Prepared by the ESG Consultancy Group at CBRE Limited

CBRE

Energy Statement

Deal Ground & May Gurney, Bracondale, Norwich NR1 2EG

Reserved matters application proposal for
Serruys Property Co Ltd

June, 2023

Contents

Document Control

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Date of Issue:	16th June 2023	Version:	02
Document Reference:	Deal Ground_Energy Statement_v02	Status:	Final

Executive Summary

This Energy Statement has been prepared on behalf of Serruys Property Co Ltd ('the Applicant') in support of a reserved matters planning application for a mixed development consisting of a maximum of 670 dwellings. The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority.

The proposal seeks the approval of the reserved matters for the approval of siting, layout, appearance and landscaping for 670 dwellings pursuant to outline planning application (full details of access) for a mixed development consisting of a maximum of 670 dwellings; a local centre comprising commercial uses (A1/A2/A3): a restaurant/dining quarter and public house (A3/A4); demolition of buildings on the May Gurney site (excluding the former public house); an access bridge over the River Yare; new access road; car parking; flood risk management measures; landscape measures including earthworks to form new swales and other biodiversity enhancements including the re-use of the Grade II Listed brick Kiln for use by bats.

The ESG Consultancy Team of CBRE Limited have been commissioned to develop an energy strategy for the Application Site, including consideration of energy performance targets, in terms of carbon emissions, and inform design development for the proposed scheme design against relevant planning policies, technical guidance and legislation.

This Energy Statement outlines the key features and strategies adopted by the development team to enhance the energy performance of the proposed development.

The strategy for reducing energy use and associated carbon emissions through the design of the scheme follows the below Energy Hierarchy, namely:

- 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 by connecting to district heating networks;
- Be Green – maximise opportunities for renewable energy by producing, storing and using renewable energy on-site;

The following passive design and energy efficiency features will be implemented in the proposed strategy to reduce heat demand and energy use.

- Building fabric of high thermal performance, exceeding Part L 2021 standards.
- Robust construction details and insulation continuity for minimising thermal bridging and improving air tightness.

- External shading, in the form of balconies and deep window reveals, combined with solar control glass is proposed to limit solar gains and tackle the risk of overheating.
- Well insulated pipework for reducing distribution heat losses, thus reducing energy demand further.
- Light fittings of low energy types will be specified throughout the scheme.

An all-electric, fossil fuel free heating strategy, featuring Air Source Heat Pumps (ASHPs), is proposed for the new dwellings, to take advantage of the ongoing grid decarbonisation, thus allowing the development to become net zero carbon in due course. Photovoltaic (PV) panels, installed on roofs are also proposed for generating renewable energy on site.

An Overheating assessment has been carried out for the proposed scheme, against the Part O 2021 overheating criteria, outlining the strategy proposed to reduce the risk of overheating in the proposed dwellings.

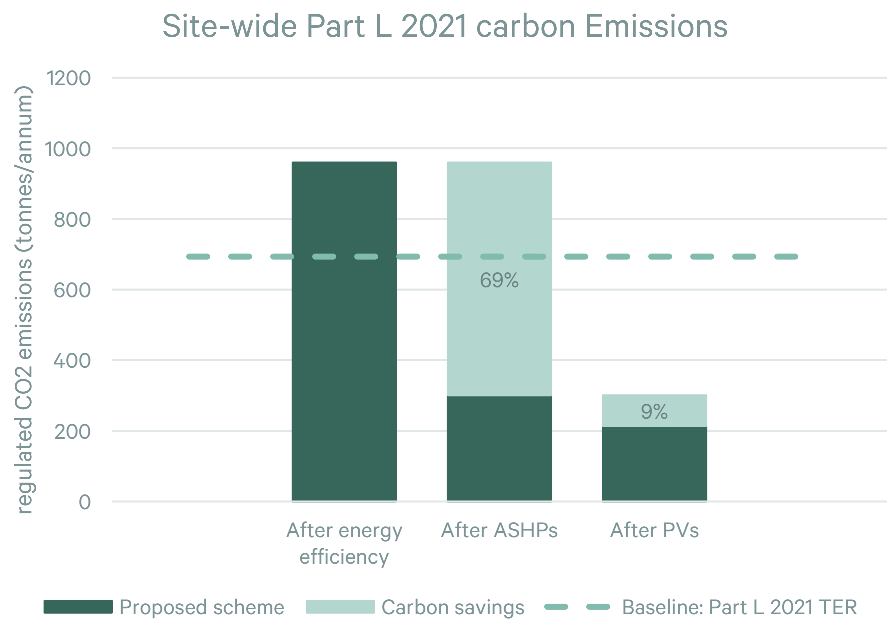
The following table demonstrates the overall reduction in regulated carbon emissions that can be achieved for the proposed development, following the energy strategy outlined in this report.

Table 1: Regulated carbon dioxide emissions (site-wide)

	Carbon emissions rate	
	$tnCO_2$ per annum	% Reduction from baseline
Baseline: Part L 2021 of the Building Regulations Compliant Development	693.5	-
Proposed scheme: After energy demand reduction & renewable energy	214.4	69%

The following figure shows the percentage reduction achieved as a result of the Low and Zero Carbon technologies proposed for on-site generation of renewable energy.

Figure 1: Carbon dioxide savings from LZC technologies



Introduction

This Energy Statement has been prepared on behalf of Serruys Property Co Ltd ('the Applicant') in support of a reserved matters planning application for a mixed development consisting of a maximum of 670 dwellings. The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority.

The ESG Consultancy Team of CBRE Limited have been commissioned to develop the energy strategy for the Application Site, including consideration of energy performance targets, in terms of carbon emissions, and informing design development for the proposed scheme design against relevant planning policies, technical guidance and legislation.

This Energy Statement outlines the key features and strategies adopted by the development team to enhance the energy performance of the proposed development.

The applicant

Serruys Property Co Ltd (hereafter referred to as 'the Applicant') is seeking reserved matters planning permission for a mixed development consisting of a maximum of 670 dwellings. The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority. The Applicant has appointed the ESG Consultancy Team of CBRE Limited (CBRE) to embed sustainability within the design proposal, working alongside the other CBRE colleagues also working on the scheme, namely planning and EIA.

Site description

The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority. The site lies within a mile of the City Centre and is 1km from Norwich Railway Station.

Proposed development

The proposal seeks the approval of the reserved matters for the approval of siting, layout, appearance and landscaping for 670 dwellings pursuant to outline planning application (full details of access) for a mixed development consisting of a maximum of 670 dwellings; a local centre comprising commercial uses (A1/A2/A3): a restaurant/dining quarter and public house (A3/A4); demolition of buildings on the May Gurney site (excluding the former public house); an access bridge over the River Yare; new access road; car parking; flood risk management measures; landscape measures including earthworks to form new swales and other biodiversity enhancements including the re-use of the Grade II Listed brick Kiln for use by bats.

Figure 2: Application Boundary shown in red

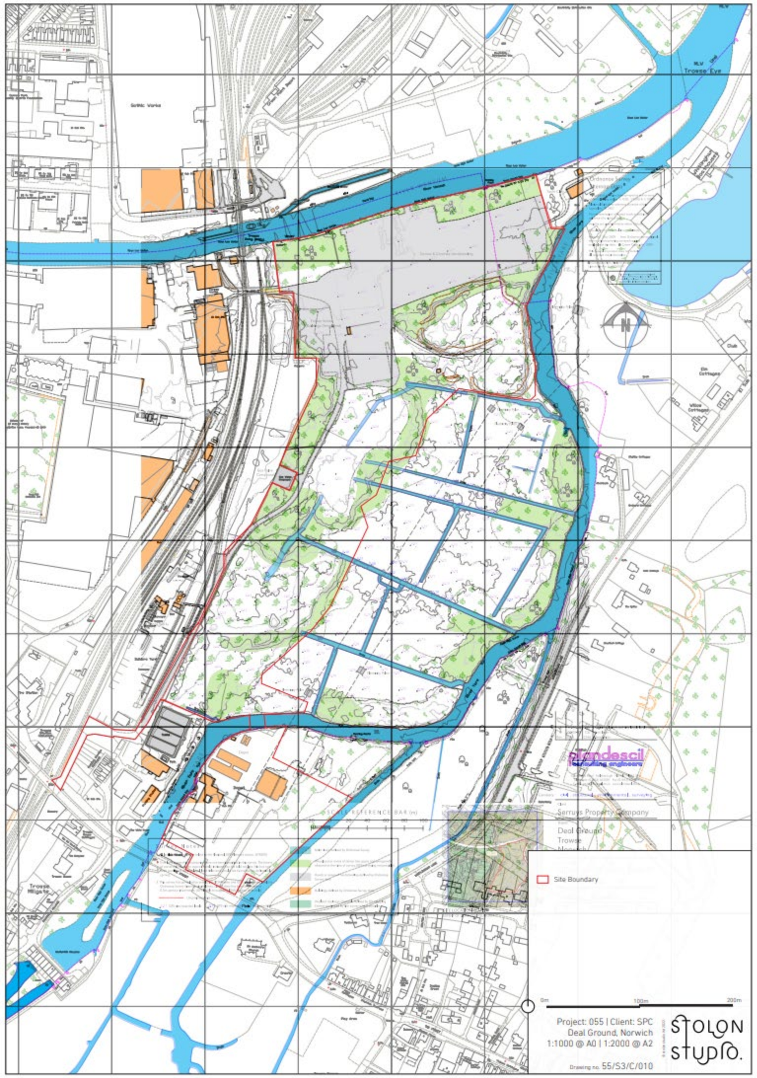


Figure 3: illustrative masterplan

Planning policy, legislation & technical guidance

Relevant planning policies

This section summarises the key legislative requirements, and the current and emerging planning policy requirements in the UK and Norwich City Council. It provides the legislative and regulatory planning context against which this Energy Statement appraises the proposed development.

National Policy

Energy White Paper, 2020

The Energy White Paper: Powering our net zero future (December 2020) is an energy policy in response to the increasing challenges faced by the UK, including climate change, decreasing domestic supplies of fossil fuel and escalating energy prices. The Energy White Paper puts the net zero carbon emissions target and UK's effort to fight climate change at its core, setting the following priorities:

- Transform the energy sector to cut UK's carbon dioxide emissions – the main contributor to global warming;
- Support a green growth of the economy, providing green jobs in new green industries;
- Secure supply and protect the fuel poor.

HM Government National Planning Policy Framework (NPPF), 2021

In respect to sustainability, the document retains its focus for the role that the planning system has to play in meeting the challenges presented by climate change. As stated in Paragraph 152:

"The planning system should support the transition to a low carbon future in a changing climate...It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure."

At Paragraph 154 it continues to state:

"New development should be planned for in ways that:

– *avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure; and,*
– *can help to reduce greenhouse gas emissions, such as through its location, orientation and design. Any local requirements for the sustainability of buildings should reflect the Government's policy for national technical standards."*

Regional Policy

Joint Core Strategy for Broadland, Norwich and South Norfolk, 2011

This Joint Core Strategy (JCS), prepared by the three councils of Broadland, Norwich and South Norfolk, working together with Norfolk County Council as the Greater Norwich Development Partnership (GNDP), sets out the long-term vision and objectives for the area, including strategic policies for steering and shaping development.

The strategy sets out the policies addressing climate change and promoting sustainability with the aim to:

- locate development in places that will minimise adverse impact on the environment, and ensure it is designed to be energy efficient and capable of being adapted as circumstances change
- use energy and water wisely and secure more energy from renewable sources

Policy 3: Energy and water sets the below targets with regards to energy efficiency:

- aim to minimise reliance on non-renewable high-carbon energy sources and maximise the use of decentralised and renewable or low-carbon energy sources and sustainable construction technologies, providing at least 10% of the scheme's expected energy requirements.

The policies within the JCS relating to environmental performance and sustainable construction are listed under Appendix A of this document.

Local Policy

Norwich Local Plan: Development Management Policies plan, 2014

The Norwich Local Plan: Development Management Policies provides detailed planning policies to help deliver the JCS strategic policies, objectives and priorities.

In particular, the DM policies plan includes a range of policies, primarily in Policies DM1 - Achieving and delivering sustainable development, DM3 - Design principles and DM4 - Renewable energy, that respectfully deal with matters relating to sustainable design and construction, energy efficiency and greenhouse gas reduction. Policy DM2 - Amenity relates to future occupiers' health and wellbeing, with particular regard given to high standard of amenity for satisfactory living and working conditions. Future proofing the proposed development against rising temperatures and tackling the risk of overheating falls within this policy requirements.

South Norfolk Local Plan: Development Management Policies document, 2015

The Development Management Policies will determine how the Council carries out its development management responsibilities to promote sustainable development.

Policy DM 3.8 'Design Principles applying to all development' sets high quality standards for new developments in terms of scale, massing, materials etc. Optimum building orientation needs to be considered for developments to benefit from sunlight and passive solar energy.

Policy DM 4.1 Renewable Energy supports maximising use of renewable energy technologies on site for reducing carbon emissions further,

Relevant legislation

HM Government Climate Change Act (2008), Chapter 27, with 2022 amendments

The Act sets out emission reduction targets that the UK must comply with legally. It represents the first global legally binding climate change mitigation target set by a country and, following a 2022 revision, requires the UK to bring all greenhouse gas emissions to at least 100% lower than the 1990 baseline, by 2050.

The "1990 baseline" means the aggregate amount of-

- Net UK emissions of carbon dioxide for that year, and
- Net UK emissions of each of the other targeted greenhouse gases of the year that is the base year for that gas.

HM Government Building Regulations Approved Document: L, Conservation of fuel and power, 2021 edition with 2023 amendments

Approved Document Part L (2021, England edition) is the Building Regulation relating to the conservation of fuel and power in buildings. The Approved Document is separated into two sections: Volume 1 and Volume 2. Volume 1 relates to new and existing dwellings and Volume 2 relates to buildings other than dwellings. Part L of the Building Regulations is the mechanism by which government is driving reductions in the regulated CO_2 emissions from new buildings.

Guidance for new buildings is given in Sections 1 to 9 of Part L, Volumes 1 & 2. This should be checked with the Building Control Body (BCB) to confirm that they meet the energy efficiency requirements.

The Amendment Regulations and accompanying Approved Document L have come into force on 15 June 2022. Part L 2021 proposes an interim reduction in carbon emissions, paving the way for greater reductions and supporting wider adoption of heat pumps in 2025. This is backed up from the recent 'Mission Zero' Chris Skidmore Net Zero review detailing the importance of regulation to enable rapid and safe introduction of emerging net zero technologies.

Part L 2021, relating to the conservation of fuel and power in buildings, applies to all components of the proposed development with regards to energy efficiency requirements and carbon emissions.

HM Government Building Regulations Approved Document: O Overheating, 2021 edition

Approved Document Part O (2021, England edition) is the Building Regulation with regards to mitigating the risk of overheating in new residential buildings.

The aim of Part O requirement is to protect the health and welfare of occupants of the building by reducing the occurrence of high indoor temperatures. Compliance with Part O can be demonstrated to building control bodies by using one of the following methods:

a. The simplified method for limiting solar gains and providing a means of removing excess heat,

b. The dynamic thermal modelling method.

All dwellings at the Proposed Development will, therefore, be assessed in accordance with the Building Regulations Part O, 2021 edition.

Energy assessment

Background

The Climate Change Act 2008 sets legally binding greenhouse gas emission reduction targets to reduce UK emissions by at least 100% of 1990 levels by 2050 (with interim targets of 37% by 2020, 51% by 2025 and 78% by 2035) and has positioned the UK on a transition pathway to a low-carbon economy.

All regions within the UK must face up to the reality of climate change and the need to limit their future contribution to this major global problem. The effects of the climate emergency are already being felt across the UK both in cities and rural areas. Developments urgently need to build resilience into its proposals and adapt to these changes, whilst also mitigating its own contribution to carbon emissions. In July 2019, Norwich City Council declared a climate emergency and set a target for the borough to reach net zero emissions by 2030.

To support these ambitions and requirements the proposed development identifies measures to contribute to being developed and operated to Net Zero Carbon (NZC) standards.

Energy Assessment

This section presents the energy assessment carried out for the proposed development and outlines the energy strategy developed, in line with the Council and Part L requirements. The assessment shows how significant carbon savings can be achieved by integrating energy efficiency measures and using renewable energy technologies on site.

The energy calculations presented in this report will need to be continually updated through the detailed design stages to reflect any changes. The energy analysis presented here should be treated as preliminary information based on the currently available data.

Building Regulations Approved Document L

On 15 June 2022, national building regulations were updated to enhance energy performance standards for new buildings through Approved Document Part L (2021, England edition).

The proposed dwellings will therefore be designed to exceed the requirements of the Approved Document L, Volume 1, in terms of carbon emissions, fabric energy efficiency and primary energy use. The non-domestic elements will be designed to exceed the requirements of the Approved Document L, Volume 2, in terms of carbon emissions and primary energy use.

