Low Zero Carbon (LZC) Feasibility Report

In reference to the;

Holmes Road Depot Regeneration Project

at;

London Borough of Camden
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1.0 EXECUTIVE SUMMARY

This outline energy strategy report provides high level guidance on low and zero carbon (LZC) measures which have been considered for this project in order to reduce energy use, and associated carbon dioxide emissions for the public sector multi-use building known as Holmes Road Depot.

Passive and Active Energy Efficiency measures, outside the scope of this report, can contribute significantly to a building's energy performance and adaptation to future climate change. Current best practice recommends improvements to a building's thermal performance before considering suitable LZCs; this theory, as has been requested by Camden Borough Council is referred to as the "Be Lean, Be Clean, Be Green" process.

After reducing the requirement for applied energy in this way, the LZC contributions will represent a larger proportion of the energy used. In fact some LZC solutions perform much better in a well-insulated and airtight building. The options presented within this report are based upon preliminary outline calculations provided by Pellings LLP and BSP which were produced at feasibility stage, with U values as determined by review of the existing structure and proposals in place at this stage.

Where necessary we have extrapolated information, and liaised with BREEAM (BRE) to identify relationships between BRUKL output documentation information and information required during a BREEAM assessment to justify requirements.

Future revisions are dependent upon more detailed programme and delivery options, budgetary assessments, technological advances and local authority requirements may see revisions to this report, although the philosophy and ethos of the report shall be retained.

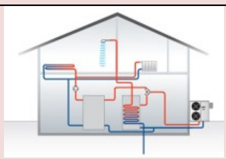
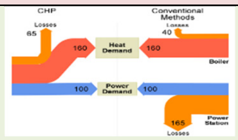
Any final savings are to be based upon detailed calculations performed during the detailed design stage, in the interim however, these calculations offer suitable guidance for the outline selection of low and zero carbon technologies and strive to satisfy Camden Borough Council requirements which are identified as follows;

"60% of the Energy credits and an ENE1 rating equivalent to BREEAM non-domestic refurbishment Excellent rating"

The aim of this report is to present the fundamental principles, to the Planning Officer, Client and professional team, of a low & zero carbon technology solution which, has been accurately selected for the project to meet the above requirements, the best selection within the context of this project and to identify those which warrant a more detailed assessment moving forward.

The recommendations pertain to technical and functional feasibility and include lifecycle costs and simple payback for the most appropriate system selected. Using IES Virtual Environment and the accredited DSM engine Apache and Macroflo Bulk airflow calculation engines model assessments for the following have been carried out;

- Non-Compliant Building – Existing Building.
- Non-Compliant Building – Be Lean.
- Compliant Building – Be Green (Photovoltaics & integration DHWS).

LZC TECHNOLOGY FEASIBILITY REVIEW		NOTES
Solar Thermal		When considering the DHWS usage this may be a practical solution. *Isolating this element & reviewing against PV, this is considered to have the least impact and therefore disregarded from recommendations resulting in PV diversion being a more efficient solution.*
Photovoltaics		A feasible LZC option; this should be assessed in greater detail with 20% DHWS generation through immersion / small power base load shedding as well as supporting other internal auxiliary energy usage and grid displacement. *A considerable saving could be afforded by utilising an 160m2 array and could be viable for a potentially credible grant for this scheme once this technology is approved.*
Wind Turbines		Not suitable due lack feasible space and potential planning restrictions potentially negating a large more effective turbine.
GSHP		Not suitable due to ground conditions and available ground for heat migration.
ASHP		ASHP only utilised for localised refrigerant based heating & cooling to offices & meeting rooms.
Biomass Boiler		Possible but less feasible than other potential technologies due to summer operation, fuel storage space requirements, fuel delivery and supply requirements as well as the Clean Air Act and city location when considering flueing. Not included.
CHP		Feasible noting a low but relatively constant base load base load. A small generation profile appertaining to selection of a small CHP engine offers both electrical load shedding & additional on-site generation and usage. *A 25kW.T unit equates to a substantial saving; we will be further considering this option following load profiling assessments.*

2.0 THE SITE

2.1 PARTICULARS

- Public Sector Multi-use site.
- Variety of multiple storey elements to interconnected buildings.
- Residential buildings providing topographical shading to partial elements of the site.
- Enhancement of building fabric and controlled fittings (glazing).
- Adaptation and replacement of M&E systems.
- Uneconomic local district connection, or waste heat resources as part of this works. It is considered as a potential future viable option with allowance incorporated during the works for connection of said system.
- Photovoltaics to load shed on-site electrical demand and provide minimal export / high on-site energy displacement.
- Energy diverter serving cylinder immersion during partial electrical usage periods.

