GNW Developments Limited

GREAT NORTHERN

Energy Statement



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Energy Statement

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WSP

8 First Street
Manchester
M15 4RP

Phone: +44 161 200 5000

WSP.com

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Prepared by	Charlotte Hodgson	Charlotte Hodgson	Charlotte Hodgson	Alistair Lambert
Signature				
Checked by	Saba Maskin	Josh Sykes	Josh Sykes	Josh Sykes
Signature				
Authorised by	Alistair Lambert	Alistair Lambert	Alistair Lambert	Alistair Lambert
Signature				
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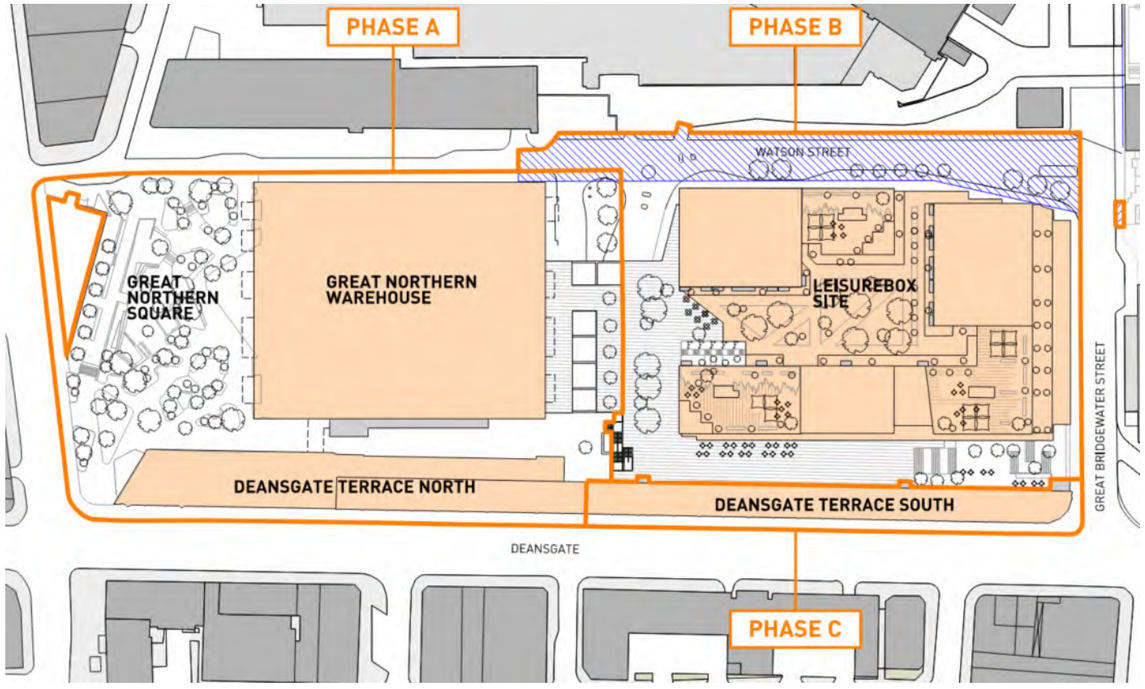
TM59TM59

EXECUTIVE SUMMARY

WSP has been commissioned by GNW Developments Limited (the applicant) to develop and prepare an Energy Statement for the Great Northern (the Proposed Development) in Manchester city.

The following document sets out the Energy and Carbon emissions of the Great Northern development for planning. The figures below show the zones considered within this energy strategy and the phasing of the development. Each zone is considered within its own section within the energy strategy in order to address how each part of the development performs.

Figure 0 – Great Northern development phases considered within the energy strategy



For clarity WSP documentation breaks the site buildings down into the following zones, for clarity in how these align to propose planning zoning:

- Zone 2 – Great Northern Warehouse (part of Phase A – SimpsonHaugh Zoning Plan)
- Zone 3 A & B – Deansgate Terrace North & South (part of Phase A & C – SimpsonHaugh Zoning Plan)
- Zone 4 – Leisure Box (part of Phase A – SimpsonHaugh Zoning Plan)

ENERGY AND CARBON TARGETS

The implications of 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 developmental phase. The Proposed Development will be brought forward under Part L 2021, and this will be used as the basis of the energy strategy;
- Where buildings are refurbished and fall under consequential improvements, the development shall take measures to meet the requirements of Part L, where this is practical and technically, functionally and economically feasible;
- In line with the Manchester Climate Change framework, emissions in Manchester will be expected to be Net Zero by 2038.

ENERGY STRATEGY

The energy strategy has been structured in accordance with the energy hierarchy; Be Lean, Be Clean, Be Green. The strategy for the Proposed Development has been developed in accordance with the desire to achieve an energy efficient and sustainable development.

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

- 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 building fabric will be designed to significantly exceed the minimum fabric requirements of Approved Document L (2021) of the Building Regulations where possible;
- A high-performance building services solution is proposed;
- All spaces will include 100% low energy lighting. Occupancy sensing will be specified where appropriate.
- Where appropriate it is planned to retain existing buildings and structures on the site, this will reduce the embodied carbon of the development.

A significant part of this development focuses upon the renovation of existing buildings that are currently in a poor state of repair, not airtight or thermally sealed and bringing them back to their former glory through restorative measures and improvement upon their energy efficiency.

New build areas will also be built to high standards beyond the requirements set out within building regulations.

RESULTS - BUILDING REGULATIONS PART L

GREAT NORTHERN WAREHOUSE (ZONE 2/ PHASE A)

As this is a listed building that is being refurbished, the warehouse building requires evidence that the development will meet the requirement for consequential improvements. The intended interventions are listed below and will be confirmed at a later stage. This does not apply to existing tenanted retail units that are being retained and occupied throughout construction, which are subject to their own fit out requirements and not considered as part of this Planning Applications Energy Strategy.

- Upgrading heating systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading cooling systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading air-handling systems that are more than 15 years old by providing new plant or improved controls;

- Upgrading general lighting systems that have an average lamp efficacy of less than 60 light source lumens per circuit-watt and that serve areas greater than 100m^2 by providing new luminaires and/or controls;
- Installing energy metering following the guidance given in CIBSE's TM39;
- Replacing existing windows, roof windows or rooflights (but excluding display windows) or doors (but excluding high-usage entrance doors) that have a U-value higher than the following:
  - For windows, roof windows and doors – 3.30W/ (m2 ·K);
  - For rooflights – 3.80W/ (m2 ·K).

DEANSGATE TERRACE NORTH (ZONE 3A/ PHASE A)

The Deansgate Terrace Zone 3A is considered as a new building, though it does contain some elements of listed structure along the Deansgate elevation. As such this element has been modelled using the approved software IES (Integrated Environmental solutions) 2022 to generate a BRUKL. This BRUKL demonstrates the compliance with Approved Document Part L of the building regulations and is contained within Appendix A. Results are summarised below:

Table 1 – Deansgate Terrace (Zone 3A/ Phase A) Carbon Emissions Results

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO_2 per annum)		% Reduction in regulated carbon emissions
	Building emission rate	Notional Building emission rate	
Compliance results	3.02	3.26	7%

A 7% reduction in emissions demonstrates compliance with building regulations and Manchester Planning Policy at this stage. These results are based upon the inputs shown in Section 4. If these inputs require modification, the BRUKL will require reproducing.

DEANSGATE TERRACE SOUTH (ZONE 3B/ PHASE C)

As this is a listed building that is being refurbished only with limited elements of new structure, this element of the building requires evidence that the development will meet the requirement for consequential improvements. The intended interventions are listed below and will be confirmed at a later stage.

- Upgrading heating systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading cooling systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading air-handling systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading general lighting systems that have an average lamp efficacy of less than 60 light source lumens per circuit-watt and that serve areas greater than 100m^2 by providing new luminaires and/or controls;
- Installing energy metering following the guidance given in CIBSE's TM39;
- Replacing existing windows, roof windows or rooflights (but excluding display windows) or doors (but excluding high-usage entrance doors) that have a U-value higher than the following:
  - For windows, roof windows and doors – 3.30W/ (m2 ·K);
  - For rooflights – 3.80W/ (m2 ·K).

LEISUREBOX (ZONE 4/ PHASE B)

The regulated carbon emissions for the residential spaces were determined using Accredited Design SAP 10 software.

The table below summarises the total baseline carbon emissions and the carbon emissions after the application of energy efficiency measures.

Table 2 – Leisurebox (Zone 4/ Phase B) Carbon Emissions Results

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)		% Reduction in regulated carbon emissions
	Building emission rate	Notional Building emission rate	
Compliance results	25.42	30.06	15%

1. INTRODUCTION

WSP has been commissioned by GNW Developments Limited (the applicant) to develop and prepare an Energy Statement for the Great Northern (the Proposed Development) in Manchester city.

The purpose of this energy assessment is to demonstrate that the proposed climate change mitigation measures comply with the local planning policies, including the energy hierarchy. It also ensures energy remains an integral part of the development's design and evolution.

This energy assessment clearly outline the applicant's commitments in terms of CO2 savings and measures proposed to reduce energy demand.

In line with planning application requirements, major developments are expected to be net zero-carbon by incorporating a series of measures outlined in the following energy hierarchy:

- Be lean: use less energy and manage demand during operation through fabric and servicing improvements and the incorporation of flexibility measures
- Be clean: exploit local energy resources (such as secondary heat) and supply energy efficiently and cleanly by connecting to district heating networks
- Be green: maximise opportunities for renewable energy by producing, storing and using renewable energy on-site
- Be seen: monitor, verify and report on energy performance through the Mayor's post construction monitoring platform

The Site is located adjacent to Deansgate and can be broadly divided into four components comprising:

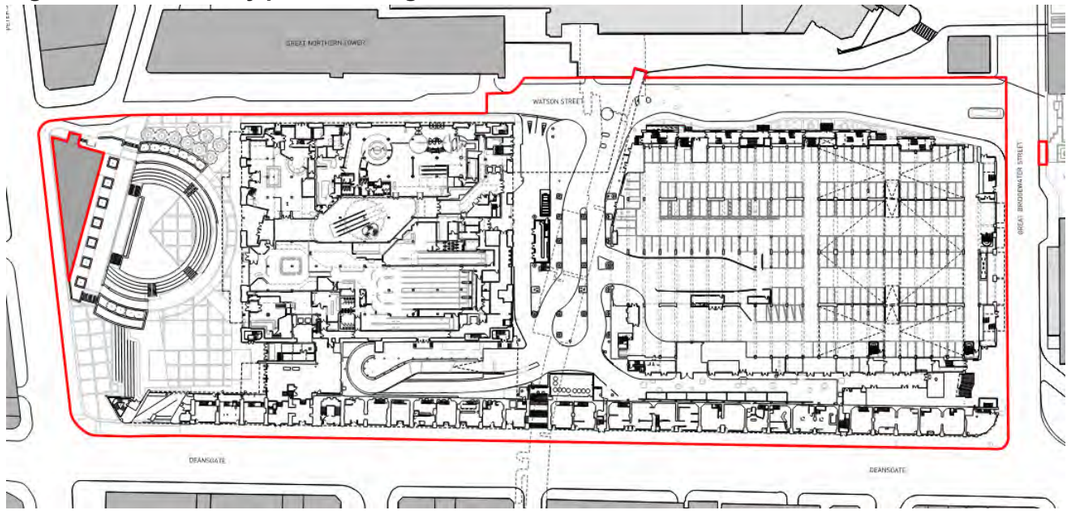
- Great Northern Square – located to the north of the application boundary, the square is an area of public realm with a mix of soft and hard landscaping with an amphitheatre-style seating arrangement in its centre, which currently acts as barrier to movement across the space;
- Great Northern Warehouse and the modern atrium – a Graded II* Listed former railway goods warehouse built between 1896 and 1899, which was refurbished in 1999 to provide retail, commercial and car parking spaces (519 spaces);
- Leisure Box – a modern addition to the Warehouse following the 1999 refurbishments. The Leisure Box contains an Odeon cinema, the Gym and car parking (721 spaces); and Deansgate Terrace – covers the length of Deansgate from Peter Street to Great Bridgewater Street;
- The 3 to 4 storey length of terraces is Grade II Listed and currently comprises a mix of retail, food & drink and commercial.

Development Details

Phased redevelopment of the Great Northern Warehouse (GNW), Deansgate Terrace and Leisure Box, including areas of public realm, comprising:

- Demolition of the central atrium, GNW car park ramps, and other modern elements, alongside removal of 519 car parking spaces from the GNW, retention of casino (Sui Generis), bowling alley and existing food and drink unit (Use Class E) alongside the refurbishment, restoration, and re-use of the Grade II* Listed Great Northern Warehouse to provide office, retail and / or food and drink use (Use Class E) and ancillary areas;
- The refurbishment, restoration, partial demolition and 3-storey extension of the Grade II Listed Deansgate Terrace (northern section) and Goods Yard Entrance to form office, retail and / or food and drink use (Use Class E) and drinking establishments / hot food takeaway (Sui Generis), with associated public realm works comprising the reconfiguration of Great Northern Square and the introduction of additional public realm with associated hard and soft landscaping, together with highways works, access and servicing facilities, rooftop plant and other associated works;
- Partial demolition of the existing leisure box prior to conversion; reconfiguration and extension of existing car parking to provide 929 parking spaces and associated plant, followed by construction of three residential buildings to provide 746 no. apartments (Use Class C3) above the retained car park comprising ground floor plus 16, 27 and 34 storeys respectively including 753 cycle parking spaces, with office, retail and / or food and drink use (Use Class E), or Sui Generis (drinking establishments / hot food takeaway) at ground floor and level 3, hard and soft landscaping, together with highways works, access and servicing facilities, rooftop plant and other associated works; and,
- External alterations and restoration of Deansgate Terrace (southern section) to provide office, retail or food and drink use (Use Class E) or Sui Generis (drinking establishments / hot food takeaway / live music venue), along with delivery of associated public realm, highways works, plant, and associated works.

Figure 1-1 - Boundary plan showing the site



PROJECT BACKROUND

The site is split into the following zones:

GREAT NORTHERN WAREHOUSE (ZONE 2/ PHASE A)

The Warehouse will be restored to its former glory by putting it back into 'splendid isolation' and removing modern alterations and additions to the listed building fabric. This will entail the conversion of the Warehouse from car parking to a state of the art c. 150,000 sqft Grade A office with amenity at ground and first floor levels. The plan is to also open up the site by demolishing the car park ramps and creating a new pedestrianised Dean Street along the western edge of the Warehouse through to the Leisure Box.

DEANSGATE TERRACE (ZONE 3A AND 3B/ PHASE A AND C)

The terraces will be restored, extended, and rejuvenated. Deansgate terraces are the longest listed terrace in Europe and the development intends to celebrate this historic listed structure, extending sections onto a newly created Dean Street adjacent to the Warehouse and to the northern edge. There will be Creation of workspaces at first floor level and above for the northern half of Deansgate, including a new build element. There will also be a creation of a "mews street" at Dean Street along with retention and refurbishment of Deansgate Mews for independents. A review of the existing entrances and potential upgrades of entrances will be undertaken.

LEISUREBOX (ZONE 4/ PHASE B):

The plan for the leisurebox is to retain, refurbish, re-clad the existing RC basement, GF, L01 parking structure and demolish the upper levels of the Leisurebox (existing Cinema). Basement, GF and Mezzanine. The leisurebox will contain car parking spaces comprising a combination of existing and new build parking spaces. The new build upper floors will be a best in class residential scheme above the Leisure Box Car Park to provide circa 750 units operated together as a large-scale build to rent operation together with high quality amenity provision creating a mixed use district where people truly can live, work and play.

1.1.1. SUMMARY

The table below gives an overview of relevant Approved Document Part L requirements:

Table 1-1 – Overview of Relevant Part L Requirements

ZONE	RELEVANT REGULATIONS	NEW BUILD/ REFURBISHMENT
Great Northern Warehouse **(Zone 2)**	Approved Document L, Conservation of fuel and power, Volume 2: Buildings other than dwellings	Refurbishment
Deansgate Terrace **(Zone 3A and 3B)**	Approved Document L, Conservation of fuel and power, Volume 2: Buildings other than dwellings	New build element and refurbishment
Leisurebox **(Zone 4)**	Approved Document L, Conservation of fuel and power, Volume 1: Dwellings	New build

The project includes extensive refurbishment activity for both the Great Northern Warehouse and Deansgate Terrace.

The following buildings are Listed, and a description of the listings are provided below for completeness:

- **Great Northern Warehouse**: The warehouse is Grade II* Listed, which reflects the outstanding national importance of the building, being considered, in its day, to be one of the most advanced railway goods exchanges in the country. The warehouse forms an important group with, and is an integral part of, the adjoining Grade II Listed Deansgate terrace;
- **223-233 Deansgate Terrace and 235-291 Deansgate Terrace (with Former Goods Yard Entrance:** The terrace of 34 shop units are Grade II Listed in two separate parts, No's 223-233, and No's 235-291. The listed status of the terrace reflects its national importance architecturally and historically. The arched entrance into the former goods yard at the junction of Peter Street and Deansgate falls in part within the southern boundary of the Peter Street Conservation Area.

2. POLICY CONTEXT

2.1. OVERVIEW

The Proposed development is designed in line with current national, regional, and local policy.

The key policies are set out in the National Planning Policy Framework (July 2021), Greater Manchester Places for everyone (2021), the Manchester Core Strategy Development Plan document (2012-2027) and the Manchester Climate Change Framework (2020-2025).

2.2. NATIONAL PLANNING POLICY

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. This will include:

- 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.

2.3. LOCAL PLANNING POLICY

THE MANCHESTER CORE STRATEGY 2012-2027

Table 2-1 – Summary of key policies in the Manchester Core Strategy 2012-2027

POLICY TITLE	SUMMARY OF POLICY
Policy EN 16: Air Quality	The Council will seek to improve the air quality within Manchester, and particularly within Air Quality Management Areas, located along Manchester's principal traffic routes and at Manchester Airport. Developers will be expected to take measures to minimise and mitigate the local impact of emissions from traffic generated by the development, as well as emissions created by the use of the development itself, including from Combined Heat and Power and biomass plant. When assessing the appropriateness of locations for new development the Council will consider the impacts on air quality, alongside other plan objectives. This includes cumulative impacts, particularly in Air Quality Management Areas.
Policy EN6 Target Framework for CO_2 reductions from low or zero carbon energy supplies	Applications for residential development of 10 or more units and all other development over 1,000 sq m will be expected as a minimum to meet the target shown below unless this can be shown not to be viable. This should be demonstrated through an energy statement, submitted as part of the Design and Access Statement. Such a statement will be expected to set out the projected regulated energy demand and associated CO_2 emissions for all phases of the development. Domestic CO_2 emission reduction Network development area - CHP/district heating anchor or connection or where not feasible a 15% increase on Part L 2010 Electricity Intense buildings - +15% increase on Part L 2010 Micro generation area - +15%increase on Part L 2010 Non – Domestic CO_2 emission reduction Network development area – CHP/district heating anchor or connection or where not feasible, a 15% increase on Part L 2010 Electricity intense buildings (Applies to commercial uses with a high proportion of emissions from electricity use (>45 kg CO_2/m^2)) - +10%increase on Part L 2010 Micro generation area - +15% increase on Part L 2010

POLICY TITLE	SUMMARY OF POLICY
Policy EN7 Energy Infrastructure opportunities	There will be a general presumption in favour of low and zero carbon decentralised energy schemes, subject to considerations. In determining proposals for development, consideration will be given to the need to safeguard strategic energy sites and network routes, both proposed or existing, where these have been identified as having strategic significance for the delivery of low or zero carbon energy infrastructure or, would be required in order to achieve the successful regeneration of an area in line with targets for reducing carbon emissions.
Policy EN 8 Adaption to climate change	All new development will be expected to be adaptable to climate change in terms of the design, layout, siting, and function of both buildings and associated external spaces. Developers will be permitted to use green infrastructure elements such as green roofs, green walls, street trees and waterways to contribute to compliance with CO2 mitigation under Policy EN6, subject to sufficient evidence to quantify their contribution to compliance.

2.4. LOCAL POLICY

2.4.1. THE PLACES FOR EVERYONE PLAN (AUGUST 2021)

Table 2-2 – Summary of The Places for Everyone Plan (August 2021) – Not yet formally adopted

POLICY TITLE	SUMMARY OF POLICY
Policy JP-S 6 Clean air	A comprehensive range of measures will be taken to support improvements in air quality, focusing particularly on locations where people live, where children learn and play, where there are impacts on the green infrastructure network and where air quality targets are not being met. These measures are listed out within Policy JP-S 6 within the places for everyone document.
Policy JP-S 2 Carbon and Energy	The aim of delivering a carbon neutral Greater Manchester no later than 2038, with a dramatic reduction in greenhouse gas emissions, will be supported through a range of measures including: Promoting retrofitting Promoting the use of renewable and low carbon energy, heating, and cooling Taking a positive approach to low carbon & renewable technology. Developments should be net zero carbon from 2028 by following the energy hierarchy I. Minimise energy demand: ii. Maximise energy efficiency; iii. Utilise renewable energy; iv. Utilise low carbon energy; and v. Utilise other energy sources. All new dwellings should seek a minimum 19% carbon reduction against Part L of the 2013 building regulations (Or until this level is superseded by changes to national building regulations) For renewable energy generation priority should be given to PV installation where technically feasible, alternative technologies will be appropriate where the equivalent generation is evidenced. For non-residential developments, achieve at least BREEAM excellent standard (or equivalent) for the 'Ene 01 – reduction of energy use and carbon emissions' category rising to 'BREEAM outstanding' equivalent for ENE 01 from 2028
Policy JP-S 3 Heat and Energy Networks	The provision of decentralised energy infrastructure is critical to the delivery of the objectives for low carbon growth, carbon reductions and an increase in local energy generation.
Policy JP-S 7 Resource Efficiency	The achievement of a circular economy and a zero-waste economy will play a key role in meeting Greater Manchester's ambition of becoming a leading green city region by 2038. Measures to achieve this are set out within the policy document.

2.5. LOCAL POLICY

2.5.1. MANCHESTER CLIMATE CHANGE FRAMEWORK (AUGUST 2021)

Table 2-3 – Summary of the Manchester Climate Change Framework (2020-2025)

OBJECTIVE TITLE	SUMMARY OF OBJECTIVE
5.1 Staying within our Carbon Budgets	This objective seeks to ensure that Manchester plays its full part in helping to meet the Paris Agreement objectives by keeping direct CO2 emissions within a limited carbon budget, taking commensurate action on aviation CO2 emissions, and addressing our indirect / consumption-based carbon emissions. To emit a maximum of 15 million tonnes CO2 from our homes, workplaces, and ground transport from 2018. Manchester will reduce our direct CO2 emissions by at least 50% between 2020-25. In line with this budget Manchester will emit: • A maximum of 6.9 million tonnes during 2018-22

OBJECTIVE TITLE	SUMMARY OF OBJECTIVE
	• A maximum of 3.6 million tonnes during 2023-2711.
5.2 Climate Adaption and Resilience Objective	This objective seeks to ensure that Manchester adapts the city's buildings, infrastructure, and natural environment to the changing climate and to increase the climate resilience of our residents and organisations taking the following actions: 1) Act on the existing evidence and research on climate change impacts and risks to target available adaptation and resilience effort and resources. This means focusing on infrastructure, communities, and businesses at risk from flooding in particular. 2) Increase the amount of urban green infrastructure cover, aiming for a 10% increase by 2038 from 2018 levels, in line with the Greater Manchester aim20.
5.3 Health and Wellbeing	The Health and Wellbeing objective seeks to improve the health and wellbeing of everyone in Manchester through actions that also contribute to our objectives for CO2 reduction and adaption and resilience, with particular focus on those most in need.
5.4 Inclusive, Zero Carbon and Resilient Economy	This objective seeks to ensure that Manchester establishes an inclusive, zero carbon and climate resilient economy where everyone can benefit from playing an active role in decarbonising and adapting the city to the changing climate.
6.1 Headline Areas for Urgent Action	This objective concludes the above objectives and sets out areas for urgent action. The following relevant headlines for this Energy Statement are: 1) Existing buildings – There are currently extremely low levels of domestic and non-domestic retrofitting taking place in the city. Addressing this requires significant new interventions. The aim being to get our existing buildings as close to zero carbon as possible by significantly increasing their energy efficiency and generating renewable energy on-site. New buildings – We need to ensure that we build and operated new buildings to zero carbon standards as soon as possible. In order to do this the ideal way would be through the UK Government establishing a national zero carbon definition and methodology, and for Manchester City Council to implement this standard.

