mounted and wired.CONTROLLER Em - EC-MANAGER: controller Em is a multifunction and multiple-input unit for the regulation of speed of three-phase electronically commutated motors installed on axial fans designed to regulate different EC motors in a simultaneous and coordinated way, using programmable input signals.Power supply: 20-24VDC/AC ±10%-230-460Vac ±20% - 50 / 60Hz.Working temperatures: -20°C÷50°C Input from external signal or transducer: 0-20mA, 4-20mA, 0-5V, 0-10V. 2 MODBUS RS485 connections (COM 0 on PC side & COM 1 on fan side).Possibility to connect temperature probes (by default) or pressure probes.Min. and Max. fan speed setting.Auxiliary contacts - available contacts: S1 - direct mode (by default with NO contact) - reverse (with NC contact); SP - selection of setpoints 1 or 2 (SP1 by default with NO contact; SP2 with NC contact); S5 - night speed limitation (by default OFF with NO contact; ON with NC contact); S2 - controller ON-OFF (by default ON with NO contact; OFF with NC contact); S6: max. spray speed enable; TK - contact for connection of the thermal motor protection (by default FANS ON with NC contact; FANS OFF with NO contact). 3 programmable relays: RL1 - general controller alarm; RL2 - fan alarm; RL3 - relay for heat exchanger cleaning start.2 programmable analog outputs (for fan regulation or spray activation).Display showing the main parameters.LED indicator of controller status.Auxiliary power supply outputs: 5.0 Volt (Vrr) stable; 10.0 Volt (Vrr) stable; 20 Volt ±10%.Controller mounted, wired and programmed according to the calculation board of the fan unit. NTC temperature probe(s) (10kOhm) fitted with silicone cable and stainless steel terminal.Storage temperature -20 °C ÷ 70 °C. Pressure transducer(s) 4-20mA fitted with silicone cable (2 wires), 7/16" 20UNF (8-28V) -25 °C ÷ 80°C (0-30bar (0-50bar upon request)).Advanced functions: Emergency fan speed - fan rotation speed in the case of a control system fault; Overspeed - possibility to increase the speed setpoint above the max. fan speed value (by-pass MAX RPM limit); Speed-off - possibility to reduce the speed setpoint below the min. fan speed value (by-pass MIN RPM limit); Low capacity - is used to switch off groups of fans in the case of low temperatures, high temperature variations between day and night; Anti-lock - is used to start the fans if they are supposed not to operate for a long time; Washing - is used to program a washing cycle of the heat exchanger (start, frequency, duration), including reverse fan rotation and activation of the RL3 relay for washing system start-up; Cleaning - is used to program a washing cycle of the heat exchanger (start, frequency, duration, rotation speed), including reverse fan rotation, Reverse fan rotation - possibility to operate the fans in reverse rotation (manually enabled on the display).

EPSELV - EPS SYSTEM COMPLETED WITH VERTICAL PADS (LOOSE PANELS)

Cooling adiabatic system with evaporative panels. The incoming air to the exchanger goes through a system of wet panels and thanks to adiabatic evaporation (dependent on humidity and ambient temperature) it cools permitting or increasing the heat exchange between air and exchanger.
The EPS system is made of a modular assembly kit: dismantlable frame in stainless steel, which has inside the evaporative panels in treated cellulose, the water distribution piping on the panels equipped with full cone distribution nozzles, extra water collection driptray and modular draining with pipes and connections resistant to low and high temperatures, resistant to UV rays and to aggressive substances with pre-assembled EPDM lamellar gaskets. Upper covers openable for nozzle cleaning. Easy disassemblable nozzles to reduce maintenance duration. Plenum closing sheets in stainless steel painted in epoxy-polyester powders RAL 7035. The system is supplied with assembly kit of piping of water distribution the modules: HD polyethylene pipe, brass fittings, flexible metal hoses in stainless steel, fixing brackets, protection pipes sheets and stainless steel screws.
The system is supplied with the connection to the network piping premounted by manufacturer: HD polyethylene tube, brass fittings, manual ramp balancing valves, charging solenoid valve, discharging solenoid valve, if the facilitated EPSSPV/S system has been selected. Completed with motorized charging control valves and flow gauge if the electronic EPSELV/S system has been selected. Fixing brackets and screws in stainless steel. For the electronic system a control panel with dedicated logic is available.
Refer back to EPS technical manual and to QEPS control panel technical panel.

Q - THREE-PHASE ELECTRICAL PANEL FOR EPS 400V-3-50HZ ADIABATIC SYSTEM

Description: plastic UV-resistant box, protection class IP55.Power supply: 3~ 400V / 50Hz+PE.Main switch featuring auxiliary contact for switch status indicator.Fuse protection of main power supply.Regulation board sending 0-10V signal to adiabatic board depending on measurements made by either pressure or temperature probe.Regulation board provided with programmable auxiliary contacts (on/off, setpoint1&setpoint2, etc.) (added in P and Z controllers).Adiabatic board featuring 4 trimmers for the setup of pause time between two consecutive start-ups, ice alarm temperature, delay in adiabatic valve/pump activation and closing delay.Adiabatic board featuring alarm auxiliary contacts and possibility of manual spray activation.Clean contact for remote pump activation (the panel does not feature any pump protections, which must be provided for by the fitter).Low ambient temperature indicator contact: for ambient temperature drops below the setpoint (optional, with NTC ambient probe only).Automatic system for setpoint entry directly on controller: optimisation on controller with maximised operation in dry conditions, trimmer setup to optimise sprayed water consumption. Execution in compliance with CE regulations.Panel mounted and wired.

EPS MOUNTED IN FACTORY

Eps mounted in factory. Attention please check the final drawing for transport dimensions:
the dimensions and weight of the unit shown on the software data sheet do not include mounted eps panels .

TECHNICAL SPECIFICATION SHEET

Ventilation Equipment Ltd

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**	
Unit Reference	ADQ12316-01-A			
Model Reference	Non-standard			

AHU Details				
Design Supply Air Volume	11	m^3/s		
External Static Pressure	500	Pa		
Unit Velocity	1.67	m/s		
Design Extract Air Volume	11	m^3/s		
External Static Pressure	500	Pa		
Unit Velocity	1.67	m/s		

Energy Use				
	Supply on Clean Filters	Extract on Clean Filters	Overall	
Specific Fan Power	1.14	0.96	2.00	$kW/(m^3/s)$

AHU Construction		**Construction**	
Framework\Profile	56mm Anodized Post	Unit Location	Internal
Panel Depth	45 mm	Weather Roof	None
External Panel Finish	Mica Coated steel 0.90mm	Baseframe	200 x 75 PFC
Internal Panel Finish	Galv Sheet 0.9mm	Casing performance (EN 1886 Standard)	
Insulation	Mineral Wool 45mm	Leakage Class	L1
		Casing strength	D1
		Thermal Transmittance	T3
		Thermal Bridge	TB3

Overall Unit Dimensions				
	Length	Width	Height	Weight (Per Unit)
	5656 mm	3800 mm	4000 mm	5871 kg

Section Weights and Dimensions				
Section No.	Length	Width	Height	Weight Approx +/-5%
A	1732 mm	3800 mm	1900 mm	1327 kg
B	850 mm	3800 mm	3800 mm	1415 kg
C	1450 mm	3800 mm	1900 mm	880 kg
D	1624 mm	3800 mm	1900 mm	1076 kg
E	978 mm	3800 mm	1900 mm	365 kg
F	1732 mm	3800 mm	1900 mm	808 kg

Inlet Section			**Construction**	
Component	Damper		Casing	Aluminium - Class 2
Air Pressure Drop	2.00	Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.

Heating Coil			**Construction**	
Air On / Off	-5.00/5.0	°C/°C	Casing Material	FeZn 1.5 mm
Duty	134.02	kW	Tube Material	CU
Water(Inlet)/(Outlet)	82.00/71.00	°C/°C	Fin Material	AL-0.11
Water PD	7.53	kPa	Connection Size	1 x 2"(F) / 1 x 2"(R)
Water Flow Rate	2.99	L/s		
Air Pressure Drop	11.00	Pa		
Internal Volume	37.90	l		

Accessories

Valve and actuator to be supplied and fitted by others
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**
Unit Reference	ADQ12316-01-A		
Model Reference	Non-standard		

Panel and Bag Filter			**Construction**	
Panel Clean PD	51	Pa	Panel Grade	Coarse 85%(ISO16890)
Panel Mean	85	Pa	Panel Media	Card Frame-Cotton/Synthetic Media
Panel Recommended Dirty	120	Pa	Panel Size 1 / Qty	12 x 594 x 594 x 45 mm
			Panel Size 2 / Qty	6 x 594 x 394 x 45 mm
Bag Clean PD	66	Pa	Bag Grade	ePM1 60%(ISO16890)
Bag Mean	128	Pa	Bag Media	25mm Galv Frame/Glass Fibre
Bag Recommended dirty	190	Pa	Bag Size 1 / Qty	12 x 595 x 595 x 635mm
			Bag Size 2 / Qty	6 x 592 x 392 x 635mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted Dwyer Minihelic gauge (Range 0-500 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Heat Wheel Section				**Construction**
	Winter	**Summer**		
Supply Air On (db/RH)	5.00/90.0	30.00/50.0	°C/%	Matrix Type A: Condensation
Supply Air Off (db/RH)	16.60/44.10	25.40/65.80	°C/%	Product Type
Exhaust Air On (db/RH)	20.00/50.0	24.00/50.0	°C/%	1: Condensation rotor (ST)
Exhaust Air Off (db/RH)	8.40/99.00	28.60/37.90	°C/%	
Heat Recovery	166.30	63.30	kW	
Efficiency	77.40	77.40	%	
Supply Pressure Drop	125.00	137.00	Pa	
Exhaust Pressure Drop	132.00	134.00	Pa	

Accessories

Condensation Rotor for sensible heat recovery
Heat exchanger selection compliant to ERP2018 (Ecodesign directive 1253/2014)
Variable speed drive_factory fitted & wired (Internally to Heat Wheel section) for integration into the control system (Requires 0-10v input signals)
Factory fitted IP54 external terminal box c/w wiring to Heat Wheel Controller
Segmented thermal wheel