2.2 ENVIRONMENTAL ASSESSMENT

2.2.1 General

The Camden Borough Council has requested that this project, although specifically not requiring a BREEAM assessment, must consider a fair level of Energy competence credits in a way which appreciates the building works in order to hone into energy efficiency and enhancement of the building.

More directly, a requirement to gain 60% of the energy credits has been requested. This is to be based upon the BREEAM Non-Domestic Refurbishment 2014 assessment process.

In addition, an ENE1 rating equivalent to BREEAM Non-Domestic Refurbishment 2014 Excellent rating must be achieved.

2.2.2 BREEAM Category 6 (Energy)

From reviewing the potentially available energy credits for a Non-Domestic Refurbishment 2014 BREEAM assessment, we see that there is a potential of 34 credits available, however, upon review, we feel that only **25** of these total credits would be relevant to this project.

Without appointing a BREEAM assessor to verify this, we can only speculate at this stage based upon reviewing BREEAM guidance of each sub-category.

Based upon this assumption, and assessing the sub-category compliance notes (CN), we believe such works could achieve **15 credits**, suggesting an overall weighting percentage of **60%**; a synopsis of assessment of these individual sub-categories is shown in Table 1 overleaf.

Table 1: [BREEAM Non-Domestic Refurbishment 2014 Category 6 (Energy) credit assessment.]

Ref.	Sub-category title.	Available credits.	Description of sub-category.	Holmes Road comments.	Relevant credits.	Anticipated credits.
ENE01	Reduction of energy use and carbon emissions.	Up to 15	Site energy performance assessment.	See section 2.2.3.	15	9 (see 2.2.3).
ENE02	Energy monitoring.	2	Energy monitoring & Sub-metering.	Monitoring & metering achievable.	2	2
ENE03	External lighting.	1	Colour rendering and efficiency of external lighting.	No existing lighting works.	1	0
ENE04	Low carbon design.	3	Passive design & LZC technologies & free cooling.	Thermal comfort report to be produced, CN 5, CN6.12 Meaningful reduction – (glazing & curtain walling).	3	2
ENE05	Energy efficient cold storage.	2	Industrial refrigeration, cold storage and associated GWP.	**Not** relevant to this project.	0	0
ENE06	Energy efficient transportation systems.	3	Lift installations and efficiency of equipment.	Reclaimed credits re: specification	2	2
ENE07	Energy efficient laboratory systems	5	Energy efficient laboratory equipment.	**Not** relevant to this project.	0	0
ENE08	Energy efficient equipment	2	Unregulated energy assessment.	Unregulated energy assessment **not** carried out.	2	0
ENE09	Drying space	1	Dwelling drying space allowance.	**Not** relevant; only where dwellings are included within works.	0	0
Total relevant and anticipated credits					25	15

2.2.3 BREEAM Sub-Category (ENE01)

From reviewing the potentially available energy credits within the sub-category ENE01, we see that there is a potential of 15 credits available.

Based upon the BREEAM calculation methodology, we see potentially +10 credits being achieved, largely due to the excessive reduction in energy attributed through new lighting, replacement plant and Photovoltaic panel installation (as defined elsewhere within this report) along with curtain walling and glazing replacements.

As a simplistic assessment reviewing the carbon reduction overall, the “Be Green” **Designed Actual Building** carbon emissions reviewed against the **Existing Actual Building** carbon emissions drawn from BRUKL output documents suggests a 54% reduction. This is anticipated to be further increased due to the potential efficiency and scope of the photovoltaic scheme (see section 5.2 & 6.0).

Using the BREEAM compliance checker, we see a considerably higher result although due to algorithms within the calculation procedure which reviews separate building energy demand, consumption and CO_2, this cannot be verified without a formal BREEAM pre-assessment being carried out.

It is however, upon reviewing against various methods a confident statement that the assessed BRUKL output document review could be considered as a percentage basis against the EPR_{NDR} therefore suggesting 9 credits could be contributed to the overall Energy Category assessment ***as a minimum*** as can be seen included within section 2.2.2.

Excerpt : [BREEAM Non-Domestic Refurbishment 2014 Table 27; EPR_{NDR} benchmark scale.]