Energy Modelling

The Standard Assessment Procedure (SAP 10.2) was used to assess the energy performance of the proposed residential units, in terms of regulated energy consumption and energy use for equipment and cooking appliances. The energy assessment of the scheme's non-domestic elements was carried out in line with the National Calculation Methodology (NCM), using IES VE software for Dynamic Simulation Modelling. The SAP 10.2 carbon emission factors have been used in this energy assessment, to consider the ongoing grid decarbonisation.

This energy assessment has been completed by the ESG Consultancy Group's accredited On Construction Domestic Energy Assessors and Low Carbon Energy Assessors. The model geometry was based on the planning drawings (Issue 06.05.2023) received from Stolon Studio Architects.

Appendix D provides SAP 10 worksheets and the BRUKL output document for representative units.

Baseline Carbon Emissions

The Part L Target Emission Rate (TER) has been used to determine the regulated CO_2 emissions baseline. The following tables present the baseline CO_2 emission rate and other Part L energy performance targets, set for the proposed development on the basis of the energy modelling carried out at this stage.

Table 2: Baseline carbon dioxide emissions

Regulated carbon dioxide emissions ($tnCO_2$ per annum)	Domestic elements	Non-Domestic elements
Total Floor Area (sqm)	57,032	1,974
Baseline: Part L 2021 of the Building Regulations Compliant Development	672.2	21.2

Table 3: Part L notional building targets

Energy performance of notional building	Domestic elements	Non-Domestic elements
Target primary energy rate	62.48 kWh_{PE}/m^2	115.11 kWh_{PE}/m^2
Target emission rate	11.8 $kgCO_2/m^2$	10.8 $kgCO_2/m^2$
Target fabric energy efficiency rate	34.7 kWh/m^2	n/a

Energy Hierarchy

The energy strategy proposed for the development follows the below Energy Hierarchy, prioritising demand reduction and energy efficiency measures to low carbon heat provision and renewable energy generation.

Table 4: The 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

Reduce energy demand

At the first step of the Energy Hierarchy, the energy demand of the scheme should be reduced through passive design measures, such as optimising the buildings' orientation and form, and specifying building fabric of high thermal performance. The proposed energy strategy follows a fabric first approach, thus integrating the following passive design measures.

Building orientation

Orientation varies across the proposed development. In principle, the proposed design aims to provide all residential areas with adequate levels of daylight for enhanced visual comfort and sunlight for passive heating in winter. Glazing areas, in particular on south and west facades that are more sensitive to solar gains and have a higher risk of overheating, have been optimised, to balance heat losses, solar gains and daylighting.

Building form

Simplified and compact building forms provide lower surface areas and less thermal junctions, compared to irregular forms. As a result, heat losses either through the envelope surface or element junctions are reduced thus reducing heating demand. The proposed design aims to avoid complex, irregular forms, where possible, to reduce energy demand.

Passive solar design & daylight

The make-up of the proposed façades have been optimised to balance the proportion of glazing to solid wall, thus providing optimum amount of daylight and winter solar heating, while limiting excessive solar gains in summer. External shading in the form of balconies and deep window reveals, combined with high performance glass is proposed throughout the scheme for additional solar control.

An Overheating Assessment has been completed by CBRE Ltd (Appendix B), showing that, as a result of the proposed passive design measures, the risk of overheating in the assessed dwellings can be reduced considerably in line with Part O 2021.

Building fabric

Building fabric of enhanced thermal properties is proposed for the scheme to reduce heat losses as far as practical and cut energy demand for heating. Low U-values, exceeding the Part L standards, and robust construction details are proposed to reduce heat losses further.

Eliminating thermal bridging is critical for reducing heat demand and complying with the Part L Fabric Energy Efficiency Target. The Part L guidance in limiting thermal bridging by applying insulation continuously, thus avoiding any breaks, and using less conductive materials, will be followed to achieve a low y value.

Certified thermal details and products should be used to ensure building fabric is designed to the highest standards. At this stage, performance targets following Government approved details (Scottish Building Standards) have been used with regards to psi-values.

Airtightness

Robust construction details will be also used to reduce heat losses through infiltration, thus improving the buildings' air tightness. An air permeability rate of 4 m^3/m^2hr @50Pa is targeted for the scheme at construction.

Performance targets

The tables below list the key targets with regards to the building fabric thermal performance, as assumed in the energy assessment. Achieving the below targets will reduce the energy demand prior to considering additional energy efficiency measures and renewable energy technologies for the proposed development.

Table 5: Proposed building fabric specifications - Domestic

Domestic elements		
U-value [W/m²K]	Walls	0.15 – Exposed walls 0.20 – Semi exposed walls (adjacent to unheated communal areas) 0.20 – Ashlar walls (under eaves) 0.00 – Party walls (for a fully filled cavity with effective sealing at all exposed edges and in line with insulation layers in abutting elements)
	Floor	0.13 – Ground floor, First floor (above unheated areas) & Exposed floor elements
	Roof	0.10
	Windows	1.20 – g-value: 0.50
	Doors	1.00 (Solid entrance doors)
Air permeability	5 m^3/m^2hr @50Pa	
Thermal bridging	Appendix E psi-values have been assumed at this stage for the proposed development. These are based on Government approved details (Scottish Building Standards).	

Table 6: Proposed building fabric specifications – Non-Domestic

Non-Domestic elements		
U-value [W/m²K]	Walls	0.15
	Floor	0.13
	Roof	0.10
	Windows	1.20 – g-value: 0.40
	Doors	1.00 (Solid entrance doors)
Air permeability	5 m^3/m^2hr @50Pa	

Use energy efficiently

After reducing energy demand, the next step is to use energy efficient building services systems, low energy lighting and energy saving controls to reduce fuel consumption.

Space Heating and Hot Water

An all-electric, fossil fuel free heating strategy, using heat pumps, is proposed to take advantage of the ongoing grid decarbonisation, thus allowing the development to become net zero carbon in due course.

Individual Air Source Heat Pumps (ASHPs) are proposed for the houses to provide both space heating and domestic hot water. A communal energy centre with ASHPs is proposed for each apartment block to provide low carbon heat. To estimate carbon savings from ASHPs, gas-fired boilers are assumed at this stage.

Ventilation

Dwellings will rely on natural ventilation with intermittent extract fans for maintaining indoor air quality, in line with Part F 2021 Volume 1 requirements.

Building services insulation

The hot water distribution network, including any hot water tanks and internal pipework, will be insulated to high standards to reduce heat losses. This is critical not only for reducing energy demand but also reduce heat gains from pipework in summer that could potentially increase the risk of overheating.

Allowance for the remaining system pipework losses will be accounted for within the final heat source selection and sizing. Heat losses from the LTHW distribution network will be calculated in detail at next stage once the details of the final pipework configuration are established.

Lighting

Low energy light fittings of LED types will be used within the dwellings and also in all communal areas. PIR sensors will be provided in communal areas to reduce energy consumption further.

Commercial units

The energy assessment of the commercial units has been carried out on the basis of Shell and Core development. Reasonable assumptions have been made at this stage, regarding the efficiencies of services that will be installed during first fit-out work, in the calculation of the building primary energy rate and building emission rate.

Commercial units are assumed to be served by reverse cycled heat pumps, e.g. in the form of a Variable refrigerant Flow (VRF) system or DX split units, to provide space heating and comfort cooling. Direct electric water heaters are assumed for hot water supply. The units are assumed to rely mostly on natural ventilation with mechanical ventilation provided in back of house areas in the form of extract ventilation e.g. in toilets and kitchen facilities. Low energy light fittings is assumed for all spaces, including display lighting, and energy saving lighting controls, such as PIR sensors in secondary areas e.g. toilets and daylight sensors in front of house areas.

Performance targets

The tables below list the key performance targets with regards to energy efficiency, for the domestic and non-domestic elements separately.

Table 7: Proposed building services specifications - Domestic

Domestic elements	
Space heating & DHW	Houses: Individual ASHPs (SAP default SCOP) with thermal storage (Assumed volume: 300L & Heat loss rate <2.36kWh/24h)
	Flats: Heat Interface Units (HIUs) installed in each flat, fed by a communal energy centre using ASHPs SCOP: 3.0 A distribution loss factor of 1.23 has been assumed at this stage.
Heating controls	Houses: Time and Temperature zone control
	Flats: Charging system linked to use of community heating, with programmer and TRVs
Water usage	Dwellings to achieve a water use target less than 105 litres/person/day Showers: 9 litres/min assumed at this stage
Ventilation	Natural ventilation with intermittent extract fans
Lighting	All light fittings will be dedicated low energy types i.e. LED fittings (Notional building specifications have been used at this stage)

Table 8: Proposed building services specifications – Non-Domestic

Non-Domestic elements (Shell & Core)	
Heating & Comfort cooling	A VRF system is assumed to provide space heating and comfort cooling within each commercial unit SCOP 4.0 / SEER 5.50/ EER 3.5
Hot water	Hot water in the commercial units will be provided by point of use 100% efficient electric heaters
Ventilation	Extract ventilation assumed in the following areas: Kitchen: 20ACH (SFP: 0.8 W/l/s) Toilets: 10ACH (SFP: 0.4 W/l/s)
Metering	All systems and lighting systems have provision for metering that warns “out of range” values
Power factor	>0.95
Lighting	All light fittings will be dedicated low energy types i.e. LED fittings General lighting: 100 luminaire lm/W Display lighting: 80 luminaire lm/W (with time switch) PIR sensors (Auto on/off) in BOH areas (toilets, circulation) Daylight sensors in main areas

Overheating & Cooling assessment

The proposed design follows the below cooling hierarchy to reduce the risk of overheating and therefore demand for active cooling.

Table 9: The Cooling Hierarchy

1	reduce the amount of heat entering a building through orientation, shading, high albedo materials, fenestration, insulation and the provision of green infrastructure
2	minimise internal heat generation through energy efficient design
3	manage the heat within the building through exposed internal thermal mass and high ceilings
4	provide passive ventilation
5	provide mechanical ventilation
6	provide active cooling systems.

Measures to eliminate the risk of overheating have been considered and will be integrated in the design of the new dwellings. The following will be applied to maintain thermal comfort during summer within the main living areas:

- Openable windows throughout the day to allow for natural ventilation.
- Windows can be also left open during the night to allow for night-time cooling i.e. cool down the structure by taking advantage of lower external temperatures at night.
- Ground floor windows and windows in accessible rooms will be designed secure so they can be left open at night or when unoccupied.
- Tenants will be advised to purchase A-rated appliances of low energy consumption to reduce internal heat gains. Energy efficiency light fittings that emit less heat than standard types thus reducing overheating will be also specified.

An Overheating Assessment, presented in Appendix B, has been carried out for the proposed scheme against the Part O 2021 overheating criteria. Results show that all assessed unit types comply with the overheating criteria.

Non-regulated energy use

The energy consumption and associated carbon emissions for non-regulated end uses have been calculated at this stage, using SAP 10 and the NCM for the domestic and non-domestic elements respectively. The carbon emission rate due to the small power, cooking and other appliances is circa 360 $tnCO_2$.

The following strategies are proposed to reduce non-regulated energy use in dwellings:

- Kitchens should be fitted out with energy efficient A-rated appliances or, alternatively, information about high efficiency appliances should be provided to future occupants.
- Installation of energy meters with display monitors, for encouraging occupants to become more interested and involved in how energy is being used in their house.
- Information should be provided to occupants explaining best practice operation of the installed systems to reduce the energy costs and carbon emissions.

It is estimated that proposed strategies may reduce unregulated carbon emissions by at least 10%. However, at this stage, this can only be an assumption as small power consumption depends mainly on occupant’s behaviour.

Heating infrastructure

Once demand for energy has been minimised, the next step of the Energy Hierarchy is about exploiting local energy resources (such as secondary heat) and supplying energy efficiently and cleanly to reduce CO_2 emissions further. The opportunity to connect to a local district heating network, for providing low carbon heat to the proposed development, has been explored by the team.

Given that a heat network is not currently available in close proximity to the proposed site, an all-electric heating system using heat pumps is proposed for providing low carbon heat and take advantage of the ongoing grid decarbonisation, for achieving net zero carbon in the long term.

Renewable energy

Low and zero carbon systems, generating renewable energy on site, have been considered to further reduce carbon emissions, in line with the Council's policies. A feasibility study of the following renewable energy technologies has been completed at this stage:

- Biomass Boilers;
- Wind Turbines;
- Heat Pumps (Ground/Water/Air);
- Solar Hot Water Heating;
- Photovoltaic panels.

Air Source Heat Pumps (ASHPs) and Photovoltaic (PV) panels were identified as the most appropriate technologies for this site. Appendix C of this report provides brief commentary on the technologies not considered suitable for the scheme.

Air Source Heat Pumps

Individual ASHPs and communal energy centres using ASHPs are proposed for the houses and apartment blocks respectively to provide low carbon heat. Commercial units are assumed to have reverse-cycled heat pumps for providing both space heating and comfort cooling when required.

ASHPs work by absorbing heat from the outside air and transferring it to a fluid, which is compressed to increase its temperature. This heat is then transferred from the compressed fluid into the central heating system, to use for both heating and hot water.

At detailed design stage, the external plant will be designed such that the noise levels from the ASHP units will be in accordance with relevant industry standards to reduce or eliminate any noise pollution.

The system will comply with the minimum performance requirement set out in Enhanced Capital Allowance. The end user will be provided with detailed information on how to control and operate the system in the most efficient way.

Table 10: Proposed renewable energy technology (ASHPs)

Low Zero Carbon technologies		
Air Source Heat Pumps (ASHPs)	**Heating fuel**	Electricity
	SCOP	3.0 – Dwellings 4.0 – Commercial units

Photovoltaic panels

Installation of Photovoltaic panels, mainly on flat roofs and pitched roof areas facing due south, is proposed for all the houses and apartment blocks. Where possible, the PV installation will be maximised, considering though the following restrictions:

- Parts of the apartment blocks' available roof area will be occupied by the energy centre hosting the outdoor ASHP and other plant units.
- Adequate space from the roof edge should be provided for safety and access, and also avoiding overshadowing from the roof parapet.
- When installed on flat roofs, PVs should be installed at a distance from any surrounding roof features that may overshadow them, such as plant screens, stair landings, lift and riser shafts, flues etc. Enough space should be also allowed between successive rows to avoid overshadowing and allow for access.

At next stage a MCS accredited team should be consulted to ensure the output of the PV array is maximised by optimising the location and orientation of the PVs and using the most efficient panels available in the market. The system's layout should consider local health and safety requirements, including accessibility requirements for system maintenance, cleaning the modules, and carrying out maintenance on any of the components. The following table shows this stage assumptions regarding PVs, as used in SAP. Appendix E shows a breakdown of the proposed PV arrays per house type and apartment block.

The energy output of the PV panels, circa 618 MWh, will be used to meet the energy demand of the houses and the energy demand of the blocks' communal energy centre. PV panels will offer carbon savings of circa 86 tnCO_2 per year.

Table 11: Proposed renewable energy technology (PVs)

Low Zero Carbon technologies		
Photovoltaic (PV) panels	**Size**	1.00 m x 1.70 m
	Output	350 Wp
	Orientation	Varies, majority due SE/SW
	Inclination	10 degrees (Flats) 30-45 degrees (Houses)
Proposed PV arrays	**No. PVs**	581 no. total – apartment blocks 2,040 no. total – houses
	Total area	4,456 m^2
	Total output	917kWp

Carbon Savings

In order to demonstrate that the energy hierarchy has been followed and that, accordingly, reduction in energy demand has been prioritised over the use of low and zero carbon energy, it is necessary to show the carbon reduction achieved both before and after the provision of low and zero carbon energy separately. The baseline for the carbon reduction is the relevant TER.

The following table demonstrates the overall reduction in regulated carbon emissions that can be achieved for the proposed development. An overall reduction of 70% over the Part L 2021 target emission rate could be achieved by integrating the recommended energy efficiency measures and renewable energy technologies to the proposed design.

Table 12: Regulated carbon dioxide emissions (site-wide)

	Carbon emissions rate	
	$tnCO_2$ per annum	% Reduction from baseline
Baseline: Part L 2021 of the Building Regulations Compliant Development	693.5	-
Proposed scheme: After energy demand reduction & renewable energy	214.4	69%

The following figure shows the percentage reduction achieved as a result of the Low and Zero Carbon technologies proposed for on-site generation of renewable energy.

Figure 4: Carbon dioxide savings from LZC technologies

The following table demonstrates that the proposed development complies with the Approved Document L, Volumes 1 & 2 energy performance targets.

Table 13: Part L, Volume 1 compliance

Domestic elements	Target	Proposal
Primary energy rate	62.48 kWh_{PE}/m^2	38.95 kWh_{PE}/m^2
Emission rate	11.8 $kgCO_2/m^2$	3.4 $kgCO_2/m^2$
Fabric energy efficiency rate	34.7 kWh/m^2	33.6 kWh/m^2

Table 14: Part L, Volume 2 compliance

Non-domestic elements	Target	Proposal
Primary energy rate	115.11 kWh_{PE}/m^2	112.57 kWh_{PE}/m^2
Emission rate	10.76 $kgCO_2/m^2$	10.42 $kgCO_2/m^2$

Conclusion

In summary, this Energy Statement confirms that the proposed design incorporates the energy efficiency features required to comply with the current planning policy requirements of the Norwich Local Plan.

