Georgiana Street, London NW1 0QS

Bangor Wharf

Report to accompany planning application:

Energy & Sustainability Assessment
Couch Perry Wilkes

February 2017

couchperrywilkes
engineering change

Bangor Wharf
Energy and Sustainability Assessment for Planning

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1.0 Executive Summary

In accordance with London Plan policy 5.2, 5.3, 5.5, 5.6, 5.7 and 5.9, Couch Perry Wilkes (CPW) has produced Sustainability and Energy Assessment to support a planning application for the proposed residential development located in Georgiana Street, Bangor Wharf site. The project encompasses demolition of all buildings on-site and new buildings of 1-6 storeys in height to include 40 residential (C3) units (16 x 1 bed, 15 x 2 bed and 9 x 3 bed) of which 34 would be market units and 6 affordable, 813 m^2 (GEA), of new office floor space (B1a), 55 m^2 (GEA) storage and distribution floor space (B8) and associated works to highways and landscaping.

This is the second iteration of the Energy and Sustainability Assessment Report incorporating previous constructive feedback in relation to achieving the carbon emission reduction and potential connection to a decentralised energy network.

The statement will demonstrate how the scheme will incorporate energy efficiency measures, decentralised energy sources and Low and Zero Carbon (LZC) technology solutions to reduce the predicted regulated CO_2 emissions of the development by at least 35.0% against Building Regulations Part L 2013 standards.

Couch Perry and Wilkes have carried out an energy appraisal of the development, and have adopted the following strategy to offset a minimum of 35% CO_2 emissions.

1. By utilising good passive measure by utilising good envelope design and proficient use of services a 7.60% reduction of CO_2 emissions has been achieved (Be Lean).

2. By introducing an onsite Combined Heat Power (CHP) installation to provide circa 30% of the annual heating usage and 98% of the annual water heating for the building a 25.27% reduction of CO_2 emissions has been achieved (Be Clean).

3. In addition to using an onsite combined heat power installation a Solar Photovoltaic installation shall be introduced which provides a 2,218 kWh/annum, 3 kWp Peak (approx. 24m^2) output this will contribute to a 2.42% reduction of CO_2 emissions associated with the building (Be Green).

In line with policy 5.2E, the remaining regulated carbon dioxide emission, to 100 per cent, are to be off-set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere.

In addition to the residential units the development also contains new B1 type office spaces on the ground floor which will follow the principles of the Building Regulations Part L2A and requirements from the London Plan. In order for the units to comply with the above requirements the following solution has been derived:

- Space heating provided by CHP,
- Domestic hot water provided by electric point of use heaters
- Mechanical Ventilation Heat Recovery Ventilation (MVHR),
- Air permeability of the building – 4.0 $m^3/(h.m^2)$ at 50Pa
- Windows U-value – 1.3 W/m^2K (g-value – 0.4)
- PV requirement – 6317kWt (approx. 8.5kWp peak output, 68m^2 array)

- The London Heat Map has been reviewed, and it has highlighted a potential opportunity of a heat network being extended / introduced around the Bangor Wharf in the future. With this in mind, within the plantroom a space allocation has been provided with a view to potential connection in the future.

Air Quality and Acoustic Assessments

Air quality and acoustic assessments have been undertaken by Mayer Brown and Sharps Redmore (respectively) of which results show that the area is subject to excessive pollution levels. As a result, mitigation measures shall be required to protect existing and prospective residents. These shall include the following methods:

- Boiler & CHP Plant – A low emission strategy shall be implemented that utilises low NOx boilers and CHP plant.
  Based on the plant selection it is currently anticipated that the following NOx will be emitted from the following plant prior to the NOx filtration:
  - Boiler – 36 mg/kWh @ 0% O2
  - CHP - 0 mg/kWh @ 0% O2

  Note 1. NOx emissions are provided from the manufacturers' datasheets.
- Ventilation – The majority of the building will be provided with the heat recovery mechanical ventilation with exception to few apartments where local mechanical extract will be provided. However, mechanical supply ventilation complete with carbon filtration may be necessary to optimise air quality and limit sound transmission in habitable areas (the extent of which shall be confirmed during the next stage of the project).

2.0 Introduction

In accordance with London Plan policy 5.2, 5.3, 5.5, 5.6, 5.7 and 5.9, Couch Perry Wilkes (CPW) has produced Sustainability and Energy Assessment to support a planning application for the proposed residential development located in Georgiana Street, Bangor Wharf site. The project encompasses demolition of all buildings on-site and new buildings of 1-6 storeys in height to include 40 residential (C3) units (16 x 1 bed, 15 x 2 bed and 9 x 3 bed) of which 34 would be market units and 6 affordable, 813 m^2 (GEA), of new office floor space (B1a), 55 m^2 (GEA) storage and distribution floor space (B8) and associated works to highways and landscaping. The statement will demonstrate how the scheme will:

- Incorporate energy efficiency measures, decentralised energy sources and Low and Zero Carbon (LZC) technology solutions to reduce the predicted regulated CO_2 emissions of the development by at least 35.0% against Building Regulations Part L 2013.

The London Plan Policy is aligned with Policy 5.2 of the London Plan 2011 which sets out an Energy Hierarchy for reducing CO_2 emissions in the form:

1. Be Lean: use less energy
2. Be Clean: supply energy efficiently
3. Be Green: use renewable energy

The Energy Hierarchy is further developed through Policies 5.3, 5.5 and 5.6 pertaining to decentralised energy networks and Policy 5.7 pertaining to the provision of renewable energy.

This report will address all aspects of the above in accordance with Greater London Authority (GLA) guidance published in March 2016.

3.0 Energy Benchmarking

3.1 Estimated Energy Demands and CO_2 Emissions

In order to benchmark the proposed new development, estimated energy demands and CO_2 emissions data have been calculated utilising approved DSM software for the residential and non-residential part of the development (SAP and DSM respectively). These estimated energy consumptions are indicative only at this stage. They will, however, be used as a guideline to assess the percentage of the building's total energy consumption and CO_2 emissions that could be reduced or offset in accordance with the Energy Hierarchy.

In accordance with GLA guidance, it is prudent for this report to reflect the benchmark data derived from approved software which uses government and industry agreed National Calculation Methodology (NCM) room templates containing standard operating conditions.

To assist with the formulation of an energy strategy, the estimated regulated energy consumption and CO_2 emissions of each scenario for the notional development have been derived from software:

1. The estimated energy demands for residential part of the development are shown below:

The total predicted regulated notional development energy consumption is: **235,499 kWhr per year**

The total predicted notional CO_2 emissions are (TER): **47,539 kgCO_2 per year**

2. The estimated energy demands for commercial part of the development are shown below:

The total predicted regulated notional development energy consumption is: **36,593 kWhr per year**

The total predicted notional CO_2 emissions are (TER): **13,823 kgCO_2 per year**

Note 2. CO_2 emission factors of 0.216 for Gas and 0.519 for Electricity have been used to calculate the above and are taken from Building Regulations Approved Documents.

