

Energy Strategy

Project Oasis

November 2011

Mott MacDonald
Fulcrum

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Issue and revision record

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B	11th December 2007	Christopher Eaton	Dan Widdon	-	Issued for Planning
C	25th November 2011	Anna MacKenzie	Jeff Anderson	Peter Mark	Issued for renewable planning application

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Content

Executive Summary

This document explains the findings from an analysis of the Proposed Development at Project Oasis and the ability to achieve both the current London Plan and the London Borough of Camden's Core Strategy energy related planning policy, as well as the CO_2 emission reductions that are expected to be from the 2010 Building Regulations.

Various potential technology combinations have been assessed for their ability to achieve the targets that are required Project Oasis. The final strategy will include good energy efficiency standards and incorporate a combination of:

- Photovoltaics
- Air Source Heat Pumps

The energy strategy for Project Oasis follows the energy hierarchy set out in the London Plan for developments to follow: use less energy ("lean"), supply energy efficiently through CHP ("clean") and use renewable energy ("green").

Table 1**Error! Reference source not found.** looks at the indicative CO_2 emissions and energy demand after each stage of the energy hierarchy.

The energy consumption and CO_2 emissions for a 2010 Building Regulations compliant scheme has been estimated as around 36.2 t CO_2/year.

For the "lean" element of the hierarchy, a high level of energy efficiency will be used. The total carbon emissions of Project Oasis after considering demand reduction measures only has been estimated to be 37.2 t CO_2/year. This does not meet 2010 Building Regulations through energy efficiency measures alone.

For the "clean" element of the hierarchy, the preferred approach is to take advantage of efficient cooling through the use of high efficiency Air Source Heat Pumps. CHP or connection to a communal heating network is not feasible due to the size of the building, the relatively small hot water and heating demand and the lack of any existing network to connect into. The total carbon emissions of Project Oasis after considering demand reduction measures and efficient cooling has been estimated to be 36.8 t CO_2/year (an improvement of 1% over the "lean" scheme. Further reductions in CO_2 emissions are still required to meet 2010 Building Regulations.

For the "green" element of the hierarchy, the proposed strategy is to use Air Source Heat Pumps to provide 100% of the heating demand, and Photovoltaics to displace a proportion of the electricity used. The total carbon emissions of Project Oasis after considering demand reduction measures, efficient cooling, ASHP and Photovoltaics has been estimated to be 31.75t CO_2/year (an improvement of 13.7% over the "clean" scheme. This strategy exceeds the requirements for CO_2 emissions under 2010 Building Regulations, reducing them by 12.3%.

The technical feasibility and economic viability of these will alter as the detailed design and financial incentives (particularly any changes to feed-in tariffs or any detailed announcement on the renewable heat incentive) evolve.

Table 1: Indicative Energy Demand and Carbon Dioxide Emissions after each stage of the Energy Hierarchy

Indicative Energy Demand and Carbon dioxide emissions	Regulated TCO_2/yr (kWhr/yr)	Unregulated TCO_2/yr (kWhr/yr)	Total TCO_2/yr (kWhr/yr)
Building Regulations 2010 Part L Compliant Development	*36.19 (117,000)*	*26.06 (52,000)*	*62.25 (169,000)*
After energy demand reduction	*37.14 (110,000)*	*26.06 (52,000)*	*63.19 (162,000)*
After CHP/efficient cooling	*36.8 (110,000)*	*26.06 (52,000)*	*62.86 (162,000)*
After renewable energy	*31.75 (101,000)*	*26.06 (52,000)*	*57.81 (153,000)*

Table 2: Carbon Dioxide Savings from each stage of the Energy Hierarchy

	Carbon dioxide emissions (Tonnes CO_2 per annum)		Carbon dioxide savings (%)	
	Regulated	Total	Regulated	Total
Savings from energy demand reduction	*-0.95*	*-0.95*	*-2.63%*	*-2.63%*
Savings from CHP/efficient cooling	*0.34*	*0.34*	*1.00%*	*1.00%*
Savings from renewable energy	*5.05*	*5.05*	*13.72%*	*13.72%*
Total Cumulative Savings	*4.44*	*4.44*	*12.3%*	*12.3%*

This strategy is in compliance with the London Plan and London Borough of Camden in-so-far as all avenues of demand reduction and low and zero carbon technology have been explored, and put forward where feasible. While % targets are not met, the overall reductions are still very good and these are the maximum CO_2 emissions considered feasible from a practical, technical and cost perspective.

This strategy is in compliance with the London Plan and London Borough of Camden in-so-far as all avenues of demand reduction and low and zero carbon technology have been explored, and put forward where feasible. While Table 3 shows that the % targets are not met, the overall reductions are still very good and these are the maximum CO_2 emissions considered feasible from a practical, technical and cost perspective.

Table 3: Performance of Project Oasis against planning policy targets

	London Borough of Camden Target	London Plan Target	Project Oasis Proposed
Total % reduction from Part L 2010 compliant building	*Not stated*	*25%*	*12%*
% reduction from renewables	*20%*	*20%*	*13%*

1. Introduction

Mott MacDonald Fulcrum have prepared this report to set out how the Proposed Development at 202-204 Finchley Road (Project Oasis) meets current energy related planning policy in line with the London Borough of Camden and the Replacement London Plan adopted in July 2011. This report supersedes the "Renewable Energy Technologies Recommendations" report produced by Fulcrum Consulting and issued for planning in late 2007, and is intended to provide the update required for the renewal planning application for Project Oasis.

Project Oasis is a 1300m^2 office building over 3 storeys.

2. Policy Background

Energy consumption associated with the built environment is estimated to be responsible for anything up to 50% of Greenhouse Gas (GHG) emissions in industrialised countries. As such, many nations are beginning to focus on the built environment in an attempt to achieve significant emissions reductions.

2.1 National policy

In 2006 the Department for Communities and Local Government consulted on proposals to increase the requirements of Building Regulations in England and Wales in 3-yearly steps en route to eventually requiring all new dwellings to be 'zero carbon' from 2016. Since 2006, a raft of new policies have been announced aimed at supporting the achievement of this target and further improving the sustainability of future development in England and Wales.

Key policies are outlined below:

2.1.1 Planning Policy Statement 1 (PPS1), 2005

PPS1 sets out the Government's overarching planning policies on the delivery of sustainable development through the planning system and it states that:

'Sustainable development is the core principle underpinning planning'

The PPS covers areas of Social Cohesion & Inclusion; Protection & Enhancement of the Environment; Prudent use of Natural Resources; Sustainable Economic Development; and Integrating Sustainable Development in Development Plans.

It goes on to lay out how planning authorities should seek to deliver sustainable development through the various regional and local policies they develop.

2.1.2 Planning and Climate Change Supplement to PPS1, 2007

The Planning and Climate Change Supplement to PPS1 outlines how planning, in delivering new development and the associate infrastructure, should help to lower greenhouse gas (GHG) emissions and improve adaptability and resilience to a changing climate. In particular, it provides regional and local planning authorities with Key Planning Objectives[1] and decision-making principles to be used when constructing their spatial strategies.

2.1.3 Planning Policy Statement 22 (PPS22) – Renewable Energy, 2004

PPS22 outlines Government guidance for planning authorities on the use of different renewable energy generating technologies and how planning authorities should consider the opportunity for incorporating these technologies into new development.

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[1] See PPS1:
http://www.communities.gov.uk/documents/planningandbuilding/pdf/planningpolicystatement1.pdf

2.1.4 Revisions to Planning Policy

A statement by the then Housing Minister John Healey in July 2009 acknowledged lowering of land values due to planning gain costs and prioritises sustainability above all other areas whilst emphasising a need for 'viability'. In a subsequent statement the Minister has also stated the intention to combine the existing PPS1 and PPS22 documents into a new planning policy document.

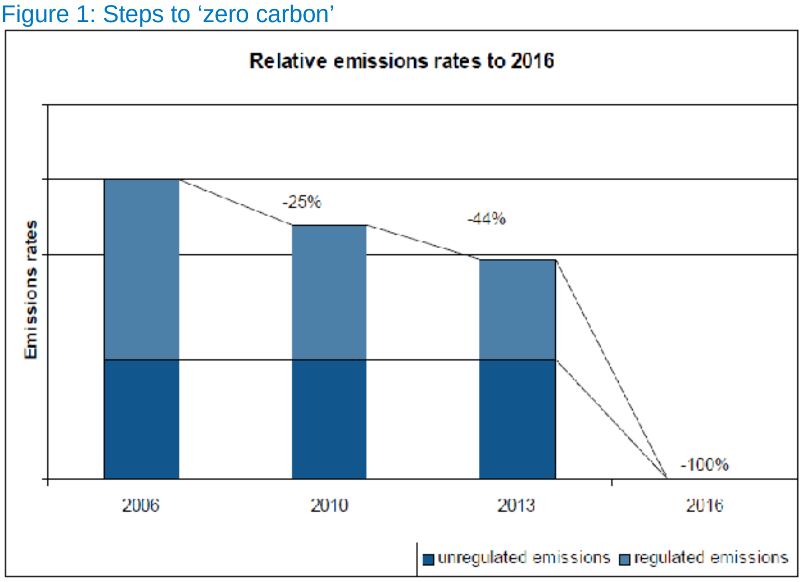
The ensuing consultation document "Planning Policy Statement: Consultation" significantly promotes opportunities for decentralised energy systems and where possible the use of district heating systems. Further it states that due to the increasing CO_2 reductions coming through from Building Regulations revisions, from 2013 it may not be necessary to require planning policy targets on the percentage of energy to come from decentralised energy sources but that if Local Authorities decide to adopt a target from 2010-13 that the Secretary of State will support this. It also contains reference to the July 2009 statement and notes an intention to place an equal priority on sustainability with other cost considerations (e.g. land value).

This document consultation closed on the 1st June 2010 with the summary of consultee responses still waiting to be published.

2.1.5 Building Regulations and Zero Carbon

The original timeline to 'zero carbon' proposed in the 'Building a Greener Future' consultation (2007) document is shown in Figure 1: Steps to 'zero carbon' below:

Figure 1: Steps to 'zero carbon'



Source: Building a Greener Future, 2007

Table 4: Timeline to 'zero carbon' as proposed in Building a Greener Future

Date	2010	2013	2016
Carbon improvement as compared to Part L 2006	25%	44%	'True zero carbon'
Equivalent energy/carbon standard in the Code	Code Level 3	Code Level 4	Code Level 6

Source: Building a Greener Future, 2007

The consultation document stated that 'Zero carbon means that, over a year, the net carbon emissions from the total energy use in the home would be zero'.

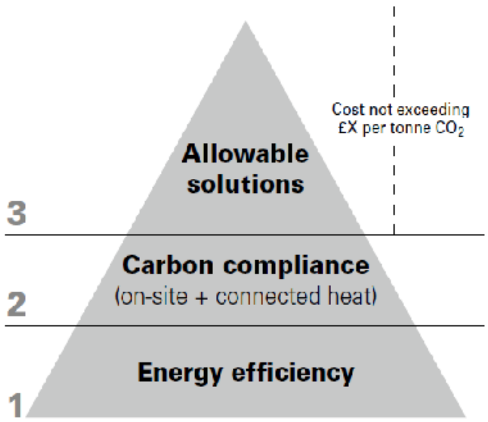
In the 2009 pre-budget speech the Chancellor outlined an ambition to see 'zero carbon' new non-domestic buildings from 2019 with schools and public buildings being zero carbon earlier, in 2016 and 2018 respectively.

There have been a number of different definitions of 'zero carbon' used by Government for different purposes. Recently this culminated in a further consultation entitled 'The Definition of Zero Carbon Homes and Non-Domestic Buildings' which solicited views on a unified definition of 'zero carbon' for the built environment.

The proposals focused almost entirely on the domestic sector and outlined a hierarchical approach to the definition, requiring high levels of energy efficiency, followed by a degree of on-site mitigation before allowing sites that were unable to mitigate their total predicted carbon emissions on-site to utilize a variety of 'allowable solutions' that included various off-site options. This is illustrated in Figure 2:

Figure 2: 'Zero Carbon' Hierarchy as outlined in *"Definition of Zero Carbon Homes & Non-Domestic Buildings*

Zero Carbon Hierarchy



List of 'Allowable Solutions'

Carbon compliance beyond the minimum standard

Energy efficient appliances / control schemes

Export of LZC heat / cooling to surrounding developments

S106 planning obligations

Retrofitting of existing buildings in the locality

Investment in LZC energy infrastructure

Off-site renewable electricity via private wire

Any other measures announced by Government

2.1.6 Recent Developments

In May 2010 the new Approved Document L2A: Conservation of Fuel and Power (New Buildings other than dwellings) (2010 edition) was published. This came into force in October 2010. This imposed greater CO_2 reductions requirements from new buildings in order to pass building regulations. For non-domestic buildings, this is equivalent to an aggregate reduction of 25% over Part L 2006. The actual % reduction required will depend on the actual building in question. Planning policies, in particular the London Plan, were then updated to reflect these changes.

The changes have had a fundamental impact on the way developers achieve compliance with the Building Regulations, a 'pass' often being extremely difficult without the use of low carbon technologies.

2.2 Regional Policy

The London Plan 2011

The replacement London Plan superceded the 2008 London Plan in July 2011. The following hierarchy illustrated in Table 5: Energy Hierarchy of the London Plan summarises the policies within the London Plan that will be used to assess planning applications.

Table 5: Energy Hierarchy of the London Plan

	Energy Hierarchy of the London Plan
1	**Using less energy** – (policy 5.3) particularly by adopting sustainable design and construction measures
2	**Supplying energy efficiently** – (policy 5.5 & 5.6) in particular by prioritising decentralised energy generation
3	**Using renewable energy** – (policy 5.7) A reduction in CO_2 emissions of through on-site renewable energy technologies where feasible

Source: Chapter 5 of the London Plan 2011

The Replacement London Plan 2011 goes further in its requirements and redefines the Energy Hierachy somewhat. Table 5 describes the % reduction in CO_2 emissions required for both building regulations (Part L 2010) and the revised London Plan. % reductions are expressed over Part L 2010.

A key difference between the 2008 London Plan and the 2011 London Plan is that importance is placed on overall CO_2 emissions reductions from all stages of the Energy Hierarchy combined (as laid out in Table 6). In addition, paragraph 5.42 of the London Plan states that there is the "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 where feasible… Where they contribute to the highest overall and most cost effective carbon dioxide emissions savings for a development proposal".