Table 27 EPR_{NDR} benchmark scale

BREEAM Credits	EPR_{NDR}	Rating	Minimum requirements
1	≥ 0.06	Pass Good Very Good	None
2	≥ 0.12		
3	≥ 0.18		
4	≥ 0.24		
5	≥ 0.30		
6	≥ 0.36	Excellent	Requires a minimum of 6 credits to be achieved (equivalent to an EPR_{NDR} of ≥ 0.36).
7	≥ 0.42		
8	≥ 0.48		
9	≥ 0.54		
10	≥ 0.60	Outstanding	Requires a minimum of 10 credits to be achieved (equivalent to an EPR_{NDR} of ≥ 0.60).
11	≥ 0.66		
12	≥ 0.72		
13	≥ 0.78		
14	≥ 0.84		
15	≥ 0.90		

2.3 LAND USE, LOCALITY AND NOISE SENSITIVITY

The building is located in an urban area within the Borough of Camden. There will no doubt be acoustic measures associated with the planning requirements due to external comfort cooling condensers. The acoustic requirements are as defined by the acoustic engineer and clarification from London Borough of Camden for noise breakout to be 10dB below that of the lowest recorded ambient noise. The efficiencies of both ventilation systems which will be treated by acoustic louvres and condensers complete with acoustic panels shall however have no reduction in energy efficiency.

The location of the site results in wind turbines not being considered suitable due to noise and visual impact to the building and the surrounding area. Medium capacity top discharge ASHP units have been considered as feasible for heating / cooling to office areas; replacement of existing equipment past its economic lifespan will enhance the buildings overall energy efficiency.

3.0 CONSTRUCTION & ENHANCEMENTS (BE LEAN – REDUCE DEMAND)

By reviewing realistic proposals to date as part of the scheme, we can confirm that the following existing building fabric and system enhancements are both feasible and cost effective.

Element	Proposed enhancements	Resultant effect	Energy reduction		Cost saving
Ground Floor	No enhancement	-	0	kWh/m^2	£ -
External Walls	Increase internal insulation	Reduction in U-value to 0.254 W/m^2.K	58.57	kWh/m^2	£ 1,304.00
Doors	Replacement Doors	Reduction in U-value to 1.78 W/m^2.K	52.11	kWh/m2	£ 5,910.00
Windows	Replacement windows	Reduction in U-value to 1.56 W/m^2.K			
Ventilation & infiltration	Survey to identify & minimise leakage	Reduction of air permeability from 25m3/hr m^2 to 8m3/hr m^2	Holistic		£ 1,798.00
Lighting	Replacement to LED luminaires	Reduction of energy consumption	16.32	kWh/m^2	£ 6,708.00
Boilers	Replacement of existing boiler plant	Higher efficiency boiler plant (92.23% to 96%)	84.05	kWh/m^2	£ 552.00
Hot Water Generation	Revised Hot water generation strategy to include PV diverter	Increased overall generation efficiency	36.55	kWh/m^2	£ 272.00
Air Source Heat Pump	Replacement of inefficient systems & new systems to re-	Heating enhancement & Cooling enhancement (refer to auxillary			
Ventilation	Replacment mechanical ventilation strategy	Increased efficiencies of ventilaiton systems overall (refer			

The measures as defined within the above table will dramatically reduce the energy use of the building; it has been recorded upon reviewing thermal model output data that the following reductions are prevalent relating to a 49% reduction.

Building System	Energy	
Heating	26.71	kWh/m^2
Cooling	3.63	kWh/m^2
Lighting	13.86	kWh/m^2
Hot Water	36.55	kWh/m^2
Auxiliary (Pumps, motors, etc.)	2.31	kWh/m^2
Total energy load	86.06	kWh/m^2

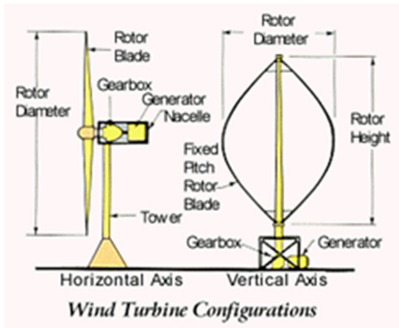
4.0 SYSTEMS AND BUILDING LOADS (BE CLEAN – ENERGY EFFICIENCY)

Based upon the existing building layout and proposed refurbishment works, the “Be Clean” Building Emission Rate (BER) value remains unaltered at this stage.

5.0 INTRODUCTION TO LOW AND ZERO CARBON TECHNOLOGIES

The following provides an introduction to the main renewable technologies as considered within this study. Whilst most are directly connected with the saving of carbon emissions, rainwater harvesting is included as, whilst not attributable to saving energy, it will save water in the processes of irrigation.

