Georgiana Street, London NW1 0QS

Bangor Wharf

Report to accompany planning application:

ONE HOUSING
LIVING BETTER

Energy & Sustainability Assessment
Couch Perry Wilkes
February 2016

Contents

1.0 Executive Summary

In accordance with London Plan policy 5.3, 5.6 and 5.7, Couch Perry Wilkes (CPW) has produced Sustainability and Energy Statement to support a planning application for the proposed residential development located in Georgiana Street, Bangor Wharf. The development contains 46 units split over 6 levels comprising of 18 one bedroom flats, 19 two bedroom flats, 9 three bedroom flats and new office floor space. Overall the scheme provides for 3760m^2 Gross Internal Area (GIA).

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.

Four energy strategies, each achieving the minimum of 35% reduction in carbon dioxide emissions were investigated.

The following energy strategies to the residential units were investigated to test the various viable scenarios available, all of which are compliant with the London Plan:

- Strategy 1:
    - 40% of space and water heating met by CHP,
    - Mechanical Ventilation with Heat Recovery (MVHR) to all apartments,
    - Air permeability of the building – 3.0 m^3/(h.m^2) at 50Pa
    - Windows u-value – 1.3 W/m^{2}K
    - Estimated PV Array – 55m^2
- Strategy 2
    - 60% of space and water heating met by CHP,
    - Mechanical Ventilation with Heat Recovery (MVHR) to all apartments,
    - Air permeability of the building – 3.0 m^3/(h.m^2) at 50Pa
    - Windows u-value – 1.3 W/m^{2}K
    - Estimated PV Array – 0m^2
- Strategy 3
    - 40% of space and water heating met by CHP,
    - Mechanical Extract Ventilation (CMEV) to all apartments,
    - Air permeability of the building – 4.0 m^3/(h.m^2) at 50Pa
    - Windows u-value – 1.3 W/m^{2}K
    - Estimated PV Array – 115m^2
- Strategy 4
    - 60% of space and water heating met by CHP,
    - Mechanical Extract Ventilation (CMEV) to all apartments,
    - Air permeability of the building – 4.0 m^3/(h.m^2) at 50Pa
    - Windows u-value – 1.3 W/m^{2}K
    - Estimated PV Array – 41m^2

Our preferred scheme would be based on Strategy 4 but all of the above strategies still comply.

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

  - 60% of space heating met by CHP,
  - Electric point of use water heaters
  - Mechanical Ventilation Heat Recovery Ventilation (MVHR),
  - Air permeability of the building – 4.0 $m^3/(h.m^2)$ at 50Pa
  - Windows u-value – 1.4 W/m^2K
  - Estimated PV Array - $33m^2$

- 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. Supplementary NOx filtration and/or a catalytic convertor may also be required on the CHP exhaust to reduce emissions further.
- Ventilation – Where possible, natural ventilation and 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, 5.6 and 5.7, Couch Perry Wilkes (CPW) has produced a Sustainability and Energy Statement to support a planning application for the proposed residential development located in Georgiana Street, Bangor Wharf. The development contains 46 units split over 6 levels comprising of 18 one bedroom flats, 19 two bedroom flats, 9 three bedroom flats and new office floor space. Overall the scheme provides for 3760m^2 Gross Internal Area (GIA). 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 2015.

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 (SAP). 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 **Scenario 1** are shown below:

The total predicted regulated notional development energy consumption is: **180,756 kWhr per year**
The total predicted notional CO_2 emissions are (TER): **54318 kgCO_2 per year**

2. The estimated energy demands for **Scenario 2** are shown below:

The total predicted regulated notional development energy consumption is: **180,756 kWhr per year**
The total predicted notional CO_2 emissions are (TER): **54318 kgCO_2 per year**

3. The estimated energy demands for **Scenario 3** are shown below:

The total predicted regulated notional development energy consumption is: **210,019 kWhr per year**
The total predicted notional CO_2 emissions are (TER): **54318 kgCO_2 per year**

4. The estimated energy demands for **Scenario 4** are shown below:

The total predicted regulated notional development energy consumption is: **210,019 kWhr per year**
The total predicted notional CO_2 emissions are (TER): **54318 kgCO_2 per year**

Note 1. 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	
External Walls	U = 0.35	U = 0.18	
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 3.0 - $4.0m^3/m^2/hr$ @ 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 - 70%.

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/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.