OBJECTIVE TITLE	SUMMARY OF OBJECTIVE
	2) 100% Renewable Energy – Manchester needs to significantly increase the amount of electricity generated from solar photovoltaic (PV) panels. Gas – The UK is pushing to stop using Natural Gas. Either replacing systems with electric systems or biogas and/ or hydrogen. 3) Transport and flying – Designs should encourage people to walk and/ or use public transport and/ or cycle. 4) Food – Seasonal produce and less waste should be encouraged 5) The things we buy and throw away – People should be encouraged to buy less, buy better, repair and recycle 6) Green Infrastructure and nature-based solutions- Parks, gardens, woodlands, and street trees should be encouraged.

2.6. BUILDING REGULATIONS (PART L)

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 developmental phase.

The residential components of the Proposed Development will be assessed against Approved Document L1 (AD L1) which relates to new build residential buildings and all the non-residential components will be assessed against Approved Document L2 (AD L2) relating to new build non-residential buildings.

Additionally, the new Part O, requires new residential buildings to comply with a set of overheating requirements based on CIBSE TM59.

2.7. SUMMARY

The main policies listed above are all relevant for the Great Northern Development and it will be best to encourage reductions upon Part L of the building regulations wherever possible. However, since the update of both the Places for Everyone Plan (August 2021) and the Manchester Core Strategy (2012-2027) there has been an update to Part L of the building regulations (2021). This latest Part L is already a 27% reduction against Part L 2010 and the current understanding is that the new Part L 2021 will be compliant with MCC policy without the reductions mentioned within Table 2-1 and Table 2-2, this has been clarified with the developments Building Control Officer.

3. ZONE 2 GREAT NORTHERN WAREHOUSE (PHASE A)

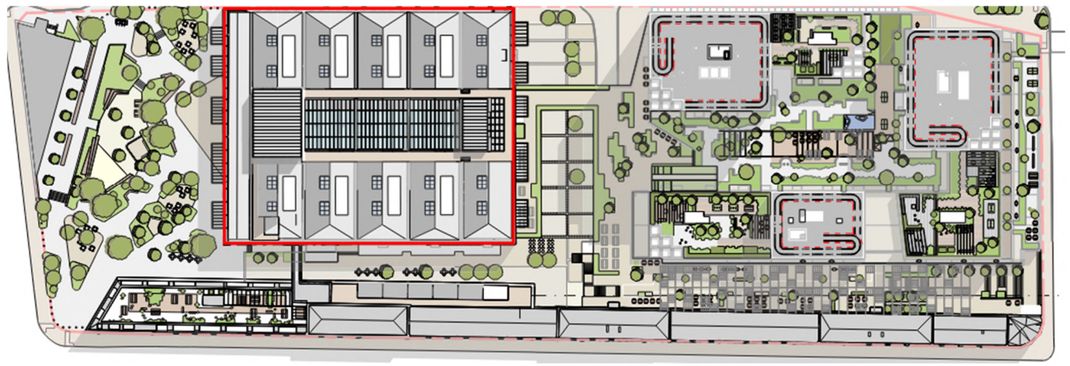
The Great Northern Warehouse building is Grade II* Listed and it is important to restore the Warehouse to its former glory by putting it back into ‘splendid isolation’ and removing modern alterations and additions to the listed building fabric.

This building is in a poor condition and will be brought back to life with the completion of the development. Many of the building’s original features in this area have been covered up and concealed.

Though there is no evidence to suggest significant structural defect, repointing to brickwork and stonework repairs is required. Repair is also required to prevent further water ingress and damp penetration. Windows generally are in poor condition with some missing ironmongery and require replacement of glass and full refurbishment and redecoration. Openers have been sealed shut and hinges are not in working order. Overall condition of external elevations is generally good but the roof has been completely replaced with artificial slates; the latter of which show damage caused by access, vandalism and projectiles.

Proposals to the building, include; demolition of the car park ramps, atrium and other redundant structures constructed during the 1998 conversion of the site and sensitive refurbishment of the Great Northern Warehouse to provide new workspace uses at the upper levels, and to carefully repair and enhance the listed fabric.

Figure 3-1 – Overall Site Plan with the Great Northern Warehouse (Phase A) highlighted in red



3.1. BE LEAN: DEMAND REDUCTION

The ‘Be Lean’ section of the energy hierarchy focuses on energy reduction measures through passive means.

The Warehouse is currently in extremely poor condition. The current use for this building at the levels above the existing retail and casino spaces is as a multi-story car park that is not currently watertight or thermally sealed sufficiently.

This development will seek to significantly improve the fabric of the building through upgrades to glazing and thermal efficiency at roof level. However, it is not possible to upgrade the current wall or glazing u value due to the listed nature of this building as options such as internal dry lining or external cladding would significantly impact the building and be unacceptable from a heritage perspective.

Options explored for the treatment of the masonry walls include; lining and insulation the walls internally would create a significant improvement in the building’s overall fabric performance. However, it was considered that this would be detrimental to the character of the listed building. Therefore, the proposed treatment of the masonry walls is to leave them exposed internally.

However, interventions will be made to reduce the energy use through passive means wherever possible.The options explored for refurbishment of the existing windows. Re-glazing the windows with single glazing (as they would have been originally) was discounted, as this would have the lowest thermal performance, and introduce safety issues in the event of breakage. The replacement of window frames with modern replicas was also discounted, despite the fact that this would potentially offer the best thermal performance, as this would also have the most harmful impact to the characterof the listed building. The proposed option comprises the re-glazing of the windows with either vacuum glazing or a slimline DGU (subject to further mock-up and testing), which is considered to provide the optimum performance improvement, whilst respecting the historic character of the original windows

3.1.1. GREAT NORTHERN WAREHOUSE BUILDING FABRIC

The table below sets out the proposed planned performance for the fabric of the Great Northern Warehouse:

Table 3-1 - Building fabric Great Northern Warehouse

FABRIC ASSUMPTIONS	U VALUES LIMIT	CURRENT PLANNED PERFORMANCE
Exposed Floor U-value (w/m2K)	Listed building element	1.60
Roof U-value (w/m2K)	Listed building element	0.16
Wall U-value (w/m2K)	Listed building element	1.40

FABRIC ASSUMPTIONS	U VALUES LIMIT	CURRENT PLANNED PERFORMANCE
Glazing U-value (w/m2K)	Listed building element	2.90 (TM54 analysis is based on a U value of 1.6W/m^{2}K)
Glazing g-value	Listed building element	0.3 (TM54 analysis is based on a U value of 0.57)
Rooflight U-value (w/m2K)	Listed building element	2.20
Rooflight g-value	Listed building element	0.3
Air permeability	Listed building element	30.0 m^3/hr.m^2@50pa

3.1.2. GREAT NORTHERN WAREHOUSE BUILDING SERVICES

An energy efficient HVAC system is proposed to allow the project to meet the low energy targets agreed.

The proposed HVAC strategy can be summarised as follows:

- The proposed conversation of office will be provided with new mechanical ventilation via a Under Floor Air Distribution System (UFAD) and new central roof mounted Air Handling Units (AHUs);
- The UFAD system also provides the heating and cooling to the offices. This solution consists of a series of floor mounted heating/ cooling downflow units located on the floor which blow cooled (or heated) air into the raised floor plenum. Outside air is introduced into the system via a plenum at the top of each downflow unit where it is mixed with recirculated air from the space prior to being drawn through the unit and supplied into the floor void. Air is introduced locally to the occupied zone via “fan-tiles” which are selected to operate at 30% of their nominal airflow to avoid discomfort owing to air movement. Optionally, each fan tile can incorporate a small electric heater (electronically controlled) for user adjustment of supply air temperature;
- Proposed toilet areas are provided with new dedicated high efficient extract fans routing to roof level;
- A new “energy centre” is provided at roof level consisting of a series of high efficient electric Air Source Heat Pumps (ASHPs) that provide the heating & cooling load to serve the full office elements as well as the existing and new proposed retail units, including the casino;
- High efficient LED lighting is proposed throughout landlord areas.

Performance Specification

The table below lists the general design rationale and proposed specification for the MEP building services:

Table 3-2 - Proposed energy conservation measures

ELEMENT	DESIGN RATIONALE
Air Handling Plant	Ventilation is proposed to be through centralised AHUs (Air handling unit) supply and extract ventilation system with local UFAD fan tiles. The local units will achieve a specific fan power (SFP) of 0.25W/l/s or lower and the central unit will have a fan power of 1.3 W/l/s.
Space Heating	Space heating will be served by a UFAD system. The seasonal Coefficient of Performance (SCOP) of the central ASHP that feeds this system at roof will be 3.86 or higher.
Domestic Hot Water	DHW shall be produced by direct or storage electric heater with a seasonal efficiency of 1.
Cooling Plant	Cooling will be provided from the UFAD system. The central ASHP that feeds this system at roof will have a minimum Seasonal energy efficiency ratio (SEER) of 5.00.
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 throughout currently assumed with an efficiency of 4 w/m2. Lighting has been assumed with automatic on-off controls in offices/ reception/ toilets and lifts and stores are assumed to have lighting controls manual on- auto off.

The measures above set out the first steps taken to reduce the energy reduction of Great Northern Warehouse through passive means.

3.2. BE CLEAN: SUPPLY ENERGY EFFICIENTLY

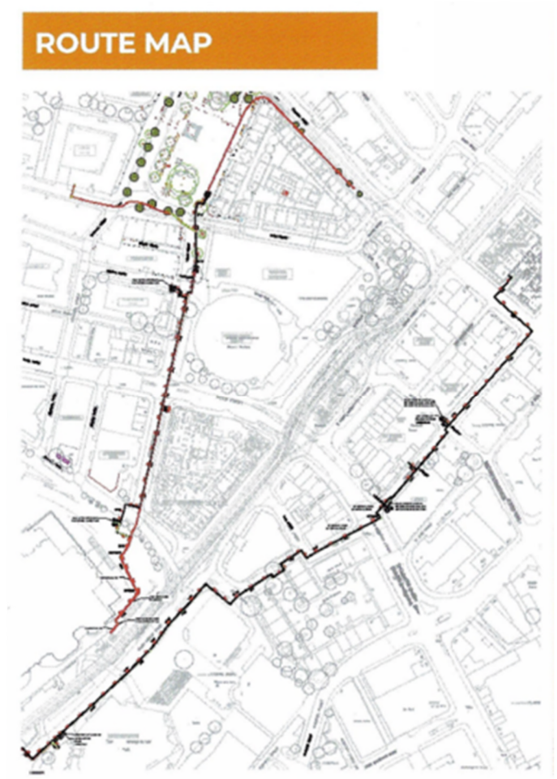
After consumption has been reduced through the application of energy efficiency measures, the next step is to consider heating infrastructure.

It is not proposed to connect to the existing Manchester Civic Quarter Heat Network (CQHN) as it would be less energy efficient than providing heating/ cooling through renewable means on site.

The Manchester Civic Quarter Heat Network (CQHN) is a £20million energy centre located in the heart of the city. Its aim is to provide a heat and power system to several iconic buildings in and around the city of Manchester.

The new network consists of a 2km district heating network and an energy centre containing a 3.3MWe CHP engine and two 12MW gas boilers that generate energy for landmarks including Manchester Town Hall and Town Hall Extension, Central Library, Manchester Central Convention Centre, The Bridgewater Hall, Heron House, and the Manchester Art Gallery.

Figure 3-2 - Manchester District Heating Route Map



3.2.1. SUSTAINABILITY

The existing CQHN is currently gas powered.

Given the decarbonisation of grid electricity, the use of mains gas for provision of heating is becoming less favourable from a sustainability perspective, as well as for air quality. Furthermore, as the grid decarbonises and electricity is utilised for heat generation the relative impact of in-use energy consumption upon whole life carbon decreases.

As the construction of heat networks is a carbon intensive process, it is not favourable from a whole life carbon perspective as well as an energy use perspective to utilise such an approach.

Decentralised solutions with the decreased infrastructure requirement and lower embodied carbon may be more environmentally sound.

Ongoing discussions with Manchester City Council regarding the future ambitions of the network are underway and the viability of connecting into the district heating network will be further investigated during later design stages.

However, at this stage it is not proposed to connect to the network until the operators can advise on the systems transition to more renewable energy generation that would reduce the carbon more than that of the current proposed systems.

The image below shows how the warehouse's ASHP ambient loop network could be connected to a District Heat Network.

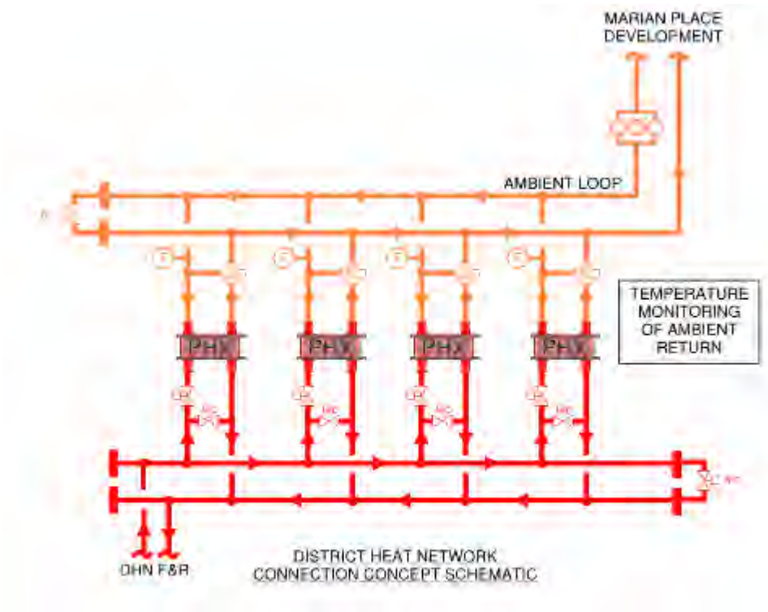


Figure 3-3 - Typical DHN Concept Schematic

3.3. BE GREEN: USE RENEWABLE ENERGY

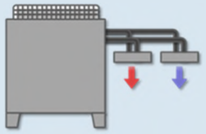
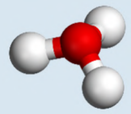
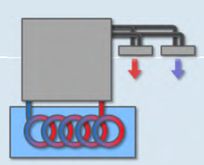
Renewable energy technologies can provide a source of energy on-site that is not primarily based on the consumption of fossil fuels or grid electricity and/ or utilise a heat source that is renewable such as Air Source Heat Pumps (ASHP) and solar photovoltaic (PV) systems.

In this section an evaluation of a number of renewable energy technologies has been undertaken below and outlines how they may be applied to the proposed development. This section also shows the carbon/ energy usage of the building and how the renewable technologies help in reducing the building's operational energy.

3.3.1. GREAT NORTHERN WAREHOUSE RENEWABLE TECHNOLOGIES

Table 3-3 sets out the feasibility for the renewable technologies and indicates which technologies are applicable for the Great Northern Warehouse.

Table 3-3 - Renewable Energy Feasibility

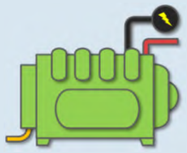
TECHNOLOGY	PROS, CONS & FEASIBILITY
AIR SOURCE HEAT PUMPS (ASHPs)	This technology uses electricity and is commonly installed in a range of development types to provide low-energy heating and cooling.  ASHPs are capable of providing heating and/ or cooling utilising heat from outside air. The use of ASHPs are an effective Low and Zero Carbon (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 and gas 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.
	Suitability to proposed development: Incorporating an ASHP solution for the development is an energy and carbon efficient solution that provides heating, cooling and hot water to the building, has a neutral impact on local air quality and is a long-term low carbon solution for the development.
HYDROGEN	Hydrogen is a fuel which when consumed in a fuel cell, produces only water.  Hydrogen is considered a clean fuel. When hydrogen is consumed within a fuel cell the only waste product is water. Hydrogen can be produced from a variety of domestic resources, such as natural gas, nuclear power, biomass and renewables (solar and wind). However, most hydrogen is produced using coal or natural gas. Coal and Natural gas both emit harmful by – products into the atmosphere so whilst hydrogen itself is favourable the processes used to produce the chemical element have a high environmental footprint.
	Suitability to proposed development: The use of hydrogen is not feasible for this development as when considering its whole lifecycle it would have a greater carbon impact and be less efficient than providing heating/ cooling through other means.
GROUND SOURCE HEAT PUMP (GSHP)	Similar to air source heat pumps this technology uses electricity to provide heating and or cooling for buildings. As the name suggests ground source heat pumps use the ground as the heat source as opposed to outside air. 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 systems such as underfloor heating. The space required for installation of underground pipework in the form of or horizontally does not make GSHPs suitable for constrained sites.
	Suitability to proposed development: The use of a GSHP is not considered due to the high costs and potential problems of installing pipework deep underground in this city centre location.
WATER SOURCE HEAT PUMP	Similar to air source and ground source heat pumps, this technology uses electricity to provide heating and or cooling for buildings. Water source heat pumps use a body of water (a river for example) as the heat exchanger as opposed to the air or ground.  WSHPs have a significantly higher coefficient of performance (COP) than ASHPs due to the higher temperature of the heat source which is relatively constant throughout the year. Low flow temperatures from the WSHPs further reduce the energy consumption and carbon emissions. 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 for the Proposed Development.

FEASIBLE
FURTHER INVESTIGATION REQUIRED
UNFEASIBLE

Suitability to proposed development: The water source heat pump is not considered for this development as there is no suitable body of water close to the site.

COMBINED HEAT AND POWER (CHP)

A device which uses an engine to generate electricity and heat simultaneously, contributing towards the development's heating and power demands

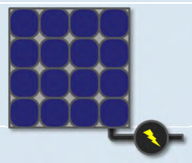


CHP's capture and utilise the heat that is a by-product of the electricity generation process. By generating heat and power a CHP could help to reduce carbon emissions compare to the separate means of conventional generation via a boiler and power station. However, the grid is undergoing decarbonisation at a rapid rate therefore the use of a CHP is significantly less efficient.

Suitability to proposed development: The use of CHP is not favoured due to the air quality issues and reduced carbon effectiveness as a result of grid decarbonisation. Therefore, it is not considered for the development

PHOTOVOLTAICS

Panels or sheets that can generate electricity directly from sunlight, which can be installed on the roofs or facades of buildings, or as a standalone 'array'.

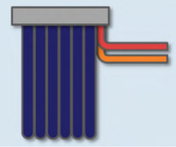


Photovoltaics (PV) are arguably the most practical solution for onsite renewable generation in an urban environment. To maximise their effectiveness they do require roof space at a suitable orientation which is not overshadowed.

Suitability to proposed development: An area on the roof has been identified which currently provides ideal conditions for the installation of roof mounted PV panels on the roof of the Great Northern Warehouse and Deansgate terraces north. The installation of PV is actively promoted by the council and will benefit the scheme; therefore, the installation of roof mounted PV is feasible and considered for the development.

SOLAR WATER HEATING

Collectors which generate heat directly from sunlight and can be installed on the roof of buildings to make a contribution towards the domestic hot water demand

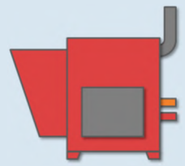


Solar thermal hot water (STHW) generation involves capturing solar radiant heat to preheat or heat domestic hot water. Correctly located and orientated, solar thermal systems can meet a proportion of a building's domestic hot water dependent on the expected demand profile and available space for locating STHW panels.

Suitability to proposed development: The majority of roof space will be used for roof mounted PV panels. The limited roof space available on the Proposed Development after the inclusion of those is insufficient to provide any meaningful contribution to the development's heating requirements from solar. This can be investigated further to determine its impact.

BIOMASS BOILER

A type of boiler which typically uses wood chips, pellets or logs to heat water for space heating and domestic hot water, although other sources of biomass can be used



Biomass heating has embodied environmental impacts from transport and fuel combustion which makes it less desirable in Air Quality Management Areas (AQMAs).

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.

Suitability to proposed development: There is a range of issues including high maintenance, large flue and space requirements for both the biomass boiler and the fuel.

WIND POWER

Wind turbines convert the winds' Kinetic energy into Mechanical power/ electricity.



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.

Suitability to proposed development:: 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. On that basis they are not proposed for the Proposed Development.

The following renewable technologies have been deemed relevant for the Great Northern Warehouse building:

- Air Source Heat Pump (ASHP)
- Photovoltaic panels

The following table and figure sets out the parameters for the PV considered on the roof of the warehouse:

Table 3-4 – PV parameters Warehouse

PV PARAMETER	VALUE
Area of PV	236 m^2
Orientation of PV from north	180 degrees
Inclination of PV	0 degrees
Shading factor	1
Module nominal efficiency	20%
Output requirement (Warehouse)	36,500kwh/annum
Electrical Conversion Efficiency	0.96



Figure 3-4 - Image showing PV locations on the roof of the Warehouse

3.3.2. GREAT NORTHERN WAREHOUSE OPERATIONAL ENERGY

CIBSE TM54 methodology has been used to calculate the Energy Use Intensity for the Great Northern Warehouse area of the Great Northern development as it is proposed in this planning application.

The calculated TM54 operational energy figures are detailed in the form of Energy Use Intensity in kWh/yr. The assessment shows an overall annual energy consumption in the region of 2,713 MWh/year. The highest energy consumption is reported for the servers which accounts for approximately 33% of all the energy demand. The second highest demands come from equipment energy as well as fans and pumps energy. Both categories each account for approximately 20% of the total energy demand. Results are reported in the table below.

Table 3-5 – Energy Use Breakdown

ENERGY USE	ELECTRICITY (KWH)	ELECTRICITY (KWH/M^2)
Lighting	202,321	12
Lifts	14,977	1
Small power	538,114	31
Server Rooms (kWh)	897,987	52
PV Generation (kWh)	-36,470	-2

Domestic hot water	125,836	7
Space heating	407,231	24
Space cooling	14,031	1
Fans and pumps	549,141	32
Total	**2,713,168 kWh**	**158 kWh/m²**

3.3.3. GREAT NORTHERN WAREHOUSE CONSEQUENTIAL IMPROVEMENTS

As the Great Northern Warehouse is a Graded II* Listed building being refurbished, it falls under Approved Document Part L requirement for consequential improvements. Therefore, the building shall take measures to meet the requirements of Part L, where this is practical and technically, functionally and economically feasible.

The intended interventions are listed below and will be confirmed at a later stage of design:

- Upgrading heating systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading cooling systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading air-handling systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading general lighting systems that have an average lamp efficacy of less than 60 light source lumens per circuit-watt and that serve areas greater than 100m2 by providing new luminaires and/or controls;
- Installing energy metering following the guidance given in CIBSE's TM39;
- Installing energy metering following the guidance given in CIBSE's TM39;
- Replacing existing windows, roof windows or rooflights (but excluding display windows) or doors (but excluding high-usage entrance doors) that have a U-value higher than the following:
  - For windows, roof windows and doors – 3.30W/ (m2 ·K);
  - For rooflights – 3.80W/ (m2 ·K).

