Atlantic Wharf, Butetown Masterplan Energy Strategy

in support of Hybrid Planning Application for

Atlantic Wharf Masterplan

Cardiff Arena and Hotel

Issue 1.0

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Contents

1 Executive Summary

This document is part of a suite of documents forming the Environmental Impact Assessment.

An energy statement in support of the Atlantic Wharf, Butetown Masterplan with the Cardiff Arena and a Hotel development encompassed within this.

The application includes:

- Atlantic Wharf, Butetown Masterplan – Outline Application
- Cardiff Arena – Detailed Application
- Associated Hotel – Detailed Application

The energy statement is structured as an energy strategy to support the masterplan area as a whole together with energy statements for each of the detailed applications.

Section 3 describes the relevant policies including:

- UK and National Policy around Climate Change
- Future Wales
- National Building Regulations Part L Compliance
- One Planet Cardiff
- Local Planning Policies

Section 4 presents the masterplan energy strategy. We present a short introduction to the concept of operational net-zero in the context of a masterplan, followed by description of the energy hierarchy approach to design. This is followed by a description of the whole system approach to a masterplan area,

A whole system approach is to consider both the masterplan area as a whole and its relationship with the wider energy system. With the whole system approach, we recognise that “net zero” for a single building can be difficult and expensive to achieve, while net-zero for a mixed-use development with complementary energy demand profiles and the opportunity for linking into the wide area heat and power networks is a more tractable problem.

Demand side measures (including passive measures, energy efficiency and demand side response options) are considered alongside the energy infrastructure (which includes energy delivery and energy storage systems) and energy supply options including environmental energy sources, decentralised energy systems and linking into local or wider area networks.

A key element of this strategy is the adoption of “smart” infrastructure which combined with demand side response will make best use of the on-site energy supply options.

Renewable low carbon technologies can be located at the most appropriate areas within the masterplan area rather than behind the meter on each building. This also offers opportunities for:

- taking advantage of complementary energy uses
- delivering improved demand and supply side matching
- using more of the onsite generated energy, onsite
- system wide energy control and energy use scheduling

This is rather more complex than the typical energy strategy applied at the single building level but the approach lends itself to consider the opportunities for “smart” infrastructure including a smart micro-grid where individual buildings take part in demand side response to maximise the use of available on-site renewables and excess renewable generation associated with one building can be shared between buildings within the masterplan.

In section 4.8 we introduce the concept of building a carbon reduction stack, that is combining the projected

carbon trajectory of the supplied grid electricity and the heat network with continued reduction in energy demand through progressive improvements in control and building management, finally addressing the carbon gap with fuel substitution and replacement of fossil fuel derived energy with renewable alternatives.

A description of the carbon trajectory of the UK electricity grid is given together with a review of the carbon intensity figures used in the National Calculation Methodology for assessing compliance with Part L2A. It is shown that the reduction in carbon intensity of the UK grid has led to a potential conflict between saving operational costs and saving carbon due to the difference in costs of electricity and gas compared to the comparable carbon savings.

An outline estimate of the masterplan energy demands is presented in section 4.14, while the carbon implications of this are discussed in section 4.15.

It is noted that the electricity grid carbon factor is now broadly comparable with that of gas and is projected to fall further. This means that gas fired CHP as a means of supply to heat networks is no longer considered a low carbon technology. It is also noted that Zero Waste Scotland have recently published a technical report on the climate change impacts of burning municipal waste in Scotland [1]

The report notes. *"The fossil content of waste is the most significant factor affecting greenhouse gas emissions per tonne of waste burnt in EfW plants"*

and concludes:

> *The carbon intensity of EfW plants operating in Scotland in 2018 was higher than alternative energy sources. Electricity-only plants emitted nearly twice as many greenhouse gas emissions for each unit of power generated compared to the average of energy technologies supplying the marginal electricity grid in the UK in 2018. Converting these plants to combined heat and power systems would reduce their carbon intensity but not to the level of the UK grid. As a result,* ***EfW can no longer be considered a source of low carbon energy within a UK and Scottish context.***

It is noted that the results are highly dependent on the carbon factors used and that for electricity and heat these depend on a series of assumptions.

Notwithstanding the above conclusion we have prepared an assessment based on the low carbon factor presented for the EfW Viridor plant. An appraisal of the effectiveness of heat networks for the outline masterplan against Future Wales policy 16 is presented in section 4.16.

It is concluded that the proposed heat network and electricity derived heating using heat pumps both offer low carbon solutions. Where the building needs both heat and cooling then the higher efficiencies offered by heat recovery and heat pumps will provide a faster low carbon trajectory than using the heat network. However, where there are no environmental heat sources or waste heat is available the heat networks will offer a lower carbon alternative if this can be shown to be technically feasible and cost effective.

The masterplan energy strategy is summarized in section 4.17.

1. System design is based on the Energy Hierarchy, prioritising demand reduction, energy efficiency before on-site renewables at the building level.
2. A whole system approach to the masterplan area is adopted where local area energy assets are considered (including on-site renewables, private wire and local energy storage) alongside building integrated solutions. The aim of which is to facilitate demand side flexibility and shared access to embedded renewables across the masterplan.
3. A carbon reduction plan is required for each element of the masterplan development based on a defined carbon reduction stack to establish a trajectory to reducing carbon emissions to the minimum practical by the target climate neutral date.
4. Provide offsets for the residual carbon to achieve climate neutral goal for the whole development.
5. Maintain options to connect to the wide area heat network for all heat uses where the heat network

[1] Zero Waste Scotland - The climate change impacts of burning municipal waste in Scotland Updated, June 2021.

provides an effective solution.

6. Where waste heat is available such as where there is a combined heat and cooling demand then use high efficiency electrical solutions.
7. Where a smaller local heat network is more effective (such as 5th generation heat networks or heat pump solutions based on the available environmental heat) then these should be adopted where they can be shown to be more effective.

Section 5 and section 6 then provide energy statements in support of the detailed applications for the Arena and the Hotel. The energy strategy for the buildings under the detailed application then follow that outlined in Chapter 4 for the masterplan.

In the first instance the design follows the energy hierarchy prioritising demand reduction and energy efficiency before considering renewable and low carbon technologies.

The energy demands for an arena differ considerably between normal quiescent operation and when a concert is in operation, therefore the energy strategy needs to address the peak demands for heating, cooling and power.

The strategy is to use a proven and tested strategy to prioritise low carbon renewable technology for the base load and then for the short duration peak load either using gas boilers or if feasible the heat network.

The low carbon technology is then operated at highest utilisation and provides the biggest contribution to reducing carbon.

For the Hotel the VRF solution offers high heat and cooling efficiency, but the biggest heat load is the hot water demand. Here we are proposing that the option to connect the DHW to the heat network is established and if feasible implemented.

2 Introduction

2 .1 Purpose of this document.

Sonas Energy Ltd has been appointed by Robertson Property Ltd and Cardiff Council (the Applicants) to prepare an energy statement in support of a proposed hybrid planning application.

This document is part of a suite of documents forming the Environmental Impact Assessment.

The application Site comprises two main elements: the Atlantic Wharf, Butetown Masterplan and the Arena and Hotel development encompassed within this.

It is the Applicant's intention to submit one overarching hybrid planning application for the Proposed Development with the Atlantic Wharf, Butetown Masterplan element submitted in outline and the Arena and Hotel elements submitted in detail.

The application includes:

- Atlantic Wharf, Butetown Masterplan – Outline Application
- Cardiff Arena – Detailed Application
- Hotel – Detailed Application

This document is the Energy Statement and comprises the Energy Strategy for the masterplan and supporting Energy Statements for the Cardiff Arena and associated Hotel. (Figure 1).

2 .2 Document Structure

In section 3 we examine the relevant energy and associated policies and targets that the proposed development needs to consider and in section 4 lay out the proposed energy strategy for the masterplan area.

This strategy examines the defined masterplan area in the context of its environs and neighbouring developments and sets out the energy framework for developments encompassed within the masterplan area.

At this stage we have prepared an assessment of the projected annual energy demand of the masterplan based on the proposed accommodation schedule and benchmark data for the proposed building uses. This provides a reference demand for evaluation of the proposed energy strategy.

For the masterplan area we take a "whole system approach" this is where we consider the opportunities to integrate and manage renewable and low carbon technologies using emerging "smart" energy infrastructure rather than simply consider each separate element of the development in isolation.

By looking at complementary energy demand profiles from the various energy uses we can enable technologies such as smart -microgrid and heat networks to be deployed across the masterplan area. Having set the energy framework for masterplan area in Section 4, we then provide energy statements in support of the proposed development for Cardiff Arena (Section 5) and the Hotel (Section 6). These then recognise the proposed energy strategy for the masterplan area.

With the UK declaration of Climate Emergency in 2019, national and local policy and indeed low carbon technologies are rapidly evolving. This document seeks to set out a framework for not only achieving current greenhouse gas emission standards as set out in the Building Regulations Part L but also provides a framework for the carbon trajectory for the masterplan that aligns with UK, National and Local climate change policy ambitions.

2 .3 Planning Submission

Due to the scale of the masterplan and the anticipated development programme, the energy framework needs to be flexible and able to respond to regulatory changes, market forces and technological advances.

This document is based upon our understanding of the current development proposals and information set out in the submitted masterplan and individual building plans.

It is designed to be a working document and should be reviewed and updated as necessary when more

technical information and detailed proposals are brought forward for the masterplan area.

It is anticipated that the final energy measures implemented for each element will be confirmed at the Reserved Matters stage, subject to development feasibility and viability testing. It will be the responsibility of the developer of each subsequent phase of the masterplan to ensure that the future proposals comply with this energy strategy in a commercially viable manner.

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2 .4 Site Location and Description

The masterplan area to be submitted in outline will encompass the Arena and Hotel as well as a large portion of the Inner Harbour between the houses at Hailliard Court at its northern extent and the A4232 at its southern boundary.

The outline application Site, which encompasses an area of approximately 14.2 hectares (ha) sits between Bute East Dock and the Future Inn to the east, Lloyd George Avenue to the west, the A4232 and the Wales Millennium Centre to the south and Hailliard Court and Silurian Park to the north. The Site is currently occupied by County Hall and its car park, the Red Dragon Centre, Hotel and their car parks, part of Silurian Park, Schooner Way and Hemingway Road.

The overarching Atlantic Wharf, Butetown Masterplan aims to deliver a leisure led mixed use development to enhance Cardiff Bay's credentials as a nationally significant visitor destination. The masterplan proposes a mix of uses including residential, offices, hotel, retail, leisure and transport but seeks to place key leisure infrastructure (including the Arena and Event Square) as the focus areas of the plan.

Figure 2-1 - Masterplan Area - red ,

Arena and Hotel (Full)

The proposed location for the Arena and Hotel sits between Cardiff County Hall to the east, Hemingway Road to the south and residences within Halliard Court and Lloyd George Avenue to the north and west. This area of the Site is currently utilised as surface car parking for County Hall and also includes the southern extent of Schooner Way and part of Silurian Park in the north west corner of the proposed Site.

The majority of the masterplan proposals will form the subject of the hybrid planning application and are anticipated to include:

- Cardiff Arena and Hotel (a new 15,000 seat capacity indoor Arena and 182no - key Hotel);
- a new Red Dragon Centre – redevelopment to deliver: a new leisure offer (relocating Hollywood Bowl, the gym, casino etc.); an Odeon LUX; and a new food and beverage offering;
- 150 residential dwellings;
- Cultural Quarter: a new cultural quarter adjacent to the Wales Millennium Centre (WMC) including the WMC Academy, “This is Wales” visitor attraction and the Contemporary Art Museum;
- Commercial Quarter: a new 170,000sqft headquarter office building fronting onto an event square, a new 150 bed 4 star plus, 14 storey Hotel located on the site of the existing County Hall and a new mixed use development fronting Lloyd George Avenue to the west and the new event square to the east, comprising a residential led development with the opportunity for vertically integrated mixed uses including offices, Hotels and residential with the potential to deliver 250 residential dwellings;
- Event Square: a major new event square and family attraction to the south of the Arena and north of the new Red Dragon Centre;
- Residential Quarter: a new residential quarter on the site of the existing County Hall with the potential to deliver 600-700 residential dwellings; and
- Car Parking: a consolidation of the existing surface car parking into a multi-storey car park (MSCP) which delivers 1,300 spaces between the Red Dragon Centre and existing Future Inns Hotel.

3 Energy Policy and Regulation

3 .1 Introduction

Within this section we present an overview of the UK, National and local policy requirements in relation to energy and associated carbon emissions associated with the provision of energy infrastructure and the energy solutions for the proposed development.

3 .2 UK and National Policy – Climate Change

In June 2019, the UK became the first major economy to pass a "net zero" emissions law. In February 2021, the Welsh Government set out its legal commitment to achieve net zero emissions by 2050, but with an aspiration to "get there sooner".

This declaration was in recognition of the growing consensus around the Paris Climate Change Agreement. The Paris agreement seeks to limit the effect that the continued growth of emissions of carbon dioxide and other greenhouse gases would have on climate change and the resulting economic, environmental, and social impacts.

In March 2019 Cardiff Council passed a motion to join with other councils across the UK in declaring a global 'climate emergency'. This has now been followed by the "One Planet Cardiff Strategy" published in August 2020 which sets out a vision for how Cardiff aims to become a "Carbon Neutral Council", and a "Carbon Neutral City" by 2030.

At that time, the recommended emissions reductions pathway set by Committee of Climate Change advice would mean Wales will meet its commitments under the Paris Agreement, in a bid to limit global heating to 1.5°C.

However, recent reports suggest a much graver global trajectory, with a recent report by the United Nations estimating the world is on track to warm by more than 3°C. It is now anticipated that COP26 (26th United Nations' Climate Change Conference of the Parties) in the UK in November 2021 will push for increased commitment across the planet.

In 2020 the Covid -19 pandemic struck. To some extent the political urgency to deal with climate change that was apparent in 2019 has declined as governments deal with the immediate threat of Covid-19 and the economic effects of the pandemic and recovery phases.

However, there have been calls from all quarters to "build back better" to leverage the required investment in building the economy to also address the challenges of climate change. This has been supported by a number of financial and policy commitments.

In May 2021 the UK government launched its 10-point plan for a green industrial revolution.

It is claimed that this will mobilise £12 billion of UK government investment, and potentially 3 times as much from the private sector, to create and support green jobs and a green recovery.

There are several elements of this 10-point plan that are directly relevant to Atlantic Quay, specifically initiatives around:

- greener buildings
- green public transport, cycling and walking
- accelerating the shift to zero emission vehicles
- protecting our natural environment
- green finance and innovation
- driving the growth of low carbon hydrogen

3 .3 Future Wales

In February 2021, *Future Wales: The National Plan 2040* was published, which forms the National

Development Framework for Wales, setting out the direction for development to 2040. The National Plan aims to provide a clear, long term spatial strategy for Government policy, action and investment in Wales.

This policy document influences all levels of the planning system in Wales and helps shape the Strategic and Local Development Plans prepared by Councils.

The energy-related policies within this document include:

> Policy 16 – Heat networks: "Large scale mixed-use development should, **where feasible**, have a heat network with a renewable / low carbon or waste heat energy source. **Planning applications for such development should prepare an Energy Masterplan to establish whether a heat network is the most effective energy supply option and, for feasible projects, a plan for its implementation.";** and
>
> Policy 17 – Renewable and Low Carbon Energy and Associated Infrastructure: "The Welsh Government strongly supports the principle of developing renewable and low carbon energy from all technologies and at all scales to meet our future energy needs. In determining planning applications for renewable and low carbon energy development, decision-makers must give significant weight to the need to meet Wales' international commitments and our target to generate 70% of consumed electricity by renewable means by 2030 in order to combat the climate emergency."

3 .4 National Building Regulations Part L

The energy efficiency requirements of the Building Regulations are set out in Part L of Schedule 1 and in a number of specific building regulations. Approved Documents L1A and L2A set out the requirements for conservation of fuel and power in dwellings and nondomestic buildings respectively.

The current editions of Part L1A and Part L2A took effect on 31 July 2014, having been approved and issued by the Welsh Ministers to provide practical guidance on ways of complying with the energy efficiency requirements of the Building Regulations 2010 for Wales as amended.

3 .5 One Planet Cardiff

One Planet Cardiff is a strategic response to the climate emergency. The draft One Planet Cardiff Strategy proposes a wide range of ambitious actions that will begin to form the basis of a delivery plan to achieve Carbon Neutrality by 2030. It aims to do this in a way that supports new green economies and greater social wellbeing in the city. This draft suggests a target for the Council's operations to be Carbon Neutral by 2030 and for Cardiff Council to work with city wide partners to develop a road map and action plan for a Carbon Neutral City by 2030.

3 .6 Local Planning Policies

Cardiff Council's Local Development Plan (LDP) was adopted on 28th January 2016 and is the basis for decision making on land use planning in Cardiff. The purpose of the LDP is to guide and manage development in Cardiff through to 2026. The LDP is supported by Supplementary Planning Guidance covering a range of planning-based topics. The Council is currently in the process of preparing a new LDP for Cardiff to replace the existing Local Development Plan. The new plan will be called the Cardiff Replacement Local Development Plan and will shape Cardiff over the period 2021 to 2036.

The LDP remains up to date, it is reviewed every four years from the date of adoption. The Council agreed to begin preparing a new LDP earlier in 2021 and this will include the Council's new strategy and policies over 15 years to 2036 with adoption timetabled for 2024. Given the time taken for a new LDP to be put in place and the need for it to be reviewed every four years, the future years covered by the LDP therefore change.

Specific Local Planning Policies

KP5 - Good Quality and Sustainable Design

"All new development will be required to be of a high quality, sustainable design and make a positive contribution to the creation of distinctive communities, places and spaces by…maximising renewable energy solutions";

KP6 New Infrastructure:

"New development will make appropriate provision for, or contribute towards, all essential, enabling and necessary infrastructure required as a consequence of the development".

Necessary infrastructure includes sustainable energy infrastructure, with consideration of power, heating, cooling and electrification of transport;

KP15 - Climate Change

"To mitigate against the effects of climate change and adapt to its impacts, development proposals."

Factors relevant to this energy statement include:

- Reducing carbon emissions
- Protecting and increasing carbon sinks
- Adapting to the implications of climate change at both a strategic and detailed design level
- Promoting energy efficiency and increasing the supply renewable energy

Policy KP15 requires the development to incorporate an energy efficient design and embedded renewable energy generation. This statement aims to demonstrate sufficient consideration has been given to issues such as high standards of insulation, cooling, low energy construction methods, orientation and construction materials, in line with Policies KP5, EN12, KP15 and KP18.

The Arena is also targeting a BREEAM 'Excellent' rating.

EN12 - Renewable Energy and Low Carbon Technologies

> *"Development proposals are required to maximise the potential for renewable energy. The Council will encourage developers of major and strategic sites to incorporate schemes which generate energy from renewable and low carbon technologies. This includes opportunities to minimise carbon emissions associated with the heating, cooling and power systems for new development."*

The application should reduce carbon emissions associated with heating and cooling through the implementation of renewable energies. This document contains an Energy Assessment which outlines the financial viability and technical feasibility of installing renewables,

3 .7 Summary of Policy Requirements

The key energy and associated CO_2 requirements for the Proposed Development from local and national policy requirements are as follows:

- To comply with Part L of the Building Regulations (Wales), subject to changes in the National Regulations.
- To reduce carbon emissions and implement energy efficiency (policy KP15) – no quantified carbon reduction over Part L is specified.
- To minimise carbon emissions associated with heating, cooling and power systems (policy EN15) – no quantified carbon reduction over Part L is specified.
- To make appropriate provision for, or contribute towards, necessary infrastructure, including district heating and sustainable energy infrastructure (policy KP6); and
- To maximise the potential for renewable / low carbon energy (policies EN12, KP15 and KP5) – no quantified carbon reduction over Part L or requirement to meet a certain percentage of energy demand

is specified.

- Future Wales policy 16: Planning applications for such development should prepare an Energy Masterplan to establish whether a heat network is the **most effective** energy supply option and, for feasible projects, a plan for its implementation.";
- Future Wales policy 17 Decision-makers must give significant weight to the need to meet Wales' international commitments and our target to generate 70% of consumed electricity by renewable means by 2030 in order to combat the climate emergency."

4 Masterplan Energy Strategy

4 .1 Introduction

Atlantic Wharf is a flagship development for Cardiff Council and the development here provides a real opportunity to address the "One Planet Cardiff Strategy" and provide an exemplar of what can be achieved.

Strategic aims for Cardiff Council at Atlantic Wharf will not only include mitigation of climate change through reduction of operational carbon emissions, but also address structural and behavioural changes likely because of Covid 19 pandemic.

We are beginning to see the effects in the retail market and in the scale and type of demand for office accommodation as these structural and behavioural changes play out.

We are also now at a point where projects need to provide adaptation to the locked-in inevitable effects of climate change including an increase in the frequency and magnitude of more extreme weather events. This is dealt with in a separate submission[2].

The carbon targets set out in the building regulations fall short of the various aspirations for carbon neutrality or the achievement of net zero and it is likely that UK National and local policy will have to be altered if climate change ambitions are to be met.

For example, Part L of the building regulations refer to the performance of a building under specific conditions that refer to the building as designed and constructed. Less attention is focussed on how buildings are used or the way in which their carbon emissions increase or decrease with time. These parameters are controlled out-with the planning system and include fiscal measures through the taxation systems (incentives and penalties) to change behaviour in desirable ways. These measures include setting the climate change levy on fossil fuels, adjustments to the carbon floor tax and incentives such as the Renewable Heat Incentive or its proposed replacements (the Clean Heat Grant and The Green Gas Support Scheme).

How all this will play out with respect to the Atlantic Quay may not be clear for some time, but it is necessary to recognise the drivers now to determine a strategic framework for development and to recognise the opportunities to contribute to both mitigation of climate change and "future proofing" the development to align with the declared trajectories to net zero.

4 .2 What is "Net zero" or "Climate Neutral"?

Net zero is the achievement of a target of net-zero emissions of all greenhouse gases. The "net-zero" concept is to reduce emissions of carbon dioxide and other greenhouse gases to a minimum and offset the balance through various means to achieve a net **operational** carbon emission footprint of zero on an annual basis. In general, this does not include so called "embodied carbon" within the materials used in construction of the development, although there are some methods of evaluating the carbon contribution of manufacture and construction and these might be included in a lifecycle carbon assessment.

Climate change caused by burning fossil fuels is a global problem and Climate Neutral refers to requiring that the sum of human activity over a defined period (the temporal boundary) is neutral with respect to the global atmosphere. For most carbon accounting protocols for operational emissions this temporal boundary is one year although lifecycle carbon accounting is also used.

Carbon Neutral / Net zero can be assessed on a global basis. That is, that the sum of all human activity should have a "net zero" effect on the global climate and is therefore climate neutral.

However, the net zero or climate neutral concept is also applied to a region or even a building. Here net zero generally refers to reducing the direct emissions of carbon dioxide and other so called greenhouse gases within a defined boundary. This can be geographic boundary as in the masterplan area, or an organisational boundary (such as Cardiff Council's own operations).

[2] Chapter 17 ES - Climate Change

Net Zero then requires accounting for the carbon emissions associated with indirect emissions from the consumption of grid electricity, imported water, exported wastes, and can also include the carbon emissions associated with other materials and components that cross the defined boundary as illustrated below.

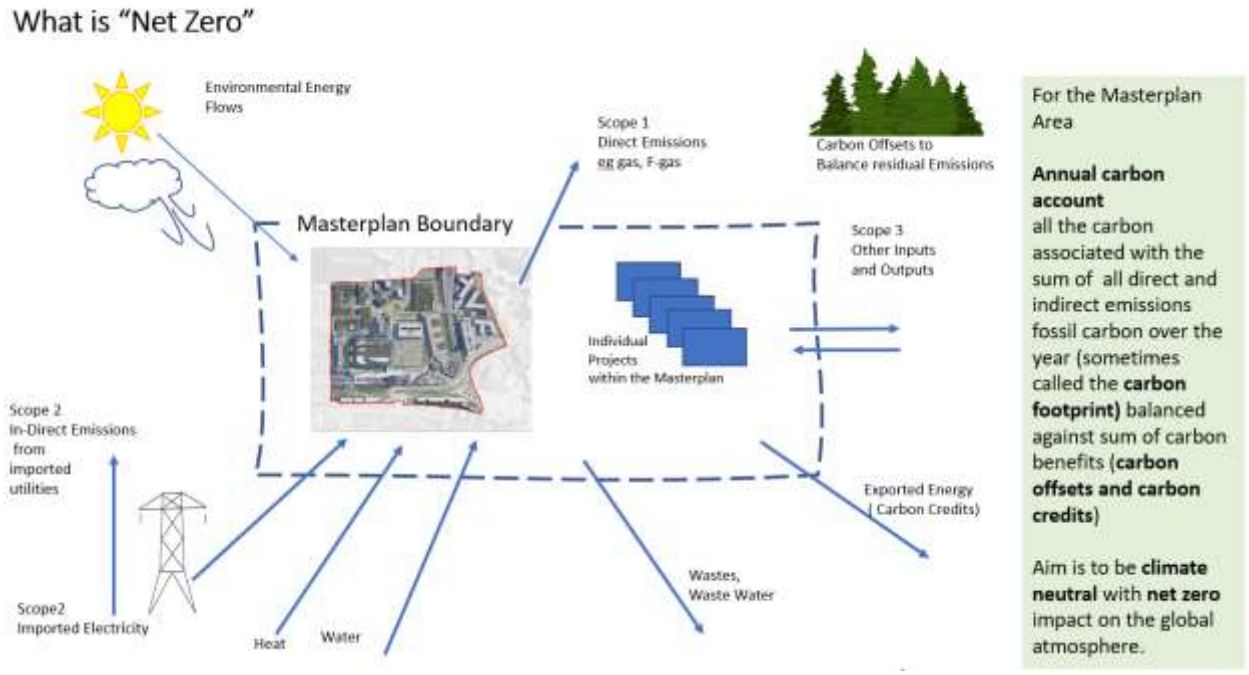


Figure 4-1 - Illustration of Net zero for a geographic boundary

4 .3 Energy Hierarchy

A common strategic approach to developing an energy strategy is to require the designers to adopt the nationally and locally recognised energy hierarchy. This is a design approach of reducing energy demand in the first instance, using energy efficiently and, only then, providing renewable and low carbon energy generation technologies where it is appropriate to do so. The energy hierarchy is illustrated below.

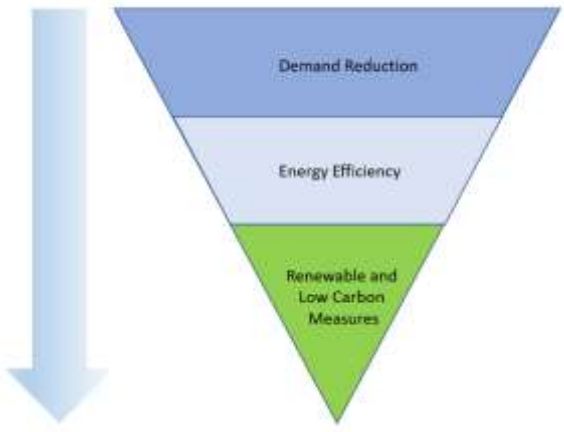


Figure 4-2 - Energy Hierarchy

For new development this is sometimes called the "fabric first" approach. That is, starting with the fabric, reduce

heating and cooling demand by use of passive measures (building massing and orientation, use of shading devices, window sizes, insulation U-values, infiltration rates etc).

The next step in the hierarchy is to specify energy efficient plant. Typical measures include specifying efficient LED lighting throughout, using variable speed drives pumps and fans to allow greater control of energy-consuming equipment; improved control systems, specifying efficient white goods etc.

The first two stages reduce primary energy demand. The third stage is then to introduce sufficient renewable and low carbon energy measures to achieve the specific carbon emission rate required by the Building Regulations.

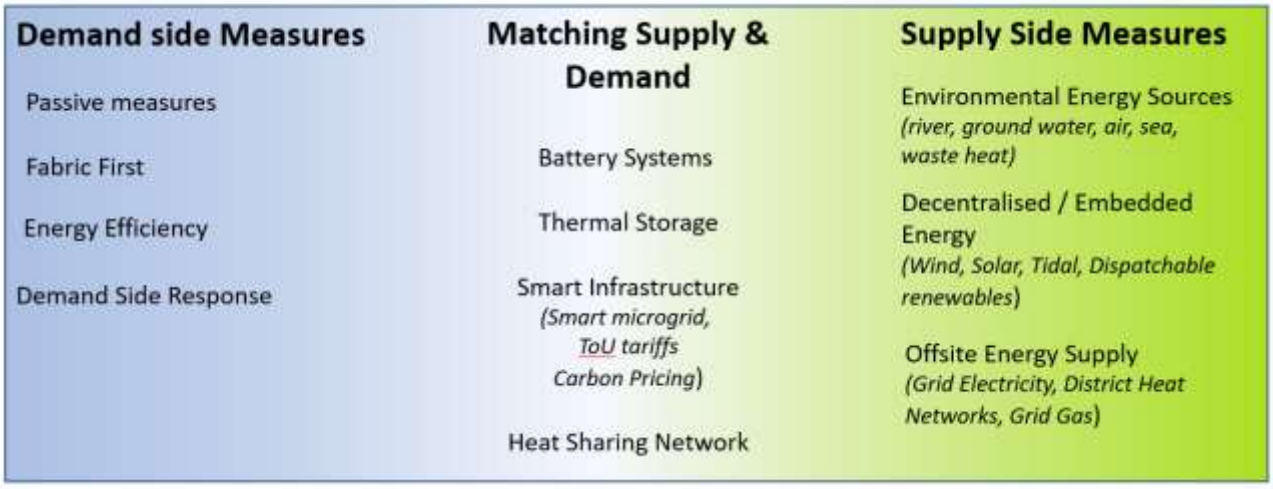
While this approach is both necessary and sufficient to achieve individual building compliance it falls short of achieving a trajectory to net zero at some point in the future across the masterplan. To simply require each building within the masterplan to achieve net zero at the construction completion stage is likely to be impractical and expensive.

4 .4 Whole System Approach

For a masterplan where we also have due consideration of the energy infrastructure including decentralised energy systems combined with external utility requirements then a "Whole System" approach to the development is appropriate.

A whole system approach is to consider both the masterplan area as a whole and its relationship with the wider energy system. However, for the purposes of this report it is convenient to consider the masterplan area as the local energy network and the wider context as the wide area network.

With the whole system approach, we recognise that "net zero" for a single building can be difficult and expensive to achieve, while net-zero for a mixed-use development with complementary energy demand profiles and the opportunity for linking into the wide area heat and power networks is a more tractable problem.