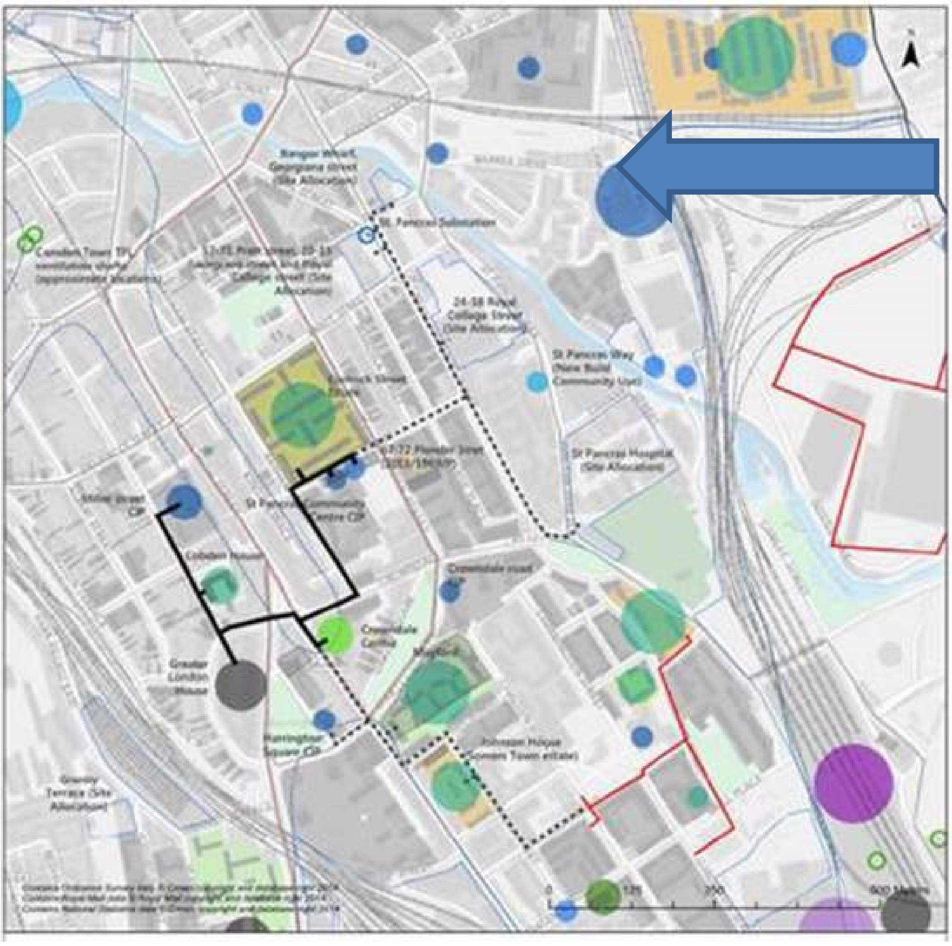
To complement the significant improvements in envelope design and lighting provision, the correct selection of the building services heating and ventilation systems being proposed will also drastically reduce the inherent energy consumption of the site.

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 controls 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.



Bangor Wharf Development

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 5.6 on decentralised energy networks. As a result, additional 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	No, low NO_x boilers providing the heating

Technology	Brief Description	Benefits	Issues/Limitations	Feasible for site
			extreme conditions 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 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. 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 30kW 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.

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 9620 Kwh/annum (approximate array with an active area of 74m2) will be required to support B1 space and the residential development as outlined within the Strategy 4 to satisfy the requirements outlined within London Plan.

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:

Strategy 1:

	Carbon Dioxide Emissions (Tonnes CO_2 per annum)
	Regulated Energy
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.318
After Energy Demand Reduction	46.513
After CHP	38.677
After Renewable Energy	35.032

Table 3. Strategy 1: CO_2 Emissions after each Stage of the Energy Hierarchy

	Regulated CO_2 Savings	
	Tonnes	%
Savings from Energy Demand Reduction	7.805	14.4
Saving from CHP	7.836	14.4
Saving from Renewable Energy	3.645	6.7
Total Cumulative Savings	**19.286**	**35.51**
Total Target Savings	**19.011**	**35%**
Annual Surplus	**0.275**	

Table 4. Strategy 1: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

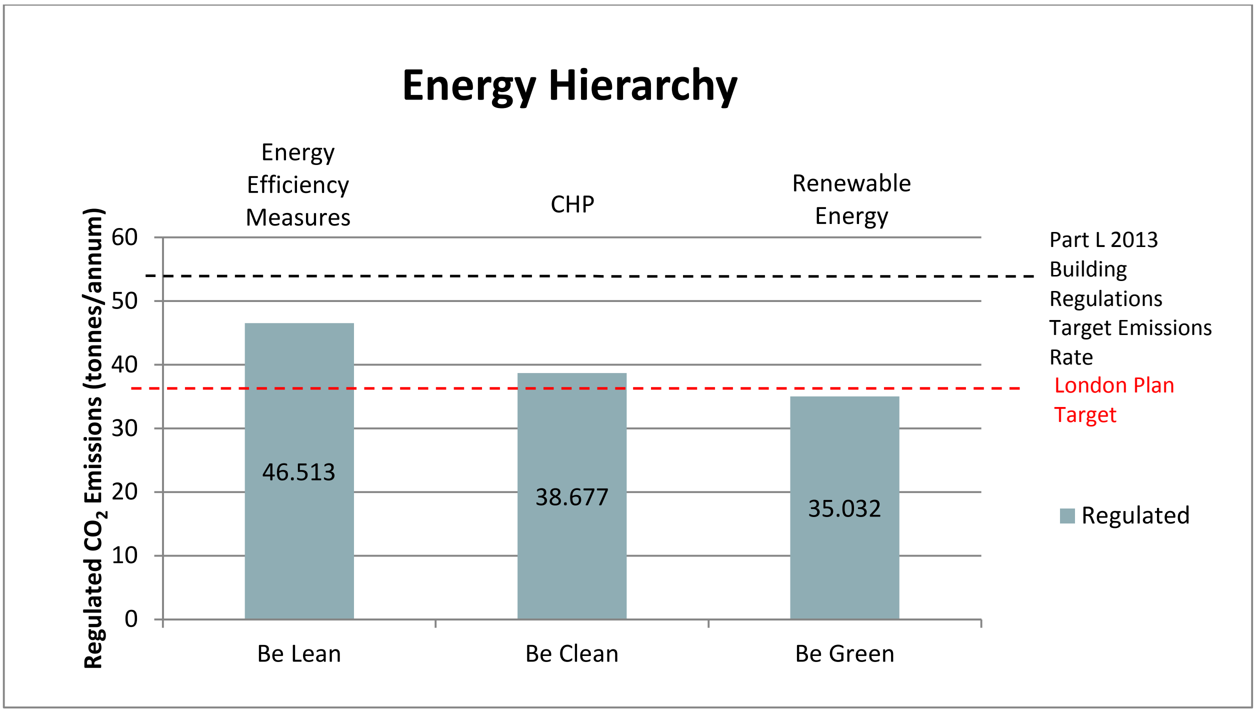


Figure 6. Strategy 1: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

PV Requirements:

- Estimated PV generation – 7100 kWh,
- Estimated PV Array – 55m^2

Strategy 2:

	Carbon Dioxide Emissions (Tonnes CO_2 per annum)
	Regulated Energy
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.318
After Energy Demand Reduction	46.513
After CHP	34.731
After Renewable Energy	34.731

Table 5. Strategy 2: CO_2 Emissions after each Stage of the Energy Hierarchy

	Regulated CO_2 Savings	
	Tonnes	%
Savings from Energy Demand Reduction	7.805	14.4
Saving from CHP	11.782	21.7
Saving from Renewable Energy	0	0
Total Cumulative Savings	**19.587**	**36.10**
Total Target Savings	**19.011**	**35%**
Annual Surplus	**0.576**	

Table 6. Strategy 2: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

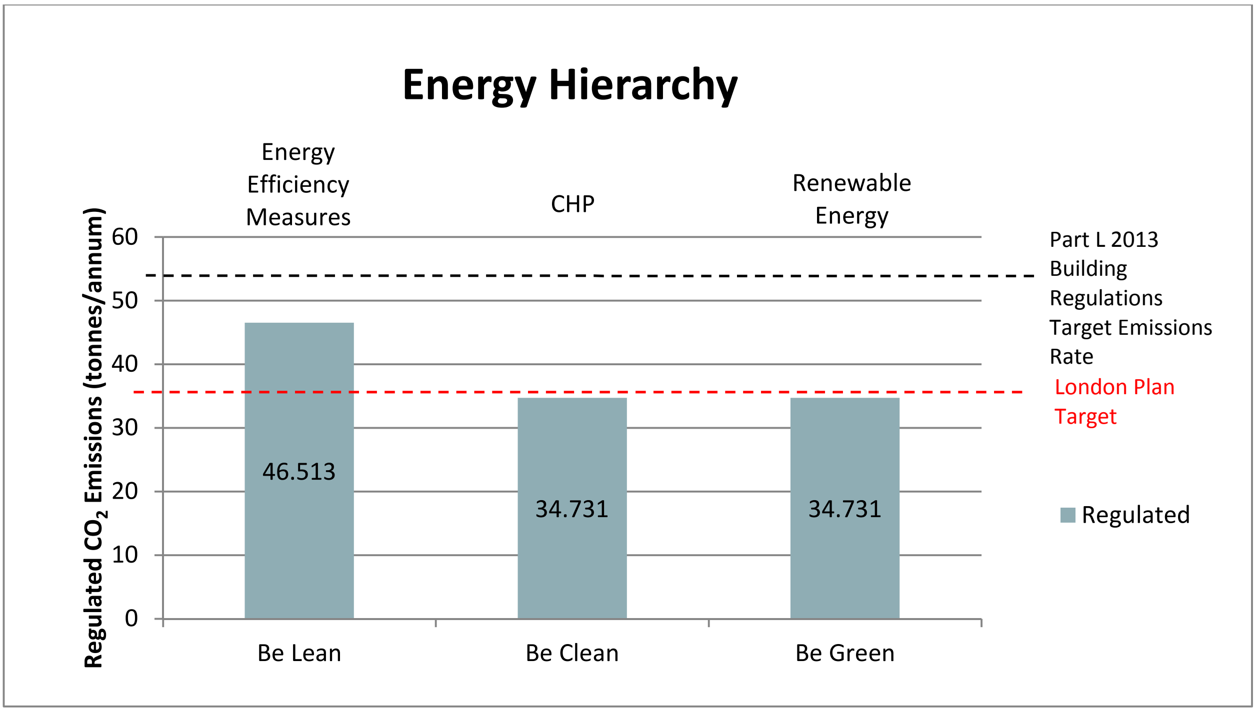


Figure 7. Strategy 2: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

PV Requirements:

- Estimated PV generation – 0 kWh,
- Estimated PV Array – 0m^2

Strategy 3:

	Carbon Dioxide Emissions (Tonnes CO_2 per annum)
	Regulated Energy
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.318
After Energy Demand Reduction	52.219
After CHP	42.808
After Renewable Energy	35.077

Table 7. Strategy 3: CO_2 Emissions after each Stage of the Energy Hierarchy

	Regulated CO_2 Savings	
	Tonnes	**%**
Savings from Energy Demand Reduction	2.099	3.9
Saving from CHP	9.411	17.3
Saving from Renewable Energy	7.731	14.2
Total Cumulative Savings	**19.241**	**35.40**
Total Target Savings	**19.011**	**35%**
Annual Surplus	**0.230**	