4.0 Energy Efficiency – Be Lean

In order to deliver an environmentally responsible building, an exemplar approach is being proposed based on low energy design principles. In summary, this approach involves energy demand minimisation through effective building form and orientation, good envelope design and proficient use of services; such that the building itself is being used as the primary environmental modifier.

Long term energy benefits are best realised by reducing the inherent energy demand of the building in the first instance. These benefits are described and quantified as follows:

4.1 Building Design – Energy Efficiency

The general construction design standards to be adopted must exceed the requirements of the current (2013 Edition) Part L Building Regulations which stipulate an improvement on the CO_2 emissions of an aggregated 6% against 2010 standards.

The building envelope will be designed to ensure that the fabric and form of the residential development encompasses the low energy sustainability principles.

The following table (Table 1) describes the proposed minimum building envelope thermal performance criteria.

Element	Part L 2013 Building Regulations U-Value (W/m^2K)	Target U-Value (W/m^2K)	Notes
General Glazing (including frame) and Roof Lights	U = 2.20	U = 1.30	g-value: North, East – 0.50, offices – 0.40, south and west elevation – 0.40 with blinds
External Walls	U = 0.35	U = 0.18	Metsec
Roof	U = 0.25	U = 0.15	
Ground Floor	U = 0.25	U = 0.12	
Thermal Bridging ψ Value	-	0.13 W/mK	

Table 1. Summary of Building Envelope Thermal Performance Criteria

In accordance with the requirements of a low energy building, the air tightness characteristics will be addressed. With robust design, the target proposed for the building is $4.0m^3/m^2/hr$ @ 50Pa. This compares to the current Part L Building Regulations standard of $10m^3/m^2/hr$ @ 50Pa and hence represents an improvement of 60%.

High levels of natural daylight will be provided, wherever possible, through effective window design. The glazing specifications for the new building will be optimised to ensure that the glazed elements provide excellent thermal performance combined with optimum solar reflectance to minimise summer solar heat gains along with high daylight transmittance factors to maximise daylight factors. Encouraging the correct quality and quantity of daylight to penetrate the building is key to reducing the amount of light required from artificial sources and hence energy requirements.

It is imperative that the lighting design philosophy provides the correct quality of lighting with minimum energy input and hence reduce internal heat gains. In the building, all luminaires using fluorescent and compact fluorescent lamps will utilise high frequency control gear, and lighting schemes within occupied areas will be appropriately zoned to allow control of luminaires via switches/ and or absence detection and daylight sensors where applicable. Output performance or Light Output Ratios (LORs) will have to exceed 80%.

Lighting to the external areas within the scheme will employ the latest lighting technology.

To complement the significant improvements in envelope design and lighting provision, the correct selection of the building services heating and ventilation systems being proposed will also drastically reduce the inherent energy consumption of the site.

The provision of an effective control and metering philosophy is fundamental to the efficient operation of the building's environmental services. The following provides an overview of the plant efficiency and control measures that are proposed:

- Low NO_x high efficiency boilers.
- Low temperature flow and return hot water heating to maximise heat generating efficiency and minimise distribution losses.
- High efficiency heat recovery ventilation within the apartments where applicable.
- Modular open architecture control systems and associated network for controlling the main plant.
- High efficiency low energy motors to be used to drive the localised mechanical ventilation systems.
- Variable speed pumps to be used to promote lower operating costs and help match energy usage with the operating profile and occupancy of the building.
- Sub-metering to be provided such that approximately 90% of the input energy from each utility service may be accounted for at end use. The Building Management System (BMS) will be interfaced to provide automatic monitoring and targeting of all sub-meters to promote energy management and deliver lower consumption.

5.0 Decentralised Energy – Be Clean

Opportunities to connect the planned development to existing or future decentralised heat distribution networks, including those featuring Combined Heat and Power (CHP) plant, have been investigated with reference to the London Heat Map.

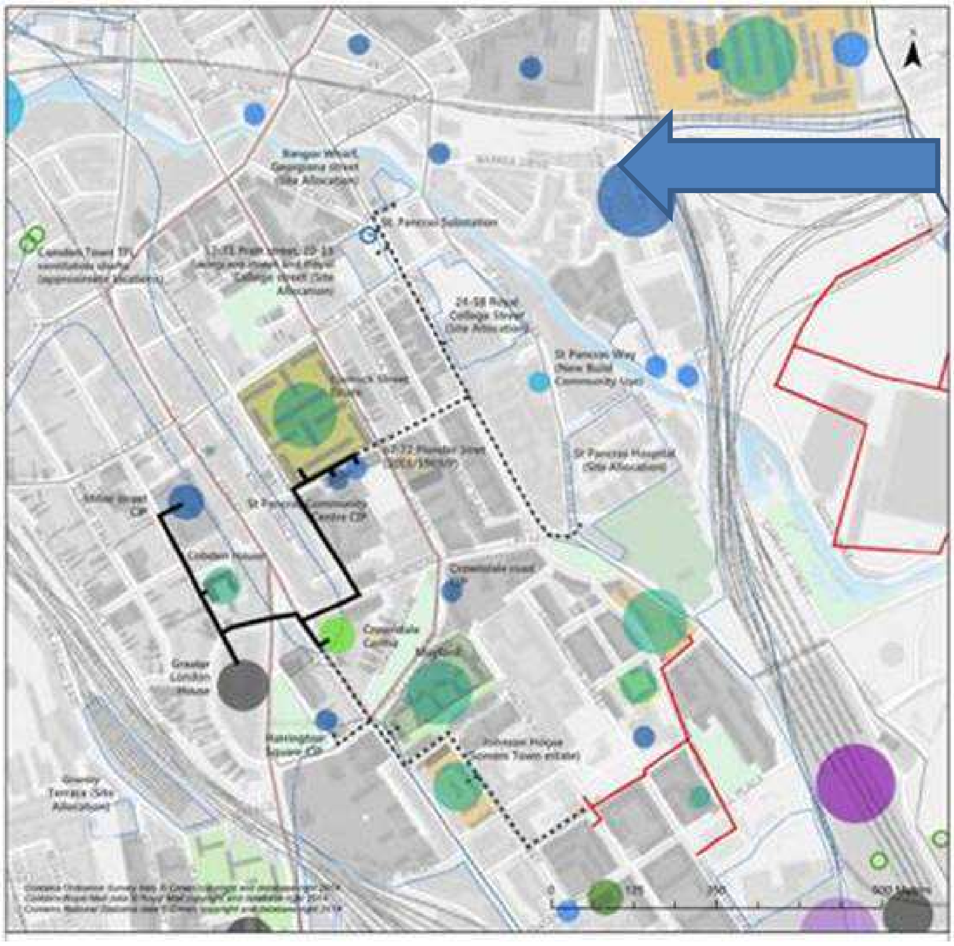

Figure 1. London Heat Map Image of Proposed Site Showing Potential Future Network

A recent study of this area suggested potential for a decentralised energy connection between the Bangor Wharf site and other nearby developments.

