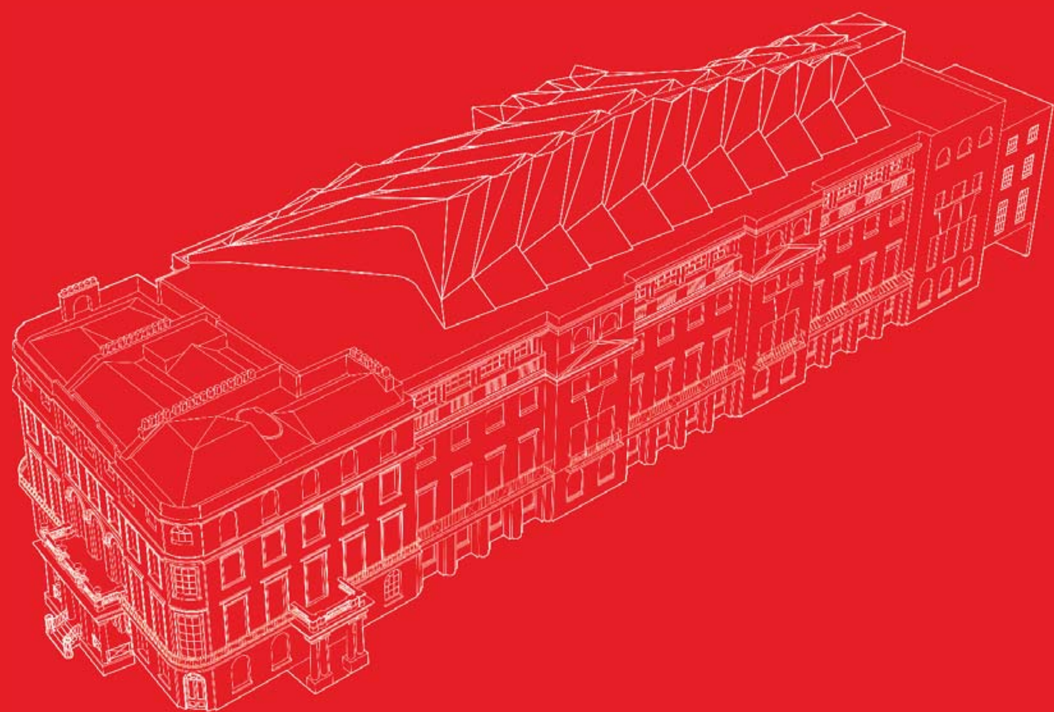
WHICH? HEADQUARTERS

2 MARYLEBONE ROAD AND 1-9 ALBANY STREET

ENERGY | SUSTAINABILITY STATEMENT

AUGUST 2013



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EXECUTIVE SUMMARY

The following Energy Statement has been produced to explain the energy strategy proposed for the Which? Headquarters building (WHQ).

The building is located at 2 Marylebone Road & 1-9 Albany Street, London. The proposed new roof and refurbishment of the office space seeks to minimise its environmental impact by reducing its energy consumption.

The project is comprised of both a refurbishment and extension. The project includes replacing the existing building service systems and adding an additional level on the existing 1980s building roof.

The Camden Council have set out certain requirements that the Energy Statement must cover in detail. The following summarises each requirement:

1. 2008 BREEAM (refurbishment) target to achieve at least "Very Good":
The following table shows the estimated scores for each category of the BREEAM 2008 (refurbishment) pre-assessment. WHQ will be aiming for an 'Excellent' rating.

Credit allocation	% Achieved	Env. Weighting	Score
Management	90.00	0.12	10.80
Health & Well-being	61.54	0.15	9.23
Energy	52.17	0.19	9.91
Transport	100.00	0.08	8.00
Water	66.67	0.06	4.00
Materials	84.62	0.125	10.58
Waste	85.71	0.075	6.43
Land Use & Ecology	80.00	0.1	8.00
Pollution	50.00	0.1	5.00
Innovation	20.00	0.1	2.00
Rating			73.95% EXCELLENT

BREEAM 2008 (refurbishment) Scoring for WHQ

2. Target 60% un-weighted credits in the BREEAM energy section:
Camden Planning Guidance Note 3 states that 60% of un-weighted energy credits, 40% of un-weighted water credits and 40% of un-weighted materials credits are strongly recommended in the BREAM assessment. We note that these are 'strongly encouraged' and not a mandatory requirement.

Design restraints due to the grade II* listed building's retained façade and site pollution issues have restricted the building's design to achieving a score of 52.17%. (Please refer to Section 5 for more detail).

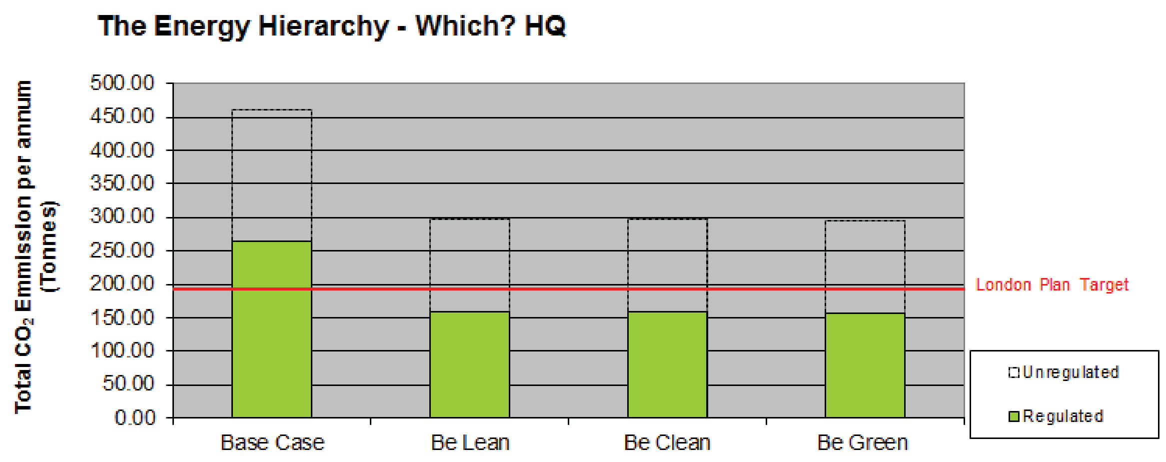
However, the refurbishment of the building achieves a vast improvement from the environmental performance of the building over the existing situation. The Camden Planning Guidance document targets for water and materials are greatly exceeded.

3. Reduction in Carbon Emissions use by area to the new build by 20% from on-site renewable energy:

- The proportion of carbon emission **saving**s from renewable technology to new build areas – **8%**
- The annual quantified carbon emissions **shortfall** in the policy requirement – **2,997 kgCO_2**
- The annual carbon emission **savings** by refurbishment and extension to the whole building – **106,706 kgCO_2**
- The annual carbon emission savings to the whole building far **exceeds** the requirement to offset carbon emissions by 20% to the new build area
- There is an annual carbon emission saving **35 times greater** than the renewable technology shortfall due to the improvements of the building. The improvements include both the refurbishment and extension spaces.

Due to planning restrictions, the only on-site renewable technology deemed suitable for the development is Photovoltaic Solar Panels (PV) (please refer to Section 7 for more detail). Approximately 50m² of hi-spec thin film Photovoltaic solar panels was used to achieve an 8% reduction of the carbon emissions to the new build areas.

However, it has been demonstrated that the overall carbon emission savings compared to the existing building will **exceed 40%** once all recommendations have been implemented.



Whole Building: The Energy Hierarchy Graph

The above chart illustrates the four stage process **'Base Case, Be Lean, Be Clean, Be Green'** for the proposed development at WHQ. The newly refurbished building; including the new roof and extensions, achieves a **41.5%** reduction of carbon emissions as compared to the "Base Case" model.

4. Demonstrate all other sustainability measures that are incorporated into the whole building:
Rain water is recycled for irrigation purposes. Rain water will be collected and stored in a rain water tank (in the basement plant room or possibly in the sub-basement) and the rain water will feed the irrigation pipe network buried in the green wall at west façade. (Please refer to the Stage C Building Services report for details).