4. ZONE 3A AND 3B DEANSGATE TERRACE (PHASE A & C)

The terraces will be restored, extended, and rejuvenated. Deansgate terraces are the longest listed terrace in Europe and the development intends to celebrate this historic listed structure, extending sections onto a newly created Dean Street adjacent to the Warehouse and to the northern edge.

Similar to the Great Northern Warehouse, there is no evidence to suggest significant structural defect, repointing to brickwork and stonework repairs is required. Where stones have fractured or shown large losses, they will need to be replaced in a new stone to match the original as near as possible.

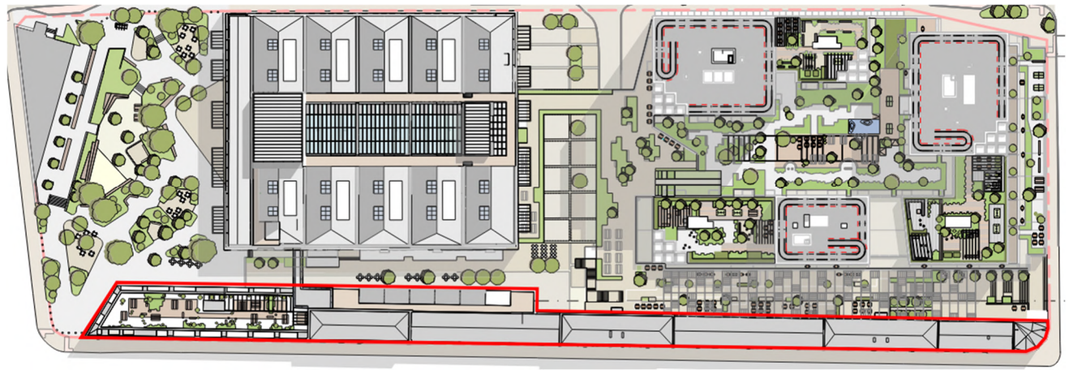
Repair is also required to prevent further water ingress and damp penetration. Overall condition of external elevations is generally good but roof repairs are required, particularly to slipped, displaced and broken tiles, at parapet interfaces, and to mortar joints to ridge tiles, although full roof covering replacement recommended.

Proposals to the terraces include:

Deansgate Terrace North: Demolition of the existing non-original structures added in the 1990's conversion. Part new build, part refurbishment of existing space to create new office studios space within the upper three levels, with part existing and part new build commercial retail space at ground floor with active frontages to Deansgate and Dean Street. Fabric repairs and refurbishment as recommended within conditions surveys.

Deansgate Terrace South: Light refurbishment of existing internal spaces to provide flexible commercial spaces within upper levels, in addition to community space and ground and first floor commercial retail spaces with active frontages to Deansgate and to Deansgate Mews. Fabric repairs and refurbishment as recommended within conditions surveys.

Figure 4-1 **– Overall Site Plan with the Deansgate Terraces highlighted in red**



4.1. BE LEAN: DEMAND REDUCTION

Deansgate Terrace Northern end is predominantly new build; however, it does include elements of Grade II Listed in two separate parts, No's 223-233, and No's 235-291. 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 building fabric of the proposed development is optimised to reduce heat loss in winter months and minimise heat gains in summer months. This will reduce the energy required to heat and cool the proposed development.

Deansgate Terrace Southern end will undergo refurbishment only.

4.1.1. DEANSGATE TERRACE NORTH BUILDING FABRIC

All new building fabric will be designed to exceed the limiting fabric requirements of Part L (2021) of the Building Regulations as applicable. It should be noted that it is not possible to upgrade the existing wall U value on the Deansgate Elevation due to the listed nature of this building and retention of heritage elements.

Table 4-1 sets out the U values used within zone 3A of the proposed development:

Table 4-1 - Building Fabric Zone 3A

FABRIC ASSUMPTIONS	U VALUES LIMIT	CURRENT PLANNED PERFORMANCE
Exposed Floor U-value (W/m²K)	0.18	0.15
Roof U-value (W/m²K)	0.18	0.15
Wall new build U-value (W/m²K)	0.26	0.2
Wall existing U value (W/m²K)	0.26	1.4*
New Glazing U-value (W/m²K)	1.6	1.4
New Glazing g-value	0.28	0.4
New Rooflight U-value (W/m²K)	2.2	1.7
New Rooflight g-value		0.4

***VAL**ue exceeds the limiting U value for the existing wall within the thermal modelling software as this is a listed building element.

4.1.2. DEANSGATE TERRACE SOUTH BUILDING FABRIC

As this building is listed there may not be much opportunity to improve the building fabric.

Table 4-2 - Building Fabric Zone 3B

FABRIC ASSUMPTIONS	U VALUES LIMIT	CURRENT PLANNED PERFORMANCE
Existing Exposed Floor U-value (w/m2K)	Listed building element	-
Existing Roof U-value(w/m2K)	Listed building element	-
Existing Wall U-value (w/m2K)	Listed building element	1.4
Existing Glazing U-value (restored) (w/m2K)	Listed building element	2.0
Existing Glazing g-value	Listed building element	-
Air permeability	Listed building element	10 $m^3/hr.m^2$@50pa

4.1.3. DEANSGATE TERRACE NORTH BUILDING SERVICES

Within the offices the following HVAC systems are proposed:

- All new office space shall be ventilated either by natural ventilation or mechanical ventilation with heat recovery, with the intention to use as much natural ventilation as possible, subject to window condition and room depth and dedicated mechanical extract to WCs and kitchenettes;
- The offices that are provided with mechanical ventilation will be provided with heating and cooling provision via VRF units which will be situated within a central roof plant compound. The VRF circuits will enable efficient simultaneous heating and cooling across the Terraces. The heating/ coolth will be delivered via the air using ceiling mounted FCUs;
- Electric heating panels to back of house areas, WCs and naturally ventilated office spaces;
- New point of use electric hot water generation to toilets and kitchenettes.

Performance Specification

The general design rationale and proposed specification for the MEP building services is set out in the table below:.

Table 4-3 - Proposed energy conservation measures

ELEMENT	DESIGN RATIONALE
Air Handling Plant	Ventilation is proposed to be through a dedicated supply and extract ventilation system. Outdoor intake and exhaust louvers will be formed at high level on the rear façade. The local units will achieve a specific fan power (SFP) of 0.8W/l/s or lower.
Energy Recovery	Where appropriate, MVHR systems will incorporate heat recovery systems. These transfer waste heat from the exhaust air stream to the supply air stream via a run around coil. The MVHR's will incorporate thermal wheels with a minimum heat recovery efficiency of 79%.
Space Heating	Space heating will be served by an ambient loop with an ASHP as the primary heat generator. The combined seasonal Coefficient of Performance (SCOP) of the ASHP will be 3.86 or higher.
Domestic Hot Water	DHW shall be produced by direct or storage electric heater with a seasonal efficiency of 1
Cooling Plant	Cooling will be provided from the ASHP with a minimum Seasonal energy efficiency ratio (SEER) of 5.00
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 throughout currently assumed with an efficiency of 110lum/watt. Lighting has been assumed with automatic on-off controls in offices/ reception/ toilets and lifts and stores are assumed to have lighting controls manual on- auto off.
Display Lighting	Display lighting can be a significant source of energy consumption in reception areas. High efficiency display lighting will be specified throughout to reduce the carbon emissions and cooling loads associated with display lighting provision. This will exceed Part L limiting values and the limits within the Part L notional building calculation. Display lighting lamp efficacy to target 110lm/W.

The measures above set out the first steps taken to reduce the energy reduction of Zone 3A of the Deansgate terraces through passive means.

4.1.4. DEANSGATE TERRACE SOUTH BUILDING SERVICES

Within the offices areas the following HVAC systems are proposed, this is predominantly a strip out and replace of the existing end of life services:

- All new office space shall be ventilated by natural ventilation with dedicated mechanical extract to WCs and kitchenettes only;

- Electric heating panels to all back of house areas, WCs and office spaces;
- New point of use electric hot water generation to toilets and kitchenettes.

4.2. BE CLEAN: SUPPLY ENERGY EFFICIENTLY

After consumption has been reduced through the application of energy efficiency measures, the next step is to consider heating infrastructure.

It is not planned to connect to the current Manchester Civic Quarter Heat Network (CQHN) as discussed in previous sections.

4.3. BE GREEN: USE RENEWABLE ENERGY

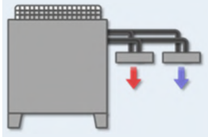
Renewable energy technologies can provide a source of energy on-site that is not primarily based on the consumption of fossil fuels or grid electricity and/or utilises a heat source that is renewable such as air source and solar photovoltaic systems.

No renewable technologies are proposed for use on Deansgate Terrace South as this is a listed building that will have limited interventions, with more suitable opportunities elsewhere within the development to incorporate renewable technologies.

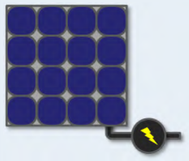
4.3.1. DEANSGATE TERRACE NORTH RENEWABLE TECHNOLOGIES

An evaluation of a number of renewable energy technologies has been undertaken in section 3.3.1. Table 4-4 sets out the renewable technologies proposed for the Deansgate Terrace Zone 3A of the development.

Table 4-4 - Renewable Technology Feasibility

TECHNOLOGY	PROS, CONS & FEASIBILITY
AIR SOURCE HEAT PUMPS (ASHPs) 	This technology uses electricity and is commonly installed in a range of development types to provide low-energy heating and cooling. ASHPs are capable of providing heating and/or cooling utilising air temperatures. The use of ASHPs are an effective Low and Zero Carbon (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. **Suitability to proposed development:** Incorporating an ASHP solution for the development of Deansgate Terrace North is an energy and carbon efficient technology that provides heating, cooling and hot water to the building, has a neutral impact on local air quality and is a long-term low carbon solution for the development.

FEASIBLE
FURTHER INVESTIGATION REQUIRED
UNFEASIBLE

PHOTOVOLTAICS 	Panels or sheets that can generate electricity directly from sunlight, which can be installed on the roofs or facades of buildings, or as a standalone ‘array’. Photovoltaics (PV) are arguably the most practical solution for onsite renewable generation in an urban environment. To maximise their effectiveness they do require roof space at a suitable orientation which is not overshadowed. **Suitability to proposed development:** An area on the roof of Deansgate terraces North has been identified which currently provides ideal conditions for the installation of roof mounted PV panels on the roof of the Great Northern Warehouse and Deansgate terraces north. The installation of PV is actively promoted by the council and will benefit the scheme; therefore, the installation of roof mounted PV is feasible and considered for the development.

The following renewable technologies have been deemed relevant for Deansgate Terraces North, new build element:

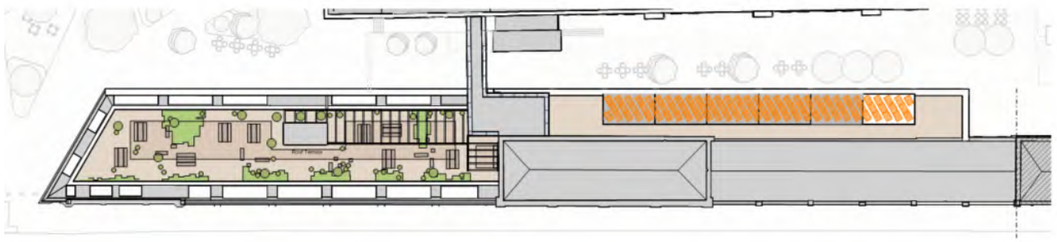
- Air Source Heat Pump (ASHP)
- Photovoltaic panels

The following table and image sets out the parameters for the PV considered on the roof of the Terrace Zone 3A:

Table 4-5 – PV parameters Terraces

PV parameter	Value
Area of PV	172m2
Orientation of PV from north	180 degrees
Inclination of PV	35 degrees
Shading factor (Terraces and Warehouse	1
Module nominal efficiency (Terraces)	21%
Output requirement (Terraces)	31,990kwh/annum
Electrical Conversion Efficiency	0.98

Figure 4-2 - Image showing PV locations of the roof of the Terraces



4.3.2. DEANSGATE TERRACES NORTH CARBON EMISSIONS (ZONE 3A/ PHASE A)

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 developmental phase

The Deansgate Terrace North is the new build area of the terraces and therefore is the only part of the terraces that requires a compliance check. This section has been modelled using the approved software IES (Integrated Environmental solutions) 2022 in order to generate a BRUKL.

This BRUKL demonstrates the compliance with Part L of the building regulations and is contained within appendix A.

Results are summarised below and visualised below:

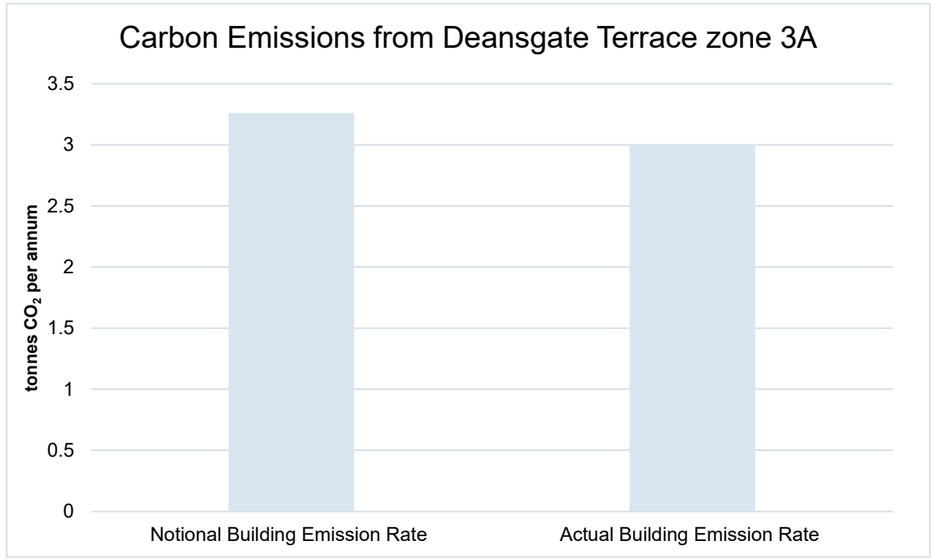
Table 4-6 - Be Green: Carbon emissions after providing renewable energy

	Carbon Dioxide Emissions for non-domestic buildings (tonnesCO_2 per annum)		% Reduction in regulated carbon emissions
	Building emission rate	Notional Building emission rate	
Compliance results	**3.02**	**3.26**	**7%**

A 7% reduction in emissions demonstrates compliance with building regulations and Manchester Planning policy at this stage.

These results are based upon the inputs shown in section 4. If these inputs require modification, the BRUKL will require reproducing.

Figure 4-3 - Carbon emissions from Deansgate Terrace Zone 3A



4.3.3. DEANSGATE TERRACE SOUTH CONSEQUENTIAL IMPROVEMENTS (ZONE 3B/ PHASE C)

As this is a listed building that is being refurbished, Zone 3B area of the Terrace falls under Approved Document Part L requirement for consequential improvements. Therefore, the building shall take measures to meet the requirements of Part L, where this is practical and technically, functionally, and economically feasible.

The intended interventions are listed below and will be confirmed at a later stage of design:

- Upgrading heating systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading cooling systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading air-handling systems that are more than 15 years old by providing new plant or improved controls;
- Upgrading general lighting systems that have an average lamp efficacy of less than 60 light source lumens per circuit-watt and that serve areas greater than 100m2 by providing new luminaires and/or controls;
- Installing energy metering following the guidance given in CIBSE's TM39;
- Installing energy metering following the guidance given in CIBSE's TM39;
- Replacing existing windows, roof windows or rooflights (but excluding display windows) or doors (but excluding high-usage entrance doors) that have a U-value higher than the following:

- For windows, roof windows and doors – 3.30W/ (m2 ·K);
- For rooflights – 3.80W/ (m2 ·K).

5. ZONE 4 LEISUREBOX (PHASE B):

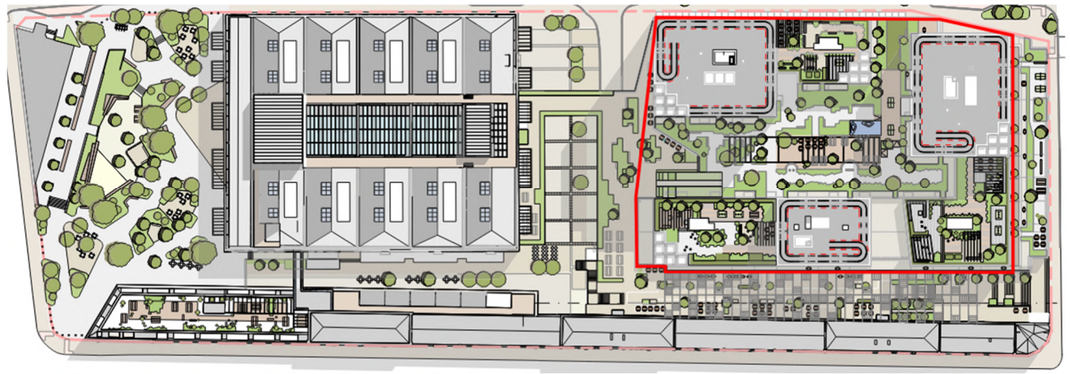
The plan for the Leisurebox is demolition of the upper section of the Leisurebox building, retaining and re-using the car park structure below, and the construction of new retail and residential uses above to provide 746 new homes within three buildings, designed to compliment the setting of the listed buildings and to respond to issues of microclimate and privacy/ amenity to nearby residential buildings.

Proposals include:

- Residents' Podium - A generous shared flexible and comfortable amenity space for the residential community. A space to dwell, to meet and relax. This space will promote a sense of shared ownership, and contribute to a livable, healthy residential neighbourhood.
- Residents' Terraces - High quality, tactile sheltered shared roof terraces providing far-reaching panoramas of the city.

These spaces will foster a sense of community and delight within each individual building.

Figure 5-1 - Leisurebox area



5.1. BE LEAN: DEMAND REDUCTION

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

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 building fabric of the proposed development is optimised to reduce heat loss in winter months and minimise heat gains in summer months. This will reduce the energy required to heat and cool the proposed development.

The building fabric will be designed to exceed the limiting fabric requirements of Part L (2021) of the Building Regulations as applicable.

5.1.1. LEISUREBOX BUILDING FABRIC

The Leisurebox residential area is newbuild so there is scope to reduce the energy consumption as far as possible through passive means.

Table 5-1 - Building Fabric for zone 4

FABRIC ASSUMPTIONS	U VALUES LIMIT	CURRENT PLANNED PERFORMANCE
Exposed Floor U-value (w/m2K)	0.18	0.13
Roof U-value (w/m2K)	0.16	0.11
Wall U-value (w/m2K)	0.26	0.17*
Balcony Walls (w/m2K)	0.26	0.26
Balcony door – glazed (w/m2K)	1.6	1.50
Balcony door g value		0.40
Glazing U-value (all glazing areas excluding purge vents) (w/m2K)	1.6	1.50
Glazing g-value		0.40
Air permeability	8	5

*This value is inclusive of repeating thermal bridging (precast brackets), however it does not include non-repeating thermal bridging (psi-values), such as window lintel/jamb/sill, party floor, balcony and so on. Default psi-values have been assumed for thermal bridging.

5.1.2. LEISUREBOX BUILDING SERVICES

The proposed HVAC strategy can be summarised as follows within the residential apartments within the Zone 4:

- Each apartment will be provided with a Mechanical Ventilation Heat Recovery (MVHR) unit. This will be in the utility cupboard within each apartment and ducted at ceiling void level. All the apartments have rapid vent openings that will satisfy the Building Regulations to purge ventilate the apartments;

- The apartment heating will be provided by electric panel heaters. All heaters will be complete with 7-day timers and temperature control and fed from the consumer unit located within the utility cupboard. Within the residential bathrooms, electric towel radiators shall be provided and fitted with temperature control complete with a 7-day timer.
- Domestic hot water shall be generated within each residential apartment via dedicated un-vented electric hot water heaters. Any common residential areas shall be provided with local electric hot water heaters.

5.2. OVERHEATING ANALYSIS

An overheating analysis has been undertaken for the Leisurebox area of the proposed development as it is mandatory to meet the requirements set out by Approved Document Building Regulations Part O.

The steps taken to reduce potential overheating and reliance on air conditioning systems is in accordance with the following cooling hierarchy.

1. Minimise internal heat generation through energy efficient design
2. Reduce the amount of heat entering a building in summer through orientation, shading, fenestration, insulation and green roofs and walls
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
4. Passive ventilation
5. Mechanical ventilation

Dynamic thermal models have been built in IES VE 2022 to verify the internal conditions of the residential elements of the development. All residential occupied spaces have been analysed against CIBSE TM59 and are compliant.

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

- Manchester_DSY1_2020High50 (a moderately warm summer).

5.2.1. CIBSE TM59 OVERHEATING CRITERIA

For the residential apartments, in line with TM59 requirements, the analysis is conducted not only to ensure comfort during the hottest daytime periods i.e., the first criterion defined in TM52, but to also ensure a sufficient comfort level during the night. The following criteria are specified by TM59 and any space failing one of the criteria can be considered overheating:

- Criteria (a): For living rooms, kitchens, and bedrooms: The number of hours during which Delta T is greater than or equal to one degree Kelvin during the period May to September inclusive shall not be more than 3% of occupied hours;
- Criteria (b): For bedroom comfort only: The operative temperature in the bedroom from 10pm to 7am shall not exceed 26°C for more than 1% of annual hours

5.3. APPROVED DOCUMENT PART O

In addition to the Part L Building Regulations the Government has introduced the Approved document Part O for Overheating. This document came into effect on 15th June 2022 for use in England. This document is still based upon CIBSE TM59 methodology, however some changes have been made in response to the limitations within TM59.

A summary of the main changes introduced by Part O are outlined below:

- The document sets out the standards for overheating in new residential buildings;
- Compliance with overheating criteria will become mandatory and evidence will need to be submitted to Building Control prior to project completion;
- The document introduces 2 requirements to be met:
  - Requirement O1 Overheating mitigation can be met using two methods: the simplified method (not suitable for buildings with more than one residential unit which use a communal heating or hot water system) or the dynamic thermal modelling. The second one (Dynamic thermal analysis method) is based on the TM59 methodology currently used to demonstrate compliance with planning. However, the new Approved Document sets out limits on CIBSE's TM59 methodology regarding ventilation opening hours and mitigating measures that shall be included to limit solar gains.
  - Requirement O1(2)(a) is met if the strategy is usable by occupants taking into account acoustic, air quality and security constraints. The guidance sets out a unique methodology for checking compliance with overheating while ensuring safety and reasonable enjoyment of occupants of their residence. Enhanced coordination is required with these disciplines to ensure compliance.
- Blinds cannot be used for the purposes of demonstrating compliance with Part O.
- Windows should be modelled as closed at night in all rooms at ground floor or easily accessible.
- Mechanical cooling is not prohibited by the requirements, but the building should be constructed to meet minimum requirements without this.
- The building control body should be provided with a report that demonstrates that the residential building passes CIBSE's TM59 assessment of overheating; and
- A Home User Guide shall be provided to the owners of new dwellings with a list of information and non-technical advice on how to keep the dwelling cool in hot weather.

The development will need to comply with Part O 2021 at the as built stage, the design has been future proofed to ensure compliance later.

5.4. OVERHEATING ANALYSIS - RESIDENTIAL

The passive design of the units has been considered in detail, and the orientation and massing has considered its position on the application site relative to other buildings which will provide an element of shading but also to maximise daylight opportunities as well as ensuring sufficient purge vent windows are provided to maximise air flow.