Having taken this into account, the London Heat Map was investigated in conjunction with the London Plan policy 5.5 and 5.6 on decentralised energy networks. As a result, a space will be provided within the plant room of the proposed development for the provision of connection into a network when available.

We have also evaluated whether the proposed Combined Heat and Power system for Bangor Wharf could be extended to serve nearby developments. Unfortunately this has been deemed unfeasible due to the spatial constraints of the site.

6.0 Appraisal of Renewable and Low Carbon Technology Energy Options – Be Green

The technical feasibility and economic viability of installing each LZC technology at the residential development at Bangor Wharf have been assessed in order to discount any unsuitable options at an early stage. A summary of the feasibility process is tabulated below and an overview of each viable technology is given subsequently.

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
Solar Photovoltaic	Solar photovoltaic panels convert solar radiation into electrical energy through semiconductor cells. They are not to be confused with solar panels which use the sun's energy to heat water (or air) for water and space heating.	Low maintenance/no moving parts Easily integrated into building design No ongoing costs Income generated from Feed-in Tariff (FIT)	Any overshadowing reduces panel performance Panels ideally inclined at 30º to the horizontal facing a southerly direction	Yes, it is currently considered as a feasible LZC technology
Solar Thermal	Solar thermal energy can be used to contribute towards space heating and hot water requirements. The two commonest forms of collector are panel and evacuated tube.	Low maintenance Little/no ongoing costs Income generated from Renewable Heat Incentive (RHI) scheme	Must be sized for the building hot water requirements Panels ideally inclined at 30º to the horizontal facing a southerly direction	No, consideration for CHP to be used to suit domestic water load. A reliable energy source needs to be used to ensure hot water is generated.
Ground Source Heat Pump (GSHP)	GSHP systems tap into the earth's considerable energy store to provide both heating and cooling to buildings. A number of installation methods are possible including horizontal trench, vertical boreholes, piled foundations (energy piles) or plates/pipe work submerged in a large body of water. The design, installation and operation of GSHPs is well established.	Minimal maintenance Unobtrusive technology Flexible installation options to meet available site footprint Income generated from Renewable Heat Incentive (RHI) scheme	Large area required for horizontal pipes Full ground survey required to determine geology More beneficial to the development if cooling is required Integration with piled foundations must be done at an early stage	No, prohibitively expensive installation costs and no land available
Air Source Heat Pump	Electric or gas driven air source heat pumps extract thermal energy from the surrounding air and transfer it to the working fluid (air or water).	Efficient use of fuel Relatively low capital costs	Specialist maintenance More beneficial to the development if cooling is required Requires defrost cycle in extreme conditions	No, low NO_x boilers providing the heating

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
			Some additional plant space required	
Wind Turbine *(Stand-alone column mounted)*	Wind generation equipment operates on the basis of wind turning a propeller, which is used to drive an alternator to generate electricity. Small scale (1kW – 15kW) wind turbines can be pole or roof mounted.	Low maintenance/ongoing costs Minimum wind speed available *(www.bwea.com)* Excess electricity can be exported to the grid Income generated from Feed-in Tariff (FIT)	Planning issues Aesthetic impact and background noise Space limitations on site Wind survey to be undertaken to verify 'local' viability	No, not suitable on this site
Wind Turbine *(Roof Mounted)*	As above	Low maintenance/ongoing costs Minimum wind speed available *(www.bwea.com)* Excess electricity can be exported to the grid Income generated from Feed-in Tariff (FIT)	Planning issues Aesthetic impact and background noise Structural/vibration impact on building to be assessed Proximity of other buildings raises issues with downstream turbulence Wind survey to be undertaken to verify 'local' viability	No, not suitable on this site
Gas Fired Combined Heat and Power	A Combined Heat and Power (CHP) installation is effectively a mini on-site power plant providing both electrical power and thermal heat. CHP is strictly an energy efficiency measure rather than a renewable energy technology.	Potential high CO_2 saving available Efficient use of fuel Excess electricity can be exported to the grid Subject to UKPN Approval Benefits from being part of an energy centre/district heating scheme	Maintenance intensive Sufficient base thermal and electrical demand required Some additional plant space required	Yes, it is currently considered as a feasible LZC technology
Bio-fuel Fired Combined Heat and Power	As above.	Potential high CO_2 saving available Efficient use of fuel Excess electricity can be exported back to the grid Benefits from being part of an energy centre/district heating	Maintenance intensive Sufficient base thermal and electrical demand required Significant plant space required Biomass fuelled systems are at early stages of	No, limited availability of fuel making it economically unviable

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
		scheme Income generated from Renewable Obligation Certificates (ROCs) and Renewable Heat Incentive (RHI) scheme	commercialisation Large area needed for fuel delivery and storage Reliable biomass fuel supply chain required	
Bio-Renewable Energy Sources *(Automated feed – wood-fuel boiler plant)*	Modern wood-fuel boilers are highly efficient, clean and almost carbon neutral (the tree growing process effectively absorbs the CO_2 that is emitted during combustion). Automated systems require mechanical fuel handling and a large storage silo.	Stable long term running costs Potential good CO_2 saving Income generated from Renewable Heat Incentive (RHI) scheme	Large area needed for fuel delivery and storage Reliable fuel supply chain required Regular maintenance required Significant plant space required	No, limited availability of fuel making it economically unviable
Fuel Cells and Fuel Cell Combined Heat and Power	Fuel cells convert the energy of a controlled chemical reaction, typically involving hydrogen and oxygen, into electricity, heat and water vapour. Fuel cell stacks operate in the temperature range 65°C – 800°C providing co-generation opportunities in the form of Combined Heat and Power (CHP) solutions.	Zero CO_2 emissions if fired on pure hydrogen and low CO_2 emissions if fired on other hydrocarbon fuels Virtually silent operation since no moving parts High electrical efficiency Excess electricity can be exported back to the grid Benefits from being part of an energy centre/district heating scheme	Expensive Pure hydrogen fuel supply and distribution infrastructure limited in the UK Sufficient base thermal and electrical demand required Some additional plant space required Reforming process, used to extract hydrogen from alternative fuels, requires energy; lowering overall system efficiency	No, expensive, emerging technology

Table 2. Summary of Renewable and Low Carbon Technology Energy Options

6.1 Combined Heat and Power

A CHP installation is effectively an on-site mini power station providing both electrical power and thermal heat. CHP is strictly an energy efficiency measure rather than a renewable energy technology. A CHP system operates by burning a primary fuel (normally natural gas) by use of either a reciprocating engine or turbine, which in turn drive an alternator to generate electrical power. The heat emitted by the engine and exhaust gases is recovered and used to heat the building or to provide hot water.