In the whole system approach, we consider the local and wider area energy systems.

In this approach demand side measures (including passive measures, energy efficiency and demand side response options) are considered alongside the energy infrastructure (which includes energy delivery and energy storage systems) and energy supply options including environmental energy sources, decentralised energy systems and linking into local or wider area networks.

A key element of the whole system approach is the adoption of "smart" infrastructure which combined with demand side response will make best use of the on-site energy supply options.

Renewable low carbon technologies can be located at the most appropriate areas within the masterplan area rather than behind the meter on each building. This also offers opportunities for:

- taking advantage of complementary energy uses

- delivering improved demand and supply side matching
- using more of the onsite generated energy, onsite
- system wide energy control and energy use scheduling

This is rather more complex than the typical energy strategy applied at the single building level. The whole system approach takes advantage of the differences in energy demand profile for different types of building uses and builds this into the renewable low carbon energy supply including the energy storage and supply strategy.

This approach lends itself to consider the opportunities for “smart” infrastructure including a smart micro-grid where individual buildings take part in demand side response to maximise the use of available on-site renewables and excess renewable generation associated with one building can be shared between buildings within the masterplan.

The energy strategy for the masterplan is therefore a whole system approach.

4 .5 Electricity Grid Carbon Trajectory

The average annual carbon intensity of the UK electricity grid has fallen significantly in recent years and is projected to fall further in the period from 2020 to 2035.

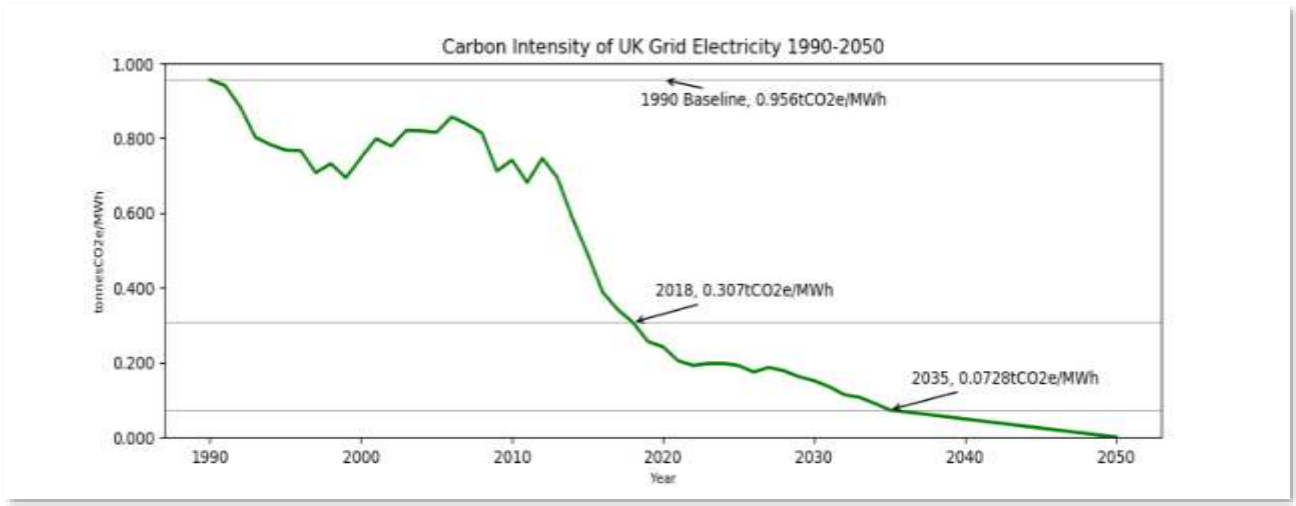


Figure 4-3 - Annual Average Carbon Intensity of UK Electricity Grid Supplied Electricity - Source BEIS Carbon Reporting and Green Book Projections.

The graph above shows the BEIS projected annual average carbon intensity of electricity supplied through the UK electricity grid. This year the carbon intensity of grid supplied electricity will fall below that of heat supplied by a high efficiency gas boiler. By 2035 the figure is expected to be sub- 75g/kWh. This means that carbon emissions associated with electrically driven heat, power and cooling across the masterplan will follow a similar trajectory. In addition, utility supply that also depends on grid electricity (such as water and waste-water, will also follow similar trajectories).

Previously when the UK electricity grid had a higher carbon intensity than it does today Combined Heat and Power (CHP) projects could be shown to be a good investment offering a lifecycle financial savings and offering carbon reduction. However, now with the current, reduced carbon factors for grid electricity, gas fired CHP does not offer any carbon savings while still offering cost savings. As the grid decarbonises further gas fired CHP projects will present steadily increasing carbon burdens. Gas fired CHP is therefore no longer considered a low carbon technology.

It is this mismatch between carbon savings and financial savings that presents real decarbonisation challenges

to successfully deliver net zero. It is likely that government will need to use tax incentives and disincentives to switch priorities, for example by increasing climate change levy on fossil fuels and providing increased subsidy on renewable heat and power. Interventions of this nature on the power side have achieved a rapid decarbonisation of the UK electricity supply industry, first by switching from coal to high efficiency gas fired combined cycle plant, and more recently with extensive investment in solar, and on and offshore wind.

Until the fiscal and tax regime around grid gas is better aligned with climate change aspirations then there is a significant economic penalty in achieving net zero too quickly.

4 .6 Gas Grid Trajectory

Progress in deep decarbonisation of heat and transport has not been as rapid as decarbonisation of the power grid although the growth in battery electric vehicles is accelerating and alternative fuels are being developed including biofuels and synthetic fuels together with carbon capture and storage.

There are some large-scale investment projects that have been announced as part of the government 10 - point plan which may offer prospects of some decarbonisation of the gas grid. These include biomethane injection and plans to introduce up to 20% green hydrogen into the gas grid. These developments may go some way to reducing the carbon intensity of the gas grid, but calculations show that the reduction in carbon intensity of the gas grid is likely to be much less than that achieved in the power grid.

4 .7 Carbon associated with UK grid supplied electricity

The rapid decarbonisation of the UK electricity grid has not been reflected in the National Calculation Methodology (NCM), The current methodology for assessing Part L2a is defined in the NCM modelling guide. The current edition was updated in in 2016 and 2018. The fuel emission factors for non-domestic buildings are defined in page 56 table 22 reproduced below.

Table 22 Fuel emission factors for non-domestic buildings

Fuel type	kWh/kWh	$kgCO_2/kWh$
Natural gas	1.112	0.212
LPG	1.068	0.242
Biogas	1.092	0.098
Fuel oil	1.068	0.313
Coal	1.009	0.385
Anthracite	1.009	0.375
Manufactured smokeless fuel (inc. Coke)	1.175	0.419
Dual fuel (mineral + wood)	1.027	0.226
Biomass	1.070	0.069
Grid supplied electricity	2.580	0.522
Grid displaced electricity	2.580	0.522
Waste heat[38]	1.148	0.075

Table 1 - Table 22 from NCM modelling guide (for buildings other than dwellings in Wales)

The figure of 0.522kgCO_2/kWh for grid supplied electricity is well above the current UK grid average (for example the 2021 UK Government GHG Conversion factors has the UK grid supplied electricity factor 0.21233

$kgCO_2e/kWh$ with an additional 0.01879 $kgCO_2e/kWh$ for transmission and distribution. That is the current grid carbon factor for reporting is 56% lower than the NCM figure.

This presents two problems. Firstly, it means that the NCM Part L 2A compliance calculation methodology overestimates the carbon associated with electricity and electrically produced heat (as from electrically heat pumps) compared with alternatives.

Secondly with the real UK average grid carbon co-efficient much lower than represented in compliance modelling then carbon savings associated with electricity reduction are now over estimated.

With a high carbon factor for grid electricity and a much higher cost of electricity per MWh then a MWh of gas then previously all attention was focused of energy reductions associated with reducing electricity demand as this achieved both large carbon savings and large financial savings and so it could be shown that energy, carbon and operational cost savings were well aligned.

The draft NCM for 2021 Part L2A has, to some extent, addressed the problem in compliance modelling.

Table 30 CO_2 emission and primary energy factors for grid-supplied electricity and grid-displaced electricity EXCEPT that generated by PV systems

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$kgCO_2/kWh$	0.163	0.160	0.153	0.143	0.132	0.120	0.111	0.112	0.122	0.136	0.151	0.163
kWh/kWh	1.602	1.593	1.568	1.530	1.487	1.441	1.410	1.413	1.449	1.504	1.558	1.604

Table 31 CO_2 emission and primary energy factors for grid-displaced electricity by generation from PV systems

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$kgCO_2/kWh$	0.196	0.190	0.175	0.153	0.129	0.106	0.092	0.093	0.110	0.138	0.169	0.197
kWh/kWh	1.715	1.697	1.645	1.567	1.478	1.389	1.330	1.336	1.405	1.513	1.623	1.718

Table 2 - Proposed Grid Electricity Carbon Factors for 2021 in draft 2021 NCM (highlighted as original draft)

The draft NCM is proposing a monthly average rather than yearly average to reflect the seasonal variation in renewable generation in the current UK generation mix.

However, all the grid carbon estimates place the UK electricity grid average is less than carbon associated with heat produced from grid gas.

UK electricity (2012 reporting figures including T&D 0.2311 $kgCO_2e/kWh$, heat from grid gas at 85% efficiency $=0.212/0.85 = 0.249kgCO_2/kWh(th)$)

This in turn leads to a major mismatch between the objective of reducing carbon and that of reducing operational energy costs as shown in the table below.

	Operational Saving per/yr	Carbon Emssion Saving 2021 kgCO2/yr	Carbon Value Saved 2021	Operational Saving 2021-2045	Carbon Emissions 2021-2045 kg CO2	Carbon Value 2021-2045
Grid Electricity	£ 145.00	113.13	£ 2.32	£ 3,625.00	1661	£ 137.79
Grid Gas	£ 38.30	183.87	£ 12.95	£ 957.50	4597	£ 527.58
Heat Network	£ 60.00	43.80	£ 3.08	£ 1,500.00	1095	£ 125.67

Table 3 Comparison of Operational Cost and Carbon Savings

Table 3 above shows the figures for saving 1 MWh of energy either as saving 1MWh of electricity, 1MWh of gas or 1MWh of heat. The carbon emission values in this case are taken from BEIS Valuation of Energy use and greenhouse gas emissions, last updated 2020. [3] (This provides projected carbon emission figures to 2050.

For the heat network comparison, we have used the emission factor (0.0438 $kgCO_2/kWh(th)$ as advised by Cardiff Heat Network Ltd. This is 42% lower than the waste heat figure used in the NCM table 1 above)

For heat price we have used a reference price of 6p/kWh and for carbon value we have used the medium traded and nontraded value from the BEIS publication together with the medium electricity and gas prices.

The table shows mismatch between achieving operational cost saving and saving in carbon emissions for the fuel types.

This mismatch between objectives is even worse when considering the cumulative operational costs and cumulative emissions.

The cumulative operational cost savings from saving 1MWh of electricity is £3625 while the cumulative operational savings from saving 1MWh of gas would only be £957.50. While the cumulative carbon savings are 1661kg of CO_2 from the 1MWh of electricity saved but 4567kg for saving 1MW of gas.

The last column in the table shows the carbon value are the central values from the BEIS Table 3: Carbon prices and sensitivities.

Previously when the carbon intensity of the UK electricity grid was much higher, then energy savings led to relatively short payback times and “spend to save” was aligned with saving carbon. However, this meant that much more attention was focussed on electricity-based energy efficiency rather than saving gas as this delivered better financial returns.

Where we are now is that gas remains relatively cheap but has a much higher carbon emission per MWh than heat produced from electricity. This means that, for example gas fired CHP remains economically attractive, but it now produces higher carbon emissions than simply using grid gas and grid electricity and is no longer considered a low carbon technology.

As the electricity grid continues to decarbonise then simply achieving compliance with Part L2A is no longer sufficient.

Heat pumps offer much lower carbon emissions for meeting climate change targets and achieving deep decarbonisation of heat due to the projected decarbonisation of the electricity grid.

Heat pumps also offer the potential for zero carbon heat when running on locally generated renewable energy.

The low carbon co-efficient for grid electricity is reduced by the factors of the seasonal coefficient of performance and this in turn leads to very large carbon reductions per unit of heat.

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[3] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

The key parameter for evaluating both the carbon emissions and the operational cost comparator for a heat pump system is the overall energy efficiency of the system. Heat pumps work by harvesting relatively large quantities of environmental heat at low temperatures and delivering this heat at a higher temperature. The input energy required to do this is less than the heat delivered, and the efficiency is represented by a Coefficient of Performance (COP).

For heat pumps this heat efficiency figure varies with the temperature of the environmental source and the temperature of the delivered heat. High efficiencies are achieved with low temperature lifts. That is the difference between the temperature of the environmental source and the temperature of the delivered heat. Therefore, for high heat pump efficiency attention is focussed on the flow temperature and the temperature of the delivered heat.

For a typical air source heat pump the COP when evaluated on an annual basis might be around 2.5 while for a ground source this can be 3.5 or higher and above depending on the ground source temperatures. In commercial buildings with heat and cooling demand heat pump-based systems with heat recovery can offer even higher efficiencies in the range 5.5 – 6.5.

Table 4 below illustrates the cumulative effect when we take into account both decarbonisation of the electricity grid and the increase in cost of carbon emissions to 2045.

The COP figure makes a considerable difference to both operational costs and carbon emissions as illustrated below which shows a COP of 2.5 and a COP of 6.0.

To produce 1MWh of Heat	Op Cost	Carbon Emissions per year	Carbon Cost 2021	Op Cost 2021-2045	Carbon Emissions 2021-2045	Carbon Cost 2021-2045
Gas Boiler@ 90%	£ 42.56	204.3	£ 14.39	£ 1,063.89	5107.5	£ 586.20
Heat network	£ 60.00	43.80	£ 3.08	£ 1,500.0	1095.0	£ 125.67
HP at COP2.5	£ 58.00	45.25	£ 0.93	£ 1,450.0	664.5	£ 55.12
HP at COP6.0	£ 24.17	18.85	£ 0.39	£ 604.2	276.9	£ 22.97

Table 4 – Comparison of cost, carbon emissions of delivering 1MWh of heat.

Table 4 shows the comparison of delivering 1MWth of heat from either a heat network or using a heat pump system compared with a modern high efficiency gas boiler.

This clearly shows the issue with continuing to rely on grid gas. With carbon emissions using 2021 carbon figures the gas boiler emits four times the carbon than the alternative low carbon options and 5 to 10 times more when considered on a cumulative basis from 2021 to 2045.

The low carbon costs for 2021 for heat pumps arise from the lower traded carbon prices for electricity compared to untraded prices applicable to gas. The effect is less out to 2045 as the BEIS traded and un-traded carbon prices converge by 2030, however in all cases the heat pump carbon price figures are significantly lower.

The table also shows the effect of a high COP figure on heat pump commercial viability as the higher COP offers **both operational costs below that of grid gas** (when using the BEIS cost comparators) and **by far the lowest lifecycle carbon emissions.** (277kgCO_2 compared to 5107kgCO_2 for a high efficiency gas boiler).

The above analysis shows that to address the climate change emergency we need to, not only move beyond simple compliance with building regulations, but we also need to provide a credible pathway to net zero taking into account the projected fall in the carbon intensity of grid supplied electricity.

This also shows that simply focussing on achieving Part L compliance with fixed carbon intensities at the point of calculation but does not consider the projected de-carbonisation of grid electricity and so can lead to selecting a technology with higher lifecycle carbon emissions.

4 .8 Building the Carbon Reduction Plan

As the masterplan is built out then it is suggested that the energy strategy needs to be flexible and able to respond to regulatory, fiscal and taxation changes and technological advances. It is unlikely to be economically viable to require that each building within the masterplan achieves climate neutrality at building completion, rather the buildings need to be designed with viable and realistic carbon reduction plans that align with the climate ambitions of the whole development and to take advantage of the build out of low carbon infrastructure as the masterplan development proceeds.

This approach fully recognises the falling carbon intensity of the UK electricity grid together with the "whole system approach" to the masterplan development where smart infrastructure combined with embedded renewables, energy storage and demand side response offers the ability to progressively reduce carbon emissions with time.

We call this element of the energy strategy "the carbon reduction stack".

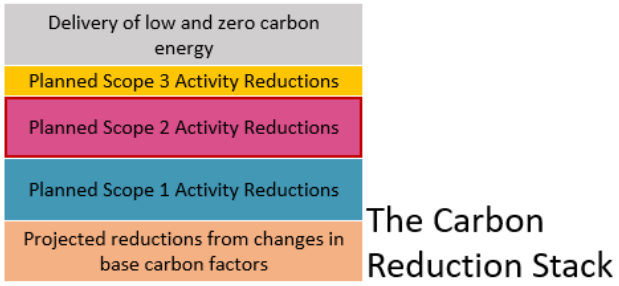


Figure 4-4 - Carbon Reduction Stack

The carbon reduction stack follows the carbon reporting approach where we split out the activities and the carbon associated with those activities and consider how each of the identified elements will evolve with time.

This is intended to be a dynamic image where year on year carbon reduction is achieved in line with the selected trajectory to net zero. The reason for splitting out the activity data from the carbon co-efficient used is that reduction (or increase) in carbon emissions reported can change even if the energy use does not change.

Much of the large reductions in carbon footprint reported are due to the decarbonisation of the UK electricity grid with the shutting of coal fired power stations and their replacement with combined cycle gas stations and more recently the growth of renewables on the grid.

The introduction of carbon reduction plans as a strategic element of the masterplan energy strategy helps bring out the many interactions to consider. For example, as we approach deep decarbonisation of heat and transport with a shift from fossil fuels to electrified heating and transport, then scope 1 activity (direct emssions from gas) will reduce while scope 2 activity (indirect emissions from grid supplied electricity) will inevitably increase.

The carbon reduction stack is intended to represent a dynamic approach where all elements contribute to the carbon footprint including:

- the carbon intensity supplied heat and power
- measures to reduce energy demand directly and progressively
- the opportunity to use alternative fuels, and
- build out of decentralised renewable energy sources and infrastructure in the local and wider energy system networks

4 .9 Masterplan Energy Strategic Approach

These three elements of the masterplan energy strategy can be combined within an illustration that shows how they relate to each other. Of course, the common themes of demand reduction, energy efficiency and increasing use of renewables run through all three strategic models. The diagram overleaf is an illustration how the three elements of the masterplan strategy relate to each other.

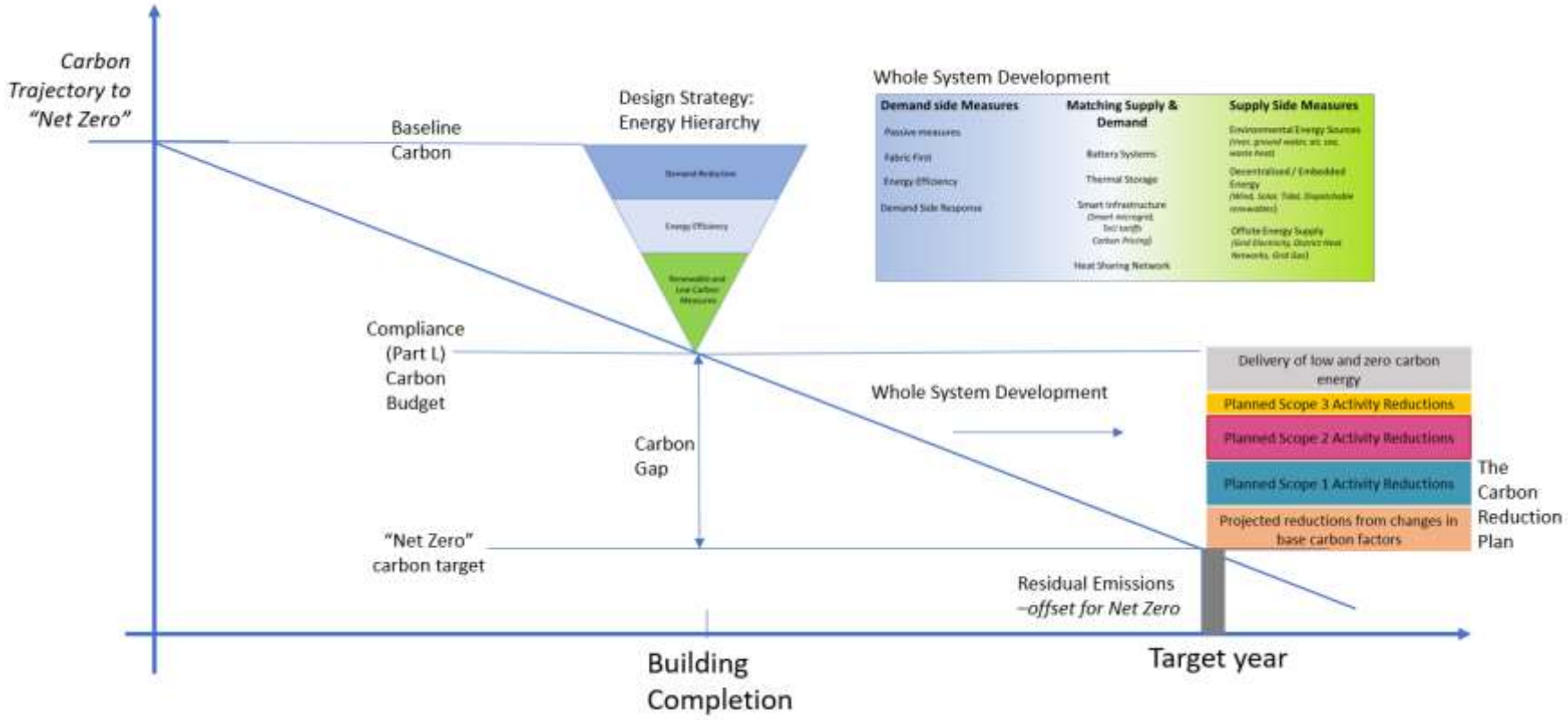


Figure 4-5 - Pathways to Net Zero - Illustration of Masterplan Energy Strategy

The energy strategy for each individual development follows the energy hierarchy to achieve Part L carbon reduction targets. This however leaves a carbon gap between the compliance carbon budget and the net zero target. The energy strategy for the masterplan area is to take a whole systems approach, developing "smart" infrastructure offering demand side response, energy sharing and low carbon heat and power to the client buildings to enable them to achieve a cost-effective pathway to net zero. **This means that each building within the defined masterplan area will not only need to achieve compliance with building regulations at completion but also have a realistic implementable carbon reduction plan to get down to an agreed residual emissions level by the masterplan net zero target year.** The carbon reduction plan will include projected reductions in carbon intensity of imported utilities as well as fuel substitutions and demand reduction measures.

To monitor progress, we expect each major development to commit to provision of annual carbon reporting.

This might be under the BEIS Streamlined Energy and Carbon Reporting, or one of the recognised climate change commitments schemes such as UNFCC Race to Zero or the Climate Pledge (10years Early).

The developer(s) will put in place a mechanism to collate annual reports from each of the major developments on the masterplan and report progress the masterplan as a whole as the development is built out.

4 .10 Wide Area Power Infrastructure

In section 4.4 we noted that it is helpful to consider both the masterplan area as a whole and its relationship with the wider energy system. In this section we describe the wide area energy infrastructure, that is the infrastructure on the periphery of the masterplan area.

At present power is distributed by the local DNO operator, in this case Western Power are the license holders. The DNO's job is to distribute power from the UK transmission grid to the homes and businesses within their region of operation. The DNO provides the metered point of connection (POC) to the end user. The DNO does not supply electricity, this is done by a separate electricity supply company. The consumer is free to select their electricity supplier. The electricity supplier then pays the DNO for the use of the distribution network.

Although many new developments will simply ask the local DNO to provide the local power network infrastructure, this is not essential. There are two options.

One is to use one of the licensed IDNO's (Independent DNO) to provide the network's extension (Such as the local area network and in return for the capital investment they will receive payments from the electricity supply companies for that segment of the distribution network.)

When there is a DNO (or IDNO) network then access to the network for local distribution of power generated by on site renewables is a licensed activity and incurs networks access charges.

The second option is for private wire. Under this arrangement an on-site electricity generator supplies electricity directly to an end user via a direct, unlicensed 'private' wire rather than over the licensed distribution network. Here the end user may also own the generator and private wire, or these may be owned by a third party who sells electricity to the end user through a power purchase agreement.

An example of this might be where extensive solar is installed (for example on the carparks) and the resulting solar generation is used elsewhere in the local area masterplan. The business case for this is that the private wire supply avoids network charges, and the generator and end user can share the financial savings. Private wire schemes can then encourage increased penetration of renewables into the masterplan area supporting the delivery of net zero.

Private wire however precludes end users from selecting their chosen electricity provider and to avoid this there are sleeved arrangements where the IDNO allows pseudo private wire connection across their local network provided the generators and end user are both on the network.

It is understood the Cardiff Heat Network Ltd are considering offering a private wire connection from the Viridor EfW CHP plant

How these options are implemented depends on the wide area power network and the location of primary sub stations.

Given recent developments within the vicinity of the area WPD have indicated that power availability is limited. There is a small portion of capacity available, but this is unlikely to be sufficient for the full masterplan area. As a result, WPD have indicated that a new primary substation might be required to serve the full masterplan area.

4 .11 Wide Area Heat Infrastructure

Cardiff Heat Network Ltd are planning a district wide heat network. The heat source is waste heat from the Viridor Cardiff Energy Recovery Facility (ERF) located to the east of the site. A new gas fired energy centre is proposed to provide top-up heat and cover the ERF down time.

It is proposed that the heat network spine will pass through the masterplan site offering the opportunity to connect to the wide area heat network.

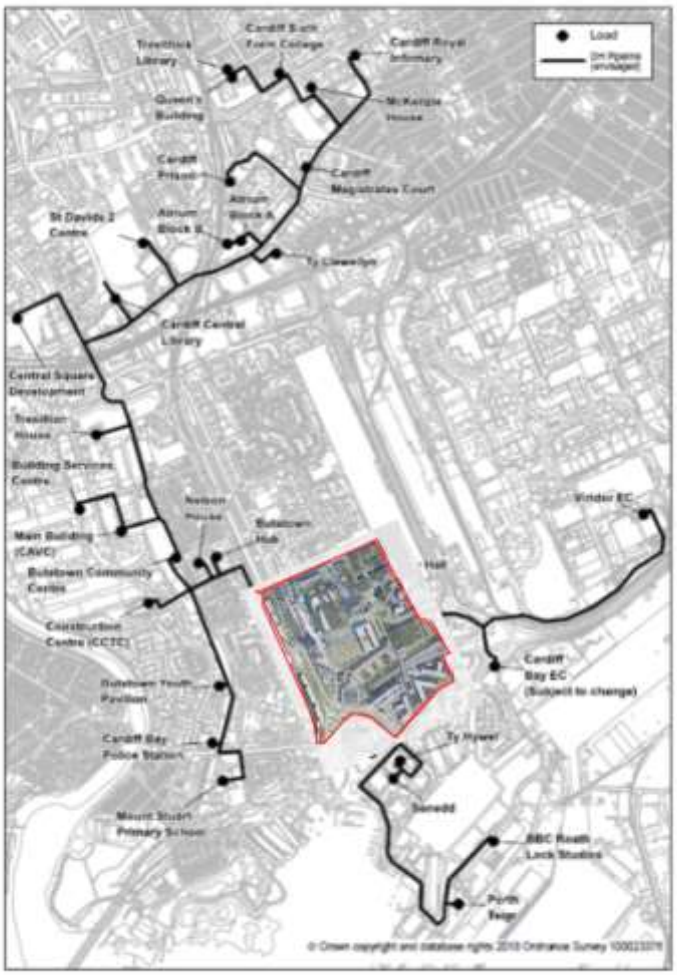


Figure 4-6 -Masterplan area overlaid in heat network plan

The precise route of the heat network spine through the development remains to be determined.

4 .12 Masterplan Proposed Local Area Power Infrastructure

As noted in section 4.4 we are proposing a “whole system” approach. For power the aim is to minimise import and export to the wider grid and maximise the use of embedded energy assets. We would propose maximising the use of a smart micro-grids, where electricity generated locally can be used locally. The simplest way to connect embedded renewable generation is “behind the meter”. That is with, for example, building integrated solar where the connection to the building energy system is behind the utility meter.

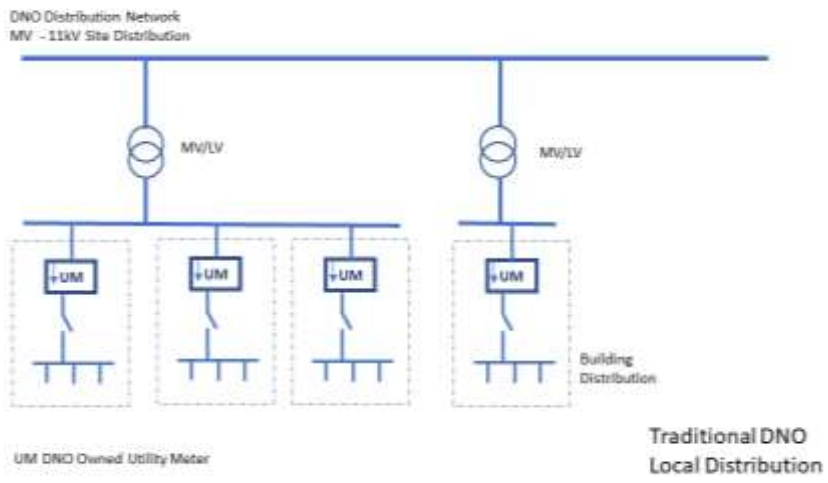


Figure 4-7 - Traditional DNO Infrastructure

Figure 4-7 above shows the traditional Distribution Network Operator (DNO) structure with each building having a utility meter and building distribution connected through it.

When the building has embedded renewable generation then ideally all renewable power will be used within the building, however it is possible at small scale to secure an export tariff. In this case the utility meter is a two-way device allowing import and export as show below.