Internal layouts have also been refined to allow the daylighting requirements to be achieved without reliance on excessive amounts of glazing. Façade options have been studied to minimise heat loss

and undesirable solar gains, and to investigate the introduction of external shading measures which have not been required.

5.4.1. MODELLING ASSUMPTIONS

For the purposes of this analysis the following key assumptions have been made based on CIBSE TM59 guidance:

Occupancy and equipment gains

- Maximum sensible heat gain of 75W/person and a maximum latent heat gain of 55W/person are assumed in living spaces;
- Lighting energy is assumed at 2W/m2 from 6pm to 11pm;
- Gain profiles are as described on the table below.

Table 5-2 - Occupancy and equipment load assumptions as per as CIBSE TM59

UNIT/ROOM TYPE	OCCUPANCY	EQUIPMENT LOAD
Studio	2 people at all times	Peak load of 450W from 6pm to 8pm 200W from 8pm to 10pm 110W from 9am to 6pm and from 10pm to 12pm Base load of 85W for the rest of the day
1-bedroom apartment Kitchen/Living/Dining	1 person from 9am to 10pm; room is unoccupied for the rest of the day	Peak load of 450W from 6pm to 8pm 200W from 8pm to 10pm 110W from 9am to 6pm and from 10pm to 12pm Base load of 85W for the rest of the day
2-bedroom apartment Kitchen/Living/Dining	2 people from 9am to 10pm; room is unoccupied for the rest of the day	Peak load of 450W from 6pm to 8pm 200W from 8pm to 10pm 110W from 9am to 6pm and from 10pm to 12pm Base load of 85W for the rest of the day
3-bedroom apartment Kitchen/Living/Dining	3 people from 9am to 10pm; room is unoccupied for the rest of the day	Peak load of 450W from 6pm to 8pm 200W from 8pm to 10pm 110W from 9am to 6pm and from 10pm to 12pm Base load of 85W for the rest of the day
3-bedroom apartment Kitchen/Living/Dining	3 people at 25% gains from 9am to 10pm; room is unoccupied for the rest of the day	Peak load of 300W from 6pm to 8pm Base load of 50W for the rest of the day
3-bedroom apartment Living Room	3 people at 75% gains from 9am to 10pm; room is unoccupied for the rest of the day	Peak load of 150W from 6pm to 8pm 60W from 9am to 6pm and from 10pm to 12pm Base load of 35W for the rest of the day
Double bedroom	2 people at 70% gains from 11pm to 8am 2 people at full gains from 8am to 9am and from 10pm to 11pm 1 person at full gains from 9am to 10pm	Peak load of 80W from 8am to 11pm Base load of 10W during sleeping hours
Single bedroom (too small to accommodate double bed)	1 person at 70% gains from 11pm to 8am 1 person at full gains from 8 am to 11pm	Peak load of 80W from 8am to 11pm Base load of 10W during sleeping hours

The TM59 assumptions above are stringent and worst-case scenario and assume full occupation during the day in all apartments. This is to account for vulnerable people such as children and the elderly and for people on shift work who may remain in their residences during the day.

The scheme is compliant with CIBSE TM59, the results of the TM59 analysis can be found in the appendix.

5.4.2. VENTILATION

- The primary means of reducing overheating risk is to open purge panels. Purge panels are to have 50% openable area. For this analysis, purge panels have been modelled as a grille on a semi exposed wall of a high-rise building. Occupants are considered to start opening windows when the internal temperature exceeds 22°C, with windows fully open when internal temperature reaches

26°C, in line with Part O. All doors with access to the balcony have been assessed with 90% openable area;
- MVHR is assumed to operate continuously in residential rooms as per to meet minimum fresh air requirements.

5.4.3. OVERHEATING IN CORRIDORS

CIBSE TM59 states that at least one corridor should be included in the overheating analysis if the corridors contain communal heating distribution pipework. The overheating test for corridors should be based on the number of annual hours for which an operative temperature of 28°C is exceeded, rather than 26°C for bedrooms. If the operative temperature exceeds 28°C for more than 3% of the total annual hours, there is a significant overheating risk.

This calculation has not been undertaken due to the services strategy of localised electric panel heaters in the apartments, as such there is no distribution pipework within corridors and risers.

5.5. BE CLEAN: SUPPLY ENERGY EFFICIENTLY

After consumption has been reduced through the application of energy efficiency measures, the next step is to consider heating infrastructure.

It is not planned to connect to the current Manchester Civic Quarter Heat Network (CQHN) as discussed in previous sections.

5.6. BE GREEN: USE RENEWABLE ENERGY

No renewable technologies have been proposed within the Leisurebox area as more suitable opportunities are available elsewhere within the proposed development and a significant reduction in operational carbon has been achieved through passive design measures.

There is also limited roof space for PV provision and the introduction of ASHPs for heating/ DHW provision for the residential units is not considered economically viable.

Electricity is decarbonising at a rapid rate as shown via the carbon factors since 2013 within the table below. Electric heaters are proposed for the Leisurebox and due to the reductions in carbon factors, electric heating is now the favourable option for new residential developments.

Table 5-3 - SAP carbon factors

FUEL TYPE	PART L 2013 ($KG.CO_2/KWH$)	SAP10.0 ($KG.CO_2/KWH$)	SAP10.2 ($KG.CO_2/KWH$)
Grid Supplied Electricity	0.519	0.233	0.136
Natural Gas	0.216	0.210	0.210

5.7. RESULTS: LEISUREBOX CARBON EMISSIONS

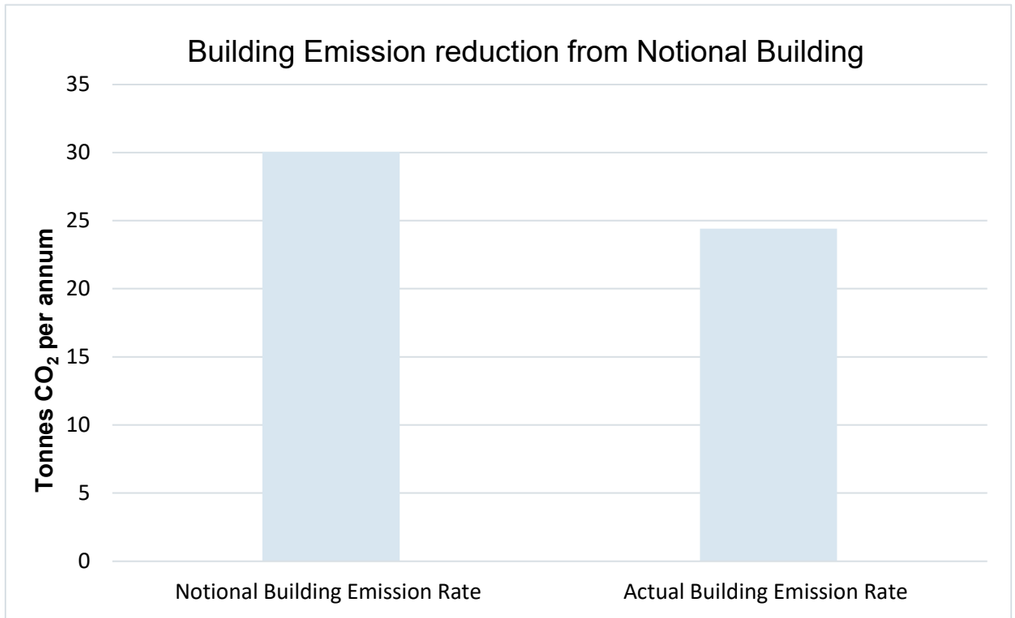
The regulated carbon emissions for the residential spaces were determined using Accredited Design SAP 10 software.

The table below summarise the total baseline carbon emissions and the carbon emissions after the application of energy efficiency measures since there are no low and zero carbon technologies currently planned for the Leisurebox area of the development.

Table 5-4 – Leisurebox Carbon Emissions

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO_2 per annum)		% Reduction in regulated carbon emissions
	Building emission rate	Notional Building emission rate	
Compliance results	25.42	30.06	15%

Figure 5-2 - Leisurebox carbon emissions reduction



6.

6. BE SEEN

The ‘Seen’ aspect of the Lean, Clean, Green and Seen approach to an energy strategy recognises that in the past various measures were described and adopted in the project proposals, but the reality of actual energy consumption and carbon savings was often worse than predicted.

When buildings were occasionally assessed to compare real life consumption with predicted consumption the reality was often far from the original intentions for a wide variety of reasons.

This was described in energy management circles as a ‘performance gap’.

Common sense is clearly to monitor the actual results against the targets derived from the design.

The ‘Be Seen’ aspect now formalises this process and requires an obligation for monitoring, targeting and reporting monthly figures for a minimum of 5 years.

There is a full commitment to meeting this obligation and enthusiasm and confidence that the design targets can be achieved in practice. A suitable Building Energy Management System (BEMS) will be applied in order to monitor energy use via sub meters. Where there are discrepancies, the reasons behind the discrepancies will be established and corrective action taken.

7. CONCLUSION

This section summarises the compliance results for new build elements of the development as well as the approach being taken on zones undergoing refurbishment.

The table below gives a high-level overview of the scheme and relevant regulations.

Zone	Relevant Regulations	New Build/Refurbishment
Great Northern Warehouse (Zone 2)	Approved Document L, Conservation of fuel and power, Volume 2: Buildings other than dwellings	Refurbishment
Deansgate Terrace (Zone 3A and 3B)	Approved Document L, Conservation of fuel and power, Volume 2: Buildings other than dwellings	New build element and refurbishment
Leisurebox (Zone 4)	Approved Document L, Conservation of fuel and power, Volume 1: Dwellings	New build

The project includes extensive refurbishment activity for both the Great Northern Warehouse and Deansgate Terrace.

The table below summarises the measures which are included within the scheme, in line with Table D1 of Approved Document L, Conservation of fuel and power, Volume 2: Buildings other than dwellings, which summarises energy efficiency measures which are typically considered technically, functionally and economically feasible in normal circumstances.

Improvement Measure	Great Northern Warehouse (Zone 2)	Deansgate Terrace (Zone 3A and 3B)
Upgrading heating systems	Included	Included
Upgrading cooling systems	Included	Included
Upgrading air-handling systems	Included	Included
Upgrading lighting systems	Included	Included
Installing energy metering	Included	Included
Upgrading thermal elements	Where considerate to heritage	Where considerate to heritage
Replacing windows or doors	Where considerate to heritage	Where considerate to heritage
Installing LZC energy generation	Included	Included

ZONE 2 GREAT NORTHERN WAREHOUSE (PHASE A)

As the Great Northern Warehouse is a Graded II* Listed building being refurbished, it falls under Approved Document Part L requirement for consequential improvements.

ZONE 3A AND 3B DEANSGATE TERRACE (PHASE A & C)

The Deansgate terrace Zone 3A is the new build area of the terraces.

This building is compliant with Part L of the building regulations and Manchester Planning Policy as per table below.

Table 6-1 – Deansgate Terrace (Zone 3a/ Phase A) Carbon Emissions Results

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO_2 per annum)		% Reduction in regulated carbon emissions
	Building emission rate	Notional Building emission rate	
Compliance results	**3.02**	**3.26**	**7%**

The Deansgate terrace Zone 3B is being refurbished, it falls under Approved Document Part L requirement for consequential improvements.

ZONE 4 LEISUREBOX (PHASE B)

This building is compliant with Part L of the Building Regulations and Manchester Planning Policy as per table below.

Table 6-2 – Leisurebox (Zone 4/ Phase B) Carbon Emissions Results

	Carbon Dioxide Emissions for non-domestic buildings (Tonnes CO_2 per annum)		% Reduction in regulated carbon emissions
	Building emission rate	Notional Building emission rate	
Compliance results	**25.42**	**30.06**	**15%**

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Appendix A

BRUKL 'BE GREEN TERRACES

PUBLIC

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

GreatNorthern_terraces_Rev01

As designed

Date: Wed Oct 26 13:35:10 2022

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.15

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.15

BRUKL compliance check version: v6.1.b.0

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m²]: 123.06

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	3.26	
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	3.02	
Target primary energy rate (TPER), kWh/m^2.annum	34.39	
Building primary energy rate (BPER), kWh/m^2.annum	30.26	
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	0.6	1.4	00000002:Surf[1]
Floors	0.18	0.15	0.15	00000002:Surf[3]
Pitched roofs	0.16	-	-	No Pitched roofs in building
Flat roofs	0.18	0.15	0.15	02000000:Surf[2]
Windows** and roof windows	1.6	1.4	1.4	00000002:Surf[4]
Rooflights***	2.2	1.7	1.7	02000000:Surf[0]
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)]

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

$U_{i\text{-Calc}}$ = Calculated maximum individual element 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.

N.B.: 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- GN VRF + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.86	5	0	-	0.79
Standard value	2.5*	5	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.					

2- GN Elec Heating

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0.45	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

"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
00.01.06 - Entrance	-	-	-	-	-	0.8	-	-	-	-	N/A
01.01.04 - Office 2	-	-	-	-	-	0.8	-	-	-	-	N/A
01.01.05 - Office 3	-	-	-	-	-	0.8	-	-	-	-	N/A
01.01.06 - Office 4	-	-	-	-	-	0.8	-	-	-	-	N/A
01.01.07 - Office 5	-	-	-	-	-	0.8	-	-	-	-	N/A
01.01.08 - Office 6	-	-	-	-	-	0.8	-	-	-	-	N/A
02.01.05 - Office 1	-	-	-	-	-	0.8	-	-	-	-	N/A
02.01.06 - Office 2	-	-	-	-	-	0.8	-	-	-	-	N/A
02.01.07 - Office 3	-	-	-	-	-	0.8	-	-	-	-	N/A
02.01.08 - Office 4	-	-	-	-	-	0.8	-	-	-	-	N/A
02.01.09 - Office 5	-	-	-	-	-	0.8	-	-	-	-	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
02.01.10 - Office 6	-	-	-	-	-	0.8	-	-	-	-	N/A
01.01.03 - space for wcs	-	-	0.4	-	-	-	-	-	-	-	N/A
01.01.03 - Office 1	-	-	-	-	-	0.8	-	-	-	-	N/A
Toilets	-	-	0.4	-	-	-	-	-	-	-	N/A
00.02.14 - Office entrance	-	-	-	-	-	0.8	-	-	-	-	N/A
00.02.14 - Office entrance	-	-	-	-	-	0.8	-	-	-	-	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
00.01.05 - Circulation	110	-	-
00.01.06 - Entrance	110	-	-
00.01.05 - Circulation	110	-	-
01.01.04 - Office 2	110	-	-
01.01.05 - Office 3	110	-	-
01.01.06 - Office 4	110	-	-
01.01.07 - Office 5	110	-	-
01.01.08 - Office 6	110	-	-
00.01.05 - Circulation	110	-	-
01.02.11 - Office 10	110	-	-
01.02.12 - Office 11	110	-	-
01.02.13 - Office 12	110	-	-
01.02.14 - Office 13	110	-	-
01.02.15 - Office 14	110	-	-
01.02.16 - Office 15	110	-	-
00.01.05 - Circulation	110	-	-
01.02.17 - Office 16	110	-	-
00.01.05 - Circulation	110	-	-
02.01.05 - Office 1	110	-	-
02.01.06 - Office 2	110	-	-
02.01.07 - Office 3	110	-	-
02.01.08 - Office 4	110	-	-
02.01.09 - Office 5	110	-	-
02.01.10 - Office 6	110	-	-
00.01.05 - Circulation	110	-	-
02.02.10 - Office 9	110	-	-
02.02.11 - Office 10	110	-	-
02.02.12 - Office 11	110	-	-
02.02.13 - Office 12	110	-	-
02.02.14 - Office 13	110	-	-
02.02.15 - Office 14	110	-	-
02.02.16 - Office 15	110	-	-
00.01.05 - Circulation	110	-	-

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
00.01.05 - Circulation	110	-	-
00.01.05 - Circulation	110	-	-
00.01.05 - Circulation	110	-	-
01.01.03 - space for wcs	110	-	-
01.01.03 - Office 1	110	-	-
00.01.05 - Circulation	110	-	-
00.01.05 - Circulation	110	-	-
00.01.05 - Circulation	110	-	-
00.01.05 - Circulation	110	-	-
Toilets	110	-	-
00.02.14 - Office entrance	110	-	-
00.02.12 - Bin Store	110	-	-
00.01.05 - Circulation	110	-	-
00.02.14 - Office entrance	110	-	-

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?
00.01.06 - Entrance	YES (+95.5%)	NO
01.01.04 - Office 2	NO (-13.5%)	NO
01.01.05 - Office 3	YES (+26.3%)	NO
01.01.06 - Office 4	YES (+50%)	NO
01.01.07 - Office 5	YES (+64.5%)	NO
01.01.08 - Office 6	NO (-24.6%)	NO
01.02.11 - Office 10	NO (-40.4%)	NO
01.02.12 - Office 11	NO (-52.7%)	NO
01.02.13 - Office 12	NO (-55.2%)	NO
01.02.14 - Office 13	NO (-56.2%)	NO
01.02.15 - Office 14	NO (-56.3%)	NO
01.02.16 - Office 15	NO (-56.6%)	NO
01.02.17 - Office 16	NO (-59.6%)	NO
02.01.05 - Office 1	YES (+17.8%)	NO
02.01.06 - Office 2	YES (+41.7%)	NO
02.01.07 - Office 3	NO (-7.5%)	NO
02.01.08 - Office 4	YES (+101.7%)	NO
02.01.09 - Office 5	YES (+112.9%)	NO
02.01.10 - Office 6	YES (+20.7%)	NO
02.02.10 - Office 9	NO (-18.3%)	NO
02.02.11 - Office 10	NO (-34.1%)	NO
02.02.12 - Office 11	NO (-36.7%)	NO
02.02.13 - Office 12	NO (-37.8%)	NO
02.02.14 - Office 13	NO (-38.7%)	NO
02.02.15 - Office 14	NO (-39.7%)	NO
02.02.16 - Office 15	NO (-44.1%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
01.01.03 - Office 1	NO (-44.5%)	NO
00.02.14 - Office entrance	NO (-52.5%)	NO
00.02.14 - Office entrance	NO (-55.2%)	NO

Regulation 25A: Consideration of high efficiency alternative energy systems

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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	2731.9	2731.9
External area [m²]	3666.1	3782.2
Weather	MAN	MAN
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	2255.8	1338.96
Average U-value [W/m²K]	0.62	0.35
Alpha value* [%]	23.2	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
100	**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
	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/m²]

	Actual	Notional
Heating	20.64	11.34
Cooling	1.19	1.25
Auxiliary	1.88	1.09
Lighting	6.07	8.37
Hot water	1.75	1.66
Equipment*	28.13	28.13
TOTAL**	**31.53**	**23.7**

* 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/m²]

	Actual	Notional
Photovoltaic systems	11.71	0.79
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*11.71*	*0.79*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	126.58	94.22
Primary energy [kWh/m²]	30.26	34.39
Total emissions [kg/m²]	3.02	3.26

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] Other local room heater - unfanned, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity										
	Actual	357.1	0	99.2	0	1.6	1	0	1	0
	Notional	240.2	0	47.3	0	1.6	1.41	0	----	----
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	107.4	34.9	7.9	2.6	3	3.79	3.74	3.86	5
	Notional	70.2	45.3	7	2.7	1.3	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

SAP CALCULATION EXAMPLE

PUBLIC

Full SAP Calculation Printout

Property Reference	Leisurebox Residential Rev 2	Issued on Date	08/11/2022
Assessment Reference	1Bed Mid Terrace Exposed Floor	Prop Type Ref	
Property			

SAP Rating	50 E	DER	14.38	TER	16.40
Environmental	90 B	% DER<TER	12.32		
CO_2 Emissions (t/year)	0.69	DFEE	62.96	TFEE	35.95
Compliance Check	See BREL	% DFEE < TFEE	-75.14		
% DPER < TPER	-65.80	DPER	150.53	TPER	90.79

Assessor Details	Ms. Charlotte Hodgson	Assessor ID	Y529-0001
Client	Trilogy Real Estate LLP		

SAP 10 WORKSHEET FOR New Build (As Designed) (Version 10.2, February 2022)
CALCULATION OF DWELLING EMISSIONS FOR REGULATIONS COMPLIANCE

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1. Overall dwelling characteristics

			Area (m2)		Storey height (m)		Volume (m3)	
Ground floor			53.7500 (1b)	x	3.0000 (2b)	=	161.2500 (1b)	-
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)		53.7500						(4)
Dwelling volume					(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	161.2500	(5)

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2. Ventilation rate

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		m3 per hour	
Number of open chimneys	0 * 80 =	0.0000	(6a)
Number of open flues	0 * 20 =	0.0000	(6b)
Number of chimneys / flues attached to closed fire	0 * 10 =	0.0000	(6c)
Number of flues attached to solid fuel boiler	0 * 20 =	0.0000	(6d)
Number of flues attached to other heater	0 * 35 =	0.0000	(6e)
Number of blocked chimneys	0 * 20 =	0.0000	(6f)
Number of intermittent extract fans	0 * 10 =	0.0000	(7a)
Number of passive vents	0 * 10 =	0.0000	(7b)
Number of flueless gas fires	0 * 40 =	0.0000	(7c)
		Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(6c)+(6d)+(6e)+(6f)+(6g)+(7a)+(7b)+(7c) =	0.0000 / (5) =	0.0000	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.2500	(18)
Number of sides sheltered		3	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.7750	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.1938	(21)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wind speed	5.1000	5.0000	4.9000	4.4000	4.3000	3.8000	3.8000	3.7000	4.0000	4.3000	4.5000	4.7000	(22)
Wind factor	1.2750	1.2500	1.2250	1.1000	1.0750	0.9500	0.9500	0.9250	1.0000	1.0750	1.1250	1.1750	(22a)
Adj infilt rate	0.2470	0.2422	0.2373	0.2131	0.2083	0.1841	0.1841	0.1792	0.1938	0.2083	0.2180	0.2277	(22b)

Balanced mechanical ventilation with heat recovery

If mechanical ventilation	0.5000 (23a)
If exhaust air heat pump using Appendix N, (23b) = (23a) x Fmv (equation (N5)), otherwise (23b) = (23a)	0.5000 (23b)
If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) =	74.4000 (23c)

Effective ac	0.3750	0.3702	0.3653	0.3411	0.3363	0.3121	0.3121	0.3072	0.3217	0.3363	0.3460	0.3557	(25)

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3. Heat losses and heat loss parameter

Element	Gross m2	Openings m2	NetArea m2	U-value W/m2K	A x U W/K	K-value kJ/m2K	A x K kJ/K	
Window (Uw = 1.50)			5.3100	1.4151	7.5142			(27)
Rapid Vent			3.5400	1.5000	5.3100			(26a)
Heatloss Floor 1			53.7500	0.2000	10.7500			(28b)

External Wall 1	24.4500	8.8500	15.6000	0.1700	2.6520	0.0000	0.0000 (29a)
Total net area of external elements Aum(A, m2)			78.2000				(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		26.2262		(33)
Party Wall 1			56.5200	0.0000	0.0000	180.0000	10173.6001 (32)
Party Ceiling 1			53.7500			0.0000	0.0000 (32b)
Internal Partitions			42.3600			9.0000	381.2400 (32c)
Corridor Wall			12.3600			75.0000	927.0000 (32c)

Heat capacity Cm = Sum(A x k)	(28)...(30) + (32) + (32a)...(32e) = 11481.8401 (34)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K	213.6156 (35)