Supply Fan - Fan Array 3 x 1			**Construction**	
Design Air Volume	11	m³/s	Impeller	Backward Curve
Total Fan Resistance	970	Pa	Internal Isolation	
Fan Speed	1741	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	8.75	Volts		
Maximum Fan Speed	1910	r/min		
Efficiency	76.53	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	9.00	Amps	Type	EC
Total Input Power	4.65	kW	Rating	IE4
Motor Power	5.85	kW		
Motor Speed	1741	r/min		
Electrical Supply	400/3/50.00			

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**
Unit Reference	ADQ12316-01-A		
Model Reference	Non-standard		

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Over temperature protection thermister (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

Chilled Water Coil			**Construction**	
Air On (db/wb)	30.00/20.00	°C/°C	Casing Material	FeZn 1.5 mm
Air Off (db/wb)	20.0/16.4	°C/°C	Tube Material	CU
Duty	73.42	kW	Fin Material	AL-0.11
Water(Inlet)/(Outlet)	6.00/12.00	°C/°C	Connection Size	1 x 1 1/2"(F) / 1 x 1 1/2"(R)
Water PD	23.52	kPa	Eliminators	No
Water Flow Rate	2.91	L/s	Drain Tray	Sloped 304 1.5
Face Velocity	1.94	m/s		
Air Pressure Drop	33.00	Pa		
Internal Volume	36.10	l		

Accessories

Traffolyte label - Drain Trap Instruction
Valve and actuator to be supplied and fitted by others
Split Coil - Extended pipework by others

Access Section		
Length	500	mm
Access Side	Right	

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Heating Coil			**Construction**	
Air On / Off	5.00/21.0	°C/°C	Casing Material	FeZn 1.5 mm
Duty	106.65	kW	Tube Material	CU
Water(Inlet)/(Outlet)	82.00/71.00	°C/°C	Fin Material	AL-0.11
Water PD	13.86	kPa	Connection Size	1 x 1 1/2"(F) / 1 x 1 1/2"(R)
Water Flow Rate	2.38	L/s		
Air Pressure Drop	13.00	Pa		
Internal Volume	20.90	l		

Accessories

Valve and actuator to be supplied and fitted by others
Traffolyte Component label
Split Coil - Extended pipework by others

Outlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

Inlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**	
Unit Reference	ADQ12316-01-A			
Model Reference	Non-standard			

Panel Filter			**Construction**	
Clean PD	51	Pa	Grade	Coarse 85%(ISO16890)
Mean	85	Pa	Media	Card Frame-Cotton/Synthetic Media
Recommended dirty	120	Pa	Withdrawal	Front
			Size 1 / Qty	12 x 594 x 594 x 45 mm
			Size 2 / Qty	6 x 594 x 394 x 45 mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Exhaust Fan - Fan Array 3 x 1			**Construction**	
Design Air Volume	11	m³/s	Impeller	Backward Curve
Total Fan Resistance	748	Pa	Internal Isolation	
Fan Speed	1592	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	8.00	Volts		
Maximum Fan Speed	1910	r/min		
Efficiency	77.76	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	9.00	Amps	Type	EC
Total Input Power	3.53	kW	Rating	IE4
Motor Power	5.85	kW		
Motor Speed	1593	r/min		
Electrical Supply	400/3/50.00			

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Fan Healthy Contacts (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

Outlet Section			**Construction**	
Component	Damper		Casing	Aluminium - Class 2
Air Pressure Drop	2.00	Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-1**	**Serving**	**AHU-Tunnel-01**
Unit Reference	ADQ12316-01-A		
Model Reference	Non-standard		

AHU Acoustic Data:

Acoustic Data (Supply AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Supply AHU Inlet Lw (dB)	74	77	76	75	70	64	54	45
Supply AHU Outlet Lw (dB)	80	85	82	88	85	78	66	60

Acoustic Data (Extract AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Extract AHU Inlet Lw (dB)	77	77	80	80	77	75	72	63
Extract AHU Outlet Lw (dB)	83	87	85	91	89	87	85	78

Resultant AHU Breakout

Frequency (Hz)	63	125	250	500	1K	2K	4K	8K
Supply Lw (dB)	82	84	78	68	67	62	61	54
Extract Lw (dB)	81	81	77	68	65	61	60	52
AHU Spectrum Lw (dB)	85	86	81	71	69	64	63	56
Resultant AHU Level @ 3m	64	65	60	50	49	44	43	35
Overall AHU “A” weighted Breakout @ 3m	56							

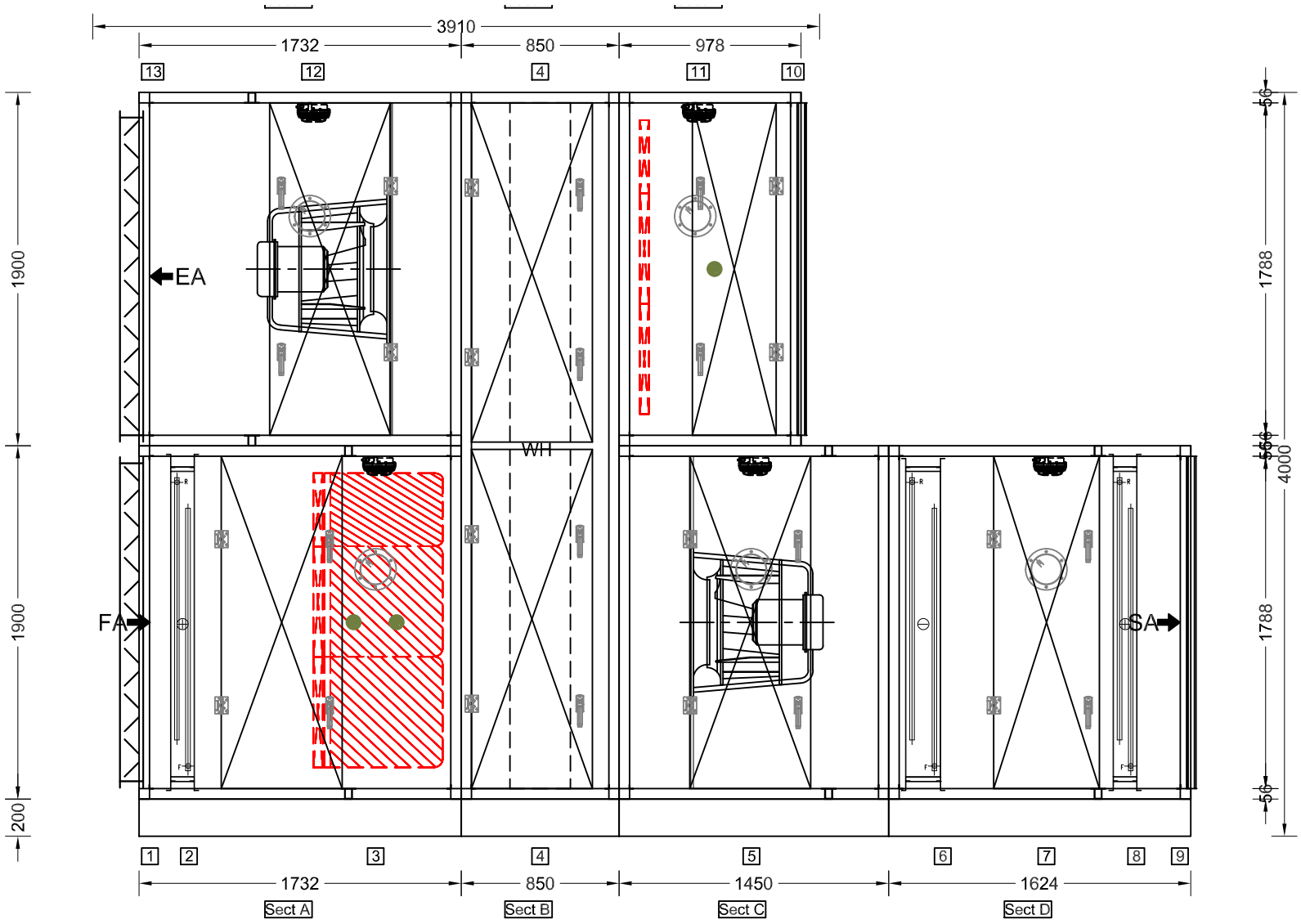
IMPORTANT NOTES

Sound Power levels subject to a correction of +6 dB should be applied across all octave bands for unit casing adjustment

The In-duct Sound Power Level Spectra are in dB re-1pW.

The overall A-weighted sound pressure level is at a distance of 3m with spherical free-field propagation. It is expressed in dB re-20 µPa and is presented for comparative purposes only.

Resultant sound pressure includes all selected AHU component losses within the above calculation.