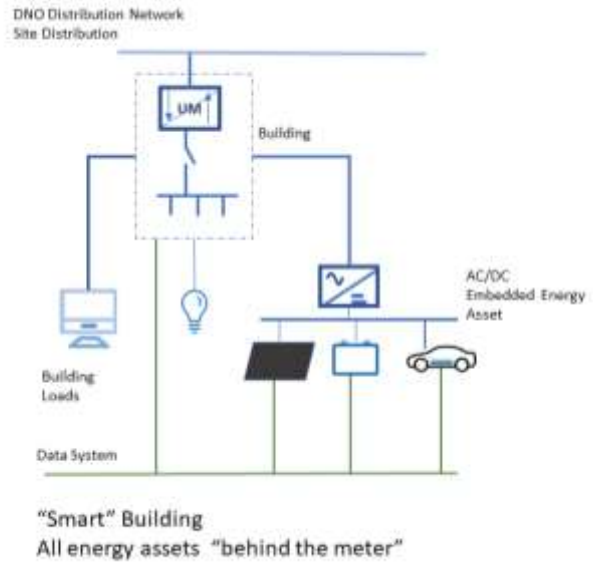


Figure 4-8 Building Renewables and Car Charging connected "behind the meter"

"Smart" controls can be introduced to schedule power use when renewable power is available. As the amount of solar generation is increased it is also possible to connect local battery storage behind the meter to capture excess solar generation and store it for when the building needs it. This reduces the amount of electricity exported to the grid and maximises the use of the self-generated renewable electricity.

Not all buildings are able to accommodate the sufficient renewable generation for its needs. At the masterplan

level the opportunity exists to introduce Smart “microgrids”.

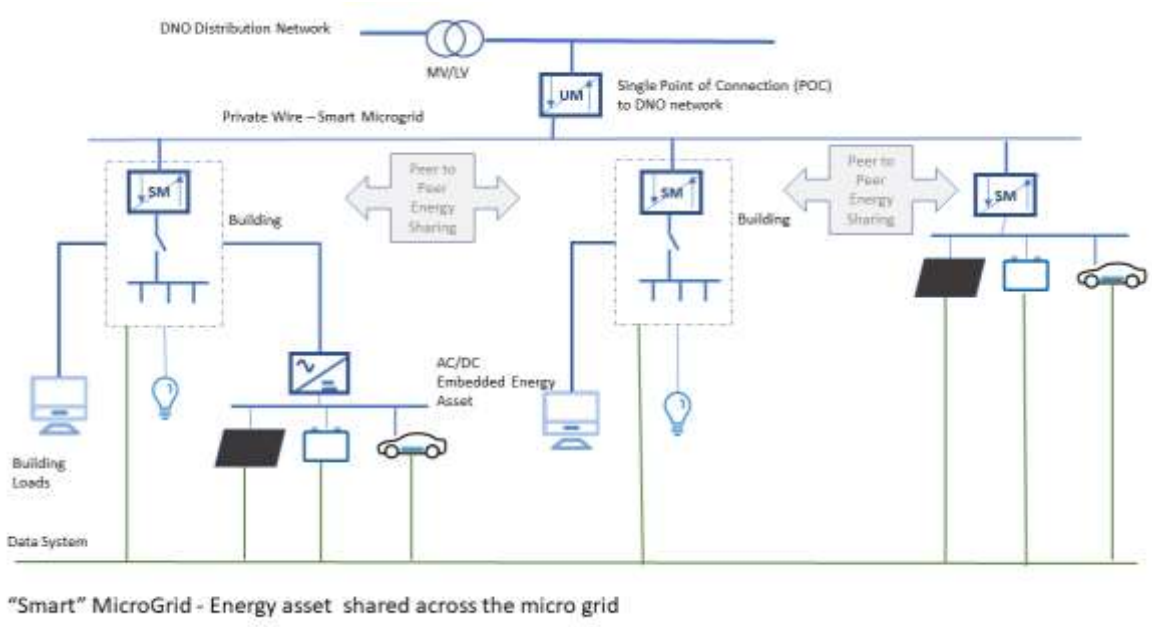


Figure 4-9 Smart Microgrid concept

Figure 4.9 shows the smart microgrid concept. Here the utility connection to the wider power network is moved from the building to a single point of connection feeding private wire distribution. The private wire then joins participating buildings through sub meters. This topology facilitates the used of shared energy assets as illustrated on the right-hand side of the figure, as well as allowing direct peer to peer energy sharing through the building sub meters.

The reason the microgrid is termed “smart” is that as well as distributing local renewable energy through the microgrid, data is also made available. A data network then permits time of use energy use, effective demand side control to maximise the availability and use of renewable energy assets across the masterplan area.

It is of course possible to consider hybrid arrangements where both utility and private networks co-exist and buildings can switch from wider area to local supply.

Smart microgrids are at an early stage of development but they offer a solution to the expected increased loads on the national grid infrastructure as we move to deep decarbonisation of both heat and transport.

Within Atlantic Wharf we have identified specific zones. The build out of these will be in phases and therefore a single local smart micro-grid would be difficult to implement. Moreover, with different owner and tenure types across the masterplan the ability to provide direct connection to the DNO network needs to be provided for some building uses (notably residential where consumers expect to be able to purchase electricity from any supplier and have it distributed through the network).

It is possible to set up PPA Power Purchase Agreements to export surplus renewable generation through the local DNO and to purchase locally but this then incurs transmission and distribution charges for grid access.

We propose to use private wire networks where appropriate. These will be clusters of consumers such as in the individual quarters or within blocks of flats.

Masterplan quarters

- Arena Quarter
- Mixed Use Quarter

- Cultural Quarter
- Waterfront Quarter
- Bute East Dock Quarter
- Car Parking Quarter

Figure 4-10 Illustration of Private Wire connecting embedded solar and grid scale battery

The Car Park Quarter lends itself to private wire for both solar generation, vehicle charge points and with space for utility scale battery.

While the largest roof space for solar is the Arena, based on the current masterplan the Mixed Use Quarter and Cultural Quarter also provide significant opportunities for PV arrays.

We therefore propose that allowance is made for these four areas to share private wire supply. This will facilitate the build out of solar.

At this stage only the Arena is supported by solar, further development of solar will depend on need and opportunity as the masterplan buildout progresses.

4 .13 Masterplan Proposed Local Area Heat Infrastructure

The proposed area wide heat network of Cardiff Heat Network Ltd is routed through the masterplan area. This provides a spine for connection of the local area network as illustrated below. At this stage the effectiveness of connecting each building with the masterplan onto the heat networks has not been determined and the diagram is illustrative only. Figure 4-12 shows an indicative plan where the area wide heat network spine passes through the masterplan with defined points of connection to local heat networks.

In general heat networks can be classified by the flow and return temperatures as show in the figure below.

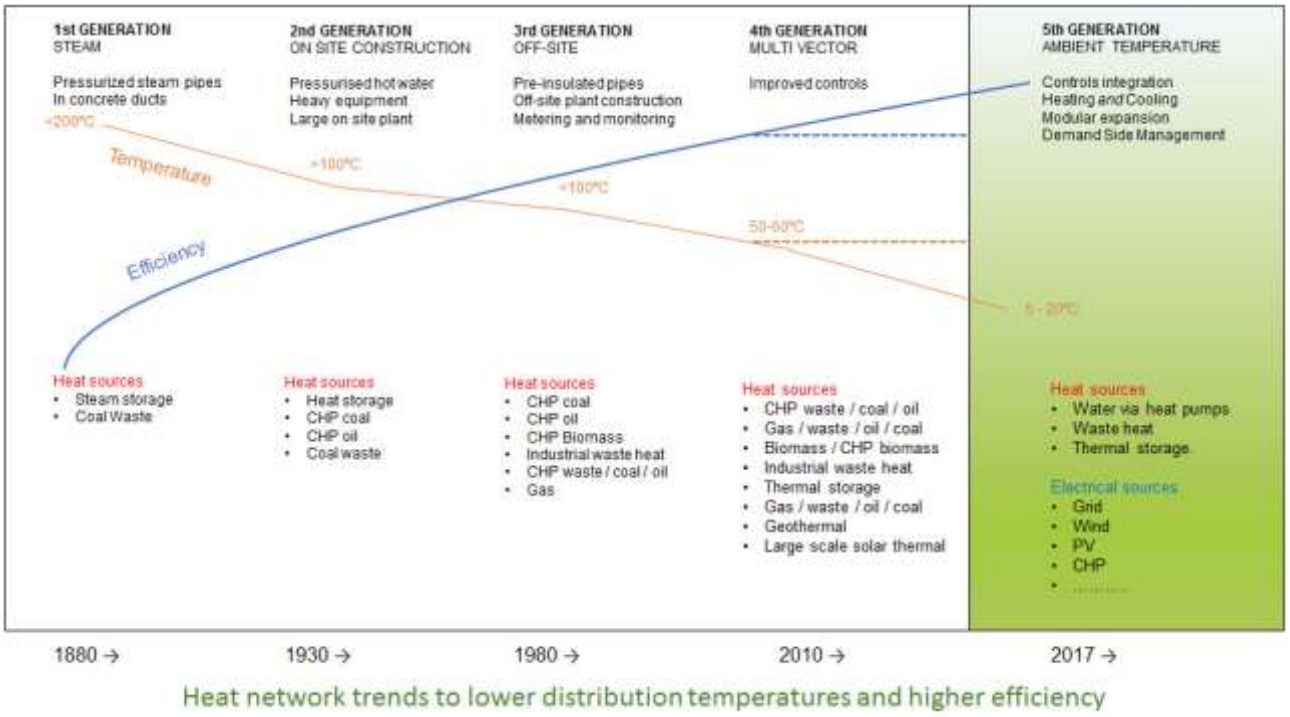


Figure 4-11 - Illustration of the heat network generations (GSHP Association)

For each of the Local Area Heat Networks we would propose a modern 4th generation solution with flow temperatures restricted to 65C. This is to future proof the investment and ensure that the network can be efficiently fed from low grade environmental heat using central heat pumps, without having to change the secondary or tertiary heat network and associated plant.

So called 4th generation networks offer lower standing loses overall and are compatible with heat pump technology. It is recognised that higher flow temperature heat pumps are possible, but the COP are intrinsically lower and operating costs much higher.

Figure 4-12 Illustration of Local heat Network.

As an alternative to connecting to the wide area network, a 5th generation or ambient loop solution offers a number of advantages for a new build development.

These advantages include the ability to use a wider range of lower grade environmental heat sources. A 5th generation also allows high efficiency chiller operation as rather than rejecting waste heat to air (contributing to the city heat island effect) the chillers use water source and reject heat to the ambient loop.

The tertiary building circuits are then fed from building integrated heat pumps. Access to district ambient loop is by a service agreement with fixed annual charge.

Figure 4-13 Illustration of 5th Generation Ambient Loop as the heat Network solution

The selection of the most effective option and the fit with policy is considered in Section 4.15 below.

4 .14 Masterplan Demand

We have carried out a high-level assessment of the energy demand of the outline masterplan together with more detailed assessment of the energy demand of the detailed application for the Arena and the Hotel.

A Business as Usual Assessment (BAU) is provided based on using conventional gas boilers for heat and power supplied directly from the national grid.

A second assessment is made based on an all-electric solution to assess the standalone power demands assuming the heat demand is supplied by local heat pumps.

A third assessment is provided which is assuming the heat is supplied from the wide area heat network.

		Annual Estimates	
BAU Demand		Fossil MWh/yr	Power MWh/yr
Outline Masterplan		29,656	11,486
Detailed - Hotel	BAU Demand	1,205	510
Detailed Arena	BAU Demand	2,789	5,211
Total BAU		33,649	17,207
All Electric Solution			Power MWh/yr
Outline Masterplan			20,489
Detailed - Hotel			1,430
Detailed Arena			6,159
			28,077
Heat network and Elec Chiller		Heat MWh/yr	Power MWh/yr
Outline Masterplan		25,207	11,486
Detailed - Hotel		1,129	201
Detailed Arena		2,370	5,211
		28,706	16,898

Table 5 - Masterplan Energy Demand Assessment

Notes on table 5

1. *Building demand is based on the gross internal area and utilises TM46 and CIBSE Guide F benchmark data.*
2. *TM46 and CIBSE Guide F are the best practice values. These may be an over-estimate of demand as buildings will be designed to meet or exceed the current Part L compliance requirements at point of design and construction. Nevertheless, it does provide an estimate with which to evaluate the effectiveness of various infrastructure solutions.*
3. *Fossil Gas is used as heat demand proxy by assuming a 85% gas boiler efficiency based on Gross CV.*
4. *All electric is based on assuming an average COP of 2.8 to assess electricity demand from the heat demand figures.*

There will be a number of buildings within the masterplan which have a cooling demand. We have assessed the coolth demand from CIBSE guide F for prestige and luxury Hotels only together with the Arena.

Coolth Assessment	MWth
Outline Masterplan	1,698
Arena	1,193
Total	**2,891**

Table 6 - Coolth Assessment for Outline Masterplan and Arena

The heat demand across the outline masterplan and the detailed applications of Arena and Hotel is just short of 30,000MWh /year while the coolth demand is assessed as less than a tenth of this. This suggests there is not a strong case for a either a thermal cooling network or recovering heat from the chiller plant across the network.

However, heat recovery at the Arena with its high cooling load may be an effective option.

4 .15 Masterplan Carbon Assessment

We have prepared a carbon assessment of the three options out to 2045. A summary is shown below.

		Carbon Emssions tCO2/yr			
BAU Demand		**2022**	**2025**	**2030**	**2045**
Outline Masterplan		6,660	6,641	6,386	5,839
Detailed - Hotel	BAU Demand	275	274	263	239
Detailed Arena	BAU Demand	1,060	1,052	936	688
Total BAU		7,996	7,966	7,585	6,766
All Electric Solution					
Outline Masterplan		2,154	2,119	1,665	689
Detailed - Hotel		150	148	116	48
Detailed Arena		647	637	500	207
		2,951	2,903	2,282	944
Heat network and Elec Chiller					
Outline Masterplan		2,422	2,402	2,148	1,601
Detailed - Hotel		76	75	71	61
Detailed Arena		662	653	538	289
		3,159	3,130	2,756	1,951

Table 7 - Masterplan Carbon Assessment

Notes on table 7

1. *The Carbon coefficients used for UK grid gas and power are taken from the BEIS publication Valuation of Energy Use and Greenhouse Gas (Supplementary Guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government.)*
2. *The carbon associated with power is taken as the BEIS projected Grid average, as is the gas. No allowance for carbon reduction of the UK gas grid is made.*
3. *The Carbon Coefficient for Heat at point of supply is taken correspondence with Cardiff Heat Networks who advised on an evaluation figure of 0.0438kgCO_2e/kWth heat and allowing 10% standing losses.*
4. *There is no allowance in the above figures for either on site or demand side response, (shifting power demands to period of lower carbon generation). Both of which will offer routes to lower carbon intensities that shown in table 5.*

The carbon table above shows that both options provide substantial carbon savings by 2030 and that the carbon emissions will continue to fall beyond 2030.

The all-electric solution does show lower carbon figures than connecting to the Cardiff Heat Network network, but this is due to using a constant 0.0438kgCO_2e/kWth for the supplied heat.

For carbon reporting purposes there is not a lot of data on the carbon impacts of using heat from energy from waste plants. Zero Waste Scotland have recently published a technical report on the climate change impacts of burning municipal waste in Scotland [4]

[4] Zero Waste Scotland - The climate change impacts of burning municipal waste in Scotland Updated, June 2021.

The report states that *"The net emissions of residual municipal waste sent to both EfW and landfill **is highly dependent** on the composition of that waste. The fossil content of waste is the most significant factor affecting greenhouse gas emissions per tonne of waste burnt in EfW plants"*

The report concludes:

> *The carbon intensity of EfW plants operating in Scotland in 2018 was higher than alternative energy sources. Electricity-only plants emitted nearly twice as many greenhouse gas emissions for each unit of power generated compared to the average of energy technologies supplying the marginal electricity grid in the UK in 2018. Converting these plants to combined heat and power systems would reduce their carbon intensity but not to the level of the UK grid. As a result, **EfW can no longer be considered a source of low carbon energy within a UK and Scottish context.***

The carbon coefficient for heat supplied by the Cardiff Heat Network is based on the BRE Assessment method for SBEM for Part L compliance calculations adjusted for grid electricity coefficient. It is not based on an environmental impact assessment of the Viridor Plant and no data has been supplied on the waste composition or how this is expected to change with time.

4 .16 Masterplan Heat Network Assessment

Future Wales, Policy 16 – Heat networks: states that

1. "Large scale mixed-use development should, **where feasible**, have a heat network with a renewable / low carbon or waste heat energy source.
2. Planning applications for such development should prepare an Energy Masterplan to establish whether a heat network is the most effective energy supply option and, for feasible projects, a plan for its implementation."

With an estimated aggregate annual heat load of 28,706MWh/year across the masterplan then the heat density is sufficiently high that a heat network appears technically feasible. However as noted below account needs to be taken of the construction phasing of both the masterplan build-out and the provision of the heat network.

The question to be addressed is the is a heat network the "most effective energy supply option" for the new build masterplan.

There are several options for heat networks:

1. Adoption of the 3rd/4th generation heat network based on deployment of Cardiff Heat Network across the site.
2. 4th generation heat network based on central heat supply
3. 5th generation heat network based on distributed heat sources

Future Wales policy 16 does not define what criteria are to apply to judge the "effectiveness" of a heat network as heat supply option.

At present it is understood from discussions with the Cardiff Heat Network Ltd the plan is for a central heat supply network based on waste heat from the ErF facility with a new gas fired energy centre to provide continuity of heat delivery.

The plan is a for an extensive roll-out of the network to include heat retrofit and therefore the network has been designed as a relatively high temperature (3rd/4th generation) network. This may not be the most effective solution for a new build development.

However, the CHN Ltd plan is that the spine of the network will cross the masterplan area and this will provide the opportunity to connect onto any local heat network within the masterplan area.

Evaluation of effectiveness may include:

1. Technically feasible – Is the proposed the heat network solution technically feasible?
2. Cost effective- Are the capital and operational costs effective when considered against alternative means of achieving the same low carbon solution?

3. Is it an effective solution to address climate change? Does the solution provide an effective route to net zero in the timescales required by the National targets?

Technically feasible.

For the early stage developments of the Arena and the Hotel described in sections 5 and 6 then it may not be technically feasible to connect on completion as the network may not be ready. Therefore, provision will be made for connection should this be an effective solution at a later date. It will be technically feasible to provide provision for connection across the remainder of the masterplan area.

Cost effective.

This is a complex issue as it will depend on the detailed capital cost of making the connection, how this is to be funded and if capital connection costs are to be recouped from the end-user as part of a connection or service charge. Whether it is operationally cost effective requires that the operating costs are compared on a like for like basis. Traditionally operational costs for a heat network are compared with the counterfactual case of a distributed gas fired solution based on individual gas boilers, but in this case an approach was used to gauge the effectiveness of gas fired CHP against the counterfactual. Both of which are not applicable here due to the relatively high carbon emissions associated with fossil gas use.

The evaluation of cost effectiveness will be the operational cost of low carbon heat delivered by the heat network against an alternative low carbon solution of heat. This is an evaluation of the proposed heat network against a heat pump solution. At present the operational costs for connecting to the CHN Ltd have not been disclosed and therefore it is difficult to evaluate relative operational cost effectiveness.

In general, the counter factual case of the heat pump solution will depend on the individual building, the available environmental heat sources and the need or otherwise for cooling. Where the building has simultaneous (or closely spaced) heating and cooling demands, as is the case of the Arena and Hotel, then high heating and cooling efficiencies are possible, and this reduces the operational cost of the heat pump solution compared to the heat network.

For example, at a heating efficiency of 5.13 which is the baseload heat efficiency for the Arena and an electricity cost of 12p/kWh then the delivered heat cost is 2.4p/kWh which is comparable with that of heat supplied by a high efficiency gas boiler. However, in a residential situation with an air source heat pump the seasonal efficiency can be as low as 2.5 and domestic tariffs are much higher (typically 16p/kWh at present) then the delivered heat price would be 6.4p/kWh a value comparable with heat network prices.

For the Hotel the VRF solution also provides very high efficiencies for heat (with a mean heating efficiency of 5.99) as shown in the energy demand.

Hotel BRUKL - Hotel	Actual kWh/m3	Notional kWh/m3
Heat	6.63	29.68 kWh/m3
Cool	0.44	1.31
Hot Water	203.81	214.47

Table 8 - Hotel BRUKL Summary of Energy Demand against Notional

The high hot water demand of the Hotel and the replacement of the gas boilers for peak heat demand in the Arena offer the opportunity for the heat network to provide and effective lower carbon alternative and so provision is made for connection to the heat network for these two early-stage developments within the masterplan.

Effective Route to net zero

The effectiveness of the heat network to support climate neutral Cardiff by 2030 depends on the carbon

intensity of the heat supplied, how this will change with time and how it compares with alternatives. In section 4.18 below we have provided carbon projections of the masterplan heat demand met by a heat network and a more distributed heat pump solution. This shows that when considered in conjunction with the power trajectory both solutions offer trajectories to significantly lower carbon than a gas boiler.

For the graph in Section 4.18 we have assumed an average efficiency for the heat pump of 2.8 across the masterplan area. As noted above, some of the developments will be able to be operated at much higher efficiencies and so will offer faster routes to net zero based on the heat-pump solution.

The carbon trajectory for heat supplied by the Cardiff Heat Network is unknown. However they have provide figure of :

CHN Ltd Heat supplied Carbon Factor: 0.0438 kgCO2/kWh(th)

This is significantly lower than the figure used for Part L2A compliance based on 2014 building regulations of 0.075 $kgCO_2r$/kWh(th).

The low figure presented results from the fact that the waste heat is taken from a section of the ErfF plant which has a very low impact on the ability to produce electricity. Calculation of carbon intensity then includes a factor for the parasitic electricity used to drive the network and a factor based on use of gas boilers to substitute when EfW is unavailable.

CHN Ltd also identify a number of environmental heat sources which it is claimed could be used with large scale heat pumps in the future.

For evaluation of carbon of heat supplied from CHN we have assumed a fixed carbon co-efficient of heat from CHN Ltd.

gCO2/kWh(th)	2021	2030	2045
Heat network	43.80	43.80	43.80
Grid Electricity	138.83	81.26	33.62
HP at 2.5	55.53	32.51	13.45
HP at 6.0	23.14	13.54	5.60

Table 9 - Comparison of Heat Intensity from various heat delivery options

In table 9 we have shown the comparison based on gCO_2/kW(th) rather than $kgCO_2$/kWth as is used elsewhere in this report as the carbon emissions per kg are very low for these low carbon heat solutions.

At a heat efficiency of 2.5 the heat delivered by heat pump would have a slightly higher carbon intensity than the heat network in 2021 but by 2030 the carbon intensity of the heat pump solution would be significantly lower. For the high efficiency VRF solutions proposed for the main heating in the Hotel and the baseload for the Arena then the carbon intensities of heat produced by the heat pump solution are significantly lower than heat supplied by the network.

Moreover, these figures do not account for standing losses in the heat network which will increase the carbon intensity, nor the potential to use electricity of lower carbon intensity than grid average in the heat pump solution. For a distributed heat pump network these opportunities include:

a) Embedded renewables within the masterplan area (mostly solar).

b) Use of demand side response coupled with local thermal stores to preferentially use grid electricity on half hourly settled basis when carbon- intensity is lower.

c) Preferentially access off-site renewable generation through a sleeved PPA arrangement.

4 .17 Masterplan Energy Strategy

For the Masterplan area the recommended infrastructure strategy is a smart microgrid coupling the mixed-use sectors to maximise the potential for on-site renewable generation and provide the infrastructure to facilitate demand side response, local energy trading and sleeved PPA's.

This will enable an independent energy system operator to finance and operate the micro-grid and embedded energy assets to provide a cost-effective route to maximising the amount of renewable generation deployed and used across the masterplan site.

Low carbon heat will be supplied by heat pump based distributed heat network solutions or, where effective, from the Wide Area Heat Network operated by CHN Ltd. As noted in section 4.14 above both solutions offer much lower annual carbon emissions than a business-as-usual solution.

The energy strategy is:

1. System design is based on the Energy Hierarchy, prioritising demand reduction and energy efficiency before on-site renewables at the building level.
2. A whole system approach to the masterplan area is adopted where local area energy assets are considered (including on-site renewables, private wire and local energy storage) alongside building integrated solutions. The aim of which is to facilitate demand side flexibility and shared access to embedded renewables across the masterplan.
3. A carbon reduction plan is required for each element of the masterplan development based on a defined carbon reduction stack to establish a trajectory to reducing carbon emissions to the minimum practical by the target climate neutral date.
4. Provide offsets for the residual carbon to achieve climate neutral goal for the whole development.
5. Maintain options to connect to the wide area heat network for all heat uses where the heat network provides an effective solution.
6. Where waste heat is available, such as where there is a combined heat and cooling demand, then use high efficiency electrical solutions.
7. Where a smaller local heat network is more effective (such as 5th generation heat networks or heat pump solutions based on the available environmental heat) then these should be adopted where they can be shown to be more effective.

We have constructed a model of the energy demand and carbon trajectory for masterplan. This model contains a set of assumptions for each of the above elements and allows a sensitivity analysis to be undertaken.

The assumptions are common to each of the heat network options.

Variable Assumptions:

1. Installed Solar in MWp – This is the total sum of the embedded solar installed across the masterplan area.
2. Demand Side Response carbon savings – This is the carbon savings achieved by using time of use carbon data and moving demand to low carbon times slots. Over the last few years the difference between times of peak and low carbon has shown a reduction of around 20% in the carbon intensity of the power provided. (Source: https://data.nationalgrideso.com/carbon-intensity1/historic-generation-mix which provides national carbon intensity figures for grid supplied electricity.)

See for example:

At the time of writing: National Grid for week of 2nd-8th August 2021 Gird Carbon Intensity:

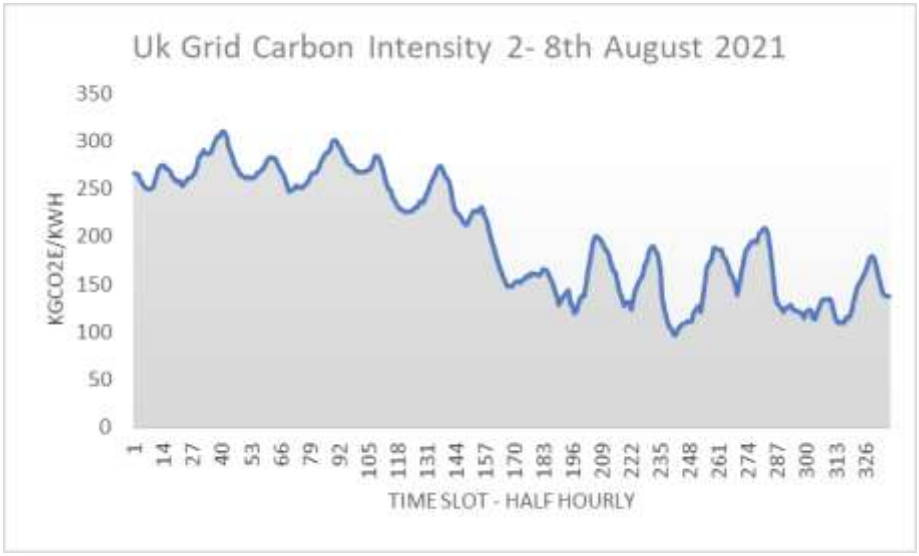


Figure 4-14 UK National Grid Carbon Intensity - source national Grid ESO

The variation for a 24-hour period is approx. 20%.

3. Continuous improvement of energy efficiency targeting an annual percentage reduction in primary energy demand.
4. Demand side flexibility is greater on the heat systems side as buildings can be preheated or cooled and demand for pumps/fans moved from high carbon time periods with a distributed heat pump solution, as thermal storage can also be deployed providing further demand side response opportunities. DSR will also be deployed with vehicle charging by utilising time of use tariffs to shift demand to low-cost periods.

5. Finally, at the top of the carbon reduction stack is the opportunity to directly source low carbon energy. This could include alternative fuels for gas boilers (biomethane or hydrogen or direct purchase of low carbon electricity through a Power Purchase Agreement) with the microgrid solution with private wire PPA rather than the central supply of grid power.

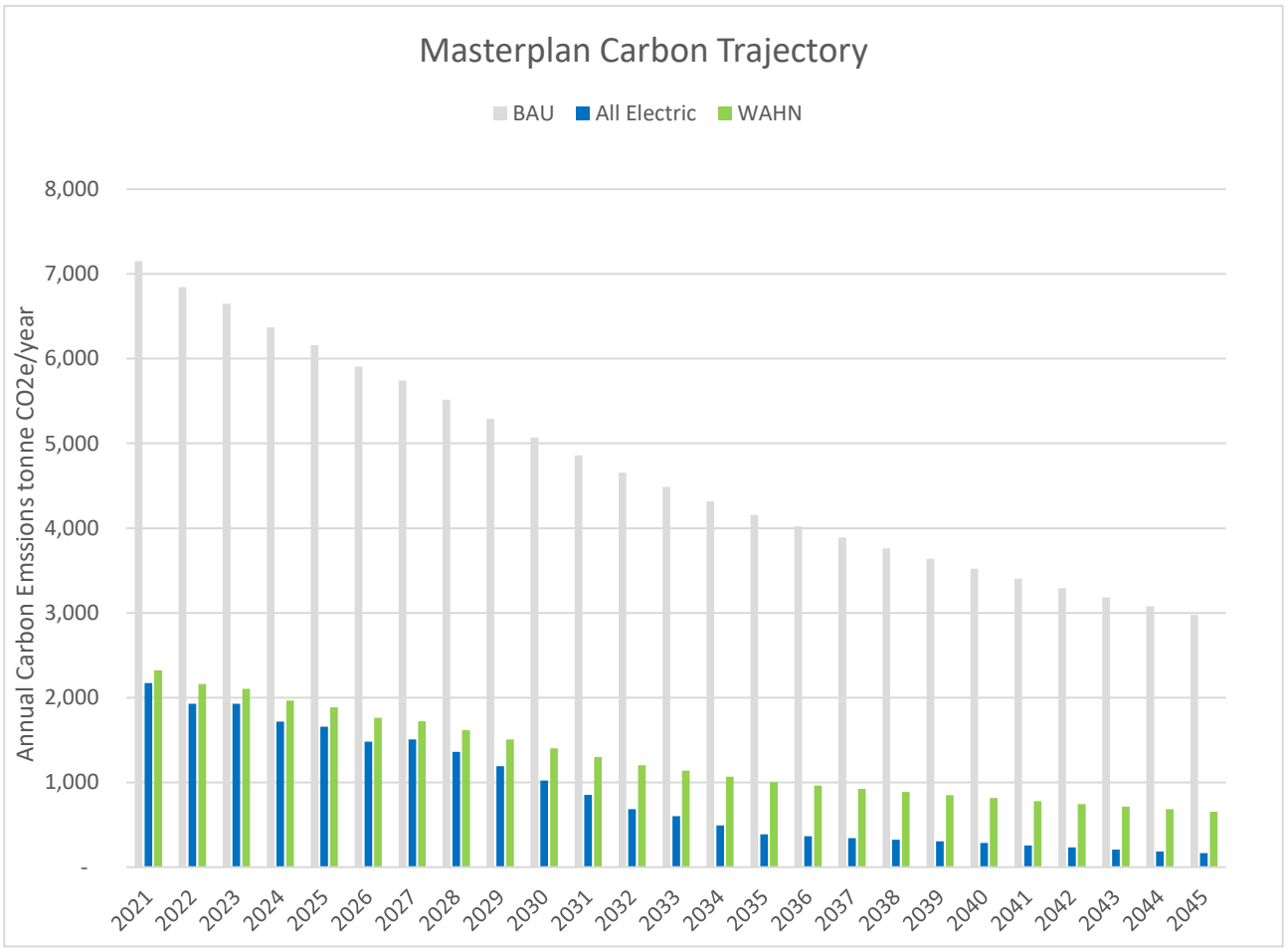


Figure 4-15 Masterplan Carbon Trajectory (using model assumption set 4 below.)