Table 8. Strategy 3: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

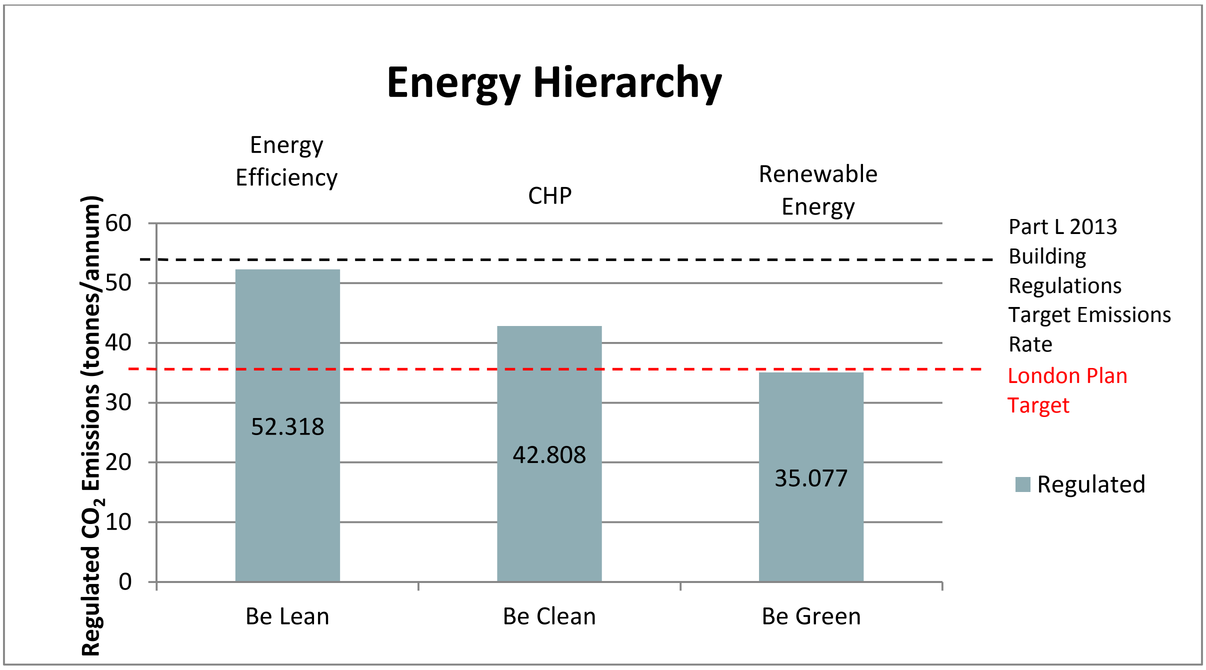


Figure 8. Strategy 2: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

PV Requirements:

- Estimated PV generation – 14900 kWh,
- Estimated PV Array – 115m^2

Strategy 4:

	Carbon Dioxide Emissions (Tonnes CO_2 per annum)
	Regulated Energy
Baseline: Part L 2013 of the Building Regulations Compliant Development	54.317
After Energy Demand Reduction	52.055
After CHP	37.963
After Renewable Energy	35.249

Table 9. Strategy 4: CO_2 Emissions after each Stage of the Energy Hierarchy

	Regulated CO_2 Savings	
	Tonnes	%
Savings from Energy Demand Reduction	2.262	4.1
Saving from CHP	14.092	26
Saving from Renewable Energy	2.714	5
Total Cumulative Savings	**19.068**	**35.10**
Total Target Savings	**19.011**	**35%**
Annual Surplus	**0.057**	

Table 10. Strategy 4: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

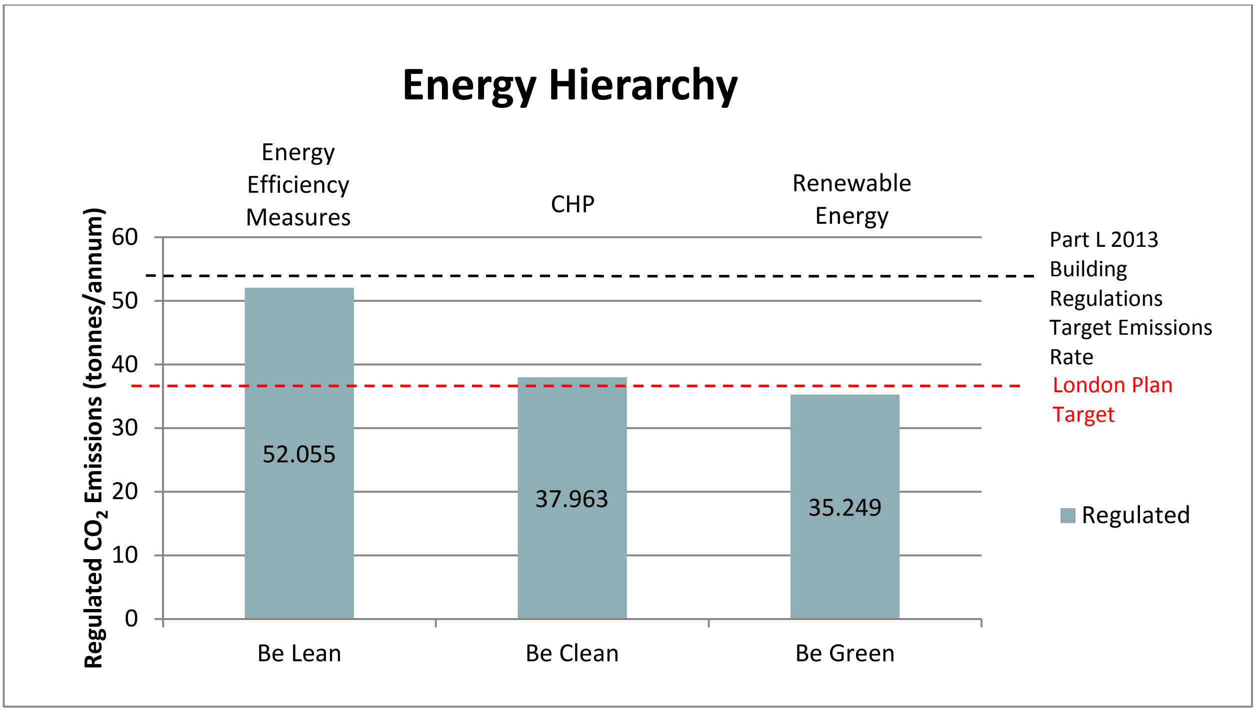


Figure 9. Strategy 4: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

PV Requirements:

- Estimated PV generation – 5230 kWh,
- Estimated PV Array – 41m^2

Commercial Office Space:

	Carbon Dioxide Emissions ($Tonnes\ CO_2$ per annum)
	Regulated Energy
Baseline: Part L 2013 of the Building Regulations Compliant Development	7.734
After Energy Demand Reduction	7.396
After CHP	7.299
After Renewable Energy	5.027

Table 11. Commercial Unit: CO_2 Emissions after each Stage of the Energy Hierarchy

	Regulated CO_2 Savings	
	Tonnes	%
Savings from Energy Demand Reduction	2.099	3.9
Saving from CHP	9.411	17.3
Saving from Renewable Energy	7.731	14.2
Total Cumulative Savings	**19.241**	**35.40**
Total Target Savings	**19.011**	**35%**
Annual Surplus	**0.230**	

Table 12. Commercial Unit: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

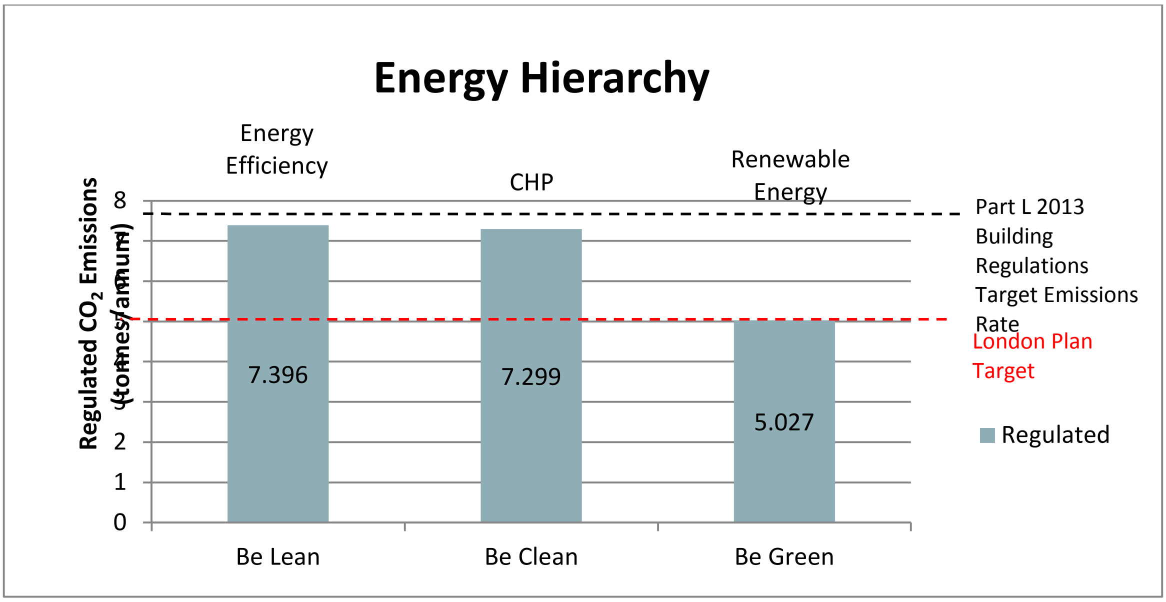


Figure 10. Commercial Unit: Regulated CO_2 Savings from each Stage of the Energy Hierarchy

PV Requirements:

- Estimated PV generation – 4290 kWh,
- Estimated PV Array – 33m^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 which equates to a minimum of 40% reduction in CO_2 emission comparing to notional development of Building Regulations Part L 2010 version.

- **Strategy 4 for Residential Units:**
  - 60% of space and water heating met by CHP,
  - Mechanical Extract Ventilation (CMEV) to all apartments,
  - Air permeability of the building – 4.0 m^3/(h*m^2) at 50Pa
  - Windows u-value – 1.3 W/m^{2}K
  - Estimated PV Array - 41m2
- **Commercial Office Space:**
  - 60% of space heating met by CHP,
  - Electric point of use water heaters
  - Mechanical Ventilation Heat Recovery Ventilation (MVHR),
  - Air permeability of the building – 4.0 m^3/(h*m^2) at 50Pa
  - Windows u-value – 1.4 W/m^{2}K
  - Estimated PV Array - 33m2

8.0 Appendix A – SAP Documentation

See accompanying documentation.