Unit Height including base 4000mm

Unit Width 3800mm

Section A: Weight = 1327Kgs
Components
1 Inlet
2 Water Heating Coil
3 Panel & Bag Filter
Section B: Weight = 1415Kgs
Components
4 Rotary Heat Exchanger
Section C: Weight = 880Kgs
Components
5 FANARRAY
Section D: Weight = 1076Kgs
Components
6 Water Cooling Coil
7 Access
8 Water Heating Coil
9 Outlet
Section E: Weight = 365Kgs
Components
10 Inlet
11 Panel Filter
Section F: Weight = 808Kgs
Components
12 FANARRAY
13 Outlet

ELEVATION

M&Y Ventilation Equipment Limited
First Floor Offices,
104 Franklynn Road, Haywards Heath,
West Sussex RH16 4DN

T: 0844 756 0202
F: 0844 756 0203
Email: sales@myventilation.co.uk
Web: www.airhandlingunits.co.uk

Project	:	Tunnels London	Project ref	:	12316-1-A	Date	: 28 Sep 2023
Unit reference	:	AHU-Tunnel-01	Unit number	:	12316	Title	:
Number off	:	1	Revision	:	A	Not to scale	

TECHNICAL SPECIFICATION SHEET

Ventilation Equipment Ltd

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-2**	**Serving**	**AHU-Basement-01**	
Unit Reference	ADQ12316-02-0			
Model Reference	Non-standard			

AHU Details		
Design Supply Air Volume	3	m^3/s
External Static Pressure	200	Pa
Unit Velocity	1.7	m/s
Design Extract Air Volume	3	m^3/s
External Static Pressure	200	Pa
Unit Velocity	1.7	m/s

Energy Use				
	Supply on Clean Filters	Extract on Clean Filters	Overall	
Specific Fan Power	1.00	0.79	1.79	$kW/(m^3/s)$

AHU Construction		**Construction**	
Framework\Profile	56mm Anodized Post	Unit Location	Internal
Panel Depth	45 mm	Weather Roof	None
External Panel Finish	Mica Coated steel 0.90mm	Baseframe	200 x 75 PFC
Internal Panel Finish	Galv Sheet 0.9mm	Casing performance (EN 1886 Standard)	
Insulation	Mineral Wool 45mm	Leakage Class	L1
		Casing strength	D1
		Thermal Transmittance	T3
		Thermal Bridge	TB3

Overall Unit Dimensions				
	Length	Width	Height	Weight (Per Unit)
	4956 mm	2100 mm	2200 mm	2520 kg

Section Weights and Dimensions				
Section No.	Length	Width	Height	Weight Approx +/-5%
A	1682 mm	2100 mm	1000 mm	615 kg
B	700 mm	2100 mm	2000 mm	548 kg
C	1250 mm	2100 mm	1000 mm	387 kg
D	1324 mm	2100 mm	1000 mm	491 kg
E	978 mm	2100 mm	1000 mm	165 kg
F	1682 mm	2100 mm	1000 mm	314 kg

Inlet Section		**Construction**	
Component	Damper	Casing	Aluminium - Class 2
Air Pressure Drop	1.00 Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.

Heating Coil			**Construction**	
Air On / Off	-5.00/5.0	°C/°C	Casing Material	FeZn 1.5 mm
Duty	36.55	kW	Tube Material	CU
Water(Inlet)/(Outlet)	82.00/71.00	°C/°C	Fin Material	AL-0.11
Water PD	6.62	kPa	Connection Size	1 x 1"(F) / 1 x 1"(R)
Water Flow Rate	0.82	L/s		
Air Pressure Drop	15.00	Pa		
Internal Volume	8.40	l		

Accessories

Valve and actuator to be supplied and fitted by others
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-2**	**Serving**	**AHU-Basement-01**
Unit Reference	ADQ12316-02-0		
Model Reference	Non-standard		

Panel and Bag Filter			**Construction**	
Panel Clean PD	64	Pa	Panel Grade	Coarse 85%(ISO16890)
Panel Mean	92	Pa	Panel Media	Card Frame-Cotton/Synthetic Media
Panel Recommended Dirty	120	Pa	Panel Size 1 / Qty	3 x 594 x 394 x 45 mm
			Panel Size 2 / Qty	3 x 594 x 292 x 45 mm
Bag Clean PD	85	Pa	Bag Grade	ePM1 60%(ISO16890)
Bag Mean	137	Pa	Bag Media	25mm Galv Frame/Glass Fibre
Bag Recommended dirty	190	Pa	Bag Size 1 / Qty	3 x 592 x 392 x 635mm
			Bag Size 2 / Qty	3 x 595 x 295 x 635mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted Dwyer Minihelic gauge (Range 0-500 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Heat Wheel Section				**Construction**
	Winter	**Summer**		
Supply Air On (db/RH)	5.00/90.0	30.00/50.0	°C/%	Matrix Type A: Condensation
Supply Air Off (db/RH)	17.20/45.20	25.10/66.90	°C/%	Product Type
Exhaust Air On (db/RH)	20.00/50.0	24.00/50.0	°C/%	1: Condensation rotor (ST)
Exhaust Air Off (db/RH)	7.80/99.00	28.90/37.30	°C/%	
Heat Recovery	50.70	18.40	kW	
Efficiency	81.30	81.30	%	
Supply Pressure Drop	181.00	198.00	Pa	
Exhaust Pressure Drop	191.00	193.00	Pa	

Accessories

Condensation Rotor for sensible heat recovery
Heat exchanger selection compliant to ERP2018 (Ecodesign directive 1253/2014)
Variable speed drive_factory fitted & wired (Internally to Heat Wheel section) for integration into the control system (Requires 0-10v input signals)
Factory fitted IP54 external terminal box c/w wiring to Heat Wheel Controller
Segmented thermal wheel

Supply Fan - Fan Array 1 x 1			**Construction**	
Design Air Volume	3	m³/s	Impeller	Backward Curve
Total Fan Resistance	808	Pa	Internal Isolation	
Fan Speed	2249	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	8.72	Volts		
Maximum Fan Speed	2480	r/min		
Efficiency	74.69	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	6.30	Amps	Type	EC
Total Input Power	3.25	kW	Rating	IE4
Motor Power	4.15	kW		
Motor Speed	2249	r/min		
Electrical Supply	400/3/50.00			

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-2**	**Serving**	**AHU-Basement-01**
Unit Reference	ADQ12316-02-0		
Model Reference	Non-standard		

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Over temperature protection thermister (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

Chilled Water Coil			**Construction**	
Air On (db/wb)	30.00/20.00	°C/°C	Casing Material	FeZn 1.5 mm
Air Off (db/wb)	20.0/16.5	°C/°C	Tube Material	CU
Duty	39.58	kW	Fin Material	AL-0.11
Water(Inlet)/(Outlet)	6.00/12.00	°C/°C	Connection Size	1 x 1 1/4"(F) / 1 x 1 1/4"(R)
Water PD	27.37	kPa	Eliminators	No
Water Flow Rate	1.57	L/s	Drain Tray	Sloped 304 1.5
Face Velocity	2.33	m/s		
Air Pressure Drop	46.00	Pa		
Internal Volume	15.80	l		

Accessories

Traffolyte label - Drain Trap Instruction
Valve and actuator to be supplied and fitted by others

Access Section		
Length	400	mm
Access Side	Right	

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Heating Coil			**Construction**	
Air On / Off	5.00/21.0	°C/°C	Casing Material	FeZn 1.5 mm
Duty	58.17	kW	Tube Material	CU
Water(Inlet)/(Outlet)	82.00/71.00	°C/°C	Fin Material	AL-0.11
Water PD	5.90	kPa	Connection Size	1 x 1 1/4"(F) / 1 x 1 1/4"(R)
Water Flow Rate	1.30	L/s		
Air Pressure Drop	18.00	Pa		
Internal Volume	9.00	l		

Accessories

Valve and actuator to be supplied and fitted by others
Traffolyte Component label

Outlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

Inlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-2**	**Serving**	**AHU-Basement-01**	
Unit Reference	ADQ12316-02-0			
Model Reference	Non-standard			

Panel Filter			**Construction**	
Clean PD	64	Pa	Grade	Coarse 85%(ISO16890)
Mean	92	Pa	Media	Card Frame-Cotton/Synthetic Media
Recommended dirty	120	Pa	Withdrawal	Front
			Size 1 / Qty	3 x 594 x 394 x 45 mm
			Size 2 / Qty	3 x 594 x 292 x 45 mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Exhaust Fan - Fan Array 1 x 1			**Construction**	
Design Air Volume	3	m³/s	Impeller	Backward Curve
Total Fan Resistance	559	Pa	Internal Isolation	
Fan Speed	2072	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	8.03	Volts		
Maximum Fan Speed	2480	r/min		
Efficiency	70.86	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	6.30	Amps	Type	EC
Total Input Power	2.37	kW	Rating	IE4
Motor Power	4.15	kW		
Motor Speed	2073	r/min		
Electrical Supply	400/3/50.00			

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Fan Healthy Contacts (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

Outlet Section			**Construction**	
Component	Damper		Casing	Aluminium - Class 2
Air Pressure Drop	1.00	Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-2**	**Serving**	**AHU-Basement-01**
Unit Reference	ADQ12316-02-0		
Model Reference	Non-standard		

AHU Acoustic Data:

Acoustic Data (Supply AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Supply AHU Inlet Lw (dB)	65	72	74	70	65	58	55	49
Supply AHU Outlet Lw (dB)	73	78	81	82	81	75	65	62

Acoustic Data (Extract AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Extract AHU Inlet Lw (dB)	75	81	80	78	73	70	74	69
Extract AHU Outlet Lw (dB)	81	86	85	87	87	84	85	82

Resultant AHU Breakout

Frequency (Hz)	63	125	250	500	1K	2K	4K	8K
Supply Lw (dB)	77	79	79	65	65	61	63	59
Extract Lw (dB)	81	84	79	66	65	60	63	59
AHU Spectrum Lw (dB)	83	85	82	68	68	63	66	62
Resultant AHU Level @ 3m	62	65	61	48	47	43	46	41
Overall AHU “A” weighted Breakout @ 3m	56							