List of Thermal Bridges

	Length	Psi-value	Total
K1 Element			
E2 Other lintels (including other steel lintels)	3.9500	1.0000	3.9500
E3 Sill	3.9500	0.1000	0.3950
E4 Jamb	17.9200	0.1000	1.7920
E4 Jamb	17.9200	0.1000	1.7920
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.2800	3.4440
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.2800	3.4440
E18 Party wall between dwellings	3.0000	0.2400	0.7200
E18 Party wall between dwellings	3.0000	0.2400	0.7200
P3 Party wall - Intermediate floor between dwellings (in blocks of flats)	18.8400	0.0000	0.0000
E5 Ground floor (normal)	8.1500	0.3200	2.6080
P1 Party wall - Ground floor	18.8400	0.3200	6.0288
E16 Corner (normal)	3.0000	0.1800	0.5400
E16 Corner (normal)	3.0000	0.1800	0.5400
E25 Staggered party wall between dwellings	3.0000	0.2400	0.7200
E25 Staggered party wall between dwellings	3.0000	0.2400	0.7200

Thermal bridges (Sum(L x Psi) calculated using Appendix K)	27.4138 (36)
Point Thermal bridges	(36a) = 0.0000
Total fabric heat loss	(33) + (36) + (36a) = 53.6400 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 x (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m	19.9564	19.6986	19.4409	18.1521	17.8944	16.6056	16.6056	16.3479	17.1211	17.8944	18.4099	18.9254	(38)
Heat transfer coeff	73.5963	73.3386	73.0808	71.7921	71.5343	70.2456	70.2456	69.9878	70.7611	71.5343	72.0498	72.5653	(39)
Average = Sum(39)m / 12 =												71.7276	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.3692	1.3644	1.3596	1.3357	1.3309	1.3069	1.3069	1.3021	1.3165	1.3309	1.3405	1.3501	(40)
HLP (average)												1.3345	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

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4. Water heating energy requirements (kWh/year)

Assumed occupancy												1.8006 (42)
Hot water usage for mixer showers	81.6157	80.3892	78.6019	75.1823	72.6586	69.8443	68.2447	70.0184	71.9628	74.9845	78.4776	81.3030 (42a)
Hot water usage for baths	24.7595	24.3918	23.8740	22.9192	22.2043	21.4116	20.9834	21.4976	22.0574	22.9057	23.8801	24.6758 (42b)
Hot water usage for other uses	34.8110	33.5451	32.2793	31.0134	29.7476	28.4817	28.4817	29.7476	31.0134	32.2793	33.5451	34.8110 (42c)
Average daily hot water use (litres/day)												129.8493 (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	141.1862	138.3261	134.7552	129.1149	124.6105	119.7376	117.7098	121.2636	125.0337	130.1695	135.9029	140.7898	(44)
Energy conte	223.6045	196.9746	207.1137	176.7518	167.7497	147.2314	142.3598	150.1496	154.1790	176.6388	193.6186	220.4428	(45)
Energy content (annual)										Total = Sum(45)m =		2156.8142	
Distribution loss (46)m = 0.15 x (45)m	33.5407	29.5462	31.0671	26.5128	25.1625	22.0847	21.3540	22.5224	23.1269	26.4958	29.0428	33.0664	(46)
Water storage loss:													
Store volume												162.0000	(47)
a) If manufacturer declared loss factor is known (kWh/day):												1.0000	(48)
Temperature factor from Table 2b												0.6000	(49)
Enter (49) or (54) in (55)												0.6000	(55)
Total storage loss	18.6000	16.8000	18.6000	18.0000	18.6000	18.0000	18.6000	18.6000	18.0000	18.6000	18.0000	18.6000	(56)
If cylinder contains dedicated solar storage	18.6000	16.8000	18.6000	18.0000	18.6000	18.0000	18.6000	18.6000	18.0000	18.6000	18.0000	18.6000	(57)
Primary loss	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(59)
Combi loss	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(61)
Total heat required for water heating calculated for each month	242.2045	213.7746	225.7137	194.7518	186.3497	165.2314	160.9598	168.7496	172.1790	195.2388	211.6186	239.0428	(62)
WWHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63a)
PV diverter	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63b)
Solar input	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63c)
FGHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63d)
Output from w/h	242.2045	213.7746	225.7137	194.7518	186.3497	165.2314	160.9598	168.7496	172.1790	195.2388	211.6186	239.0428	(64)
										Total per year (kWh/year) = Sum(64)m =		2375.8142	(64)
12Total per year (kWh/year)												2376	(64)
Electric shower(s)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(64a)
										Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m =		0.0000	(64a)
Heat gains from water heating, kWh/month	89.2285	78.9340	83.7453	73.1700	70.6568	63.3544	62.2146	64.8048	65.6645	73.6124	78.7782	88.1772	(65)

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5. Internal gains (see Table 5 and 5a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5), Watts													
(66)m	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	91.6504	101.4700	91.6504	94.7054	91.6504	94.7054	91.6504	91.6504	94.7054	91.6504	94.7054	91.6504	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	156.9586	158.5874	154.4830	145.7453	134.7155	124.3490	117.4236	115.7948	119.8992	128.6369	139.6667	150.0332	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	(69)
Pumps, fans	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(70)
Losses e.g. evaporation (negative values) (Table 5)													
	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	(71)
Water heating gains (Table 5)													
	119.9308	117.4614	112.5609	101.6250	94.9688	87.9923	83.6218	87.1032	91.2007	98.9414	109.4141	118.5178	(72)
Total internal gains													
	418.5495	427.5285	408.7040	392.0854	371.3443	357.0564	342.7055	344.5581	355.8150	369.2384	393.7960	410.2111	(73)

6. Solar gains

[Jan]	Area m2	Solar flux Table 6a W/m2	g Specific data or Table 6b	FF Specific data or Table 6c	Access factor Table 6d	Gains W	
West	5.3100	19.6403	0.4000	0.0000	0.7700	32.1213	(80)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	32.1213	62.8360	103.4819	150.9222	184.9609	189.3404	180.2597	154.8404	120.3538	74.5602	40.0514	26.4150	(83)
Total gains	450.6707	490.3645	512.1859	543.0076	556.3052	546.3967	522.9652	499.3985	476.1688	443.7986	433.8474	436.6260	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (C)	21.0000	(85)

Utilisation factor for gains for living area, ni1,m (see Table 9a)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	43.3364	43.4887	43.6421	44.4255	44.5856	45.4036	45.4036	45.5708	45.0728	44.5856	44.2666	43.9521	
alpha	3.8891	3.8992	3.9095	3.9617	3.9724	4.0269	4.0269	4.0381	4.0049	3.9724	3.9511	3.9301	
util living area	0.9871	0.9807	0.9690	0.9354	0.8634	0.7164	0.5597	0.6010	0.8101	0.9439	0.9789	0.9886	(86)
MIT	19.3090	19.4895	19.7829	20.2170	20.5981	20.8731	20.9643	20.9523	20.7766	20.2937	19.7491	19.2955	(87)
Th 2	19.7870	19.7907	19.7944	19.8130	19.8167	19.8354	19.8354	19.8392	19.8279	19.8167	19.8093	19.8018	(88)
util rest of house	0.9834	0.9752	0.9596	0.9143	0.8156	0.6213	0.4259	0.4685	0.7312	0.9211	0.9718	0.9853	(89)
MIT 2	18.2849	18.4658	18.7572	19.1900	19.5410	19.7737	19.8255	19.8245	19.7034	19.2724	18.7378	18.2825	(90)
Living area fraction									fLA = Living area / (4) =			0.5181	(91)
MIT	18.8155	18.9962	19.2887	19.7221	20.0887	20.3433	20.4155	20.4089	20.2595	19.8016	19.2618	18.8074	(92)
Temperature adjustment												0.3000	
adjusted MIT	19.1155	19.2962	19.5887	20.0221	20.3887	20.6433	20.7155	20.7089	20.5595	20.1016	19.5618	19.1074	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9809	0.9724	0.9576	0.9185	0.8406	0.6897	0.5289	0.5700	0.7835	0.9275	0.9700	0.9829	(94)
Useful gains	442.0454	476.8472	490.4770	498.7660	467.6236	376.8419	276.5798	284.6533	373.0775	411.6056	420.8271	429.1778	(95)
Ext temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000	(96)
Heat loss rate W	1090.3689	1055.7970	956.5294	798.4790	621.5430	424.5181	289.0983	301.5688	457.0799	679.6897	897.8692	1081.7591	(97)
Space heating kWh	482.3527	389.0542	346.7430	215.7934	114.5161	0.0000	0.0000	0.0000	0.0000	199.4546	343.4703	485.5205	(98a)
Space heating requirement - total per year (kWh/year)												2576.9048	
Solar heating kWh	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(98b)
Solar heating contribution - total per year (kWh/year)												0.0000	
Space heating kWh	482.3527	389.0542	346.7430	215.7934	114.5161	0.0000	0.0000	0.0000	0.0000	199.4546	343.4703	485.5205	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												2576.9048	
Space heating per m2										(98c) / (4) =		47.9424	(99)

9a. Energy requirements - Individual heating systems, including micro-CHP

Fraction of space heat from secondary/supplementary system (Table 11)	0.0000 (201)
Fraction of space heat from main system(s)	1.0000 (202)
Efficiency of main space heating system 1 (in %)	100.0000 (206)
Efficiency of main space heating system 2 (in %)	0.0000 (207)
Efficiency of secondary/supplementary heating system, %	0.0000 (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating requirement	482.3527	389.0542	346.7430	215.7934	114.5161	0.0000	0.0000	0.0000	0.0000	199.4546	343.4703	485.5205	(98)

Space heating efficiency (main heating system 1)
100.0000 100.0000 100.0000 100.0000 0.0000 0.0000 0.0000 0.0000 100.0000 100.0000 100.0000 (210)
Space heating fuel (main heating system)
482.3527 389.0542 346.7430 215.7934 114.5161 0.0000 0.0000 0.0000 0.0000 199.4546 343.4703 485.5205 (211)
Space heating efficiency (main heating system 2)
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (212)
Space heating fuel (main heating system 2)
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (213)
Space heating fuel (secondary)
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (215)

Water heating
Water heating requirement
242.2045 213.7746 225.7137 194.7518 186.3497 165.2314 160.9598 168.7496 172.1790 195.2388 211.6186 239.0428 (64)
Efficiency of water heater 100.0000 (216)
(217)m 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 100.0000 (217)
Fuel for water heating, kWh/month
242.2045 213.7746 225.7137 194.7518 186.3497 165.2314 160.9598 168.7496 172.1790 195.2388 211.6186 239.0428 (219)
Space cooling fuel requirement
(221)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (221)
Pumps and Fa 8.8887 8.0285 8.8887 8.6020 8.8887 8.6020 8.8887 8.8887 8.6020 8.8887 8.6020 8.8887 (231)
Lighting 21.3793 17.1513 15.4429 11.3141 8.7393 7.1401 7.9723 10.3627 13.4601 17.6604 19.9474 21.9735 (232)
Electricity generated by PVs (Appendix M) (negative quantity)
(233a)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (233a)
Electricity generated by wind turbines (Appendix M) (negative quantity)
(234a)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (234a)
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)
(235a)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (235a)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)
(235c)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (235c)
Electricity generated by PVs (Appendix M) (negative quantity)
(233b)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (233b)
Electricity generated by wind turbines (Appendix M) (negative quantity)
(234b)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (234b)
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)
(235b)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (235b)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)
(235d)m 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (235d)
Annual totals kWh/year
Space heating fuel - main system 1 2576.9048 (211)
Space heating fuel - main system 2 0.0000 (213)
Space heating fuel - secondary 0.0000 (215)
Efficiency of water heater 100.0000
Water heating fuel used 2375.8142 (219)
Space cooling fuel 0.0000 (221)

Electricity for pumps and fans:
(BalancedWithHeatRecovery, DataSheet: in-use factor = 1.4000, SFP = 0.5320)
mechanical ventilation fans (SFP = 0.5320) 104.6577 (230a)
Total electricity for the above, kWh/year 104.6577 (231)
Electricity for lighting (calculated in Appendix L) 172.5436 (232)

Energy saving/generation technologies (Appendices M ,N and Q)
PV generation 0.0000 (233)
Wind generation 0.0000 (234)
Hydro-electric generation (Appendix N) 0.0000 (235a)
Electricity generated - Micro CHP (Appendix N) 0.0000 (235)
Appendix Q - special features
Energy saved or generated -0.0000 (236)
Energy used 0.0000 (237)
Total delivered energy for all uses 5229.9202 (238)

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP

	Energy kWh/year	Emission factor kg CO2/kWh	Emissions kg CO2/year	
Space heating - main system 1	2576.9048	0.1545	398.0281	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	2375.8142	0.1413	335.7361	(264)
Space and water heating			733.7642	(265)
Pumps, fans and electric keep-hot	104.6577	0.1387	14.5173	(267)
Energy for lighting	172.5436	0.1443	24.9034	(268)
Total CO2, kg/year			773.1849	(272)
Dwelling Carbon Dioxide Emission Rate (DER)			14.3800	(273)

13a. Primary energy - Individual heating systems including micro-CHP

	Energy kWh/year	Primary energy factor kg CO2/kWh	Primary energy kWh/year	
Space heating - main system 1	2576.9048	1.5719	4050.5160	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	2375.8142	1.5225	3617.2936	(278)
Space and water heating			7667.8096	(279)
Pumps, fans and electric keep-hot	104.6577	1.5128	158.3262	(281)
Energy for lighting	172.5436	1.5338	264.6531	(282)
Total Primary energy kWh/year			8090.7888	(286)
Dwelling Primary energy Rate (DPER)			150.5300	(287)

SAP 10 WORKSHEET FOR New Build (As Designed) (Version 10.2, February 2022)
CALCULATION OF TARGET EMISSIONS

1. Overall dwelling characteristics

		Area (m2)		Storey height (m)		Volume (m3)	
Ground floor		53.7500 (1b)	x	3.0000 (2b)	=	161.2500 (1b) -	
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	53.7500						(4)
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	161.2500	(5)

2. Ventilation rate

			m3 per hour	
Number of open chimneys		0 * 80 =	0.0000	(6a)
Number of open flues		0 * 20 =	0.0000	(6b)
Number of chimneys / flues attached to closed fire		0 * 10 =	0.0000	(6c)
Number of flues attached to solid fuel boiler		0 * 20 =	0.0000	(6d)
Number of flues attached to other heater		0 * 35 =	0.0000	(6e)
Number of blocked chimneys		0 * 20 =	0.0000	(6f)
Number of intermittent extract fans		2 * 10 =	20.0000	(7a)
Number of passive vents		0 * 10 =	0.0000	(7b)
Number of flueless gas fires		0 * 40 =	0.0000	(7c)
			Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(6c)+(6d)+(6e)+(6f)+(6g)+(7a)+(7b)+(7c) =		20.0000 / (5) =	0.1240	(8)
Pressure test			Yes	
Pressure Test Method			Blower Door	
Measured/design AP50			5.0000	(17)
Infiltration rate			0.3740	(18)
Number of sides sheltered			3	(19)
Shelter factor		(20) = 1 - [0.075 x (19)] =	0.7750	(20)
Infiltration rate adjusted to include shelter factor		(21) = (18) x (20) =	0.2899	(21)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wind speed	5.1000	5.0000	4.9000	4.4000	4.3000	3.8000	3.8000	3.7000	4.0000	4.3000	4.5000	4.7000	(22)
Wind factor	1.2750	1.2500	1.2250	1.1000	1.0750	0.9500	0.9500	0.9250	1.0000	1.0750	1.1250	1.1750	(22a)
Adj infilt rate	0.3696	0.3623	0.3551	0.3189	0.3116	0.2754	0.2754	0.2681	0.2899	0.3116	0.3261	0.3406	(22b)
Effective ac	0.5683	0.5656	0.5630	0.5508	0.5486	0.5379	0.5379	0.5359	0.5420	0.5486	0.5532	0.5580	(25)

3. Heat losses and heat loss parameter

Element	Gross m2	Openings m2	NetArea m2	U-value W/m2K	A x U W/K	K-value kJ/m2K	A x K kJ/K	
TER Semi-glazed door			3.5400	1.0000	3.5400			(26a)
TER Opening Type (Uw = 1.20)			5.3100	1.1450	6.0802			(27)
Heatloss Floor 1			53.7500	0.1300	6.9875			(28b)
External Wall 1	24.4500	8.8500	15.6000	0.1800	2.8080			(29a)
Total net area of external elements Aum(A, m2)			78.2000					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		19.4157			(33)
Party Wall 1			56.5200	0.0000	0.0000			(32)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K 213.6156 (35)

List of Thermal Bridges

	Length	Psi-value	Total
K1 Element			
E2 Other lintels (including other steel lintels)	3.9500	0.0500	0.1975
E3 Sill	3.9500	0.0500	0.1975
E4 Jamb	17.9200	0.0500	0.8960
E4 Jamb	17.9200	0.0500	0.8960
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.0700	0.8610
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.0700	0.8610
E18 Party wall between dwellings	3.0000	0.0600	0.1800
E18 Party wall between dwellings	3.0000	0.0600	0.1800
P3 Party wall - Intermediate floor between dwellings (in blocks of flats)	18.8400	0.0000	0.0000
E5 Ground floor (normal)	8.1500	0.1600	1.3040
P1 Party wall - Ground floor	18.8400	0.0800	1.5072
E16 Corner (normal)	3.0000	0.0900	0.2700
E16 Corner (normal)	3.0000	0.0900	0.2700
E25 Staggered party wall between dwellings	3.0000	0.0600	0.1800
E25 Staggered party wall between dwellings	3.0000	0.0600	0.1800

Thermal bridges (Sum(L x Psi) calculated using Appendix K) 7.9802 (36)
Point Thermal bridges (36a) = 0.0000

Total fabric heat loss (33) + (36) + (36a) = 27.3959 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 x (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m	30.2406	30.0994	29.9611	29.3114	29.1898	28.6239	28.6239	28.5191	28.8419	29.1898	29.4357	29.6928	(38)
Heat transfer coeff	57.6364	57.4953	57.3570	56.7072	56.5857	56.0198	56.0198	55.9150	56.2377	56.5857	56.8316	57.0887	(39)

Average = Sum(39)m / 12 = 56.7066

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.0723	1.0697	1.0671	1.0550	1.0528	1.0422	1.0422	1.0403	1.0463	1.0528	1.0573	1.0621	(40)
HLP (average)												1.0550	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

Assumed occupancy 1.8006 (42)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage for mixer showers	54.4105	53.5928	52.4013	50.1215	48.4391	46.5629	45.4964	46.6790	47.9752	49.9897	52.3184	54.2020	(42a)
Hot water usage for baths	23.5215	23.1722	22.6803	21.7732	21.0941	20.3410	19.9342	20.4227	20.9546	21.7604	22.6861	23.4420	(42b)
Hot water usage for other uses	33.0704	31.8679	30.6653	29.4628	28.2602	27.0576	27.0576	28.2602	29.4628	30.6653	31.8679	33.0704	(42c)

Average daily hot water use (litres/day) 102.0368 (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	111.0025	108.6329	105.7469	101.3575	97.7934	93.9615	92.4883	95.3618	98.3925	102.4154	106.8724	110.7145	(44)
Energy conte	175.8008	154.6918	162.5290	138.7534	131.6487	115.5366	111.8566	118.0779	121.3278	138.9767	152.2593	173.3521	(45)

Energy content (annual) Total = Sum(45)m = 1694.8106

Distribution loss (46)m = 0.15 x (45)m	26.3701	23.2038	24.3793	20.8130	19.7473	17.3305	16.7785	17.7117	18.1992	20.8465	22.8389	26.0028	(46)

Water storage loss:

Store volume 162.0000 (47)

a) If manufacturer declared loss factor is known (kWh/day): 1.4582 (48)

Temperature factor from Table 2b 0.5400 (49)

Enter (49) or (54) in (55) 0.7875 (55)

Total storage loss	24.4111	22.0487	24.4111	23.6236	24.4111	23.6236	24.4111	24.4111	23.6236	24.4111	23.6236	24.4111	(56)
If cylinder contains dedicated solar storage	24.4111	22.0487	24.4111	23.6236	24.4111	23.6236	24.4111	24.4111	23.6236	24.4111	23.6236	24.4111	(57)
Primary loss	23.2624	21.0112	23.2624	22.5120	23.2624	22.5120	23.2624	23.2624	22.5120	23.2624	22.5120	23.2624	(59)
Combi loss	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(61)
Total heat required for water heating calculated for each month	223.4742	197.7517	210.2024	184.8890	179.3221	161.6722	159.5300	165.7513	167.4634	186.6502	198.3949	221.0256	(62)
WWHRS	-24.8742	-21.9989	-23.0360	-19.0747	-17.7770	-15.2119	-14.2587	-15.1627	-15.7388	-18.5543	-21.0198	-24.4136	(63a)
PV diverter	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	(63b)
Solar input	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63c)
FGHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63d)
Output from w/h	198.6000	175.7527	187.1664	165.8142	161.5451	146.4603	145.2713	150.5886	151.7246	168.0959	177.3751	196.6120	(64)

Total per year (kWh/year) = Sum(64)m = 2025.0064 (64)

12Total per year (kWh/year) 2025 (64)

Electric shower(s)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(64a)

Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m = 0.0000 (64a)

Heat gains from water heating, kWh/month	96.5925	85.8829	92.1797	83.0440	81.9119	75.3244	75.3311	77.3997	77.2500	84.3485	87.5347	95.7783	(65)

5. Internal gains (see Table 5 and 5a)

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	91.6504	101.4700	91.6504	94.7054	91.6504	94.7054	91.6504	91.6504	94.7054	91.6504	94.7054	91.6504	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	156.9586	158.5874	154.4830	145.7453	134.7155	124.3490	117.4236	115.7948	119.8992	128.6369	139.6667	150.0332	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	(69)
Pumps, fans	3.0000	3.0000	3.0000	3.0000	3.0000	0.0000	0.0000	0.0000	0.0000	3.0000	3.0000	3.0000	(70)
Losses e.g. evaporation (negative values) (Table 5)	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	(71)
Water heating gains (Table 5)	129.8286	127.8020	123.8974	115.3389	110.0967	104.6172	101.2514	104.0318	107.2916	113.3717	121.5760	128.7343	(72)
Total internal gains	431.4474	440.8691	423.0405	408.7992	389.4723	373.6814	360.3351	361.4867	371.9060	386.6687	408.9578	423.4276	(73)

6. Solar gains

[Jan]	Area m2	Solar flux Table 6a W/m2	g Specific data or Table 6b	FF Specific data or Table 6c	Access factor Table 6d	Gains W

West			5.3100		19.6403		0.6300		0.7000		0.7700		31.8723 (80)
Solar gains	31.8723	62.3490	102.6800	149.7526	183.5274	187.8730	178.8627	153.6404	119.4210	73.9824	39.7410	26.2102 (83)	
Total gains	463.3197	503.2181	525.7204	558.5518	572.9997	561.5543	539.1978	515.1272	491.3270	460.6511	448.6989	449.6378 (84)	

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (C)													21.0000 (85)
Utilisation factor for gains for living area, ni1,m (see Table 9a)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	55.3365	55.4724	55.6062	56.2433	56.3641	56.9335	56.9335	57.0402	56.7128	56.3641	56.1202	55.8675	
alpha	4.6891	4.6982	4.7071	4.7496	4.7576	4.7956	4.7956	4.8027	4.7809	4.7576	4.7413	4.7245	
util living area													
	0.9829	0.9731	0.9542	0.8991	0.7894	0.6095	0.4513	0.4903	0.7176	0.9104	0.9692	0.9850 (86)	
MIT	19.8385	20.0009	20.2433	20.5771	20.8300	20.9625	20.9927	20.9892	20.9183	20.6111	20.1843	19.8152 (87)	
Th 2	20.0235	20.0257	20.0278	20.0377	20.0396	20.0483	20.0483	20.0499	20.0449	20.0396	20.0358	20.0319 (88)	
util rest of house													
	0.9785	0.9663	0.9421	0.8727	0.7378	0.5298	0.3566	0.3934	0.6418	0.8814	0.9602	0.9811 (89)	
MIT 2	18.6925	18.8983	19.2022	19.6126	19.8946	20.0255	20.0456	20.0456	19.9888	19.6615	19.1386	18.6692 (90)	
Living area fraction										fLA = Living area / (4) =		0.5181 (91)	
MIT	19.2863	19.4696	19.7416	20.1123	20.3793	20.5110	20.5363	20.5345	20.4704	20.1535	19.6804	19.2630 (92)	
Temperature adjustment												0.0000	
adjusted MIT	19.2863	19.4696	19.7416	20.1123	20.3793	20.5110	20.5363	20.5345	20.4704	20.1535	19.6804	19.2630 (93)	