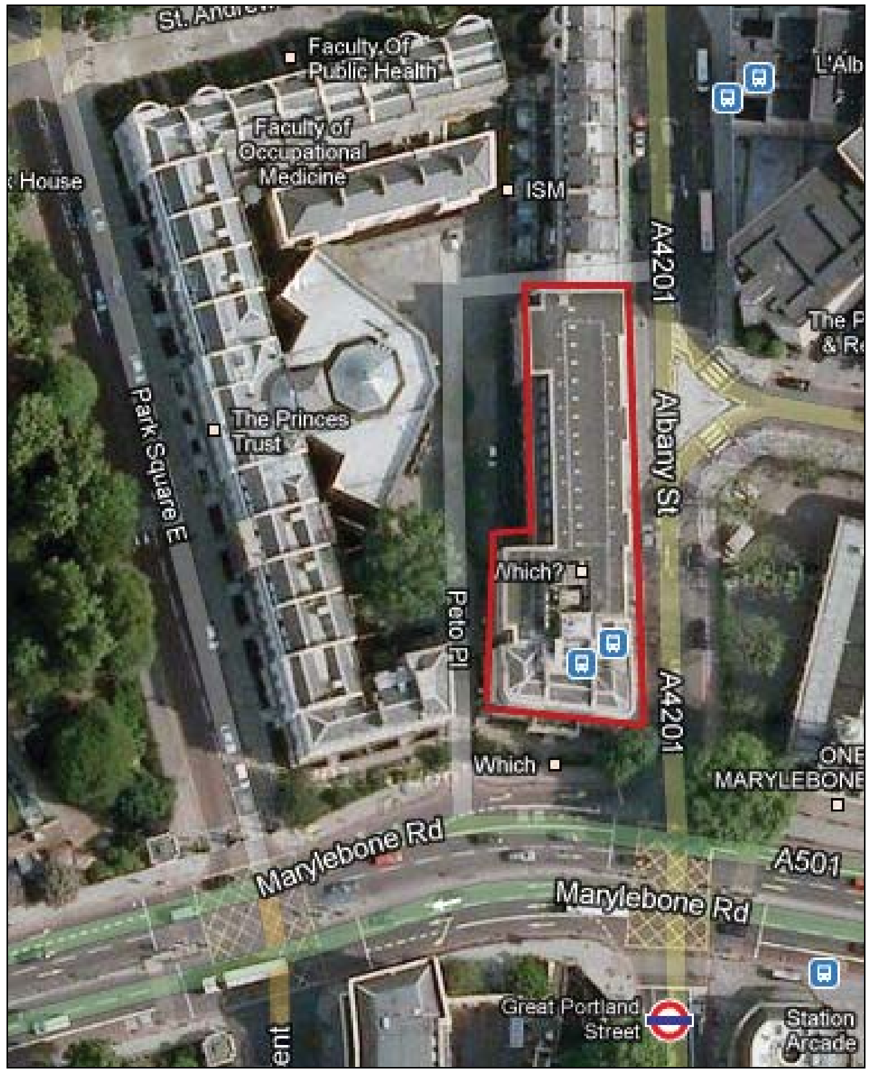
5. <u>Solar Gain Statement</u>: Demonstrate that the new roof and extension building design optimises solar gain without resulting in overheating:

The new roof extension has been provided with a low U value and g value glazing solution. Glazing has been provided to the roof at pitches facing away from the south. Whilst providing natural light during daylight hours, this will reduce glare and unnecessary solar gain. The new level 4 external walls facing Albany Street have North East facing glazing in order to improve day lighting and comfort whilst avoiding overheating. The glazing overlooking Peto Place has been provided with vertical fins that act as local shading. (Please refer to Section 4 for more detail).

1 Introduction

Number 2 Marylebone Road is a Grade II* listed early 19th Century building listed for group value with the Regent's Park Nash terraces. The building connects to 1-9 Albany Street, a modern, 1980's office extension. The site is located in the Regent's Park Camden Conservation Area and forms the single office building occupied by the headquarters of Which? (WHQ).

Which? is a product-testing and consumer campaigning charity with a magazine, website as well as various other services. Which? have a consumer based influence that is constantly increasing. Changes in working practices and staff structure, as a result of a rapid shift towards digital publishing, alongside anticipated increases in staff numbers, mean that the existing office space is unsuitable for its continued occupation without extension and refurbishment. The existing building is without the desired facilities to host events such as awards ceremonies, roundtable discussions, lobbying events and seminars. At present, Which? expend considerable resources (which could be better directed towards its charitable aims) in renting conference space off the premises. The refurbishment of the building will address this deficiency.



WHQ from the Google Maps satellite view

The plan to extend includes a new level added at the existing 1980s building roof, with new 'pods'; modifying the Peto Place elevation to accommodate lifts, toilets, meeting rooms etc. The extension will add under 20% to the building internal net area. The Albany Street 'extension' will be fully refurbished. The Marylebone Road building will have a 'light' refurbishment.

Gross External Areas
Existing building GEA: 66,812ft²/6,207m²
Existing building typical floor area: 12,863ft²/1,195m²
Proposed building GEA: 77,500ft²/7,200m²
Uplift in GEA between the existing and proposed buildings: 10,689ft²/993m²
New roof: 6,857ft²/637m²

Building regulations Part L 2010 will apply to the development. The London Plan 2011 policies will also apply. Further details will be explained in Section 2.

Thornton Reynolds have investigated the options for the building services to offer the most relevant solutions that can be applied to both reduce the energy consumption of the building and to provide a comfortable working environment.

The office space will be provided with energy efficient cooling and heating, whereas functional space will be fitted out with separate systems to accommodate the needs of the occupancy.

Building fabric U values will exceed what is recommended within Building regulations Part L2A within the new extension space. Building U values will exceed what is expected for the refurbishment where it is deemed financially acceptable and where the reduction of energy costs are most significant.

2 Policy and Planning

Kohn Pedersen Fox Associates (KPF) issued information to Camden Council Planning and Built Environment for a pre-planning meeting which took place on the 2nd of November 2012. At the meeting, it was accepted that as the majority of the building is a refurbishment, Part L2B 2010 (Conservation of Fuel and Power in Existing Buildings Other Than Dwellings) applies. However, the renewables commitment of the London Plan to seek 20% renewables shall apply to the extension 'New Build' elements. Therefore, Part L2A 2010 requirements will be adopted for the new roof and extension areas.

The London Plan 2011 Policy 5.7 indicates 20% renewable contribution, "*There is a presumption that all major development proposals will seek to reduce carbon dioxide emissions by at least 20 per cent through the use of on-site renewable energy generation wherever feasible. The Mayor encourages the use of a full range of renewable energy technologies, which should be incorporated wherever site conditions make them feasible and where they contribute to the highest overall and most cost effective carbon dioxide emissions savings for a development proposal.*"

In addition, although Planner's published advice is for a BREEAM pre-assessment achieving 'Very Good' as part of the planning submission, they have advised that to obtain a favourable view of a planning decision, the aim should be for an 'Excellent'.

Camden Council strongly encourage that there should be a target to achieve 60% of the un-weighted credits within the energy section of BREEAM. This is in accordance with development policy DP22-Promoting Sustainable Design and Construction.

The Energy Statement should also include evidence showing that solar gain has not been exceeded in individual rooms. The standard is set by criterion 3 in the building regulations Part L2A.

2.1 Approach

Throughout the pre-planning stage of the design, the policies on energy have been considered thoroughly in order to achieve, above and beyond, what is required by Camden Council and the London Plan on the refurbishment, new roof and extensions.

The following energy hierarchy method was used:

- "Be Lean": use less energy;
- "Be Clean": use energy efficiently;
- "Be Green": use renewable energy.

The purpose of the "Be Lean" stage is to highlight how the building emission rate (BER) of the refurbishment, new roof and extension areas has been reduced passively by way of intelligent design. The new roof and extension meets Part L2A standards and in most cases goes above and beyond what is required. The refurbished building meets Part L2B standards.

The "Be Clean" stage seeks clean energy systems implemented on site.

The "Be Green" assesses the feasible renewable technologies that can be adopted on site.

Using the energy hierarchy, the new building's BER (including the refurbishment, new roof and extension areas) will be measured together and compared to a "Base Case" (measured by the building's current energy consumption).

Also, using the energy hierarchy, the new roof and extension will be measured separately to the refurbishment and assessed against a target emission rate (TER) to establish how a 20% reduction of carbon emissions can be achieved.

Reducing the building's energy consumption by way of intelligent design is paramount to both the planning requirements and the desires of Which?.

The design criteria used for the pre-application mechanical design calculations have been sourced from the CIBSE Guides and The British & European Standards. The figures are then transferred as an input for the IES <VE> software to produce thermal modelling results.

2.2 IES Virtual Environment Software

The IES <VE> software package provides a Dynamic Simulation Method (DSM) to assess non-domestic building energy consumption and its carbon dioxide emissions. The building envelope and service parameters are set up for the model and analysed. The DSM assessment calculates the performance of the building on an iterative basis, recalculating to a very fine time resolution of every 10 minutes over a year.

IES<VE> Development Site Thermal Model

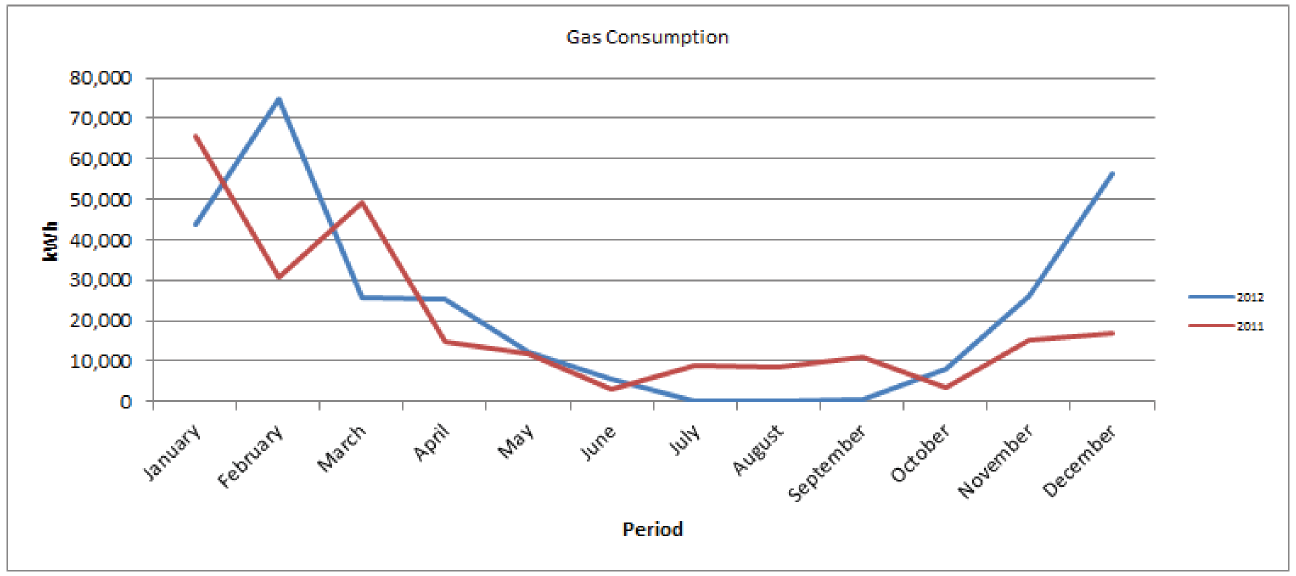
The location of the building is set using the correct environmental data, including the;