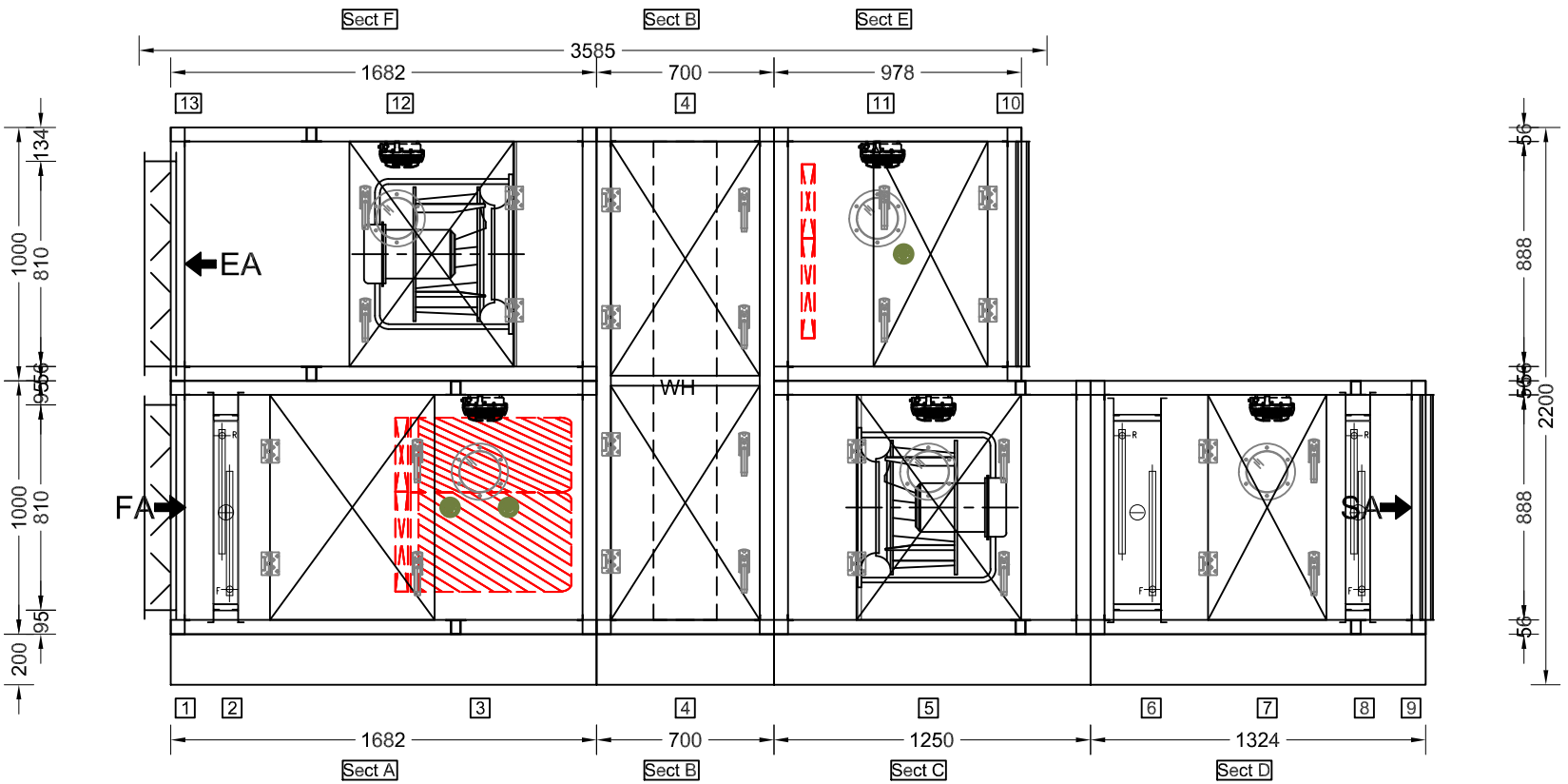
IMPORTANT NOTES

Sound Power levels subject to a correction of +6 dB should be applied across all octave bands for unit casing adjustment

The In-duct Sound Power Level Spectra are in dB re-1pW.

The overall A-weighted sound pressure level is at a distance of 3m with spherical free-field propagation. It is expressed in dB re-20 µPa and is presented for comparative purposes only.

Resultant sound pressure includes all selected AHU component losses within the above calculation.



Unit Height including base 2200mm

Unit Width 2100mm

Section A: Weight = 615Kgs
Components
1 Inlet
2 Water Heating Coil
3 Panel & Bag Filter

Section B: Weight = 548Kgs
Components
4 Rotary Heat Exchanger

Section C: Weight = 387Kgs
Components
5 FANARRAY

Section D: Weight = 491Kgs
Components
6 Water Cooling Coil
7 Access
8 Water Heating Coil
9 Outlet

Section E: Weight = 165Kgs
Components
10 Inlet
11 Panel Filter

Section F: Weight = 314Kgs
Components
12 FANARRAY
13 Outlet

ELEVATION

M&Y Ventilation Equipment Limited
First Floor Offices,
104 Franklynn Road, Haywards Heath,
West Sussex RH16 4DN

T: 0844 756 0202
F: 0844 756 0203
Email: sales@myventilation.co.uk
Web: www.airhandlingunits.co.uk

Project	:	Tunnels London	Project ref	:	12316-2-0	Date	: 28 Sep 2023
Unit reference	:	AHU-Basement-01	Unit number	:	12316	Title	:
Number off	:	1	Revision	:	0	Not to scale	

TECHNICAL SPECIFICATION SHEET

Ventilation Equipment Ltd

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-3**	**Serving**	**AHU-Bar-01**	
Unit Reference	ADQ12316-03-0			
Model Reference	Non-standard			

AHU Details				
Design Supply Air Volume	4	m^3/s		
External Static Pressure	300	Pa		
Unit Velocity	1.61	m/s		
Design Extract Air Volume	4	m^3/s		
External Static Pressure	300	Pa		
Unit Velocity	1.61	m/s		

Energy Use				
	Supply on Clean Filters	Extract on Clean Filters	Overall	
Specific Fan Power	1.08	0.91	1.99	$kW/(m^3/s)$

AHU Construction		**Construction**	
Framework\Profile	56mm Anodized Post	Unit Location	Internal
Panel Depth	45 mm	Weather Roof	None
External Panel Finish	Mica Coated steel 0.90mm	Baseframe	200 x 75 PFC
Internal Panel Finish	Galv Sheet 0.9mm	Casing performance (EN 1886 Standard)	
Insulation	Mineral Wool 45mm	Leakage Class	L1
		Casing strength	D1
		Thermal Transmittance	T3
		Thermal Bridge	TB3

Overall Unit Dimensions				
	Length	Width	Height	Weight (Per Unit)
	4218 mm	2300 mm	2700 mm	2728 kg

Section Weights and Dimensions				
Section No.	Length	Width	Height	Weight Approx +/-5%
A	1682 mm	2300 mm	1250 mm	712 kg
B	700 mm	2300 mm	2500 mm	673 kg
C	1836 mm	2300 mm	1250 mm	763 kg
D	978 mm	2300 mm	1250 mm	192 kg
E	1682 mm	2300 mm	1250 mm	389 kg

Inlet Section			**Construction**	
Component	Damper		Casing	Aluminium - Class 2
Air Pressure Drop	1.00	Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.

Heating Coil			**Construction**	
Air On / Off	-5.00/5.0	°C/°C	Casing Material	FeZn 1.5 mm
Duty	48.73	kW	Tube Material	CU
Water(Inlet)/(Outlet)	82.00/71.00	°C/°C	Fin Material	AL-0.11
Water PD	8.72	kPa	Connection Size	1 x 1 1/4"(F) / 1 x 1 1/4"(R)
Water Flow Rate	1.09	L/s		
Air Pressure Drop	12.00	Pa		
Internal Volume	13.30	l		

Accessories

Valve and actuator to be supplied and fitted by others
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-3**	**Serving**	**AHU-Bar-01**
Unit Reference	ADQ12316-03-0		
Model Reference	Non-standard		

Panel and Bag Filter			**Construction**	
Panel Clean PD	59	Pa	Panel Grade	Coarse 85%(ISO16890)
Panel Mean	89	Pa	Panel Media	Card Frame-Cotton/Synthetic Media
Panel Recommended Dirty	120	Pa	Panel Size 1 / Qty	3 x 594 x 594 x 45 mm
			Panel Size 2 / Qty	1 x 292 x 594 x 45 mm
			Panel Size 3 / Qty	3 x 594 x 292 x 45 mm
Bag Clean PD	77	Pa	Bag Grade	ePM1 60%(ISO16890)
Bag Mean	133	Pa	Bag Media	25mm Galv Frame/Glass Fibre
Bag Recommended dirty	190	Pa	Bag Size 1 / Qty	3 x 595 x 595 x 635mm
			Bag Size 2 / Qty	1 x 295 x 595 x 635mm
			Bag Size 3 / Qty	3 x 595 x 295 x 635mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted Dwyer Minihelic gauge (Range 0-500 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

Heat Wheel Section				**Construction**
	Winter	**Summer**		
Supply Air On (db/RH)	5.00/90.0	30.00/50.0	°C/%	Matrix Type A: Condensation
Supply Air Off (db/RH)	17.30/45.30	25.10/67.10	°C/%	Product Type
Exhaust Air On (db/RH)	20.00/50.0	24.00/50.0	°C/%	1: Condensation rotor (ST)
Exhaust Air Off (db/RH)	7.70/99.00	28.90/37.20	°C/%	
Heat Recovery	69.10	25.00	kW	
Efficiency	82.20	82.20	%	
Supply Pressure Drop	166.00	182.00	Pa	
Exhaust Pressure Drop	175.00	178.00	Pa	

Accessories

Condensation Rotor for sensible heat recovery
Heat exchanger selection compliant to ERP2018 (Ecodesign directive 1253/2014)
Variable speed drive_factory fitted & wired (Internally to Heat Wheel section) for integration into the control system (Requires 0-10v input signals)
Factory fitted IP54 external terminal box c/w wiring to Heat Wheel Controller
Segmented thermal wheel

Supply Fan - Fan Array 1 x 1			**Construction**	
Design Air Volume	4	m³/s	Impeller	Backward Curve
Total Fan Resistance	876	Pa	Internal Isolation	
Fan Speed	2102	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	8.51	Volts		
Maximum Fan Speed	2370	r/min		
Efficiency	73.66	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	10.00	Amps	Type	EC
Total Input Power	4.75	kW	Rating	IE4
Motor Power	6.50	kW		
Motor Speed	2102	r/min		
Electrical Supply	400/3/50.00			

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-3**	**Serving**	**AHU-Bar-01**
Unit Reference	ADQ12316-03-0		
Model Reference	Non-standard		

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Over temperature protection thermister (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

DX Cooling Coil			**Construction**	
Air On (db/wb)	30.00/20.00	°C/°C	Casing Material	FeZn 1.5 mm
Air Off (db/wb)	20.0/16.0	°C/°C	Tube Material	CU
Duty	60.28	kW	Fin Material	AL-0.10
Refrigerant	R410a		Connection Size	5.00(S) / 2x35 mm(L)
Refrigerant PD	9.64	kPa	Eliminators	No
Evaporating Temp	6.00	°C	Drain Tray	Sloped 304 1.5
Face Velocity	2.02	m/s		
Air Pressure Drop	44.00	Pa		
Internal Volume	23.60	l		