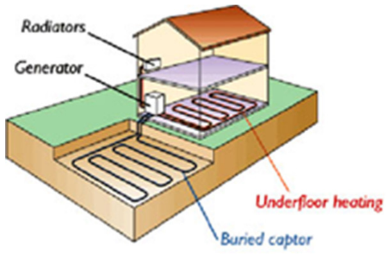
Solar photovoltaic panels (PV) - PV cells convert sunlight into usable electricity via through semi-conductor cells. Due to the relatively low efficiencies of this system, large areas are required to provide useful amounts of electricity. As PV cells also only provide their peak power (referred to as kWp when designing systems) during the mid-summer months, their use for power needs to be carefully considered as modern buildings will have natural day lighting with linked lighting systems reducing the necessity for power during those times. The big advantage comes when comfort cooling is being used as these use considerable amounts of electrical energy during the summer months. PV cells are also a high cost option but will become more attractive when the new feed in tariffs is factored in.



Wind turbines - Wind turbines come in vertical and horizontal axis forms and generate electrical energy from the wind. They have in the past received poor reputations through their carbon intensive constructions and issues associated with noise and unsightly wind farms. However, smaller systems are becoming increasingly more common and more accepted and have been used to power schools, sports centres and business parks with domestic scale wind turbines now becoming available from local DIY stores. Small scale horizontal and vertical axis wind turbines are shown here.

Solar Thermal - Solar water heating is currently one of the most cost-effective and affordable renewable technology. Solar water heating systems gather energy radiated by the sun and convert it into useful heat in the form of hot water. Solar collectors absorb the sun’s radiation via a fluid (usually water/antifreeze) then transferring the heat to a store and finally integrating into the building’s hot water service system. By the use of refrigerant technology in modern solar tubes, useful heat can even be extracted on cloudy days, further improving their effectiveness. A typical installation is shown here.

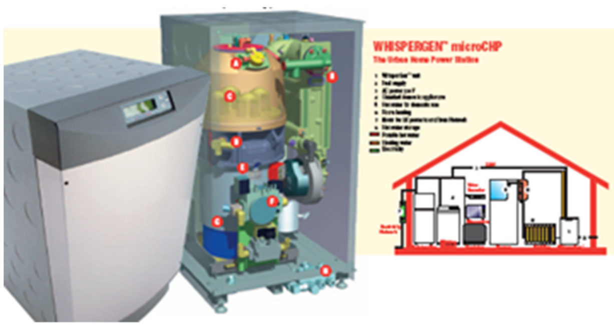
Heat Pump Technology - Most commonly available as ground source & air source. Ground source heat pumps take heat from under the ground using liquid (water and antifreeze) circulating in horizontal pipes or a vertical borehole. The heat extracted is raised in temperature by use of a heat pump and the heat is generally used to warm water for space heating, often in the form of under floor heating. The principle of operation of air source heat pumps is the same except they absorb energy from the air, rather than the ground.



Biomass - Biomass is organic matter of recent origin. It doesn't include fossil fuels, which have taken millions of years to evolve. The CO_2 released when energy is generated from biomass is balanced by that absorbed during the fuel's production.

This is termed a carbon neutral process, but only when the source of the fuels is renewable, like a sustainable rotation coppice woodland. Such fuels range from logs to compressed wood shaving pellets and plant designed for their use range from gasification plant, designed to provide large scale (district wide) heat via a very clean combustion process to smaller purpose designed automatic boilers which burn a range of biomass fuels.

Combined heat & power - This is the production of both heating and electrical power for the site via burning fuel to provide steam to serve heating plant and power generation plant to turn it into electricity. Small scale CHP also exist, called Micro CHP or mCHP, using engines running on natural gas and increasingly more commonly, sterling engines.



Whilst the smaller options generally utilise fossil fuels, biodiesels could be used and in some cases vegetable oil in larger applications. Such systems however are very high maintenance and in the case of biomass systems incorporating steam turbines and heating, considerable space is required as well as day to day operation and maintenance attendance costs need to be considered. The main vital pre-requisite of a CHP system is that power and heat is required at the same time, and a base load exists for CHP plant to operate efficiently and cost effectively.

5.1 SOLAR THERMAL

Solar collectors (panels) absorb solar radiation and convert it to heat which is transferred to a hot water cylinder by circulating fluid through a series of pipes to pre-heat the water in the cylinder.

This pre-heated water is then further heated to useable temperature by an auxiliary system (boiler or electric immersion heater). Solar hot water systems do not usually contribute to the central heating system.