Table 6: London Plan 2011, Policy 5.2B

Target Reductions	Building Regulations, 2010		London Plan[2]	
Dates	Domestic [5]	Non-Domestic [3]	Domestic[4]	Non-Domestic[5]
2010-2013	0%	0%	25%	25%
2013 – 2016	25%	25%	40%	40%
2016 – 2019	'Zero Carbon'[6]	100%[7]	'Zero carbon'	As per building regs
2020 – 2027	'Zero Carbon'	'Zero Carbon'	'Zero carbon'	'Zero carbon'

Source: Chapter 5 of the London Plan 2011

2.3 Local Policy

Camden Core Strategy 2010-2025, Local Development Framework

- CS13 – Tackling climate change through promoting higher environmental standards
  - DP22 – Promoting Sustainable Design and Construction. The council will require development to incorporate sustainable design and construction measures that consider design, fabric and services. In addition, non-domestic developments of 500sqm of floorspace or above are to achieve "very good" in BREEAM assessments (with "Excellent" being achieved after 2016).

Camden Planning Guidance CPG3, Sustainability

- The Energy Hierarchy – Camden's planning guidance refers to the Energy Hierarchy (also used by the GLA and detailed in the London Plan).

2.4 Funding & Incentivisation

There are no funding requirements attached to the development.

Financial incentives that could be utilised at Project Oasis include:

- Feed-In-Tariffs (FITs), which allow the generator to earn a regulated income for 20 years (or 25 years in the case of solar) from every kilowatt hour of electricity generated from renewable sources. Eligible technologies include:
  - Anaerobic digestion
  - Hydro
  - Micro-CHP
  - Solar PV
  - Wind

  The government spending review has meant that changes to the tariff levels were made in August 2011. Additionally, further cuts in the tariff are expected from 12th December 2011 although the extent of the cuts are still under review.

[2] See http://www.london.gov.uk/shaping-london/london-plan/strategy/chapter5.jsp

[3] Target reduction expressed relative to a 2010 gas-fuelled base-case

[4] Calculated using flat 25% approach for new homes in accordance with the final 2010 Part L Building Regulations.

[5] Calculated using aggregate 25% approach for new non-dom buildings in accordance with the final 2010 Part L Building Regs

[6] "Total carbon": CO_2 emissions from all energy uses within the building, including appliance loads

[7] Regulated energy only

- Renewable Heat Incentive (RHI) allows the generator to earn a regulated income for twenty years from every kilowatt hour of heat generated from renewable sources. The first phase of the RHI currently includes:

  - Biomass boilers
  - Solar Thermal
  - Ground Source Heat Pumps
  - Water Source Heat Pumps
  - On-Site Biogas Combustion
  - Deep Geothermal
  - Energy from Municipal Solid Waste
  - Injection of biomethane into the grid.

  The second phase of the scheme will be rolled out later and may include other technologies including Air Source Heat Pumps, direct air heating, large solar thermal (>200kW), large biogas (>200kW) and bioliquids.

  The RHI was due to be launched at the end of September 2011, however has been delayed due to an EU query on the level of state subsidy. It has been expected at the end of November 2011 although further delays are possible. Any installations installed before launch may still qualify, provided installation and commissioning occurred after 15th July 2009 and they meet final eligibility criteria.

Relevant incentives are discussed in Appendix A.

2.5 Policy and Incentive Implications for Project Oasis

Project timelines for Project Oasis mean that it must comply with Part L 2010 and is unlikely to be affected by changes to building regulations due in 2013. This means that the development must now seek to improve CO_2 emissions over Part L 2006 standards by at approximately 25%. The aggregate approach used for non-domestic buildings, with the 25% reduction in CO_2 emissions being the average target over the non-domestic sector, means that government approved SBEM calculations will define exactly the improvement needed through the Target Emissions Rate (TER).

The below Table 7 summarises the different policy implications and targets that the energy strategy will address.

Table 7: Summary of Policy Implications and Targets

Table Heading Left	Implications and Targets
Building Regulations	▪ Part L 2010. Approximately a 25% improvement in CO_2 emissions over Part L 2006
The London Plan	▪ Demonstrate a “Lean, Clean, Green” approach to CO_2 emissions reductions. ▪ Seek to achieve a 25% improvement in CO_2 emissions beyond building regulations 2010. ▪ Aim to achieve a 20% reduction in CO_2 emissions from an energy efficient scheme utilising CHP/communal energy networks through the use of renewables.
London Borough of Camden	▪ Demonstrate a “Lean, Clean, Green” approach to CO_2 emissions reductions. ▪ Aim to achieve a 20% reduction in CO_2 emissions through the use of renewables.

The project will be able to benefit from both the Feed-In-Tariff (FIT) and the Renewable Heat Incentive (RHI) is renewable electricity and heat are generated.

3. Energy Assessment Approach

The approach taken for the energy assessment is to examine the relevant planning policies, calculate energy demand estimates for the proposed development and investigate the various energy scenarios to meet the policy requirements. The approach demonstrates the expected energy and carbon dioxide savings through a “lean, clean and green” strategy as outlined in the both Camden’s policies (in particular outlined in CP3) and the London Plan:

- reduce energy demand to a minimum;
- meet this demand as efficiently as possible; and
- use onsite renewable and/or low carbon energy sources to supply a significant proportion of the Proposed Developments requirements.

Reducing the demand first will reduce the amount of energy that needs to be supplied by renewable or low carbon sources.

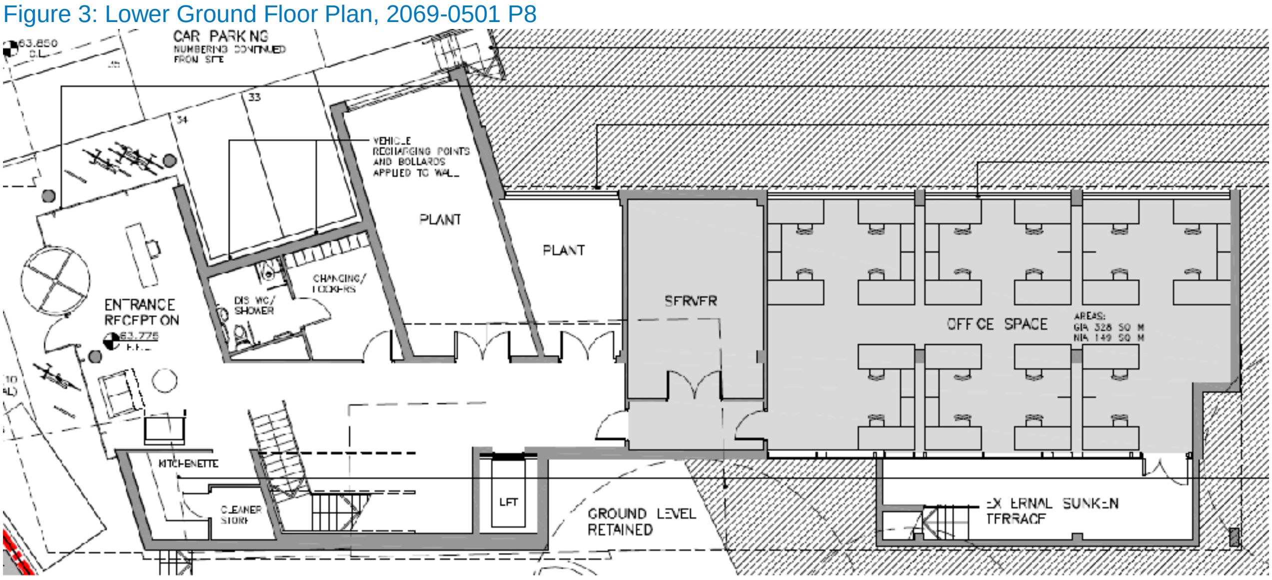
3.1 Accommodation Schedule

The Proposed Development at for Project Oasis is for 1,300 square metres (sqm) of floor space. The energy assessment has been based on the floor plans listed below provided by the architect Jestico and Whiles. A ‘model’ of the building has been re-created within TAS to create a detailed estimation of the building’s energy use based on the different zones and building functions within it.

- Lower Ground Floor Plan, 2069-0501 P8
- Upper Ground Floor Plan, 2069-0502 P7
- First Floor Plan, 2069-0503 P7
- Roof Plan, 2069-0505 P4
- North Elevation South Elevation, 2069-0511 P3
- West Elevation East Elevation, 2069-0512 P3

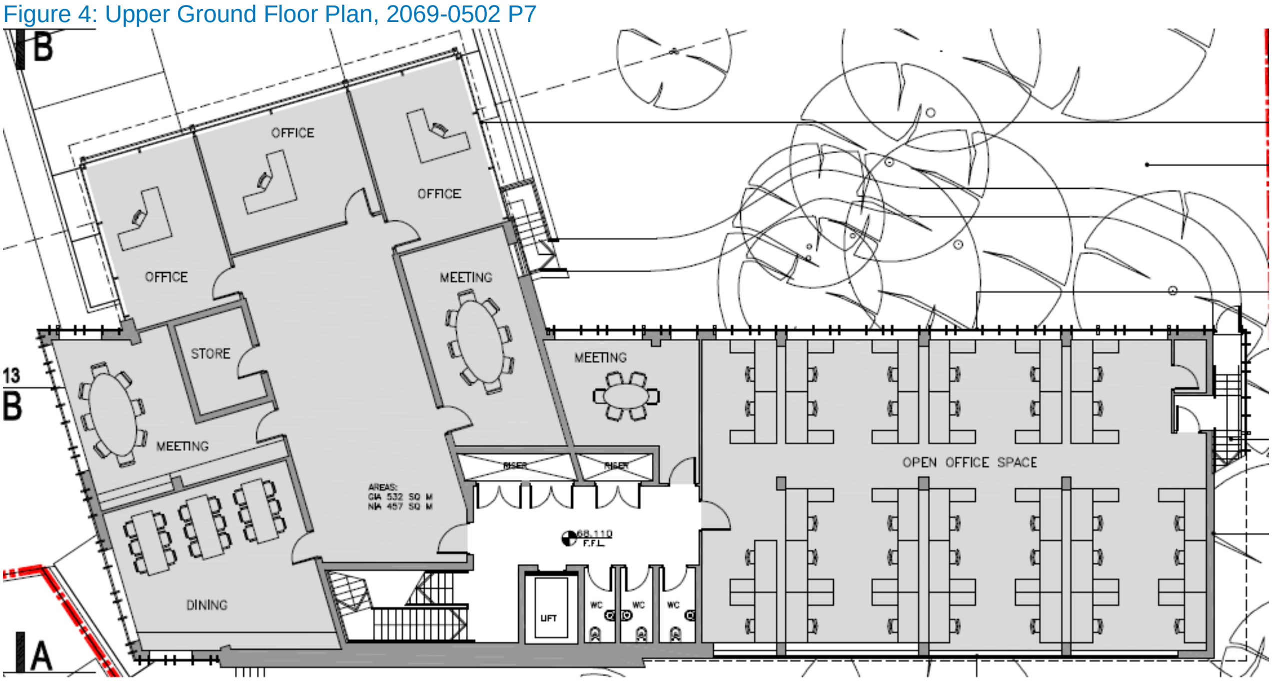
The arrangement is over 3 storeys, as seen in the floor plans below.

Figure 3: Lower Ground Floor Plan, 2069-0501 P8



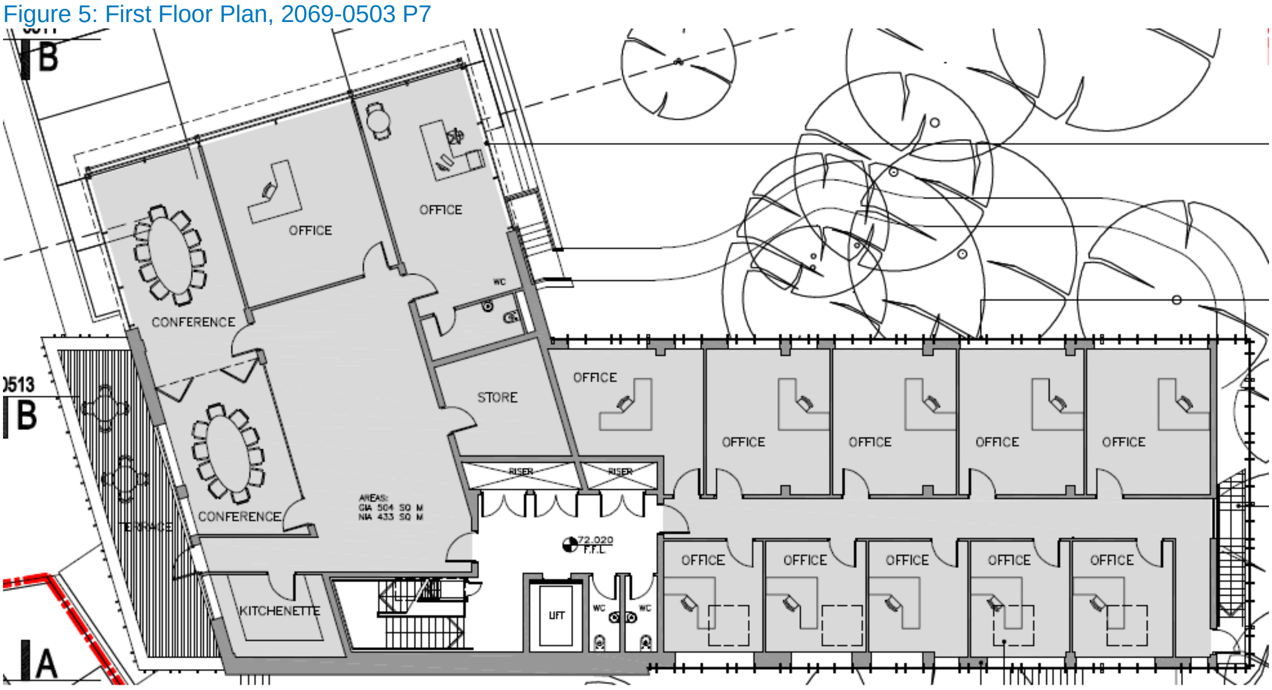
Source: Jestico&Whiles

Figure 4: Upper Ground Floor Plan, 2069-0502 P7



Source: Jestico & Whiles

Figure 5: First Floor Plan, 2069-0503 P7



Source: Jestico&Whiles

3.2 Baseline Energy Demand and CO_2 Emissions

The baseline used to compare the CO_2 emissions savings for the energy strategy is based on the 'notional building' generated by the thermal dynamic modelling using approved software TAS v9.2.1, which covers all regulated energy demands. The 'notional building' generated is identical to the proposed building in terms of form and servicing. The 'notional' building applies set efficiencies determined by the National Calculation Methodology (NCM), in order to determine the energy demand and CO_2 emissions of this building, and hence determine the Target Emissions Rate (TER) the actual building must improve upon in order to pass Building Regulations.