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9743	0.9615	0.9379	0.8750	0.7572	0.5695	0.4056	0.4435	0.6772	0.8853	0.9561	0.9771 (94)	
Useful gains	451.3988	483.8229	493.0821	488.7118	433.8542	319.8101	218.7125	228.4393	332.7096	407.8040	428.9889	439.3619 (95)	
Ext temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000 (96)	
Heat loss rate W													
	863.7581	837.6833	759.4994	635.8212	491.1222	331.1317	220.5126	231.1828	358.2580	540.5911	714.9641	859.9275 (97)	
Space heating kWh													
	306.7954	237.7942	198.2145	105.9188	42.6074	0.0000	0.0000	0.0000	0.0000	98.7935	205.9021	312.9008 (98a)	
Space heating requirement - total per year (kWh/year)												1508.9266	
Solar heating kWh													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (98b)	
Solar heating contribution - total per year (kWh/year)												0.0000	
Space heating kWh													
	306.7954	237.7942	198.2145	105.9188	42.6074	0.0000	0.0000	0.0000	0.0000	98.7935	205.9021	312.9008 (98c)	
Space heating requirement after solar contribution - total per year (kWh/year)												1508.9266	
Space heating per m2											(98c) / (4) =	28.0731 (99)	

9a. Energy requirements - Individual heating systems, including micro-CHP

Fraction of space heat from secondary/supplementary system (Table 11)												0.0000 (201)	
Fraction of space heat from main system(s)												1.0000 (202)	
Efficiency of main space heating system 1 (in %)												92.3000 (206)	
Efficiency of main space heating system 2 (in %)												0.0000 (207)	
Efficiency of secondary/supplementary heating system, %												0.0000 (208)	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating requirement													
	306.7954	237.7942	198.2145	105.9188	42.6074	0.0000	0.0000	0.0000	0.0000	98.7935	205.9021	312.9008 (98)	
Space heating efficiency (main heating system 1)													
	92.3000	92.3000	92.3000	92.3000	92.3000	0.0000	0.0000	0.0000	0.0000	92.3000	92.3000	92.3000 (210)	
Space heating fuel (main heating system)													
	332.3893	257.6318	214.7502	114.7549	46.1618	0.0000	0.0000	0.0000	0.0000	107.0353	223.0792	339.0041 (211)	
Space heating efficiency (main heating system 2)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (212)	
Space heating fuel (main heating system 2)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (213)	
Space heating fuel (secondary)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (215)	
Water heating													
Water heating requirement													
	198.6000	175.7527	187.1664	165.8142	161.5451	146.4603	145.2713	150.5886	151.7246	168.0959	177.3751	196.6120 (64)	
Efficiency of water heater												79.8000 (216)	
(217)m	85.0315	84.7384	84.1886	83.0822	81.5244	79.8000	79.8000	79.8000	79.8000	82.9105	84.3951	85.0965 (217)	
Fuel for water heating, kWh/month													
	233.5605	207.4062	222.3180	199.5785	198.1555	183.5343	182.0442	188.7075	190.1311	202.7437	210.1723	231.0458 (219)	
Space cooling fuel requirement													
(221)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (221)	
Pumps and Fa	7.3041	6.5973	7.3041	7.0685	7.3041	7.0685	7.3041	7.3041	7.0685	7.3041	7.0685	7.3041 (231)	
Lighting	19.0431	15.2771	13.7553	10.0778	7.7843	6.3599	7.1011	9.2303	11.9893	15.7306	17.7677	19.5724 (232)	
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)m	-2.0923	-3.3479	-5.4527	-6.9733	-8.3115	-8.0599	-7.9647	-7.1124	-5.7795	-4.1660	-2.4375	-1.7658 (233a)	
Electricity generated by wind turbines (Appendix M) (negative quantity)													
(234a)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (234a)	
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)													
(235a)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (235a)	
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)													

(235c)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235c)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233b)m	-0.2224	-0.4953	-1.0390	-1.6457	-2.2636	-2.3065	-2.2776	-1.8856	-1.3291	-0.7327	-0.3043	-0.1738	(233b)
Electricity generated by wind turbines (Appendix M) (negative quantity)													
(234b)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(234b)
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)													
(235b)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235b)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)													
(235d)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235d)

Annual totals kWh/year		
Space heating fuel - main system 1	1634.8067	(211)
Space heating fuel - main system 2	0.0000	(213)
Space heating fuel - secondary	0.0000	(215)
Efficiency of water heater	79.8000	
Water heating fuel used	2449.3975	(219)
Space cooling fuel	0.0000	(221)
Electricity for pumps and fans:		
Total electricity for the above, kWh/year	86.0000	(231)
Electricity for lighting (calculated in Appendix L)	153.6890	(232)
Energy saving/generation technologies (Appendices M ,N and Q)		
PV generation	-78.1391	(233)
Wind generation	0.0000	(234)
Hydro-electric generation (Appendix N)	0.0000	(235a)
Electricity generated - Micro CHP (Appendix N)	0.0000	(235)
Appendix Q - special features		
Energy saved or generated	-0.0000	(236)
Energy used	0.0000	(237)
Total delivered energy for all uses	4245.7542	(238)

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP

	Energy kWh/year	Emission factor kg CO2/kWh	Emissions kg CO2/year	
Space heating - main system 1	1634.8067	0.2100	343.3094	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	2449.3975	0.2100	514.3735	(264)
Space and water heating			857.6829	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	153.6890	0.1443	22.1821	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-63.4635	0.1321	-8.3807	
PV Unit electricity exported	-14.6755	0.1244	-1.8257	
Total			-10.2064	(269)
Total CO2, kg/year			881.5879	(272)
Target Carbon Dioxide Emission Rate (TER)			16.4000	(273)

13a. Primary energy - Individual heating systems including micro-CHP

	Energy kWh/year	Primary energy factor kg CO2/kWh	Primary energy kWh/year	
Space heating - main system 1	1634.8067	1.1300	1847.3316	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	2449.3975	1.1300	2767.8192	(278)
Space and water heating			4615.1508	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	153.6890	1.5338	235.7333	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-63.4635	1.4879	-94.4278	
PV Unit electricity exported	-14.6755	0.4566	-6.7004	
Total			-101.1282	(283)
Total Primary energy kWh/year			4879.8567	(286)
Target Primary Energy Rate (TPER)			90.7900	(287)

SAP 10 WORKSHEET FOR New Build (As Designed) (Version 10.2, February 2022)

CALCULATION OF FABRIC ENERGY EFFICIENCY

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1. Overall dwelling characteristics

		Area (m2)		Storey height (m)		Volume (m3)	
Ground floor		53.7500 (1b)	x	3.0000 (2b)	=	161.2500 (1b) -	
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	53.7500						(4)
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	161.2500	(5)

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2. Ventilation rate
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			m3 per hour
Number of open chimneys		0 * 80 =	0.0000 (6a)
Number of open flues		0 * 20 =	0.0000 (6b)
Number of chimneys / flues attached to closed fire		0 * 10 =	0.0000 (6c)
Number of flues attached to solid fuel boiler		0 * 20 =	0.0000 (6d)
Number of flues attached to other heater		0 * 35 =	0.0000 (6e)
Number of blocked chimneys		0 * 20 =	0.0000 (6f)
Number of intermittent extract fans		2 * 10 =	20.0000 (7a)
Number of passive vents		0 * 10 =	0.0000 (7b)
Number of flueless gas fires		0 * 40 =	0.0000 (7c)
			Air changes per hour
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(6c)+(6d)+(6e)+(6f)+(6g)+(7a)+(7b)+(7c) =		20.0000 / (5) =	0.1240 (8)
Pressure test			Yes
Pressure Test Method			Blower Door
Measured/design AP50			5.0000 (17)
Infiltration rate			0.3740 (18)
Number of sides sheltered			3 (19)
Shelter factor	(20) = 1 - [0.075 x (19)] =		0.7750 (20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =		0.2899 (21)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wind speed	5.1000	5.0000	4.9000	4.4000	4.3000	3.8000	3.8000	3.7000	4.0000	4.3000	4.5000	4.7000	(22)
Wind factor	1.2750	1.2500	1.2250	1.1000	1.0750	0.9500	0.9500	0.9250	1.0000	1.0750	1.1250	1.1750	(22a)
Adj infilt rate	0.3696	0.3623	0.3551	0.3189	0.3116	0.2754	0.2754	0.2681	0.2899	0.3116	0.3261	0.3406	(22b)
If exhaust air heat pump using Appendix N, (23b) = (23a) x Fmv (equation (N5)), otherwise (23b) = (23a)												0.0000	(23b)
If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) =												0.0000	(23c)
Effective ac	0.5683	0.5656	0.5630	0.5508	0.5486	0.5379	0.5379	0.5359	0.5420	0.5486	0.5532	0.5580	(25)

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3. Heat losses and heat loss parameter

Element	Gross m2	Openings m2	NetArea m2	U-value W/m2K	A x U W/K	K-value kJ/m2K	A x K kJ/K	
Window (Uw = 1.50)			5.3100	1.4151	7.5142			(27)
Rapid Vent			3.5400	1.5000	5.3100			(26a)
Heatloss Floor 1			53.7500	0.2000	10.7500			(28b)
External Wall 1	24.4500	8.8500	15.6000	0.1700	2.6520	0.0000	0.0000	(29a)
Total net area of external elements Aum(A, m2)			78.2000					(31)
Fabric heat loss, W/K = Sum (A x U)				(26)...(30) + (32) =	26.2262			(33)
Party Wall 1			56.5200	0.0000	0.0000	180.0000	10173.6001	(32)
Party Ceiling 1			53.7500			0.0000	0.0000	(32b)
Internal Partitions			42.3600			9.0000	381.2400	(32c)
Corridor Wall			12.3600			75.0000	927.0000	(32c)
Heat capacity Cm = Sum(A x k)				(28)...(30) + (32) + (32a)...(32e) =			11481.8401	(34)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K							213.6156	(35)

List of Thermal Bridges

	Length	Psi-value	Total
K1 Element			
E2 Other lintels (including other steel lintels)	3.9500	1.0000	3.9500
E3 Sill	3.9500	0.1000	0.3950
E4 Jamb	17.9200	0.1000	1.7920
E4 Jamb	17.9200	0.1000	1.7920
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.2800	3.4440
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.2800	3.4440
E18 Party wall between dwellings	3.0000	0.2400	0.7200
E18 Party wall between dwellings	3.0000	0.2400	0.7200
P3 Party wall - Intermediate floor between dwellings (in blocks of flats)	18.8400	0.0000	0.0000
E5 Ground floor (normal)	8.1500	0.3200	2.6080
P1 Party wall - Ground floor	18.8400	0.3200	6.0288
E16 Corner (normal)	3.0000	0.1800	0.5400
E16 Corner (normal)	3.0000	0.1800	0.5400
E25 Staggered party wall between dwellings	3.0000	0.2400	0.7200
E25 Staggered party wall between dwellings	3.0000	0.2400	0.7200

Thermal bridges (Sum(L x Psi) calculated using Appendix K)			27.4138 (36)
Point Thermal bridges		(36a) =	0.0000
Total fabric heat loss	(33) + (36) + (36a) =		53.6400 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 x (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m	30.2406	30.0994	29.9611	29.3114	29.1898	28.6239	28.6239	28.5191	28.8419	29.1898	29.4357	29.6928	(38)
Heat transfer coeff	83.8805	83.7394	83.6011	82.9513	82.8298	82.2639	82.2639	82.1591	82.4818	82.8298	83.0757	83.3328	(39)
Average = Sum(39)m / 12 =												82.9507	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.5606	1.5579	1.5554	1.5433	1.5410	1.5305	1.5305	1.5285	1.5345	1.5410	1.5456	1.5504	(40)
HLP (average)												1.5433	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

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4. Water heating energy requirements (kWh/year)

Assumed occupancy 1.8006 (42)
Hot water usage for mixer showers
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (42a)
Hot water usage for baths
23.5215 23.1722 22.6803 21.7732 21.0941 20.3410 19.9342 20.4227 20.9546 21.7604 22.6861 23.4420 (42b)
Hot water usage for other uses
33.0704 31.8679 30.6653 29.4628 28.2602 27.0576 27.0576 28.2602 29.4628 30.6653 31.8679 33.0704 (42c)
Average daily hot water use (litres/day) 51.8722 (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use													
	56.5920	55.0401	53.3456	51.2360	49.3543	47.3986	46.9918	48.6829	50.4173	52.4257	54.5540	56.5124	(44)
Energy conte	89.6278	78.3763	81.9902	70.1395	66.4403	58.2821	56.8326	60.2796	62.1696	71.1412	77.7221	88.4848	(45)
Energy content (annual)										Total = Sum(45)m =		861.4863	
Distribution loss (46)m = 0.15 x (45)m													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(46)
Water storage loss:													
Total storage loss													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(56)
If cylinder contains dedicated solar storage													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(57)
Primary loss	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(59)
Combi loss	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(61)
Total heat required for water heating calculated for each month													
	76.1837	66.6199	69.6917	59.6186	56.4743	49.5398	48.3077	51.2376	52.8442	60.4700	66.0638	75.2121	(62)
WWHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63a)
PV diverter	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63b)
Solar input	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63c)
FGHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63d)
Output from w/h													
	76.1837	66.6199	69.6917	59.6186	56.4743	49.5398	48.3077	51.2376	52.8442	60.4700	66.0638	75.2121	(64)
										Total per year (kWh/year) = Sum(64)m =		732.2634	(64)
12Total per year (kWh/year)												732	(64)
Electric shower(s)													
	43.5737	38.8246	42.3949	40.4570	41.2161	39.3162	40.6267	41.2161	40.4570	42.3949	41.5977	43.5737	(64a)
Heat gains from water heating, kWh/month													
	29.9393	26.3611	28.0216	25.0189	24.4226	22.2140	22.2336	23.1134	23.3253	25.7162	26.9154	29.6965	(65)

Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m = 495.6486 (64a)

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5. Internal gains (see Table 5 and 5a)

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	91.6504	101.4700	91.6504	94.7054	91.6504	94.7054	91.6504	91.6504	94.7054	91.6504	94.7054	91.6504	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	156.9586	158.5874	154.4830	145.7453	134.7155	124.3490	117.4236	115.7948	119.8992	128.6369	139.6667	150.0332	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	(69)
Pumps, fans	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(70)
Losses e.g. evaporation (negative values) (Table 5)													
	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	(71)
Water heating gains (Table 5)													
	40.2411	39.2278	37.6635	34.7485	32.8261	30.8528	29.8839	31.0665	32.3962	34.5648	37.3825	39.9146	(72)
Total internal gains													
	338.8598	349.2950	333.8066	325.2088	309.2016	299.9169	288.9675	288.5214	297.0105	304.8619	321.7643	331.6079	(73)

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6. Solar gains

[Jan]	Area m2	Solar flux Table 6a W/m2	g Specific data or Table 6b	FF Specific data or Table 6c	Access factor Table 6d	Gains W	
West	5.3100	19.6403	0.4000	0.0000	0.7700	32.1213	(80)

Solar gains	32.1213	62.8360	103.4819	150.9222	184.9609	189.3404	180.2597	154.8404	120.3538	74.5602	40.0514	26.4150	(83)
Total gains	370.9810	412.1310	437.2885	476.1311	494.1625	489.2572	469.2273	443.3618	417.3643	379.4221	361.8158	358.0228	(84)

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7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (C) 21.0000 (85)
Utilisation factor for gains for living area, ni1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	38.0231	38.0872	38.1502	38.4491	38.5055	38.7704	38.7704	38.8198	38.6679	38.5055	38.3915	38.2731	
alpha	3.5349	3.5391	3.5433	3.5633	3.5670	3.5847	3.5847	3.5880	3.5779	3.5670	3.5594	3.5515	
util living area													
	0.9933	0.9895	0.9826	0.9619	0.9153	0.8096	0.6714	0.7158	0.8841	0.9692	0.9889	0.9941	(86)

MIT	18.8548	19.0448	19.3722	19.8622	20.3367	20.7275	20.9020	20.8734	20.5820	19.9703	19.3392	18.8262	(87)
Th 2	19.6424	19.6443	19.6462	19.6552	19.6569	19.6647	19.6647	19.6662	19.6617	19.6569	19.6535	19.6499	(88)
util rest of house	0.9912	0.9862	0.9767	0.9472	0.8775	0.7153	0.5088	0.5614	0.8169	0.9545	0.9848	0.9923	(89)
MIT 2	17.7322	17.9223	18.2485	18.7354	19.1867	19.5253	19.6368	19.6256	19.4157	18.8476	18.2227	17.7090	(90)
Living area fraction									fLA = Living area / (4) =			0.5181	(91)
MIT	18.3139	18.5039	18.8307	19.3193	19.7825	20.1482	20.2923	20.2721	20.0200	19.4293	18.8012	18.2878	(92)
Temperature adjustment												0.0000	
adjusted MIT	18.3139	18.5039	18.8307	19.3193	19.7825	20.1482	20.2923	20.2721	20.0200	19.4293	18.8012	18.2878	(93)

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8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9883	0.9824	0.9718	0.9426	0.8818	0.7539	0.5917	0.6388	0.8384	0.9512	0.9812	0.9897	(94)
Useful gains	366.6510	404.8601	424.9774	448.7784	435.7555	368.8747	277.6603	283.2006	349.9034	360.9244	355.0024	354.3401	(95)
Ext temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000	(96)
Heat loss rate W	1175.4903	1139.1853	1030.8633	864.2914	669.4752	456.4178	303.7455	318.1286	488.2935	731.3286	972.0835	1173.9786	(97)
Space heating kWh	601.7764	493.4665	450.7791	299.1694	173.8875	0.0000	0.0000	0.0000	0.0000	275.5807	444.2984	609.8111	(98a)
Space heating requirement - total per year (kWh/year)												3348.7691	
Solar heating kWh	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(98b)
Solar heating contribution - total per year (kWh/year)												0.0000	
Space heating kWh	601.7764	493.4665	450.7791	299.1694	173.8875	0.0000	0.0000	0.0000	0.0000	275.5807	444.2984	609.8111	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												3348.7691	
Space heating per m2											(98c) / (4) =	62.3027	(99)

8c. Space cooling requirement

Calculated for June, July and August. See Table 10b

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ext. temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000	
Heat loss rate W	0.0000	0.0000	0.0000	0.0000	0.0000	773.2804	608.7526	624.4089	0.0000	0.0000	0.0000	0.0000	(100)
Utilisation	0.0000	0.0000	0.0000	0.0000	0.0000	0.6172	0.7065	0.6698	0.0000	0.0000	0.0000	0.0000	(101)
Useful loss	0.0000	0.0000	0.0000	0.0000	0.0000	477.2945	430.0923	418.2113	0.0000	0.0000	0.0000	0.0000	(102)
Total gains	0.0000	0.0000	0.0000	0.0000	0.0000	529.3918	508.1185	479.7574	0.0000	0.0000	0.0000	0.0000	(103)
Space cooling kWh	0.0000	0.0000	0.0000	0.0000	0.0000	37.5101	58.0516	45.7902	0.0000	0.0000	0.0000	0.0000	(104)
Cooled fraction									fC = cooled area / (4) =			1.0000	(105)
Intermittency factor (Table 10b)	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	(106)
Space cooling kWh	0.0000	0.0000	0.0000	0.0000	0.0000	9.3775	14.5129	11.4476	0.0000	0.0000	0.0000	0.0000	(107)
Space cooling requirement												35.3380	(107)
Energy for space heating												62.3027	(99)
Energy for space cooling												0.6575	(108)
Total												62.9601	(109)
Fabric Energy Efficiency (DFEE)												63.0	(109)

SAP 10 WORKSHEET FOR New Build (As Designed) (Version 10.2, February 2022)
CALCULATION OF TARGET FABRIC ENERGY EFFICIENCY

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1. Overall dwelling characteristics

		Area (m2)		Storey height (m)		Volume (m3)	
Ground floor		53.7500 (1b)	x	3.0000 (2b)	=	161.2500 (1b) - (4)	
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	53.7500						
Dwelling volume		(3a)+(3b)+(3c)+(3d)+(3e)...(3n) =				161.2500	(5)

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2. Ventilation rate

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	m3 per hour	
Number of open chimneys	0 * 80 =	0.0000 (6a)
Number of open flues	0 * 20 =	0.0000 (6b)
Number of chimneys / flues attached to closed fire	0 * 10 =	0.0000 (6c)
Number of flues attached to solid fuel boiler	0 * 20 =	0.0000 (6d)
Number of flues attached to other heater	0 * 35 =	0.0000 (6e)

Number of blocked chimneys	0 * 20 =	0.0000 (6f)
Number of intermittent extract fans	2 * 10 =	20.0000 (7a)
Number of passive vents	0 * 10 =	0.0000 (7b)
Number of flueless gas fires	0 * 40 =	0.0000 (7c)
	Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(6c)+(6d)+(6e)+(6f)+(6g)+(7a)+(7b)+(7c) =	20.0000 / (5) =	0.1240 (8)
Pressure test		Yes
Pressure Test Method		Blower Door
Measured/design AP50		5.0000 (17)
Infiltration rate		0.3740 (18)
Number of sides sheltered		3 (19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.7750 (20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.2899 (21)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wind speed	5.1000	5.0000	4.9000	4.4000	4.3000	3.8000	3.8000	3.7000	4.0000	4.3000	4.5000	4.7000	(22)
Wind factor	1.2750	1.2500	1.2250	1.1000	1.0750	0.9500	0.9500	0.9250	1.0000	1.0750	1.1250	1.1750	(22a)
Adj infilt rate	0.3696	0.3623	0.3551	0.3189	0.3116	0.2754	0.2754	0.2681	0.2899	0.3116	0.3261	0.3406	(22b)
If exhaust air heat pump using Appendix N, (23b) = (23a) x Fmv (equation (N5)), otherwise (23b) = (23a)												0.0000	(23b)
If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) =												0.0000	(23c)
Effective ac	0.5683	0.5656	0.5630	0.5508	0.5486	0.5379	0.5379	0.5359	0.5420	0.5486	0.5532	0.5580	(25)

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3. Heat losses and heat loss parameter

Element	Gross m2	Openings m2	NetArea m2	U-value W/m2K	A x U W/K	K-value kJ/m2K	A x K kJ/K	
TER Semi-glazed door			3.5400	1.0000	3.5400			(26a)
TER Opening Type (Uw = 1.20)			5.3100	1.1450	6.0802			(27)
Heatloss Floor 1			53.7500	0.1300	6.9875			(28b)
External Wall 1	24.4500	8.8500	15.6000	0.1800	2.8080			(29a)
Total net area of external elements Aum(A, m2)			78.2000					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		19.4157			(33)
Party Wall 1			56.5200	0.0000	0.0000			(32)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K		213.6156 (35)