4 .18 Sensitivity Analysis

For the sensitivity analysis we have provided a range of values for the masterplan plan strategy assumptions and illustrated the resultant carbon intensity for the years 2030 and 2045. Figure 4-154 above is the trajectory for the 4 sets of assumptions in the table.

The sensitivity analysis shows that under a wider range of assumptions low carbon heating is always much better than BAU using gas.

Modelled Assumptions				Annual Carbon Emissions 2030 – tonnesCO_2/yr			Annual Carbon Emissions 2045 – tonnesCO2/yr		
DSR Savings	Activity Red	PPA MWh/yr	Solar MWp	BAU	All Elec	WAHN	BAU	All Elec	WAHN
0%	0%	0	0	7,583	2,282	2,756	6778	944	1,951
10%	1%	4000	1	6512	1619	2,103	5,155	554	1363
20%	1%	4000	5	6335	1,338	1,816	5,036	438	1,244
20%	3%	4000	5	5,067	1,002	1,398	2977	162	654

Table 10 Sensitivity Analysis Masterplan strategy

Perhaps unsurprisingly, the all-electric solution is most sensitive to increases in low carbon generation- either on site with the increase in solar or offsite using a low carbon PPA.

In all cases continued energy efficiency to reduce primary demand incrementally reduces carbon emissions with time.

It should also be noted that the space demands for solar preclude achieving a carbon neutral position wholly with embedded renewables.

Building integrated wind would help, but at present there is planning presumption against on site wind generation, we have therefore assumed that wind generation will be purchased off site through a PPA arrangement.

4 .19 Role of Carbon Offsets to achieve a Climate Neutral Position

The aim is that each development within the masterplan will have a carbon reduction plan to achieve minimal practical operational greenhouse gas emissions by 2030, This carbon reduction plan will be based on the defined carbon reduction stack for that development showing a plan that achieves a year-on-year energy saving of between 1 and 3% per annum.

This in itself will not achieve a climate neutral position and it is assumed that residual emissions will need to be offset by purchasing approved offsets if the requirement for a climate neutral development by a specific date is to be achieved.

Offsetting refers to a carbon reduction that occurs outside of the boundary of an organisation and can be either an emission reduction or a removal enhancement (See figure 4.1)

For Climate Neutral Cardiff consideration will be given to the choice of off-set schemes.

International offset schemes tend to be cheaper than UK schemes (e.g. the Woodland Carbon Code and the Peatland Code only offset UK based emissions), it is likely that Welsh Government advice would recommend national as opposed to international schemes, to ensure that money flowing into offset schemes contribute to Wales' overall climate neutral commitment.

It should be noted that carbon sequestration options are finite and limited, especially as many industries are planning on using biomass for their activities and the growing global population will demand more space for agriculture. Therefore, although offsetting can be used to achieve a declared Climate Neutral position it is essential that focus is maintained on reducing their operational emissions over time.

4 .20 Masterplan Summary

The Energy Strategy may be summarised in the following principles.

1. The Atlantic Wharf as a whole will seek to achieve an operational climate neutral position by 2030 in accordance with One Planet Cardiff.

2. The aim is that each element of the development will have a carbon reduction plan aimed at continuous improvements in energy efficiency and eliminating all avoidable greenhouse gas emissions by 2030 and offsetting unavoidable residual emissions by 2030.

3. It is recognised that the role of carbon offsetting needs to be defined at city and national level, but it is likely that national offsetting schemes will be preferred.

A strategic approach set out in section 4.8.

1. System design is based on the Energy Hierarchy, prioritising demand reduction, energy efficiency before on-site renewables at the building level.
2. A whole system approach to the masterplan area is adopted where local area energy assets are considered (including on-site renewables, private wire and local energy storage) alongside building integrated solutions. The aim of which is to facilitate demand side flexibility and shared access to embedded renewables across the masterplan.
3. A carbon reduction plan is required for each element of the masterplan development based on a defined carbon reduction stack to establish a trajectory to reducing carbon emissions to the minimum practical by the target climate neutral date.
4. Provide offsets for the residual carbon to achieve climate neutral goal for the whole development.
5. Maintain options to connect to the wide area heat network for all heat uses where the heat network provides an effective solution.
6. Where waste heat is available such as where there is a combined heat and cooling demand then use high efficiency electrical solutions.
7. Where a smaller local heat network is more effective (such as 5th generation heat networks or heat pump solutions based on the available environmental heat) then these should be adopted where they can be shown to be more effective.

An estimate of the masterplan energy demand is presented. This is a high-level assessment of the energy demand of the outline masterplan together with more detailed assessment of the energy demand of the detailed application for the Arena and the Hotel.

A Business-as-Usual Assessment (BAU) is provided based on using conventional gas boilers for heat and power supplied directly from the national grid.

A second assessment is made based on an all-electric solution (All Elec) to assess the standalone power demands assuming the heat demand is supplied by local heat pumps.

A third assessment is provided which is assuming the heat is supplied from the wide area heat network (WAHN).

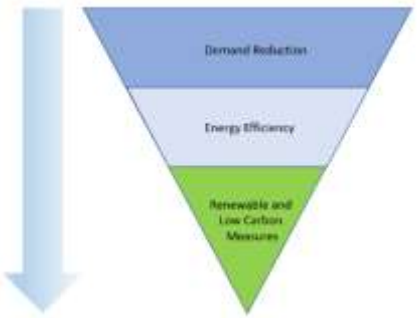
Both the All Elec and WAHN show substantial reductions in carbon compared to the BAU reference.

The energy strategy is modelled out until 2045 and it is shown that carbon reduction plans are required for each element of the masterplan to minimise carbon emissions and achieve a carbon trajectory consistent with UK national and Cardiff City wide policy ambitions.

5 Cardiff Arena Energy Statement

5 .1 Introduction

The energy strategy for the Arena follows that outlined in Chapter 4 for the masterplan. In the first instance the design follows the energy hierarchy prioritising demand reduction and energy efficiency before considering renewable and low carbon technologies.



The energy demands for an Arena differ considerably between normal quiescent operation and when a concert is in operation, therefore the energy strategy needs to address the peak demands for heat, cooling and power.

A proven and tested strategy is to prioritise low carbon renewable technology for the base load and then provide high efficiency HVAC technology for the short duration peak loads.

The low carbon technology is then operated at highest utilisation and provides the biggest contribution to reducing carbon. This strategy provides our base case design.

5 .2 Energy Demand Assessment

An energy demand assessment has been completed for both the operational energy demand based on a comparable venue and the regulated energy model required for Part L2A compliance based on 2014 Regulations as amended.

It should be noted there is a wide range of possible annual energy demand figures as the actual energy demand will depend on the operational parameters of the Arena (for example, the number and type of concert events, the occupancy achieved and the time of year of these and the amount of unregulated energy used at the events).

There is therefore a wide disparity between the energy demand from a comparable venue and the statutory SBEM calculation as required for Part L2A compliance.

Demand Based on Actual of Comparable Building (Birmingham Arena)		
Heating	2370.3	MWh/year
Cooling	1193.39	MWh/year
Power	4812.84	MWh/year

5 .3 Compliance with Wales Building Regulations Part L 2014

Appendix 8.2 provides the SBEM results for both an air source heat pump providing the baseload heating system and either gas boilers or connection to the heat network providing the peak demand.

BRUKL Output Document	Arena As Designed	Arena Heat Network
Building CO_2 emission rate (BER) $kgCO_2/m^2.annum$	14.7	11.7

Target CO_2 emission rate (TER) $kgCO_2/m^2.annum$	16.3	16.6
Building Primary Energy Consumption (BPEC kWh/m^2.annum	98.2	99.15
Target Primary Energy Consumption (BPEC kWh/m^2.annum	98.74	99.91

This shows that the as designed and heat network options are broadly comparable under the 2014 National Calculation Methodology, with the heat network offering an improvement in BER.

However as noted in section 4.7 this is based on a high carbon factor for grid electricity of $0.522kgCO_2/kWh$ which is 56% higher than current electricity grid.

5 .4 Demand Reduction measures

A fabric first approach is taken to drive down the energy requirements of the building. Ambitious targets for fabric efficiency and air permeability have been set.

The following design principles and techniques have been adopted to minimise building energy demand:

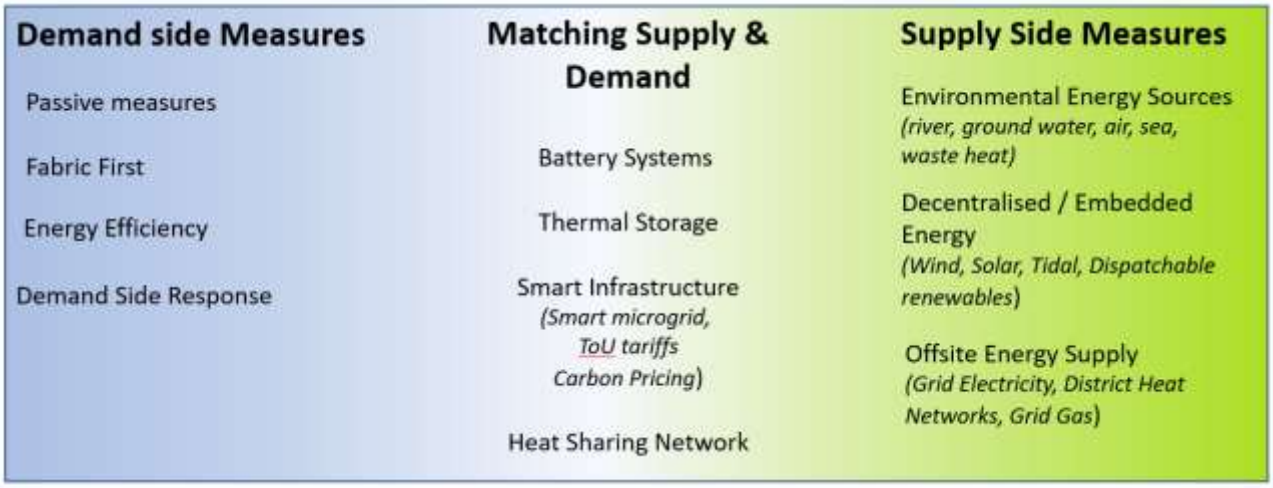
- Orientation of the buildings to optimise for capture of winter sun and promote passive design
- Maximise the use of natural daylight (where considered appropriate for an Arena)
- Consider unique solutions to bring natural daylight to internal spaces (where appropriate)
- Incorporating thermal mass to store and release energy
- Implement façade air tightness and include high performance façade insulation
- U values lower than 0.2 W/m².K
- Infiltration target to be set at 3m³/(m².hr)

5 .5 Energy Efficiency Measures

The development will incorporate a number of these key energy efficiency features:

- The main Arena space is conditions (heat and cooling with fan coil units)
- In base (non event) heating load is handled with a ASHP
  - While high efficiency gas boiler provide for the peak heat loads ds associated with events
  - Events cooling demand is met with air cooled chillers
  - 1500m2 of PV panels (6300kWp installation providing nearly 3000MWh/annum)
  - Maximise the use of efficient LED technology within the lighting design
  - Maximise use of daylight linked dimming to control artificial lighting output
  - Maximise use of presence or absence control within design
  - Heat recovery technology to the ventilation systems and waste-water systems
  - Demand ventilation – only provide the required ventilation when needed
  - Incorporation of variable speed control for fans and pumps
  - Where possible look to share ventilation air between spaces (Arena & concourse areas as an example)

5 .6 Whole System Approach



The relationship of the building to the masterplan energy systems and the wider area energy network is described in sections 4.10 – 4.13 and an assessment of the effectiveness of the connecting to the wide area network is presented in section 4 .15

The masterplan strategy is that individual buildings will connect into the local area heat and power networks where this the most effective supply option in accordance with the Future Wales policies 16 and 17.

The proposal for a smart microgrid will offer the Arena the opportunity to access embedded renewable generation planned across the masterplan area, following policy 17 and as identified as part of the carbon reduction plan.

For the heat network it is not clear at present that the Cardiff Heat Network as proposed will be the most effective supply option at building completion, but provision is made for retro-fit to replace the high efficiency gas boiler providing the peak demand should the Wide area heat network prove to be an effective solution.

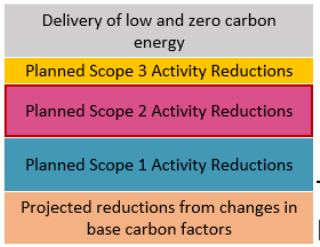
As noted in section 4 both baseload heat pump solution and heat networks are low carbon solutions offering comparable levels of carbon reduction compared to a business-as-usual gas fired boiler and grid electricity solution.

In the as-designed solution baseload heat and cooling is provided by high efficiency VRF units of 5.13 and 4.44 heating and cooling efficiency respectively. While short duration peak heat and peak cooling is provided by gas boiler and electric chillers.

These baseload VRF units will be fed by grid electricity, this provides for a decreasing carbon trajectory following the grid decarbonisation projection, with additional decarbonisation as embedded renewable generation is built out in accordance with the masterplan strategy.

Provision is made for retrofit of plate heat exchangers to replace the gas boilers for the peak heat duty should this prove an effective solution.

5 .7 Carbon Reduction Plan



The Carbon Reduction Stack

The first element of the climate reduction stack is the reduction anticipated decarbonisation from the energy infrastructure.
This will follow the decarbonisation of the grid and decarbonisation of the wide area heat network.

As a new build, seasonal commissioning will be used to achieve demand reduction and energy efficiency through optimising the building management system (BMS) and control strategy activity reductions.

Finally at the top of the stack will be carbon reductions from adoption of renewable energy through power purchase agreements. Purchasing green electricity and if necessary, substituting fossil gas for green gas.

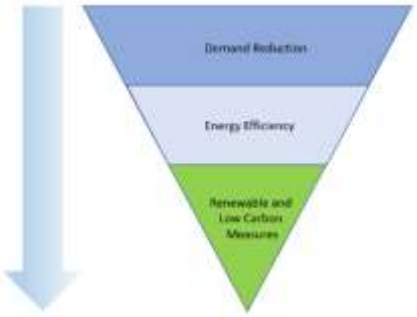
To monitor progress, we expect each major development to commit to provision of annual carbon reporting.

This might be under the BEIS Streamlined Energy and Carbon Reporting, or one of the recognised climate change commitments schemes such as UNFCC Race to Zero or the Climate Pledge (10 years Early).

The developer/landlord? will put in place a mechanism to collate annual reports from each of the major developments on the masterplan and report progress the masterplan as a whole as the development is built out.

6 Hotel Energy Statement

6 .1 Introduction



The energy strategy for the Hotel follows that outlined in Chapter 4 for the masterplan. In the first instance the design follows the energy hierarchy prioritising demand reduction and energy efficiency before considering renewable and low carbon technologies.

The energy demands for an Hotel include heat, power and cooling and the heat load is made up of demand for space heating and a considerable demand for hot water.

The Client, Operator and Project Team have the following aspirations for the project in relation to the provision of MEP services:

• Provide a functional and comfortable environment for both guests and staff.

- Recognise the considerable energy usage of the Hotel, review and adopt practical energy efficient solutions across all mechanical and electrical systems.
- Provide solutions that allow plant maintenance and replacement to be carried out safely, and without disruption to the operation of the Hotel wherever practical.
- Minimise the impact of the Hotel on the existing environment

6 .2 Energy Demand Assessment

An energy demand assessment has been completed based on the regulated energy model required for Part L2A compliance based on 2014 Regulations as amended. (Appendix 8.2).

Hotel BRUKL Model	MWh/annum
Power	201.043
Space Heating	183.994
DHW	944.98

6 .3 Compliance with Wales Building Regulations Part L 2014

Appendix 8.2 provides the SBEM results for both an air source heat pump providing the baseload heating and DHW system or space heat alone and Heat Networks providing the DHW

BRUKL Output Document	Hotel As Designed	Hotel Heat Network
Building CO_2 emission rate (BER) $kgCO_2/m^2$.annum	55.5	27.6
Target CO_2 emission rate (TER) $kgCO_2/m^2$.annum	57.8	57.8
Building Primary Energy Consumption (BPEC kWh/m^2.annum	287.55	294.89
Target Primary Energy Consumption (BPEC kWh/m^2.annum	317.94	317.94

This shows that the heat network option is significantly better under the 2014 National Calculation Methodology, with the heat network offering an improvement in BER.

However as noted in section 4.7 this is based on a high carbon factor for grid electricity of 0.522kgCO_2/kWh which is 56% higher than current electricity grid.

6 .4 Demand Reduction measures

The first passive design stage is crucial in helping to achieve a low energy building as it looks to reduce the need for energy to be generated in the first instance. During the early stages of development, close attention will be paid to co-ordination and integration of the design, where practical, to:

- Consider orientation, form and internal layout to optimize the design considering planning / operational requirements and the site constraints.
- Provide the potential for natural ventilation where practical (reducing requirements for mechanical services).
- Reduce direct solar gain to reduce the energy consumption for comfort cooling or air conditioning.
- Improve the daylight factors in all areas.
- Improve the building thermal envelope performance (reducing air permeability, U-values and g-values).
- Optimise window design to provide balance between the conflicting considerations and allow beneficial heat gains in winter, preclude excessive heat gains in warmer months and achieve good day lighting levels year-round. This considers orientation, glazed area, use of high-performance glazing and form (e.g. tall narrow windows to increase depth of daylight penetration), consideration of window reveals, horizontal and vertical building projections and external solar shading to achieve a balanced design.

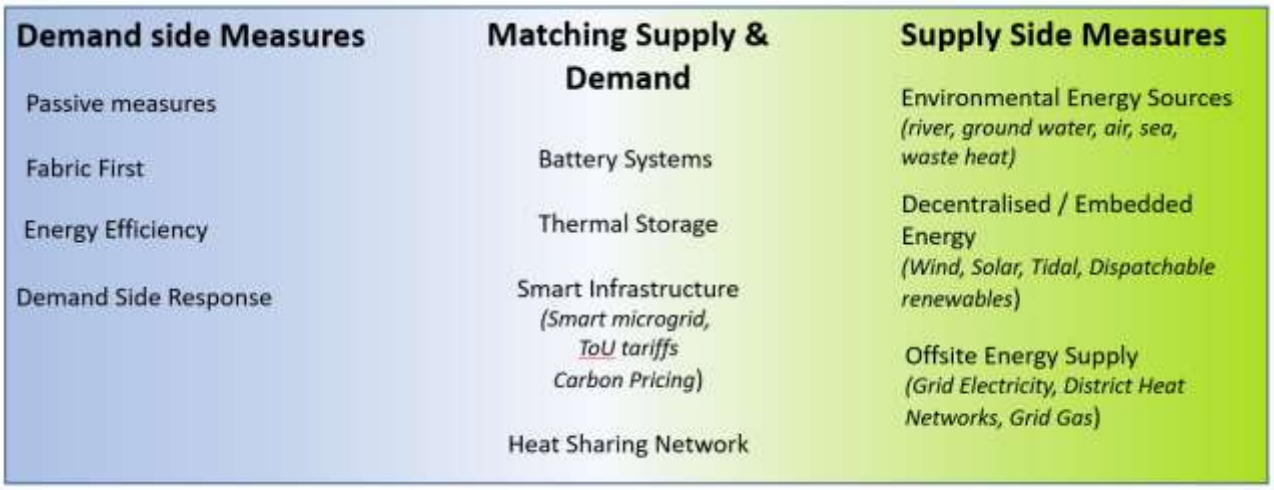
6 .5 Energy Efficiency Measures

Options will then be considered to reduce energy use and to use and recover energy efficiently, e.g.:

- High efficiency VRF units with heat recovery for all conditioned spaces These units provide heating and cooling efficiencies of 5.13 and 4.44 respectively
- High efficiency lighting systems with appropriate artificial lighting levels and controls.
- Strategies to improve control and flexibility of the installations including provision of local user controls.
- Energy efficient equipment including the use of high efficiency motors with variable frequency drives (e.g. fans, pumps, etc.).
- Regenerative lift drives.
- Zoning of equipment to allow plant to be turned off or enable out of hours setback in appropriate unoccupied spaces.
- High efficiency energy recovery for ventilation systems where practical.
- Smart metering
- Low velocity pipework / ductwork and low pressure air filters to reduce fan and pump power consumption.

- Provision of user guidance, training and support to the building occupiers to increase awareness and to ensure that systems are operated as intended.

6 .6 Whole Systems Approach



The relationship of the building to the masterplan energy systems and the wider area energy network is described in sections 4.10 – 4.13 and an assessment of the effectiveness of the connecting to the wide area network is presented in section 4 .15

The masterplan strategy is that individual buildings will connect into the local area heat and power networks where this the most effective supply option in accordance with the Future Wales policies 16 and 17.

The proposal for a smart microgrid will offer the Hotel the opportunity to access embedded renewable generation planned across the masterplan area, following policy 17 and as identified as part of the carbon reduction plan.

For the heat network it is not clear at present that the Cardiff Heat Network as proposed will be the most effective supply option at building completion, but provision is made for retro-fit for the heat network to provide the DHW load should the Wide area heat network prove to be an effective solution.

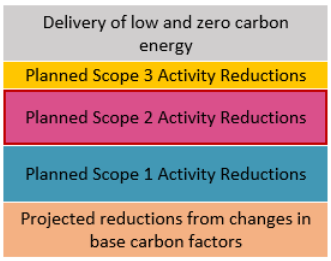
As noted in section 4 both baseload heat pump solution and heat networks are low carbon solutions offering comparable levels of carbon reduction compared to a business-as-usual gas fired boiler and grid electricity solution.

In the as-designed solution baseload heat and cooling is provided by high efficiency VRF units of 5.99 on average.

These main heating and cooling VRF units will be fed by grid electricity, this provides for a decreasing carbon trajectory following the grid decarbonisation projection, with additional decarbonisation as embedded renewable generation is built out in accordance with the masterplan strategy.

Provision is made for retrofit of plate heat exchangers to replace the gas boilers for the DHW should this prove an effective solution.

6 .7 Carbon Reduction Plan



The Carbon Reduction Stack

The first element of the climate reduction stack is the reduction anticipated from decarbonisation the energy infrastructure.
This will follow the decarbonisation of the grid and decarbonisation of the wide are heat network.

As a new build, seasonal commissioning will be used to achieve demand reduction and energy efficiency through optimising the building management system (BMS) and control strategy activity reductions.

Finally at the top of the stack will be carbon reduction from adoption of renewable energy through power purchase agreements. Purchasing green electricity and if necessary, substituting fossil gas for green gas.

To monitor progress, we expect each major development to commit to the provision of annual carbon reporting.

This might be under the BEIS Streamlined Energy and Carbon Reporting, or one of the recognised climate change commitments schemes such as UNFCC Race to Zero or the Climate Pledge (10years Early).

The Developer/Landlord will put in place a mechanism to collate annual reports from each of the major developments on the masterplan and report progress the masterplan as a whole as the development is built out.

7 Conclusions

7.1 Introduction

An energy statement in support of the Atlantic Wharf, Butetown Masterplan with the Cardiff ArenaArena and HHotel development encompassed within this.

The application includes:

- Atlantic Wharf, Butetown Masterplan – Outline Application
- Cardiff Arena – Detailed Application
- Associated Hotel – Detailed Application

The energy statement is structured as an energy strategy to support the masterplan area as a whole, together with energy statements for each of the detailed applications.

The energy statements for the detailed applications follow the masterplan strategy with design based on the energy hierarch, prioritising demand reduction and energy efficiency before considering renewable and low carbon technologies.

For the masterplan area we propose a whole system approach by considering the masterplan area as a whole and its relationship with the wider energy system.

With the whole system approach, we recognise that “net zero” for a single building can be difficult and expensive to achieve, while net-zero for a mixed-use development with complementary energy demand profiles and the opportunity for linking into the wide area heat and power networks is a more tractable problem.

In the whole system approach, we consider both the local and wider area energy systems.

In this approach, demand side measures (including passive measures, energy efficiency and demand side response options) are considered alongside the energy infrastructure (which includes energy delivery and energy storage systems) and energy supply options including environmental energy sources, decentralised energy systems and linking into local or wider area networks for heat and power.

A key element of the whole system approach is the adoption of “smart” infrastructure which combined with demand side response will make best use of the on-site energy supply options.

Renewable low carbon technologies can be located at the most appropriate areas within the masterplan area rather than behind the meter on each building. This also offers opportunities for:

- taking advantage of complementary energy uses
- delivering improved demand and supply side matching
- using more of the onsite generated energy, onsite
- system wide energy control and energy use scheduling

Finally we look at the trajectory to net zero and the need to build carbon reductions plans. These will include recognition of the effect of decarbonising the heat and power networks and the opportunity for continued demand side response and energy efficiency. It also allows developments to take advantage of the progressive build out on of site renewable energy and finally fuel substitution and replacing energy purchases with alternative low carbon sources.

7.2 Summary

The Energy Strategy may be summarized in the following principles.

1. The Atlantic Wharf as a whole will seek to achieve an operational climate neutral position by 2030 in accordance with One Planet Cardiff.

2. The aim is that each element of the development will have a carbon reduction plan aimed at continuous improvements in energy efficiency and eliminating all avoidable greenhouse gas emissions by 2030 and offsetting unavoidable residual emissions by 2030.

3. It is recognised that the role of carbon offsetting needs to be defined at city and national level, but it is likely that national offsetting schemes will be preferred.

The key elements of the strategic approach as set out in section 4.8 are:

1. System design is based on the Energy Hierarchy, prioritising demand reduction, energy efficiency before on-site renewables at the building level.
2. A whole system approach to the masterplan area is adopted where local area energy assets are considered (including on-site renewables, private wire and local energy storage) alongside building integrated solutions. The aim of which is to facilitate demand side flexibility and shared access to embedded renewables across the masterplan.
3. A carbon reduction plan is required for each element of the masterplan development based on a defined carbon reduction stack to establish a trajectory to reducing carbon emissions to the minimum practical by the target climate neutral date.
4. Provide offsets for the residual carbon to achieve climate neutral goal for the whole development.
5. Maintain options to connect to the wide area heat network for all heat uses where the heat network provides an effective solution.
6. Where waste heat is available such as where there is a combined heat and cooling demand then use high efficiency electrical solutions.
7. Where a smaller local heat network is more effective (such as 5th generation heat networks or heat pump solutions based on the available environmental heat) then these should be adopted where they can be shown to be more effective.