The energy demand of the notional building stays constant regardless of the servicing strategy employed.

Non-regulated energy demands have been derived from TAS v9.2.1 (these are not accounted for in the TER).

The CO_2 emissions of the notional building (and hence the TER) changes depending on the servicing strategy employed. The CO_2 emissions for the baseline CO_2 emissions are based on the serving strategy illustrated in Table 8.

Table 8: Serving Strategy of Notional Building, used for Baseline TER

	Technology/Fuel
Hot water	Oil
Space heating	Air Source Heat Pump
Space cooling	Air Source Heat Pump
Electricity	Grid
Ventilation	Mechanical with heat recovery

Using this method the baseline CO_2 emission is estimated to be 36.19 tCO_2/year using 2010 Building Regulations regulated emissions (Table 9).

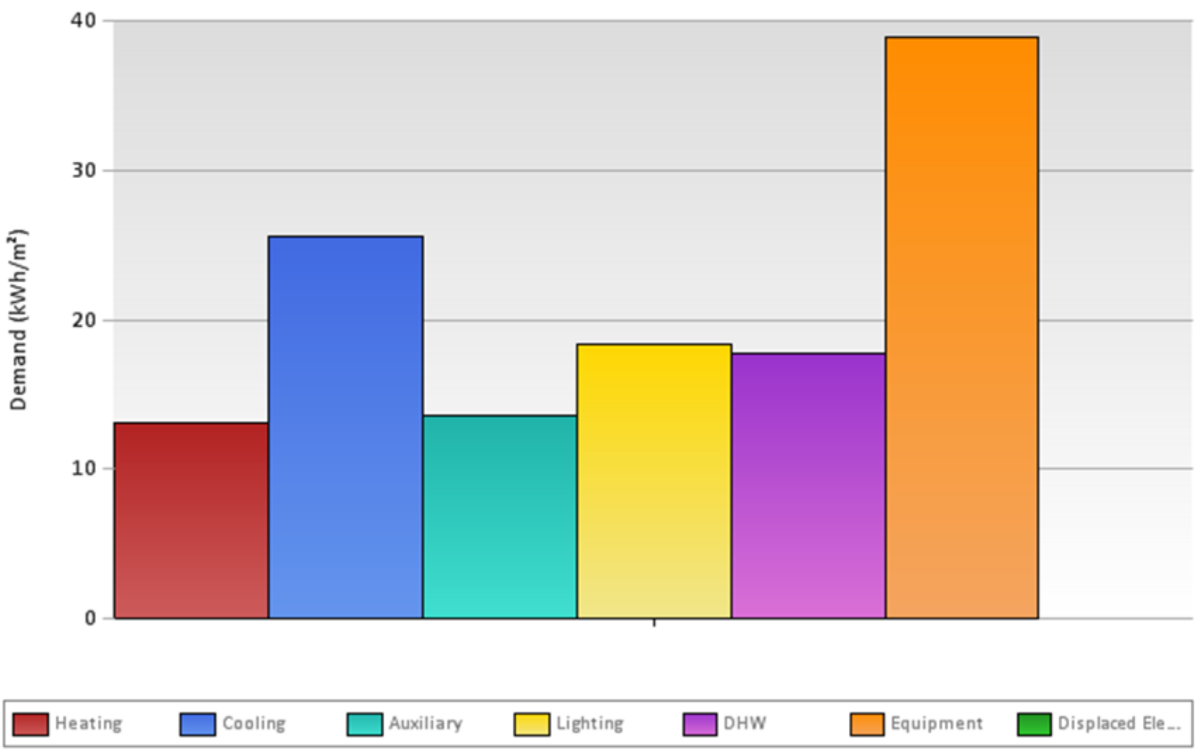
Table 9: Regulated and non-regulated CO_2 emissions of Part L 2010 compliant scenario

Part L 2010 Compliant Scenario			
	Regulated	Non-Regulated	Total
Site baseline CO_2 Emissions (tCO_2/year)	36.19	26.06	62.25

Figure 6: Energy demand breakdown of 'Notional' building. Building Regulations Compliant Scenario, (TER)

Tas UK Building Regulations Studio

Notional Annual Demand



	Heating	*Cooling*	*Auxiliary*	*Lighting*	*DHW*	*Equipment*	*Displaced Electricity*
Demand (kWh/m^2)	13.16	25.58	13.57	18.34	17.81	38.94	0.00

Source: Mott MacDonald Fulcrum, TAS Model, Project Oasis

3.3 Energy Hierarchy Methodology

The methodology used for the energy consumption and CO_2 emissions assessment is in line with the GLA's Energy Hierarchy outlined in the London Plan and the document 'Energy Planning: GLA Guidance on preparing energy statements'. This also conforms to requirements laid out within the policies of the London Borough of Camden. The following sections of this document look at each of the three steps within the Energy Hierarchy:

- Lean – Demand Reduction and Energy Efficiency
- Clean – Heating and Cooling Infrastructure
- Green – Renewable Energy

4. “Lean” – Demand Reduction and Energy Efficiency

4.1 Summary of Demand Reduction Measures

The energy efficiency standards used for analysis are shown in Table 10.

Table 10: Assumed Build Specification and Demand Reduction Measures

Case Study Building Fabric and Efficiency Values	BR 2010 Minimum Requirements	Project Oasis Assumed Energy Efficiency
Wall U-value (W/m²K)	0.30	0.28
Roof U-value (W/m²K)	0.20	0.2
Floor U-value (W/m²K)	0.25	0.2
Window & Door U-value (W/m²K)	2	1.4
Window g-value	N/A	0.18
Light transmittance (%)	N/A	34%
Airtightness (m³/hr/m²)	10	5
Heat Loss Parameter (W/m^{2}k)	-	0.8
Lighting Efficiency (W/m2/100lux)	-	3.5
Daylight linking	-	In perimeter areas
Presence detection	-	YES
Ventilation Type	-	Mechanical, with low velocity ductwork to minimise fan power SPF 1.7W/l/s Local fan coil units 0.6W/l/s Toilet Extract 0.6W/l/s (6 l/s/m^2)
Ventilation heat recovery		70% efficient
Cooling		Air Source Heat Pump, Seasonal SEER of 4.0.
Free Cooling		Through Air Source Heat Pump during winter and interseasonal periods (set point 14°C)
Heating		Air Source Heat Pump Seasonal COP 3.6
Heating/Cooling distribution efficiency		95%

4.2 Building Fabric

Lower U-values represent greater thermal performance. U-values have been improved over building regulations minimum requirements. This requires the use of slightly thicker fabric material which has been taken into account in the building design. The extent to which U-values have been improved has been balanced against internal heat gains. As this is an office development the heating demand is not great, and therefore greater levels of fabric insulation would be detrimental if this led to increased the cooling demands. Therefore further improvement on U-values is not recommended.

Window g-values and solar transmittance have been optimised to limit heat gain (reducing cooling demand) but also to allow good daylight penetration to reduce lighting demands.

The building is fully serviced requiring a fast thermal response time, therefore significant thermal mass has not been accounted for.

4.3 Building form and orientation

The building is orientated along an east-west axis. This allows solar gain to be controlled to best effect.

The lower ground floor has offices situated along the north side with access and service areas located along the south side. This allows the offices to benefit from the uniform north light, eliminates direct glare from sunlight aiding comfort, and significantly reducing solar gains received in this area – something that is important in an office building with typically high levels of internal heat gains.

The upper ground floor and first floor has offices arranged on both north and south facades. Solar gain and glare is controlled more easily on south facades than east and west facing façades. Therefore conference rooms have been situated on the south-west façade.

Existing trees on the site will be retained and will provide shading during summer months.

4.4 Building Services

It is also proposed that high efficiency plant such as variable speed pumps, efficient fans, demand controlled ventilation with heat recovery and improved chiller energy efficiency ratio (EER) would be included where applicable.

Duct sizes have been increased as far as possible, allowing lower velocity air movement and consequently minimising fan power.

Zoning has been done to optimise the cooling strategy for perimeter areas as well as to account for natural daylight. As per the NCM, a 6m perimeter zone was created wherever the glazing represented more than 15% of the wall area. As such, effective daylight linking can be applied to the rows of artificial lighting within the 6m perimeter zone as well as providing more cooling to these spaces and les to the internal ones.

4.5 Ventilation

Mechanical Ventilation with Heat Recovery will be utilised in order to recover and re-use useful heat from outgoing ventilation air.

4.6 Lighting

Very good improvements in lighting efficiency have been made. 100% of lighting will use energy efficient fittings with good output ratio equivalent to an average of 3.5 W/m^2/100lux across the floorplate. Lighting will be linked to presence detection to ensure lighting is only on when necessary, and lighting in perimeter spaces (6m from the glazing) will be daylight linked in order that electric lighting levels will adjust according to the amount of daylight available.

Zoning has been done to optimise the cooling strategy for perimeter areas as well as to account for natural daylight. As per the NCM, a 6m perimeter zone was created wherever the glazing represented more than 15% of the wall area. As such, effective daylight linking can be applied to the rows of artificial lighting within the 6m perimeter zone as well as providing more cooling to these spaces and les to the internal ones.

4.7 Equipment (non-regulated energy uses)

It is recommended that the building occupants actively seek and employ strategies for reducing electricity used by appliances. Recommendations include:

- Ensure Voltage Optimisation is specified
- Ensure computers and other electronic equipment are shut down when people leave
- Do no leave devices in standby mode overnight
- Purchase appliances that have a high energy star rating (A or A+ rated)
- Investigate efficient IT strategies such as remote computing

4.8 Energy Monitoring, metering and controls

It is proposed that a centralised building management system is installed in order to allow for efficient control and monitoring of all systems. Metering will be enabled to allow any changes in energy use to be monitored. This will report out of range values as well.

4.9 CO_2 Emissions of 'Lean' scheme and reductions from Baseline

The energy provision for the "lean" scheme is summarised in Table 11. The CO_2 emissions of this scheme and the reductions beyond the baseline are illustrated in Table 12.

A comparison of the established baseline CO_2 emissions (building regulations baseline) for and the anticipated emissions of the proposed "lean" scheme after demand reductions measures are applied are shown in Figure 7.

The energy demand reduction measures proposed, are not enough alone to achieve building regulations compliance. The reason for this is primarily due to CO_2 emissions associated with domestic hot water. Electric point-of-use water heaters are proposed as there is no gas connection to the site.

Table 11: Energy Provision for "Lean Scheme"

Energy Demand	Energy delivery technology
Hot water	Point of use electric
Space heating	Air Source Heat Pump (standard efficiency)
Space cooling	Air Source Heat Pump (standard efficiency)
Electricity	Grid

Table 12: CO_2 Emissions

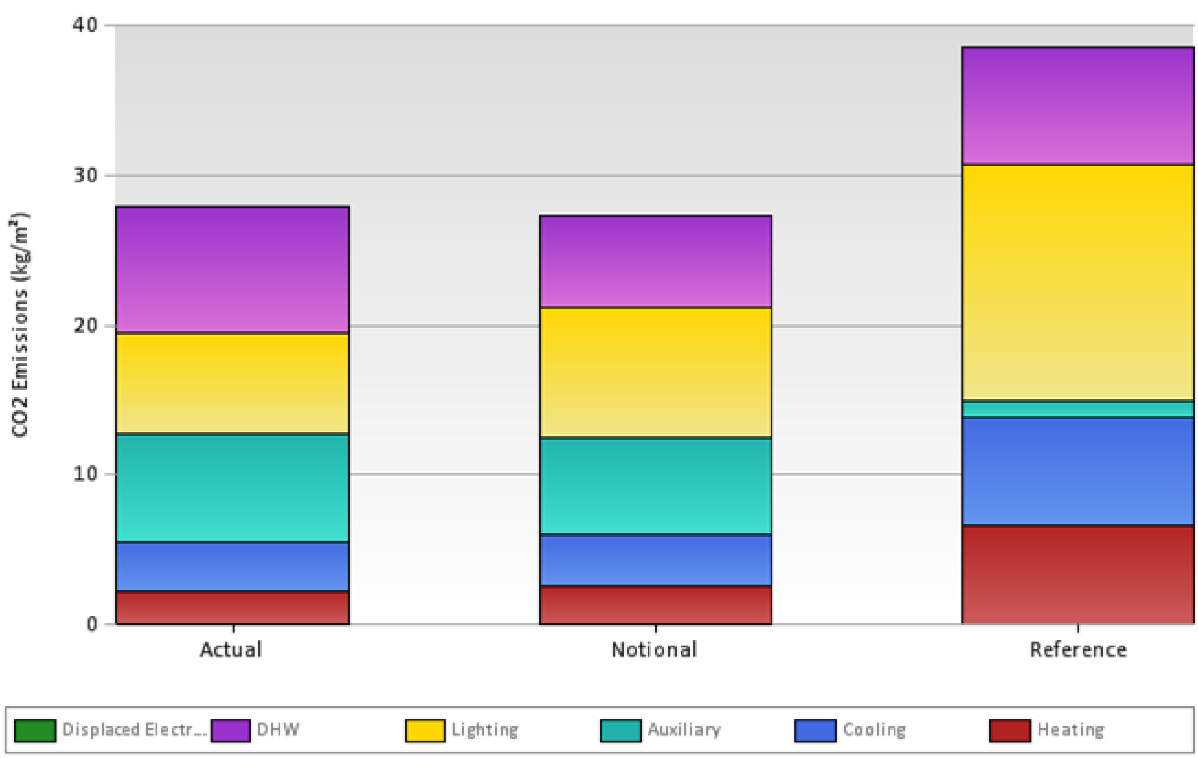
Energy efficient scheme, "Lean"	
Site baseline CO_2 Emissions (tCO_2/year)	36.19
Site Total CO_2 Emissions (tCO_2/year) (including non-regulated electricity)	62.25
Reductions beyond baseline	-2.63%

Energy efficient scheme, "Lean"

Figure 7: Predicted CO_2 emissions of "Lean" case compared with Base Case.

Tas UK Building Regulations Studio

Annual CO2 Emissions Comparison



	Actual	Notional	Reference
Heating (kgCO2/m²)	2.22	2.59	6.61
Cooling (kgCO2/m²)	3.26	3.40	7.29
Auxiliary (kgCO2/m²)	7.28	6.49	1.05
Lighting (kgCO2/m²)	6.70	8.77	15.82
DHW (kgCO2/m²)	8.52	6.01	7.84
Displaced Electricity (kgCO2/m²)	0.00	0.00	0.00
*Equipment (kgCO2/m²) **	*19.63*	*19.63*	*20.13*
Total (kgCO2/m²)	27.97	27.26	38.60
Total Floor Area (m²)	1327.59	1327.59	1327.59

** Energy used by equipment does not contribute to total value – it is presented here for comparison only*

5. “Clean” – Heating and Cooling Infrastructure including CHP

Demand for energy has been minimised using the measures described within section 5. This section explores the energy systems that have been investigated in order to provide energy more efficiently and cleanly.