- Dry-bulb temperature
- Wet-bulb temperature
- External dew-point temperature
- Wind speed
- Wind direction (E of N)
- Direct radiation
- Diffuse radiation
- Global radiation
- Solar altitude
- Solar azimuth
- Cloud cover
- Atmospheric pressure
- External relative humidity
- External moisture content

The building orientation and geometry is based on the latest Architectural drawings received 25th June 2013. The thermal model replicates the building's geometry as much as is possible.

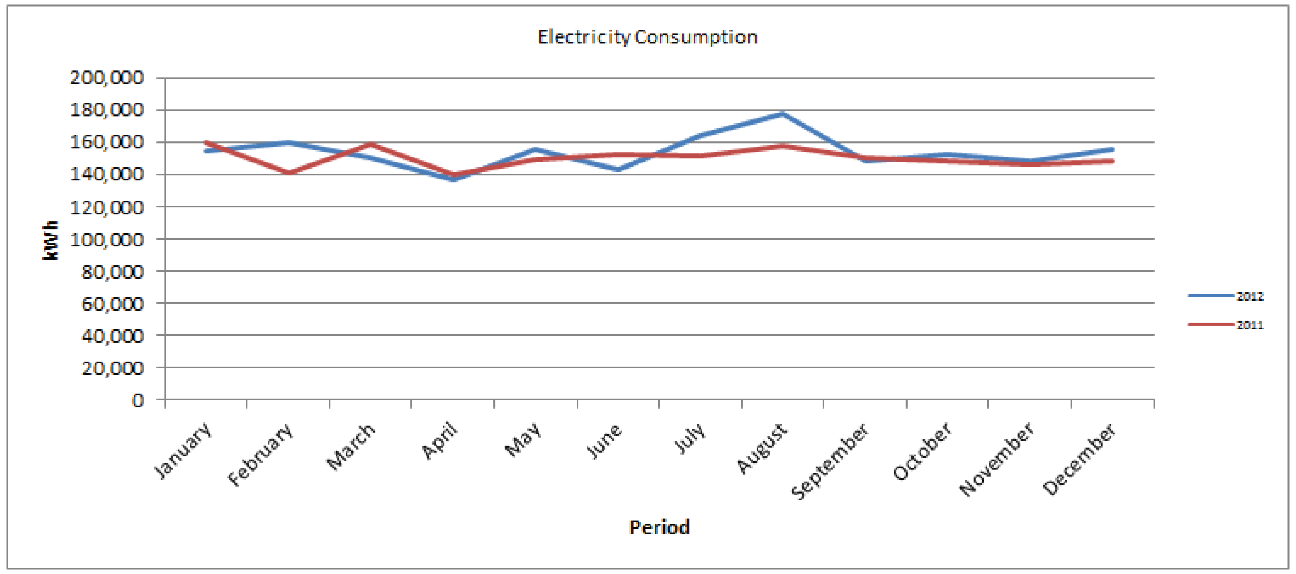
3 "Base Case"

3.1 WHQ 2011/2012 Gas Consumption



WHQs total gas consumption for 2012 was 195 MWh which is up from the 2011 figure of 151MWh - an increase of 29%. February and December sees the greatest variance. However, February 2011 was considered the mildest February since 2002, whereas February 2012 was snowy and cold across London.

3.2 WHQ 2011/2012 Electricity Consumption



The above table includes both regulated and unregulated electricity consumption at WHQ. WHQ's total Electricity consumption for 2012 was 1,112 MWh which is up from the 2011 figure of 1,077MWh - an increase of 3%. August sees the greatest variance with an increase of 5% from 2011. August 2012 was a hot month compared to August 2011 that saw a relatively cool temperature in London.

By comparing the data, 2012 had a greater range of temperatures, therefore resulting in increased loads from heating in the winter months and cooling in the summer months. Energy prices are continuing to soar and temperatures are becoming extreme. Cooling loads will increase as the global temperatures rise.

It is therefore important to consider efficiencies and seasonal efficiencies of the new systems that will be implemented on site. The appropriateness of updating the building's fabric will also be considered against payback periods and carbon payback compared to other energy measures.

4 "Be Lean"

4.1 Building Fabric

Part L2A Construction Standards	Limiting Fabric Parameters (W/m²K)	Proposed New Roof Space minimum U-value (W/m²K)
Roof	**0.25**	**0.15**
External Wall	**0.35**	**0.15**
Exposed Floor	**0.25**	**0.15**
External Glazing	**2.2**	**1.1**

New Roof and Extension U-values used

The 1980s extension roof building achieves above and beyond the minimum requirements set by Building Regs Part L2A 2010. The new extension will be provided with high performance building fabric alongside a low air permeability rate.

The existing building's U values have been calculated as below the Part L2B threshold. It has been deemed inappropriate to direct funds at completely upgrading the whole of the existing building fabric, because the payback period for upgrading the fabric has been calculated at +50 years. By using an iterative method of running separate detailed thermal models, it was concluded that improving the efficiency of the HVAC systems provides a shorter payback period.

4.2 Part L: Part L2A Criterion 3: Limiting the effects of solar gains in summer

The new roof extension has been provided with a low U value glazing solution. The glazing type includes a low solar gain approach to restrict the rate at which long wavelength infra-red light enters the internal space; this in turn reduces the susceptibility of overheating in the summer and lower cooling loads.

Frames will be sufficiently sealed and insulated to avoid air leakage and thermal bridging.

Glazing has been provided to the roof at pitches facing away from the south. Whilst providing natural light during daylight hours, this will reduce glare and unnecessary solar gain. The new level 4 external walls facing Albany Street have northeast facing glazing in order to improve day lighting and comfort whilst avoiding overheating.

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?
GF Lifts	N/A	N/A
1F Lifts	N/A	N/A
1F Meeting Room	NO (-72%)	NO
2F Lifts	N/A	N/A
2F Meeting Room	NO (-69.8%)	NO
3F Lifts	N/A	N/A
3F Meeting Room	NO (-68.3%)	NO
4F Food Prep/Store	NO (-61.6%)	NO
4F Meeting Room	NO (-69.6%)	NO
1F Open Office	NO (-74%)	NO
GF Circulation	N/A	N/A
2F Open Office	NO (-70.7%)	NO
3F Open Office	NO (-65.9%)	NO
4F Meeting Room	NO (-62.1%)	NO
4F Meeting Room	NO (-79.6%)	NO
4F Internal Public Zone	NO (-32.6%)	NO
4F Lifts	N/A	N/A

BRUKL Report excerpt: Solar Gain limits for new extension and roof space (N/A = Not Applicable)

The solar gain has not been exceeded for the new extension and roof space. Low g values in conjunction with the orientation of the glazing has provided sufficient measures to ensure that the solar gains from the sun do not exceed the solar gain limit.

4.3 Airtightness

In order to reduce the energy consumption in buildings, it is important to improve the air tightness. Improved air tightness significantly reduces heat loss (especially overnight). The current building has not been air-tested. The 1980s building will be heavily refurbished so there will be an aim to achieve an airtight building. However, the grade II* building is only being provided with a light refurbishment due to the planning requirement to keep the façade. The new roof extension will be designed to reach an air tightness of below 5m³/(hm²) @ 50 Pa which meets modern standards. The total targeted figure for the whole building is a figure of 10m³/(hm²) @ 50 Pa which is the current building regulation's limit for new build.

4.4 Mechanical Ventilation with Heat Recovery

Air Handling Units (AHU) with high efficiency heat recovery flat plate heat exchangers will be selected (assumed 50%-75% efficiency) with low specific fan powers of approximately 2.2l/s. The system will provide fresh air to the habited spaces such as office space, meeting rooms and reception areas etc.

4.5 Pumps and Fans

Variable speed pumps and fans with pressure control will be sourced. The pumps and fans will run at partial load to avoid unnecessary energy consumption.

4.6 Rainwater Harvesting

Rain water is recycled for irrigation purposes. Rain water will be collected and stored in a rain water tank (in the basement plant room or possibly in the sub-basement) and the rain water will feed the irrigation pipe network buried in the green wall at west façade (please refer to the Stage C Building Services report for details).