Figure 2. Small Scale Gas Fired CHP System

The viability of CHP is dependant upon the building base load requirements for both heat and power. 24 hour buildings with high heat demands and constant power demands lend themselves to CHP.

The noise levels associated with a CHP installation should not be overlooked. Typically, acoustic enclosures and upgraded low noise attenuators are employed to ensure noise levels don't exceed 65dBA when 1m from the unit. On confined sites, the plant room structure can be enhanced and attenuators fitted to the mechanical ventilation to prevent any noise issues.

CHP systems are normally grid connected to enable any excess generated electricity to be exported to the grid when circumstances allow – Subject to UKPN Approval. In order to charge the electricity supplier for any energy that is exported, a bi-directional electricity meter will have to be installed. Technical approval must be obtained from the Distribution Network Operator (DNO) to enable the CHP system to run in parallel with the grid. For a CHP system to operate in 'parallel mode' with the DNO electrical supply, the design and installation must be undertaken with reference to the requirements of the following standards and regulations for synchronisation, protection and isolation:

G59/1	Electricity Councils Chief Engineers Regulations
72/23/EEC	The Low Voltage Directive
89/336/EC	Electromagnetic Compatibility
17th Edition	IEE Wiring Regulations
BS EN 60034	General requirements for rotating electrical machines

The benefits of connecting a building with extended occupancy hours to a CHP system or, better still, a CHP system forming part of a district/community heating network like this system are well known.

The key to establishing the viability of CHP for inclusion on a particular project is to model/predict the occupancy profile, particularly in terms of the base domestic hot water demands associated with the building.

An initial evaluation indicates that a CHP system with a thermal capacity of circa 20kW would be viable for the scheme given the envisaged load profile and domestic hot water requirements. A thermal buffer vessel will be provided to prevent the CHP engine shutting down unnecessarily when the heating load demand falls during the course of the day.

SAV Systems supply a modular unit with an electrical output of 9kW@30% efficiency and a thermal output of 19.2kW@60% that would effectively contribute to the carbon reduction of the development.

“Where this proposal includes embedded co-generation of electricity using Combined Heat and Power (CHP), Photo-voltaic cells (PV) or the like, it is assumed that the relevant Distribution Network Operator (DNO)/National Grid plc (NG) will allow connection of the same to their network. This situation may be subject to change at any time based on the limited capacity of the DNO’s/NG’s existing switchgear to withstand a system fault levels that are increased by the addition of embedded generation to a level where work is required to replace assets. There may also be restrictions imposed by National Grid on the DNO to restrict reverse power flows into their network, which again could limit the amount of embedded generation that can be connected. The situation will remain uncertain until a formal offer from the DNO has been accepted and NG has provided a statement of works confirming that their assets do not require upgrading.”

6.2 Solar Photovoltaic (PV) Panels

Solar photovoltaic panels convert solar radiation into electrical energy through semiconductor cells. They are not to be confused with solar panels which use the sun's energy to heat water (or air) for water and space heating.

Figure 3. CPW Photovoltaic Installations: Project Epic (BREEAM Excellent Office – above left) and Castle Wood (BREEAM Excellent School – above right)

Photovoltaic panels are available in a number of forms including mono-crystalline, polycrystalline, amorphous silicon (thin film) or hybrid panels (discussed later). They are fixed or integrated into a building's un-shaded south facing façade or pitched roof ideally at an incline of 30º to the horizontal for maximum energy yield.

Figure 4. Solar PV Louvres on the South Facade

It is essential that the panels remain un-shaded, as even a small shadow can significantly reduce output. The individual modules are connected to an inverter to convert their direct current (DC) into alternating current (AC) which is usable in buildings.

Although sloping rooftops provide an ideal site for fixing PV panels using traditional mounting frames, there are a number of alternative solutions whereby PV panels can be incorporated into the actual building fabric of the development.

Solar louvres use PV panels to provide solar shading on the south façade of buildings as part of the brise soleil (see above), and this can be a highly effective way of controlling overheating and help reduce glare.

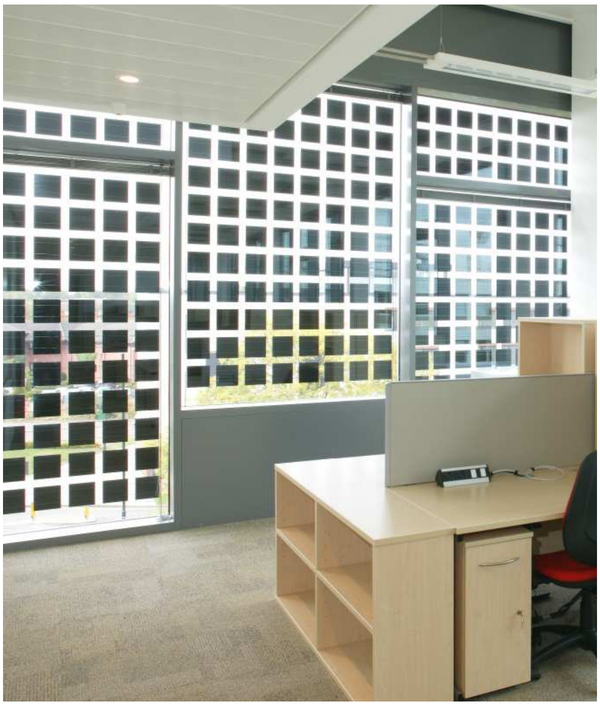 

Figure 5. CPW Solar Glazing Installation, University of Warwick - Materials and Analytical Sciences Building

Solar glazing uses a combination of solar PV and glass, where the PV cells are laminated between two panes of specialised glazing (see above). The resulting glass laminate serves the dual function of creating energy and shade at the same time, reducing the risk of overheating. Solar glazing can be used wherever conventional glass would be specified, especially in atria. Bespoke designs allow for varying light penetration by changing the spacing between individual cells. Typically, a combination of 50% PV and 50% translucent glazing is used.

Vertical solar facades can be used to directly replace conventional rain screen cladding materials providing a smooth, flat facade surface for the building. Where circumstances allow, the PV panels can be tilted towards the sun to maximize the energy yield.

Photovoltaic technology may be feasibly incorporated into the building design with little/no maintenance or on-going costs. Installations are scalable in terms of active area; size being restricted only by available façade and/or roof space.

A particular advantage of solar PV, even over other types of LZC technology, is that running costs are very low (requires no fossil fuel for operation) and, since there are no moving parts, very little maintenance is required.