5.1 Connection to Existing Low Carbon Heat Distribution Networks including Combined Heat and Power (CHP)

By utilising a communal heating network, efficiencies can be made as generally larger energy systems use fuel more efficiently than smaller energy systems. Centralised energy systems can supply a combination of hot water, space heating, space cooling, and power to a site through an energy network. Although central to the development, such systems are considered to be decentralised in relation to grid energy generation and distribution.

The most common form of centralised energy supply is community heating. This is where space heating and hot water is delivered to multiple buildings/dwellings by centralised plant via a network of insulated pipes buried in the ground. The pipe network would generally be installed at the same time as other services (water, drainage, etc) to minimise costs.

Most heat generation technologies discussed in this report can be used for centralised generation and some (such as CHP) only become commercially viable if used in this way.

In order for centralised heat generation plant to be sized cost-effectively, a thermal store is often needed in which to hold the heat until it is required. This could be in the form of a large central store, plot-based stores, or individual stores (such as a hot water cylinder in every dwelling), or a combination of the three, depending on the specific requirements of the development.

One further benefit of centralised energy systems is that the means of energy generation can be easily modified and added to in the future. This means that they can more effectively future-proof a development because as new more efficient and environmentally friendly heating/cooling/electricity generation technologies are proven and become cost effective, they can be ‘plugged in’ to the community distribution system with minimal disruption, and therefore reduce the risk associated with changing fuel economies.

For any communal system, such as one that requires an ESCo (Energy Services Company), the influence of revenue streams will affect the choice of energy strategy. Recent and likely future changes to the government’s incentive strategies mean that this is a complicated and evolving area.

5.1.1 Communal Energy Networks at Project Oasis

The heat demand at Project Oasis is very small as the building’s total floor area is only 1300m^2. The site does not currently have gas connection and connection is not planned. Efficient space heating will be provided electrically through the use of Air Source Heat Pumps. Hot water demand will be satisfied through point-of-use water heaters, which are the most efficient way of providing small amounts of hot water. Therefore, since there is little hot water demand, connection to an existing or future communal energy network would not be considered an efficient option for this development.

Potential connection to existing communal energy networks in the area has however been investigated. The London Heat Map[8] shows that the nearest CHP unit to be 1.1km away, near Chalk Farm library. The nearest Energy from Waste and other power plants are all a number of miles away and connection to them is not considered feasible. London Borough of Camden has identified the West Hampstead Interchange as an Opportunity Area and the Finchley Road/Chalk Farm corridor as an area that will experience significant future development. There may be opportunity for Communal Energy Networks to be set up in these areas in the future. However, considering the very small heat demands Project Oasis building will have, connection to these networks would not be considered beneficial.

5.2 Site Wide Heating Network

The Project Oasis development is a single building office development of 1300m^2. Creation of a site wide heating network is therefore not applicable.

5.3 Combined Heat and Power (CHP) and Trigeneration (CCHP)

Combined Heat and Power units are essentially small electricity power stations. They generate electricity and are more efficient than power stations because the heat generated as a by product of electricity generation is used to provide heating and hot water to buildings.

To gain the maximum efficiency from a CHP system it is desirable to use 100% of its electrical and heat output for more than 4000 hours a year. CHP units are therefore usually sized to meet base heat provision loads with additional top up provided from supplementary sources, such as gas or biomass/biofuel fired boilers.

Typically, CHP units would be integrated into a heating network or serve large buildings with significant base heat loads in order to be most effective.

Trigeneration is combined cooling, heat, and power (CCHP), usually this involves the production of cooling from CHP heat via absorption chillers. The greater heat demand can increase the viability of the CHP operation as well as its size. This can lead to greater potential carbon emission reductions as it removes the need for cooling from electrical chillers depending on relative carbon efficiencies of the heat source and the chillers.

The feasibility of CCHP depends on the size, type and profile of the cooling load as well as the nature of the heat source. Absorption chillers tend to have large capacities and operate better when producing a steady, constant output.

5.3.1 CHP and CCHP at Project Oasis

Due to the size and proposed use of the building at Project Oasis, heat demand in terms of both space heating and hot water will be low, and for this reason, a CHP unit is not considered a feasible technology for the development. Similarly, the small size of the development means that CCHP is also not considered a feasible technology. These technologies have not therefore been considered further.

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[8] The London Heat Map, http://www.londonheatmap.org.uk/Mapping/

5.4 Cooling

Natural and mechanical ventilation alone will not be sufficient to meet the cooling demands of the building. Therefore, it is proposed that the building will be efficiently cooled using Fan Coil Units as a primary source of space cooling fed from Air Source Heat Pumps. In order to optimise the performance and reduce the running costs, an Air Source Heat Pump unit(s) will be the main plant installed in this primary circuit. This unit has the capacity to provide “free cooling” during the anticipated winter and inter-seasonal cooling periods and boost heat pump performance. A seasonal efficiency (SCOP – Seasonal Coefficient Of Performance) of 4.0 can be obtained by an Air Source Heat Pump during the cooling cycle. This means the unit will be capable of producing 4 units of cooling energy for every 1 unit of electricity it consumes. The FCU’s (Fan Coil Units) will have ‘wet’ heating and cooling coils fed from the ASHP’s (Air Source Heat Pumps) which will directly condition the area being served. A 14°C set point will be proposed as a ‘summer bypass’ to directly provide fresh air from outside to the condition the spaces requiring cooling. The ventilation units will be capable of recovering waste energy and are projected at a thermal efficiency of 70%.

An analysis of the carbon efficiency of the air source heat pump against a traditional chiller system has been carried out. In reality an ASHP system may be slightly less than an efficient chiller system for cooling. However, only by a small fraction. The ASHP system is still considered preferable to the chiller system as it can also be used in heating mode. We can see from the Table 13 below that the CO_2 efficiency of and ASHP system in heating mode is better than that of a gas boiler, and combining the efficiencies in cooling mode and heating mode the ASHP system is still more efficient. Realistic seasonal efficiencies have been chosen to carry out the analysis.

Table 13: Carbon Efficiency of Gas Boiler + Chiller vs ASHP system

Fuel	Efficiency (%)	CO_2 Emissions Factor ($kgCo_2/kWh/m^2$) of Fuel	CO_2 efficiency of Technology
HEATING			
Gas	90	0.198	0.220
ASHP elec (heating)	280	0.517	0.185
COOLING			
Chiller elec	330	0.517	0.157
ASHP elec (cooling)	320	0.517	0.161
COMBINED			
Gas + Chiller	-	-	0.178
ASHP	-	-	0.169

5.5 Carbon Emission Reductions

CHP will not be used for the building, and connection to a communal energy network is not feasible. Therefore CO_2 emissions reductions are not possible through these means.

However, to provide efficient cooling of the office building, Air Source Heat Pumps are proposed. Air Source Heat Pumps are a low carbon / renewable technology. The GLA’s guidance on preparing energy statements states that efficient cooling and renewable cooling opportunities should be identified at the “Clean” stage of the energy hierarchy, but also that ASHP can be counted as a renewable and classed under the “Green” section too.

The energy provision for the "clean" scheme is summarised in Table 14. The CO_2 emissions of this scheme and the reductions beyond the "lean" scheme are illustrated in Table 15.

A comparison of the established baseline CO_2 emissions (building regulations baseline) for and the anticipated emissions of the proposed "clean" scheme after demand reductions measures are applied are shown in Figure 7.

The energy demand reduction measures and efficient cooling proposed, are not enough alone to achieve building regulations compliance. The reason for this is primarily due to CO_2 emissions associated with domestic hot water. Electric point-of-use water heaters are proposed as there is no gas connection to the site.

Table 14: Energy Provision

Energy Demand	Energy delivery technology
Hot water	Point of use electric
Space heating	Air Source Heat Pump (standard efficiency[9])
Space cooling	Air Source Heat Pump
Electricity	Grid

The resulting emission reductions are listed in Table 15.

Table 15: CO_2 Emissions

Energy efficient scheme with ASHP	
Regulated CO_2 Emissions (tCO_2/year)	36.8
Reductions beyond Energy Efficient baseline	0.34%

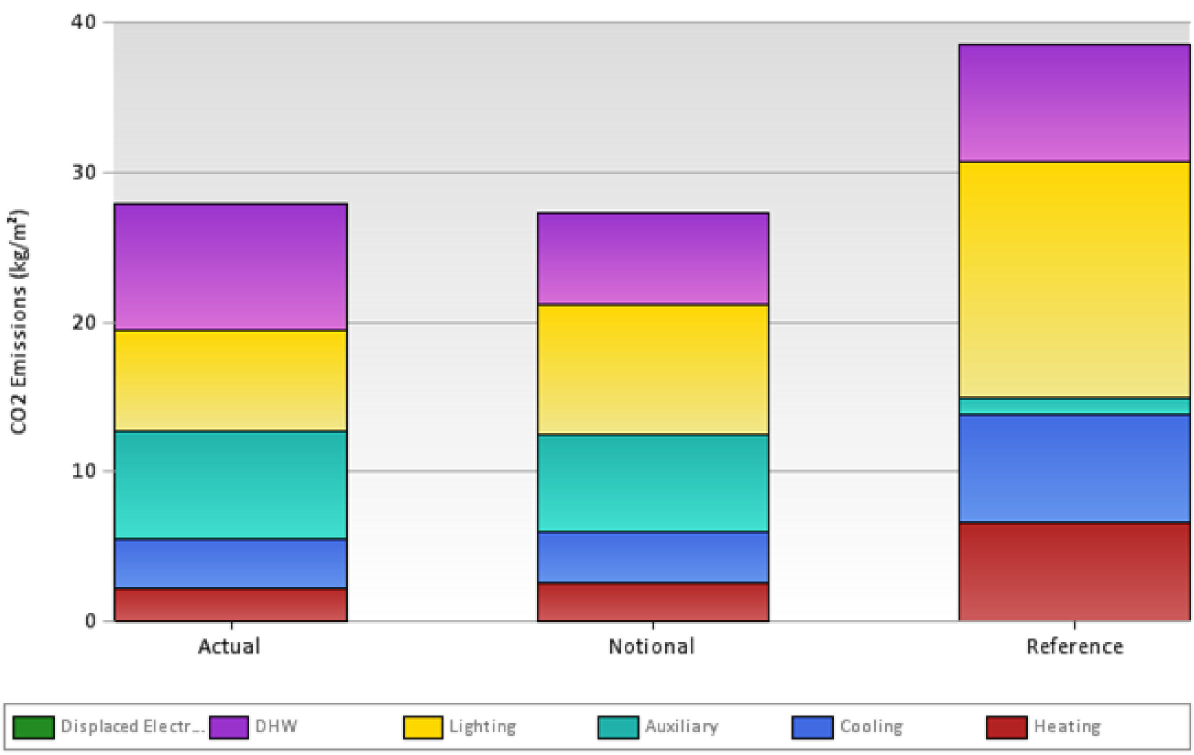
[9] Standard efficiency for 'heating' has been included in the "Clean" stage of the energy strategy in order that only efficient cooling is recognised in the CO_2 emissions reductions figures. High ASHP efficiencies are used for the "Green" section of the energy hierarchy.

Energy efficient scheme with ASHP

Figure 8: CO_2 Emissions of "Clean" case compared with Base Case

Tas UK Building Regulations Studio

Annual CO2 Emissions Comparison



	Actual	*Notional*	*Reference*
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Displaced Electricity (kgCO2/m²)	0.00	0.00	0.00
*Equipment (kgCO2/m²) **	*19.63*	*19.63*	*20.13*
Total (kgCO2/m²)	27.97	27.78	38.60
Total Floor Area (m²)	1327.59	1327.59	1327.59

** Energy used by equipment does not contribute to total value – it is presented here for comparison only*

Source: Mott MacDonald Fulcrum TAS output

6. "Green" - Renewable Energy

In this section options are investigated for further reducing the predicted CO_2 emissions of Project Oasis through renewable energy technologies.

These reductions will be measured against the Energy Efficient Baseline with Efficient Cooling established in Section 6.

The technology combinations have been selected taking into account the energy profiles for the Site, the building service requirements for the particular type of energy being generated and the location and access potential of the site. Table 16 below displays the selection process.

Table 16: Compatible Green Supply Options

Energy	Use	ST	PV	Wood	Wind	ASHP	GSHP / ATES
Heat	Hot water supply	✓	×	✓	×	×	×
Heat	Space heating (or for cooling)	×	×	✓	×	✓	✓
Electricity	Lights, pumps and fans (Part L regulated); small power and appliances (Non-regulated under Part L)	×	✓	×	✓	×	×

6.1 Energy Efficient Scheme with Efficient Cooling and Solar Thermal

6.1.1 Description of Technology

Solar thermal panels are generally used for the production of hot water and consist of roof mounted panels which can efficiently capture heat energy from the sun. In the UK, solar thermal panel systems can provide around 50-60% of the annual energy requirement for domestic hot water applications in dwellings. Summertime operation of the system is normally sufficient to meet full hot water demand, but in the winter supplementary heat from other sources is required.

As well as contributing to the hot water production in individual buildings, solar thermal panels can be used as part of a community heat network. The available roof area of buildings served may limit the amount of solar thermal panels that can be integrated into a particular scheme.

Two main types of solar water heating system are used in the UK: flat plate collectors and evacuated glass heat tubes. Manufacturers' figures show that in London energy produced from solar water heating is an average of 401kWh/m^2/yr for flat plate collectors, and 518kWh/m^2/yr from an evacuated tube system. For either type of collector, the most benefit can be gained if they are mounted facing within 45º of South, at an angle of around 30º. Other mounting positions are feasible, but output will be reduced.

Flat Plate Collector

Flat plate collectors circulate water around a black coloured receiver plate, which is heated by direct sunshine and to some extent by indirect light, with the heat retained by a thermally efficient glazed panel above. Flat plate collectors can be integrated into the roof system, giving the possibility of offsetting some of the cost of the collector against savings in roofing materials.

Evacuated Glass Tube Collector

Evacuated heat tubes are more efficient than flat plate collectors, especially at the low solar radiation levels which occur in Britain; however they are also more expensive. They consist of rows of parallel transparent glass tubes, each containing an absorber tube. Sunlight enters through the outer glass tube and strikes an absorber tube, at which point it converts into heat energy.