Property Ref	House Type.	Multiplier	Floor Area	Total Floor Area	Y Value	Design Air Pressure	Heating Controls	Cylinder Volume	Wet Rooms	Ventilation Reference	DER	TER	% Reduction	Block Compliance	Site Wide	DFEE	TFEE	% Reduction	Block Compliance
3120-A001	Ground Floor Flat	1	59.57	59.57	0.13	4		HIU	1	VA MVDC MSA	24.18	23.95	-0.95			69.46	75.57	8.08	
3120-A101	First Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	17.81	18.19	2.09			46.74	51.43	9.11	
3120-A102	First Floor Flat	1	87.91	87.91	0.13	4		HIU	2	VA MVDC MSA	18.73	18.55	-0.95			54.43	58.13	6.36	
3120-A201	Second Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	14.29	15.17	5.79			31.31	35.69	12.27	
3120-A202	Second Floor Flat	1	87.91	87.91	0.13	4		HIU	2	VA MVDC MSA	16.13	17.16	5.98			43.11	50.99	15.44	
3120-A301	Third Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	14.27	15.17	5.92			31.27	35.69	12.37	
3120-A302	Third Floor Flat	1	62.83	62.83	0.13	4		HIU	1	VA MVDC MSA	16.16	17.46	7.44			36.40	43.59	16.50	
3120-A401	Fourth Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	16.12	17.65	8.65			39.25	48.59	19.21	
3120-A402	Fourth Floor Flat	1	62.83	62.83	0.13	4		HIU	1	VA MVDC MSA	19.38	20.73	6.51			50.05	60.45	17.20	
3120-B101	First Floor Flat	1	70.03	70.03	0.13	4		HIU	2	VA MVDC MSA	18.66	18.99	1.73			50.01	55.84	10.44	
3120-B102	First Floor Flat	1	86.02	86.02	0.13	4		HIU	2	VA MVDC MSA	17.67	17.53	-0.80			48.97	52.58	6.86	
3120-B103	First Floor Flat	1	50.47	50.47	0.13	4		HIU	1	VA MVDC MSA	18.43	19.01	3.04	4.25		42.73	45.50	6.08	12.22
3120-B104	First Floor Flat	1	50.91	50.91	0.13	4		HIU	1	VA MVDC MSA	20.93	21.54	2.85			53.17	58.85	9.64	
3120-B201	Mid Floor Flat	2	70.03	140.06	0.13	4		HIU	2	VA MVDC MSA	14.82	15.85	6.52			33.48	39.83	15.95	
3120-B202	Mid Floor Flat	2	86.02	172.04	0.13	4		HIU	2	VA MVDC MSA	13.91	14.61	4.80			32.78	37.72	13.10	
3120-B203	Mid Floor Flat	2	50.47	100.94	0.13	4		HIU	1	VA MVDC MSA	15.04	16.07	6.40			27.82	30.13	7.67	
3120-B204	Mid Floor Flat	2	50.91	101.82	0.13	4		HIU	1	VA MVDC MSA	17.09	18.03	5.21			36.56	40.82	10.45	
3120-B401	Fourth Floor Flat	1	70.03	70.03	0.13	4		HIU	2	VA MVDC MSA	15.44	16.67	7.37			36.14	43.98	17.84	
3120-B402	Fourth Floor Flat	1	86.02	86.02	0.13	4		HIU	2	VA MVDC MSA	15.08	16.77	10.08			37.80	48.70	22.38	
3120-B403	Fourth Floor Flat	1	50.47	50.47	0.13	4		HIU	1	VA MVDC MSA	15.23	16.37	6.95			28.68	31.72	9.57	
3120-B404	Fourth Floor Flat	1	50.91	50.91	0.13	4	**Boilers** Efficiency:97.4% % of Space Heating: 100%	HIU	1	VA MVDC MSA	17.09	18.07	5.40		4.16	36.56	41.01	10.86	
3120-B601	Top Floor Flat	1	88.13	88.13	0.13	4		HIU	2	VA MVDC MSA	17.98	18.09	0.61			50.58	55.85	9.45	
3120-B602	Top Floor Flat	1	96.00	96.00	0.13	4		HIU	2	VA MVDC MSA	16.34	16.59	1.51			45.41	50.56	10.17	
3120-B603	Top Floor Flat	1	71.09	71.09	0.13	4		HIU	2	VA MVDC MSA	19.21	19.66	2.30			52.53	58.49	10.18	
3120-C001	Ground Floor Flat	1	71.33	71.33	0.13	4		HIU	2	VA MVDC MSA	19.21	18.84	-1.99			53.24	54.29	1.94	
3120-C002	Ground Floor Flat	1	62.13	62.13	0.13	4		HIU	1	VA MVDC MSA	19.49	19.42	-0.34			51.15	53.74	4.82	
3120-C101	First Floor Flat	1	76.12	76.12	0.13	4		HIU	2	VA MVDC MSA	15.29	16.50	7.35			36.81	44.01	16.37	
3120-C102	First Floor Flat	1	74.02	74.02	0.13	4		HIU	2	VA MVDC MSA	15.26	16.54	7.74			36.17	43.55	16.94	
3120-C103	First Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	18.77	19.46	3.53			44.12	48.15	8.37	
3120-C104	First Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	18.34	18.79	2.41			43.95	48.31	9.01	
3120-C201	Second Floor Flat	1	76.12	76.12	0.13	4		HIU	2	VA MVDC MSA	15.05	16.02	6.08			35.78	41.58	13.96	
3120-C202	Second Floor Flat	1	74.02	74.02	0.13	4		HIU	2	VA MVDC MSA	14.68	15.36	4.44			33.64	37.51	10.33	
3120-C203	Second Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	16.3	16.71	2.43	4.03		33.26	33.84	1.71	11.06
3120-C204	Second Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	15	16.02	6.36			29.48	34.11	13.56	
3120-C301	Third Floor Flat	1	76.12	76.12	0.13	4		HIU	2	VA MVDC MSA	15.29	16.39	6.74			36.78	43.46	15.38	
3120-C302	Third Floor Flat	1	74.02	74.02	0.13	4		HIU	2	VA MVDC MSA	14.91	15.72	5.18			34.63	39.37	12.03	
3120-C303	Third Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	16.3	16.71	2.43			33.26	33.84	1.71	
3120-C304	Third Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	15	16.02	6.36			29.48	34.11	13.56	
3120-C401	Fourth Floor Flat	1	86.79	86.79	0.13	4		HIU	1	VA MVDC MSA	18.63	19.44	4.18			53.04	62.34	14.92	
3120-C402	Fourth Floor Flat	1	53.75	53.75	0.13	4		HIU	1	VA MVDC MSA	21.88	23.01	4.90			57.82	68.09	15.08	
3120-C403	Fourth Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	20.98	21.33	1.65			53.25	57.84	7.94	
3120-C404	Fourth Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	19.71	20.35	3.15			49.53	56.48	12.30	
		Total Floor Area		3089.97															