A summary of the key energy efficiency features and LZC technologies proposed for the development is detailed below. As a result, the scheme could achieve a 69% reduction over Part L 2021 target emission rate.

Table 15: Energy Strategy – Key features

Passive design

- High performance building fabric
- Robust construction details, for reducing thermal bridging
- Low airtightness
- Optimised glazing to wall ratios, for reducing solar gains

Energy efficiency

- All-electric systems, taking advantage of ongoing grid decarbonisation for achieving NZC
- LED light fittings
- Well insulated pipework, for reducing distribution losses and heat demand

Renewable technologies

- Air Source Heat Pumps, for low carbon heating
- Photovoltaic Panels, for on-site energy generation

Appendix A – Planning policies

This section details the key legislative, and the current and emerging planning policy requirements of Norwich City Council. It provides the legislation and regulatory planning context against which this Energy Statement appraises the proposals.

Joint Core Strategy for Broadland, Norwich and South Norfolk (2011)

– Policy 3: Energy and water

Norwich development management policies local plan (2014)

– Policy DM1: Achieving and delivering sustainable development
– Policy DM2: Ensuring satisfactory living and working conditions
– Policy DM3: Delivering high quality design
– Policy DM4: Providing for renewable and low carbon energy

South Norfolk Local Plan: Development Management Policies Document (2015)

– Policy DM 3.8 Design Principles applying to all development
– Policy DM 4.1 Renewable Energy

Appendix B – Overheating Assessment

Prepared by the ESG Consultancy Group at CBRE Limited

CBRE

Overheating Assessment

Deal Ground & May Gurney, Bracondale, Norwich NR1 2EG

Reserved matters application proposal for
Serruys Property Co Ltd

June, 2023

Contents

Document Control

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Date of Issue:	16th June 2023	Version:	02
Document Reference:	Deal Ground_Overheating Assessment_v02	Status:	Final

Executive summary

This Overheating Assessment has been prepared on behalf of Serruys Property Co Ltd ('the Applicant') in support of a reserved matters planning application for a mixed development consisting of a maximum of 670 dwellings. The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority.

The proposal seeks the approval of the reserved matters for the approval of siting, layout, appearance and landscaping for 670 dwellings pursuant to outline planning application (full details of access) for a mixed development consisting of a maximum of 670 dwellings; a local centre comprising commercial uses (A1/A2/A3): a restaurant/dining quarter and public house (A3/A4); demolition of buildings on the May Gurney site (excluding the former public house); an access bridge over the River Yare; new access road; car parking; flood risk management measures; landscape measures including earthworks to form new swales and other biodiversity enhancements including the re-use of the Grade II Listed brick Kiln for use by bats.

The ESG Consultancy Team of CBRE Limited have been commissioned to develop the strategy for the Application Site to mitigate the risk of overheating, including consideration of the cooling hierarchy, and inform design development for the proposed scheme design against relevant planning policies, technical guidance and legislation.

An overheating assessment, including dynamic thermal modelling, has been carried out for the proposed development, in line with the guidance and data sets in CIBSE TM59 and TM49 respectively, taking into account the associated Approved Document O requirements.

The assessment identifies those apartments that are at higher risk of overheating. These include units with a larger glazing area, units with S/SW-facing windows, top-floor units receiving higher solar gains, units where cross ventilation is not possible and units with easily accessible windows. A sample of unit types, representing these dwellings, have been assessed against the Part O 2021 overheating criteria.

The analysis results show that all the sample rooms, assessed against the DSY1 weather data, comply with the overheating criteria, i.e. during moderately warm summer conditions the risk of overheating is low. The risk of overheating in communal corridors has been also assessed. The design of the proposed house types has been developed in line with the guidance provided in Part O's simplified method, with regards to glazing ratios. Therefore, these have been excluded by the dynamic thermal modelling analysis described in this report.

The following sections outline the key design principles integrated in the proposed design for mitigating the risk of overheating. The report also provides guidelines on how to operate dwellings in the most efficient way to avoid overheating during warmer weather. These should be included in a Home User Guide, provided to the future occupants.

Introduction

This Overheating Assessment has been prepared on behalf of Serruys Property Co Ltd ('the Applicant') in support of a reserved matters planning application for a mixed development consisting of a maximum of 670 dwellings. The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority.

The ESG Consultancy Team of CBRE Limited have been commissioned to develop the strategy for the Application Site to mitigate the risk of overheating, including consideration of the cooling hierarchy, and inform design development for the proposed scheme design against relevant planning policies, technical guidance and legislation.

An overheating assessment, including dynamic thermal modelling, has been carried out for the proposed development, in line with the guidance and data sets in CIBSE TM59 and TM49 respectively, taking into account the associated Approved Document O requirements.

The applicant

Serruys Property Co Ltd (hereafter referred to as 'the Applicant') is seeking reserved matters planning permission for a mixed development consisting of a maximum of 670 dwellings. The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority. The Applicant has appointed the ESG Consultancy Team of CBRE Limited (CBRE) to embed sustainability within the design proposal, working alongside the other CBRE colleagues also working on the scheme, namely planning and EIA.

Site description

The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority. The site lies within a mile of the City Centre and is 1km from Norwich Railway Station.

Proposed development

The proposal seeks the approval of the reserved matters for the approval of siting, layout, appearance and landscaping for 670 dwellings pursuant to outline planning application (full details of access) for a mixed development consisting of a maximum of 670 dwellings; a local centre comprising commercial uses (A1/A2/A3): a restaurant/dining quarter and public house (A3/A4); demolition of buildings on the May Gurney site (excluding the former public house); an access bridge over the River Yare; new access road; car parking; flood risk management measures; landscape measures including earthworks to form new swales and other biodiversity enhancements including the re-use of the Grade II Listed brick Kiln for use by bats.

Figure 1: Application Boundary shown in red

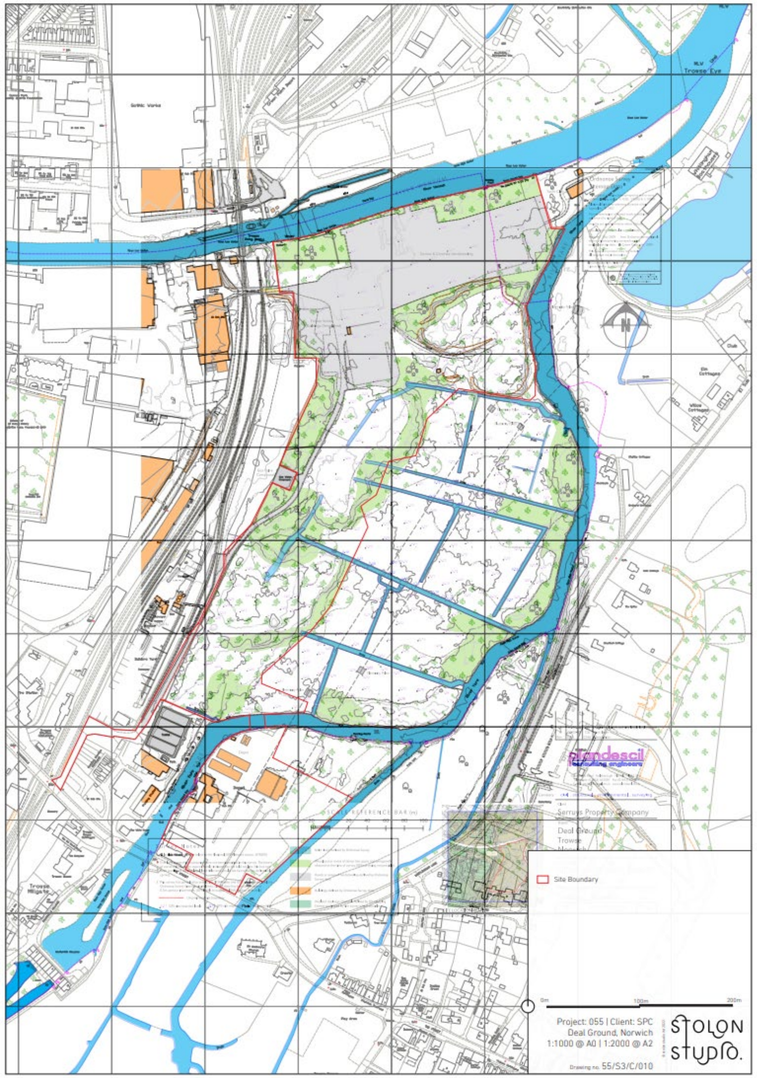


Figure 2: illustrative masterplan

Overheating criteria

Approved Document O 2021

Part O 2021 of the Building Regulations sets the requirement (O1) to tackle the risk of overheating in respect of a dwelling, institution or any other building containing one or more rooms for residential purposes, other than a room in a hotel ("residences"). This is to:

- Limit unwanted solar gains in summer.
- Provide an adequate means to remove heat from the indoor environment.

Compliance with the above requirement can be demonstrated by using one of the following methods: the simplified method and the dynamic thermal modelling method.

The simplified method provides guidance on limiting solar gains in terms of maximum allowed glazing areas depending on building location, façade orientation and whether cross ventilation is possible.

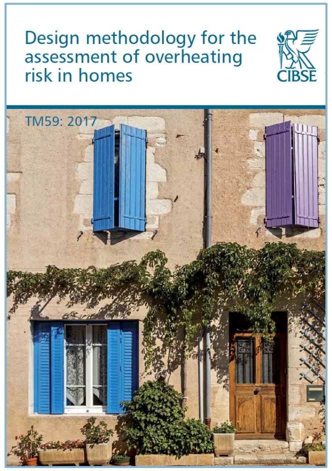
The design of the proposed house types has been developed in line with the guidance provided in the simplified method, with regards to glazing ratios.

The second option provides a standardised approach to predicting overheating risk for residential buildings that uses dynamic thermal modelling, considering the following:

- CIBSE's TM59 methodology for predicting overheating risk.
- The limits on the use of CIBSE's TM59 methodology set out in ADO paragraphs 2.5 and 2.6.
- The acceptable strategies for reducing overheating risk in ADO paragraphs 2.7 to 2.11.

Given that a communal low carbon heating system per residential block is proposed for providing space heating and hot water, the dynamic thermal modelling method has been followed for assessing the risk of overheating in the proposed apartments. This report provides details of the assessment and presents results in terms of compliance with the CIBSE TM59 overheating criteria, explained in the following section.

CIBSE TM59 Overheating criteria for dwellings



CIBSE has published TM59 'Design methodology for the assessment of overheating risk in homes' in May 2017. The guidance replaces TM52 to be used in residential buildings.

TM59 provides designers with a standardised approach to predicting overheating risk for residential building designs using dynamic thermal analysis.

The methodology provides a baseline for all domestic overheating risk assessments. Studies for buildings of multi-residential character, including student accommodation, care homes etc. can also employ this methodology as a starting point, provided that any deviation is clearly stated and justified.

Compliance is based on passing both of the following two criteria.

CIBSE TM59 Overheating criteria for communal corridors

According to CIBSE TM59, the inclusion of corridors in the overheating analysis is mandatory where community heating pipework runs through them. The overheating test for corridors should be based on the number of annual hours for which an operative temperature of 28°C is exceeded.

Whilst there is no mandatory target to meet, if an operative temperature of 28°C is exceeded for more than 3% of the total annual hours, then this should be identified as a significant risk within the report.

Table 1: CIBSE TM59 Overheating criteria for dwellings

Hours of exceedance (H_e) criteria for homes predominantly naturally ventilated	
Criterion (a)	For living rooms, bedrooms and kitchens: the number of hours (H_e) during which ΔT, the difference between the actual operative temperature in the room at any time (T_{op}) and T_{max} the limiting maximum acceptable temperature, is greater than or equal to one degree (K) during the period May to September inclusive shall not be more than 3 per cent of occupied hours.
Criterion (b)	For bedrooms only: to guarantee comfort during the sleeping hours the operative temperature in the bedroom from 10 pm to 7 am shall not exceed 26°C for more than 1% of annual hours. (Note: 1% of the annual hours between 22:00 and 07:00 for bedrooms is 32 hours, so 33 or more hours above 26°C will be recorded as a fail).

- Criterion (a) provides an understanding of how often a room is likely to exceed its comfort range during the summer months.
- Criterion (b) applies only to bedrooms, assessing thermal comfort during night-time throughout the year.

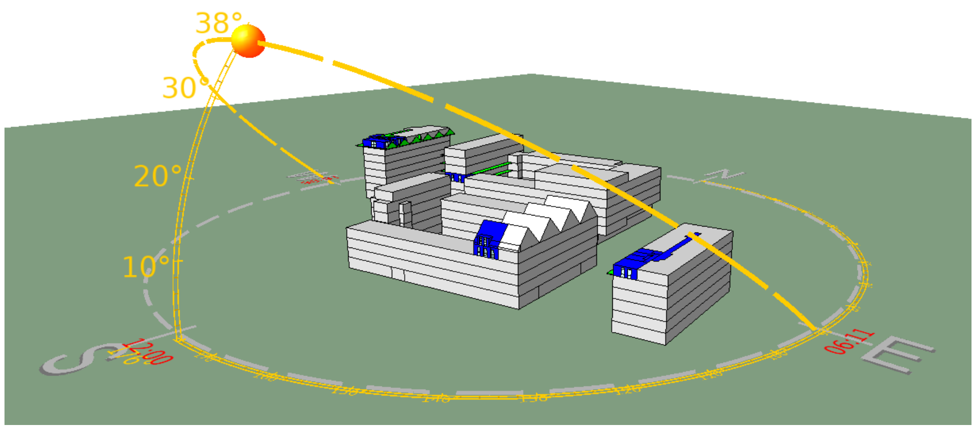
Thermal modelling

Thermal modelling has been carried out using IES Virtual Environment (Version 2023.0.0.0). IES software is approved by CIBSE AM11 'Building Energy and Environmental Modelling' (2015) to provide full dynamic thermal analysis.

A sample of unit types, representing dwellings with a higher risk of overheating, have been identified and assessed against the Part O 2021 overheating criteria, in line with the guidance and data sets in CIBSE TM59 and TM49 respectively.

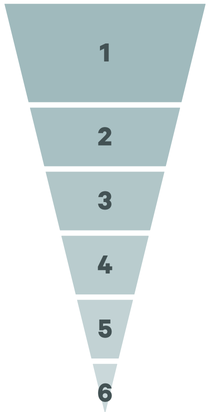
The model geometry (*Figure 3*) was based on the planning drawings (Issue 06.05.2023) received from Stolon Studio Architects.

Figure 3: IES VE thermal model



Passive design

The strategy to mitigate the risk of overheating in the proposed dwellings follows the below Cooling Hierarchy, prioritising passive design solutions to reduce excessive heat gains.



1. reduce the amount of heat entering a building through orientation, shading, high albedo materials, fenestration, insulation and the provision of green infrastructure
2. minimise internal heat generation through energy efficient design
3. manage the heat within the building through exposed internal thermal mass and high ceilings
4. provide passive ventilation
5. provide mechanical ventilation
6. provide active cooling systems.

The following passive design measures have been incorporated in the design of the proposed development.

Orientation

The orientation of each dwelling is expected to vary across the development. To reduce the risk of overheating, glazing areas on the south and west facades have been optimised to reduce solar gains, as rooms on these elevations tend to have a higher risk of overheating.

Units with windows on these elevations have been included in this study, to assess the risk of overheating considering the highest solar gains possible.

Building fabric & fenestration

Building fabric of high performance, in terms of U-values and airtightness, will be specified to reduce heat transfer from the ambient environment, during warmer weather. In addition, all party walls/floors between apartments and plant rooms, risers etc. will be well insulated to prevent any heat transfer. Please refer to the Energy Statement issued by the Energy Consultancy team of CBRE Limited for information on the targeted fabric performance specifications.

Windows of high performance will be provided to all units. These will have a low U-value (1.20 W/m^{2}K) to reduce heat losses during winter and prevent heat transfer from outside during summer. Given the above thermal performance required for the windows, these are likely to meet the solar performance target set for both the flats and houses, G-value of 0.50.

Thermal mass is a property that enables building materials to absorb, store, and later release significant amounts of heat. Therefore, depending on the proposed construction system, dwellings could benefit from the structure's inherent thermal mass that when combined with a night-time cooling strategy can store excess heat during the day and remove it during the night.

Glazing ratios

Glazing areas have been kept at optimum level to allow daylight in while reducing solar gains in summer and minimise the risk of overheating. The guidance provided in the simplified method of Part O, has been applied to the proposed house types. Dynamic thermal modelling, allowing for more flexibility regarding the window design, has been used to assess the risk of overheating in sample apartments.

Shading

External shading, in the form of balconies and deep window recess, is proposed throughout the scheme to reduce solar gains further.