An initial assessment has determined that a PV installation achieving 8535 kWh/annum (approximate array with an active area of 92m2) will be required to support B1 space and the residential development to satisfy the requirements outlined within London Plan.

"Where this proposal includes embedded co-generation of electricity using Combined Heat and Power (CHP), Photo-voltaic cells (PV) or the like, it is assumed that the relevant Distribution Network Operator (DNO)/National Grid plc (NG) will allow connection of the same to their network. This situation may be subject to change at any time based on the limited capacity of the DNO's/NG's existing switchgear to withstand a system fault levels that are increased by the addition of embedded generation to a level where work is required to replace assets. There may also be restrictions imposed by National Grid on the DNO to restrict reverse power flows into their network, which again could limit the amount of embedded generation that can be connected. The situation will remain uncertain until a formal offer from the DNO has been accepted and NG has provided a statement of works confirming that their assets do not require upgrading."

7.0 Summary and Conclusions

In order to deliver an environmentally responsible development, an exemplar approach is being proposed based on low energy design principles. In summary, this approach involves energy demand minimisation through effective building form and orientation, good envelope design and proficient use of services before considering the use of LZC technologies to decarbonise the energy supply – in line with the Energy Hierarchy.

It has been shown via accredited computer modelling that, by incorporating best practice energy efficiency measures together with a solar photovoltaic panels and CHP, the CO_2 emissions for the scheme, can be reduced by 35% compared to a 2013 version of notional development as follows:

Residential Apartments:

	Carbon Dioxide Emissions (Tonnes CO_2 per annum)
	Regulated Energy
Baseline: Part L 2013 of the Building Regulations Compliant Development	47.539
After Energy Demand Reduction	43.925
After CHP	31.912
After Renewable Energy	30.761

Table 3. CO_2 Emissions after each Stage of the Energy Hierarchy

	Regulated CO_2 Savings	
	Tonnes	%
Savings from Energy Demand Reduction	3.614	7.6
Saving from CHP	12.013	25.27
Saving from Renewable Energy	1.151	2.42
Total Cumulative Savings	**16.778**	**35.29**
Total Target Savings	**16.639**	**35%**
Annual Surplus	**0.139**	

Table 4. Regulated CO_2 Savings from each Stage of the Energy Hierarchy

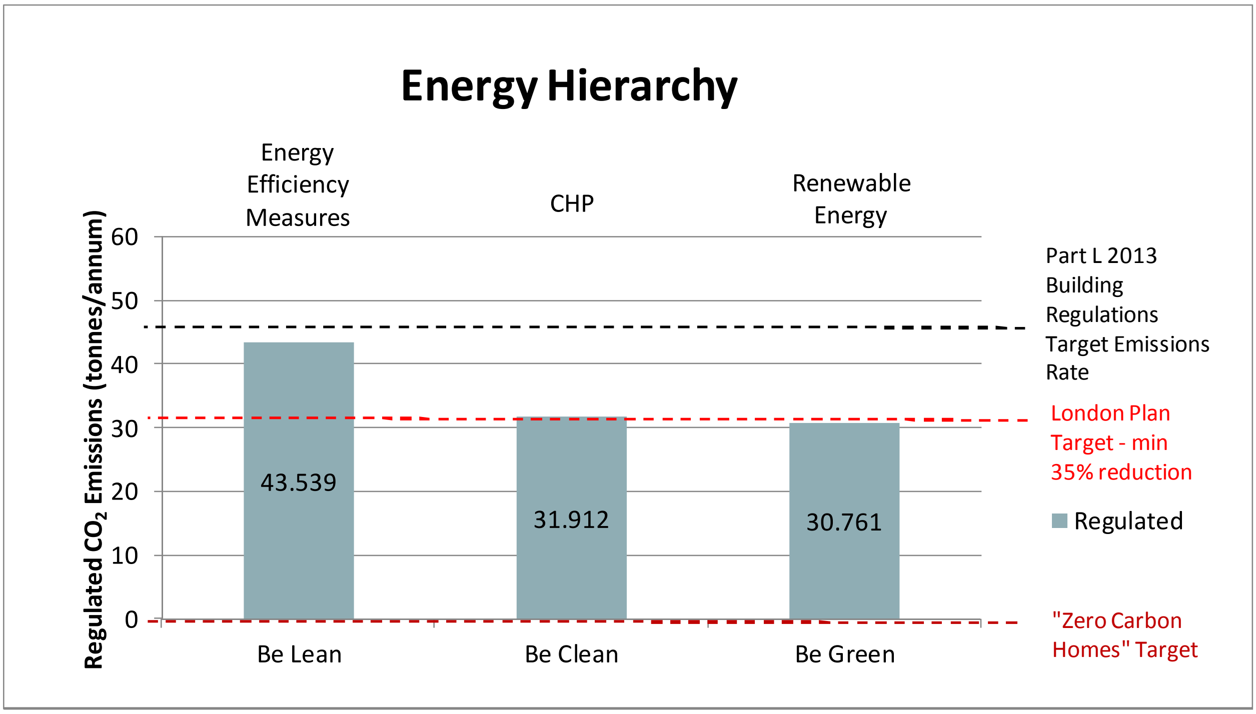

Figure 6. Strategy 1: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

PV Requirements:

- Estimated PV generation – 2218 kWh,
- Estimated PV Array – 24m^2

Commercial B1 Office & B8 Storage Space:

	Carbon Dioxide Emissions (Tonnes CO_2 per annum)
	Regulated Energy
Baseline: Part L 2013 of the Building Regulations Compliant Development	13.823
After Energy Demand Reduction	12.684
After CHP	12.076
After Renewable Energy	8.810

Table 5. Commercial Unit: CO_2 Emissions after each Stage of the Energy Hierarchy

	Regulated CO_2 Savings	
	Tonnes	%
Savings from Energy Demand Reduction	1.139	8.2
Saving from CHP	608	4.4
Saving from Renewable Energy	3.266	23.6
Total Cumulative Savings	**5.013**	**36.2**
Total Target Savings	**4.838**	**35%**
Annual Surplus	**0.175**	