There are two standard types of collector: flat plate and evacuated tube;

- Flat plate collectors are simple but effective devices, comprising a dark plate within an insulated box with a glass or durable plastic cover. The plate is usually coated with a 'selective' coating to ensure that it has high absorption but low emissivity (heat loss by re-radiation).
- Evacuated tube collectors are more sophisticated, with a series of metal strip collectors inside glass vacuum tubes. Their efficiencies are usually higher and they are more effective in cold weather because of their low heat losses, but they do tend to be more expensive than flat plate collectors, and succumb more easily to vandalism.

This system could have a reduction against the overall Building demand noting that the DHWS Load is the peak load within the building during the daytime hours. A detailed design review of heating / DHWS loads will clarify system input.

Characteristics	Un-shaded roof area required. Collectors are sited on south-facing roofs Space required for hot water storage vessel near to collectors. Cost effectiveness – medium. Reliability – medium. Maintenance requirement – low. CO_2 savings – low / medium.
Advantages	Relatively simple to install. Payback time – higher than considered suitable in this instance. Grant funding may be available.
Disadvantages	High capital cost.
Recommendation	Reviewed however more effective measures included.
Potential savings	Although an initial assessment considers these it is considered more productive to review other systems at this stage. Dependent upon a more detailed analysis of DHWS systems input into the heating / DHWS LTHW systems may be viable.

NB: See section 5.2 for further integration of LZC systems.

5.2 PHOTOVOLTAICS

Photovoltaic systems or PV for short, use solar cells to produce electrical energy that can be utilised, via an inverter, within the building. This offsets the use of electrical energy from the grid and thus offsetting the carbon emitted in the process of generating electricity and transmitting it. On such a site, load shedding could contribute heavily to auxiliary energy usage and in part internal area lighting as well as small power.

As electricity is predominantly generated using fossil fuels, including a substantial degree of coal, the use of electricity is very carbon intensive when compared to the same unit of Gas energy. It is important to remember this when considered systems whilst reviewing simple paybacks.

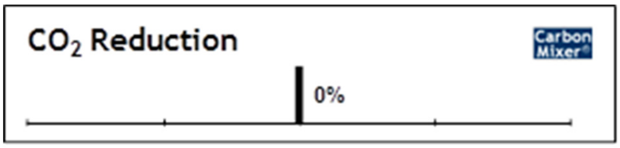
Solar panels are commonly best known as separate panels which are attached to buildings to provide solar electrical energy. Building integrated photovoltaics (BIPV) are the integration of photovoltaics into a buildings structure, providing an offset cost associated with it replacing a building fabric. Such well known systems are the use of photovoltaics in curtain walling and replacement roof tiles.

Considerations need to be made towards the installation of solar PV's. Panels are arranged in series in order to achieve the required voltage and therefore operate in banks of panels. Therefore, any existing shading that may affect the installation needs to be fully assessed.

Characteristics	Un-shaded roof area required. Collectors are sited on south-facing roofs pref. higher inclines (15 – 45). Space required for inverter. Cost effectiveness – medium. Reliability – medium. Maintenance requirement – low but specialist. CO_2 savings – medium
Advantages	Relatively simple to install. Payback times improved but in excess of 15 years with reduced feed in tariffs. Grant funding may be available.
Disadvantages	High capital cost. Shading results in low or zero payback (not in this instance).
Recommendation	Feasible
Potential savings	Based upon the BRUKL document analysis, a reduction of 13.011 kWh/annum could be achieved however utilising more efficient panels, inverters and DHWS immersion diverters we can see a saving of 17,458 kWh/annum with a resulting simple payback of 10.25yr.

5.3 WIND TURBINE

Discounted for the report due to planning conditions and site special installation options.



Zero carbon offsetting can be seen following brief assessment due to any feasible scale being considered.

Characteristics	Uninterrupted air flows are required Can visibly promote green credentials. Cost effectiveness – low. Reliability – medium. Maintenance requirement – low but specialist. CO_2 savings – medium.
Advantages	Relatively simple to install. Payback times improved but still in excess of 15 years with reduced feed in tariffs. Grant funding may be available.
Disadvantages	High capital cost. More difficult to retrofit into existing buildings. Air flows are generally not consistent in dense urban locations. Noise & vibration could be an issue.
Recommendation	Not feasible due to location of development

5.4 GROUND SOURCE HEAT PUMPS

Despite increasing use in other countries, Ground Source Heat Pumps (GSHP) are a relatively underutilised technology in the UK, although the performance of systems is now such that, properly designed and installed, they represent a very carbon-efficient form of space heating. Heat pumps take low temperature heat and upgrade it to a higher, more useful temperature.