6.1.2 Applicability to Project Oasis

Project Oasis is anticipated to exhibit typical office domestic hot water loads of approximately 5 litres per person per day. Assuming occupancy of up to 100 people (based on 1 person per 10m2), just 500 litres per day would be required. This demand is spread over the entire working day. Solar hot water collectors produce their peak outputs when the sun is at its highest point in the sky (i.e. approximately 3 hours before and after 12pm). Supplying an office with hot water from solar collectors involves storing warm water for extended periods of time, with associated risks where the water is held below 60°C; the temperature at which microbes can no longer survive.

No use of solar hot water is proposed for Project Oasis due to the relatively small impact this would have on overall emissions of the site and the problems associated with storing warm water for extended periods of time.

6.2 Energy Efficient Scheme with Efficient Cooling and Biomass/Biofuel

6.2.1 Description of Technology

Biomass boilers are similar to gas fired boilers except that they are specifically designed to burn biomass, typically in the form of woodchip, wood pellets, logs, or straw. Liquid biofuels can also be used.

Biomass boilers are most appropriate in areas where a local and secure source of fuel can be found. If the source of biomass is not local to the site there will be increased CO_2 released during transportation.

There are fuel sourcing issues which need to be addressed when considering biomass boilers. If using woodchip, a crucial issue is the moisture content, since this significantly affects the calorific value of the fuel. Generally a moisture content of 25% or below is recommended (fresh cut wood tends to have a moisture content of over 50%). Wet wood also needs a much larger storage facility and produces considerable quantities of water vapour in the flue gases, which can condense along with wood acids and corrode the plant.

A large area is required to store the biomass fuel, which needs to be located close to the boiler and be easily accessible to enable fuel deliveries. An efficient heating system will need a thermal store to even out many of the peaks and troughs of the heat demand against the constant boiler heat-output. For processed fuel systems such as woodchip or pellet, automatic transmission from the store to the boiler can be achieved, which can reduce the need to manually stoke the boiler and the size of thermal store required. Liquid biofuels are easier to store and movement of the fuel is easier.

There are a number of different types of biofuels; the most common at present are FAME (Fatty Acid Methyl Ester) and MWVF (Modified Waste Vegetable Fat). FAME is produced from oils from crops such as rapeseed (RPSO), and is the biofuel with the most intensive production method. The term biodiesel is commonly used to describe FAME. MWVF can be produced from an additive process in which waste vegetable fat is blended with natural solvents. Both FAME and MWVF can be used in standard diesel boilers with modified burners. A third type of biofuel is oil, such as filtered waste palm oil from restaurants/fast food outlets, which has hardly undergone any processing, but which requires greater modification to the boiler in order for suitable efficiencies to be gained.

At present FAME is commonly produced as a 5% blend transport fuel. Some companies will sell 100% biodiesel, but for use as a heating fuel prices are generally not competitive. The waste vegetable oil for production of MWVF can usually be sourced for free from restaurants/fast food outlets. At present MWVF is not normally available to be bought from an offsite manufacturer, but can be manufactured on site if a suitable contract can be set up.

The use of biomass is classed as an almost carbon neutral process because the CO_2 released during the burning of biomass is balanced by that absorbed by the plants during their growth. There will, however, be some CO_2 emissions relating to the planting, harvesting, processing and transportation of the biomass. Taking this into consideration, the net CO_2 emissions from woody biomass is generally regarded as approximately 85% lower than those from using gas. Emissions from liquid biofuel fired boilers are more difficult to define due to the different fuel types available, but even the most intensively produced (FAME), if used as 100% biodiesel, would give CO_2 emission reductions of at least 50% compared to gas fired boilers.

6.2.2 Applicability to Project Oasis

Biomass boilers are a useful way to achieve significant CO_2 savings where space heating is required.

For biomass/biofuel fired boilers to be a viable option, the site needs to be suited to the delivery regime required, and there needs to be sufficient space for a biomass store. Regular lorry deliveries of biomass throughout the year (but more often over the winter months) could also be a concern for neighbouring properties.

Biomass boiler plant requires regular servicing and the impact of this is not considered justified for a commercial office building with typically high power but low space heating and hot water demands. As the site is located adjacent to a railway tunnel with light conditional loading capacity, the delivery directly to the building is not possible, and would necessitate either blowing (solid biomass) or pumping (liquid biofuels) from Finchley Road. The road vehicle delivery of biomass to this building is not considered appropriate as this would result in temporary obstruction of the roadway each time fuel was delivered. In addition, the future cost of biomass fuel is uncertain. Therefore biomass boilers are not recommended for this office building and have not been considered further.

6.3 Energy Efficient Scheme with Efficient Cooling and Ground Source Heat Pump

6.3.1 Description of Technology

Ground source heating/cooling utilises heat pump technology. A heat pump is a device that moves heat energy from one place to another and from a lower to a higher temperature, or visa versa. Heat pumps are available as both heating only or reverse cycle heating/cooling systems and are classified according to the type of heat source and the heat distribution medium used, as described below.

Typical systems use a refrigeration cycle and use electricity as the energy input driving the process. They are generally more efficient for heating applications which use lower temperatures (such as underfloor heating). The efficiency of heat pumps is measured in terms of COP (coefficient of performance). The lower the temperature difference (seasonally) between the average source and sink temperature the higher the operational COP. Higher COP's mean lower CO_2 emissions.

Ground source heat pumps are typically water-to-water heat pumps. The COP of the system will depend on the source water temperature and the temperature to which it is being raised, but typically lies between 3 and 5.

There are many different variations of ground source energy systems available, but the main types involve utilising the natural thermal conditions of the ground, large bodies of underground water, or large bodies of surface water.

The earth absorbs a large proportion of incident solar radiation, which keeps the ground/groundwater in the UK at a stable temperature of around 11-12 °C throughout the year. This is warmer than the mean winter air temperature and cooler than the mean summer air temperature. This heat/coolth can be utilised using a water-to-air or water-to-water heat pump connected to a ground heat exchanger, in one of the following combinations:

Closed Loop Ground Coupled Heat Exchange

This is typically a network of pipes laid either horizontally or vertically in the ground, through which a liquid is pumped in a continuous loop. The low-grade heat contained within the ground is extracted via the liquid and can be converted to higher-grade heat (i.e. water temperature of 40-65°C) by a heat pump. In the summer, the cooler ground enables the extraction of cooler-than-ambient liquid, which can be used to cool buildings.

Open Loop Ground Water Heat Exchange

In this scenario borehole water is extracted for heat exchange as above and then rejected to a watercourse or the main drain. This technique is considered by many to be environmentally poor in terms of water utilisation, compared to a closed loop system, but generally has a higher COP. In the summer, the cooler-than-ambient groundwater can be used to cool buildings.

Open Loop Surface Water Heat Exchange

This system uses surface water such as lakes and rivers for heat exchange and is likely to have a lower COP than an open loop groundwater system as the lake/river source is likely to be colder in winter and warmer in summer than a ground water source.

6.3.2 Applicability to Project Oasis

Horizontal ground source heating/cooling requires large areas of land under which to lay the pipework. Project Oasis does not have sufficient area associated with the building in which to dig horizontal trenches for pipework. At this site it may therefore be more practicable to use vertical ground source heating/cooling via a number of interconnected boreholes. This would take up less ground area, and is also a more efficient system.

The original application made in 2007 identified Ground Source Heat Pumps as the most suitable renewable energy technology for the site, granted that ground conditions proved suitable. However subsequent studies and investigation have indicated that a Ground Source Heat Pump solution would not be the most appropriate technology for achieving the desired carbon reduction figures at Project Oasis, for the following reasons:

1. Unequal heating and cooling demands

The previous energy strategy was compiled using benchmark figures from the ECON 19 standard. However developments since this time have shown that there are discrepencies between real world operation and the benchmarks given in this standard. This report is based on thermal dynamic modelling of the building using approved software TAS. We can see in the energy breakdown in section xx that the cooling demands of the development are significantly higher than the heating demands. Ground Source Heat Pumps work most efficiently in the long term if heating and cooling demands are equal. If cooling demands are higher than heating demands, in practice this will mean that more heat is ‘dumped’ to the ground during the year than in removed. This will lead over time to a build up of heat in the ground, leading to a loss in performance and efficiency over time.

2. Increased number of boreholes to satisfy heating and cooling demands without the use of additional technology such as Air Source Heat Pump

A study conducted by Fulcrum Consulting in 2008[10] showed that 18x 80m deep boreholes could be accommodated on site (spacing at 8m apart, which would make some allowance for the unequal heating and cooling demands). However, to satisfy the peak heating and cooling demands 32 boreholes would be needed. This would require an additional heating and cooling technology to be installed on the site. Air Source Heat Pump is believed to be the most appropriate technology, given the wish to avoid gas connection and its ability to provide both heating and cooling. Installing two different technologies however is both technically and economically impractical. And given that Air Source Heat Pumps deliver significant CO_2 savings in themselves, the benefit of installing and additional Ground Source system would seem an inordinate burden to the developer. It was found that the Ground Source Heat Pump + Air Source Heat Pump scenario emitted only 5% less CO_2 than the Air Source Heat Pump scenario alone. There will therefore be more cost effective methods of achieving CO_2 savings.

3. Ground conditions and the presence of a rail tunnel running beneath the site.

The site is close to the West Hampstead Interchange, and a rail tunnel runs directly below the site. Due to the size constraints posed on drilling rig from the tunnel width and height, coupled with the general loading difficulties on the site, would require a small drilling rig be used. This would increase the construction time and drive the cost of the system up, not to mention impact the larger construction schedule. Also, due to the tunnel, the header connection for the ground loop will have to meander substantially, possibly rising above ground over the rail tunnel. These factors will drive the cost of the system up.

For the above reasons, and Ground Source Heat Pumps are not longer considered to be the most suitable technology for the Project Oasis site.

6.4 Energy Efficient Scheme with Efficient Cooling and Air Source Heat Pump

6.4.1 Description of Technology

Air Source Heat Pumps upgrade naturally occurring low temperature heat within the air, to useful higher temperature heat for space heating or hot water provision. The process can be reversed to provide cooling.

Air Source Heat Pumps utilise heat pump technology in the same way as Ground Source Heat Pumps – the difference being where the heat is gathered from (or dumped to). Typical systems use a refrigeration cycle and use electricity as the energy input driving the process. They are generally more efficient for heating applications which use lower temperatures (such as underfloor heating). The efficiency of heat pumps is measured in terms of COP (coefficient of performance). The lower the temperature difference (seasonally) between the average source and sink temperature the higher the operational COP. Higher COP's mean lower CO_2 emissions. External air temperature in the UK is more variable than ground temperature – air temperatures will be greatest in summer when cooling demand is also at its greatest and at their lowest with heating demand is greatest. For this reason, Air Source Heat Pumps are slightly less efficient than Ground Source Heat Pumps and vary with external air temperature. However, efficiencies are still high enough for the systems to be more efficient than direct electric heating or gas heating.

The COP of the system will depend on the source air temperature and the temperature to which it is being raised, but typically lies between 2.5 and 4.

[10] 'Energy Options Revisited Filenote', Fulcrum Consulting, 3551 Project Oasis, 6th March 2008.

Air Source Heat Pumps typically consist of an outdoor unit and an indoor unit. The outdoor units can be situated at roof or ground level, and can be located within enclosures provided there is enough air circulation.

Air Source Heat Pumps do emit some noise, however levels are low in comparison to background noise levels of urban areas and noise attenuation measures can be employed.

6.4.2 Applicability to Project Oasis

Air Source Heat Pumps require a reasonable sized floor area to situate, maintain and allow adequate airflow around the unit to perform efficiently and optimise the amount of air on to the coils within the unit. Project Oasis does have sufficient area associated with the building in which to install and mount the units. At this site it may acceptable that the ASHP units are stacked in modulation as this would take up less ground area and free up space for additional plant items, if the site is expanded, and heating/cooling capacity increases.

Subsequent studies and investigations have indicated that an Air Source Heat Pump solution is an appropriate sustainable technology for achieving the desired carbon reduction figures at Project Oasis.

Air Source Heat Pump units require specific space provisions around the unit for adequate air movement however this impact is not considered a major problem for a commercial office building with a low space heating and hot water demand. As the ASPH's will be installed at roof level they will effectively be out of sight to the public, would not obstruct personnel/vehicles and remain clear of debris and items that could block the air path for the heating/cooling cycle. In addition, the cost of installation of ASHP's is considerably lower than GSHP's (Ground Source Heat Pumps) due to the amount of ground excavation required.

An analysis of the carbon efficiency of the air source heat pump against a traditional chiller system has been carried out. The ASHP system has been demonstrated, in Table 17, to be more efficient than a gas boiler heating system. Realistic seasonal efficiencies have been chosen to carry out the analysis.

Table 17: Carbon Efficiency of Gas Boiler + Chiller vs ASHP system

Fuel	Efficiency (%)	CO_2 Emissions Factor ($kgCo_2/kWh/m^2$) of Fuel	CO_2 efficiency of Technology
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COMBINED			
Gas + Chiller	-	-	0.178
ASHP	-	-	0.169

6.5 Energy Efficient Scheme with Efficient Cooling and Photovoltaic Panels (PV)

6.5.1 Description of Technology

Photovoltaics (PV) are solar panels that generate electricity. PV used in the UK can generate some electricity even on overcast days, although peak output is attained around midday on a sunny summer's day.

PV offers a simple, proven, elegant solution to generating renewable electricity. PV arrays can be incorporated as a building integrated photovoltaic array (BIPV), e.g. as part of a roof or façade or mounted independently on the roof. However, the capital cost of PV is large, and therefore to ensure payback of the system, correct siting is key. PV arrays may be grid-connected to export electricity to the grid if there is a surplus of electricity, and the Feed-In-Tariff offers attractive income possibilities for electricity both generated and exported to the grid.

There are four main types of solar PV: thin-film, polycrystalline, monocrystalline, and hybrid. These are available in a number of different formats such as solar tiles which can be used as a direct replacement for roof tiles, standard panels, and glass laminates.