Occupants should be advised to install internal shading for additional solar control. Internal shading should be in the form of horizontal or vertical fins depending on orientation to not intervene with the window free area. In line with Part O, internal shading and foliage has not been considered in the overheating modelling.

However, both measures could help mitigate the risk of overheating, in particular during more severe summer weather conditions as described by the DSY2 and DSY3 weather files.

Natural Ventilation

A natural ventilation strategy with fully openable windows is proposed for all dwellings. The openable area of the windows has been optimised to increase fresh air supply.

Ground floor and easily accessible rooms, in particular bedrooms, should have windows that can be opened securely at night. Part O guidelines on security should be followed to allow for fresh air supply when the rooms are not occupied. Open windows or doors can be made secure by using any of the following:

- fixed or lockable louvred shutters,
- fixed or lockable window grilles or railings.

Energy efficiency lighting & appliances

Internal heat generation will be minimised by installing energy efficient light fittings of LED types. Future occupants should be also advised to use A-rated appliances that emit lower heat gains to reduce the risk of overheating.

Occupancy PIR sensors should be also provided in all communal circulation areas to reduce internal heat gains from lighting further.

Heat distribution infrastructure

Well insulated pipework will be specified to reduce heat losses from hot water pipes running across communal corridors and inside dwellings. The length of the heat distribution pipework will be minimised as much as possible and insulation will be applied continuously to reduce heat losses further.

With conventional community heating systems, the distribution flow and return temperatures are normally around 80°C / 60°C. The proposed heating system, using ASHPs, could be designed at lower temperatures, circa 55°C / 50°C. Therefore, with the lower flow and return temperatures, heat losses will be reduced considerably.

Green areas

The proposed landscape design will contribute to improving the site's microclimate thus reducing the impact of the heat island effect.

Trees provided at street floor level will also provide an additional level of shading to ground floor rooms. The impact of these has not been included in our analysis, in line with Part O.

Modelling input data

The following table summarises the key input data used in the overheating assessment of the proposed scheme. The following design principles should be followed to ensure compliance with Part O 2021. The output of our simulation corelates to this input data and is only correct when the input data is valid.

Part O 2021	Modelling input data
Building category	Category II: Normal expectation (for new buildings and renovations).
Sample size	The assessed dwellings have been selected in line with the guidance provided in Section 3.1 of TM59. These include unit types with larger glazing areas, units with S/SW-facing windows, top-floor units receiving higher solar gains and units where cross ventilation is not possible. Please refer to Appendix B with regards to the sample unit types assessed against Part O.
Weather file	As required by TM59, the study has been carried out using the latest CIBSE weather data file for Norwich: Design Summer Year (DSY1, representing a moderately warm summer) weather file for 2020s, high emissions, 50% percentile scenario.
Ventilation strategy	Thermal modelling has been carried out assuming fully openable windows throughout the day (window frame set at 25%). Opening types and areas have been modelled as shown on elevations. Windows have been also assumed to be left fully open during the night, as per Part O, for taking advantage of the lower external temperatures.
Window and door openings	When a room is occupied during the day (8am to 11pm), openings have been modelled to operate as per the following Part O guidance. - Start to open when the internal temperature exceeds 22°C. - Be fully open when the internal temperature exceeds 26°C. - Start to close when the internal temperature falls below 26°C.

	- Be fully closed when the internal temperature falls below 22°C. At night (11pm to 8am), openings have been modelled as fully open if both of the following apply. - The opening is on the first floor or above and not easily accessible. - The internal temperature exceeds 23°C at 11pm. In all dwellings, internal doors in living room, kitchens and bedrooms have been assumed to be left open if needed during the day to allow for cross ventilation thus increasing air movement inside the house. These are kept closed, however, at night for privacy as per TM59 guidance. Window panes shown as top-hung are assumed to open by 30 degrees.
Air speed	The modelled air speed inside the rooms have been set at 0.1 m/s in line with the TM59 methodology.
Exposure type	A conservative at this stage exposure type for semi-exposed walls has been assumed for all windows.
Air infiltration	0.15 ACH.
Pipework losses (communal corridors)	To minimise heat losses from hot water pipework, highly insulated pipes will run through the communal areas of the apartment blocks. The following assumptions have been made with regards to distribution pipework losses. Corridor ceiling void: 500 W LTHW riser: 72 W HIU units: 78 W These are early-stage conservative assumptions that should be reviewed at next design stage when the details of the proposed specifications and design are known.

Part O 2021	Modelling input data

TM59 internal gains

Occupancy & Equipment

Room	No. people	Occup. Sensible	Occup. Latent	Equip. Sensible
Single Bed	1 no.	75 W	55 W	80 W
Double Bed	2 no.	150 W	110 W	80 W
Studio	2 no.	150 W	110 W	450 W
Living room/ Kitchen	Same with no. of bedrooms	75 W per person	55 W per person	450 W
Living room				150 W
Kitchen				300 W

The following graphs show the TM59 heat gain profiles used in the assessment.

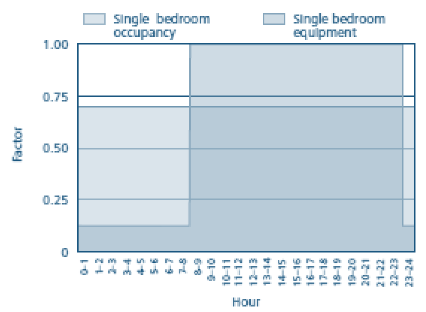
TM59 internal gains

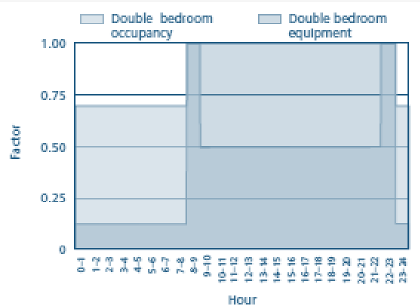
Lighting

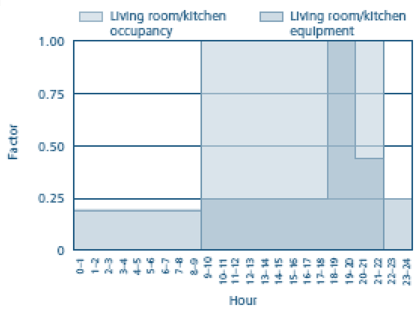
Low energy light fittings (LED) will be installed throughout the dwellings.

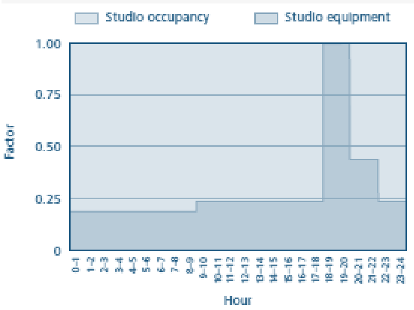
A power density of 2W/sqm has been assumed in line with TM59 (switched on from 18:00 to 23:00).

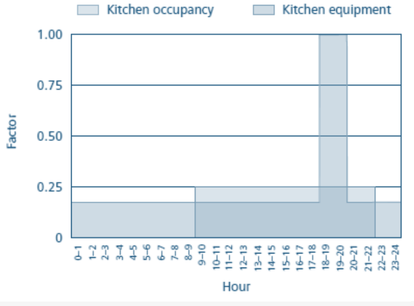
TM59 Heat gain profiles

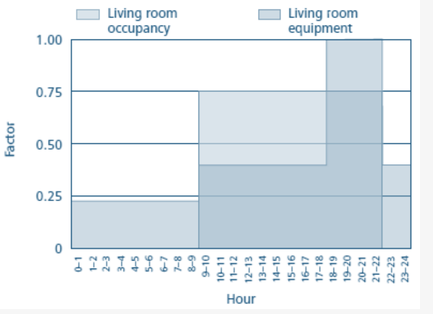









Kitchen occupancy
Kitchen equipment
1.00
0.75
0.50
0.25
0
Factor
Hour


Living room occupancy
Living room equipment
1.00
0.75
0.50
0.25
0
Factor
Hour

Analysis results

Dwellings

Dynamic thermal modelling has been carried out in line with the guidance and data sets in CIBSE TM59 and TM49 respectively, taking into account the associated Approved Document O requirements.

The risk of overheating has been assessed against the CIBSE DSY1 weather file. The table below provides a summary of the analysis results.

Table 2: No. of assessed room types passing TM59 Overheating criteria

Assessed units	No.	Criterion (a)	Criterion (b)	Part O 2021 Compliance
Flats – Double Bedrooms	4	Pass	Pass	Pass
Flats – Single Bedrooms	6	Pass	Pass	Pass
Flats – Open plan Kitchen/Living rooms	4	Pass	Pass	Pass

Results show that all assessed unit types pass the TM59 overheating criteria. Detailed results for each room, in terms of number of occupied hours when internal dry resultant temperature is within the TM59 comfort range, are presented in Appendix A.

Communal corridors

The risk of overheating in communal corridors has been also assessed, in line with CIBSE TM59. The assessment at this stage was carried out for core communal corridors with no windows or long corridors with only one side window.

During extreme weather conditions, the following ventilation strategy should be considered to reduce the risk of overheating in the communal corridors and, therefore, reduce heat transfer to the adjacent dwellings. Communal corridors, where natural ventilation is not possible or not effective enough, should utilise an environmental ventilation system which could sit along site (and be part of) the smoke extract system. This involves a small motorised environmental ventilation damper being provided at each floor within the smoke shaft wall. The finer details of this will be part of the design development through the next phase. A supply flow rate of circa 3ACH would be required to ensure the risk of overheating in communal corridors is reduced.

The following table provides results in terms of annual percentage of hours when operative temperature exceeds 28°C. Once the proposed ventilation strategy has been developed in detail, internal conditions in the communal areas will be assessed further.

Table 3: Risk of overheating in communal corridors

Room	% Annual hrs when dry resultant T exceeds 28°C (< 3%)
B6. Communal corridor	Pass (1.2%)
B7. Communal corridor	Pass (2%)

Guidelines on managing the risk of overheating

The following mitigation measures should be considered, in the event of a heatwave, to minimise the risk of overheating in the proposed dwellings and ensure thermal comfort for future occupants. These should be included in a Home User Guide distributed to the occupants.

- Comprehensive instructions on how to operate windows should be given to future occupants to control thermal comfort in their rooms.
- Occupants should be advised to leave the windows open whenever the internal room temperature rises over 22°C. However, when the external temperature is higher than the internal temperature (in hot summer days) windows need to remain closed for that period. As soon as the external temperature cools down, these should be left open again to provide fresh air in the dwellings.
- Occupants should be advised to leave their windows open during the night on warm summer days to take advantage of the low external temperatures during the night for cooling down their rooms and remove the excessive heat that builds up throughout the day.
- Occupants should be advised to install internal shading devices e.g. curtains or blinds of low solar transmittance to control solar gains. These should be in the form of horizontal or vertical fins depending on orientation to not intervene with the window free area. Use of internal shading devices is recommended on sunny and warm days to prevent direct solar gains been transmitted into the rooms. These should be left closed when the rooms are not occupied.
- Occupants should be advised that, when using the curtains/blinds, they should make sure that these do not cover the openable area of the windows completely so that the air movement is not blocked. Curtains should be installed such that the main openable area of the window is not fully covered but allow for as much air flow as possible. Depending on the position of the sun they should raise/open the shading devices to those windows that do not receive direct sunlight thus allowing more fresh air.
- All fixed building elements such as ceiling lights and fridges will be very energy efficient. It is essential that the occupants also use energy efficient equipment, for example, energy efficient light fittings of LED types and A+ rated electrical appliances such as TVs that consume less energy should be specified and promoted to reduce internal heat gains.
- Occupants should be also advised against prolonged use of any appliances during hot summer days.

Conclusion

This Overheating Assessment has been prepared on behalf of Serruys Property Co Ltd ('the Applicant') in support of a reserved matters planning application for a mixed development consisting of a maximum of 670 dwellings. The site is located in East Norwich, on the edge of Trowse Newton, bordering the Norfolk Broads. It straddles three local Authorities: Norwich City Council, South Norfolk and the Broads Authority.

The ESG Consultancy Team of CBRE Limited have been commissioned to develop the strategy for the Application Site to mitigate the risk of overheating, including consideration of the cooling hierarchy, and inform design development for the proposed scheme design against relevant planning policies, technical guidance and legislation.

The analysis results show that all the sample rooms, assessed against the DSY1 weather data, comply with the overheating criteria, i.e. during moderately warm summer conditions the risk of overheating is low. The risk of overheating in communal corridors has been also assessed. In corridors where natural ventilation is not possible or limited, mechanical means of ventilation should be provided to comply with the relevant overheating criterion. The design of the proposed house types has been developed in line with the guidance provided in Part O's simplified method, with regards to glazing ratios, thus excluded from the dynamic thermal modelling analysis described in this report.

To ensure minimum disruption during the event of a hot spell, it is important that occupants are aware of how to operate the building following the guidelines provided in Section 8. These should be included in a Home User Guide distributed to the occupants.

This report and the supporting thermal modelling are based on guidance provided by CIBSE TM59. It is also using predicted weather conditions as described in TM59 and assumes future occupants will follow the recommendations of this report. The output of our simulation corelates to this input data and is only correct when the input data is valid. All results provided by an overheating analysis are indication of risk of overheating rather than an accurate prediction of absolute internal temperatures under operational conditions. Occupant perception of thermal comfort is a complex area and the most recent CIBSE guides TM59 have tried to consider this to some extent, however they do not claim to predict risk of discomfort for every occupant.

Appendix A – CIBSE 2020s DSY1 results

Naturally ventilated rooms – Criterion (a)

Criterion (a) states that for living rooms, kitchens and bedrooms, the number of hours during which T is greater than or equal to 1K from May to September (or November to March for southern hemisphere locations) shall not exceed 3% of occupied hours.

Room name	Occupied hours	No. hours DT ≥ 1°K	% Occupied hours DT ≥ 1°K	Criterion (a) check
B1-F7-SINGLE BEDROOM	3672	33	0.9	Pass
B1-F7-LIVING/KITCHEN	1989	53	2.7	Pass
B1-F7-BEDROOM 1	3672	9	0.2	Pass
B1-F7-BEDROOM 2	3672	19	0.5	Pass
B2-F4-DOUBLE BEDROOM	3672	37	1.0	Pass
B2-F4-LIVING/KITCHEN	1989	47	2.4	Pass
B6-F4-DOUBLE BEDROOM	3672	25	0.7	Pass
B6-F4-SINGLE BEDROOM 1	3672	42	1.1	Pass
B6-F4-SINGLE BEDROOM 2	3672	45	1.2	Pass
B6-F5-LIVING/KITCHEN	1989	49	2.5	Pass
B7-F5-DOUBLE BEDROOM 1	3672	48	1.3	Pass
B7-F5-SINGLE ROOM	3672	52	1.4	Pass
B7-F5-DOUBLE BEDROOM2	3672	42	1.1	Pass
B7-F5-LIVING/KITCHEN	1989	56	2.8	Pass

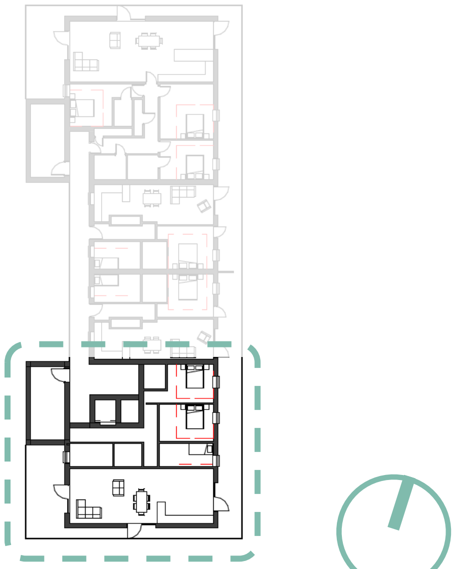
Naturally ventilated rooms – Criterion (b)

Criterion (b) states that the operative temperature of the bedrooms from 22:00-07:00 shall not exceed 26°C for more than 1% of annual hours (33 hours is therefore recorded as a fail). Any rooms that are not bedrooms are therefore not assessed, hence the corresponding N/A values.