Accessories

Coil is selected for use as a Reverse Cycle Heat Pump (Initial selection only - design approval required)
Traffolyte Component label

Outlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

Inlet Section			**Construction**	
Component	Spigot		Casing	Not Applicable
Air Pressure Drop	0.00	Pa	Control	Not Applicable

Panel Filter			**Construction**	
Clean PD	59	Pa	Grade	Coarse 85%(ISO16890)
Mean	89	Pa	Media	Card Frame-Cotton/Synthetic Media
Recommended dirty	120	Pa	Withdrawal	Front
			Size 1 / Qty	3 x 594 x 594 x 45 mm
			Size 2 / Qty	1 x 292 x 594 x 45 mm
			Size 3 / Qty	3 x 594 x 292 x 45 mm

Accessories

Factory fitted Dwyer Minihelic gauge (Range 0-250 Pa)
Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-3**	**Serving**	**AHU-Bar-01**	
Unit Reference	ADQ12316-03-0			
Model Reference	Non-standard			

Exhaust Fan - Fan Array 1 x 1			**Construction**	
Design Air Volume	4	m³/s	Impeller	Backward Curve
Total Fan Resistance	652	Pa	Internal Isolation	
Fan Speed	1966	r/min		
Frequency @ Design Speed	50.00	Hz		
Control Voltage	7.96	Volts		
Maximum Fan Speed	2370	r/min		
Efficiency	71.30	%		

Motor Data (Electrical Loads per Fan)			**Construction**	
FLC	10.00	Amps	Type	EC
Total Input Power	3.66	kW	Rating	IE4
Motor Power	6.50	kW		
Motor Speed	1967	r/min		
Electrical Supply	400/3/50.00			

Accessories

Factory fitted IP44 Internal bulkhead light (42W) wired to an IP66 external switch
Factory fitted viewport
Removable wire mesh guard is fitted behind the fan access door.
Fan Healthy Contacts (For integration in to the controls system)
Fan Label kit, Fan Access, Traffolyte Warning label - Fan run down, Danger label - Safety, Electrical Isolation
Factory Fitted Inlet Guard
EC Fan(s) c/w externally mounted & wired IP66 rated isolator & IP54 terminal box with an integral speed potentiometer and terminals for BMS connections.

Outlet Section			**Construction**	
Component	Damper		Casing	Aluminium - Class 2
Air Pressure Drop	1.00	Pa	Control	Extended Spindle

Accessories

Damper actuators to be provided and fitted by others.
Traffolyte Component label

TECHNICAL SPECIFICATION SHEET

Project: Tunnels London
Quotation Reference: ADQ12316
Date: 10 Oct 2023

Customer Unit Reference	**AHU-3**	**Serving**	**AHU-Bar-01**
Unit Reference	ADQ12316-03-0		
Model Reference	Non-standard		

AHU Acoustic Data:

Acoustic Data (Supply AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Supply AHU Inlet Lw (dB)	64	77	74	72	67	61	55	49
Supply AHU Outlet Lw (dB)	76	86	83	86	85	81	76	72

Acoustic Data (Extract AHU Sound Resultant Level):

Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Extract AHU Inlet Lw (dB)	70	83	79	78	74	72	74	69
Extract AHU Outlet Lw (dB)	79	89	85	88	87	85	86	82

Resultant AHU Breakout

Frequency (Hz)	63	125	250	500	1K	2K	4K	8K
Supply Lw (dB)	76	84	77	66	65	60	63	57
Extract Lw (dB)	77	85	77	65	64	59	62	57
AHU Spectrum Lw (dB)	80	87	80	69	68	63	66	60
Resultant AHU Level @ 3m	59	67	60	48	47	42	45	39
Overall AHU “A” weighted Breakout @ 3m	56							

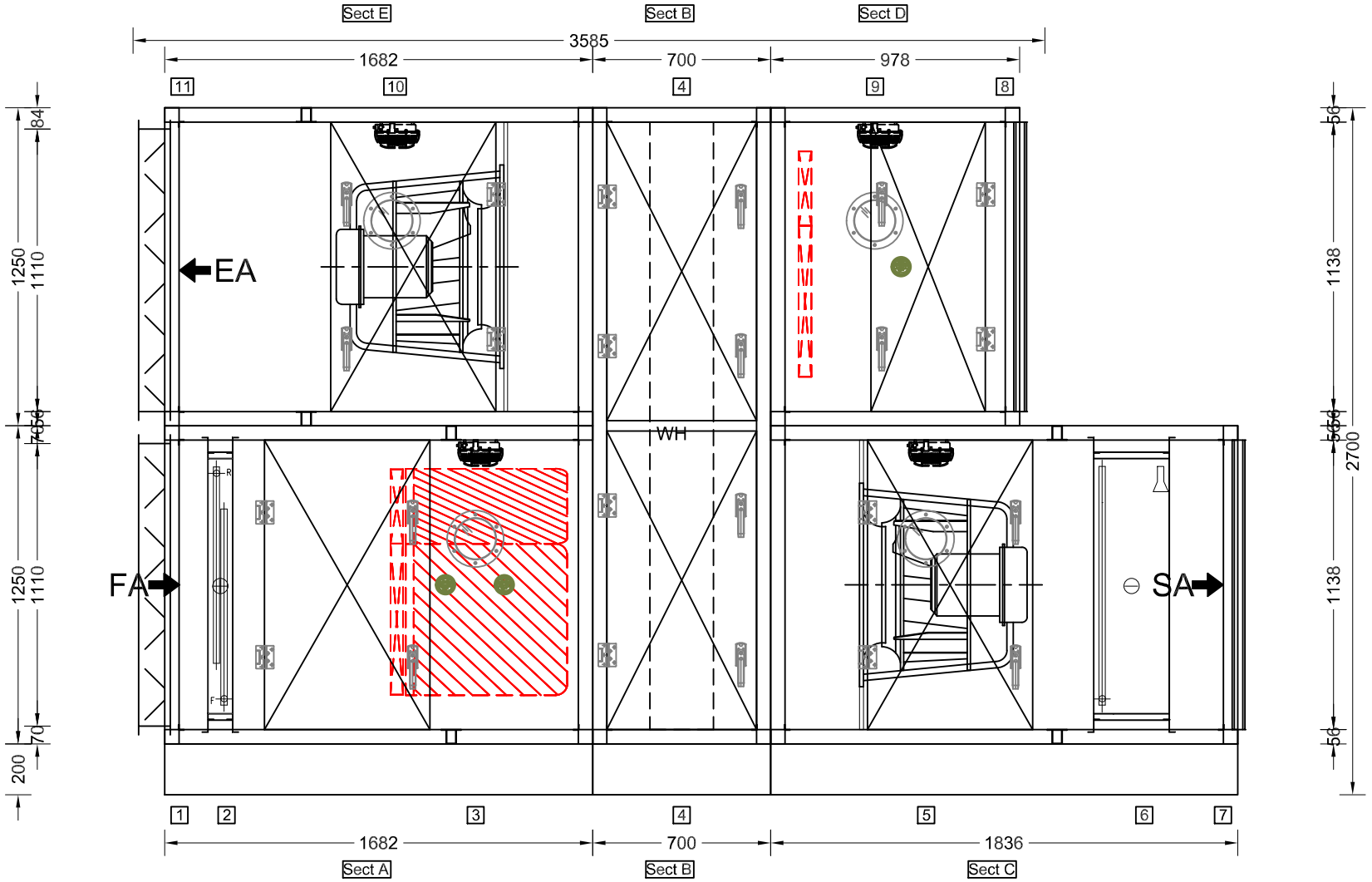
IMPORTANT NOTES

Sound Power levels subject to a correction of +6 dB should be applied across all octave bands for unit casing adjustment

The In-duct Sound Power Level Spectra are in dB re-1pW.

The overall A-weighted sound pressure level is at a distance of 3m with spherical free-field propagation. It is expressed in dB re-20 µPa and is presented for comparative purposes only.

Resultant sound pressure includes all selected AHU component losses within the above calculation.



Unit Height including base 2700mm

Unit Width 2300mm

Section A: Weight = 712Kgs
Components
1 Inlet
2 Water Heating Coil
3 Panel & Bag Filter
Section B: Weight = 673Kgs
Components
4 Rotary Heat Exchanger
Section C: Weight = 763Kgs
Components
5 FANARRAY
6 DX Cooling Coil
7 Outlet
Section D: Weight = 192Kgs
Components
8 Inlet
9 Panel Filter
Section E: Weight = 389Kgs
Components
10 FANARRAY
11 Outlet

ELEVATION

M&Y Ventilation Equipment Limited
First Floor Offices,
104 Franklynn Road, Haywards Heath,
West Sussex RH16 4DN

T: 0844 756 0202
F: 0844 756 0203
Email: sales@myventilation.co.uk
Web: www.airhandlingunits.co.uk

Project	:	Tunnels London	Project ref	:	12316-3-0	Date	: 28 Sep 2023
Unit reference	:	AHU-Bar-01	Unit number	:	12316	Title	:
Number off	:	1	Revision	:	0	Not to scale	

Item 3.1 Quantum oil-free water cooled chiller G050-E2M-LL-DK (3:2) (R-1234ze)

The performance values specified are quoted in accordance with AHRI standard 551/591 (SI) tolerances.