4.7 Light Fittings and Controls

The lighting design at WHQ will be designed to include a mix of low energy compact fluorescent lighting with LEDs placed in areas where deemed feasible. Time-clock with manual override and daylight-linked dimming will be provided in high occupation areas. Auto on/off (presence detection) will be included in areas where use is less frequent.

4.8 Energy Efficient Plant

The Active Chilled Beam system will act as the delivery of the heating, cooling, ventilation and some lighting in most of the spaces in the 1980s building at WHQ. The HVAC source will be positioned in various plant rooms. The cooling will be supplied by either air cooled or water cooled chillers that have their own refrigeration circuits to create cooling for a water circuit linked to the active beams. The heating will be supplied via high efficiency gas supplied boilers that have the potential to link up to a water condensing circuit to use the energy that would have otherwise been lost to the atmosphere.

The listed building will undergo a light refurbishment only. As such the internal layout does not include large enough open spaces to warrant active chilled beams. 4 Pipe Fan Coil Units (FCU) will be placed in the grade II* listed building areas.

Heating and Cooling Systems will use time and thermostatic controls alongside load compensators to ensure that the systems are used only when necessary.

4.9 Demand Controlled Ventilation

A Building Management System (BMS) will control the mechanical ventilation in the designated spaces. The wet room areas will only use the MVHR when deemed necessary. Therefore, timed extract fans will be used only when sensors deem the space occupied (by way of PIR/Temperature/CO_2 sensors).

4.10 Enhanced user Understanding

Management is encouraged to actively help users understand the control systems that will be placed at WHQ. Although energy saving measures will be implemented to the design, saving energy through occupational behaviour has an immeasurable effect. A BMS system, with an energy monitoring device, should be regularly monitored to assess the occupational behaviour. Identifying where consumption has either been increased or decreased, within the building, will help the facilities team to assess, control and therefore lower energy consumption. A BMS that can identify consumption by zone is advised.

5 BREEAM Pre-Assessment

5.1 Overall Score

Eight Associates have been appointed, as registered BREEAM assessors, to produce a preliminary assessment of the new offices development within the Which? main office in Camden, London. The development will be initially assessed under BREEAM for Offices 2008, as it is mainly a refurbishment of an existing building, with some extension included. The assessment is based on information from meetings and discussions with the design team in February 2013 and June 2013.

The current predicted score of the development is 73.95%, which equates to an 'Excellent' rating. The desired score for the development is 'Excellent', which would require a minimum score of at least 70%. The policy set by Camden requires a rating of 'Very Good', therefore the building achieves an environmental performance in excess of policy.

In order to achieve BREEAM 2008 (refurbishment) 'Excellent', a minimum of 6 credits is required under Ene01; the Ene01 score is directly related to the building EPC rating. A provisional EPC output is calculated by the thermal modelling software package IES<VE> (please refer to section 2 for further detail). The table below has been extracted from the BREEAM guide and identifies the requirements.

Table 9 CO_2 index benchmarks and BREEAM credits

	CO_2 Index (EPC Rating)	
BREEAM Credits	New Build	Refurbishment
1	63	100
2	53	87
3	47	74
4	45	61
5	43	50
6	40	47
7	37	44
8	31	41
9	28	36
10	25	31
11	23	28
12	20	25
13	18	22
14	10	18
15	0	15
Exemplar credit 1	<0	≤0
Exemplar credit 2	*True zero carbon building*	

Ene01: EPC Rating and BREEAM credit benchmarks

"For assessments of buildings that are a mixture of new build and existing building refurbishment a weighted benchmark scale is used. The weighted benchmark scale is determined using the area (m²) for new build and area (m²) for refurbishment and the two benchmark scales in Table 9 CO_2 index benchmarks and BREEAM credits for new build and refurbishment. If there is a higher proportion of new build to refurbishment then the weighted scale will be biased towards the benchmark scale for new buildings and vice-versa if there is a higher proportion of refurbished element. As the benchmarks are influenced by the split in areas between the new build element and major refurbished element of the assessed building, the benchmarks will change the new build/refurbishment area totals change." *BREEAM 2008 (refurbishment guide)*

Two options were originally assessed for the WHQ building. Option 1; A standard VRF (Variable Refrigerant Flow) type heating/cooling system including all areas and Option 2; a Chilled Beam heating/cooling system to the main 1980's building and VRF fan coil units to the existing grade II* listed building. The EPC rating under option 1 achieved a C. The EPC rating under option two achieved a B. Option two achieved the relevant 6 credits from the BREEAM table 9 on the left.

Please refer to the table below for the overall BREEAM 2008 (refurbishment) score:

Credit allocation	% Achieved	Env. Weighting	Score
Management	90.00	0.12	10.80
Health & Well-being	61.54	0.15	9.23
Energy	52.17	0.19	9.91
Transport	100.00	0.08	8.00
Water	66.67	0.06	4.00
Materials	84.62	0.125	10.58
Waste	85.71	0.075	6.43
Land Use & Ecology	80.00	0.1	8.00
Pollution	50.00	0.1	5.00
Innovation	20.00	0.1	2.00
Rating			73.95% EXCELLENT

Total BREEAM 2008 (refurbishment) Score

5.2 Energy Criteria

Design restraints due to the grade II* listed building's retained façade and site pollution issues have restricted the building's design, to achieving a score of 52.17%. Camden Council ask for an **aim** to target 60%.

To achieve 60% for the energy section, 2 more credits would need to be found. The only credits that can be improved upon are in sections Ene01 and Ene05. Ene01 is based on an EPC score. The refurbishment would need to achieve an EPC score of 41 to get the relevant credits. To get a score of 41, improvements would need to be made to the grade II* listed building that would be in conflict with the planning requirements that only a light refurbishment be made.

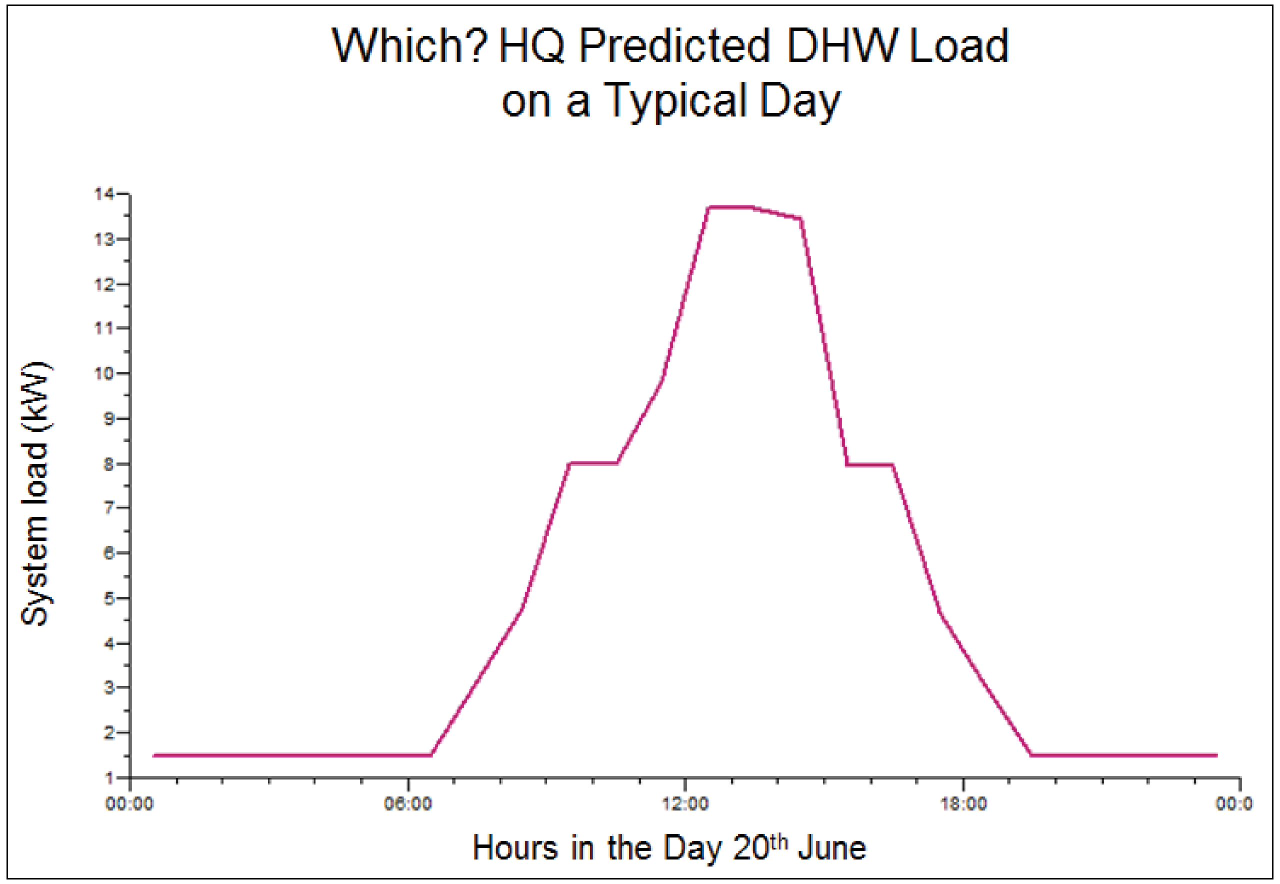
Ene05 is based on providing on-site renewable technologies. To gain an extra 2 credits from this section, 15% of the whole building's energy consumption must be offset by renewable technologies. It has been deemed unfeasible at the WHQ location to get a 15% on-site contribution with such planning restrictions mentioned within section 6.