Property Ref	House Type.	Multiplier	Floor Area	Total Floor Area	Y Value	Design Air Pressure	Heating Controls	Cylinder Volume	Wet Rooms	Ventilation Reference	DER	TER	% Reduction	Block Compliance	Site Wide	DFEE	TFEE	% Reduction	Block Compliance
3120-A001	Ground Floor Flat	1	59.57	59.57	0.13	4		HIU	1	VA MVDC MSA	17.29	23.95	27.82			69.46	75.57	8.08	
3120-A101	First Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	12.94	18.19	28.86			46.74	51.43	9.11	
3120-A102	First Floor Flat	1	87.91	87.91	0.13	4		HIU	2	VA MVDC MSA	13.53	18.55	27.07			54.43	58.13	6.36	
3120-A201	Second Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	10.55	15.17	30.45			31.31	35.69	12.27	
3120-A202	Second Floor Flat	1	87.91	87.91	0.13	4		HIU	2	VA MVDC MSA	11.76	17.16	31.45			43.11	50.99	15.44	
3120-A301	Third Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	10.54	15.17	30.51			31.27	35.69	12.37	
3120-A302	Third Floor Flat	1	62.83	62.83	0.13	4		HIU	1	VA MVDC MSA	11.84	17.46	32.18			36.40	43.59	16.50	
3120-A401	Fourth Floor Flat	1	71.21	71.21	0.13	4		HIU	1	VA MVDC MSA	11.79	17.65	33.19			39.25	48.59	19.21	
3120-A402	Fourth Floor Flat	1	62.83	62.83	0.13	4		HIU	1	VA MVDC MSA	14.02	20.73	32.37			50.05	60.45	17.20	
3120-B101	First Floor Flat	1	70.03	70.03	0.13	4		HIU	2	VA MVDC MSA	13.52	18.99	28.80			50.01	55.84	10.44	
3120-B102	First Floor Flat	1	86.02	86.02	0.13	4		HIU	2	VA MVDC MSA	12.81	17.53	26.93			48.97	52.58	6.86	
3120-B103	First Floor Flat	1	50.47	50.47	0.13	4		HIU	1	VA MVDC MSA	13.4	19.01	29.51	30.16		42.73	45.50	6.08	12.22
3120-B104	First Floor Flat	1	50.91	50.91	0.13	4		HIU	1	VA MVDC MSA	15.1	21.54	29.91			53.17	58.85	9.64	
3120-B201	Mid Floor Flat	2	70.03	140.06	0.13	4		HIU	2	VA MVDC MSA	10.91	15.85	31.18			33.48	39.83	15.95	
3120-B202	Mid Floor Flat	2	86.02	172.04	0.13	4		HIU	2	VA MVDC MSA	10.26	14.61	29.78			32.78	37.72	13.10	
3120-B203	Mid Floor Flat	2	50.47	100.94	0.13	4		HIU	1	VA MVDC MSA	11.1	16.07	30.92			27.82	30.13	7.67	
3120-B204	Mid Floor Flat	2	50.91	101.82	0.13	4		HIU	1	VA MVDC MSA	12.48	18.03	30.78			36.56	40.82	10.45	
3120-B401	Fourth Floor Flat	1	70.03	70.03	0.13	4	**CHP** Efficiency:90% Heat to Power Ratio: 2.0 % of Space & Water Heating: 60% **Boilers** Efficiency:97.4% % of Space Heating: 40%	HIU	2	VA MVDC MSA	11.33	16.67	32.03			36.14	43.98	17.84	
3120-B402	Fourth Floor Flat	1	86.02	86.02	0.13	4		HIU	2	VA MVDC MSA	11.05	16.77	34.11			37.80	48.70	22.38	
3120-B403	Fourth Floor Flat	1	50.47	50.47	0.13	4		HIU	1	VA MVDC MSA	11.22	16.37	31.45			28.68	31.72	9.57	
3120-B404	Fourth Floor Flat	1	50.91	50.91	0.13	4		HIU	1	VA MVDC MSA	12.48	18.07	30.92		30.11	36.56	41.01	10.86	
3120-B601	Top Floor Flat	1	88.13	88.13	0.13	4		HIU	2	VA MVDC MSA	13.01	18.09	28.09			50.58	55.85	9.45	
3120-B602	Top Floor Flat	1	96.00	96.00	0.13	4		HIU	2	VA MVDC MSA	11.88	16.59	28.39			45.41	50.56	10.17	
3120-B603	Top Floor Flat	1	71.09	71.09	0.13	4		HIU	2	VA MVDC MSA	13.88	19.66	29.41			52.53	58.49	10.18	
3120-C001	Ground Floor Flat	1	71.33	71.33	0.13	4		HIU	2	VA MVDC MSA	13.89	18.84	26.26			53.24	54.29	1.94	
3120-C002	Ground Floor Flat	1	62.13	62.13	0.13	4		HIU	1	VA MVDC MSA	14.1	19.42	27.41			51.15	53.74	4.82	
3120-C101	First Floor Flat	1	76.12	76.12	0.13	4		HIU	2	VA MVDC MSA	11.22	16.50	32.01			36.81	44.01	16.37	
3120-C102	First Floor Flat	1	74.02	74.02	0.13	4		HIU	2	VA MVDC MSA	11.2	16.54	32.29			36.17	43.55	16.94	
3120-C103	First Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	13.63	19.46	29.95			44.12	48.15	8.37	
3120-C104	First Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	13.33	18.79	29.07			43.95	48.31	9.01	
3120-C201	Second Floor Flat	1	76.12	76.12	0.13	4		HIU	2	VA MVDC MSA	11.05	16.02	31.04			35.78	41.58	13.96	
3120-C202	Second Floor Flat	1	74.02	74.02	0.13	4		HIU	2	VA MVDC MSA	10.8	15.36	29.69			33.64	37.51	10.33	
3120-C203	Second Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	11.95	16.71	28.47	30.02		33.26	33.84	1.71	11.06
3120-C204	Second Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	11.05	16.02	31.02			29.48	34.11	13.56	
3120-C301	Third Floor Flat	1	76.12	76.12	0.13	4		HIU	2	VA MVDC MSA	11.21	16.39	31.62			36.78	43.46	15.38	
3120-C302	Third Floor Flat	1	74.02	74.02	0.13	4		HIU	2	VA MVDC MSA	10.96	15.72	30.30			34.63	39.37	12.03	
3120-C303	Third Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	11.95	16.71	28.47			33.26	33.84	1.71	
3120-C304	Third Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	11.05	16.02	31.02			29.48	34.11	13.56	
3120-C401	Fourth Floor Flat	1	86.79	86.79	0.13	4		HIU	1	VA MVDC MSA	13.48	19.44	30.67			53.04	62.34	14.92	
3120-C402	Fourth Floor Flat	1	53.75	53.75	0.13	4		HIU	1	VA MVDC MSA	15.75	23.01	31.54			57.82	68.09	15.08	
3120-C403	Fourth Floor Flat	1	51.02	51.02	0.13	4		HIU	1	VA MVDC MSA	15.15	21.33	28.98			53.25	57.84	7.94	
3120-C404	Fourth Floor Flat	1	57.66	57.66	0.13	4		HIU	1	VA MVDC MSA	14.27	20.35	29.88			49.53	56.48	12.30	
				3089.97															