Table 6. Commercial Unit: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

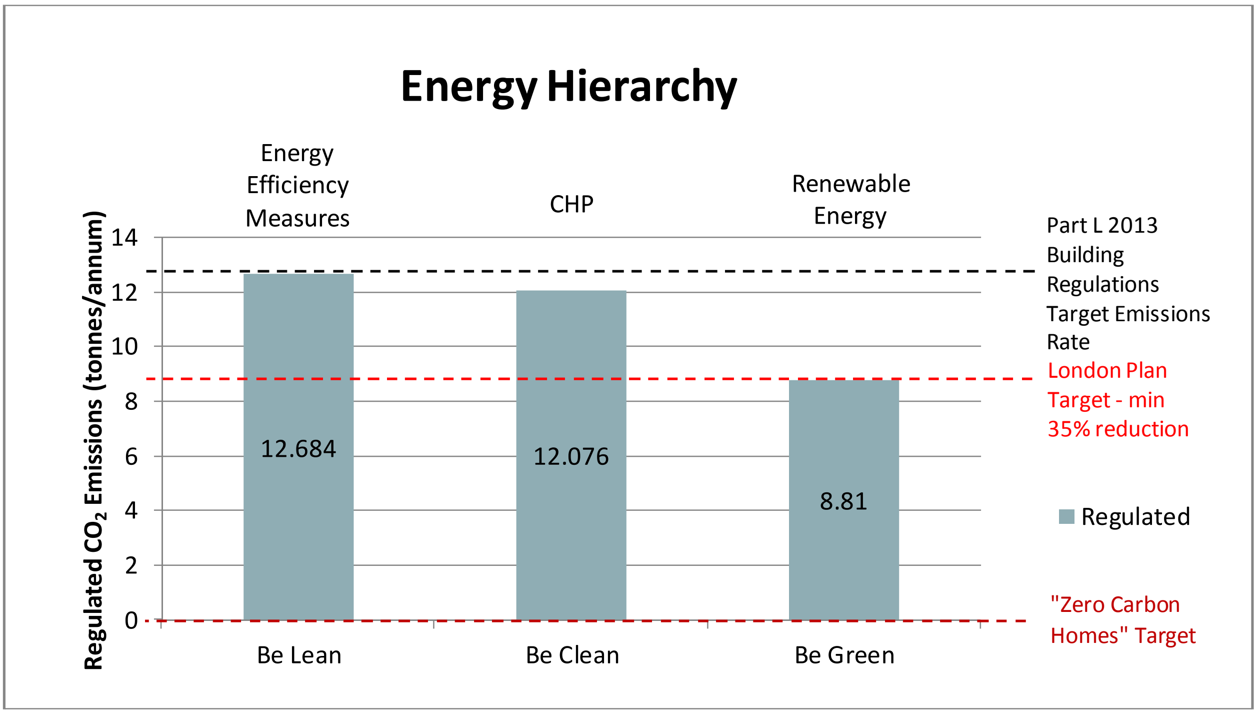

Figure 7. Commercial Unit: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

PV Requirements:

- Estimated PV generation – 6317 kWh,
- Estimated PV Array – 68m^2

Recommendation/Conclusion:

Having reviewed the feasibility of installing each LZC technology solution, the following combination is the most favourable option for the scheme, at this stage, in order to provide a minimum of 35% reduction in CO_2 emission comparing to notional development of Building Regulations Part L 2013 version.

- **Strategy 4 for Residential Units:**
  - 30% of space heating met by CHP,
  - 98% of water heating met by CHP (allowance made for maintenance and service)
  - Mechanical Ventilation with heat Recovery (MVHR) to all private apartments,
  - Mechanical Extract Ventilation (CMEV) to affordable apartments
  - Air permeability of the building – 4.0 $m^3/(h*m^2)$ at 50Pa
  - Windows U-value – 1.3 W/m^2K
  - PV requirement – 2,218 kWh/annum, 3 kWp Peak (approx. 24m^2)

- **Commercial B1 Office Space:**
  - Space heating provided by CHP,
  - Domestic hot water provided by electric point of use heaters
  - Mechanical Ventilation Heat Recovery Ventilation (MVHR),
  - Air permeability of the building – 4.0 $m^3/(h.m^2)$ at 50Pa
  - Windows U-value – 1.3 W/m^2K (g-value – 0.4)
  - PV requirement – 6317kWt (approx. 8.5kWp peak output, 68m^2 array)

8.0 Appendix A – SAP Documentation

See accompanying documentation.

Bangor Wharf, London

London Plan - Be Lean

Property Ref	House Type.	Total Floor Area (TFA)	DER	TER	% Reduction	Block % Reduction (all plots)	DFEE	TFEE	% Reduction	Block % Reduction (all plots)
4907-0022-3120-A101	A101 1FF	73.76	17.27	17.18	-0.53		43.68	46.65	6.37	
4907-0022-3120-A102	A102 1FF	89.72	18.67	17.63	-5.88		53.69	54.30	1.13	
4907-0022-3120-A201	A201 2FF	73.76	14.08	14.41	2.28		29.69	32.28	8.02	
4907-0022-3120-A202	A202 2FF	89.72	15.04	14.65	-2.69		37.60	38.92	3.39	
4907-0022-3120-A301	A301 3FF	84.88	14.27	14.23	-0.29		33.39	35.41	5.70	
4907-0022-3120-A401	A401 4FF	84.88	17.78	17.54	-1.39		48.64	52.51	7.38	
4907-0022-3120-B101	B101 1FF	82.73	16.19	17.91	9.62		48.24	53.27	9.43	
4907-0022-3120-B102	B102 1FF	92.11	15.37	16.27	5.54		46.04	47.77	3.61	
4907-0022-3120-B103	B103 1FF	50.43	17.46	18.35	4.84	6.24%	44.03	42.00	-4.84	5.89%
4907-0022-3120-B104	B104 1FF	51.33	18.6	20.40	8.84		49.85	53.20	6.29	
4907-0022-3120-B201	B201 2FF	82.73	12.85	15.09	14.87		33.84	38.95	13.13	
4907-0022-3120-B202	B202 2FF	92.11	12.11	13.46	10.05		31.73	33.44	5.10	
4907-0022-3120-B203	B203 2FF	50.43	14.16	15.47	8.47		28.63	26.86	-6.58	
4907-0022-3120-B204	B204 2FF	51.33	14.8	17.21	14.00		33.08	36.80	10.11	
4907-0022-3120-B401	B401 4FF	82.73	16.57	18.36	9.77		49.77	55.58	10.45	
4907-0022-3120-B402	B402 4FF	92.11	15.74	16.84	6.53		47.56	50.68	6.16	
4907-0022-3120-B403	B403 4FF	50.43	17.38	18.64	6.75		43.95	43.50	-1.02	
4907-0022-3120-B404	B404 4FF	51.33	18.45	20.90	11.73		49.27	55.75	11.62	
4907-0022-3120-C101	C101 1FF	71.38	16.74	18.81	10.99		48.22	53.94	10.61	
4907-0022-3120-C102	C102 1FF	72.37	16.67	17.98	7.29		47.83	50.32	4.96	
4907-0022-3120-C103	C103 1FF	52.6	18.71	20.18	7.28		50.19	52.81	4.95	
4907-0022-3120-C104	C104 1FF	58.93	16.63	18.36	9.45		43.23	45.54	5.08	
4907-0022-3210-C201	C201 2FF	71.38	13.43	15.85	15.28		33.86	38.84	12.82	
4907-0022-3210-C202	C202 2FF	72.37	13.39	15.09	11.29		33.41	35.54	6.00	
4907-0022-3210-C203	C203 2FF	52.6	15.48	16.80	7.85	9.89%	35.91	35.32	-1.69	7.49%
4907-0022-3210-C204	C204 2FF	58.93	13.31	15.31	13.06		28.14	29.61	4.96	
4907-0022-3210-C402	C402 4FF	72.37	13.39	15.09	11.29		33.41	35.54	6.00	
4907-0022-3210-C403	C403 4FF	52.6	17.57	19.27	8.80		45.30	48.10	5.83	
4907-0022-3210-C404	C404 4FF	58.93	16.34	18.65	12.40		42.01	47.03	10.68	
4907-0022-3210-C501	C501 5FF	71.38	17.16	19.35	11.30		49.93	56.71	11.96	
4907-0022-3210-C502	C502 5FF	98.35	16.4	17.43	5.93		51.22	55.32	7.42	