A few meters below the surface, the ground maintains a constant year-round temperature of 11-12ºC and because of its high thermal mass, heat during the summer is stored and can be pumped into a building. Although the ground temperature may not necessarily be higher than ambient air temperature in winter, it is more stable compared to the wide temperature range of ambient air. This makes system design more robust.

GSHPs can be used to provide space heating (or cooling) to buildings. They cannot be seen from the outside of the building, so aesthetic design is not an issue. Although they require an electricity supply, the use of fossil heating fuels is offset, resulting in reduced overall carbon emissions. The measure of efficiency of a heat pump is given by the Coefficient of Performance (CoP), which is defined as the ratio of the heat output, divided by the quantity of electrical energy put in. CoPs of 3 or more should be achievable with GSHP systems, giving good energy and running cost savings. This means that for every unit of electricity used to pump the heat, 3 or more units of heat are produced, resulting in high system efficiencies.

Characteristics	Either a horizontal or vertical ground collector is required; the choice will depend on land area available, local ground conditions and excavation costs. Ground surveys will generally be required. Cost effectiveness – medium. Reliability – high. Maintenance requirement – low but specialist. CO_2 savings – medium.
Advantages	Well established technology. Can be used for cooling as well as heating. Payback up to 15 years subject to collection methodology. Grant funding may be available.
Disadvantages	High capital cost, particularly with vertical boreholes. More difficult to retrofit into existing buildings. Supply water at lower temperatures than traditional boiler plant, more suitable for underfloor heating in a new, well insulated, airtight building. Slow response in older more heavyweight buildings. Noise could be an issue. Secondary heat generator will be required for hot water and maybe heating.
Recommendation	Concerns regarding the amount of available ground and the condition of the ground suggest at this stage this technology need not be considered further.

5.5 AIR SOURCE HEAT PUMPS

Air source heat pumps (ASHPs) use the same principles as the GSHP described previously. The basis of the heat pump, therefore, is to take low-grade energy from the surrounding air by means of a fan pulling the outside air over a heat exchanger (evaporator); this energy is then upgraded and the higher temperature refrigerant vapour is released by means of another heat exchanger (condenser).

In ASHPs this heat exchange can be to the air inside the dwelling, and distributed to the different rooms by ducts and supply grilles. Alternatively, the heat exchange can be to water; it is this hot water that is the basis for the dwelling's heating circuit. This heating circuit can be an under-floor heating system or fan-coil units installed in the different rooms, or a combination of the two.

Unlike the GSHP, where the temperature of the ground is relatively stable throughout the year, in an air source heat pump the source air temperature range can be highly variable – not only seasonally but also daily. Also heat pumps operate at their most efficient when the source temperature is as high as possible, but in the UK the mean air temperature for winter is lower than the mean ground temperature.

All of these factors have an impact on seasonal efficiency for ASHPs, which is lower compared to GSHP. At low air temperatures the evaporator coil is likely to need defrosting. However, modern air source heat pumps can operate at better efficiencies than a gas fired boiler, even at lower ambient temperatures, and can also provide higher hot water temperatures if required.

Characteristics	Design and selection of system is crucial for optimum performance. Cost effectiveness – medium. Reliability – high. Maintenance requirement – low but specialist. CO_2 savings – medium.
Advantages	Well established technology. Can be used for cooling as well as heating. Payback up to 12 years Grant funding may be available.
Disadvantages	More difficult to retrofit into existing buildings. Supply water at lower temperatures than traditional boiler plant, more suitable for underfloor heating in a new, well insulated, airtight building. Slow response in older more heavyweight buildings. Noise could be an issue. Secondary heat generator may be required for hot water and maybe heating.
Recommendation	Feasible, subject to proposed improvements to existing building, and should be assessed in greater detail if applicable following discussions regarding site acoustics.
Potential Savings	Not considered suitable for overall heating of building therefore not considered as part of RHI LZC scheme. Heating & cooling will be provided for offices and meeting rooms by smaller ASHP units

5.6 BIOMASS

Biomass is the use of fuels that have been 'grown', collected, processed and used as a fuel. Various systems exists, one of the more popular being a pellet based system burnt in furnaces, with the pellets being from anything combustible including processed animal droppings to wood pellets from forest management (Pruning) or managed woodlands (trees grown for the purpose)
Liquid fuels are beginning to be developed, based upon fermented bio waste fuel and sunflower based fuel which burn very similar to diesel oil.