8 Appendices

Appendix 1 Tables

8 .1 Masterplan Demand Estimates

All Electric Solution	MWh/yr
Outline Masterplan	20,489
Detailed - Hotel	1,430
Detailed Arena	6,159
Total Demand	28,077

Figure 8-1 All Electric Solution based on Heat pump technology

Heat network and Elec Chiller		MWh/yr
Outline Masterplan	Power	11,486
	Heat	25,207
Detailed - Hotel	Power	201
	Heat	1,129
Detailed Arena	Power	5,211
	Heat	2,370
Total	Power	16,898
	Heat	28,706

Figure 8-3 Heat Network with Electric Chiller

	Annual Estimates	
BAU Demand		MWh/yr
Outline Masterplan	Power	11,486
	Fossil	29,656
Detailed - Hotel	Power	201
	Fossil	1,328
Detailed Arena	Power	5,211
	Fossil	2,789
Total Demand	Power	16,898
	Fossil	33,772

Figure 8-2 - BAU - Gas Boiler and Grid Electricity

8 .2 BRUKL Output Documents

1. Cardiff Arena v1 PFC Full
2. Cardiff Arena – WH
3. Travelodge v4 – Evo 3-R3
4. Travelodge v4 – WH

BRUKL Output Document

Compliance with Wales Building Regulations Part L 2014

Llywodraeth Cymru
Welsh Government

Project name

Cardiff Arena v1 PFC Full

As designed

Date: Wed Aug 11 21:22:19 2021

Administrative information

Building Details

Address: Cardiff, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Carlina Fernandes

Telephone number:

Address: 4 Pierhead St, Cardiff, CF10 4QP

Criterion 1: The calculated BER and BPEC for the building must not exceed the targets

Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	14.7	
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	16.3	
Building Primary Energy Consumption (BPEC), $kWh/m^2.annum$	98.2	
Target Primary Energy Consumption (TPEC), $kWh/m^2.annum$	98.74	
Do the building's emissions and primary energy consumption exceed the targets?	BER =< TER	BPEC =< TPEC

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.2	0.2	RM00006B:Surf[0]
Floor	0.25	0.15	0.15	RM00005C:Surf[0]
Roof	0.25	0.15	0.15	10000000:Surf[2]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	RM00006B:Surf[1]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

* There might be more than one surface where the maximum U-value occurs.
** 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.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

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- Fan Coils

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1.07	4.2	0	1.99	0.75
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

2- Spill Air + Fan Coils

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1.07	4.5	0	1.99	0.75
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

3- LTHW Radiator

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.98	-	0.2	0	-
Standard value	0.91*	N/A	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 gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

4- LTHW Unit Heaters

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.98	-	0.2	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

5- DX CRAC Unit

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	4.96	4.96	0	0	-
Standard value	0.91*	1	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

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

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
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 supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
1.001 PREMIUM LOUNGE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.002 CONCESSION	-	-	-	-	-	-	-	0.3	-	-	N/A
1.003 CONCOURSE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.009 CLEANER	-	-	0.5	-	-	-	-	-	-	-	N/A
1.010 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.012 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.016 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
1.017 CLOAKROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
1.033 BAR	-	-	-	-	-	-	-	0.2	-	-	N/A
1.035 LOUNGE-SPONSOR	-	-	-	-	-	-	-	0.2	-	-	N/A
1.036 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.037 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.038 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.039 PRIVATE BANQUET	-	-	-	-	-	-	-	0.2	-	-	N/A
1.040 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.041 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.048 CATERING	-	-	-	-	-	-	-	0.2	-	-	N/A
1.048 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
1.051 ROOM 2-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.052 ROOM 1-MP/PRESS	-	-	-	-	-	-	-	0.2	-	-	N/A
1.058 ROOM 4-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.061 ROOM 5-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.065 ROOM 6-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.066 ROOM 3-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.067 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.068 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.070 ROOM 7-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.076 GREEN ROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
1.086 ROOM 8-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.087 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.088 WC	-	-	0.5	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
1.089 ROOM 9-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.091 ROOM 10-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.094 ROOM 1-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.096 ROOM 12-OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.097 ROOM 13-OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.099 ROOM 14-FLEXIBLE OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.102 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.107 MEETING	-	-	-	-	-	-	-	0.2	-	-	N/A
1.112 OPEN PLAN	-	-	-	-	-	-	-	0.2	-	-	N/A
1.117 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.126 FINANCE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.127 NAMING RIGHT SPONSORS	-	-	-	-	-	-	-	0.2	-	-	N/A
1.128 POST/PRINT	-	-	-	-	-	-	-	0.2	-	-	N/A
1.131 FREEZER WALK-IN GENERAL GOODS	-	-	-	-	-	-	-	0.2	-	-	N/A
1.142 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
1.152 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.153 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.154 PRIVATE BANQUET	-	-	-	-	-	-	-	0.2	-	-	N/A
1.155 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.156 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.157 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.158 CLUB LOUNGE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.160 BAR	-	-	-	-	-	-	-	0.2	-	-	N/A
1.176 CLOAKROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
1.177 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE SOUTH	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE SOUTH EAST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE SOUTH WEST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE WEST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 COUNCOURSE EAST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.007 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.019 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.021 BAR	-	-	-	-	-	-	-	0.2	-	-	N/A
2.024 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.025 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.027 LOBBY	-	-	-	-	-	-	-	0.2	-	-	N/A
2.039 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.042 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.050 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.054 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
2.057 INFO POINT	-	-	-	-	-	-	-	0.2	-	-	N/A
2.080 FIRST AID	-	-	-	-	-	-	-	0.2	-	-	N/A
2.091 QUIET ROOM	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
2.094 STORE	-	-	-	-	-	-	-	0.2	-	-	N/A
2.098 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
2.101 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.109 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.113 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.128 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.129 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.138 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.141 MERCH	-	-	-	-	-	-	-	0.2	-	-	N/A
G.001 FOYER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.002 FOYER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.003 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
G.005 CELLAR	-	-	-	-	-	-	-	0.2	-	-	N/A
G.006 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.008 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.023 CAFE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.026 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.039 STORE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.040 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
G.041 CLEANER	-	-	0.5	-	-	-	-	-	-	-	N/A
G.042 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.045 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.046 CELLAR	-	-	-	-	-	-	-	0.2	-	-	N/A
G.047 BOH - STORAGE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.050 BOH - STORAGE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.052 FIRST AID	-	-	-	-	-	-	-	0.2	-	-	N/A
G.053 WORKSHOP	-	-	-	-	-	-	-	0.2	-	-	N/A
G.065 BOH - STORAGE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.066 DINING	-	-	-	-	-	-	-	0.2	-	-	N/A
G.070 CREW MALE	-	-	0.5	-	-	-	-	-	-	-	N/A
G.071 CREW LOCKER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.072 CREW FEMALE	-	-	0.5	-	-	-	-	-	-	-	N/A
G.075 OFFICE 1	-	-	-	-	-	-	-	0.2	-	-	N/A
G.076 OFFICE 2	-	-	-	-	-	-	-	0.2	-	-	N/A
G.106 WINE & SPIRITS	-	-	-	-	-	-	-	0.2	-	-	N/A
G.108 CHILLED KEG STORE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.112 H. PRODUCTION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.119 CCTV/EVENT CONTROL SPACE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.120 CRISIS MEETING ROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
G.123 FIRST AID	-	-	-	-	-	-	-	0.2	-	-	N/A
G.125 RECEPTION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.126 BRIEFING/BREAKOUT	-	-	-	-	-	-	-	0.2	-	-	N/A
G.127 SIGN-IN/UNIFORM	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
G.130 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.133 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.134 LOCKER	-	-	0.5	-	-	-	-	-	-	-	N/A
G.135 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.143 PREMIUM ARRIVAL	-	-	-	-	-	-	-	0.2	-	-	N/A
G.144 LOBBY	-	-	-	-	-	-	-	0.2	-	-	N/A
G.147 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.149 MERCH	-	-	-	-	-	-	-	0.2	-	-	N/A
G.154 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.160 OFFICE MANAGER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.161 OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.162 BOX OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.172 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
1.001 PREMIUM LOUNGE	-	95	-	1460
1.002 CONCESSION	-	95	-	1624
1.003 CONCOURSE	-	95	-	934
1.004 CLOAKROOM	95	-	-	27
1.005 MEP	95	-	-	9
1.006 CLOAKROOM	95	-	-	27
1.007 MEP	95	-	-	9
1.008 WC	-	95	-	79
1.009 CLEANER	-	95	-	136
1.010 WC	-	95	-	605
1.011 STORE	95	-	-	10
1.012 WC	-	95	-	300
1.013 CLEANER	-	95	-	47
1.014 WC	-	95	-	79
1.015 CONCOURSE	-	95	-	332
1.016 CIRCULATION	-	95	-	206
1.017 CLOAKROOM	95	-	-	40
1.019 M13d-MEP	95	-	-	15
1.020 CIRCULATION	-	95	-	36
1.021 P4 & M12	95	-	-	12
1.022 E15-MEP	95	-	-	19
1.023 CIRCULATION	-	95	-	40
1.024 M13b-MEP	95	-	-	19
1.025 CIRCULATION	-	95	-	59
1.027 - ICT SER	95	-	-	53
1.028 CORE	-	95	-	75

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
1.029 CORE	-	95	-	44
1.031 M13b-MEP	95	-	-	22
1.032 STORAGE	95	-	-	42
1.033 BAR	-	95	-	248
1.035 LOUNGE-SPONSOR	-	95	-	2207
1.036 BOXES	95	-	-	244
1.037 BOXES	95	-	-	228
1.038 BOXES	95	-	-	250
1.039 PRIVATE BANQUET	-	95	-	107
1.040 BOXES	95	-	-	244
1.041 BOXES	95	-	-	286
1.042 LOBBY	-	95	-	40
1.043 CLEANER	-	95	-	91
1.044 WC	-	95	-	86
1.045 LOBBY	-	95	-	23
1.048 CATERING	-	95	-	220
1.048 CONCESSION	-	95	-	565
1.050 WC	-	95	-	72
1.051 ROOM 2-ARTIST	95	-	-	350
1.052 ROOM 1-MP/PRESS	95	-	-	295
1.053 BIN STORE	95	-	-	9
1.054 E15 MEP	95	-	-	18
1.055 M13b-MEP	95	-	-	24
1.056 CIRCULATION	-	95	-	265
1.058 ROOM 4-ARTIST	95	-	-	282
1.059 WC	-	95	-	69
1.060 WC	-	95	-	69
1.061 ROOM 5-ARTIST	95	-	-	330
1.062 WC	-	95	-	111
1.063 CIRCULATION	-	95	-	743
1.065 ROOM 6-LOUNGE ARTIST	95	-	-	749
1.066 ROOM 3-ARTIST	95	-	-	297
1.067 WC	-	95	-	148
1.068 WC	-	95	-	148
1.069 WC	-	95	-	143
1.070 ROOM 7-LOUNGE ARTIST	95	-	-	800
1.071 M12-MEP	95	-	-	8
1.072 P4	95	-	-	23
1.073 CORE	-	95	-	79
1.075 CORE	-	95	-	50
1.076 GREEN ROOM	95	-	-	855
1.077 M13a-MEP	95	-	-	25
1.078 E15-MEP	95	-	-	9

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
1.080 CORE	-	95	-	76
1.082 E15-MEP	95	-	-	19
1.083 E11 - ICT SER	95	-	-	48
1.085 M13e-MEP	95	-	-	2
1.086 ROOM 8-LOUNGE ARTIST	95	-	-	788
1.087 WC	-	95	-	148
1.088 WC	-	95	-	148
1.089 ROOM 9-LOUNGE ARTIST	95	-	-	815
1.091 ROOM 10-ARTIST	95	-	-	442
1.092 WC	-	95	-	107
1.093 WC	-	95	-	113
1.094 ROOM 1-ARTIST	95	-	-	519
1.095 CORE	-	95	-	60
1.096 ROOM 12-OFFICE	95	-	-	389
1.097 ROOM 13-OFFICE	95	-	-	328
1.098 M13f-MEP	95	-	-	28
1.099 ROOM 14-FLEXIBLE OFFICE	95	-	-	977
1.100 FURNITURE STORE	95	-	-	31
1.101 LAUNDRY	95	-	-	31
1.102 WC	-	95	-	141
1.105 CORE	-	95	-	75
1.107 MEETING	95	-	-	393
1.108 LOCKER	-	95	-	44
1.109 WC	-	95	-	85
1.110 CIRCULATION	-	95	-	800
1.111 M13c-MEP	95	-	-	18
1.112 OPEN PLAN	95	-	-	1624
1.113 GM	95	-	-	174
1.114 OM	95	-	-	171
1.115 COO	95	-	-	160
1.116 MR	95	-	-	151
1.117 WC	-	95	-	150
1.119 CORE	-	95	-	79
1.120 M12-MEP	95	-	-	6
1.121 P4	95	-	-	6
1.122 E15-MEP	95	-	-	19
1.124 CLEANER	-	95	-	75
1.125 E11 - ICT SER	95	-	-	53
1.126 FINANCE	95	-	-	233
1.127 NAMING RIGHT SPONSORS	95	-	-	275
1.128 POST/PRINT	95	-	-	238
1.129 CATERING	-	95	-	2402
1.131 FREEZER WALK-IN GENERAL GOODS	95	-	-	32

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
1.132 CHILLER VEG	95	-	-	26
1.133 CHILLER DAIRY	95	-	-	26
1.134 FREEZER ICE CREAM	95	-	-	26
1.135 FREEZER RAW MEAT	95	-	-	29
1.136 DRY GOOD STORE	95	-	-	29
1.137 CHILLER RAW MEAT	95	-	-	27
1.138 PANTRY	95	-	-	191
1.140 E15-MEP	95	-	-	16
1.141 M13b-MEP	95	-	-	24
1.142 CONCESSION	-	95	-	545
1.143 CATERING	-	95	-	347
1.146 WC	-	95	-	46
1.147 LOBBY	-	95	-	44
1.148 CLEANER	-	95	-	94
1.149 LOBBY	-	95	-	41
1.152 BOXES	95	-	-	286
1.153 BOXES	95	-	-	244
1.154 PRIVATE BANQUET	-	95	-	107
1.155 BOXES	95	-	-	250
1.156 BOXES	95	-	-	235
1.157 BOXES	95	-	-	237
1.158 CLUB LOUNGE	-	95	-	2140
1.160 BAR	-	95	-	246
1.161 M13b-MEP	95	-	-	22
1.164 CORE	-	95	-	44
1.165 CORE	-	95	-	75
1.166 E11-ICT SER	95	-	-	55
1.167 CIRCULATION	-	95	-	102
1.168 CIRCULATION	-	95	-	60
1.169 M13c-MEP	95	-	-	19
1.170 CIRCULATION	-	95	-	40
1.171 E15-MEP	95	-	-	19
1.172 P4 & M12	95	-	-	11
1.173 CIRCULATION	-	95	-	36
1.174 M13D-MEP	95	-	-	15
1.176 CLOAKROOM	95	-	-	40
1.177 CIRCULATION	-	95	-	203
2.001 CONCOURSE SOUTH	-	95	-	1898
2.001 CONCOURSE SOUTH EAST	-	95	-	581
2.001 CONCOURSE SOUTH WEST	-	95	-	581
2.001 CONCOURSE WEST	-	95	-	1008
2.001 COUNCOURSE EAST	-	95	-	984
2.005 MEP	95	-	-	9

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
2.007 CONCESSION	-	95	-	1683
2.009 MEP	95	-	-	8
2.013 M13d-MEP	95	-	-	15
2.014 P4 & M12	95	-	-	11
2.015 E15-MEP	95	-	-	19
2.016 CIRCULATION	-	95	-	40
2.017 M13b-MEP	95	-	-	19
2.019 CIRCULATION	-	95	-	78
2.020 CHANGING PLACE	-	95	-	116
2.021 BAR	-	95	-	179
2.022 CLEANER	-	95	-	42
2.023 WC	-	95	-	73
2.024 WC	-	95	-	611
2.025 WC	-	95	-	251
2.027 LOBBY	-	95	-	93
2.028 WC	-	95	-	55
2.031 E11 - ICT SER	95	-	-	51
2.032 CORE	-	95	-	88
2.033 CORE	-	95	-	56
2.035 M13b-MEP	95	-	-	22
2.037 LOBBY	-	95	-	61
2.039 CONCESSION	-	95	-	640
2.040 LOBBY	-	95	-	54
2.042 WC	-	95	-	323
2.043 WC	-	95	-	66
2.045 LOBBY	-	95	-	53
2.047 CLEANER	-	95	-	59
2.048 M13b-MEP	95	-	-	24
2.049 E15-MEP	95	-	-	16
2.050 WC	-	95	-	272
2.051 LOBBY	-	95	-	55
2.054 BELLY UP	-	95	-	192
2.055 LOBBY	-	95	-	41
2.057 INFO POINT	95	-	-	315
2.058 WC	-	95	-	114
2.059 E11 - ICT SER	95	-	-	51
2.061 BIN STORE	95	-	-	42
2.062 P4-MEP	95	-	-	5
2.063 M12-MEP	95	-	-	8
2.065 CORE	-	95	-	93
2.066 E9-CENTRAL BATTERY 4H	95	-	-	48
2.067 CIRCULATION	-	95	-	284
2.068 CORE	-	95	-	53

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
2.069 E15-MEP	95	-	-	19
2.070 CORE	-	95	-	87
2.072 M13a-MEP	95	-	-	24
2.073 M12-MEP	95	-	-	9
2.078 CORE	-	95	-	86
2.080 FIRST AID	95	-	-	392
2.081 E9-CENTRAL BATTERY 4H	95	-	-	34
2.082 CIRCULATION	-	95	-	214
2.083 M13c-MEP	95	-	-	30
2.085 M12-MEP	95	-	-	10
2.086 P4-MEP	95	-	-	6
2.087 E15-MEP	95	-	-	19
2.088 CORE	-	95	-	91
2.090 LIFT	95	-	-	212
2.091 QUIET ROOM	95	-	-	337
2.092 WC	-	95	-	115
2.093 E11 - ICT SER	95	-	-	50
2.094 STORE	95	-	-	315
2.096 LOBBY	-	95	-	41
2.098 BELLY UP	-	95	-	192
2.100 LOBBY	-	95	-	55
2.101 WC	-	95	-	272
2.102 E15-MEP	95	-	-	16
2.103 M13b-MEP	95	-	-	24
2.104 CLEANER	-	95	-	59
2.107 LOBBY	-	95	-	53
2.108 WC	-	95	-	66
2.109 WC	-	95	-	323
2.111 LOBBY	-	95	-	53
2.113 CONCESSION	-	95	-	639
2.115 LOBBY	-	95	-	61
2.118 M13b-MEP	95	-	-	22
2.120 CORE	-	95	-	55
2.121 CORE	-	95	-	88
2.122 E11 - ICT SER	95	-	-	63
2.126 LOBBY	-	95	-	65
2.127 WC	-	95	-	55
2.128 WC	-	95	-	255
2.129 WC	-	95	-	678
2.131 M13c-MEP	95	-	-	19
2.132 CIRCULATION	-	95	-	40
2.133 E15-MEP	95	-	-	19
2.135 P4 & M12	95	-	-	11

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
2.136 M13d-MEP	95	-	-	16
2.137 CIRCULATION	-	95	-	49
2.138 CIRCULATION	-	95	-	74
2.139 WC	-	95	-	54
2.140 CLEANER	-	95	-	118
2.141 MERCH	95	-	-	529
4.001 PLANT	95	-	-	3838
4.002 CELLAR	-	95	-	175
4.003 CORE	-	95	-	75
4.004 CORE	-	95	-	56
4.013 CORE	-	95	-	97
4.020 CORE	-	95	-	96
4.031 CORE	-	95	-	56
4.032 CORE	-	95	-	75
4.033 CELLAR	-	95	-	173
4.042 LOBBY	-	95	-	44
G.001 FOYER	-	95	-	280
G.002 FOYER	-	95	-	3108
G.003 BELLY UP	-	95	-	298
G.004 STORE	95	-	-	15
G.005 CELLAR	95	-	-	99
G.006 CONCESSION	-	95	-	716
G.007 EVENT FLOOR	-	95	-	42232
G.008 CIRCULATION	-	95	-	45
G.009 E16 - FRONT OF HOUSE HOOK-UP PANEL 400A	95	-	-	13
G.013 CIRCULATION	-	95	-	27
G.014 M12 MEP	95	-	-	5
G.015 M13d-MEP	95	-	-	10
G.016 P4	95	-	-	10
G.018 E15-MEP	95	-	-	13
G.019 CIRCULATION	-	95	-	27
G.020 M13b-MEP	95	-	-	13
G.021 WC	-	95	-	49
G.022 WC	-	95	-	49
G.023 CAFE	-	95	-	199
G.024 WC	-	95	-	37
G.026 WC	-	95	-	333
G.027 E12 - ICT INTAKE	95	-	-	22
G.028 CORE	-	95	-	108
G.029 CORE	-	95	-	48
G.031 E7 - ICT MER	95	-	-	260
G.032 E8 - PAVA SECURE ROOM	95	-	-	51
G.033 E1 - METER	95	-	-	37

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
G.034 E2 - CLIENT HV	95	-	-	45
G.035 E4 - SUBSTATION NO. 2	95	-	-	71
G.036 E6 - LV SWITCHROOM NO. 2	95	-	-	78
G.037 E8 - PAVA SECURE ROOM	95	-	-	54
G.039 STORE	95	-	-	26
G.040 BELLY UP	-	95	-	161
G.041 CLEANER	-	95	-	91
G.042 WC	-	95	-	754
G.043 CIRCULATION	-	95	-	149
G.044 STORE	95	-	-	10
G.045 CONCESSION	-	95	-	796
G.046 CELLAR	95	-	-	38
G.047 BOH - STORAGE	95	-	-	177
G.048 CIRCULATION	-	95	-	326
G.050 BOH - STORAGE	95	-	-	263
G.051 E16 - CENTRE STAGE R HOOK-UP PANEL 63A	95	-	-	8
G.052 FIRST AID	95	-	-	224
G.053 WORKSHOP	95	-	-	76
G.055 E11 - ICT SER	95	-	-	43
G.055 ICT SER	95	-	-	28
G.056 M11 - GAS INTAKE & DOMESTIC WATER PLANTROOM	95	-	-	123
G.057	-	95	-	51
G.058 CORE	-	95	-	63
G.060 CORE	-	95	-	55
G.061 CIRCULATION	-	95	-	179
G.063 CORE	-	95	-	56
G.064 E15-MEP	95	-	-	13
G.065 BOH - STORAGE	95	-	-	155
G.066 DINING	95	-	-	909
G.067 KITCHEN	-	95	-	698
G.068 CIRCULATION	-	95	-	208
G.070 CREW MALE	-	95	-	208
G.071 CREW LOCKER	95	-	-	347
G.072 CREW FEMALE	-	95	-	228
G.073 WC	-	95	-	91
G.074 CLEANER	-	95	-	62
G.075 OFFICE 1	95	-	-	332
G.076 OFFICE 2	95	-	-	462
G.077 CORE	-	95	-	85
G.078 PYRO STORE	95	-	-	16
G.079 COSHH STORE	95	-	-	15
G.092 CORE	-	95	-	57
G.094 CIRCULATION	-	95	-	204

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
G.095 CIRCULATION	-	95	-	165
G.096 E15-MEP	95	-	-	13
G.097 P4-MEP	95	-	-	6
G.098 CORE	-	95	-	61
G.100 CORE	-	95	-	55
G.101 E5 - LV SWITCHROOM 1	95	-	-	55
G.102 HAWKING STORE	95	-	-	38
G.103 E3 - SUBSTATION NO.1	95	-	-	38
G.104 E3 - SUBSTATION NO.1	95	-	-	38
G.105 E15 - GENERATOR FUEL	95	-	-	32
G.106 WINE & SPIRITS	95	-	-	22
G.108 CHILLED KEG STORE	95	-	-	82
G.109 E11 - ICT SER	95	-	-	45
G.110 CIRCULATION	-	95	-	123
G.111 CIRCULATION	-	95	-	179
G.112 H. PRODUCTION	95	-	-	168
G.113 RACK	95	-	-	19
G.115 E16 CENTRE STAGE HOOK-UP PANEL 630A	95	-	-	7
G.116 WC	-	95	-	42
G.117 CIRCULATION	-	95	-	85
G.118 OFFICE	95	-	-	145
G.119 CCTV/EVENT CONTROL SPACE	95	-	-	382
G.120 CRISIS MEETING ROOM	95	-	-	204
G.121 PANTRY	95	-	-	11
G.122 WC	-	95	-	42
G.123 FIRST AID	95	-	-	328
G.125 RECEPTION	95	-	-	369
G.126 BRIEFING/BREAKOUT	95	-	-	538
G.127 SIGN-IN/UNIFORM	95	-	-	328
G.128 STORE	95	-	-	17
G.129 CIRCULATION	-	95	-	33
G.130 WC	-	95	-	247
G.131 WC	-	95	-	43
G.132 CLEANER	-	95	-	41
G.133 WC	-	95	-	255
G.134 LOCKER	-	95	-	378
G.135 CONCESSION	-	95	-	703
G.136 STORE	95	-	-	10
G.139 WC	-	95	-	43
G.140 LOBBY	-	95	-	20
G.141 WC	-	95	-	115
G.143 PREMIUM ARRIVAL	-	95	-	311
G.144 LOBBY	-	95	-	242

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
G.146 CIRCULATION	-	95	-	110
G.147 WC	-	95	-	609
G.148 MERCH OFFICE	95	-	-	181
G.149 MERCH	95	-	-	325
G.150 WC	-	95	-	48
G.151 CLEANER	-	95	-	45
G.152 WC	-	95	-	42
G.154 WC	-	95	-	288
G.156 CORE	-	95	-	47
G.157 CORE	-	95	-	106
G.158 E11 - ICT SER	95	-	-	42
G.160 OFFICE MANAGER	95	-	-	173
G.161 OFFICE	95	-	-	245
G.162 BOX OFFICE	95	-	-	800
G.163 OFFICE MANAGER	95	-	-	166
G.164 M13b-MEP	95	-	-	13
G.165 CIRCULATION	-	95	-	27
G.166 E15-MEP	95	-	-	13
G.167 P4	95	-	-	9
G.168 CIRCULATION	-	95	-	27
G.169 M12-MEP	95	-	-	5
G.170 M13d-MEP	95	-	-	10
G.172 CIRCULATION	-	95	-	45
LEVEL 3 - CIRCULATION	-	95	-	37
LEVEL 3 - CORE	-	95	-	68
LEVEL 3 - CORE	-	95	-	96
LEVEL 3 - CORE	-	95	-	72
LEVEL 3 - CORE	-	95	-	69
LEVEL 3 - CORE NORTH EAST	-	95	-	426
LEVEL 3 - CORE NORTH WEST	-	95	-	428
LEVEL 3 - LOBBY	-	95	-	36
LEVEL 3 - LOBBY	-	95	-	41

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1.001 PREMIUM LOUNGE	YES (+48.2%)	NO
1.002 CONCESSION	N/A	N/A
1.003 CONCOURSE	N/A	N/A
1.016 CIRCULATION	N/A	N/A
1.017 CLOAKROOM	N/A	N/A
1.033 BAR	N/A	N/A
1.035 LOUNGE-SPONSOR	N/A	N/A
1.036 BOXES	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1.037 BOXES	N/A	N/A
1.038 BOXES	N/A	N/A
1.039 PRIVATE BANQUET	N/A	N/A
1.040 BOXES	N/A	N/A
1.041 BOXES	N/A	N/A
1.048 CATERING	N/A	N/A
1.048 CONCESSION	N/A	N/A
1.051 ROOM 2-ARTIST	N/A	N/A
1.052 ROOM 1-MP/PRESS	N/A	N/A
1.058 ROOM 4-ARTIST	N/A	N/A
1.061 ROOM 5-ARTIST	N/A	N/A
1.065 ROOM 6-LOUNGE ARTIST	N/A	N/A
1.066 ROOM 3-ARTIST	N/A	N/A
1.070 ROOM 7-LOUNGE ARTIST	N/A	N/A
1.076 GREEN ROOM	N/A	N/A
1.086 ROOM 8-LOUNGE ARTIST	N/A	N/A
1.089 ROOM 9-LOUNGE ARTIST	N/A	N/A
1.091 ROOM 10-ARTIST	N/A	N/A
1.094 ROOM 1-ARTIST	N/A	N/A
1.096 ROOM 12-OFFICE	N/A	N/A
1.097 ROOM 13-OFFICE	N/A	N/A
1.099 ROOM 14-FLEXIBLE OFFICE	N/A	N/A
1.107 MEETING	N/A	N/A
1.112 OPEN PLAN	N/A	N/A
1.113 GM	N/A	N/A
1.114 OM	N/A	N/A
1.115 COO	N/A	N/A
1.116 MR	N/A	N/A
1.126 FINANCE	N/A	N/A
1.127 NAMING RIGHT SPONSORS	N/A	N/A
1.128 POST/PRINT	N/A	N/A
1.131 FREEZER WALK-IN GENERAL GOODS	N/A	N/A
1.138 PANTRY	N/A	N/A
1.142 CONCESSION	N/A	N/A
1.152 BOXES	N/A	N/A
1.153 BOXES	N/A	N/A
1.154 PRIVATE BANQUET	N/A	N/A
1.155 BOXES	N/A	N/A
1.156 BOXES	N/A	N/A
1.157 BOXES	N/A	N/A
1.158 CLUB LOUNGE	NO (-99%)	NO
1.160 BAR	NO (-91.3%)	NO
1.176 CLOAKROOM	N/A	N/A
1.177 CIRCULATION	N/A	N/A
2.001 CONCOURSE SOUTH	YES (+31.5%)	NO
2.001 CONCOURSE SOUTH EAST	N/A	N/A
2.001 CONCOURSE SOUTH WEST	N/A	N/A
2.001 CONCOURSE WEST	N/A	N/A
2.001 COUNCOURSE EAST	NO (-82.6%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
2.007 CONCESSION	N/A	N/A
2.019 CIRCULATION	N/A	N/A
2.021 BAR	N/A	N/A
2.027 LOBBY	N/A	N/A
2.031 E11 - ICT SER	N/A	N/A
2.039 CONCESSION	N/A	N/A
2.054 BELLY UP	N/A	N/A
2.057 INFO POINT	N/A	N/A
2.080 FIRST AID	N/A	N/A
2.090 LIFT	N/A	N/A
2.091 QUIET ROOM	N/A	N/A
2.094 STORE	N/A	N/A
2.098 BELLY UP	N/A	N/A
2.113 CONCESSION	N/A	N/A
2.122 E11 - ICT SER	N/A	N/A
2.138 CIRCULATION	N/A	N/A
2.141 MERCH	N/A	N/A
4.002 CELLAR	N/A	N/A
4.033 CELLAR	N/A	N/A
G.001 FOYER	NO (-20.8%)	NO
G.002 FOYER	NO (-2.1%)	NO
G.003 BELLY UP	N/A	N/A
G.005 CELLAR	N/A	N/A
G.006 CONCESSION	N/A	N/A
G.008 CIRCULATION	N/A	N/A
G.023 CAFE	NO (-8.4%)	NO
G.031 E7 - ICT MER	N/A	N/A
G.039 STORE	N/A	N/A
G.040 BELLY UP	N/A	N/A
G.045 CONCESSION	N/A	N/A
G.046 CELLAR	N/A	N/A
G.047 BOH - STORAGE	N/A	N/A
G.050 BOH - STORAGE	N/A	N/A
G.052 FIRST AID	N/A	N/A
G.053 WORKSHOP	N/A	N/A
G.065 BOH - STORAGE	N/A	N/A
G.066 DINING	N/A	N/A
G.071 CREW LOCKER	N/A	N/A
G.075 OFFICE 1	N/A	N/A
G.076 OFFICE 2	N/A	N/A
G.106 WINE & SPIRITS	N/A	N/A
G.108 CHILLED KEG STORE	N/A	N/A
G.112 H. PRODUCTION	N/A	N/A
G.118 OFFICE	N/A	N/A
G.119 CCTV/EVENT CONTROL SPACE	N/A	N/A
G.120 CRISIS MEETING ROOM	N/A	N/A
G.123 FIRST AID	N/A	N/A
G.125 RECEPTION	N/A	N/A
G.126 BRIEFING/BREAKOUT	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
G.127 SIGN-IN/UNIFORM	N/A	N/A
G.135 CONCESSION	N/A	N/A
G.143 PREMIUM ARRIVAL	N/A	N/A
G.144 LOBBY	N/A	N/A
G.148 MERCH OFFICE	N/A	N/A
G.149 MERCH	N/A	N/A
G.160 OFFICE MANAGER	YES (+3%)	NO
G.161 OFFICE	N/A	N/A
G.162 BOX OFFICE	YES (+2.2%)	NO
G.163 OFFICE MANAGER	N/A	N/A
G.172 CIRCULATION	N/A	N/A

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER and BPEC

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	32207.6	29777.6
External area [m^2]	38477.8	38477.8
Weather	CAR	CAR
Infiltration [m^3/hm^2@ 50Pa]	3	4
Average conductance [W/K]	7748.92	10283.1
Average U-value [W/m^2K]	0.2	0.27
Alpha value* [%]	10.51	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
99	**D2 General Assembly and Leisure, Night Clubs, and Theatres**
	Others: Passenger terminals
	Others: Emergency services
1	**Others: Miscellaneous 24hr activities**
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

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

	Actual	Notional
Heating	11.17	14.24
Cooling	1.68	1.27
Auxiliary	13.02	9.87
Lighting	13.22	19.21
Hot water	13.73	13.14
Equipment*	28.77	26.47
TOTAL**	**52.81**	**57.74**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	9.26	6.88
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	58.37	61.55
Primary energy* [kWh/m^2]	98.2	106.8
Total emissions [kg/m^2]	14.7	16.3