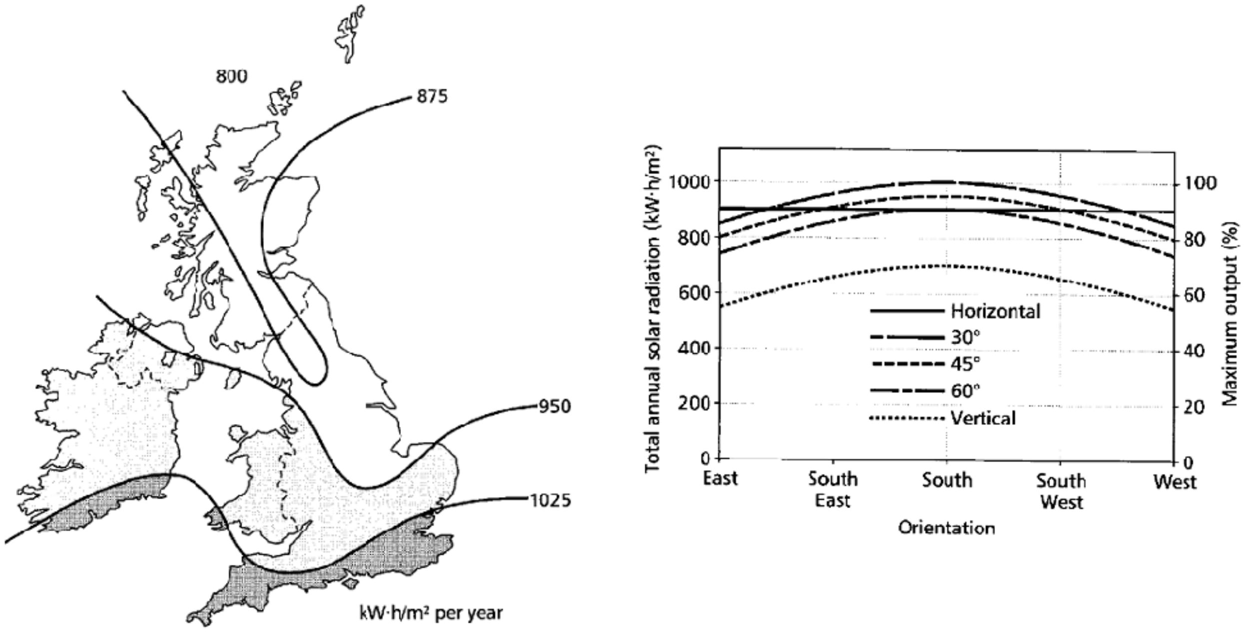
In the UK, the maximum total annual solar radiation is usually found at an orientation of due south and a tilt of 37 degrees. The typical annual output from an unshaded 1m^2 array in such a position is around 50-150kWh per year.

Most PV products have a lifetime of around 20-30 years. The on-going maintenance costs are reasonably low since there are no moving parts. However, the panels require inverter inspections and cleaning to eliminate deposited dust that reduces the efficiency of the system.

6.5.2 Solar radiation

PV panels should face between SE and SW, at an elevation of about 30° – 40°. The graph below shows the average annual total solar radiation on a horizontal surface and the relative output of PV panels mounted in orientations between East and West, as well as the relative output for different tilt angles of the panels. For flat roof areas it is not expected that orientation will be a problem unless height restrictions are in place.

Figure 9: Annual solar irradiation in the UK and Ireland & Relative electricity output for different orientations and tilt angles



Source: DTI – Photovoltaics in Buildings Design Guide, 1999

6.5.3 Risk of overshadowing

There should be no overshadowing of the PV panels, as this reduces their overall efficiency. Even shading a small part of a PV panel could significantly reduce its efficiency and the efficiency of other PV panels connected in the string. Overshadowing can be caused by trees, other buildings, roofs of adjacent buildings, dormer windows, roof furniture, etc.

6.5.4 Grid connection

When connecting a new PV installation to the electricity grid, the main concerns of the Distribution Network Operator are safety and power quality. The installation needs protection to ensure the disconnection from the grid if a loss of mains condition happens. For these reasons, installations of <5kW will need to comply with Engineering Recommendation G83/1. Above 5kW, Engineering Recommendation G59 applies.

Electricity Supply Regulations 1988 requires a connection agreement between the consumer and the Distribution Network Operator and a “power purchase agreement” needed in order to be able to sell excess electricity back to the grid.

6.5.5 Operation & Maintenance

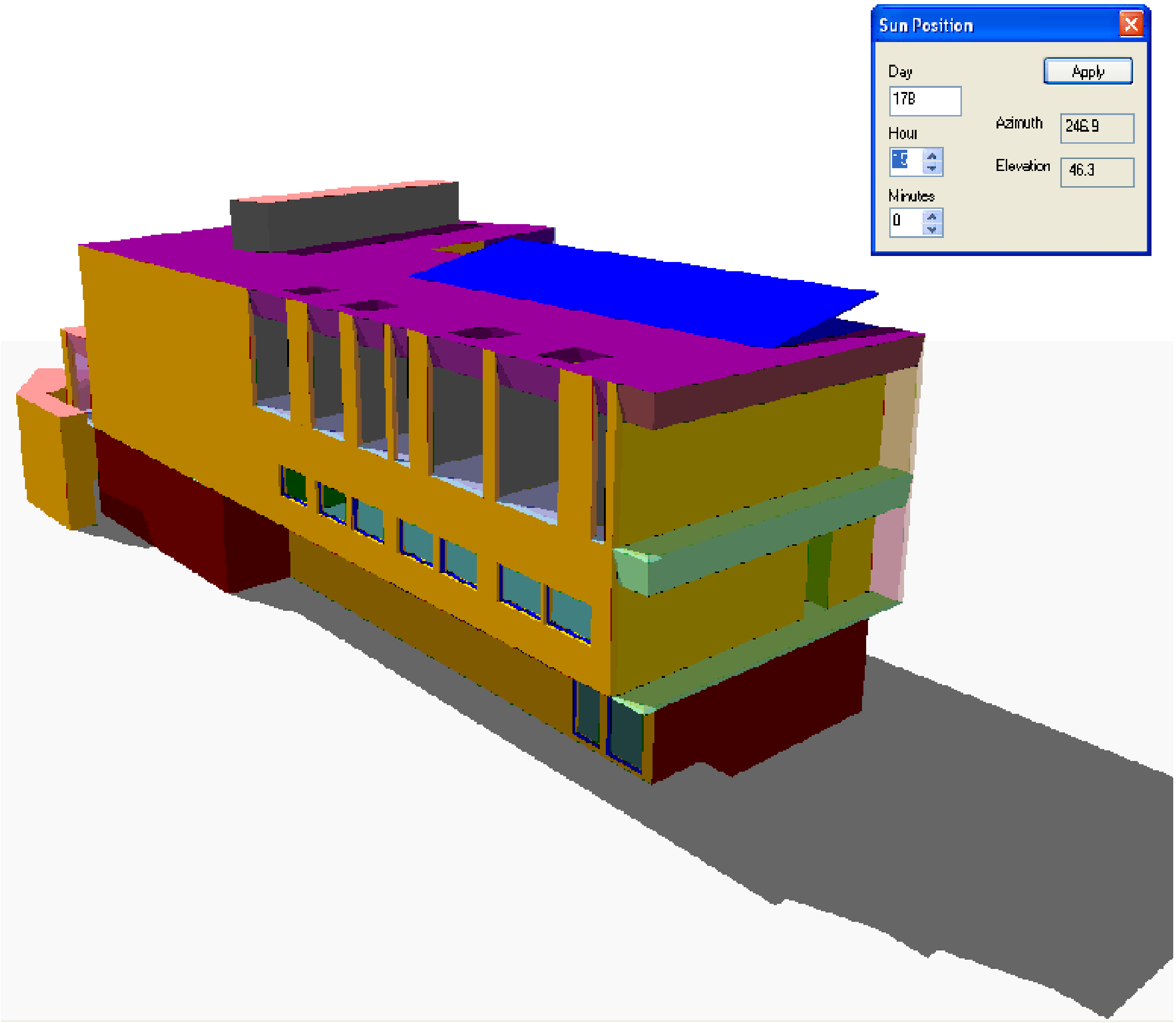
PV systems have relatively low maintenance requirements and running costs. Nevertheless, the cost of replacing inverters should be accounted for. Overshading from nearby trees will have to be assessed as part of a maintenance strategy, and some pruning may be necessary.

6.5.6 Cost and output reliability

The production of electricity through photovoltaic cells has become increasingly common in the UK. The recently started Feed-In Tariffs scheme offer significant revenue for PV. Previously, the majority of large scale projects that have utilised this technology have had significant grant funding in order to facilitate their inclusion. It should also be noted that the FIT scheme has a built in degression rate and is also due for review in 2013.

6.5.7 Applicability to Project Oasis

Figure 10: Proposed PV array on Project Oasis (parapet around roof not shown)



Source: Mott MacDonald Fulcrum, TAS output, Project Oasis

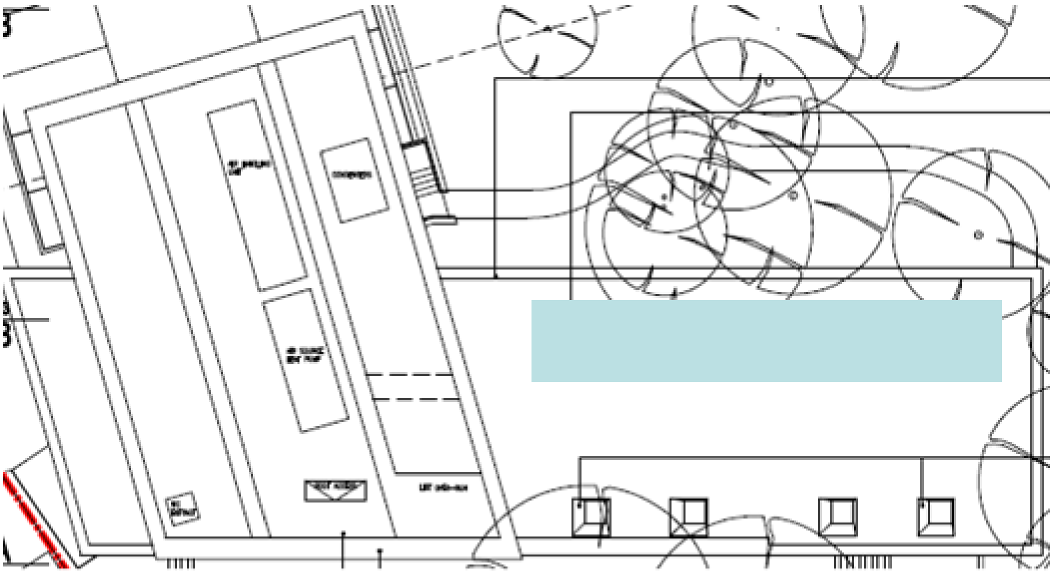
6.5.7.1 Roof availability

When assessing the available roof space that can be utilised for Photovoltaic panels, an area is desired where safe access can be guaranteed for installation and on-going maintenance of the panels. In the case of safe access to the panels not being available, a moveable access platform (hoist) will need to be utilised. This needs to be taken into consideration in later design.

In addition, it is important that the area of roof selected for the siting of Photovoltaic panels is unshaded for the majority of the day. Shading and even partial shading dramatically affects the output of the PV system and therefore impacts its economic and whole life cost feasibility.

A 2m high parapet runs around the perimeter of the roof at Project Oasis. Taking this into account, and the positioning of other essential plant on the roof space, an optimum array configuration is show in Figure 11. The shaded area shows the proposed PV array, measuring 17.5 by 5 metres, a total of 87.5m^2, approximately 9kWp. Extending the array beyond this size would risk overshading and would make access for maintenance difficult and more risky. This area is unshaded by the parapets or adjacent higher section of the building. An inclination of 11° has been chosen in order that the PV array is not visible above the parapet. Output from this potential array is discussed in Section 6.7.

Figure 11: Project Oasis Roof, area suitable for PV shaded.



Source: Roof plan from Jestico & Whiles and indication of PV from Mott MacDonald Fulcrum

The area of roof selected has been identified as free of other mechanical plant, and has also been identified as suitable for use as a Green or Brown Roof. There are successful examples of green roofs where PV has been successfully integrated, particularly if the PVs are inclined.

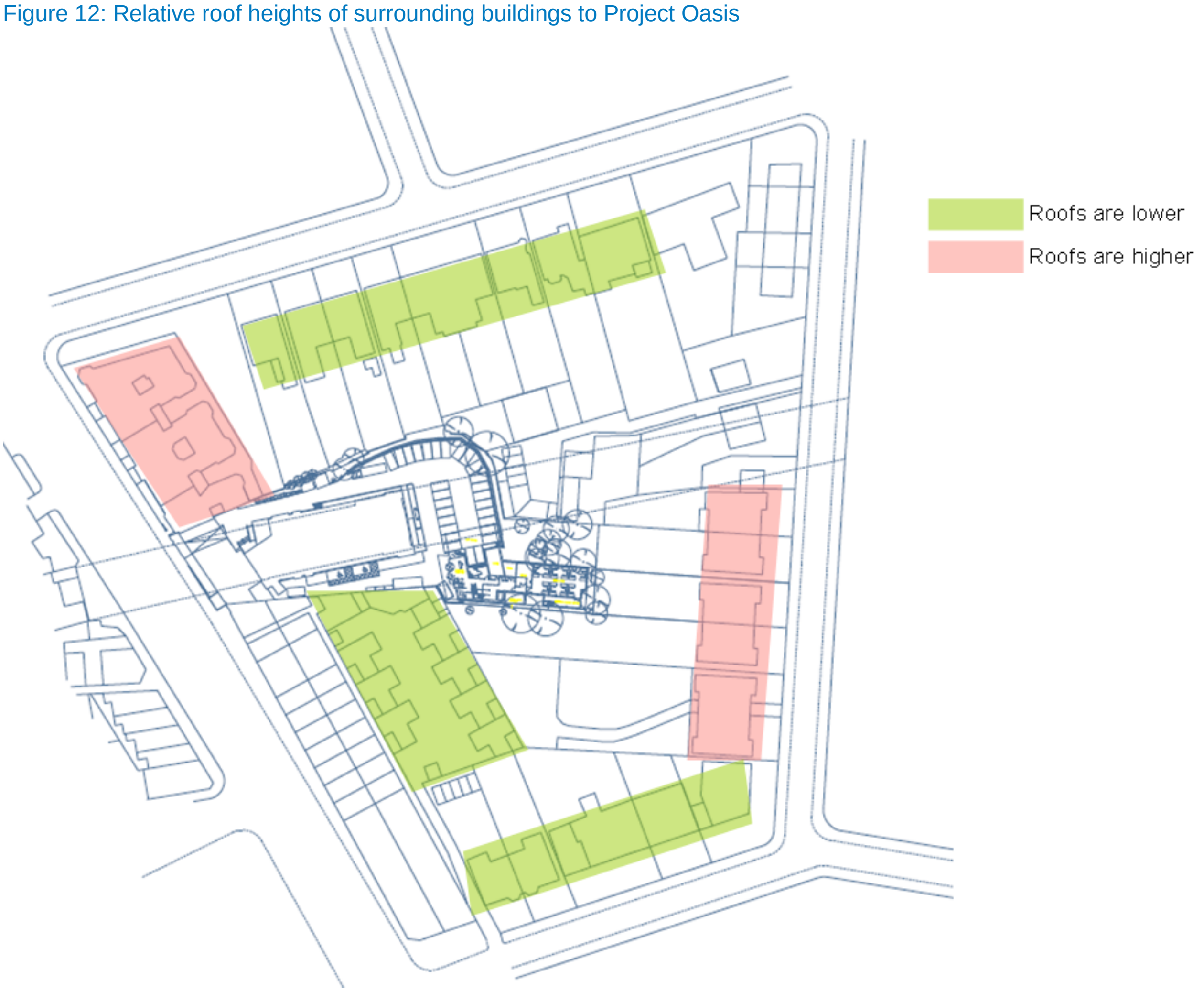
As well as technical feasibility there also needs to be a consideration of economic viability. Currently the feed-in tariff for PV provides a payback period that is within the predicted lifetime of the system, however, the October 2010 spending review has meant the tariff is being reviewed, and proposed cuts (due in

December 2011) are significant, reducing the tariff from 37.8p/kW to 16.8p/kW. The financial viability of PV is therefore likely to change.