In domestic situations, log burning and pellet burning solutions are available from automatic feed wood pellet boilers to a more simplistic approach of a simple log burner incorporating a back boiler, in fact, the most carbon neutral option is the latter type burning wood from on-site tree management.

Where wood pellets are sourced from more remote parts, or even shipped in from abroad, the carbon emissions as a result of their transportation can eliminate any carbon savings associated with their use. As a result careful sourcing is necessary. Unlike gas boilers which can be switched on and off quickly and efficiently, wood boilers cannot. As a result, the use of a thermal store and sizing to meet part of the load to ensure they operate at full capacity and efficiency as much as possible is important.

Characteristics	Correct sizing is critical. Thermal store will be required. Requires fuel storage. Requires a secure and close supply of fuel. Cost effectiveness – medium. Reliability – high. Maintenance requirement – medium. CO_2 savings – high.
Advantages	Well established technology. Payback up to 15 years Grant funding may be available.
Disadvantages	High capital cost. More difficult to retrofit into existing buildings. Delivery of fuel is physically restrictive in dense urban locations. Requires basement or ground floor plant rooms with easy access for fuel delivery. Additional plant space for fuel storage is required. May not be acceptable by the Planning Authority in an Air Quality Management area. May require separate heat generator for summer hot water demands. Start-up times are longer.
Recommendation	Possible but less feasible due to summer operation, fuel storage requirements, fuel supply and local air quality issues.
Potential Savings	Not assessed due to excessive required plant space which is not feasible.

5.7 COMBINED HEAT AND POWER

Micro combined heat and power (CHP), for use in dwellings, is being presented as a direct replacement for the gas boiler. However, unlike a conventional gas boiler, the system will generate electricity as well as heat for space heating and hot water. Micro CHP installations run on natural gas and are therefore not renewable, but bio-gas systems are a future possibility.

CHP is considered to be a low carbon technology because it produces much less CO_2 emissions whilst generating heat and power when compared to the national grid.

Aside from the fuel and electricity connections, the main elements of a CHP installation consist of a prime mover, an alternator, a heat recovery system and a control system. There are several types of prime mover used in micro CHP systems but the most common type serving the domestic sector for single dwellings is the Stirling engine. Other types of prime mover in development for micro CHP systems include fuel cells and organic Rankine cycle systems.

The carbon saving potential of Micro-CHP has been found to be best in buildings which require long and consistent heating periods and best suited to larger buildings with heating demands over 20MWh/yr (after other cost effective and practical energy saving measures have already been implemented).

A typical domestic sized micro-CHP unit will deliver the same comfort levels as a modern boiler dependent upon thermal output however capacity notwithstanding, hydraulic interface will be the same. Although a small increase in gas usage is often seen with such systems, the heat generation combined with electrical production results in reducing the emissions, especially within such a building. In this instance, potentially, a saving of up to 30% could be achieved.

Characteristics	Low carbon technology producing heat & power Correctly sizing the heat output to the heat demand of the property is vital to fulfil potential. Thermal store will be required. Cost effectiveness – medium. Reliability – low. Maintenance requirement – high. CO_2 savings – medium.
Advantages	Payback up to 15 years (with reduced feed in tariffs). Feed in Tariffs make this more financially feasible. Local generation of electricity is usually cheaper than buying directly from the grid and Grant funding may be available.
Disadvantages	High capital cost. Still widely considered to be an emerging technology in development for dwelling applications. There is a high incidence of unreliability in currently installed units. As grid carbon intensity reduces (from an increase in renewables), so the benefits from micro-CHP fall accordingly.
Recommendation	Possible but not recommended due to technological developing system and the minimal constant load required to accurately match the saving potential..
Potential Savings	A 12kWe unit could provide the considerable savings due to utilised generated electrical energy. Carbon Reduction details will be subsequently defined following profiling assessment and any viable strategy incorporated within an addendum to this report.

6.0 LZC RECOMMENDATIONS (BE GREEN)

The first step in assessing the feasibility of Low and Zero Carbon technologies is to gain an understanding of the energy use in the building.

We have reviewed the DSM models and benchmarking to estimate the energy use and carbon dioxide (CO_2) emissions associated with the most relevant technologies as identified earlier within this report.

The construction of the building and elemental U- Values contribute greatly (although may change dependent upon final design however the LZC technology input within each model run were progressive and assessed against BER / TER holistically with the controlled U values defined within this report;

Results were conclusive with the highest betterment as below;

- Best Compliant Building - Photovoltaics & DHWS integration.
- BER betterment against existing building - 54%

At this stage, the following has been determined as the most effective LZC system is as follows;

- Photovoltaic Array: - 160m2 high efficiency monocrystalline PV array (20.03kWp).