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	48	27.4	13.1	2.2	22.8	1.02	3.5	1.07	4.5
	Notional	56.7	36.7	18.3	2.7	15.2	0.86	3.79	----	----
[ST] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	38.8	25.6	10.6	2.2	21	1.02	3.26	1.07	4.2
	Notional	52.6	22.3	17	1.6	13.7	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	107.8	0	32.2	0	16.1	0.93	0	0.98	0
	Notional	119.6	0	38.5	0	19.4	0.86	0	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	0	1282.6	0	120.7	0	4.71	2.95	4.96	4.96
	Notional	0	995.9	0	73	0	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	144.7	0	43.2	0	3.3	0.93	0	0.98	0
	Notional	189.6	0	61.1	0	1.6	0.86	0	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

BRUKL Output Document

Compliance with Wales Building Regulations Part L 2014

Llywodraeth Cymru
Welsh Government

Project name

Cardiff Arena - WH

As designed

Date: Thu Aug 12 14:47:56 2021

Administrative information

Building Details

Address: Cardiff, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Carlina Fernandes

Telephone number:

Address: 4 Pierhead St, Cardiff, CF10 4QP

Criterion 1: The calculated BER and BPEC for the building must not exceed the targets

Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	11.7	
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	16.6	
Building Primary Energy Consumption (BPEC), $kWh/m^2.annum$	99.15	
Target Primary Energy Consumption (TPEC), $kWh/m^2.annum$	99.91	
Do the building's emissions and primary energy consumption exceed the targets?	BER =< TER	BPEC =< TPEC

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.2	0.2	RM00006B:Surf[0]
Floor	0.25	0.15	0.15	RM00005C:Surf[0]
Roof	0.25	0.15	0.15	10000000:Surf[2]
Windows***, roof windows, and rooflights	2.2	1.6	1.6	RM00006B:Surf[1]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

* There might be more than one surface where the maximum U-value occurs.
** 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.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

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- Fan Coils

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.98	4.2	0	1.99	0.75
Standard value	N/A	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

2- Spill Air + Fan Coils

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.98	4.5	0	1.99	0.75
Standard value	0.91*	2.55	N/A	1.6^	0.5
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82. ^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

3- LTHW Radiator

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.98	-	0.2	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

4- LTHW Unit Heaters

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.98	-	0.2	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

5- DX CRAC Unit

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	4.96	4.96	0	0	-
Standard value	0.91*	1	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

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

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
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 supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
1.001 PREMIUM LOUNGE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.002 CONCESSION	-	-	-	-	-	-	-	0.3	-	-	N/A
1.003 CONCOURSE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.009 CLEANER	-	-	0.5	-	-	-	-	-	-	-	N/A
1.010 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.012 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.016 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
1.017 CLOAKROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
1.033 BAR	-	-	-	-	-	-	-	0.2	-	-	N/A
1.035 LOUNGE-SPONSOR	-	-	-	-	-	-	-	0.2	-	-	N/A
1.036 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.037 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.038 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.039 PRIVATE BANQUET	-	-	-	-	-	-	-	0.2	-	-	N/A
1.040 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.041 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.048 CATERING	-	-	-	-	-	-	-	0.2	-	-	N/A
1.048 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
1.051 ROOM 2-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.052 ROOM 1-MP/PRESS	-	-	-	-	-	-	-	0.2	-	-	N/A
1.058 ROOM 4-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.061 ROOM 5-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.065 ROOM 6-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.066 ROOM 3-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.067 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.068 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.070 ROOM 7-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.076 GREEN ROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
1.086 ROOM 8-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.087 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.088 WC	-	-	0.5	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
1.089 ROOM 9-LOUNGE ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.091 ROOM 10-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.094 ROOM 1-ARTIST	-	-	-	-	-	-	-	0.2	-	-	N/A
1.096 ROOM 12-OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.097 ROOM 13-OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.099 ROOM 14-FLEXIBLE OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.102 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.107 MEETING	-	-	-	-	-	-	-	0.2	-	-	N/A
1.112 OPEN PLAN	-	-	-	-	-	-	-	0.2	-	-	N/A
1.117 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
1.126 FINANCE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.127 NAMING RIGHT SPONSORS	-	-	-	-	-	-	-	0.2	-	-	N/A
1.128 POST/PRINT	-	-	-	-	-	-	-	0.2	-	-	N/A
1.131 FREEZER WALK-IN GENERAL GOODS	-	-	-	-	-	-	-	0.2	-	-	N/A
1.142 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
1.152 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.153 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.154 PRIVATE BANQUET	-	-	-	-	-	-	-	0.2	-	-	N/A
1.155 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.156 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.157 BOXES	-	-	-	-	-	-	-	0.2	-	-	N/A
1.158 CLUB LOUNGE	-	-	-	-	-	-	-	0.2	-	-	N/A
1.160 BAR	-	-	-	-	-	-	-	0.2	-	-	N/A
1.176 CLOAKROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
1.177 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE SOUTH	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE SOUTH EAST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE SOUTH WEST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 CONCOURSE WEST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.001 COUNCOURSE EAST	-	-	-	-	-	-	-	0.2	-	-	N/A
2.007 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.019 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.021 BAR	-	-	-	-	-	-	-	0.2	-	-	N/A
2.024 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.025 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.027 LOBBY	-	-	-	-	-	-	-	0.2	-	-	N/A
2.039 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.042 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.050 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.054 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
2.057 INFO POINT	-	-	-	-	-	-	-	0.2	-	-	N/A
2.080 FIRST AID	-	-	-	-	-	-	-	0.2	-	-	N/A
2.091 QUIET ROOM	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
2.094 STORE	-	-	-	-	-	-	-	0.2	-	-	N/A
2.098 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
2.101 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.109 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.113 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.128 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.129 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
2.138 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
2.141 MERCH	-	-	-	-	-	-	-	0.2	-	-	N/A
G.001 FOYER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.002 FOYER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.003 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
G.005 CELLAR	-	-	-	-	-	-	-	0.2	-	-	N/A
G.006 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.008 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.023 CAFE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.026 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.039 STORE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.040 BELLY UP	-	-	-	-	-	-	-	0.2	-	-	N/A
G.041 CLEANER	-	-	0.5	-	-	-	-	-	-	-	N/A
G.042 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.045 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.046 CELLAR	-	-	-	-	-	-	-	0.2	-	-	N/A
G.047 BOH - STORAGE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.050 BOH - STORAGE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.052 FIRST AID	-	-	-	-	-	-	-	0.2	-	-	N/A
G.053 WORKSHOP	-	-	-	-	-	-	-	0.2	-	-	N/A
G.065 BOH - STORAGE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.066 DINING	-	-	-	-	-	-	-	0.2	-	-	N/A
G.070 CREW MALE	-	-	0.5	-	-	-	-	-	-	-	N/A
G.071 CREW LOCKER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.072 CREW FEMALE	-	-	0.5	-	-	-	-	-	-	-	N/A
G.075 OFFICE 1	-	-	-	-	-	-	-	0.2	-	-	N/A
G.076 OFFICE 2	-	-	-	-	-	-	-	0.2	-	-	N/A
G.106 WINE & SPIRITS	-	-	-	-	-	-	-	0.2	-	-	N/A
G.108 CHILLED KEG STORE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.112 H. PRODUCTION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.119 CCTV/EVENT CONTROL SPACE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.120 CRISIS MEETING ROOM	-	-	-	-	-	-	-	0.2	-	-	N/A
G.123 FIRST AID	-	-	-	-	-	-	-	0.2	-	-	N/A
G.125 RECEPTION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.126 BRIEFING/BREAKOUT	-	-	-	-	-	-	-	0.2	-	-	N/A
G.127 SIGN-IN/UNIFORM	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
G.130 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.133 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.134 LOCKER	-	-	0.5	-	-	-	-	-	-	-	N/A
G.135 CONCESSION	-	-	-	-	-	-	-	0.2	-	-	N/A
G.143 PREMIUM ARRIVAL	-	-	-	-	-	-	-	0.2	-	-	N/A
G.144 LOBBY	-	-	-	-	-	-	-	0.2	-	-	N/A
G.147 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.149 MERCH	-	-	-	-	-	-	-	0.2	-	-	N/A
G.154 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
G.160 OFFICE MANAGER	-	-	-	-	-	-	-	0.2	-	-	N/A
G.161 OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.162 BOX OFFICE	-	-	-	-	-	-	-	0.2	-	-	N/A
G.172 CIRCULATION	-	-	-	-	-	-	-	0.2	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
1.001 PREMIUM LOUNGE	-	95	-	1460
1.002 CONCESSION	-	95	-	1624
1.003 CONCOURSE	-	95	-	934
1.004 CLOAKROOM	95	-	-	27
1.005 MEP	95	-	-	9
1.006 CLOAKROOM	95	-	-	27
1.007 MEP	95	-	-	9
1.008 WC	-	95	-	79
1.009 CLEANER	-	95	-	136
1.010 WC	-	95	-	605
1.011 STORE	95	-	-	10
1.012 WC	-	95	-	300
1.013 CLEANER	-	95	-	47
1.014 WC	-	95	-	79
1.015 CONCOURSE	-	95	-	332
1.016 CIRCULATION	-	95	-	206
1.017 CLOAKROOM	95	-	-	40
1.019 M13d-MEP	95	-	-	15
1.020 CIRCULATION	-	95	-	36
1.021 P4 & M12	95	-	-	12
1.022 E15-MEP	95	-	-	19
1.023 CIRCULATION	-	95	-	40
1.024 M13b-MEP	95	-	-	19
1.025 CIRCULATION	-	95	-	59
1.027 - ICT SER	95	-	-	53
1.028 CORE	-	95	-	75

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
1.029 CORE	-	95	-	44
1.031 M13b-MEP	95	-	-	22
1.032 STORAGE	95	-	-	42
1.033 BAR	-	95	-	248
1.035 LOUNGE-SPONSOR	-	95	-	2207
1.036 BOXES	95	-	-	244
1.037 BOXES	95	-	-	228
1.038 BOXES	95	-	-	250
1.039 PRIVATE BANQUET	-	95	-	107
1.040 BOXES	95	-	-	244
1.041 BOXES	95	-	-	286
1.042 LOBBY	-	95	-	40
1.043 CLEANER	-	95	-	91
1.044 WC	-	95	-	86
1.045 LOBBY	-	95	-	23
1.048 CATERING	-	95	-	220
1.048 CONCESSION	-	95	-	565
1.050 WC	-	95	-	72
1.051 ROOM 2-ARTIST	95	-	-	350
1.052 ROOM 1-MP/PRESS	95	-	-	295
1.053 BIN STORE	95	-	-	9
1.054 E15 MEP	95	-	-	18
1.055 M13b-MEP	95	-	-	24
1.056 CIRCULATION	-	95	-	265
1.058 ROOM 4-ARTIST	95	-	-	282
1.059 WC	-	95	-	69
1.060 WC	-	95	-	69
1.061 ROOM 5-ARTIST	95	-	-	330
1.062 WC	-	95	-	111
1.063 CIRCULATION	-	95	-	743
1.065 ROOM 6-LOUNGE ARTIST	95	-	-	749
1.066 ROOM 3-ARTIST	95	-	-	297
1.067 WC	-	95	-	148
1.068 WC	-	95	-	148
1.069 WC	-	95	-	143
1.070 ROOM 7-LOUNGE ARTIST	95	-	-	800
1.071 M12-MEP	95	-	-	8
1.072 P4	95	-	-	23
1.073 CORE	-	95	-	79
1.075 CORE	-	95	-	50
1.076 GREEN ROOM	95	-	-	855
1.077 M13a-MEP	95	-	-	25
1.078 E15-MEP	95	-	-	9

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
1.080 CORE	-	95	-	76
1.082 E15-MEP	95	-	-	19
1.083 E11 - ICT SER	95	-	-	48
1.085 M13e-MEP	95	-	-	2
1.086 ROOM 8-LOUNGE ARTIST	95	-	-	788
1.087 WC	-	95	-	148
1.088 WC	-	95	-	148
1.089 ROOM 9-LOUNGE ARTIST	95	-	-	815
1.091 ROOM 10-ARTIST	95	-	-	442
1.092 WC	-	95	-	107
1.093 WC	-	95	-	113
1.094 ROOM 1-ARTIST	95	-	-	519
1.095 CORE	-	95	-	60
1.096 ROOM 12-OFFICE	95	-	-	389
1.097 ROOM 13-OFFICE	95	-	-	328
1.098 M13f-MEP	95	-	-	28
1.099 ROOM 14-FLEXIBLE OFFICE	95	-	-	977
1.100 FURNITURE STORE	95	-	-	31
1.101 LAUNDRY	95	-	-	31
1.102 WC	-	95	-	141
1.105 CORE	-	95	-	75
1.107 MEETING	95	-	-	393
1.108 LOCKER	-	95	-	44
1.109 WC	-	95	-	85
1.110 CIRCULATION	-	95	-	800
1.111 M13c-MEP	95	-	-	18
1.112 OPEN PLAN	95	-	-	1624
1.113 GM	95	-	-	174
1.114 OM	95	-	-	171
1.115 COO	95	-	-	160
1.116 MR	95	-	-	151
1.117 WC	-	95	-	150
1.119 CORE	-	95	-	79
1.120 M12-MEP	95	-	-	6
1.121 P4	95	-	-	6
1.122 E15-MEP	95	-	-	19
1.124 CLEANER	-	95	-	75
1.125 E11 - ICT SER	95	-	-	53
1.126 FINANCE	95	-	-	233
1.127 NAMING RIGHT SPONSORS	95	-	-	275
1.128 POST/PRINT	95	-	-	238
1.129 CATERING	-	95	-	2402
1.131 FREEZER WALK-IN GENERAL GOODS	95	-	-	32

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
1.132 CHILLER VEG	95	-	-	26
1.133 CHILLER DAIRY	95	-	-	26
1.134 FREEZER ICE CREAM	95	-	-	26
1.135 FREEZER RAW MEAT	95	-	-	29
1.136 DRY GOOD STORE	95	-	-	29
1.137 CHILLER RAW MEAT	95	-	-	27
1.138 PANTRY	95	-	-	191
1.140 E15-MEP	95	-	-	16
1.141 M13b-MEP	95	-	-	24
1.142 CONCESSION	-	95	-	545
1.143 CATERING	-	95	-	347
1.146 WC	-	95	-	46
1.147 LOBBY	-	95	-	44
1.148 CLEANER	-	95	-	94
1.149 LOBBY	-	95	-	41
1.152 BOXES	95	-	-	286
1.153 BOXES	95	-	-	244
1.154 PRIVATE BANQUET	-	95	-	107
1.155 BOXES	95	-	-	250
1.156 BOXES	95	-	-	235
1.157 BOXES	95	-	-	237
1.158 CLUB LOUNGE	-	95	-	2140
1.160 BAR	-	95	-	246
1.161 M13b-MEP	95	-	-	22
1.164 CORE	-	95	-	44
1.165 CORE	-	95	-	75
1.166 E11-ICT SER	95	-	-	55
1.167 CIRCULATION	-	95	-	102
1.168 CIRCULATION	-	95	-	60
1.169 M13c-MEP	95	-	-	19
1.170 CIRCULATION	-	95	-	40
1.171 E15-MEP	95	-	-	19
1.172 P4 & M12	95	-	-	11
1.173 CIRCULATION	-	95	-	36
1.174 M13D-MEP	95	-	-	15
1.176 CLOAKROOM	95	-	-	40
1.177 CIRCULATION	-	95	-	203
2.001 CONCOURSE SOUTH	-	95	-	1898
2.001 CONCOURSE SOUTH EAST	-	95	-	581
2.001 CONCOURSE SOUTH WEST	-	95	-	581
2.001 CONCOURSE WEST	-	95	-	1008
2.001 COUNCOURSE EAST	-	95	-	984
2.005 MEP	95	-	-	9

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
2.007 CONCESSION	-	95	-	1683
2.009 MEP	95	-	-	8
2.013 M13d-MEP	95	-	-	15
2.014 P4 & M12	95	-	-	11
2.015 E15-MEP	95	-	-	19
2.016 CIRCULATION	-	95	-	40
2.017 M13b-MEP	95	-	-	19
2.019 CIRCULATION	-	95	-	78
2.020 CHANGING PLACE	-	95	-	116
2.021 BAR	-	95	-	179
2.022 CLEANER	-	95	-	42
2.023 WC	-	95	-	73
2.024 WC	-	95	-	611
2.025 WC	-	95	-	251
2.027 LOBBY	-	95	-	93
2.028 WC	-	95	-	55
2.031 E11 - ICT SER	95	-	-	51
2.032 CORE	-	95	-	88
2.033 CORE	-	95	-	56
2.035 M13b-MEP	95	-	-	22
2.037 LOBBY	-	95	-	61
2.039 CONCESSION	-	95	-	640
2.040 LOBBY	-	95	-	54
2.042 WC	-	95	-	323
2.043 WC	-	95	-	66
2.045 LOBBY	-	95	-	53
2.047 CLEANER	-	95	-	59
2.048 M13b-MEP	95	-	-	24
2.049 E15-MEP	95	-	-	16
2.050 WC	-	95	-	272
2.051 LOBBY	-	95	-	55
2.054 BELLY UP	-	95	-	192
2.055 LOBBY	-	95	-	41
2.057 INFO POINT	95	-	-	315
2.058 WC	-	95	-	114
2.059 E11 - ICT SER	95	-	-	51
2.061 BIN STORE	95	-	-	42
2.062 P4-MEP	95	-	-	5
2.063 M12-MEP	95	-	-	8
2.065 CORE	-	95	-	93
2.066 E9-CENTRAL BATTERY 4H	95	-	-	48
2.067 CIRCULATION	-	95	-	284
2.068 CORE	-	95	-	53

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
2.069 E15-MEP	95	-	-	19
2.070 CORE	-	95	-	87
2.072 M13a-MEP	95	-	-	24
2.073 M12-MEP	95	-	-	9
2.078 CORE	-	95	-	86
2.080 FIRST AID	95	-	-	392
2.081 E9-CENTRAL BATTERY 4H	95	-	-	34
2.082 CIRCULATION	-	95	-	214
2.083 M13c-MEP	95	-	-	30
2.085 M12-MEP	95	-	-	10
2.086 P4-MEP	95	-	-	6
2.087 E15-MEP	95	-	-	19
2.088 CORE	-	95	-	91
2.090 LIFT	95	-	-	212
2.091 QUIET ROOM	95	-	-	337
2.092 WC	-	95	-	115
2.093 E11 - ICT SER	95	-	-	50
2.094 STORE	95	-	-	315
2.096 LOBBY	-	95	-	41
2.098 BELLY UP	-	95	-	192
2.100 LOBBY	-	95	-	55
2.101 WC	-	95	-	272
2.102 E15-MEP	95	-	-	16
2.103 M13b-MEP	95	-	-	24
2.104 CLEANER	-	95	-	59
2.107 LOBBY	-	95	-	53
2.108 WC	-	95	-	66
2.109 WC	-	95	-	323
2.111 LOBBY	-	95	-	53
2.113 CONCESSION	-	95	-	639
2.115 LOBBY	-	95	-	61
2.118 M13b-MEP	95	-	-	22
2.120 CORE	-	95	-	55
2.121 CORE	-	95	-	88
2.122 E11 - ICT SER	95	-	-	63
2.126 LOBBY	-	95	-	65
2.127 WC	-	95	-	55
2.128 WC	-	95	-	255
2.129 WC	-	95	-	678
2.131 M13c-MEP	95	-	-	19
2.132 CIRCULATION	-	95	-	40
2.133 E15-MEP	95	-	-	19
2.135 P4 & M12	95	-	-	11

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
2.136 M13d-MEP	95	-	-	16
2.137 CIRCULATION	-	95	-	49
2.138 CIRCULATION	-	95	-	74
2.139 WC	-	95	-	54
2.140 CLEANER	-	95	-	118
2.141 MERCH	95	-	-	529
4.001 PLANT	95	-	-	3838
4.002 CELLAR	-	95	-	175
4.003 CORE	-	95	-	75
4.004 CORE	-	95	-	56
4.013 CORE	-	95	-	97
4.020 CORE	-	95	-	96
4.031 CORE	-	95	-	56
4.032 CORE	-	95	-	75
4.033 CELLAR	-	95	-	173
4.042 LOBBY	-	95	-	44
G.001 FOYER	-	95	-	280
G.002 FOYER	-	95	-	3108
G.003 BELLY UP	-	95	-	298
G.004 STORE	95	-	-	15
G.005 CELLAR	95	-	-	99
G.006 CONCESSION	-	95	-	716
G.007 EVENT FLOOR	-	95	-	42232
G.008 CIRCULATION	-	95	-	45
G.009 E16 - FRONT OF HOUSE HOOK-UP PANEL 400A	95	-	-	13
G.013 CIRCULATION	-	95	-	27
G.014 M12 MEP	95	-	-	5
G.015 M13d-MEP	95	-	-	10
G.016 P4	95	-	-	10
G.018 E15-MEP	95	-	-	13
G.019 CIRCULATION	-	95	-	27
G.020 M13b-MEP	95	-	-	13
G.021 WC	-	95	-	49
G.022 WC	-	95	-	49
G.023 CAFE	-	95	-	199
G.024 WC	-	95	-	37
G.026 WC	-	95	-	333
G.027 E12 - ICT INTAKE	95	-	-	22
G.028 CORE	-	95	-	108
G.029 CORE	-	95	-	48
G.031 E7 - ICT MER	95	-	-	260
G.032 E8 - PAVA SECURE ROOM	95	-	-	51
G.033 E1 - METER	95	-	-	37

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
G.034 E2 - CLIENT HV	95	-	-	45
G.035 E4 - SUBSTATION NO. 2	95	-	-	71
G.036 E6 - LV SWITCHROOM NO. 2	95	-	-	78
G.037 E8 - PAVA SECURE ROOM	95	-	-	54
G.039 STORE	95	-	-	26
G.040 BELLY UP	-	95	-	161
G.041 CLEANER	-	95	-	91
G.042 WC	-	95	-	754
G.043 CIRCULATION	-	95	-	149
G.044 STORE	95	-	-	10
G.045 CONCESSION	-	95	-	796
G.046 CELLAR	95	-	-	38
G.047 BOH - STORAGE	95	-	-	177
G.048 CIRCULATION	-	95	-	326
G.050 BOH - STORAGE	95	-	-	263
G.051 E16 - CENTRE STAGE R HOOK-UP PANEL 63A	95	-	-	8
G.052 FIRST AID	95	-	-	224
G.053 WORKSHOP	95	-	-	76
G.055 E11 - ICT SER	95	-	-	43
G.055 ICT SER	95	-	-	28
G.056 M11 - GAS INTAKE & DOMESTIC WATER PLANTROOM	95	-	-	123
G.057	-	95	-	51
G.058 CORE	-	95	-	63
G.060 CORE	-	95	-	55
G.061 CIRCULATION	-	95	-	179
G.063 CORE	-	95	-	56
G.064 E15-MEP	95	-	-	13
G.065 BOH - STORAGE	95	-	-	155
G.066 DINING	95	-	-	909
G.067 KITCHEN	-	95	-	698
G.068 CIRCULATION	-	95	-	208
G.070 CREW MALE	-	95	-	208
G.071 CREW LOCKER	95	-	-	347
G.072 CREW FEMALE	-	95	-	228
G.073 WC	-	95	-	91
G.074 CLEANER	-	95	-	62
G.075 OFFICE 1	95	-	-	332
G.076 OFFICE 2	95	-	-	462
G.077 CORE	-	95	-	85
G.078 PYRO STORE	95	-	-	16
G.079 COSHH STORE	95	-	-	15
G.092 CORE	-	95	-	57
G.094 CIRCULATION	-	95	-	204

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
G.095 CIRCULATION	-	95	-	165
G.096 E15-MEP	95	-	-	13
G.097 P4-MEP	95	-	-	6
G.098 CORE	-	95	-	61
G.100 CORE	-	95	-	55
G.101 E5 - LV SWITCHROOM 1	95	-	-	55
G.102 HAWKING STORE	95	-	-	38
G.103 E3 - SUBSTATION NO.1	95	-	-	38
G.104 E3 - SUBSTATION NO.1	95	-	-	38
G.105 E15 - GENERATOR FUEL	95	-	-	32
G.106 WINE & SPIRITS	95	-	-	22
G.108 CHILLED KEG STORE	95	-	-	82
G.109 E11 - ICT SER	95	-	-	45
G.110 CIRCULATION	-	95	-	123
G.111 CIRCULATION	-	95	-	179
G.112 H. PRODUCTION	95	-	-	168
G.113 RACK	95	-	-	19
G.115 E16 CENTRE STAGE HOOK-UP PANEL 630A	95	-	-	7
G.116 WC	-	95	-	42
G.117 CIRCULATION	-	95	-	85
G.118 OFFICE	95	-	-	145
G.119 CCTV/EVENT CONTROL SPACE	95	-	-	382
G.120 CRISIS MEETING ROOM	95	-	-	204
G.121 PANTRY	95	-	-	11
G.122 WC	-	95	-	42
G.123 FIRST AID	95	-	-	328
G.125 RECEPTION	95	-	-	369
G.126 BRIEFING/BREAKOUT	95	-	-	538
G.127 SIGN-IN/UNIFORM	95	-	-	328
G.128 STORE	95	-	-	17
G.129 CIRCULATION	-	95	-	33
G.130 WC	-	95	-	276
G.131 WC	-	95	-	43
G.132 CLEANER	-	95	-	41
G.133 WC	-	95	-	255
G.134 LOCKER	-	95	-	378
G.135 CONCESSION	-	95	-	703
G.136 STORE	95	-	-	10
G.139 WC	-	95	-	43
G.140 LOBBY	-	95	-	20
G.141 WC	-	95	-	115
G.143 PREMIUM ARRIVAL	-	95	-	311
G.144 LOBBY	-	95	-	242

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
G.146 CIRCULATION	-	95	-	110
G.147 WC	-	95	-	609
G.148 MERCH OFFICE	95	-	-	181
G.149 MERCH	95	-	-	325
G.150 WC	-	95	-	48
G.151 CLEANER	-	95	-	45
G.152 WC	-	95	-	42
G.154 WC	-	95	-	288
G.156 CORE	-	95	-	47
G.157 CORE	-	95	-	106
G.158 E11 - ICT SER	95	-	-	42
G.160 OFFICE MANAGER	95	-	-	173
G.161 OFFICE	95	-	-	245
G.162 BOX OFFICE	95	-	-	800
G.163 OFFICE MANAGER	95	-	-	166
G.164 M13b-MEP	95	-	-	13
G.165 CIRCULATION	-	95	-	27
G.166 E15-MEP	95	-	-	13
G.167 P4	95	-	-	9
G.168 CIRCULATION	-	95	-	27
G.169 M12-MEP	95	-	-	5
G.170 M13d-MEP	95	-	-	10
G.172 CIRCULATION	-	95	-	45
LEVEL 3 - CIRCULATION	-	95	-	37
LEVEL 3 - CORE	-	95	-	68
LEVEL 3 - CORE	-	95	-	96
LEVEL 3 - CORE	-	95	-	72
LEVEL 3 - CORE	-	95	-	69
LEVEL 3 - CORE NORTH EAST	-	95	-	426
LEVEL 3 - CORE NORTH WEST	-	95	-	428
LEVEL 3 - LOBBY	-	95	-	36
LEVEL 3 - LOBBY	-	95	-	41

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1.001 PREMIUM LOUNGE	YES (+48.2%)	NO
1.002 CONCESSION	N/A	N/A
1.003 CONCOURSE	N/A	N/A
1.016 CIRCULATION	N/A	N/A
1.017 CLOAKROOM	N/A	N/A
1.033 BAR	N/A	N/A
1.035 LOUNGE-SPONSOR	N/A	N/A
1.036 BOXES	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
1.037 BOXES	N/A	N/A
1.038 BOXES	N/A	N/A
1.039 PRIVATE BANQUET	N/A	N/A
1.040 BOXES	N/A	N/A
1.041 BOXES	N/A	N/A
1.048 CATERING	N/A	N/A
1.048 CONCESSION	N/A	N/A
1.051 ROOM 2-ARTIST	N/A	N/A
1.052 ROOM 1-MP/PRESS	N/A	N/A
1.058 ROOM 4-ARTIST	N/A	N/A
1.061 ROOM 5-ARTIST	N/A	N/A
1.065 ROOM 6-LOUNGE ARTIST	N/A	N/A
1.066 ROOM 3-ARTIST	N/A	N/A
1.070 ROOM 7-LOUNGE ARTIST	N/A	N/A
1.076 GREEN ROOM	N/A	N/A
1.086 ROOM 8-LOUNGE ARTIST	N/A	N/A
1.089 ROOM 9-LOUNGE ARTIST	N/A	N/A
1.091 ROOM 10-ARTIST	N/A	N/A
1.094 ROOM 1-ARTIST	N/A	N/A
1.096 ROOM 12-OFFICE	N/A	N/A
1.097 ROOM 13-OFFICE	N/A	N/A
1.099 ROOM 14-FLEXIBLE OFFICE	N/A	N/A
1.107 MEETING	N/A	N/A
1.112 OPEN PLAN	N/A	N/A
1.113 GM	N/A	N/A
1.114 OM	N/A	N/A
1.115 COO	N/A	N/A
1.116 MR	N/A	N/A
1.126 FINANCE	N/A	N/A
1.127 NAMING RIGHT SPONSORS	N/A	N/A
1.128 POST/PRINT	N/A	N/A
1.131 FREEZER WALK-IN GENERAL GOODS	N/A	N/A
1.138 PANTRY	N/A	N/A
1.142 CONCESSION	N/A	N/A
1.152 BOXES	N/A	N/A
1.153 BOXES	N/A	N/A
1.154 PRIVATE BANQUET	N/A	N/A
1.155 BOXES	N/A	N/A
1.156 BOXES	N/A	N/A
1.157 BOXES	N/A	N/A
1.158 CLUB LOUNGE	NO (-99%)	NO
1.160 BAR	NO (-91.3%)	NO
1.176 CLOAKROOM	N/A	N/A
1.177 CIRCULATION	N/A	N/A
2.001 CONCOURSE SOUTH	YES (+31.5%)	NO
2.001 CONCOURSE SOUTH EAST	N/A	N/A
2.001 CONCOURSE SOUTH WEST	N/A	N/A
2.001 CONCOURSE WEST	N/A	N/A
2.001 COUNCOURSE EAST	NO (-82.6%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
2.007 CONCESSION	N/A	N/A
2.019 CIRCULATION	N/A	N/A
2.021 BAR	N/A	N/A
2.027 LOBBY	N/A	N/A
2.031 E11 - ICT SER	N/A	N/A
2.039 CONCESSION	N/A	N/A
2.054 BELLY UP	N/A	N/A
2.057 INFO POINT	N/A	N/A
2.080 FIRST AID	N/A	N/A
2.090 LIFT	N/A	N/A
2.091 QUIET ROOM	N/A	N/A
2.094 STORE	N/A	N/A
2.098 BELLY UP	N/A	N/A
2.113 CONCESSION	N/A	N/A
2.122 E11 - ICT SER	N/A	N/A
2.138 CIRCULATION	N/A	N/A
2.141 MERCH	N/A	N/A
4.002 CELLAR	N/A	N/A
4.033 CELLAR	N/A	N/A
G.001 FOYER	NO (-20.8%)	NO
G.002 FOYER	NO (-2.1%)	NO
G.003 BELLY UP	N/A	N/A
G.005 CELLAR	N/A	N/A
G.006 CONCESSION	N/A	N/A
G.008 CIRCULATION	N/A	N/A
G.023 CAFE	NO (-8.4%)	NO
G.031 E7 - ICT MER	N/A	N/A
G.039 STORE	N/A	N/A
G.040 BELLY UP	N/A	N/A
G.045 CONCESSION	N/A	N/A
G.046 CELLAR	N/A	N/A
G.047 BOH - STORAGE	N/A	N/A
G.050 BOH - STORAGE	N/A	N/A
G.052 FIRST AID	N/A	N/A
G.053 WORKSHOP	N/A	N/A
G.065 BOH - STORAGE	N/A	N/A
G.066 DINING	N/A	N/A
G.071 CREW LOCKER	N/A	N/A
G.075 OFFICE 1	N/A	N/A
G.076 OFFICE 2	N/A	N/A
G.106 WINE & SPIRITS	N/A	N/A
G.108 CHILLED KEG STORE	N/A	N/A
G.112 H. PRODUCTION	N/A	N/A
G.118 OFFICE	N/A	N/A
G.119 CCTV/EVENT CONTROL SPACE	N/A	N/A
G.120 CRISIS MEETING ROOM	N/A	N/A
G.123 FIRST AID	N/A	N/A
G.125 RECEPTION	N/A	N/A
G.126 BRIEFING/BREAKOUT	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
G.127 SIGN-IN/UNIFORM	N/A	N/A
G.135 CONCESSION	N/A	N/A
G.143 PREMIUM ARRIVAL	N/A	N/A
G.144 LOBBY	N/A	N/A
G.148 MERCH OFFICE	N/A	N/A
G.149 MERCH	N/A	N/A
G.160 OFFICE MANAGER	YES (+3%)	NO
G.161 OFFICE	N/A	N/A
G.162 BOX OFFICE	YES (+2.2%)	NO
G.163 OFFICE MANAGER	N/A	N/A
G.172 CIRCULATION	N/A	N/A