Sample Multiplication (M)	TFA x DER x M	TFA x TER x M	TFA x DFEE x M	TFA x TFEE x M
1	1,274	1,267	3221.681272	3440.966578
1	1,675	1,582	4817.09737	4871.989546
1	1,039	1,063	2190.078395	2381.162188
1	1,349	1,314	3373.838659	3492.068934
1	1,211	1,208	2834.454094	3005.667122
1	1,509	1,488	4128.199181	4457.347362
1	1,339	1,482	3991.066467	4406.813269
1	1,416	1,499	4240.663179	4399.662782
1	881	925	2220.296226	2117.877894
1	955	1,047	2558.816529	2730.713279
1	1,063	1,249	2799.315956	3222.507702
1	1,115	1,240	2922.797259	3079.966469
2	1,428	1,560	2887.764786	2709.394126
2	1,519	1,767	3395.594923	3777.547604
2	2,742	3,039	8234.722559	9195.639679
2	2,900	3,102	8760.955605	9335.880506
3	2,629	2,820	6648.469574	6581.581586
2	1,894	2,146	5058.264391	5723.349991
2	2,390	2,685	6883.772339	7700.568761
2	2,413	2,602	6922.637972	7283.933992
1	984	1,061	2640.187569	2777.786507
1	980	1,082	2547.293522	2683.59733
1	959	1,131	2417.26475	2772.67358
1	969	1,092	2417.890982	2572.307279
1	814	884	1889.016948	1857.642823
1	784	902	1658.156217	1744.768891
1	969	1,092	2417.890982	2572.307279
1	924	1,013	2382.827556	2530.289786
1	963	1,099	2475.482581	2771.49872
1	1,225	1,381	3564.001436	4048.100607
1	1,613	1,715	5037.2019	5440.911371
40	43,925	47,539		
DER/TER	7.60%			

Bangor Wharf, London

London Plan - Be Clean

Property Ref	House Type.	Total Floor Area (TFA)	DER	TER	% Reduction	Block % Reduction (all plots)	DFEE	TFEE	% Reduction	Block % Reduction (all plots)
4907-0022-3120-A101	A101 1FF	73.76	12.67	17.18	26.24		43.68	46.65	6.37	
4907-0022-3120-A102	A102 1FF	89.72	14.14	17.63	19.81		53.69	54.30	1.13	
4907-0022-3120-A201	A201 2FF	73.76	9.99	14.41	30.66		29.69	32.28	8.02	
4907-0022-3120-A202	A202 2FF	89.72	11.08	14.65	24.35		37.60	38.92	3.39	
4907-0022-3120-A301	A301 3FF	84.88	10.35	14.23	27.26		33.39	35.41	5.70	
4907-0022-3120-A401	A401 4FF	84.88	13.31	17.54	24.10		48.64	52.51	7.38	
4907-0022-3120-B101	B101 1FF	82.73	12.07	17.91	32.62		48.24	53.27	9.43	
4907-0022-3120-B102	B102 1FF	92.11	11.53	16.27	29.14		46.04	47.77	3.61	
4907-0022-3120-B103	B103 1FF	50.43	12.32	18.35	32.85	31.79%	44.03	42.00	-4.84	5.89%
4907-0022-3120-B104	B104 1FF	51.33	13.32	20.40	34.72		49.85	53.20	6.29	
4907-0022-3120-B201	B201 2FF	82.73	9.26	15.09	38.65		33.84	38.95	13.13	
4907-0022-3120-B202	B202 2FF	92.11	8.78	13.46	34.78		31.73	33.44	5.10	
4907-0022-3120-B203	B203 2FF	50.43	9.55	15.47	38.27		28.63	26.86	-6.58	
4907-0022-3120-B204	B204 2FF	51.33	10.12	17.21	41.19		33.08	36.80	10.11	
4907-0022-3120-B401	B401 4FF	82.73	12.39	18.36	32.53		49.77	55.58	10.45	
4907-0022-3120-B402	B402 4FF	92.11	11.84	16.84	29.69		47.56	50.68	6.16	
4907-0022-3120-B403	B403 4FF	50.43	12.26	18.64	34.22		43.95	43.50	-1.02	
4907-0022-3120-B404	B404 4FF	51.33	13.2	20.90	36.85		49.27	55.75	11.62	
4907-0022-3120-C101	C101 1FF	71.38	12.32	18.81	34.49		48.22	53.94	10.61	
4907-0022-3120-C102	C102 1FF	72.37	12.28	17.98	31.70		47.83	50.32	4.96	
4907-0022-3120-C103	C103 1FF	52.6	13.46	20.18	33.30		50.19	52.81	4.95	
4907-0022-3120-C104	C104 1FF	58.93	11.93	18.36	35.04		43.23	45.54	5.08	
4907-0022-3210-C201	C201 2FF	71.38	9.53	15.85	39.88		33.86	38.84	12.82	
4907-0022-3210-C202	C202 2FF	72.37	9.51	15.09	37.00		33.41	35.54	6.00	
4907-0022-3210-C203	C203 2FF	52.6	10.74	16.80	36.07	34.70%	35.91	35.32	-1.69	7.49%
4907-0022-3210-C204	C204 2FF	58.93	9.13	15.31	40.36		28.14	29.61	4.96	
4907-0022-3210-C402	C402 4FF	72.37	9.51	15.09	37.00		33.41	35.54	6.00	
4907-0022-3210-C403	C403 4FF	52.6	12.5	19.27	35.12		45.30	48.10	5.83	
4907-0022-3210-C404	C404 4FF	58.93	11.68	18.65	37.38		42.01	47.03	10.68	
4907-0022-3210-C501	C501 5FF	71.38	12.67	19.35	34.51		49.93	56.71	11.96	
4907-0022-3210-C502	C502 5FF	98.35	12.49	17.43	28.36		51.22	55.32	7.42	