The 60% may well have been feasible if constraints on the design were not so important for this particular project.

6 "Be Clean"

6.1.1 Combined Heat & Power

Combined Heat and Power (CHP) can provide effective on-site generation of electricity which, through the direct use of the 'waste heat' from the process, makes its use more efficient than separate utility provided electricity and on site heat generation. However, one of the difficulties is the increased levels of NO_x gases created from the CHP, which need to be exhausted at an appropriate point around the building. This usually requires a very tall discharge chimney. The WHQ building is located in an already polluted area of central London. Adding a CHP plant will increase the amount of pollution. A significantly tall chimney is required to carry away the high NO_x concentrated flue gases.



Predicted DHW load on a typical working day at WHQ

The above shows that there is an approximate 14kWp load on a typical day for the "Be Lean" WHQ building. The demand profile is significantly lower, with 8kWh or below for most of the day. Placing a centralised CHP plant at WHQ would lead to the problem of a CHP boiler that switches on and off. This modulated effect would then lead to maintenance issues and severe inefficiencies over time. Boiler backups would need to be included which would then be used as the main hot water system feed, rendering a central CHP plant a gimmick rather than a solution.

CHP is best suited for large developments that have relatively constant water heating load profiles, including large residential projects and industrial parks. The WHQ refurbishment and extension project has a relatively small load to be able to sufficiently produce enough energy to avoid the CHP boiler from cutting off. This would lead to mechanical malfunction over time. The project doesn't have a large enough constant base load in order to choose a practical sized CHP plant.

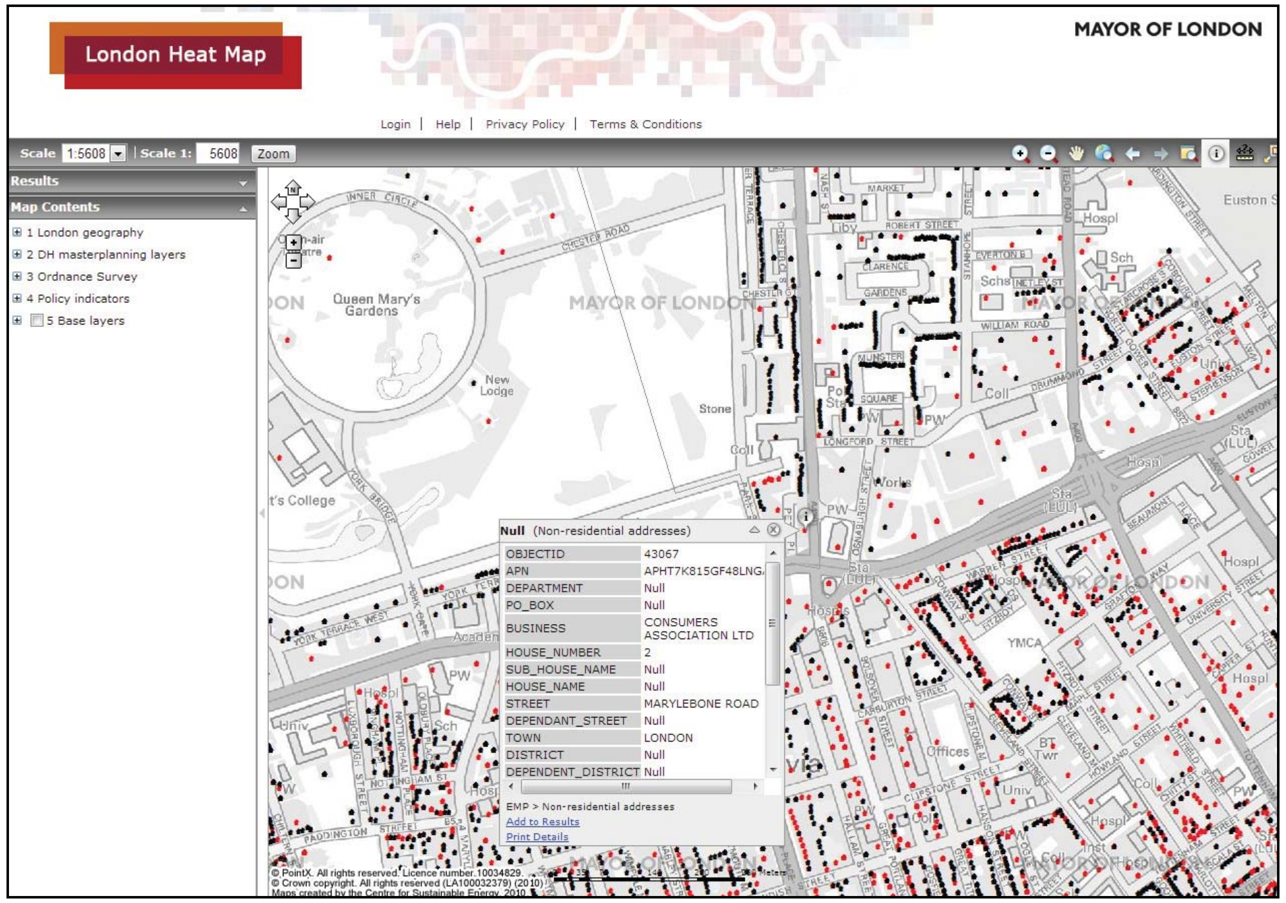
It should be noted that the advantage of using CHP is that it uses natural gas to generate electricity, and natural gas has a much lower carbon density (0.198kgCO_2/kWh) than grid displaced electricity (0.529kgCO_2/kWh). But in terms of energy, it uses more kWh to generate the same amount of electricity than using the electricity directly from the grid which is deemed unfavourable to BREEAM Ene01.

Considering all of these points, CHP technology is not adopted.

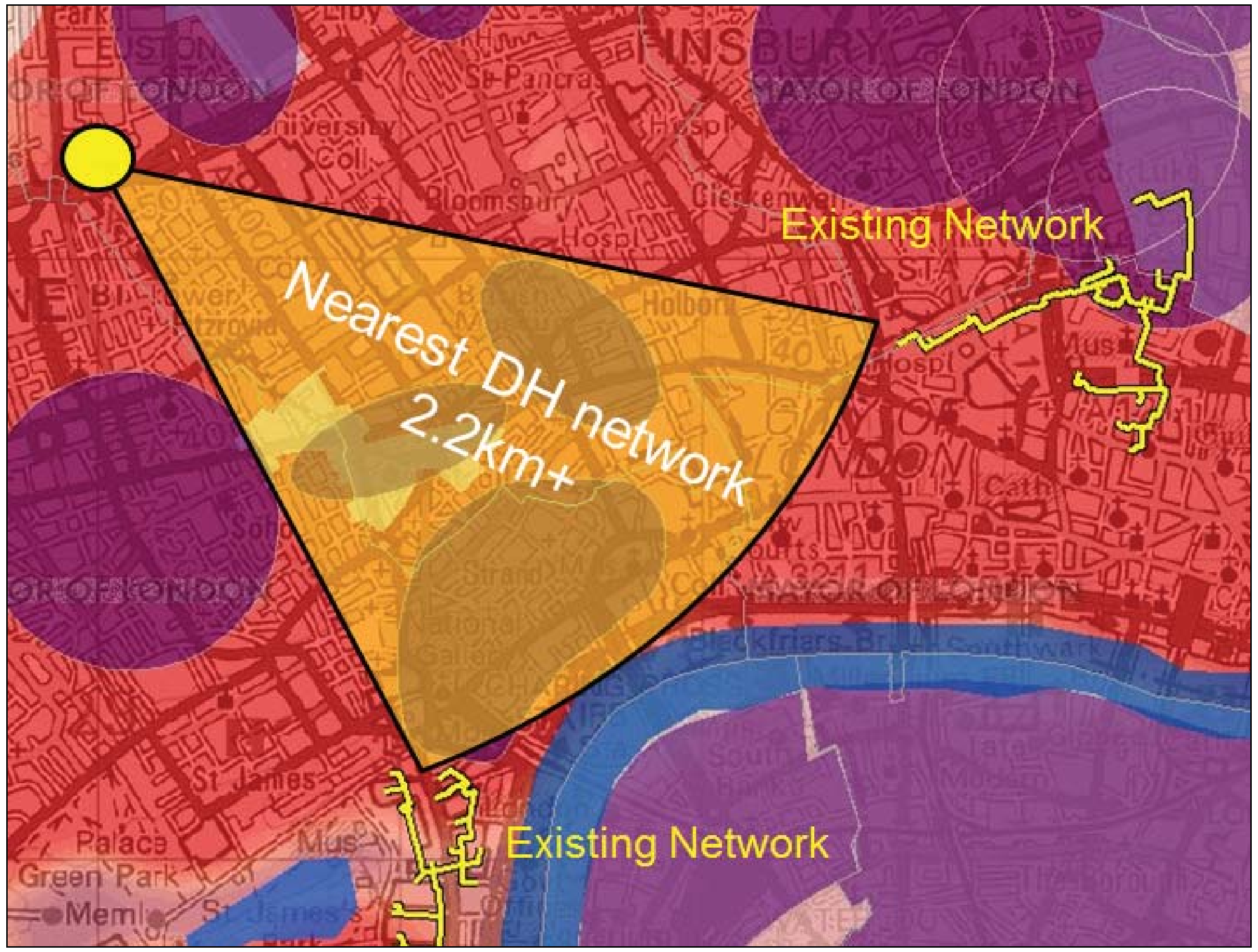
6.2 London Heat Map Reference

As per the GLA guidance, the site has been investigated on the London Heat Map interactive map. The building is identified on the London Heat Map as reference object ID 43067.