Technical data: Heat rejection operation

created with Selectum version 2.94.127, database 26.07.2023 and CPREngine 2825 , valid per chiller

Profile	**Design point Refrigerating machine operation**	
Cooling capacity	%	100
Cooling capacity Qo	**kW**	**400**
Thermal output Qc	kW	468
Electrical power consumption	kW	67,9
EER		5,89
SEER		9,52
Space cooling annual consumption index ηs,c		377,80
SEPR HT		8,56
Maximum refrigeration capacity Qo	kW	484
Evaporator		
Chilled medium / Concentration		Water
Volume flow	m³/h	57,2
Chilled medium inlet temperature	**°C**	**12,00**
Chilled medium outlet temperature	**°C**	**6,00**
Pressure drop total	bar	0,23
Fouling factor	m²K/W	0,000018
Number of passes		2
Condenser		
Cooling medium / Concentration		Water
Volume flow	m³/h	81,0
Cooling medium inlet temperature	**°C**	**29,00**
Cooling medium outlet temperature	**°C**	**34,00**
Pressure drop total	bar	0,29
Fouling factor	m²K/W	0,000044
Number of passes		2
Number	Item	2

Profile	**Decreasing (1,9K/10%) condenser inlet temperature**					
Cooling capacity	%	100	75	50	25	25 [Min]
Cooling capacity Qo	kW	400	300	200	100	100
Thermal output Qc	kW	468	339	219	107	107
Electrical power consumption	kW	67,9	38,8	19,0	6,5	6,5
EER		5,89	7,72	10,55	15,29	15,29
Maximum refrigeration capacity Qo	kW	484				
Evaporator						
Chilled medium / Concentration		Water				
Volume flow	m³/h	57,2				
Chilled medium inlet temperature	°C	12,00	10,50	9,00	7,50	7,50
Chilled medium outlet temperature	°C	6,00	6,00	6,00	6,00	6,00
Pressure drop total	bar	0,23				
Fouling factor	m²K/W	0,000018				
Number of passes		2				
Condenser						
Cooling medium / Concentration		Water				
Volume flow	m³/h	81,0				
Cooling medium inlet temperature	°C	29,00	24,25	19,50	14,75	14,75
Cooling medium outlet temperature	°C	34,00	27,86	21,83	15,89	15,89
Pressure drop total	bar	0,29				
Fouling factor	m²K/W	0,000044				
Number of passes		2				
Compressor						
Type		Oil-free turbocompressor				
Number	Item	2				

Profile	**SEER: Ordinance (EU) 2016/2281 for comfort coolers**				
Cooling capacity	%	100	74	47	21
Cooling capacity Qo	kW	498	369	234	105
Thermal output Qc	kW	592	418	257	113
Electrical power consumption	kW	93,6	49,7	23,4	7,8
EER		5,32	7,42	9,99	13,49
Space cooling annual consumption index η		378			
Eco-Design-Directive: minimum value		from 01.01.2021: η = 252			
Yearly power consumption	kWh/a	54651			
Capacity control		variable			
Reduction coefficient for devices with fixed and graduated capacity		-			
SEER		9,52			
Maximum refrigeration capacity Qo	kW	498			
Evaporator					
Chilled medium / Concentration		Water			
Volume flow	m³/h	85,5			
Chilled medium inlet temperature	°C	12,00	10,70	9,35	8,05
Chilled medium outlet temperature	°C	7,00	7,00	7,00	7,00
Pressure drop total	bar	0,44			
Fouling factor	m²K/W	0,000000			
Number of passes		2			
Condenser					
Cooling medium / Concentration		Water			
Volume flow	m³/h	102,5			
Cooling medium inlet temperature	°C	30,00	26,00	22,00	18,00
Cooling medium outlet temperature	°C	35,00	29,52	24,16	18,95
Pressure drop total	bar	0,42			
Fouling factor	m²K/W	0,000000			
Number of passes		2			
Compressor					
Number	Item	2			

Technical data: Heat recovery operation

Profile	**Design point heat recovery operation**	
Cooling capacity	%	100
Cooling capacity Qo	**kW**	**400**
Thermal output Qc	**kW**	**508**
Electrical power consumption	kW	107,7
EER		3,72
Maximum refrigeration capacity Qo	kW	440
Evaporator		
Chilled medium / Concentration		Water
Volume flow	m³/h	57,2
Chilled medium inlet temperature	**°C**	**12,00**
Chilled medium outlet temperature	**°C**	**6,00**
Pressure drop total	bar	0,23
Fouling factor	m²K/W	0,000018
Number of passes		2
Condenser		
Cooling medium / Concentration		Water
Volume flow	m³/h	44,2
Cooling medium inlet temperature	**°C**	**40,00**
Cooling medium outlet temperature	**°C**	**50,00**
Pressure drop total	bar	0,23
Fouling factor	m²K/W	0,000044
Number of passes		2
Compressor		
Type		Oil-free turbocompressor
Number	Item	2

Profile	**Heat recovery**				
Cooling capacity	%	100	75	50	37 [Min]
Cooling capacity Qo	kW	400	300	200	148
Thermal output Qc	kW	508	383	252	188
Electrical power consumption	kW	107,7	83,2	52,5	40,3
EER		3,72	3,60	3,81	3,67
COP_HR		8,43	8,20	8,61	8,34
Maximum refrigeration capacity Qo	kW	440			
Maximum heating capacity Qc	kW	562			
Evaporator					
Chilled medium / Concentration		Water			
Volume flow	m³/h	57,2			
Chilled medium inlet temperature	°C	12,00	10,50	9,00	8,22
Chilled medium outlet temperature	°C	6,00	6,00	6,00	6,00
Pressure drop total	bar	0,23			
Fouling factor	m²K/W	0,000018			
Number of passes		2			
Condenser					
Cooling medium / Concentration		Water			
Volume flow	m³/h	44,2			
Cooling medium inlet temperature	°C	40,00	42,46	45,03	46,27
Cooling medium outlet temperature	°C	50,00	50,00	50,00	50,00
Pressure drop total	bar	0,23			
Fouling factor	m²K/W	0,000044			
Number of passes		2			
Compressor					
Type		Oil-free turbocompressor			
Number	Item	2			

Dimensions, weights and fill quantities		
L x W x H*	mm	3282 x 1783 x 1949
Transport weight	kg	3653
Operating weight	kg	4030
Refrigerant R-1234ze	kg	195
Chilled medium content in evaporator	l	110
Cooling medium content in condenser for heat rejection operation	l	
Cooling medium content in condenser for heat recovery operation	l	119
**) These are maximum specifications. For exact specifications please refer to the dimension sheet. Options may increase the total weight.*		
Variable flow rate control		
Minimum flow rate evaporator	m^3/h	22,3
Maximum flow rate evaporator	m^3/h	107,0
Minimum flow rate condenser for heat rejection operation	m^3/h	26,1
Maximum flow rate condenser for heat rejection operation	m^3/h	125,3
Minimum flow rate condenser for heat recovery operation	m^3/h	16,7
Maximum flow rate condenser for heat recovery operation	m^3/h	80,2
Minimum flow rate condenser		
Maximum flow rate condenser		
A change of the flow rate set point has influence on performance values.		
Electrical data		
Voltage/frequency	V/Hz	400V/50Hz
Compressor switch-on method	-	Direct (integrated VSD)
Max electrical power consumption	kW	127,0
Max current consumption	A	215
Start-up current per compressor	A	< 5
Active factor (cos φ) **	-	> 0,95
Motor cooling	-	refrigerant cooled
Voltage supply control	V DC	24
Control voltage	V/Hz	230/50
Control cabinet / power choke protection class	-	IP 54 / IP 54
Supply line cross section ***	mm^2	3 x 95/50 mm^2
Supply line fuse protection ***	A	max. 200
Power element short-circuit current capability	kA	38
) Measured with artificial mains network* *)Supply line cross sections and fuse protection should be adapted to local situations, if required, and should also be controlled by the executing company* *Options may increase the total current consumption. You will find the design of the final and total power consumption in the circuit diagram.* *Lightning protection and planning of electrical grounding are in the responsibility of the customer.*		

Sound data			
Sound power level in accordance with DIN EN ISO 3744	dB(A)	93	
Medium sound pressure level of measurement surface in 1m distance in open air above a reflecting surface in accordance with DIN EN ISO 3744	dB(A)	74	
At 100% design point at 400 kW cooling capacity			
Colours			
Frame	RAL 5015 (sky blue)		
Condenser	RAL 3020 (traffic-light red)		
Economizer (optional)	RAL 3020 (traffic-light red)		
Assembly conditions		Minimum	Maximum
Installation altitude	m	1	1000 above sea level
Ambient temperature (Design Day Max)	°C	1	40
Usage limitations		Minimum	Maximum
Evaporator outflow temperature:	°C	3	18
Evaporator inflow temperature:	°C	4	32
Condenser outflow temperature:	°C	20	57
Condenser inflow temperature:	°C	12	53
An adjustment of the operating conditions (media flow and return temperatures) compared to the technical data fro the offer by the operator requires inspection and approval by the manufacturer. This also applies in particular if thes changed operating conditions continue to lie within the general operating limits.			
GWP (Global Warming Potential) and CO2 equivalent			
GWP as per IPCC (AR4) and regulation (EC) no. 517/2014			7
CO2 equivalent (AR4) (1000kg)			1,365
GWP as per IPCC (AR5)			< 1
CO2 equivalent (AR5) (1000kg)			0,195

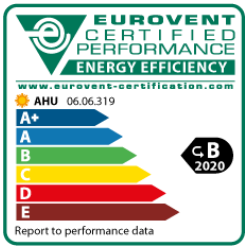
Project: Tunnels NDA
Unit name: 1 - AHU01 - Design data

Date: 02/11/2023
35 / 1.0.20231004.1111558
Unit ID: AD-10001583959

GOLD F SD CX SA EA
Manufactured by Swegon, Kvänum, Sweden

Dimensioning data	1		
Unit size		025	
Air density		1.200	kg/m³
Supply air flow		2.000	m³/s
Static pressure drop	Outdoor air duct	0	Pa
	Supply air duct	300	Pa
Extract air flow		2.000	m³/s
Static pressure drop	Extract air duct	300	Pa
	Exhaust air duct	0	Pa
Climate data		London Weather C.,	Great Britain
Weather station, reference		LONDON CITY,	Great Britain
Design outdoor temperature, summer		30.0	°C
Design outdoor humidity, summer		50	%
Design outdoor temperature, winter		-4.0	°C
Design outdoor humidity, winter		100	%
Supply air temperature, summer		18.0	°C
Supply air temperature, winter		18.0	°C