6.5.7.2 Overshading

Project Oasis is surrounded by other buildings. The site plan below shows the proximity of these buildings. Sectional drawings and elevations show that taller buildings are present around the site. The distance of these buildings, and the shading analysis below, suggest there is likely to be good sun penetration to the site throughout the day with minimal shading to roofs, meaning that photovoltaic panels should be effective in their electrical output.

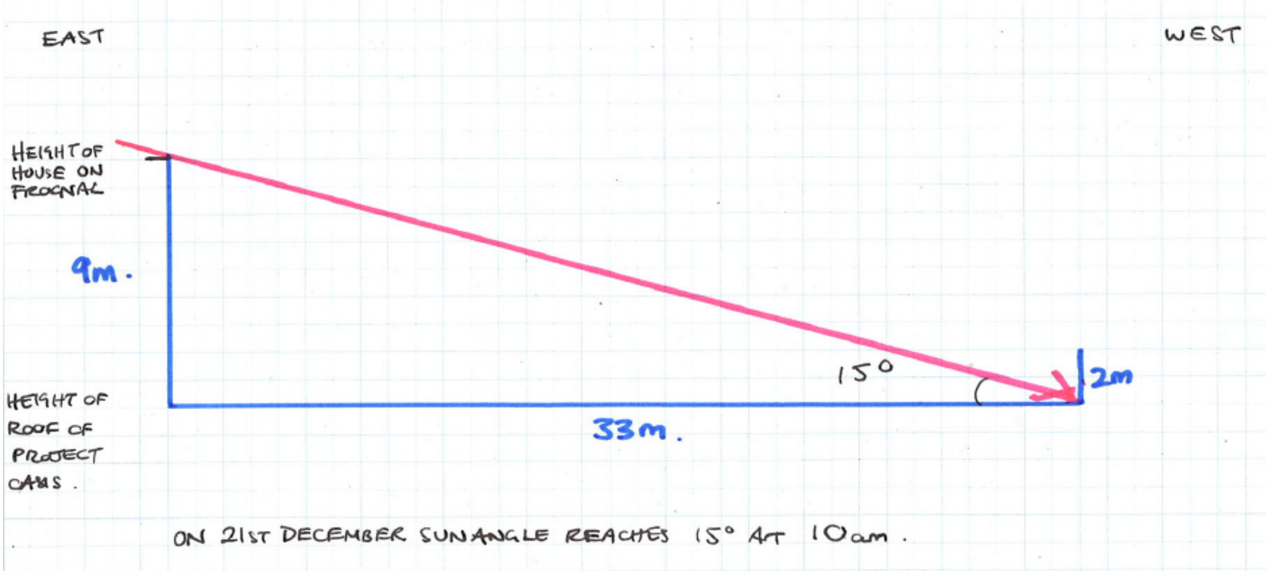
Figure 12: Relative roof heights of surrounding buildings to Project Oasis



Source: Elevation drawings 2069-0511 and 2069-0512

The buildings that pose risk to overshading the available roof space on Project Oasis are the houses to the East, located along Frognal (Figure 12). The roofs of these houses are 9m above the roof of Project Oasis, and are located 33m away. Calculations (Figure 13) show that once the sun is higher than 15 degrees, the sun will rise over the houses and hit the roof. Taking the worst case scenario, December 21st, the sun would reach 15 degrees at 10am. Therefore, these houses do not appear to pose a significant risk of overshading.

Figure 13: Project Oasis: Shading Analysis from houses on Frognal



Source: Mott MacDonald Fulcrum

Site plans show the presence of trees around the building, these are thought to be below the level of the roof on the south side, however allowance needs to be made for tree growth, and therefore should be re-visited during detailed design. Regular tree pruning may also be necessary to ensure the PV panels do not become over-shaded during the course of the building's life.

Photovoltaics are regarded as suitable for Project Oasis. CO_2 emissions reductions are discussed in section 6.7.

6.6 Energy Efficient Scheme with Efficient Cooling and Wind Turbines

6.6.1 Description of Technology

Wind turbines generate electricity from the wind. They typically grouped into horizontal axis or vertical axis turbines, and come in a large range of sizes, from micro-turbines that can be used on boats through to commercial scale wind turbines used out at sea.

Project Oasis is nestled within a dense built up urban area. A number of studies have shown that wind turbines are generally less suited to dense urban areas as their output will be affected by potentially lower and more disrupted wind speeds. Additionally, the use of larger more cost-effective machines may be undesirable due to the proximity of buildings.

Small wind turbines exist such as the ‘Swift’ from Renewable Devices which is rated at 1.5kW at 12m/s. This machine is design to be roof mounted. Each of these is expected to offset approximately 500kWh per year at the reduced wind speeds of an urban location. A slightly larger 6kW vertical axis turbine such as the ‘Quiet Revolution’ from XCO2 would achieve more significant CO_2 savings (around 1000kWh/year for this scheme) and is considered more visually appealing by some people. This size of turbine is positioned on a mast at ground level, but is considered too large to be mounted on most buildings.

A medium scale turbine would only suitable for being positioned on ground-based structures (masts). A machine such as the Proven WT6000 6kW would be expected to produce approximately 5,000 kWh per year on this urban site. This machine has a blade diameter of 9m and would need to be positioned on a 12m mast, making the total height 17.5m at the tip of the blade.

Table 18: Turbine Details

Turbine	Proven Energy WT6000	Quiet Revolution qr5
Manufacture	Proven Wind Turbines	XCO2
Website	www.provenenergy.co.uk	www.quietrevolution.co.uk
Text Left	 Stand alone or building mounted	 Stand alone or building mounted
Rotor Diameter	5.5	4.2m
Pylon Height	At least 12m	9m
Approx Annual Output at site, per turbine	5000 kWh	1,000kWh

6.6.2 Issues to be aware of

Wind turbine outputs are strongly dependent on wind speed and turbulence therefore their location needs to be considered carefully. Generally, turbines should either be located away from obstructions such as buildings (ideally 10 x height of obstruction downstream) or on the top of tall buildings. There are likely to be considerable difficulties in locating the required number of the smaller turbines on the Proposed Development. There are also potential issues with noise and shadow flicker as well as the effects of the turbines on the buildings structure and the visual impact, particularly on townscape. Given these issues wind turbines are not considered as a preferable solution.

6.6.3 Applicability to Project Oasis

6.6.3.1 Average Wind Speeds

The average annual wind speed for locations in the UK is provided by DECC's online Wind Speed Database. For this site the following average wind speeds are shown in Figure 14.

Figure 14: NAOBL Wind Estimates for Project Oasis (NW3 6BX)

NOABL Windspeed Database

for the 1km grid square 526 185 (TQ2685)

Wind speed at 10m agl (in m/s)

5.7	5.9	5.5
5.3	5.6	5.1
4.8	5.0	5.0

Source: DECC

It should be noted, however, that these estimates do not take into consideration landforms (e.g. hills and wood stands) and are often found to over estimate actual wind conditions. Studies have shown these estimates to be very wrong in many cases, and the only reliable way of estimating the wind speeds and patterns on the site are to install wind monitoring equipment for at least 12 months.

6.6.3.2 Location

There are several issues that must be considered from the use of wind turbines. The proximity of a wind turbine to residential, institutional and commercial type properties must be considered; in relation to issues such as noise, flicker, radar interruption, visual amenity, ice throw and bat strike.

The site of the Project Oasis building is not exposed. It is bordered on all sides by buildings, many of which are taller than the proposed Project Oasis building. Small scale turbines mounted on the roof of the building are not likely to receive enough quality wind to generate electricity. Each of these is expected to offset approximately 500kWh per year at the reduced wind speeds of an urban location. Multiple machines of this scale would be required to produce the energy required to meet the 20% requirement of LB Camden.

The slightly larger 'Quiet Revolution' from XCO2 would achieve more significant CO_2 savings (around 1000kWh/year for this scheme). The turbine would need to be positioned on a mast anchored at ground level, with the turbine higher than the roof level of the building. A medium scale turbine would only suitable for being positioned on ground-based structures (masts). A machine such as the Proven WT6000 6kW would be expected to produce 5,000 kWh per year. This machine has a blade diameter of 5.5m and would need to be positioned on a 12m mast, making the total height 17.5m at the tip of the blade.

Large scale wind turbine technology does not seem to be a valid candidate as renewable energy technology for the energy strategy at Project Oasis due to the small size of the site and the urban location. Large scale application of wind technology is not suited for the site since it requires a large expanse of land and could have several negative environmental impacts.

However, no land exists for a medium scale turbine at Project Oasis and there may be planning risk associated with proposing multiple, roof-mounted machines. Therefore they are not recommended as part of the energy strategy at this stage.

6.7 Carbon Emissions Reduction from Feasible Technologies

The renewable energy technologies identified as feasible for the Project Oasis building and site are Photovoltaics and Air Source Heat Pumps. These technologies have been taken and added to the design simulation model in TAS, in order to calculate predicted CO_2 emissions reductions.

6.7.1 Energy Efficient Scheme with Air Source Heat Pump

Air Source Heat Pumps have been identified as an appropriate technology for Project Oasis. Project Oasis has heating and cooling demands, and no gas supply. It is therefore proposed that Air Source Heat Pumps are provided to supply 100% space heating and 100% space cooling demands.

CO_2 emissions reductions from only ASHP have been analysed, using the energy supply options in Table 19. The CO_2 emissions reductions realised through this strategy are laid out in Table 20.

The CO_2 emissions reductions below the "clean" case through using efficient ASHP is only 2%. This is because the notional building used to generate the base case under Building Regulations 2010 assumes ASHP heating also. Therefore, we will consider the use of Photovoltaic panels too.

Table 19: Energy Supply Options

Energy Demand	Energy delivery technology
Hot water	Point-of-use electric
Space heating	ASHP
Space cooling	ASHP
Electricity	Grid electricity

Table 20: CO_2 Emissions

Energy efficient scheme + efficient cooling + AHSP heating, "Green"	
Site baseline CO_2 Emissions (tCO_2/year)	36.06
Site Total CO_2 Emissions (tCO_2/year) (including non-regulated electricity)	62.12
Reductions beyond "Lean" scenario	2%

6.7.2 Energy Efficient Scheme with ASHP and Photovoltaics

The energy provision for the “green” scheme is summarised in Table 11. The CO_2 emissions of this scheme and the reductions beyond the baseline are illustrated in Table 12.

A comparison of the established baseline CO_2 emissions (building regulations baseline) and the anticipated emissions of the proposed “green” scheme after demand reductions measures are applied are shown in Figure 15Figure 7.

The energy demand reduction measures and servicing strategy proposed together with the use of photovoltaics improve upon CO_2 emissions over the “clean” scheme by 13.7%. While this is not the 20% target outlined in planning policy, this is the maximum area of un-shaded PV the roof will support. All other renewable energy technologies have been analysed and no further feasible technologies have been identified. Therefore a 13.7% reduction in CO_2 emissions from renewables is the the maximum anticipated feasible reduction for Project Oasis.