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 30kW CHP 33PV 130WM2

As designed

Date: Mon Feb 22 14:49:15 2016

Administrative information

Building Details

Address: Bangor Wharf B1 30kW CHP 33PV 130WM2, ,

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.2

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.2

BRUKL compliance check version: v5.2.b.1

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

1.1	CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	16
1.2	Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	16
1.3	Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	10.3
1.4	Are emissions from the building less than or equal to the target?	BER =< TER
1.5	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 which do not meet standards in the 2013 Non-Domestic Building Services Compliance Guide are displayed in red.

2.a Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.18	0.18	00000000:Surf[1]
Floor	0.25	0.12	0.12	00000000:Surf[0]
Roof	0.25	-	-	UNKNOWN
Windows***, roof windows, and rooflights	2.2	1.4	1.4	00000000:Surf[5]
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/(m²K)]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]

$U_{i\text{-}Calc}$ = 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

2.b 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	>0.95

1- LTHW Heating Via Radiator with Mechanical Ventilation

	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	0.5
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- Elec Hot Water

	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	0.3
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**
00_OFFICE	-	-	-	1.8	-	-	-	-	-	-	N/A
00_OFFICE	-	-	-	1.8	-	-	-	-	-	-	N/A
00_OFFICE	-	-	-	1.8	-	-	-	-	-	-	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	
00_OFFICE	60	-	-	2541
00_OFFICE	60	-	-	690
00_OFFICE	60	-	-	1853

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?
00_OFFICE	NO (-66.8%)	NO
00_OFFICE	NO (-22.9%)	NO
00_OFFICE	YES (+12.1%)	NO

Criterion 4: The performance of the building, as built, should be consistent with the 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?	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]	483.4	483.4
External area [m^2]	945.3	945.3
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	4	3
Average conductance [W/K]	347.81	426.68
Average U-value [W/m^{2}K]	0.37	0.45
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
100	**B1 Offices and Workshop businesses**
	B2 to B7 General Industrial and Special Industrial Groups
	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/m^2]

	Actual	Notional
Heating	13.07	21.27
Cooling	0	0
Auxiliary	8.49	4.37
Lighting	13.33	16.14
Hot water	2.93	3.17
Equipment*	42.18	42.18
TOTAL**	**37.04**	**44.96**

* 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/m^2]

	Actual	Notional
Photovoltaic systems	8.87	0
Wind turbines	0	0
CHP generators	0.78	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	39.15	66.02
Primary energy* [kWh/m^2]	87.65	90.83
Total emissions [kg/m^2]	10.3	16

* 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	39.1	0	10.5	0	8.5	0.9	0	0.95	0
	Notional	66	0	21.3	0	4.4	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	**$U_{i\text{-}Typ}$**	**$U_{i\text{-}Min}$**	**Surface where the minimum value occurs***
Wall	0.23	0.18	00000000:Surf[1]
Floor	0.2	0.12	00000000:Surf[0]
Roof	0.15	-	UNKNOWN
Windows, roof windows, and rooflights	1.5	1.4	00000000:Surf[5]
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
$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)]			$U_{i\text{-}Min}$ = 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