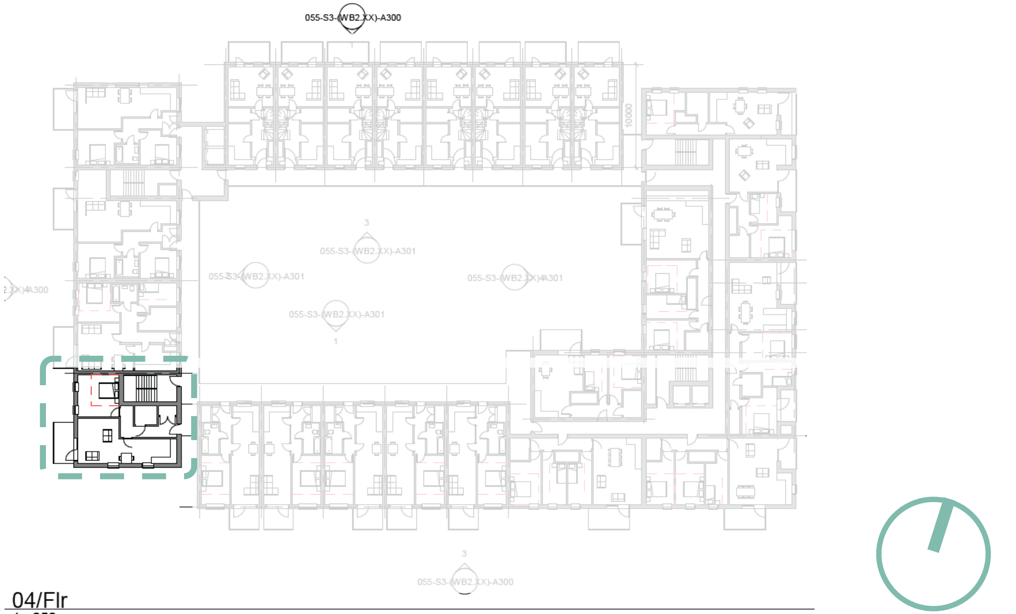
Room name	No. hours > 26°C 22:00-24:00	No. hours > 26°C 00:00-07:00	Total hours > 26°C	Criterion b check
B1-F7-SINGLE BEDROOM	7	1	8	Pass
B1-F7-LIVING/KITCHEN	N/A	N/A	N/A	N/A
B1-F7-BEDROOM 1	7	1	8	Pass
B1-F7-BEDROOM 2	7	1	8	Pass
B2-F4-DOUBLE BEDROOM	8	1	9	Pass
B2-F4-LIVING/KITCHEN	N/A	N/A	N/A	N/A
B6-F4-DOUBLE BEDROOM	12	4	16	Pass
B6-F4-SINGLE BEDROOM 1	9	2	11	Pass
B6-F4-SINGLE BEDROOM 2	9	1	10	Pass
B6-F5-LIVING/KITCHEN	N/A	N/A	N/A	N/A
B7-F5-DOUBLE BEDROOM 1	11	3	14	Pass
B7-F5-SINGLE ROOM	9	1	10	Pass
B7-F5-DOUBLE BEDROOM2	7	1	8	Pass
B7-F5-LIVING/KITCHEN	N/A	N/A	N/A	N/A

Appendix B – Assessed unit types

Wensum Edge - Block 1	Wensum Edge - Block 2

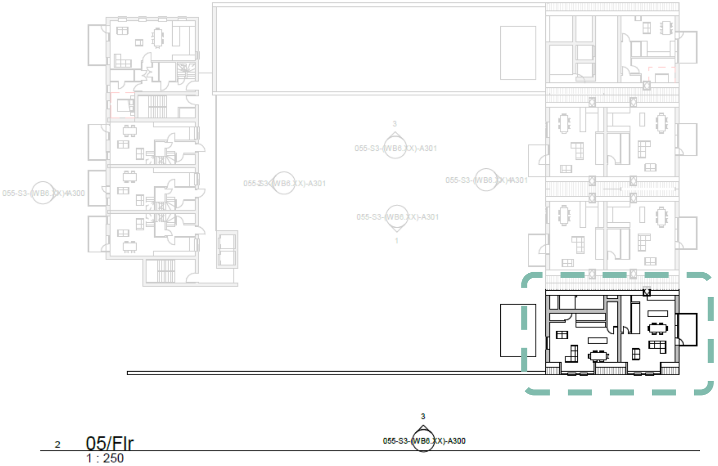


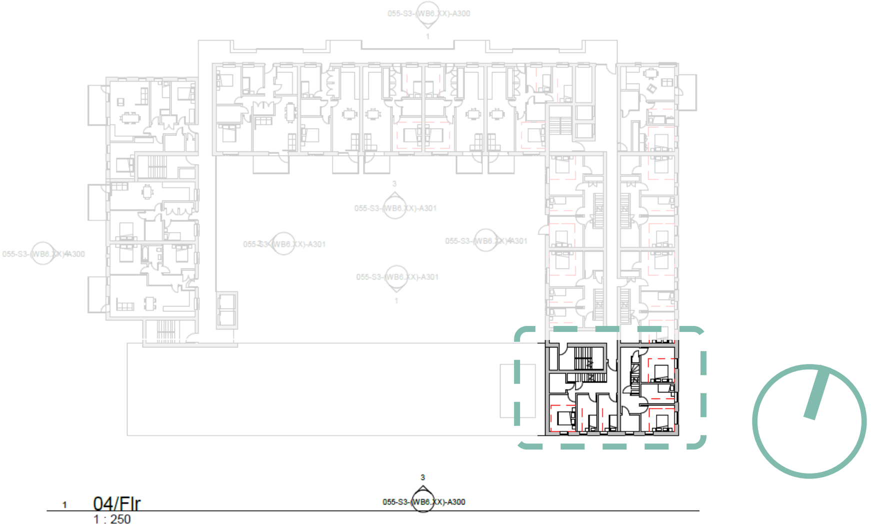
07/Flr
1 : 250



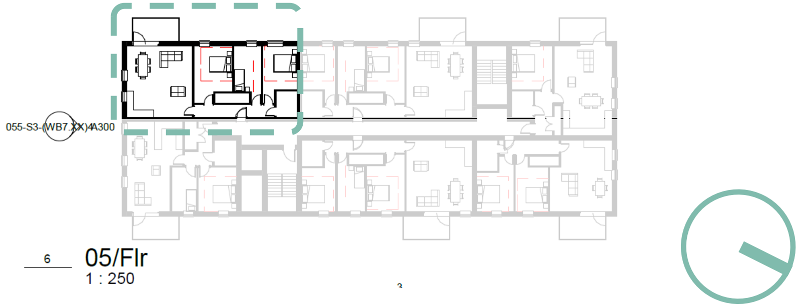
04/Flr
1 : 250

Wensum Edge - Block 6





Wensum Edge - Block 7



Wensum Edge Block Plan

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Appendix C - Non-feasible LZC technologies

Biomass boiler

Residential developments have a high hot water demand throughout the year. Therefore, there are concerns regarding the supply chain and the reliability of supply throughout the project life. The impact of frequent fuel deliveries on local traffic and noise should also be considered. There are also concerns within local authorities over air-quality issues associated with biomass boilers.

The issues outlined above, together with the fact that biomass boilers need very large fuel storages to reduce the frequency of deliveries, especially for this scale of development, means that we would not consider this option either appropriate or practical for this scheme.

Wind turbines

The urban setting of the development means that the wind speed may not be consistent and reliable to generate the expected energy. Previous studies on wind turbine performance in urban climate have shown that air turbulence in urban areas will usually result in lower energy production than expected.

Also, installation of wind turbines might not be acceptable in a dense residential urban environment due to noise issues and aesthetic impacts. We would, therefore, consider wind turbines inappropriate for the site.

Ground/Water to water heat pumps

The possibility of utilising a Ground Source Heat Pump has been considered for the scheme. With a closed loop borehole system, it would be possible to drop loops and extract heat from the ground, which has a constant temperature throughout the year, typically above 5oC.

ASHPs are working with air temperatures that fluctuate between -5°C to 25°C for most of the year. This means there are times during the year when the ASHP will be more efficient than the GSHP, in particular during summer when heat pumps need to cover demand for domestic hot water, but when it gets much colder in winter, GSHPs will be more efficient. With regards to capital cost, GSHPs are more expensive to install and also rely on the use of energy to pump fluid around the distribution network.

Therefore, as a ground source system is considered to be more complex, technically risky and costly, an ASHP system is proposed instead for the scheme.

Water sourced heat pumps operate on the same principles, with a water source nearby the site acting as the heat medium, instead of the ground.

Solar hot water heating

Solar thermal hot water systems can work well on residential developments, in particular on houses. However, it is decided that the available space on the roof will be used for installation of PV panels that need less maintenance and can offset electricity use through on-site energy generation.

In addition, PVs are best coupled with the ASHPS proposed for heating, feeding heat pumps with the electricity they need to operate. In the case of solar water panels, these would compete against the ASHPs when it comes to hot water generation thus limiting their annual capacity.

Appendix D - SAP 10 worksheets & BRUKL

Full SAP Calculation Printout

Property Reference	HT H ET			Issued on Date	16/06/2023
Assessment Reference	06-After renewables			Prop Type Ref	SAMPLE SAP
Property	NORWICH				
SAP Rating	82 B	DER	3.61	TER	11.75
Environmental	97 A	% DER < TER			69.28
CO_2 Emissions (t/year)	0.35	DFEE	38.93	TFEE	40.73
Compliance Check	See BREL	% DFEE < TFEE			4.42
% DPER < TPER	30.29	DPER	43.02	TPER	61.71
Assessor Details	Mr. Panagiotis Dalapas			Assessor ID	AZ85-0001
Client					

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

1. Overall dwelling characteristics

	Area (m2)		Storey height (m)		Volume (m3)
Ground floor	42.1700 (1b)	x	2.6000 (2b)	=	109.6420 (1b) -
First floor	41.8200 (1c)	x	2.8000 (2c)	=	117.0960 (1c) -
Second floor	31.1600 (1d)	x	3.0000 (2d)	=	93.4800 (1d) -

Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n) 115.1500 (4)
Dwelling volume (3a)+(3b)+(3c)+(3d)+(3e)...(3n) = 320.2180 (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	4 * 10 =	40.0000 (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) = 40.0000 / (5) = 0.1249 (8)
Pressure test Yes
Pressure Test Method Blower Door
Measured/design AP50 5.0000 (17)
Infiltration rate 0.3749 (18)
Number of sides sheltered 1 (19)

Shelter factor (20) = 1 - [0.075 x (19)] = 0.9250 (20)
Infiltration rate adjusted to include shelter factor (21) = (18) x (20) = 0.3468 (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	0.4422	0.4335	0.4248	0.3815	0.3728	0.3295	0.3295	0.3208	0.3468	0.3728	0.3901	0.4075	(22b)
Effective ac	0.5978	0.5940	0.5902	0.5728	0.5695	0.5543	0.5543	0.5515	0.5601	0.5695	0.5761	0.5830	(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	
Door			2.1200	1.0000	2.1200			(26)
Window (Uw = 1.20)			12.4600	1.1450	14.2672			(27)
GF			42.1700	0.1500	6.3255	75.0000	3162.7500	(28a)
EXPOSED FLR OVER ENTRANCE			1.6500	0.1500	0.2475	20.0000	33.0000	(28b)
Wall1	127.0000	14.5800	112.4200	0.1500	16.8630	110.0000	12366.2000	(29a)
ASHLAR WALL UNDER EAVES	24.6000		24.6000	0.2000	4.9200	9.0000	221.4000	(29a)

Plane	8.2000		8.2000	0.1000	0.8200	9.0000	73.8000	(30)
Slope	32.4700		32.4700	0.1500	4.8705	9.0000	292.2300	(30)
CEILING UNDER EAVES	10.6600		10.6600	0.1500	1.5990	9.0000	95.9400	(30)
BAY ROOF	2.0000		2.0000	0.1500	0.3000	9.0000	18.0000	(30)
Total net area of external elements Aum(A, m2)			248.7500					(31)
Fabric heat loss, W/K = Sum (A x U)				(26)...(30) + (32) =	52.3327			(33)
Party Wall 1			44.2800	0.0000	0.0000	70.0000	3099.5999	(32)
Studwall partitions			180.0000			9.0000	1620.0000	(32c)
Internal Floor 1			40.1700			18.0000	723.0600	(32d)
Internal Floor 2			31.1600			18.0000	560.8800	(32d)
Internal Ceiling 1			40.1700			9.0000	361.5300	(32e)
Internal Ceiling 2			31.1600			9.0000	280.4400	(32e)

Heat capacity Cm = Sum(A x k) (28)...(30) + (32) + (32a)...(32e) = 22908.8299 (34)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K 198.9477 (35)
List of Thermal Bridges

K1 Element	Length	Psi-value	Total
E2 Other lintels (including other steel lintels)	7.7700	0.0540	0.4196
E3 Sill	4.7400	0.0400	0.1896
E4 Jamb	27.7000	0.0490	1.3573
E5 Ground floor (normal)	20.3300	0.0380	0.7725
E6 Intermediate floor within a dwelling	37.0100	0.0120	0.4441
E11 Eaves (insulation at rafter level)	8.2000	-0.0310	-0.2542
E12 Gable (insulation at ceiling level)	2.0000	0.0870	0.1740
E13 Gable (insulation at rafter level)	11.6000	0.0910	1.0556
E16 Corner (normal)	18.6000	0.0400	0.7440
E18 Party wall between dwellings	5.2000	0.0490	0.2548
P1 Party wall - Ground floor	8.2000	0.0660	0.5412
P2 Party wall - Intermediate floor within a dwelling	16.4000	0.0000	0.0000
P5 Party wall - Roof (insulation at rafter level)	8.2000	0.2110	1.7302
R6 Flat ceiling	16.4000	0.0380	0.6232
E17 Corner (inverted – internal area greater than external area)	13.4000	-0.0290	-0.3886
E16 Corner (normal)	6.0000	0.0380	0.2280
E20 Exposed floor (normal)	3.3400	0.1080	0.3607
E21 Exposed floor (inverted)	3.3400	0.1090	0.3641
E15 Flat roof with parapet	4.0000	0.1000	0.4000
E24 Eaves (insulation at ceiling level - inverted)	2.0500	0.0370	0.0758

Thermal bridges (Sum(L x Psi) calculated using Appendix K) 9.0920 (36)
Point Thermal bridges (36a) = 0.0000
Total fabric heat loss (33) + (36) + (36a) = 61.4246 (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	63.1659	62.7648	62.3716	60.5249	60.1793	58.5709	58.5709	58.2730	59.1904	60.1793	60.8783	61.6091	(38)
Heat transfer coeff	124.5906	124.1895	123.7963	121.9495	121.6040	119.9955	119.9955	119.6976	120.6151	121.6040	122.3030	123.0337	(39)
Average = Sum(39)m / 12 =												121.9479	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.0820	1.0785	1.0751	1.0590	1.0560	1.0421	1.0421	1.0395	1.0475	1.0560	1.0621	1.0685	(40)
HLP (average)												1.0590	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

Assumed occupancy 2.8425 (42)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage for mixer showers	80.8633	79.6480	77.8772	74.4891	71.9888	69.2004	67.6155	69.3729	71.2993	74.2932	77.7541	80.5534	(42a)
Hot water usage for baths	31.0333	30.5724	29.9234	28.7267	27.8306	26.8370	26.3003	26.9448	27.6466	28.7097	29.9311	30.9284	(42b)
Hot water usage for other uses	43.7396	42.1491	40.5585	38.9680	37.3775	35.7869	35.7869	37.3775	38.9680	40.5585	42.1491	43.7396	(42c)

Average daily hot water use (litres/day) 143.0892 (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	155.6362	152.3695	148.3591	142.1838	137.1969	131.8244	129.7028	133.6952	137.9139	143.5615	149.8342	155.2214	(44)
Energy conte	246.4896	216.9722	228.0225	194.6425	184.6933	162.0934	156.8642	165.5426	170.0616	194.8115	213.4663	243.0392	(45)

Energy content (annual) Total = Sum(45)m = 2376.6991
Distribution loss (46)m = 0.15 x (45)m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	36.9734	32.5458	34.2034	29.1964	27.7040	24.3140	23.5296	24.8314	25.5092	29.2217	32.0199	36.4559	(46)

Water storage loss:
Store volume 300.0000 (47)
a) If manufacturer declared loss factor is known (kWh/day): 2.8600 (48)
Temperature factor from Table 2b 0.5400 (49)
Enter (49) or (54) in (55) 1.5444 (55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Total storage loss	47.8764	43.2432	47.8764	46.3320	47.8764	46.3320	47.8764	47.8764	46.3320	47.8764	46.3320	47.8764	(56)
If cylinder contains dedicated solar storage	47.8764	43.2432	47.8764	46.3320	47.8764	46.3320	47.8764	47.8764	46.3320	47.8764	46.3320	47.8764	(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	317.6284	281.2266	299.1613	263.4865	255.8321	230.9374	228.0030	236.6814	238.9056	265.9503	282.3103	314.1780	(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	317.6284	281.2266	299.1613	263.4865	255.8321	230.9374	228.0030	236.6814	238.9056	265.9503	282.3103	314.1780	(64)