Currently there is no district heating network sufficiently close enough to link to 2 Marylebone & 1-9 Albany Street.

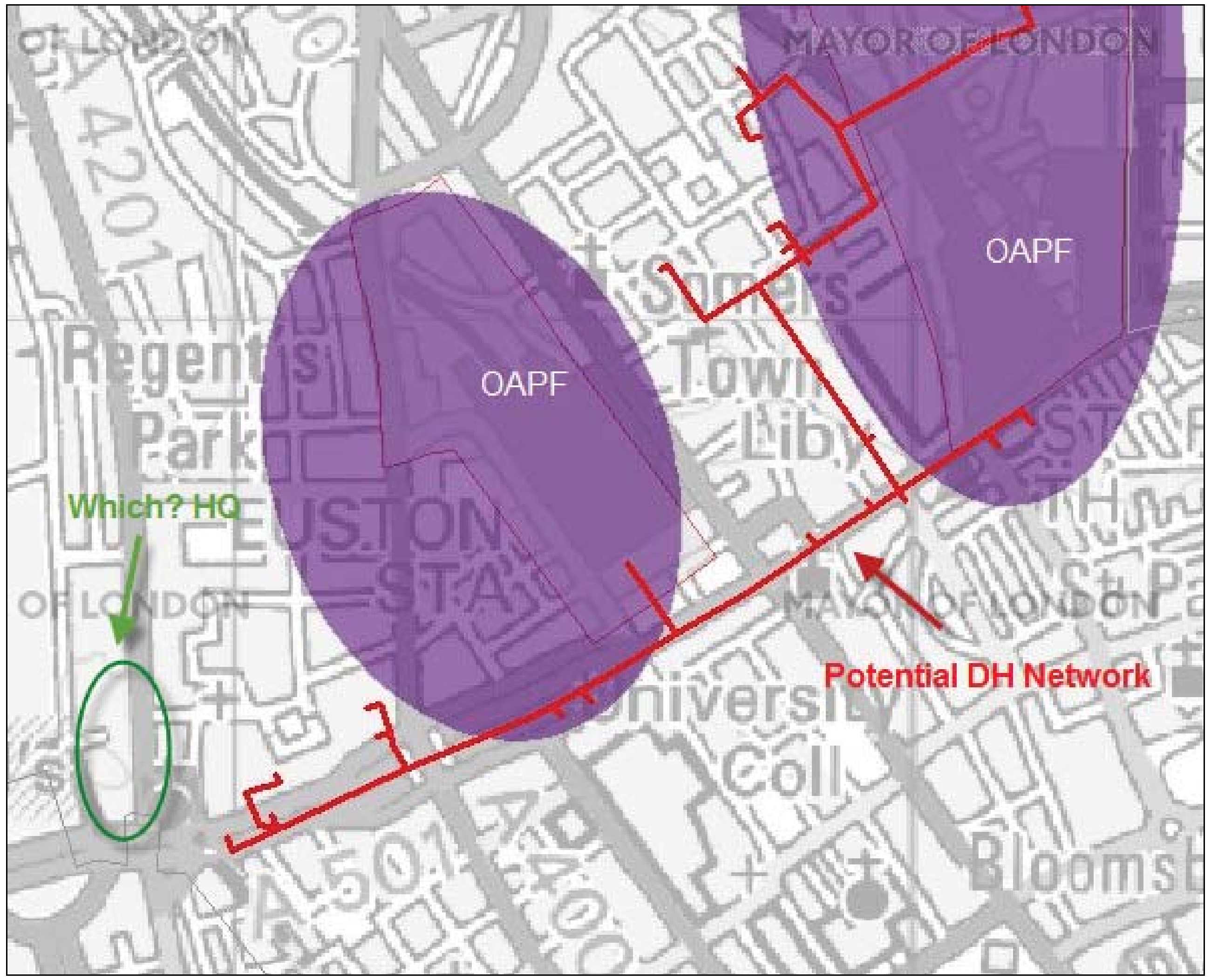


London Heat Map, 2 Marylebone & 1-9 Albany Street Existing Building Reference



London Heat Map, 2 Marylebone & 1-9 Albany Street, Existing Networks

The area closest to the development site that currently has a network is too far to connect into specifically for WHQs heating demand. The closest network, located at Whitehall, is approximately 2.2km away. Using £1,000 per metre as a rough figure for the cost of the works, to fit below surface level pipework connections to the network, the estimated cost could be in the region of £2,000,000+.



London Heat Map, 2 Marylebone & 1-9 Albany Street, Potential Networks

However, if the Council finds a way in which to place CHP/decentralised plant at their local sites, a further study should be conducted into the possible connection to WHQ by way of a local network. Camden Council have inferred that there is little intention to provide district heating in the local area. Any further discussion for a DH network in the future lay outside the WHQ building works timeframe. The correspondence is documented in the appendix.

7 "Be Green"

7.1 Low and Zero Carbon (LZC) Technologies

Low and Zero carbon technologies available are;

- Biomass;
- Liquid Biofuel;
- Photovoltaic Solar Panels;
- Wind Energy;
- Solar Thermal Systems;
- Ground/Water Source Heat Pumps;
- Air Source Heat Pumps.

(Based on the Greater London Authority Guidance on preparing energy assessments, September 2011)

Our comments on the suitability of such technologies at WHQ are as follows;

7.1.1 Biomass

Biomass uses either; processed 'pellet' type or loose wood 'chips' to burn in a boiler to create hot water. A sealed Low Pressure Hot Water (LPHW) system usually circulates the heat throughout the building.

A considerable amount of additional plant space will be needed with the introduction of a Biomass boiler. Storage of the wood will need to be considered including the delivery space and delivery turning circle.

WHQ sits within central London, therefore the poor air quality produced (biomass creates greater levels of NO_x and pollutants than regular gas boilers) and the wood pellet/chips storage space constraints make it an unacceptable option.

The latest Camden "Air quality action plan" 2009-2012 Section 2, Objective 4 (The "Air quality action plan" 2013-2015 is currently under public consultation) strongly discourages using Biomass boilers. Furthermore, the existing congested local traffic would be worsened by regular deliveries. Therefore this technology is not adopted.

7.1.2 Liquid Biofuel

Usually interpreted as Biofuel Combined Heat and Power (although boilers can also be fired by this fuel), the 'biodiesel' can be either created through recycled food waste oil, or from the crop of developing countries, which has been linked to de-forestation.

As with Biomass, it requires additional space for storage and 'feed' machinery to deliver the fuel to the burners. Similar to Biomass, the poor air quality (biofuel also creates greater levels of NO_x and pollutants) and increased traffic make this technology unfeasible. Therefore this technology is not adopted.

7.1.3 Photovoltaic Solar Panels

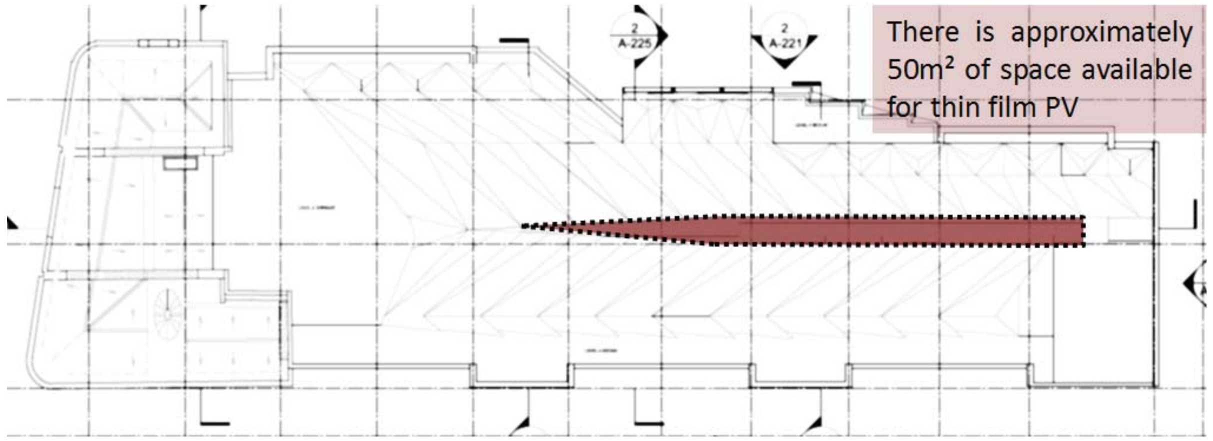
Photovoltaic solar panels (PV) use semi-conductor cells that convert the sun's energy into electricity. The cells are modulated from which a connection is made to an inverter to convert the direct current into a more useable alternating current. PV can still produce electricity under cloudy and overcast weather conditions.