Table 21: Energy Supply Options

Energy Demand	Energy delivery technology
Hot water	Point-of-use electric
Space heating	ASHP (100%)
Space cooling	ASHP (100%)
Electricity	87.5m^2 poly-crystalline photovoltaic panels (at 11 degree incline, south facing and unshaded)and grid electricity

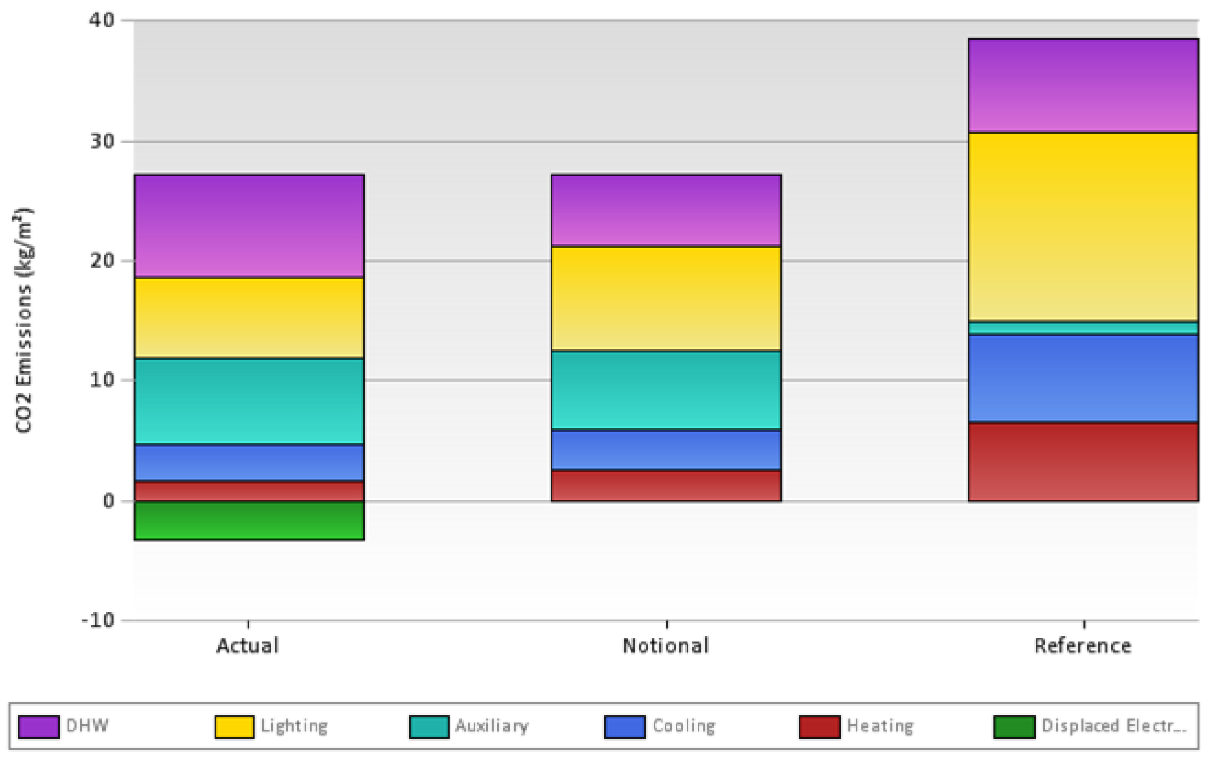
Table 22: CO_2 Emissions

Energy efficient scheme + efficient cooling + AHSP heating + PV, “Green”	
Site baseline CO_2 Emissions (tCO_2/year)	31.75
Site Total CO_2 Emissions (tCO_2/year) (including non-regulated electricity)	57.81
Reductions beyond “Lean” scenario	13.72%

Figure 15: CO_2 Emissions Breakdown, “Green” – Energy Efficient + efficient cooling + ASHP heating + PV

Tas UK Building Regulations Studio

Annual CO2 Emissions Comparison



	Actual	Notional	Reference
Heating (kgCO2/m²)	1.58	2.59	6.61
Cooling (kgCO2/m²)	3.09	3.40	7.29
Auxiliary (kgCO2/m²)	7.28	6.49	1.05
Lighting (kgCO2/m²)	6.70	8.77	15.82
DHW (kgCO2/m²)	8.52	6.01	7.84
Displaced Electricity (kgCO2/m²)	-3.24	0.00	0.00
*Equipment (kgCO2/m²) **	*19.63*	*19.63*	*20.13*
Total (kgCO2/m²)	23.92	27.26	38.60
Total Floor Area (m²)	1327.59	1327.59	1327.59

** Energy used by equipment does not contribute to total value – it is presented here for comparison only*

Source: Mott MacDonald Fulcrum

7. Discussion & Conclusions

7.1 Proposed Strategy

This document discusses how the energy strategy for Project Oasis follows the energy hierarchy set out in the London Plan: use less energy ("lean"), supply energy efficiently through CHP ("clean") and use renewable energy ("green").

The baseline used to compare the CO_2 emissions savings for the energy strategy is estimated to be 36 tCO_2/year using 2010 Building Regulations. [insert references to tables]

For the "lean" element of the hierarchy, a high level of energy efficiency will be used in the building fabric and building services. Due to the exceedingly high (and in many cases unrealistic) efficiencies used in the Notional Building – which generates the Target Emissions Rate (TER), the proposed energy efficiency measures for Project Oasis alone are not enough to exceed the TER and meet Building Regulations. The CO2 emissions reductions compared to the baseline are -1%. [insert references to tables]

For the "clean" element of the hierarchy, it has been identified that connection to an existing community energy network or installing a Combined Heat and Power unit for the building would not be appropriate, due to the small scale of the office building. There is very small demand for heat and currently no gas supply to the site, therefore the preferred approach will be to use an efficient electric heating and hot water system. Cooling demand will be satisfied efficiently through the use of an Air Source Heat Pump system to provide efficient, low carbon cooling. Despite the improved efficiency of the cooling system this is still not enough to pass building regulations. The CO_2 emissions reductions compared to the "lean" scenario are 0.34%. [insert references to tables]

For the "green" element of the hierarchy, as an Air Source Heat Pump is the preferred cooling option, a reversible Air Source Heat Pump is proposed to provide the heating demand also. This is also particularly suitable since there is no gas connection to the site. In addition, an element of the roof space has been identified as suitable for a photovoltaic installation. This has been selected taking into account space requirements for Air Source Heat Pumps and other plant, and overshading by parapet walls and adjacent buildings. The extent to which trees may overshadow the roof needs to be monitored and future growth checked. The CO_2 emissions reductions compared to the "clean" scenario are 13.7%. [insert references to tables]

The total cumulative savings beyond the Target Emissions Rate using the "green" scenario is 12.3%.

Table 23: Indicative CO_2 emissions at different stages of the energy hierarchy for Project Oasis

Indicative Carbon dioxide emissions (Tonnes CO_2 per annum)	Regulated	Unregulated	Total
Building Regulations 2010 Part L Compliant Development [TER]	36.19 (A)	26.06	62.25
After energy demand reduction	37.14 (B)	26.06	63.19
After energy demand reduction +efficient ASHP cooling	36.80 (C)	26.06	62.86
After energy demand reduction & efficient ASHP cooling & ASHP heating	36.06	26.06	62.12
After energy demand reduction & efficient ASHP cooling & ASHP heating & PV	31.75 (D)	26.06	57.81

Table 24: CO_2 emissions reductions, including % reductions and cumulative savings

CO_2 emissions reductions	Tonnes CO_2	%
Savings from energy demand reduction	*-0.95*	*-2.63%*
Savings from efficient cooling	*0.34*	*1.00%*
Savings from renewable energy	*5.05*	*13.72%*
Total Cumulative Savings	*4.44*	*12.3%*

Table 25: Indicative energy demand, regulated and unregulated

Indicative Energy Demand (kWh per annum)	Regulated	Unregulated	Total
Building Regulations 2010 Part L Compliant Development [TER]	117,451.89	51,696.35	169,148.24
After energy demand reduction	109,991.72	51,696.35	161,688.07
After energy demand reduction +efficient ASHP cooling	109,991.72	51,696.35	161,688.07
After energy demand reduction & efficient ASHP cooling & ASHP heating [V01]	109,991.72	51,696.35	161,688.07
After energy demand reduction & efficient ASHP cooling & ASHP heating & PV [V10]	101,427.88	51,696.35	153,124.23

7.2 Comparison to Targets

Compared to the targets indicated by the planning policies of the London Borough of Camden and the London Plan, the proposed CO_2 reduction targets are shown in Table 26. The London Borough of Camden and the London Plan sets a renewables target of 20% reductions in CO_2 emissions – the strategy proposed at Project Oasis achieves a 13% reduction. The London Plan also sets an overall CO_2 reduction target from Part L 2010 of 25% - the strategy at Project Oasis achieves a 12% reduction.

Table 26: Planning targets

	London Borough of Camden Target	London Plan Target	Project Oasis Proposed
Total % reduction from Part L 2010 compliant building	Not stated	25%	12%
% reduction from renewables	20%	20%	13%

While the specific targets have not been met, the CO_2 emissions reductions achieved are still significant for a building of this size and type.

7.2.1 Scope for further CO_2 emissions reductions

There is not significant scope for further reductions of CO_2 emissions.

The efficiency of the building fabric has been optimised to reduce heat losses but also to limit the build up of heat gains. Glazing is efficient, limiting heat gains but also allowing good daylight penetration. It has not been possible to push improvements as far as the 'notional building' and pass building regulations through energy efficiency alone. This is in large part due to the hot water demand and provision. No gas is supplied to the site, and the cost of supplying gas and installing gas boilers for domestic hot water outweighs the benefits in predicted CO_2 emissions. Domestic hot water demand has in reality been proven to be less than modelling predicts, and electric point-of-use water heaters are in practice an efficient way of providing small quantities of hot water.

CHP and community heating and not appropriate for this building. Efficient cooling through the use of Air Source Heat Pumps is proposed.

All renewable energy technologies have been considered. The following have been discounted as unfeasible for the site:

- Biomass/biofuel – due to site access limitations for delivery of fuel and a shortage of storage area.
- Solar hot water – due to a very small hot water demand
- Ground Source Heat Pump – due to the proximity of underground rail tunnels and the imbalance in heating and cooling demands
- Wind – due to the enclosed nature of the site, as well as being in an urban location anyway.

The renewables identified as feasible for the site are:

- Photovoltaics – there is sufficient roof area available for 87m^2 of photovoltaic panel
- Air Source Heat Pump – ASHP can be provided to supply 100% of space heating and 100% of space cooling needs.

The technical feasibility and economic viability of these technolgies will alter as the detailed design and financial incentives (particularly any changes to feed-in tariffs or any detailed announcement on the renewable heat incentive) evolve. At this stage it is proposed that renewable energy provision is to be met through Air Source Heat Pumps and 87 sq m of photovoltaic panels.

Appendix A. Financial Incentives

A.1. Feed-In Tariffs

A Feed-In-Tariff (FIT) is a policy mechanism which is designed to encourage small scale renewable electricity generation by allowing the generator to earn a regulated income from every kilowatt hour generated. As of 2010, FIT legislation is in place in 63 countries across the world.

From April 2010 Feed-in tariffs (FIT) are available in the UK for electrical generation from renewable sources. The tariff value varies with the source and size of generation. At the time of writing, the tariff levels are under review and are due to change very shortly. It is recommended that exact levels for different technologies and sizes of installations are checked with DECC.

PV panels of less than 10kW installed on new buildings did benefit from a generation tariff of 37.8 pence/kWh for electricity produced and consumed in the development – however the spending review is likely to see this cut to 16.8 pence/kWh. The onsite consumption would offset the cost of imported power, offering a further benefit. However if there is no onsite consumption, the electricity could be exported and would receive an additional export tariff of 3 pence/kWh. These levels incentivise consumption on site rather than export.

The tariff levels remain fixed for the lifetime of a particular system, which is 25 years for PV. However to incentivise early installation a 7% annual degression rate will apply to reduce the generation tariff for new installations after 2012.

Listing of generation tariff levels up to March 2012

Energy Source	Scale	Tariff (p/kWh)[A]	Duration (years)
Energy Source	Scale	Tariff (p/kWh)	Duration (years)
Anaerobic digestion	≤250kW	14.0	20
Anaerobic digestion	>250kW - 500kW	13.0	20
Anaerobic digestion	>500kW	9.4	20
Hydro	≤15 kW	20.9	20
Hydro	>15 - 100kW	18.7	20
Hydro	>100kW - 2MW	11.5	20
Hydro	>2MW - 5MW	4.7	20
Micro-CHP [B]	<2 kW	10.5	10
Solar PV[D]	≤4 kW new	37.8	25
Solar PV[D]	≤4 kW retrofit	43.3	25
Solar PV[D]	>4-10kW	37.8	25
Solar PV[D]	>10 - 50kW	32.9	25
Solar PV[D]	>50 - 150kW	19.0	25
Solar PV[D]	>150 - 250kW	15.0	25
Solar PV	>250kW - 5MW	8.5	25
Solar PV	Standalone	8.5	25
Wind	≤1.5kW	36.2	20
Wind	>1.5 - 15kW	28.0	20
Wind	>15 - 100kW	25.3	20

Energy Source	Scale	Tariff (p/kWh)[A]	Duration (years)
Wind	>100 - 500kW	19.7	20
Wind	>500kW - 1.5MW	9.9	20
Wind	>1.5MW - 5MW	4.7	20
Existing generators transferred from RO	9.4	to 2027	

Source: www.fitariffs.co.uk

A.2. Renewable Heat Incentive

The Renewable Heat Incentive (RHI) is a forthcoming piece of legislation to provide a fixed rate financial incentive for renewable heat. The Government intended to introduce the Renewable Heat Incentive to encourage renewable heat generation at the end of September 2011, however this has been delayed. The full details are still under consultation and may be subject to some variation but is intended that the scheme will pay an incentive per kWh based on a fixed rate of return for heat generated from renewable technologies such as biomass, solar thermal or heat pumps. The rate of return is intended to be around 12% for all technologies except solar thermal which would be 6%. The incentivisation levels in the current model appear to favour small scale installation, i.e. those up to 500 kW. This is a consequence of the RHI that should be monitored as it will affect the scale at which the industry will respond and therefore where technology risk is mitigated and skills are developed.

Appendix B – BRUKL Report

BRUKL Output Document

HM Government

Compliance with England and Wales Building Regulations Part L 2010

Project name

Oasis — As designed

Date: Fri Nov 18 14:57:00 2011

Administrative information

Building Details

Address: 202-204 Finchley Road, London,

Certification tool

Calculation engine: TAS

Calculation engine version: "v9.2.1"

Interface to calculation engine: TAS

Interface to calculation engine version: v9.2.1

BRUKL compliance check version: v4.1.c.1

Owner Details

Name: -

Telephone number: -

Address: -, -, -

Certifier details

Name: Yudish Dabee

Telephone number: 02075201300

Address: 62-68 Rosebery Avenue, London, EC1R 4RR

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

1.1	CO_2 emission rate from the notional building, $kgCO_2/m^2$.annum	27.3
1.2	Target CO_2 emission rate (TER), $kgCO_2/m^2$.annum	27.3
1.3	Building CO_2 emission rate (BER), $kgCO_2/m^2$.annum	23.8
1.4	Are emissions from the building less than or equal to the target?	BER =< TER
1.5	Are as built details the same as used in the BER calculations?	Separate submission

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

2.a Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.28	0.28	External Wall
Floor	0.25	0.2	0.2	Upper Floor
Roof	0.25	0.2	0.2	Ceiling
Windows***, roof windows, and rooflights	2.2	1.39	2.32	Frame_Curtain Wall
Personnel doors	2.2	-	-	No personal doors in project
Vehicle access & similar large doors	1.5	-	-	No vehicle doors in project
High usage entrance doors	3.5	1.44	1.44	Glass South Entrance Door

$U_{a\text{-}Limit}$ = 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
m³/(h.m²) at 50 Pa	10	5

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m²]	1328	1328
External area [m²]	2330	2330
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	5	5
Average conductance [W/K]	1607	1076
Average U-value [W/m²K]	0.69	0.46
Alpha value* [%]	26.94	26.94

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

Building Use

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

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	3.3	5.42
Cooling	6.45	7.11
Auxiliary	15.22	13.57
Lighting	14.01	18.34
Hot water	17.81	21.31
Equipment*	38.94	38.94
TOTAL	56.79	65.74

* Energy used by equipment does not count towards the total for calculating emissions.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	6.45	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Indicative Target
Heating + cooling demand [MJ/m²]	128.92	139.46
Total consumption [kWh/m²]	56.79	65.74
Total emissions [kg/m²]	23.8	27.3