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER and BPEC

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	32207.6	29777.6
External area [m^2]	38477.8	38477.8
Weather	CAR	CAR
Infiltration [m^3/hm^2@ 50Pa]	3	4
Average conductance [W/K]	7748.93	10283.1
Average U-value [W/m^2K]	0.2	0.27
Alpha value* [%]	10.51	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
99	**D2 General Assembly and Leisure, Night Clubs, and Theatres**
	Others: Passenger terminals
	Others: Emergency services
1	**Others: Miscellaneous 24hr activities**
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

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

	Actual	Notional
Heating	11.76	15.49
Cooling	1.69	1.22
Auxiliary	13.02	9.87
Lighting	13.23	19.21
Hot water	13.77	13.14
Equipment*	28.79	26.47
TOTAL**	**53.47**	**58.93**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	9.29	6.86
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	58.8	64.69
Primary energy* [kWh/m^2]	99.48	108.06
Total emissions [kg/m^2]	11.7	16.6

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	48	27.4	14.3	2.2	22.8	0.93	3.5	0.98	4.5
	Notional	59.4	35.1	19.1	2.6	15.2	0.86	3.79	----	----
[ST] Fan coil systems, [HS] LTHW boiler, [HFT] Waste Heat, [CFT] Electricity										
	Actual	40.1	26.5	12	2.3	21.2	0.93	3.26	0.98	4.2
	Notional	60.6	20.6	19.5	1.5	13.7	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Waste Heat, [CFT] Electricity										
	Actual	107.9	0	32.2	0	16.1	0.93	0	0.98	0
	Notional	130.9	0	42.2	0	19.4	0.86	0	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	0	1282.4	0	120.7	0	4.71	2.95	4.96	4.96
	Notional	0	989.6	0	72.5	0	0.86	3.79	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Waste Heat, [CFT] Electricity										
	Actual	145.8	0	43.5	0	3.3	0.93	0	0.98	0
	Notional	194.2	0	62.6	0	1.6	0.86	0	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

BRUKL Output Document

Compliance with Wales Building Regulations Part L 2014

Llywodraeth Cymru
Welsh Government

Project name

Travelodge v4 - Evo 3-R3

As designed

Date: Fri Aug 06 11:33:01 2021

Administrative information

Building Details

Address: Cardiff, CF10

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Carolina Fernandes

Telephone number:

Address: 4 Pierhead St, Cardiff, CF10 4QP

Criterion 1: The calculated BER and BPEC for the building must not exceed the targets

Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	55.5	
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	57.8	
Building Primary Energy Consumption (BPEC), $kWh/m^2.annum$	287.55	
Target Primary Energy Consumption (TPEC), $kWh/m^2.annum$	317.94	
Do the building's emissions and primary energy consumption exceed the targets?	BER =< TER	BPEC =< TPEC

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	Surface where the maximum value occurs*
Wall**	0.35	0.22	0.22	SP000000:Surf[2]
Floor	0.25	0.18	0.18	SP000000:Surf[0]
Roof	0.25	0.16	0.16	RS000066:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.5	1.5	SP000000:Surf[1]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

* There might be more than one surface where the maximum U-value occurs.
** 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.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- VRF B (all public areas)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.13	4.44	0	0	0.79
Standard value	2.5*	1	N/A	N/A	0.65
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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

2- VRF B Back Office

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.13	4.44	0	0	0.83
Standard value	2.5*	1	N/A	N/A	0.65
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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

3- VRF A (bar store cooling unit)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.13	4.44	0	0	-
Standard value	2.5*	1	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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

4- T - Elec Radiator w/ central Ext

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0.19	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

5- VRF C (all guestrooms)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	6.06	4.88	0	0	-
Standard value	2.5*	1	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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

6- VRF D (all larger guestrooms)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.7	4.5	0	0	-
Standard value	2.5*	1	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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

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

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
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 supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
01. 11 Kitchen	-	-	-	1.7	-	-	-	-	-	-	N/A
01.07 RECEPTION	-	-	-	1.6	-	-	-	-	-	-	N/A
01.08 OFFICE	-	-	-	1.6	-	-	-	-	-	-	N/A
01.10 STORE	0.3	-	-	-	0.3	-	-	-	-	-	N/A
01.12 RESTAURANT	-	-	-	1.6	-	-	-	-	-	-	N/A
01.16 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
01.17 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
01.19 LINEN	-	-	0.6	-	-	-	-	-	-	-	N/A
02.07 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
02.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
03.07 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
03.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
04.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
05.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A

General lighting and display lighting

Zone name	Luminous efficacy [lm/W]			General lighting [W]
	Luminaire	Lamp	Display lamp	
Standard value	60	60	22	
01. 11 Kitchen	-	90	-	372
01.03 LOBBY	-	90	-	38
01.04 STAIR	-	90	-	45
01.06 LOBBY	-	90	-	56
01.07 RECEPTION	-	90	15	135
01.08 OFFICE	90	-	-	158
01.10 STORE	90	-	-	17
01.12 RESTAURANT	-	90	15	1113
01.13 CORRIDOR	-	90	-	27
01.14 LOBBY	-	90	-	21
01.15 STAFF	90	-	-	134
01.16 WC	-	90	-	40

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
01.17 WC	-	90	-	40
01.18 CORRIDOR	-	90	-	177
01.19 LINEN	90	-	-	39
01.20 STAIR	-	90	-	45
02.03 LOBBY	-	90	-	34
02.04 STAIR	-	90	-	42
02.07 LINEN ROOM	90	-	-	45
02.08 CORRIDOR	-	90	-	120
02.09 CORRIDOR	-	90	-	159
02.10 LINEN ROOM	90	-	-	37
02.11 STAIR	-	90	-	42
03.03 LOBBY	-	90	-	34
03.04 STAIR	-	90	-	42
03.06 CORRIDOR	-	90	-	35
03.07 LINEN ROOM	90	-	-	45
03.08 CORRIDOR	-	90	-	90
03.09 CORRIDOR	-	90	-	159
03.10 LINEN ROOM	90	-	-	36
03.11 STAIR	-	90	-	42
101 DOUBLE ROOM	-	90	-	34
102 DOUBLE ROOM	-	90	-	34
103 DOUBLE ROOM	-	90	-	34
104 DOUBLE ROOM	-	90	-	34
105 DOUBLE ROOM	-	90	-	33
106 DOUBLE ROOM	-	90	-	33
107 DOUBLE ROOM	-	90	-	34
108 DOUBLE ROOM	-	90	-	34
109 DOUBLE ROOM	-	90	-	33
110 DOUBLE ROOM	-	90	-	33
111 DOUBLE ROOM	-	90	-	34
112 DOUBLE ROOM	-	90	-	34
113 DOUBLE ROOM	-	90	-	33
114 DOUBLE ROOM	-	90	-	33
115 DOUBLE ROOM	-	90	-	34
116 DOUBLE ROOM	-	90	-	34
117 DOUBLE ROOM	-	90	-	33
118 DOUBLE ROOM	-	90	-	33
119 DOUBLE ROOM	-	90	-	34
120 DOUBLE ROOM	-	90	-	34
121 DOUBLE ROOM	-	90	-	33
122 DOUBLE ROOM	-	90	-	33
123 DOUBLE ROOM	-	90	-	34
124 DOUBLE ROOM	-	90	-	33

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
125 DOUBLE ROOM	-	90	-	34
126 DOUBLE ROOM	-	90	-	34
201 ACCESSIBLE ROOM	-	90	-	41
202 ACCESSIBLE ROOM	-	90	-	39
203 ACCESSIBLE ROOM	-	90	-	39
204 FAMILY ROOM	-	90	-	40
205 FAMILY ROOM	-	90	-	40
206 FAMILY ROOM	-	90	-	40
207 FAMILY ROOM	-	90	-	40
208 FAMILY ROOM	-	90	-	40
209 FAMILY ROOM	-	90	-	40
210 FAMILY ROOM	-	90	-	40
211 FAMILY ROOM	-	90	-	40
212 FAMILY ROOM	-	90	-	39
213 FAMILY ROOM	-	90	-	39
214 DOUBLE ROOM	-	90	-	30
215 DOUBLE ROOM	-	90	-	30
216 DOUBLE ROOM	-	90	-	30
217 DOUBLE ROOM	-	90	-	30
218 DOUBLE ROOM	-	90	-	30
219 DOUBLE ROOM	-	90	-	30
220 DOUBLE ROOM	-	90	-	30
221 DOUBLE ROOM	-	90	-	30
222 DOUBLE ROOM	-	90	-	30
223 DOUBLE ROOM	-	90	-	30
224 DOUBLE ROOM	-	90	-	30
225 DOUBLE ROOM	-	90	-	30
226 DOUBLE ROOM	-	90	-	30
227 DOUBLE ROOM	-	90	-	30
228 DOUBLE ROOM	-	90	-	30
229 DOUBLE ROOM	-	90	-	30
230 DOUBLE ROOM	-	90	-	30
231 DOUBLE ROOM	-	90	-	30
232 DOUBLE ROOM	-	90	-	30
233 DOUBLE ROOM	-	90	-	30
234 DOUBLE ROOM	-	90	-	30
235 DOUBLE ROOM	-	90	-	30
236 DOUBLE ROOM	-	90	-	29
237 DOUBLE ROOM	-	90	-	29
238 DOUBLE ROOM	-	90	-	30
239 DOUBLE ROOM	-	90	-	30
301 ACCESSIBLE ROOM	-	90	-	42
302 ACCESSIBLE ROOM	-	90	-	39

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
303 FAMILY ROOM	-	90	-	41
304 FAMILY ROOM	-	90	-	40
305 FAMILY ROOM	-	90	-	40
306 FAMILY ROOM	-	90	-	40
307 FAMILY ROOM	-	90	-	40
308 FAMILY ROOM	-	90	-	40
309 FAMILY ROOM	-	90	-	40
310 FAMILY ROOM	-	90	-	40
311 FAMILY ROOM	-	90	-	40
312 FAMILY ROOM	-	90	-	39
313 FAMILY ROOM	-	90	-	39
314 DOUBLE ROOM	-	90	-	30
315 DOUBLE ROOM	-	90	-	30
316 DOUBLE ROOM	-	90	-	30
317 DOUBLE ROOM	-	90	-	52
318 DOUBLE ROOM	-	90	-	30
320 DOUBLE ROOM	-	90	-	30
321 DOUBLE ROOM	-	90	-	30
322 DOUBLE ROOM	-	90	-	30
323 DOUBLE ROOM	-	90	-	30
324 DOUBLE ROOM	-	90	-	30
325 DOUBLE ROOM	-	90	-	30
326 DOUBLE ROOM	-	90	-	30
327 DOUBLE ROOM	-	90	-	30
328 DOUBLE ROOM	-	90	-	30
329 DOUBLE ROOM	-	90	-	30
330 DOUBLE ROOM	-	90	-	30
331 DOUBLE ROOM	-	90	-	30
332 DOUBLE ROOM	-	90	-	30
333 DOUBLE ROOM	-	90	-	30
334 DOUBLE ROOM	-	90	-	30
335 DOUBLE ROOM	-	90	-	30
336 DOUBLE ROOM	-	90	-	30
337 DOUBLE ROOM	-	90	-	30
338 DOUBLE ROOM	-	90	-	30
339 DOUBLE ROOM	-	90	-	30
Ensuite	-	90	-	26
Ensuite	-	90	-	26
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	31
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	21
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20

General lighting and display lighting

	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	25
Ensuite	-	90	-	26
Ensuite	-	90	-	26
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	20
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
Ensuite	-	90	-	21
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	21
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	31
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	26
Ensuite	-	90	-	25
04.11 STAIR	-	90	-	41
04.04 STAIR	-	90	-	42
04.03 LOBBY	-	90	-	34
04.09 CORRIDOR	-	90	-	159
04.08 CORRIDOR	-	90	-	120
402 ACCESSIBLE ROOM	-	90	-	74
428 DOUBLE ROOM	-	90	-	30
430 DOUBLE ROOM	-	90	-	30
432 DOUBLE ROOM	-	90	-	30
434 DOUBLE ROOM	-	90	-	30
436 DOUBLE ROOM	-	90	-	29
438 DOUBLE ROOM	-	90	-	30
424 DOUBLE ROOM	-	90	-	30
426 DOUBLE ROOM	-	90	-	30
420 DOUBLE ROOM	-	90	-	30
422 DOUBLE ROOM	-	90	-	30
416 DOUBLE ROOM	-	90	-	30
418 DOUBLE ROOM	-	90	-	30
414 DOUBLE ROOM	-	90	-	30
429 DOUBLE ROOM	-	90	-	30
431 DOUBLE ROOM	-	90	-	30
433 DOUBLE ROOM	-	90	-	30
435 DOUBLE ROOM	-	90	-	30
437 DOUBLE ROOM	-	90	-	29
439 DOUBLE ROOM	-	90	-	30
425 DOUBLE ROOM	-	90	-	30
427 DOUBLE ROOM	-	90	-	30
421 DOUBLE ROOM	-	90	-	30
423 DOUBLE ROOM	-	90	-	30
417 DOUBLE ROOM	-	90	-	52
403 FAMILY ROOM	-	90	-	41
415 DOUBLE ROOM	-	90	-	30
411 FAMILY ROOM	-	90	-	40
409 FAMILY ROOM	-	90	-	40
407 FAMILY ROOM	-	90	-	40
405 FAMILY ROOM	-	90	-	40
412 FAMILY ROOM	-	90	-	39
410 FAMILY ROOM	-	90	-	40

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
408 FAMILY ROOM	-	90	-	40
406 FAMILY ROOM	-	90	-	40
404 FAMILY ROOM	-	90	-	75
04.10 LINEN ROOM	90	-	-	36
413 FAMILY ROOM	-	90	-	39
05.11 STAIR	-	90	-	44
05.04 STAIR	-	90	-	45
05.03 LOBBY	-	90	-	37
05.09 CORRIDOR	-	90	-	176
05.08 CORRIDOR	-	90	-	100
514 SUPER DOUBLE ROOM	-	90	-	34
518 SUPER DOUBLE ROOM	-	90	-	33
520 SUPER DOUBLE ROOM	-	90	-	33
522 SUPER DOUBLE ROOM	-	90	-	33
524 SUPER DOUBLE ROOM	-	90	-	33
526 SUPER DOUBLE ROOM	-	90	-	33
528 SUPER DOUBLE ROOM	-	90	-	33
530 SUPER DOUBLE ROOM	-	90	-	33
532 SUPER DOUBLE ROOM	-	90	-	33
534 SUPER DOUBLE ROOM	-	90	-	33
538 SUPER DOUBLE ROOM	-	90	-	34
516 SUPER DOUBLE ROOM	-	90	-	33
519 SUPER DOUBLE ROOM	-	90	-	56
521 SUPER DOUBLE ROOM	-	90	-	33
523 SUPER DOUBLE ROOM	-	90	-	33
525 SUPER DOUBLE ROOM	-	90	-	33
527 SUPER DOUBLE ROOM	-	90	-	33
529 SUPER DOUBLE ROOM	-	90	-	33
531 SUPER DOUBLE ROOM	-	90	-	33
533 SUPER DOUBLE ROOM	-	90	-	33
535 SUPER DOUBLE ROOM	-	90	-	33
537 SUPER DOUBLE ROOM	-	90	-	33
539 SUPER DOUBLE ROOM	-	90	-	33
512 SUPER FAMILY ROOM	-	90	-	42
515 SUPER DOUBLE ROOM	-	90	-	34
511 SUPER FAMILY ROOM	-	90	-	43
509 SUPER FAMILY ROOM	-	90	-	43
507 SUPER FAMILY ROOM	-	90	-	43
505 SUPER FAMILY ROOM	-	90	-	43
503 SUPER FAMILY ROOM	-	90	-	44
502 SUPER ACCESSIBLE ROOM	-	90	-	78
510 SUPER FAMILY ROOM	-	90	-	43
508 SUPER FAMILY ROOM	-	90	-	43

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
506 SUPER FAMILY ROOM	-	90	-	43
504 SUPER FAMILY ROOM	-	90	-	78
536 SUPER DOUBLE ROOM	-	90	-	33
05.06 CORRIDOR	-	90	-	39
05.10 LINEN ROOM	90	-	-	39
513 SUPER FAMILY ROOM	-	90	-	42
Ensuite	-	90	-	22
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	22
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	37
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	30
Ensuite	-	90	-	30
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	21
00.20 STAIR	-	90	-	46
GF.13 COLD WATER TANK GF.04 STAIR	90	-	-	199
GF.03 ENTRANCE LOBBY	-	90	-	94
GF.04 STAIR	-	90	-	46
GF.06 LV ROOM	90	-	-	62
GF.07 ELECTRICAL INCOMER	90	-	-	78
GF.09 LINEN INTAKE	90	-	-	28
GF.10 REFUSE	90	-	-	27
GF.11 HOT WATER TANK	90	-	-	95
GF.12 LOBBY	-	90	-	55

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
01. 11 Kitchen	N/A	N/A
01.07 RECEPTION	NO (-56.4%)	NO
01.08 OFFICE	NO (-89.6%)	NO
01.10 STORE	N/A	N/A
01.12 RESTAURANT	NO (-57.1%)	NO
01.15 STAFF	NO (-85.1%)	NO
101 DOUBLE ROOM	NO (-82.6%)	NO
102 DOUBLE ROOM	NO (-82.9%)	NO
103 DOUBLE ROOM	NO (-81%)	NO
104 DOUBLE ROOM	NO (-81.9%)	NO
105 DOUBLE ROOM	NO (-80.7%)	NO
106 DOUBLE ROOM	NO (-81.7%)	NO
107 DOUBLE ROOM	NO (-81%)	NO
108 DOUBLE ROOM	NO (-81.8%)	NO
109 DOUBLE ROOM	NO (-80.9%)	NO
110 DOUBLE ROOM	NO (-81.7%)	NO
111 DOUBLE ROOM	NO (-81%)	NO
112 DOUBLE ROOM	NO (-81.8%)	NO
113 DOUBLE ROOM	NO (-81%)	NO
114 DOUBLE ROOM	NO (-81.7%)	NO
115 DOUBLE ROOM	NO (-80.8%)	NO
116 DOUBLE ROOM	NO (-81.8%)	NO
117 DOUBLE ROOM	NO (-80.9%)	NO
118 DOUBLE ROOM	NO (-81.7%)	NO
119 DOUBLE ROOM	NO (-81.3%)	NO
120 DOUBLE ROOM	NO (-81.8%)	NO
121 DOUBLE ROOM	NO (-81.3%)	NO
122 DOUBLE ROOM	NO (-81.7%)	NO
123 DOUBLE ROOM	NO (-82.3%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
124 DOUBLE ROOM	NO (-81.5%)	NO
125 DOUBLE ROOM	NO (-83.1%)	NO
126 DOUBLE ROOM	NO (-82%)	NO
201 ACCESSIBLE ROOM	NO (-82%)	NO
202 ACCESSIBLE ROOM	NO (-78.6%)	NO
203 ACCESSIBLE ROOM	NO (-78.5%)	NO
204 FAMILY ROOM	NO (-73.7%)	NO
205 FAMILY ROOM	NO (-78%)	NO
206 FAMILY ROOM	NO (-74.1%)	NO
207 FAMILY ROOM	NO (-77.9%)	NO
208 FAMILY ROOM	NO (-75%)	NO
209 FAMILY ROOM	NO (-77.9%)	NO
210 FAMILY ROOM	NO (-74.9%)	NO
211 FAMILY ROOM	NO (-78%)	NO
212 FAMILY ROOM	NO (-79.3%)	NO
213 FAMILY ROOM	NO (-81.6%)	NO
214 DOUBLE ROOM	NO (-81.5%)	NO
215 DOUBLE ROOM	NO (-82.9%)	NO
216 DOUBLE ROOM	NO (-79.5%)	NO
217 DOUBLE ROOM	NO (-81.9%)	NO
218 DOUBLE ROOM	NO (-79.2%)	NO
219 DOUBLE ROOM	NO (-81.7%)	NO
220 DOUBLE ROOM	NO (-79.5%)	NO
221 DOUBLE ROOM	NO (-81.8%)	NO
222 DOUBLE ROOM	NO (-79.6%)	NO
223 DOUBLE ROOM	NO (-81.7%)	NO
224 DOUBLE ROOM	NO (-79.8%)	NO
225 DOUBLE ROOM	NO (-81.8%)	NO
226 DOUBLE ROOM	NO (-79.9%)	NO
227 DOUBLE ROOM	NO (-81.7%)	NO
228 DOUBLE ROOM	NO (-80.1%)	NO
229 DOUBLE ROOM	NO (-81.8%)	NO
230 DOUBLE ROOM	NO (-79.9%)	NO
231 DOUBLE ROOM	NO (-81.7%)	NO
232 DOUBLE ROOM	NO (-80.1%)	NO
233 DOUBLE ROOM	NO (-81.8%)	NO
234 DOUBLE ROOM	NO (-79.9%)	NO
235 DOUBLE ROOM	NO (-81.7%)	NO
236 DOUBLE ROOM	NO (-79.8%)	NO
237 DOUBLE ROOM	NO (-81.5%)	NO
238 DOUBLE ROOM	NO (-81.2%)	NO
239 DOUBLE ROOM	NO (-82.2%)	NO
301 ACCESSIBLE ROOM	NO (-82%)	NO
302 ACCESSIBLE ROOM	NO (-78.5%)	NO
303 FAMILY ROOM	NO (-78.5%)	NO
304 FAMILY ROOM	NO (-72.6%)	NO
305 FAMILY ROOM	NO (-78%)	NO
306 FAMILY ROOM	NO (-72.9%)	NO
307 FAMILY ROOM	NO (-77.9%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
308 FAMILY ROOM	NO (-73.6%)	NO
309 FAMILY ROOM	NO (-77.9%)	NO
310 FAMILY ROOM	NO (-74.2%)	NO
311 FAMILY ROOM	NO (-78%)	NO
312 FAMILY ROOM	NO (-78.3%)	NO
313 FAMILY ROOM	NO (-81.6%)	NO
314 DOUBLE ROOM	NO (-80.5%)	NO
315 DOUBLE ROOM	NO (-82.9%)	NO
316 DOUBLE ROOM	NO (-78.8%)	NO
317 DOUBLE ROOM	NO (-81.8%)	NO
318 DOUBLE ROOM	NO (-78.5%)	NO
320 DOUBLE ROOM	NO (-78.5%)	NO
321 DOUBLE ROOM	NO (-81.8%)	NO
322 DOUBLE ROOM	NO (-78.5%)	NO
323 DOUBLE ROOM	NO (-81.7%)	NO
324 DOUBLE ROOM	NO (-78.6%)	NO
325 DOUBLE ROOM	NO (-81.8%)	NO
326 DOUBLE ROOM	NO (-78.4%)	NO
327 DOUBLE ROOM	NO (-81.7%)	NO
328 DOUBLE ROOM	NO (-78.4%)	NO
329 DOUBLE ROOM	NO (-81.8%)	NO
330 DOUBLE ROOM	NO (-78.3%)	NO
331 DOUBLE ROOM	NO (-81.7%)	NO
332 DOUBLE ROOM	NO (-78.6%)	NO
333 DOUBLE ROOM	NO (-81.8%)	NO
334 DOUBLE ROOM	NO (-78.5%)	NO
335 DOUBLE ROOM	NO (-81.7%)	NO
336 DOUBLE ROOM	NO (-78.8%)	NO
337 DOUBLE ROOM	NO (-81.7%)	NO
338 DOUBLE ROOM	NO (-79.9%)	NO
339 DOUBLE ROOM	NO (-81.8%)	NO
402 ACCESSIBLE ROOM	NO (-81.1%)	NO
428 DOUBLE ROOM	NO (-78.9%)	NO
430 DOUBLE ROOM	NO (-78.9%)	NO
432 DOUBLE ROOM	NO (-79%)	NO
434 DOUBLE ROOM	NO (-78.9%)	NO
436 DOUBLE ROOM	NO (-78.9%)	NO
438 DOUBLE ROOM	NO (-80.3%)	NO
424 DOUBLE ROOM	NO (-78.8%)	NO
426 DOUBLE ROOM	NO (-78.8%)	NO
420 DOUBLE ROOM	NO (-78.9%)	NO
422 DOUBLE ROOM	NO (-78.7%)	NO
416 DOUBLE ROOM	NO (-79%)	NO
418 DOUBLE ROOM	NO (-78.8%)	NO
414 DOUBLE ROOM	NO (-80.4%)	NO
429 DOUBLE ROOM	NO (-82.6%)	NO
431 DOUBLE ROOM	NO (-82.5%)	NO
433 DOUBLE ROOM	NO (-82.6%)	NO
435 DOUBLE ROOM	NO (-82.5%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
437 DOUBLE ROOM	NO (-82.3%)	NO
439 DOUBLE ROOM	NO (-82.8%)	NO
425 DOUBLE ROOM	NO (-82.5%)	NO
427 DOUBLE ROOM	NO (-82.5%)	NO
421 DOUBLE ROOM	NO (-82.6%)	NO
423 DOUBLE ROOM	NO (-82.5%)	NO
417 DOUBLE ROOM	NO (-82.6%)	NO
403 FAMILY ROOM	NO (-78.5%)	NO
415 DOUBLE ROOM	NO (-83.6%)	NO
411 FAMILY ROOM	NO (-78%)	NO
409 FAMILY ROOM	NO (-77.9%)	NO
407 FAMILY ROOM	NO (-77.9%)	NO
405 FAMILY ROOM	NO (-78%)	NO
412 FAMILY ROOM	NO (-77.4%)	NO
410 FAMILY ROOM	NO (-72.7%)	NO
408 FAMILY ROOM	NO (-72.4%)	NO
406 FAMILY ROOM	NO (-72%)	NO
404 FAMILY ROOM	NO (-86.2%)	NO
413 FAMILY ROOM	NO (-81.6%)	NO
514 SUPER DOUBLE ROOM	NO (-76%)	NO
518 SUPER DOUBLE ROOM	NO (-73.9%)	NO
520 SUPER DOUBLE ROOM	NO (-74%)	NO
522 SUPER DOUBLE ROOM	NO (-74%)	NO
524 SUPER DOUBLE ROOM	NO (-74.3%)	NO
526 SUPER DOUBLE ROOM	NO (-74%)	NO
528 SUPER DOUBLE ROOM	NO (-74.3%)	NO
530 SUPER DOUBLE ROOM	NO (-74.1%)	NO
532 SUPER DOUBLE ROOM	NO (-74.1%)	NO
534 SUPER DOUBLE ROOM	NO (-74%)	NO
538 SUPER DOUBLE ROOM	NO (-75.6%)	NO
516 SUPER DOUBLE ROOM	NO (-74%)	NO
519 SUPER DOUBLE ROOM	NO (-79.6%)	NO
521 SUPER DOUBLE ROOM	NO (-79.6%)	NO
523 SUPER DOUBLE ROOM	NO (-79.6%)	NO
525 SUPER DOUBLE ROOM	NO (-79.6%)	NO
527 SUPER DOUBLE ROOM	NO (-79.5%)	NO
529 SUPER DOUBLE ROOM	NO (-79.6%)	NO
531 SUPER DOUBLE ROOM	NO (-79.5%)	NO
533 SUPER DOUBLE ROOM	NO (-79.7%)	NO
535 SUPER DOUBLE ROOM	NO (-79.6%)	NO
537 SUPER DOUBLE ROOM	NO (-79.3%)	NO
539 SUPER DOUBLE ROOM	NO (-83%)	NO
512 SUPER FAMILY ROOM	NO (-76.6%)	NO
515 SUPER DOUBLE ROOM	NO (-80.8%)	NO
511 SUPER FAMILY ROOM	NO (-78%)	NO
509 SUPER FAMILY ROOM	NO (-77.9%)	NO
507 SUPER FAMILY ROOM	NO (-77.9%)	NO
505 SUPER FAMILY ROOM	NO (-78%)	NO
503 SUPER FAMILY ROOM	NO (-78.5%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
502 SUPER ACCESSIBLE ROOM	NO (-81.1%)	NO
510 SUPER FAMILY ROOM	NO (-72%)	NO
508 SUPER FAMILY ROOM	NO (-71.9%)	NO
506 SUPER FAMILY ROOM	NO (-71.8%)	NO
504 SUPER FAMILY ROOM	NO (-86.1%)	NO
536 SUPER DOUBLE ROOM	NO (-73.9%)	NO
513 SUPER FAMILY ROOM	NO (-81.6%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER and BPEC

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	4636.6	4636.6
External area [m^2]	4856.3	4856.3
Weather	CAR	CAR
Infiltration [m^3/hm^2@ 50Pa]	3	4
Average conductance [W/K]	1425.57	2671.55
Average U-value [W/m^2K]	0.29	0.55
Alpha value* [%]	10.09	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
100	**C1 Hotels**
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

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

	Actual	Notional
Heating	6.63	29.68
Cooling	0.44	1.31
Auxiliary	5.08	4.1
Lighting	11.46	13.04
Hot water	203.81	214.47
Equipment*	26.82	26.82
TOTAL**	**227.42**	**262.61**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	6.36
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	105.68	154.43
Primary energy* [kWh/m^2]	287.55	317.94
Total emissions [kg/m^2]	55.5	57.8

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Other local room heater - unfanned, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity										
	Actual	150.6	0	41.8	0	10	1	0	1	0
	Notional	171.4	0	55.2	0	9.6	0.86	0	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	13.2	101	0.8	4.3	11.8	4.87	6.45	5.13	6.79
	Notional	38.2	87.4	8	6.4	15.7	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	170.2	0.6	8.2	0	0	5.76	6.68	6.06	7.03
	Notional	248.4	12.4	52	0.9	0	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	133.8	1.2	6.9	0	0	5.42	6.52	5.7	6.86
	Notional	190.1	10.3	39.8	0.8	0	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	15.9	153	0.9	6.6	20.1	4.87	6.45	5.13	6.79
	Notional	35.6	177.9	7.5	13	6.9	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	16.8	155.8	1	6.7	8.2	4.87	6.45	5.13	6.79
	Notional	94.2	206.7	19.7	15.2	2.9	1.33	3.79	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

BRUKL Output Document

Compliance with Wales Building Regulations Part L 2014

Llywodraeth Cymru
Welsh Government

Project name

Travelodge v4 - WH

As designed

Date: Thu Aug 12 15:40:25 2021

Administrative information

Building Details

Address: Cardiff, CF10

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.13

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.13

BRUKL compliance check version: v5.6.b.0

Certifier details

Name: Carolina Fernandes

Telephone number:

Address: 4 Pierhead St, Cardiff, CF10 4QP

Criterion 1: The calculated BER and BPEC for the building must not exceed the targets

Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	27.6	
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	57.8	
Building Primary Energy Consumption (BPEC), $kWh/m^2.annum$	294.89	
Target Primary Energy Consumption (TPEC), $kWh/m^2.annum$	317.94	
Do the building's emissions and primary energy consumption exceed the targets?	BER =< TER	BPEC =< TPEC

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.22	0.22	SP000000:Surf[2]
Floor	0.25	0.18	0.18	SP000000:Surf[0]
Roof	0.25	0.16	0.16	RS000066:Surf[0]
Windows***, roof windows, and rooflights	2.2	1.5	1.5	SP000000:Surf[1]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

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

* There might be more than one surface where the maximum U-value occurs.
** 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.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	3

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- VRF B (all public areas)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.13	4.44	0	0	0.79
Standard value	2.5*	1	N/A	N/A	0.65
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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

2- VRF B Back Office

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.13	4.44	0	0	0.83
Standard value	2.5*	1	N/A	N/A	0.65
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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

3- VRF A (bar store cooling unit)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.13	4.44	0	0	-
Standard value	2.5*	1	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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

4- T - Elec Radiator w/ central Ext

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0.19	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

5- VRF C (all guestrooms)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	6.06	4.88	0	0	-
Standard value	2.5*	1	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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

6- VRF D (all larger guestrooms)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	5.7	4.5	0	0	-
Standard value	2.5*	1	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. For types <=12 kW output, refer to EN 14825 for limiting standards.					