Sample Multiplication (M)	TFA x DER x M	TFA x TER x M	TFA x DFEE x M	TFA x TFEE x M
1	935	1,267	3221.681272	3440.966578
1	1,269	1,582	4817.09737	4871.989546
1	737	1,063	2190.078395	2381.162188
1	994	1,314	3373.838659	3492.068934
1	879	1,208	2834.454094	3005.667122
1	1,130	1,488	4128.199181	4457.347362
1	999	1,482	3991.066467	4406.813269
1	1,062	1,499	4240.663179	4399.662782
1	621	925	2220.296226	2117.877894
1	684	1,047	2558.816529	2730.713279
1	766	1,249	2799.315956	3222.507702
1	809	1,240	2922.797259	3079.966469
2	963	1,560	2887.764786	2709.394126
2	1,039	1,767	3395.594923	3777.547604
2	2,050	3,039	8234.722559	9195.639679
2	2,181	3,102	8760.955605	9335.880506
3	1,855	2,820	6648.469574	6581.581586
2	1,355	2,146	5058.264391	5723.349991
2	1,759	2,685	6883.772339	7700.568761
2	1,777	2,602	6922.637972	7283.933992
1	708	1,061	2640.187569	2777.786507
1	703	1,082	2547.293522	2683.59733
1	680	1,131	2417.26475	2772.67358
1	688	1,092	2417.890982	2572.307279
1	565	884	1889.016948	1857.642823
1	538	902	1658.156217	1744.768891
1	688	1,092	2417.890982	2572.307279
1	658	1,013	2382.827556	2530.289786
1	688	1,099	2475.482581	2771.49872
1	904	1,381	3564.001436	4048.100607
1	1,228	1,715	5037.2019	5440.911371
40	31,912	47,539		
DER/TER	32.87%			

9.0 Appendix B – BRUKL output document

See accompanying documentation.

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

Bangor Wharf B1 B8 Part L Analysis_with 20kW CHP + 6317kWh PV68

As designed

Date: Tue Feb 21 15:03:30 2017

Administrative information

Building Details

Address: London, NW1 0QS

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.6

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.6

BRUKL compliance check version: v5.2.g.3

Owner Details

Name:

Telephone number:

Address: , ,

Certifier details

Name: Couch Perry Wilkes

Telephone number: 0121 709 6600

Address: Interface 100 , Arleston Way, Solihull, B90 4LH

Criterion 1: The calculated CO_2 emission rate for the building should not exceed the target

CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	18.2
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	18.2
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	11.6
Are emissions from the building less than or equal to the target?	BER =< TER
Are as built details the same as used in the BER calculations?	Separate submission

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

Values not achieving 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	0.18	0.18	L0000001:Surf[5]
Floor	0.25	0.12	0.12	L0000001:Surf[0]
Roof	0.25	0.15	0.15	L0000002:Surf[1]
Windows***, roof windows, and rooflights	2.2	1.33	1.33	L0000001: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/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* 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	4

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	NO
Whole building electric power factor achieved by power factor correction	<0.9

1- LTHW Heating Via Radiator with Mechanical Ventilation (Heat Recovery - 75%)

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.95	-	0.3	0	0.75
Standard value	0.91*	N/A	N/A	N/A	0.65
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.					

2- LTHW Heating Via Radiator with Nat Vent

	Heating efficiency	**Cooling efficiency**	**Radiant efficiency**	**SFP [W/(l/s)]**	**HR efficiency**
This system	0.95	-	0	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.					

1- Domestic Hot Water - Point of use system

	Water heating efficiency	**Storage loss factor [kWh/litre per day]**
This building	1	0.002
Standard value	1	N/A

1- CHECK2-CHP

	CHPQA quality index	**CHP electrical efficiency**
This building	0	0.29
Standard value	Not provided	N/A

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**
L00:RETAIL UNIT01	-	-	-	1.6	-	-	-	-	-	-	N/A
L00:RETAIL UNIT02	-	-	-	1.6	-	-	-	-	-	-	N/A
L00:RETAIL UNIT03	-	-	-	1.6	-	-	-	-	-	-	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
L00:RETAIL UNIT04	-	-	-	1.6	-	-	-	-	-	-	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	
L00:RETAIL UNIT01	60	-	-	924
L00:RETAIL UNIT02	60	-	-	3089
L00:RETAIL UNIT03	60	-	-	1426
L00:RETAIL UNIT04	60	-	-	1940
B8 Storage	60	-	-	83

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?
L00:RETAIL UNIT01	NO (-49%)	NO
L00:RETAIL UNIT02	NO (-72.5%)	NO
L00:RETAIL UNIT03	NO (-45.9%)	NO
L00:RETAIL UNIT04	NO (-37.2%)	NO

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

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?	YES
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	759.5	759.5
External area [m²]	1698	1698
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	4	3
Average conductance [W/K]	495.09	697.26
Average U-value [W/m²K]	0.29	0.41
Alpha value* [%]	10	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
93	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
7	**B8 Storage or Distribution**
	C1 Hotels
	C2 Residential Inst.: Hospitals and Care Homes
	C2 Residential Inst.: Residential schools
	C2 Residential Inst.: Universities and colleges
	C2A Secure Residential Inst.
	Residential spaces
	D1 Non-residential Inst.: Community/Day Centre
	D1 Non-residential Inst.: Libraries, Museums, and Galleries
	D1 Non-residential Inst.: Education
	D1 Non-residential Inst.: Primary Health Care Building
	D1 Non-residential Inst.: 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/m²]

	Actual	Notional
Heating	15.12	19.41
Cooling	0	0
Auxiliary	7.64	2.96
Lighting	16.74	22.87
Hot water	2.71	2.94
Equipment*	39.13	39.13
TOTAL**	**39.49**	**48.18**

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

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	8.32	0
Wind turbines	0	0
CHP generators	2.71	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	36.83	60.25
Primary energy* [kWh/m²]	93.26	104.23
Total emissions [kg/m²]	11.6	18.2

* 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] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	37.5	0	5.7	0	8.1	0.85	0	0.95	0
	Notional	58.5	0	18.8	0	3.1	0.86	0	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	27.8	0	6.6	0	2.2	0.85	0	0.95	0
	Notional	83	0	26.8	0	1.2	0.86	0	----	----

Key to terms

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

Key Features

The BCO can give particular attention to items with specifications that are better than typically expected.

Building fabric

Element	U_{i-Typ}	U_{i-Min}	Surface where the minimum value occurs*
Wall	0.23	0.18	L0000001:Surf[5]
Floor	0.2	0.12	L0000001:Surf[0]
Roof	0.15	0.15	L0000002:Surf[1]
Windows, roof windows, and rooflights	1.5	1.33	L0000001:Surf[1]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

U_{i-Typ} = Typical individual element U-values [W/(m²K)]

U_{i-Min} = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
$m^3/(h.m^2)$ at 50 Pa	5	4