List of Thermal Bridges

	Length	Psi-value	Total
K1 Element			
E2 Other lintels (including other steel lintels)	3.9500	0.0500	0.1975
E3 Sill	3.9500	0.0500	0.1975
E4 Jamb	17.9200	0.0500	0.8960
E4 Jamb	17.9200	0.0500	0.8960
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.0700	0.8610
E7 Party floor between dwellings (in blocks of flats)	12.3000	0.0700	0.8610
E18 Party wall between dwellings	3.0000	0.0600	0.1800
E18 Party wall between dwellings	3.0000	0.0600	0.1800
P3 Party wall - Intermediate floor between dwellings (in blocks of flats)	18.8400	0.0000	0.0000
E5 Ground floor (normal)	8.1500	0.1600	1.3040
P1 Party wall - Ground floor	18.8400	0.0800	1.5072
E16 Corner (normal)	3.0000	0.0900	0.2700
E16 Corner (normal)	3.0000	0.0900	0.2700
E25 Staggered party wall between dwellings	3.0000	0.0600	0.1800
E25 Staggered party wall between dwellings	3.0000	0.0600	0.1800

Thermal bridges (Sum(L x Psi) calculated using Appendix K)		7.9802 (36)
Point Thermal bridges	(36a) =	0.0000
Total fabric heat loss	(33) + (36) + (36a) =	27.3959 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 x (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m	30.2406	30.0994	29.9611	29.3114	29.1898	28.6239	28.6239	28.5191	28.8419	29.1898	29.4357	29.6928	(38)
Heat transfer coeff	57.6364	57.4953	57.3570	56.7072	56.5857	56.0198	56.0198	55.9150	56.2377	56.5857	56.8316	57.0887	(39)
Average = Sum(39)m / 12 =												56.7066	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.0723	1.0697	1.0671	1.0550	1.0528	1.0422	1.0422	1.0403	1.0463	1.0528	1.0573	1.0621	(40)
HLP (average)												1.0550	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

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4. Water heating energy requirements (kWh/year)

Assumed occupancy		1.8006 (42)

Hot water usage for mixer showers

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(42a)

Hot water usage for baths

23.5215	23.1722	22.6803	21.7732	21.0941	20.3410	19.9342	20.4227	20.9546	21.7604	22.6861	23.4420	(42b)

Hot water usage for other uses

33.0704	31.8679	30.6653	29.4628	28.2602	27.0576	27.0576	28.2602	29.4628	30.6653	31.8679	33.0704	(42c)

Average daily hot water use (litres/day)		51.8722 (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	56.5920	55.0401	53.3456	51.2360	49.3543	47.3986	46.9918	48.6829	50.4173	52.4257	54.5540	56.5124	(44)
Energy conte	89.6278	78.3763	81.9902	70.1395	66.4403	58.2821	56.8326	60.2796	62.1696	71.1412	77.7221	88.4848	(45)

Energy content (annual) Total = Sum(45)m = 861.4863
Distribution loss (46)m = 0.15 x (45)m
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (46)
Water storage loss:
Total storage loss
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (56)
If cylinder contains dedicated solar storage
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (57)
Primary loss 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (59)
Combi loss 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (61)
Total heat required for water heating calculated for each month
76.1837 66.6199 69.6917 59.6186 56.4743 49.5398 48.3077 51.2376 52.8442 60.4700 66.0638 75.2121 (62)
WWHRS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (63a)
PV diverter -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 (63b)
Solar input 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (63c)
FGHRS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 (63d)
Output from w/h
76.1837 66.6199 69.6917 59.6186 56.4743 49.5398 48.3077 51.2376 52.8442 60.4700 66.0638 75.2121 (64)
Total per year (kWh/year) = Sum(64)m = 732.2634 (64)
12Total per year (kWh/year) 732 (64)
Electric shower(s)
43.5737 38.8246 42.3949 40.4570 41.2161 39.3162 40.6267 41.2161 40.4570 42.3949 41.5977 43.5737 (64a)
Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m = 495.6486 (64a)
Heat gains from water heating, kWh/month
29.9393 26.3611 28.0216 25.0189 24.4226 22.2140 22.2336 23.1134 23.3253 25.7162 26.9154 29.6965 (65)

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5. Internal gains (see Table 5 and 5a)

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	90.0325	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	91.6504	101.4700	91.6504	94.7054	91.6504	94.7054	91.6504	91.6504	94.7054	91.6504	94.7054	91.6504	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	156.9586	158.5874	154.4830	145.7453	134.7155	124.3490	117.4236	115.7948	119.8992	128.6369	139.6667	150.0332	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	32.0032	(69)
Pumps, fans	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(70)
Losses e.g. evaporation (negative values) (Table 5)													
	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	-72.0260	(71)
Water heating gains (Table 5)													
	40.2411	39.2278	37.6635	34.7485	32.8261	30.8528	29.8839	31.0665	32.3962	34.5648	37.3825	39.9146	(72)
Total internal gains													
	338.8598	349.2950	333.8066	325.2088	309.2016	299.9169	288.9675	288.5214	297.0105	304.8619	321.7643	331.6079	(73)

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6. Solar gains

[Jan]	Area m2	Solar flux Table 6a W/m2	g Specific data or Table 6b	FF Specific data or Table 6c	Access factor Table 6d	Gains W	
West	5.3100	19.6403	0.6300	0.7000	0.7700	31.8723	(80)

Solar gains	31.8723	62.3490	102.6800	149.7526	183.5274	187.8730	178.8627	153.6404	119.4210	73.9824	39.7410	26.2102	(83)
Total gains	370.7321	411.6440	436.4865	474.9614	492.7291	487.7899	467.8303	442.1618	416.4316	378.8442	361.5054	357.8181	(84)

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7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (C) 21.0000 (85)
Utilisation factor for gains for living area, ni1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	55.3365	55.4724	55.6062	56.2433	56.3641	56.9335	56.9335	57.0402	56.7128	56.3641	56.1202	55.8675	
alpha	4.6891	4.6982	4.7071	4.7496	4.7576	4.7956	4.7956	4.8027	4.7809	4.7576	4.7413	4.7245	
util living area													
	0.9930	0.9875	0.9766	0.9390	0.8523	0.6815	0.5150	0.5629	0.7966	0.9524	0.9865	0.9940	(86)
MIT	19.6386	19.8103	20.0705	20.4480	20.7556	20.9399	20.9872	20.9808	20.8703	20.4764	20.0044	19.6151	(87)
Th 2	20.0235	20.0257	20.0278	20.0377	20.0396	20.0483	20.0483	20.0499	20.0449	20.0396	20.0358	20.0319	(88)
util rest of house													
	0.9910	0.9841	0.9697	0.9205	0.8080	0.5992	0.4094	0.4554	0.7258	0.9342	0.9821	0.9924	(89)
MIT 2	18.7894	18.9611	19.2192	19.5909	19.8699	20.0185	20.0445	20.0437	19.9711	19.6251	19.1625	18.7725	(90)
Living area fraction									fLA = Living area / (4) =			0.5181	(91)
MIT	19.2294	19.4011	19.6603	20.0350	20.3288	20.4959	20.5330	20.5292	20.4370	20.0662	19.5988	19.2091	(92)
Temperature adjustment												0.0000	
adjusted MIT	19.2294	19.4011	19.6603	20.0350	20.3288	20.4959	20.5330	20.5292	20.4370	20.0662	19.5988	19.2091	(93)

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8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9889	0.9813	0.9665	0.9204	0.8225	0.6395	0.4641	0.5109	0.7570	0.9348	0.9796	0.9905	(94)

Useful gains	366.6281	403.9400	421.8718	437.1750	405.2886	311.9339	217.1342	225.9014	315.2519	354.1358	354.1347	354.4289 (95)
Ext temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000 (96)
Heat loss rate W												
	860.4786	833.7466	754.8340	631.4343	488.2687	330.2882	220.3247	230.8850	356.3782	535.6516	710.3242	856.8472 (97)
Space heating kWh												
	367.4248	288.8301	247.7239	139.8667	61.7372	0.0000	0.0000	0.0000	0.0000	135.0478	256.4564	373.7992 (98a)
Space heating requirement - total per year (kWh/year)												1870.8862
Solar heating kWh												
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 (98b)
Solar heating contribution - total per year (kWh/year)												0.0000
Space heating kWh												
	367.4248	288.8301	247.7239	139.8667	61.7372	0.0000	0.0000	0.0000	0.0000	135.0478	256.4564	373.7992 (98c)
Space heating requirement after solar contribution - total per year (kWh/year)												1870.8862
Space heating per m2											(98c) / (4) =	34.8072 (99)

8c. Space cooling requirement

Calculated for June, July and August. See Table 10b

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ext. temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000	
Heat loss rate W													
	0.0000	0.0000	0.0000	0.0000	0.0000	526.5858	414.5463	424.9538	0.0000	0.0000	0.0000	0.0000	(100)
Utilisation	0.0000	0.0000	0.0000	0.0000	0.0000	0.8283	0.8989	0.8727	0.0000	0.0000	0.0000	0.0000	(101)
Useful loss	0.0000	0.0000	0.0000	0.0000	0.0000	436.1759	372.6196	370.8767	0.0000	0.0000	0.0000	0.0000	(102)
Total gains	0.0000	0.0000	0.0000	0.0000	0.0000	527.6767	506.4857	478.3548	0.0000	0.0000	0.0000	0.0000	(103)
Space cooling kWh													
	0.0000	0.0000	0.0000	0.0000	0.0000	65.8805	99.5963	79.9637	0.0000	0.0000	0.0000	0.0000	(104)
Cooled fraction										fC = cooled area / (4) =		1.0000	(105)
Intermittency factor (Table 10b)													
	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	(106)
Space cooling kWh													
	0.0000	0.0000	0.0000	0.0000	0.0000	16.4701	24.8991	19.9909	0.0000	0.0000	0.0000	0.0000	(107)
Space cooling requirement												61.3601	(107)
Energy for space heating												34.8072	(99)
Energy for space cooling												1.1416	(108)
Total												35.9488	(109)
Fabric Energy Efficiency (TFEE)												35.9	(109)

;

Appendix C

TM59TM59

PUBLIC

GNW-WSP-Z0-XX-RP-M-500502
Great Northern Warehouse – Leisure Box Apartments - TM59 & AVO Considerations – Rev 01

TO	**Trilogy**	**FROM**	**Aamirah Bham / Alistair Lambert**
DATE	**11 October 2022**	**CONFIDENTIALITY**	**Confidential**
SUBJECT	**TM59 Initial Overheating Assessment – Residential Apartments**		

1. EXECUTIVE SUMMARY

This Design Development Note (DDN) has been produced to assess the overheating risk for a sample of the Great Northern Warehouse Leisure Box Apartments.

CIBSE TM59 methodology has been utilised to assess the overheating risk within a relevant selection of units. Compliance with TM59 minimum criteria has been analysed using the Manchester weather Centre data. Current scenario weather files were considered with the possibility of considering future weather files at further stages.

WSP understands that some facades of the development are exposed to high noise levels which may limit the use of natural ventilation for reducing the risk of overheating within the affected dwellings, however we have been advised by Hilson Moran that there is no air quality constraints. To account for acoustic requirements, this TM59 study includes profiles on the openable purge ventilation panels in accordance with AVO guidance and WSP acoustic requirements.

The Leisure Box Apartments pass CIBSE TM59. Typical apartments for each tower were based at Levels; 5, 19, 31 and 32. (Shown below in Figures 1 to 4).



Figure 1: Apartments modelled at Level 5

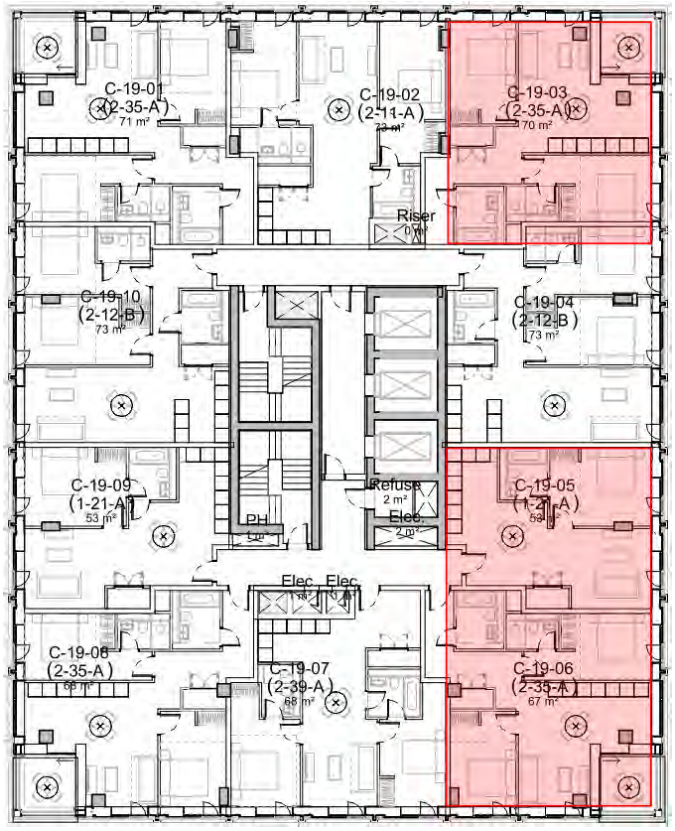


Figure 2: Apartments modelled at Level 19 Tower C

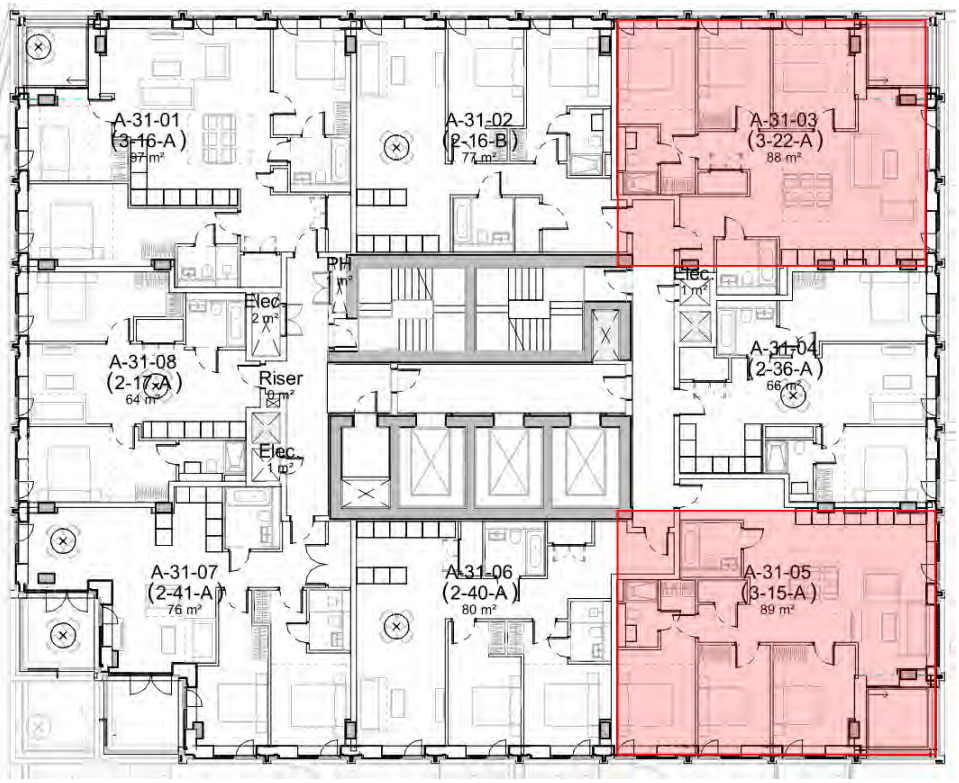


Figure 3: Apartments modelled at Level 31 Tower A

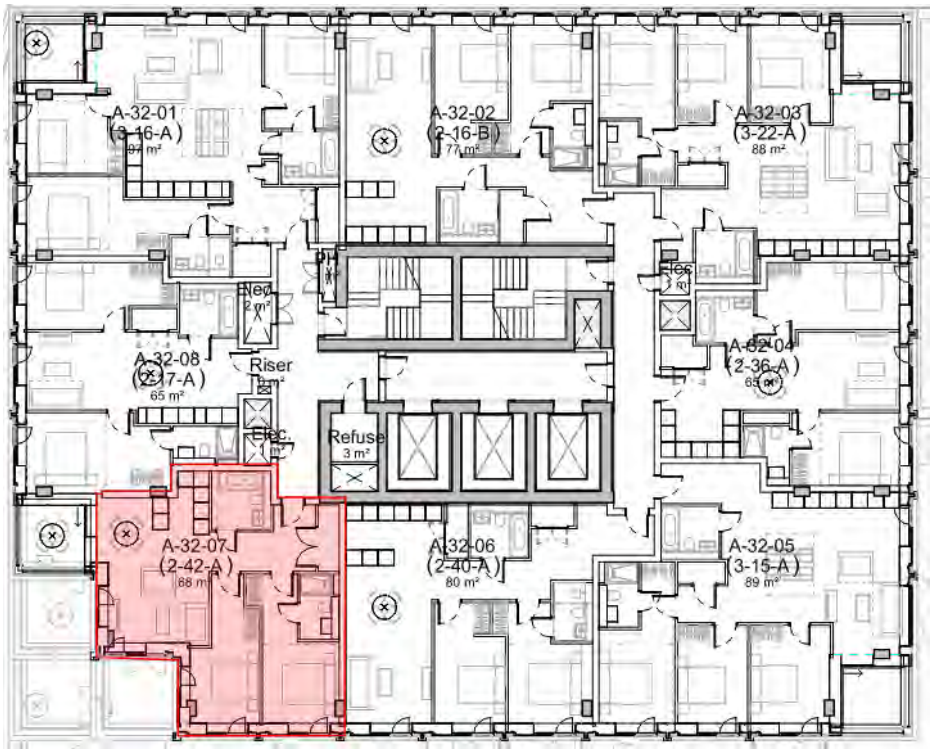


Figure 4: Apartments modelled at Level 32 Tower A

Acoustic proposals
As per advice from WSP Acoustics to demonstrate consideration with AVO we are restricting window opening times, which is not a TM59 requirement.

Following discussion with Manchester City Council and Environmental Health on 22/09/22 they have confirmed that daytime noise should be considered as part of the Acoustics ES chapter.

2. INTRODUCTION

This Design Development Note (DDN) has been produced to assess the overheating risk for a sample of apartments in the Leisure Box following on from discussions within the design team.

3. METHODOLOGY

The overheating study has been carried out in line with the recommendations made by the CIBSE documents 'TM52: 2013: The Limits of Thermal Comfort: Avoiding Overheating', and 'TM59 2017: Design Methodology for the Assessment of Overheating Risk in Homes'.
Compliance with TM59 is based on passing both of the following two criteria, as the homes are 'predominantly naturally ventilated, including homes that have mechanical ventilation with heat recovery (MVHR), with good opportunities for natural ventilation in the summer'. We shall be using the following:

- Criteria (a): For living rooms, kitchens and bedrooms: The number of hours during which the operative temperature of the space is above the adaptive temperature of the space by one-degree Kelvin during the period May to September inclusive shall not be more than 3% of occupied hours.
- Criteria (b): For bedrooms only: The operative temperature in the bedroom from 10pm to 7am shall not exceed 26°C for more than 1% of annual hours (i.e. 33 or more hours is a fail).

WSP utilised a dynamic simulation software package, the Virtual Environment (VE) suite from Integrated Environmental Solutions (IES) to perform overheating assessments according to CIBSE TM52 (2013) and TM59 (2017) guidance.

The sample size has been selected based on the guidance from the CIBSE TM59 document.
"Sample Size: Guidance – The assessment should try to identify all the dwellings that are at risk of overheating. These are likely to be those (a) with large glazing areas, (b) on the topmost floor, (c) having less shading, (d) having large, sun-facing windows, (e) having a single aspect, or (c) having limited optioning windows."

The IES models were developed based on the design received by Simpson Haugh architects on the 3rd October. The samples apartments were modelled in IES-VE software and tested for overheating according to TM59 methodology (sample floor/ apartment) shown in Figures 3-5, (views taken from IES model). These floor levels were assessed as considered "worst case" based on the façade detailing and massing of the site taking into account the adjacent buildings which have been modelled as shown below.



Figure 5: Apartments from Tower C at Level 19

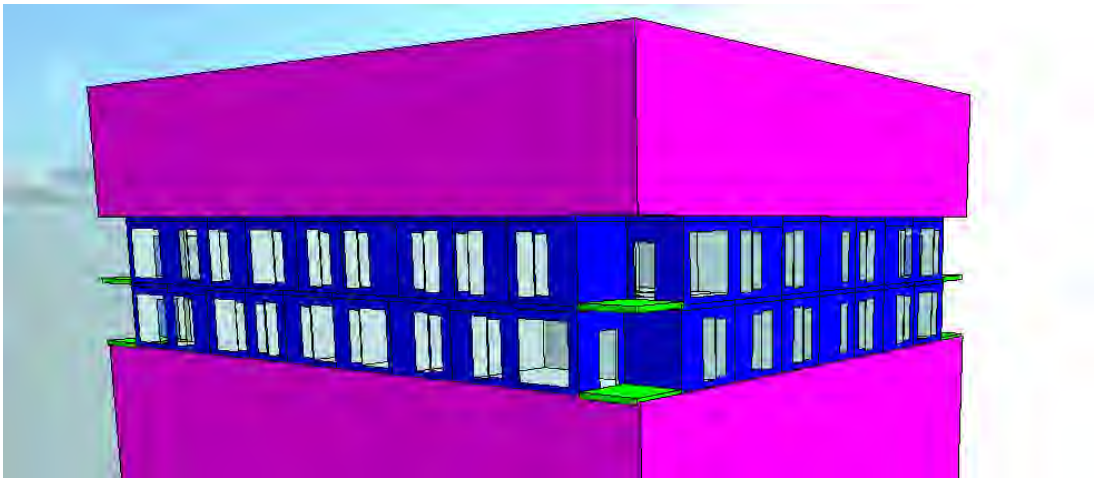


Figure 6: Apartments from Tower A at Levels 31 & 32.

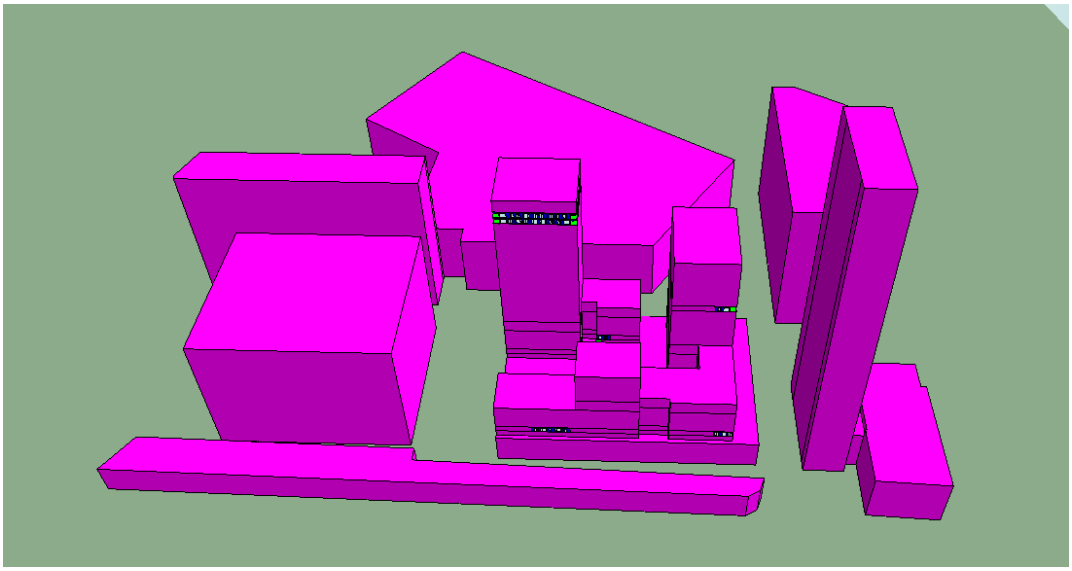


Figure 7: Leisure Box apartments with adjacent buildings.