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

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
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 supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
01. 11 Kitchen	-	-	-	1.7	-	-	-	-	-	-	N/A
01.07 RECEPTION	-	-	-	1.6	-	-	-	-	-	-	N/A
01.08 OFFICE	-	-	-	1.6	-	-	-	-	-	-	N/A
01.10 STORE	0.3	-	-	-	0.3	-	-	-	-	-	N/A
01.12 RESTAURANT	-	-	-	1.6	-	-	-	-	-	-	N/A
01.16 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
01.17 WC	-	-	0.5	-	-	-	-	-	-	-	N/A
01.19 LINEN	-	-	0.6	-	-	-	-	-	-	-	N/A
02.07 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
02.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
03.07 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
03.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
04.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A
05.10 LINEN ROOM	-	-	0.6	-	-	-	-	-	-	-	N/A

General lighting and display lighting

Zone name	Luminous efficacy [lm/W]			General lighting [W]
	Luminaire	Lamp	Display lamp	
Standard value	60	60	22	
01. 11 Kitchen	-	90	-	372
01.03 LOBBY	-	90	-	38
01.04 STAIR	-	90	-	45
01.06 LOBBY	-	90	-	56
01.07 RECEPTION	-	90	15	135
01.08 OFFICE	90	-	-	158
01.10 STORE	90	-	-	17
01.12 RESTAURANT	-	90	15	1113
01.13 CORRIDOR	-	90	-	27
01.14 LOBBY	-	90	-	21
01.15 STAFF	90	-	-	134
01.16 WC	-	90	-	40

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
01.17 WC	-	90	-	40
01.18 CORRIDOR	-	90	-	177
01.19 LINEN	90	-	-	39
01.20 STAIR	-	90	-	45
02.03 LOBBY	-	90	-	34
02.04 STAIR	-	90	-	42
02.07 LINEN ROOM	90	-	-	45
02.08 CORRIDOR	-	90	-	120
02.09 CORRIDOR	-	90	-	159
02.10 LINEN ROOM	90	-	-	37
02.11 STAIR	-	90	-	42
03.03 LOBBY	-	90	-	34
03.04 STAIR	-	90	-	42
03.06 CORRIDOR	-	90	-	35
03.07 LINEN ROOM	90	-	-	45
03.08 CORRIDOR	-	90	-	90
03.09 CORRIDOR	-	90	-	159
03.10 LINEN ROOM	90	-	-	36
03.11 STAIR	-	90	-	42
101 DOUBLE ROOM	-	90	-	34
102 DOUBLE ROOM	-	90	-	34
103 DOUBLE ROOM	-	90	-	34
104 DOUBLE ROOM	-	90	-	34
105 DOUBLE ROOM	-	90	-	33
106 DOUBLE ROOM	-	90	-	33
107 DOUBLE ROOM	-	90	-	34
108 DOUBLE ROOM	-	90	-	34
109 DOUBLE ROOM	-	90	-	33
110 DOUBLE ROOM	-	90	-	33
111 DOUBLE ROOM	-	90	-	34
112 DOUBLE ROOM	-	90	-	34
113 DOUBLE ROOM	-	90	-	33
114 DOUBLE ROOM	-	90	-	33
115 DOUBLE ROOM	-	90	-	34
116 DOUBLE ROOM	-	90	-	34
117 DOUBLE ROOM	-	90	-	33
118 DOUBLE ROOM	-	90	-	33
119 DOUBLE ROOM	-	90	-	34
120 DOUBLE ROOM	-	90	-	34
121 DOUBLE ROOM	-	90	-	33
122 DOUBLE ROOM	-	90	-	33
123 DOUBLE ROOM	-	90	-	34
124 DOUBLE ROOM	-	90	-	33

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
125 DOUBLE ROOM	-	90	-	34
126 DOUBLE ROOM	-	90	-	34
201 ACCESSIBLE ROOM	-	90	-	41
202 ACCESSIBLE ROOM	-	90	-	39
203 ACCESSIBLE ROOM	-	90	-	39
204 FAMILY ROOM	-	90	-	40
205 FAMILY ROOM	-	90	-	40
206 FAMILY ROOM	-	90	-	40
207 FAMILY ROOM	-	90	-	40
208 FAMILY ROOM	-	90	-	40
209 FAMILY ROOM	-	90	-	40
210 FAMILY ROOM	-	90	-	40
211 FAMILY ROOM	-	90	-	40
212 FAMILY ROOM	-	90	-	39
213 FAMILY ROOM	-	90	-	39
214 DOUBLE ROOM	-	90	-	30
215 DOUBLE ROOM	-	90	-	30
216 DOUBLE ROOM	-	90	-	30
217 DOUBLE ROOM	-	90	-	30
218 DOUBLE ROOM	-	90	-	30
219 DOUBLE ROOM	-	90	-	30
220 DOUBLE ROOM	-	90	-	30
221 DOUBLE ROOM	-	90	-	30
222 DOUBLE ROOM	-	90	-	30
223 DOUBLE ROOM	-	90	-	30
224 DOUBLE ROOM	-	90	-	30
225 DOUBLE ROOM	-	90	-	30
226 DOUBLE ROOM	-	90	-	30
227 DOUBLE ROOM	-	90	-	30
228 DOUBLE ROOM	-	90	-	30
229 DOUBLE ROOM	-	90	-	30
230 DOUBLE ROOM	-	90	-	30
231 DOUBLE ROOM	-	90	-	30
232 DOUBLE ROOM	-	90	-	30
233 DOUBLE ROOM	-	90	-	30
234 DOUBLE ROOM	-	90	-	30
235 DOUBLE ROOM	-	90	-	30
236 DOUBLE ROOM	-	90	-	29
237 DOUBLE ROOM	-	90	-	29
238 DOUBLE ROOM	-	90	-	30
239 DOUBLE ROOM	-	90	-	30
301 ACCESSIBLE ROOM	-	90	-	42
302 ACCESSIBLE ROOM	-	90	-	39

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
303 FAMILY ROOM	-	90	-	41
304 FAMILY ROOM	-	90	-	40
305 FAMILY ROOM	-	90	-	40
306 FAMILY ROOM	-	90	-	40
307 FAMILY ROOM	-	90	-	40
308 FAMILY ROOM	-	90	-	40
309 FAMILY ROOM	-	90	-	40
310 FAMILY ROOM	-	90	-	40
311 FAMILY ROOM	-	90	-	40
312 FAMILY ROOM	-	90	-	39
313 FAMILY ROOM	-	90	-	39
314 DOUBLE ROOM	-	90	-	30
315 DOUBLE ROOM	-	90	-	30
316 DOUBLE ROOM	-	90	-	30
317 DOUBLE ROOM	-	90	-	52
318 DOUBLE ROOM	-	90	-	30
320 DOUBLE ROOM	-	90	-	30
321 DOUBLE ROOM	-	90	-	30
322 DOUBLE ROOM	-	90	-	30
323 DOUBLE ROOM	-	90	-	30
324 DOUBLE ROOM	-	90	-	30
325 DOUBLE ROOM	-	90	-	30
326 DOUBLE ROOM	-	90	-	30
327 DOUBLE ROOM	-	90	-	30
328 DOUBLE ROOM	-	90	-	30
329 DOUBLE ROOM	-	90	-	30
330 DOUBLE ROOM	-	90	-	30
331 DOUBLE ROOM	-	90	-	30
332 DOUBLE ROOM	-	90	-	30
333 DOUBLE ROOM	-	90	-	30
334 DOUBLE ROOM	-	90	-	30
335 DOUBLE ROOM	-	90	-	30
336 DOUBLE ROOM	-	90	-	30
337 DOUBLE ROOM	-	90	-	30
338 DOUBLE ROOM	-	90	-	30
339 DOUBLE ROOM	-	90	-	30
Ensuite	-	90	-	26
Ensuite	-	90	-	26
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	31
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	21
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	25
Ensuite	-	90	-	26
Ensuite	-	90	-	26
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	20
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	21
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	21
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	31
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	20
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	19
Ensuite	-	90	-	26
Ensuite	-	90	-	25
04.11 STAIR	-	90	-	41
04.04 STAIR	-	90	-	42
04.03 LOBBY	-	90	-	34
04.09 CORRIDOR	-	90	-	159
04.08 CORRIDOR	-	90	-	120
402 ACCESSIBLE ROOM	-	90	-	74
428 DOUBLE ROOM	-	90	-	30
430 DOUBLE ROOM	-	90	-	30
432 DOUBLE ROOM	-	90	-	30
434 DOUBLE ROOM	-	90	-	30
436 DOUBLE ROOM	-	90	-	29
438 DOUBLE ROOM	-	90	-	30
424 DOUBLE ROOM	-	90	-	30
426 DOUBLE ROOM	-	90	-	30
420 DOUBLE ROOM	-	90	-	30
422 DOUBLE ROOM	-	90	-	30
416 DOUBLE ROOM	-	90	-	30
418 DOUBLE ROOM	-	90	-	30
414 DOUBLE ROOM	-	90	-	30
429 DOUBLE ROOM	-	90	-	30
431 DOUBLE ROOM	-	90	-	30
433 DOUBLE ROOM	-	90	-	30
435 DOUBLE ROOM	-	90	-	30
437 DOUBLE ROOM	-	90	-	29
439 DOUBLE ROOM	-	90	-	30
425 DOUBLE ROOM	-	90	-	30
427 DOUBLE ROOM	-	90	-	30
421 DOUBLE ROOM	-	90	-	30
423 DOUBLE ROOM	-	90	-	30
417 DOUBLE ROOM	-	90	-	52
403 FAMILY ROOM	-	90	-	41
415 DOUBLE ROOM	-	90	-	30
411 FAMILY ROOM	-	90	-	40
409 FAMILY ROOM	-	90	-	40
407 FAMILY ROOM	-	90	-	40
405 FAMILY ROOM	-	90	-	40
412 FAMILY ROOM	-	90	-	39
410 FAMILY ROOM	-	90	-	40

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
408 FAMILY ROOM	-	90	-	40
406 FAMILY ROOM	-	90	-	40
404 FAMILY ROOM	-	90	-	75
04.10 LINEN ROOM	90	-	-	36
413 FAMILY ROOM	-	90	-	39
05.11 STAIR	-	90	-	44
05.04 STAIR	-	90	-	45
05.03 LOBBY	-	90	-	37
05.09 CORRIDOR	-	90	-	176
05.08 CORRIDOR	-	90	-	100
514 SUPER DOUBLE ROOM	-	90	-	34
518 SUPER DOUBLE ROOM	-	90	-	33
520 SUPER DOUBLE ROOM	-	90	-	33
522 SUPER DOUBLE ROOM	-	90	-	33
524 SUPER DOUBLE ROOM	-	90	-	33
526 SUPER DOUBLE ROOM	-	90	-	33
528 SUPER DOUBLE ROOM	-	90	-	33
530 SUPER DOUBLE ROOM	-	90	-	33
532 SUPER DOUBLE ROOM	-	90	-	33
534 SUPER DOUBLE ROOM	-	90	-	33
538 SUPER DOUBLE ROOM	-	90	-	34
516 SUPER DOUBLE ROOM	-	90	-	33
519 SUPER DOUBLE ROOM	-	90	-	56
521 SUPER DOUBLE ROOM	-	90	-	33
523 SUPER DOUBLE ROOM	-	90	-	33
525 SUPER DOUBLE ROOM	-	90	-	33
527 SUPER DOUBLE ROOM	-	90	-	33
529 SUPER DOUBLE ROOM	-	90	-	33
531 SUPER DOUBLE ROOM	-	90	-	33
533 SUPER DOUBLE ROOM	-	90	-	33
535 SUPER DOUBLE ROOM	-	90	-	33
537 SUPER DOUBLE ROOM	-	90	-	33
539 SUPER DOUBLE ROOM	-	90	-	33
512 SUPER FAMILY ROOM	-	90	-	42
515 SUPER DOUBLE ROOM	-	90	-	34
511 SUPER FAMILY ROOM	-	90	-	43
509 SUPER FAMILY ROOM	-	90	-	43
507 SUPER FAMILY ROOM	-	90	-	43
505 SUPER FAMILY ROOM	-	90	-	43
503 SUPER FAMILY ROOM	-	90	-	44
502 SUPER ACCESSIBLE ROOM	-	90	-	78
510 SUPER FAMILY ROOM	-	90	-	43
508 SUPER FAMILY ROOM	-	90	-	43

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
506 SUPER FAMILY ROOM	-	90	-	43
504 SUPER FAMILY ROOM	-	90	-	78
536 SUPER DOUBLE ROOM	-	90	-	33
05.06 CORRIDOR	-	90	-	39
05.10 LINEN ROOM	90	-	-	39
513 SUPER FAMILY ROOM	-	90	-	42
Ensuite	-	90	-	22
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	22
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	37
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	30
Ensuite	-	90	-	30
Ensuite	-	90	-	23
Ensuite	-	90	-	23
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21
Ensuite	-	90	-	21

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
Ensuite	-	90	-	21
00.20 STAIR	-	90	-	46
GF.13 COLD WATER TANK GF.04 STAIR	90	-	-	199
GF.03 ENTRANCE LOBBY	-	90	-	94
GF.04 STAIR	-	90	-	46
GF.06 LV ROOM	90	-	-	62
GF.07 ELECTRICAL INCOMER	90	-	-	78
GF.09 LINEN INTAKE	90	-	-	28
GF.10 REFUSE	90	-	-	27
GF.11 HOT WATER TANK	90	-	-	95
GF.12 LOBBY	-	90	-	55

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
01. 11 Kitchen	N/A	N/A
01.07 RECEPTION	NO (-56.4%)	NO
01.08 OFFICE	NO (-89.6%)	NO
01.10 STORE	N/A	N/A
01.12 RESTAURANT	NO (-57.1%)	NO
01.15 STAFF	NO (-85.1%)	NO
101 DOUBLE ROOM	NO (-82.6%)	NO
102 DOUBLE ROOM	NO (-82.9%)	NO
103 DOUBLE ROOM	NO (-81%)	NO
104 DOUBLE ROOM	NO (-81.9%)	NO
105 DOUBLE ROOM	NO (-80.7%)	NO
106 DOUBLE ROOM	NO (-81.7%)	NO
107 DOUBLE ROOM	NO (-81%)	NO
108 DOUBLE ROOM	NO (-81.8%)	NO
109 DOUBLE ROOM	NO (-80.9%)	NO
110 DOUBLE ROOM	NO (-81.7%)	NO
111 DOUBLE ROOM	NO (-81%)	NO
112 DOUBLE ROOM	NO (-81.8%)	NO
113 DOUBLE ROOM	NO (-81%)	NO
114 DOUBLE ROOM	NO (-81.7%)	NO
115 DOUBLE ROOM	NO (-80.8%)	NO
116 DOUBLE ROOM	NO (-81.8%)	NO
117 DOUBLE ROOM	NO (-80.9%)	NO
118 DOUBLE ROOM	NO (-81.7%)	NO
119 DOUBLE ROOM	NO (-81.3%)	NO
120 DOUBLE ROOM	NO (-81.8%)	NO
121 DOUBLE ROOM	NO (-81.3%)	NO
122 DOUBLE ROOM	NO (-81.7%)	NO
123 DOUBLE ROOM	NO (-82.3%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
124 DOUBLE ROOM	NO (-81.5%)	NO
125 DOUBLE ROOM	NO (-83.1%)	NO
126 DOUBLE ROOM	NO (-82%)	NO
201 ACCESSIBLE ROOM	NO (-82%)	NO
202 ACCESSIBLE ROOM	NO (-78.6%)	NO
203 ACCESSIBLE ROOM	NO (-78.5%)	NO
204 FAMILY ROOM	NO (-73.7%)	NO
205 FAMILY ROOM	NO (-78%)	NO
206 FAMILY ROOM	NO (-74.1%)	NO
207 FAMILY ROOM	NO (-77.9%)	NO
208 FAMILY ROOM	NO (-75%)	NO
209 FAMILY ROOM	NO (-77.9%)	NO
210 FAMILY ROOM	NO (-74.9%)	NO
211 FAMILY ROOM	NO (-78%)	NO
212 FAMILY ROOM	NO (-79.3%)	NO
213 FAMILY ROOM	NO (-81.6%)	NO
214 DOUBLE ROOM	NO (-81.5%)	NO
215 DOUBLE ROOM	NO (-82.9%)	NO
216 DOUBLE ROOM	NO (-79.5%)	NO
217 DOUBLE ROOM	NO (-81.9%)	NO
218 DOUBLE ROOM	NO (-79.2%)	NO
219 DOUBLE ROOM	NO (-81.7%)	NO
220 DOUBLE ROOM	NO (-79.5%)	NO
221 DOUBLE ROOM	NO (-81.8%)	NO
222 DOUBLE ROOM	NO (-79.6%)	NO
223 DOUBLE ROOM	NO (-81.7%)	NO
224 DOUBLE ROOM	NO (-79.8%)	NO
225 DOUBLE ROOM	NO (-81.8%)	NO
226 DOUBLE ROOM	NO (-79.9%)	NO
227 DOUBLE ROOM	NO (-81.7%)	NO
228 DOUBLE ROOM	NO (-80.1%)	NO
229 DOUBLE ROOM	NO (-81.8%)	NO
230 DOUBLE ROOM	NO (-79.9%)	NO
231 DOUBLE ROOM	NO (-81.7%)	NO
232 DOUBLE ROOM	NO (-80.1%)	NO
233 DOUBLE ROOM	NO (-81.8%)	NO
234 DOUBLE ROOM	NO (-79.9%)	NO
235 DOUBLE ROOM	NO (-81.7%)	NO
236 DOUBLE ROOM	NO (-79.8%)	NO
237 DOUBLE ROOM	NO (-81.5%)	NO
238 DOUBLE ROOM	NO (-81.2%)	NO
239 DOUBLE ROOM	NO (-82.2%)	NO
301 ACCESSIBLE ROOM	NO (-82%)	NO
302 ACCESSIBLE ROOM	NO (-78.5%)	NO
303 FAMILY ROOM	NO (-78.5%)	NO
304 FAMILY ROOM	NO (-72.6%)	NO
305 FAMILY ROOM	NO (-78%)	NO
306 FAMILY ROOM	NO (-72.9%)	NO
307 FAMILY ROOM	NO (-77.9%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
308 FAMILY ROOM	NO (-73.6%)	NO
309 FAMILY ROOM	NO (-77.9%)	NO
310 FAMILY ROOM	NO (-74.2%)	NO
311 FAMILY ROOM	NO (-78%)	NO
312 FAMILY ROOM	NO (-78.3%)	NO
313 FAMILY ROOM	NO (-81.6%)	NO
314 DOUBLE ROOM	NO (-80.5%)	NO
315 DOUBLE ROOM	NO (-82.9%)	NO
316 DOUBLE ROOM	NO (-78.8%)	NO
317 DOUBLE ROOM	NO (-81.8%)	NO
318 DOUBLE ROOM	NO (-78.5%)	NO
320 DOUBLE ROOM	NO (-78.5%)	NO
321 DOUBLE ROOM	NO (-81.8%)	NO
322 DOUBLE ROOM	NO (-78.5%)	NO
323 DOUBLE ROOM	NO (-81.7%)	NO
324 DOUBLE ROOM	NO (-78.6%)	NO
325 DOUBLE ROOM	NO (-81.8%)	NO
326 DOUBLE ROOM	NO (-78.4%)	NO
327 DOUBLE ROOM	NO (-81.7%)	NO
328 DOUBLE ROOM	NO (-78.4%)	NO
329 DOUBLE ROOM	NO (-81.8%)	NO
330 DOUBLE ROOM	NO (-78.3%)	NO
331 DOUBLE ROOM	NO (-81.7%)	NO
332 DOUBLE ROOM	NO (-78.6%)	NO
333 DOUBLE ROOM	NO (-81.8%)	NO
334 DOUBLE ROOM	NO (-78.5%)	NO
335 DOUBLE ROOM	NO (-81.7%)	NO
336 DOUBLE ROOM	NO (-78.8%)	NO
337 DOUBLE ROOM	NO (-81.7%)	NO
338 DOUBLE ROOM	NO (-79.9%)	NO
339 DOUBLE ROOM	NO (-81.8%)	NO
402 ACCESSIBLE ROOM	NO (-81.1%)	NO
428 DOUBLE ROOM	NO (-78.9%)	NO
430 DOUBLE ROOM	NO (-78.9%)	NO
432 DOUBLE ROOM	NO (-79%)	NO
434 DOUBLE ROOM	NO (-78.9%)	NO
436 DOUBLE ROOM	NO (-78.9%)	NO
438 DOUBLE ROOM	NO (-80.3%)	NO
424 DOUBLE ROOM	NO (-78.8%)	NO
426 DOUBLE ROOM	NO (-78.8%)	NO
420 DOUBLE ROOM	NO (-78.9%)	NO
422 DOUBLE ROOM	NO (-78.7%)	NO
416 DOUBLE ROOM	NO (-79%)	NO
418 DOUBLE ROOM	NO (-78.8%)	NO
414 DOUBLE ROOM	NO (-80.4%)	NO
429 DOUBLE ROOM	NO (-82.6%)	NO
431 DOUBLE ROOM	NO (-82.5%)	NO
433 DOUBLE ROOM	NO (-82.6%)	NO
435 DOUBLE ROOM	NO (-82.5%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
437 DOUBLE ROOM	NO (-82.3%)	NO
439 DOUBLE ROOM	NO (-82.8%)	NO
425 DOUBLE ROOM	NO (-82.5%)	NO
427 DOUBLE ROOM	NO (-82.5%)	NO
421 DOUBLE ROOM	NO (-82.6%)	NO
423 DOUBLE ROOM	NO (-82.5%)	NO
417 DOUBLE ROOM	NO (-82.6%)	NO
403 FAMILY ROOM	NO (-78.5%)	NO
415 DOUBLE ROOM	NO (-83.6%)	NO
411 FAMILY ROOM	NO (-78%)	NO
409 FAMILY ROOM	NO (-77.9%)	NO
407 FAMILY ROOM	NO (-77.9%)	NO
405 FAMILY ROOM	NO (-78%)	NO
412 FAMILY ROOM	NO (-77.4%)	NO
410 FAMILY ROOM	NO (-72.7%)	NO
408 FAMILY ROOM	NO (-72.4%)	NO
406 FAMILY ROOM	NO (-72%)	NO
404 FAMILY ROOM	NO (-86.2%)	NO
413 FAMILY ROOM	NO (-81.6%)	NO
514 SUPER DOUBLE ROOM	NO (-76%)	NO
518 SUPER DOUBLE ROOM	NO (-73.9%)	NO
520 SUPER DOUBLE ROOM	NO (-74%)	NO
522 SUPER DOUBLE ROOM	NO (-74%)	NO
524 SUPER DOUBLE ROOM	NO (-74.3%)	NO
526 SUPER DOUBLE ROOM	NO (-74%)	NO
528 SUPER DOUBLE ROOM	NO (-74.3%)	NO
530 SUPER DOUBLE ROOM	NO (-74.1%)	NO
532 SUPER DOUBLE ROOM	NO (-74.1%)	NO
534 SUPER DOUBLE ROOM	NO (-74%)	NO
538 SUPER DOUBLE ROOM	NO (-75.6%)	NO
516 SUPER DOUBLE ROOM	NO (-74%)	NO
519 SUPER DOUBLE ROOM	NO (-79.6%)	NO
521 SUPER DOUBLE ROOM	NO (-79.6%)	NO
523 SUPER DOUBLE ROOM	NO (-79.6%)	NO
525 SUPER DOUBLE ROOM	NO (-79.6%)	NO
527 SUPER DOUBLE ROOM	NO (-79.5%)	NO
529 SUPER DOUBLE ROOM	NO (-79.6%)	NO
531 SUPER DOUBLE ROOM	NO (-79.5%)	NO
533 SUPER DOUBLE ROOM	NO (-79.7%)	NO
535 SUPER DOUBLE ROOM	NO (-79.6%)	NO
537 SUPER DOUBLE ROOM	NO (-79.3%)	NO
539 SUPER DOUBLE ROOM	NO (-83%)	NO
512 SUPER FAMILY ROOM	NO (-76.6%)	NO
515 SUPER DOUBLE ROOM	NO (-80.8%)	NO
511 SUPER FAMILY ROOM	NO (-78%)	NO
509 SUPER FAMILY ROOM	NO (-77.9%)	NO
507 SUPER FAMILY ROOM	NO (-77.9%)	NO
505 SUPER FAMILY ROOM	NO (-78%)	NO
503 SUPER FAMILY ROOM	NO (-78.5%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
502 SUPER ACCESSIBLE ROOM	NO (-81.1%)	NO
510 SUPER FAMILY ROOM	NO (-72%)	NO
508 SUPER FAMILY ROOM	NO (-71.9%)	NO
506 SUPER FAMILY ROOM	NO (-71.8%)	NO
504 SUPER FAMILY ROOM	NO (-86.1%)	NO
536 SUPER DOUBLE ROOM	NO (-73.9%)	NO
513 SUPER FAMILY ROOM	NO (-81.6%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER and BPEC

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

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

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	4636.6	4636.6
External area [m^2]	4856.3	4856.3
Weather	CAR	CAR
Infiltration [m^3/hm^2@ 50Pa]	3	4
Average conductance [W/K]	1425.57	2671.55
Average U-value [W/m^2K]	0.29	0.55
Alpha value* [%]	10.09	10

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

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
100	**C1 Hotels**
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
	C2 Residential Institutions: Universities and colleges
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

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

	Actual	Notional
Heating	6.63	29.68
Cooling	0.44	1.31
Auxiliary	5.08	4.1
Lighting	11.46	13.04
Hot water	203.81	214.47
Equipment*	26.82	26.82
TOTAL**	**227.42**	**262.61**

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

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	6.36
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	105.68	154.43
Primary energy* [kWh/m^2]	294.89	317.94
Total emissions [kg/m^2]	27.6	57.8

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Other local room heater - unfanned, [HS] Direct or storage electric heater, [HFT] Electricity, [CFT] Electricity										
	Actual	150.6	0	41.8	0	10	1	0	1	0
	Notional	171.4	0	55.2	0	9.6	0.86	0	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	13.2	101	0.8	4.3	11.8	4.87	6.45	5.13	6.79
	Notional	38.2	87.4	8	6.4	15.7	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	170.2	0.6	8.2	0	0	5.76	6.68	6.06	7.03
	Notional	248.4	12.4	52	0.9	0	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	133.8	1.2	6.9	0	0	5.42	6.52	5.7	6.86
	Notional	190.1	10.3	39.8	0.8	0	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	15.9	153	0.9	6.6	20.1	4.87	6.45	5.13	6.79
	Notional	35.6	177.9	7.5	13	6.9	1.33	3.79	----	----
[ST] Split or multi-split system, [HS] Heat pump (electric): air source, [HFT] Electricity, [CFT] Electricity										
	Actual	16.8	155.8	1	6.7	8.2	4.87	6.45	5.13	6.79
	Notional	94.2	206.7	19.7	15.2	2.9	1.33	3.79	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency
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