Total per year (kWh/year) = Sum(64)m = 3214.3011 (64)

```
12Total per year (kWh/year)                                                                                   3214 (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
              138.8688   123.5468   132.7285   119.7938   118.3216   108.9713   109.0684   111.9539   111.6207   121.6859   126.0528   137.7216 (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         142.1228   142.1228   142.1228   142.1228   142.1228   142.1228   142.1228   142.1228   142.1228   142.1228   142.1228   142.1228 (66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5
              157.2545   174.1031   157.2545   162.4963   157.2545   162.4963   157.2545   157.2545   162.4963   157.2545   162.4963   157.2545 (67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5
              278.7575   281.6501   274.3607   258.8426   239.2538   220.8430   208.5435   205.6509   212.9402   228.4583   248.0472   266.4579 (68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5
               37.2123    37.2123    37.2123    37.2123    37.2123    37.2123    37.2123    37.2123    37.2123    37.2123    37.2123    37.2123 (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)
             -113.6982  -113.6982  -113.6982  -113.6982  -113.6982  -113.6982  -113.6982  -113.6982  -113.6982  -113.6982  -113.6982  -113.6982 (71)
Water heating gains (Table 5)
              186.6517   183.8493   178.3985   166.3803   159.0344   151.3490   146.5973   150.4757   155.0287   163.5563   175.0733   185.1097 (72)
Total internal gains
              691.3004   708.2394   678.6506   656.3560   624.1794   600.3251   578.0321   579.0179   596.1020   617.9059   654.2535   677.4589 (73)

-----------------------------------------------------------------------------------------------
6. Solar gains
-----------------------------------------------------------------------------------------------

[Jan]                                      Area       Solar flux              g                 FF           Access              Gains
                                             m2        Table 6a    Specific data     Specific data           factor                  W
                                                           W/m2     or Table 6b       or Table 6c         Table 6d
-----------------------------------------------------------------------------------------------
North                                    4.1700         10.6334          0.5000           0.7500           0.7700            11.5232 (74)
South                                    8.2900         46.7521          0.5000           0.7500           0.7700           100.7210 (78)
-----------------------------------------------------------------------------------------------

Solar gains   112.2441   186.9764   247.5431   297.5907   328.4419   324.8386   313.6224   290.1850   264.4893   204.1330   133.6040    96.6385 (83)
Total gains   803.5445   895.2158   926.1937   953.9467   952.6213   925.1637   891.6545   869.2028   860.5913   822.0389   787.8575   774.0973 (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            51.0758    51.2408    51.4035    52.1820    52.3302    53.0317    53.0317    53.1637    52.7593    52.3302    52.0311    51.7221
alpha           4.4051     4.4161     4.4269     4.4788     4.4887     4.5354     4.5354     4.5442     4.5173     4.4887     4.4687     4.4481
util living area
                0.9907     0.9839     0.9734     0.9448     0.8804     0.7359     0.5684     0.6018     0.8048     0.9441     0.9825     0.9920 (86)

MIT            19.8442    19.9839    20.1739    20.4432    20.6827    20.8575    20.9138    20.9084    20.8126    20.5158    20.1448    19.8294 (87)
Th 2           20.0156    20.0184    20.0212    20.0344    20.0369    20.0484    20.0484    20.0506    20.0440    20.0369    20.0319    20.0267 (88)
util rest of house
                0.9882     0.9798     0.9661     0.9285     0.8423     0.6564     0.4563     0.4915     0.7371     0.9244     0.9772     0.9900 (89)
MIT 2          18.6633    18.8428    19.0855    19.4312    19.7179    19.9100    19.9533    19.9525    19.8658    19.5257    19.0590    18.6531 (90)
Living area fraction                                                                    fLA = Living area / (4) =     0.1633 (91)
MIT            18.8561    19.0291    19.2632    19.5964    19.8754    20.0647    20.1101    20.1086    20.0204    19.6873    19.2363    18.8451 (92)
Temperature adjustment                                                                                           0.0000
adjusted MIT   18.8561    19.0291    19.2632    19.5964    19.8754    20.0647    20.1101    20.1086    20.0204    19.6873    19.2363    18.8451 (93)

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8. Space heating requirement
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                 Jan        Feb        Mar        Apr        May        Jun        Jul        Aug        Sep        Oct        Nov        Dec
Utilisation     0.9844     0.9742     0.9588     0.9193     0.8348     0.6579     0.4639     0.4986     0.7352     0.9155     0.9714     0.9866 (94)
Useful gains  790.9873   872.1607   888.0663   876.9722   795.2635   608.6504   413.6756   433.4054   632.6967   752.5502   765.3467   763.6929 (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
             1813.5556  1754.6892  1580.0336  1304.4248   994.1630   655.7382   421.1999   443.9086   714.0912  1105.0572  1484.3004  1801.8439 (97)
Space heating kWh
              760.7908   593.0592   514.8237   307.7659   147.9813     0.0000     0.0000     0.0000     0.0000   262.2652   517.6467   772.3844 (98a)
Space heating requirement - total per year (kWh/year)                                                          3876.7170
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
              760.7908   593.0592   514.8237   307.7659   147.9813     0.0000     0.0000     0.0000     0.0000   262.2652   517.6467   772.3844 (98c)
Space heating requirement after solar contribution - total per year (kWh/year)                                 3876.7170
Space heating per m2                                                                          (98c) / (4) =    33.6667 (99)

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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 %)                                                            170.0000 (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
              760.7908   593.0592   514.8237   307.7659   147.9813     0.0000     0.0000     0.0000     0.0000   262.2652   517.6467   772.3844 (98)
Space heating efficiency (main heating system 1)
              170.0000   170.0000   170.0000   170.0000   170.0000     0.0000     0.0000     0.0000     0.0000   170.0000   170.0000   170.0000 (210)
Space heating fuel (main heating system)
              447.5240   348.8583   302.8374   181.0388    87.0478     0.0000     0.0000     0.0000     0.0000   154.2736   304.4980   454.3438 (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
              317.6284   281.2266   299.1613   263.4865   255.8321   230.9374   228.0030   236.6814   238.9056   265.9503   282.3103   314.1780 (64)
Efficiency of water heater                                                                                   170.0000 (216)
(217)m        170.0000   170.0000   170.0000   170.0000   170.0000   170.0000   170.0000   170.0000   170.0000   170.0000   170.0000   170.0000 (217)
Fuel for water heating, kWh/month
              186.8402   165.4274   175.9772   154.9921   150.4895   135.8455   134.1194   139.2243   140.5327   156.4414   166.0649   184.8106 (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    0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000     0.0000 (231)
Lighting       32.6744    26.2126    23.6015    17.2915    13.3564    10.9123    12.1842    15.8375    20.5713    26.9907    30.4859    33.5825 (232)
Electricity generated by PVs (Appendix M) (negative quantity)
(233a)m       -43.8003   -65.9997  -100.3017  -116.4487  -125.5868  -111.1666  -109.7462  -102.0461   -88.1794   -75.3271   -49.1495   -37.4201 (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       -11.5903   -25.9667   -55.0431   -89.8016  -127.4711  -136.8973  -135.3501  -113.2740   -81.9264   -41.8958   -16.4612    -8.9927 (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                                                                          2280.4218 (211)
Space heating fuel - main system 2                                                                             0.0000 (213)
Space heating fuel - secondary                                                                                 0.0000 (215)
Efficiency of water heater                                                                                   170.0000
Water heating fuel used                                                                                     1890.7653 (219)
Space cooling fuel                                                                                             0.0000 (221)

Electricity for pumps and fans:
Total electricity for the above, kWh/year                                                                      0.0000 (231)
Electricity for lighting (calculated in Appendix L)                                                          263.7009 (232)

Energy saving/generation technologies (Appendices M ,N and Q)
PV generation                                                                                              -1869.8425 (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                                                                         2565.0455 (238)

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12a. Carbon dioxide emissions - Individual heating systems including micro-CHP
-----------------------------------------------------------------------------------------------
                                                                    Energy       Emission factor         Emissions
                                                                  kWh/year            kg CO2/kWh       kg CO2/year
Space heating - main system 1                                    2280.4218                0.1550          353.4952 (261)
Total CO2 associated with community systems                                                                 0.0000 (373)
Water heating (other fuel)                                       1890.7653                0.1408          266.2791 (264)
Space and water heating                                                                                   619.7743 (265)
Pumps, fans and electric keep-hot                                   0.0000                0.0000            0.0000 (267)
Energy for lighting                                               263.7009                0.1443           38.0602 (268)

 Energy saving/generation technologies
PV Unit electricity used in dwelling                            -1025.1723                0.1344         -137.7496
PV Unit electricity exported                                     -844.6703                0.1230         -103.8662
Total                                                                                                    -241.6158 (269)
Total CO2, kg/year                                                                                        416.2187 (272)
EPC Dwelling Carbon Dioxide Emission Rate (DER)                                                             3.6100 (273)

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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	2280.4218	1.5739	3589.1462	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	1890.7653	1.5207	2875.3628	(278)
Space and water heating			6464.5090	(279)
Pumps, fans and electric keep-hot	0.0000	0.0000	0.0000	(281)
Energy for lighting	263.7009	1.5338	404.4732	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1025.1723	1.4966	-1534.2779	
PV Unit electricity exported	-844.6703	0.4512	-381.1008	
Total			-1915.3787	(283)
Total Primary energy kWh/year			4953.6035	(286)
Dwelling Primary energy Rate (DPER)			43.0200	(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	42.1700 (1b)	x	2.6000 (2b)	=	109.6420 (1b) -
First floor	41.8200 (1c)	x	2.8000 (2c)	=	117.0960 (1c) -
Second floor	31.1600 (1d)	x	3.0000 (2d)	=	93.4800 (1d) -
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n) 115.1500					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	320.2180 (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	4 * 10 =	40.0000	(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) =	40.0000 / (5) =	0.1249	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3749	(18)
Number of sides sheltered		1	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.9250	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3468	(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	0.4422	0.4335	0.4248	0.3815	0.3728	0.3295	0.3295	0.3208	0.3468	0.3728	0.3901	0.4075	(22b)
Effective ac	0.5978	0.5940	0.5902	0.5728	0.5695	0.5543	0.5543	0.5515	0.5601	0.5695	0.5761	0.5830	(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 Opaque door			2.1200	1.0000	2.1200			(26)
TER Opening Type (Uw = 1.20)			12.4600	1.1450	14.2672			(27)
GF			42.1700	0.1300	5.4821			(28a)
EXPOSED FLR OVER ENTRANCE			1.6500	0.1300	0.2145			(28b)
Wall1	127.0000	14.5800	112.4200	0.1800	20.2356			(29a)
ASHLAR WALL UNDER EAVES	24.6000		24.6000	0.1800	4.4280			(29a)
Plane	8.2000		8.2000	0.1100	0.9020			(30)

	Gross	NetArea	U-value	A x U	
Slope	32.4700	32.4700	0.1100	3.5717	(30)
CEILING UNDER EAVES	10.6600	10.6600	0.1100	1.1726	(30)
BAY ROOF	2.0000	2.0000	0.1100	0.2200	(30)
Total net area of external elements Aum(A, m2)		248.7500			(31)
Fabric heat loss, W/K = Sum (A x U)		(26)...(30) + (32) =		52.6137	(33)
Party Wall 1		44.2800	0.0000	0.0000	(32)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K 198.9477 (35)

List of Thermal Bridges

K1 Element	Length	Psi-value	Total
E2 Other lintels (including other steel lintels)	7.7700	0.0500	0.3885
E3 Sill	4.7400	0.0500	0.2370
E4 Jamb	27.7000	0.0500	1.3850
E5 Ground floor (normal)	20.3300	0.1600	3.2528
E6 Intermediate floor within a dwelling	37.0100	0.0000	0.0000
E11 Eaves (insulation at rafter level)	8.2000	0.0400	0.3280
E12 Gable (insulation at ceiling level)	2.0000	0.0600	0.1200
E13 Gable (insulation at rafter level)	11.6000	0.0800	0.9280
E16 Corner (normal)	18.6000	0.0900	1.6740
E18 Party wall between dwellings	5.2000	0.0600	0.3120
P1 Party wall - Ground floor	8.2000	0.0800	0.6560
P2 Party wall - Intermediate floor within a dwelling	16.4000	0.0000	0.0000
P5 Party wall - Roof (insulation at rafter level)	8.2000	0.0800	0.6560
R6 Flat ceiling	16.4000	0.0600	0.9840
E17 Corner (inverted – internal area greater than external area)	13.4000	-0.0900	-1.2060
E16 Corner (normal)	6.0000	0.0900	0.5400
E20 Exposed floor (normal)	3.3400	0.3200	1.0688
E21 Exposed floor (inverted)	3.3400	0.3200	1.0688
E15 Flat roof with parapet	4.0000	0.5600	2.2400
E24 Eaves (insulation at ceiling level - inverted)	2.0500	0.2400	0.4920

Thermal bridges (Sum(L x Psi) calculated using Appendix K)		15.1249	(36)
Point Thermal bridges	(36a) =	0.0000	
Total fabric heat loss	(33) + (36) + (36a) =	67.7386	(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	63.1659	62.7648	62.3716	60.5249	60.1793	58.5709	58.5709	58.2730	59.1904	60.1793	60.8783	61.6091	(38)
Heat transfer coeff	130.9045	130.5034	130.1102	128.2634	127.9179	126.3094	126.3094	126.0116	126.9290	127.9179	128.6169	129.3477	(39)
Average = Sum(39)m / 12 =												128.2618	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.1368	1.1333	1.1299	1.1139	1.1109	1.0969	1.0969	1.0943	1.1023	1.1109	1.1170	1.1233	(40)
HLP (average)												1.1139	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Assumed occupancy												2.8425	(42)
Hot water usage for mixer showers	71.8785	70.7983	69.2242	66.2125	63.9900	61.5115	60.1026	61.6648	63.3772	66.0384	69.1147	71.6031	(42a)
Hot water usage for baths	31.0333	30.5724	29.9234	28.7267	27.8306	26.8370	26.3003	26.9448	27.6466	28.7097	29.9311	30.9284	(42b)
Hot water usage for other uses	43.7396	42.1491	40.5585	38.9680	37.3775	35.7869	35.7869	37.3775	38.9680	40.5585	42.1491	43.7396	(42c)
Average daily hot water use (litres/day)												134.8055	(43)
Daily hot water use	146.6513	143.5197	139.7061	133.9072	129.1981	124.1354	122.1899	125.9871	129.9917	135.3067	141.1949	146.2710	(44)
Energy conte	232.2599	204.3702	214.7231	183.3123	173.9255	152.6390	147.7781	155.9983	160.2928	183.6099	201.1580	229.0251	(45)
Energy content (annual)											Total = Sum(45)m =	2239.0922	
Distribution loss (46)m = 0.15 x (45)m	34.8390	30.6555	32.2085	27.4968	26.0888	22.8958	22.1667	23.3997	24.0439	27.5415	30.1737	34.3538	(46)