The three basic kinds of solar cells available are:

- Monocrystalline: with a typical efficiency of 15-18%
- Polycrystalline: with a typical efficiency of 13-15%
- Thin film: with a typical efficiency of 7-10%

Through increased popularity, there is a very competitive market for PV and therefore the industry has become research intensive and improved efficiencies have been achieved as a result.

PV can be installed as part of the building's fabric, such as walls, roof tiles and glazing.



Roof area available for thin film PV technology

The views from Albany Street, Peto place and Marylebone Road have been deemed significantly important to the local area, therefore the area available for PV has been restricted. The grade II* listed building roof space will be unable to hold PV due to the assumed site pollution and possible damage to the historic fabric.

As a consequence to the complicated restrictions imposed on the rooftop design, the new 'origami' inspired roof provides the option for installing thin film adhesive PV technology. In recent years, PV technology has become more efficient and more affordable. The thermal modelling exercise identified that approximately $120m^2$-$130m^2$ of high performance thin film PV (efficiency of 10%) at an inclination of 10% is required to achieve the 20% carbon reduction target for the new roof extension. However, $50m^2$ of roof space is available for implementing the technology. Although Monocrystalline PV has a much higher efficiency, the thin film adhesive PV matches the profile of the roof. Therefore this technology is adopted.

7.1.4 Wind Energy

Wind turbines can produce electricity. Wind turbines harness the kinetic energy in the wind, converting it into electrical energy for use within a building and/or export to the grid.

Wind turbines are most effective when average wind speeds are +10m/s. Wind speeds in London on average are approximately 4m/s.

The location of the building is set in a dense urban area and thus installing a wind turbine would create noise and site pollution that would be deemed unsuitable for the area. Therefore, the wind turbine would need to be concealed from view. The turbine would be ineffective as it would be sheltered from the wind by taller, adjacent buildings. Therefore this technology is not adopted.

7.1.5 Solar Thermal Systems

Solar Hot Water Collectors (SHWC) use the sun’s energy to primarily heat water for Domestic Hot Water (DHW) use.

The SHWC are usually mounted on roof space to most effectively collect the suns energy. Typically, the energy is then stored in buffer vessels, ready for use when there is a demand. The systems are usually coupled with gas boiler backups to help top up the heat energy when demand is higher than that for which the vessels can supply.

The collectors and buffer vessels are usually sized to accommodate the total DHW demand. The two main types of collector are:

- Flat-plate collectors;
- Evacuated tube collectors.

Similar to PV panels, solar hot water panels would be installed on the roof. PV offsets electricity use in the building, while solar hot water system offsets gas use. PV appears to be a better solution to achieve the carbon reduction required with the minimal amount of roof space. Therefore this technology is not adopted.

7.1.6 Ground/Water Source Heat Pumps

Generally, at depths of 4metres and below, the ground’s temperature stays at a constant 10°C through the entire year. Heating and cooling systems can exploit this condition by way of a heat pump. There are two major systems that can utilise the ground energy storage:

- Open loop;
- Closed loop.

Open Loop Abstraction Heat Pumps

The use of boreholes to abstract water from the Thames Valley chalk aquifer is an expensive and difficult renewable technology to apply, and the fixed costs require a minimum size of development to be an economically feasible investment. Each borehole can cost in the region of £80K (although prices vary according to specific site conditions) and an abstraction and re-injection borehole would be required here as a minimum.

Parsons Brinckerhoff Desktop Study

A desktop study was conducted by Parsons Brinckerhoff to look into the possibility of Open Loop Abstraction. The following comments were made:

“*(I)* have had a look to see whether shallow water *(is)* a possibility from the River Terrace Gravels (RTG). For information *(you)* need at least 2 – 3m *saturated* thickness of RTG for this option to be viable. Summary of findings from the BGS archive below:

- TQ28SE31 RTG 0.5m thick, no record of water;
- TQ28SE1263 RTG not present, borehole dry to 12m;
- TQ28SE319 RTG 3m thick, wet at base;
- TQ28SE1408 RTG 3m thick, no record of water;
- TQ28SE1407 RTG 5m thick, no water encountered;
- TQ28SE14 RTG not present;
- TQ28SE461 RTG 1.5m thick, no record of water;
- TQ28SE2147 RTG not present;
- TQ28SE231 RTG not present.

In summary the above records indicate that RTG occurrence is sporadic and where *(it)* does approach reasonable thickness saturation is minimal. *(It is)* Possible that tube lines dewatering the RTG where otherwise might have contained water.

In conclusion then, the shallow RTG *(is)* not an option for this development. Deeper Chalk *(is)* a possibility but *(is)* probably constrained by separation achievable within site perimeter*(s)* (<100m) and *(the)* cost…£100k to £150k per borehole in the Chalk.”

Closed Loop Ground Source Heat Pumps

Due to the site constraints, ground/water source heat pumps are not feasible. There is insufficient horizontal area to bury heat exchangers, and it will not be financially feasible to carry out the boreholes.

7.1.7 Air Source Heat Pumps

Variable Refrigerant Flow (VRF) systems can use refrigerant to reject heat into an occupied space or reject heat to the atmosphere. The heat pump consumes electrical power to drive a compressor that upgrades the refrigerant from a low temperature low pressure gas/liquid into a high pressure high temperature gas. The efficiency, better known as the Coefficient of Performance (COP), of ASHPs are much higher than that of regular heating and cooling systems. However, there is still debate as to the effectiveness of its ability to offset carbon because the technology uses grid supplied electricity. Also, COP values can dip dramatically when outside temperature ranges are high. Air to refrigerant or water heat pumps, for heating purposes, are recognised by the GLA.

The cooling for the WHQ building is provided by water cooled chillers. Using recovered heat from the condensing water loop for heating and DHW purposes is a more practical solution than introducing air source heat pumps. Due to restrictions on where the roof plant can be positioned, there is little space for heat rejection. Therefore the LZC technology was not considered further. A Plate Heat Exchanger (PHX) is introduced to the chillers for this redevelopment, so that wasted heat can be recovered by the boiler system to provide heating or DHW to the building.

8 Results and Findings

The carbon density for UK gas is 0.198kgCO_2/kWh. The carbon density for grid electricity in the UK is 0.517kgCO_2/kWh for grid supplied electricity and 0.529kgCO_2/kWh for grid displaced electricity.

This means that to achieve carbon reduction targets, it is more effective to displace electricity use than heat energy (gas) use. This favours the generation technologies of PV, wind turbines and CHP. CHP, biomass and wind turbines have been deemed as unsuitable. PV is therefore advised to be placed on site.

The London Plan's three step process of, 'Be Lean, Be Clean, Be green' has been explored. We report that if the recommended "Be Lean" and "Be Green" steps are applied, the new building's CO_2 emission rate will have improved upon the "Base Case" Emission Rate by over 40% for the whole building compared to the building's current consumption.

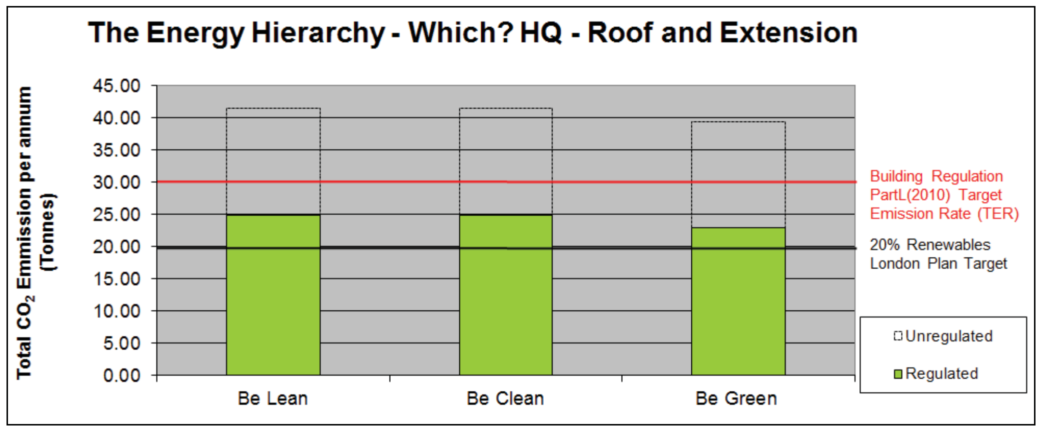
8.1 Energy Hierarchy –

8.1.1 New Extension and Roof Space

The new extension areas and roof space were measured separately to establish whether a 20% reduction of the BER can be achieved by way of renewable technology after the "Be Lean" and "Be Clean" stages. The building used the PartL2A calculation method from the IES <VE> software.

The annual carbon dioxide emission for natural gas is predicted to be 9,500kgCO_2 with the annual lighting and auxiliary carbon dioxide emissions at 7,378kgCO_2 and 8,055kgCO_2 respectively. The combined annual carbon dioxide emissions are 24,933kgCO_2.

The equivalent Building Regulation's compliant development has a combined total regulated carbon dioxide emission rate of 30,229kgCO_2 per annum. The development has a combined total unregulated carbon dioxide emission rate of 16,526kgCO_2 per annum.



Extension and Roof space The Energy Hierarchy Graph

The above chart illustrates the three stage process **'Be Lean, Be Clean, Be Green'** for the proposed new roof and extension at WHQ. A CO_2 reduction of 5 tonnes of CO_2 per annum would achieve a 20% reduction once the "Be Lean" stage has been implemented.