MODELLING ASSUMPTIONS

Occupancy and equipment gains are specified by the TM59 guidance. For clarity, the following assumptions have been used and the proposals for purge vent openings are also detailed below:

Table 1 – Model assumptions – Residential

Assumptions	Target performance
Wall (W/m2. K) (including frame and thermal bridging)	0.17 W/m2K (650mm precast build-up).
Glazing G-value (all glazing areas excluding purge vents)	0.4
Glazing U-value (all glazing areas excluding purge vents) (W/m2. K)	1.5 - including glass, frame, and metal spandrel panels.
Balcony Door G-value (all glazing areas excluding purge vents)	0.4
Balcony Door U-value (all glazing areas excluding purge vents) (W/m2. K)	1.5
Balcony External Wall U (W/m2. K)	0.26
Floor plan	As per SHP Transmittal - 00066.pdf
Façade layout	As per SHP Transmittal - 00066.pdf
Angle of north	TBC in IES model (WSP)
Weather data	Manchester_DSY1_2020High50.epw
Bedroom ventilation (l/s)	8
Bathroom ventilation (l/s)	8
Kitchen/ diner ventilation (l/s)	13
Vent panel design	Glazed - open area in the façade with dimensions of 0.63m x 2.08m In IES these have been modelled as a grille on a semi exposed wall of a high-rise building with a G value of 0.2 and U value of 1.5 W/m2K including frame and infill solid panel.
Purge vent panel conditions	50% openable area with 0.4 coefficient of discharge
Bedroom ventilation opening hours profile	Only openable 7am-11pm when the temperature exceeds 22°C[1] (hours of opening advised by WSP Acoustics)

[1] Windows in each room should be controlled separately and modelled as open when both the internal dry bulb temperature exceeds 22°C and the room is occupied (as stated in section 3.3 of TM59 2017).

Living room ventilation opening profile	Only openable 7am-11pm when the temperature exceeds 22°C[2] (hours of opening advised by WSP Acoustics)
Blind shading coefficient	0.28
Blind operational profile	When incident solar irradiance exceeds 300W/m^2
Air Pemeability m3/h/m2 @ 50 Pa)	3

4. RESULTS

The following section sets out the results from the TM59 overheating study with acoustic considerations applied. Opening hours as specified above as defined by WSP Acoustics. Note that there is no TM59 criteria for closing windows at any time but windows in each room should be controlled separately and modelled as open when both the internal dry bulb temperature exceeds 22 °C and the room is occupied.

[2] Windows in each room should be controlled separately and modelled as open when both the internal dry bulb temperature exceeds 22°C and the room is occupied (as stated in section 3.3 of TM59 2017).

Table 2: TM59 results.

All apartments modelled pass with glazed purge panels (with a G value of 0.2).

Room Name	Criteria a	Criteria b	Passes TM59	Notes
	% Hours T_{op} Tmax >= 1°C	Hours between 10pm – 7am > 26°C (per annum)		
A-31-4 Bedroom 1	0.3	3	YES	
A-31-4 Kitchen/Living Room	0.4	2	YES	
A-31-10 Bedroom 1	0	0	YES	
A-31-10 Kitchen/Living Room	0	0	YES	
A-31-1 Bedroom 1	1	16	YES	
A-31-1 Bedroom 2	0.4	8	YES	
A-31-1 Kitchen/Living Room	0.4	5	YES	
A-31-2 Bedroom 1	0.1	2	YES	
A-31-2 Bedroom 2	0	0	YES	
A-31-2 Kitchen/Living Room	0.1	1	YES	
A-31-3 Bedroom 1	0.1	2	YES	
A-31-3 Bedroom 2	0.1	2	YES	
A-31-3 Kitchen/Living Room	0.7	4	YES	
A-31-6 Bedroom 1	0	0	YES	
A-31-6 Bedroom 2	0.1	2	YES	
A-31-6 Kitchen/Living Room	0.6	4	YES	
A-31-7 Bedroom 1	0	0	YES	
A-31-7 Bedroom 2	0	0	YES	
A-31-7 Kitchen/Living Room	0	0	YES	
A-31-8 Bedroom 1	0	0	YES	
A-31-8 Bedroom 2	0	0	YES	
A-31-8 Kitchen/Living Room	0	0	YES	
A-31-5 Bedroom 1	0.9	8	YES	
A-31-5 Bedroom 2	0.6	5	YES	
A-31-5 Kitchen/Living Room	0.6	3	YES	
A-31-9 Bedroom 2	0	0	YES	
A-31-9 Bedroom 2	0	0	YES	
A-31-9 Kitchen/Living Room	0	0	YES	

A-32-2 Bedroom 1	0	0	YES	
A-32-2 Bedroom 2	0	1	YES	
A-32-2 Kitchen/Living Room	0	0	YES	
A-32-4 Bedroom 1	0.2	3	YES	
A-32-4 Bedroom 2	0.2	3	YES	
A-32-4 Kitchen/Living Room	0	0	YES	
A-32-6 Bedroom 1	0	0	YES	
A-32-6 Bedroom 2	0	0	YES	
A-32-6 Kitchen/Living Room	0	0	YES	
A-32-8 Bedroom 1	0	0	YES	
A-32-8 Bedroom 2	0	0	YES	
A-32-8 Kitchen/Living Room	0	0	YES	
A-32-1 Bedroom 1	0	0	YES	
A-32-1 Bedroom 2	0.1	2	YES	
A-32-1 Bedroom 3	0	0	YES	
A-32-1 Kitchen/Living Room	0.1	2	YES	
A-32-2 Bedroom 1	0.2	3	YES	
A-32-2 Bedroom 2	0.4	5	YES	
A-32-2 Bedroom 3	0.4	5	YES	
A-32-2 Kitchen/Living Room	0.1	2	YES	
A-32-5 Bedroom 1	0	0	YES	
A-32-5 Bedroom 2	0.2	3	YES	
A-32-5 Bedroom 3	0	0	YES	
A-32-5 Kitchen/Living Room	0.3	2	YES	
A-32-7 Bedroom 1	0	0	YES	
A-32-7 Bedroom 2	0	0	YES	
A-32-7 Bedroom 3	0	0	YES	
A-32-7 Kitchen/Living Room	0	0	YES	
A5-05-04 - Bedroom 1	0	0	YES	
A5-05-05 -Bedroom 1	0	0	YES	
A5-05-05 - Bedroom 2	0	0	YES	
A5-05-10 - Bedroom 1	0	0	YES	
B-05-13 - Bedroom 1	0	0	YES	

B-05-13 - Bedroom 2	0	0	YES	
B-05-14 - Bedroom 1	0	1	YES	
C-05-01 - Bedroom 1	0	0	YES	
C-05-01 - Bedroom 2	0	0	YES	
C-05-10 - Bedroom 1	0.3	5	YES	
C-05-10 - Bedroom 2	0.1	2	YES	
C-05-14 - Bedroom 1	0	0	YES	
C-05-14 - Bedroom 2	0	0	YES	
C-19-03 - Bedroom 1	0.5	12	YES	
C-19-03 - Bedroom 2	0	0	YES	
C-19-03 - Kitchen/Living Room	0	0	YES	
C-19-05 - Bedroom 1	0	0	YES	
C-19-05 - Kitchen/Living Room	0	0	YES	
C-19-06 - Bedroom 1	0.1	2	YES	
C-19-06 - Bedroom 2	0	1	YES	
C-19-06 - Kitchen/Living Room	0.5	3	YES	
B-05-14 - Kitchen/Living Room	0.5	2	YES	
B-05-13 - Kitchen/Living Room	0.4	2	YES	
C-05-14 - Kitchen/Living Room	0	0	YES	
C-05-10 - Kitchen/Living Room	0.7	4	YES	
A-05-10 - Kitchen/Living Room	0.2	2	YES	
A-05-04 - Kitchen/Living Room	0	0	YES	
A5-05-05 - Kitchen/Living Room	0	0	YES	
C-05-01 - Kitchen/Living Room	0	0	YES	

5. PURGE VENTILATION OPENING HOURS

All apartments meet the proposed acoustic requirements (bedrooms – purge vents closed 11pm-7am and living rooms – closed 11pm-7am) and pass TM59.

The tables below present a further level of detail within the sample of apartments across levels 5,19, 31 and 32 (apartments chosen are shown in Figures 8 to 11). These show throughout a month, the hours that the purge vents are required to open to comply with TM59 requirements.

Please note that the below results are indicative and based on the dynamic simulation worst case scenario, the actual weather conditions and operational parameters will vary whilst the building is in use.

All windows open when the temperature exceeds 22°C.

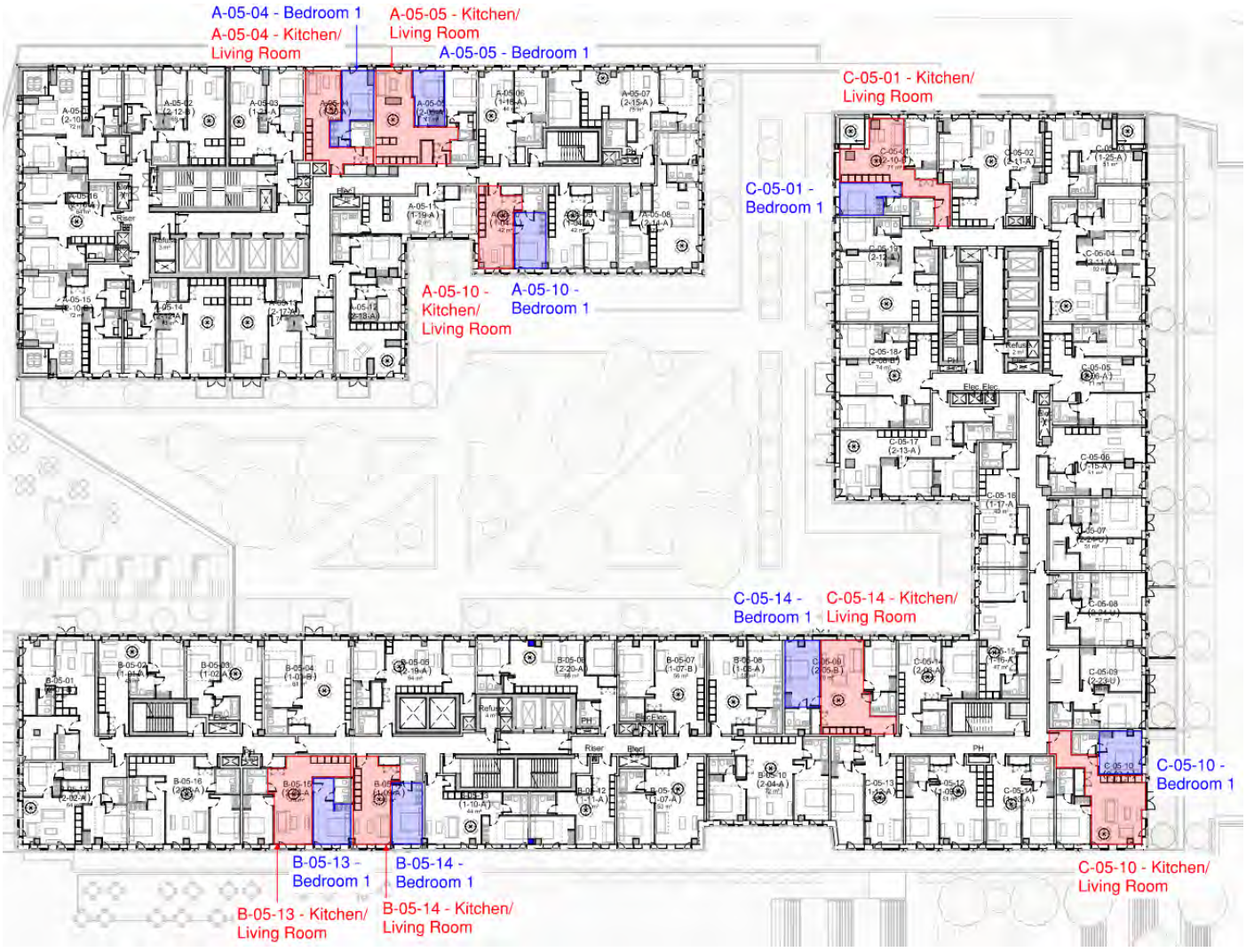


Figure 8: Sample apartments on Level 5

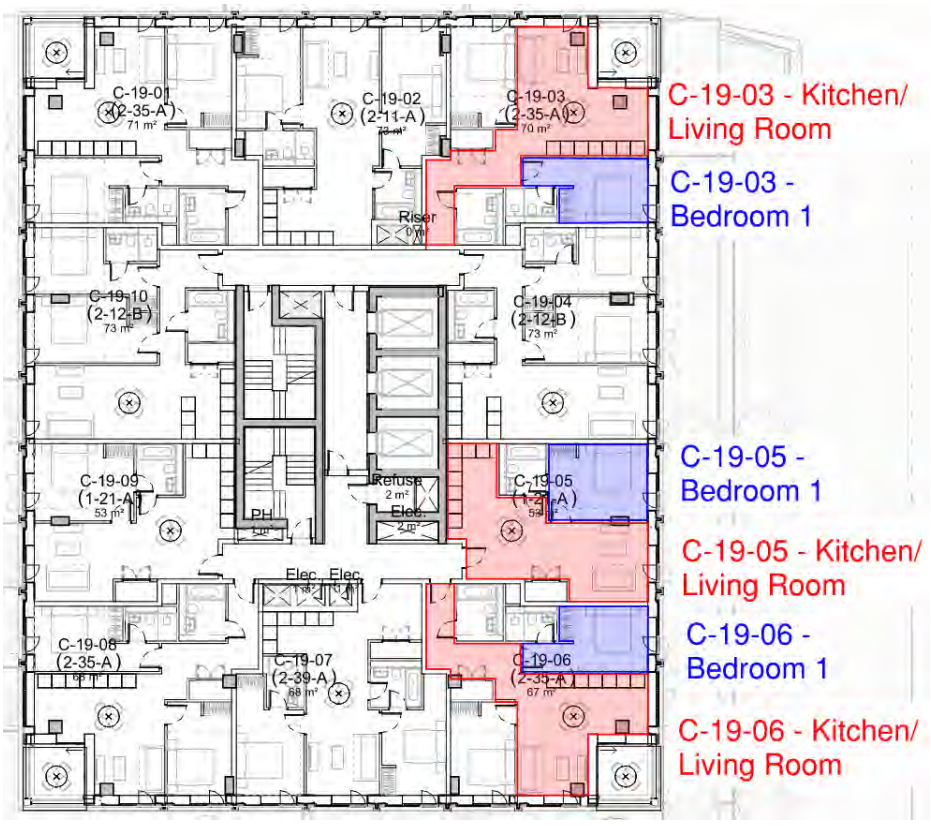


Figure 9: Sample Apartments at Level 19

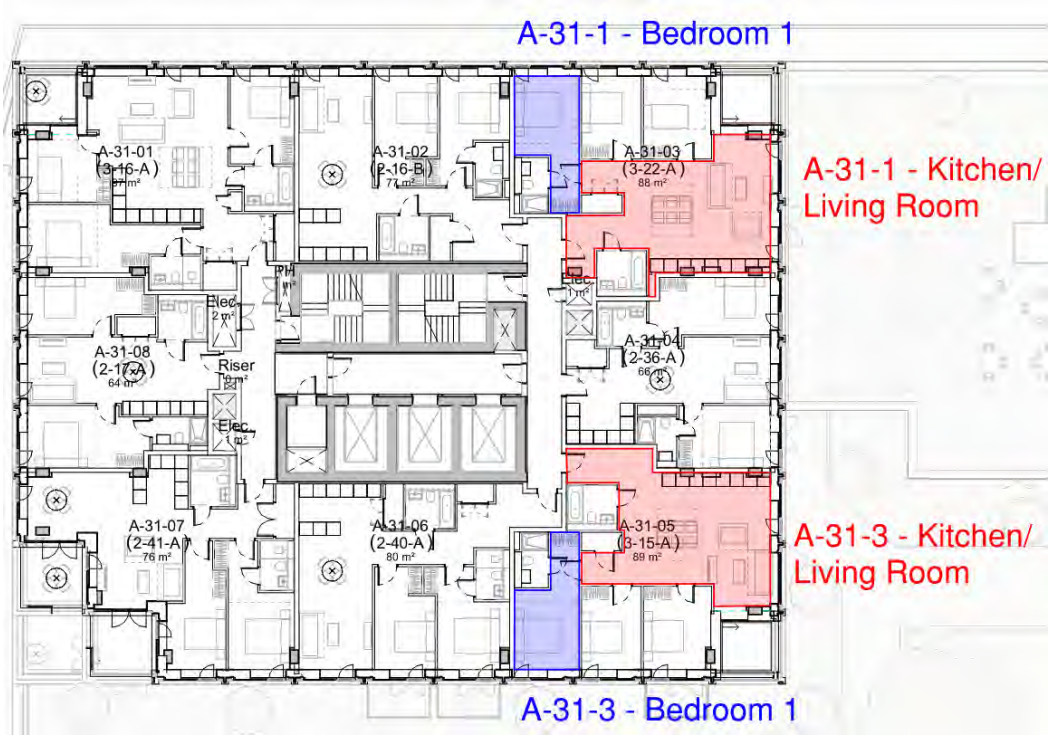


Figure 10: Sample Apartments at Level 31

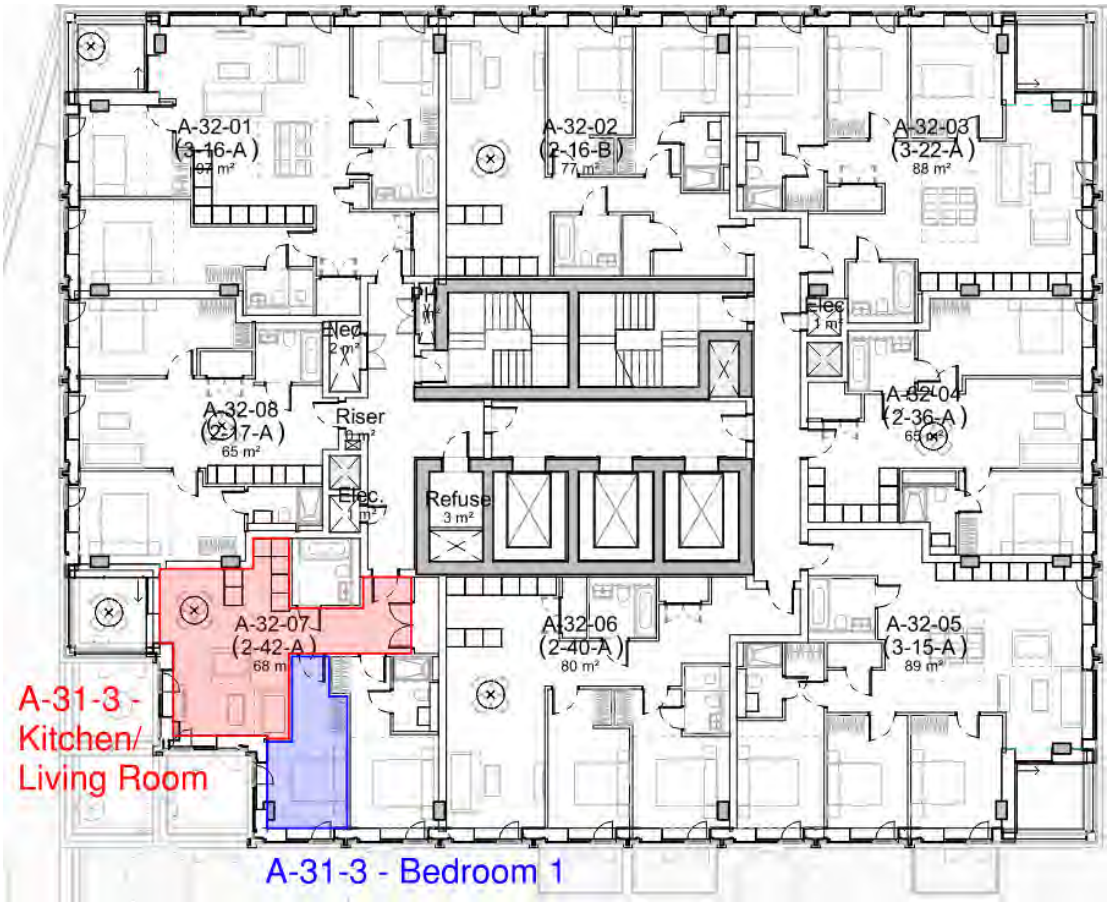


Figure 11: Sample Apartment at Level 32

Table 3 – TM59 Further Analysis – Window Opening Analysis

East Apartment 1 bed: A-05-04	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	11	10
June (30)	47	46
July (31)	77	82
Aug (31)	92	95
Sep (30)	27	24

East Apartment 2 bed: A-05-05	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	15	13
June (30)	50	46
July (31)	80	82
Aug (31)	93	94
Sep (30)	37	24

West Apartment 1 bed: A-05-10	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	0	6
June (30)	0	37
July (31)	0	79
Aug (31)	0	94
Sep (30)	0	16

West Apartment 1 bed: B-05-14	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	22	22
June (30)	53	53
July (31)	84	85
Aug (31)	93	96
Sep (30)	39	38

West Apartment 2 bed: B-05-13	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	23	21
June (30)	58	55
July (31)	85	86
Aug (31)	95	97
Sep (30)	46	42

East Apartment 2 bed: C-05-14	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	5	4
June (30)	38	33
July (31)	76	75
Aug (31)	93	93
Sep (30)	20	14

South West Apartment 2 bed: C-05-10	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	27	21
June (30)	51	34
July (31)	79	57
Aug (31)	82	63
Sep (30)	33	21

North East Apartment 2 bed: C-05-01	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	10	11
June (30)	42	44
July (31)	67	77
Aug (31)	81	85
Sep (30)	16	22

South Apartment 2 bed: C-19-03	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	36	28
June (30)	60	39
July (31)	80	70
Aug (31)	85	79
Sep (30)	53	40

South Apartment 1 bed: C-19-05	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	10	7
June (30)	39	41
July (31)	73	79
Aug (31)	90	93
Sep (30)	27	24

South West Apartment 2 bed: C-19-06	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	17	25
June (30)	46	54
July (31)	67	79
Aug (31)	73	86
Sep (30)	33	38

South East Apartment A-31-3	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	20	33
June (30)	51	59
July (31)	72	83
Aug (31)	73	88
Sep (30)	41	57

South West Apartment A-31-1	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	39	0
June (30)	64	0
July (31)	89	0
Aug (31)	98	0
Sep (30)	61	0

North West Apartment A-32-5	Kitchen/ Living Room	Largest Bedroom (Bedroom 1)
Month (days in month)	**% of hours purge panel is open between 7am and 11pm**	**% of hours purge panel is open between 7am and 11pm**
May (31)	24	11
June (30)	62	7
July (31)	84	73
Aug (31)	88	85
Sep (30)	47	26

6. CONCLUSION

In conclusion, all apartments comply with TM59, Tables 1 and 2 above.

As per advice from WSP Acoustics to show compliance with AVO we are restricting window opening times, which is not a TM59 requirement. As per this advice; Bedroom ventilation opening hours profile - Open 7am-11pm only (closed at all other times). Living room ventilation opening profile - Open 7am-11pm (closed at all other times).

Further, table 3 provides a breakdown of the % of hours in a month that the purge vent is required to be open to comply with TM59.

8 First Street
Manchester
M15 4RP

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