Key Performance Data			
Specific fan power SFPv	With clean filter and including effect of OACF & EATR	1.92	kW/(m³/s)
Supply air dry temp. efficiency ratio (+5/+25°C)		69.0	%
Eurovent Energy Efficiency Class	Summer: B ↪ 2020	Winter: B	2016
Eurovent; Fs_Pref:	Summer: 0.90	Winter:	0.90
ErP Commission Regulation (EU) No 1253/2014		Compliant	2018



Project: Tunnels NDA
Unit name: 1 - AHU01 - Design data

Date: 02/11/2023
35 / 1.0.20231004.1111558
Unit ID: AD-10001583959

Casing	
Construction	Frameless, double skinned panels with mineral wool insulation
Panels	52mm thick with 1mm thick steel sheet inside and out. Outer sheet with grey painted finish
Thermal insulation class	T2
Thermal bridging class	TB2
Casing leakage class	L1(M) / L2(R) according to EN 1886:2007 at -400 Pa and +700 Pa
Casing strength	D1(M)
Hygiene	Compliant with the requirements of VDI 6022
Insulating material	Version F, casing 3: Standard

Electrical connections	
GOLD F SD CX SA EA Supply air	3-phase, 5-wire, 400 V-10/+15%, 50 Hz, 10 A
GOLD F SD CX SA EA Extract air	3-phase, 5-wire, 400 V-10/+15%, 50 Hz, 10 A

Functional sections viewed in the direction of air flow	Velocity m/s	Air Temperature in/out Winter °C	Air Temperature in/out Summer °C	Power kW	Design Pressure drop Pa	Noise Level dB(A)
Outdoor air duct					-0	71
Damper					-4	
End section					-4	
Filter	1.68				-119	
Coil heat exchanger	1.85	-4.0/13.6	30.0/26.5		-196	
Fan				2.270	711	
Heating coil, water, in casing	1.98	14.5/18.0		8.49	-14	
Cooling coil, water, in casing	2.06		27.4/18.0	33.34	-66	
End section					-7	
Supply air duct					-300	79
Extract air duct					-300	71
End section					-4	
Filter	1.68				-68	
Coil heat exchanger	1.85	22.0/4.4	25.0/28.6		-196	
Fan				1.860	579	
End section					-6	
Damper					-4	
Exhaust air duct					-0	83

Sound power to duct, measured according to ISO 5136
Noise reduction for function section included to duct.
Sound power emitted to surroundings, measured according to ISO 3741

Frequency band	63	125	250	500	1k	2k	4k	8k		All	
To supply air duct	80	75	75	76	73	71	69	69	dB	79	dB(A)
To outdoor air duct	76	76	78	65	58	56	51	54	dB	71	dB(A)
To extract air duct	75	75	78	64	57	56	54	57	dB	71	dB(A)
To exhaust air duct	81	76	78	80	77	76	74	74	dB	83	dB(A)
To surroundings	74	66	59	63	48	47	44	47	dB	61	dB(A)

GOLD-Unit with control system

Components are arranged according to airflow direction

Quantity — Supply air

1 — Damper, TBSA-6-120-050-1-1

Damper motor: With spring return	
Damper blade: Uninsulated	
Static pressure drop	4 Pa

1 — End section, outdoor air

Static pressure drop	4 Pa

1 — Filter

Filter class ePM1 50% (F7)	
2x(592x592x520-10), 1x(287x592x520-5)	
Velocity in the filter section	1.68 m/s
Recommended design pressure drop	119 Pa
Initial pressure drop	69 Pa
Final pressure drop	169 Pa

1 — Coil heat exchanger, G025F3SDP01

No.of tube rows	12
No.of circuits	5
Nom. pipe connection, coil	32 ext.
Fin spacing	2.0 mm
Air side	
Pressure drop	196 Pa
Air velocity	1.85 m/s
Outdoor Air Correction Factor, OACF	1.00
Exhaust Air Transfer Ratio, EATR	< 0.1 %
Supply air dry temp. efficiency ratio (+5/+25°C)	69.0 %
Supply air dry temp. efficiency at balanced airflows (design temp.)	67.3 %
Annual energy efficiency, dry conditions	85.0 %
Annual energy efficiency	85.0 %

LOT without freezing	-4.0	°C
Temperature efficiency, supply air, summer	70.8	%

Outdoor temperature	Temperature efficiency of supply air according to EN308
-4.0 °C	67.6 %
1.0 °C	68.2 %
6.0 °C	68.8 %
11.0 °C	69.2 %
16.0 °C	69.6 %
21.0 °C	70.0 %

Supply air side, winter	In	Out	
Air temperature	-4.0	13.6	°C
Relative humidity	100	29	%
Heating power		42.66	kW

Extract air side, winter	In	Out	
Air temperature	22.0	4.4	°C
Relative humidity	20	63	%

Supply air side, summer	In	Out	
Air temperature	30.0	26.5	°C
Relative humidity	50	61	%

Extract air side, summer	In	Out	
Air temperature	25.0	28.6	°C
Relative humidity	50	40	%

Amount of drained water, extract air, winter	-0.000	l/min
Liquid side		
Flow of liquid	0.803	l/s
Liquid velocity		
Total sum of liquid pressure losses	159.8	kPa
Total sum of coil liquid volumes	138	l
Recommended lowest set value of shunt temperature	2.1	°C
Ethylene-glycol	30	%/kg

Quantity	Product	Article name
1	Shunt unit, GOLD SD	TBXZ-5-42-030

1 Fan

Fan of type GOLD Wing+ — Fan size: 25

Withdrawable fan with integrated airflow measurement

Direct drive with speed controlled EC motor. Efficiency class corresponding to IE5

Isolated with internal flexible connection and rubber anti-vibration mounting

Standard connection, internal		
Supply air flow	2.000	m³/s
The fan system effect is included in the fan performances		
Design static pressure (wet conditions)	711	Pa
Static pressure rise in the SFPv calculation	650	Pa
Temperature rise caused by the fan	0.9	°C
Min speed	280	rpm
Speed in the SFPv calculation	1,752	rpm
Design speed	1,800	rpm
Max speed	2,100	rpm
Design electric power to motor(s)	2.270	kW
Electric power to motor(s) in the SFPv calculation	2.080	kW
Rated motor power/motor	3.400	kW
Motor option	2	
Motor code	DOMEL 751.3.501-401	
Number of fans/motors in the air stream	1	
Overall static efficiency drive	62.5	%
Maximum motor efficiency (incl. motor control 93.0%)	94.0	%
Efficiency grade; FMEG, plenum fan, incl. motor control	71.00	
Regulation(EU)No 327/2011 overall efficiency	67.0	%
Specific fan power efficiency	1.04	kW/(m³/s)

Frequency band	63	125	250	500	1k	2k	4k	8k		All	
To supply air duct	80	75	75	76	73	71	69	69	dB	79	dB(A)
To outdoor air duct	76	76	78	65	58	56	51	54	dB	71	dB(A)
To surroundings	71	63	56	60	45	44	41	44	dB	58	dB(A)
To surroundings incl. exh. air	74	66	59	63	48	47	44	47	dB	61	dB(A)

1 Air cooler and air heater, water, in casing, TCLK030G01

1 Heating coil, water, in casing, TCLA030G01

Article number: 32987501

Valve kit heating/cooling

Incl. actuator, freeze guard sensor, connection cable and valve (kvs = 4)

Capacity variant	1	
No.of tube rows	1	
No.of circuits	8	
Nom. pipe connection, coil	25	ext.
Fin spacing	2.0	mm
Pressure drop	14	Pa
Air velocity	1.98	m/s

	In	Out	
Air temperature	14.5	18.0	°C
Relative humidity	28	22	%

Required coil capacity	8.49	kW
Excess capacity of the coil	170	%

	In	Out	
Liquid temperature	45.0	40.0	°C

Flow of liquid	0.410	l/s
Liquid velocity	0.75	m/s
Liquid pressure drop	8.1	kPa
Liquid volume of the coil	4	l
Nom. pipe connection size, valve	15	DN
Liquid pressure drop, open valve	13.6	kPa

Quantity	Product	Article name
1	Valve kit, heating and cooling	TBVL-3-040-1

1 Cooling coil, water, in casing, TCKA030G01

Article number: 80559201

Valve kit heating/cooling

Incl. actuator, freeze guard sensor, connection cable and valve (kvs = 16)

Capacity variant	1	
No.of tube rows	4	
No.of circuits	14	
Nom. pipe connection, coil	32	ext.
Fin spacing	2.5	mm

Cooling

Pressure drop, dry	55	Pa
Pressure drop, wet	66	Pa
Air velocity	2.06	m/s

	In	Out	
Air temperature	27.4	18.0	°C
Relative humidity	58	90	%

Sensible coil capacity	23.25	kW
Required total coil capacity	33.34	kW
Excess capacity of the coil	21	%
Amount of drained water	0.238	l/min

	In	Out	
Liquid temperature	7.0	12.0	°C

Flow of liquid	1.590	l/s
Liquid velocity	1.03	m/s
Liquid pressure drop	24.4	kPa
Liquid volume of the coil	16	l
Nom. pipe connection size, valve	32	DN
Liquid pressure drop, open valve	12.8	kPa

Quantity	Product	Article name
1	Valve kit, heating and cooling	TBVL-3-160-2
1	Drain trap	TBXZ-1-40-1

1 **End section, supply air**

Static pressure drop	7	Pa

Quantity — Extract air

1 **End section, extract air**

Static pressure drop	4	Pa

1 **Filter**

Filter class ePM10 60% (M5)
2x(592x592x520-10), 1x(287x592x520-5)

Velocity in the filter section	1.68	m/s
Recommended design pressure drop	68	Pa
Initial pressure drop	34	Pa
Final pressure drop	102	Pa

1 **Coil heat exchanger, G025F3SDP01**

No.of tube rows	12	
No.of circuits	5	
Nom. pipe connection, coil	32	ext.
Fin spacing	2.0	mm
Pressure drop, dry	196	Pa
Pressure drop, wet	196	Pa
Air velocity	1.85	m/s