Water storage loss:													
Store volume												300.0000	(47)
a) If manufacturer declared loss factor is known (kWh/day):												2.1127	(48)
Temperature factor from Table 2b												0.5400	(49)
Enter (49) or (54) in (55)												1.1409	(55)
Total storage loss	35.3664	31.9439	35.3664	34.2256	35.3664	34.2256	35.3664	35.3664	34.2256	35.3664	34.2256	35.3664	(56)
If cylinder contains dedicated solar storage	35.3664	31.9439	35.3664	34.2256	35.3664	34.2256	35.3664	35.3664	34.2256	35.3664	34.2256	35.3664	(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	290.8887	257.3252	273.3519	240.0499	232.5543	209.3765	206.4069	214.6271	217.0304	242.2387	257.8956	287.6539	(62)
WWHRS	-32.8598	-29.0615	-30.4315	-25.1985	-23.4841	-20.0955	-18.8363	-20.0306	-20.7916	-24.5110	-27.7680	-32.2513	(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	258.0289	228.2637	242.9204	214.8514	209.0702	189.2810	187.5706	194.5966	196.2388	217.7277	230.1276	255.4026	(64)
									Total per year (kWh/year) = Sum(64)m =			2624.0794	(64)
12Total per year (kWh/year)												2624	(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	124.1295	110.3171	118.2985	106.3414	104.7333	96.1425	96.0393	98.7725	98.6874	107.9533	112.2751	123.0539	(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	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	159.6437	176.7484	159.6437	164.9652	159.6437	164.9652	159.6437	159.6437	164.9652	159.6437	164.9652	159.6437	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	278.7575	281.6501	274.3607	258.8426	239.2538	220.8430	208.5435	205.6509	212.9402	228.4583	248.0472	266.4579	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	(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)	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	(71)
Water heating gains (Table 5)	166.8407	164.1624	159.0033	147.6964	140.7705	133.5313	129.0851	132.7587	137.0658	145.0986	155.9376	165.3950	(72)
Total internal gains	673.8787	691.1977	661.6446	640.1410	608.3048	584.9763	562.9091	563.6901	580.6080	601.8374	637.5868	660.1335	(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	
North	4.1700	10.6334	0.6300	0.7000	0.7700	13.5513	(74)
South	8.2900	46.7521	0.6300	0.7000	0.7700	118.4478	(78)

Solar gains	131.9991	219.8842	291.1107	349.9667	386.2477	382.0102	368.8199	341.2575	311.0394	240.0604	157.1183	113.6468	(83)
Total gains	805.8778	911.0819	952.7553	990.1076	994.5525	966.9865	931.7290	904.9477	891.6474	841.8978	794.7051	773.7803	(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	48.6123	48.7617	48.9090	49.6132	49.7472	50.3807	50.3807	50.4998	50.1348	49.7472	49.4769	49.1974	
alpha	4.2408	4.2508	4.2606	4.3075	4.3165	4.3587	4.3587	4.3667	4.3423	4.3165	4.2985	4.2798	
util living area	0.9908	0.9836	0.9723	0.9425	0.8767	0.7342	0.5695	0.6043	0.8055	0.9441	0.9827	0.9922	(86)
MIT	19.4551	19.6574	19.9293	20.3076	20.6443	20.8895	20.9717	20.9631	20.8232	20.4004	19.8742	19.4308	(87)
Th 2	19.9709	19.9737	19.9765	19.9895	19.9920	20.0034	20.0034	20.0055	19.9990	19.9920	19.9870	19.9819	(88)
util rest of house	0.9884	0.9793	0.9646	0.9252	0.8371	0.6520	0.4527	0.4894	0.7358	0.9241	0.9775	0.9902	(89)
MIT 2	18.1781	18.4368	18.7827	19.2626	19.6641	19.9284	19.9917	19.9890	19.8656	19.3836	18.7234	18.1547	(90)
Living area fraction									fLA = Living area / (4) =			0.1633	(91)
MIT	18.3866	18.6361	18.9699	19.4332	19.8242	20.0853	20.1517	20.1480	20.0219	19.5496	18.9113	18.3631	(92)
Temperature adjustment												0.0000	
adjusted MIT	18.3866	18.6361	18.9699	19.4332	19.8242	20.0853	20.1517	20.1480	20.0219	19.5496	18.9113	18.3631	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9830	0.9715	0.9545	0.9133	0.8293	0.6594	0.4710	0.5069	0.7377	0.9128	0.9696	0.9854	(94)
Useful gains	792.1396	885.1104	909.4134	904.2762	824.7801	637.6690	438.8017	458.6790	657.7303	768.4482	770.5325	762.4839	(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	1843.9997	1792.6059	1622.4572	1351.0235	1039.2258	692.8465	448.6156	472.2931	751.6665	1144.8141	1519.1268	1831.9605	(97)
Space heating kWh	782.5839	609.8370	530.5046	321.6581	159.5476	0.0000	0.0000	0.0000	0.0000	280.0163	538.9879	795.6906	(98a)
Space heating requirement - total per year (kWh/year)												4018.8261	
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	782.5839	609.8370	530.5046	321.6581	159.5476	0.0000	0.0000	0.0000	0.0000	280.0163	538.9879	795.6906	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												4018.8261	
Space heating per m2										(98c) / (4) =		34.9008	(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	782.5839	609.8370	530.5046	321.6581	159.5476	0.0000	0.0000	0.0000	0.0000	280.0163	538.9879	795.6906	(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)	847.8699	660.7118	574.7612	348.4919	172.8577	0.0000	0.0000	0.0000	0.0000	303.3762	583.9523	862.0700	(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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Water heating requirement	258.0289	228.2637	242.9204	214.8514	209.0702	189.2810	187.5706	194.5966	196.2388	217.7277	230.1276	255.4026	(64)
Efficiency of water heater												79.8000	(216)
(217)m	86.3842	86.1536	85.7621	84.9627	83.4612	79.8000	79.8000	79.8000	79.8000	84.6251	85.9012	86.4314	(217)
Fuel for water heating, kWh/month	298.6990	264.9497	283.2493	252.8774	250.4997	237.1943	235.0509	243.8554	245.9133	257.2850	267.8979	295.4975	(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	33.1708	26.6109	23.9601	17.5542	13.5594	11.0781	12.3693	16.0781	20.8839	27.4008	30.9491	34.0927	(232)
Electricity generated by PVs (Appendix M) (negative quantity) (233a)m	-40.8837	-58.3762	-84.9345	-96.6511	-105.1363	-98.4001	-97.1556	-91.2786	-81.0470	-67.2669	-45.1988	-35.2579	(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	-20.8615	-44.1410	-88.2320	-133.2610	-176.9533	-178.1226	-176.0591	-148.7438	-108.5739	-63.4043	-27.9390	-16.4796	(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	4354.0911	(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	3132.9693	(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)	267.7074	(232)
Energy saving/generation technologies (Appendices M ,N and Q)		
PV generation	-2084.3578	(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	5756.4100	(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	4354.0911	0.2100	914.3591	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	3132.9693	0.2100	657.9236	(264)
Space and water heating			1572.2827	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	267.7074	0.1443	38.6385	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-901.5867	0.1343	-121.1219	
PV Unit electricity exported	-1182.7712	0.1257	-148.7049	
Total			-269.8267	(269)
Total CO2, kg/year			1353.0237	(272)
EPC Target Carbon Dioxide Emission Rate (TER)			11.7500	(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	4354.0911	1.1300	4920.1229	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	3132.9693	1.1300	3540.2553	(278)

Space and water heating			8460.3782 (279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008 (281)
Energy for lighting	267.7074	1.5338	410.6186 (282)
Energy saving/generation technologies			
PV Unit electricity used in dwelling	-901.5867	1.4965	-1349.2206
PV Unit electricity exported	-1182.7712	0.4615	-545.8389
Total			-1895.0595 (283)
Total Primary energy kWh/year			7106.0381 (286)
Target Primary Energy Rate (TPER)			61.7100 (287)

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

1. Overall dwelling characteristics

	Area (m2)		Storey height (m)		Volume (m3)
Ground floor	42.1700 (1b)	x	2.6000 (2b)	=	109.6420 (1b) -
First floor	41.8200 (1c)	x	2.8000 (2c)	=	117.0960 (1c) -
Second floor	31.1600 (1d)	x	3.0000 (2d)	=	93.4800 (1d) -

Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n) 115.1500 (4)
Dwelling volume (3a)+(3b)+(3c)+(3d)+(3e)...(3n) = 320.2180 (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	4 * 10 =	40.0000 (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) = 40.0000 / (5) = 0.1249 (8)
Pressure test Yes
Pressure Test Method Blower Door
Measured/design AP50 5.0000 (17)
Infiltration rate 0.3749 (18)
Number of sides sheltered 1 (19)

Shelter factor (20) = 1 - [0.075 x (19)] = 0.9250 (20)
Infiltration rate adjusted to include shelter factor (21) = (18) x (20) = 0.3468 (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	0.4422	0.4335	0.4248	0.3815	0.3728	0.3295	0.3295	0.3208	0.3468	0.3728	0.3901	0.4075 (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)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Effective ac	0.5978	0.5940	0.5902	0.5728	0.5695	0.5543	0.5543	0.5515	0.5601	0.5695	0.5761	0.5830 (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	
Door			2.1200	1.0000	2.1200			(26)
Window (Uw = 1.20)			12.4600	1.1450	14.2672			(27)
GF			42.1700	0.1500	6.3255	75.0000	3162.7500	(28a)
EXPOSED FLR OVER ENTRANCE			1.6500	0.1500	0.2475	20.0000	33.0000	(28b)
Wall1	127.0000	14.5800	112.4200	0.1500	16.8630	110.0000	12366.2000	(29a)
ASHLAR WALL UNDER EAVES	24.6000		24.6000	0.2000	4.9200	9.0000	221.4000	(29a)
Plane	8.2000		8.2000	0.1000	0.8200	9.0000	73.8000	(30)
Slope	32.4700		32.4700	0.1500	4.8705	9.0000	292.2300	(30)
CEILING UNDER EAVES	10.6600		10.6600	0.1500	1.5990	9.0000	95.9400	(30)
BAY ROOF	2.0000		2.0000	0.1500	0.3000	9.0000	18.0000	(30)
Total net area of external elements Aum(A, m2)			248.7500					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		52.3327			(33)

Party Wall 1	44.2800	0.0000	0.0000	70.0000	3099.5999	(32)
Studwall partitions	180.0000			9.0000	1620.0000	(32c)
Internal Floor 1	40.1700			18.0000	723.0600	(32d)
Internal Floor 2	31.1600			18.0000	560.8800	(32d)
Internal Ceiling 1	40.1700			9.0000	361.5300	(32e)
Internal Ceiling 2	31.1600			9.0000	280.4400	(32e)

Heat capacity Cm = Sum(A x k) (28)...(30) + (32) + (32a)...(32e) = 22908.8299 (34)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K 198.9477 (35)
List of Thermal Bridges

K1 Element	Length	Psi-value	Total
E2 Other lintels (including other steel lintels)	7.7700	0.0540	0.4196
E3 Sill	4.7400	0.0400	0.1896
E4 Jamb	27.7000	0.0490	1.3573
E5 Ground floor (normal)	20.3300	0.0380	0.7725
E6 Intermediate floor within a dwelling	37.0100	0.0120	0.4441
E11 Eaves (insulation at rafter level)	8.2000	-0.0310	-0.2542
E12 Gable (insulation at ceiling level)	2.0000	0.0870	0.1740
E13 Gable (insulation at rafter level)	11.6000	0.0910	1.0556
E16 Corner (normal)	18.6000	0.0400	0.7440
E18 Party wall between dwellings	5.2000	0.0490	0.2548
P1 Party wall - Ground floor	8.2000	0.0660	0.5412
P2 Party wall - Intermediate floor within a dwelling	16.4000	0.0000	0.0000
P5 Party wall - Roof (insulation at rafter level)	8.2000	0.2110	1.7302
R6 Flat ceiling	16.4000	0.0380	0.6232
E17 Corner (inverted – internal area greater than external area)	13.4000	-0.0290	-0.3886
E16 Corner (normal)	6.0000	0.0380	0.2280
E20 Exposed floor (normal)	3.3400	0.1080	0.3607
E21 Exposed floor (inverted)	3.3400	0.1090	0.3641
E15 Flat roof with parapet	4.0000	0.1000	0.4000
E24 Eaves (insulation at ceiling level - inverted)	2.0500	0.0370	0.0758

Thermal bridges (Sum(L x Psi) calculated using Appendix K) 9.0920 (36)
Point Thermal bridges (36a) = 0.0000
Total fabric heat loss (33) + (36) + (36a) = 61.4246 (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	63.1659	62.7648	62.3716	60.5249	60.1793	58.5709	58.5709	58.2730	59.1904	60.1793	60.8783	61.6091 (38)
Heat transfer coeff	124.5906	124.1895	123.7963	121.9495	121.6040	119.9955	119.9955	119.6976	120.6151	121.6040	122.3030	123.0337 (39)
Average = Sum(39)m / 12 =												121.9479

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HLP	1.0820	1.0785	1.0751	1.0590	1.0560	1.0421	1.0421	1.0395	1.0475	1.0560	1.0621	1.0685 (40)
HLP (average)												1.0590
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31

4. Water heating energy requirements (kWh/year)

Assumed occupancy 2.8425 (42)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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	31.0333	30.5724	29.9234	28.7267	27.8306	26.8370	26.3003	26.9448	27.6466	28.7097	29.9311	30.9284 (42b)
Hot water usage for other uses	43.7396	42.1491	40.5585	38.9680	37.3775	35.7869	35.7869	37.3775	38.9680	40.5585	42.1491	43.7396 (42c)
Average daily hot water use (litres/day)												68.5360 (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily hot water use	74.7729	72.7215	70.4819	67.6947	65.2081	62.6240	62.0873	64.3223	66.6146	69.2683	72.0801	74.6680 (44)
Energy conte	118.4220	103.5544	108.3281	92.6707	87.7826	77.0035	75.0892	79.6444	82.1424	93.9964	102.6914	116.9120 (45)

Energy content (annual) Total = Sum(45)m = 1138.2371
Distribution loss (46)m = 0.15 x (45)m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Distribution 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 (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	100.6587	88.0212	92.0789	78.7701	74.6152	65.4530	63.8258	67.6978	69.8211	79.8969	87.2877	99.3752 (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	100.6587	88.0212	92.0789	78.7701	74.6152	65.4530	63.8258	67.6978	69.8211	79.8969	87.2877	99.3752 (64)

Total per year (kWh/year) = Sum(64)m = 967.5015 (64)
12Total per year (kWh/year) 968 (64)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Electric shower(s)	57.5627	51.2888	56.0054	53.4453	54.4482	51.9383	53.6695	54.4482	53.4453	56.0054	54.9523	57.5627 (64a)

Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m = 654.7719 (64a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heat gains from water heating, kWh/month	39.5553	34.8275	37.0211	33.0538	32.2658	29.3478	29.3738	30.5365	30.8166	33.9756	35.5600	39.2345 (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	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	157.2545	174.1031	157.2545	162.4963	157.2545	162.4963	157.2545	157.2545	162.4963	157.2545	162.4963	157.2545	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	278.7575	281.6501	274.3607	258.8426	239.2538	220.8430	208.5435	205.6509	212.9402	228.4583	248.0472	266.4579	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	(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)													
	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	(71)
Water heating gains (Table 5)													
	53.1658	51.8267	49.7595	45.9081	43.3681	40.7608	39.4810	41.0437	42.8008	45.6661	49.3889	52.7345	(72)
Total internal gains													
	554.8145	573.2167	547.0115	532.8838	505.5131	489.7369	470.9157	469.5858	483.8741	497.0157	525.5691	542.0837	(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	
North	4.1700	10.6334	0.5000	0.7500	0.7700	11.5232	(74)
South	8.2900	46.7521	0.5000	0.7500	0.7700	100.7210	(78)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	112.2441	186.9764	247.5431	297.5907	328.4419	324.8386	313.6224	290.1850	264.4893	204.1330	133.6040	96.6385	(83)
Total gains	667.0586	760.1931	794.5546	830.4745	833.9551	814.5756	784.5381	759.7708	748.3634	701.1487	659.1732	638.7222	(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	51.0758	51.2408	51.4035	52.1820	52.3302	53.0317	53.0317	53.1637	52.7593	52.3302	52.0311	51.7221	
alpha	4.4051	4.4161	4.4269	4.4788	4.4887	4.5354	4.5354	4.5442	4.5173	4.4887	4.4687	4.4481	
util living area													
	0.9955	0.9913	0.9847	0.9652	0.9176	0.7944	0.6319	0.6692	0.8594	0.9672	0.9911	0.9963	(86)
MIT	19.4037	19.5951	19.8572	20.2367	20.5856	20.8626	20.9633	20.9520	20.7853	20.3353	19.8154	19.3832	(87)
Th 2	20.0156	20.0184	20.0212	20.0344	20.0369	20.0484	20.0484	20.0506	20.0440	20.0369	20.0319	20.0267	(88)
util rest of house													
	0.9942	0.9889	0.9803	0.9539	0.8877	0.7196	0.5133	0.5544	0.8008	0.9543	0.9882	0.9953	(89)
MIT 2	18.5566	18.7489	19.0112	19.3938	19.7270	19.9715	20.0358	20.0326	19.9104	19.4947	18.9791	18.5444	(90)
Living area fraction									fLA = Living area / (4) =			0.1633	(91)
MIT	18.6949	18.8871	19.1493	19.5314	19.8671	20.1170	20.1873	20.1827	20.0532	19.6319	19.1157	18.6814	(92)
Temperature adjustment												0.0000	
adjusted MIT	18.6949	18.8871	19.1493	19.5314	19.8671	20.1170	20.1873	20.1827	20.0532	19.6319	19.1157	18.6814	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9919	0.9852	0.9749	0.9464	0.8813	0.7257	0.5318	0.5717	0.8014	0.9473	0.9845	0.9933	(94)
Useful gains	661.6618	748.9458	774.6340	785.9963	735.0036	591.1133	417.2110	434.3261	599.7552	664.1846	648.9402	634.4328	(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													
	1793.4700	1737.0487	1565.9386	1296.4994	993.1577	662.0172	430.4557	452.7838	718.0456	1098.3180	1469.5513	1781.6974	(97)
Space heating kWh													
	842.0653	664.0051	588.7306	367.5622	192.0666	0.0000	0.0000	0.0000	0.0000	322.9953	590.8400	853.5649	(98a)
Space heating requirement - total per year (kWh/year)												4421.8301	
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													