Below the system final analysis data and lifecycle costing information can be seen;

Solar Selection analysis				
Solar Output	2.72	kWh/m^2	3.6494	kWh/m^2
Affected site Area	4783.7	m^2	4783.7	m^2
Annual AC Output	13011.664	kWh/annur	17458	kWh/annum
Electrical tariff	0.12	£/kWh	0.105	£/kWh
100%			£ 1,833.05	
FIT			0.041	£/kWh
100%			£ 715.76	
Unmonitored Export			0.044	£/kWh
50%			£ 384.07	
Annual saving on-site	£ 1,561.40		£ 2,932.88	
Capital Cost	£ 29,980.00		£ 26,559.00	
Gem Apollo Diverter			£ 3,500.00	
Simple Payback	19.20072124		10.25	years

Lifecycle costing Analysis				
System life			25	years
Capital Cost			£ 30,059.00	
Inverter replacement / warranty			£ 2,000.00	
5 year inspections (25 yr system life)			£ 3,750.00	
Replacement diverter			£ 3,500.00	
Lifecycle costs			£ 39,309.00	
Annual saving on-site	£ -		£ 2,932.88	
Energy tariff engaged saving			£ 70.39	2%
Lifecycle saving on-site			£ 75,081.80	
Total lifecycle costs			-£ 35,772.80	

7.0 GRANTS

The Renewable Heat Incentive is considered to be a viable grant for this project based upon selected LZC technology and the implementation of the design of said technology into the building.

The Non-Domestic Renewable Heat Incentive (RHI) is a Government environmental programme that provides financial incentives to increase the uptake of renewable heat. For the non-domestic sector broadly speaking it provides a subsidy, payable for up to 20 years, to eligible, non-domestic renewable heat generators and producers of biomethane for injection based in Great Britain.

All of which is subject to the detailed scheme rules. It is understood that some LZC technologies will be further included within this scheme during the construction phase of this project and should be considered as such at this stage.

By providing a long-term financial incentive, the objective of the Non-Domestic RHI is to significantly increase the proportion of heat generated from renewable sources. By driving change in a heat sector currently dominated by fossil fuel technologies, the RHI can help the UK meet Carbon Reduction targets to reduce carbon emissions and improve energy security.

Enhanced Capital Allowance (ECA) based upon equipment registered on the Energy Technology List could also be considered based upon the final scheme agreed for design.

APPENDIX A BRUKL DOCUMENT (54% REDUCTION)

Further betterment of the documented U-Values will be seen through the detailed design stage.

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

1654 Holmes Road Depot

As designed

Date: Wed Jul 20 11:07:46 2016

Administrative information

Building Details

Address: Holmes Road Depot, 78 Holmes Road, London, NW5 3AP

Certification tool

Calculation engine: SBEM

Calculation engine version: v5.2.g.3

Interface to calculation engine: Virtual Environment

Interface to calculation engine version: v7.0.5

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

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

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	22
Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	22
Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	21.9
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	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.29	1.52	1F00001D_W1_-1
Floor	0.25	0.23	0.98	GF00000B_F_-1
Roof	0.25	0.38	1.37	1F00001D_C_-1
Windows***, roof windows, and rooflights	2.2	2.59	6.69	GF00001C_C-W0
Personnel doors	2.2	1.8	1.8	GF000001_W2-W0
Vehicle access & similar large doors	1.5	-	-	"No external vehicle access doors"
High usage entrance doors	3.5	-	-	"No external high usage entrance doors"

$U_{a\text{-}Limit}$ = 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	8

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	4783.7	4783.7
External area [m²]	7580.7	7580.7
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	8	3
Average conductance [W/K]	3931.45	2757.65
Average U-value [W/m²K]	0.52	0.36
Alpha value* [%]	14.32	16.45

* 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
99	**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
1	**Others: Miscellaneous 24hr activities**
	Others: Car Parks 24 hrs
	Others - Stand alone utility block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	29.71	21.54
Cooling	3.63	2.25
Auxiliary	2.31	0.98
Lighting	13.86	15.3
Hot water	33.71	35.93
Equipment*	42.49	42.49
TOTAL**	83.22	75.99

* 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	4.99	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	2.72	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	189.46	157.97
Primary energy* [kWh/m²]	141.57	126.86
Total emissions [kg/m²]	21.9	22

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

END OF DOCUMENT