Accesssories and other technical data, see supply air

1 **Fan**

Fan of type GOLD Wing+	Fan size: 25

Withdrawable fan with integrated airflow measurement		
Direct drive with speed controlled EC motor. Efficiency class corresponding to IE5		
Isolated with internal flexible connection and rubber anti-vibration mounting		
Standard connection, internal		
Extract air flow	2.000	m³/s
The fan system effect is included in the fan performances		
Design static pressure (wet conditions)	579	Pa
Static pressure rise in the SFPv calculation	545	Pa
Temperature rise caused by the fan	0.8	°C
Min speed	280	rpm
Speed in the SFPv calculation	1,666	rpm
Design speed	1,694	rpm
Max speed	2,100	rpm
Design electric power to motor(s)	1.860	kW
Electric power to motor(s) in the SFPv calculation	1.760	kW
Rated motor power/motor	3.400	kW
Motor option	2	
Motor code	DOMEL 751.3.501-401	
Number of fans/motors in the air stream	1	
Overall static efficiency drive	62.3	%
Maximum motor efficiency (incl. motor control 93.0%)	94.0	%
Efficiency grade; FMEG, plenum fan, incl. motor control	71.00	
Regulation(EU)No 327/2011 overall efficiency	67.0	%
Specific fan power efficiency	0.88	kW/(m³/s)

Frequency band	63	125	250	500	1k	2k	4k	8k		All	
To extract air duct	75	75	78	64	57	56	54	57	dB	71	dB(A)
To exhaust air duct	81	76	78	80	77	76	74	74	dB	83	dB(A)
To surroundings	70	62	55	59	44	43	40	43	dB	58	dB(A)

1 **End section, exhaust air**

Static pressure drop	6	Pa

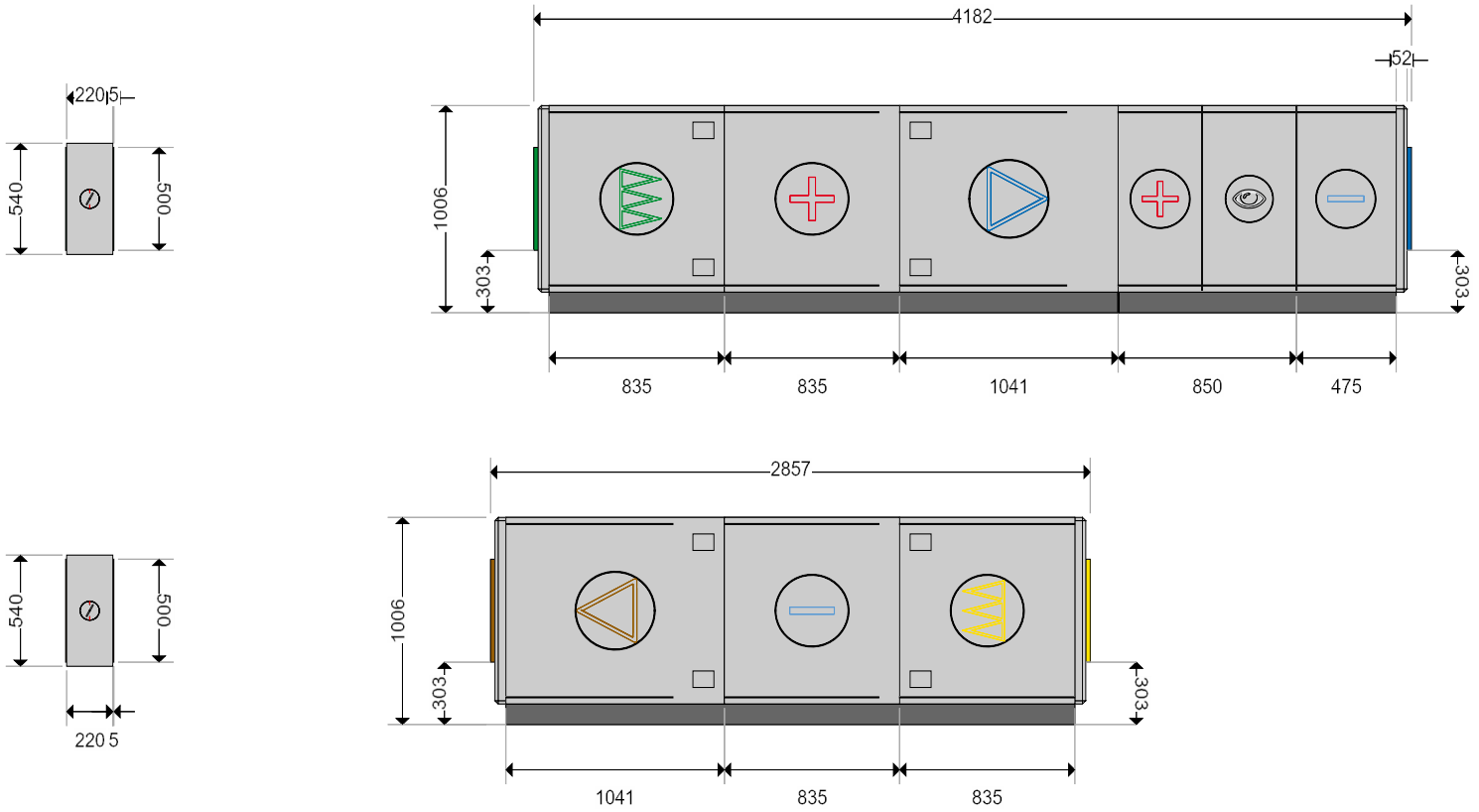
1 **Damper, TBSA-6-120-050-1-1**

Damper motor: With spring return		
Damper blade: Uninsulated		
Static pressure drop	4	Pa

Quantity	Accessories
1	**IQlogic plus (medium)**

TBIQ3201

AHU Design
Sketch: Inspection side



GOLD F SD CX SA EA		
Unit size	025	
Total weight, supply air	899	kg
Total weight, extract air	678	kg
Duct Component Weight	50	kg
Length, supply air max	4,182	mm
Length, extract air max	2,857	mm
Height, max	1,006	mm
Width, max	1,800	mm

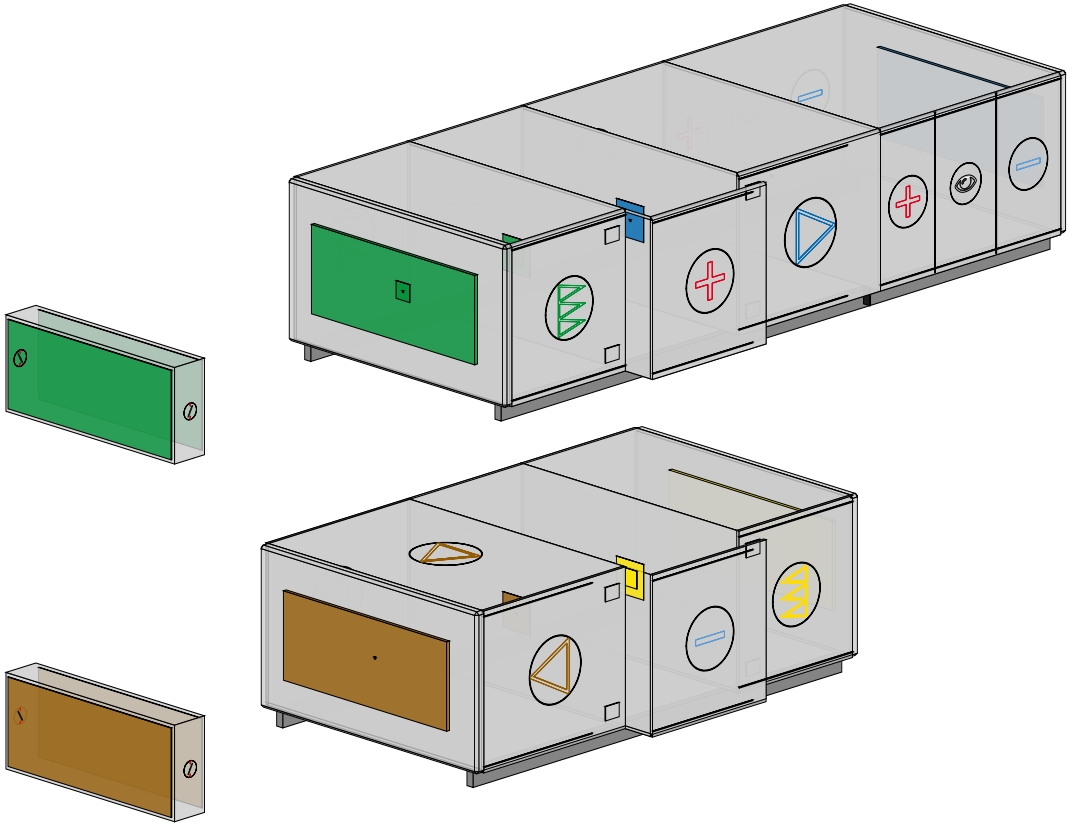
Connection size		
outdoor air	1,200 x 500	mm
exhaust air	1,200 x 500	mm
supply air	1,200 x 500	mm
extract air	1,200 x 500	mm

Project: Tunnels NDA
Unit name: 1 - AHU01
Unit ID: AD-10001583959
35 / 1.0.20231004.1111558
Date: 02/11/2023

Outdoor air
Supply air
Extract air
Exhaust air

Swegon

AHU Design
Sketch: Above left



GOLD F SD CX SA EA		
Unit size	025	
Total weight, supply air	899	kg
Total weight, extract air	678	kg
Duct Component Weight	50	kg
Length, supply air max	4,182	mm
Length, extract air max	2,857	mm
Height, max	1,006	mm
Width, max	1,800	mm

Connection size		
outdoor air	1,200 x 500	mm
exhaust air	1,200 x 500	mm
supply air	1,200 x 500	mm
extract air	1,200 x 500	mm

Project: Tunnels NDA
Unit name: 1 - AHU01
Unit ID: AD-10001583959
35 / 1.0.20231004.1111558
Date: 02/11/2023

Outdoor air
Supply air
Extract air
Exhaust air

Swegon

WSP House
70 Chancery Lane
London
WC2A 1AF
Phone: +44 20 7314 5000

WSP.com