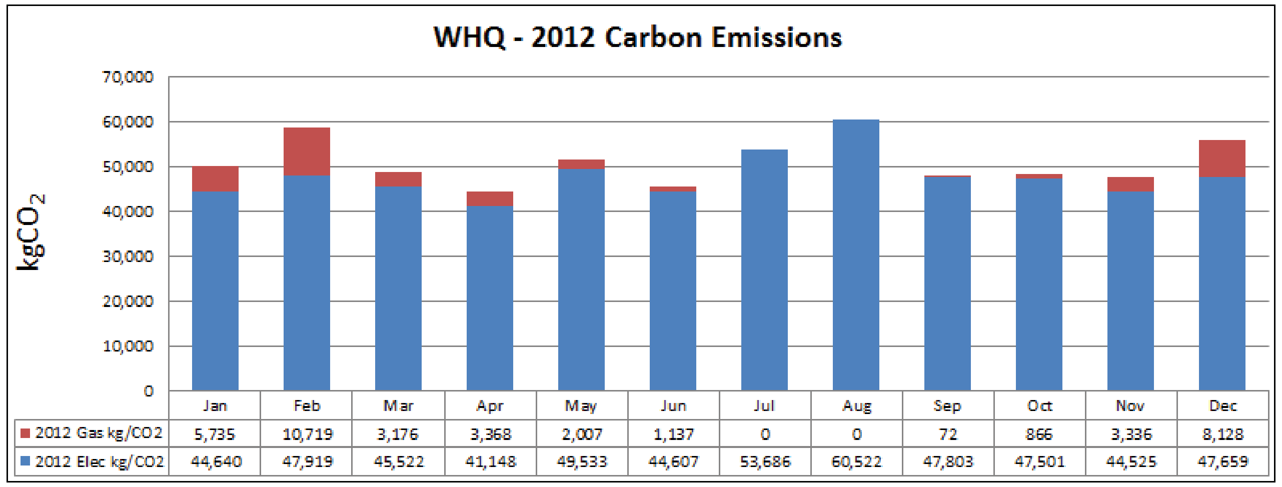
	Carbon Dioxide Savings (Tonnes CO_2 per annum)		Carbon Dioxide Savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand	5.30	5.30	17.5%	11.3%
Savings from CHP	0.00	0.00	0.0%	0.0%
Savings from renewable energy	1.99	1.99	8.0%	4.8%
Total Cumulative Savings	7.29	7.29	24.1%	15.6%

Extension and Roof space Carbon Dioxide Savings

The table above shows carbon dioxide savings of 17.5% on the TER after the 'Be Lean' stage. Introducing PV equates to a further 8% saving on the TER, and an overall 24.1% CO_2 reduction.

Approximately 50m² of hi-spec thin film PV is applied to the roof to achieve a reduction in carbon emissions by 2 tonnesCO_2/year.

8.1.2 Current Building Emissions

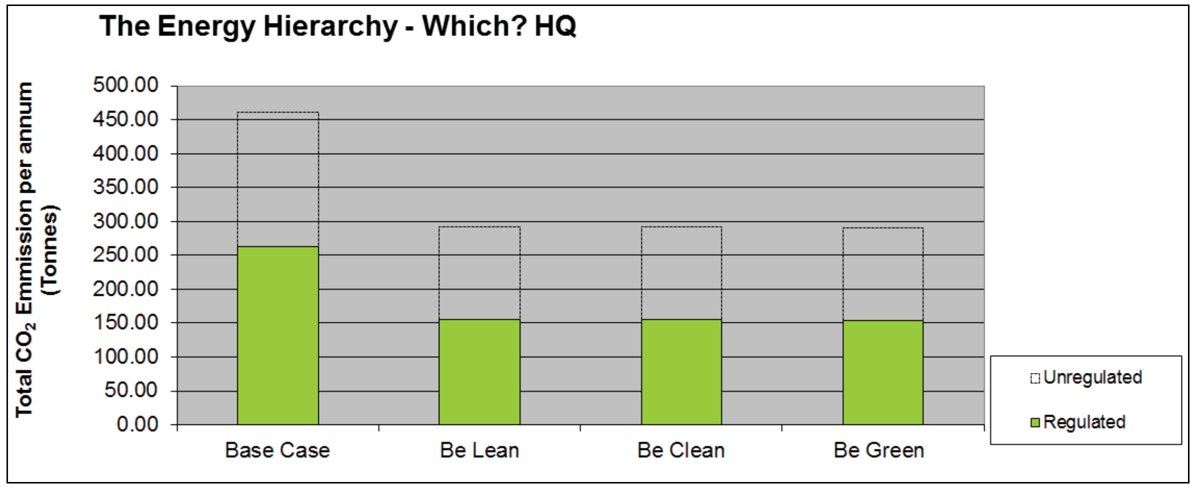


Current WHQ Gas and Electricity Carbon Emissions

Based on figures taken from 2012 data, WHQs equivalent regulated BER is currently 51.1 kgCO_2/m².

8.1.3 Whole Building

After the completion of the refurbishment and extension, WHQs carbon emission rate for natural gas is predicted to be 49,113kgCO_2 with the annual lighting and auxiliary carbon dioxide emissions at 45,813kgCO_2 and 55,398kgCO_2 respectively. The combined annual carbon dioxide emissions are 155,462kgCO_2.



Whole Building: The Energy Hierarchy Graph

The above chart illustrates the four stage process **'Base Case, Be Lean, Be Clean, Be Green'** for the proposed development at WHQ.

	Carbon Dioxide Savings (Tonnes CO_2 per annum)		Carbon Dioxide Savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand	106.71	169.09	40.7%	36.7%
Savings from CHP	0.00	0.00	0.0%	0.0%
Savings from renewable energy	1.99	1.99	1.3%	0.7%
Total Cumulative Savings	108.70	171.08	41.5%	37.1%

Whole Building Carbon Dioxide Savings

The table above shows carbon dioxide savings of 40.7% on the "Base Case" after the "Be Lean" stage. The introduction of PV would equate to a further 1.3% saving on the "Be Lean" stage, and an overall 41.5% CO_2 reduction.

9 Conclusions

The concluding points can be summarized as follows:

- **An overall rating of 'Excellent' has been targeted for BREEAM 2008 (refurbishment)**
- **Design constraints due to the grade II* listed building's retained façade and site pollution issues have restricted the building's ability to reach a 60% target in the BREEAM 2008 energy section achieving a score of 52.17%, which still achieves the 'Excellent' score that goes above and beyond what is required**
- **Implementing approximately 50m² of hi-spec thin film Photovoltaic solar panels on-site will achieve an 8% reduction of the New Roof and Extensions' Carbon Emission Rate**
- **The BRUKL report highlights that the new roof and extension does not exceed the Part L2A criterion 3 regulation for solar gains**
- **The whole building will be designed to improve upon the "Base Case" carbon emission rate by over 40%**
- **Rainwater harvesting will be implemented on site**

10 APPENDIX I – Possible District Heating Connections

From: Garner, Harold <Harold.Garner@Camden.gov.uk> Sent: Mon 20/05/2013 0
To: 'Andy Love'
Cc: Xinyi Shu
Subject: RE: 2 Marylebone Road - Available DH networks to surrounding area

Dear Andy

There are no networks in the area capable of extension to 2 Marylebone Road.

Regards

Harold

Harold Garner
Sustainability manager (technical projects)
Environment and Transport
Culture and Environment
London Borough of Camden

Telephone: 0207 974 2701
Mobile: 07876 447472
Web: camden.gov.uk
7th floor
Argyle Street
London WC1H 8EQ

Please consider the environment before printing this email.

From: Andy Love [mailto:alove@thorntonreynolds.com]
Sent: 20 May 2013 09:48
To: Garner, Harold
Cc: Xinyi Shu
Subject: RE: 2 Marylebone Road - Available DH networks to surrounding area

Dear Harold

We are currently writing up an Energy and Sustainability report for the refurbishment at 2 Marylebone Road.

Although I appreciate it was last month that our phone discussion took place, but are you able to please give some reply on the email below however small?

The District heating Map shows possible future local connections to 2 Marylebone Road, however, our phone conversation seemed to suggest that no network has been proposed.

Kind regards,

Andy Love
Assistant Engineer

thornton | reynolds
tel: +44 (0)20 79283100
81 Southwark Street, London SE1 0HX

From: Andy Love [mailto:alove@thorntonreynolds.com]
Sent: 30 April 2013 11:15
To: 'harold.garner@camden.gov.uk'
Cc: Reynolds; Xinyi Shu
Subject: 2 Marylebone Road - Available DH networks to surrounding area

Dear Harold

As discussed before, Thornton Reynolds are a Building Services Consultancy designing the systems for a refurbishment and extension at 2 Marylebone Road.

We understand from our phone discussion earlier today that there are:

- community residential heating schemes in the surrounding area to 2 Marylebone Road, however, they are self-contained and unable to export enough energy for 2 Marylebone's purpose
- currently no connections available in the surrounding area that can export a load sufficient for our building
- currently no agreed District Heating Networks being placed within the local area

We will continue to design the heating system at 2 Marylebone Road with the above in mind.

Please feel free to comment on the above.

Thank you for your time.

Kind regards,

Andy Love
Assistant Engineer

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11 APPENDIX II – Which? Offices BREEAM for Offices 2008 Pre-Assessment Summary