	842.0653	664.0051	588.7306	367.5622	192.0666	0.0000	0.0000	0.0000	0.0000	322.9953	590.8400	853.5649	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												4421.8301	
Space heating per m2											(98c) / (4) =	38.4006	(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	1127.9578	887.9668	909.7021	0.0000	0.0000	0.0000	0.0000	(100)
Utilisation	0.0000	0.0000	0.0000	0.0000	0.0000	0.7032	0.7979	0.7737	0.0000	0.0000	0.0000	0.0000	(101)
Useful loss	0.0000	0.0000	0.0000	0.0000	0.0000	793.1833	708.5110	703.8294	0.0000	0.0000	0.0000	0.0000	(102)
Total gains	0.0000	0.0000	0.0000	0.0000	0.0000	875.5642	843.9251	818.2338	0.0000	0.0000	0.0000	0.0000	(103)

Space cooling kWh													
	0.0000	0.0000	0.0000	0.0000	0.0000	59.3142	100.7481	85.1169	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	14.8286	25.1870	21.2792	0.0000	0.0000	0.0000	0.0000	(107)
Space cooling requirement												61.2948	(107)
Energy for space heating												38.4006	(99)
Energy for space cooling												0.5323	(108)
Total												38.9329	(109)
Fabric Energy Efficiency (DFEE)												38.9	(109)

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

1. Overall dwelling characteristics

	Area (m2)		Storey height (m)		Volume (m3)
Ground floor	42.1700 (1b)	x	2.6000 (2b)	=	109.6420 (1b) -
First floor	41.8200 (1c)	x	2.8000 (2c)	=	117.0960 (1c) -
Second floor	31.1600 (1d)	x	3.0000 (2d)	=	93.4800 (1d) -
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n) 115.1500					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	320.2180 (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	4 * 10 =	40.0000	(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) =	40.0000 / (5) =	0.1249	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3749	(18)
Number of sides sheltered		1	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.9250	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3468	(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													
	0.4422	0.4335	0.4248	0.3815	0.3728	0.3295	0.3295	0.3208	0.3468	0.3728	0.3901	0.4075	(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	0.5978	0.5940	0.5902	0.5728	0.5695	0.5543	0.5543	0.5515	0.5601	0.5695	0.5761	0.5830	(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 Opaque door			2.1200	1.0000	2.1200			(26)
TER Opening Type (Uw = 1.20)			12.4600	1.1450	14.2672			(27)
GF			42.1700	0.1300	5.4821			(28a)
EXPOSED FLR OVER ENTRANCE			1.6500	0.1300	0.2145			(28b)
Wall1	127.0000	14.5800	112.4200	0.1800	20.2356			(29a)
ASHLAR WALL UNDER EAVES	24.6000		24.6000	0.1800	4.4280			(29a)
Plane	8.2000		8.2000	0.1100	0.9020			(30)
Slope	32.4700		32.4700	0.1100	3.5717			(30)
CEILING UNDER EAVES	10.6600		10.6600	0.1100	1.1726			(30)
BAY ROOF	2.0000		2.0000	0.1100	0.2200			(30)

Total net area of external elements Aum(A, m2)	248.7500		(31)
Fabric heat loss, W/K = Sum (A x U)	(26)...(30) + (32) =	52.6137	(33)
Party Wall 1	44.2800	0.0000 0.0000	(32)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K		198.9477	(35)

List of Thermal Bridges

K1 Element	Length	Psi-value	Total
E2 Other lintels (including other steel lintels)	7.7700	0.0500	0.3885
E3 Sill	4.7400	0.0500	0.2370
E4 Jamb	27.7000	0.0500	1.3850
E5 Ground floor (normal)	20.3300	0.1600	3.2528
E6 Intermediate floor within a dwelling	37.0100	0.0000	0.0000
E11 Eaves (insulation at rafter level)	8.2000	0.0400	0.3280
E12 Gable (insulation at ceiling level)	2.0000	0.0600	0.1200
E13 Gable (insulation at rafter level)	11.6000	0.0800	0.9280
E16 Corner (normal)	18.6000	0.0900	1.6740
E18 Party wall between dwellings	5.2000	0.0600	0.3120
P1 Party wall - Ground floor	8.2000	0.0800	0.6560
P2 Party wall - Intermediate floor within a dwelling	16.4000	0.0000	0.0000
P5 Party wall - Roof (insulation at rafter level)	8.2000	0.0800	0.6560
R6 Flat ceiling	16.4000	0.0600	0.9840
E17 Corner (inverted – internal area greater than external area)	13.4000	-0.0900	-1.2060
E16 Corner (normal)	6.0000	0.0900	0.5400
E20 Exposed floor (normal)	3.3400	0.3200	1.0688
E21 Exposed floor (inverted)	3.3400	0.3200	1.0688
E15 Flat roof with parapet	4.0000	0.5600	2.2400
E24 Eaves (insulation at ceiling level - inverted)	2.0500	0.2400	0.4920

Thermal bridges (Sum(L x Psi) calculated using Appendix K)		15.1249	(36)
Point Thermal bridges	(36a) =	0.0000	
Total fabric heat loss	(33) + (36) + (36a) =	67.7386	(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	63.1659	62.7648	62.3716	60.5249	60.1793	58.5709	58.5709	58.2730	59.1904	60.1793	60.8783	61.6091	(38)
Heat transfer coeff	130.9045	130.5034	130.1102	128.2634	127.9179	126.3094	126.3094	126.0116	126.9290	127.9179	128.6169	129.3477	(39)
Average = Sum(39)m / 12 =												128.2618	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.1368	1.1333	1.1299	1.1139	1.1109	1.0969	1.0969	1.0943	1.1023	1.1109	1.1170	1.1233	(40)
HLP (average)												1.1139	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Assumed occupancy												2.8425	(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	31.0333	30.5724	29.9234	28.7267	27.8306	26.8370	26.3003	26.9448	27.6466	28.7097	29.9311	30.9284	(42b)
Hot water usage for other uses	43.7396	42.1491	40.5585	38.9680	37.3775	35.7869	35.7869	37.3775	38.9680	40.5585	42.1491	43.7396	(42c)
Average daily hot water use (litres/day)												68.5360	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	74.7729	72.7215	70.4819	67.6947	65.2081	62.6240	62.0873	64.3223	66.6146	69.2683	72.0801	74.6680	(44)
Energy conte	118.4220	103.5544	108.3281	92.6707	87.7826	77.0035	75.0892	79.6444	82.1424	93.9964	102.6914	116.9120	(45)
Energy content (annual)										Total = Sum(45)m =		1138.2371	
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	100.6587	88.0212	92.0789	78.7701	74.6152	65.4530	63.8258	67.6978	69.8211	79.8969	87.2877	99.3752	(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	100.6587	88.0212	92.0789	78.7701	74.6152	65.4530	63.8258	67.6978	69.8211	79.8969	87.2877	99.3752	(64)
								Total per year (kWh/year) = Sum(64)m =				967.5015	(64)
12Total per year (kWh/year)												968	(64)
Electric shower(s)	57.5627	51.2888	56.0054	53.4453	54.4482	51.9383	53.6695	54.4482	53.4453	56.0054	54.9523	57.5627	(64a)
					Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m =							654.7719	(64a)
Heat gains from water heating, kWh/month	39.5553	34.8275	37.0211	33.0538	32.2658	29.3478	29.3738	30.5365	30.8166	33.9756	35.5600	39.2345	(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	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	142.1228	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	159.6437	176.7484	159.6437	164.9652	159.6437	164.9652	159.6437	159.6437	164.9652	159.6437	164.9652	159.6437	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	278.7575	281.6501	274.3607	258.8426	239.2538	220.8430	208.5435	205.6509	212.9402	228.4583	248.0472	266.4579	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	37.2123	(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)	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	-113.6982	(71)
Water heating gains (Table 5)	53.1658	51.8267	49.7595	45.9081	43.3681	40.7608	39.4810	41.0437	42.8008	45.6661	49.3889	52.7345	(72)
Total internal gains	557.2038	575.8620	549.4008	535.3527	507.9024	492.2058	473.3050	471.9751	486.3430	499.4050	528.0380	544.4730	(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	
North	4.1700	10.6334	0.6300	0.7000	0.7700	13.5513	(74)
South	8.2900	46.7521	0.6300	0.7000	0.7700	118.4478	(78)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	131.9991	219.8842	291.1107	349.9667	386.2477	382.0102	368.8199	341.2575	311.0394	240.0604	157.1183	113.6468	(83)
Total gains	689.2029	795.7462	840.5115	885.3194	894.1501	874.2160	842.1249	813.2326	797.3824	739.4654	685.1564	658.1198	(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, nil,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	48.6123	48.7617	48.9090	49.6132	49.7472	50.3807	50.3807	50.4998	50.1348	49.7472	49.4769	49.1974	
alpha	4.2408	4.2508	4.2606	4.3075	4.3165	4.3587	4.3587	4.3667	4.3423	4.3165	4.2985	4.2798	
util living area	0.9949	0.9899	0.9821	0.9597	0.9073	0.7802	0.6188	0.6570	0.8488	0.9632	0.9899	0.9958	(86)
MIT	19.3295	19.5367	19.8168	20.2141	20.5763	20.8582	20.9611	20.9491	20.7768	20.3079	19.7594	19.3053	(87)
Th 2	19.9709	19.9737	19.9765	19.9895	19.9920	20.0034	20.0034	20.0055	19.9990	19.9920	19.9870	19.9819	(88)
util rest of house	0.9935	0.9872	0.9768	0.9467	0.8741	0.7015	0.4968	0.5384	0.7864	0.9488	0.9867	0.9947	(89)
MIT 2	18.4493	18.6572	18.9368	19.3358	19.6795	19.9256	19.9904	19.9869	19.8624	19.4323	18.8896	18.4334	(90)
Living area fraction									fLA = Living area / (4) =			0.1633	(91)
MIT	18.5930	18.8007	19.0805	19.4792	19.8259	20.0778	20.1489	20.1440	20.0117	19.5753	19.0316	18.5757	(92)
Temperature adjustment												0.0000	
adjusted MIT	18.5930	18.8007	19.0805	19.4792	19.8259	20.0778	20.1489	20.1440	20.0117	19.5753	19.0316	18.5757	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9908	0.9829	0.9707	0.9384	0.8675	0.7081	0.5158	0.5563	0.7873	0.9410	0.9825	0.9924	(94)
Useful gains	682.8676	782.1162	815.8756	830.7688	775.7010	619.0329	434.3599	452.3659	627.7932	695.8544	673.1426	653.1098	(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	1871.0184	1814.0947	1636.8513	1356.9240	1039.4454	691.9026	448.2571	471.7885	750.3693	1148.1015	1534.6057	1859.4672	(97)
Space heating kWh	883.9842	693.4895	610.8059	378.8318	196.2259	0.0000	0.0000	0.0000	0.0000	336.4718	620.2535	897.5299	(98a)
Space heating requirement - total per year (kWh/year)												4617.5924	
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	883.9842	693.4895	610.8059	378.8318	196.2259	0.0000	0.0000	0.0000	0.0000	336.4718	620.2535	897.5299	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												4617.5924	
Space heating per m2											(98c) / (4) =	40.1007	(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	1187.3088	934.6899	957.6880	0.0000	0.0000	0.0000	0.0000	(100)
Utilisation	0.0000	0.0000	0.0000	0.0000	0.0000	0.7096	0.8017	0.7768	0.0000	0.0000	0.0000	0.0000	(101)
Useful loss	0.0000	0.0000	0.0000	0.0000	0.0000	842.4961	749.3360	743.9469	0.0000	0.0000	0.0000	0.0000	(102)
Total gains	0.0000	0.0000	0.0000	0.0000	0.0000	942.5972	908.6675	878.2226	0.0000	0.0000	0.0000	0.0000	(103)
Space cooling kWh	0.0000	0.0000	0.0000	0.0000	0.0000	72.0728	118.5204	99.9012	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	18.0182	29.6301	24.9753	0.0000	0.0000	0.0000	0.0000 (107)
Space cooling requirement												72.6236 (107)
Energy for space heating												40.1007 (99)
Energy for space cooling												0.6307 (108)
Total												40.7314 (109)
Fabric Energy Efficiency (TFEE)												40.7 (109)

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name — **Shell and Core**

Block 6 - Comercial

As designed

Date: Tue Jun 06 17:54:02 2023

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.21

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.21

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

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Foundation area [m²]: 435.61

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

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	10.76	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	10.42	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	115.11	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	112.57	
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	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.15	0.15	00000000:Surf[5]
Floors	0.18	0.13	0.13	00000000:Surf[0]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	-	-	No flat roofs in building
Windows** and roof windows	1.6	1.2	1.2	00000000:Surf[1]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	1	1	00000008:Surf[1]
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

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]
* 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/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	5

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- Split units

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	4	5.5	0	-	-
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.

"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	Zone	Standard
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1		
01.E.Restaurant-Kitchen	-	-	-	-	-	-	-	-	0.8	-	N/A
01.E.Restaurant-Toilets	-	-	0.4	-	-	-	-	-	-	-	N/A

Shell and core configuration

Zone	Assumed shell?
00.E.Restaurant	YES
00.E.Restaurant-Circulation	YES
00.E.Restaurant-Office	YES
00.E.Retail 01	YES
00.E.Retail 02	YES
01.E.Restaurant-Circulation	YES
01.E.Restaurant-Circulation	YES
01.E.Restaurant-Kitchen	YES
01.E.Restaurant-Toilets	YES

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.E.Restaurant	100	80	1.5

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.E.Restaurant-Circulation	100	-	-
00.E.Restaurant-Office	100	-	-
00.E.Retail 01	100	80	1.5
00.E.Retail 02	100	80	1.5
01.E.Restaurant-Circulation	100	-	-
01.E.Restaurant-Circulation	100	-	-
01.E.Restaurant-Kitchen	100	-	-
01.E.Restaurant-Toilets	100	-	-

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.E.Restaurant	NO (-19.2%)	NO
00.E.Restaurant-Circulation	N/A	N/A
00.E.Restaurant-Office	N/A	N/A
00.E.Retail 01	NO (-41%)	NO
00.E.Retail 02	NO (-86%)	NO
01.E.Restaurant-Circulation	NO (-32.8%)	NO
01.E.Restaurant-Circulation	N/A	N/A
01.E.Restaurant-Kitchen	NO (-74.8%)	NO
01.E.Restaurant-Toilets	NO (-55.5%)	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?	YES
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]	871.2	871.2
External area [m²]	1370.1	1370.1
Weather	NOR	NOR
Infiltration [m³/hm²@ 50Pa]	5	3
Average conductance [W/K]	473.83	602.5
Average U-value [W/m²K]	0.35	0.44
Alpha value* [%]	25	10

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

Building Use

% Area	Building Type
45	**Retail/Financial and Professional Services**
55	**Restaurants and Cafes/Drinking Establishments/Takeaways**
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	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	14.79	21.75
Cooling	5.7	3.89
Auxiliary	12.99	11.19
Lighting	15.33	14.65
Hot water	27.13	25.78
Equipment*	69.02	69.02
TOTAL**	**75.94**	**77.26**

* 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	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	293.23	282.44
Primary energy [kWh_{PE}/m²]	112.57	115.11
Total emissions [kg/m²]	10.42	10.76

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	208.9	84.3	14.8	5.7	13	3.92	4.11	4	5.5
	Notional	217.6	64.8	21.8	3.9	11.2	2.78	4.63	---	---

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 E – Indicative PV arrays' size

Apartment blocks		no. PVs	House types	no. PVs
Wensum Edge	Block 1	40	HT-A (2B/3P)	6
	Block 2	154	HT-B (3B/5P)	6
	Block 3 & 4	116	HT-D (4B/6P)	6
	Block 5	40	HT-G (4B/7P)	6
	Block 6	108	HT-H (3B/5P)	8
	Block 7	49	HT-I (3B/6P)	8
The Views	Block 1	30	HT-L (4B/5P)	6
	Block 2a	12	HT-O (3B/4P)	9
	Block 2b	12	HT-P (5B/8P)	9
Yare Edge	Block 1c	20	HT-A (2B/3P)	6

Appendix F – Thermal bridging

	Ref.	Junction detail	Psi-value	Detail no.
Junctions with an external wall	E1	Steel lintel with perforated steel base plate	0.053	610363
	E2	Other lintels (including other steel lintels)	0.054	610340
	E3	Sill	0.040	610341
	E4	Jamb	0.049	610342
	E5	Ground floor (normal)	0.038	610344
	E20	Exposed floor (normal)	0.108	610360
	E21	Exposed floor (inverted)	0.109	610361
	E22	Basement floor	0.072	610366
	E6	Intermediate floor within a dwelling	0.012	610349
	E7	Party floor between dwellings (in blocks of flats)	0.130	610348
	E10	Eaves (insulation at ceiling level)	0.042	610334
	E24	Eaves (insulation at ceiling level - inverted)	0.037	610362
	E11	Eaves (insulation at rafter level)	-0.031	610336
	E12	Gable (insulation at ceiling level)	0.087	610335
	E13	Gable (insulation at rafter level)	0.091	610337
	E14	Flat roof	0.049	610338
	E15	Flat roof with parapet	0.100	610339
	E16	Corner (normal)	0.040	610355
	E17	Corner (inverted – internal area greater than external area)	-0.063	610356
	E18	Party wall between dwellings	0.049	610347
	E25	Staggered party wall between dwellings	0.079	610357
Junctions with a party wall	P1	Ground floor	0.066	610352
	P6	Ground floor (inverted)	0.124	610367
	P7	Exposed floor (normal)	0.149	610358
	P8	Exposed floor (inverted)	0.216	610359
	P4	Roof (insulation at ceiling level)	0.332	610353
	P5	Roof (insulation at rafter level)	0.211	610354
Junctions within a roof or with a room-in-roof	R1	Head of roof window	0.107	610435
	R2	Sill of roof window	0.118	610437
	R3	Jamb of roof window	0.078	610436
	R6	Flat ceiling	0.038	610446
	R7	Flat ceiling (inverted)	-0.02	610447
	R8	Roof to wall (rafter)	0.02	610444
	R9	Roof to wall (flat ceiling)	0.048	610445

CBRE

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